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Accuracy of Self-Reported Fishing Locations

in the New England Multispecies Trawl Fishery

Thomas A. Nies (contact author)[1]
tnies@nefmc.org
978-465-0492
978-465-3116 (facsimile)

Andrew J. Applegate IV[1]

[1]New England Fishery Management Council
50 Water Street
Newburyport, MA 01950

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Abstract

The assessment and management of fish stocks requires knowing the location of fishing activity. This information can be obtained using observer reports, self-reporting of locations by fishermen, or vessel monitoring systems. In the multispecies trawl fishery off the coast of the northeastern United States, the primary tool for assigning catches to location is a paper logbook prepared by fishermen. We examined logbooks completed by trawl vessels from 2003 through 2005 to determine the accuracy of the reported catch locations. The logbook positions were compared to observer reports and positions determined from vessel monitoring systems. When logbooks were used to assign fishing activity to a statistical reporting area, 20 to 30 percent of observed fishing activity was assigned to the wrong statistical area. The significance of these errors depends on the use of the logbook information.

Introduction

Management and assessment of fisheries often requires knowing the location of fishing activity. Many management measures apply to a specific location or area. The impact of measures thus depends on the amount and types of fishing activity that takes place in that area. Species are frequently assessed based on stocks that are defined by spatial characteristics. Assessments that use catch information must assign the catch to the appropriate stock area.

There are several methods for assigning catch to a specific location. Fishing activity can be directly observed through on-board observers or other at-sea methods. A second approach is through self-reporting of fishing location by fishermen. This information can be collected either through dockside interviews or through information submitted by fishermen. Finally, the growing use of vessel monitoring systems (VMS) may allow identifying the location of fishing activity through analysis of position information (Deng et al. 2005; Murawski et al. 2005; Applegate and Nies, in press).

The Northeast Multispecies Fishery targets twelve demersal (groundfish) species assigned to nineteen stocks (often collectively referred to as regulated groundfish). Fishing activity occurs in the offshore coastal waters from New Jersey to Maine in depths to 150 fathoms. Primary gears used in the fishery are bottom trawls, sink gillnets, and demersal longlines. Catches of each species are assigned to stocks based on three-digit statistical areas (Figure 1). The fishery is managed through a complex web of effort controls, including limits on fishing time (days-at-sea), gear restrictions, landing limits, and fixed and seasonal closed areas. Vessels fishing for regulated groundfish are required to submit paper vessel logbooks (vessel trip reports, or VTRs) for each fishing trip.

The position information in the VTRs is the primary tool used to determine the location of fishing activity in this Northeast Region of the United States and is also used for a variety of purposes. Logbook information is used to attribute the catch to geographic stock areas (Wigley at al. 1998), to apportion effort by statistical area for estimating discards (Shepard 2004), to assign observer coverage (Rago et al. 2005), and to distribute fishing effort for a model that estimates the impacts of proposed effort controls (NEFMC 2003; NEFMC 2006). VTR position information has also been used to determine locations for fixed and seasonal closed areas (NEFMC 1999) and to allocate fishing effort to areas in order to estimate takes of protected species such as marine mammals and turtles (e.g. Bisack 2004; Murray 2005). VTRs can be used to attribute biological samples collected dockside to the appropriate stock area (Burnett, pers. comm.). Researchers have used VTR position information for other reasons, such as to document distribution of fishing effort (Murawski et al. 2005) and to show that vessels from the same community fish in similar locations (St. Martin and Arber, in press). Orphanides and Magnusson (2007) use VTRs to characterize bottom-trawl fisheries off the east coast of the United States.

The accuracy of vessel logbooks has been examined in other fisheries with mixed results. For example, Mangeas et al. (2005) found that logbook catch data in the Indian Ocean tuna purse seine fishery was highly variable, with location information unreliable even

though most vessels were equipped with Global Positioning Systems. Walsh et al. (2005) compared logbooks and observer reports in a Hawaii based longline fishery, but focused on catch estimates and not position reports. Management of the Nearshore Trawl Fishery off the coast of California acknowledges that position information in logbooks is often inaccurate and may not be sufficiently precise to characterize fishing locations or population distributions (California Department of Fish and Game 2006). With respect to the Northeast Region of NMFS, Rago et al. (op. cit.) compared VTR positions to observer reports, but only at the broad scale used to allocate observer coverage. Murawski et al. (op. cit.) compared overall effort distribution as determined by logbooks and VMS but did not explicitly compare fishing activity on a trip-by-trip basis. Salthaug (2006) compared VMS activity to detailed logbook data for two Norwegian trawl vessels in order to determine if VMS data could be used to identify fishing activity. In this case, however, the logbook data was collected under contract between the Norwegian Institute of Marine Research (IMR) and a reference fleet. These logbooks recorded haul location and start and stop times, and are not analogous to the less detailed information reported in the Northeast Region's VTR system. The comparisons were not used to determine the accuracy of the logbooks. Palmer and Wigley (2007, in press) compared the assignment of commercial fisheries landings to stock area using VMS and VTR.

Two recent changes in this fishery make it possible to evaluate the errors that may result from using the position information reported on VTRs. First, as a result of a court decision in 2001 the level of observer coverage in the multispecies fishery was increased during calendar years 2002 through 2005. Second, several recently adopted management programs required the use of a VMS to participate. This paper will examine the accuracy of VTR position information for trawl vessels participating in the Northeast Multispecies Fishery by comparing VTR-reported fishing locations to locations recorded by observer reports and VMS.

Materials and Methods

Three data sources are used in this analysis: VTRs, observer reports, and VMS position reports. The VTR is a paper logbook completed by fishermen and submitted (by mail) to the National Marine Fisheries Service (NMFS). The data are then entered into a database. Regulations require vessel operators to record numerous data elements that describe fishing activity: for example, species, quantity kept, quantity discarded, fishing location, three-digit statistical area fished, crew size, gear characteristics, date landed, and date sailed. The following analyses only used fishing location, statistical area, date sailed, date landed, and gear type. Vessels are only required to report one fishing position for each statistical area or gear used. Reporting instructions tell fishermen to report "where most of your fishing effort occurred" within a specific three-digit statistical area (NMFS Fishing Vessel Trip Report Reporting Instructions, available at http://www.nero.noaa.gov/ro/fso/vtr_inst.pdf). Each time a vessel changes gear or statistical area (SA) a new VTR page is supposed to be prepared.

Position information can be recorded in the VTRs either as a latitude and longitude pair or as loran line time differences. Operators are also required to report the three-digit

statistical area. The position information on the VTR can be in error for several reasons. Positions may be inaccurately recorded either on purpose (to disguise fishing activity) or in error. In addition to reporting erroneous positions, there are several data recording errors that can occur. Vessel operators may neglect to report a position, they may report a position that is not within the reported statistical area, or they may report a position but not a statistical area. During the years 2003 through 2005, the Northeast Fisheries Science Center (NEFSC) used an algorithm that evaluated the information provided by fishermen and assigned a statistical area according to the result. This area was entered into the database using the data label CAREA, or derived area. Several codes were also entered for each record to document how the derived area was determined. One such field was defined as AREA_IND. The following entries were used for this field:

0 = Derived area ("C" areas, or CAREA) same as reported area; derived area and point locations used.
1 = Derived area adjacent to reported area; derived area and point locations used.
2 = Reported area differs from derived area (not adjacent); reported area used, point locations null.

An AREA_IND of “2” places more reliability on the reported statistical area as opposed to the reported loran or latitude/longitude. The database also retains the statistical area reported by the fisherman. In this analysis, this area is called REP_AREA. Data was used from calendar years 2003 through 2005 in this paper.

The Northeast Region Observer Program places trained fisheries observers on fishing vessels, including multispecies vessels. Observers record detailed information on fishing activity, including data elements such as the start and ending position of hauls or tows, date and time sailed, quantity kept and discarded on each tow or set, gear characteristics, statistical area fished, vessel identification, and biological sampling information (e.g. length and sex). Observer reports are entered into a database. For these analyses analysis, the data elements used included gear type, statistical area, position of the end of the haul, catch, date sailed, date landed, and vessel identifiers. The allocation of observer coverage is described by Rago and Wigley (2005). Among other analyses, they show that assignment of observers to the vessels in this fishery is generally unbiased.

