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Using positional data from vessel monitoring systems (VMS) to validate the logbook-reported area fished and the stock allocation of commercial fisheries landings, 2004-2011[1]

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Abstract
Vessel monitoring system (VMS) positional data from northeast United States fisheries were used to validate the statistical area fished and stock allocation of commercial landings derived from mandatory logbooks. A gear-specific speed algorithm was applied to VMS positions collected between 2004 and 2011 from the otter trawl, scallop dredge, sink gillnet and benthic longline fisheries to estimate the location of fishing activity. Estimated fishing locations were used to re-allocate the stock area landings of eight federally managed groundfish species. The accuracy of the VMS method relative to the mandatory logbooks was assessed using haul locations and catch data recorded by at-sea observers. VMS-based allocations generally outperformed VTR-based allocations; VMS methods achieved stock allocations more similar to observer-based allocations in 85 of the 144 cases examined (59.0%; 18 stocks over 8 years).

In more recent years, the performance of the VMS-based allocation has been more similar to that of the VTR-based algorithm. The similarities in the recent performance of the two allocation methods is likely attributable to a growing number of smaller vessels that are now required to use VMS whereas as historically, VMS was only required of the larger offshore trawlers participating in special management programs. The VMS algorithm tended to overestimate the number of statistical areas fished such that when a trip's fishing activity occurred in a single statistical area, logbooks more accurately reflected the true fishing location. On trips where fishing activity occurred in multiple statistical areas, the VMS algorithm showed appreciable gains relative to logbook data. VMS-based methods show promise as a means of validating the VTR-based allocations. However, given the limited extent of VMS both over time and in breadth of fisheries covered, it is not an acceptable surrogate for VTR-based allocations, but does provide a valuable tool for monitoring vessel reporting compliance and evaluating the potential impacts of vessel misreporting.

Introduction

Among the federally managed fish species in the northeast United States (U.S.), eight species are managed and assessed as two or more discrete stocks. The eight species are: Atlantic cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), yellowtail flounder (*Limanda ferruginea*), winter flounder (*Pseudopleuronectes americanus*), windowpane flounder (*Scophthalmus aquosus*), goosefish (*Lophius americanus*), silver hake (*Merluccius bilinearis*) and red hake (*Urophycis chuss*). Stock units are comprised of statistical area groupings (Fig. 1) with stocks defined by divisions that, in most cases, relate to oceanographic features (e.g., Gulf of Maine, Georges Bank; Table 1). All of the species are managed under the Northeast Multispecies Fisheries Management Plan (NEFMC, 1985), with the exception of goosefish which is managed under the Monkfish Fisheries Management Plan (NEFMC, 1998).

In the northeast U.S., dealer weighout data are assumed to be a census of commercial landings amounts. Commercial landings are allocated to management stocks using the statistical areas reported on the mandatory paper logbooks (Wigley et al., 1998). These logbooks are referred to as vessel trip reports (VTRs). Current VTR regulations require that on completion of a fishing trip, a logbook report must be submitted which documents the total catch by species for each statistical area in which fishing occurred (Title 50 of the U.S. Congressional Federal Register, Part 648.7). Despite the regulations, it is known that misreporting of statistical area occurs, most frequently in the form of underreporting the number of statistical areas fished when fishing occurs in more than one area (Palmer et al., 2007; A. Applegate and T. Nies pers. comm.). While, underreporting of statistical areas does not necessarily translate to the misclassification of commercial landings to stock areas, the potential exists and the magnitude of these effects on the allocation of commercial landings requires evaluation.

The most reliable source of fisheries-dependent catch and effort data in the northeast U.S. are available from the information collected by at-sea fisheries observers. However, because these data are limited in their coverage (e.g., generally < 5% of all certain fisheries in a given year, Wigley et al., 2007) they cannot provide the synoptic coverage necessary to allocate commercial landings to stock area with any regularity. Vessel monitoring systems (VMS) in the northeast were first implemented for the limited-access scallop fisheries in 1998 (NEFMC, 1993). The use of VMS has increased over time (Fig. 2) and expanded to cover many fisheries (Table 2). Historically the larger off-shore vessels participating in the limited-access scallop and special-access groundfish fisheries were more likely to be equipped with VMS compared to the smaller near-shore vessels. With the passage of Framework 17 to the Atlantic sea scallop Fishery Management Plan (FMP; NEFMC, 2005) and Framework 42 to the Multispecies FMP (NEFMC, 2006), VMS is now required for a greater proportion of the smaller near-shore scallop and groundfish fleets. While VMS does not provide census coverage of these fleets, it does provide census coverage of trips taken by those vessels equipped with VMS. Given the increasing use of VMS in the region, this represents a potential tool to conduct large-scale validation of the statistical areas reported on VTRs.

Vessel positions obtained from VMS have been used as a proxy for the location of fishing effort in prior work (Deng et al., 2005; Murawski et al., 2005; Mills et al., 2007). Commonly, the average vessel speed is used to differentiate fishing activity from non fishing activity (Deng et al., 2005; Murawski et al., 2005). Many VMS programs do not require the transmission of instantaneous vessels speeds; only a vessel position and a date and time stamp. This has changed recently in some fisheries (Mills et al. 2007); however, most users of VMS data must infer vessel speed and course from averages calculated from successive positions. Northeast U.S. VMS regulations only require the transmission of the position and the associated date and time. Positions are typically collected once per 30 min from vessels participating in the limited access scallop fishery and once per 60 min from vessels participating in the groundfish fishery (Table 2). The classification error of fishing versus non-fishing activity will depend in part on whether the vessels speeds available to the analysis represent instantaneous vessels speeds or averaged vessels speeds calculated from the distance traveled between VMS polling events. As the VMS polling frequency increases, the relative accuracy of the calculated speeds decreases (Figure 3). The average vessel speed method can achieve accuracy levels as great as 99%, however it can also result in the incorrect classification of non-trawling activity (Mills et al., 2007) leading to an overestimation of fishing intensity. A more complex method utilizing both vessel speed and directionality has been attempted (Mills et al., 2007); however, this method did not improve the detection of fishing activity and reduced the inclusion of false positives only slightly (0.7%).

When using the vessel-speed method, the amount of classification error is sensitive to the VMS polling rate (Figure 3, Palmer, 2008), the speed ranges used to define fishing activity and the practices of the fishery under observation (e.g., how much overlap exists between the vessel-speed signals of fishing and non-fishing activity, how long are individual hauls). With the exception of Mills et al. (2007) much of the work so far published in the fisheries literature has utilized VMS data without a quantitative assessment of the classification error of fishing vs. non-fishing activity when the vessel-speed method is used. This paper assesses the ability of the VMS vessel-speed method to detect the statistical area fished and allocate fishery landings to stock area by comparing results to matching NEFOP trips. The method is then applied to assess VTR area reporting compliance and its impacts on the current VTR-based allocation method used in the northeast US.

Materials and methods

Data sources

VTR logbook trip, gear and species catch data were extracted from the VTR logbook reports from calendar years 2004 to 2011; prior to 2004, fewer than 500 vessels were equipped with VMS units in the Northeast Region, thus limiting the scope of a VMS-based allocation (Fig. 2). The analytical datasets were post-processed to remove any overlapping trips (i.e., trips taken by the same vessel with a date of sail occurring before the date of landing of a previous trip). Overlaps occur because of VTR reporting and/or data entry errors. This process resulted in the removal of between 1.2% and 2.2% of the total annual reported VTR trips from 2004 and 2011. Of the remaining trips, only those trips where at least one of the eight study species were reported as retained catch were retained in the dataset (Atlantic cod, haddock, yellowtail flounder, winter flounder, windowpane flounder, monkfish, silver hake, and red hake). Because the focus was on assessing the impact of statistical area misreporting on the proration of commercial landings, discards were not included in these analyses. All species weights were converted to live weight in kilograms (kg) using standard species conversion factors established by the Northeast Fisheries Science Center (NEFSC). The VTR dataset was further restricted to include only the four major gear types responsible for species landings in the region: fish bottom otter trawl (OTF), scallop dredge (DRS), sink gillnet (GNS) and benthic longline (LLB). VTR species landings were then assigned to a stock area based on the statistical area fished reported on the logbook (Palmer and Wigley, 2007; Table 1). The final VTR subsets used in this analysis contained between 23,000 and 34,000 trips per year (Table 3).

All available VMS data were extracted from the VMS database for each vessel and assigned to the appropriate VTR trip by matching on the vessel and assigning all VMS point locations with dates between the VTR date of sailing and date landed to the respective trip. The average vessel speed was calculated by dividing the haversine distance (Sinnott, 1984) by the time difference between consecutive VMS positions. All positions were assigned to a National Marine Fisheries Service (NMFS) statistical area (Fig. 1). Summaries of the number of VMS-VTR matched trips by year are included in Table 3.

In the northeast U.S., at-sea fisheries observers are coordinated by the NEFSC's Northeast Fisheries Observer Program (NEFOP). Beginning in May, 2010 at-sea monitors (ASMs) were also deployed in the groundfish fishery. While the data collected by ASMs could be included in this analysis for the years 2010 and 2011, to date it has not been. Future updates of this work will attempt to incorporate ASM data. All NEFOP trips which could be matched to the list of VMS-VTR matched trips were extracted from the observer database. Matches were established using the vessel, date of sailing and date landed as reported on the VTR; trips with multiple matches were removed from the analyses. For all matched trips the associated haul duration, statistical area fished, species and retained catch weights were also extracted; retained catch weights were converted to live weight in kilograms (kg) using standard NEFSC conversion factors. Summaries of the number of matches by year are included in Table 3.

Method development and application

Past research using northeast U.S. VMS data have differentiated fishing activity from non-fishing activity by using only upper-speed bounds; < 3.5 knots for bottom trawl vessels (Murawski et al., 2005) and < 5.0 knots for scallop dredge vessels (Rago and McSherry, 2001). To our knowledge no attempt has been made to identify fishing activity from the VMS signals of fixed-gear vessels (i.e., sink gillnet, benthic longline). We attempted to improve vessel-speed classifications and extend the application to fixed-gear vessels through a combination of visual examination of the percent frequency distributions of VMS-derived average speeds, knowledge of fishing operations and observations from high-frequency polled GPS data.

Percent frequency distributions of VMS average vessel speed were plotted for all gear types (Fig. 4). These were then compared to percent frequency distributions of activity-specific (fishing vs. non-fishing) instantaneous vessel speeds from high-frequency polled GPS data (1 fix/10 seconds) collected from vessels involved in NMFS Cooperative Research projects (Fig. 5). These data sets included precise observations of the dates and times of fishing activity. Six trips taken by five separate vessels were analyzed; two groundfish bottom trawl trips, two scallop dredge trips and two gillnet trips. Individual vessel speed observations from all trips were combined by gear type and activity was classified as either 'fishing' or 'other'. For mobile gear, ‘fishing’ was defined as the period from winch brake lock to winch brake release; presumably the period when the gear is actually in contact with the bottom. For fixed gillnet gear, ‘fishing’ was defined as the period when gear is being hauled back. Unfortunately, high frequency polling data were not available for benthic longline activity. It is assumed that fixed gears such as sink gillnet and benthic longline gear are likely to be fished in very specific and limited geographic areas on a given trip, thus it is unlikely fishing is occurring on multiple fish stocks on a single trip. If this assumption is true, these analyses will not be as sensitive to misclassification of fixed gear activity relative to mobile gear activity.

VMS-based bottom otter trawl activity exhibits a very pronounced bi-modal distribution of vessel speeds. It was assumed that the first mode (2.8 knots) represented fishing activity and the second mode (8.0 knots) was indicative of steaming activity. Fishing activity falls within a very narrow range from approximately 2.0 to 5.0 knots as evidenced by the distributions observed from the high-frequency GPS data. A fishing speed window of 2.0 knots < fishing activity < 4.0 knots was used. This window fits the high-frequency polled GPS well, correctly classifying 99.2% of fishing activity. However, it also incorrectly categorizes 31.8% of non-fishing activity as fishing activity (Fig. 5). It is expected, that a portion of the non-fishing activity falling inside the window of fishing speed represents activity associated with the hauling and setting of the gear, which suggests that the impact of false-positives on statistical area fished estimation may not be as great as the 31.8% figure implies.

The VMS-based average-vessel-speed distribution of scallop dredge activity has a nearly tri-modal distribution (Fig. 4). Unlike bottom otter trawl speed distributions there is a high percentage of activity close to 0.0 knots. This may be indicative of shucking activity when vessels are drifting and allowing the crew to shuck scallops and clear the deck. The primary mode (4.2 knots) was assumed to represent fishing activity and the 8.2 knot mode was assumed to represent steaming activity. Scallop dredge fishing activity occurs over a broader range compared to trawl activity, falling between approximately 2 to 7 knots as evidenced by the distributions observed from the high-frequency GPS data (Fig. 5). A fishing speed window of 2.5 knots < fishing activity < 6.0 knots was used. This window fit the high-frequency polled GPS well, correctly classifying 98.3% of fishing activity; however, it incorrectly categorized 69.3% of non-fishing activity.

Like scallop dredge activity, VMS-observed sink gillnet average speed distributions have a tri-modal distribution (Fig. 4). Based on personal knowledge of gillnet operations, the first mode (0.6 knots) was interpreted as representing the hauling of gillnet gear, the second mode (3.0 knots) as re-setting the nets and the third mode (8.2 knots) as steaming activity. The majority of presumed hauling activity occurred between the speeds of 0.1 and 1.3 knots. This window did not fit the high-frequency polled GPS well. Only 50.0 % of the fishing activity was correctly identified. Conversely, this speed window incorrectly classified only 25.3% of non-fishing activity. Given the limited scope of the high frequency polling data (i.e., 2 trips taken by 1 vessel) and the likelihood that the geographic extent of fixed gear vessels is somewhat limited, a decision was made to use the 0.1 and 1.3 knot speed window.

Benthic longline average speed distributions have a bimodal distribution (Fig. 4). The first mode (0.8 knots) was interpreted as representing the hauling and setting of the longline gear and the second mode (10.0 knots) as steaming to and from the fishing grounds. For benthic longline gear the same speed used for gillnet gear was used (0.1 < fishing activity < 1.3 knots).

Those VMS locations identified as representative of fishing activity were then used to determine the statistical areas in which fishing occurred. Statistical areas fished were compared across data sources to assess whether the statistical areas derived from VMS-defined fishing activity represented an improvement over VTR reported statistical areas relative to NEFOP data. Trips were broken into two categories: single area trips (fishing occurs in only one statistical area per trip) and multi-area trips (fishing occurs in more than one statistical area per trip). Because all stock boundaries are divided along statistical area boundaries, correct reporting of multi-area trips are of the greatest concern. These are the trips having the potential to fish on multiple stocks of fish in a single trip and where misreporting of statistical area(s) may lead to incorrect estimates of stock removals. For each trip, the levels of agreement between the NEFOP, VMS and VTR statistical areas were categorized as in agreement ('Complete'), not in agreement ('None') or in partial agreement ('Partial'; at least one statistical area was in agreement, but not all). Agreement levels were contingent on agreement among both the number of statistical areas reported and the identity of those statistical areas. For example, if a VTR reports that fishing occurred in statistical areas 515 and 521 and VMS positions indicate that fishing occurred in 515 and 521 then the trip would be considered to be in agreement ('Complete'). If the VTR reported fishing in 515, and the VMS data suggests fishing occurred in 515 and 521, then the trip would be considered to be in partial agreement ('Partial'). If the VTR reported fishing in 515, and the VMS data suggests fishing occurred only in 521, then the trip would not be considered to be in agreement ('None'). The same analysis was repeated on the larger set of VMS and VTR matched trips.

A VMS-based allocation algorithm was devised using the statistical areas fished from the VMS data to re-allocate VTR-reported landings to stock area. Fishing activity was assigned to stock area based on the species landed and statistical area in which the fishing activity was occurring. The time spent fishing in each stock area was estimated as the sum of fishing activity blocks occurring in each stock area. The duration of one activity block is contingent on the VMS polling frequency which is variable, but generally once per 30 minutes for scallop vessels and once per hour for groundfish vessels. Total VTR trip landings for each species (*s*) were allocated to stock area (*k*) based on the ratio of time spent fishing in each stock area as determined from VMS locations (Equation 1).

(1) $$\hat{L}_{sk} = \left(\left(\sum l_{si}\right) + l_{sk}\right) \bullet \left(\frac{t_k}{\left(\sum t_i\right) + t_k}\right)$$

where:

$\hat{L}_{sk}$ = VMS prorated trip landings for species *s*, stock *k* (kg)
l_s = trip landings for species *s* in stock area, *k*, as derived from VTR reports (kg)
l_i = trip landings for species *s* in stock areas *i*, where $i \neq k$, as derived from VTR reports (kg)
t_k = time spent fishing in stock area, *k*, as derived from VMS positional data (days)
t_i = time spent fishing in stock area *i*, where $i \neq k$, as derived form VMS positional data (days)

The results of the VMS-based allocation were compared to landings allocation derived from both NEFOP and VTR data sources to assess the relative accuracy of the VTR-based allocation and determine if the VMS-based algorithm resulted in improved estimates of landings by stock area. VTR and NEFOP species landings were prorated by assigning landings to stock area based on the reported statistical area. All comparisons were performed through an examination of the percent allocation to stock area as opposed to absolute landings because percent allocations derived from the traditional VTR source are used to allocate the amounts of commercial landings as determined through dealer weighout data (Wigley et al., 1998). The same analysis was performed on the larger VMS-VTR matched data set.

The VMS-based allocation method assumes a constant species catch-per-unit-effort (CPUE) at all fishing locations (i.e., species catch is distributed only as a function of the time spent fishing in each stock area). This assumption neglects species habitat preferences (e.g., sediment composition, water depth and temperature, etc.) which would result in species being more likely to be caught in some locales and not others. To assess the degree to which this assumption was violated, individual species trip allocations from the VMS-method were compared to the same allocations as determined from NEFOP observations using linear regression.

Results

Method validation using NEFOP data

Statistical area agreement between NEFOP and VTR was > 94% for single area trips across all years between 2004 and 2011, but less than 17% for multi-area trips (Table 4). Nearly all disagreements among the 'partial' multi-area trips matches (> 98%) are due to under-reporting of statistical areas (fewer statistical areas reported on the VTR compared to NEFOP); for example there were 105 trips in 2004, 337 in 2005, 166 in 2006, 247 in 2007 and 219 in 2008. There was a general trend towards improved VTR reporting of multi-area trips between 2004 and 2006, though the level of accurate reporting has remained constant at approximately 15% since 2007, with the exception of 8% accurate reporting of multi-area trips in 2010. Given the small sample size, limited number of years of NEFOP comparisons and potential for observer-type effects on VTR-reporting, caution should be taken in inferring any meaningful conclusion based on these apparent trends.

