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Contents

LIST OF ACRONYMNS AND ABBREVIATIONS

ASM: At-Sea Monitor

CV: Coefficient of variation

DAS: Days-at-sea

FSB: Fisheries Sampling Branch

GUI: Graphical user interface

NEFOP: Northeast Fisheries Observer Program

NEFSC: Northeast Fisheries Science Center

NMFS: National Marine Fisheries Service

NOAA: National Oceanic and Atmospheric Administration

ODDS: Observer Declare and Deploy System

PHP: hypertext preprocessor

PIN: Personal identification number

PLSQL: **Procedural Language/Structured Query Language**

PTNS: Pre-Trip Notification System

SBRM: Standardized Bycatch Reporting Methodology

SMP: Special Management Program

U.S.: United States

VMS: Vessel Monitoring System

ABSTRACT

Historically, a dock intercept process was used to deploy observers in the northeast United States multispecies (groundfish) fishery. In this process, fishing trips for observer coverage were manually selected using pre-defined specifications established by the National Marine Fisheries Service's Northeast Fisheries Science Center. Amendment 16 to the Northeast Multispecies Fisheries Management Plan implemented major changes in the groundfish fishery, which affected the magnitude and complexity of observer deployment. These changes included: (a) creation of an additional 15 active groundfish sectors; (b) an approximate four-fold increase in the level of observer coverage; (c) introduction of a new class of trained observers; (d) potential for industry-funded observer coverage to supplement government-funded coverage; and (e) the need for the observer deployment process to directly support in-season monitoring of fishery discards. The dock intercept process was insufficient to adequately address these new provisions, and an automated observer pre-trip notification system (PTNS) was implemented in the northeast groundfish fishery on 1 May 2010. The PTNS uses a self-adjusting probability-based, tiered selection process to randomly assign observer coverage across the groundfish fleet on a proportional basis for the purpose of monitoring discards. The PTNS also addresses other objectives, such as monitoring of special management programs and protected species bycatch. In this paper, we discuss the design, implementation, and performance of the PTNS over the past three years.

INTRODUCTION

Historically, at-sea observers have been deployed in the large-mesh groundfish fishery occurring off the northeast United States using a dock intercept process. Observer service providers would manually select fishing trips for coverage using pre-defined specifications established by the National Marine Fisheries Service's (NMFS) Northeast Fisheries Science Center (NEFSC). The pre-defined specifications were in the form of a prioritized sea day schedule established through the annual Standardized Bycatch Reporting Methodology (SBRM) process (Wigley et al. 2007). Sea day schedules support stratified random sampling designs by providing a list of observed sea days needed for coverage within a particular stratum. Observer service providers used the sea day schedules along with a randomized list of vessels likely to be active in the fishery to manually select trips for observer coverage based on knowledge of local fleet activity. There were exceptions to the dock intercept process; for example, observer deployment in some special management programs (SMPs, e.g., participation in the United States/Canada Resource Sharing Area on Georges Bank) was accomplished using a pre-trip call-in system. However, for the majority of observer coverage, particularly in the groundfish fishery, observer deployment was accomplished using a manual dock intercept process.

Amendment 16 to the Northeast Multispecies Fisheries Management Plan (NEFMC 2010) brought about major changes to the northeast groundfish fishery, including some which affected the degree and complexity of observer coverage. Most notably, Amendment 16 implemented a new management regime in the northeast groundfish fishery colloquially referred to as 'sector management.' One of the more significant requirements under sector management was the need to estimate total sector catches in-season. To meet these requirements the breadth and complexity of the groundfish monitoring effort had to be expanded while at the same time continuing to meet the demands of existing monitoring programs. It was widely recognized that a dock-intercept process would be insufficient to meet the increased demands. A more sophisticated and integrated observer deployment system would be needed prior to the start of sector management, which began at the start of the 2010 groundfish fishing year on May 1, 2010[1].

Amendment 16 and sector management

Increased observer coverage

Prior to sector management, observer coverage rates in the groundfish fishery averaged less than 8% between 2000 and 2009 (Figure 1). Coverage rates were primarily controlled by the available funding; however, since 2008 the SBRM Omnibus Amendment (MAFMC/NEFMC 2007) required that coverage rates be sufficient to achieve a 30% coefficient of variation (CV) on estimates of fishery discards. Within the SBRM framework the 30% CV criteria was applied at

[1] The Northeast Multispecies fishing year runs annually from May 1 to April 30.

the fleet and species group level. SBRM species groupings were consistent with the scope of existing fishery management plans (e.g., large-mesh groundfish). SBRM fleets were broadly defined by their regional (New England, Mid-Atlantic) and gear (e.g., large mesh otter trawl) characteristics. Using the broad SBRM stratification scheme, the existing observer coverage levels were generally sufficient to achieve discard estimates with CVs below the 30% threshold for the groundfish complex (Wigley et al. 2011). Additionally, for most individual groundfish species, the 30% CV criteria were met when estimating discards at the level of stock management units (NEFSC 2008, 2012).

Amendment 16 specified that "*minimum coverage levels must meet the coefficient of variation in the Standardized Bycatch Reporting Methodology. The required levels of coverage will be set by NMFS…and may consider factors other than the SBRM CV standard when determining appropriate levels*" (NEFMC 2010). While Amendment 16 did not explicitly define the stratification levels to which the 30% CV would apply, it was generally interpreted that it would be applied at stratification levels identical to those used for the estimation of in-season groundfish discards which were stratified by sector, gear, and stock. There were expected to be 18 active sectors (including the common pool, which includes those vessels that did not join organized sectors), six gear types, and 16 stocks (including sub-stocks like the eastern Georges Bank cod, *Gadus morhua*, and haddock, *Melanogrammus aeglefinus*). The maximum number of possible discard strata combinations exceeded 1,700. It was known that observer coverage levels much higher than the approximate 8% that had been historically achieved would be needed to meet SBRM precision requirements under sector management (Northeast Fisheries Science Center Discard Peer Review, http://nefsc.noaa.gov/groundfish/discard/). In addition to the precision concerns, there were also practical considerations, such as funding availability and achieving a coverage level that would deter observer bias (e.g., Benoît and Allard 2009). Ultimately, NMFS determined that there would need to be approximately 22-30% observer coverage of the groundfish fishery in addition to the approximate 8% coverage provided by existing monitoring efforts.

Sector vessels would be subject to the increased groundfish observer coverage levels whenever the vessel was sailing on a fishing trip designated as a 'groundfish' trip. A groundfish trip is defined as any trip where the vessel will be fishing under a Northeast Multispecies day-at-sea (DAS). While sector vessels were exempt from DAS requirements, the usage of DAS would continue to be monitored and used to determine the directed nature of the fishing trip. Based on these rules, in addition to trips targeting groundfish, groundfish trips may also include trips targeting monkfish (*Lophius americanus*), spiny dogfish (*Squalus acanthias*), and skates (Rajidae). Under Amendment 16, vessels intending to sail on a groundfish trip would be required to submit notification to NMFS of their intent to fish at least 48 hours in advance of sailing, in order to facilitate the deployment of fisheries observers.

A new class of observer

Amendment 16 originally specified that, beginning with fishing year 2012 (May 2012), all sectors must fund NMFS-approved at-sea monitoring programs. In the interim (i.e., fishing years 2010 and 2011), NMFS agreed to fund observer coverage levels in excess of existing federally funded monitoring to meet the increased coverage demands. Observers certified through the Northeast Fisheries Observer Program (NEFOP) to provide baseline fishery coverage collect a suite of information on fishery operations that extends beyond the core information needed to support in-season monitoring of groundfish sectors. Anticipating a future shift from NMFS-funded to industry-funded observers, a lower-cost alternative to NEFOP observers was created that were termed 'at-sea monitors,' or ASMs. The data collection protocols for ASMs are restricted to collecting haul-by-haul catch estimates and length frequency information. ASMs do not perform any of the additional biological sampling or data collection required of the NEFOP observers, though they do collect minimal protected species bycatch information. In contrast to the single service provider contract awarded to provide NEFOP coverage, multiple service providers were contracted to provide ASM coverage. Additionally, sectors could contract with individual service providers to fund ASM coverage beyond the NMFS-funded levels (i.e., industry-funded ASM); to date, however, no sector has done so. All coverage types, regardless of funding source and program objective, would be used in support of groundfish discard estimation for both stock assessments and in-season quota monitoring.

Complexity of proportional deployments

In a given fishing year, not all of the 1,700 possible discard strata would be expected to be active. For example, some sectors' operations were likely to fish only certain gear types, in addition to being geographically restricted to one or two regions (Figure 2), which would preclude the harvesting of certain groundfish stocks. However, it was not known *a priori* which strata would be active. Given the large scale changes to the fishery as a result of sector management, the behavior of the groundfish fleet in prior years would likely be a poor predictor of expected behavior from May 1, 2010 and beyond. The efficient and effective support of fine-scale discard stratification would require the capacity to dynamically identify active strata and deploy observer coverage in these strata in a statistically unbiased manner. This was a marked departure from the sea day schedule approach, in which the stratification scheme was static and the behavior of the fleet was assumed to be similar from one year to the next. An additional aspect of the in-season discard estimation methods was that sectors would be subject to an assumed discard rate early in the fishing year, when there were insufficient in-season observations in strata from which a reliable estimate could be derived. Given this, it was desirable to achieve some level of 'front-loading' to get in-season information early in the fishing year in a way that would not introduce a temporal bias into the resulting discard estimates.

Maintenance of existing coverage objectives

While Amendment 16 and sector management brought about many changes to the groundfish monitoring program, it did not reduce the obligation to continue ongoing monitoring efforts in support of other programmatic objectives. These included coverage of vessels participating in certain SMPs, such as the Georges Bank United States/Canada Resource Sharing Area and closed area access programs. In addition, NMFS is mandated to provide seasonal coverage of certain groundfish gear types to monitor the bycatch of protected species like marine mammals. Monitoring of protected species is also covered under the SBRM Omnibus Amendment. The sampling protocols employed on gillnet trips is limited with respect to fish sampling, and as such these trips are not applied against groundfish trip coverage requirements and excluded from the discard estimation process.

Summary of needs

Amendment 16 and sector management introduced considerable complexity into the manner in which observers would need to be deployed in the groundfish fishery. To meet these demands, a sophisticated and integrated observer deployment system would be needed that was capable of automatically, and efficiently, allocating observer coverage across the range of monitoring programs. The highest priority of such a system would be to support the stratified random deployment of observers within the groundfish fishery in an unbiased manner. Given the range of possible observer programs (e.g., NEFOP, NMFS-funded ASM, industry-funded ASM) across the groundfish fishery, such a system would need to support multiple selection protocols as well as observer coverage rates. Coverage rates could vary from program-to-program, and potentially from sector-to-sector. Because some observer programs would utilize multiple service providers, there needed to be an efficient and equitable method for assigning trips to individual providers proportional to the relative capacity of each service provider (i.e., number of employed observers). Since multiple ASM service providers would exist, it was desirable to select multiple providers; this would improve the likelihood of a trip being covered in the event that the first provider selected did not have an observer available for deployment. Lastly, from the perspective of the fishing industry, the system would need to be simple and easy to use, and would allow for the trip and provider selection processes to be accomplished through a single action.

With these requirements in mind, the NMFS Northeast Fisheries Science Center (NEFSC) set out to design an observer pre-trip notification system (PTNS) beginning in late winter of 2010. While other similar systems have been developed and deployed in North America since 2010 (e.g., NMFS - Alaska Region developed and deployed their Observer Declare and Deploy System; USOFR 2012), to our knowledge the PTNS was a first-of-its-kind automated observer deployment system. Much of the design work could not begin until the details of Amendment 16 were finalized, which left only a few months to design, test, develop, and deploy a sophisticated next-generation observer deployment system. Given the short development time frames and new fishery management regime, it was inevitable that improvements in the initial design would be required. During the first year of deployment PTNS was incrementally improved, resulting in the current system, which has been meeting a range of observer deployment requirements since May 1, 2011. In this paper we discuss the design, implementation, and performance of the PTNS over its three-year implementation in the groundfish fishery. Additionally, we identify areas of possible improvements that would benefit not only the PTNS, but the design of similar systems around the world.

SYSTEM DESIGN

During the preliminary PTNS design phase, several critical system features were identified. We have attempted to describe the need and basic design of the PTNS with respect to these features, but it is not intended to be an exhaustive list of all of system features. The following descriptions capture the major PTNS features that are central to its successful operation.

Hierarchal tiers

The most important design feature identified was the need to establish a hierarchy in the selection process. Because of the multiple coverage objectives that the PTNS would need to address, it was critical that the relative priorities of each of the objectives were established such that coverage was assigned in order of relative importance. Within the hierarchal structure, individual monitoring programs were assigned to priority levels, or tiers. Each tier had an associated type of observer coverage (e.g., NEFOP observer for NEFOP-level coverage) for which there may or may not have been multiple providers. The hierarchal design features of the PTNS are described below:

> *Sampling unit* **–** The object that is being sampled from the population, or sampling frame. Within the PTNS, the fishing trip was identified as the sampling unit. The PTNS selection process would be trip-based, such that the target coverage rates would be evaluated with respect to the ratio of observed trips relative to total trips occurring within a defined stratum. While other sampling frames were considered, such as total fishing effort (e.g., days absent) and total groundfish landings, the difficulty in defining a sampling unit in these terms at the point of notification (i.e., prior to a trip sailing) precluded their use in the PTNS. Fundamentally, if the coverage deployment was unbiased, the proportionality of trip-based coverage would be equal to those of other metrics.
>
> *Selection tiers* - Discrete hierarchal levels within the observer selection process. Many of the selection tiers would correspond to explicit monitoring programs such as NEFOP, protected species (limited fish sampling), and ASM monitoring (limited biological sampling). In general, the placement of the tiers within the hierarchy would be dictated by overall importance relative to resource monitoring. The more important tiers would be placed at the top of the selection process, and trips would move down through the selection process until the trip was selected at a given tier. Once a trip was selected at one selection tier, it would exit the selection process and could not re-enter. The selection of a

trip at a selection tier would not guarantee that an observer would be assigned to cover the trip, since the trip would still have to enter the provider assignment process post-selection. There would be four different types of tiers: ‘conditional,’ ‘list,’ ‘probability-based,’ and ‘sea day schedule’. *Conditional tiers* refer to those tiers where trips are issued waivers if they met certain defined conditions. *List tiers* refer to those tiers where a vessel was either on the ‘list’ or not on the ‘list’. List tiers exist in two forms: automatic waiver and automatic selection. *Probability-based tiers* rely on a stratified random selection process to determine whether a trip is selected for coverage. *Sea day schedule tiers* rely on fixed sea day schedules; if a trip declared into a stratum for which there is still a positive balance on the sea day schedule, it would be selected for coverage. A full list of selection tiers and a general description of each are provided in Table 1.

Observer coverage types - The type of observer coverage deployed on a fishing trip. Each selection tier would have only a single coverage type. The possible coverage types would be: NEFOP coverage, NEFOP-limited (protected species), NMFS-funded ASM, and industry-funded ASM. The relationship between selection tiers and coverage types is shown in Table 1.

Observer providers **-** A company contracted to provide fishery observers. Each provider may be contracted to cover multiple selection tiers, and or, multiple coverage types. For coverage types where multiple providers exist, a weighted probability selection would be used to identify two service providers (provider 1, provider 2) for each trip. The probability of provider selection would be proportional to the number of certified observers each provider has at the time of the notification. Provider 1 would receive the right of first refusal, and if provider 1 declined the trip or failed to accept the trip in a specified amount of time, the trip would be offered to provider 2. The details of this selection are described later in this paper.

The relationship between selection tiers and observer coverage types is shown in Table 1. Figure 3 provides a schematic of the progression of a fishing trip as it moves through the PTNS groundfish selection process. All of the selection tiers that would preclude a trip from being selected are placed at the beginning of the selection process to ensure that only those trips eligible for coverage reach the lower selection tiers where positive selection of a trip is possible. The ordering of the four initial list tiers (manual waiver, set-only gillnet, do not deploy - safety, do not deploy - coverage) is irrelevant, as trips must pass through all four in order to reach tiers capable of a positive selection.

Trips could be issued manual waivers by PTNS staff on a case-by-case basis. Manual waivers are most commonly issued when a vessel operator wants to sail less than 48 hours from the trip notification to avoid impending weather. In these situations a PTNS staff member would occasionally grant the vessel a temporary waiver of coverage if the vessel has a good record of compliance. Gillnet vessels may take what are referred to as ‘set-only’ trips, which are trips in which gillnet gear is set, but not hauled. There is no harvesting of fish on these trips, so the deployment of an observer is unnecessary. These trips would be monitored for compliance external to the PTNS to ensure that they are truly set-only trips. The 'do not deploy' list tiers have two purposes. The first tier of this type is to protect the safety of observers. If a vessel has been identified as unsafe or constituting a hostile work environment for an observer, vessels will be temporarily placed on this list until the issues can be resolved. Many of these situations represent compliance problems and often require the intervention of NMFS Office of Law Enforcement. Once the issue has been addressed, the vessel is removed from the list. The second 'do not deploy' tier type is used to allow a temporary reprieve to vessels that have experienced unusually high coverage until their coverage rates are reduced below a specified level. Because the PTNS works to achieve coverage targets at the stratum level, not the individual vessel level, occasionally there can be a wide disparity of individual vessel coverage within a stratum, particularly when a stratum contains several non-compliant vessels or vessels attempting to avoid observer coverage. To achieve target coverage rates for a stratum, low coverage on a small number of vessels must be compensated by other vessels within the stratum receiving above-average coverage. The PTNS tracks individual vessel coverage rates and automatically monitors for high- and low-coverage vessels. The details of this system monitoring will be described in a subsequent section. Vessels identified as high-coverage are placed in the 'do not deploy - coverage' and vessels identified as low-coverage are placed in the 'keep active' tier, which will be described below.

The next selection tiers are the NEFOP-level coverage, SMP, and protected species tiers (Tiers 5 through 7; Table 1). These constitute the core monitoring programs in the region, independent of additional coverage needed to meet groundfish sector coverage demands. These were identified as the top monitoring priority for the groundfish fishery. The NEFOP and SMP are probability-based tiers; however, the protected species coverage is assigned using a sea day schedule. The difference in design was reflective of the desire of the end-user group that assigns protected species coverage to continue to use their existing sea day schedule method for observer selection. The sea day schedule selection specifies a set number of sea days of observer coverage by month, port, and gear-type. Any trip that reaches this tier will be evaluated to determine if it meets the criteria for which there is a positive balance on the sea day schedule. The sea day schedule is filled on a first-come, first-filled basis. If the trip does meet the criteria it will be selected for coverage. Trips not selected at the NEFOP, SMP, and protected species tiers will drop through to the ASM selection tiers. In the initial design discussions it was not known when, and if, there would ultimately be an industry-funded component to the system. For this reason, the NMFS-funded tier was placed higher in the selection process than the industry-funded component. The last tier is the 'keep active' tier. This tier is used to ensure coverage of vessels that have experienced below-average observer coverage despite automated system efforts to randomly deploy observers. Observer coverage for trips selected in the 'keep active' tier are assigned using the observer coverage associated with the next highest selection tier (e.g., if

NMFS-funded ASM coverage is the next highest tier turned on within the PTNS, ‘keep active’ trips will be assigned NMFS-funded ASMs).

Within each of the probability-based tiers (NEFOP, SMP, NMFS-funded ASM, and industry-funded ASM), a ‘must deploy’ sub-tier exists. These sub-tiers are used to address vessel compliance issues, specifically observer avoidance behavior. Before a vessel enters into the probability based selection for any of these tiers, the vessel is checked against a list to determine if it has been previously identified as ‘non-compliant’ based on prior PTNS usage patterns. The compliance aspect of the system will be described in depth in a subsequent section. Trips that enter the probability-based sub-tiers will be assigned coverage based on a stratified random selection algorithm. The details of the selection algorithm are covered in the next section.

Methods to establish observer deployment probabilities

The primary objective of the PTNS is the stratified random deployment of observers within the groundfish fishery in support of in-season discard estimation. Specifically, the PTNS needs to be able to deploy observers in an unbiased manner within each stratum, contingent on a target coverage rate. The level of stratification applied within the PTNS was designed to be consistent with the in-season discard estimation methods which were based on sector, gear and mesh size (i.e., gear category), and fish stock. Since the specific species/fish stocks that would be caught on a particular trip were not known *a priori*, the PTNS used the intended fishing area as a proxy for fish stocks. The fishing areas were divided into three regions (Gulf of Maine, Georges Bank, and Southern New England/Mid-Atlantic; Figure 2) which generally corresponded with the management units used for the various groundfish stocks.

The target coverage rates are determined external to the PTNS based on considerations that include the desired precision of discard estimates, compliance monitoring needs (i.e., reduction of observer effects; Benoît and Allard 2009), and funding availability. Target coverage rates would likely require manual adjustment throughout the fishing year to compensate for changes in trip length, amount of fishing effort (number of trips), estimated effort remaining in the fishing year, number of observers available, and overall compliance with PTNS notification requirements.

With the exceptions noted above (e.g., do not deploy, set-only gillnet, must-deploy, protective species sea day, and keep-active tiers), the selection method for the majority of trips entering the PTNS should incorporate a probability-based sampling scheme utilizing random selection of fishing trips. There are numerous manners by which the trip selection probability could be determined ranging from the simple to the complex. From an initial design review, several desirable features of the selection method were identified:

1. Ability to achieve a target coverage rate.
2. Some level of ‘front-loading’ to get in-season information early in the fishing year to limit the influence of assumed discard rates in the calculation of discard estimates. While

the ‘front-loading’ aspect was desirable, it had to be accomplished in such a way as to limit the amount of temporal bias in the level of observer coverage.

3. Ideally, the selection criteria should have a self-adjusting capacity so that it can make fine-scale adjustments to the target coverage rates based on the actual realized coverage rates for the stratum, in the event that coverage rates are perturbed from the desired target rate.

With these criteria in mind, three different selection methods were considered and evaluated through simulation. The methods do not constitute an exhaustive list of possible methods; rather, they were selected because of their simplicity and ability to achieve a target level of observer coverage over time. Under all three methods, each trip is assigned a random number from 0.000 to 1.000 (r_{tier}). The trip is selected if $r_{tier} \leq$ a tier’s selection probability (p_{tier}). The selection probability (p_{tier}) is some function of either the target coverage rate (t_{tier}) or stratum trip counts with the independent control variable, varying by method.

The three candidate methods were investigated and evaluated using simple, single-tier simulations. The simulations were programmed using SAS software, Version 9 (SAS Institute Inc., Cary, NC, USA). Simulations assumed that all trips entered into the system occurred (no cancellations), and that trips selected for coverage received coverage (providers could not decline trips). Trips were entered into the simulation one at a time, and each iteration was carried out to 100 trips. Each simulation was run for 500 iterations, and the performance of the method was evaluated based on the mean coverage rate and precision. While the simplistic nature of these simulations may not capture the nuances of a production system and the limited iterations may not characterize the true precision, the simulations were sufficient to evaluate the general characteristics of each the methods and offer an objective means with which to identify an optimal method. The three candidate methods are described below.

Fixed method

The fixed method represented the simplest of the three methods explored, and addressed only the criteria to achieve a specified coverage rate. In the fixed method, every trip had a fixed probability of being selected for observer deployment that is equal to the target observer coverage (Equation 1, Figure 4).

[Equation 1] $p = c_t$

Where:

p is the probability of trip being observed
c_t is the target coverage level

Incremental method

The incremental method attempted to address the probability of zero coverage early in the fishing year by applying some front-loading capacity. The incremental method starts with a specified high fixed coverage rate (e.g., 1.0), with the coverage rate decreasing in fixed increments as each successive trip entered the stratum (Equation 2), until it reaches a defined target coverage rate (Equation 3, Figure 5). The method operates independent of the realized observer coverage rate; the probability of a trip being selected for observer coverage is dependent only on its order of occurrence in the stratum, not whether previous trips were selected for observer deployment. In this respect, the incremental method did not contain a self-adjusting mechanism.

[Equation 2] $p = 1 - t(i)$ unless $c_t > 1 - t(i)$ then $p = c_t$

The number of trips that must exist in a stratum before the target observer coverage is reached is:

[Equation 3] $t = \left[\frac{1-t}{i}\right] + 1$ (*integer*)

Where:

p is the probability of trip being observed
c_t is the target coverage level
t is the number of trips in a stratum when the pre-notification for a trip occurs
i is the increment value

Linear method

In addition to the ability to achieve a target coverage rate and front-loading capacity, the linear method also employed a self-adjusting capacity. The self-adjusting feature allowed the system to adjust the selection probabilities based on the realized coverage rates, thereby providing a correction mechanism if realized coverage rates deviated from the target coverage rates. In the linear method, a linear regression was fit between two control points: a specified maximum selection probability, and a target coverage rate (Equation 4, Figure 6). The control points represented the fixed behavior of any assignment of observer coverage levels; when no trips were observed within a stratum, observer coverage was assigned at the specified maximum selection probability (e.g., 1.0), and when the observer coverage within a stratum was equal to the target coverage level, any additional trips were assigned coverage at a probability equal to the target observer coverage rate. The probability of a trip being selected for coverage at all other points was determined using a simple linear regression. The trip selection probability could not drop below the specified minimum. A minimum level may be desirable for compliance reasons such that even when realized observer coverage levels are high, a vessel operator could expect that there is some probability that the trip will be observed.

[Equation 4] $p = \left[\frac{c_t - 1}{c_t}\right] c_r + c_{max}$ unless $c_{min} > \left[\frac{c_t - 1}{c_t}\right] c_r + c_{max}$, then $p = c_{min}$

Where:

p is the probability of trip being observed
c_t is the target observer coverage level
c_r is the realized (actual) coverage level when the pre-notification for a trip occurs
c_{max} is the maximum selection probability
c_{min} is the minimum selection probability

The compensatory nature of the linear method attempted to stabilize the realized coverage rate at the target coverage rate as quickly as possible. By setting the minimum coverage rate higher, it limited the ability of the method to compensate for high realized coverage rates.

Method comparisons and preferred alternative

Both the linear and fixed methods have the tendency to reach the target coverage rate in fewer trips relative to the incremental method (Figure 7). The duration it takes for the linear method to reach the target coverage rate is positively related to the specified minimum coverage rate. The fixed method is susceptible to a large amount of variability when there are few trips within the stratum, but does tend to approach the target coverage rate over time. One drawback to the fixed method is the high probability of having no observer coverage for a stratum when trip counts are low (Figure 8). The lower the target observer coverage rate, the higher the probability of having zero observed trips. This quality may not be desirable, given the likelihood of small stratum sizes (< 10 trips) expected under sector management and the desire to move away from the assumed discard rate into an in-season discard rate. Both the fixed and incremental methods achieve approximately normal distribution of stratum coverage (Figures 9 and 10). The self-adjusting nature of the linear method works to reduce the overall variance in the stratum coverage, thereby achieving non-normal distributions.

Unlike the fixed method, both the incremental and linear method have zero theoretical probability of having no observer coverage. However, in practice, all methods have some probability of having no observer coverage. This can occur if the selected observer service provider(s) are unable to deploy an observer on the first trip in a stratum. One benefit of the linear approach is that the probability of selection is based on realized observer coverage, not the total number of trips taken in the stratum. In the event that the first trip within a stratum is not observed, the linear method will assign a probability of 1.0 to the next trip occurring within the stratum. The impacts of provider cancelation were not evaluated in this simulation.