In the past there have been varying levels of observer coverage in this fishery due to budgetary constraints and competing priorities. As a result of a court order in early 2002, observer coverage in the multispecies fishery increased during the period 2002 through 2005. Increased funding was also allocated by legislators. The court order mandated that a minimum of five percent of all multispecies trips be observed. In addition, a number of special management programs were implemented on May 1, 2004 that allow fishermen to target healthy stocks of groundfish subject to constraints on activity designed to limit catch of stocks that need rebuilding. Because of the unique nature of these programs, NMFS targeted higher levels of observer coverage in these programs. As a result, observer coverage in all facets of the fishery was not at the same level. Table 5 shows the number of observed trawl trips by observer program.

Many vessels in the multispecies fishery were equipped with a VMS. VMS units provide a location at irregular, random intervals, approximately once each hour though additional positions are sometimes required. The VMS units in the Northeast Region can also be used to transmit data between the vessel and the shore. These positions are recorded and entered into a database. All of the special management programs implemented in 2004 required use of a VMS both for position information and to facilitate daily catch reporting. As a result, the number of vessels using VMS increased in 2004, but still did not include all vessels in the multispecies fishery. The distance traveled between subsequent positions reported by the VMS can be used to provide an average speed over that time period (Murawski et al. 2005; Applegate and Nies, in press). Trawl vessels are assumed to be fishing when these speeds are within specific limits, and transiting when they are not.

The analyses in this paper combined information from the VTR, observer, and VMS databases in order to compare fishing locations on matching trips. Prior to 2006, the three databases described did not have a data element that linked records. In order to match records, a logical link was created based on the vessel identifier, date sailed, and date landed. Records were matched only if all three elements were an exact match. Because of differences between databases in the date of sailing or landing, not every trip can be matched across all three databases. In addition, there are VTRs or observed trips by vessels that were not equipped with a VMS that could not be used in the analyses that used VMS.

The focus in this paper was on trips using trawl gear since this gear accounts for the majority of multispecies landings and trawl vessels are mobile and typically fish in different locations on the same trip.

Initial Data Exploration

Yellowtail flounder (*Limanda ferruginea*) is an important groundfish target species that is allocated to three different stocks. In 2004, two of the three stocks were subject to restrictive management measures due to poor stock status, while measures for the third were designed to promote targeting since the stock was believed to be in good condition. Several trips were identified in the VTR that reported landing more yellowtail flounder from SA 521 than allowed under the regulations. These trips landed amounts similar to vessels fishing in a special management program that allowed access into a groundfish closed area to target yellowtail flounder, and took place when this program was open. In one instance, the vessel reportedly fished in SA 515, a deep water area of the Gulf of Maine that is not likely to support large catches of yellowtail flounder. This led to the suspicion that these trips were incorrectly assigned to the Cape Cod/Gulf of Maine (CC/GOM) yellowtail flounder stock area, either by the NEFSC algorithm or by the fishermen. Since vessels in the special management program were required to use a VMS, it was possible to compare the actual locations fished on a trip to the statistical area reported and/or assigned in the database.

For the vessels identified, it was found that they had not even transited the CC/GOM yellowtail flounder stock area during the trips in question (see Figure 2 for an example of

one such trip). A further exploration randomly selected twenty-five trips out of fifty that were identified using otter trawl gear in 2004 and landing more than 1,000 pounds of yellowtail flounder and coded with Area_Ind= 2. The VMS positions of these vessels were examined to determine areas fished, and this was compared to the area reported by the operator, the area assigned by the algorithm, and the area determined by the reported position (latitude/longitude or loran lines). Results are summarized in Table 1. Of the twenty-five vessels that were randomly selected, thirteen could be matched with VMS trips. Of the thirteen VMS trips, the VMS area fished did not match the assigned statistical area in seven trips. Of those seven trips, the VMS area did not match the area reported by the operator, the area assigned by the algorithm, or the area based on the coordinates reported by the operator on four trips. On three of these trips, the VMS area matched the area reported by the operator but not the area assigned by the algorithm. The assigned area matched the VMS area on six of the thirteen trips, but the area calculated from the reported coordinates did not match the VMS or assigned area for these trips. To summarize, the algorithm used to assign CAREA determined the correct area on less than half the trips examined, but other obvious alternatives (for example, using the calculated statistical area in all cases) did not perform any better.

CY 2004/2005 Yellowtail Flounder Trip Analysis

These preliminary results heightened interest in a more rigorous examination to determine how well the assigned area reflected the actual area fished. Since this is primarily an issue for species that have multiple stock areas, this examination focused on yellowtail flounder. The VTRs were queried to identify all trips using bottom trawls (VTR codes OTB or OTF) that landed 226.8 kg (500 pounds) or more of yellowtail flounder in 2004 and 2005. These selection criteria were used for two reasons: to get the number of trips and data points to a reasonable level for an initial analysis, and to focus on trips that landed most of the yellowtail flounder in 2004 and 2005. VTR records were matched with VMS data based on sailing and landing dates and permit number. Not all records could be matched, since not all vessels were required to use a VMS. Each VMS position was coded as “fishing” or “transiting” based on the average speed between successive VMS locations (Applegate and Neis, in press). VMS positions coded as “fishing” were plotted using a Geographic Information System (GIS) and converted to a raster layer using the density function of ESRI Arcview 9.1©.

Once plotted, charts were prepared showing VMS-determined fishing locations by assigned statistical area (CAREA). In the charts larger circles represents more fishing activity. Several examples are shown in Figure 3 for CY 2004 and Figure 4 for CY 2005. It can be readily seen that in most instances there is considerable fishing activity outside the statistical area assigned to the trip (CAREA). For example, trips with a CAREA of 525 in CY 2005 appear to have fished in SA 521, 522, 525, 526, and 562. Trips coded with SA 561 fished extensively in SA 561 and 562, and a small amount in SA 522. Trips coded in SA 562 fished extensively in SA 561, 562, and 525, with a small amount of fishing in SA 562. Similar observations can be made for CY 2004.

In order to quantify the differences between the assigned statistical area and the statistical area based on the plotted VMS positions, a table was constructed summing the number of

VTR positions by CAREA and by VMS statistical area (Table 2 and Table 3). These tables show that nearly half the VMS-derived positions located in SA 522, 562, and 526 were assigned to a different statistical area by the CAREA code. Interestingly, however, when the positions are assigned to yellowtail flounder stock areas (each consisting of multiple statistical areas) there is little difference in the percentage of VMS fishing activity assigned to stock area whether using CAREA or VMS area.

Since these plots and tables suggest that vessels commonly fish in more than one statistical area while reporting they fished in only one area, there was an interest in determining whether this biases the assignment of VTR landings to stock area. For each trip, a "VMS statistical area" was determined based on the location of most fishing activity for that trip (much like the majority of fishermen who report a single statistical area via VTRs for the entire trip). The landings of yellowtail flounder were then summed by stock area based on CAREA and by stock area based on the VMS statistical area. Note that the assignment of observers to fishing trips was weighted towards specific management programs and thus the analysis of the matched trips may not be indicative of the fishery as a whole. In addition, since only one statistical area was assigned for each trip based on the majority of VMS positions for that trip, all landings from a trip are attributed to one statistical area. It is possible that some activity took place in other areas and the following summary over-estimates the landings from each area.

Nonetheless, when the VMS position data were used to assign a trip's yellowtail flounder landings to the single statistical area having the majority of the trip's fishing effort, 20% of the trips and landings during 2004 would have been reported in a different statistical area (Table 2), sometimes in a statistical area assigned to a different yellowtail flounder stock. Some areas had a greater amount of disagreement than others. For example, about 30% of the landings reported by fishermen on VTRs as being caught in SA 525 would have been more accurately assigned to SA 562, both areas in the Georges Bank stock. None of the landings on VTRs reported as caught in SA 526 would have been allocated there if the VMS data were used to identify the area where the most fishing activity took place on those trips.

Similar inaccuracies were evident in 2005 (Table 3). Overall, 17 percent of trips and 11% of yellowtail flounder landings were reported inaccurately on the VTR, assuming that a trip's landings came from a single statistical area as normally reported by fishermen. In SA 526, only 2,000 of 23,690 lbs. were reported on VTRs from the statistical area where most of the trip's effort actually occurred according to the VMS. Some relatively large errors in catch assignment by the VTRs occurred for the Southern New England/Mid-Atlantic stock. In a notable case, 47,500 lbs. were assigned to statistical SA 537, part of the Southern New England/Mid-Atlantic yellowtail flounder stock, but the VMS indicated that the landings should have been reported as being from SA 525 which is considered in the Georges Bank stock. This single error accounted for half the difference in landings attributed to the Southern New England/Mid-Atlantic stock using the VTR and VMS methods.