The statistical area agreement between NEFOP and VMS-based statistical areas was lower (≥ 88.0%) for single-area trips compared to the NEFOP-VTR comparisons (Table 5). The cause of disagreement among single-area trips is primarily due to the overestimation of statistical areas fished by the VMS-based method. The overestimation results from the VMS-based method misclassifying non-fishing activity as fishing activity. Agreement among multi-area trips is greater (> 67%) when using the VMS-method compared to the VTR-reported statistical area trips, with only a single trip in complete disagreement across the time series (2009). Among statistical areas in partial agreement there was a tendency for the VMS-method to overestimate the number of statistical areas fished (e.g., 59.5% of partial matches in 2004, 53.3% in 2005, 50.8% in 2006, 57.3% in 2007, and 56.3% in 2008). The performance of the VMS-based method in detecting statistical areas fished is not equivalent for all gear types; a closer examination of the VMS-NEFOP statistical area comparison in 2005 showed that 80.3%

(535 of 666) of trawl trips, 65.4% (17 of 26) of dredge trips, 83.8% (88 of 105) of gillnet trips and 97.1% (101 of 104) of longline trips have agreement levels of ‘Complete’. This finding supports the assumption that the misclassification of the location of fixed gear fishing activity is less likely compared to mobile gear activity.

The VMS-based allocation method arrived at annual stock allocations closer to NEFOP allocations relative to the VTR-based allocations for 85 of the 144 stock comparisons examined (eighteen stocks over five years; Tables 6 – 13). There were no species allocations for which the VMS-based allocation under-performed the VTR allocation in all eight years. There was a general improvement in the VMS-based allocation between 2004 and 2006 with the number of species for which it under-performed the VTR allocation decreasing from three in 2004 to only one in 2006. However, the VMS method did not outperform the VTR method in 2007 and 2010, and only marginally better in 2008 and 2009. The two methods were equal in 2011 in terms of number of stocks. Of all species, goosefish, silver hake and red hake had the greatest percent difference relative to the NEFOP allocation. Comparisons of the individual trip stock allocations between the VMS-based method and NEFOP allocation in 2005 showed strong agreement between VMS and NEFOP stock allocations ($r = 0.823$, $p < 0.001$, $n=514$; Fig. 6), however there was considerable spread in the residuals. There are large differences in the NEFOP landings compared to VTR landings shown in Tables 6 – 13 for some species, most notably monkfish (e.g., in 2004 NEFOP estimated 380 mt compared to the VTR estimate of 71 mt). The exact reasons for these discrepancies are unknown, however there is a tendency for self-reported hail weights to be biased low (Palmer et al., 2007). Additionally, monkfish tails constitute a large proportion of monkfish landings and these are often incorrectly reported on VTRs as whole monkfish (Palmer et al., 2007). A conversion factor of 3.32 is applied to monkfish tail landings to convert these to whole weights; incorrect reporting of monkfish tails as whole monkfish will results in the underestimation of VTR monkfish landings by approximately a factor of 3.

Extrapolation to larger VMS-VTR matched dataset

The NEFOP-VMS-VTR subset of data used to validate the VMS-based method is relatively small compared to the total population of VTR-recorded trips (Table 3). The validation results suggest that for some trips monitored through VMS, the VMS-based allocation method can be used to gauge the accuracy of the stock allocations as determined through VTR reports. The VMS-VTR matched set is a much larger dataset. The subset of VTR reports examined (eight species caught using the four gear types) account for only approximately a quarter of the total VTR reports in a given year (Table 3), however this dataset accounts for greater than 95% of the landings of all the study species across the time series through 2008 (Table 14). Interestingly, beginning in 2009, the percentage of species landings included in the VTR subset began to decline, most notably for haddock which declined precipitously to only 56.9% of the total haddock landings by 2011. This decline is almost definitely due to increased use of the haddock separator trawl and Ruhle trawl from 2009 through 2011. Future updates of this work should include these gears types in the trawl category.

Similarly, VMS coverage is available for only 5,892 to 25,924 of the VTR trips in a given year (Table 3), but these trips typically account for a majority of the total landings of individual species (Table 14). By 2006, VMS data were available for trips responsible for landing greater than 70% of all species but goosefish; coverage of goosefish landings is low because there are no specific VMS requirements for the goosefish fishery (Table 2). Since 2008 VMS data covered > 70% of all species landings with the exception of monkfish, windowpane flounder and silver hake. The sole exception is the coverage of haddock landings in 2011 which is likely explained by the exclusion of the haddock separator and Ruhle trawl from this analysis. There has been a slight decline in the number of vessels covered by VMS since 2007 (Fig. 2). It is unclear whether this has contributed to the decrease in the percentage of landings covered by VMS or is reflective of vessel matriculation from the fishery.

All demersal species examined in this analysis are primarily caught by the otter trawl fishery except goosefish where gillnet gear is responsible for the majority of the landings. Gillnet is the secondary gear type for all species with the exception of haddock and silver hake which are secondarily targeted by benthic longline (Tables 15 -22). VMS coverage of the landings by most gear types is highly variable, though generally increasing with time; there is a general pattern of low gillnet coverage of the landings of most species during the time series.

Examination of the VTR statistical area reporting using VMS-based statistical areas fished showed similar patterns to those observed in the NEFOP-VMS-VTR comparisons. Agreement levels of single-area trips exceeded 92% in all years and always less than 8.6% for multi-area trips (Table 23). This level of agreement is less than that observed in the NEFOP-VTR comparison. It is unclear whether these lower rates of agreement in the single-area trips are due to the overestimation of the number of statistical areas fished by the VMS method, an observer-effect, or some other factor. Closer examination of the partial matches revealed that the number of vessels apparently under-reporting the number of statistical areas fished was 397 in 2004, 477 in 2005 and 629 in 2006. Those vessels that likely frequently under-report trips (> 5 trips in a year) are responsible for the majority of the potentially under-reported trips. In 2004 there were 179 vessels that appeared to frequently under-report accounting for 1,876 of 2,797 of partial agreement trips (67.1%). In 2005, there were 221 vessels in this category, accounting for 2,787 of the 3,837 partial agreement trips (72.6%) and in 2006 there were 268 vessels which potentially under-reported the number of areas fished, accounting for 3,815 of the 5,251 partial agreement trips (72.7%). The number of vessels in this category increased in 2007 to 307 vessels accounting for 4,485 of the 5,489 partial agreement trips (81.7%) before falling in 2008 to 199 vessels accounting for 2,747 of 3,686 partial agreement trips (74.5%). Since 2008 the numbers have increased substantially. In 2009 there were 629 vessels accounting for 5,221 of the 5,302 partial agreement trips (98.5%). The number of vessels in 2010 and 2011 were in 2009, 581 and 548, respectively accounting 4626 of 4700 partial agreement trips (98.4%) in 2010, and 4727 of 4831 partial agreement trips (97.8%) in 2011.

It is important to consider the implications of the matched trip set composition when interpreting the performance of the VMS-based method. The performance relative to the VTR method is contingent on the number of multi-area trips and the gear composition of the matched data set. For example; a higher proportion of multi-area trips in the examined dataset would appear to improve the performance of the method. The percentage of multi-stock trips recorded by VMS increased in 2005 followed by a decline in 2006 to levels below 2004 values for all but windowpane, silver hake and red hake trips (Table 24). The declines generally continued through 2009, but exhibited a slight increase for a few species in 2010 and 2011, likely as result of the change in management regimes from the days-at-sea system to a sector-based system. Those trips fishing on multiple stocks are predominantly (≥ 99.0%) mobile-gear vessels (Table 25), implying that fixed-gear fishing effort occurs primarily in localized geographic areas such that landings from fixed-gear trips are unlikely to have come from multiple stocks. This supports the prior assumption that the misinterpretation of the VMS speed signals from fixed-gear trips is unlikely to result in the misallocation of landings.

The perceived under-reporting of statistical areas in the VTR data led to minor (< 5%) differences in the overall species allocations; only six stocks in the eight year time-series exhibited differences in stock allocations exceeding 4.0% (2006: northern and southern windowpane flounder, ± 4.7%; 2010: Georges Bank and southern New England winter flounder, ± 4.1%; %; 2011: Georges Bank and southern New England winter flounder, ± 4.1%; Tables 26 – 33). However, these small differences in percent allocation have a disproportionate effect on the less abundant stock such as such as Gulf of Maine haddock, southern New England yellowtail, southern windowpane and northern silver hake. For these, stocks, minor differences can be large (≥ 5.0%) relative to the percent of the total species landings allocated to that stock (Tables 26 – 33). These impacts are most notable in the stock allocations of the southern New England/mid-Atlantic yellowtail flounder. Stock allocation differences between the VTR and VMS methods were ≤ 1.6% for all years, however commercial landings of this stock were ≤ 6.4% of the total stock landings as estimated from the VTR reports resulting in relative differences of 53.8, 61.9 and 25.0% for the years 2004, 2005 and 2006 respectively. In 2007 and 2008 the relative differences were < 2%. Of the 144 stock/year combinations analyzed the VMS-based method stock allocations had ≥ 5.0% relative difference compared to the VTR-based allocations for 36 of the comparisons.

There was a tendency for the VTR-method to over-allocate the Georges Bank Atlantic cod and haddock stocks relative to the VMS method (2004 haddock was an exception). In the case of cod, while there is evidence of directional bias, unlike haddock the differences have been small (≤ 2% from 2006-2011, Table 34). There were no consistent trends in the over/under-allocation of Georges Bank yellowtail and winter flounder stocks and under/over-allocate the Gulf of Maine and southern New England stocks. The direction of stock allocation differences for goosefish, windowpane flounder, silver hake and red hake was variable from year to year.

Discussion

The underreporting of statistical areas on VTR logbooks is a problem that affects greater than 80% of the multi-area trips examined. The VTR underreporting rates from this study agree closely with past studies that have used both NEFOP and haul-by-haul self reported data (Palmer et al., 2007). While the impacts of this underreporting are relatively small in regards to overall stock allocation percentages, the relative impacts on less abundant stocks such as southern New England/mid-Atlantic yellowtail can be substantial. This is in agreement with the findings of other studies that have examined this issue using more restrictive data sets (A. Applegate and T. Nies pers. comm.). These discrepancies have implications on the estimation of fishery removals and the assessment of these stocks. While the impacts are minimal for the majority of stocks examined, the extent of the impacts on those few stocks that are significantly affected (e.g., southern New England yellowtail flounder) suggests that this is a problem deserving of attention.

Many of the stock assessments of these eight species use finer stratification of commercial landings (e.g., quarter and market category) to estimate landings at age numbers used in virtual population analysis (VPA), or similar assessment models (Mayo and Terceiro, 2005). This paper does not consider the impacts of statistical area reporting patterns on these finer scale stratifications of commercial landings, however the accuracy of finer-scale allocations would be sensitive to the number of multi-area trips included in each strata. It is possible that the effects of statistical area mis-reporting on stock allocations are reduced due to offsetting errors (i.e., a trip that misallocates 1,100 kg to the Georges Bank cod stock would be largely offset by a trip that misallocates 1,200 kg to the Gulf of Maine cod stock). However, the spatial accuracy of VTR reports is critical not only for the assessment of fish species, but also of protected species such as sea turtles (e.g., Murray, 2004, 2005, 2006; Orphanides and Bisak, 2006) and marine mammals (Belden et al., 2006). When these data are used at finer spatial scales the accuracy of VTR reports becomes increasingly important.

It is important to consider that the results of these analyses apply only to the trips monitored by VMS; however by 2006, trips responsible for the large majority of species landings examined were monitored by VMS (Table 14). VMS coverage of some fisheries such as the Northeast multispecies complex is nearing a census, with all vessels required to use a VMS unit when fishing on a Multispecies Days-At-Sea (DAS) (NEFMC, 2010). The increased coverage improves the utility of VMS data as a validation tool for managers and as a data set of spatial fishing patterns for analysts. The number of vessels responsible for the landings of the eight species examined has remained constant at slightly less than 1,200 (Table 3), however the number of these vessels monitored by VMS has increased from 38.5% (453 of 1,176) in 2004 to 80.5% 679 of 843) by 2011. The increase in VMS usage appears to have occurred primarily among the smaller-nearshore fleet in response to VMS requirements to participate in the general category scallop fishery (NEFMC, 2005) and the NE multispecies fishery (NEFMC, 2006) as indicated by the drop in percentage of multi-stock area trips recorded by VMS from 2004 to 2008 (Table 24). This decrease in the number of multiple stock area trips may explain the improved performance of VTR-based allocations in the later part of the time series (2007-2011, Tables 9-13). Increases in the number of multi-stock trips since 2010 are likely the result of the switch to sector management which may afford vessels greater flexibility to move among areas. For all allocated groundfish species (cod, haddock, yellowtail flounder and winter flounder), there has been an increase in the percentage of multi-stock trips since 2009.

The results are sensitive to the accuracy of average VMS vessel-speeds in differentiating fishing activity from non-fishing activity as well as the validity of the VMS-based allocation. This study defines fishing activity using narrower speed ranges than have been used in past studies which should lead to more conservative estimates of fishing effort. The speed range used for the mobile gears agree closely with the speeds obtained from high-frequency polling of vessels GPS units suggesting that these ranges are reasonable. The speed ranges used for gillnet gear did not correspond all that well with the high frequency GPS polling data; however, given the low percentage of fixed gear trips fishing on multiple stock areas (Table 25), the lack of agreement should not negatively impact these analyses. Additionally, this study relied on average vessel speeds not instantaneous vessel speeds, which are more analogous to the speeds estimated from high-frequency GPS polling. The averaging process blurs activity from observation to observation, potentially leading to an incorrect determination of fishing activity (Fig. 3; Deng et al., 2005; Palmer, 2008). These impacts were not explicitly considered in this study and represent an area of uncertainty.

The speed ranges adequately classify fishing activity (> 98% success for mobile gear, ≥ 50% success for gillnet gear), but tend to overestimate the amount of fishing by incorrectly classifying non-fishing effort as fishing (69.3% misclassification of non-fishing scallop activity). The overestimation was apparent in the comparisons of statistical areas fished between VMS and NEFOP data (Table 5). Future work should focus on the use of more advanced statistical procedures such as mixture distribution models (e.g., Marin et al., 2005) to decompose the mixed distributions of vessels speed. The fine scale observations taken from cooperative research vessels could be used identify likely parameterization of the underlying probability density functions.

VMS data indicate where it is likely that fishing effort is occurring but provide no information on catch composition. A critical assumption of the VMS-based allocation is that the proportion of species caught across multiple stock areas on a fishing trip is only a function of the time spent fishing in each stock area. In the Gulf of Mexico penaeid shrimp fishery, this assumption has generally held true (Cole et al., 2006), however, it may not be appropriate in a multispecies groundfish fishery where the species habitat preference is variable and the target species changes from trip to trip. While the relationship between VMS and NEFOP allocations was significant suggesting that an assumption of constant CPUE is valid, there was a considerable amount of variability (Fig. 6). However, the use of groundfish habitat models (e.g., Rooper et al., 2005) could be used to improve the catch allocation used in this paper. The large degree of variability in this relationship is not independent of overestimating the time spent in an area by the VMS method; disproportionate overestimation of time spent fishing in a particular stock area will have a direct affect on the VMS-based allocation.

The various uncertainties and shortcomings of the VMS allocation method point out that this is not a replacement for a VTR-based allocation. Additionally, the low vessel coverage of historical VMS data (Fig. 2) limits its use as a tool to correct historical misreporting. However, the results do show that VMS data can be used as a tool to monitor the accuracy and completeness of VTRs and guide efforts to improve VTR compliance. The number of vessels which are potentially under-reporting statistical areas on a frequent basis is smaller (< 700 vessels) relative to the total number of vessels submitting VTRs (> 2,000; Table 3). Improvements are needed in the compliance of VTR reporting regulations, particularly among those vessels likely to be fishing on multiple fish stocks. Given the manageable size of the problem and availability of tools to monitor these data, the quality of self-reported data should be monitored and improved through targeted outreach and education activities.

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Tables

Table 1. Statistical areas used to define species stock units for eight species examined.

Species	Stock area	Statistical areas
Atlantic cod *(Gadus morhua)*	Georges Bank (GBK)	521, 522, 525, 526, 533, 534, 537 - 539, 541 - 543, 551, 552, 561, 562, 611 - 616, 621 - 629, 631 - 639
	Gulf of Maine (GOM)	464, 465, 467, 511 - 515
Haddock *(Melanogrammus aeglefinus)*	Georges Bank (GBK)	521, 522, 525, 526, 533, 534, 537 - 539, 541 - 543, 551, 552, 561, 562, 611 - 616, 621 - 629, 631 - 639
	Gulf of Maine (GOM)	464, 465, 467, 511 - 515
Yellowtail flounder *(Limanda ferruginea)*	Georges Bank (GBK)	522, 525, 551, 552, 561, 562
	Cape Cod/Gulf of Maine (GOM)	464, 465, 467, 511, 512, 513, 514, 515, 521
	Southern New England/ Mid-Atlantic (SNE)	526, 533, 534, 537 - 539, 541 - 543, 611 - 616, 621 - 629, 631 - 639
Winter flounder *(Pseudopleuronectes americanus)*	Georges Bank (GBK)	522, 525, 551, 552, 561, 562
	Gulf of Maine (GOM)	464, 465, 467, 511, 512, 513, 514, 515
	Southern New England/ Mid-Atlantic (SNE)	521, 526, 533, 534, 537 - 539, 541 - 543, 611 - 616, 621 - 629, 631 - 639
Windowpane flounder *(Scophthalmus aquosus)*	North (NOR)	464, 465, 467, 511 - 515, 521, 522, 525, 542, 543, 551, 552, 561, 562
	South (SOU)	526, 533, 534, 537 - 539, 541, 611 - 616, 621 - 629, 631 - 639
Goosefish *(Lophius americanus)*	North (NOR)	464, 465, 467, 511 - 515, 521, 522, 551, 561
	South (SOU)	525, 526, 533, 534, 537 - 539, 541 - 543, 552, 562, 611 - 616, 621 - 629, 631 - 639
Silver hake *(Merluccius bilinearis)*	North (NOR)	464, 465, 467, 511 - 515, 521, 522, 551, 561
	South (SOU)	525, 526, 533, 534, 537 - 539, 541 - 543, 552, 562, 611 - 616, 621 - 629, 631 - 639
Red hake *(Urophycis chuss)*	North (NOR)	464, 465, 467, 511 - 515, 521, 522, 551, 561
	South (SOU)	525, 526, 533, 534, 537 - 539, 541 - 543, 552, 562, 611 - 616, 621 - 629, 631 - 639

Table 2. Fishery management plan (FMP) actions passed by the Northeast Fisheries Management Council (NEFMC) and Mid-Atlantic Fisheries Management Council (MAFMC) affecting the use of Vessel Monitoring System (VMS) in the northeast United States through December 31, 2006. Note: if a vessel is subject to VMS regulations from multiple programs, the most restrictive regulation applies.