Because of the front-loading aspect of the incremental method and its inability to set trip selection probabilities below the target coverage rate, the realized coverage tends to be biased high relative to the target rate. The effects of the incremental method’s front-loading can never be mitigated. These impacts are greatest when there are a low number of trips within the stratum and increase with smaller increment values.

The linear selection method addressed the concerns identified with both the fixed and incremental methods; specifically, the probability of having zero trips within a stratum early on in the fishing year and a prolonged coverage bias introduced from the front-loading. The lower the minimum coverage rate, the faster the front-loading biases were addressed. Additionally, the self-correcting aspect of the linear method worked to reduce the overall variance in the coverage rates relative to both the fixed and incremental methods. Based on these simple simulations, the linear selection method performed optimally and had all of the desirable properties outlined in the design phase.

'Combined' versus 'separate' tier relationships

Whenever a trip enters a PTNS selection tier it receives a random value, r_{tier}, ranging from 0 to 1.0. A tier selection probability, p_{tier}, is then estimated using the linear method, and when $r_{tier} \leq p_{tier}$, the trip is selected for coverage. When a selection system has more than a single tier, there are two ways that tier selection probabilities can be designed: 'separate' or 'combined'. In a 'combined' system, each trip receives a single r value and the individual tier selection probabilities are cumulative. For example, in a system with three tiers where the target coverage rates of the first, second, and third tiers are 0.08, 0.30, and 0.12 respectively, the target values (p) used within the PTNS are cumulative, such that the first tier is assigned a 0.08 target probability, the second tier is assigned a 0.38 target (0.08 + 0.30), and the third tier is assigned a 0.50 target (0.08 + 0.30 + 0.12). The realized coverage rates necessary to estimate the p value in the linear method are estimated by combining the coverage from all tiers, such that the PTNS only needs to track a single coverage rate for each stratum. The primary advantage of the 'combined' method is that it is relatively simple to implement, since the PTNS only needs to track realized coverage at the stratum level and not for each strata-tier combination. The major disadvantage of the 'combined' method is that in order for it to achieve the target coverage rates for each individual tier, the minimum coverage level specified within the linear method must be set equal to the target coverage rate for all but the last tier (Figure 11), thereby diminishing the compensatory nature of the linear method.

A 'separate' system treats the selection of each tier independently from the rest such that each trip receives an r value for each tier it enters. The target coverage rates are set equal to the desired target and work independent of the coverage in all other tiers. To implement this design, the PTNS must track coverage rates for each strata-tier combination. In this sense, a 'separate' system is more complicated to implement; however, the major advantage of the 'separate' system is that the minimum coverage level can be set to any desired value to maximize the compensatory nature of the linear method (Figure 11).

The performance of the two system designs was evaluated using simple multi-tier simulations. These simulations were built on the initial single-tier simulation code. Simulations were done using both two- and three- tier systems, with the tier coverage rates for tiers one, two, and three set at 0.08, 0.30, and 0.12 respectively. The coverage rates were chosen based on anticipated target coverage rates for the NEFOP and NMFS-funded ASM in fishing year 2010, and an arbitrary value was chosen for industry-funded ASM coverage. Example runs from the simulations are shown in Figure 12. In the 'combined' system, there is a notable high bias that persists in the lowest tier (tier 1) for several trips. This effect is similar to what was observed in the incremental selection method. Since the minimum coverage level must be set to the target coverage level, the 'combined' system is very much like the incremental method in the sense that it has no mechanism to compensate for the initial high coverage induced by the front-loading. The high bias in the lowest tier is offset by below-target coverage in tiers two and three. Additionally, because of the diminished ability of the 'combined' system to self-correct coverage in excess of the target coverage rate, the system is slow to respond to perturbations as occurred in tier 2 of the three-tier example. This perturbation negatively impacted the ability of the system to meet the coverage requirements of tier 3. Conversely, the 'separate' system equilibrates to the target coverage rates for all tiers relatively quickly, and perturbations from the target are minimal. A 'separate' system allows the PTNS to take full advantage of the compensatory nature of the linear selection logic, and also ensures that perturbations affecting one tier are isolated and do not affect the other tiers.

When the PTNS was first implemented on May 1, 2010, it was based on the 'combined' design. The choice in design was purely pragmatic, based on the short amount of time available to design, build, and implement the initial system. It was recognized from the beginning that a 'separate' system would be optimal, but it was believed that there was insufficient time to implement a system with that complexity in the initial design. During the first year, work began to revise the PTNS to incorporate the 'separate' design, with the revised system implemented at the start of the 2011fishing year.

Observer avoidance and coverage equitability

When the PTNS was first implemented on May 1, 2010, it contained no mechanism to address the intentional avoidance of observer coverage by vessels. Shortly after implementation it became clear that some vessels were avoiding observer coverage by canceling trips scheduled for observer coverage at proportions higher than trips not scheduled for observer coverage. In August 2010, the PTNS was redesigned to fix this loophole. The redesign forced vessels that cancelled trips scheduled for observer coverage to be automatically selected for observer coverage on all subsequent trips until a trip had been covered by an observer. The design was intended to reduce the incentive to cancel trips scheduled for observer coverage and ensure more equitable coverage across all vessels. This solution created a new sub-tier within each of the probability based tiers which was termed 'must deploy.' This was a list tier such that anytime a vessel canceled a trip scheduled for coverage, it would be placed on the 'must deploy' list corresponding to the type of coverage that was canceled. For example, if a trip selected for NEFOP coverage was canceled, the vessel would be added to the NEFOP 'must deploy' sub-tier. The next time a trip from the vessel entered the NEFOP selection tier, it would be checked against the list prior to undergoing random selection. If the vessel was listed, the trip would automatically be selected for NEFOP coverage. Once a vessel successfully carried an observer following placement on the 'must deploy' list, it would be removed from the 'must deploy' list at all levels. If a vessel canceled trips at multiple tiers prior to carrying an observer, it could be placed on the 'must deploy' list for multiple tiers. The PTNS would recognize a vessel as having carried an observer once a provider had indicated within the PTNS that an observer had been deployed on a vessel.

The redesign was effective at forcing vessels that were attempting to avoid coverage to carry observers. Unfortunately, the redesign negatively impacted compliant vessels that were not intentionally avoiding observer coverage, but rather legitimately attempting to fish around weather windows, crew availability, etc. These impacts were exacerbated during the winter fishing months, when 'day-boat' vessels (i.e., small vessels which typically take trips ≤ 48 hours) were forced to cancel a higher proportion of declared trips due to inclement weather. As a result, active, compliant 'day-boat' vessels ended up experiencing observer coverage well in excess of the target coverage rates in fishing year 2010. A more effective means of addressing observer avoidance that did not penalize compliant vessels was needed.

Prior to the start of the 2011 fishing year, work began to develop improved methods of dealing with observer avoidance without negatively impacting compliant vessels. The need to delay notifying the vessel of the PTNS trip selection until 48 hours prior to the sail date was identified. Frequently, 'day-boat' vessel operators would make trip declarations in weekly batches and notify their intent to fish every day in the coming week, not knowing which days would offer favorable sea conditions and/or an available crew. Once the operator had a better understanding of sea conditions and crew availability, they would cancel notifications for trips on which they did not intend to sail, a process that was often done in advance of the 48-hour notification requirement. In the initial PTNS design, vessel operators were informed immediately after declaration which trips were scheduled for coverage. This allowed the vessel operators to consider an additional piece of information when deciding which trips to take or cancel; this was particularly true of those vessels looking to avoid observer coverage. To address this, the PTNS was modified so that vessel operators were not informed of the selection status of a given trip until 48 hours prior to the trip sail date (the PTNS still made the selection at the time of entry, but notification was delayed). Any cancelations made prior to the 48-hour period would be done without knowledge of the coverage status; therefore, trips canceled outside of the 48-hour window would not be subjected to subsequent 'must deploy' targeting.

For those vessels that canceled trips within the 48-hour window, the goal was to identify only vessels that were intentionally avoiding observer coverage; however, identifying these vessels proved difficult. Since PTNS operates at the stratum level and not at the individual vessel level, any vessel that has received below-target coverage must be offset by one or more vessels with above-target coverage within the same stratum. From a system operation perspective, it is irrelevant whether the low coverage was due to random chance or intentional avoidance of observer coverage through selective cancelation; both causes affect all other vessels within their stratum identically. Rather than attempting to identify vessels intentionally avoiding observer coverage, the solution envisioned would simply target all low-coverage vessels that cancelled trips scheduled for observer coverage. This would require significant changes within the PTNS to enable it to track individual vessel coverage levels, and then be able to utilize this information to determine whether a vessel would be subject to 'must deploy' assignment following cancelation of a trip scheduled for observer coverage.

In an effort determine appropriate '*low coverage*' threshold values, a modeled version of the PTNS was created to simulate its performance under varying levels of low-coverage thresholds. The modeled PTNS was more sophisticated than earlier PTNS simulation models, in that it accounted for provider cancelations and allowed for differential vessel cancelation rates. Additionally, it categorized vessels into two groups: 'compliant' and 'non-compliant.' Compliant vessels were those that canceled trips scheduled for observer coverage at the same rate they canceled trips receiving a waiver. Non-compliant vessels were identified as those with higher cancelation rates on trips scheduled to carry an observer compared to trips receiving a waiver. While both compliant and non-compliant vessels would be targeted for canceling observer coverage when their overall coverage rate was below the threshold value, the identification of the two groups assisted with understanding how the PTNS modifications would affect each group. The modeled PTNS lacked one important component compared to the actual PTNS: trips were entered individually and not in weekly blocks as is common among 'day-boat' vessels. Therefore, the graduated notification aspect of the proposed redesign was not considered in these simulations.

Simulation runs were performed using actual PTNS notifications from the 2010 groundfish fishing year. The simulated population was created from a real stratum (sector, gear, fishing region) containing several active 'day-boat' vessels. Only the first 1000 trips from the selected stratum were included in the simulations. Because the simulated set was constructed of actual PTNS notifications, the individual vessel behavior (cancelation rates, compliant vs. non-compliant, total trips declared, etc.) was self-determined from the data. Three separate simulations were performed using three different '*low-coverage*' threshold values. In all simulations the provider decline rate was fixed at 10% (i.e., the selected provider decline 10% of the trips initially offered). The simulated PTNS included a single tier with a target coverage rate of 30% and a minimum selection rate of 1%. Each simulation was run through 250 iterations. The selected low-threshold coverage levels were 0%, 30% (equal to the target), and 100%. The 0% low-coverage threshold provides a simulation of the initial May 1, 2010 PTNS design, where vessels were not targeted following the cancellation of a trip scheduled for an observer. The 100% low-coverage threshold provides a simulation of the PTNS post August 2010, when vessels were targeted following the cancelation of a trip scheduled for observer coverage regardless of their current coverage rates or coverage status. Setting the low-coverage threshold equal to the target coverage (30%) represents a compromise between the two systems.

The results from the simulations indicate that setting the low-coverage threshold equal to the target coverage (30%) produced the least biased overall stratum coverage with respect to the interquartile range (Figure 13). Comparatively, the 0% threshold and 100% threshold tended to produce biased low and high coverage, respectively. Under all three simulations, the distribution of stratum coverage tended to be above target until 10 to 25 trips had occurred in the stratum. These results are consistent with single-tier simulations of the linear method (Figure 7), reflecting the residual effects of front-loaded coverage. The stratum coverage rates stabilized around 75 trips under all three simulation scenarios.

Setting the low-coverage threshold equal to the target coverage produced the most equitable distributions of vessel-level observer coverage relative to the 0% and 100% thresholds (Figure 14). The 0% threshold does nothing to affect the non-compliant vessels, which subsequently experience coverage rates much lower than the target 30%. The compliant vessels tend to have above-target coverage, which is needed to meet overall stratum targets given the low coverage of non-compliant vessels. The 100% low-coverage threshold results in above-target coverage for all vessels, regardless of status, since all vessels are penalized for cancelation of trips scheduled for observer coverage, regardless of their realized coverage rate. When the low-coverage threshold was set equal to the target, the median coverage of non-compliant vessels was below-target; however, the interquartile range of most of the non-compliant vessels extended above the target level. Median coverage of non-compliant vessels tended to approach the target with increasing activity. For compliant vessels, the opposite was true, with slightly elevated coverage for low-activity vessels and near-target coverage for higher activity vessels. Overall, the variability in coverage declined with increasing vessel activity. A general conclusion from this is that there is some degree of system acclimation required before the compliance aspect of the PTNS has an effect; e.g., with a limited number of trips, low-activity compliant vessels tend to experience above-target coverage and non-compliant vessels tend to experience below-target coverage. The acclimation period is most likely attributable to providers declining trips that were selected by the PTNS for coverage, thus reflecting actual conditions under which the PTNS operates. Since not all trips selected for coverage will receive coverage, some amount of time is required for any coverage adjustments to be effective, whether the adjustments are due to the compensating nature of the linear method or are an attempt to address low-coverage through coverage thresholds.

Given the general lack of bias and reduced variability properties of the 30% low-coverage threshold, a second simulation exercise was performed examining how a system would perform with a minimum trip criterion. Under this simulation, the coverage thresholds were not applied until a vessel had taken more than 10 trips. This minimum trip criterion was based on the knowledge that there is a high degree of random variability among the coverage of vessels that have only taken a few trips. This compares to the first simulation exercise which focused on achieving equitable vessel-level coverage regardless of a vessel's activity level. The results of this second simulation suggest that a minimum trip criteria of 0 results in median unbiased stratum coverage, whereas the median coverage tended to be below-target under the 10-trip minimum scenario (Figure 15). The explanation for these results can be seen in the coverage distributions of the individual vessels (Figure 16). Since most of the non-compliant vessels in this simulation were low-activity vessels, there was little opportunity for the PTNS to positively affect their coverage. Consequently, the median coverage of compliant vessels tended to be slightly higher under the 10-trip minimum scenario.

Based on the collective simulation results, the PTNS was modified to use a low-coverage threshold equal to the target threshold with no minimum trip requirement. Setting the low-coverage threshold equal to the target coverage rate was expected to reduce the likelihood that vessels not intentionally attempting to avoid observer coverage would experience excessively high observer coverage, without negatively impacting the overall stratum coverage rates. Additionally, treating all low-coverage vessels equally, regardless of the number of trips a vessel had taken, would ensure more equitable vessel-level coverages and a higher probability that the realized strata coverage rates would be equal to the specified targets.

Provider selection

Unlike NEFOP coverage, where the service provider contract is issued to a single provider, the ASM contracts (either NMFS or industry-funded) could potentially be issued to multiple providers. For tiers where multiple providers could exist, a systematic method was needed to offer trips to individual providers in an objective manner. Additionally, there was a desire to offer individual ASM trips to multiple providers on a given trip to increase the likelihood that an observer would be assigned to each trip selected for ASM coverage.

The agreed-upon solution for assigned coverage types where multiple providers existed was to apply a weighted probability selection to identify two service providers for each trip (provider 1 and provider 2). The probability of provider selection would be proportional to the number of certified observers each provider had in service at the time of the notification. This is a variant of probability-proportional-to-size (PPS) sampling, with the selection performed sequentially without replacement (select provider 1, remove it from the provider list, select provider 2 based on recalculated proportions). Under this selection process, provider 1 would receive the right of first refusal, and if provider 1 declined the trip or failed to accept the trip in a specified amount of time, the trip would then be offered to provider 2.

The provider selection process is performed based on the following six steps (*ASM coverage has been used as an example for any coverage selection where multiple providers exist*):

1. Assign each trip selected for ASM coverage a random number, $r_{provider}$, between 0 and 1.
2. Calculate the proportion of observers each provider has relative to the total number. **Note that provider observer counts are updated within the system on a regular basis (e.g., monthly).*
3. Order the providers based on the proportion of monitors and calculate the cumulative proportions.
4. Select the provider where $r_{provider1}$ ≤ the provider's cumulative proportion, but greater than the provider with the next lowest cumulative proportion. This provider becomes

provider 1 (see example in Table 2: if $r_{provider}$ = 0.294 then provider 2 would be selected as ASM provider D).

5. Remove the selected ASM provider 1 and recalculate the cumulative proportions (repeat steps 2 and 3).
6. Select the provider where $r_{provider} \leq$ the provider's cumulative proportion, but greater than the provider with the next lowest cumulative proportion. (see example in Table 2: if $r_{provider}$ = 0.294 then provider A would be selected as ASM provider 2).

SYSTEM IMPLEMENTATION AND PERFORMANCE

The PTNS was initially implemented on May 1, 2010. Between the start of the 2010 fishing year and end of the 2012 fishing year, the PTNS has undergone eight revisions, three of which represent major modifications (Table 3). The current system has been in place since May 2, 2011. The section below describes the major components of the PTNS.

System components

There are five major components to the PTNS production system (Figure 17). The most visible aspect of the PTNS is the web-based graphical user interface, or GUI (Figure 18). The web-based GUI is written with the following scripting languages: Perl, PHP (hypertext preprocessor), JavaScript, and jQuery. The application runs on an Apache web server located outside the NEFSC firewall with a Linux CentOS operating system. The purpose of the user interface is multi-faceted; it is used by vessel representatives (e.g., owners, operators, sector managers), observer service providers, and PTNS staff. The primary function of the PTNS user interface is to allow vessel representatives to make initial trip declarations as well as to view and edit pending trips; however, not all vessel operators use the web-based application directly. A fraction of the groundfish fleet submits their trip information to on-duty PTNS staff either through a toll-free telephone number or via email. A PTNS staff member then enters the trip information on behalf of the vessel representative. Regardless of the submission method, all trips are ultimately entered through the web-based application either by a vessel representative or PTNS staff. The web interface is also used by observer service providers to manage offered trips and report vessel assignments. All trip entries and changes made through the GUI write directly to an Oracle database.

Vessels that intend to fish in the groundfish (multispecies) fishery, and hold either a multispecies category D (hook gear), F (large mesh individual DAS), E (combination), K (open access), or A (individual DAS) permit, are required to notify their intent to take a groundfish trip through the PTNS at least 48 hours in advance of sailing. When making an initial trip declaration, the vessels must login with the vessel permit number and a personal identification number (PIN). This allows the system to identify the vessel as well as the groundfish sector to which it belongs, since there is a unique relationship at any given time between a vessel and groundfish sector. The vessel must provide the PTNS with the following information: anticipated sail date and time, estimated trip duration, port of departure, the type of gear that will be used on the trip, and the general fishing region (regions shown in Figure 2). Additionally, the vessel must indicate if it intends to fish in an SMP, since some SMPs have separate observer coverage levels that must be achieved in addition to the baseline coverage required for the groundfish fishery.

The PTNS utilizes two separate Oracle databases (PTNS components two and three; Figure 17). The first Oracle database resides outside the NEFSC firewall and serves as the principal production database for the PTNS GUI. The second database is located inside the NEFSC firewall and serves as the master PTNS database where all the core support tables originate. The master database has established database links to other core fisheries-dependent data collection programs to ensure the consistency of data content and coding schemes across systems. If, for example, changes are made to a vessel's permit status through the Permit System, it would automatically be reflected in the PTNS master database. The master database also serves as an archive of the data collected and managed in the production system; **Procedural Language/Structured Query Language (**PLSQL) procedures execute hourly to backup the core data entry tables from the production system. Nightly, PLSQL procedures push support table updates from the master to the production database.

The fourth component of the PTNS is a set of Perl cron jobs, which run every 15 minutes on the Apache web server (Figure 17). The cron jobs are responsible for making database edits to vessel and provider status selections as well as the sending of automated email notifications whenever any of the system time thresholds have been crossed (Figure 19). Fishing trips can be declared up to nine days prior to the date of sailing, but must be declared at least 48 hours prior the scheduled sail date. The vessel is not informed of a trip's preliminary selection status at the time of notification; 48 hours prior to the trip sail date, the cron job changes the trip status from 'pending' to either 'waived' or 'selected for observer coverage,' based on the results of the selection process that occurred when the trip was entered. An email is then automatically sent to the vessel notifying it of its selection status. If the trip was selected for coverage, an email is also sent to the selected observer provider. In the case of trips scheduled for NEFOP coverage, the provider will have 24 hours to make a determination as to whether or not it will deploy an observer on that trip. In the event the provider does not make a determination within the 24-hour window, the cron job will automatically decline the trip for the provider, issue the vessel a waiver, and notify the vessel via email. In the case of trips scheduled for NMFS-funded ASM coverage, the first provider has 12 hours to make a determination as to whether or not it will deploy an ASM for the trip (from 48 hours prior until 36 hours prior to the trip sail date). If provider 1 either declines the trip or fails to act within the 12-hour window, the trip is offered to provider 2. Provider 2 then has until 24 hours prior to the trip sail date to make a selection determination. If provider 2 fails to act, at the end of the 24-hour window the vessel will be issued a waiver and notified via email.

The fifth component of the PTNS is a web-based reporting and monitoring utility. The chief function of this utility is to provide a PTNS system administrator with a near real-time understanding of system performance and industry usage (i.e., a system dashboard). In addition to providing general information on system performance, it also tracks several areas of vessel compliance. The web-based reporting and monitoring utility was developed using SAS (Cary, NC) and runs daily. Several minor database maintenance procedures are controlled automatically through the SAS code, including the maintenance of the ‘keep active’ and ‘do not deploy-coverage’ list tiers.

System performance over time

There are two primary objectives of the PTNS: 1) optimize the sea days allocated to the fishery in a given contract year; and, 2) distribute the available sea days in a manner that provides unbiased observer coverage of the fishery (i.e., proportional to fishing activity). Annually, the PTNS is budgeted a fixed number of NEFOP and NMFS-funded ASM sea days for coverage of the groundfish fishery (e.g., NEFSC/NERO 2012). These allocated sea days represent the total number of sea days the PTNS has available for each contract year. Provider contract years run from April 1 to March 31 and therefore do not entirely overlap with the fishing year. From this allocation of sea days, an estimate is made to establish interim coverage rates for use in the PTNS at the start of each contract year. These estimates are based on the budgeted sea days and an expectation of the coming year’s fishing activity. The interim target rates are usually adjusted soon after the start of the year based on a close monitoring of the sea day burn rate (i.e., rate at which sea days are being utilized) by a system administrator. Using the PTNS web-based reporting and monitoring utility, the system administrator evaluates the sea day burn rates of both NEFOP and NMFS-funded ASM sea days relative to two factors:

> *Constant burn trajectory:* This provides a general overview of the sea day burn rate and indicates whether sea days are being burned too fast (the sea day budget will be exceeded before the end of the year) or too slow (a surplus of sea days will remain at the end of the year). If fishing activity were constant throughout the year, then the PTNS target rates would only have to be adjusted to maintain a constant sea day burn; however, there are temporal variations in fleet activity throughout the year and it is critical that sea day burns are controlled to ensure that observer coverage is temporally unbiased.

> *Comparison of the current year's fishing activity to that of the previous year:* This provides the administrator with an indication of the expected seasonal trends in the fishery based on previous fishing years, as well a gauge of whether the current year’s fishing activity is higher or lower relative to previous years (Figure 20). Both are taken into consideration and used to make adjustments to the PTNS target coverage rates which control the sea day burn rates.

The target coverage rates used in PTNS often have little bearing on the realized coverage rates. They can be considered unitless accelerator/decelerator knobs. For example the PTNS NEFOP target coverage rate may have to be adjusted to 0.15 (15%) to achieve a specific burn rate, which may result in a realized observer coverage of 6%. A number of factors affect the relationship between the target coverage rates, burn rates, and realized observer coverage, although one of the most common factors is the number of observers/monitors currently available for the groundfish fishery and the subsequent provider decline rates. For example, if 100% of available observers are being assigned to trips and yet the sea days are still being under-burned, subsequent increases to the target coverage rates will not increase the sea day burn rates or realized coverage rates. Given the complexities of running the PTNS, one should avoid preconceived notions about expected coverage rates that were established at the start of the fishing year based on the total allocated sea days. The realized coverage rates at the end of the year will be contingent on the number of sea days initially allocated, the activity of the groundfish fishery, and the availability of observers/monitors.

The following sections will describe the performance of the PTNS in years 2010 through 2012 relative to meeting its two primary objectives: utilization of the allocated sea days and unbiased observer coverage of the fishery.

Sea day burn rates, target coverage rates and trip selection probabilities

In contract years 2010 through 2012, over 90% of the allocated NMFS-funded ASM sea days were utilized annually, with the sea day burn exceeding the allocated sea days in 2011 (1% overage; Table 4, Figure 21). In contract years 2010 through 2012, 80-99% of the NEFOP sea days were utilized. The magnitude of the NEFOP sea day under-utilization in 2010 (85% utilization) and 2011 (80% utilization) is undesirable, though the reasons for the under-utilization vary by year. PTNS target coverage rates were adjusted over time in an effort to optimize the sea day utilization (Figure 22). Modifications to the PTNS target coverage rates impact the relationship between trip selection probabilities and realized stratum coverage, consistent with the linear selection design of the PTNS (Figure 23). Changes to PTNS target coverage rates affect the slope of the relationship between the trip selection probability and the realized stratum coverage; as PTNS target coverage rates are increased, the trip selection probability for a given realized stratum coverage increases. Consistent with the self-adjusting design of the PTNS, at a fixed PTNS target coverage rate the trip selection probabilities vary linearly, depending on the current realized coverage for each stratum. It is important to note that from May 2010 to April 2011, the trip selection probabilities for the NEFOP tier were capped at the target due to the combined tier design.

In 2010, the realized coverage rates for the NEFOP tier were generally in excess of the PTNS target coverage rates (Figure 24). Typically, when realized coverage rates exceeded the targets, the system would compensate by lowering the trip selection probability. However, due to the combined tier design of the 2010 PTNS, the minimum coverage rate of the NEFOP tier had to be held equal to the target coverage rate, which negatively impacted the compensatory capabilities of the PTNS. Because the realized coverage rates were in excess of the PTNS NEFOP targets, it is highly likely that the system could have achieved higher coverage rates had the target rates been increased. This would have improved the utilization of NEFOP sea days in 2010. Target coverage rates were not increased for the NEFOP tier until around November 1 (Figure 22), and only from 0.08 to 0.10. The target coverage rates for the NEFOP tier in 2010 should have been increased earlier in the year to better utilize the allocated NEFOP sea days.

In 2011, the NEFOP sea day burn slowed about the same time as in 2010 (approximately June 1). The similarities in timing may be coincidental, or they may relate to the deployment of NEFOP observers in other fisheries. The service provider for NEFOP observers is instructed to offer preference to certain non-groundfish fisheries when demand for observers is high. Increased activity in other fisheries, such as herring, which tends to increase in early summer, may compete with the groundfish fishery when the number of observers is limited. Unlike 2010, the 2011 NEFOP target coverage rates were continually increased beginning in early July (Figure 22), in an effort to counteract the slow burn. The increased target coverage rates had little impact on the sea day burns (Figure 21). During this period, the PTNS was exhibiting signs of system stress: realized coverage rates dropped below target coverage rates and the trip selection probabilities spiked in excess of 0.30 (Figure 24). Despite the increased probability of trip selection, the PTNS was unsuccessful in increasing the sea day burn to a level that would fully utilize the allocated NEFOP sea days. The unresponsiveness of the sea day burn to increases in target coverage rates is symptomatic of there being too few observers to fully utilize the allocated NEFOP sea days (i.e., observer saturation). A comparison of the percentage of PTNS trips selected at the NEFOP tier in 2011 (40.0%) to the percentage observed (7.3%) further illustrates the impacts of observer saturation (Table 5); i.e., in an effort to increase the burn of NEFOP sea days, the PTNS was assigning trips for NEFOP-level coverage at a rate 5.5 times that which could actually be achieved by the available NEFOP observers.

