Northeast Fisheries Science Center Reference Document 22-11

An Economic Analysis of the Multispecies Catch Share Program

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An Economic Analysis of the Multispecies Catch Share Program

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I. EXECUTIVE SUMMARY

This report evaluates the economic performance of the groundfish fleet over fishing years (FY) 2007-2015 to capture and compare economic trends before and after implementation of catch share management enacted under Amendment 16 to the Multispecies Fishery Management Plan (FMP) (NEFMC 2009).[1] Economic performance is evaluated at 3 operational perspectives: the groundfish trip-, vessel-, and entity/business-level. Where possible, average economic performance during FY 2007-2009 is compared to that of 2010-2015 to assess changes both before and after groundfish catch share management. Information on groundfish fishing fleet structure, landings trends and compositions, operating costs, revenues, and net revenues are summarized and compared across the 2 time periods. A summary of major findings is presented in Table 1. The number of trips, vessels, and entities follow an overall decreasing trend over the entire analysis period (FY 2007-2015), each decreasing by an average of 57%, 40%, and 37%, respectively, post-catch share implementation. Every vessel size class decreased in number of vessels when comparing averages from the 2 time periods, with the <30', 30' to <50', 50' to <75' and 75+' size classes decreasing in average numbers by 37%, 45%, 40%, an 16%, respectively. Vessel characteristics change marginally when comparing pre- and post-catch share averages, where average vessel length, gross tons, and horsepower increases by 4%, 11%, and 6%, respectively, and vessel age decreases by 6%, which may suggest a shift toward a more efficient fleet. Similar to fleet size, gross landings also follow a more or less decreasing trend over the analysis period (FY 2007-2015) with average gross landings decreasing by 24% and 10% for trips and vessel, respectively, between the 2 time periods. Despite decreases in gross landings, median trip landings increased from 1,128 lbs. to 2,284 lbs. (102%), and median vessel landings increased from 147 thousand lbs. to 202 thousand lbs. (38%) when averaged over 2007-2009 and 2010-2015, respectively. Trip and vessel landings compositions show signs of higher diversification post-catch share implementation with increases in the median numbers of landed species and decreases in the average Herfindahl-Hirschman index (HHI) values. Groundfish trip and vessel operating costs, revenues, and net revenues are overall higher during the 2010-2015 period compared to the 2007-2009 period. The average percent of revenue earned from groundfish species decreased post-catch share by 9% and 35% for trips and vessels, respectively. Median groundfish trip net revenue increased from $1,452 to $2,379 (64%) when averaged over 2007-2009 and 2010-2015, respectively, and median groundfish vessel net revenue increased by 36% from $150K to $204K when averaged over the pre- and post-catch share time periods, respectively. Median net revenue increased, on average, for each vessel size class during the post-catch share time period, most notably for the smallest vessel size class where average median vessel net revenue increased by 1181%. This increase was most likely driven by smaller vessels with low or even negative net revenues exiting the fishery during the post-catch share time period. An average of 5% of groundfish trips incurred negative net revenues when averaged over both the 2007-2009 and 2010-2015 time periods. The average percent of groundfish vessels with negative net revenues decreased from 6% to 5% over the pre- and post-catch share time periods, respectively. An average of 2% of vessels in the <30' size class incurred negative net revenues in both the 2007-2009 and 2010-2015 time periods. Further, an average of 3% of vessels in the 30' to <50' size class incurred negative net revenues when averaged over both periods. Notably, ~0% of vessels in the 2 largest vessel size

[1] Groundfish fishing years start on May 1st and end on April 30th such that the pre-catch share period includes data from May 1, 2007, to April 30, 2010, and the post-catch share period includes data from May 1, 2010, to April 30, 2016.

classes—50’ to <75 and >75’—earned negative net revenues in both time periods. The Gini coefficients suggest a relatively high concentration of net revenue among groundfish trips and vessels, with average Gini coefficients of 0.70 and 0.53 for trips and vessels, respectively, when averaged over 2007-2009. When averaged over the post-catch share time period, the level of concentration remains relatively high for both trips and vessels with average Gini coefficients decreasing to 0.68 (-1%) for trips and increasing to 0.55 (3%) for vessels. The economic metrics and measures provided in this report, along with other published works, may be used to evaluate the progress made in reference to economically focused goals and objectives set by Amendment 16 to the Multispecies FMP. Lastly, more robust and consistent economic data are needed to enhance the evaluation of the economic performance of the groundfish fleet.

II. INTRODUCTION

In recent years, the Northeast Multispecies Fishery, also known as the groundfish fishery, has undergone major shifts in management. One of the most notable changes to the fishery was the implementation of the catch share program under Amendment 16 to the Multispecies Fishery Management Plan (FMP) in 2010 (NEFMC 2009). This amendment shifted the fishery from effort controls (i.e., Days at Sea [DAS] and trip limits) to output controls in the form of hard quotas (Annual Catch Limits [ACLs]). Amendment 16 also expanded the sector allocation program, allowing for vessels to join "sectors" within which vessels can self-organize, manage, and lease/trade quota. This management plan was implemented to meet the requirements of the Magnuson-Stevens Act (Sustainable Fisheries…1996), which includes measures to decrease mortality targets within groundfish stocks while mitigating economic impacts on fishing communities. More specifically, Amendment 16 contains 15 goals and objectives which can be assessed, to varying degrees, both before and after catch share implementation. Objective 8 of Amendment 16 to the Northeast Multispecies FMP aims to, "Develop biological, economic, and social measures of success for the groundfish fishery and resource that insure accountability in achieving fishery management objectives" (NEFMC 2009). To partially achieve this objective, this report assesses various economic trends and indicators with a focus on net revenue within the groundfish fishery both before and after the implementation of Amendment 16. This analysis largely follows the analytical framework suggested by NOAA's Guidance for Conducting Review of Catch Share Programs (Morrison 2017). Additionally, this report evaluates metrics from different tiers of groundfish-related businesses to establish a holistic view of economic performance. This work, along with others, can aid in assessing the economic trends and performance measures within the groundfish fishery over time as they relate to the implementation of the catch share program.

III. METHODS AND ANALYTICAL APPROACH

In this analysis, economic trends and indicators are evaluated from 3 business perspectives: the groundfish trip-, vessel-, and entity-level. Broadening the definition of a groundfish fishing unit allows for a more holistic view of the businesses which depend, to varying degrees, on groundfish species. The period of analysis covers the 3 fishing years prior to and 5 years post-sector implementation (i.e., May 01, 2007-April 30, 2016). This time period is consistent with NOAA's guidance and was selected by the New England Fisheries Management Council for purposes of the program review (Swasey et al. 2021). When possible, the economic performance metrics were averaged over FY 2007-2009 and compared to those averaged over 2010-2015. In this study, a groundfish trip is defined as any commercial fishing trip meeting the following criteria:

i) at least 1 pound of any of the regulated large-mesh groundfish species was landed using groundfish gear (e.g., otter trawl, gillnet, bottom longline, hook and line), and
ii) the trip took place in either state or federal waters.[2]

[2] Identifiable Northwest Atlantic Fisheries Organization (NAFO) trips were excluded.

Any vessel that took at least 1 groundfish trip, as previously defined, during a specific groundfish fishing year (FY) is classified as an "active" groundfish vessel. The groundfish entity perspective broadens the scope of the analysis to include costs and revenues from the entire business, such that a single entity can include multiple vessels and multiple owners. This broader analysis includes revenues and costs from both groundfish and non-groundfish vessels that still contribute to the overall business operation. Groundfish entities were established by linking permits and individuals based on a business identification number.[3] For example, if 2 vessel owners are associated with the same business, all of their vessels are considered a single "entity" or ownership group. To be considered a groundfish fishing entity, the ownership group must be affiliated with at least 1 active groundfish vessel. Table 2 depicts how ownership groups are defined and the criteria for being considered a member of a groundfish entity in this analysis.[4] Although ownership information is required on the permit application, this information has only been databased for scallop and groundfish permits from 1996-2009 and was not databased for all permits until 2010. For this reason, entity-related information regarding total affiliated groundfish and non-groundfish vessels, landings, net revenues, etc., are only reported for years following permit year 2009 (i.e., FY 2010-2015).

The framework for this analysis is primarily shaped the by the economic goals and objectives of Amendment 16 to the multispecies FMP, specifically goals 2 and 8 and Objective 7, along with NOAA's guidance for conducting economic analyses and catch share reviews (NEFMC 2009; NMFS 2007; Morrison 2017). Given this guidance, topics such as harvest capacity, fleet composition and consolidation, and landings trends are assessed within this report. Trends in trip costs, revenues, and net revenues (revenues less fishing trip-related costs) along with measures of net revenue concentration and distribution are also examined. In this report, "net revenues" are defined as the revenues earned from landings after deducting trip costs. Net revenues are an important metric as they are typically split amongst the vessel owner, captain, and crew members. "Trip costs" are those associated with fishing operation at-sea and, in this report, include the following components: the cost of supplies, crew groceries, bait, fuel, ice, water, and oil. Due to data limitations, this analysis does not consider additional quota leasing costs or revenues, sector membership fees, general fixed costs, or additional business costs. Despite these limitations, the methods provided in this section are consistent with those described by NOAA's Guidance for Conducting Review of Catch Share Programs and National Marine Fisheries Service's (NMFS) Economic Guidelines (Morrison 2017; NMFS 2007).

In this analysis, the term "consolidation" refers to a shift toward fewer vessels or entities but of larger size as a proportion of the groundfish fleet. The term "concentration," on the other hand, is used in multiple contexts in this report but generally relates to the relative unevenness of a particular metric. For example, the Herfindahl-Hirschman index (HHI) is used to measure the change landing shares derived from different fish species. The HHI ranges in increasing concentration from 0.0 to 1.0. In this example, concentration may increase either because of a decrease in the number of species landed, an increase in the share of specific species, or both. In this analysis, concentration in terms of net revenues refers to the relative unevenness in the

[3] Groundfish entities are created based on the guidance of the Regulatory Flexibility Act (RFA) definition such that entities are based on unique ownership groups.

[4] Note that the criteria applied for defining ownership groups are limited to so-called "valid permits" that were not in the Confirmation of Permit History (CPH) program. Once a vessel permit has been placed in CPH, there is no annual renewal requirement, which means that annual changes in affiliated ownership can no longer be tracked.

distribution of net revenues among groundfish trips, vessels, and entities measured using net revenue quantile assessments and Gini coefficients. Where possible, the metrics described in this section are gauged at each business level (i.e., trip-, vessel-, and entity-level) to lend insight into fleet-level economic performance, distributional impacts, and trends in economic efficiency.

IV. DATA

A variety of data sources, economic models, and computational methods were used in generating the datasets used in this analysis. Databases were accessed to acquire data for 3 specific bodies of work: trip cost estimation; trip-level revenues and revenue approximation; and the classification of groundfish trips, vessels, and entities. Operating cost data (i.e., trip costs) are collected on commercial fishing trips by onboard observers from 2 programs: the Northeast Fisheries Observer Program (NEFOP) and the At-Sea Monitor (ASM) Program. Onboard observers collect cost information incurred on a specific trip, including the cost of supplies, water, groceries, bait, and oil. The price and quantity of ice and fuel is also collected by onboard observers. For this analysis, these 7 trip cost components are summed to create a composite value for at-sea operational costs incurred on each trip. The trip costs collected by onboard observers from the NEFOP and ASM programs were queried from the Observer Database (OBDBS) and merged into a full account of commercial fishing trips[5] from calendar year 2007-2016, acquired from the Vessel Trip Report (VTR) database. Trip costs, however, are only collected from a small sample of the total population of annual commercial fishing trips (~4%). For this reason, the remaining trips without trip costs (i.e., any trip without an OBDBS record in the VTR master dataset) were estimated using econometric modeling, where separate models are developed for the major gears used on observed trips and for trip duration (i.e., single vs. multiday trips). Because observer coverage is stratified to fulfill biological data needs rather than economic, some trip cost estimation models suffer from selection bias (Werner et al. 2020). To test and correct for this bias, trip costs were modeled using the Heckman Selection method. In cases where selection bias was not statistically significant, a log transformed Ordinary Least Squares (OLS) model was used instead. Based on statistical testing for sample selection bias, the Heckman selection modeling technique was used to estimate trip costs for the following gear and trip durations: trawl multiday trips, dredge day and multiday trips, gillnet multiday trips, longline multiday trips, seine trips, and pot and trap multiday trips. OLS models are used to estimate trip costs for the remaining gears at the day-trip level: trawl, gillnet, longline, and pot and traps. Harpoon, hand line, and less commonly used gear types (i.e., dive gear) were grouped together and also modeled using OLS. This allowed for estimation of trip costs for the full profile of trips taken during FY 2007-2015.

Commercial fishing trip revenue data are recorded in the Commercial Fisheries Database System (CFDBS), commonly referred to as "dealer data." To estimate revenue, the VTR trip data were merged with dealer data using the VTR serial number which has been included as a data element in the mandatory dealer reporting systems since 2004. However, 44% of VTR trips did not have an exact dealer record match. For these records, trip revenue was estimated by multiplying an imputed species price[6] by the quantity of each species kept on the VTR record. Federal Vessel Permit Data were used to identify groundfish ownership groups. All monetary values are presented

[5] Landings and trips were only accounted for if the vessel submitted a VTR record.

[6] Species prices were calculated using dealer data landings and revenues. To allocate a price to each species and trip, prices were imputed using a hierarchical algorithm (Table 3).

in 2015 constant U.S. dollars and were adjusted using the Gross Domestic Product Implicit Price Deflator[7].

V. RESULTS

i. Harvest Capacity and Fleet Structure

a. Harvest Capacity and Fleet Structure Overview

Prior to catch share implementation, excess capacity was identified in the multispecies fishery (Terry 2008). A portion of Goal 2 of Amendment 16 to the groundfish FMP aims to balance fleet capacity with the resource to enhance economic efficiency. Although Terry (2008) defines harvest capacity in terms of the maximum output derived from a set of inputs, measuring harvest capacity is difficult to replicate. It is common for catch share reviews to focus on changes in fleet size and often report initial decreases in fleet size post-catch share implementation (GMFMC 2013; Agar et al. 2014; Sigler et al. 2001; NEFMC 2017). The number of groundfish trips, active vessels, and entities are examined both before and after catch share management to track changes in fleet size over time. Additionally, average vessel characteristics are summarized for each fishing year to evaluate changes in vessel composition within the groundfish fleet.

b. Fleet Size and Structure

Decreases in fleet size occur both before and after catch share implementation (Figure 1). From FY 2007-2015, the number of groundfish trips decreased by 69% (22,413 to 6,849 trips), the number of active groundfish vessels decreased by 55% (610 to 276 active vessels), and the number of groundfish fishing entities decreased by 57% (544 to 235 entities). Trips, vessels, and entities incurred larger average percent decreases in numbers post-catch share compared to the pre-catch share period with average percent decreases of 1%, 8%, and 9% from 2007-2009 and average percent decreases of 22%, 10%, and 10% from 2010-2015 for groundfish trips, vessels, and entities, respectively. The largest year-to-year decrease occurred between FY 2009 and FY 2010, where the number of trips, vessels, and entities declined by 52%, 23%, and 21%, respectively. When percent decreases from 2009-2010 are omitted from the calculation, the number of vessels and entities decrease, on average, by 7% and 8%, respectively, while trips decrease by 14% over the post-catch share time period. The large decreases in fleet size over 2009-2010 may suggest progress on Goal 2 of Amendment 16; however, the continual decline in fleet size may be driven by a combination of internal and external factors.

All vessel size classes decrease in number of active vessels when comparing numbers averaged over 2007-2009 to those averaged over 2010-2015. During 2007-2009, an average of 27, 297, 178, and 63 active vessels operated within the <30', 30' to <50', 50' to <75' and >75' vessel size class categories, respectively. When averaged over 2010-2015, the number of active vessels decreased to 17, 165, 106 and 54 active vessels for each of the respective vessel size categories. Each vessel size class generally decreased in the number of active vessels over 2007-2015. However, the 75'+ and 50' to <75' size classes increased in number of active vessels after the implementation of the catch share program in 2011 and in 2012 (Figure 2). The <30' size class also increased in active vessels during certain fishing years, once in 2009 and again in 2013. When considering average percent changes, the 2 smallest vessel size classes incurred larger percent

[7] Accessible at: https://fred.stlouisfed.org/series/GDPDEF

decreases when averaged over 2010-2015 relative to 2007-2009 while the 2 larger vessel size classes incurred lower average percent decreases over 2010-2015 compared to 2007-2009. On average, the <30' vessel size class incurred a 9% increase over the pre-catch share period while the 30' to <50', 50' to <75' and 75'+ vessel size classes incurred average decreases of 6%, 16%, and 5%. All vessels size classes incurred average decreases over the 2010-2015 time period, with decreases of 14%, 13%, 6%, and 4% for each vessel size class, respectively. The smallest vessel size group incurred the largest percent decrease in number of vessels compared to other vessel size groups both before and after the implementation of the catch share program.

From 2007-2008 the smallest vessel size group (<30') decreased by 11% and then increased by 29% from 2008-2009 (Figure 3). From 2009-2010, this size class incurred the largest decrease (29%) which decreased further over 2011-2012 by an additional 20%. From 2012-2013 the number of <30' sized vessels increased by 13% but decreased by 17% and 20% over 2013-2014 and 2014-2015, respectively. This resulted in a 9% average increase during the pre-catch share period and an average decrease of 14% of during the post-catch share time period for the <30' vessel size class. The 30' to <50' vessel size class also incurred larger decreases in number of vessels over 2010-2015, with an average decrease of 13% compared to a 6% decrease over 2007-2009. Conversely, the 50' to <75' and 75'+ vessel size classes had higher average percent decreases in number of vessels during the pre-catch share period compared to the post-catch share time period. The 50' to <75' size class incurred an average decrease of 16% in number of vessels before catch share implementation compared to a 6% average decrease post-catch share management, while the 75'+ size group had an average decrease of 5% in number of vessels pre-catch share and a 4% average decrease post-catch share implementation. The 75'+ size class had the overall lowest average percent decreases in number of vessels in both the pre- and post-catch share time periods compared to other vessel size classes. Each size class experienced maximum decreases in numbers of vessels from 2009-2010, with decreases of 29%, 26%, 21%, and 10% for the <30', 30' to <50', 50' to <75', and 75'+ size groups, respectively.

c. Active Vessel Characteristics

The relative proportion of each vessel size class changed over time for some size categories when comparing averages from before and after catch share implementation. On average, the <30' vessel size class comprised 5% of the fleet over both the 2007-2009 and 2010-2015 time periods (Figure 4). The relative abundance of vessels in the <30' size class fluctuated post-catch share, slightly increasing from 2008-2009. The average share of 30' to <50' sized vessels within the fleet decreased from 53% to 48% over the pre- and post-catch share time periods, respectively. Moreover, the proportion of 30' to <50' sized vessels increased over 2007-2009 but continuously declined from 2010-2015. The 50' to <75' vessel size class contained 31% of the groundfish fleet both pre- and post-catch share implementation while the 75'+ vessel size category increased from 11% to 16% of active vessels when comparing averages from pre- and post-catch share management. The percent of 50' to <75' sized vessels within the fleet decreased over 2007-2009 but then mostly increased over 2010-2015. The largest vessel size category slightly increased over the pre-catch share time period but increased from 14% to 17% over 2010-2015. An increase in the proportion of larger vessels is an indication that larger vessels may be more likely to continue to be active in the post-catch share environment relative to smaller vessels.

Groundfish vessel length, tonnage, and horsepower followed an overall increasing trend from 2010-2015. When comparing pre- and post-catch share averages, vessel length (ft.) increased by 4%, gross tonnage by 11%, and horsepower by 6% (Figure 5). Moreover, the average vessel age followed a decreasing trend from 2010-2015, decreasing by 6% when comparing averages

from pre- and post-catch share enactment. The changes in fleet characteristics are a reflection of the changes in the composition of the active fleet, as previously noted. The change in vessel characteristics could also indicate that smaller, less efficient vessels may be exiting the fishery in greater numbers than larger vessels during 2010-2015.

The number of active, non-groundfish fishing vessels affiliated with groundfish entities decreased over 2010-2015 (Figure 6). There were 77 active, non-groundfish fishing vessels associated with groundfish entities in 2010; this number decreased to 47 non-groundfish fishing vessels in 2013. The number of affiliated non-groundfish fishing vessels increased in 2014 to 59 vessels but decreased to an all-time low of 46 vessels in 2015. Overall, this result suggests that groundfish entities may be exiting the groundfish fishery rather than diversifying permits across non-groundfish vessels over the post-catch share time period.

The average number of vessels associated with a groundfish entity generally decreased over the 2010-2015 time period with an average of 1.87 vessels affiliated with a groundfish entity in 2010 decreasing to an average of 1.70 affiliated vessels in 2015 (Figure 7). The median number of vessels associated with groundfish entities stayed constant at 1 over the 2010-2015 time period. The differences between the mean and median number of vessel affiliates highlights the skewed distribution of entity size classes where the majority are single-vessel entities but the average entity size is impacted by the maximum vessels per entity, which is greater than 15 vessels in each of the years assessed.

d. Groundfish Entity Size and Structure

There are marginal changes in the relative number of each entity size class over the 2010-2015 period. Overall, the proportion of single-vessel entities increased from 61% to 64% from 2010-2015 (Figure 8). The increase in the percent of single-vessel entities was mostly driven by the decrease in the largest entity size class, (i.e., entities affiliated with 5 or more vessels) which decreased from 5% to 3% when comparing percentages from 2010-2015. Entities affiliated with 2 and 3 vessels saw little change over the 2010-2015 period. Two-vessel entities comprised about 23% of all groundfish entities in both 2010 and 2015 while entities affiliated with 3 vessels decreased from 8% to 7% of entities from 2010-2015. Though the relative proportion of entity size classes changed marginally, each entity size class followed an overall decreasing trend in the number of entities over the 2010-2015 time period.

ii. Landings Trends and Compositions

a. Landings Overview

Landings trends (all species) were assessed across the 3 groundfish business-level perspectives. First, an overview of median landings is presented and assessed in relation to exogenous factors. Landings per unit effort (LPUE) was also assessed at the trip-level to gauge how output per hour changes before and after the catch share program. Gross landings, including both groundfish and non-groundfish species, were evaluated individually for groundfish trips, vessels, and entities along with changes in landings composition.

Median landings of all species landed on groundfish trips and groundfish vessels were higher post-catch share compared to pre-catch share management. Median groundfish trip landings over 2010-2015 were more than twice as high as average landings from 2007-2009, increasing from 1,128 lbs. to 2,284 lbs., a 102% increase (Figure 9). Further, the highest median landings occurred in 2014 and the least in 2009 (2,983 lbs. and 1,075 lbs., respectively). Median landings at the vessel-level, averaged over 2010-2015, were 1.4 times greater than median landings

averaged over 2007-2009, increasing from an average of 147,000 lbs. to 203,000 lbs., a 38% increase. Entity-level median landings fluctuated post-catch share implementation, but no comparison can be drawn to 2007-2009 due to database limitations.