Date effective	Fishery	Measure	Description	Reference
May 1998	Atlantic scallop	Amendment 4	Required VMS for all limited access full- and part-time vessels (hourly polling). **Note: Amendment 4 effective March 1994, but VMS implementation delayed by NMFS until May 1998.*	NEFMC 1993
May 1999	Atlantic herring	Original FMP	Required VMS for all category 1 vessels (hourly polling).	NEFMC 1999
May 2001	Atlantic scallop	Framework Adjustment 14	Required VMS for all limited access occasional-category vessels when participating in area access programs (half-hourly polling).	NEFMC 2001
May 2004	Northeast multispecies	Amendment 13	Required VMS for all vessels accessing the US/Canada shared resource area (half-hour polling within US/Canada area, hourly polling outside).	NEFMC 2003
November 2004	Atlantic scallop	Framework Adjustment 16	Required VMS for all general category vessels participating in area access programs (half-hour polling).	NEFMC 2004a
November 2004	Northeast multispecies	Framework Adjustment 40A	Required VMS for all vessels participating in special access programs (SAP) and when fishing under the Regular B Days-at-Sea (DAS) Program (hourly polling).	NEFMC 2004b
October 2005	Atlantic scallop	Framework Adjustment 17	Required VMS for all general category vessels landing > 40 lb scallop meats (half-hour polling).	NEFMC 2005
November 2006	Northeast multispecies	Framework Adjustment 42	Required VMS for all limited access NE multispecies DAS vessels using multispecies DAS (hourly polling).	NEFMC 2006
May 2010	Northeast multispecies	Amendment 16	Required VMS for all limited access NE multispecies DAS vessels using multispecies DAS or on a sector trip (hourly polling).	NEFMC 2010

Table 3. Summary of the Vessel Trip Report (VTR), Vessel Monitoring System (VMS), and Northeast Fisheries Observer Program (NEFOP) 2004 to 2011 data sets, by number of trips and number of vessels.

Year	Category	Number of trips	Number of Vessels
2004	VTR dataset	114,491	2,629
	VTR subset	32,272	1,176
	VMS-VTR matched set	5,892	453
	NEFOP-VMS-VTR matched set	249	150
2005	VTR dataset	121,442	2,599
	VTR subset	33,090	1,161
	VMS-VTR matched set	9,909	622
	NEFOP-VMS-VTR matched set	901	252
2006	VTR dataset	118,548	2,497
	VTR subset	32,431	1,155
	VMS-VTR matched set	19,165	886
	NEFOP-VMS-VTR matched set	514	255
2007	VTR dataset	112,902	2,404
	VTR subset	33,288	1,102
	VMS-VTR matched set	25,924	957
	NEFOP-VMS-VTR matched set	771	328
2008	VTR dataset	105,352	2,271
	VTR subset	33,645	1,064
	VMS-VTR matched set	20,825	845
	NEFOP-VMS-VTR matched set	655	316
2009	VTR dataset	105,387	2,154
	VTR subset	31,525	983
	VMS-VTR matched set	25,128	826
	NEFOP-VMS-VTR matched set	1,006	392
2010	VTR dataset	103,425	2,171
	VTR subset	24,341	919
	VMS-VTR matched set	19,523	759
	NEFOP-VMS-VTR matched set	727	334
2011	VTR dataset	97,853	2,012
	VTR subset	23,054	843
	VMS-VTR matched set	18,347	679
	NEFOP-VMS-VTR matched set	901	306

Table 4. Summary of the agreement levels between statistical areas fished recorded by the Northeast Fisheries Observer Program (NEFOP) and the statistical areas fished reported on Vessel Trip Reports (VTR) from matched fishing trips from 2004 to 2011. Trip subcategories are based on the NEFOP-reported number of statistical areas fished. **Note: percentages may not sum to 100 due to rounding.*

Year	Trip category	Number of trips	Agreement level	Number of trips	Percent of total category trips (%)
2004	Single area	135	Complete	129	95.6
			None	6	4.4
			Partial	0	0.0
	Multi-area	114	Complete	6	5.3
			None	2	1.8
			Partial	106	93.0
2005	Single area	490	Complete	462	94.3
			None	27	5.5
			Partial	1	0.2
	Multi-area	411	Complete	57	13.9
			None	13	3.2
			Partial	341	83.0
2006	Single area	305	Complete	293	96.1
			None	10	3.3
			Partial	2	0.7
	Multi-area	209	Complete	35	16.7
			None	6	2.9
			Partial	168	80.4
2007	Single area	469	Complete	442	94.6
			None	27	5.4
			Partial	0	0.0
	Multi-area	302	Complete	46	15.2
			None	9	3.0
			Partial	247	81.8
2008	Single area	385	Complete	367	95.3
			None	17	4.4
			Partial	1	0.3
	Multi-area	270	Complete	42	15.5
			None	5	1.9
			Partial	223	82.6
2009	Single area	671	Complete	650	96.9
			None	21	3.1
			Partial	0	0.0
	Multi-area	335	Complete	52	15.5
			None	15	4.5
			Partial	268	80.0
2010	Single area	491	Complete	468	95.3
			None	19	3.9
			Partial	4	0.8
	Multi-area	236	Complete	19	8.1
			None	12	5.1
			Partial	205	86.9
2011	Single area	635	Complete	605	95.3
			None	26	4.1
			Partial	4	0.6
	Multi-area	266	Complete	40	15.0
			None	12	4.5
			Partial	214	80.5

Table 5. Summary of the agreement levels between statistical areas fished recorded by the Northeast Fisheries Observer Program (NEFOP) and the statistical areas fished as determined using Vessel Monitoring System (VMS) positional data from matched fishing trips from 2004 to 2011. Trip subcategories are based on the NEFOP-reported number of statistical areas fished. **Note: percentages may not sum to 100 due to rounding.*

Year	Area category	Number of trips	Agreement level	Number of trips	Percent of total category trips (%)
2004	Single area	135	Complete	123	91.1
			None	0	0.0
			Partial	12	8.9
	Multi-area	114	Complete	77	67.5
			None	0	0.0
			Partial	37	32.5
2005	Single area	490	Complete	431	88.0
			None	1	0.2
			Partial	58	11.8
	Multi-area	411	Complete	306	74.5
			None	0	0.0
			Partial	105	25.5
2006	Single area	306	Complete	274	89.5
			None	0	0.0
			Partial	32	10.5
	Multi-area	208	Complete	149	71.6
			None	0	0.0
			Partial	59	28.4
2007	Single area	469	Complete	437	93.2
			None	0	0.0
			Partial	32	6.8
	Multi-area	302	Complete	227	75.2
			None	0	0.0
			Partial	75	24.8
2008	Single area	385	Complete	350	90.9
			None	2	0.5
			Partial	33	8.5
	Multi-area	270	Complete	190	70.4
			None	0	0.0
			Partial	80	29.6
2009	Single area	671	Complete	617	92.0
			None	3	0.4
			Partial	51	7.6
	Multi-area	335	Complete	225	67.2
			None	1	0.3
			Partial	109	32.5
2010	Single area	491	Complete	445	90.6
			None	2	0.4
			Partial	44	9.0
	Multi-area	236	Complete	148	62.7
			None	0	0.0
			Partial	88	37.3
2011	Single area	635	Complete	579	91.2
			None	1	0.2
			Partial	55	8.7
	Multi-area	266	Complete	184	69.2
			None	0	0.0
			Partial	82	30.8

Table 6. Comparison of the Northeast Fisheries Observer Program (NEFOP), Vessel Trip Reports (VTR), and Vessel Monitoring System (VMS) stock allocations of 2004 commercial landings based on 249 matched trips. Bold text is used to indicate which method, VTR or VMS, achieve results closest to NEFOP allocations. Stock areas are Gulf of Maine (GOM), Georges Bank (GBK), southern New England/mid-Atlantic (SNE), northern (NOR), and southern (SOU). **Note: allocations may not sum to 100 due to rounding.*

Species	**Total Observer species landings (kg)**	**Total VTR species landings (kg)**	**Stock area**	**NEFOP landings allocation (kg)**	**VTR landings allocation (kg)**	**VMS landings allocation (kg)**	**NEFOP stock allocation (%)**	**VTR stock allocation (%)**	***VTR difference (%)***	**VMS stock allocation (%)**	***VMS difference (%)***
Atlantic cod *(Gadus morhua)*	134,732	121,281	GBK	121,143	110,140	109,975	89.9	90.8	-0.9	**90.7**	**-0.8**
			GOM	13,588	11,141	11,306	10.1	9.2	0.9	**9.3**	**0.8**
Haddock *(Melanogrammus aeglefinus)*	507,806	501,287	GBK	499,955	493,985	494,177	98.5	**98.5**	**-0.1**	98.6	-0.1
			GOM	7,851	7,302	7,110	1.5	**1.5**	**0.1**	1.4	0.1
Yellowtail flounder *(Limanda ferruginea)*	252,865	281,582	GBK	247,173	271,682	274,809	97.7	96.5	1.3	**97.6**	**0.2**
			GOM	5,582	9,900	6,684	2.2	3.5	-1.3	**2.4**	**-0.2**
			SNE	109		88	0.0	0.0	0.0	**0.0**	**0.0**
Winter flounder *(Pseudopleuronectes americanus)*	170,741	203,914	GBK	152,184	168,733	184,100	89.1	82.7	6.4	**90.3**	**-1.2**
			GOM	5,362	4,452	4,727	3.1	2.2	1.0	**2.3**	**0.8**
			SNE	13,194	30,729	15,087	7.7	15.1	-7.3	**7.4**	**0.3**
Windowpane flounder *(Scophthalmus aquosus)*	153	66	NOR	144	66	42	94.4	**100.0**	**-5.6**	64.3	30.0
			SOU	9	0	23	5.6	**0.0**	**5.6**	35.7	-30.0
Goosefish *(Lophius americanus)*	380,531	71,311	NOR	335,799	54,720	55,942	88.2	76.7	11.5	**78.4**	**9.8**
			SOU	44,732	16,591	15,369	11.8	23.3	-11.5	**21.6**	**-9.8**
Silver hake *(Merluccius bilnearis)*	24,840	23,280	NOR	4,614	3,685	5,031	18.6	**15.8**	**2.7**	21.6	-3.0
			SOU	20,226	19,595	18,250	81.4	**84.2**	**-2.7**	78.4	3.0
Red hake *(Urophycis chuss)*	2,869	2,655	NOR	1,252	797	850	43.6	30.0	13.6	**32.0**	**11.6**
			SOU	1,617	1,858	1,805	56.4	70.0	-13.6	**68.0**	**-11.6**

Table 7. Comparison of the Northeast Fisheries Observer Program (NEFOP), Vessel Trip Reports (VTR), and Vessel Monitoring System (VMS) stock allocations of 2005 commercial landings based on 901 matched trips. Bold text is used to indicate which method, VTR or VMS, achieve results closest to NEFOP allocations. Stock areas are Gulf of Maine (GOM), Georges Bank (GBK), southern New England/mid-Atlantic (SNE), northern (NOR), and southern (SOU). **Note: allocations may not sum to 100 due to rounding.*

Species	Total Observer species landings (kg)	Total VTR species landings (kg)	Stock area	NEFOP landings allocation (kg)	VTR landings allocation (kg)	VMS landings allocation (kg)	NEFOP stock allocation (%)	VTR stock allocation (%)	*VTR difference (%)*	VMS stock allocation (%)	*VMS difference (%)*
Atlantic cod *(Gadus morhua)*	653,066	593,995	GBK	599,457	545,989	541,523	91.8	**91.9**	**-0.1**	91.2	0.6
			GOM	53,609	48,006	52,472	8.2	**8.1**	**0.1**	8.8	-0.6
Haddock *(Melanogrammus aeglefinus)*	1,456,503	1,481,989	GBK	1,431,364	1,440,899	1,433,354	98.3	**97.2**	**1.0**	96.7	1.6
			GOM	25,139	41,090	48,635	1.7	**2.8**	**-1.0**	3.3	-1.6
Yellowtail flounder *(Limanda ferruginea)*	780,959	817,279	GBK	758,539	773,181	791,561	97.1	94.6	2.5	**96.9**	**0.3**
			GOM	21,652	23,010	24,687	2.8	2.8	0.0	**3.0**	**-0.2**
			SNE	768	21,088	1,030	0.1	2.6	-2.5	**0.1**	**0.0**
Winter flounder *(Pseudopleuronectes americanus)*	548,666	640,737	GBK	463,772	520,883	534,598	84.5	81.3	3.2	**83.4**	**1.1**
			GOM	9,403	26,073	8,308	1.7	4.1	-2.4	**1.3**	**0.4**
			SNE	75,491	93,781	97,831	13.8	14.6	-0.9	**15.3**	**-1.5**
Windowpane flounder *(Scophthalmus aquosus)*	16,477	13,851	NOR	16,460	13,398	13,780	99.9	96.7	3.2	**99.5**	**0.4**
			SOU	16	454	71	0.1	3.3	-3.2	**0.5**	**-0.4**
Goosefish *(Lophius americanus)*	1,277,812	268,890	NOR	898,895	166,563	172,457	70.3	61.9	8.4	**64.1**	**6.2**
			SOU	378,917	102,327	96,433	29.7	38.1	-8.4	**35.9**	**-6.2**
Silver hake *(Merluccius bilnearis)*	75,370	72,752	NOR	23,266	26,305	26,140	30.9	36.2	-5.3	**35.9**	**-5.1**
			SOU	52,104	46,447	46,612	69.1	63.8	5.3	**64.1**	**5.1**
Red hake *(Urophycis chuss)*	4,165	3,877	NOR	3,139	2,592	2,769	75.4	66.9	8.5	**71.4**	**3.9**
			SOU	1,025	1,285	1,107	24.6	33.1	-8.5	**28.6**	**-3.9**

Table 8. Comparison of the Northeast Fisheries Observer Program (NEFOP), Vessel Trip Reports (VTR), and Vessel Monitoring System (VMS) stock allocations of 2006 commercial landings based on 514 matched trips. Bold text is used to indicate which method, VTR or VMS, achieve results closest to NEFOP allocations. Stock areas are Gulf of Maine (GOM), Georges Bank (GBK), southern New England/mid-Atlantic (SNE), northern (NOR), and southern (SOU). **Note: allocations may not sum to 100 due to rounding.*

Species	Total Observer species landings (kg)	Total VTR species landings (kg)	Stock area	NEFOP landings allocation (kg)	VTR landings allocation (kg)	VMS landings allocation (kg)	NEFOP stock allocation (%)	VTR stock allocation (%)	*VTR difference (%)*	VMS stock allocation (%)	*VMS difference (%)*
Atlantic cod *(Gadus morhua)*	234,013	207,562	GBK	201,266	176,561	177,335	86.0	85.1	0.9	**85.4**	**0.6**
			GOM	32,747	31,001	30,227	14.0	14.9	-0.9	**14.6**	**-0.6**
Haddock *(Melanogrammus aeglefinus)*	312,195	286,961	GBK	304,139	268,746	275,605	97.4	93.7	3.8	**96.0**	**1.4**
			GOM	8,056	18,215	11,356	2.6	6.3	-3.8	**4.0**	**-1.4**
Yellowtail flounder *(Limanda ferruginea)*	270,492	288,175	GBK	256,683	277,142	275,958	94.9	96.2	-1.3	**95.8**	**-0.9**
			GOM	12,548	10,029	10,530	4.6	3.5	1.2	**3.7**	**1.0**
			SNE	1,261	1,004	1,686	0.5	0.3	0.1	**0.6**	**-0.1**
Winter flounder *(Pseudopleuronectes americanus)*	193,511	202,203	GBK	165,082	168,158	171,834	85.3	83.2	2.1	**85.0**	**0.3**
			GOM	3,109	2,827	2,834	1.6	1.4	0.2	**1.4**	**0.2**
			SNE	25,321	31,219	27,535	13.1	15.4	-2.4	**13.6**	**-0.5**
Windowpane flounder *(Scophthalmus aquosus)*	11,167	8,308	NOR	10,964	7,745	8,026	98.2	93.2	5.0	**96.6**	**1.6**
			SOU	204	563	282	1.8	6.8	-5.0	**3.4**	**-1.6**
Goosefish *(Lophius americanus)*	697,289	150,874	NOR	450,096	105,992	110,857	64.5	**70.3**	**-5.7**	73.5	-8.9
			SOU	247,193	44,883	40,017	35.5	**29.7**	**5.7**	26.5	8.9
Silver hake *(Merluccius bilnearis)*	67,997	57,500	NOR	30,157	23,221	23,584	44.4	40.4	4.0	**41.0**	**3.3**
			SOU	37,840	34,278	33,916	55.6	59.6	-4.0	**59.0**	**-3.3**
Red hake *(Urophycis chuss)*	5,318	4,354	NOR	3,888	2,908	3,328	73.1	66.8	6.3	**76.4**	**-3.3**
			SOU	1,431	1,447	1,027	26.9	33.2	-6.3	**23.6**	**3.3**

Table 9. Comparison of the Northeast Fisheries Observer Program (NEFOP), Vessel Trip Reports (VTR), and Vessel Monitoring System (VMS) stock allocations of 2007 commercial landings based on 771 matched trips. Bold text is used to indicate which method, VTR or VMS, achieve results closest to NEFOP allocations. Stock areas are Gulf of Maine (GOM), Georges Bank (GBK), southern New England/mid-Atlantic (SNE), northern (NOR), and southern (SOU). **Note: allocations may not sum to 100 due to rounding.*

Species	Total Observer species landings (kg)	Total VTR species landings (kg)	Stock area	NEFOP landings allocation (kg)	VTR landings allocation (kg)	VMS landings allocation (kg)	NEFOP stock allocation (%)	VTR stock allocation (%)	*VTR difference (%)*	VMS stock allocation (%)	*VMS difference (%)*
Atlantic cod			GBK	406,039	389,822	383,746	88.5	**88.8**	**-0.2**	87.4	1.1
(Gadus morhua)	458,590	439,098	GOM	52,552	49,276	55,352	11.5	**11.2**	**0.2**	12.6	-1.1
Haddock			GBK	420,707	427,180	423,005	96.7	**95.9**	**0.8**	95.0	1.7
(Melanogrammus aeglefinus)	434,982	445,240	GOM	14,275	18,060	22,235	3.3	**4.1**	**-0.8**	5.0	-1.7
Yellowtail flounder			GBK	177,581	189,671	191,276	89.1	**89.4**	**-0.3**	90.1	-1.0
(Limanda ferruginea)			GOM	17,868	19,131	17,445	9.0	**9.0**	**0.0**	8.2	0.7
	199,270	212,210	SNE	3,821	3,408	3,489	1.9	**1.6**	**0.3**	1.6	0.3
Winter flounder			GBK	153,281	170,371	161,318	72.7	**69.1**	**3.7**	65.4	7.3
(Pseudopleuronectes americanus)			GOM	5,526	5,257	8,429	2.6	**2.1**	**0.5**	3.4	-0.8
	210,757	246,681	SNE	51,951	71,053	76,934	24.6	**28.8**	**-4.2**	31.2	-6.5
Windowpane flounder			NOR	13,637	10,286	10,329	94.5	93.7	0.8	**94.1**	**0.4**
(Scophthalmus aquosus)	14,428	10,979	SOU	792	693	650	5.5	6.3	-0.8	**5.9**	**-0.4**
Goosefish			NOR	327,731	69,999	70,227	70.4	70.1	0.3	**70.3**	**0.1**
(Lophius americanus)	465,492	99,856	SOU	137,761	29,857	29,629	29.6	29.9	-0.3	**29.7**	**-0.1**
Silver hake			NOR	26,292	37,105	34,143	35.5	37.1	-1.6	**34.1**	**1.4**
(Merluccius bilnearis)	74,105	100,047	SOU	47,813	62,942	65,905	64.5	62.9	1.6	**65.9**	**-1.4**
Red hake			NOR	8,698	7,163	7,051	63.0	**51.0**	**12.1**	50.2	12.9
(Urophycis chuss)	13,803	14,055	SOU	5,105	6,892	7,005	37.0	**49.0**	**-12.1**	49.8	-12.9