For the CY 2004 trips examined and where VMS data were collected, assigning landings to stock area after first assigning the landings to the statistical area where the majority of fishing activity took place reduces the landings assigned to the CC/GOM yellowtail flounder stock area by 34.2 percent compared to the landings assigned based on CAREA. Landings in the SNE/MA stock area would be 32.2 percent lower, and landings in the GB stock area increase by 1.8 percent. For CY 2005, stock area based on VMS reduces the landings assigned to the SNE/MA stock area by 73.2 percent and the CC/GOM stock area by 14.2 percent, while increasing the landings assigned to the GB stock area by 2.5 percent (Table 4).

This analysis illustrates that if yellowtail flounder catches on a trip are assigned to stock area based on where most fishing activity took place – rather than where the fishermen reported most fishing took place – the assignment of catches to stock area can change dramatically. In this specific example, the total annual catches of one stock (Georges Bank yellowtail flounder) were much larger than the two other stocks. As a result, a small error in the assignment of catch to stock area can make a large difference for the two smaller stocks while having relatively little impact on the larger adjacent stock.

CY 2003-2005 Trip/Observer Comparison

The previous analysis attributed all catch of a species to the statistical area where most fishing activity took place (as estimated from VMS). While this gave different results than allocating catch by VTR, it is not clear it gave more accurate results. One alternative to this approach would distribute catches to stock area based on the distribution of fishing effort as determined by VMS. These catches could then be compared to the distribution based on VTR to determine the accuracy of the VTR information. The reality, however, is that many species are not uniformly distributed across the areas fished. As a result, it may not be accurate to apportion catch to stock area based solely on the distribution of fishing effort as determined by VMS. Before an alternative to using VTRs to assign fishing activity to statistical error can be identified, the magnitude of the errors caused by using VTRs needs to be quantified.

Since observers record catch by tow, the tows on observed trips can be accurately assigned to stock area. If an observed trip can be matched to a VTR, the observed tows can also be allocated to statistical area based on the VTR reported statistical area for the same trip (CAREA). The accuracy of the VTR can be evaluated by comparing the number of tows where the observed statistical area matched the VTR statistical area to the number of observed tows where they did not match. The catch on those tows can be assigned to stock area and evaluated in the same manner. These analyses were performed for trawl gear for calendar years 2003, 2004, and 2005.

Table 6 reports the number of observed trawl trips in each year, the number of observed trawl trips that were matched to VTRs, the number of matched trips where the VTR recorded fishing in one statistical area, and the number of those trips that actually fished in more than one statistical area. While not all observed trips could be matched to a VTR, in each of the three years more than seventy-five percent of the observed trawl trips were matched. In all three years, over ninety percent of the matched trips reported fishing in

only one statistical area. According to observer reports, however, the percent of matched trawl trips that actually fished in just one statistical area was fifty-eight percent in 2003, sixty-eight percent in 2004, and sixty-two percent in 2005. In other words, for the matched trips between 22 to 32 percent fished in more than one area but reported fishing in only one area. Table 7 summarizes, by calendar year, the total number of observed trawl tows and the number of tows where the reported area did not match the observed area. Figure 5 illustrates these data by year and statistical area for areas where more than 100 tows were observed. In each of the three years, between one-quarter and one-fifth of all matched observed tows were not reported in the correct statistical area by the VTR for that trip. There is considerable variability between statistical areas. In some of the major groundfish fishing areas, the number of tows where the reported statistical area did not match the observed statistical area exceeded fifty percent of the observed tows. There appears to be year-to-year consistency for problem areas. For example, in all three years the number of correctly reported tows in statistical area 526 is less than fifty percent (note that in some years there were fewer than 100 tows observed in this area and so the errors as not shown in the attached figure). Most of the errors are the result of incorrect reporting on trips that fish in more than one area but report fishing in only one area.

This comparison demonstrates that fishing activity on the matched observed trips often occurred in statistical areas that were not reported on the VTR. The next step is to determine how these errors may affect analyses that use VTR positions. One way these data are used is to assign catch to statistical area and larger stock areas.

The impact of these discrepancies in the assignment of fishing activity to statistical area on the assignment of catch to statistical area can be illustrated using the catch reported by the observer. In a manner similar to that used to analyze tows, the catch (kept and discarded) reported by the observer on matched trawl trips was assigned to observed and reported statistical areas for three species – cod (*Gadus morhua*), yellowtail flounder, and winter flounder (*Pseudopleuronectes americanus*). These species were selected because they are targeted and caught by trawl vessels and are assessed in multiple stock areas. Cod is assessed as two stocks (Georges Bank and Gulf of Maine), yellowtail flounder as three stocks (Cape Cod/Gulf of Maine, Georges Bank, and Southern New England/Mid-Atlantic), and winter flounder is assessed as three stocks (Gulf of Maine, Georges Bank, and Southern New England/Mid-Atlantic). While these species use similar stock names, the geographic stock areas differ. Table 8 lists the statistical areas used to assign catches to a specific stock.

Results are shown in Table 9. Total observed catch is reported for each year. The total is then compared to the amount of catch that is accurately assigned to the observed statistical area – that is, the VTR-reported area is the same as the observed area. The percent of the VTR-reported catch that is assigned to the correct statistical area (based on the observer report) is then calculated. In general, the accuracy of the VTR-reported area is better for yellowtail flounder than for cod and winter flounder. Overall, eighty-four percent of yellowtail flounder on these trawl trips was accurately assigned to statistical area by VTR for 2003, declining to seventy-nine percent in 2004 before increasing to eighty-nine percent in 2005. Note that in the case of yellowtail flounder, the difference

between allocation by observer and allocation by VTR is nearly identical to the differences between allocation by VMS and allocation by VTR. The accuracy for cod was lower in 2003 and 2004 (seventy-four percent and seventy-two percent, respectively), but improved to eighty-three percent in 2005. Winter flounder accuracy was seventy percent in 2003, and improved to seventy-four percent in 2004 and seventy-seven percent in 2005.

The reliability of the VTR information improves if the catch on the observed trips is aggregated to stock area rather than statistical area. Table 10 data show that for cod and yellowtail flounder over ninety percent of the observed catch was reported in the correct stock area by VTRs in all three years, while for winter flounder the percentage ranged from a low of eighty-two percent in 2003 to eighty-five percent in 2004 and ninety-two percent in 2005. These overview statistics should be viewed with caution as they obscure problems for specific stocks, particularly if catches of one stock are significantly larger than catches of an adjacent stock.

How do these errors affect assignment of the observed catch to stock area, rather than statistical area? Catch on these observed trawl trips was assigned to stock area based on observed and reported statistical areas. In addition, since cod catch in statistical areas 561 and 562 is managed under the terms of a resource sharing understanding with Canada, cod catch is also reported for those two areas. Results are summarized in Table 11. The assignment of cod catch to stock area in 2003 and 2005 showed little difference between the observed and VTR-reported stock area. In 2004, however, the VTR-reported stock area under-estimated catch in the Gulf of Maine and statistical areas 561 and 562. For yellowtail flounder, the catch of Cape Cod/Gulf of Maine yellowtail flounder and Georges Bank yellowtail flounder was accurately reported in 2003 and 2004. In 2005, the VTR-reported catch of Cape Cod/Gulf of Maine yellowtail flounder was higher than the observed catch. The catch of Southern New England/Mid-Atlantic yellowtail flounder was under-reported by the VTR in 2003 but significantly over-reported in 2004 and 2005. Winter flounder catches show more variability from year to year. Gulf of Maine winter flounder was over-estimated by the VTR in 2004 and 2005 but under-estimated in 2003. Georges Bank winter flounder was over-estimated in 2003 but the differences were less than five percent in 2004 and 2005. There were only small differences for Southern New England/Mid-Atlantic winter flounder in 2003 and 2005, but the VTR under-estimated the catch on the trips examined in 2004.