Interestingly, the PTNS also exhibited signs of stress in 2011 with respect to the coverage of the NMFS-funded ASM tier: realized coverage rates were generally below target coverage rates, and there were large increases in the trip selection probabilities (Figure 24). However, unlike the NEFOP tier, the allocated sea days for the NMFS-funded ASM tier were fully utilized (Figure 21). Similar to what was done for the NEFOP tier, target coverage rates were increased early in the fishing year in response to an under-burn of sea days. Unlike the NEFOP tier, the system was responsive to the increase in target coverage rates and the sea day burns increased to a level consistent with full utilization (Figure 21). It is notable that the NMFS-funded ASM target coverage rates remained at 0.45 for the majority of fishing year 2011, yet the 0.45 target only achieved a realized coverage of 0.195 (Table 6). The discrepancy between PTNS target coverage rates and realized coverage rates can be partially explained by provider declines of offered trips. Not all trips offered to providers are accepted, so there is not a 1:1 relationship of PTNS trip selection probabilities and realized coverage. This highlights a point made previously: the PTNS target coverage rates have little bearing on the realized coverage rates and should be considered in terms of unitless accelerator/decelerator knobs and not as indicators of the realized coverage rates.

Observer coverage rates

A primary objective of the PTNS is to distribute the available sea days in a manner that provides unbiased observer coverage of the fishery such that it is proportional to fishing activity. Evaluating the coverage achievements of the PTNS can be done either using data internal to the PTNS or from external sources (Vessel Monitoring System, or VMS, activity declarations, observer data, etc.). The optimal performance of the PTNS is contingent on the accuracy of the self-reported information contained within it; most importantly, the PTNS estimates of the realized strata coverage rates. This requires that the PTNS data accurately reflect how many total groundfish trips are taken and how many are observed. Unfortunately, there is no unique trip identifier to link PTNS trip declarations to the other fisheries-dependent data sources used to monitor the groundfish fishery. Absent a trip identifier, the PTNS cannot communicate directly with the other fisheries-dependent data collection systems to verify the accuracy of its information.

While there is no direct communication between the PTNS and other fisheries-dependent systems, the information contained in other data collection systems can be used to verify externally the accuracy of PTNS data and evaluate system performance. External verification methods such as matching on the vessel permit number and sail date are often useful; however, the match between the PTNS-declared sail date and actual sail date is inexact and often off by as much as 48 hours. Due to the inability to directly match trips, validation is limited to an examination of the total number of trips taken and observed. An additional issue in externally verifying PTNS information is the difficulty in identifying strata in the VMS activity declaration. Vessel operators must submit a groundfish activity declaration via VMS to NMFS prior to sailing on every groundfish trip. The activity declaration offers the only definitive way to classify groundfish versus non-groundfish trips from a regulatory perspective. Vessel identity, and by extension sector affiliation, can be determined from the activity declaration; however, determining the other criteria of the strata definition – gear category and fishing region – is difficult and imprecise. For this reason, attempts to validate the PTNS-realized strata coverage are inexact and not altogether useful. However, because vessel- and sector-level coverage can be verified using observer data and VMS activity declarations, a gross examination of the PTNS information can be conducted at these levels. These will be discussed in subsequent sections.

Impacts of trip cancelations on PTNS trip counts

It is critically important that the PTNS maintains an accurate accounting of the true number of groundfish trips taken. This also applies to an accurate accounting of the number of trips *not* taken. Given the need to fish around weather windows, crew availability, and equipment malfunctions, it is often difficult for vessel operators to determine 48 hours in advance whether they will fish on a particular day. Vessels operators will often declare trips in weekly batches while only actually sailing on a fraction of the declared days, to maintain flexibility given the 48-hour pre-trip notification requirement. While this practice is allowed, it is required that the vessel cancel all PTNS notifications for trips not taken. The non-cancelation of trips negatively impacts

PTNS performance by inflating the total trip count, effectively lowering the PTNS-estimated realized coverage.

Trip cancelations are particularly common among the ‘day-boat’ fleet, which generally comprises smaller vessels that are more sensitive to inclement weather. The cancelation rates for day trips were consistently four to six times higher than that of multi-day trips (trip duration >48 hours; Figure 25). There is a seasonal cycle to the cancelation rates of day trips, with cancelation rates lowest during the summer months and highest in the winter months, consistent with the need to fish around weather windows. Interestingly, there are no consistent seasonal cycles for multi-day trip cancelations. The September 2, 2010 release of the PTNS (Table 3) required a major change in the underlying database such that trip-type (i.e., day, multi-day) cannot be reliably tracked prior to that release. Despite the partial information for 2010, there is a notable increase in the cancelation rates of day trips from 2010 to 2011. This does not reflect a true increase in the fraction of declared trips that did not sail; rather, it reflects efforts taken by the NEFSC Fisheries Sampling Branch (FSB) staff to improve communication and outreach with the fishing industry on the need to cancel trips not taken, as well as improved monitoring of non-canceled trips. This pattern can also be seen in a comparison of PTNS-declared trips to VMS-declared trips that will be discussed in the next section.

Comparison of external and internal vessel-level coverage

Comparison of the internal PTNS estimates of total trip counts, observed trips and coverage rates to those from external sources is critical to evaluating the performance of the PTNS. Overall, the PTNS estimates of number of observed trips compare closely with the true number of observed trips on a vessel-by-vessel basis (Figure 26). Because the determination of whether a trip was observed is based on information provided by the service providers, who are contractually obligated to enter the information, these data within the PTNS generally tend to be of a higher quality than the data input by the fishing industry. There are slight differences between the PTNS and external observer data, though these are small, with most vessels falling close to the 1:1 identity line. There is greater variability between the PTNS estimates of groundfish trips and those estimates from VMS data, though the variability has generally decreased with each successive fishing year. The large numbers of vessels above the 1:1 identity line in 2010 indicate those vessels having a high incidence of not canceling PTNS notifications for trips that did not sail. Vessels falling below the 1:1 identity line represent vessels failing to notify all groundfish trips through the PTNS. Interestingly, the number of vessels where VMS declared groundfish trips exceeded the number of PTNS notifications has increased over time (137 vessels in 2010, 187 vessels in 2011, and 197 vessels in 2012). While this could indicate declines in general PTNS compliance, the trends could be obscured by improvements in PTNS trip cancelations; for example, non-cancelation of PTNS trips could be offsetting non-notifications.

Overall the PTNS estimates of vessel coverage rates relative to the observer/VMS-based realized coverage rates have generally improved over time. In addition, the level of variability in the coverage rates among vessels decreased considerably from 2011 to 2012. The decrease in the variability in vessel-level coverage will be explored in depth in a subsequent section. While improvements have been made over time in the level of agreement between PTNS- and externally-estimated vessel coverage, there are several vessels in fishing year 2012 that exhibit much higher internal PTNS coverage rates relative to the observer/VMS-realized coverage. The most likely explanation for these discrepancies is failure to declare all groundfish trips through the PTNS. As will be shown in the next section, these vessels are not spread homogenously throughout the fishery, but rather have a tendency to belong to certain groundfish sectors. These types of patterns can be improved in the future through targeted outreach and enforcement.

Comparison of external and internal sector-level coverage

A comparison of the PTNS estimates of sector-level coverage to those obtained externally from observer and VMS activity declarations show similar patterns to the vessel-level comparisons. In fishing year 2010, there was a tendency for PTNS coverage estimates to be lower than the observer/VMS-based estimates for all but four sectors (Figure 27). As with the vessel-level coverage, the most likely reason for the lower coverage rates estimated internally within the PTNS is the non-cancelation of trips that were declared but never sailed. In both 2011 and 2012 fishing years, there was greater consistency between the PTNS estimates of sector coverage and those obtained from observer data and VMS activity declarations. This can be directly attributed to improved compliance and monitoring of non-canceled trips. The variability in coverage rates between sectors was considerably reduced from 2011 to 2012. This is consistent with the patterns observed in the internal individual vessel coverage rates. The decrease in variability reflects directed efforts to ensure equitable observer coverage across all vessels. Examination of the distribution of vessel coverage within individual sectors highlights this point (Figure 28); the size of the interquartile ranges has decreased over time, and there is less spread in the mean and median sector-level coverage rates around the overall mean.

In all years, there are one to three sectors where the PTNS has estimated much larger observer coverage rates relative to the realized observer/VMS-based coverage (Figure 27). The cause of these discrepancies is failure to declare groundfish trips through the PTNS (i.e., non-compliance with the PTNS notification requirement). One sector – the common pool – is responsible for a moderately large number of trips in each of the fishing years and represents the most egregious offender. While efforts have been made to reach out this component of the fishery, without directed enforcement of PTNS notification requirements there is little that can be done to improve compliance.

Interestingly, there are seasonal trends in the degree of compliance with the PTNS notification requirement. Overall, there is lower PTNS compliance in April and May and peak compliance July through September (Figure 29). The seasonal trends are related to fishery activity, with the compliance trends being negatively correlated with the level of targeted monkfish activity (Figure 30). Monkfish-targeted behavior (i.e., fishing on a monkfish DAS) can be determined from the VMS activity declaration. Groundfish vessels fishing on a multispecies DAS but targeting monkfish are still subject to all groundfish reporting requirements, including the filing of a PTNS notification. Based on the relationship between vessel compliance and monkfish-targeted activity, it appears that the industry is not entirely cognizant of their groundfish reporting requirements when fishing simultaneously on both monkfish and groundfish DAS. One aspect to the low PTNS compliance among the common pool vessels is that, proportionally, a much larger fraction of common pool trips are targeting monkfish compared to sector vessels. Between 2010 and 2012, greater than 56% of common pool trips were fishing on monkfish DAS, compared to less than 11% of sector trips (Table 7). Common pool compliance with the PTNS notification requirement ranged from 69-76% when not fishing on a monkfish DAS (targeted groundfish trip), but less than 15% when fishing on a monkfish DAS. Comparatively, the compliance rate among sector vessels was greater than 79% when fishing on a monkfish DAS and greater than 89% when not fishing on a monkfish DAS.

PTNS internal strata-level coverage

While it is nearly impossible to accurately verify internal PTNS strata-level coverage using external sources, given the limitations of the NMFS's Northeast Region's fisheries-dependent data collection systems, the sector- and vessel-level comparisons have shown that, overall, the data contained in the PTNS provides an accurate representation of the realized coverage rates for the majority of groundfish vessels. This provides confidence in the internal PTNS data and allows inferences to be made about the strata-based coverage using only internal PTNS data. The distribution of strata-level coverage for the NEFOP and NMFS-funded ASM tiers is consistent with the expected system performance, based on the simulation results shown in Figure 7. There is high variability for strata with limited numbers of trips, but the variability decreases with an increasing number of trips, with strata-level coverage converging on the mean tier coverage as the number of trips increases (Figure 31). Annual estimates of tier-level coverage are provided in Table 6. Overall, at the strata-level the PTNS has performed consistent with the system design.

Despite the front-loading nature of the PTNS, there are a large number of strata with no observer coverage (Figure 32). While there may be a large number of strata, it is important to consider that they are not all highly active. In 2010 through 2012, there were 429, 316, and 195 trips, respectively, among strata that received no observer coverage. Relative to the total number of trips that occur in the groundfish fishery (Table 6), these represent less than 3.5% of the total annual trips.

Examination of alternate coverage metrics

The sampling unit of the PTNS is a fishing trip, and the target coverage rates are evaluated with respect to the ratio of observed trips relative to total trips occurring within a defined stratum. Other sampling frames/coverage metrics, such as days absent or total groundfish landings, while useful to evaluate, are difficult to define at the point of trip notification and therefore impractical for use in PTNS coverage selection. However, if the trip-based coverage is accomplished in an unbiased manner, coverage should be similar regardless of the metric used to evaluate it. As part of the PTNS web-based monitoring utility, coverage of both days absent and groundfish landings are regularly monitored.

The distribution of sector-level days absent-, groundfish landings-, and trip-based coverage were compared to the aggregate annual (fishing year total) trip-based coverage to determine the uniformity of observer coverage across alternate coverage metrics and evaluate whether there was evidence of temporal bias. Aggregate annual coverage levels are provided in Table 6. Between 2010 and 2012, the aggregate annual trip-based coverage levels were within +/- 1 standard deviation of the weekly mean (mean across sectors) of all three coverage metrics (Figure 33). The degree of variability in weekly coverage rates over time is consistent with the expectation from the simulation experiments. As time progresses and more trips enter the PTNS, the variability in the realized coverage generally decreases. Overall, there is little evidence of large-scale temporal biases in the rates. There was little fluctuation of the coverage rates after stabilizing around week 8 of the fishing year, with weekly mean rates similar to the overall annual trip-based coverage. Coverage based on days absent was slightly higher than the annual trip-based coverage in 2010 and 2011. This suggests that observed trips tended to be slightly longer than unobserved trips in these fishing years, though the cause of this pattern is unclear.

External evaluation of vessel-level coverage

PTNS is designed to provide equitable coverage across strata (sector, region and gear category) with sampling within individual stratum being random. This means that the linear selection method of the PTNS does not explicitly attempt to deploy coverage equitably among vessels. However, because coverage at the vessel level should be random, the vessel-level coverage at any particular activity level (number of trips) should be uniformly distributed, with the coverage converging on the stratum mean as activity increases (i.e., variability should decrease with increased activity). A Runs Test (Bradley 1968) was performed on the r_{trip} values generated by the PTNS to demonstrate the randomness of trip coverage assignments. Runs Tests were performed on r_{trip} values from fishing years 2011 and 2012 with the NEFOP- and NMFS-funded ASM evaluated separately. Due to the major change to the system design at the end of the 2010 fishing year, tier-level r_{trip} values are not available for fishing year 2010. The p-values from the Runs Tests were in excess of 0.3 for all fishing year, tier combinations indicating that the null hypothesis of randomness could not be rejected (Table 8). This finding is not surprising, given that the PTNS produces the r_{trip} values using a random number generator. These results demonstrate the random selection on a trip-by-trip basis and, by extension, on a vessel-by-vessel basis.

While, the selection of vessels for observer coverage by the PTNS is random, there are several non-random external factors that can influence whether a vessel actually ends up carrying an observer. Shortly after implementation of the PTNS in May 2010, it became clear that there was active vessel avoidance of observer coverage. Additionally, there were concerns raised by the fishing industry, particularly from fishing vessel operators who were experiencing high levels of observer coverage, that vessel-level coverage was non-random. These two concerns were directly related: the number of vessels experiencing no coverage negatively impacted the equitability of the coverage across all vessels. Since the PTNS is attempting to maintain strata-level coverage, low coverage on some fraction of vessels within a stratum must be compensated for by raising coverage on other vessels. Over time, directed efforts were made to mitigate vessel coverage inequities in a variety of ways. The first steps were taken in the August 16, 2010 PTNS update (Table 3) in an attempt to address the observer avoidance issue. As discussed in the design section, this fix effectively addressed those vessels exhibiting observer avoidance behavior, but has the unintended consequence of increasing observer coverage on vessels legitimately canceling trips (fishing around weather windows, etc.). The May 2, 2011 PTNS update (Table 3) addressed this issue by implementing low-coverage thresholds for placement on 'must deploy' tiers. In addition, changes were made to the web-based monitoring utility to scan for vessels that either fall below or exceed specified coverage levels. The web monitoring utility temporarily adds these vessels to the 'keep active' or 'do not deploy - coverage' selection tiers. Once a vessel falls back within the tolerance range, it is removed from these list tiers and returned to the normal random selection protocols. Usage of both tiers increased over time, though generally the use of these tiers is minimal relative to the random selection tiers (Table 5).

Evaluation of vessel-level coverage using observer data and VMS activity declarations shows that, overall, vessel coverage was random and uniformly distributed at a given activity level, and, with increasing vessel activity, the coverage converges on the overall mean (Figure 34). Comparison of vessel-level coverage across fishing years shows the influence of the various system modifications on vessel-level coverage. Overall, the level of variability of vessel-level coverage has declined in each successive fishing year. Because of the expected high variability when the number of trips is low, vessels were separated into two categories: those having taken fewer than ten trips and those having taken ten trips or greater (Figure 35). The reductions in vessel coverage variability from 2010 to 2011 were primarily due to the implementation of the low-coverage monitoring modifications to the PTNS released on May 2, 2011 (Table 3). A subsequent reduction in the coverage variability occurred from 2011 to 2012. While there were no system modifications from fishing year 2011 to 2012 that would have affected the coverage variability, there were several monitoring efforts taken to ensure more equitable coverage across fishing vessels. First, as noted above, there was more active management of the 'keep active' and 'do not deploy - coverage' tiers to increase the coverage on low-coverage vessels while reducing coverage on high-coverage vessels. Secondly, beginning during the 2011 fishing year, there was a concerted outreach initiative to observer service providers to ensure equitable coverage across vessels.

Outside of observer availability, there are at least two factors that affect the decision of a provider to select a particular trip for coverage: the vessel identity and trip characteristics. Providers are informed which vessels are taking the trips they have been offered, which can potentially result in the preferential coverage of certain vessels or avoidance of others. Both actions would contribute to non-equitable coverage across vessels. In 2010, there was considerable variability in vessel-level coverage including a large percentage (20%) of vessels that had received 100% coverage and those that had received no coverage at all (10%; Figure

36). By 2012 there were reductions in both extremes and an overall decline in the variability of coverage levels among vessels. There was still an undesirably high number of vessels at the two extremes, but these were largely restricted to vessels that have taken fewer than 50 trips.

One trip characteristic that may affect a provider's ability to accept a fishing trip is the port of sailing. Vessels sailing out of ports outside the region of core activity may experience lower observer coverage due to the difficulty in deploying observers to these areas, and to high travel costs in the event observers are not regularly stationed in the regions. In fishing year 2010, there was considerable disparity in coverage among states with the Mid-Atlantic states (New York, New Jersey, and Virginia) receiving lower coverage relative to the New England states (Figure 37). The lower coverage in the Mid-Atlantic states was not due to differential selection by the PTNS, but rather higher provider decline rates for these states. ASM observers are not regularly stationed in the Mid-Atlantic states. Incremental improvements were seen in the state-level coverage in both 2011 and 2012. By fishing year 2012, provider decline rates were similar across states. Some of this may have been due to improvements within the provider operations, but there was also a notable decrease in the overall number of trips sailing from Mid-Atlantic ports from 2010 through 2012.

Trip duration (e.g., day vs. multi-day) is also a trip characteristic that has the potential to affect a provider's willingness to accept a trip that has been selected by the PTNS. Logistically, multi-day trips are easier to coordinate, given the lower likelihood of a trip being canceled and greater reward in the form of more sea days per coordination efforts. In the past, providers have complained about the inequitable offering of multi-day trips to each provider. While the complaints were investigated and found to be unfounded, it is evidence of the high value of multi-day trips to providers. To evaluate the decline rate by trip type, an odds ratio test was conducted. The odds ratios indicated that day trips were between 2.9 and 7.7 times more likely to be declined than multi-day trips in 2010 and 2011 (Table 9). Correspondingly, the observer coverage rates were higher for multi-day trips. Interestingly, in 2012, multi-day trips were 2.3 times more likely to be declined than day trips, resulting in higher observer coverage of day trips. It is unknown exactly why there was a reversal in the patterns from 2011 to 2012. While it can't be quantified, it is known that in 2010 and 2011 some providers would initially accept more day trips than could be covered to increase their flexibility, given that 'day-boat' trips would experience a higher vessel cancelation rate. This practice was discontinued in 2012. There was also a change in the NEFOP service provider in 2012, which could have impacted both NEFOP and ASM coverage in unexpected ways.

Meeting the needs of other monitoring programs

In addition to deploying observer coverage to meet the base coverage requirements of the groundfish catch monitoring, the PTNS is also responsible for meeting other coverage requirements within the groundfish fishery. These include providing coverage of the four groundfish SMP and protect species bycatch monitoring.

In fishing years 2010 to 2012, use of the SMP tiers within the PTNS were seldom utilized (Table 5). The primary reason for this is that the SMP coverage requirements were always less than the base groundfish fishery coverage requirements. For example, mandated SMP coverage ranges from 10 to 20%, depending on the SMP, yet the base coverage exceeded 20% in all years (Table 6). Because of the compensatory nature of the linear selection, the probability of selection at the SMP tiers was low. In the future, if the base coverage declines below the mandated SMP coverage requirements, then use of these selection tiers would be expected to increase.

Observer deployment for the monitoring of protected species bycatch in the groundfish fishery is accommodated in the PTNS using a sea day schedule (Figure 3). The NEFSC Protected Species Branch generates a sea day schedule annually based on an expectation of fleet activity on a port, month, and gear type basis. Frequently, fleet activity within individual sea day strata are not sufficient to meet the specified sea day coverage and the unused sea days must be manually 'rolled' over to the next month. Typically, the port and gear stratification is held identical to the previous month, but occasionally the sea days are reallocated to different ports where fishing activity is more likely. The need to continually 'rollover' unused sea days highlights the difficulty and lack of efficiency of a sea day schedule deployment scheme. From the perspective of sampling design, the sea day schedule approach assumes that fishing activity during the deployment period will be identical to fishing activity from the reference period. As has been demonstrated through three years of deployment of protected species coverage using a sea day schedule, this is often not the case. Similar to how groundfish bycatch monitoring is deployed, an adaptive deployment approach where observer deployment was distributed proportional to fishing effort would offer improvements over the sea day schedule.

DISCUSSION

Overall, the PTNS has worked consistent with the system design and was successful in meeting the diverse objectives of a complex observer deployment system. The PTNS utilized over 93% of the nearly twenty-five thousand sea days allocated to it from 2010 to 2012. Equally important, the sea day utilization was accomplished in a manner that spread observer coverage proportional to fishing effort, resulting in consistent coverage over time and across multiple coverage metrics, including days absent and groundfish landings. This provides some indication that, at least at a gross level, there is no strong evidence of observer bias, though there are some indications of observed trips being slightly longer in 2010 and 2011. The issue of observer bias requires additional research and is outside the scope of this paper. The deployments of both NEFOP- and NMFS-funded ASM observers was done in such a way as to make the resulting discard rates from these two programs statistically indistinguishable across a broad range of groundfish species and gear types (Wigley et al. 2012).

The self-adjusting nature of the PTNS linear selection method was effective at reducing coverage variability and, in turn, increasing coverage equitability as additional trips entered the PTNS. Additionally, the self-adjusting nature mitigated many of the coverage rate perturbations induced by external factors, such as vessel avoidance and observer saturation. These are expected characteristics of the PTNS and reflect the importance of simulation work during the design of complex monitoring systems. Some of the real-world complexities of running such a system were not considered in the initial simulations, and required system modifications over time to address. These highlight the need to regularly evaluate system performance and identify areas of improvement.

Need for continued improvements

It is one thing to design a system that performs optimally in simple theoretical simulations, but extremely difficult to design a system robust to the realities of a production deployment. The PTNS encountered its share of these realities over time, some of which were addressed through system enhancements and others through external low-coverage monitoring and outreach to observer service providers. The net results of these efforts were sequential improvements in system performance between 2010 and 2012. Many of the remaining issues can be addressed through minor system improvements in concert with continued improvements in coverage monitoring and outreach activities. While system improvements may lead to marginal gains in performance, the biggest challenge for the PTNS is compensating for external human factors such as vessel compliance, observer availability, and objective provider selection of vessels and trips.

Perhaps the largest external factor affecting optimal performance of the PTNS relates to vessel compliance, both with respect to declaring all groundfish trips and canceling all trips that were declared but never sailed. The optimal performance of the PTNS requires the accuracy of the internal trip count information. While the analyses show that the current system has reasonable accuracy, there continue to be small differences in both the counts of observed trips and total groundfish trips. Compliance among vessels targeting monkfish continues to be the most problematic area with respect to trip counts, particularly for common pool vessels. Targeted outreach and education to this portion of the fleet could lead to large improvements in PTNS notification compliance. The cancelation of declared trips that did not sail was a large problem in fishing year 2010 but has decreased over time, primarily as the result of monitoring and outreach by the NEFSC Fisheries Sampling Branch staff. In fishing year 2012, the non-cancelation of fishing trips had minimal impact on PTNS performance. Both of these issues highlight the need for the PTNS to directly communicate with the other fisheries-dependent data collection systems, like VMS activity declarations and observer data.

A means of direct communication between data collection systems would greatly improve compliance monitoring and enforcement efforts. Equally important, a means for the PTNS to directly communicate with other data collection systems would allow the PTNS to incorporate a feedback loop to auto-correct the declaration information and maintain accurate accounting of the number of groundfish trips taken. The most obvious solution to this problem is to create a unique trip identifier that can be used to link trips across all of the regional fisheries-dependent data collection systems. The unique trip identifier should be generated by the first system that a vessel must report to for a given fishing trip; for the groundfish fishery, that system is the PTNS (i.e., 48 hours in advance of sailing). The unique trip identifier would then propagate through to the other data collection systems. As more of the region's data collection systems migrate towards electronic collection (e.g., electronic vessel trip reports), the ease of propagating a unique trip identifier from system to system should improve. Uniquely linking trips across data collection systems would also lead to improved efficiencies by reducing the amount of duplicative information currently being collected from the fishing industry.

The ability to utilize all of the sea days allocated to the PTNS is contingent upon having a sufficient number of observers available for deployment. As seen with NEFOP coverage in 2011, an insufficient number of observers can lead to sub-optimal utilization of the allocated sea days. The availability of observers is affected by many factors, including the total number of certified observers in the region, the number of allocated sea days, and the competing coverage demands of other fisheries. For service providers, balancing these demands is a difficult task requiring planning and coordination. Having too few observers is problematic from the perspective of coverage deployment, but too many observers can be detrimental to the retention of qualified observers. Maintaining sufficient observers requires a balancing of seasonal coverage demands, employee losses, and training sessions for new observers. Continued experience with balancing these demands should improve observer availability in future fishing years.

There remains a need to continue to work with observer providers to further improve the equitability of provider selection, with respect to both vessels and trips. Ensuring that providers are not preferentially selecting or declining trips based on the identity of the vessel is critical. A modification to the PTNS to hide the vessel identity from the provider until after the trip selection has been made may be one possible solution to the provider selection issue. Unfortunately, unlike the vessel identity, the trip characteristic information (port of sailing, trip duration) is critical for provider planning purposes and cannot be hidden from the provider. These areas can be addressed through real-time monitoring of provider decline rates across a range of metrics, including port of sailing and trip duration, and then working with providers to ensure unbiased selection.

While external factors pose the biggest challenges to PTNS performance, there are several areas of the PTNS where improvements could be made. The PTNS has required manual interventions to adjust target coverage rates in response to fleet behavior and provider capacity. While this is anticipated, more automated methods need to be explored to adjust target coverage rates in response to sea day burn trajectories and realized observer coverage. Not only will this reduce the extent of manual intervention on the part of the system administrator, it will also help prevent the types of sea day under-utilization similar to what occurred with the NEFOP sea days in 2010. This under-burn had less to do with observer saturation and more to do with a lack of responsiveness to the under-burn.