Table 10. Comparison of the Northeast Fisheries Observer Program (NEFOP), Vessel Trip Reports (VTR), and Vessel Monitoring System (VMS) stock allocations of 2008 commercial landings based on 655 matched trips. Bold text is used to indicate which method, VTR or VMS, achieve results closest to NEFOP allocations. Stock areas are Gulf of Maine (GOM), Georges Bank (GBK), southern New England/mid-Atlantic (SNE), northern (NOR), and southern (SOU). **Note: allocations may not sum to 100 due to rounding.*

Species	Total Observer species landings (kg)	Total VTR species landings (kg)	Stock area	NEFOP landings allocation (kg)	VTR landings allocation (kg)	VMS landings allocation (kg)	NEFOP stock allocation (%)	VTR stock allocation (%)	*VTR difference (%)*	VMS stock allocation (%)	*VMS difference (%)*
Atlantic cod			GBK	351,095	315,830	311,392	87.5	88.3	-0.8	**87.1**	**0.4**
(Gadus morhua)	401,344	357,702	GOM	50,249	41,872	46,310	12.5	11.7	0.8	**12.9**	**-0.4**
Haddock			GBK	743,721	725,050	719,921	98.8	**98.3**	**0.5**	97.6	1.2
(Melanogrammus aeglefinus)	752,855	737,893	GOM	9,134	12,843	17,971	1.2	**1.7**	**-0.5**	2.4	-1.2
Yellowtail flounder			GBK	197,165	218,113	215,660	93.1	93.9	-0.9	**92.9**	**0.2**
(Limanda ferruginea)			GOM	12,527	11,436	12,813	5.9	4.9	1.0	**5.5**	**0.4**
	211,839	232,198	SNE	2,147	2,649	3,725	1.0	**1.1**	**-0.1**	1.6	-0.6
Winter flounder			GBK	229,437	273,771	256,775	84.6	**84.0**	**0.6**	78.8	5.8
(Pseudopleuronectes americanus)			GOM	7,419	5,975	8,527	2.7	**1.8**	**0.9**	2.6	0.1
	271,056	325,728	SNE	34,201	45,982	60,426	12.6	**14.1**	**-1.5**	18.6	-5.9
Windowpane flounder			NOR	7,265	7,096	6,942	88.7	**86.9**	**1.8**	85.0	3.7
(Scophthalmus aquosus)	8,190	8,169	SOU	926	1072	1226	11.3	**13.1**	**-1.8**	15.0	-3.7
Goosefish			NOR	180,968	32,766	35,171	53.5	51.5	2.0	**55.3**	**-1.8**
(Lophius americanus)	338,356	63,624	SOU	157,388	30,857	28,453	46.5	48.5	-2.0	**44.7**	**1.8**
Silver hake			NOR	9,805	13,200	13,130	21.2	27.3	-6.0	**27.1**	**-5.9**
(Merluccius bilnearis)	46,151	48,412	SOU	36,346	35,212	35,282	78.8	72.7	6.0	**72.9**	**5.9**
Red hake			NOR	11,410	7,531	7,536	76.8	68.0	8.7	**68.1**	**8.7**
(Urophycis chuss)	14,864	11,068	SOU	3,454	3,538	3,532	23.2	32.0	-8.7	**31.9**	**-8.7**

Table 11. Comparison of the Northeast Fisheries Observer Program (NEFOP), Vessel Trip Reports (VTR), and Vessel Monitoring System (VMS) stock allocations of 2009 commercial landings based on 1,006 matched trips. Bold text is used to indicate which method, VTR or VMS, achieve results closest to NEFOP allocations. Stock areas are Gulf of Maine (GOM), Georges Bank (GBK), southern New England/mid-Atlantic (SNE), northern (NOR), and southern (SOU). **Note: allocations may not sum to 100 due to rounding.*

Species	Total Observer species landings (kg)	Total VTR species landings (kg)	Stock area	NEFOP landings allocation (kg)	VTR landings allocation (kg)	VMS landings allocation (kg)	NEFOP stock allocation (%)	VTR stock allocation (%)	***VTR difference (%)***	VMS stock allocation (%)	***VMS difference (%)***
Atlantic cod	477,580	470,386	GBK	336,421	346,404	345,761	70.4	73.6	-3.2	**73.5**	**-3.1**
(Gadus morhua)			GOM	141,159	123,983	125,335	29.6	26.4	3.2	**26.6**	**2.9**
Haddock	793,867	865,024	GBK	770,053	841,010	838,998	97.0	97.2	-0.2	**97.0**	**0.0**
(Melanogrammus aeglefinus)			GOM	23,814	24,014	26,071	3.0	2.8	0.2	**3.0**	**0.0**
Yellowtail flounder	189,484	201,137	GBK	169,600	178,475	178,403	89.5	**88.7**	**0.8**	88.7	0.8
(Limanda ferruginea)			GOM	16,480	17,261	18,584	8.7	**8.6**	**0.1**	9.2	-0.5
			SNE	3,404	5,401	4,177	1.8	2.7	-0.9	**2.1**	**-0.3**
Winter flounder	268,576	306,702	GBK	254,628	272,175	289,696	94.8	88.7	6.1	**94.5**	**0.4**
(Pseudopleuronectes americanus)			GOM	10,297	10,687	10,816	3.8	3.5	0.3	**3.5**	**0.3**
			SNE	3,651	23,840	7,974	1.4	7.8	-6.4	**2.6**	**-1.2**
Windowpane flounder	3,218	3,982	NOR	2,205	2,827	2,824	68.5	71.0	-2.5	**70.9**	**-2.4**
(Scophthalmus aquosus)			SOU	1013	1154	1157	31.5	29.0	2.5	**29.1**	**2.4**
Goosefish	340,239	77,648	NOR	233,820	40,655	40,010	68.7	**52.4**	**16.4**	51.5	17.2
(Lophius americanus)			SOU	106,419	36,993	37,583	31.3	**47.6**	**-16.4**	48.4	-17.1
Silver hake	206,506	315,393	NOR	43,000	84,301	83,801	20.8	26.7	-5.9	**26.6**	**-5.7**
(Merluccius bilnearis)			SOU	163,506	231,092	231,592	79.2	73.3	5.9	**73.4**	**5.7**
Red hake	21,629	25,593	NOR	9,550	10,600	10,542	44.2	**41.4**	**2.7**	41.2	3.0
(Urophycis chuss)			SOU	12,079	14,993	15,051	55.8	**58.6**	**-2.7**	58.8	-3.0

Table 12. Comparison of the Northeast Fisheries Observer Program (NEFOP), Vessel Trip Reports (VTR), and Vessel Monitoring System (VMS) stock allocations of 2010 commercial landings based on 727 matched trips. Bold text is used to indicate which method, VTR or VMS, achieve results closest to NEFOP allocations. Stock areas are Gulf of Maine (GOM), Georges Bank (GBK), southern New England/mid-Atlantic (SNE), northern (NOR), and southern (SOU). *Note: allocations may not sum to 100 due to rounding.*

Species	Total Observer species landings (kg)	Total VTR species landings (kg)	Stock area	NEFOP landings allocation (kg)	VTR landings allocation (kg)	VMS landings allocation (kg)	NEFOP stock allocation (%)	VTR stock allocation (%)	*VTR difference (%)*	VMS stock allocation (%)	*VMS difference (%)*
Atlantic cod			GBK	143,671	140,947	139,454	50.5	54.2	-3.7	**53.6**	**-3.1**
(Gadus morhua)	284,645	260,226	GOM	140,974	119,280	120,766	49.5	45.8	3.7	**46.4**	**3.1**
Haddock			GBK	612,033	620,650	604,853	98.3	**98.4**	**-0.1**	95.9	2.4
(Melanogrammus aeglefinus)	622,662	630,758	GOM	10,629	10,107	25,904	1.7	**1.6**	**0.1**	4.1	-2.4
Yellowtail flounder			GBK	64,490	67,521	66,250	84.6	85.9	-1.3	**84.3**	**0.3**
(Limanda ferruginea)			GOM	9,862	9,422	9,828	12.9	12.0	1.0	**12.5**	**0.4**
	76,204	78,583	SNE	1,852	1,639	2,499	2.4	**2.1**	**0.3**	3.2	-0.7
Winter flounder			GBK	73,330	86,314	80,868	94.1	**95.1**	**-1.1**	89.1	4.9
(Pseudopleuronectes americanus)			GOM	4,229	4,228	4,500	5.4	4.7	0.8	**5.0**	**0.5**
	77,951	90,730	SNE	392	188	5,361	0.5	**0.2**	**0.3**	5.9	-5.4
Windowpane flounder			NOR	4	0	0	4.8	0.0	4.8	0.0	4.8
(Scophthalmus aquosus)	76	118	SOU	73	118	118	95.2	100.0	-4.8	100.0	-4.8
Goosefish			NOR	182,516	26,102	24,233	73.7	**47.6**	**26.0**	44.2	29.4
(Lophius americanus)	247,706	54,784	SOU	65,190	28,682	30,551	26.3	**52.4**	**-26.0**	55.8	-29.4
Silver hake			NOR	81,561	56,569	60,826	25.6	18.8	6.7	**20.3**	**5.3**
(Merluccius bilnearis)	319,059	300,199	SOU	237,499	243,629	239,418	74.4	81.2	-6.7	**79.8**	**-5.3**
Red hake			NOR	7,854	7,278	7,264	46.7	**26.3**	**20.4**	26.2	20.5
(Urophycis chuss)	16,816	27,715	SOU	8,961	20,437	20,451	53.3	**73.7**	**-20.4**	73.8	-20.5

Table 13. Comparison of the Northeast Fisheries Observer Program (NEFOP), Vessel Trip Reports (VTR), and Vessel Monitoring System (VMS) stock allocations of 2011 commercial landings based on 901 matched trips. Bold text is used to indicate which method, VTR or VMS, achieve results closest to NEFOP allocations. Stock areas are Gulf of Maine (GOM), Georges Bank (GBK), southern New England/mid-Atlantic (SNE), northern (NOR), and southern (SOU). **Note: allocations may not sum to 100 due to rounding.*

Species	Total Observer species landings (kg)	Total VTR species landings (kg)	Stock area	NEFOP landings allocation (kg)	VTR landings allocation (kg)	VMS landings allocation (kg)	NEFOP stock allocation (%)	VTR stock allocation (%)	*VTR difference (%)*	VMS stock allocation (%)	*VMS difference (%)*
Atlantic cod			GBK	106,932	107,776	119,092	27.1	**29.1**	**-1.9**	32.1	-5.0
(Gadus morhua)	394,128	370,635	GOM	287,196	262,859	251,588	72.9	**70.9**	**1.9**	67.9	5.0
Haddock			GBK	176,998	210,062	205,862	85.3	87.6	-2.3	**85.9**	**-0.6**
(Melanogrammus aeglefinus)	207,598	239,773	GOM	30,601	29,712	33,911	14.7	12.4	2.3	**14.1**	**0.6**
Yellowtail flounder			GBK	64,746	76,096	68,656	59.4	63.0	-3.6	**56.9**	**2.5**
(Limanda ferruginea)			GOM	38,569	39,085	42,800	35.4	32.4	3.0	**35.5**	**-0.1**
	108,937	120,694	SNE	5,623	5,513	9,238	5.2	**4.6**	**0.6**	7.7	-2.5
Winter flounder			GBK	84,797	100,683	96,331	90.2	**90.5**	**-0.3**	86.6	3.6
(Pseudopleuronectes americanus)			GOM	8,998	10,370	10,228	9.6	**9.3**	**0.3**	9.2	0.4
	94,025	111,265	SNE	229	213	4,706	0.2	**0.2**	**0.1**	4.2	-4.0
Windowpane flounder			NOR	2	0	0	100.0				
(Scophthalmus aquosus)	2	0	SOU	0	0	0	0.0				
Goosefish			NOR	166,622	25,309	26,989	56.0	34.4	21.6	**36.7**	**19.3**
(Lophius americanus)	297,315	73,541	SOU	130,693	48,232	47,001	44.0	65.6	-21.6	**63.9**	**-20.0**
Silver hake			NOR	44,687	72,689	64,031	17.1	21.2	-4.1	**18.7**	**-1.6**
(Merluccius bilnearis)	261,664	342,592	SOU	216,977	269,903	278,562	82.9	78.8	4.1	**81.3**	**1.6**
Red hake			NOR	6,095	6,124	5,754	42.9	**29.9**	**13.0**	28.1	14.8
(Urophycis chuss)	14,191	20,471	SOU	8,096	14,347	14,716	57.1	**70.1**	**-13.0**	71.9	-14.8

Table 14. Species-level summary of the Vessel Monitoring System (VMS) dataset and Vessel Trip Reports (VTR) subset compared to total VTR landings (kg) from 2004 to 2011.

Year	Species	Total VTR landings (kg)	VTR subset (kg)	Percent of total (%)	VMS matched set (kg)	Percent of total (%)
2004	Atlantic cod *(Gadus morhua)*	5,611,244	5,432,809	96.8	1,874,015	33.4
	Haddock *(Melanogrammus aeglefinus)*	6,919,871	6,837,521	98.8	5,096,088	73.6
	Yellowtail flounder *(Limanda ferruginea)*	6,954,627	6,899,760	99.2	5,378,986	77.3
	Winter flounder *(Pseudopleuronectes americanus)*	4,515,996	4,483,488	99.3	3,127,780	69.3
	Windowpane flounder *(Scophthalmus aquosus)*	92,640	91,522	98.8	18,217	19.7
	Goosefish *(Lophius americanus)*	7,561,854	7,440,979	98.4	1,332,178	17.6
	Silver hake *(Merluccius bilinearis)*	7,454,395	7,392,633	99.2	2,071,931	27.8
	Red hake *(Urophycis chuss)*	875,228	863,357	98.6	236,830	27.1
2005	Atlantic cod *(Gadus morhua)*	5,072,510	4,983,113	98.2	2,754,687	54.3
	Haddock *(Melanogrammus aeglefinus)*	6,198,222	6,155,937	99.3	5,700,737	92.0
	Yellowtail flounder *(Limanda ferruginea)*	3,925,078	3,922,078	99.9	3,475,993	88.6
	Winter flounder *(Pseudopleuronectes americanus)*	3,473,132	3,457,729	99.6	2,800,639	80.6
	Windowpane flounder *(Scophthalmus aquosus)*	81,693	81,532	99.8	45,771	56.0
	Goosefish *(Lophius americanus)*	7,377,131	7,259,875	98.4	2,129,989	28.9
	Silver hake *(Merluccius bilinearis)*	7,526,280	7,522,877	100.0	3,531,069	46.9
	Red hake *(Urophycis chuss)*	549,641	547,200	99.6	154,666	28.1
2006	Atlantic cod *(Gadus morhua)*	4,623,801	4,546,055	98.3	3,428,790	74.2
	Haddock *(Melanogrammus aeglefinus)*	2,810,657	2,713,290	96.5	2,513,767	89.4
	Yellowtail flounder *(Limanda ferruginea)*	1,891,367	1,867,650	98.7	1,681,115	88.9
	Winter flounder *(Pseudopleuronectes americanus)*	2,589,643	2,583,503	99.8	2,128,052	82.2
	Windowpane flounder *(Scophthalmus aquosus)*	87,187	87,012	99.8	61,654	70.7
	Goosefish *(Lophius americanus)*	6,109,614	6,026,365	98.6	3,246,832	53.1
	Silver hake *(Merluccius bilinearis)*	5,331,664	5,327,921	99.9	4,606,490	86.4
	Red hake *(Urophycis chuss)*	559,679	553,489	98.9	458,731	82.0
2007	Atlantic cod *(Gadus morhua)*	6,278,969	6,171,416	98.3	5,838,287	93.0
	Haddock *(Melanogrammus aeglefinus)*	3,071,154	3,054,852	99.5	3,013,511	98.1
	Yellowtail flounder *(Limanda ferruginea)*	1,675,883	1,668,462	99.6	1,623,035	96.8
	Winter flounder *(Pseudopleuronectes americanus)*	2,517,944	2,499,538	99.3	2,172,096	86.3
	Windowpane flounder *(Scophthalmus aquosus)*	180,091	179,389	99.6	144,231	80.1
	Goosefish *(Lophius americanus)*	4,797,261	4,677,828	97.5	2,969,033	61.9
	Silver hake *(Merluccius bilinearis)*	6,198,030	6,179,560	99.7	5,749,198	92.8
	Red hake *(Urophycis chuss)*	614,724	606,624	98.7	544,902	88.6
2008	Atlantic cod *(Gadus morhua)*	7,026,980	6,942,829	98.8	4,987,617	71.0
	Haddock *(Melanogrammus aeglefinus)*	5,213,529	5,190,698	99.6	4,072,033	78.1
	Yellowtail flounder *(Limanda ferruginea)*	1,624,491	1,616,847	99.5	1,239,577	76.3
	Winter flounder *(Pseudopleuronectes americanus)*	2,226,518	2,210,008	99.3	1,875,233	84.2
	Windowpane flounder *(Scophthalmus aquosus)*	117,138	116,527	99.5	59,340	50.7
	Goosefish *(Lophius americanus)*	4,189,612	4,046,358	96.6	1,791,932	42.8
	Silver hake *(Merluccius bilinearis)*	5,767,216	5,583,469	96.8	3,801,904	65.9
	Red hake *(Urophycis chuss)*	754,050	716,744	95.1	535,823	71.1
2009	Atlantic cod *(Gadus morhua)*	7,213,351	6,987,840	96.9	6,238,260	86.5
	Haddock *(Melanogrammus aeglefinus)*	4824825	4,767,456	98.8	4,715,435	97.7
	Yellowtail flounder *(Limanda ferruginea)*	1574303	1,563,004	99.3	1,496,519	95.1
	Winter flounder *(Pseudopleuronectes americanus)*	1,987,276	1,977,504	99.5	1,913,871	96.3
	Windowpane flounder *(Scophthalmus aquosus)*	82,230	81,911	99.6	71,742	87.2
	Goosefish *(Lophius americanus)*	3,393,612	3,268,159	96.3	1,968,113	58.0
	Silver hake *(Merluccius bilinearis)*	7,237,088	7,043,396	97.3	6,691,037	92.5
	Red hake *(Urophycis chuss)*	839,694	792,563	94.4	743,386	88.5
2010	Atlantic cod *(Gadus morhua)*	6,406,843	6,046,419	94.4	5,581,321	87.1
	Haddock *(Melanogrammus aeglefinus)*	7,967,547	6,386,646	80.2	6,357,935	79.8
	Yellowtail flounder *(Limanda ferruginea)*	1,253,948	1,210,135	96.5	1,163,424	92.8
	Winter flounder *(Pseudopleuronectes americanus)*	1,424,320	1,298,805	91.2	1,279,475	89.8
	Windowpane flounder *(Scophthalmus aquosus)*	24,777	23,684	95.6	7,840	31.6
	Goosefish *(Lophius americanus)*	2,767,345	2,704,886	97.7	1,653,139	59.7
	Silver hake *(Merluccius bilinearis)*	7,448,905	7,387,146	99.2	7,152,985	96.0
	Red hake *(Urophycis chuss)*	720,282	702,341	97.5	671,390	93.2
2011	Atlantic cod *(Gadus morhua)*	6,329,892	5,869,780	92.7	5,736,502	90.6
	Haddock *(Melanogrammus aeglefinus)*	4,845,051	2,758,417	56.9	2,737,682	56.5
	Yellowtail flounder *(Limanda ferruginea)*	1,723,480	1,587,645	92.1	1,577,599	91.5
	Winter flounder *(Pseudopleuronectes americanus)*	1,934,920	1,728,472	89.3	1,714,978	88.6
	Windowpane flounder *(Scophthalmus aquosus)*	22,316	22,211	99.5	1,993	8.9
	Goosefish *(Lophius americanus)*	3,434,132	3,348,161	97.5	1,995,796	58.1
	Silver hake *(Merluccius bilinearis)*	7,362,619	7,331,558	99.6	7,116,346	96.7
	Red hake *(Urophycis chuss)*	656,697	641,792	97.7	606,409	92.3

Table 15. 2004 summary of the Vessel Monitoring System (VMS) data subsets compared to the subset of Vessel Trip Reports (VTR) landings (kg), by species and gear type (bottom otter trawl gear = OTF, scallop dredge gear = DRS, sink gillnet = GNS, and benthic longline = LLB).