LPUE is a metric which can be used to track trends in output levels given a standardized unit of effort. Average LPUE follows an increasing trend post-catch share implementation compared to the pre-catch share time period. When comparing groundfish trip landings per hour during 2007-2009 and 2010-2015, average landings increased by 22% from 176 lbs./hour to 215 lbs./hour (Figure 10). In addition, all average LPUE measurements were higher in every year post-catch share compared to all values from the pre-catch share management years. By contrast, median LPUE measures were constant in value when averaged over 2010-2015 and compared to those averaged over 2007-2009. Lastly, there was a larger range of LPUE values overall during 2010-2015 compared to 2007-2009, which is skewed in the positive direction.

b. Trip-Level Landings Trends and Compositions

Average gross landings from groundfish trips (all species) decreased after catch share management (Figure 11). From 2007-2009, gross landings from groundfish trips averaged about 83.5 million lbs. compared to an average of 63.6 million lbs. when averaged over the 2010-2015 period, a 24% decrease. On average, 61.3 million lbs. of groundfish species were landed per year over 2007-2009 compared to an average of 46.4 million lbs. of groundfish species when averaged over 2010-2015, such that average gross landings of groundfish species decreased by 24% after the implementation of the catch share program.

In addition to decreases in gross landings, landings compositions also changed between the pre- and post-catch share time periods. The mean and median number of non-groundfish species landed on groundfish trips increased over the 2010-2015 period (Figure 12). The average number of non-groundfish species landed per trip increased from 2.32 to 2.94 when averaged over 2007-2009 and 2010-2015, respectively. Median non-groundfish species trip landings increased from 2.00 to 2.67 species when averaged over 2007-2009 and 2010-2015, respectively. The average number of non-groundfish species landed per trip decreased from 2007-2009 then rose steadily from 2010-2015. The median number of non-groundfish species landed per trip was static at 2 from 2007-2011 then rose to 3 in 2012 where it remained through 2015. The increase in number of species landed post-catch share suggests that i) vessels may be actively diversifying catch or ii) vessels which targeted a lower diversity of species exited the fishery after implementation of the catch share program.

The changes in trip-level landings compositions were further assessed using the Herfindahl and inverse Herfindahl indices. The Herfindahl index (also known as Herfindahl–Hirschman Index or HHI) is a measure commonly used to estimate market concentration based on the squared sum of each firm competing in a particular market. The HHI ranges from 1/N to 1 where N is the number of firms within the industry. An HHI closer to 0 would represent highly diversified industry with many small firms. By contrast, an HHI closer to 1 is indicative of an industry dominated by a few, large firms. One can interpret a decrease in an HHI as movement toward a more dispersed market, and an increase may suggest that the industry is becoming more consolidated. Here, groundfish species were estimated as a single species to understand their total "share" in groundfish trip landings relative to landings shares for all other species on groundfish trips. The average Herfindahl index value decreased from 0.59 to 0.51 when averaged over 2007-2009 compared to those averaged over 2010-2015 (Figure 13). Median Herfindahl indices decreased from 0.54 to 0.46 when comparing averages derived from the same time periods, respectively. Overall, the values from the pre-catch share time period suggest that for any one trip,

there is a relatively low number of species landed and in relatively uneven proportions. For example, if an average of 4 species is landed per groundfish trip and each species is caught in relatively equal proportions, one would expect the HHI to be around 0.25. As the average and median index values are initially 0.59 and 0.54, this indicates that some species may be caught in higher abundances relative to other species on the trip-level. The average and median indices decrease post-catch share, suggesting that there is not only an increase in the number of different species being landed (as shown in Figure 12), but the relative abundance of these species may be more even. The inverse Herfindahl index demonstrates the number of "effective competitors" or the number of species that would need to be landed in equal amounts to produce the same HHI value. The mean and median inverse Herfindahl index values, when averaged over 2007-2009, are lower than values averaged over 2010-2015, with a mean and median value of 2.11 and 1.85 for 2007-2009, and 2.44 and 2.19 for 2010-2015. The increase in the inverse Herfindahl index values suggests that a larger number of various species would need to be landed in order to produce the same HHI in the post-catch share time period. These results suggest that a greater variety of species may be playing larger roles in the compositions of groundfish trip landings during the post-catch share time period.

c. Vessel-Level Landings Trends and Compositions

Gross landings from groundfish vessels, including landings from both groundfish and non-groundfish trips, decreased by 10% when comparing gross landings averaged over 2007-2009 to gross landings averaged over 2010-2015. An average of 144.3 million lbs. were landed over 2007-2009 compared to an average of 129.5 million gross lbs. from 2010-2015 (Figure 14). The largest inter-annual decrease in gross landings occurred over 2011 to 2012 when gross landings decreased by 14%. Gross landings peaked in 2008 and 2011 at 151 million gross lbs. The lowest gross landings occurred in 2015 with only 114 million landed lbs.

On average, the average number of non-groundfish species landed per groundfish vessel increased after catch share management. When averaged over 2007-2009, an average of 8.9 and a median of 6.7 non-groundfish species were landed compared to an average and a median of 11.1 and 8.8 when averaged over 2010-2015 (Figure 15). Further, the average number of non-groundfish species landed per groundfish vessel decreased over 2007 to 2009 but rose for 6 consecutive years to an all-time high of 12.0 non-groundfish species per vessel in 2015.

Herfindahl indices were calculated to further investigate landings compositions at the vessel-level.[8] Both mean and median Herfindahl index values were lower post-catch share when comparing averages of the 2007-2009 and the 2010-2015 time period (Figure 16). The mean Herfindahl index value, when averaged over 2007-2009, was 0.58 and decreased to 0.55 when averaged over the 2010-2015 period. The median Herfindahl index, when averaged over the pre-catch share time period, was 0.55 and decreased to 0.50 when averaged over the post-catch share time period. The HHI values suggest that a few species are more abundant in vessels' overall landings given that there is an average of 9 to 12 species landed per vessel across fishing years, as previously discussed (Figure 15). For example, if there are 10 species landed per fishing vessel and each is caught in equal proportions, the HHI would reflect a value closer to 0.1. On average, the HHI decreased post-catch share, which indicates a decrease in the dominance of a single/few species in the total vessel catch composition and a more equal proportion of catch landed. The inverse HHI increased post-catch share overall, with an average mean value of 2.19 (median 1.81),

[8] An explanation of the calculation and interpretation of the Herfindahl and Inverse Herfindahl can be found in Section ii. Landings Trends and Compositions under sub-section b. Trip-Level Landings Trends and Compositions.

which increased to 2.32 (median 1.99) when averaged over the pre- and post-catch share period, respectively. This indicates that the number of species landed would need to increase in order to produce the same HHI value during the 2010-2015 time period, further supporting that the groundfish vessel landings compositions are becoming more even and rich.

d. Entity-Level Landings and Catch Compositions

"Gross landings from groundfish entities" are defined as the total landings (all species) from all vessels affiliated with a groundfish entity. The added contribution of landings differs from the vessel-level analysis by incorporating non-groundfish vessels that still contribute to a groundfish business entity. Gross landings from groundfish entities fluctuated over the 2010-2015 period. Gross landings increased during 2010-2011 from 148 million to 179 million gross lbs. Gross landings decreased for 3 consecutive years to a minimum value of 132 million gross lbs. in 2014 but rebounded slightly in 2015 to 138 million lbs. (Figure 17). Further, gross entity landings peaked in 2011 (179 million gross lbs.). Entity-level gross landings increased the most from 2010-2011, increasing by 21%, and decreased the most from 2011-2012 with a 15% decrease. The fluctuation during the 2010-2015 time period was consistent with the vessel-level analysis, highlighting the large contribution of landings from groundfish vessels to the groundfish businesses as a whole.

The mean and median number of non-groundfish species landed per entity followed an overall increasing trend over 2010-2015. The average number of non-groundfish species landed per groundfish entity is 10.4 species in 2010. The average number of non-groundfish species increased for 4 consecutive years to 13.2 species per entity in 2014, which decreased slightly to an average of 13.0 non-groundfish species landed per entity in 2015 (Figure 18). The median number of non-groundfish species landed at the entity-level increased from 9 to 10 species from 2011 to 2012; the median number of non-groundfish species landed decreased in 2013 to 9 but increased and leveled off at 11 species in 2014 and 2015.

Here, the Herfindahl index is used to explore the relative abundance of each species landed at the entity-level. Average Herfindahl indices, describing the relative share of each species landed per groundfish entity, fluctuated marginally over the 2010-2015 time period, ranging from 0.54 to 0.52 (Figure 19).[9] Median Herfindahl indices were also relatively consistent over this time period, with an index value of 0.48 from 2010 to 2013, which decreased to 0.46 over 2013 to 2014 and increased slightly to 0.49 in 2015. The minor differences between HHI mean and median values across years, along with the relatively stable interquartile ranges, suggest that the relative abundance was similar over time where fewer species are more abundant relative to other species. The average and median inverse Herfindahl values also suggest marginal differences in relative species shares, where the average inverse HHI was 2.4 from 2010-2013 and increased slightly to 2.5 in 2014 but decreased to 2.4 in 2015. The median HHI value followed a similar trend, with values of 2.1 for 2010-2014 which increased to 2.2 in 2014 and decreased to 2.0 in 2015. These values support that of the ~10 species landed by groundfish entities (Figure 18), some are landed in higher abundances relative to other species.

[9] An explanation of the calculation and interpretation of the Herfindahl and Inverse Herfindahl can be found in section ii. Landings and Catch Compositions under sub-section b. Trip-Level Landings and Catch Compositions.

iii. Cost, Revenue, and Net Revenue Analysis

a. Cost, Revenue, and Net Revenue Analysis Overview

Trip costs, or expenses incurred during the at-sea operation of individual commercial fishing trips, were calculated at the trip and vessel level both before and after the implementation of catch share management. Entity operating costs are calculated for FY 2010-2015. In this analysis, the trip-related operating costs include the cost of supplies, groceries, bait, fuel, ice, water, and oil. The trip-level analysis includes a summary of operating costs incurred on groundfish fishing trips and a calculation of trip costs per hour. Trip costs at the vessel-level equal the sum of all operating costs incurred on any vessel that took at least 1 groundfish trip during a single fishing year. Entity-level operating costs are equal to the sum of all trip costs from all vessels within the groundfish entity for each fishing year, including all groundfish and non-groundfish operations. Revenues are also assessed at the groundfish trip-, vessel-, and entity-level. Revenues per trip, vessel, and entity include revenues earned from all species, unless otherwise stated. A summary of the percent of revenues earned from groundfish species, as a proportion of total revenues, is also assessed. Net revenues equal total revenues less trip costs and are assessed at the trip-, vessel-, and entity-level. These measures highlight economic performance of the groundfish fleet before and after the implementation of the catch share system.

b. Trip-Level Cost, Revenue, and Net Revenue Analysis

Average and median trip costs per hour change marginally across the pre- and post-catch share time period. The average cost of a trip per hour, in terms of variable costs such as fuel, ice, bait, supplies, food, water, and oil was $40.9/hour pre-catch share and $43.4/hour post-catch share when averaged over the 2 time periods, respectively (Figure 20). Median trip costs were slightly lower than average trip cots per hour with rates of $34.1/hour and $33.3/hour when averaged over the pre- and post-catch share period, respectively. Average and median trip costs per hour were largely influenced by average fuel prices, as this is a dominant component of at-sea operation (Das 2014). Trends in average hourly trip costs closely followed trends in average New England fuel prices with both average fuel prices and average trip costs per hour peaking in FY 2012 ($50.1/hour and 3.8/gallon, respectively) and decreasing to their lowest values in 2015 ($32.1/hour and 2.4/gallon, respectively).[10] Median trip costs per hour were also lowest in 2015 but peaked in 2007 with a median rate of $39.2/hour. This may suggest that vessels with low fuel efficiency, possibly driven by older, non-upgraded vessels, were more active during the pre-catch share period. This is further supported by the trends in fleet characteristics, which show a decline in average vessel age post-catch share enactment, which suggests possible increases in fleet efficiency post-catch share (see Figure 5). The difference between the average and median hourly trip costs demonstrate a skewed distribution with fewer trips incurring higher hourly costs than the majority of trips taken, which may be driven by large, less fuel-efficient vessel operation. Overall, trip costs per hour changed marginally over the pre- and post-catch share time period and mirrored trends in average New England fuel prices.

[10] Monthly New England PADD 1A retail gasoline prices in dollars per gallon (all grades and formulations) were accessed via the U.S. Energy Information Administration website and averaged by groundfish years. Values reflect non-adjusted US dollars.

Average operating costs per trip were 1.7 times higher post-catch share compared to pre-catch share with trip costs averaging $1.6K from 2007-2009 and $2.7K over 2010-2015 (Figure 21). Average trip costs per trip decreased over 2007-2009, reaching a minimum value of $1.2K per trip in 2009. Average trip costs almost doubled, increasing by 99% to $2.4K in 2010. Trip costs slightly increased from 2010 to 2013 where average trip costs peaked at $3.2K. Trip costs dropped to $3.0K and $2.2K in 2014 and 2015, respectively. Median trip-level operating costs were substantially lower than average costs but were also generally higher post-catch share compared to the pre-catch share time period. Median trip costs, when averaged over 2007-2009, equaled $311 and increased to $417 when averaged over 2010-2015. Median trip cost increased over 2009-2010 by 42% and continually rose to $526 where median costs peaked in 2013. Median trip costs decreased to $476 and $375 in 2014 and 2015, respectively. Overall, the cost of taking a trip was higher post-catch share. The increases in trip costs are most likely driven by longer trips which increased from an average of 27.0 hours in 2015 to 48.7 hours in 2019 (Table 4). Most notably, the average trip durations increased from 2009 to 2010 where the average trip duration increased from 24.2 hours to 37.9 hours, a 56% increase. The relatively large difference between mean and median trip costs highlights the skewed distribution of costs where some trips incur much higher costs than the majority of trips. The range of trip costs was also wider post-catch share compared to the pre-catch share time period.

Average and median trip revenues were also higher after catch share implementation. Average groundfish trip revenues were 1.9 times higher post-catch share compared to pre-catch share revenues. Specifically, when averaged over 2007-2009 and 2010-2015, average trip revenues equal $5.2K and $9.8K, respectively, an 88% increase. Average trip revenues decreased over 2007-2009 from $5.6K to $4.8K (Figure 22). Average trip revenues more than doubled from 2009 to 2010, increasing from $4.8K to $10.2K. Average revenues decreased from 2010-2012 to $8.2K but increased from 2012 to a maximum of $10.8K in 2015. Average revenues were about 2 to 3.6 times higher than median trip-level revenues; however, median revenues followed a pattern similar to average revenue values. Median revenue increased by 61% post-catch share compared to median revenues averaged over the pre-catch share period. Median trip revenues equaled $2.9K and $1.8K when averaged over 2007-2009 and 2010-2015, respectively. Median revenues decreased over 2007 to 2009 from $2.0K to $1.6K then increased by 94% to $3.1K over 2009 to 2010. Median revenues decreased from 2010 to 2012, increased in 2013 and 2014, and then slightly decreased to $3.0K in 2015. Overall, both average and median trip revenues are higher post-catch share. The range of trip revenue values was also wider post-catch share when compared to the pre-catch share time period. This is further supported by the difference between average and median revenues, which increased during the 2010-2015 period.

The percent of revenue earned from groundfish species as a proportion of total revenues earned on a groundfish trip was lower during 2010-2015 compared to 2007-2009. Average groundfish species revenue as a percent of total trip revenues decreased from 80.9% to 71.5% when comparing 2007-2009 and 2010-2015 percentages (Figure 23). Revenue from groundfish species make up 76.9%-86.1% of total trip revenues during 2007-2009. The percentage of groundfish species revenue decreased continuously after 2009 to a minimum of 62.9% in 2015. The median percent revenue resulting from groundfish species is overall higher than average revenue percentages, ranging from 76.4% to 97.3% over 2007-2015. Median groundfish revenue as a percent of total revenues is also higher during 2007-2009, with a median of 94.7% of revenues when averaged over the time series compared to 2010-2015, with an average median of 85.8% of revenues. The highest median percent of groundfish species revenue occurred in 2009 (97.3% of

revenues) and the lowest occurred in 2015 (76.4% of revenues). Lastly, the distribution of percentages of groundfish revenue was widest over 2013-2015. The overall decrease in the percentage of revenue earned from groundfish species may support that catch compositions are becoming more diversified at the trip-level or those who remained in the fishery are those who are less reliant on groundfish revenue, overall.

Net revenues, assessed at the trip-, vessel-, and entity-level, can reflect changes in economic efficiency within the fleet (Murphy et al. 2018). Average and median groundfish trip net revenues were higher after catch share implementation. Average net revenues for the 2010-2015 period (ranging from $5.5K to $8.6K per trip) were almost 2 times those averaged over 2007-2009 (ranging from $3.5K to $3.8K per trip) (Figure 24). Average groundfish trip net revenues more than doubled from 2009 to 2010 to $7.8K then declined over 2011 and 2012 to $5.5K but increased for 3 consecutive years to $8.6K per trip in 2015. Median net revenues were also higher during the 2010-2015 time period but are notably lower than average net revenue values. Median net revenues, averaged over 2010-2015, are 1.6 times larger than median revenues averaged over 2007-2009. Median net revenues ranged from $2.0K to $2.7K over 2010 to 2015 compared to $1.3K to $1.6K over 2007-2009. The percent differences between the mean and median revenue values are higher post-catch share implementation, ranging from 93-107% over 2010-2015 compared to 81-91% in 2007-2009. The highest average and median net revenue values per trip were earned in 2015 and 2010 ($8.6K and $2.7K, respectively). Further, there was a notable increase in the range of trip-level net revenues during the 2010-2015 period comparatively to the 2007-2009 period.

Negative net revenues occur when the cost of operating exceeds the revenues earned. A trip that does not cover costs is referred to as a "busted trip." Over a longer time period, negative net returns may be a signal that operations should be halted as costs such as fuel, ice, bait, and other variable trip costs cannot be covered. When assessing net revenues at the trip-level, average negative net revenues did not change when comparing averages from pre- and post-catch share implementation. Specifically, an average of 5% of trips earned negative net revenues during the 2007-2009 and the 2010-2015 time periods. The percent of trips with negative net revenues ranged from 2007-2015 from 3-6% (Figure 25). The highest percent of trips with negative net revenues occurred in FY 2007, 2008, and 2013 (6% of trips). Lastly, the lowest percent of trips earning negative net revenues (3%) occurred in 2015.

c. Vessel-Level Cost, Revenue, and Net Revenue Analysis

Operating costs were also calculated at the vessel-level by summing all trip costs per groundfish vessel for each fishing year. This calculation includes costs incurred on both groundfish and non-groundfish fishing trips. Average operating costs per vessel were 1.2 times higher during the post-catch share time period compared to the pre-catch share time period (Figure 26). Vessel operating costs or total trip costs equal $103K when averaged over 2007-2009 compared to $121K when averaged over the 2010-2015 time period. From 2007 to 2009, vessel operating costs decreased from $117K to $83K. From 2009 to 2010, average vessel operating costs increased by 30% to $108K and increased by another 32% from 2010-2011 to $143K. From 2011 to 2015, average vessel operating costs followed a generally decreasing trend to $91K in 2015. Median vessel operating costs were about half the value of average vessel operating costs, highlighting a skewed distribution of vessel-level costs. Median costs were about the same when comparing values from the pre- and post-catch share periods. Median vessel operating costs are about $57K when averaged over the 2007-2009 and 2010-2015 periods. From 2007-2009, median vessel trip/operating costs decreased from $64K to $44K. Median trip costs increased by 13% over 2009-

2010 and by another 40% from 2010 to 2011where median costs peaked at $69K. After 2011, median vessel operating costs decreased for 4 consecutive years to $45K in 2015. Lastly, the variation in vessel operating costs was greater during the post-catch share time period.

Trends in vessel-level revenues were assessed both before and after the implementation of the catch share system. Vessel revenues were higher in every year post-catch share compared to the 3 years analyzed before catch share implementation. Average vessel revenues were 1.4 times higher when averaged over the post-catch share time period than revenues averaged over the pre-catch share time period. Moreover, average vessel revenues equaled $313K when averaged over 2007-2009 compared to revenues averaged over 2010-2015, which equaled $446K, a 43% increase between the 2 time periods (Figure 27). From 2007-2009, the average vessel revenue was relatively stable, only slightly decreasing from $315K to $307K. Average vessel revenues increased by 38% from 2009 to 2010 to $424K, the largest percent increase of the time series. Average vessel revenues increased by an additional 19% from 2010 to 2011 where revenues peaked at $504K. Average revenues decreased by 15% over 2011-2012 to $431K then rose after 2012 to $455K in 2015. Median vessel revenues were also higher over 2010-2015 compared to median values from 2007-2009. When averaged over 2007-2008, median vessel revenues equaled $211K and $265K when averaged over 2010-2015, a 26% increase between the 2 time periods. Median vessel revenues were fairly consistent over 2007-2009, ranging from $2087K to $214K. Median vessel revenues increased by 19% from 2009 to 2010 from $211K to $251K and rose by an additional 13% from 2010 to 2011 to $285K. After peaking in 2011, median revenues decreased over 2012 and 2013 to $244K then increased over 2014 and 2015 to $282K. The difference between the median and average revenues increased post-catch share, highlighting the increase in the range of revenues over the 2010-2015 time period.

The revenue earned from groundfish species as a percent of total vessel revenues was higher during 2007-2009 compared to 2010-2015, despite higher gross vessel-level revenues during the post-catch share time period. About 51.3% of average vessel revenues were derived from groundfish species when averaged over 2007-2009 (Figure 28). Comparatively, only an average of 42.5% vessel-level revenues were derived from groundfish species when averaged over 2010-2015. There was a sharp decrease in the percentage of revenue earned from groundfish species over 2009-2010, decreasing from 54.8% to 46.0% of average vessel revenues. The median vessel revenue earned from groundfish species was somewhat higher than average percent revenue. Median percent revenue from groundfish species, however, was also higher pre-catch share when compared to post-catch share percentages, with median values of 56.0% and 36.3% when averaged over the respective time periods. Median values incurred a large decrease over 2009-2010, decreasing from 62.6% to 43.5% of revenues derived from groundfish species. Median groundfish revenue as a percent of total revenues was lowest in 2015 where only 25.2% of median the revenue was derived from groundfish species. These results suggest that though individual vessel revenues increased post-catch share, the majority of vessel-level revenues were derived from species other than groundfish.

Similar to groundfish trips, groundfish vessel net revenues were also generally higher after the enactment of catch share management. Average net revenues per vessel ranged from $199K to $224K (an average of $210K) over 2007-2009 to $283K to $364K (an average of $325K) over 2010-2015 (Figure 29). The largest inter-annual increase in average net revenues occurred over 2009-2010 (a 41% increase) and average net revenues continued to rise to $361K in 2011. After 2011, average vessel net revenues decreased for 2 consecutive years to $283K in 2013, but increased to an all-time high in 2015 ($364K). Median net revenues at the vessel-level were, again,

higher during 2010-2015, ranging from $180K-$231K compared to $138K-$162K in 2009-2007. More specifically, average median vessel net revenues increased by 36% when comparing average median values from before to after catch share management. Median vessel net revenues followed a similar trend to average net revenues, rising in 2011 ($213K), decreasing from 2012-2013 ($180K), and then rising to an all-time high of $231K in 2014-2015. There was higher variability in net revenues over 2010-2015 compared to 2007-2009, and interquartile ranges increased in the positive direction when comparing the values from pre- and post-catch share time periods.

Further, the percent differences between mean and median net revenue values were greater during 2010-2015 (42%-52%) compared to 2007-2009 (32%-36%) but did not follow consistent trends post-catch share implementation.