For some stocks, the assignment of catch to stock area does not appear sensitive to the accuracy of reported tow locations. This result is unexpected but can be explained by two factors. First, in many instances the VTR-reported statistical area may have been inaccurate but was in the correct stock area (as summarized in Table 10). As an example, cod catch reported in SA 514 may have been caught in SA 513 – both areas are within the Gulf of Maine cod stock area. Second, VTR-reported errors can be offsetting. For example, cod catch from the Gulf of Maine stock area that was incorrectly reported as from Georges Bank may be offset by cod catch from Georges Bank that was incorrectly reported as from the Gulf of Maine. Examining only total catches by stock area may obscure the lack of accuracy of the VTRs.

It cannot be determined with certainty whether the errors observed on the matched trips apply to the fishery as a whole. The distribution of observed trips in 2004 and 2005 was not even across segments of the fishery - more observed trips were allocated to special management programs. Since many of these programs limited the area that could be fished on a given trip, this may bias the results towards higher accuracy.

Discussion

From 2003 through 2005, VTR-reported fishing locations for trawl gear in the Northeast Multispecies Fishery accurately reported the statistical area fished for seventy to eighty percent of actual observed tow locations for those observed trips that could be matched to a VTR. The errors are not uniform across statistical areas. This estimate is consistent with the amount of error evident when comparing the VTR data with a similar means of assigning landings to a statistical area based on the more frequent VMS position information for each trip.

It is possible these errors in self-reported VTR data may introduce additional uncertainty into analyses that do not take them into account, particularly when the information is used to assign catch or effort to geographic areas smaller than a stock area. Errors could be introduced in subtle ways not explored in this paper. For example, biological samples may be assigned to incorrect statistical areas, protected species bycatch estimates that expand observed discard rates based on fishing effort distributions may be biased, and tagging studies that adjust returns based on VTR-distributed fishing effort may draw erroneous conclusions. While it is tempting to conclude that the VTR errors may only lead to minor errors in such analyses because much of the catch appears to be accurately reported, the impact will depend on the level of aggregation and the use of the data.

Further investigation is particularly warranted for stocks with low catches that are adjacent to stocks with much higher catches. The stocks identified as potential problems are similar to those identified in Palmer and Wigley (2007), though there are differences in the magnitude of the errors. In these instances, even small errors in assigning catch may lead to substantial errors in estimating stock size or fishing mortality. For example, Southern New England/Mid-Atlantic yellowtail flounder is a stock where errors the may result in incorrect estimates of catch. This stock was determined to be overfished and is being managed to rebuild stock biomass. Given the emphasis in U.S. management systems on rebuilding individual stocks, apparently small errors in catch assignment can have dramatic consequences for the fishing industry.

It is also clear that the majority of fishing vessel operators do not consistently complete additional VTR pages when fishing in multiple statistical areas. Fishing vessel operators should be reminded of the importance of accurately completing VTRs. Other methods for allocating catch to statistical area should be explored, such as using VMS or observer data.

Unless and until the sea sampling observer program uses a quantifiable statistical basis for the distribution of sampling effort, a better way to assign a trip’s catch to statistical

areas could be to distribute the reported landings of each species according to the distribution of VMS positions which have characteristics of fishing activity. Vessels target different species (or at least catch species at different rates) within a trip while fishing in different areas. If the landings are distributed uniformly across the VMS track while deemed to be fishing (Figures 3 and 4, for example), it can cause similar inaccuracies as those posed by the inaccurate VTR data. Stratified sea sampling data may help adjust the catch within each statistical area for unobserved trips that use VMS, but this method will require more detailed analysis.

Acknowledgments

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Figure 1. Three-digit statistical reporting areas

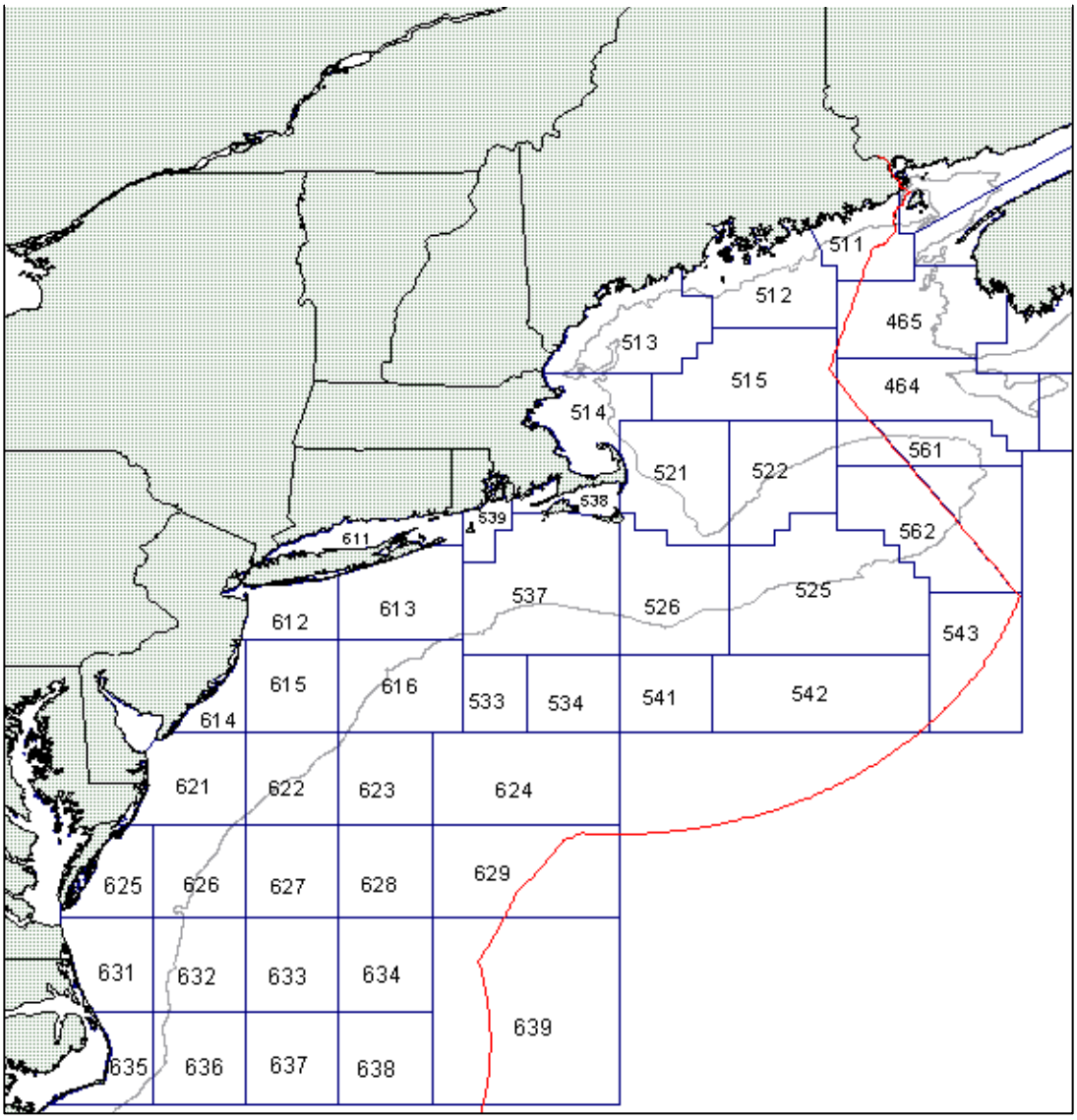


Figure 2. Example of trip landing a large amount of yellowtail flounder assigned to SA 515 but not fishing in that area according to VMS data