Species	VTR gear code	VTR			VMS			
		Number of Vessels	**Number of trips**	**VTR landings (kg)**	**Number of Vessels**	**Number of trips**	**VMS landings (kg)**	**Percent of VTR landings (%)**
Atlantic cod *(Gadus morhua)*	OTF	444	9,167	3,507,919	189	2,724	1,829,688	52.2
	DRS	6	9	535	3	3	14	2.5
	GNS	171	6,972	1,726,238	4	116	25,959	1.5
	LLB	67	1,221	198,117	21	253	18,355	9.3
Haddock *(Melanogrammus aeglefinus)*	OTF	384	6,323	5,908,548	187	2,472	4,619,014	78.2
	DRS	1	1	0	0	0	0	*N/A*
	GNS	137	3,313	133,401	3	86	9,789	7.3
	LLB	55	986	795,572	21	261	467,285	58.7
Yellowtail flounder *(Limanda ferruginea)*	OTF	404	7,337	6,749,688	181	2,061	5,373,053	79.6
	DRS	36	62	4,346	33	48	4,072	93.7
	GNS	93	1,541	145,727	2	31	1,862	1.3
	LLB	0	0	0	0	0	0	*N/A*
Winter flounder *(Pseudopleuronectes americanus)*	OTF	471	9,866	4,393,835	184	2,314	3,125,651	71.1
	DRS	18	37	750	16	26	660	87.9
	GNS	129	3,029	88,606	2	57	1,433	1.6
	LLB	9	67	298	2	10	37	12.3
Windowpane flounder *(Scophthalmus aquosus)*	OTF	158	1,291	90,880	46	105	18,217	20.0
	DRS	0	0	0	0	0	0	*N/A*
	GNS	12	63	642	0	0	0	0.0
	LLB	0	0	0	0	0	0	*N/A*
Goosefish *(Lophius americanus)*	OTF	555	9,467	1,870,948	208	2,325	880,759	47.1
	DRS	226	1,226	381,761	214	1,179	380,203	99.6
	GNS	268	8,119	5,186,982	4	118	70,362	1.4
	LLB	26	146	1,288	16	75	854	66.3
Silver hake *(Merluccius bilinearis)*	OTF	234	3,212	7,334,373	68	721	2,069,807	28.2
	DRS	0	0	0	0	0	0	*N/A*
	GNS	63	415	21,948	2	7	1,976	9.0
	LLB	4	17	36,311	2	4	148	0.4
Red hake *(Urophycis chuss)*	OTF	172	2,226	769,215	56	510	235,494	30.6
	DRS	0	0	0	0	0	0	*N/A*
	GNS	26	353	93,767	1	33	1,044	1.1
	LLB	7	21	376	3	7	292	77.6

Table 16. 2005 summary of the Vessel Monitoring System (VMS) data subsets compared to the subset of Vessel Trip Reports (VTR) landings (kg), by species and gear type (bottom otter trawl gear = OTF, scallop dredge gear = DRS, sink gillnet = GNS, and benthic longline = LLB).

Species	VTR gear code	VTR			VMS			
		Number of Vessels	Number of trips	VTR landings (kg)	Number of Vessels	Number of trips	VMS landings (kg)	Percent of VTR landings (%)
Atlantic cod *(Gadus morhua)*	OTF	381	9,005	3,201,456	229	4,415	2,491,742	77.8
	DRS	8	11	1,209	7	10	100	8.3
	GNS	157	6,711	1,574,496	21	697	164,299	10.4
	LLB	89	1,373	205,952	45	638	98,546	47.8
Haddock *(Melanogrammus aeglefinus)*	OTF	342	6,471	5,246,396	217	3,670	5,036,560	96
	DRS	3	4	15	2	3	14	93.9
	GNS	125	3,054	59,757	15	292	4,494	7.5
	LLB	80	1257	849,769	44	650	659,669	77.6
Yellowtail flounder *(Limanda ferruginea)*	OTF	352	7,138	3,815,235	218	3,175	3,473,828	91.1
	DRS	30	45	2,059	28	42	1,883	91.5
	GNS	77	1,180	104,756	5	30	259	0.2
	LLB	5	19	28	3	16	23	83.6
Winter flounder *(Pseudopleuronectes americanus)*	OTF	413	9,225	3,407,204	229	3,458	2,786,325	81.8
	DRS	37	65	13,237	36	64	12,772	96.5
	GNS	118	2,530	36,739	12	189	1,069	2.9
	LLB	11	84	549	6	66	473	86.1
Windowpane flounder *(Scophthalmus aquosus)*	OTF	158	1,057	80,999	78	227	45,762	56.5
	DRS	0	0	0	0	0	0	*N/A*
	GNS	9	77	523	0	0	0	0.0
	LLB	4	9	10	3	8	9	91.3
Goosefish *(Lophius americanus)*	OTF	493	9,197	1,857,280	260	3,603	1,359,021	73.2
	DRS	317	2,722	335,072	266	1,498	321,271	95.9
	GNS	246	8,736	5,065,683	34	801	448,437	8.9
	LLB	36	212	1,841	30	182	1,260	68.4
Silver hake *(Merluccius bilinearis)*	OTF	193	2,689	7,391,321	96	1197	3,489,085	47.2
	DRS	2	2	365	2	2	365	100.0
	GNS	41	255	20,219	1	8	4,400	21.8
	LLB	7	30	110,972	5	20	37,219	33.5
Red hake *(Urophycis chuss)*	OTF	143	1,838	482,879	69	757	152,655	31.6
	DRS	1	1	125	1	1	125	100.0
	GNS	24	239	64,020	2	25	1,810	2.8
	LLB	4	10	176	2	6	76	43.3

Table 17. 2006 summary of the Vessel Monitoring System (VMS) data subsets compared to the subset of Vessel Trip Reports (VTR) landings (kg), by species and gear type (bottom otter trawl gear = OTF, scallop dredge gear = DRS, sink gillnet = GNS, and benthic longline = LLB).

Species	VTR gear code	VTR			VMS			
		Number of Vessels	Number of trips	VTR landings (kg)	Number of Vessels	Number of trips	VMS landings (kg)	Percent of VTR landings (%)
Atlantic cod (*Gadus morhua*)	OTF	350	7,493	2,913,548	301	5,799	2,680,732	92.0
	DRS	5	8	420	4	7	184	43.8
	GNS	153	6,764	1,427,295	95	2739	656,843	46.0
	LLB	80	1,154	204,792	42	511	91,031	44.5
Haddock (*Melanogrammus aeglefinus*)	OTF	296	4,938	2,242,491	252	3,994	2,186,209	97.5
	DRS	5	5	1,303	4	4	1,299	99.7
	GNS	122	2,964	65,539	75	1275	26,864	41.0
	LLB	76	1091	403,958	42	496	299,395	74.1
Yellowtail flounder (*Limanda ferruginea*)	OTF	319	6,402	1,772,976	282	4,938	1,674,672	94.5
	DRS	24	36	4,098	23	35	4,076	99.4
	GNS	67	1,293	90,562	32	244	2,355	2.6
	LLB	5	12	14	4	11	13	96.7
Winter flounder (*Pseudopleuronectes americanus*)	OTF	381	8,460	2,534,691	310	5,530	2,115,716	83.5
	DRS	36	73	4,951	34	71	4,926	99.5
	GNS	109	2,825	43,398	64	979	6,983	16.1
	LLB	8	57	463	7	42	428	92.5
Windowpane flounder (*Scophthalmus aquosus*)	OTF	151	1,246	86,897	117	607	61,621	70.9
	DRS	1	2	7	1	2	7	100.0
	GNS	9	37	107	3	7	24	22.6
	LLB	1	1	2	1	1	2	100.0
Goosefish (*Lophius americanus*)	OTF	459	8,032	1,574,844	380	5,747	1,417,361	90.0
	DRS	336	3,917	323,214	333	3,650	317,777	98.3
	GNS	261	8,050	4,127,303	114	2910	1,510,988	36.6
	LLB	22	113	1,004	20	99	706	70.3
Silver hake (*Merluccius bilinearis*)	OTF	197	3,098	5,294,681	162	2242	4,590,130	86.7
	DRS	1	3	14	1	3	14	100.0
	GNS	37	251	18,600	22	98	11,729	63.1
	LLB	4	13	14,628	3	5	4,616	31.6
Red hake (*Urophycis chuss*)	OTF	152	1,983	525,546	119	1346	447,917	85.2
	DRS	2	2	29	2	2	29	100.0
	GNS	22	257	27,383	10	112	10,260	37.5
	LLB	4	6	531	3	5	524	98.7

Table 18. 2007 summary of the Vessel Monitoring System (VMS) data subsets compared to the subset of Vessel Trip Reports (VTR) landings (kg), by species and gear type (bottom otter trawl gear = OTF, scallop dredge gear = DRS, sink gillnet = GNS, and benthic longline = LLB).

Species	VTR gear code	VTR Number of Vessels	VTR Number of trips	VTR landings (kg)	VMS Number of Vessels	VMS Number of trips	VMS landings (kg)	Percent of VTR landings (%)
Atlantic cod	OTF	333	7,166	3,722,919	322	6,538	3,592,723	96.5
(Gadus morhua)	DRS	6	11	122	6	11	122	100.0
	GNS	145	7,724	2,224,006	135	7059	2,038,677	91.7
	LLB	62	1,048	224,369	54	952	206,764	92.2
Haddock	OTF	273	4,508	2,623,998	270	4,220	2,603,164	99.2
(Melanogrammus aeglefinus)	DRS	3	5	29	3	5	29	100.0
	GNS	113	2,985	60,006	113	2851	58,541	97.6
	LLB	60	1007	370,818	55	946	351,777	94.9
Yellowtail flounder	OTF	306	6,360	1,592,293	298	5,718	1,558,752	97.9
(Limanda ferruginea)	DRS	21	34	991	21	34	991	100.0
	GNS	78	2,089	73,751	76	1872	63,226	85.7
	LLB	6	8	1,427	5	7	66	4.6
Winter flounder	OTF	360	8,748	2,442,367	327	6,449	2,120,496	86.8
(Pseudopleuronectes americanus)	DRS	37	76	6,369	37	76	6,369	100.0
	GNS	124	3,877	50,230	104	3474	44,687	89.0
	LLB	6	45	572	5	43	545	95.3
Windowpane flounder	OTF	182	1,865	179,240	159	1133	144,127	80.4
(Scophthalmus aquosus)	DRS	1	1	5	1	1	5	100.0
	GNS	7	51	144	4	46	99	68.9
	LLB	0	0	0	0	0	0	*N/A*
Goosefish	OTF	412	6,928	811,850	367	5,586	782,931	96.4
(Lophius americanus)	DRS	330	3,458	421,485	323	3,223	417,292	99.0
	GNS	249	7,546	3,444,297	169	5152	1,768,626	51.3
	LLB	16	53	195	16	51	184	94.2
Silver hake	OTF	201	3,830	6,112,602	180	3023	5,685,483	93.0
(Merluccius bilinearis)	DRS	3	3	8	3	3	8	100.0
	GNS	50	562	24,962	45	538	23,987	96.1
	LLB	5	32	41,988	5	31	39,720	94.6
Red hake	OTF	157	2,637	590,951	130	2043	531,345	89.9
(Urophycis chuss)	DRS	0	0	0	0	0	0	*N/A*
	GNS	18	247	15,673	14	235	13,557	86.5
	LLB	0	0	0	0	0	0	*N/A*

Table 19. 2008 summary of the Vessel Monitoring System (VMS) data subsets compared to the subset of Vessel Trip Reports (VTR) landings (kg), by species and gear type (bottom otter trawl gear = OTF, scallop dredge gear = DRS, sink gillnet = GNS, and benthic longline = LLB).

Species	VTR	VTR			VMS			
	gear code	Number of Vessels	Number of trips	VTR landings (kg)	Number of Vessels	Number of trips	VMS landings (kg)	Percent of VTR landings (%)
Atlantic cod	OTF	319	8,051	3,980,275	283	5,545	2,782,826	69.9
(Gadus morhua)	DRS	3	3	20	1	1	9	45.5
	GNS	145	9,193	2,776,208	130	6811	2,052,888	73.9
	LLB	59	871	186,327	47	652	151,893	81.5
Haddock	OTF	250	4,469	4,740,122	230	3,129	3,667,918	77.4
(Melanogrammus aeglefinus)	DRS	1	2	41	1	2	41	100.0
	GNS	111	3,128	55,863	106	2402	42,170	75.5
	LLB	56	657	394,672	46	540	361,904	91.7
Yellowtail flounder	OTF	290	6,869	1,499,440	257	4,825	1,163,165	77.6
(Limanda ferruginea)	DRS	14	35	1,301	14	34	1,251	96.2
	GNS	90	2,725	111,067	84	1773	74,741	67.3
	LLB	6	59	5,039	4	9	420	8.3
Winter flounder	OTF	346	8,642	2,150,549	294	5,328	1,832,963	85.2
(Pseudopleuronectes americanus)	DRS	24	41	2,139	19	30	1,424	66.6
	GNS	125	4,402	56,329	100	3149	40,113	71.2
	LLB	8	102	992	6	49	733	73.9
Windowpane flounder	OTF	167	1,863	115,475	127	796	58,557	50.7
(Scophthalmus aquosus)	DRS	1	1	1	0	0	0	0.0
	GNS	19	80	1,051	8	33	782	74.4
	LLB	0	0	0	0	0	0	*N/A*
Goosefish	OTF	378	5,872	614,655	300	3,595	405,446	66.0
(Lophius americanus)	DRS	323	2,800	304,618	290	1,971	233,700	76.7
	GNS	237	6,226	3,126,971	147	3362	1,152,723	36.9
	LLB	7	24	114	4	15	62	54.4
Silver hake	OTF	205	3,518	5,541,597	164	2186	3,767,703	68.0
(Merluccius bilinearis)	DRS	0	0	0	0	0	0	*N/A*
	GNS	62	804	41,852	54	690	34,181	81.7
	LLB	3	4	20	3	4	20	100.0
Red hake	OTF	161	2,558	708,281	124	1532	527,891	74.5
(Urophycis chuss)	DRS	1	1	16	0	0	0	0.0
	GNS	19	298	8,284	14	257	7,783	94.0
	LLB	3	5	163	2	4	149	91.6

Table 20. 2009 summary of the Vessel Monitoring System (VMS) data subsets compared to the subset of Vessel Trip Reports (VTR) landings (kg), by species and gear type (bottom otter trawl gear = OTF, scallop dredge gear = DRS, sink gillnet = GNS, and benthic longline = LLB).

Species	VTR gear code	VTR			VMS			
		Number of Vessels	Number of trips	VTR landings (kg)	Number of Vessels	Number of trips	VMS landings (kg)	Percent of VTR landings (%)
Atlantic cod	OTF	295	8,044	3,960,249	277	6,793	3,555,956	89.8
(Gadus morhua)	DRS	0	0	0	0	0	0	*N/A*
	GNS	150	9,611	2,856,758	136	8491	2,535,301	88.7
	LLB	52	728	170,833	38	524	147,003	86.1
Haddock	OTF	234	4,065	4,285,009	232	3,726	4,246,875	99.1
(Melanogrammus aeglefinus)	DRS	0	0	0	0	0	0	*N/A*
	GNS	116	2,498	80,316	116	2356	77,884	97.0
	LLB	37	424	402,131	32	386	390,676	97.2
Yellowtail flounder	OTF	276	6,642	1,469,547	258	5,585	1,419,921	96.6
(Limanda ferruginea)	DRS	22	35	2,424	21	33	2,356	97.2
	GNS	94	2,655	86,331	87	2247	73,983	85.7
	LLB	11	72	4,702	7	21	260	5.5
Winter flounder	OTF	296	6,165	1,935,314	266	4,861	1,874,929	96.9
(Pseudopleuronectes americanus)	DRS	13	27	1,069	13	26	1,046	97.9
	GNS	101	3,699	40,438	91	3253	37,332	92.3
	LLB	11	97	684	9	62	564	82.5
Windowpane flounder	OTF	124	1,136	80,821	111	907	70,935	87.8
(Scophthalmus aquosus)	DRS	0	0	0	0	0	0	*N/A*
	GNS	15	118	1,090	12	97	807	74.1
	LLB	0	0	0	0	0	0	*N/A*
Goosefish	OTF	331	4,916	436,569	290	4,147	424,758	97.3
(Lophius americanus)	DRS	290	2,163	205,913	287	2,009	203,695	98.9
	GNS	219	5,340	2,625,544	141	3498	1,339,537	51.0
	LLB	7	23	133	6	20	123	92.2
Silver hake	OTF	201	4,317	6,989,607	171	3761	6,642,081	95.0
(Merluccius bilinearis)	DRS	2	5	27,234	2	5	27,234	100.0
	GNS	72	1145	26,487	66	1064	21,723	82.0
	LLB	1	1	69	0	0	0	0.0
Red hake	OTF	144	2,747	770,336	117	2299	721,569	93.7
(Urophycis chuss)	DRS	1	2	435	1	2	435	100.0
	GNS	20	258	21,761	14	227	21,377	98.2
	LLB	3	4	31	1	1	5	14.7

Table 21. 2010 summary of the Vessel Monitoring System (VMS) data subsets compared to the subset of Vessel Trip Reports (VTR) landings (kg), by species and gear type (bottom otter trawl gear = OTF, scallop dredge gear = DRS, sink gillnet = GNS, and benthic longline = LLB).