Automation of the 'keep active' and 'do not deploy - coverage' list tier maintenance is also needed. The process is currently managed through a semi-automated procedure run through the PTNS web-based monitoring and reporting utility; however, it requires some manual intervention on the part of a system administrator to adjust the coverage tolerance ranges that control when vessels are added and removed from these lists. The maintenance of these list tiers should be moved to the database level and linked directly back to mean vessel coverage rates such that the tolerances are established dynamically based on some plus/minus percentage of the mean vessel coverage rate at any given time.

Meeting system requirements, providing flexibility, and minimizing the burden to industry was, and continues to be, a challenge. The trip-based nature of the PTNS works well from the perspective of system design but it has proven to be burdensome for 'day-boat' operators and observer service providers. As discussed previously, many 'day-boat' vessel operators will submit a notification for every day of the week in order to maintain the flexibility to fish around weather and/or crew availability; trips on which they don't sail are then canceled both before and after the provider assignment. With the service provider potentially varying from trip to trip this translates numerous phone calls, emails, and communication with a variety of contacts in a given week and is a source of frustration. Industry has expressed a desire to be selected for an entire week's worth of trips, such that any time the vessel sails during that week, an observer must be on board and communication would only occur with a single provider. The weekly notification strategy is currently employed in the herring fleet; however, there are large differences in size and complexity between the two fisheries. Additionally, observer coverage in the herring fishery is deployed using a manual call-in system, not an automated statistical design. Weekly notifications would require significant restructuring of the PTNS but has been considered for future upgrades.

Criticisms of the PTNS

A recent report criticized several aspects of the PTNS (NEI 2011); however, these criticisms were levied without a full understanding of how the PTNS functions. One aspect of the report criticized the PTNS for not achieving normally distributed coverage. As was illustrated in the theoretical simulations (Figures 9 and 10) and documented in practice, it is not expected that the distribution of PTNS selections will be normally distributed. The linear selection method of the PTNS actively works to reduce variance, resulting in under-dispersion. The authors of the NEI (2011) report did accurately capture some of the vessel coverage equitability issues that had plagued the PTNS design in fishing year 2010; however, by the time the report was published in September 2011, these issues had largely been resolved.

The NEI (2011) authors incorrectly assumed that the inequities across sector level coverage (e.g., Figure 27 and 28) were due to varying target coverage rates across strata in response to meeting specified CV requirements. "*It is reasonably clear that combined coverage levels of NEFO[P]s and ASMs across sectors were unequal in FY 2010 from a statistical perspective…We believe* *that one plausible reason for this is that NEFSC-FSB goals in setting coverage levels were based on meeting "coefficient of variation" requirements for specific gears fished in specific areas (Gear/Area Stratum) as outlined in the 2010 SBRM process (NEFSC-FSB, 2010b). These requirements are likely to be at odds with a goal to have fair and equitable coverage levels across sectors, particularly if SBRM coverage levels vary across strata and if sectors have varying levels of participation in different strata.*" Their assumption is not correct. In 2010, all strata within a tier were assigned identical target coverage rates, with the exception of the NMFS-funded ASM target coverage rate for the common pool. The inequities across strata in 2010 were the result of differential vessel compliance with PTNS requirements and provider selections.

The NEI (2011) report also took issue with the fact that the coverage of the groundfish fishery was not achieving fishing year 2010 coverage goals of 38% that were being referenced publicly. Ultimately, the groundfish fishery was covered at approximately 29.3% in 2010 (Table 6). The discrepancy between publicly referenced targets and realized coverage raises important issues about the realities of developing sea day budgets and running a PTNS-type system. If the PTNS could operate off of a limitless budget, it could be tuned to realized target coverage rates. However, that is not the reality of how most observer deployment programs are operated. The sea days allocated prior to the start of the fishing years are contingent on many factors, one of which is the desired coverage levels. Once the fishing year begins, sea day allocations seldom change, and the realized target coverage rates are primarily a function of allocated sea days, fleet activity, and observer availability.

Expansion to other Northeast U.S. fisheries

Automated observer deployment systems will likely become more commonplace as fishery regulations become more complex in response to industry demands for greater flexibility and need for improved accuracy and precision in monitoring fishery catches. While the PTNS was a first-of-its-kind automated deployment system, since the deployment of the PTNS in May 2010, at least one other system has been developed and deployed in North America. The National Marine Fisheries Service's Alaska Region developed and deployed their Observer Declare and Deploy System (ODDS) for the groundfish and Pacific halibut, *Hippoglossus stenolepis*, fisheries on January 1, 2013 (USOFR 2012). The system has objectives similar to the PTNS in that it attempts to deploy observers in a statistically unbiased manner among a subset of the fleet chosen for trip-based selection.

Though not described in this paper, based on the initial success of the PTNS in the groundfish fishery, the PTNS was expanded to the targeted long finned squid (*Doryteuthis pealeii)* fishery in January 2011 (Table 3). There are other fisheries in the northeast U.S. with existing observer notification requirements, such as the Atlantic sea scallop (*Placopecten magellanicus*) and Atlantic herring (*Clupea harengus*) fisheries, which could be incorporated into the PTNS. For vessels participating in multiple fisheries, a single observer notification system could streamline vessel reporting requirements. Additionally, it may offer efficiencies with respect to system administration and support. While broadening the scope of the PTNS can offer many efficiencies, past experiences with large-scale improvements and application to multiple fisheries has shown that large changes to a system of this complexity are not simple and require extensive planning and development time to properly implement.

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TABLES

Table 1. List of the selection tiers within the groundfish Pre-Trip Notification System (PTNS).

Tier order	Selection tier	Tier description	Tier Type	Coverage type
1	Manual waiver	Allows for a system administrator to waive coverage of a trip.	Conditional	Waiver
2	Set-only (gillnet only)	Used to waive observer coverage on gillnet trips that are sailing only for the explicit purpose of setting gear. This is used only when there is no intention of hauling gear and subsequently no harvest of fish.	Conditional	Waiver
3	Do not deploy - safety	Used to waive observer coverage on a short-term basis when a vessel has been previously identified to be a safety concern for deployed observers.	List	Waiver
4	Do not deploy - coverage	Used to waive observer coverage on a short-term basis for individual vessels documented to have experienced excessively high coverage.	List	Waiver
5	Northeast Fisheries Observer Program (NEFOP) baseline coverage	Provides the baseline coverage of the groundfish fishery using NEFOP trained observers	Probability-based	NEFOP
6	Special Management Program (SMP) coverage	Provides coverage of SMPs in the event that the base NEFOP and ASM coverage is insufficient to meet the coverage demands of indicidual SMPs.	Probability-based	NEFOP
7	Protected species coverage	Provides coverage for the monitoring of protected species bycatch.	Sea day schedule	NEFOP-limited
8	NMFS funded At-Sea Monitoring (ASM)	Provides ASM coverage of the groundfish fishery beyond NEFOP coverage needed to meet sector monitoring demands. Trips selected at this tier are funded by NMFS.	Probability-based	ASM
9	Industry funded At-Sea Monitoring (ASM) - *optional*	Provides ASM coverage of the groundfish fishery beyond NEFOP coverage needed to meet sector monitoring demands. Trips selected at this tier are funded by industry.	Probability-based	ASM
10	Keep active	Provides coverage to meet a range of short-term compliance needs where coverage is required for certain vessels.	List	ASM

Table 2. Example of the provider selection process when multiple providers exist for a Pre-Trip Notification selection tier. In this example the random selection variable, $r_{provider}$ = 0.294. The lists are sorted in ascending order based on the number of certified observers each provider has in service at the time of the trip notification. Selection is performed based on a comparison of the random selection variable to the cumulative proportion of each provider. The selected provider of At-Sea Monitor (ASM) coverage for each step is highlighted in grey.

Provider selection step	ASM provider	Certified observers	Total observers in region	Proportion of observers in region	Cumulative proportions
1	Provider C	4	39	0.103	0.103
	Provider A	5	39	0.128	0.231
	Provider D	10	39	0.256	0.487
	Provider B	20	39	0.513	1.000
2	Provider C	4	29	0.138	0.138
	Provider A	5	29	0.172	0.310
	Provider B	20	29	0.690	1.000

Table 3. List of Pre-Trip Notification System (PTNS) modifications over time.

Version number	Date	Scope of modification	System modification
1.0.1	May 1, 2010	Major	Initial release
1.0.2	May 18, 2010	Minor	Miscellaneous bug fixes
1.0.3	June 16, 2010	Minor	Improved functionality and usability
1.1.1	August 16, 2010	Major	Handling of set-only gillnet trips and first attempt to address observer avoidance issues
1.1.2	September 2, 2010	Moderate	Addition of the protected species coverage tier, collection of trip duration information
1.1.3	November 3, 2010	Minor	Miscellaneous system work to improve functionality and prepare the system to accommodate other non-groundfish fisheries
1.2.1	December 30, 2010	Major	Incorporation of the directed long-finned squid fishery (non-groundfish)
1.2.2	January 4, 2011	Minor	Upgrade to the PTNS web-server
1.3.1	May 2, 2011	Major	Implementation of 'separate' tier selection and compliance thresholds

Table 4. Summary of the Northeast Fisheries Observer Program (NEFOP) and At-Sea Monitor (ASM) sea days allocation and utilization by fishing year.

Coverage type	Year	Allocated sea days	Utilized sea days	Percent sea days utilized (%)
NEFOP	2010	2,208	1,863	84.4%
	2011	3,386	2,694	79.6%
	2012	1,338	1,320	98.7%
ASM	2010	5,991	5,761	96.2%
	2011	6,814	6,909	101.4%
	2012	5,225	4,887	93.5%

Table 5. Summary of Pre-Trip Notification System (PTNS) trip selections by fishing year and selection tier. Trips indicated as observed within the PTNS are also summarized. *Note that trip and observed trip counts reflect internal PTNS counts and may not match the external estimates contained in Tables 6-8. Acronyms: At-Sea Monitoring (ASM), National Marine Fisheries Service (NMFS), Northeast Fisheries Observer Program (NEFOP), Special Management Program (SMP).*

Fishing year	Total annual declared trips	Tier order	Selection tier	Trips selected	Percentage of total trips (%)	Trips observed	Percentage of total trips (%)
2010	15,851	1	Manual waiver	559	3.5		0.0
		2	Set-only	108	0.7		0.0
		3	Do not deploy - safety	83	0.5		0.0
		4	Do not deploy - coverage	213	1.3		0.0
		5	NEFOP	3,354	21.2	882	5.6
		6	SMP	38	0.2	14	0.1
		7	Protected species limited coverage	203	1.3	51	0.3
		8	NMFS-funded ASM	5,489	34.6	3,044	19.2
		10	Keep active	12	0.1	4	0.0
		11	Not selected	5,792	36.5		0.0
2011	14,062	1	Manual waiver	333	2.4		0.0
		2	Set-only	172	1.2		0.0
		3	Do not deploy - safety	160	1.1		0.0
		4	Do not deploy - coverage	303	2.2		0.0
		5	NEFOP	5,618	40.0	1,029	7.3
		6	SMP	8	0.1	6	0.0
		7	Protected species limited coverage	133	0.9	111	0.8
		8	NMFS-funded ASM	4,669	33.2	3,022	21.5
		10	Keep active	228	1.6	110	0.8
		11	Not selected	2,438	17.3		0.0
2012	12,745	1	Manual waiver	213	1.7		0.0
		2	Set-only	89	0.7		0.0
		3	Do not deploy - safety	61	0.5		0.0
		4	Do not deploy - coverage	842	6.6		0.0
		5	NEFOP	2,395	18.8	806	6.3
		6	SMP	8	0.1	1	0.0
		7	Protected species limited coverage	50	0.4	45	0.4
		8	NMFS-funded ASM	2,372	18.6	1,701	13.3
		10	Keep active	709	5.6	590	4.6
		11	Not selected	6,006	47.1		0.0

Table 6. Estimates of observer coverage rates in the groundfish fishery for fishing years 2010-2012 by coverage type.
Acronyms: At-Sea Monitoring (ASM), National Marine Fisheries Service (NMFS), Northeast Fisheries Observer Program (NEFOP), Vessel Monitoring System (VMS).

Fishing Year	Tier Name	Observed trips	Total VMS trips	Tier coverage	Fraction of annual trips receiving observer coverage
2010	NEFOP	898	13,313	0.067	0.293
	NMFS-funded ASM	2,998		0.225	
2011	NEFOP	1,005	15,614	0.064	0.260
	NMFS-funded ASM	3,047		0.195	
2012	NEFOP	784	14,315	0.055	0.208
	NMFS-funded ASM	2,193		0.153	

Table 7. Summary of Pre-Trip Notification System (PTNS) compliance by fishing year, sector type (common pool or sector) and Vessel Monitoring System (VMS) activity declaration (groundfish, monkfish). PTNS compliance refers the fraction of groundfish trip declared through a VMS activity declaration with a positive PTNS notification. *Note that the PTNS trip counts only include PTNS notifications that could be matched to a VMS-declared trip within a 48 hour tolerance window.*

Sector type	Fishing year	Trip type	Total groundfish trips	Fraction of groundfish trips fishing on monkfish DAS	Trips declared into PTNS	Fraction of trips declared into PTNS
Common pool	2010	Groundfish	776	0.569	586	0.755
		Monkfish	1,026		124	0.121
	2011	Groundfish	316	0.795	228	0.722
		Monkfish	1,228		175	0.143
	2012	Groundfish	213	0.794	146	0.685
		Monkfish	819		60	0.073
Sector	2010	Groundfish	10,281	0.107	9,238	0.899
		Monkfish	1,230		979	0.796
	2011	Groundfish	12,690	0.098	11,728	0.924
		Monkfish	1,380		1,168	0.846
	2012	Groundfish	12,153	0.085	10,843	0.892
		Monkfish	1,130		908	0.804

Table 8. Results of a Runs Test for randomness on the Pre-Trip Notification System (PTNS) r_{tier} values. The Z statistics are presented by fishing year and PTNS selection tier for with the associated p-values shown in parentheses. Tier-level r_{tier} were not available prior to fishing year 2011.

Tier	2011	2012
NEFOP	0.985 (*0.325*)	0.587 (*0.557*)
NMFS-funded ASM	-0.735 (*0.462*)	0.843 (*0.399*)

Table 9. Provider decline rates by trip type (day and multi-day). Odds ratio are expressed in terms of decline rates between trip types (odds ratios are multi-day/day). *Note that 2010 is a partial year since trip type could not be tracked prior to September 2, 2010. Additionally, trip counts and associated observer coverage rates will differ from those in Table 4 due to differences in the information source (internal Pre-trip Notification System data vs. external sources).*

Fishing year	Trip type	Total trips taken	Trips offered to provider	Trips accept by provider	Trips declined by provider	Observer coverage level	Probability of provider declining the trip	Odds of provider decline	Odds ratio (95% CI)	*P*-value
2010	Day	7,771	4,485	1,859	2,626	0.24	0.59	1.41	0.12 (0.10-0.16)	<.0001
	Multi-day	1,670	576	491	85	0.29	0.15	0.17		
2011	Day	11,586	9,187	3,373	5,814	0.29	0.63	1.72	0.35 (0.31-0.39)	<.0001
	Multi-day	2,476	1,446	905	541	0.37	0.37	0.60		
2012	Day	10,390	4,316	2,654	1,662	0.26	0.39	0.63	2.30 (2.02-2.62)	<.0001
	Multi-day	2,355	1,199	491	708	0.21	0.59	1.44		

FIGURES

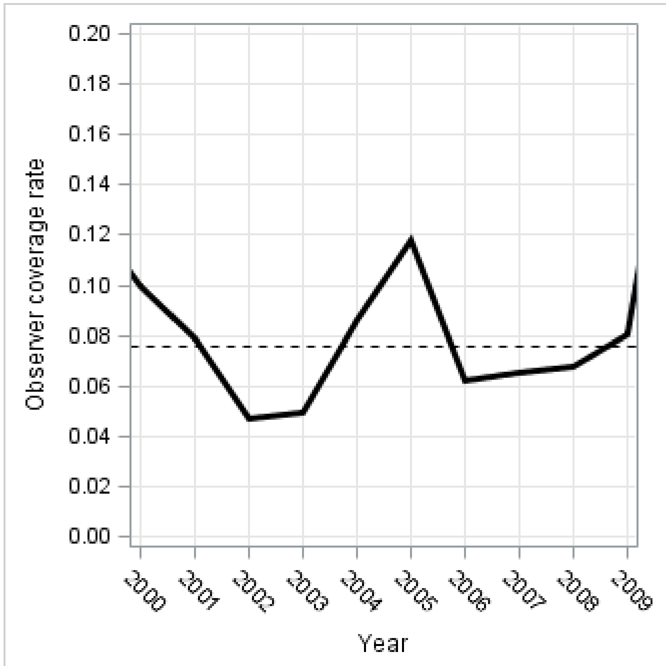

Figure 1. Observer coverage rate estimates for the northeast United States groundfish fishery between 2000 and 2009. The dashed line indicated the mean coverage rate over the time period. Note that groundfish coverage rate estimates are sensitive to many analytical assumptions and are illustrative rather than definitive.

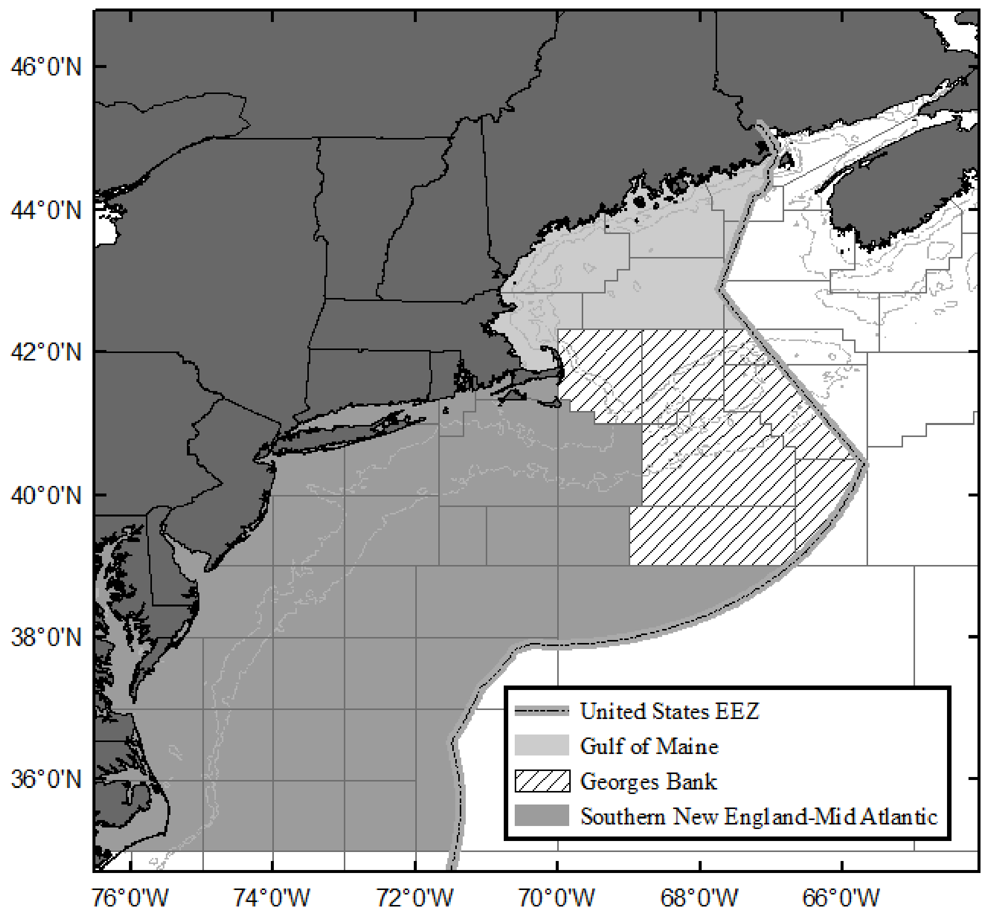

Figure 2. Map of the offshore waters of the northeast United States showing the three fishing regions as defined by the Pre-Trip Notification System within the U.S. Exclusive Economic Zone (EEZ). The gridded area delineates North Atlantic Fisheries Organization (NAFO) statistical areas. The 50 m and 100 m bathymetry lines are indicated by thin grey lines.

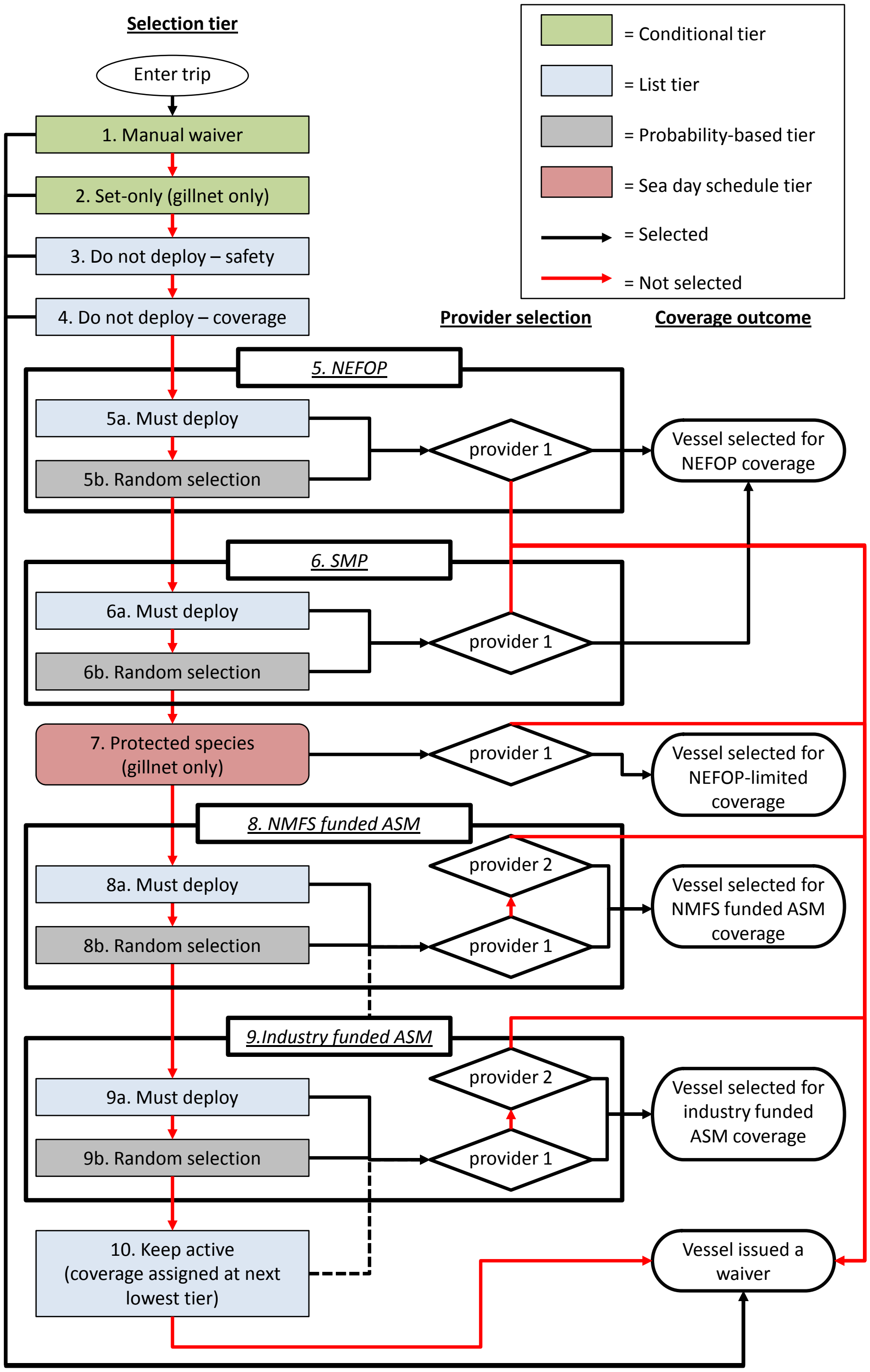

Figure 3. Schematic diagram illustrating the hierarchal tier selection of the groundfish Pre-Trip Notification System. *Acronyms: At-Sea Monitoring (ASM), National Marine Fisheries Service (NMFS), Northeast Fisheries Observer Program (NEFOP), Special Management Program (SMP).*

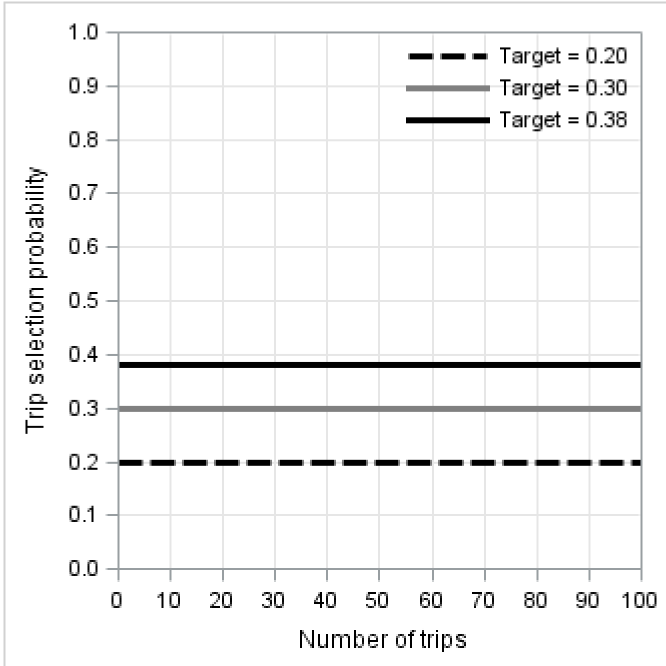

Figure 4. Schematic illustrating the ‘fixed’ method for determining trip selection probabilities. The application of the fixed method at three different target coverage rates (0.20, 0.30, 0.38) is shown.

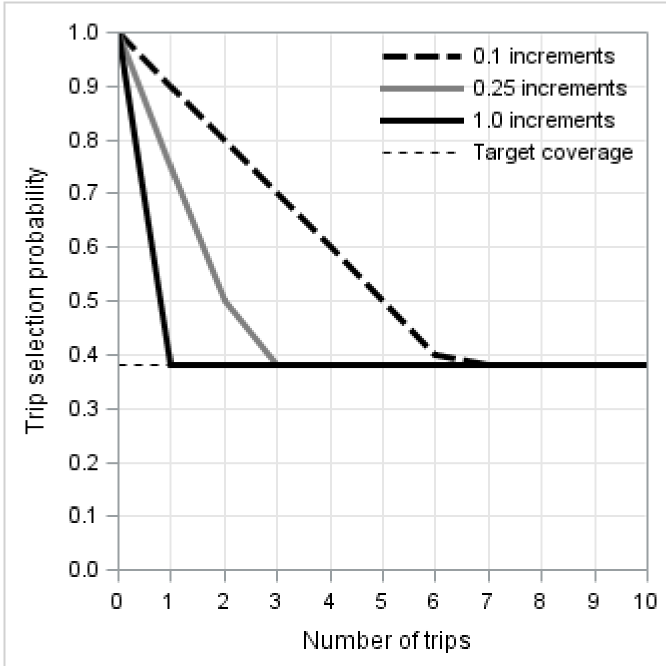

Figure 5. Schematic illustrating the ‘incremental’ method for determining trip selection probabilities. The selection probability is a function of the total number of trips existing within the stratum combined with a sequential decrementing of the selection probability based on a pre-determined increment amount (0.1, 0.25, 1.0). In all examples the target coverage rate is set at 0.38.

