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Spillovers in Regional Fisheries Management: Do Catch Shares Cause Leakage?

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Abstract

United States fisheries are managed by regional councils. Fishermen can participate in fisheries managed by multiple councils, and effort controls in one region could lead to effort leakage into another. Using difference-in-differences, we test for leakage across regional fisheries boundaries for a catch share program in New England. We find evidence that the New England groundfish sector program caused leakage into adjacent Mid-Atlantic fisheries. Aggregate Mid-Atlantic harvest volume and landed values increased among sector members after the policy change. Leakage is most acute in fisheries with low institutional barriers, similar gear, and high market substitutability with sector species.

JEL Codes: Q22, Q28, H73

Keywords: catch shares, cooperatives, difference-in-difference, regional policies, interjurisdictional differentials

Introduction

United States commercial fisheries conducted in federal waters are managed by regional fishery management councils that represent collections of states. An individual fishery is assigned to a particular management council and generally reflects the species range, its proximity to the political boundaries of participating states, and home ports of participating fishermen. However, species ranges can span management borders and ultimately link together fishermen whose home ports are in different regions. The result is that individual fishermen can participate in multiple fisheries managed by different councils. This institutional arrangement raises the question of whether a policy change for a fishery in one region will affect outcomes for fisheries in other regions that were not directly involved in the policy process. Most policy evaluation focuses on the intended effect on the target fishery and fails to account for potential ancillary effects on other fisheries. In this paper, we test for the existence of policy-induced transboundary impacts on fishery outcomes and explore the implications for regional fisheries management.

An important motivation for our study is the trend toward using catch shares to manage fisheries in the United States and in many other parts of the world. Economists have focused their empirical attention on the economic and biological consequences of catch share programs for the target fisheries. Evidence for economic efficiency gains is strong—from fishery case studies, *ex-ante* empirical analyses, and individual fishing quota market data (Weninger 1998; NRC 1999; Grafton, Squires, and Fox 2000; Newell, Sanchirico and Kerr 2005; Lian, Singh, and Weninger 2009). There is still debate about whether catch shares improve biological outcomes in the target fishery, i.e. whether apparent gains reflect other policy measures or population changes are plausibly attributable to catch shares (Costello, Gaines, and Lynham 2008; Bromley 2009; Nowlis and van Benthem 2012). As this debate continues, economists are beginning to examine the effects of catch share programs on employment (Abbott, Garber-Yonts, and Wilen 2010) and the implications of distributional consequences for policy design (Pereau, Little, Doyen, and Thebaud 2012).

Although understanding the direct effects of catch share programs is important, evidence of fishery spillovers from a range of policy contexts suggests that indirect effects are likely to matter. One area of research examines how effort for "targeted" species affects catch of non-targeted species. Scholars have found that overall fishing effort supply reflects target fishery entry and exit decisions (Bockstael and Opaluch 1983) as well as finer-scale targeting decisions within multi-species fisheries (Zhang and Smith 2011). Effort also adjusts spatially to economic incentives on fine scales such as fishing grounds (Holland and Sutinen 2000; Smith 2002; Zhang and Smith 2011) and across large regions (Mistiaen and Strand 2000; Smith and Wilen 2004; Hicks and Schnier 2008). Other work examines how regulation of one target species or one fishing location changes the opportunity cost of fishing effort and thus affects outcomes for other species and locations. There is some evidence for this process occurring within regions in which Individual Fishing Quotas (IFQs) affect the targeting of unregulated species (Asche, Gordon, and Jensen 2007; Hutniczak 2014). Others find evidence of this process in the effects of regulation of a target species on a bycatch species (Abbott and Wilen 2011). At a global scale, the hypothesis of "roving bandits" suggests that excess fishing capacity roams the globe to exploit profit opportunities where local institutions have failed to restrict access (Berkes et al. 2006). The evidence for this phenomenon is less direct than the empirical studies in fishing behavior, but the mechanism is plausible. All of this work highlights the potential for a policy change in one region to affect fishery outcomes in another.