Species	VTR gear code	VTR			VMS			
		Number of Vessels	Number of trips	VTR landings (kg)	Number of Vessels	Number of trips	VMS landings (kg)	Percent of VTR landings (%)
Atlantic cod	OTF	270	5,589	3,703,838	250	5,041	3,491,117	94.3
(Gadus morhua)	DRS	1	3	23	1	3	23	100.0
	GNS	130	7,065	2,207,779	116	6309	1,980,710	89.7
	LLB	41	461	134,779	30	341	109,471	81.2
Haddock	OTF	201	2,719	6,004,469	197	2,650	5,989,006	99.7
(Melanogrammus aeglefinus)	DRS	0	0	0	0	0	0	*N/A*
	GNS	100	1,725	41,953	99	1664	41,106	98.0
	LLB	30	346	340,225	22	310	327,823	96.4
Yellowtail flounder	OTF	244	4,380	1,087,740	233	3,920	1,051,766	96.7
(Limanda ferruginea)	DRS	65	89	1,885	65	89	1,885	100.0
	GNS	92	2,643	118,973	84	2339	109,636	92.2
	LLB	9	48	1,538	7	20	137	8.9
Winter flounder	OTF	225	3,633	1,276,975	193	2,735	1,260,099	98.7
(Pseudopleuronectes americanus)	DRS	8	10	430	8	10	430	100.0
	GNS	92	2,585	19,849	83	2332	18,636	93.9
	LLB	7	59	1,551	6	37	310	20.0
Windowpane flounder	OTF	41	543	23,459	28	177	7,753	33.1
(Scophthalmus aquosus)	DRS	0	0	0	0	0	0	*N/A*
	GNS	7	67	215	4	54	76	35.3
	LLB	1	4	11	1	4	11	100.0
Goosefish	OTF	300	3,713	376,389	263	3,161	365,238	97.0
(Lophius americanus)	DRS	242	1,381	123,871	239	1,330	123,056	99.3
	GNS	210	4,482	2,204,506	126	2755	1,164,724	52.8
	LLB	7	23	121	7	23	121	100.0
Silver hake	OTF	186	4,029	7,382,976	165	3587	7,149,060	96.8
(Merluccius bilinearis)	DRS	1	1	5	1	1	5	100.0
	GNS	50	599	4,072	44	575	3,827	94.0
	LLB	2	3	93	2	3	93	100.0
Red hake	OTF	139	2,646	695,607	115	2328	665,318	95.6
(Urophycis chuss)	DRS	0	0	0	0	0	0	*N/A*
	GNS	15	51	6,731	9	39	6,069	90.2
	LLB	2	3	3	2	3	3	100.0

Table 22. 2011 summary of the Vessel Monitoring System (VMS) data subsets compared to the subset of Vessel Trip Reports (VTR) landings (kg), by species and gear type (bottom otter trawl gear = OTF, scallop dredge gear = DRS, sink gillnet = GNS, and benthic longline = LLB).

Species	VTR gear code	VTR			VMS			
		Number of Vessels	Number of trips	VTR landings (kg)	Number of Vessels	Number of trips	VMS landings (kg)	Percent of VTR landings (%)
Atlantic cod	OTF	216	4,712	4,187,183	202	4,514	4,130,595	98.6
(Gadus morhua)	DRS	2	3	14	2	3	14	100.0
	GNS	123	5,627	1,420,454	100	5218	1,362,184	95.9
	LLB	28	517	262,129	21	456	243,710	93.0
Haddock	OTF	160	2,865	2,562,449	157	2,834	2,545,237	99.3
(Melanogrammus aeglefinus)	DRS	0	0	0	0	0	0	*N/A*
	GNS	81	2,114	51,043	78	2025	48,748	95.5
	LLB	23	408	144,925	19	389	143,697	99.2
Yellowtail flounder	OTF	205	3,647	1,469,998	195	3,542	1,462,375	99.5
(Limanda ferruginea)	DRS	74	116	8,528	74	116	8,528	100.0
	GNS	74	1,619	109,083	68	1511	106,660	97.8
	LLB	5	13	36	5	13	36	100.0
Winter flounder	OTF	189	3,335	1,695,391	160	2,625	1,684,355	99.3
(Pseudopleuronectes americanus)	DRS	25	38	1,639	24	36	1,628	99.4
	GNS	80	2,571	31,213	66	2263	28,765	92.2
	LLB	4	30	229	4	30	229	100.0
Windowpane flounder	OTF	21	430	21,731	10	38	1,986	9.1
(Scophthalmus aquosus)	DRS	0	0	0	0	0	0	*N/A*
	GNS	4	50	479	1	4	7	1.4
	LLB	0	0	0	0	0	0	*N/A*
Goosefish	OTF	291	3,117	432,850	247	2,676	425,111	98.2
(Lophius americanus)	DRS	215	1,652	119,021	215	1,562	118,006	99.1
	GNS	201	5,748	2,796,087	117	3539	1,452,480	51.9
	LLB	3	32	202	3	31	198	98.2
Silver hake	OTF	194	4,354	7,322,111	163	3844	7,107,312	97.1
(Merluccius bilinearis)	DRS	1	1	1,361	1	1	1,361	100.0
	GNS	72	1311	8,086	62	1248	7,673	94.9
	LLB	0	0	0	0	0	0	*N/A*
Red hake	OTF	137	2,746	641,584	110	2234	606,341	94.5
(Urophycis chuss)	DRS	0	0	0	0	0	0	*N/A*
	GNS	12	19	204	4	6	67	33.0
	LLB	1	1	4	0	0	0	0.0

Table 23. Summary of the agreement levels between statistical areas recorded on Vessel Trip Reports (VTR) and the statistical areas fished as determined using Vessel Monitoring System (VMS) positional data from matched fishing trips from 2004 to 2011. Trip subcategories are based on the VMS determined number of statistical areas fished. **Note: percentages may not sum to 100 due to rounding.*

Year	Trip category	Number of trips	Agreement level	Number of trips	Percent of total category trips (%)
2004	Single area	2,895	Complete	2,688	92.8
			None	194	6.7
			Partial	13	0.4
	Multi-area	2,997	Complete	74	2.5
			None	139	4.6
			Partial	2,784	92.9
2005	Single area	5,630	Complete	5,267	93.6
			None	334	5.9
			Partial	29	0.5
	Multi-area	4,279	Complete	265	6.2
			None	206	4.8
			Partial	3,808	89.0
2006	Single area	13,488	Complete	12,869	95.4
			None	590	4.4
			Partial	29	0.2
	Multi-area	5,677	Complete	234	4.1
			None	221	3.9
			Partial	5,222	92.0
2007	Single area	19,917	Complete	19,104	95.9
			None	785	3.9
			Partial	28	0.1
	Multi-area	6,007	Complete	284	4.7
			None	234	3.9
			Partial	5,489	91.4
2008	Single area	16,797	Complete	16,124	96.0
			None	641	3.8
			Partial	32	0.2
	Multi-area	4,028	Complete	172	4.3
			None	170	4.2
			Partial	3,686	91.5
2009	Single area	19,336	Complete	18,546	95.9
			None	750	3.9
			Partial	40	0.2
	Multi-area	5,792	Complete	290	5.0
			None	240	4.1
			Partial	5,262	90.8
2010	Single area	14,302	Complete	13,776	96.3
			None	496	3.5
			Partial	30	0.2
	Multi-area	5,221	Complete	343	6.6
			None	208	4.0
			Partial	4,670	89.4
2011	Single area	12,885	Complete	12,192	94.6
			None	643	5.0
			Partial	50	0.4
	Multi-area	5,467	Complete	472	8.6
			None	214	3.9
			Partial	4,781	87.5

Table 24. Frequency of trips fishing on multiple stocks based on Vessel Monitoring System (VMS) data from 2004 to 2011.

Species	2004			2005			2006			2007		
	Total trips	Multiple stock area trips	Percent (%)	Total trips	Multiple stock area trips	Percent (%)	Total trips	Multiple stock area trips	Percent (%)	Total trips	Multiple stock area trips	Percent (%)
Atlantic cod *(Gadus morhua)*	3,096	304	9.8	5,760	600	10.4	9,056	555	6.1	14,560	539	3.7
Haddock *(Melanogrammus aeglefinus)*	2,819	295	10.5	4,615	562	12.2	5,769	517	9	8,022	464	5.8
Yellowtail flounder *(Limanda ferruginea)*	2,140	186	8.7	3,263	352	10.8	5,228	367	7	7,631	436	5.7
Winter flounder *(Pseudopleuronectes americanus)*	2,407	286	11.9	3,777	604	16	6,622	453	6.8	10,042	490	4.9
Windowpane flounder *(Scophthalmus aquosus)*	105	19	18.1	236	24	10.2	617	28	4.5	1180	47	4.0
Goosefish *(Lophius americanus)*	3,697	254	6.9	6,084	511	8.4	12,406	580	4.7	14,012	426	3.0
Silver hake *(Merluccius bilinearis)*	732	17	2.3	1,227	28	2.3	2,348	38	1.6	3,595	59	1.6
Red hake *(Urophycis chuss)*	550	9	1.6	789	8	1	1,465	23	1.6	2,278	40	1.8

Species	2008			2009			2010			2011		
	Total trips	Multiple stock area trips	Percent (%)	Total trips	Multiple stock area trips	Percent (%)	Total trips	Multiple stock area trips	Percent (%)	Total trips	Multiple stock area trips	Percent (%)
Atlantic cod *(Gadus morhua)*	13,009	340	2.6	15,808	487	3.1	11,694	555	4.7	10,191	727	7.1
Haddock *(Melanogrammus aeglefinus)*	6,073	306	5.0	6,468	426	6.6	4,624	516	11.2	5,248	670	12.8
Yellowtail flounder *(Limanda ferruginea)*	6,641	264	4.0	7,886	275	3.5	6,368	314	4.9	5,182	442	8.5
Winter flounder *(Pseudopleuronectes americanus)*	8,556	327	3.8	8,202	328	4.0	5,114	379	7.4	4,954	574	11.6
Windowpane flounder *(Scophthalmus aquosus)*	829	44	5.3	1004	15	1.5	235	0	0.0	42	0	0.0
Goosefish *(Lophius americanus)*	8,943	300	3.4	9,674	362	3.7	7,269	240	3.3	7,808	234	3.0
Silver hake *(Merluccius bilinearis)*	2,880	28	1.0	4,830	51	1.1	4,166	61	1.5	5,093	53	1.0
Red hake *(Urophycis chuss)*	1,793	19	1.1	2,529	24	0.9	2,370	38	1.6	2,240	36	1.6

Table 25. Frequency of fixed (sink gillnet, benthic longline) and mobile (bottom otter trawl, scallop dredge) gear types used on trips fishing on multiple stocks based on Vessel Monitoring System (VMS) positional data from 2005 and 2011.

2005						
Species	**Number of total trips**	**Number of multiple stock area trips**	**Percent of total trips (%)**	**Gear category**	**Number of Trips**	**Percent of multiple stock area trips (%)**
Atlantic cod *(Gadus morhua)*	5,760	600	10.4	Fixed	6	1.0
				Mobile	594	99.0
Haddock *(Melanogrammus aeglefinus)*	4,615	562	12.2	Fixed	4	0.7
				Mobile	558	99.3
Yellowtail flounder *(Limanda ferruginea)*	3,263	352	10.8	Fixed	0	0.0
				Mobile	352	100.0
Winter flounder *(Pseudopleuronectes americanus)*	3,777	604	16.0	Fixed	1	0.2
				Mobile	603	99.8
Windowpane flounder *(Scophthalmus aquosus)*	236	24	10.2	Fixed	0	*0.0*
				Mobile	24	*100.0*
Goosefish *(Lophius americanus)*	6,084	511	8.4	Fixed	0	0.0
				Mobile	511	100.0
Silver hake *(Merluccius bilinearis)*	1,227	28	2.3	Fixed	0	0.0
				Mobile	28	100.0
Red hake *(Urophycis chuss)*	789	8	1.0	Fixed	0	0.0
				Mobile	8	100.0

2011						
Species	**Number of total trips**	**Number of multiple stock area trips**	**Percent of total trips (%)**	**Gear category**	**Number of Trips**	**Percent of multiple stock area trips (%)**
Atlantic cod *(Gadus morhua)*	10,191	727	7.1	Fixed	40	5.5
				Mobile	687	94.5
Haddock *(Melanogrammus aeglefinus)*	5,248	670	12.8	Fixed	27	4.0
				Mobile	643	96.0
Yellowtail flounder *(Limanda ferruginea)*	5,182	442	8.5	Fixed	9	2.0
				Mobile	433	98.0
Winter flounder *(Pseudopleuronectes americanus)*	4,954	574	11.6	Fixed	20	3.5
				Mobile	554	96.5
Windowpane flounder *(Scophthalmus aquosus)*	42	0	0.0	Fixed	0	*N/A*
				Mobile	0	*N/A*
Goosefish *(Lophius americanus)*	7,808	234	3.0	Fixed	40	17.1
				Mobile	194	82.9
Silver hake *(Merluccius bilinearis)*	5,093	53	1.0	Fixed	1	1.9
				Mobile	52	98.1
Red hake *(Urophycis chuss)*	2240	36	1.6	Fixed	0	0.0
				Mobile	36	100.0

Table 26. Results of the Vessel Monitoring System (VMS) based stock area allocation compared to the stock area allocation based on the Vessel Trip Reports (VTR) reported statistical area for 2004. Relative difference is determined as % difference/VTR stock allocation; allocations ≥ 5.0% relative differences are italicized. Stock areas are Gulf of Maine (GOM), Georges Bank (GBK), southern New England/mid-Atlantic (SNE), northern (NOR), and southern (SOU). **Note: allocations may not sum to 100 due to rounding.*

Species	Total species landings (kg)	Stock area	VTR landings allocation (kg)	VMS landings allocation (kg)	Δ landings allocation abs(kg)	∑Δ_i/total species landings (%)	VTR stock allocation (%)	VMS Stock allocation (%)	Difference (%)	Relative difference (%)
Atlantic cod (*Gadus morhua*)	1,874,015	GBK	1,384,752	1,375,601	9,151	0.98	73.9	73.4	0.5	0.7
		GOM	489,263	498,414	9,151		26.1	26.6	-0.5	-1.9
Haddock (*Melanogrammus aeglefinus*)	5,096,088	GBK	4,763,038	4,806,095	43,057	1.69	93.5	94.3	-0.8	-0.9
		GOM	333,050	289,993	43,057		6.5	5.7	0.8	*12.3*
Yellowtail flounder (*Limanda ferruginea*)	5,378,987	GBK	5,094,590	5,176,798	82,208	3.06	94.7	96.2	-1.5	-1.6
		GOM	215,710	172,386	43,324		4.0	3.2	0.8	*20.0*
		SNE	68,687	29,802	38,885		1.3	0.6	0.7	*53.8*
Winter flounder (*Pseudopleuronectes americanus*)	3,127,781	GBK	2,420,182	2,459,208	39,026	2.59	77.4	78.6	-1.2	-1.6
		GOM	94,235	95,648	1,413		3.0	3.1	0.0	0.0
		SNE	613,364	572,925	40,439		19.6	18.3	1.3	*6.6*
Windowpane flounder (*Scophthalmus aquosus*)	18,217	NOR	16,807	16,725	82	0.90	92.3	91.8	0.5	0.5
		SOU	1,410	1,492	82		7.7	8.2	-0.5	*-6.5*
Goosefish (*Lophius americanus*)	1,332,178	NOR	787,572	801,448	13,876	2.08	59.1	60.2	-1.0	-1.7
		SOU	544,606	530,730	13,876		40.9	39.8	1.0	2.4
Silver hake (*Merluccius bilinearis*)	2,071,930	NOR	404,972	343,720	61,252	*5.91*	19.5	16.6	3.0	*15.4*
		SOU	1,666,958	1,728,210	61,252		80.5	83.4	-3.0	-3.7
Red hake (*Urophycis chuss*)	236,830	NOR	61,461	64,355	2,894	2.44	26.0	27.2	-1.2	-4.6
		SOU	175,369	172,475	2,894		74.0	72.8	1.2	1.6

Table 27. Results of the Vessel Monitoring System (VMS) based stock area allocation compared to the stock area allocation based on the Vessel Trip Reports (VTR) reported statistical area for 2005. Relative difference is determined as % difference/VTR stock allocation; allocations ≥ 5.0% relative differences are italicized. Stock areas are Gulf of Maine (GOM), Georges Bank (GBK), southern New England/mid-Atlantic (SNE), northern (NOR), and southern (SOU). **Note: allocations may not sum to 100 due to rounding.*

Species	Total species landings (kg)	Stock area	VTR landings allocation (kg)	VMS landings allocation (kg)	Δ landings allocation abs(kg)	$\sum\Delta_i$/total species landings (%)	VTR stock allocation (%)	VMS stock allocation (%)	Difference (%)	Relative difference (%)
Atlantic cod (*Gadus morhua*)	2,754,687	GBK	1,920,110	1,879,800	40,310	2.93	69.7	68.2	1.5	2.2
		GOM	834,577	874,887	40,310		30.3	31.8	-1.5	*-5.0*
Haddock (*Melanogrammus aeglefinus*)	5,700,737	GBK	5,319,329	5,285,374	33,955	1.19	93.3	92.7	0.6	0.6
		GOM	381,408	415,363	33,955		6.7	7.3	-0.6	*-9.0*
Yellowtail flounder (*Limanda ferruginea*)	3,475,993	GBK	3,115,140	3,164,191	49,051	2.82	89.6	91.0	-1.4	-1.6
		GOM	286,276	281,958	4,318		8.2	8.1	0.1	1.2
		SNE	74,577	29,844	44,733		2.1	0.9	1.3	*61.9*
Winter flounder (*Pseudopleuronectes americanus*)	2,800,638	GBK	1,976,251	1,985,963	9,712	1.39	70.6	70.9	-0.3	-0.4
		GOM	132,155	112,737	19,418		4.7	4.0	0.7	*14.9*
		SNE	692,232	701,939	9,707		24.7	25.1	-0.3	-1.2
Windowpane flounder (*Scophthalmus aquosus*)	45,772	NOR	43,740	44,337	597	2.61	95.6	96.9	-1.3	-1.4
		SOU	2,032	1,435	597		4.4	3.1	1.3	*29.5*
Goosefish (*Lophius americanus*)	2,129,989	NOR	1,188,433	1,223,924	35,491	3.33	55.8	57.5	-1.7	-3.0
		SOU	941,556	906,065	35,491		44.2	42.5	1.7	3.8
Silver hake (*Merluccius bilinearis*)	3,531,070	NOR	400,744	380,084	20,660	1.17	11.3	10.8	0.6	*5.3*
		SOU	3,130,326	3,150,986	20,660		88.7	89.2	-0.6	-0.7
Red hake (*Urophycis chuss*)	154,666	NOR	39,360	37,097	2,263	2.93	25.4	24.0	1.5	*5.9*
		SOU	115,306	117,569	2,263		74.6	76.0	-1.5	-2.0

Table 28. Results of the Vessel Monitoring System (VMS) based stock area allocation compared to the stock area allocation based on the Vessel Trip Reports (VTR) reported statistical area for 2006. Relative difference is determined as % difference/VTR stock allocation; allocations ≥ 5.0% relative differences are italicized. Stock areas are Gulf of Maine (GOM), Georges Bank (GBK), southern New England/mid-Atlantic (SNE), northern (NOR), and southern (SOU). **Note: allocations may not sum to 100 due to rounding.*