Across all vessel size groups, median net revenues were higher when comparing values averaged over 2007-2009 to those averaged over 2010-2015 (Figure 30). All vessel size groups earned minimum median net revenue values prior to catch share implementation (either in FY 2007 or 2008). Further, all vessel size classes earned maximum median net revenues post-catch share implementation in either FY 2011 or 2015. The only vessel size class to have negative median net revenues in any year is the <30' vessel size group. Median net revenues increased for all vessel size classes from 2009-2011 with the exception of the smallest size class where median net revenues decreased from $1.5K to -$347 from 2010 to 2011. Median net revenues decreased for all vessel size classes from 2011 to 2012. Finally, median net revenues increased for all vessel size classes from 2014 to 2015. Overall, most vessel size classes had relatively stable median net revenues over 2007-2008 followed by increases in median net revenues from 2009-2011, but median net revenues decreased during 2012, and sometimes decreased further in 2013 and 2014. The decreases were followed by an increase in median net revenues from 2014-2015 for all size classes. Generally, all vessel size classes incurred large percent increases in median net revenues from 2008 to 2009, 2009 to 2010, and 2010 to 2011, while median net revenues changed marginally across vessel size classes from 2007-2008.

There was little change in the percentage of vessels operating below their shutdown point (i.e., incurring net revenues < $0.00) when comparing averages from before and after the catch share program. Pre-catch share implementation, an average of 6% of vessels operated below their shutdown point, ranging from 4-7% of vessels during the 2007-2009 period (Figure 31). From 2010-2015, an average of 5% (ranging from 2-9%) of vessels operated below their shutdown point. The highest percent of vessels earning negative net revenues occurred in 2011 (9%) and the lowest in 2015 (2%). The number of vessels with negative net revenues decreased most from 2008 to 2009 by 3 percentage points, but increased by 5 percentage points from 2010 to 2011. The percent of vessels with negative net revenues decreased from 9-4% from 2011 to 2012 and increased in 2013 to 6%, but decreased for 2 consecutive years to an all-time low point in 2015 (2%).

There was no change in the percent of vessels earning negative net revenues by vessel size class when comparing averages from pre- and post-catch share implementation. Vessels incurring negative net revenues were almost always in the <30' or 30' to <50' size classes (Figure 32). An average of 2% of vessels in the <30' size class operated below their shutdown point during both the 2007-2009 and 2010-2015 time periods. Similarly, an average of ~3% of vessels in the 30' to <50' size class incurred negative net revenues when averaged over 2007-2009 and 2010-2015. The percent of vessels with negative net revenues in the <30' size class remains relatively stable, around 2-3%, but the 30' to <50' size class fluctuated more dramatically over time, ranging from 1-7%, over the course of 2007-2015. The percent of vessels operating below their shutdown point increased in both the <30' and 30' to <50' vessel size classes over FY 2010-2011. Trends in

negative net revenues among the smaller vessel size classes may have been driven by increases in average New England fuel prices, which increased from $2.41/gal. $3.78/gal. from 2009 to 2012.[11] The combination of factors, such as increasing variable costs (i.e., trip costs) and decreasing ACLs, may have contributed to smaller vessels to falling below their shutdown points as they are inherently more susceptible to shifting supply curves. These vessels may have exited the fishery or halted operations resulting in a decrease in fleet size and a decrease in the number of vessels operating with negative net revenues during the latter half of the analysis.

d. Entity-Level Cost, Revenue, and Net Revenue Analysis

Operating costs were also evaluated at the entity-level to assess how costs changed during this time period from a broader business perspective. Overall, costs fluctuated over the 2010-2015 time period. Average operating costs at the entity-level increased by 31% from 2010 to 2011 ($150K to $197K, respectively; Figure 33). Average entity operating costs decreased to $182K and $183K in 2012 and 2013, respectively, then deceased further to $163K and reached an all-time low of $125K in 2015. Mean entity operating costs were about 3 times the median cost values. Median trip cost values, like average trip costs, also increased from 2010-2011, increasing by 45% from $52K to $75K. After 2011, median entity operating costs decreased continuously and reached a minimum value of $43K in 2015. There was a highly skewed distribution of operating costs at the entity-level, with few entities incurring relatively high costs compared to the general population of groundfish entities.

Entity-level revenues fluctuated slightly over the 2010-2015 time period and followed similar trends to those at the vessel-level. From 2010-2011, average entity-level revenues increased by 22% from $641K to $780K then decreased over 2012 and 2013 to $592K, increased over 2014 to $673K, then fell again in 2015 to $662K (Figure 34). Mean entity revenues were more than twice as large as median values. Median values ranged from $243K-$292K over 2010-2015. From 2010-2011, median entity revenues increased by 14% from $257K to $292K then decreased over 2012 and 2013 to $243K. Median entity revenues rose over 2014 and 2015 to $257K and $270K, respectively. The difference between mean and median entity-level revenues highlights the positively skewed range of entity-level revenues over the 2010-2015 time period.

Groundfish species revenues, as a percent of total entity revenues, were lower than vessel-level percentages and generally followed a decreasing trend over the post-catch share time period. Average groundfish revenues as a percent of total entity revenues increased by a tenth of a percent from 42.6% to 42.7% over 2010-2011 (Figure 35). From 2011 to 2012 the percent of revenues earned from groundfish species decreased to 40.4% and held constant over 2013. From 2013, the percentage earned from groundfish species decreased to 36.1% and 34.9% for 2014 and 2015, respectively. Median groundfish revenues as a percent of total entity revenues were lower than average values, suggesting that there are few entities which earn relatively higher percentages from groundfish species comparatively to the majority of groundfish entities which rely more heavily on revenues from other species. Median groundfish revenues as a percent of total entity revenues increased from 2010-2011 from 34.1% to 39.7%. After 2011, the proportion of revenue earned from groundfish species decreased for 4 consecutive years to 22.8% in 2015.

The minimum median and average percent of revenues earned from groundfish species occurred in 2015 with 34.9% and 22.85%, respectively, decreasing by 7.7 and 11.3 percentage points from 2010 percentages. Entities trends were similar to those in the vessel-level assessment,

[11] New England (PADD 1A) retail gasoline prices for all grades and all formulations in nominal dollars per gallon was obtained from the U.S. Energy Information Administration Website.

where groundfish entities earned less from groundfish species relative to other species over the course of the time series.

Groundfish entity net revenues varied during the post-catch share implementation time period. Average entity net revenues peaked in 2011 ($583K), decreased for 2 consecutive years to $409K in 2013 but increased again over 2014 and 2015 to $537K (Figure 36). Median net revenues increased from 2010 to 2011 ($213K), decreased to an all-time low in 2013 ($180K), and rose again to a maximum value of $231K in 2015. The variation in net revenues is greatest in 2011 and 2015 and least in 2010. The skewed distribution of entity net revenues is evident in all years post-catch share implementation, similar to the trip- and vessel-level analyses. Further, the percent differences in mean and median net revenues ranged from 78-93% over 2010-2015.

The trends and magnitudes of net revenues were assessed by entity size class and compared across 2010-2015 (Figure 37). On average, median net revenues earned from entities with 2 vessel affiliates were 0.7 times larger than median net revenues earned by single-vessel entities. Entities associated with 3 vessels earned median net revenues that were, on average, 1.5 times higher than those of entities comprised of 2 vessels. On average, entities with 4 vessels earned median net revenues that were about 1.2 times greater than those of entities with 3 vessel associates, on average. Notably, entities with 5 or more vessels earned median net revenues that were, on average, 5.7 times larger than those of 4-vessel entities over 2010-2015. In addition, the differences in net revenue earnings between entity size groups increased over 2010-2015 for most comparisons. For example, entities with 2 vessels earned 0.5 times as much as single vessel entities in 2010, but this increased to 0.8 times by 2015. The difference in net revenues between vessel size classes also increased for entities affiliated with 4 and 5+ vessels; however, the magnitude of this difference was greater among the larger entities. For example, entities with 4 vessels made double the median net revenues of entities with 3 vessels in 2010, but this difference increased to 1.8 times median net revenues in 2015. Entities affiliated with 5 or more vessels earned about 2 times the median revenues earned by entities affiliated with 4 vessels in 2010 which increased to 9.8 times in 2015. Almost all entity size classes incurred higher median net revenues during 2014 and 2015 compared to 2010 net revenues. In addition, all but 1 entity size class (entities associated with 3 vessels), earned maximum median net revenues in 2014 or 2015. Overall, there was no clear trend in inter-annual increases across vessel size classes over 2010-2015. The largest entity size class had the most consistent upward trend in median net revenues, only decreasing once in 2013. Median net revenues for entities associated with 5 or more vessels increased by almost 600% from 2010 to 2015, with median net revenues increasing from $805K to $5.5M. Smaller entities incurred higher variations in median net revenues over the 2010-2015 period, but of smaller magnitudes, with percent changes ranging from 1-60% across the 4 smallest entity size classes. Over 2010-2015, median net revenues for single-vessel entities ranged from $127K to $194K, median revenues for entities affiliated with 2 vessels ranged from $185K to $269K, and median net revenues for entities affiliated with 3 vessels ranged from $319K to $430K. Vessels affiliated with 4 vessels earned median revenues which ranged from $296K to $564K. Lastly, entities affiliated with 5 or more vessels earned anywhere from $805K to $5.5M in median net revenues over 2010 to 2015.

At the entity-level, only 2 entity size classes, those affiliated with either 1 or 2 vessels, operated with negative net revenues over 2010-2015 (Figure 38). On average, 8% of single-vessel entities operated below their shutdown point over 2010-2015, which increased over 2010 to 2011 from 7% to 14%, but this percentage eventually decreased to only 3% of single vessel entities with negative net revenues in FY 2015. An average of 3% (2-4%) of entities affiliated with 2 vessels operated below their shutdown point over 2010-2015. Notably, 0% of entities affiliated with 3, 4,

or 5+ vessels earned negative net revenues over the time series analyzed. The fluctuations in the number and percentage of entities earning negative net revenues may have been driven by rising operating costs (e.g., fuel) and changes in the maximum potential output (i.e., potential landings dictated by Annual Catch Limits and Sector Annual Catch Entitlements). These and other factors could have caused smaller entities, who are more susceptible to these changes, to shut down, such that the number of entities with negative net revenues decreased over time.

iv. Concentration and Distribution of Net Revenues

a. Concentration and Distribution of Net Revenues Overview

The concentration and distribution of net revenues were assessed at the trip-, vessel-, and entity-level to highlight disproportional impacts and trends that can affect fleet diversity and therefore Goal 2 and Objective 7 of Amendment 16. Net revenues were highly skewed in the groundfish fishery and have maintained a similar level of skewness over the duration of the analysis period, with the majority of trips, vessels, and entities earning lower net revenues and a few earning extremely high net revenues. Cumulative earnings distributions were assessed at the trip-, vessel-, and entity-level by ordering net revenues from smallest to largest and dividing the ranked values into equal quartiles, each approximately 25% of gross net revenues for each business level. This process allows for the quantification and visualization of the number of trips, vessels, and entities earning the lowest and highest percentages of gross net revenues.

Gini coefficients were used to quantify the level of inequality in the distribution of net revenues across the population of trips, vessels, and entities. Gini coefficients range from 0 to 1, where 0 represents perfect equality and 1 is perfect inequality, in terms of the distribution of income or in this case net revenues, among a population. Gini coefficients can be graphically represented by a Lorenz curve, which demonstrates how net revenues are distributed across a population. The calculation of the Gini coefficient, graphically described, requires the cumulative percentage of the population, ordered by net revenues from least to greatest (i.e., the Lorenz curve), to be plotted on the horizontal axis and the cumulative share of net revenues on the vertical axis. The Lorenz curve is plotted in the same graphical space as the line of equality, a 45-degree line from the origin representing a perfectly even distribution of net revenues across the population. Gini coefficients are calculated using the area below the line of equality but above the Lorenz curve, divided by the total area under the line of equality and Lorenz curve. Lorenz curves and Gini coefficients were generated for each fishing year from 2007-2015. The metrics were averaged over FY 2007-2009 and compared to averages from 2010-2015 to identify changes from pre- and post-catch share implementation.

b. Trip-Level Concentration and Distribution of Net Revenues

An average of 79% of trips fell into the first quartile of the distribution of net revenues both pre- and post-catch share management (Figure 39). Further, in 2007-2009 and 2010-2015, an average of only 2% and 3% of trips fell in the top earning quantile (Q4: Top 25%) of net revenues, respectively. The inner 2 quartiles changed slightly from 2007-2009 to 2010-2015, with the percent of trips earning 25%-50% of gross net revenues, decreasing from 15% to 12% on average between the 2 periods. Those earning within the 50%-75% quartile increased from 4% to 5% when comparing averages from pre- and post-catch share management. Overall, at the trip-level, there was little change in the percent of trips which fell within each quantile when assessed over the pre- and post-catch share time periods, changing by only a few percentage points over the duration of

the entire analysis. Overall, the distribution of net revenues was consistent but highly skewed over the 2007-2009 and 2010-2015 time periods.

The Gini coefficients suggest an uneven distribution of net revenues across groundfish trips, ranging from 0.68 to 0.7 over 2007-2015 (Figure 40). These coefficients suggest relatively high levels of unevenness in the distribution of net revenues over this time. The average Gini coefficient decreased from 0.70 to 0.69 when comparing averages from the pre- and post-catch share time periods. These results support those of the net revenues quartile assessment, which also suggests high levels of concentration in net revenues which vary marginally at the trip-level between the 2007-2009 and 2010-2015 time periods.

c. Vessel-Level Concentration and Distribution of Net Revenues

Net revenues were highly concentrated at the vessel-level where about 6% of vessels earned the top 25% of gross net revenues both before and after the implementation of catch share management (Figure 41). The level of concentration, in terms of percentage of vessels per quartile, changed marginally when assessed both before and after the enactment of catch share management. On average, the lowest quartile of net revenues (Q1: Bottom 25%) was earned by 63% of groundfish vessels during 2007-2009. This percentage increased when averaged over 2010-2015 to 65% of vessels. The percent of vessels that encompassed the inner quartiles (Q2 and Q3) only changed by a percentage point when comparing averages from before and after the catch share program. The percent of vessels within the 25%-50% quartile decreased from 19% to 18%, and the percent of vessels within the 50%-75% quartile decreased from 12% to 11%, when comparing the pre- and post-catch share averages, respectively.

Similar to the distribution of trip-level net revenues, the Gini coefficient was used to quantify the concentration of net revenues at the vessel-level (Figure 42).[12] Net revenues were less concentrated at the vessel-level compared to the trip-level, with Gini coefficients ranging from 0.51 to 0.57 over the 2007-2015 FY period. The average Gini coefficient value increased from 0.53 to 0.55 when comparing averages from 2007-2009 to 2010-2015. Net revenues are most concentrated in 2011 and 2013 where the Gini coefficient peaked at 0.57. The Gini coefficient reached a minimum in 2009 with a value of 0.51. Overall, the distribution of vessel net revenues was moderately skewed and varied marginally between the pre- and post-catch share time periods.

d. Entity-Level Concentration and Distribution of Net Revenues

At the groundfish entity-level, net revenues were highly concentrated with only 1-2% of entities (3 to 4 entities) earning the top 25% of gross net revenues and about 76% (270 to 173) of entities earning the lowest 25% of gross net revenues (Figure 43).[13] The lower middle quantile (25%-50%) of gross net revenues were earned by 17% of entities for all years except for 2011 which decreased to 16% of entities. Anywhere from 4-7% of entities earned 50%-75% of gross net revenues, increasing to 6-7% during 2013-2015. The top 25% of net revenues were earned by 1% of entities from 2010-2013, but this increased slightly to 2% of entities in 2014 and 2015.

[12] For a detailed description of the calculation and interpretation of Gini coefficients and Lorenz curves, refer to Section V.iv.b. Trip-Level Net Revenue Concentration and Distribution of Net Revenues

[13] Total net revenues earned by each groundfish entity were ordered from smallest to largest and divided into equal quartiles, each approximately 25% of the gross net revenues earned by all groundfish entities by groundfish year. This was such that the proportion of entities earning the lowest and highest percentages of gross net revenues could be identified.

Lastly, though the total number of entities decreased over the analysis period, the percent of entities within each earning quartile stayed relatively consistent over time.

Gini coefficients, measured at the entity-level, quantified the distributional unevenness of net revenues earned over time. Gini coefficients ranged from 0.66 to 0.73 during the 2010-2015 post-catch share time period. These Gini coefficients suggest relatively high levels of unevenness in the distribution of net revenues during this period (Figure 44). The highest Gini coefficient, 0.73, occurred in 2011 while the lowest Gini coefficient, 0.66, occurred in 2015. The greatest inter-annual changes occurred from 2010-2012, where the Gini coefficient increased from 2010 to 2011 from 0.69 to 0.73 then decreased to 0.69 in 2012. The only other decrease in the Gini coefficient occurred from 2014 to 2015, decreasing from 0.69 to 0.66.

VI. SUMMARY AND CONCLUSION

In this report, trends and indicators are assessed from various business-level perspectives to investigate the economic performance of the groundfish fleet before and after the enactment of catch share management. Where possible, data were analyzed over FY 2007-2009 and compared to those of 2010-2015 to understand how measures have changed over these 2 distinct time periods. The analytical framework for this report is shaped by the economic goals and objectives of Amendment 16 to the multispecies FMP (Goal 2, 8, and Objective 7) and follows NOAA's Guidance for Conducting Review of Catch Share Programs (Morrison 2017). Specifically, harvest capacity and fleet structure, landings trends and compositions, operating costs, revenues, and net revenues were assessed. The distribution and concentration of net revenues and negative net revenues were also analyzed. These assessments can be used to track the economic performance of the groundfish fleet both before and after the implementation of the catch share system.

Fleet size decreased in terms of the number of trips, vessels, and entities operating post-catch share implementation, with the <30', 30' to <50', 50' to <75' and 75'+ size classes decreasing in average numbers by 37%, 45%, 40%, and 16%, respectively. Each size class decreased most from 2009-2010. The 2 smallest vessel size classes (the <30' and 30' to <50' size classes) had relatively greater average percent decreases post-catch share management (-14% and -13%, respectively) compared to average decreases over the 2007-2009 period (9% and -6%, respectively). The converse was true for the two largest vessel size categories, (50' to <75' and 75'+ size classes) which incurred smaller average percent decreases after the catch share program (-6% and -4%) rather than before (-16% and -5%).

Active groundfish vessels post-catch share implementation demonstrate possible increases in harvesting capacity and fleet efficiency, as suggested by increases in average vessel length, gross tons, and horsepower along with decreases in average vessel age. The changes in vessel characteristics and the higher percent decreases in the number smaller sized vessels may have been driven by two interrelated factors: (1) a shift toward increasing fleet efficiency and/or (2) shifting supply curves (e.g., changing input prices, alterations in the fishery management plan) which may have disproportionately impacted smaller businesses and forced smaller vessels to exit the fishery.

LPUE demonstrated no change when comparing values from pre- and post-catch share management; however, the average LPUE measure increased when compared across these 2 time periods. In addition, median landings per trip/vessel increased post-catch share by a factor of 2 and

1.4, respectively.[14] These results may be driven by less efficient vessels exiting the fishery after catch share implementation.

Overall, gross landings at the trip- and vessel-level were lower during the post-catch share time period. Gross landings from groundfish trips and vessels decreased when comparing gross landings averaged over the pre- and post-catch share time periods, decreasing by 24% and 10% for trips and vessels, respectively. The number of non-groundfish species landed increased and the relative share of each landed species became more even at the trip- and vessel-level after the enactment of the catch share program, as suggested by the HHI index values. The increase in species richness and evenness of landed species may be driven by (1) those remaining in the fishery post-catch share may have actively diversified their targeted species or (2) the exit of those who depend more heavily on lower diversities of species landings. Gross landings were lowest in 2014 and 2015 when assessed at the entity-level, and the number of non-groundfish species landed generally increased over 2010-2015. Overall, gross landings decreased after the implementation of the catch share system from each of the business-level perspectives assessed. Additionally, those who remained in the fishery were landing less groundfish species as a proportion of their total landings while harvesting a wider variety of non-groundfish species.

Trip and vessel-level operating costs were 1.7 and 1.2 times higher, respectively, when comparing costs averaged over 2007-2009 to those averaged over 2010-2015. Trip and vessel revenues were also higher during the post-catch share time period. Average trip revenues are 1.9 times higher and vessel revenues are 1.4 times higher when comparing revenues averaged over 2007-2009 to those averaged over 2010-2015. Net revenues per trip/vessel were also overall higher during 2010-2015 when compared to the pre-catch share time period. The increase in net revenues post-catch share may be reflecting increases in economic efficiency within the remaining fleet. Trip and vessel-level net revenues vary more during 2010-2015 compared to 2007-2009, which may be partially explained by trends in ACLs and fuel prices along with additional exogenous factors. There is little to no change in the percent of trips and vessels operating below their shutdown point when comparing average percentages from 2007-2009 to 2010-2015. Notably, only the smallest vessel size class consistently contains vessels which operate with negative net revenues when assessed over time. At the entity-level, only entities affiliated with 1 or 2 vessels incurred negative net revenues over 2010-2015.

Net revenues are highly concentrated in the groundfish fishery both pre- and post-catch share implementation. The top 25% of gross net revenues were earned by only 2-4% of trips and 56% of vessels. At the trip- and vessel-level, there was little to no change in the concentration of net revenues when comparing 2007-2009 to 2010-2015 average quartile percentages and Gini coefficients. In addition, only 1-2% of entities (3-4 entities) earned the top 25% of net revenues over 2010-2015. Overall, each groundfish business-level had skewed net revenue distributions that remained relatively consistent over the pre- and post-catch share time periods.

In conclusion, results suggest possible decreases in overcapacity and possible increases in economic efficiency post-catch share implementation. Higher landings and net revenues per trip and vessel were captured post-catch share management as fleet size and gross landings continuously declined. In addition, there were higher percent decreases in the number of smaller, active vessels post-catch share enactment, which was most likely due to the reduction of less efficient vessels in the groundfish fleet but also the disproportional impacts of shifting supply curves on smaller groundfish businesses. Although net revenues were higher at the trip- and vessel-

[14] Median landings were averaged over the 2 time periods for this comparison.

level for 2010-2015 compared to 2007-2009, an uneven distribution of net revenues and a trend toward fleet consolidation (i.e., fewer vessels/entities but of larger size as a proportion of the groundfish fleet) persisted after the implementation of groundfish catch share management.

TABLES

Table 1. Summary of major report metrics, averaged over fishing year 2007-2009 and 2010-2015.