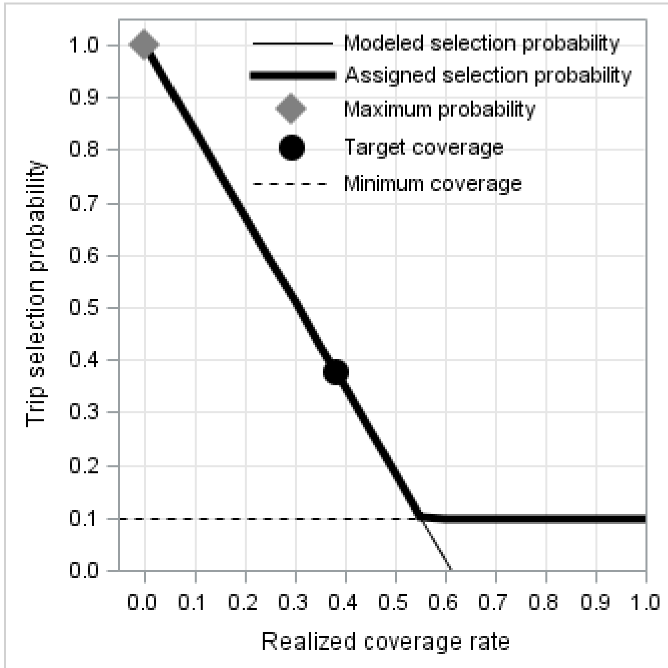

Figure 6. Schematic illustrating the 'linear' method for determining trip selection probabilities. In the 'linear' method, selection probabilities are determined based on the realized observer coverage rates for each stratum at the time at which the trip is entered into the selection process. The 'linear' method requires specification of three parameters: a maximum probability (probability of selection when realized coverage is equal to zero), a target probability (i.e., target coverage rate), and a minimum coverage rate.

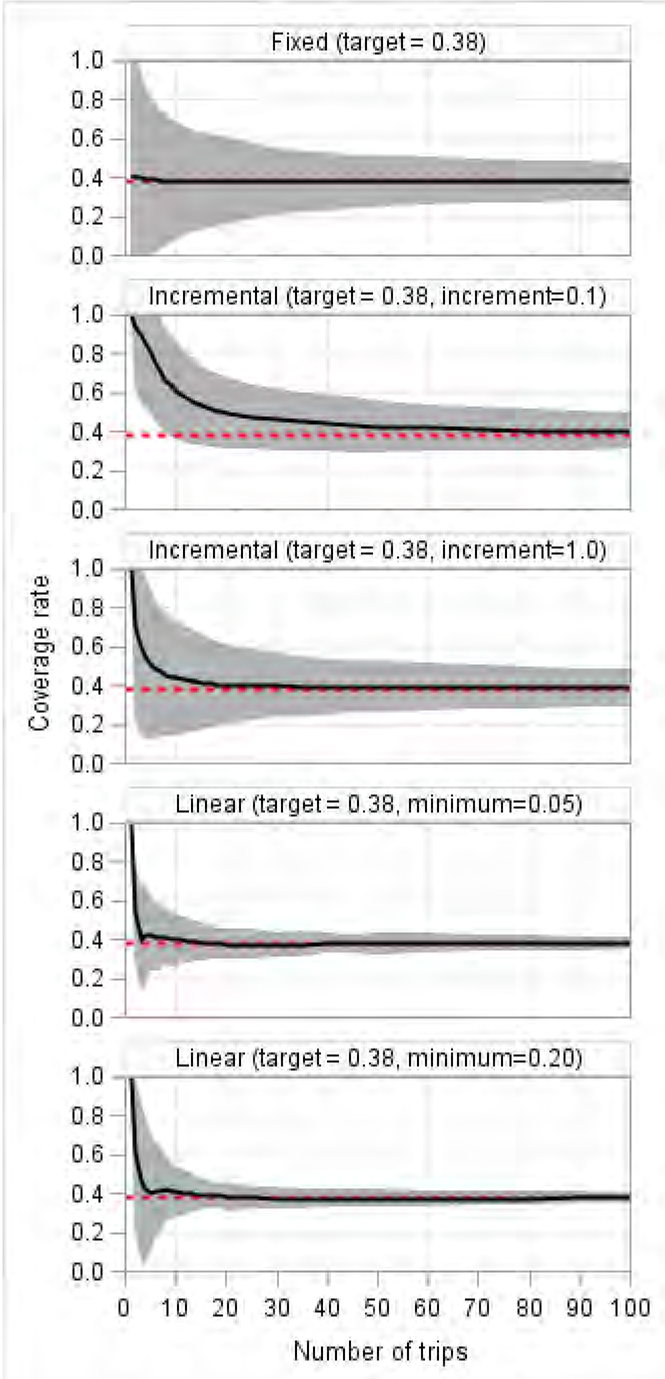

Figure 7. Comparative performance of the ‘fixed’, ‘incremental’, and ‘linear’ selection methods with respect to meeting a target coverage rate. Results are based on 500 iterations of a simple single-tier simulation with a specified target coverage rate of 0.38 (dashed red line). The mean coverage (solid black line) and 95% confidence intervals (grey band) from all simulation runs is shown.

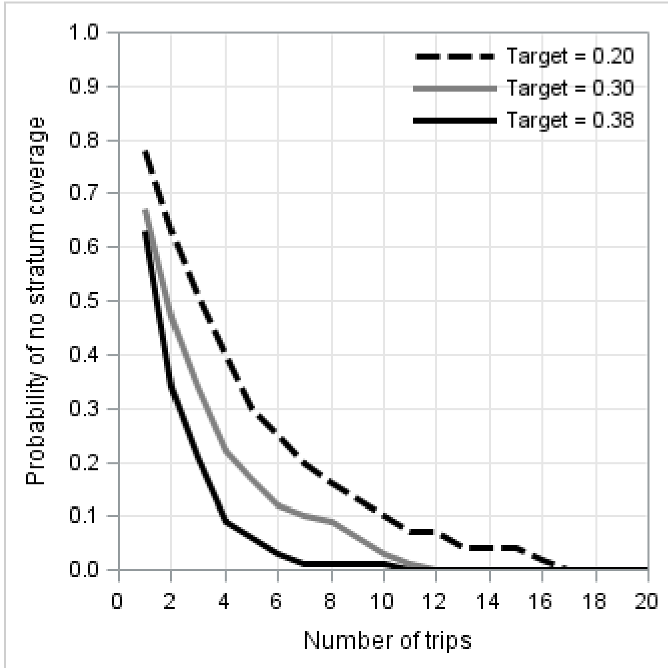

Figure 8. Mean probability of having no observer coverage within a stratum as a function of total stratum trips when using the ‘fixed’ method to assign observer coverage at three target coverage levels (0.20, 0.30, 0.38). Results shown are based on 100 iterations of a simple, single-tier simulation.

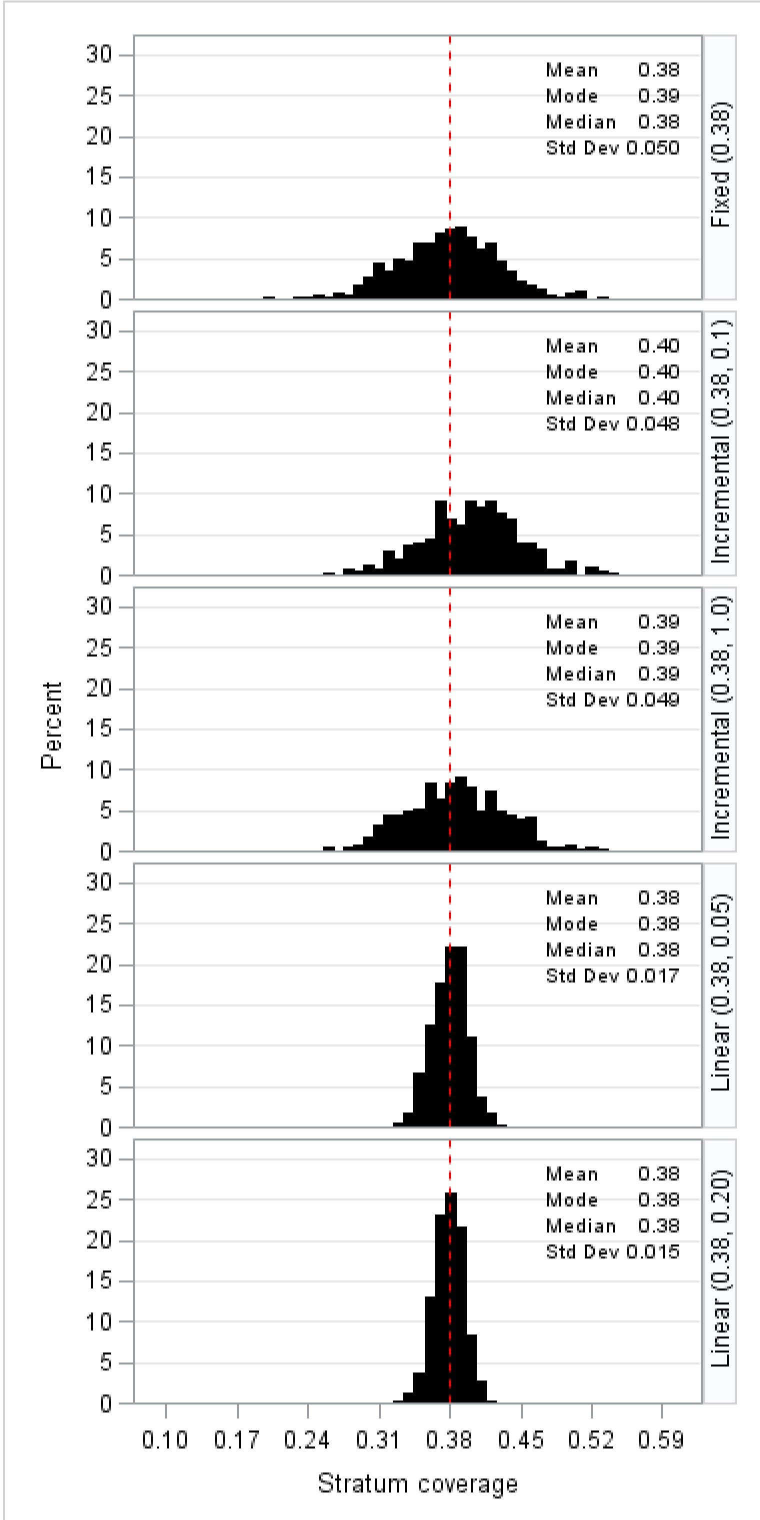

Figure 9. Histogram of coverage distributions from ‘fixed’, ‘incremental’, and ‘linear’ selection methods. Results are from 500 iterations of a simple single-tier simulation with a specified target coverage rate of 0.38 (dashed red line).

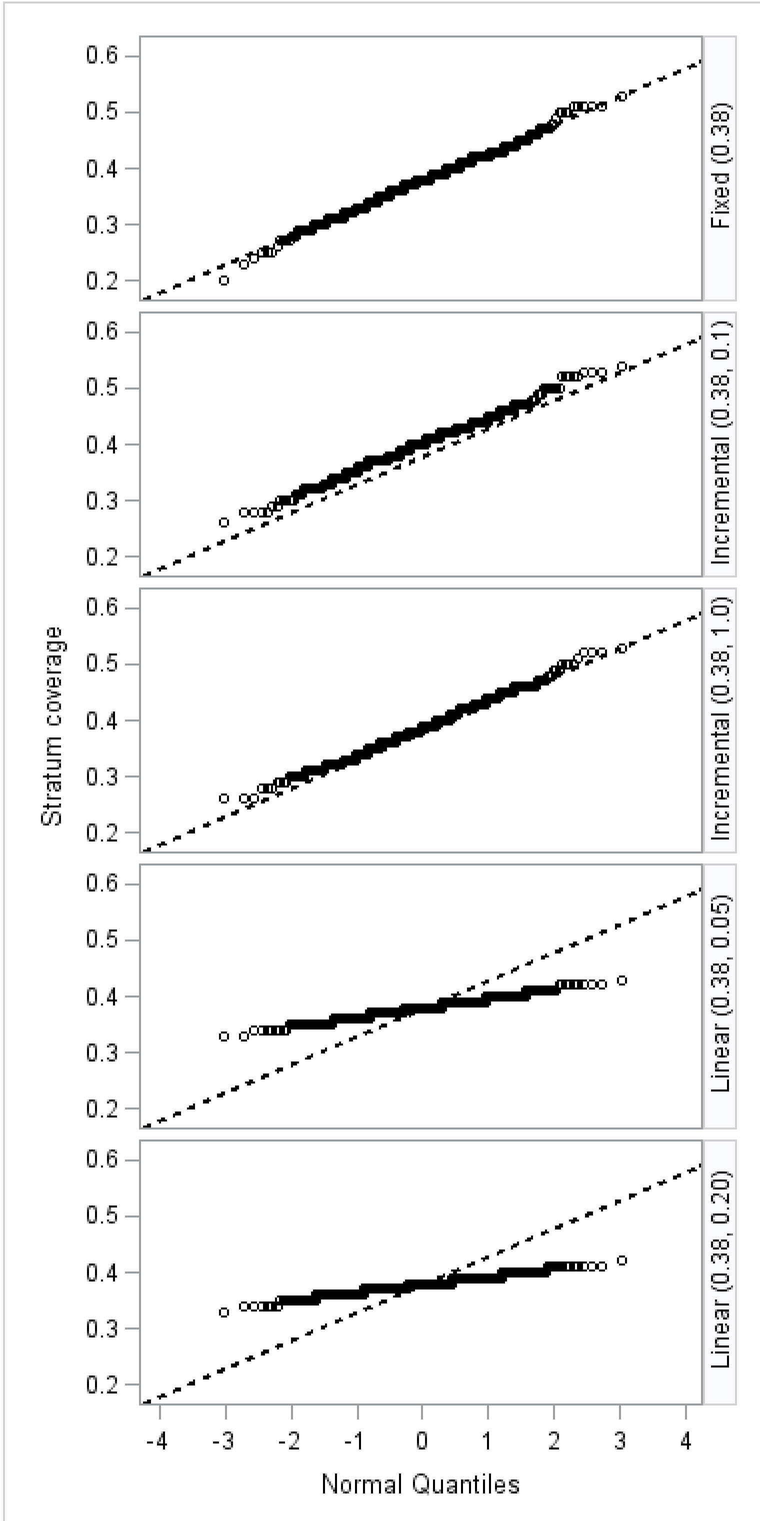

Figure 10. Quantile-quantile plots (Q-Q plots) from ‘fixed’, ‘incremental’, and ‘linear’ selection methods. Results are from 500 iterations of a simple single-tier simulation.

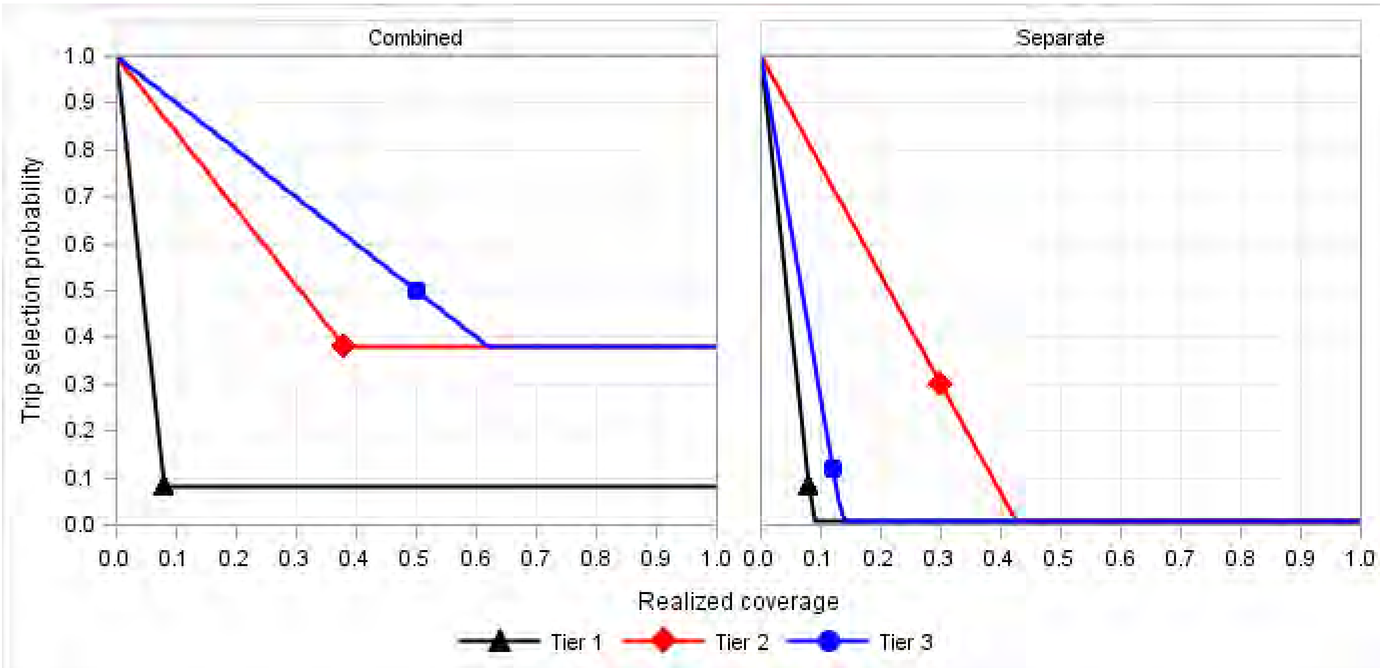

Figure 11. Examples of a 'separate' and 'combined' selection design under a three-tiered system. In both examples the target coverage rates for the selection tiers are as follows: Tier 1 = 0.08, Tier 2 = 0.30, Tier 3 = 0.12. The tier-level target coverage rates are identified by the markers in each of the plots. In a 'combined' system, each trip is assigned a single random value and the tier selection probabilities are cumulative; e.g., Tier 1 is assigned a 0.08 target probability, Tier 2 is assigned a 0.38 target (0.08 + 0.30) and Tier 3 is assigned a 0.50 target (0.08 + 0.30 + 0.12). In a 'separate' system, with the exception of the last tier, the minimum coverage rates must be set equal to the target coverage. In a 'combined' system, each trip is assigned a separate random value for each selection tier and the selection probabilities are independent of other tiers. In a 'separate' system the minimum coverage rates can be set to any desired value at or below the target coverage rate.

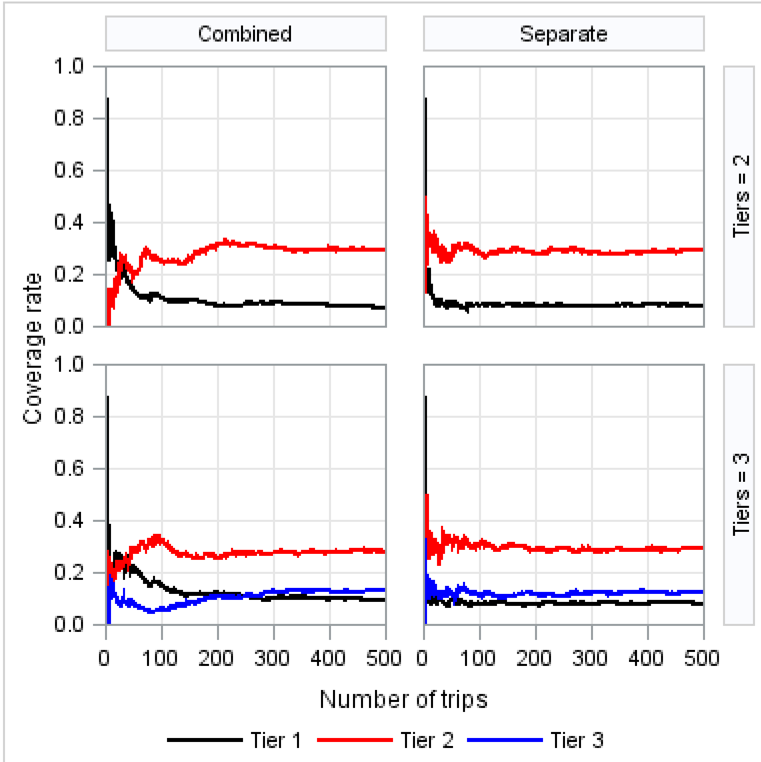

Figure 12. An example of the performance of the 'separate' and 'combined' selection designs in both a two- and three-tier system. For each scenario, 500 trips were entered into a single-stratum simulation; the results shown reflect one realization of the simulation. The target coverage rates for the tiers in each simulation are: Tier 1 = 0.08, Tier 2 = 0.30, Tier 3 = 0.12.

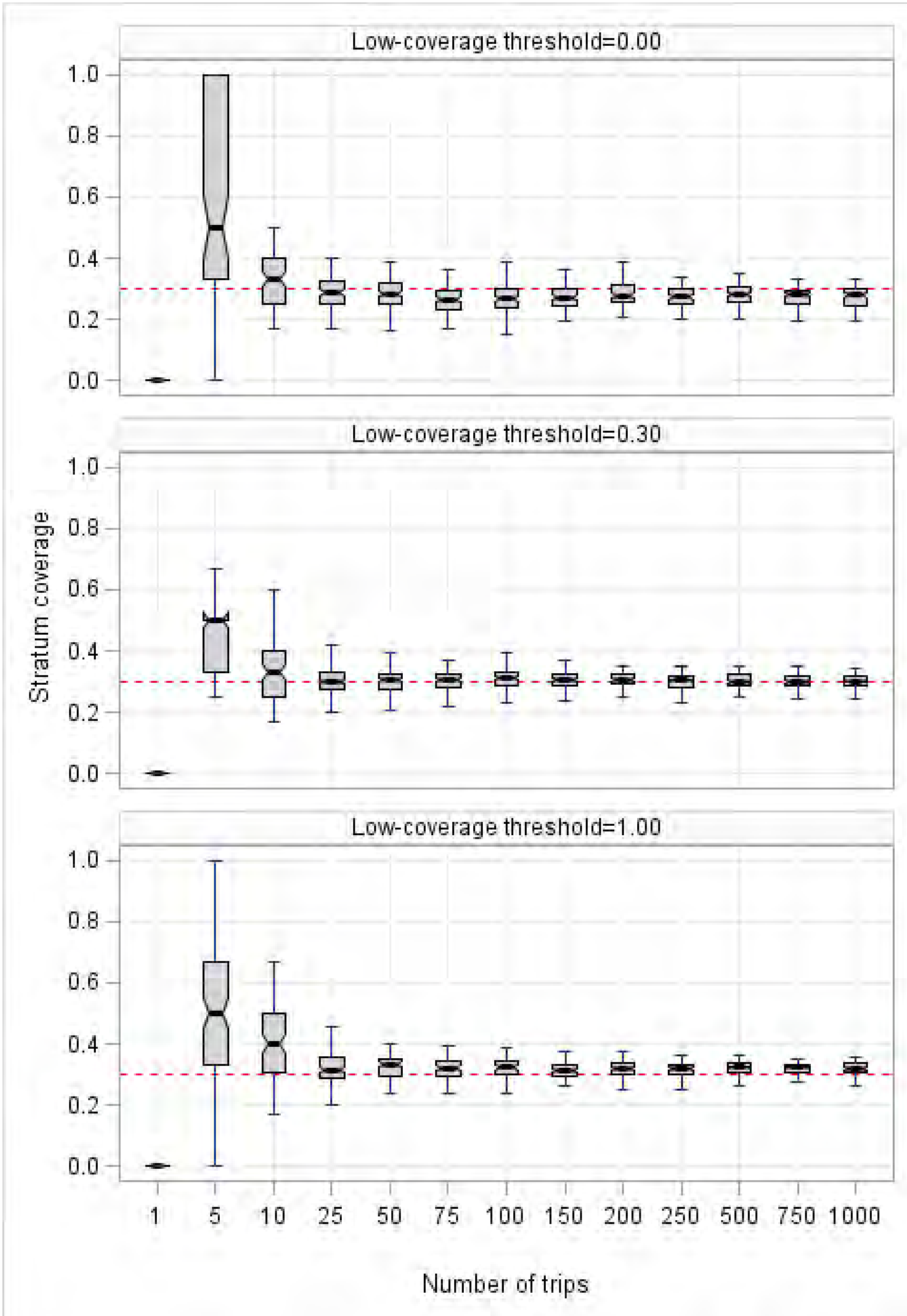

Figure 13. Distribution of 100 simulated PTNS stratum coverage rates as function of the number or trips declared using three different low-coverage thresholds: 0%, 30% (target), and 100%. In all simulations the target coverage rate was set at 30% with a 1% minimum and the provider decline rate was held constant at 10%. Boxes show the 25th, 50th and 75th percentiles; whiskers reflect the 10th and 90th percentiles.

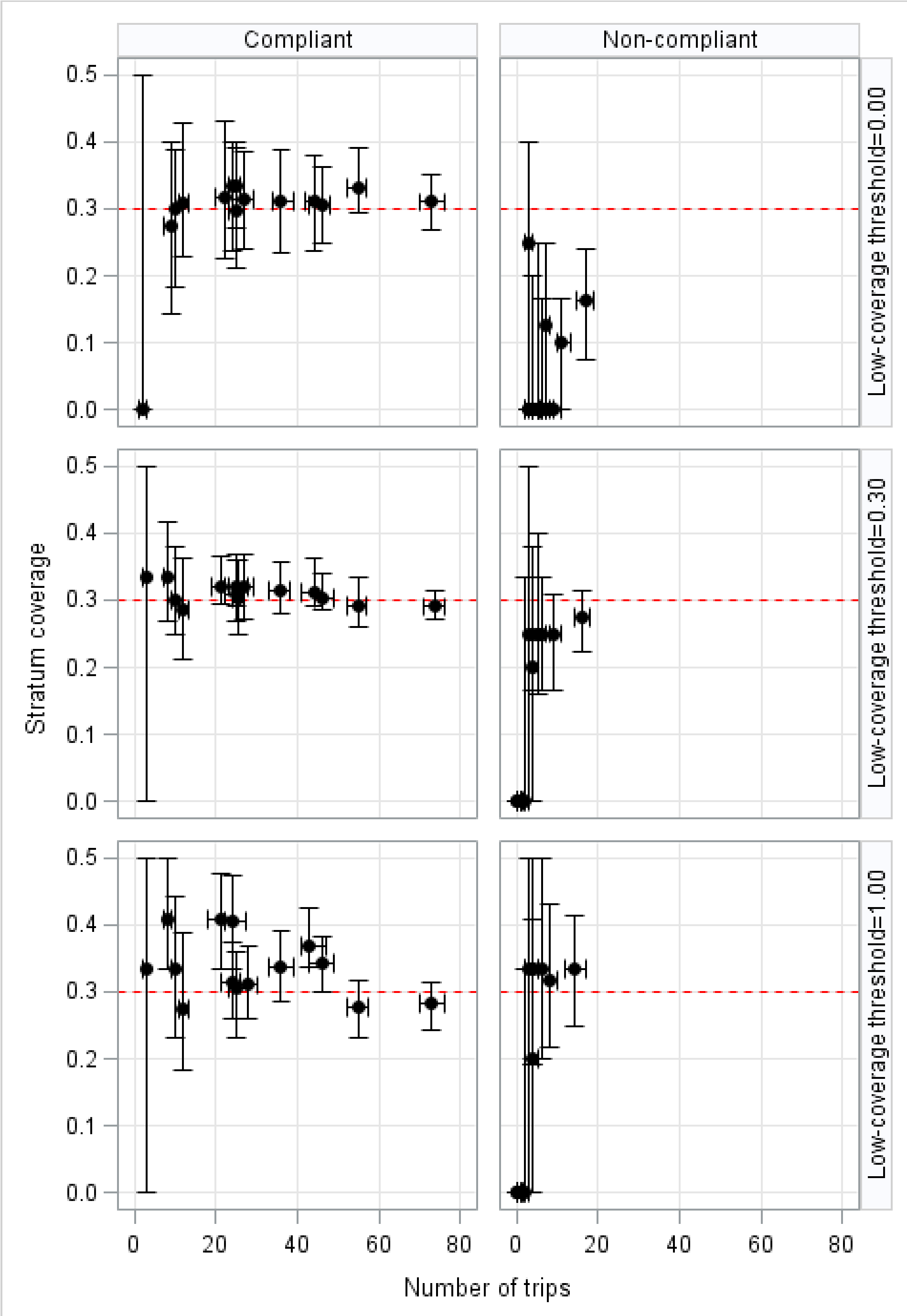

Figure 14. The median and 25th and 75th percentile of individual vessel trip counts and coverage rates from 100 PTNS simulations run under three different low-coverage thresholds: 0%, 30% (target), and 100%. In all simulations the target coverage rate was set at 30% with a 1% minimum and the provider decline rate was held constant at 10%.