Species	Total species landings (kg)	Stock area	VTR landings allocation (kg)	VMS landings allocation (kg)	Δ landings allocation abs(kg)	∑Δ$_i$/total species landings (%)	VTR stock allocation (%)	VMS Stock allocation (%)	Difference (%)	Relative difference (%)
Atlantic cod (*Gadus morhua*)	3,428,790	GBK	2,012,366	2,009,838	2,528	0.15	58.7	58.6	0.1	0.2
		GOM	1,416,424	1,418,952	2,528		41.3	41.4	-0.1	-0.2
Haddock (*Melanogrammus aeglefinus*)	2,513,766	GBK	2,175,084	2,171,158	3,926	0.31	86.5	86.4	0.2	0.2
		GOM	338,682	342,608	3,926		13.5	13.6	-0.2	-1.5
Yellowtail flounder (*Limanda ferruginea*)	1,681,115	GBK	1,253,693	1,283,732	30,039	3.57	74.6	76.4	-1.8	-2.4
		GOM	319,177	315,714	3,463		19.0	18.8	0.2	1.1
		SNE	108,245	81,669	26,576		6.4	4.9	1.6	*25.0*
Winter flounder (*Pseudopleuronectes americanus*)	2,128,053	GBK	837,904	847,487	9,583	0.91	39.4	39.8	-0.5	-1.3
		GOM	151,351	151,497	146		7.1	7.1	0.0	0.0
		SNE	1,138,798	1,129,069	9,729		53.5	53.1	0.5	0.9
Windowpane flounder (*Scophthalmus aquosus*)	61,653	NOR	36,421	39,349	2,928	*9.50*	59.1	63.8	-4.7	*-8.0*
		SOU	25,232	22,305	2,927		40.9	36.2	4.7	*11.5*
Goosefish (*Lophius americanus*)	3,246,832	NOR	1,591,261	1,624,922	33,661	2.07	49.0	50.0	-1.0	-2.0
		SOU	1,655,571	1,621,910	33,661		51.0	50.0	1.0	2.0
Silver hake (*Merluccius bilinearis*)	4,606,490	NOR	876,514	950,975	74,461	3.23	19.0	20.6	-1.6	*-8.4*
		SOU	3,729,976	3,655,515	74,461		81.0	79.4	1.6	2.0
Red hake (*Urophycis chuss*)	458,731	NOR	142,190	145,968	3,778	1.65	31.0	31.8	-0.8	-2.6
		SOU	316,541	312,763	3,778		69.0	68.2	0.8	1.2

Table 29. Results of the Vessel Monitoring System (VMS) based stock area allocation compared to the stock area allocation based on the Vessel Trip Reports (VTR) reported statistical area for 2007. Relative difference is determined as % difference/VTR stock allocation; allocations ≥ 5.0% relative differences are italicized. Stock areas are Gulf of Maine (GOM), Georges Bank (GBK), southern New England/mid-Atlantic (SNE), northern (NOR), and southern (SOU). **Note: allocations may not sum to 100 due to rounding.*

Species	Total species landings (kg)	Stock area	VTR landings allocation (kg)	VMS landings allocation (kg)	Δ landings allocation abs(kg)	$\sum\Delta_i$/total species landings (%)	VTR stock allocation (%)	VMS Stock allocation (%)	Difference (%)	Relative difference (%)
Atlantic cod	5,838,287	GBK	2,971,618	2,948,151	23,466	0.8	50.9	50.5	0.4	0.8
(*Gadus morhua*)		GOM	2,866,669	2,890,135	23,466		49.1	49.5	-0.4	-0.8
Haddock	3,013,511	GBK	2,475,073	2,471,087	3,985	0.3	82.1	82.0	0.1	0.2
(*Melanogrammus aeglefinus*)		GOM	538,438	542,423	3,985		17.9	18.0	-0.1	-0.7
Yellowtail flounder	1,623,035	GBK	1,107,416	1,128,478	21,062	2.6	68.2	69.5	-1.3	-1.9
(*Limanda ferruginea*)		GOM	376,016	356,443	19,574		23.2	22.0	1.2	*5.5*
		SNE	139,603	138,114	1,488		8.6	8.5	0.1	1.1
Winter flounder	2,172,096	GBK	766,057	713,963	52,094	4.8	35.3	32.9	2.4	*7.3*
(Pseudopleuronectes americanus)		GOM	193,425	204,320	10,895		8.9	9.4	-0.5	*-5.3*
		SNE	1,212,614	1,253,813	41,199		55.8	57.7	-1.9	-3.3
Windowpane flounder	144,231	NOR	110,327	110,067	260	0.4	76.5	76.3	0.2	0.2
(Scophthalmus aquosus)		SOU	33,904	34,164	260		23.5	23.7	-0.2	-0.8
Goosefish	2,969,033	NOR	1,106,535	1,094,480	12,056	0.8	37.3	36.9	0.4	1.1
(*Lophius americanus*)		SOU	1,862,497	1,874,553	12,056		62.7	63.1	-0.4	-0.6
Silver hake	5,749,198	NOR	1,045,749	1,065,613	19,865	0.7	18.2	18.5	-0.3	-1.9
(*Merluccius bilinearis*)		SOU	4,703,449	4,683,584	19,865		81.8	81.5	0.3	0.4
Red hake	544,902	NOR	106,960	105,305	1,655	0.6	19.6	19.3	0.3	1.6
(*Urophycis chuss*)		SOU	437,942	439,597	1,655		80.4	80.7	-0.3	-0.4

Table 30. Results of the Vessel Monitoring System (VMS) based stock area allocation compared to the stock area allocation based on the Vessel Trip Reports (VTR) reported statistical area for 2008. Relative difference is determined as % difference/VTR stock allocation; allocations ≥ 5.0% relative differences are italicized. Stock areas are Gulf of Maine (GOM), Georges Bank (GBK), southern New England/mid-Atlantic (SNE), northern (NOR), and southern (SOU). **Note: allocations may not sum to 100 due to rounding.*

Species	Total species landings (kg)	Stock area	VTR landings allocation (kg)	VMS landings allocation (kg)	Δ landings allocation abs(kg)	$\sum\Delta_i$/total species landings (%)	VTR stock allocation (%)	VMS Stock allocation (%)	Difference (%)	Relative difference (%)
Atlantic cod	4,987,617	GBK	1,977,321	1,964,655	12,666	0.5	39.6	39.4	0.3	0.6
(*Gadus morhua*)		GOM	3,010,296	3,022,962	12,666		60.4	60.6	-0.3	-0.4
Haddock	4,072,033	GBK	3,801,155	3,748,015	53,140	2.6	93.3	92.0	1.3	1.4
(*Melanogrammus aeglefinus*)		GOM	270,879	324,018	53,140		6.7	8.0	-1.3	*-16.4*
Yellowtail flounder	1,239,577	GBK	772,304	770,172	2,132	0.3	62.3	62.1	0.2	0.3
(*Limanda ferruginea*)		GOM	358,242	358,411	169		28.9	28.9	0.0	0.0
		SNE	109,030	110,993	1,963		8.8	9.0	-0.2	-1.8
Winter flounder	1,875,233	GBK	915,033	849,254	65,779	7.0	48.8	45.3	3.5	*7.7*
(Pseudopleuronectes americanus)		GOM	187,557	193,399	5,843		10.0	10.3	-0.3	-3.0
		SNE	772,643	832,579	59,936		41.2	44.4	-3.2	*-7.2*
Windowpane flounder	59,340	NOR	33,564	31,550	2,014	6.8	56.6	53.2	3.4	*6.4*
(Scophthalmus aquosus)		SOU	25,776	27,789	2,014		43.4	46.8	-3.4	*-7.2*
Goosefish	1,791,932	NOR	428,672	445,051	16,379	1.8	23.9	24.8	-0.9	-3.7
(*Lophius americanus*)		SOU	1,363,260	1,346,881	16,379		76.1	75.2	0.9	1.2
Silver hake	3,801,904	NOR	616,304	633,309	17,005	0.9	16.2	16.7	-0.4	-2.7
(*Merluccius bilinearis*)		SOU	3,185,600	3,168,595	17,005		83.8	83.3	0.4	0.5
Red hake	535,765	NOR	105,091	105,101	10	0.0	19.6	19.6	0.0	0.0
(*Urophycis chuss*)		SOU	430,673	430,664	10		80.4	80.4	0.0	0.0

Table 31. Results of the Vessel Monitoring System (VMS) based stock area allocation compared to the stock area allocation based on the Vessel Trip Reports (VTR) reported statistical area for 2009. Relative difference is determined as % difference/VTR stock allocation; allocations ≥ 5.0% relative differences are italicized. Stock areas are Gulf of Maine (GOM), Georges Bank (GBK), southern New England/mid-Atlantic (SNE), northern (NOR), and southern (SOU). **Note: allocations may not sum to 100 due to rounding.*

Species	Total species landings (kg)	Stock area	VTR landings allocation (kg)	VMS landings allocation (kg)	Δ landings allocation abs(kg)	$\sum\Delta_i$/total species landings (%)	VTR stock allocation (%)	VMS Stock allocation (%)	Difference (%)	Relative difference (%)
Atlantic cod	6,237,409	GBK	2,364,181	2,340,975	23,206	0.7	37.9	37.5	0.4	1.0
(*Gadus morhua*)		GOM	3,873,229	3,896,795	23,566		62.1	62.5	-0.4	-0.6
Haddock	4,715,389	GBK	4,366,878	4,252,054	114,823	4.9	92.6	90.2	2.4	2.7
(*Melanogrammus aeglefinus*)		GOM	348,512	463,284	114,772		7.4	9.8	-2.4	*-24.8*
Yellowtail flounder	1,496,367	GBK	1,015,204	1,015,104	99	0.4	67.8	67.8	0.0	0.0
(*Limanda ferruginea*)		GOM	334,514	337,213	2,699		22.4	22.5	-0.2	-0.8
		SNE	146,650	144,127	2,523		9.8	9.6	0.2	1.8
Winter flounder	1,912,030	GBK	1,548,132	1,567,046	18,914	2.1	81.0	82.0	-1.0	-1.2
(Pseudopleuronectes americanus)		GOM	223,636	225,689	2,052		11.7	11.8	-0.1	-0.9
		SNE	140,262	121,079	19,183		7.3	6.3	1.0	*15.8*
Windowpane flounder	71,731	NOR	37,889	37,889	0	0.0	52.8	52.8	0.0	0.0
(Scophthalmus aquosus)		SOU	33,842	33,853	11		47.2	47.2	0.0	0.0
Goosefish	1,968,113	NOR	492,458	459,188	33,269	3.4	25.0	23.3	1.7	*7.2*
(*Lophius americanus*)		SOU	1,475,656	1,508,707	33,051		75.0	76.7	-1.7	-2.2
Silver hake	6,690,492	NOR	908,843	931,201	22,358	0.7	13.6	13.9	-0.3	-2.4
(*Merluccius bilinearis*)		SOU	5,781,649	5,759,732	21,917		86.4	86.1	0.3	0.4
Red hake	743,204	NOR	141,457	144,454	2,997	0.8	19.0	19.4	-0.4	-2.1
(*Urophycis chuss*)		SOU	601,747	598,932	2,816		81.0	80.6	0.4	0.5

Table 32. Results of the Vessel Monitoring System (VMS) based stock area allocation compared to the stock area allocation based on the Vessel Trip Reports (VTR) reported statistical area for 2010. Relative difference is determined as % difference/VTR stock allocation; allocations ≥ 5.0% relative differences are italicized. Stock areas are Gulf of Maine (GOM), Georges Bank (GBK), southern New England/mid-Atlantic (SNE), northern (NOR), and southern (SOU). **Note: allocations may not sum to 100 due to rounding.*

Species	Total species landings (kg)	Stock area	VTR landings allocation (kg)	VMS landings allocation (kg)	Δ landings allocation abs(kg)	$\sum\Delta_i$/total species landings (%)	VTR stock allocation (%)	VMS Stock allocation (%)	Difference (%)	Relative difference (%)
Atlantic cod	5,580,277	GBK	1,916,429	1,878,475	37,954	1.4	34.3	33.7	0.7	2.0
(*Gadus morhua*)		GOM	3,663,849	3,702,420	38,571		65.7	66.3	-0.7	-1.0
Haddock	6,340,880	GBK	5,953,868	5,858,956	94,912	3.3	93.9	92.4	1.5	1.6
(*Melanogrammus aeglefinus*)		GOM	387,012	498,543	111,531		6.1	7.9	-1.8	*-22.4*
Yellowtail flounder	1,163,424	GBK	615,685	646,871	31,186	5.4	52.9	55.6	-2.7	-4.8
(*Limanda ferruginea*)		GOM	447,942	418,252	29,689		38.5	36.0	2.6	*7.1*
		SNE	99,797	98,286	1,511		8.6	8.4	0.1	1.5
Winter flounder	1,279,175	GBK	1,139,194	1,085,974	53,219	8.3	89.1	84.9	4.2	4.9
(Pseudopleuronectes americanus)		GOM	92,046	92,866	820		7.2	7.3	-0.1	-0.9
		SNE	47,936	100,630	52,694		3.7	7.9	-4.1	*-52.4*
Windowpane flounder	7,840	NOR	590	309	281	7.2	7.5	3.9	3.6	*91.0*
(Scophthalmus aquosus)		SOU	7,250	7,531	281		92.5	96.1	-3.6	-3.7
Goosefish	1,653,053	NOR	368,804	361,684	7,120	0.8	22.3	21.9	0.4	2.0
(*Lophius americanus*)		SOU	1,284,249	1,291,117	6,868		77.7	78.1	-0.4	-0.5
Silver hake	7,152,804	NOR	1,528,251	1,591,907	63,656	1.8	21.4	22.3	-0.9	-4.0
(*Merluccius bilinearis*)		SOU	5,624,553	5,561,078	63,474		78.6	77.7	0.9	1.1
Red hake	671,376	NOR	113,947	116,104	2,157	0.6	17.0	17.3	-0.3	-1.9
(*Urophycis chuss*)		SOU	557,429	555,286	2,143		83.0	82.7	0.3	0.4

Table 33. Results of the Vessel Monitoring System (VMS) based stock area allocation compared to the stock area allocation based on the Vessel Trip Reports (VTR) reported statistical area for 2011. Relative difference is determined as % difference/VTR stock allocation; allocations ≥ 5.0% relative differences are italicized. Stock areas are Gulf of Maine (GOM), Georges Bank (GBK), southern New England/mid-Atlantic (SNE), northern (NOR), and southern (SOU). **Note: allocations may not sum to 100 due to rounding.*

Species	Total species landings (kg)	Stock area	VTR landings allocation (kg)	VMS landings allocation (kg)	Δ landings allocation abs(kg)	$\sum\Delta_i$/total species landings (%)	VTR stock allocation (%)	VMS Stock allocation (%)	Difference (%)	Relative difference (%)
Atlantic cod	5,580,277	GBK	1,916,429	1,878,475	37,954	1.4	34.3	33.7	0.7	2.0
(*Gadus morhua*)		GOM	3,663,849	3,702,420	38,571		65.7	66.3	-0.7	-1.0
Haddock	6,340,880	GBK	5,953,868	5,858,956	94,912	3.3	93.9	92.4	1.5	1.6
(*Melanogrammus aeglefinus*)		GOM	387,012	498,543	111,531		6.1	7.9	-1.8	*-22.4*
Yellowtail flounder	1,163,424	GBK	615,685	646,871	31,186	5.4	52.9	55.6	-2.7	-4.8
(*Limanda ferruginea*)		GOM	447,942	418,252	29,689		38.5	36.0	2.6	*7.1*
		SNE	99,797	98,286	1,511		8.6	8.4	0.1	1.5
Winter flounder	1,279,175	GBK	1,139,194	1,085,974	53,219	8.3	89.1	84.9	4.2	4.9
(Pseudopleuronectes americanus)		GOM	92,046	92,866	820		7.2	7.3	-0.1	-0.9
		SNE	47,936	100,630	52,694		3.7	7.9	-4.1	*-52.4*
Windowpane flounder	7,840	NOR	590	309	281	7.2	7.5	3.9	3.6	*91.0*
(Scophthalmus aquosus)		SOU	7,250	7,531	281		92.5	96.1	-3.6	-3.7
Goosefish	1,653,053	NOR	368,804	361,684	7,120	0.8	22.3	21.9	0.4	2.0
(*Lophius americanus*)		SOU	1,284,249	1,291,117	6,868		77.7	78.1	-0.4	-0.5
Silver hake	7,152,804	NOR	1,528,251	1,591,907	63,656	1.8	21.4	22.3	-0.9	-4.0
(*Merluccius bilinearis*)		SOU	5,624,553	5,561,078	63,474		78.6	77.7	0.9	1.1
Red hake	671,376	NOR	113,947	116,104	2,157	0.6	17.0	17.3	-0.3	-1.9
(*Urophycis chuss*)		SOU	557,429	555,286	2,143		83.0	82.7	0.3	0.4

Table 34. Relative differences between VTR and VMS-based allocations by species, stock and year (summary of Tables 26-33).

Year	Atlantic cod (*Gadus morhua*)		Haddock (*Melanogrammus aeglefinus*)		Yellowtail flounder (*Limanda ferruginea*)			Winter flounder (*Pseudopleuronectes americanus*)			Windowpane flounder (*Scophthalmus aquosus*)		Goosefish (*Lophius americanus*)		Silver hake (*Merluccius bilinearis*)		Red hake (*Urophycis chuss*)	
	GBK	GOM	GBK	GOM	GBK	GOM	SNE	GBK	GOM	SNE	NOR	SOU	NOR	SOU	NOR	SOU	NOR	SOU
2004	0.7	-1.9	-0.9	12.3	-1.6	20.0	53.8	-1.6	0.0	6.6	0.5	-6.5	-1.7	2.4	15.4	-3.7	-4.6	1.6
2005	2.2	-5.0	0.6	-9.0	-1.6	1.2	61.9	-0.4	14.9	-1.2	-1.4	29.5	-3.0	3.8	5.3	-0.7	5.9	-2.0
2006	0.2	-0.2	0.2	-1.5	-2.4	1.1	25.0	-1.3	0.0	0.9	-8.0	11.5	-2.0	2.0	-8.4	2.0	-2.6	1.2
2007	0.8	-0.8	0.2	-0.7	-1.9	5.5	1.1	7.3	-5.3	-3.3	0.2	-0.8	1.1	-0.6	-1.9	0.4	1.6	-0.4
2008	0.6	-0.4	1.4	-16.4	0.3	0.0	-1.8	7.7	-3.0	-7.2	6.4	-7.2	-3.7	1.2	-2.7	0.5	0.0	0.0
2009	1.0	-0.6	2.7	-24.8	0.0	-0.8	1.8	-1.2	-0.9	15.8	0.0	0.0	7.2	-2.2	-2.4	0.4	-2.1	0.5
2010	2.0	-1.0	1.6	-22.4	-4.8	7.1	1.5	4.9	-0.9	-52.4	91.0	-3.7	2.0	-0.5	-4.0	1.1	-1.9	0.4
2011	2.0	-1.0	1.6	-22.4	-4.8	7.1	1.5	4.9	-0.9	-52.4	91.0	-3.7	2.0	-0.5	-4.0	1.1	-1.9	0.4

Figures

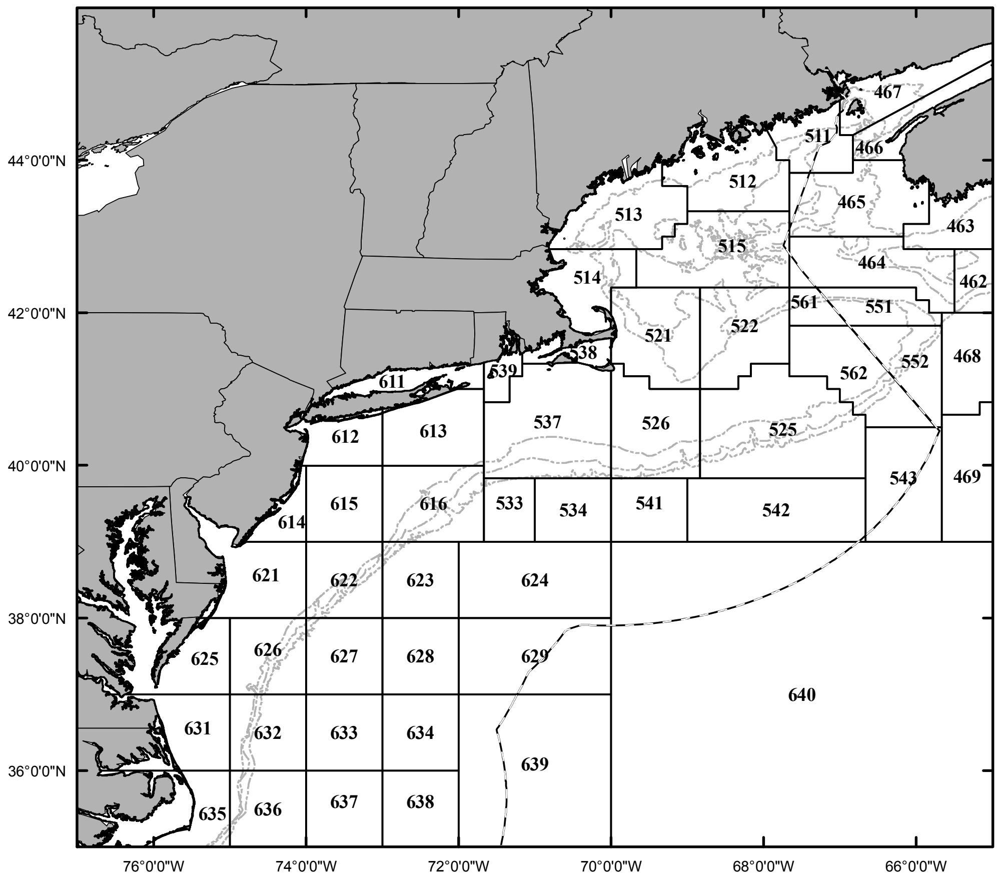

Figure 1. Statistical areas used for commercial fisheries data collection by the National Marine Fisheries Service in the Northeast Region. The 50, 100 and 500 fa bathymetric lines are shown in light gray and the U.S. Exclusive Economic Zone is indicated by the dashed black line.