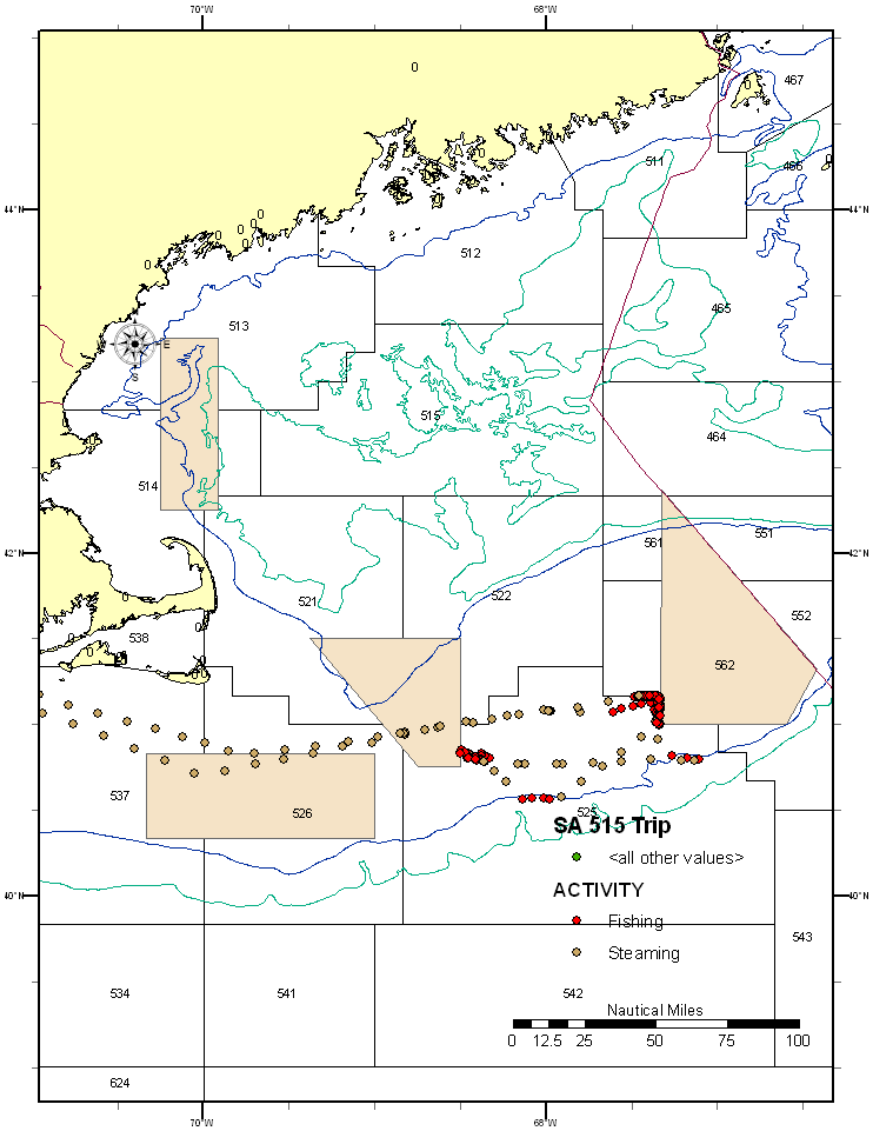


Figure 3. CY 2004 fishing effort on trips catching more than 500 pounds of yellowtail flounder by reported CAREA. SA 521 (top left), SA 525 (top right), SA 561 (bottom left) and SA 562 (bottom right). Warmer colors indicate more effort (i.e. more VMS positions at speeds indicating fishing).

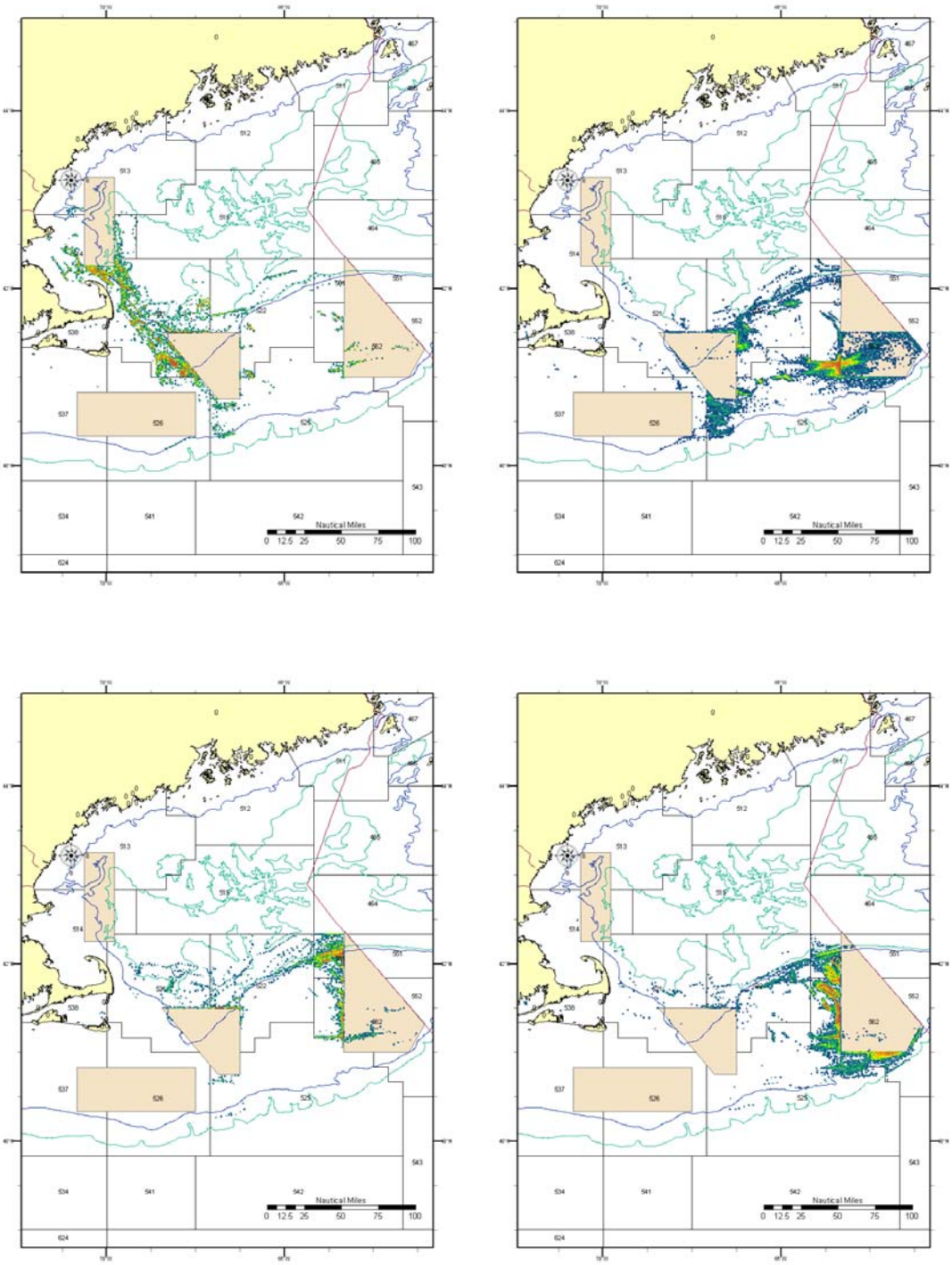


Figure 4. CY 2005 fishing effort on trips catching more than 500 pounds of yellowtail flounder by reported CAREA. SA 521 (top left), SA 525 (top right), SA 561 (bottom left) and SA 562 (bottom right). Warmer colors indicate more effort (i.e. more VMS positions at speeds indicating fishing).