Performance Metrics		Pre Catch Share (Averaged over 2007-2009)	Post Catch Share (Averaged over 2010-2015)	Percent Change (%)
Number of Groundfish Trips		22224	9559	-57%
Number of Groundfish Vessels		565	341	-40%
Number of Vessels Per Vessel Size Class	<30’	27	17	-37%
	30’ to <50’	297	165	-45%
	50’ to <75’	178	106	-40%
	75’+	63	54	-16%
Number of Groundfish Entities		498	297	-40%
Vessel Characteristics	Length (ft.)	51	53	4%
	Gross Tons	56	62	11%
	Horsepower (VHP)	403	427	6%
	Age (Years)	33	31	-6%
Gross Landings (All Groundfish Trips in Millions of lbs.)		83	64	-24%
Gross Landings (All Groundfish Vessels in Millions of lbs.)		144	130	-10%
Gross Landings (All Groundfish Entities in Millions of lbs.)		--	150	--
Median Landings Per Groundfish Trip (lbs.)		1128	2284	102%
Median Landings Per Groundfish Vessel (lbs.)		147,027	202,550	38%
Median Landings Per Groundfish Entity (lbs.)		--	208,063	--
Median Trip Landings Per Unit Effort (lbs./hr)		123	123	0%
Median Number of Non-Groundfish Species Landed / Trip		2	3	33%
Median Number of Non-Groundfish Species Landed / Vessel		7	9	33%
Median Number of Non-Groundfish Species Landed / Entity		--	10	--
Median Trip Species Shares Herfindahl–Hirschman (HHI)		0.5	0.5	-15%
Median Vessel Species Shares Herfindahl–Hirschman Index (HHI)		0.6	0.5	-9%
Median Entity Species Shares Herfindahl–Hirschman Index (HHI)		--	0.5	--

Median Trip-Level Operating Costs (2015 Constant Dollars)		311	417	34%
Median Vessel-Level Operating Costs (2015 Constant Dollars)		56,827	56,708	0%
Median Entity-Level Operating Costs (2015 Constant Dollars)		--	56,307	--
Median Trip-Level Revenues (2015 Constant Dollars)		1799	2896	61%
Median Vessel-Level Revenues (2015 Constant Dollars)		211,332	265,380	26%
Median Entity-Level Revenues (2015 Constant Dollars)		--	261,577	--
Median Percent Revenues Earned from Groundfish Species on Groundfish Trips (%)		95	86	-9%
Median Percent Revenues from Earned from Groundfish Species on Groundfish Vessels (%)		56	36	-35%
Median Percent Revenues from Earned from Groundfish Species within Groundfish Entities (%)		--	30	--
Median Trip-Level Net Revenues (2015 Constant Dollars)		1,452	2,379	64%
Median Vessel-Level Net Revenues (2015 Constant Dollars)		150,077	204,001	36%
Median Vessel-Level Net Revenues By Vessel Size Class (2015 Constant Dollars)	<30’	93	1,196	1181%
	30’ to <50’	103,403	127,419	23%
	50’ to <75’	220,698	333,437	51%
	75’+	410,062	662,622	62%
Median Entity-Level Net Revenues (2015 Constant Dollars)		--	203,105	--
Median Entity-Level Net Revenues by Entity Size (Millions of 2015 Constant Dollars)	1 Affiliate	--	0.2	--
	2 Affiliates	--	0.2	--
	3 Affiliates	--	0.3	--
	4 Affiliates	--	0.4	--
	≥5 Affiliates	--	2.6	--
Percent of Trips with Negative Net Revenues (%)		5	5	-16%
Percent of Vessels with Negative Net Revenues (%)		6	5	-17%
Percent of All Vessels with Negative Net Revenues Summarized by Vessel Size Class (%)	<30’	2	2	0%
	30’ to <50’	3	3	0%
	50’ to <75’	0	0	0%
	75’+	0	0	0%
Percent of Entities with Negative Net Revenues (%)		--	6	--
Percent of All Entities with Negative Net Revenues Summarized by Entity size (%)	1 Affiliate	--	8	--
	2 Affiliates	--	3	--
	3 Affiliates	--	0	--
	4 Affiliates	--	0	--

≥ 5 Affiliates	--	0	--
Trip Net Revenue Gini Coefficient	1	1	-1%
Vessel Net Revenue Gini Coefficient	1	1	3%
Entity Net Revenue Gini Coefficient	--	1	--

Note: Groundfish fishing years start on May 1st and end on April 30th such that the pre-catch share period includes data from May 1, 2007, to April 30, 2010, and the post-catch share period includes data from May 1, 2010, to April 30, 2016. All monetary values have been adjusted to 2015 constant U.S. dollars. Changes in percentages are calculated as changes in percentages.

Table 2. Groundfish Entity Requirements and Decision Rules

Year	Vessel Permit Number	Entity Identification	Groundfish Permit?	Included in Groundfish Enterprise Analysis?
2015	121	1	Yes	Yes
2015	177	1	No	
2015	153	1	No	
2010	552	2	No	No
2010	577	2	No	
2007	944	3	Yes	No*
2007	995	3	Yes	
2007	(Not Databased)	(Not Databased)	(Not Databased)	

Note: Ownership information for 2007 to 2009 was only databased for scallop and groundfish permits such that entity sizes and economic data are only partial assessments and therefore are excluded from the analysis.

Table 3. Average Species Price Algorithm Levels.

Price Level	Criteria				
1	Year	Month	Day	Species	Port
2	Year	Month	Day	Species	County
3	Year	Month	Day	Species	State
4	Year	Month	Day	Species	Area
5	Year	Month	Day	Species	Region
6	Year	Month	Week	Species	
7	Year	Month	Species		
8	Year	Species			
9	Species				

Table 4. Average and Median Trip Durations over Fishing Year.

Fishing Year	Mean Hours per Groundfish Trip	Median Hours per Groundfish Trip
2007	27.0	10.5
2008	26.3	10.0
2009	24.2	9.0
2010	37.9	11.3
2011	36.3	11.3
2012	38.4	12.2
2013	45.6	13.5
2014	48.5	13.5
2015	48.7	13.8

FIGURES

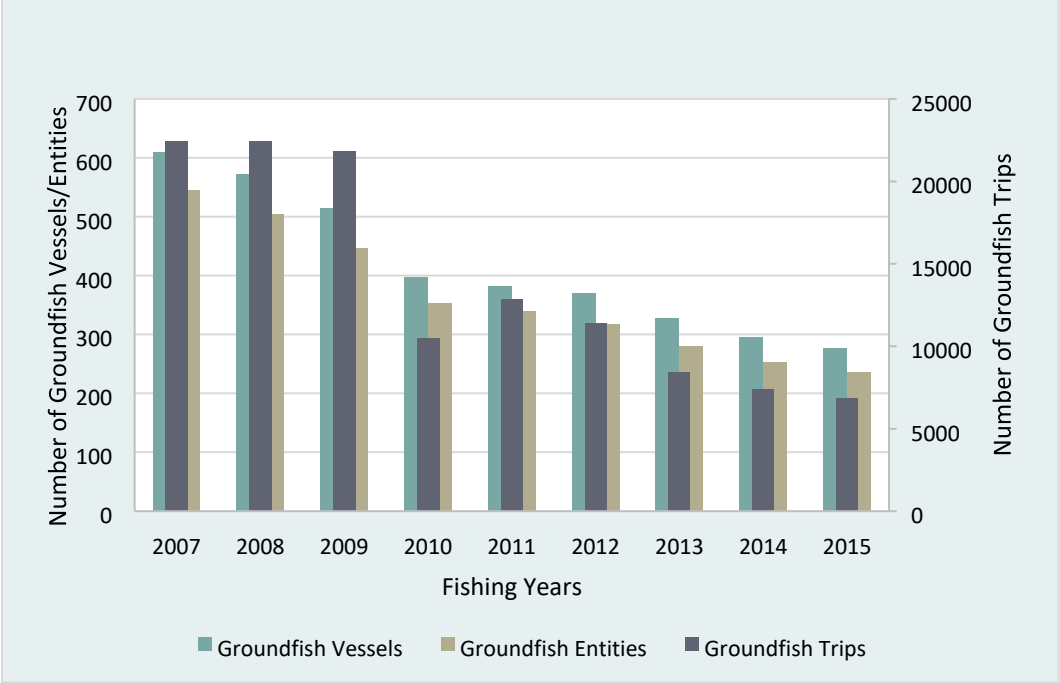


Figure 1. Number of Groundfish Trips, Active Vessels, and Entities by Fishing Year.

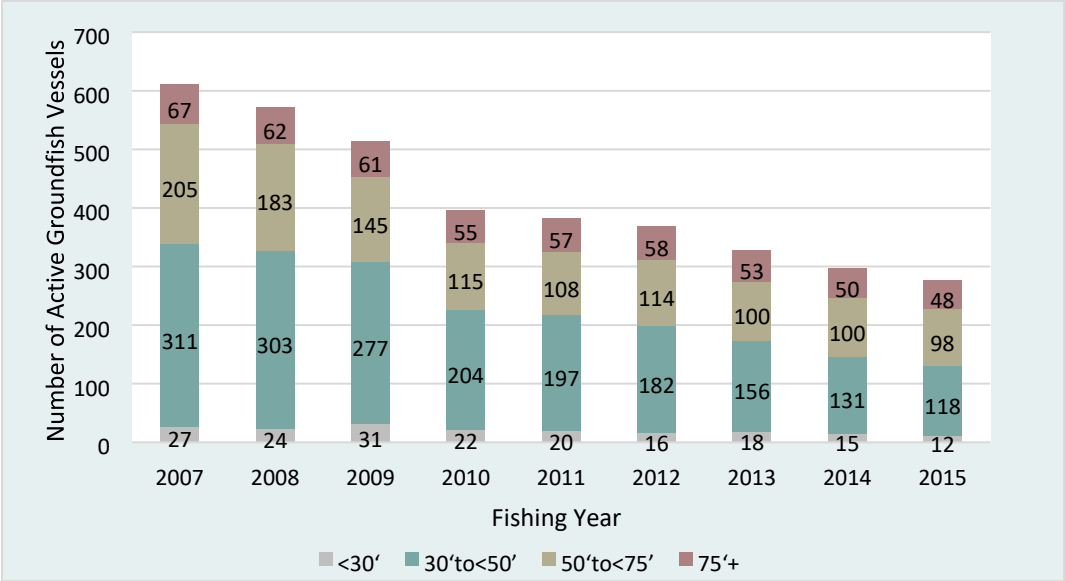


Figure 2. Number of Active Groundfish Vessels by Size Class and Fishing Year.

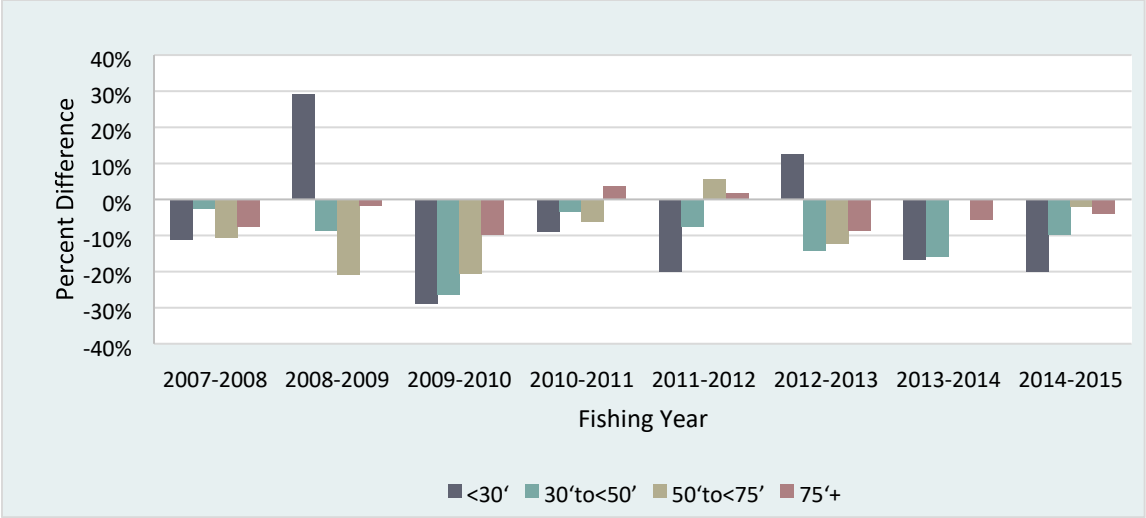


Figure 3. Percentage Increase/Decrease in Number of Vessels by Vessel Size Class between Fishing Years.

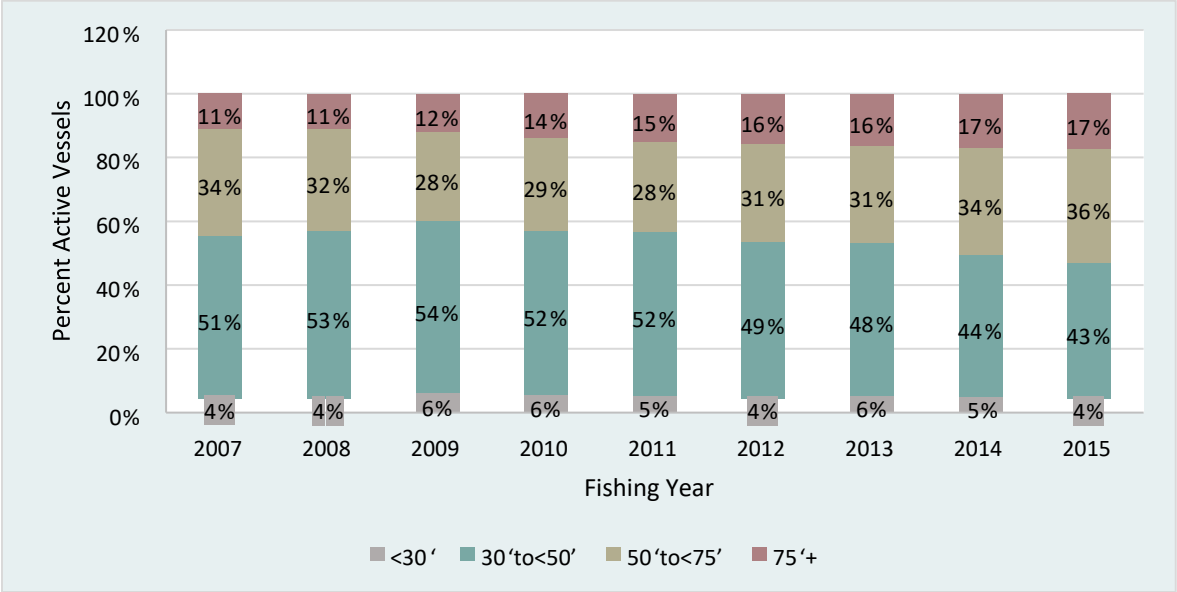


Figure 4. Percent of Active Vessels in the Groundfish Fleet by Vessel Size Class and Fishing Year.

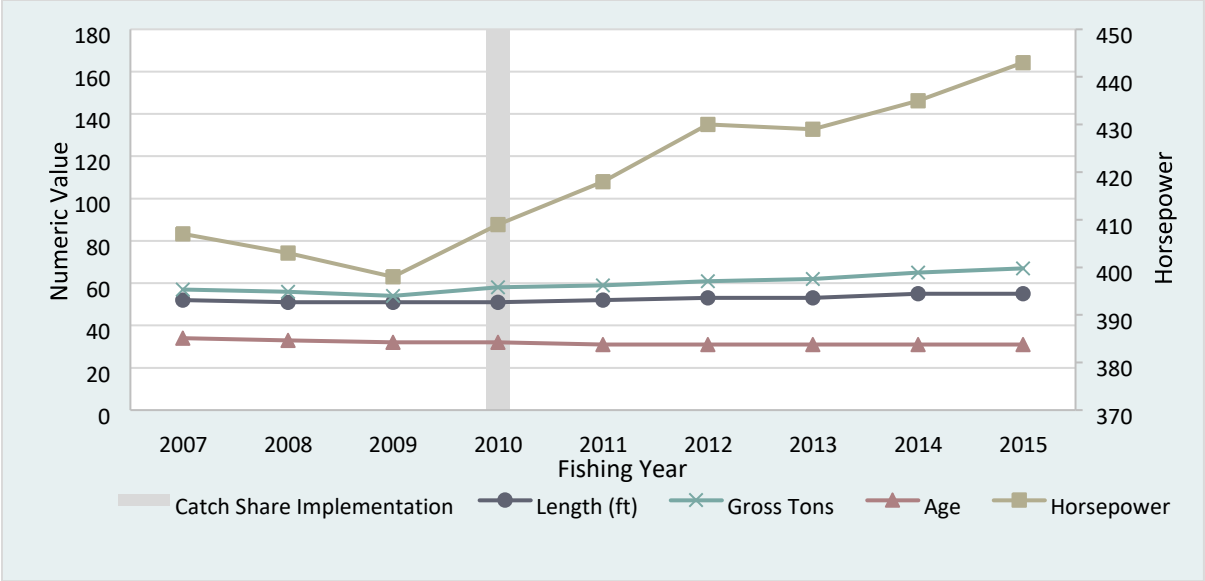


Figure 5. Average Groundfish Vessel Characteristics by Fishing Year.

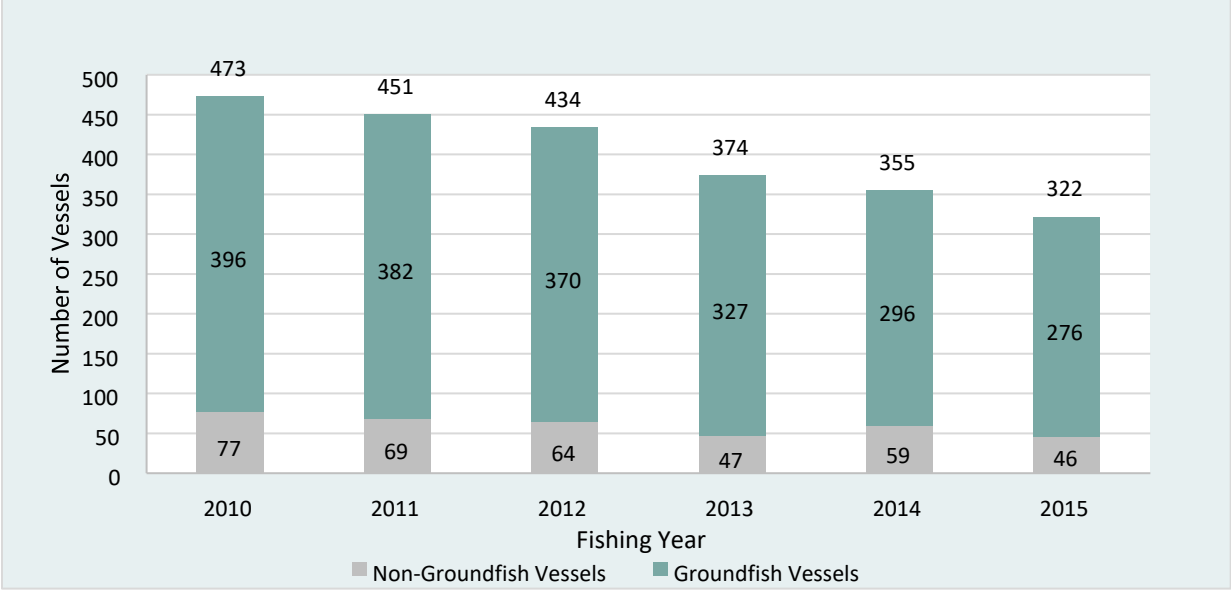


Figure 6. Total Number of Vessels Affiliated with a Groundfish Entity by Fishing Year.
Note: Affiliate data were not fully databased prior to FY 2010.

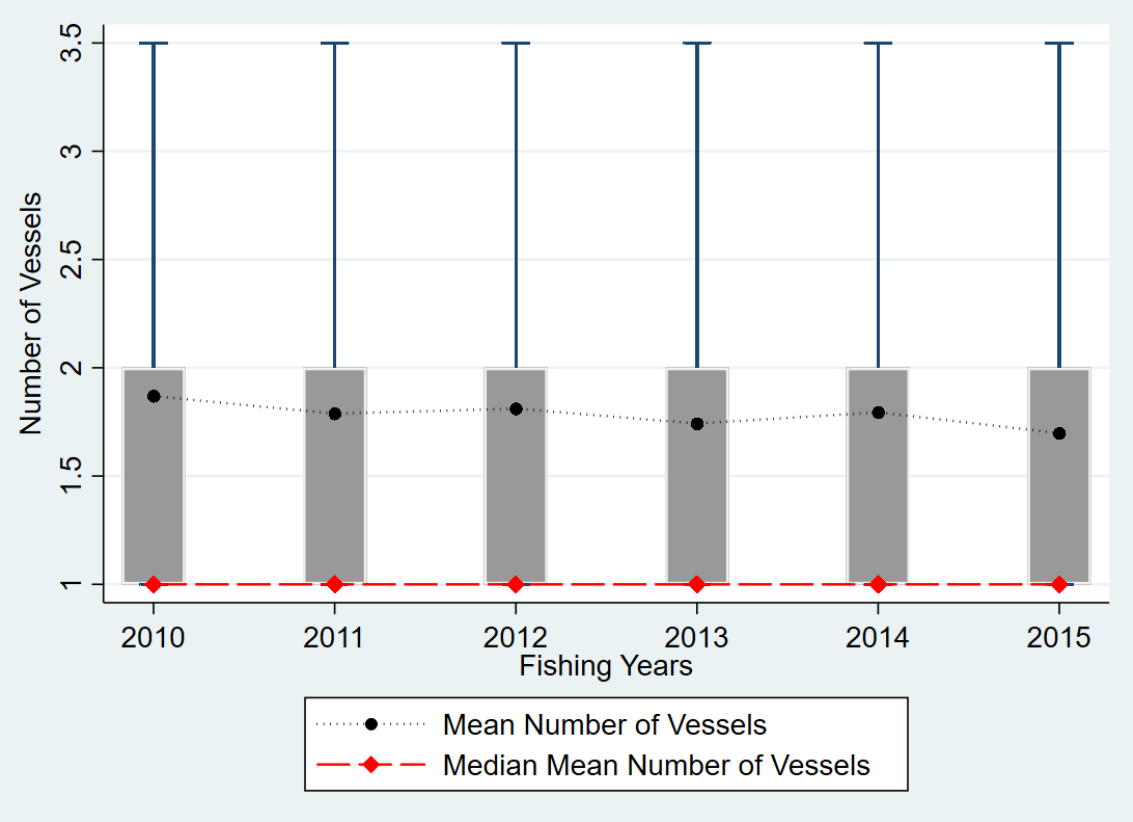


Figure 7. Box and Whisker Plot of Number of Active Vessels per Groundfish Entity by Fishing Year.