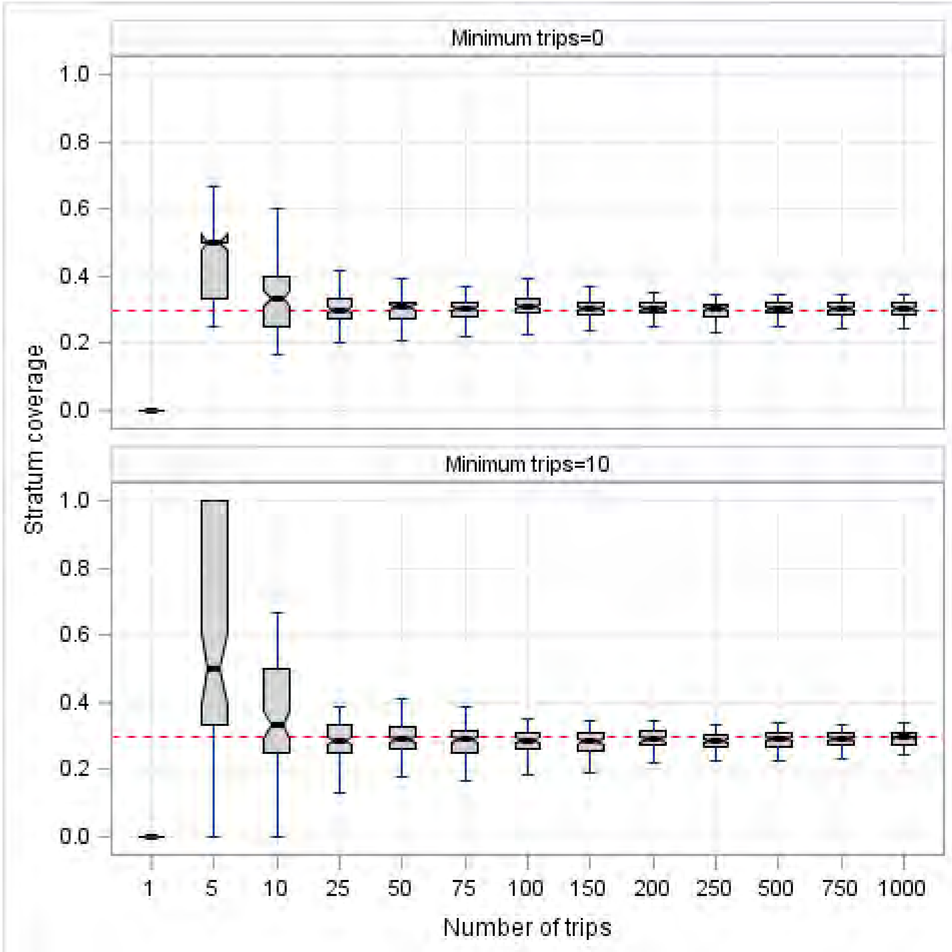

Figure 15. Distribution of 250 simulated PTNS stratum coverage rates as function of the number or trips declared using two different minimum trip thresholds: 10 trips and 0 trips. In both simulations the target coverage rate was set at 30% with a 5% minimum, the provider decline rate was held constant at 10% and the low-coverage threshold was set at 30%. Boxes show the 25th, 50th and 75th percentiles; whiskers reflect the 10th and 90th percentiles and the dots reflect the 5th and 95th percentiles. The bold red line represents the mean.

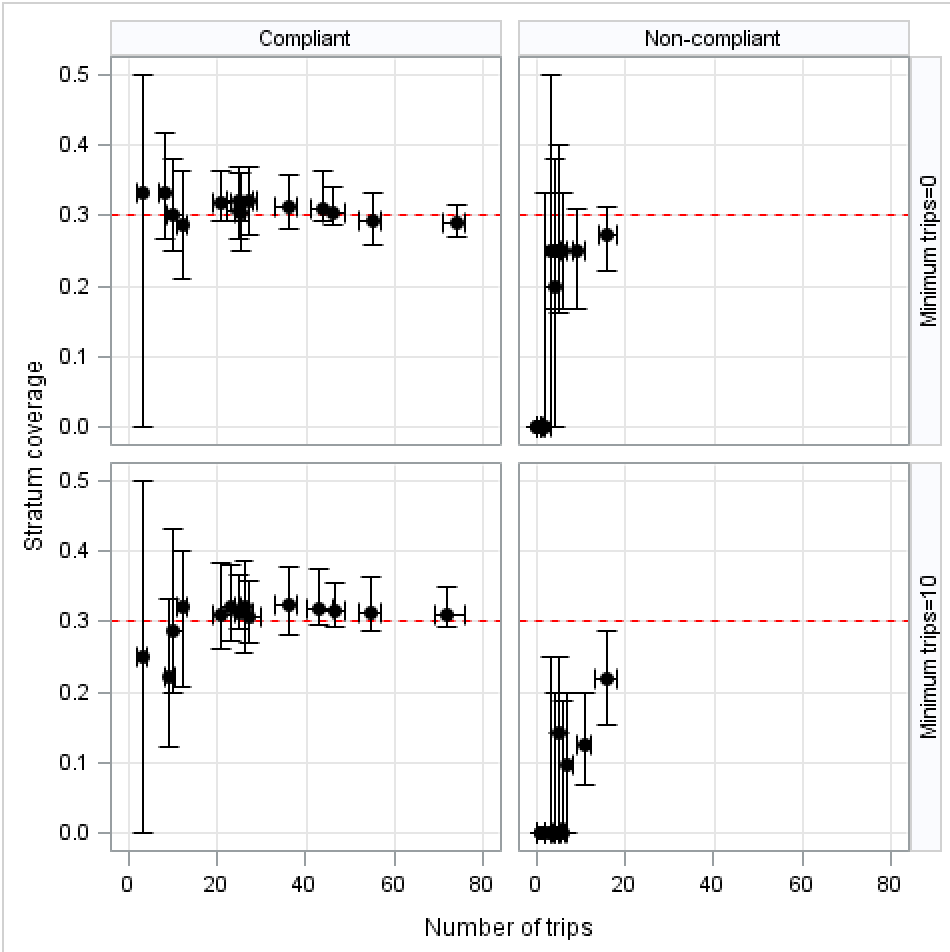

Figure 16. The mean and standard deviation of individual vessel trip counts and coverage rates from 250 PTNS simulations run under two different minimum trip thresholds: 10 trips and 0 trips. In both simulations the target coverage rate was set at 30% with a 5% minimum, the provider decline rate was held constant at 10% and the low-coverage threshold was set at 30%.

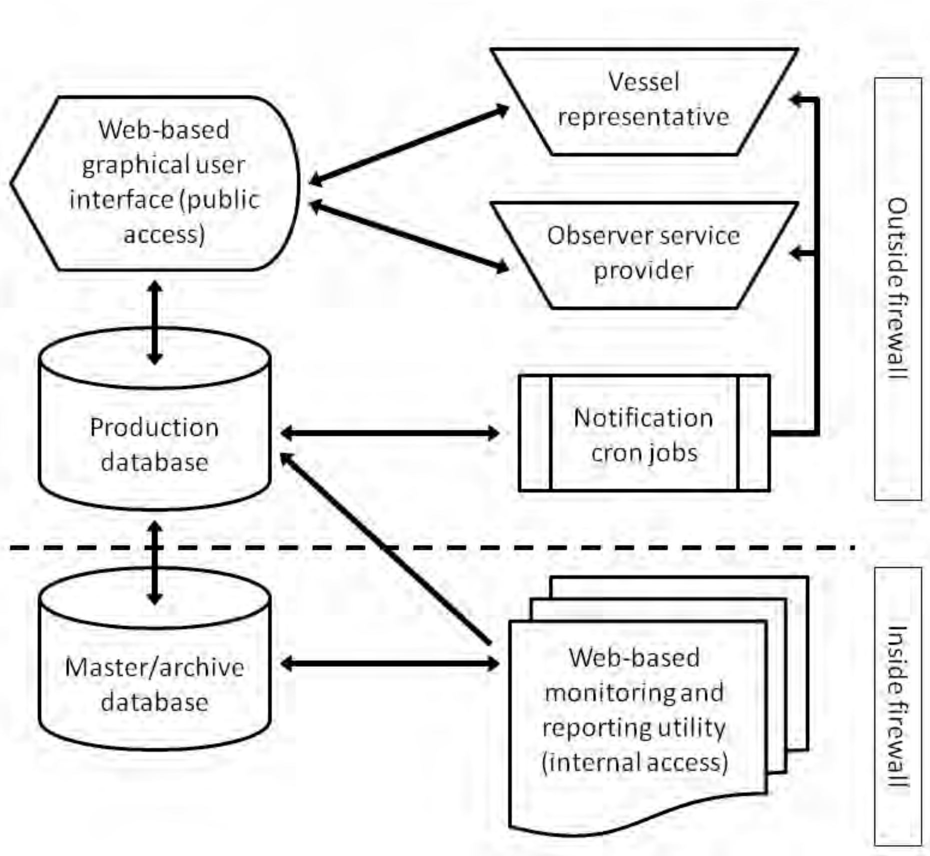

Figure 17. Data flow processes and major information technology components of the Pre-Trip Notification System (PTNS).

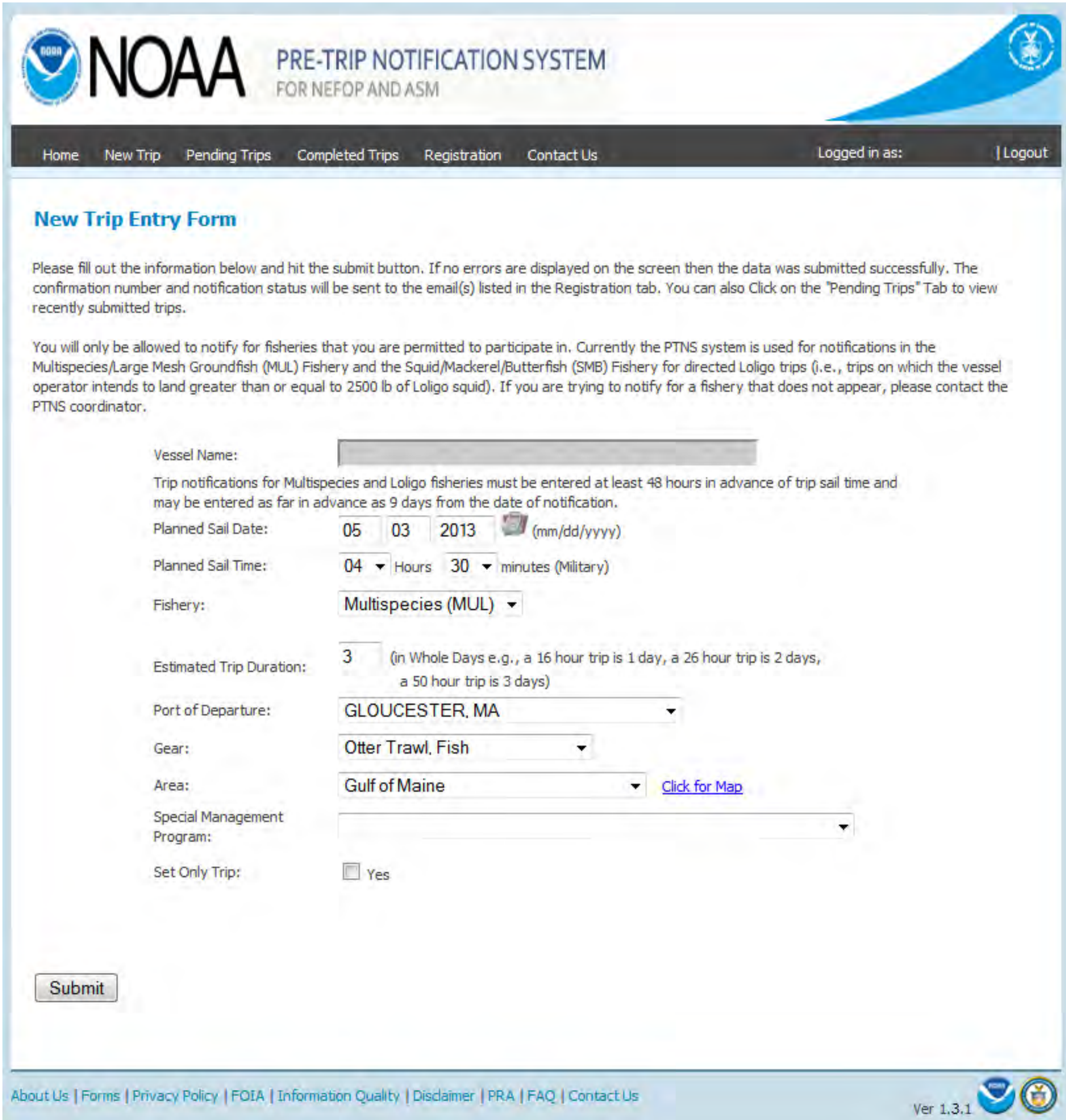

Figure 18. Screenshot of the trip declaration screen from the web-based Pre-Trip Notification System (https://fish.nefsc.noaa.gov/cgi-bin/PTNS/login.pl).

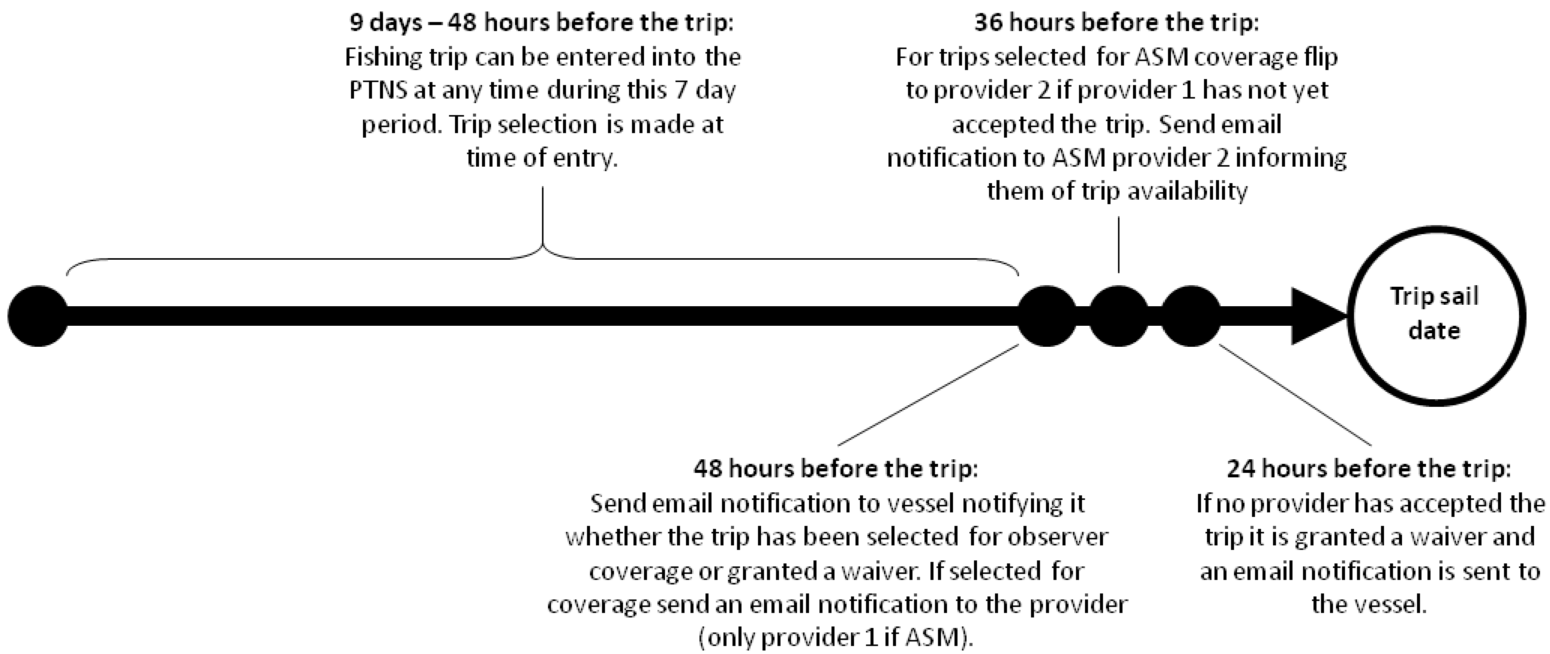

Figure 19. Timeline of observer Pre-Trip Notification System (PTNS). After initial trip entry the system events are controlled by Unix cron jobs. Once a provider has accepted a trip the PTNS will send an automatic notification to the email informing them of the selection and identifying the provider.

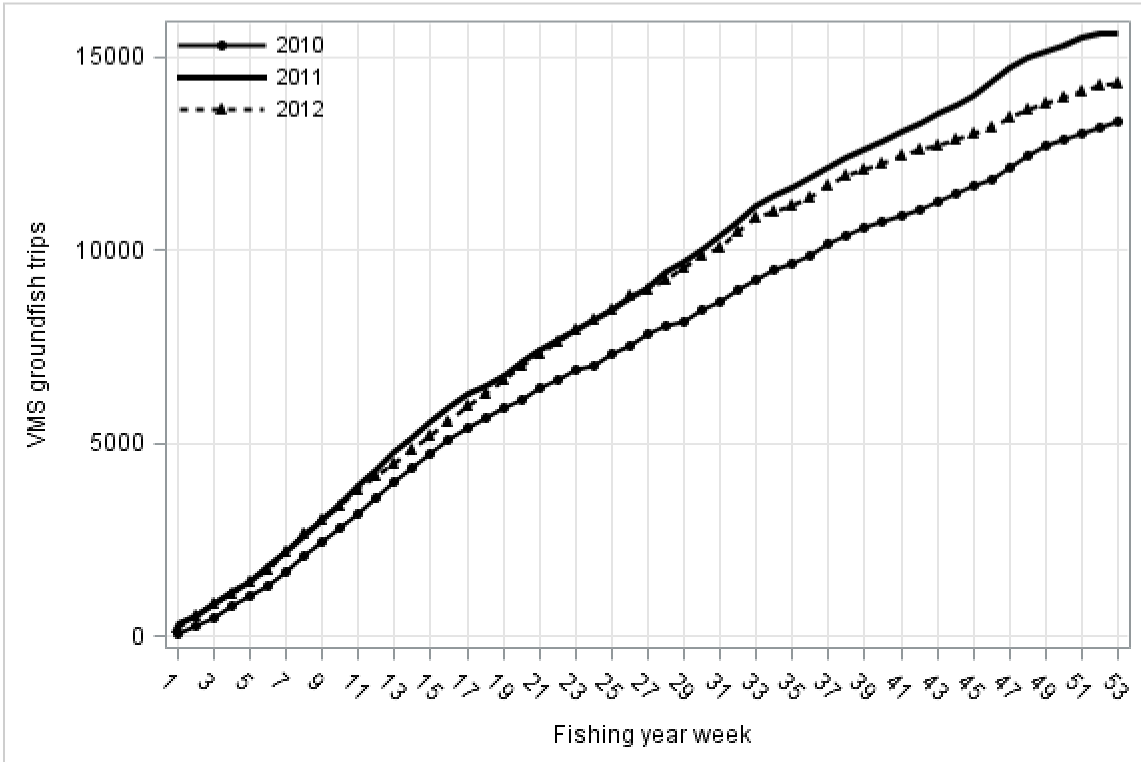

Figure 20. Groundfish trips over time by fishing year as estimated from VMS activity declarations.

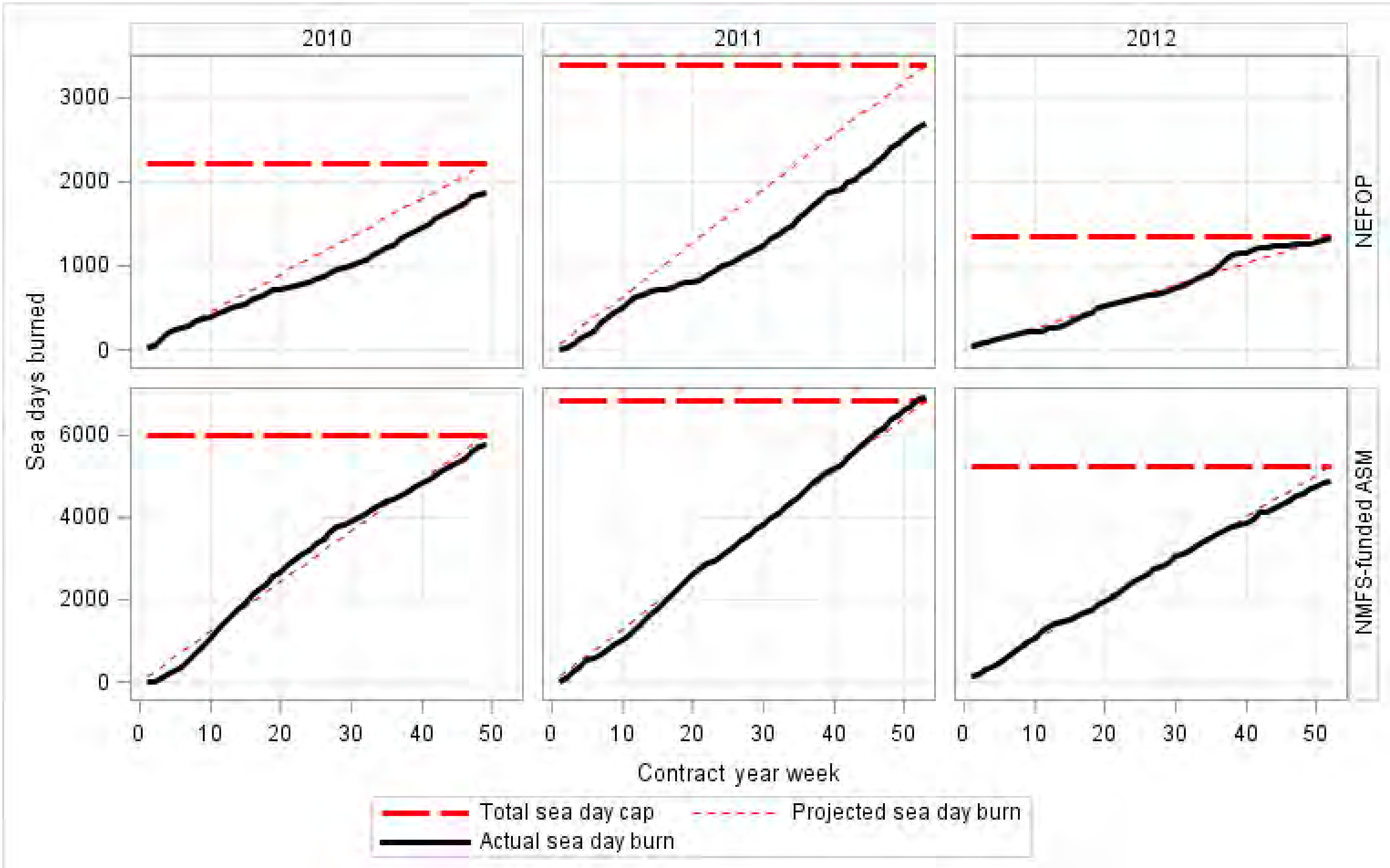

Figure 21. Sea day utilization over time (solid black line) relative to the annual allocated sea days (cap, thick dashed red line) and a constant burn trajectory (projected, dashed red line) for both Northeast Fisheries Observer Program (NEFOP) and National Marine Fisheries Service funded At-Sea Monitors (NMFS-funded ASM) for the years 2010 to 2012. *Note that the years reflect sea day contract years which run from April 1 to March 30. In 2010, the contract year did not start until the start of the groundfish fishing year on May 1, 2010.*

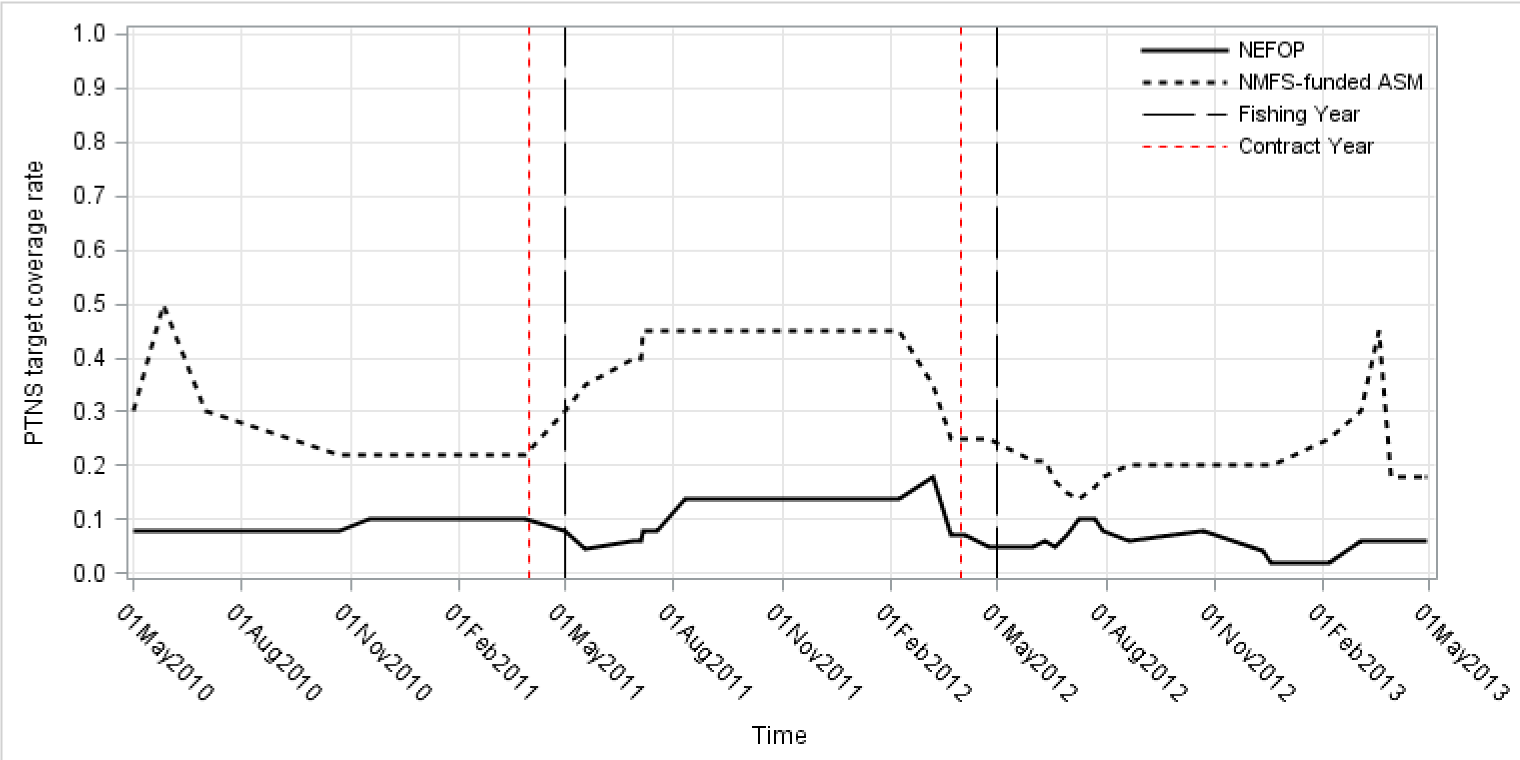

Figure 22. Target coverage rate settings of the Pre-Trip Notification System (PTNS) from May 1, 2010 to April 30, 2013 for both the Northeast Fisheries Observer Program (NEFOP) and National Marine Fisheries Service funded At-Sea Monitors (NMFS-funded ASM) tiers. The dashed red lines denote the start of the provider contract years on April 1 and the black vertical lines denote the start of individual fishing years on May 1.