Outside of fisheries, economists have paid considerable attention to policy spillovers generally, and leakage specifically. For example, if one country imposes restrictions on carbon emissions (e.g., a carbon tax or cap-and-trade system), carbon-intensive industries have an incentive to relocate to countries without these restrictions. The overall reduction in carbon is lower because of this "leakage" (Goulder and Parry 2008, Wiener 2007, Fowlie 2009). Carbon policies can also create leakage through natural resource markets. Carbon sequestered in conserved forests in one location may be offset by carbon emissions from deforestation in other areas, and there is a substantial potential for leakage in the U.S. forest sector (Murray, McCarl, and Lee 2004). Indirect evidence from trade in forest products is also consistent with a leakage mechanism; reforestation gains in seven developing countries are mostly offset by land use changes in other countries (Meyfroidt, Rudel, and Lambin 2010).

We examine the potential of leakage due to regional-specific fisheries regulation. Our empirical analysis examines the impacts of the 2010 New England Groundfish Sector Program (Sector Program hereafter) on adjacent fisheries in the Mid-Atlantic Region. Recent work using quasi-experimental methods finds evidence of economic benefits from the Sector Program on fisheries managed with that program (Scheld et al. 2012; Scheld and Anderson 2014), and survey-based research finds evidence that sector formation is correlated with social capital (Holland et al. 2013). However, empirical work on the Sector Program to date does not address the potential impacts on other fisheries. We hypothesize that regulation in one region (New England) frees up fishing capital to exploit fisheries in another region (the Mid-Atlantic) that have lower barriers to entry. Similar to how IFQs operate, the Sector Program allocates shares of groundfish total allowable catches to cooperative entities called sectors. The economic logic is that these sectors will rationalize the deployment of fishing effort, lower costs, increase revenues through market timing, and profit share. In the adjacent Mid-Atlantic Region, regulatory structures vary from regulated open access (Homans and Wilen 1997) to tradable IFQs. In practical terms, many New England Groundfish vessels had permits and established catch records for Mid-Atlantic species before the Sector Program. This regulatory history coupled with species ranges that in some cases span both regions suggest that there were low barriers to entry; the Sector Program might have lowered the opportunity cost of using capital in Mid-Atlantic fisheries. As groundfish sector management altered the deployment of fishing effort in New England, did newly idled groundfish fishermen increase their participation in the Mid-Atlantic?

We analyze the creation of the Sector Program as a natural experiment. The control group includes Mid-Atlantic fishermen who did not fish for New England groundfish (sector) species before the program. We use their fishing outcomes (catches and revenues) before and after the Sector Program to estimate our counterfactual. We use a difference-in-differences (DID) estimator to isolate the treatment effect. We estimate models with both pooled and disaggregated Mid-Atlantic species and perform falsification tests. We find evidence of leakage in the aggregate data, but the effects are heterogeneous across individual fisheries.

Background

The New England groundfish complex includes a diverse set of commercially caught demersal species. Historically, these fisheries were among the highest volume and value fisheries in the United States, with Atlantic cod (*Gadus morhua*) being the most notable species. Table 1 contains landings data for each groundfish species in 2009, the year prior to Sector Program implementation. Although all of these species are marketed as varieties of whitefish, species-specific ex-vessel price per pound ranges from \$0.48 to \$1.66. These prices reflect the continuum of market categories, including inputs into processed products like fish sticks, fillets for fish and chips, and some higher-end plate fish. Nevertheless, compared to typical high-end white-fleshed plate fish such as red snapper, grouper, and halibut, the groundfish prices are low. For context, the 2009 red snapper ex-vessel price per pound averaged across all U.S. fisheries was $3.24. Table 1 also breaks down landings by gear type. Otter trawl is the dominant gear type (61%) with substantial catches from gillnets (34%). The vast array of other fishing gear types account for only 5% of landings for which gear information is available. Across the fisheries, there is some variation in the shares of different gears. Most are heavily dominated by otter trawl, but gillnets contribute roughly half for cod and pollock.