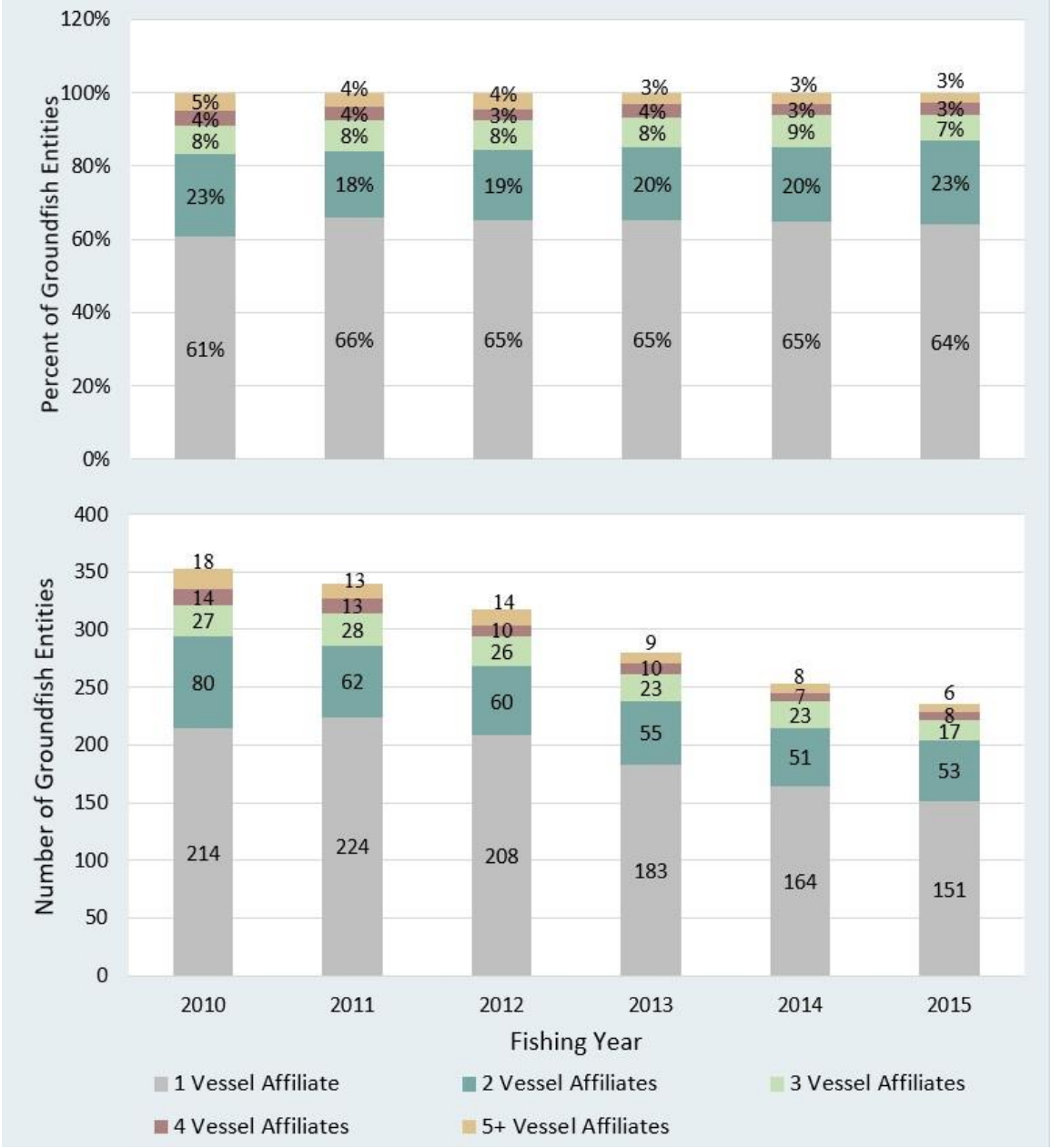


Figure 8. Percent and Number of Entities by Vessel Affiliation Size Group and Fishing Year.

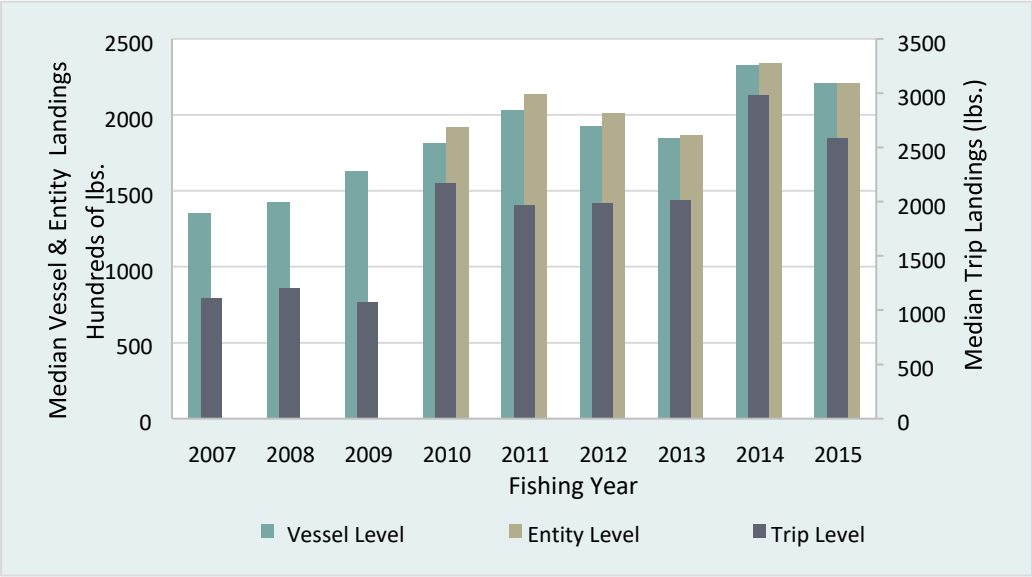


Figure 9. Median Landings (All Species) from Groundfish Trips, Vessels, and Entities.

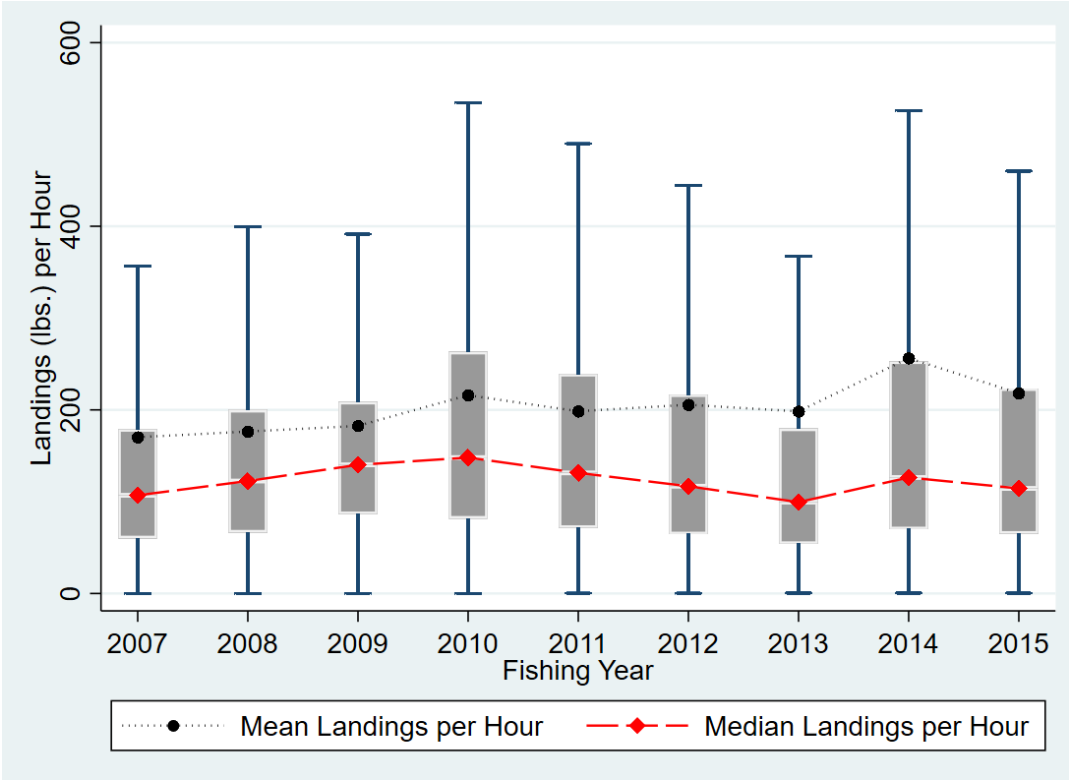


Figure 10. Groundfish Trip Landings per Hour Box and Whisker Plot (All Species) by Fishing Year.

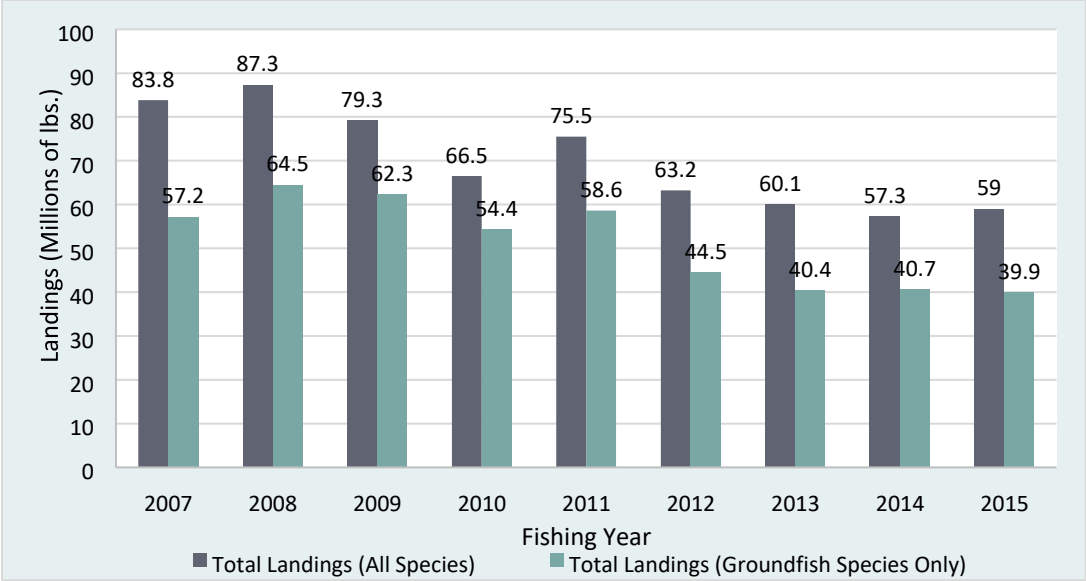


Figure 11. Gross Groundfish Trip Landings (All Species and Groundfish Species) by Fishing Year.

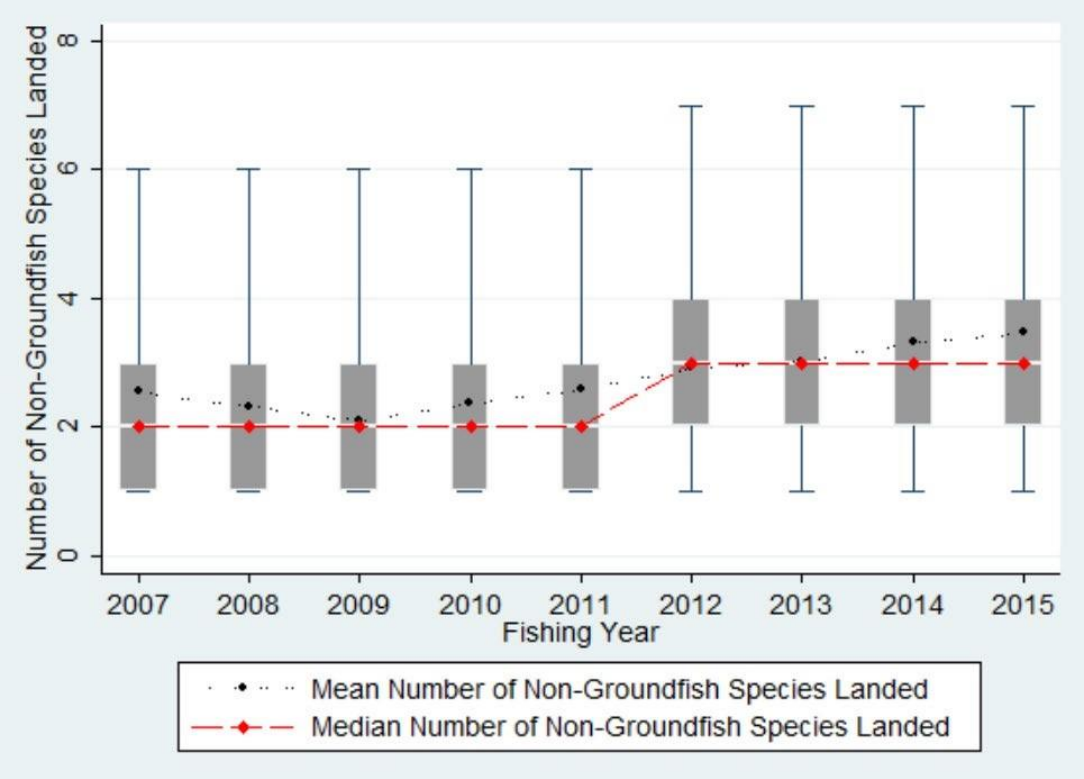


Figure 12. Number of Non-Groundfish Species Landed per Groundfish Trip Box and Whisker Plots by Fishing Year.

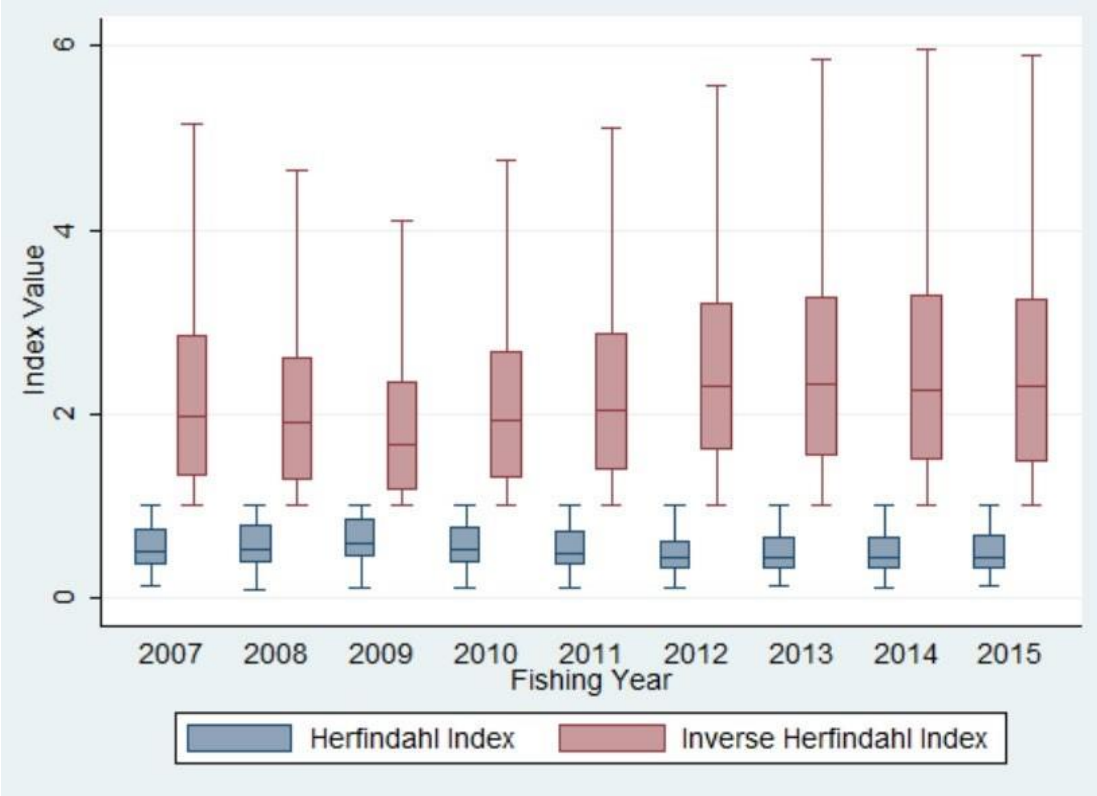


Figure 13. Trip-Level Herfindahl and Inverse Herfindahl Indices Box and Whisker Plots by Fishing Year.

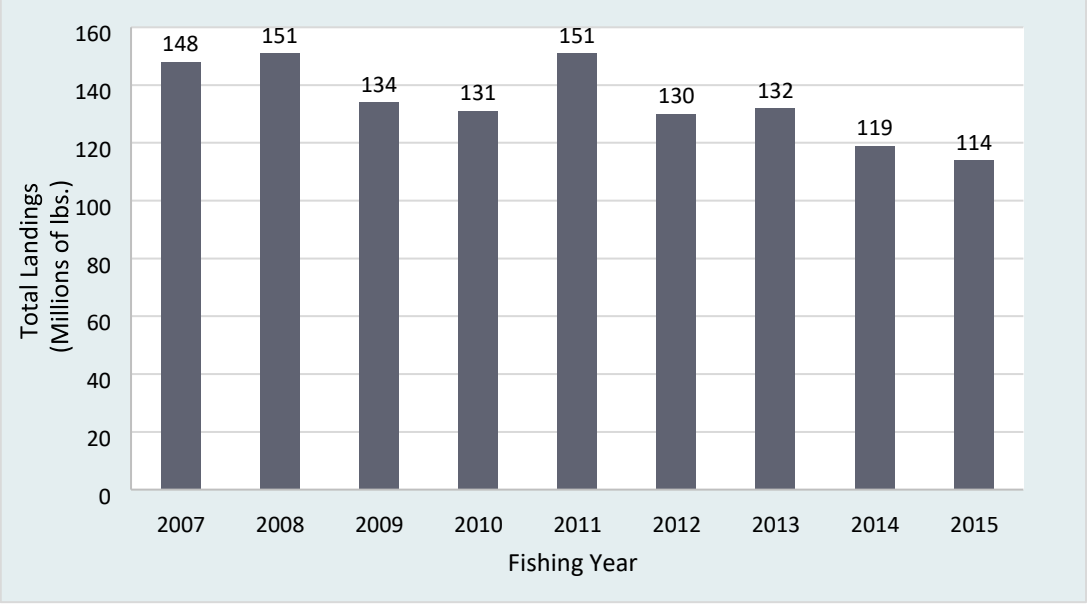


Figure 14. Gross Groundfish Vessel Landings by Fishing Year (All Species).

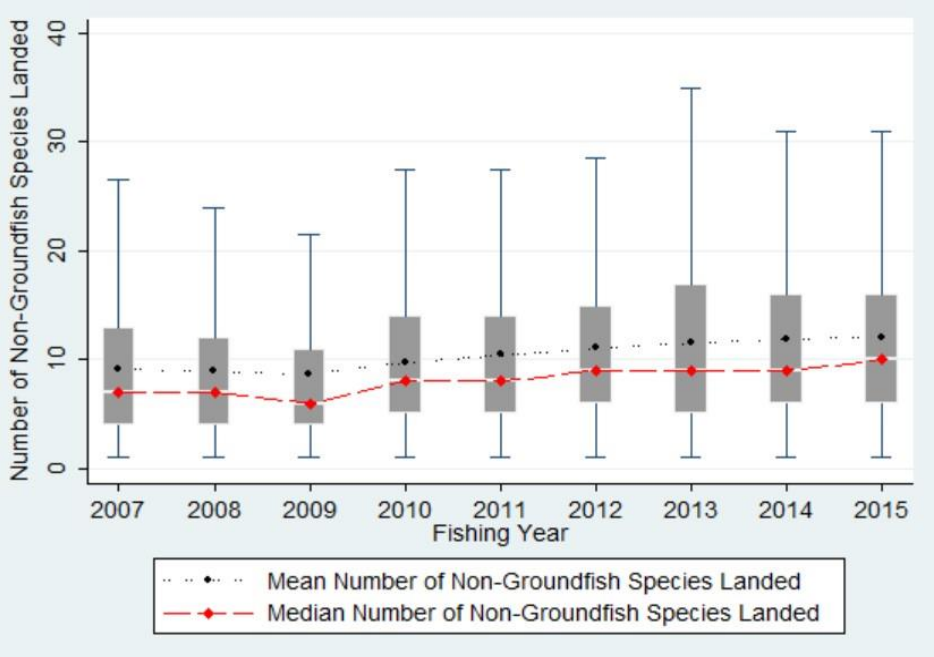


Figure 15. Number of Non-Groundfish Species Landed per Vessel Box and Whisker Plots by Fishing Year.

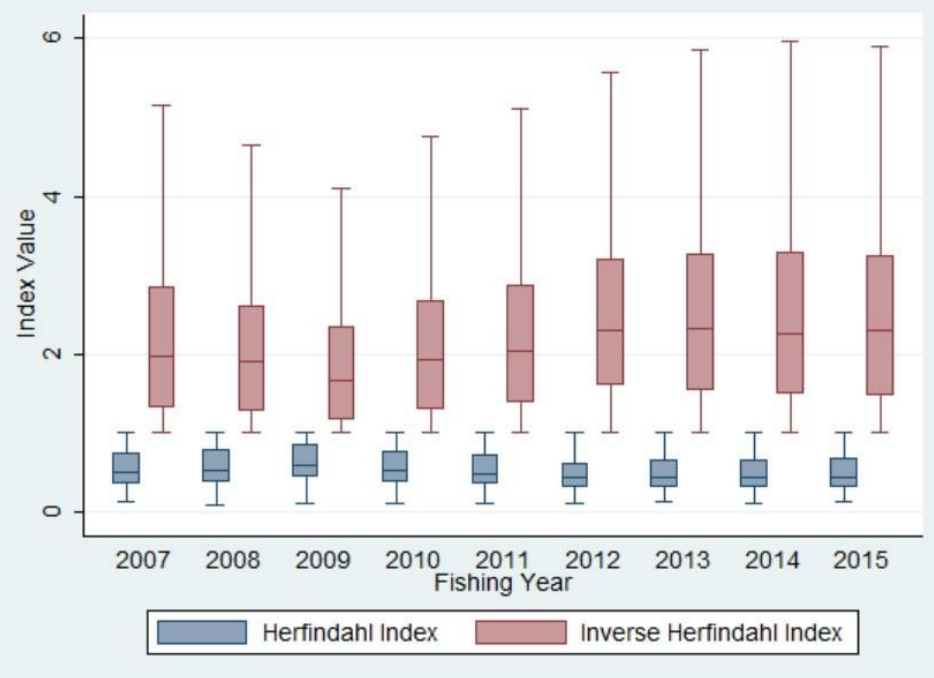


Figure 16. Vessel-Level Herfindahl and Inverse Herfindahl Indices Box and Whisker Plots by Fishing Year.

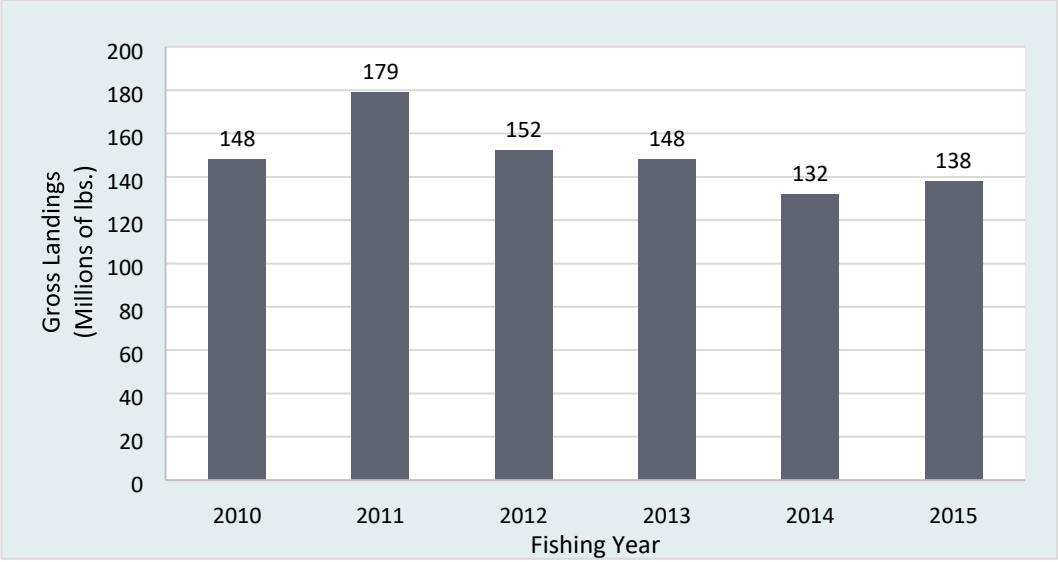


Figure 17. Gross Landings by Groundfish Entities by Fishing Year (All Species).