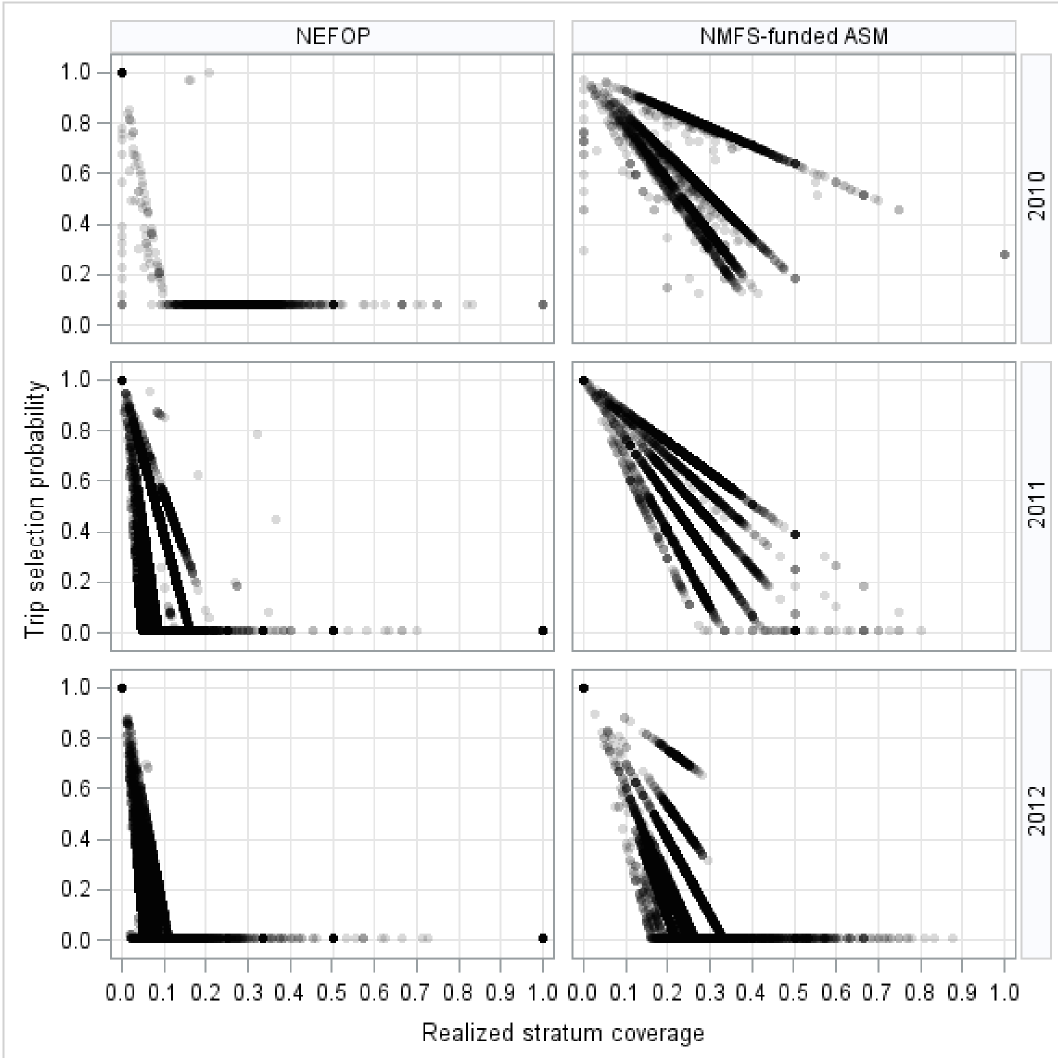

Figure 23. Relationship between the trip selection probability (*p*) and the realized stratum coverage by tier and fishing year. *Acronyms: At-Sea Monitoring (ASM), National Marine Fisheries Service (NMFS), Northeast Fisheries Observer Program (NEFOP). Note that 2010 values were recreated from the PTNS data that existed immediately prior to migration to the 2011 system; 2010 realized stratum coverages are approximated. Trips where realized stratum coverage is zero and the trip selection probability is less than 1.0 are products of this approximation. In actuality the realized stratum coverages were greater than zero at the time the trip declaration occurred.*

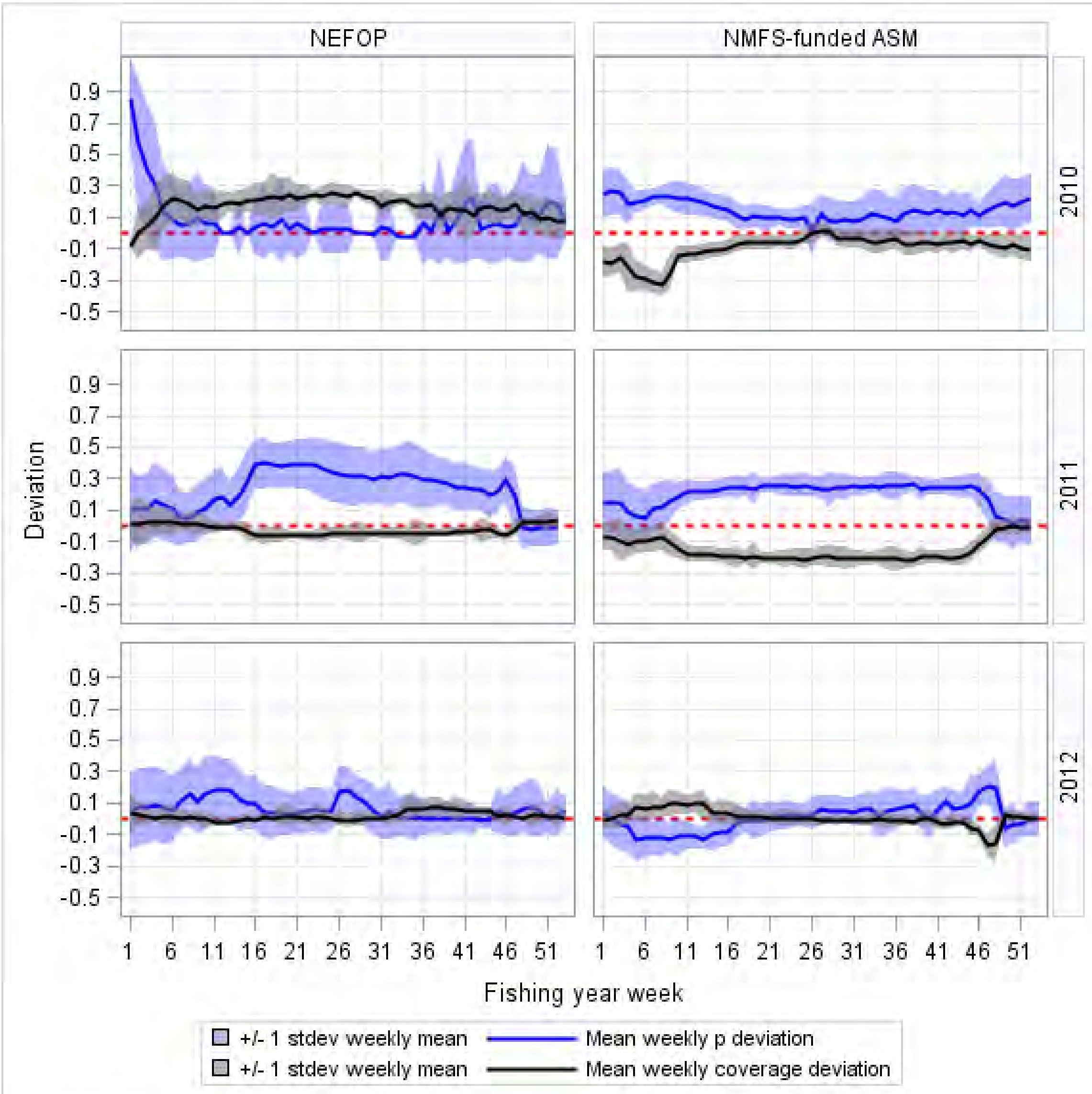

Figure 24. Deviations of the trip selection probability (*p*) and realized coverage from the target coverage rate by tier and fishing year. Results are summarized by fishing year week.

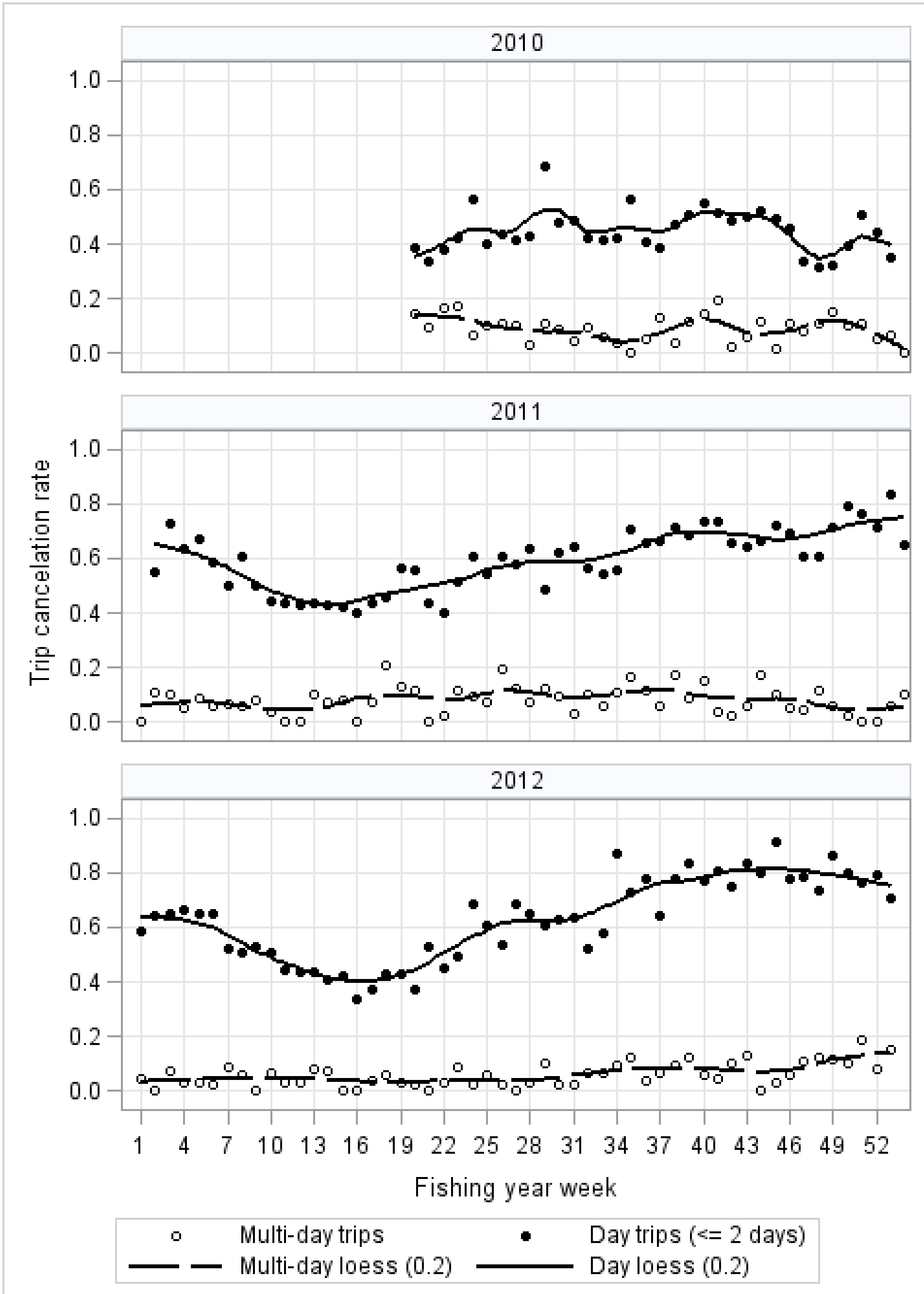

Figure 25. Trip cancellation rates by trip type (day or multi-day) and fishing year. Day trips are defined as any trip anticipated to be less than or equal to two days in duration. Multi-day trips are those trips anticipated to be longer than two days in duration.

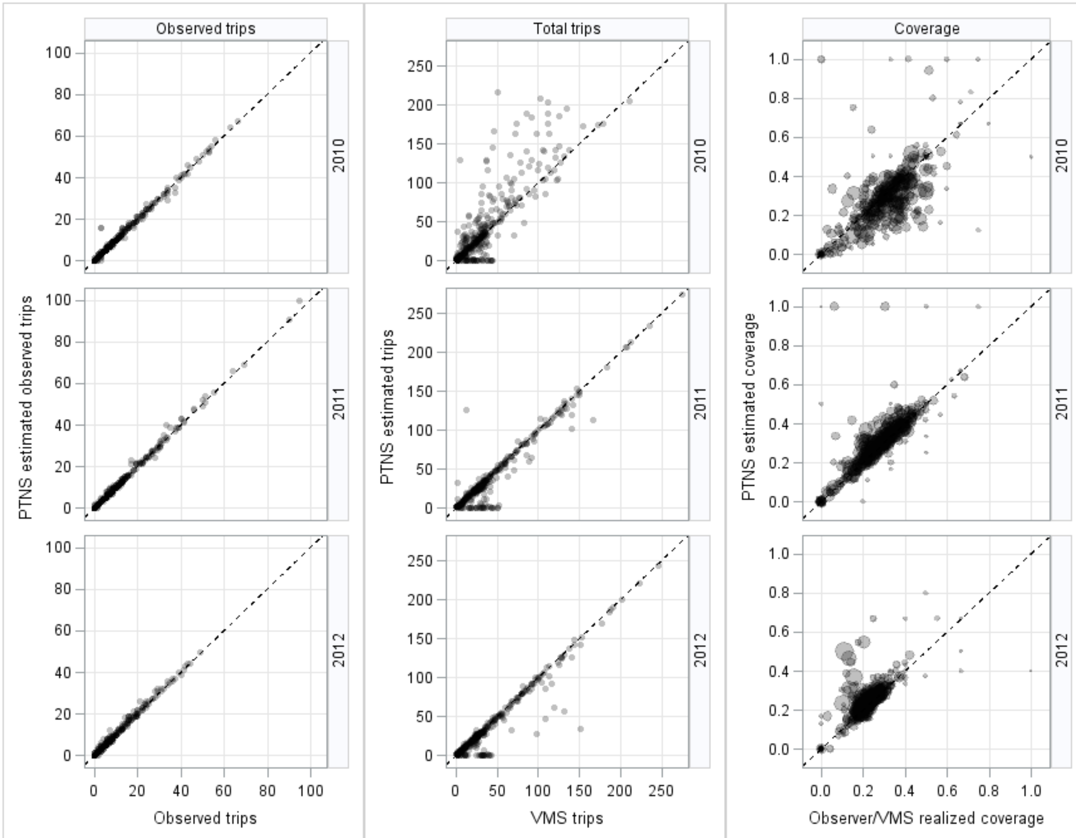

Figure 26. Comparison of the Pre-Trip Notification System (PTNS) estimate of observed, total trips and coverage rates for an individual vessel to the realized coverage estimated from observer and Vessel Monitoring System (VMS) data. Comparison plots are shown by fishing year. The dashed line indicates the 1:1 identity line.

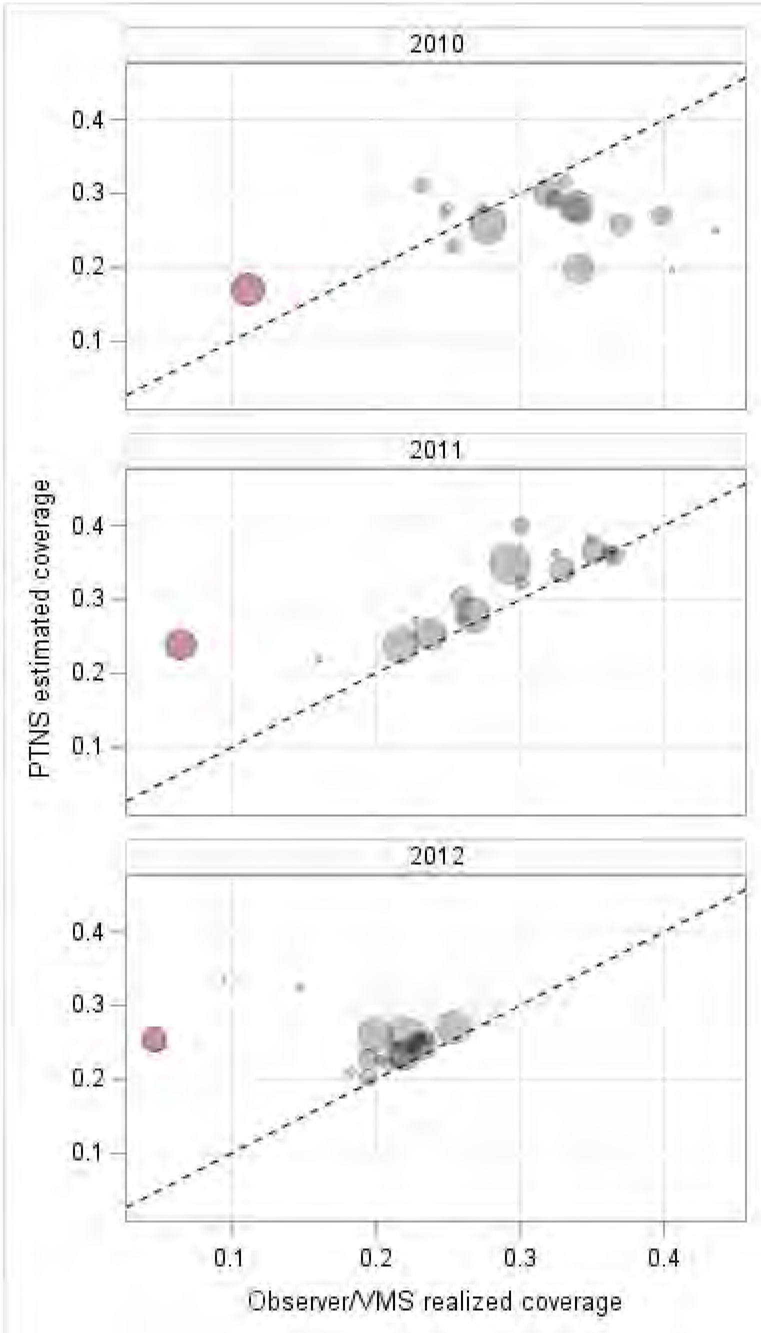

Figure 27. Comparison of the Pre-Trip Notification System (PTNS) estimated coverage for an individual sector to the realized coverage estimated from observer and Vessel Monitoring System (VMS) data. Comparison plots are shown by fishing year. The dashed line indicates the 1:1 identity line. The common pool is colored red.

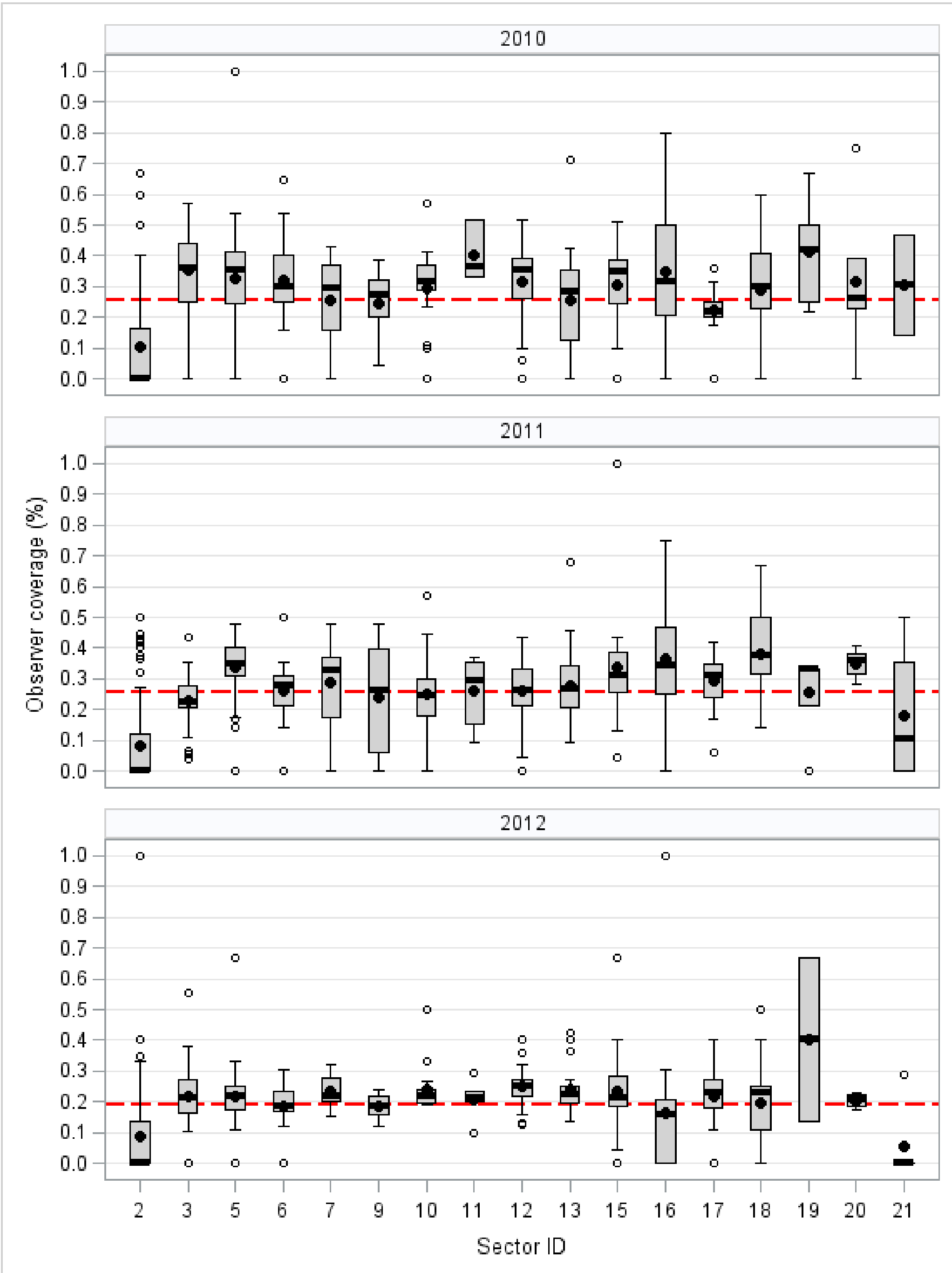

Figure 28. Box-plot distribution of vessel-level coverage within individual sectors for fishing years 2010 to 2012. The dashed red line indicates the annual mean across all vessels. The solid black line indicates the median, the black circle is the mean, the grey box represents the interquartile range (Q1 – Q3) and the whiskers indicate observations within 1.5(IQR).

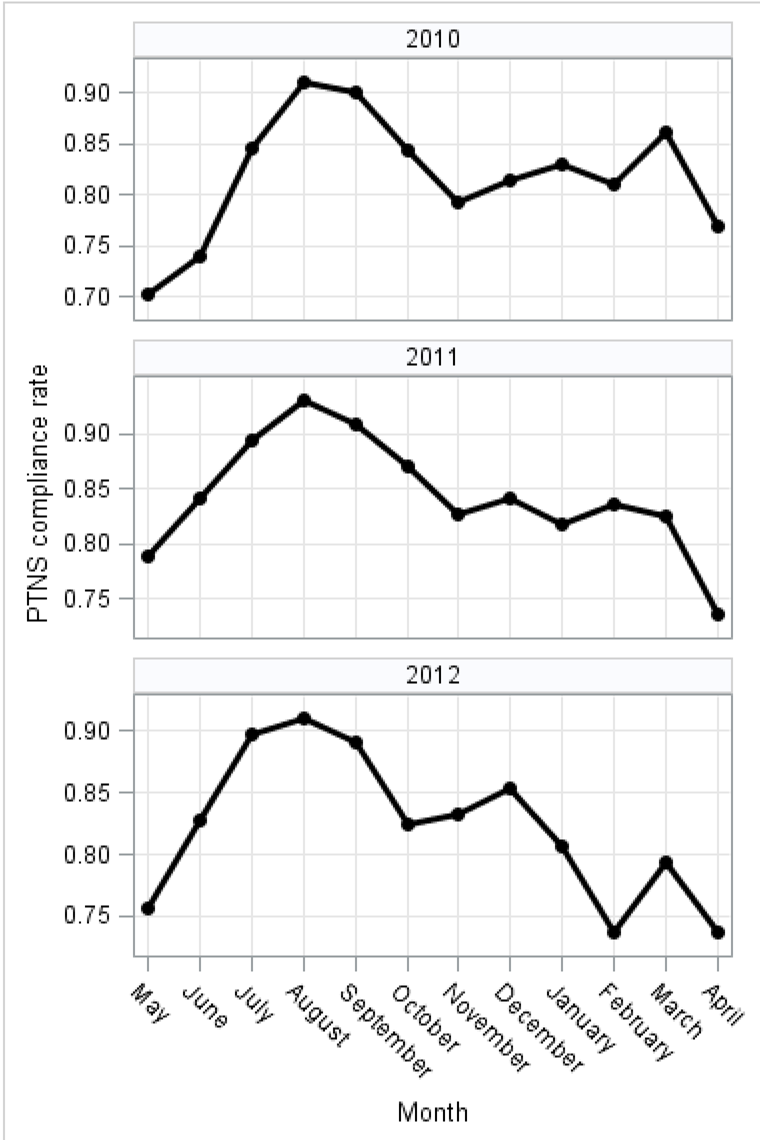

Figure 29. Monthly PTNS compliance by fishing year. PTNS compliance refers the fraction of groundfish trip declared through a VMS activity declaration with a positive PTNS notification.