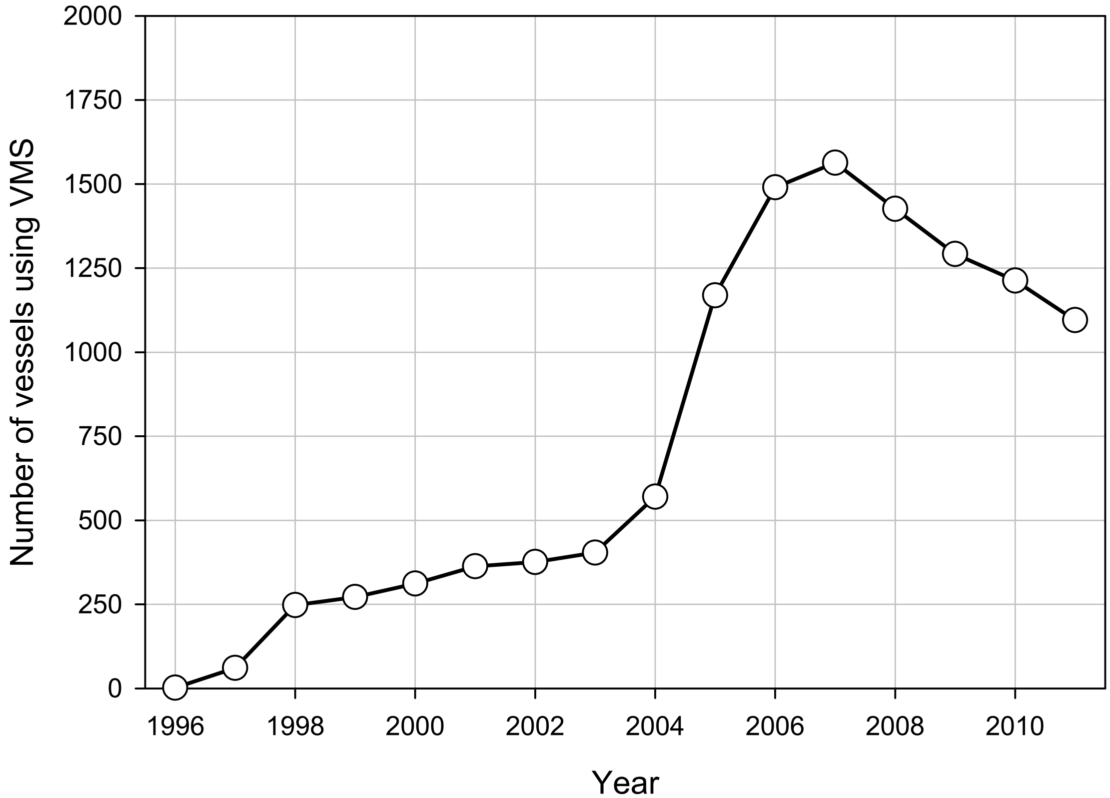

Figure 2. Number of vessels using Vessel Monitoring System (VMS) in the northeast United States between 1998 and 2011.

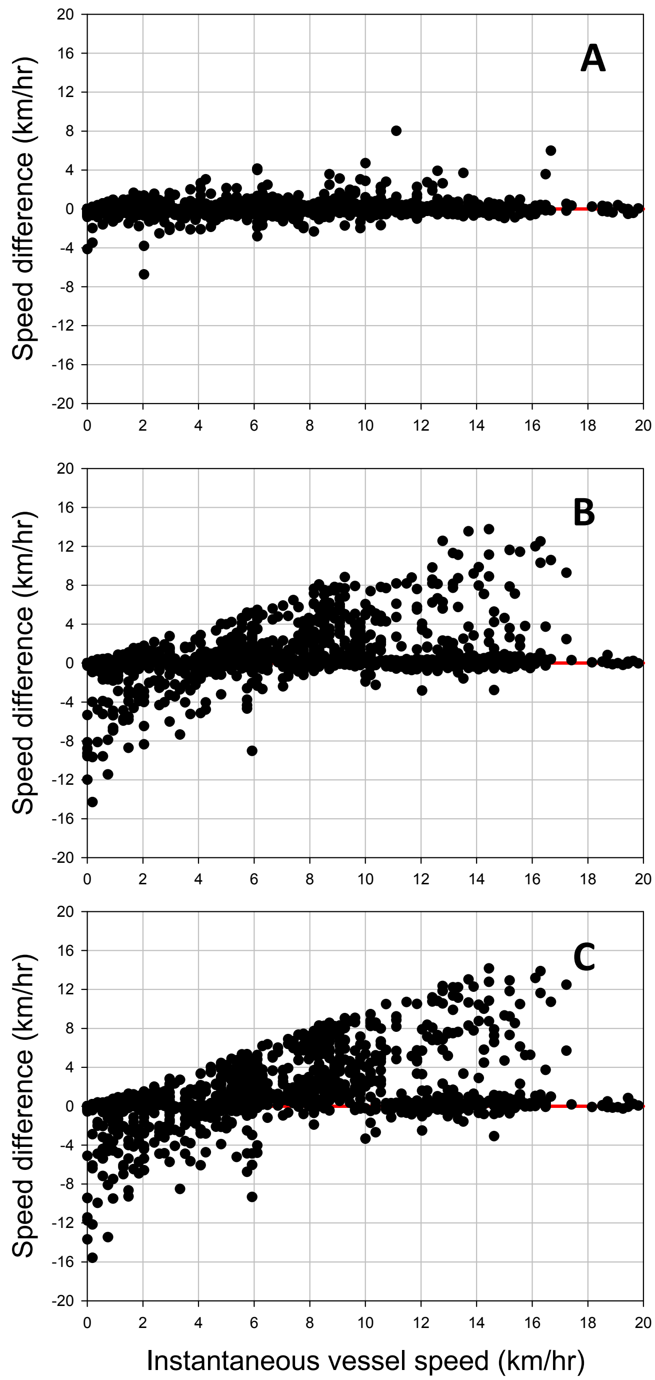

Figure 3. Vessel speeds calculated from sequential GPS polling positions to the compared to a vessel's instantaneous speed recorded directly from the GPS unit. Plot A shows the comparison of the calculated average speed of a fishing vessel compared to the vessel's instantaneous speed when the VMS polling frequency is 1 position/minute. Plot B shows the effect when the VMS polling frequency is 1 position/30 minutes. Plot C shows the effect when the VMS polling frequency is 1 position/hour.

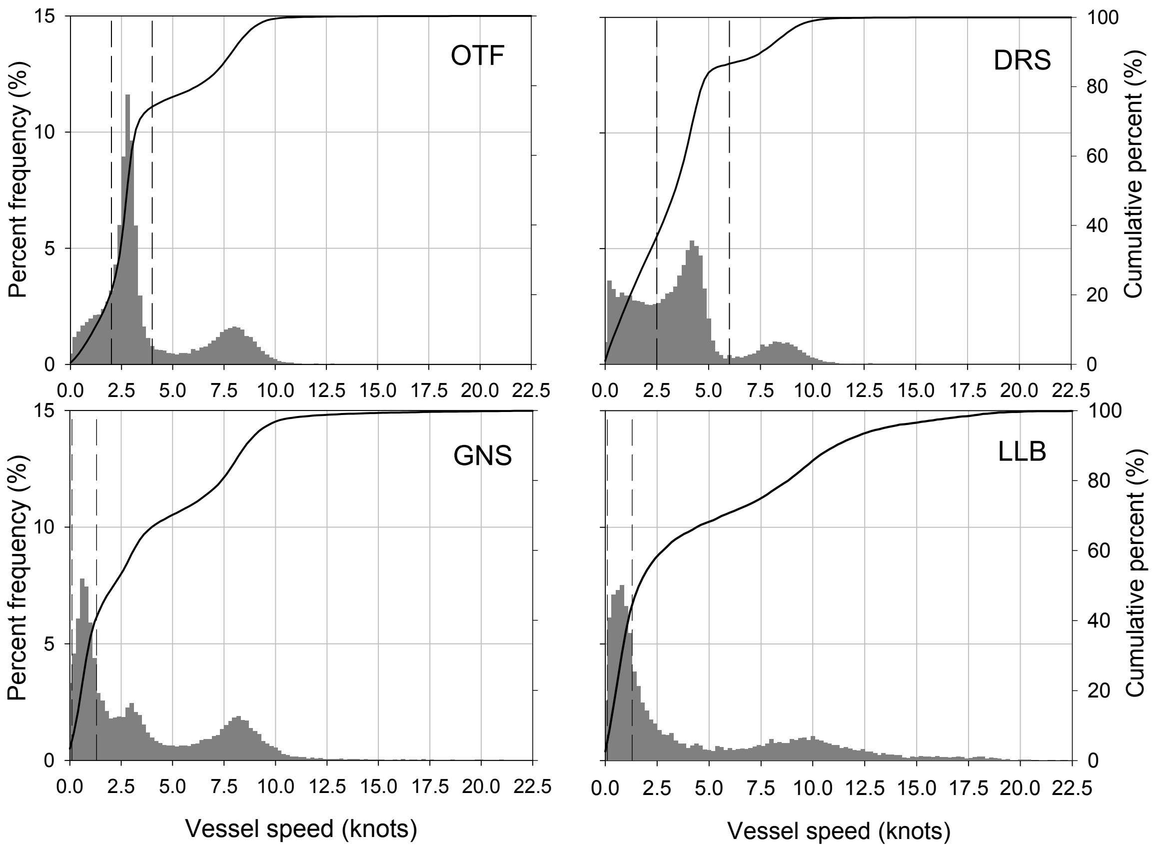

Figure 4. Percent frequency and cumulative percent distributions of average vessel speed (knots) as determined from Vessel Monitoring System (VMS) positions for vessels fishing fish bottom otter trawl (OTF), scallop dredge (DRS), sink gillnet (GNS) and benthic longline (LLB). The dashed lines represent the bounds used in this study to define fishing activity (OTF = 2.0 – 4.0 knots, DRS = 2.5 – 6.0 knots, GNS = 0.1 – 1.3 knots, LLB = 0.1 – 1.3 knots).

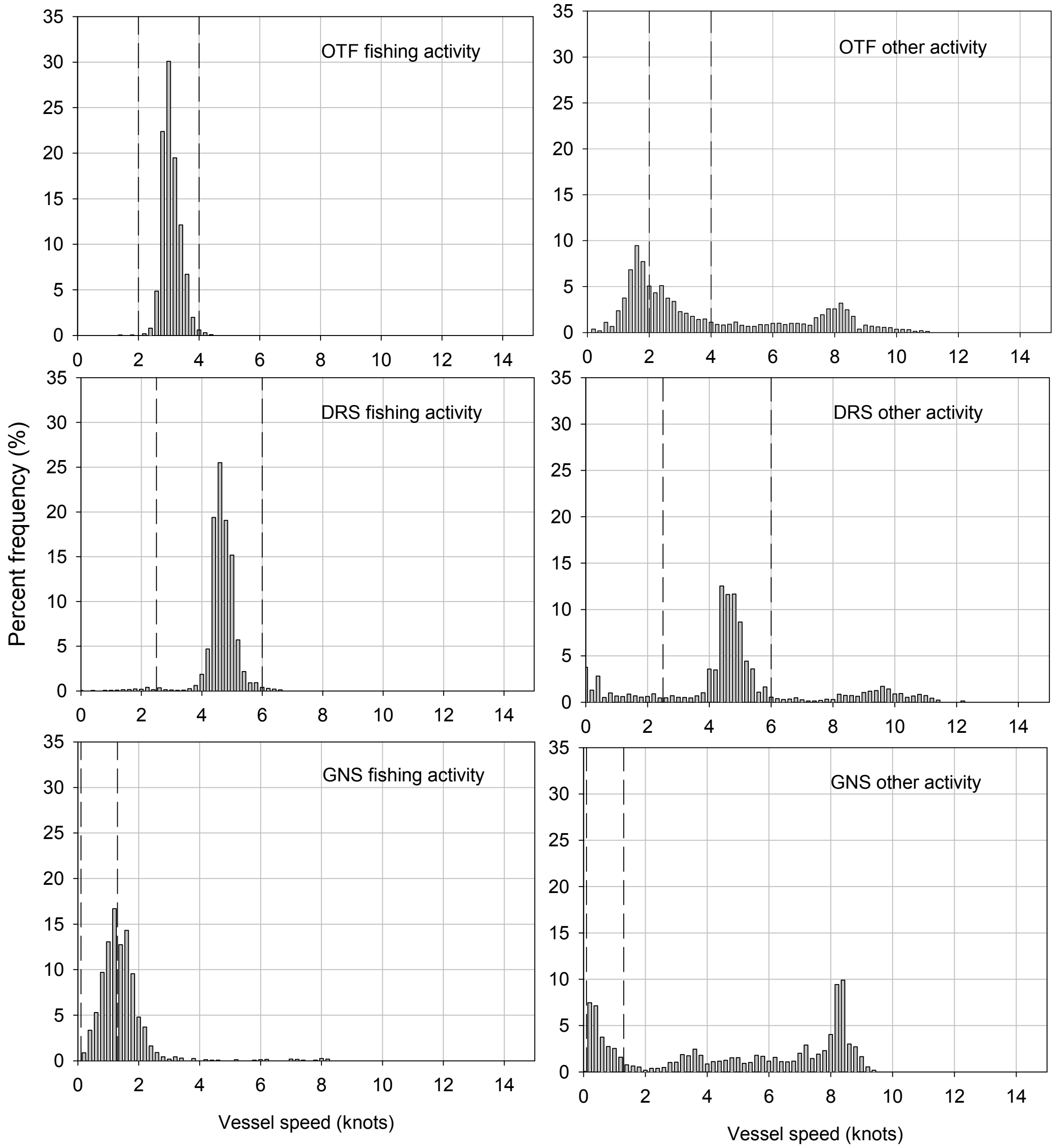

Figure 5. Percent frequency distribution of instantaneous vessel speed (knots) of vessels fishing fish bottom otter trawl gear (OTF), scallop dredge gear (DRS) and sink gillnet (GNS) characterized by both ‘fishing’ and ‘other’ activity. These data were collected using high-frequency polling of the vessel’s global positioning unit (>1 observation/20 seconds) and represent the aggregate of multiple fishing trips. The dashed lines represent the bounds used in this paper to define fishing activity (OTF = 2.0 – 4.0 knots, DRS = 2.5 – 6.0 knots, GNS = 0.1 – 1.3 knots).

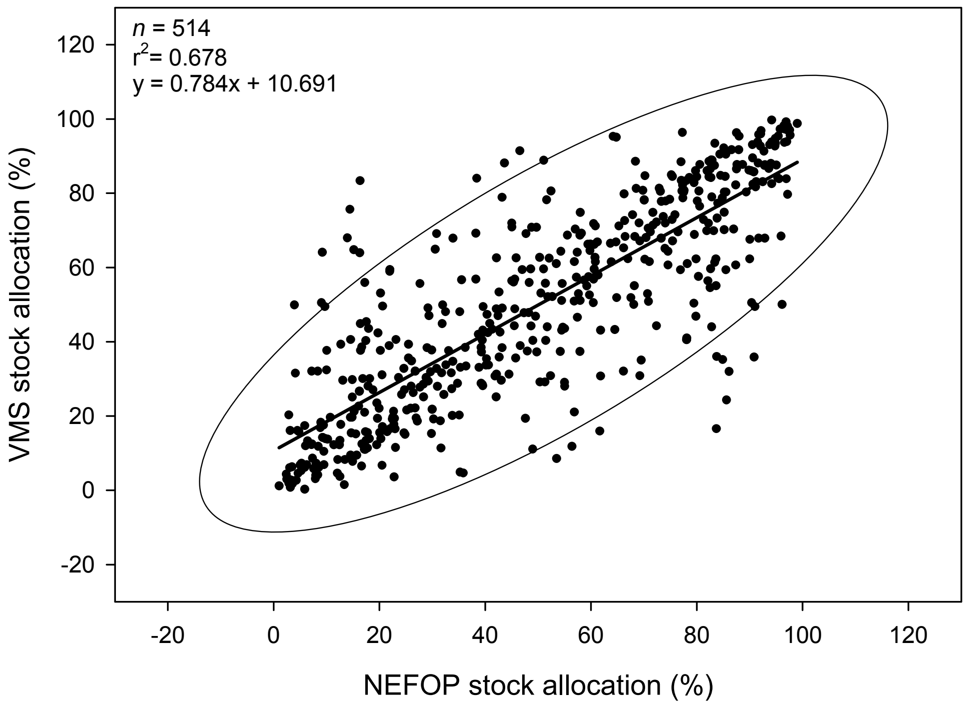

Figure 6. Comparison of 2005 Vessel Monitoring System (VMS) – Northeast Fisheries Observer Program (NEFOP) species stock allocations at the trip-level and associated 95 % confidence ellipse. Only those species-trip allocations where VMS and NEFOP-based methods agreed on the number of stock areas fished and the number of stock areas fished > 1 were compared.