After years of decline in key commercial groundfish stocks, the New England Fishery Management Council (NEFMC) implemented the Northeast Multispecies Fisheries Management Plan (FMP) in 1986 (Holland and Wiersma 2010). Attempts to improve the biological and economic performance of the fishery through effort control measures generally had failed. Groundfish landings "trended upward between 1994 and 2001 and fishing mortality on […] key groundfish stocks continued to exceed overfishing thresholds" (Holland and Wiersma 2010, p.1077). Measures included vessel buyback programs to reduce latent effort, year-round and seasonal area closures, trip limits, and a limited access program called days-at-sea (DAS).

The DAS and trip limit system was roundly unpopular. Restrictive trip limits allegedly caused fishermen to return to port early and to discard marketable catch, forgoing production efficiencies and increasing variable costs such as fuel and ice (Holland and Wiersma 2010, Akerly et al. 2011). DAS was blamed for overcapitalization in the form of gear capacity and reduced ability to time catch delivery to market demand. The latter required increased product storage costs and reduced the ex-vessel prices that onshore processors where willing to pay. In short, the initial limited access program exemplified all the inefficiencies of a race to fish that we typically associate with regulated open access.

Although economists have long championed IFQs as a solution to problems similar to those in New England groundfish, formation of a catch share program was stymied by two factors. First, the 1996 reauthorization of the MSA imposed a moratorium on new IFQ systems in the United States. The moratorium was only lifted in 2004 after the National Research Council recommended that quota programs could benefit fisheries under careful planning (McCay 2004, Chu, 2009). Second, under the current reauthorization, any catch share program in New England requires a referendum passed by a two-thirds majority of fishery participants (Magnuson-Stevens 2007). The current high bar would require broad initial quota allocations in order to gain the support of permit holders possessing low catch histories. Moreover, NEFMC was wary of investing the massive effort required to design a catch share system on which to vote given the high risk of it failing to pass the referendum and ultimately make its way into the FMP (Holland and Wiersma 2010).

Fishing cooperatives have emerged as a middle ground between regulated open access and IFQs. Fishing cooperatives around the U.S. resemble de facto IFQ programs operating outside of official regulatory authorization, and tend to occur where TAC is "exclusively allocated to a sufficiently small and cohesive group of permit holders" (Holland and Wiersma 2010, p.1076). Cooperatives cite facilitating cooperative behavior and reduced compliance costs from self-regulation as key factors in achieving biological and economic efficiency goals. With Multispecies FMP Amendment 13, NEFMC approved the first voluntary cooperative quota management bodies within the groundfish fishery, called "sectors," in 2004 (NMFS 2011, p.5)[1]. The first sector, Georges Bank Cod Hook Sector, was followed in 2006 by the Georges Bank

[1] 69 FR 22906, April 27, 2004

Cod Fixed Gear Sector, authorized by Multispecies FMP Framework (FW) 42 (NMFS 2011, p.5)[2]. By accepting a hard TAC and managing it collectively, sector members gained exemptions from trip limits, seasonal closures, and limits on DAS (NMFS 2011). Members benefited from increased efficiency, saw the value of their landings increase with advantageous timing to market demand, and even expanded their fishing activity as they were able to pursue “underutilized species without concern for lost [DAS] fishing time” (Holland and Wiersma 2010, p.1077). This potential benefit raises questions about whether fishermen would view unregulated species or species in a different management region as underutilized and redirect effort accordingly.

As the groundfish fishery continued to perform poorly under DAS, interest in expanding sector management increased, and eventually sectors were adopted broadly. NEFMC began scoping for Northeast Multispecies FMP Amendment 16 in 2006, which ultimately went into effect May 1, 2010. Amendment 16 managed 20 stocks over 13 species and allocated Annual Catch Entitlement (ACE) to 17 sectors (NMFS 2011, p.5)[3] ACE is the aggregate total of each member’s potential sector contribution (PSC) and is distributed on a stock-by-stock basis. PSC is determined on the basis of catch history from 1996-2006. Defining a static PSC qualifying period was a critical design decision as it provided assurance that a vessel’s future allocation will not decrease if its entitlement is leased out (Holland and Wiersma 2010). The Final Amendment defined sectors as “a way for fishermen to fish more efficiently and with more control over their daily activities” (NEFMC 2009, p.16). More broadly, increased sector participation was envisioned as a means to improve socioeconomic outcomes by granting fishermen the ability to make more personal business decisions during the stock rebuilding process (NEFMC 2009). Permit holders who did not enroll in a sector, or the members of sectors who did not hold ACE

[2] 71 FR 62156, October 23, 2006
[3] 75 FR 18356, April 9, 2010

for a given stock, could continue to fish under DAS rules in what is called the common pool (Holland and Wiersma 2010).