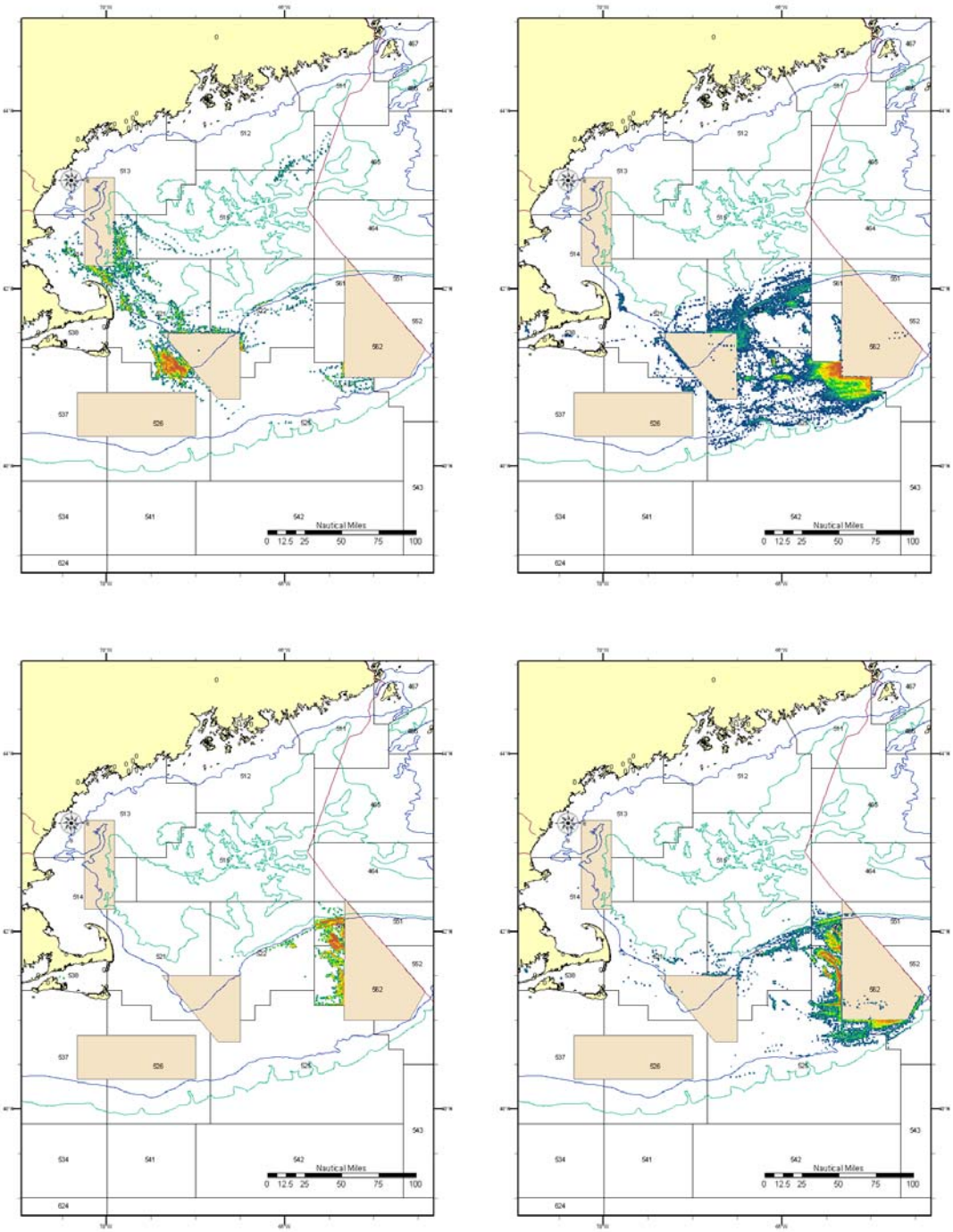
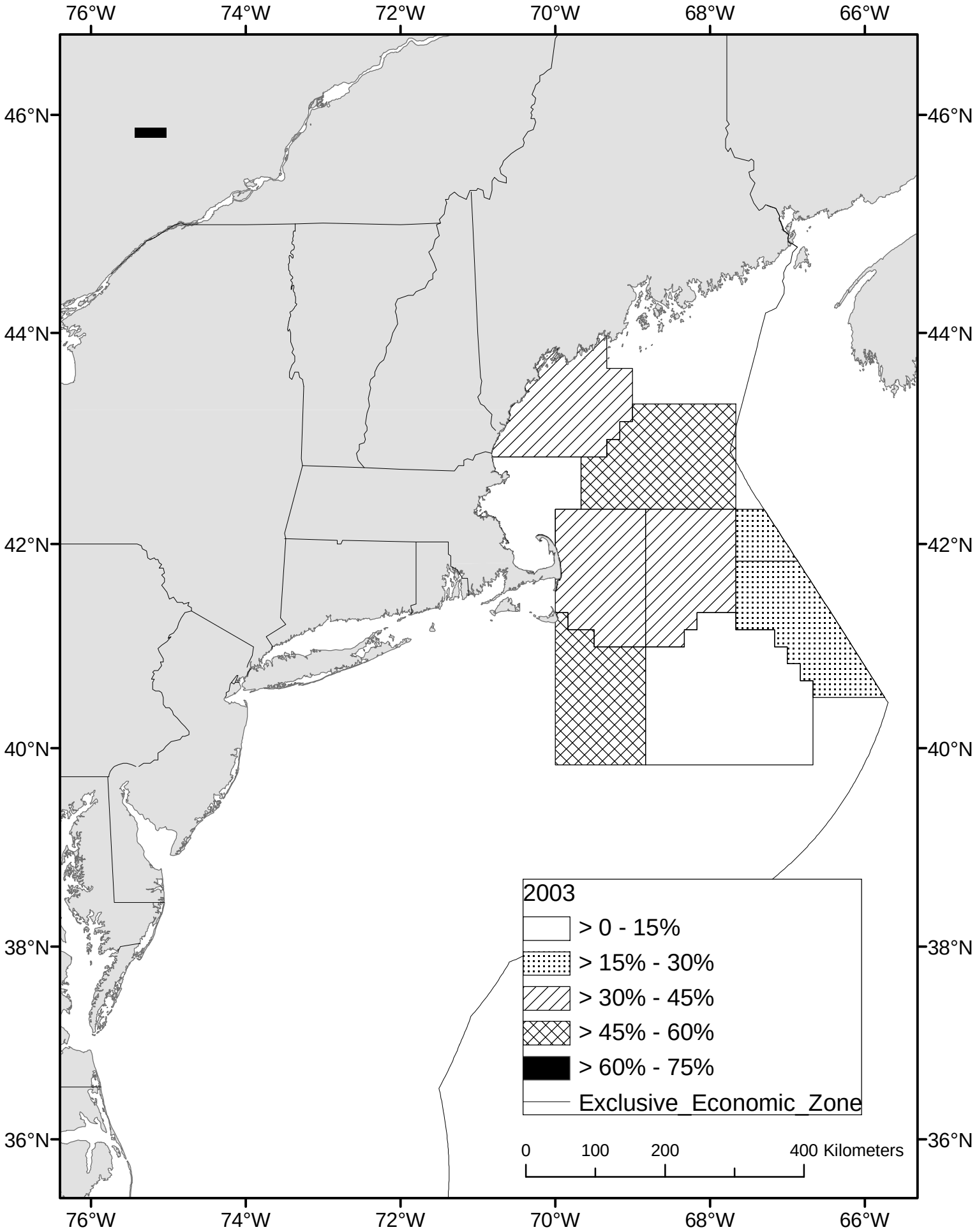
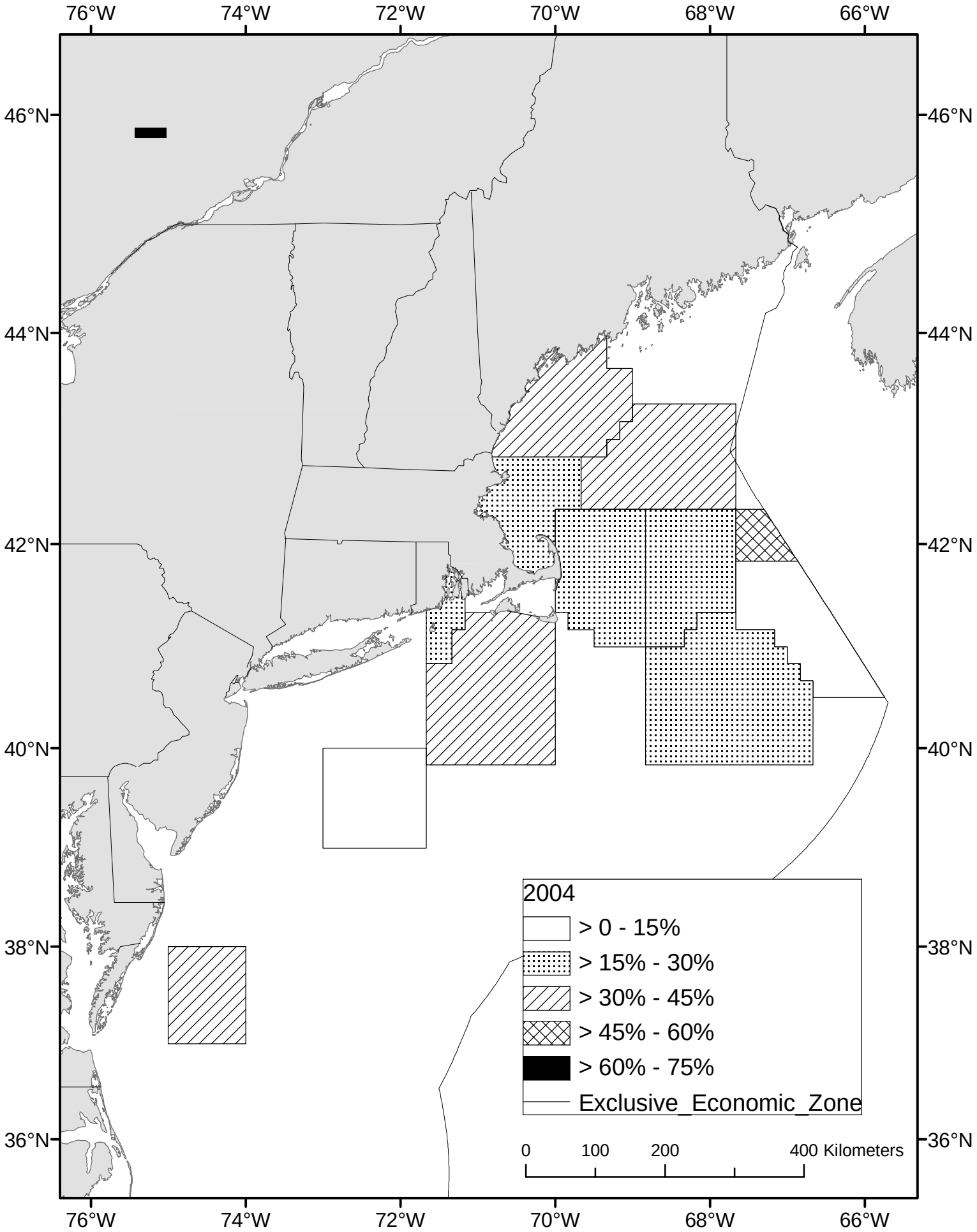