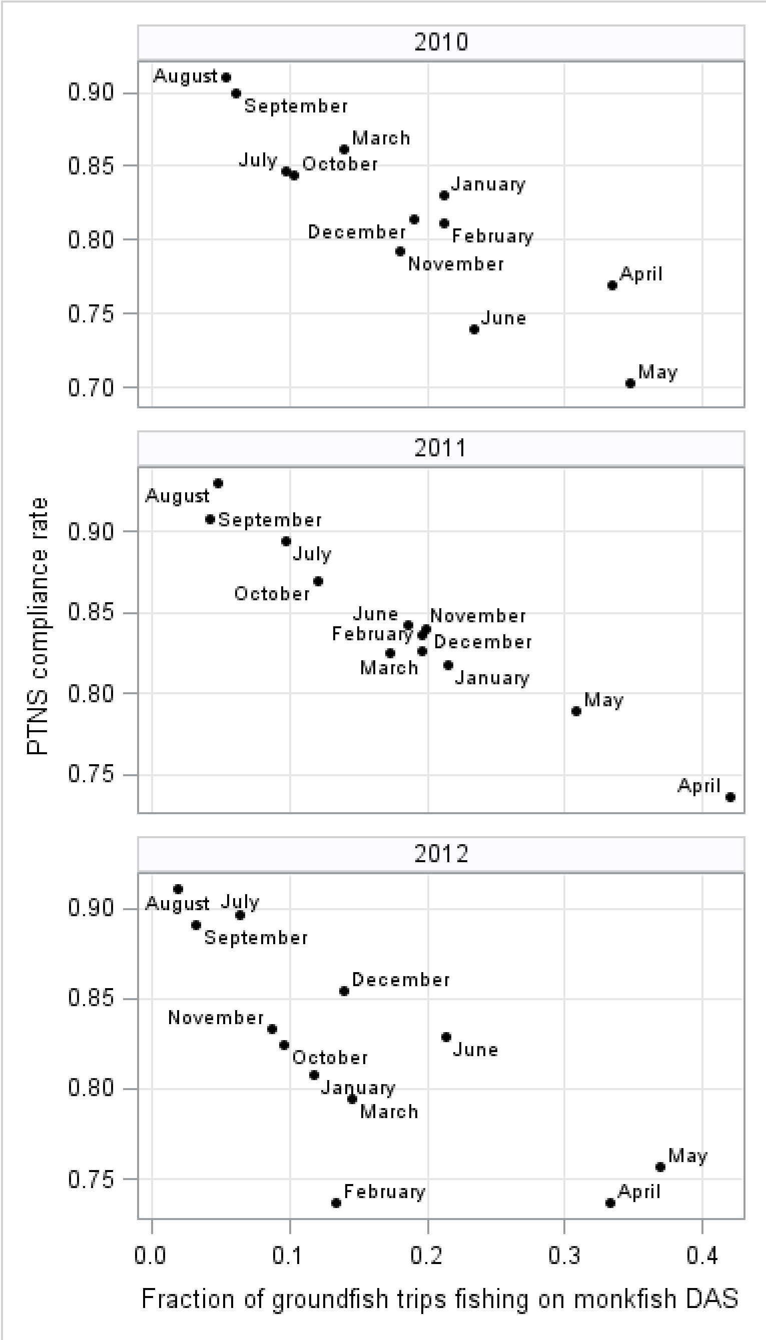

Figure 30. Relationship of monthly PTNS compliance rates as a function of the fraction of groundfish trips fishing on a monkfish day-at-sea (DAS). PTNS compliance refers the fraction of groundfish trip declared through a VMS activity declaration with a positive PTNS notification.

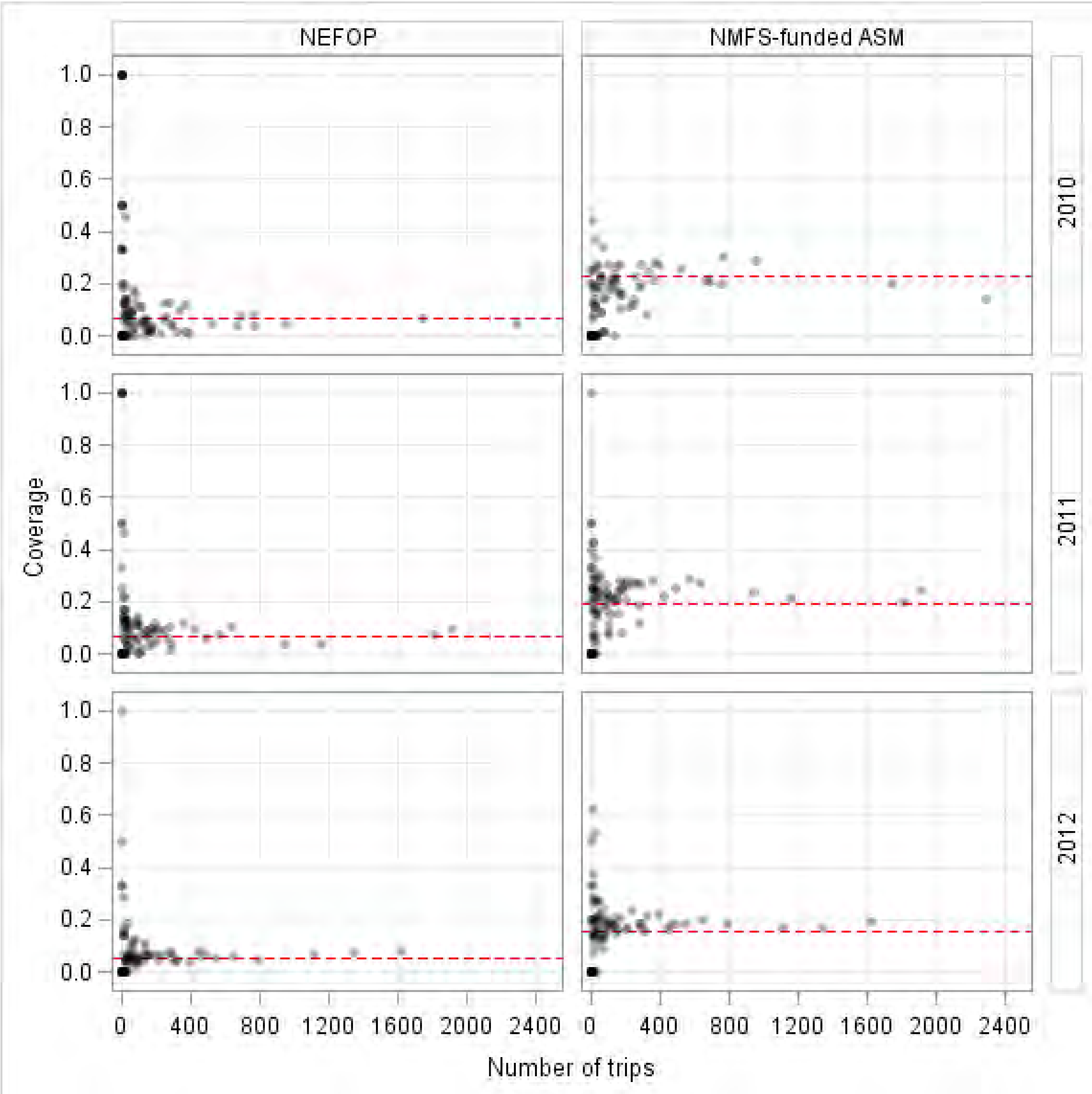

Figure 31. Comparison of individual strata coverage rates to the total number of trips taken within each stratum summarized by tier type and fishing year. The dashed red line indicates the aggregate annual trip based coverage based on total observed trips/total Vessel Monitoring System trips. *Acronyms: At-Sea Monitoring (ASM), National Marine Fisheries Service (NMFS), Northeast Fisheries Observer Program (NEFOP).*

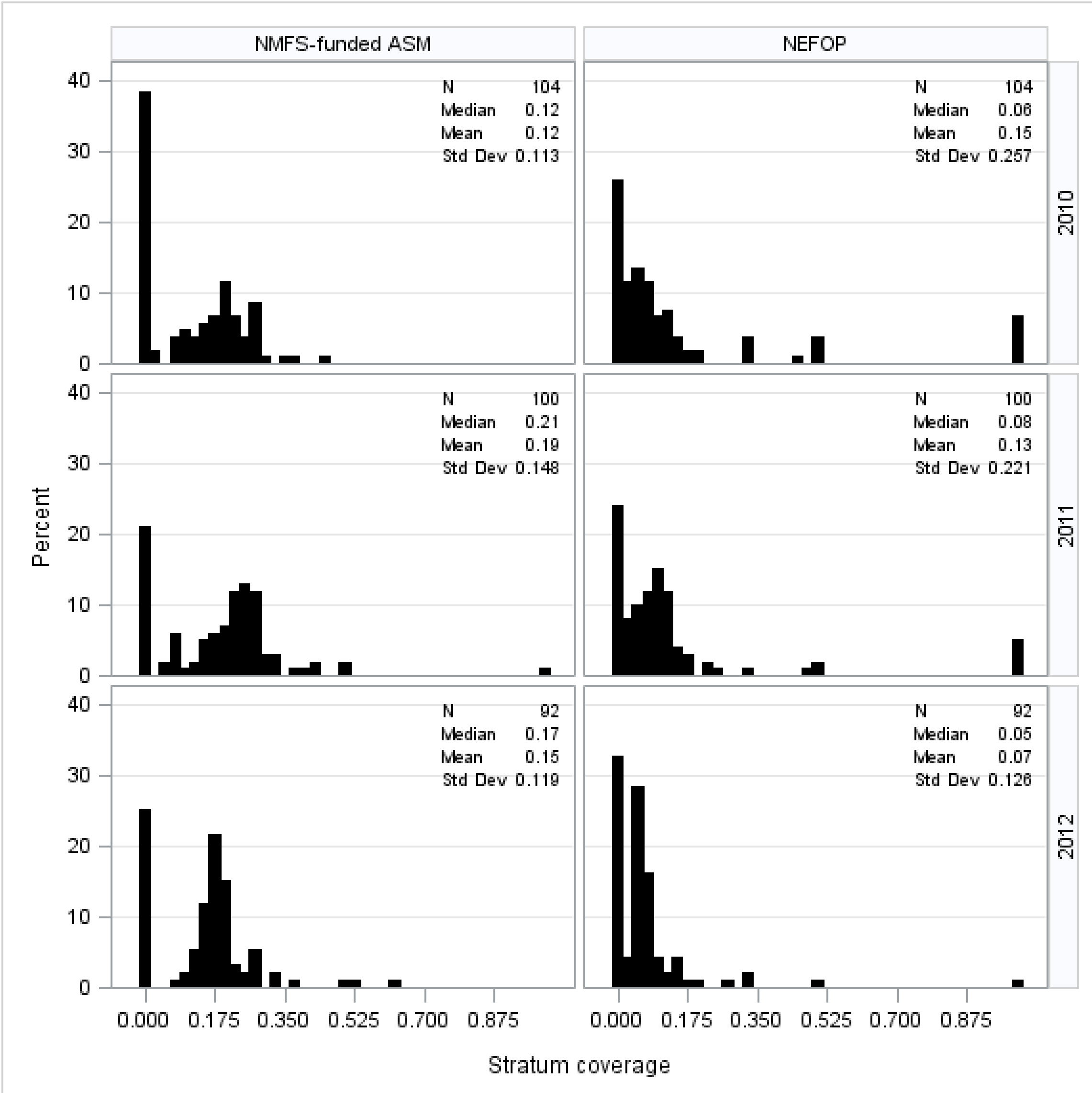

Figure 32. Histogram of strata coverage rates by tier type and fishing year. *Acronyms: At-Sea Monitoring (ASM), National Marine Fisheries Service (NMFS), Northeast Fisheries Observer Program (NEFOP).*

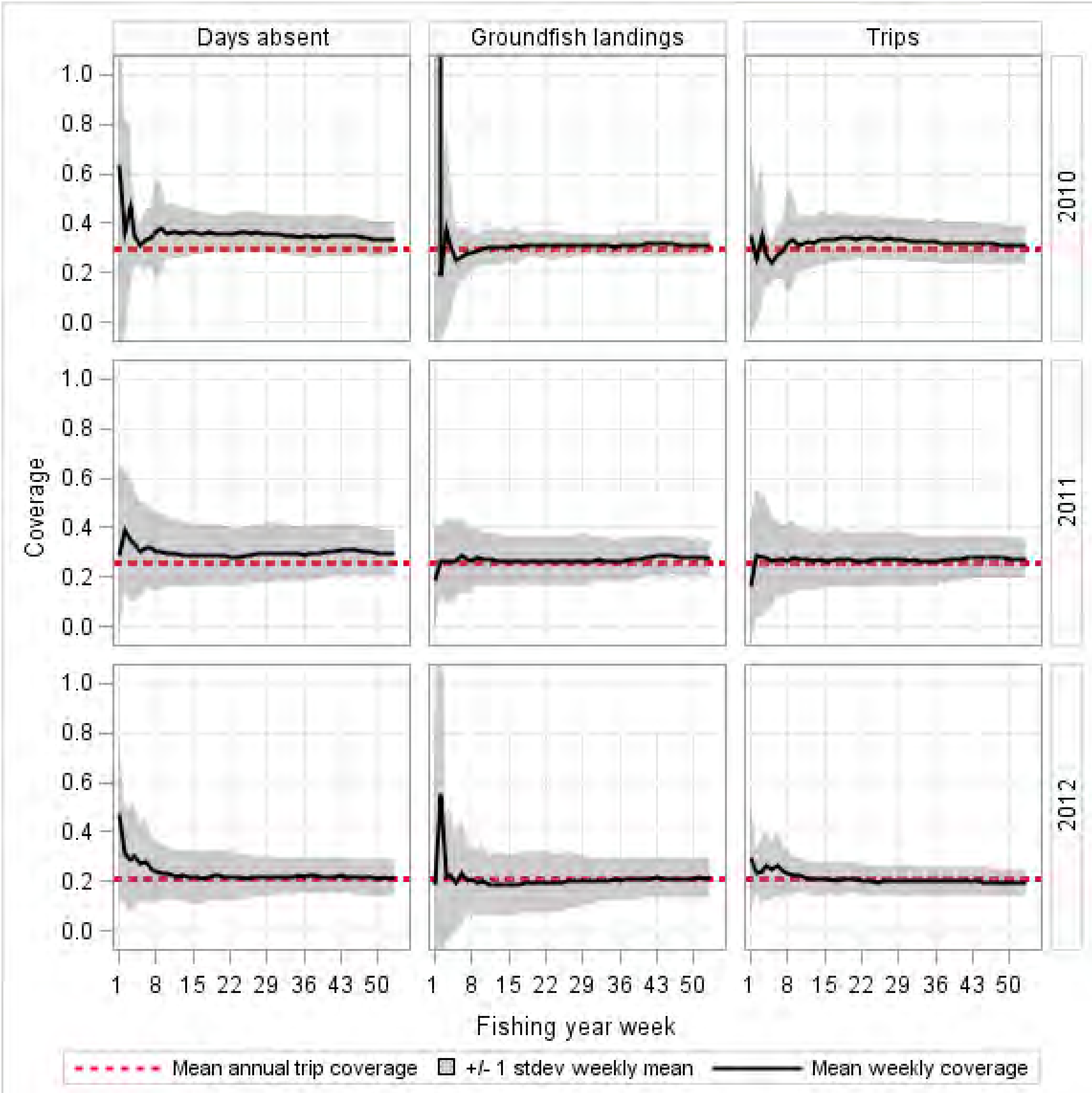

Figure 33. Mean weekly sector coverage rates over time calculated using three different metrics: days absent, groundfish landings and trips. The dashed red line indicates the aggregate annual trip based coverage (across all groundfish trips) based on total observed trips/total VMS trips.

Figure 34. Comparison of individual vessel coverage rates and the total number of trips taken by an individual vessel. The dashed red line indicates the aggregate annual trip based coverage based on total observed trips/total VMS trips.

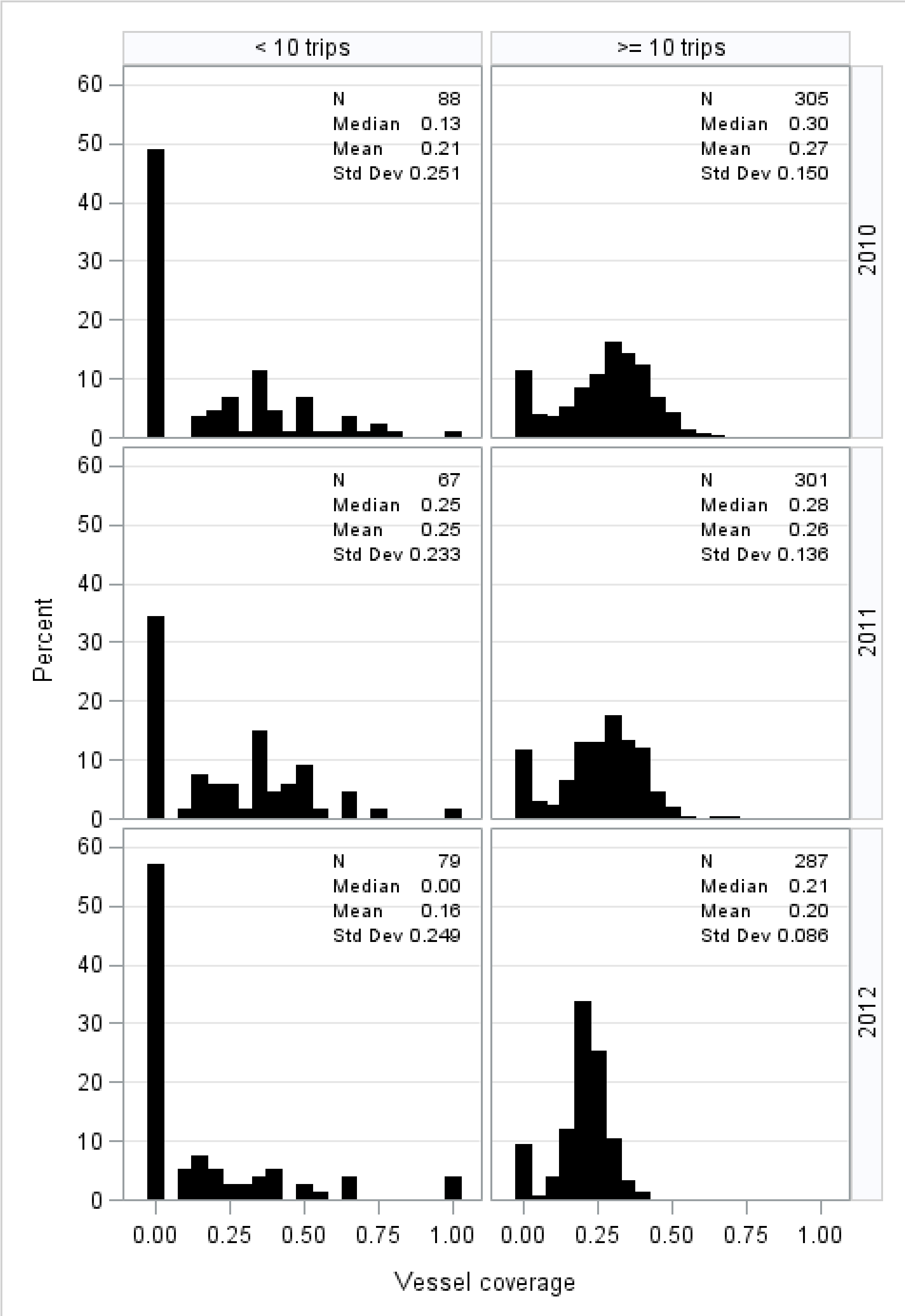

Figure 35. Histogram of individual vessel coverage rates by fishing year. Vessels are grouped into two categories: those taken fewer than 10 trips and those with 10 or more fishing trips.

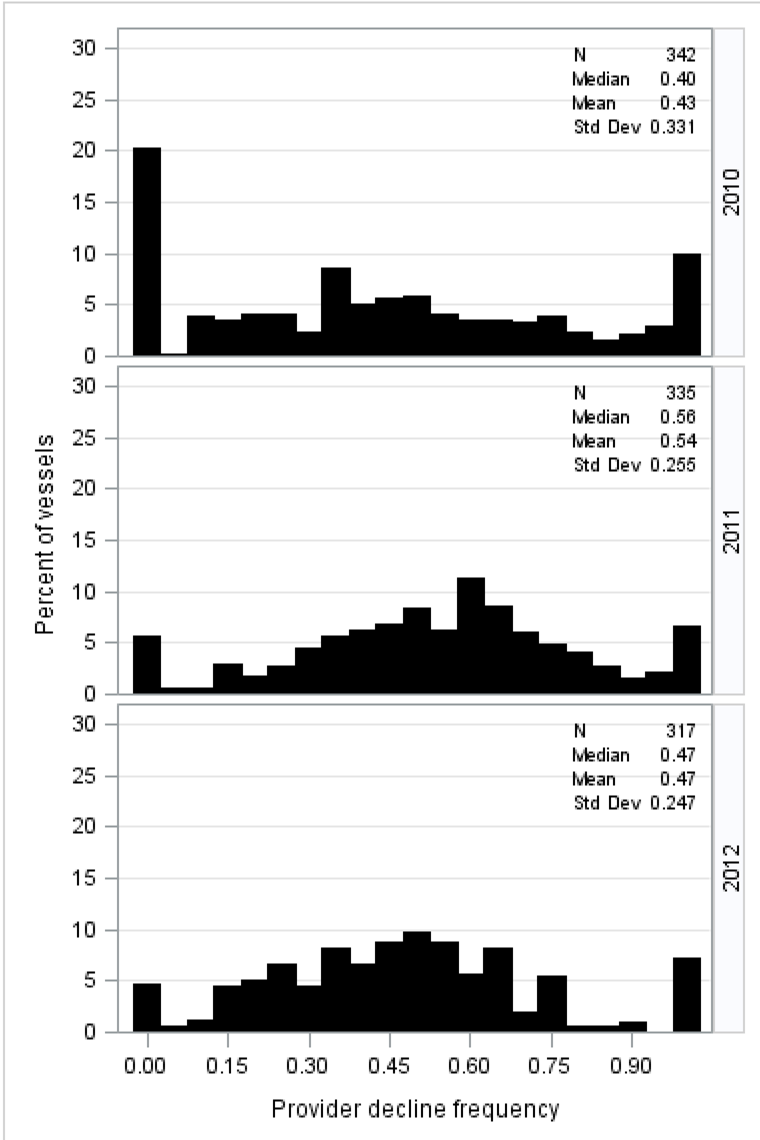

Figure 36. Histogram of provider decline rates for individual vessels by fishing year. Vessels are grouped into two categories: those taken fewer than 10 trips and those with 10 or more fishing trips.

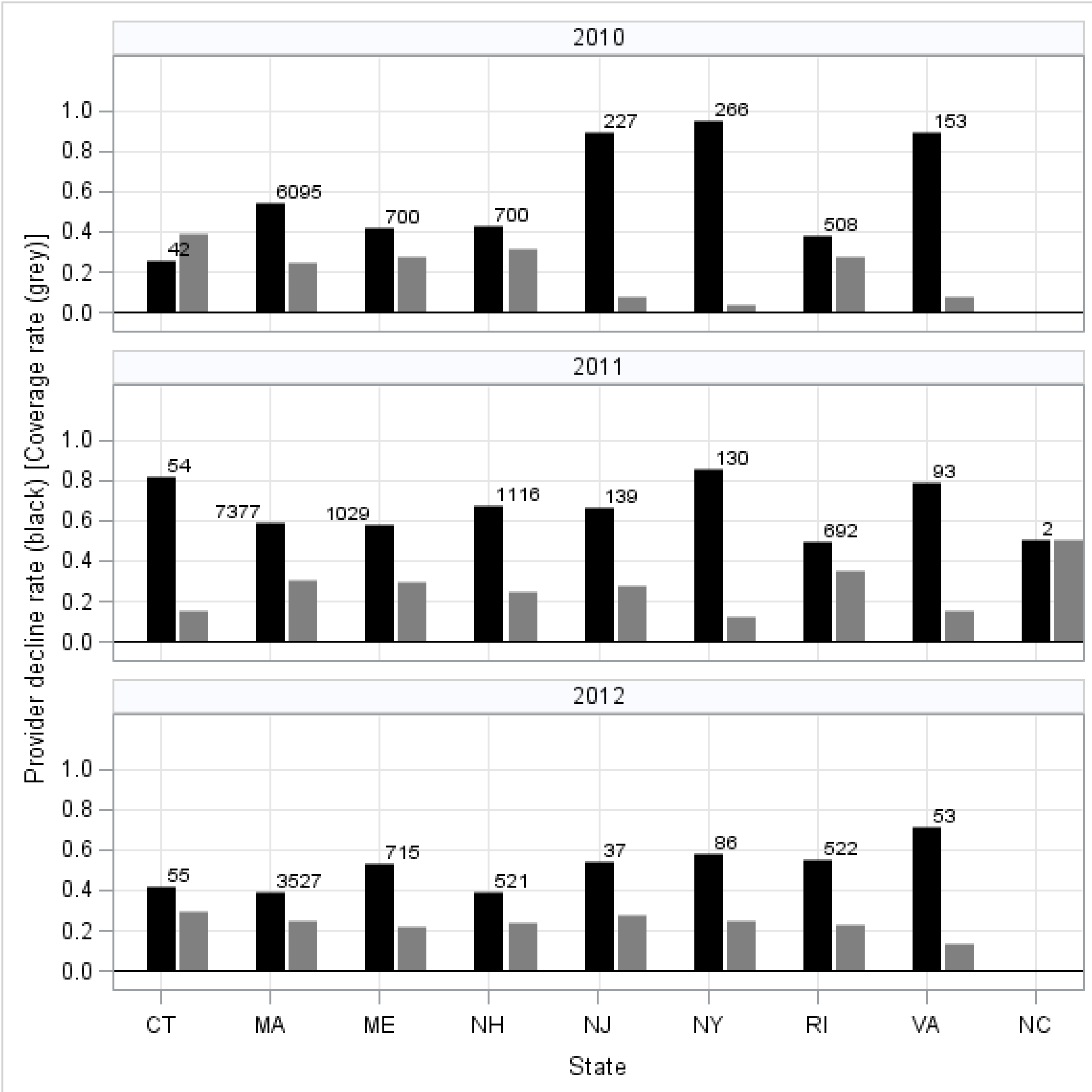

Figure 37. Provider decline rates (black) and coverage rates (grey) by fishing year state. The total number of trips offered to each provider is displayed above the decline rates.

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