After the broad implementation of the Sector Program in 2010, the vast majority of catches ended up in sectors rather than in the common pool. Pre-implementation estimates of sector participation were as high as 97% of TAC (aggregate sector ACE plus common pool quota) (Holland and Wiersma 2010). Prior to FY2011, NMFS reported that the 19 sector applications – up from 17 in FY2010 – represented over 50% of eligible multispecies permits and over 90% of landings history (PSC) (NMFS 2011). Data on retained catch for the period May 1, 2011 through January 7, 2012 reports that of 22,522.7 total metric tons (mt), sector fishermen accounted for 22,315.3 mt (99.08%) and the common pool accounted for only 207.4 mt (0.92%) (NEFMC 2012).

Hypotheses

Our hypothesis is that sector management, by promoting the efficient use of capital, frees up capital to target species in non-sector fisheries, including ones in the Mid-Atlantic Region. This mechanism would not apply to the common pool, but because the common pool is small we simply exclude these data in the analysis below.

Table 2 lists the groundfish sectors operating in 2011, the number of enrolled participants in each sector, and the states in which each sector's members make their home port. The list of home port states includes all of the New England states with marine coastlines but also includes several states from the adjacent Mid-Atlantic Region. New Jersey, for instance, is listed as a home port for fishermen in seven of the sectors. Other Mid-Atlantic states in the list include New York, North Carolina, and Virginia.

Factors that might facilitate or inhibit cross-regional spillovers are not purely geographic. We consider three possibilities: market substitutability, gear substitutability, and institutional barriers. Market substitutability would matter if fishermen have an easier time identifying buyers for products that are close market substitutes than for products that are qualitatively different. While product markets could affect spillovers, gear is likely to be even more important. If a fisherman can use the same gear to catch a different species, then the fisherman does not need to incur the costs of changing gear and potentially learning a new fishing method. If the Sector Program indeed frees up capital, it frees up vessel time and the gear on that vessel. Lastly, institutional barriers could prevent spillovers by increasing the cost of entry.

Table 3 contains landings data for species managed by the Mid-Atlantic Fishery Management Council. Here, all species are included to consider all possibilities for leakage from New England into the adjacent region. There are four species that we categorize as whitefish: summer flounder, scup, black sea bass, and tilefish. Summer flounder plausibly competes with the flounder species in the New England groundfish complex (winter flounder, yellowtail flounder, and plaice) despite having a higher ex-vessel price. Scup similarly is a plausible market competitor for the lower end whitefish species in New England (hake, pollock, and redfish). The other two species, black sea bass and tilefish, are higher end plate fish, have ex-vessel prices that are substantially above those of the highest priced groundfish, and thus are less likely to compete with groundfish directly in the market.

The species categorized as Other Seafood in Table 3 are all qualitatively different from groundfish. Monkfish, though white fleshed, is a unique product; its tale is consumed and is textured like lobster. Atlantic mackerel is a low-end, oily pelagic fish with an ex-vessel price per pound that is less than half of the lowest priced groundfish species. Butterfish is a small, bony fish that was once marketed to Asia but now has no direct target fishery and is caught as bycatch. Long-finned squid, surfclam, and ocean quahog produce very different seafood products from whitefish. Bluefish is a low-end oily fish that spoils easily and thus does not compete directly with groundfish, and spiny dogfish is a small shark that is often smoked. Despite all of these differences, participants in the sector program that substitute into Mid-Atlantic species needed to have some established catch records for those species and, in the process, may have developed relationships with buyers. Considering market substitutability overall, spillovers are most likely for scup and summer flounder but cannot be ruled out for any of the Mid-Atlantic species.