Figure 5. Percent of trawl tows where observed statistical area does not match reported statistical area, CY 2003 – CY 2005
{See attached PDF files}

CY 2003 Figure	CY 2004 Figure	CY 2005 Figure


76°W
74°W
72°W
70°W
68°W
66°W
46°N
44°N
42°N
40°N
38°N
36°N
2003
> 0 - 15%
> 15% - 30%
> 30% - 45%
> 45% - 60%
> 60% - 75%
Exclusive_Economic_Zone
0
100
200
400 Kilometers


76°W
74°W
72°W
70°W
68°W
66°W
46°N
44°N
42°N
40°N
38°N
36°N
2004
> 0 - 15%
> 15% - 30%
> 30% - 45%
> 45% - 60%
> 60% - 75%
Exclusive_Economic_Zone
0
100
200
400 Kilometers

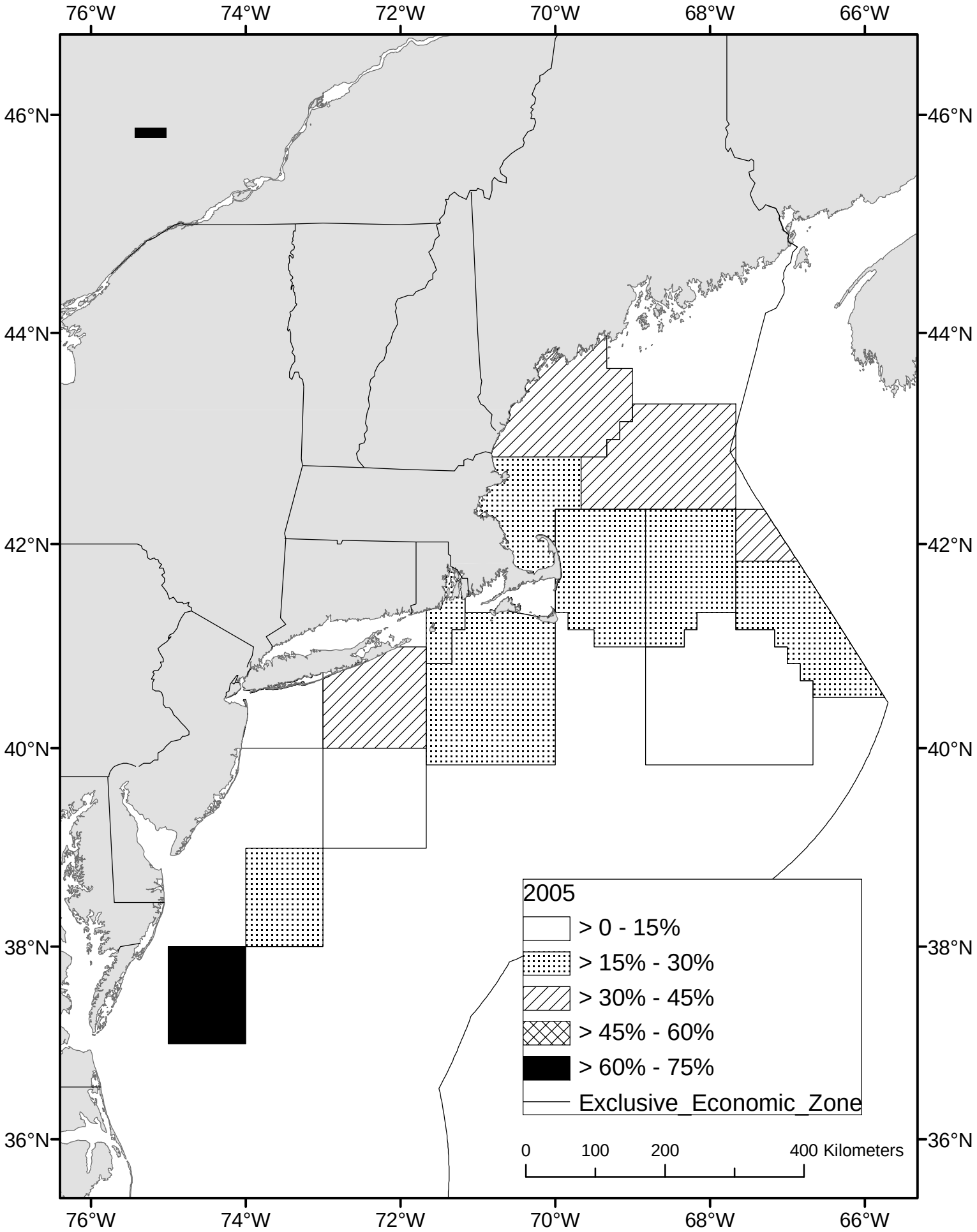

76°W
74°W
72°W
70°W
68°W
66°W
46°N
44°N
42°N
40°N
38°N
36°N
2005
> 0 - 15%
> 15% - 30%
> 30% - 45%
> 45% - 60%
> 60% - 75%
Exclusive_Economic_Zone
0
100
200
400 Kilometers

Table 1. Comparison of reported statistical area, assigned CAREA, and statistical area based on reported coordinates to areas fished as determined by VMS for thirteen selected trips in 2004.

VTR Reported Area (1)	CAREA (2)	Statistical Area determined from VTR Position (3)	Areas Fished From VMS (4)	No Match To VMS	(3)=(4) but does not equal (1) or (2	(2)=(4) but does not equal (3)
562	562	521	562			✓
562	562	537	525	✓		
521	521	611	525,526	✓		
562	562	No coordinates in VTR	562			✓
525	525	539	561,562	✓		
525	525	537	525			✓
561	561	525	562,525		✓	
561	561	525	562,525		✓	
615	615	562	562		✓	
521	521	537	525,562,537	✓		
525	525	613	522,525			✓
525	525	613	525			✓
562	562	513	525,562			

Table 2. Allocation of 2004 yellowtail flounder landings based on VTRs reported area fished (CAREA) and the primary area fished determined from VMS data. Landings in shaded areas represent incorrect VTR assignments to stock area. Landings in boxes represent catches where the VTR and VMS data were in agreement. Overall, the VTR and VMS statistical areas disagreed on 20.0% of the trips, accounting for 20.7% of the landings.