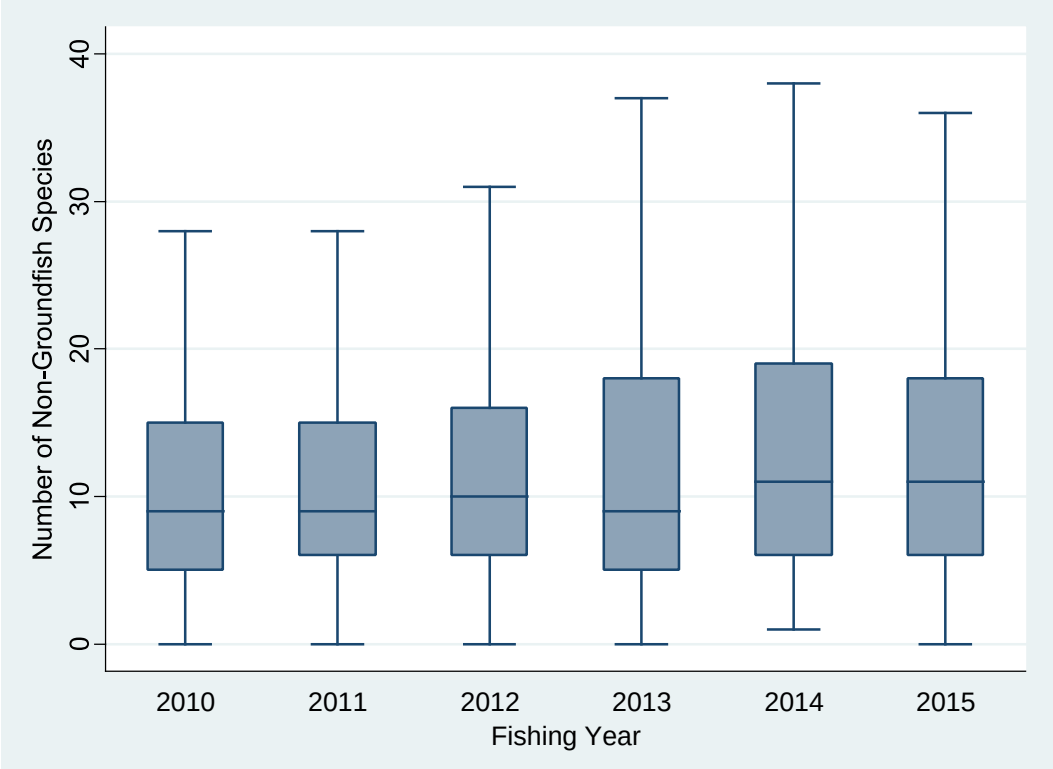


Figure 18. Number of Non-Groundfish Species Landed per Groundfish Entity Box and Whisker Plots by Fishing Year.

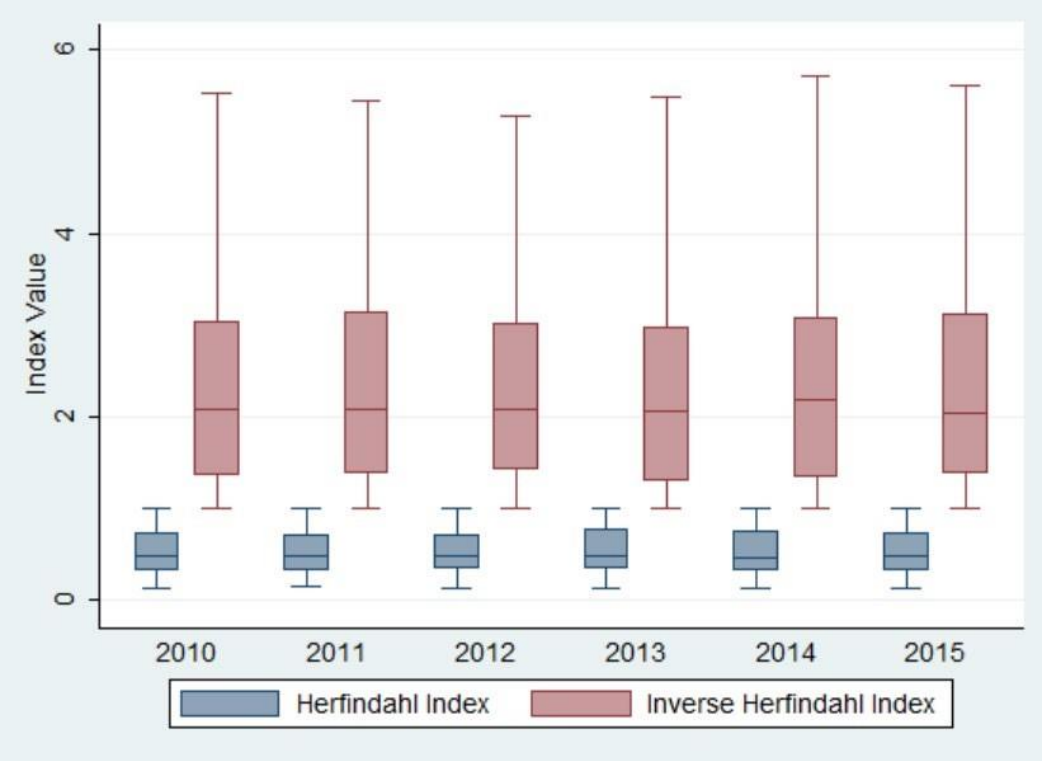


Figure 19. Entity-Level Herfindahl and Inverse Herfindahl Index Box and Whisker Plots by Fishing Year.

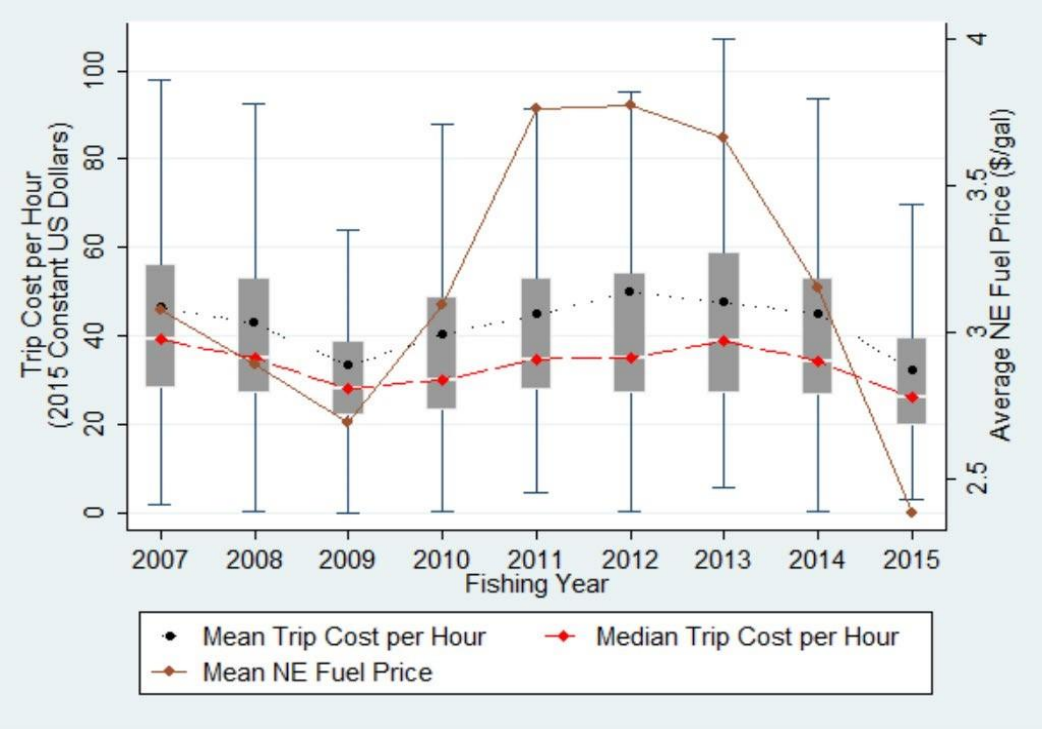


Figure 20. Trip Costs per Hour Box and Whisker Plots and Average New England Fuel Prices by Fishing Year (2007-2015).

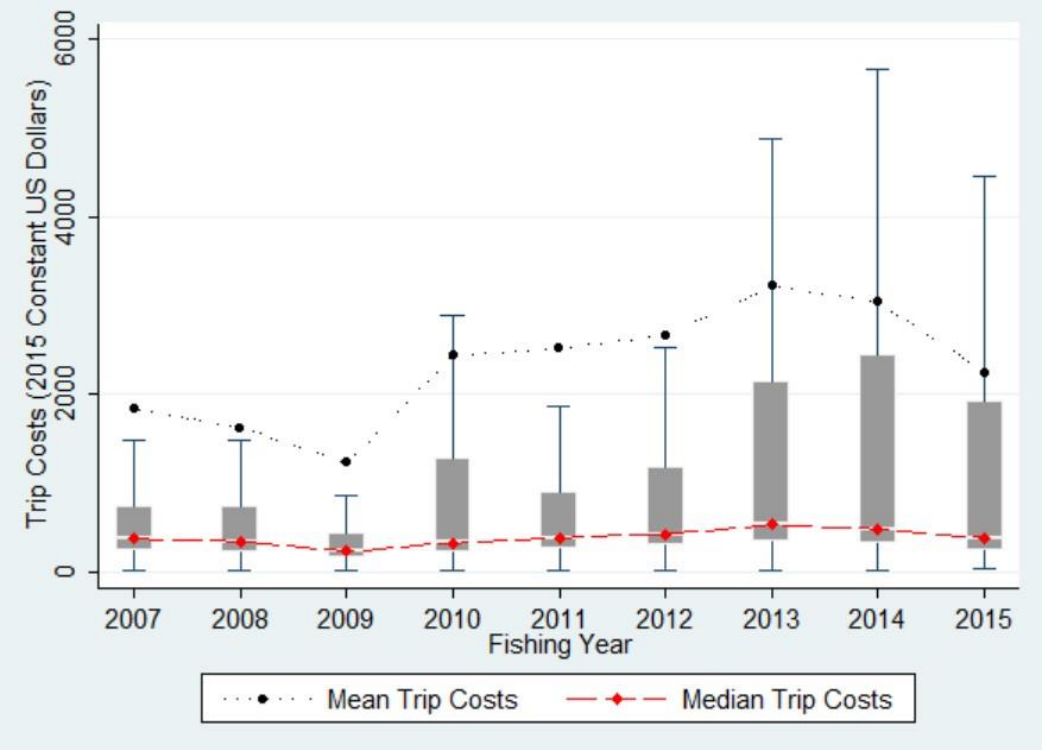


Figure 21. Groundfish Trip Costs Box and Whisker Plots by Fishing Year.

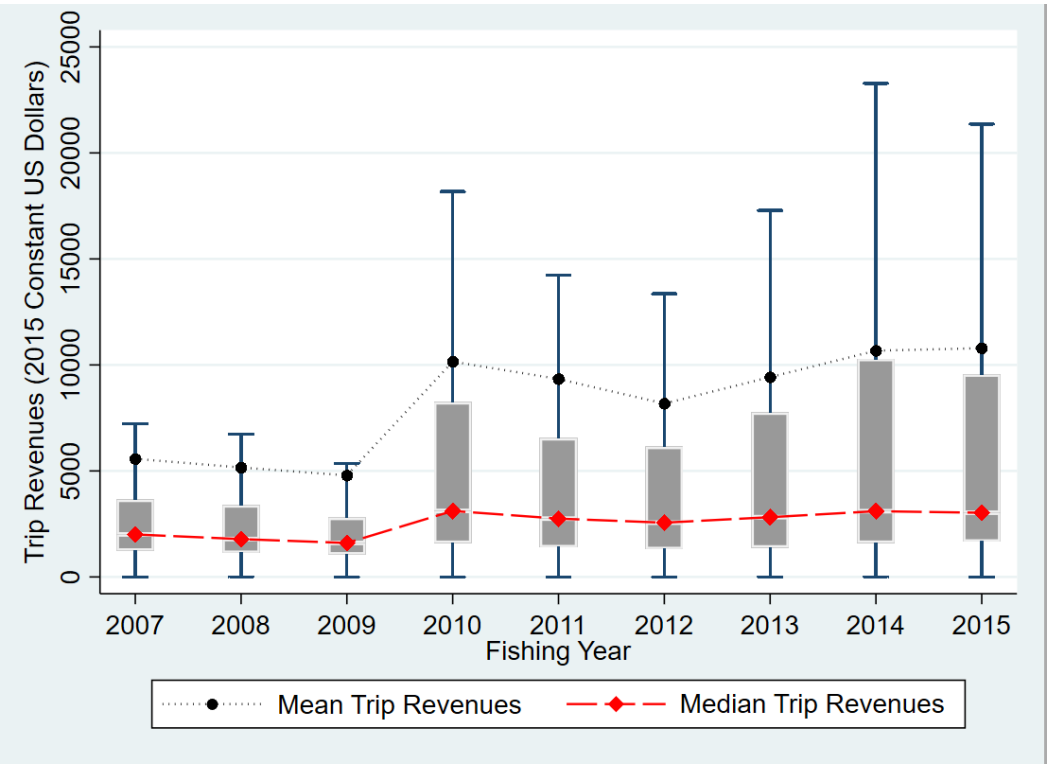


Figure 22. Groundfish Trip Revenues (All Species) Box and Whisker Plots by Fishing Year.

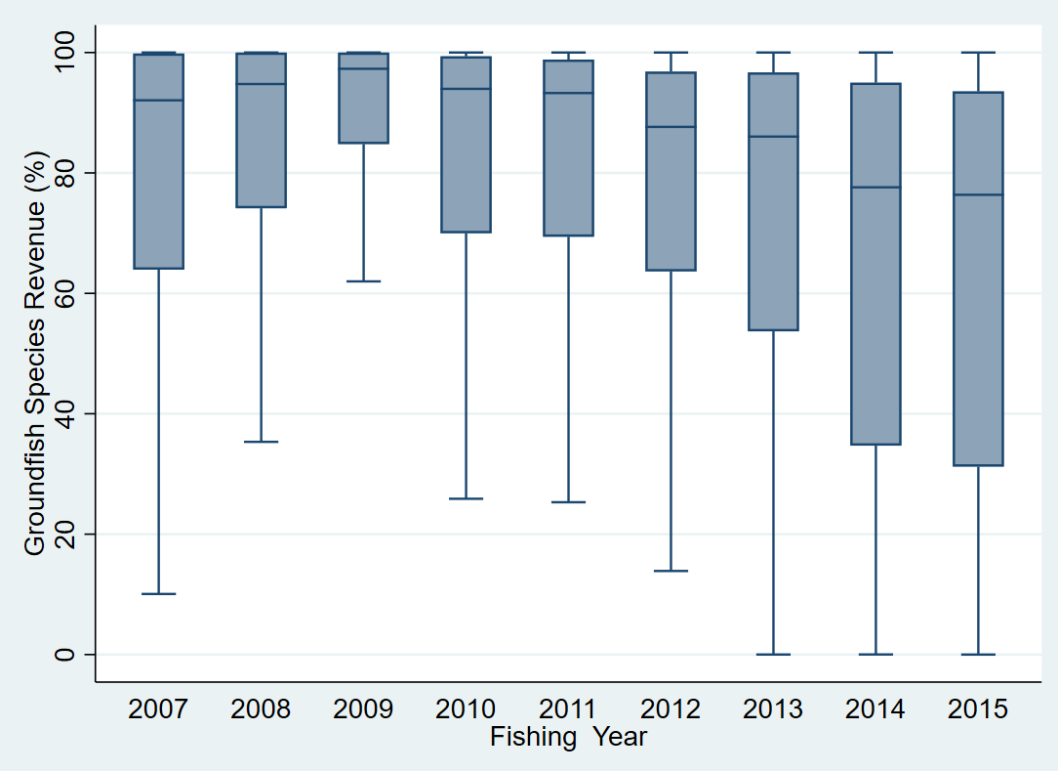


Figure 23. Groundfish Species Revenues as a Percent of Total Groundfish Trip Revenues Box Plots by Fishing Year.

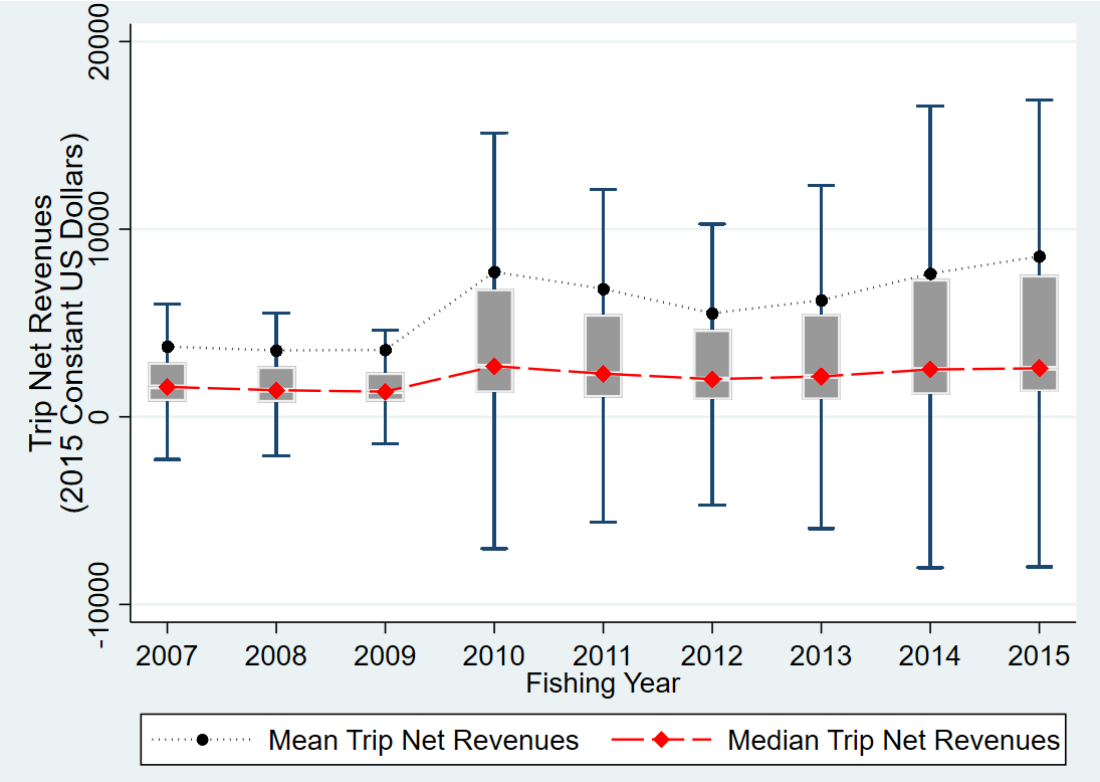


Figure 24. Groundfish Trip Net Revenues Box and Whisker Plots by Fishing Year.

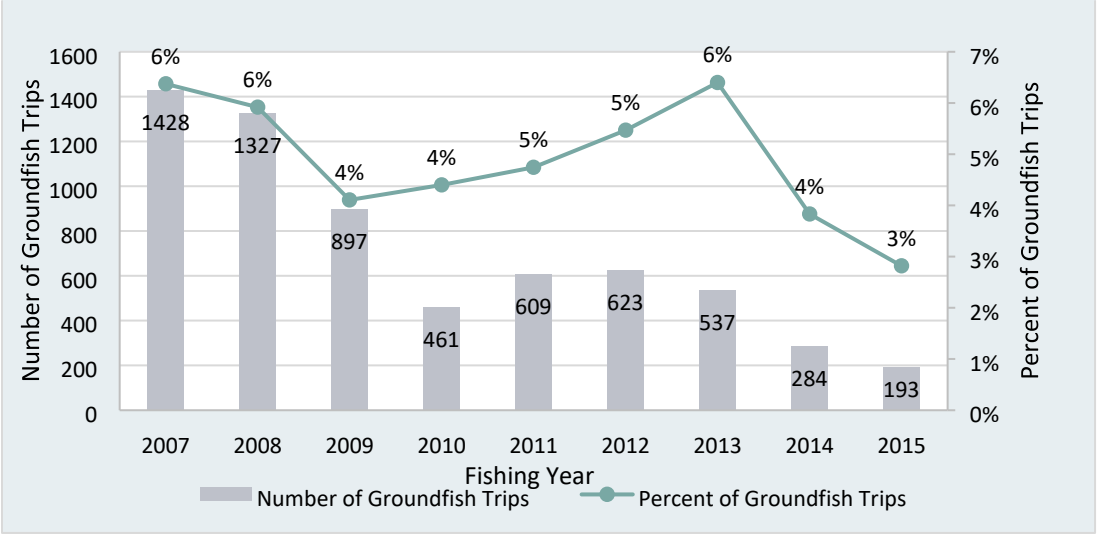


Figure 25. Number and Percent of Groundfish Trips with Negative Net Revenues over Fishing Year.

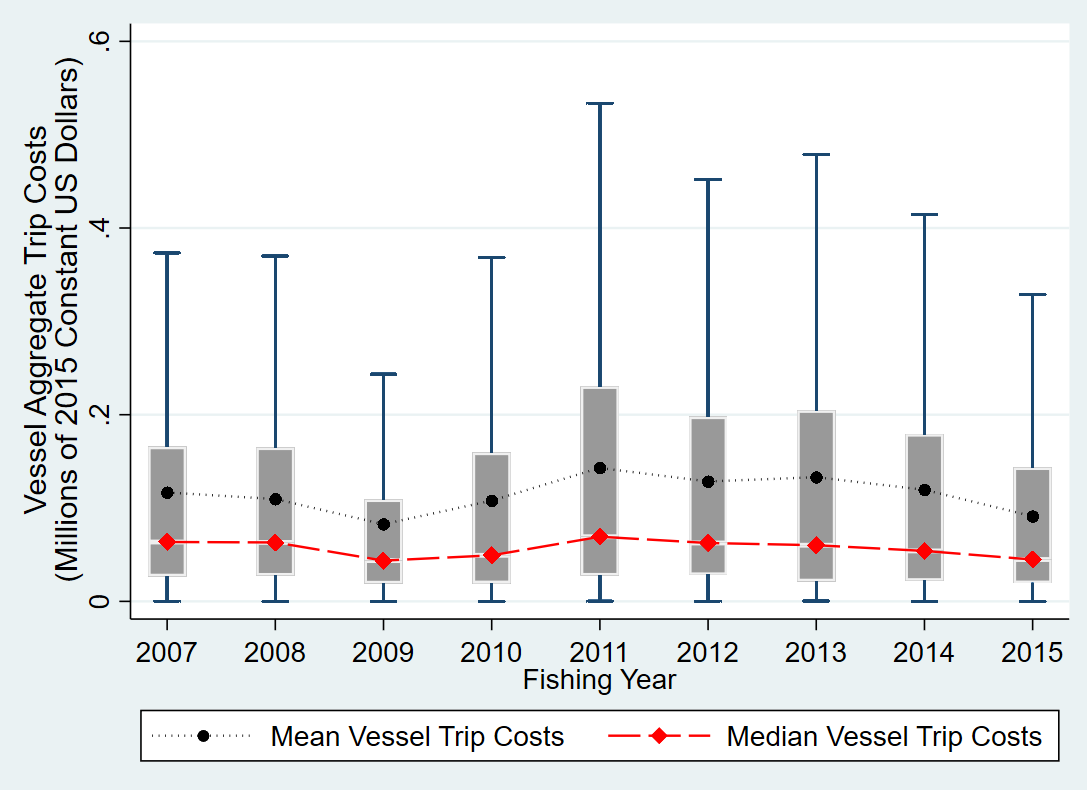


Figure 26. Groundfish Vessel Aggregate Trip Costs Box and Whisker Plots by Fishing Year.

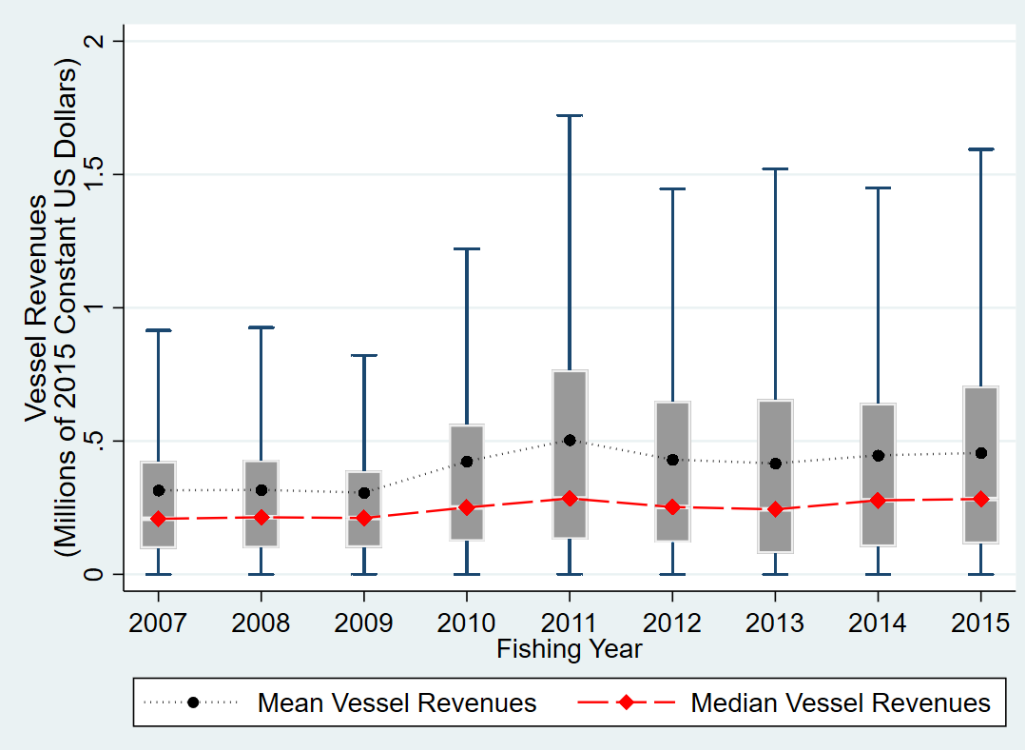


Figure 27. Groundfish Vessel Revenues Box and Whisker Plots by Fishing Year (All Species).

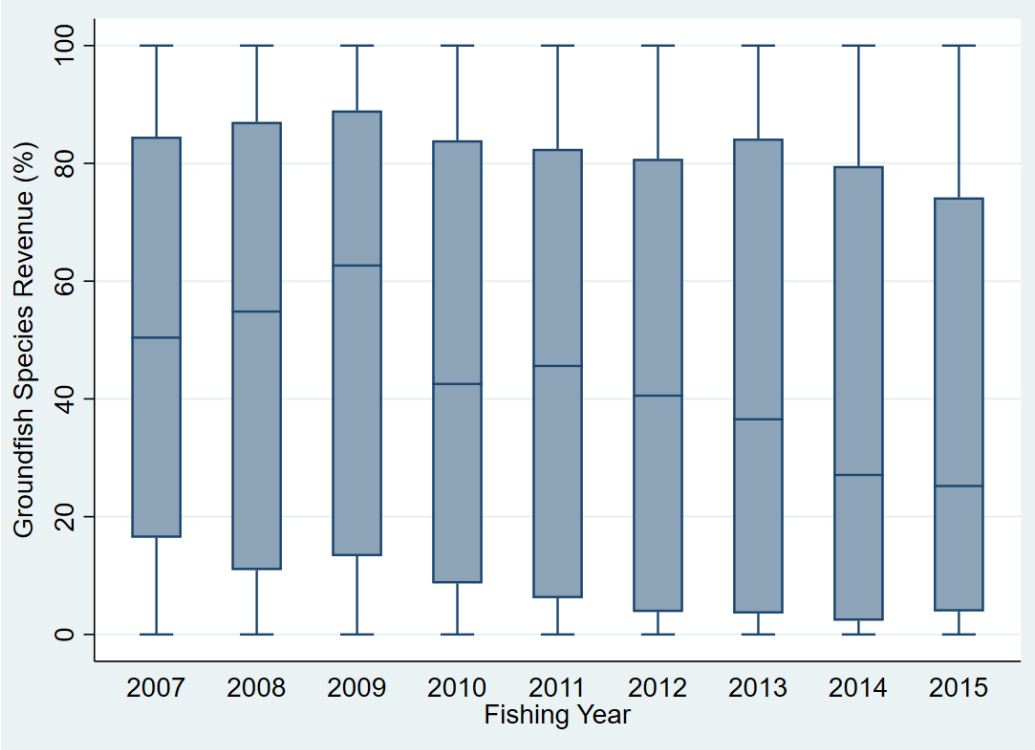


Figure 28. Box and Whisker Plots of Groundfish Species Revenues as a Percent of Total Vessel Revenues by Fishing Year.

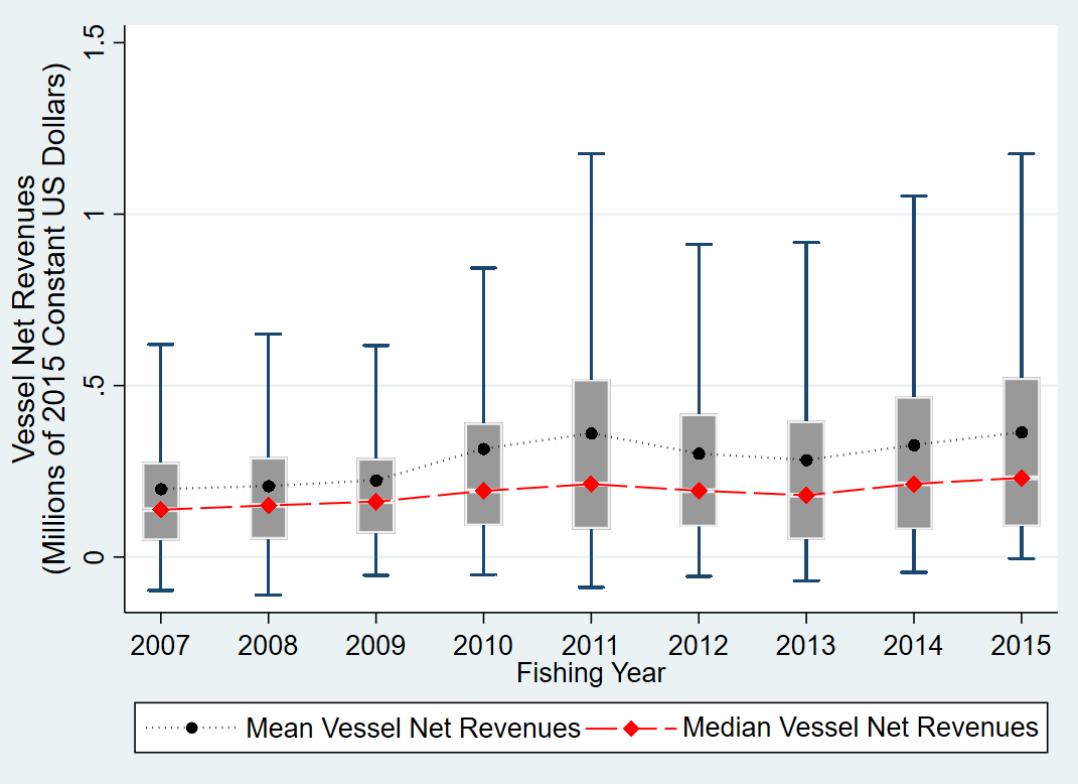


Figure 29. Groundfish Vessel Net Revenues Box and Whisker Plots by Fishing Year.

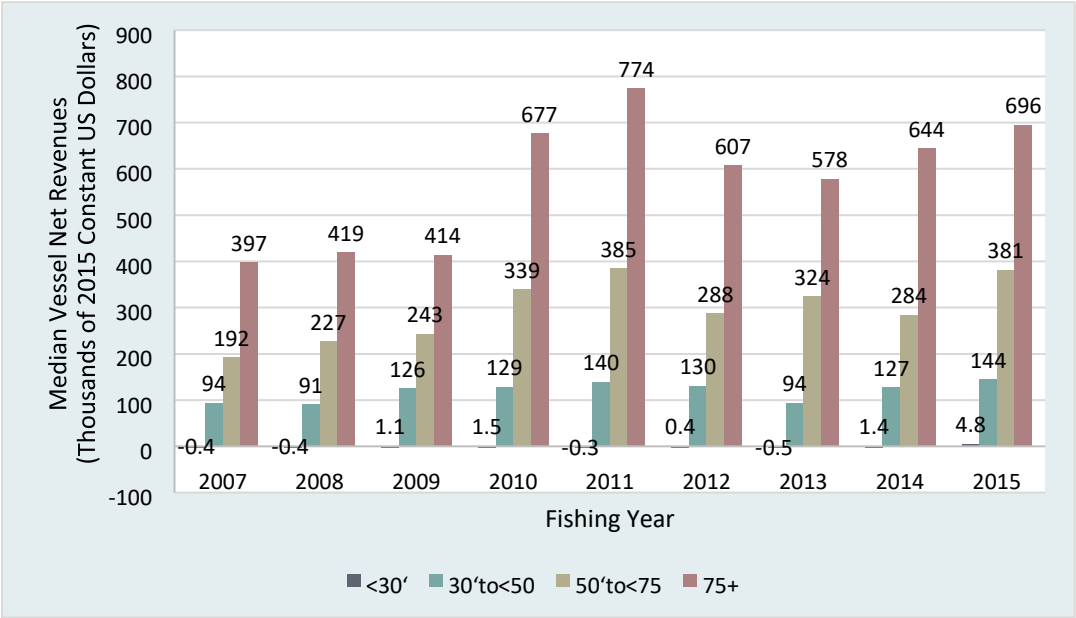


Figure 30. Median Net Revenues by Vessel Size Class over Fishing Year.

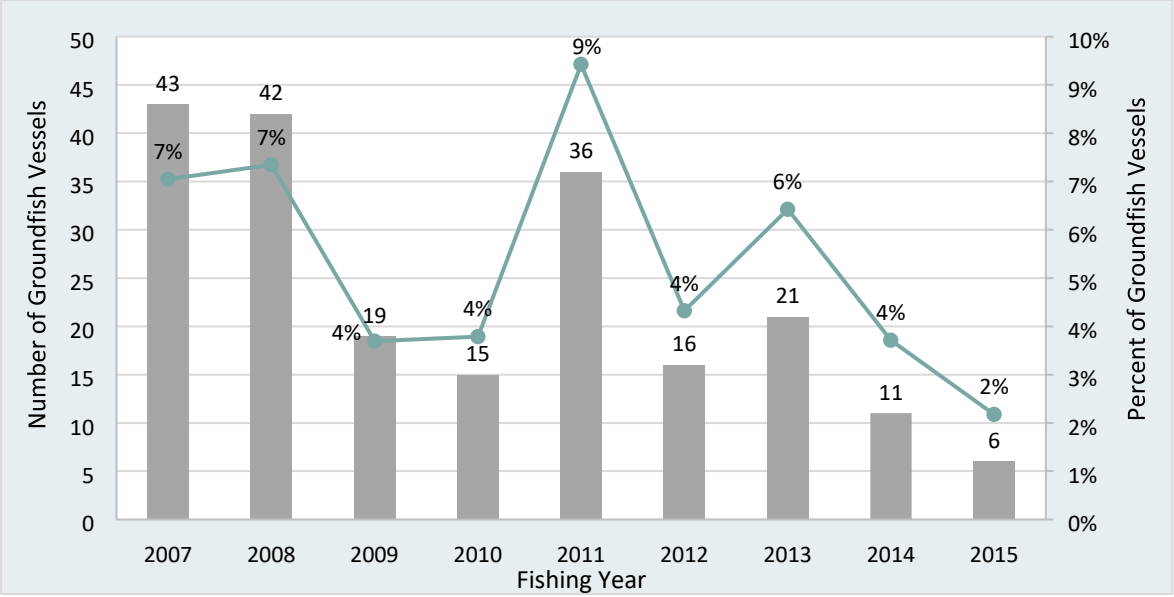


Figure 31. Number and Percent of Groundfish Vessels with Negative Net Revenues over Fishing Year.

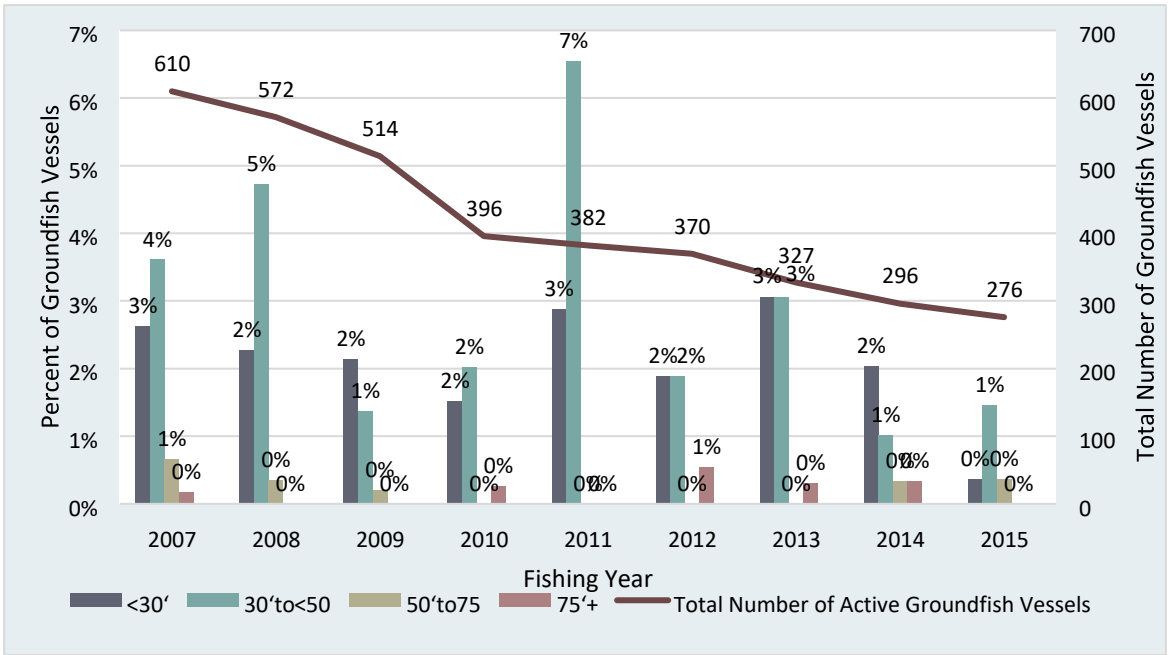


Figure 32. Percent of Total Groundfish Vessels with Negative Net Revenues by Vessel Size Class over Fishing Year.

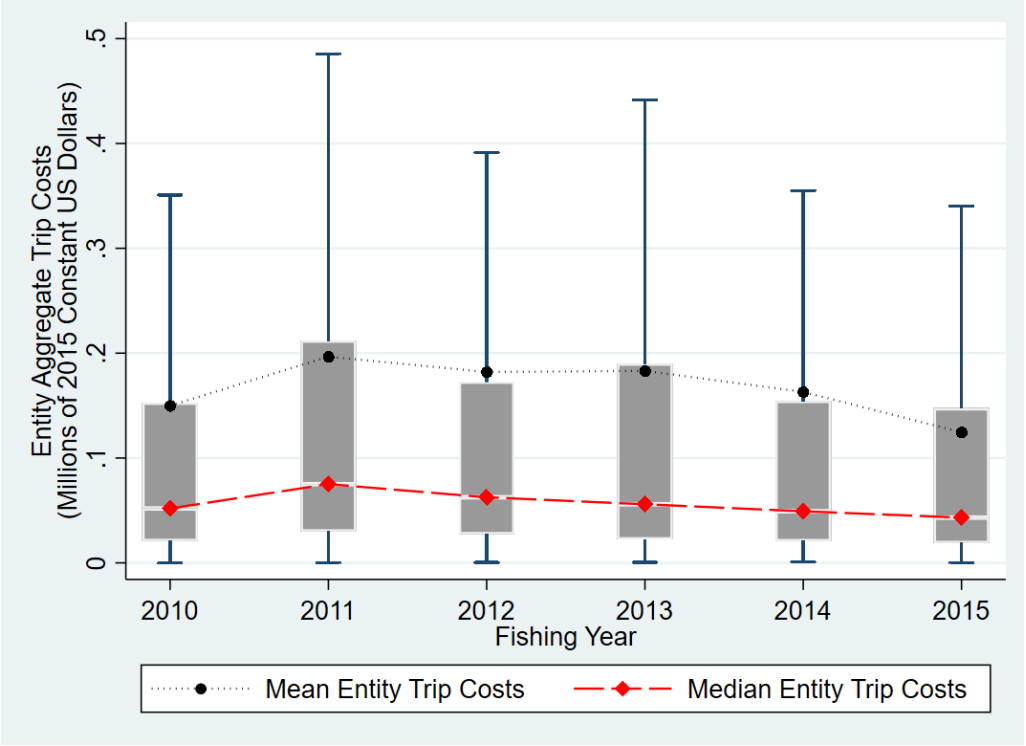


Figure 33. Groundfish Entity Aggregate Trip Costs Box and Whisker Plots by Fishing Year.

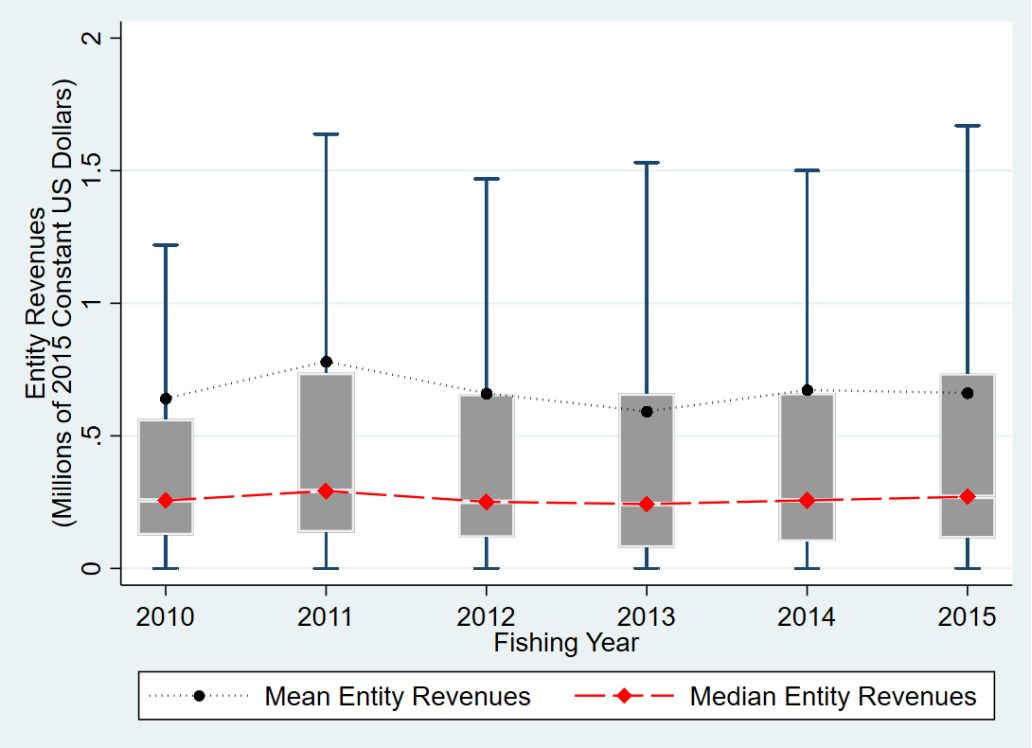


Figure 34. Groundfish Entity Revenues (All Species) Box and Whisker Plots by Fishing Year.

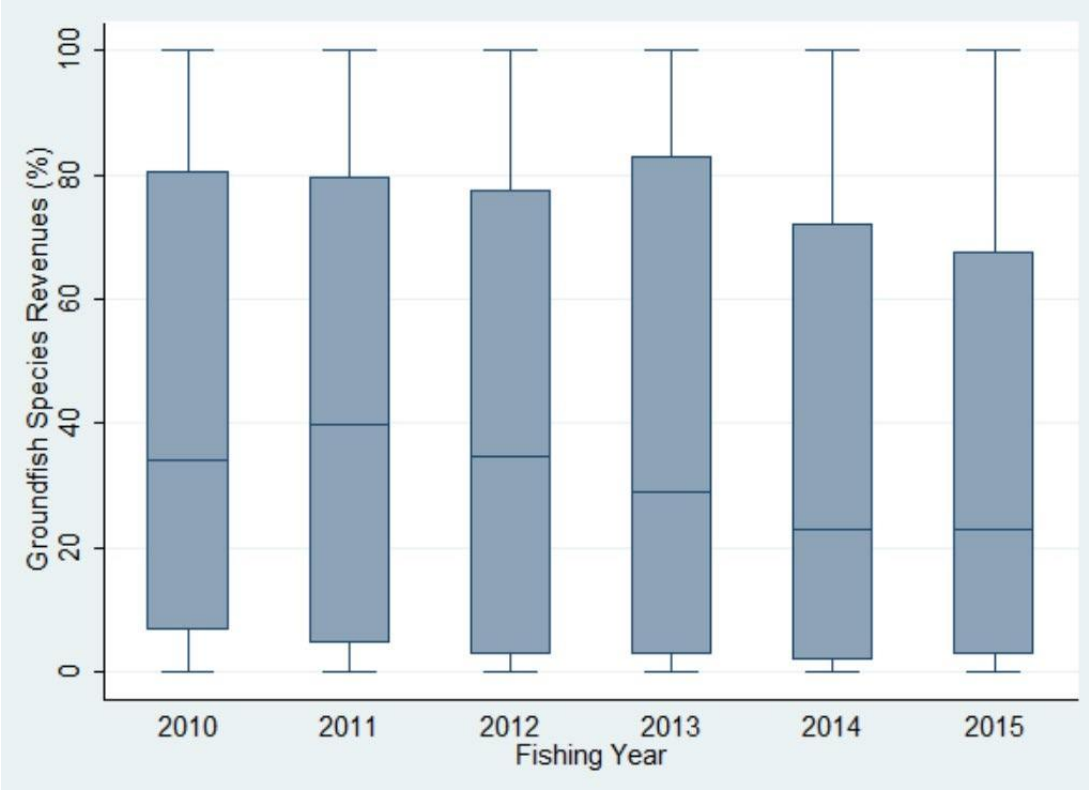


Figure 35. Box and Whisker Plots of Groundfish Species Revenues as a Percent of Total Entity Revenues.