		Primary VMS stock and statistical area												
		Cape Cod/Gulf of Maine			Georges Bank					Southern New England/Mid-Atlantic				Total VTR
CAREA stock	Stat Area	514	515	521	522	525	526	561	562	537	538	539	613	Stat Area
Cape Cod/Gulf of Maine	514	104,632		8,600										113,232
	515	1,591	985			46,830			25,600					75,006
	521	40,585		81,880	11,910	13,400	500		37,535					185,810
Georges Bank	522			1,005	227,200	111,900		5,060	26,710					371,875
	525				233,405	1,849,433		1,000	925,156					3,008,994
	526				1,600	35,000			30,000					66,600
	561				4,978			57,484	75,015					137,477
	562	6,995			61,013	530,930		34,749	6,800,547		22,565			7,456,799
SNE/MA	537									30,019		500		30,519
	539											2,700		2,700
	543					14,000								14,000
	612												650	650
	613												1,175	1,175
	615								28,950					28,950
	622				7,000									7,000
Total for VMS statistical area		153,803	985	91,485	547,106	2,601,493	500	98,293	7,949,513	30,019	22,565	3,200	1,825	11,500,787

Percent incorrect
20.0% of trips
20.4% of landings

Table 3. Allocation of 2005 yellowtail flounder landings based on VTRs reported area fished (CAREA) and the primary area fished determined from VMS data. Landings in shaded areas represent incorrect VTR assignments to stock area. Landings in boxes represent catches where the VTR and VMS data were in agreement. Overall, the VTR and VMS statistical areas disagreed on 16.8% of the trips, accounting for 11.7% of the landings.

		Primary VMS stock and statistical area													
		Cape Cod/Gulf of Maine				Georges Bank					Southern New England/Mid-Atlantic				Total VTR
VTR stock assigment	Stat Area	513	514	515	521	522	525	526	561	562	537	539	612	613	Stat Area
Cape Cod/Gulf of Maine	461								530						530
	513	4,500	1,720				14,700								20,920
	514	500	153,372	850	7,098					780					162,600
	515				600	3,240									3,840
	521		10,405	700	92,854	3,475	26,800	4,000							138,234
Georges Bank	522		3,195			153,186	62,530		1,275	19,680					239,866
	525				2,000	115,365	3,278,377	6,640		17,200					3,419,582
	526					4,500	4,700	2,000		12,490					23,690
	561					3,405			41,334	67,220					111,959
	562					16,560	115,140		19,840	1,396,842					1,548,382
Southern New England/ Mid-Atlantic	537						47,500				25,036				72,536
	538		2,150												2,150
	539										3,730	500			4,230
	543					4,500	15,355								19,855
	612												600		600
	613										700			558	1,258
	622									765					765
	625						14,600								14,600
Total for VMS statistical area		5,000	170,842	1,550	102,552	304,231	3,579,702	12,640	62,979	1,514,977	29,466	500	600	558	5,785,597

Percent incorrect
16.8% of trips
11.0% of landings

Table 4. Yellowtail flounder landings allocated by stock boundaries from reported statistical areas on vessel trip reports (VTR), compared to landings allocations made using the statistical area where the most fishing effort on each trip occurs according to the vessel monitoring system (VMS).

2004	Categorized by			
Stocks	VTR CAREA	VMS	Difference	Percent
Cape Cod/Gulf of Maine	374,048	246,273	(127,775)	-34.2%
Georges Bank	11,041,745	11,196,905	155,160	1.4%
SNE/MA	84,994	57,609	(27,385)	-32.2%

2005	Categorized by			
Stocks	VTR CAREA	VMS	Difference	Percent
Cape Cod/Gulf of Maine	326,124	279,944	(46,180)	-14.2%
Georges Bank	5,343,479	5,474,529	131,050	2.5%
SNE/MA	115,994	31,124	(84,870)	-73.2%

Table 5. Number of observed trawl trips by program and year

Program Name	2003	2004	2005
REGULAR B-DAS PROGRAM		20	233
STANDARD SEA SAMPLING TRIPS	555	868	994
TRAINING TRIPS	25	116	134
US/CANADA MANAGEMENT AREA		105	508
Total	580	1,109	1,869

Table 6. Summary of observed trawl trips matched to VTR

	Year		
	2003	2004	2005
Total Observed Trawl Trips	580	1109	1869
Observed Trips Matched to VTR	445	897	1,572
Matched Trips Reporting One Area	415	859	1,437
Percent of Matched Trips Reporting One Area	93%	96%	91%
Percent of Matched Trips Actually Fishing in One Area	58%	68%	62%
Matched Trips Reporting One Area But Fishing in Multiple Areas	161	254	468
Percent of Matched Trips Reporting One Area But Fishing in Multiple Areas	39%	30%	33%

Table 7. Comparison of observed trawl tow locations and reported trawl tow locations for observed trips matched to vessel trip reports, 2003 – 2005

Calendar Year	Number of Tows Observed	Number of Tows where Observed Area<> Reported Area	Percent of Tows Where Observed Area <> Reported Area
2003	5512	1678	30%
2004	8650	2022	24%
2005	21,287	4423	21%

Table 8. Geographic stock areas for cod, yellowtail flounder, and winter flounder

Stock Name	Cod	Yellowtail Flounder	Winter Flounder
Gulf of Maine	510 - 515		510-515
Cape Cod/Gulf of Maine		511-515, 521	
Georges Bank	520s, 530s, 540s, 6600s, 551, 552, 561, 562	522, 525, 551, 552, 561, 562	522, 525, 551, 552, 561, 562
Southern New England/Mid-Atlantic		526,537-539,611-639	521,526,537-539,600s

Table 9. Percent of observed cod, yellowtail flounder, and winter flounder catch on matched trawl trips assigned to the correct statistical area by the VTR

Calendar Year	Observed Cod Catch (kg.)	Cod Caught, Observed Area= Reported Area	% Correct	Observed Yellowtail Flounder Catch (kg.)	Yellowtail Caught, Observed Area= Reported Area	% Correct	Observed Winter Flounder Catch (kg.)	Winter Flounder Caught, Observed Area= Reported Area	% Correct
2003	326,407	240,401	74%	195,161	164,504	84%	138,046	96,977	70%
2004	247,614	177,625	72%	474,873	375,272	79%	216,598	159,595	74%
2005	905,804	753,760	83%	1,190,489	1,063,373	89%	435,410	336,380	77%

Table 10. Percent of observed cod, yellowtail flounder, and winter flounder catch on matched trawl trips assigned to the correct stock area by the VTR

Calendar Year	Observed Cod Catch (kg.)	Cod Caught, Observed Stock Area= Reported Stock Area	% Correct	Observed Yellowtail Flounder Catch (kg.)	Yellowtail Caught, Observed Stock Area= Reported Stock Area	% Correct	Observed Winter Flounder Catch (kg.)	Winter Flounder Caught, Stock Area= Reported Stock Area	% Correct
2003	326,407	320,152	98%	195,161	191,048	98%	138,046	113,207	82%
2004	247,614	230,764	93%	474,873	463,100	98%	216,598	183,522	85%
2005	905,804	845,588	93%	1,190,489	1,175,538	98%	435,410	399,680	92%

Table 11. Comparison of observed catch (kg.), by reported and observed stock area, on matched trawl trips, CY 2003 – CY 2005. Difference of more than 10 percent are italicized, while differences of 5-10 percent are underlined.

	2003			2004			2005		
	Observed Area	Reported Area	Reported/ Observed	Observed Area	Reported Area	Reported/ Observed	Observed Area	Reported Area	Reported/ Observed
					Cod				
GOM	57,747	57,722	100%	57,746	50,252	*87%*	90,245	92,635	103%
GB	26,608	268,685	100%	155,645	148,780	104%	814,549	810,790	100%
561/562	109,271	108,795	100%	56,572	47,659	*84%*	105,909	104,481	99%
Total	326,407			247,614			905,804		
					Yellowtail Flounder				
CC/GOM	42,102	43,329	103%	37,955	37,608	99%	56,464	61,255	108%
GB	149,385	149,581	100%	435,056	429,357	99%	1,126,359	1,105,157	98%
SNE/MA	3,674	2,251	*61%*	1,861	7,907	*425%*	7,666	23,971	*313%*
Total	195,161			474,873			1,190,489		
					Winter Flounder				
GOM	55,541	50,798	91%	62,578	72,635	*116%*	87,969	93,163	106%
GB	39,497	45,085	*114%*	86,312	81,984	95%	230,763	222,920	97%
SNE/MA	42,775	42,162	99%	67,542	61,978	92%	114,639	116,076	101%
Total	138,046			216,598			435,410		