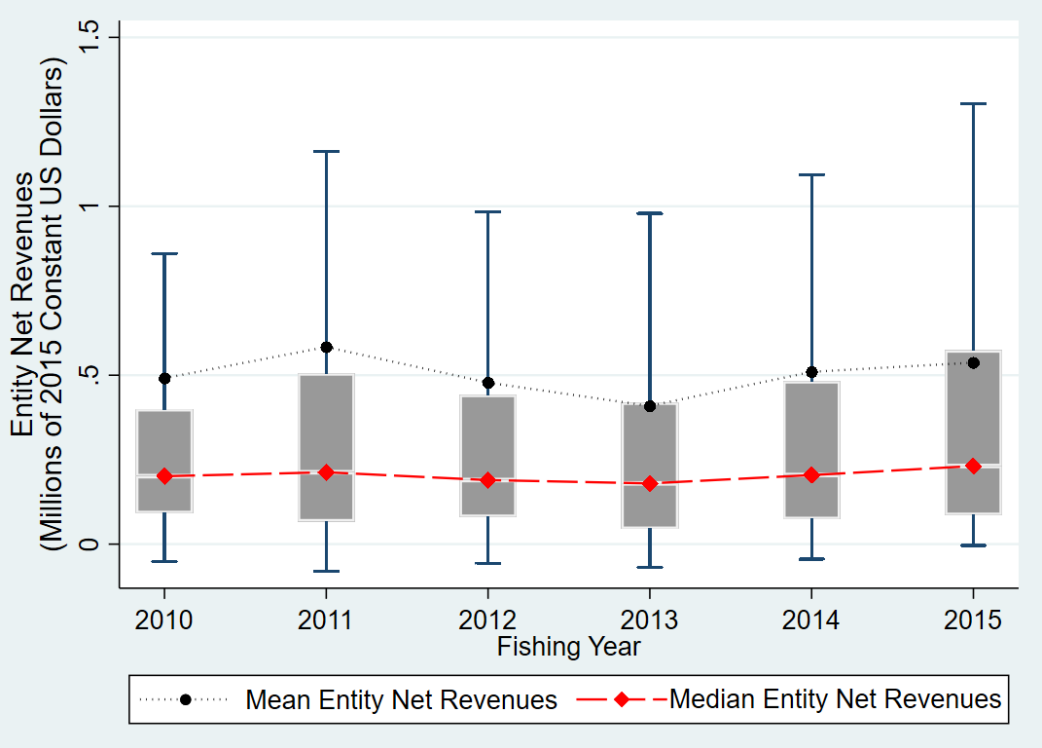


Figure 36. Groundfish Entity Net Revenues Box and Whisker Plot by Fishing Year

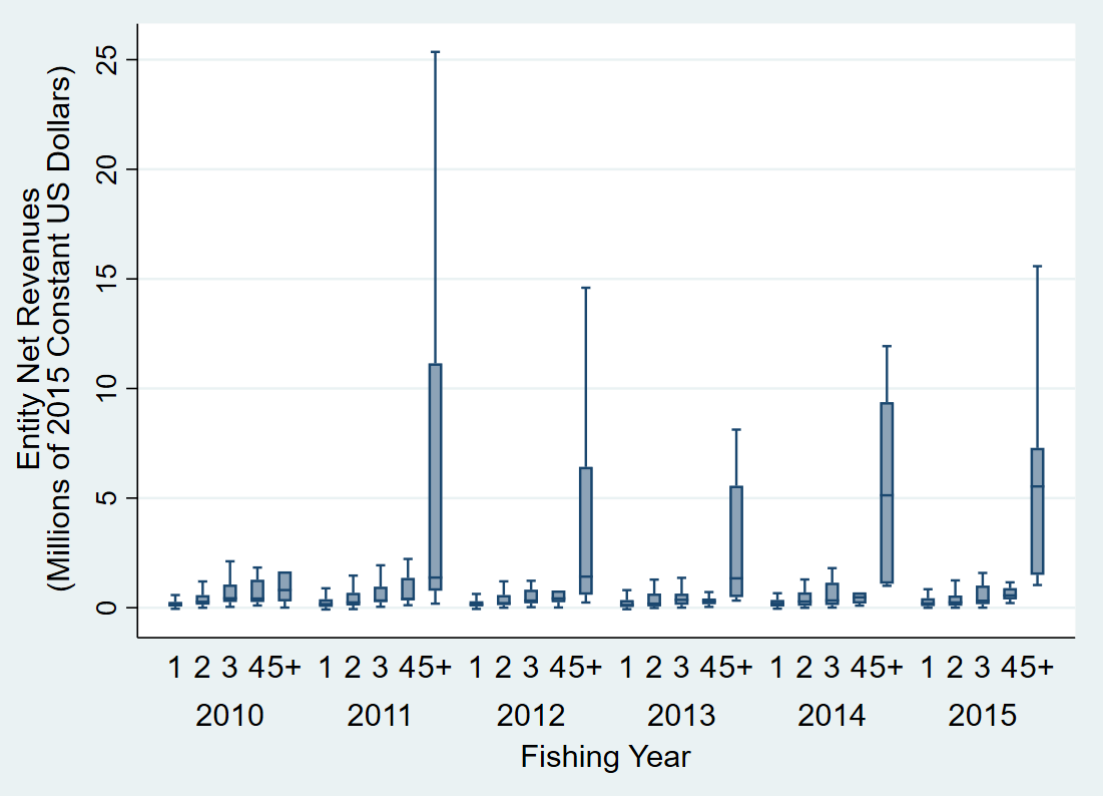


Figure 37. Groundfish Entity Net Revenues Box and Whisker Plots by Groundfish Entity Size Class and Fishing Year.

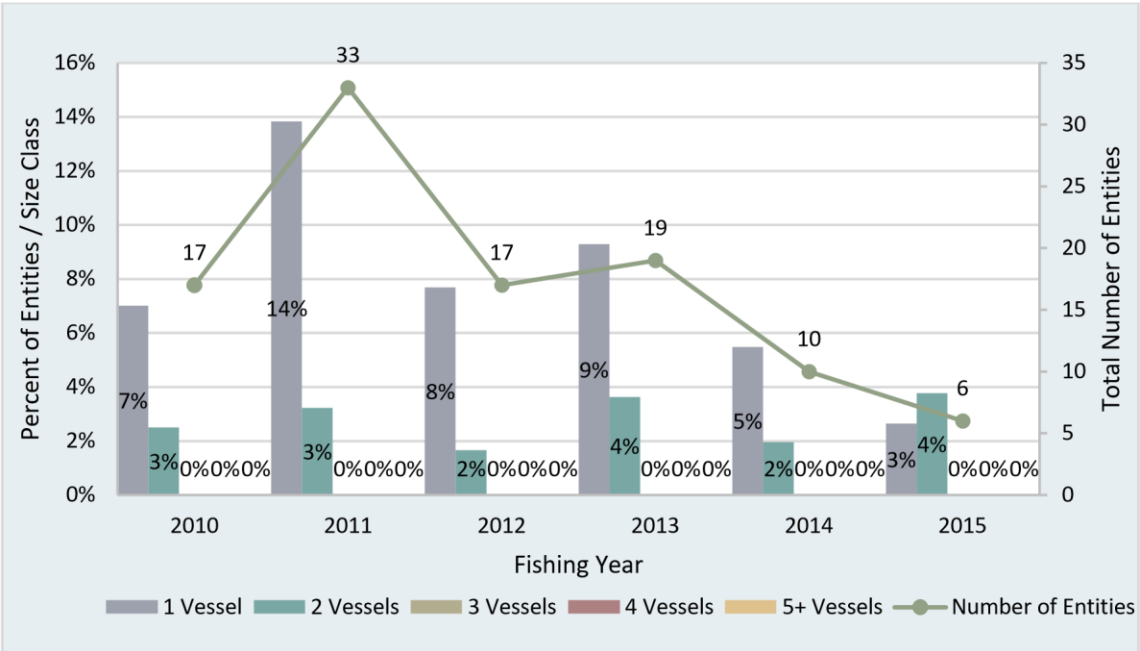
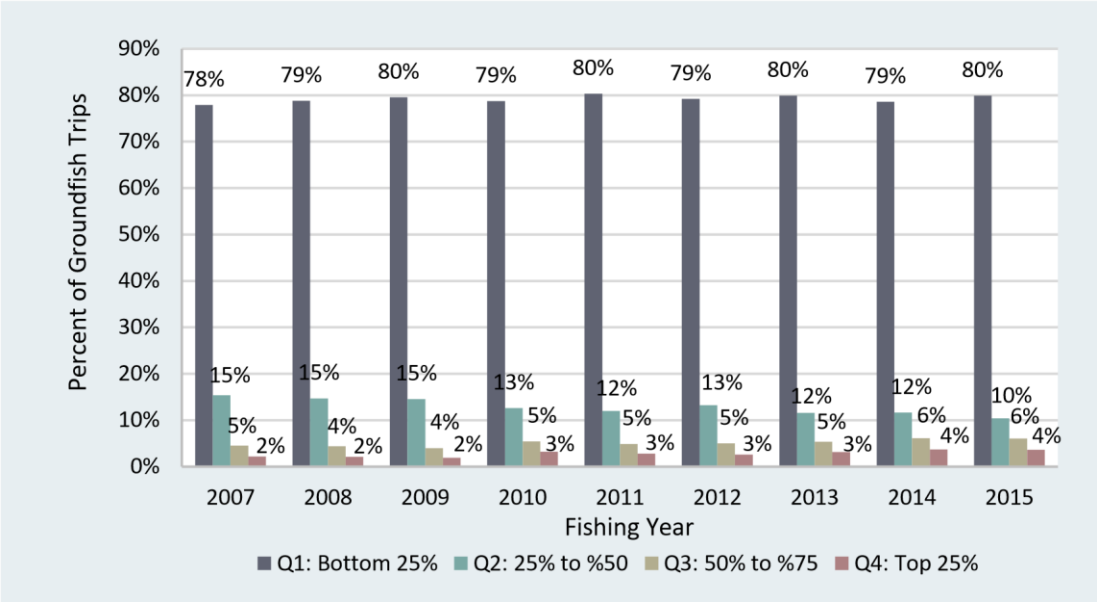


Figure 38. Percent and Number of Entities with Negative Net Revenues by Entity Size Class over Fishing Year.



Fishing 39. Percent of Trips by Net Revenues Quartiles over Fishing Year.

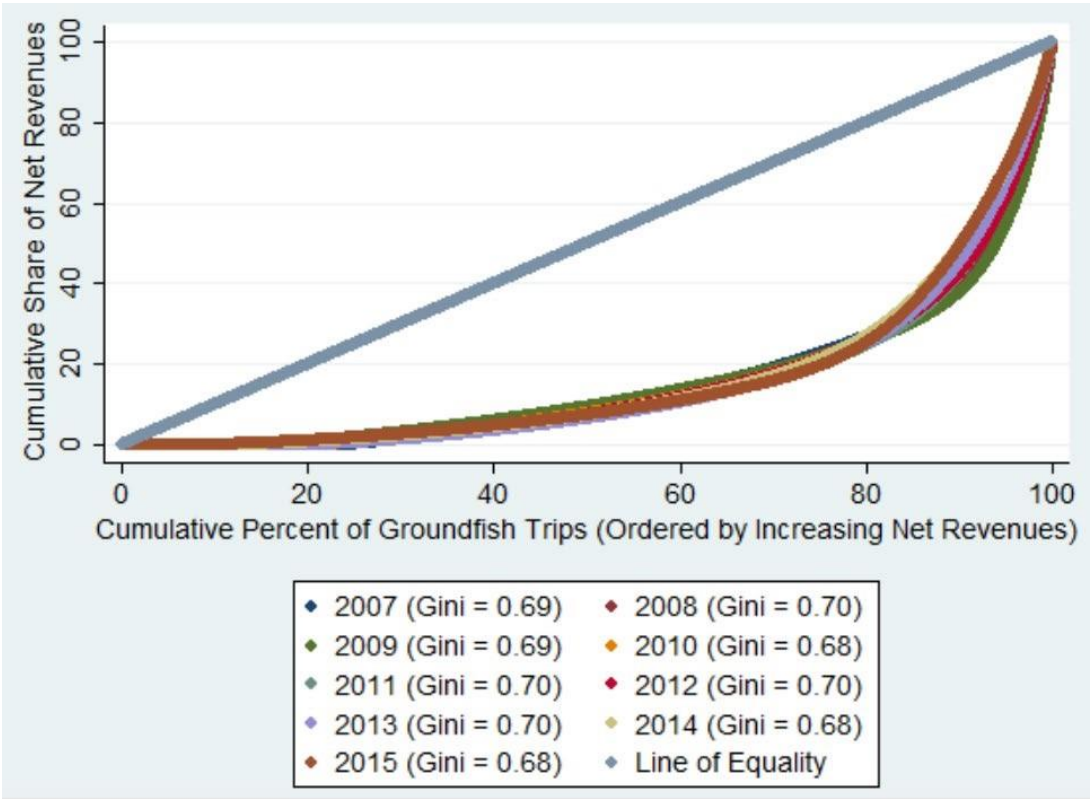


Figure 40. Lorenz Curves and Gini Coefficients by Cumulative Groundfish Trips, Ordered by Increasing Net Revenues.

Note: Lorenz curves presented for groundfish years 2007-2015 overlap due to similarities in values.

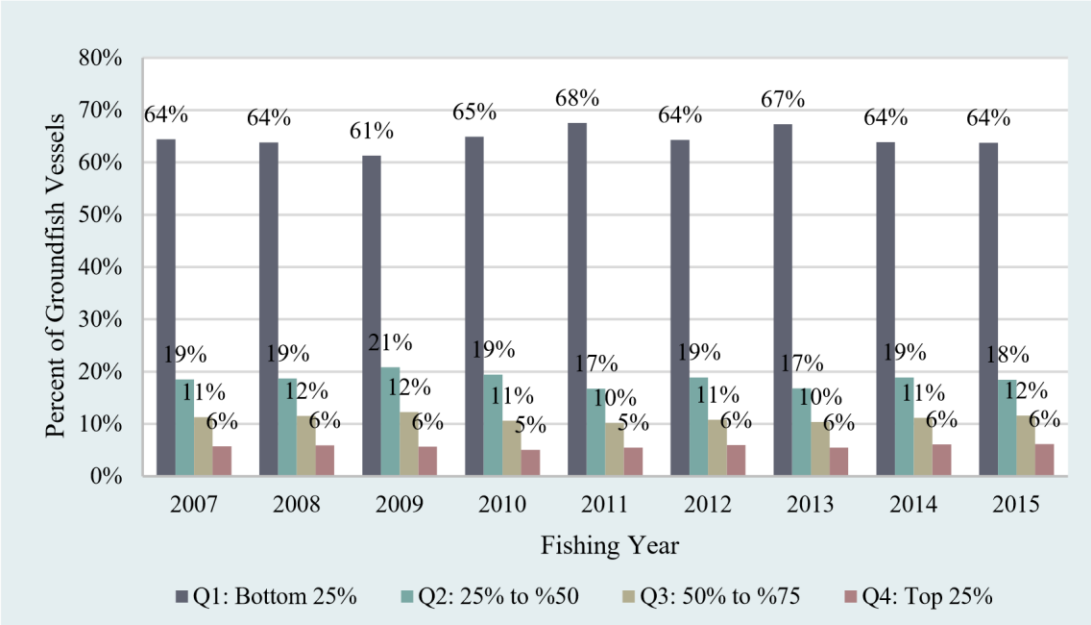


Figure 41. Percent of Vessels by Net Revenues Quartiles over Fishing Year.

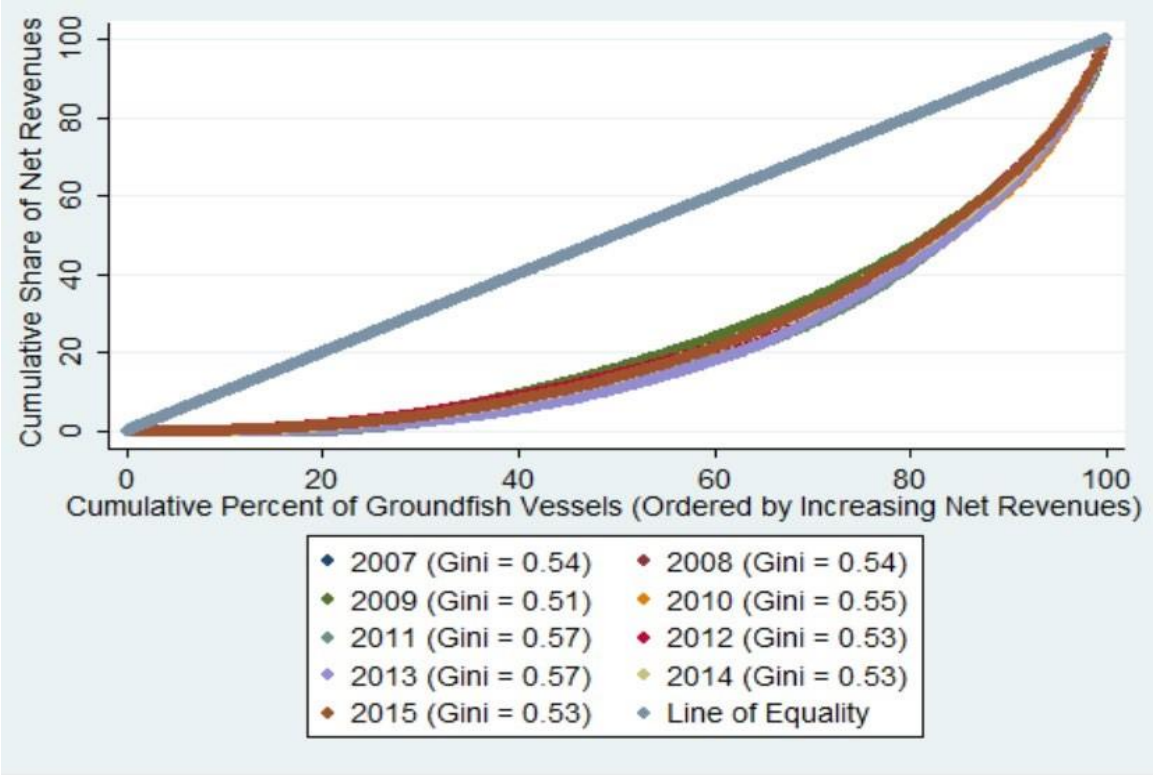


Figure 42. Lorenz Curves and Gini Coefficients by Cumulative Groundfish Vessels, Ordered by Increasing Net Revenues.

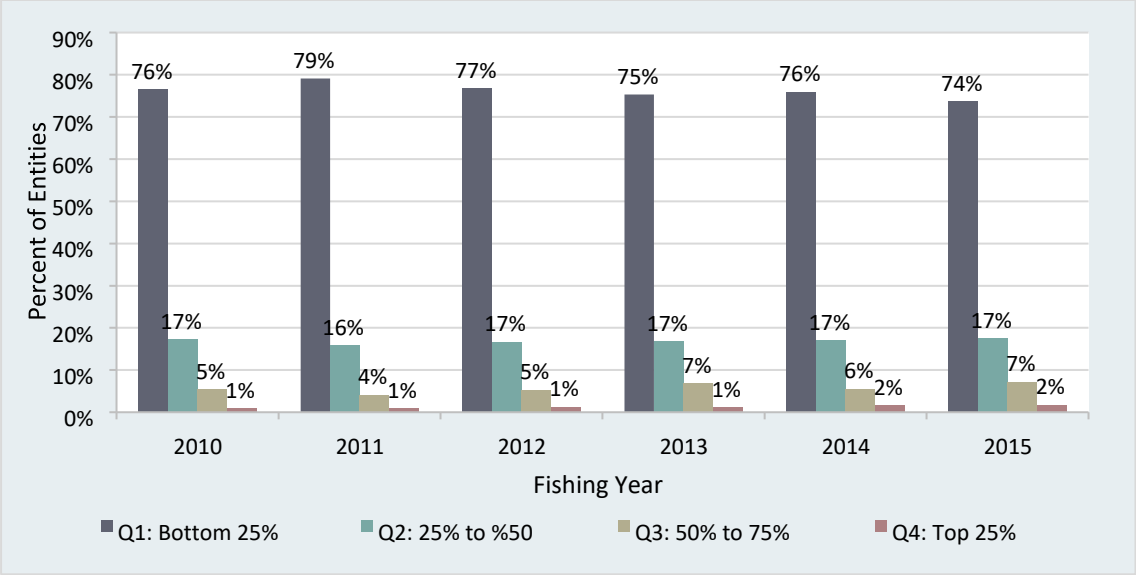


Figure 43. Percent of Entities by Net Revenues Quartiles over Fishing Year.

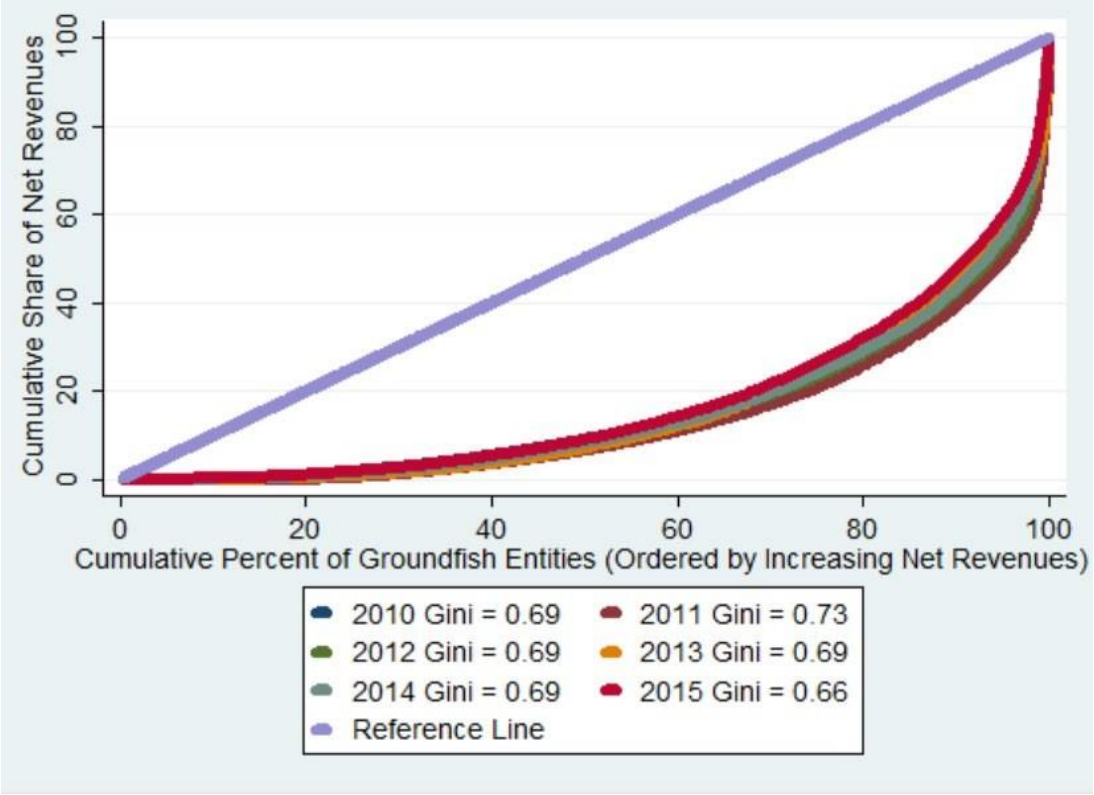


Figure 44. Lorenz Curves and Gini Coefficients by Cumulative Groundfish Entities, Ordered by Increasing Net Revenues.

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