Analyzing Mid-Atlantic landings by gear reinforces some of the market relationships but offers some other possible substitutes. Both summer flounder and scup are caught primarily by otter trawl, which is the dominant gear type for groundfish. As such, these species appear even more likely as spillover candidates. Black sea bass and golden tilefish are caught primarily by other gears (pots for bass and long line for tilefish). Combined with their market differentiation, spillovers for these species seem very unlikely. The same is true for surfclam and ocean quahog, which are caught with hydraulic dredges. In contrast, Atlantic mackerel, butterfish, and long-finned squid are all dominated by otter trawl, making these species strong candidates for spillovers for groundfish fishermen using otter trawls. Monkfish is a reasonable candidate on the basis of gear, with a substantial percentage of otter trawl but a higher percentage of gillnets. Spiny dogfish seems less likely with nearly a third of landings coming from other gears and only a quarter from otter trawl. Bluefish is dominated by gillnet gear, so the likelihood of spillover hinges on whether gillnet groundfish fishermen are likely to spillover. Overall, given the dominance of otter trawl in groundfish, the best candidates for spillover on the basis of gear are summer flounder, Atlantic mackerel, butterfish, and long-finned squid, and secondary candidates include monkfish and scup.

Most of the species in the Mid-Atlantic are managed with regulated restricted access. Three exceptions include surfclam and ocean quahog, which are managed with tradable IFQs, and golden tilefish, which is transitioning to IFQ-based management and the bulk of the TAC is caught by a small co-op (Kitts, Pinto da Silva, and Rountree 2007). In principle, a fisherman could purchase IFQ to enter these fisheries, but in practice this is a more substantial barrier to entry than for non-IFQ species. On the basis of institutional barriers, spillovers are less likely for surfclams, ocean quahog, and golden tilefish, but other Mid-Atlantic species appear equally plausible.

Data and Methods

We are interested in testing for a causal relationship between the expansion of New England's groundfish sector management program and altered levels of participation in Mid-Atlantic commercial fisheries. To this end, we employ a difference-in-differences estimator that relies on defining treatment and control groups and measuring outcomes before and after the policy change. In this case, treatment groups are collections of the individual fishermen who may or may not have altered their level of fishing behavior in Mid-Atlantic fisheries after the implementation of NEFMC Northeast Multispecies FMP Amendment 16 on May 1, 2010. For statistical comparison, control groups are defined to include the individual fishermen who participated in Mid-Atlantic fisheries during the same study years, but were not affected by policy change in New England. The model estimates the level of a measured outcome for the average individual fishermen included in the sample.

Although the ideal outcome of interest is fishing effort, we lack a direct measure of effort and instead use two alternative outcome variables: landed volume and revenue. For these variables, NMFS collects complete data from both fishermen and fish-dealers, so the commercial fisheries database contains some cross checks. For this study, we have access to this database, which includes every individual fishing vessel's landed quantity and dollar amount by species for every day from January 1, 2006 through November 30, 2011. Data on raw landings by individual vessel permits were reshaped to form a balanced panel around the sharp Sector Program implementation date of May 1, 2010.

Treatment groups are defined to include those individual fishermen whom one might expect to be changing their Mid-Atlantic fishery participation in response to the expansion of groundfish sectors. We consider three different formulations of treatment (visually shown in Figure 1):

Group 1: All fishermen who reported landing any species managed under the New England Northeast Multispecies (groundfish) FMP, between 2006-2011;

Group 2: All fishermen who are enrolled in one of the 17 New England groundfish sectors;

Group 3: All fishermen who are enrolled in one of the 17 New England groundfish sectors, but who are reported by their sector manager as "inactive" in that year's Sector Operations Plan submitted for NMFS approval prior to the May 1 start of the fishing year.

Group 1 provides the broadest definition of treatment. Running a model with this treatment definition would indicate the effect of groundfish sector management, if any, on the level of Mid-Atlantic fishery participation for any individual whose landings history links him or her to the New England groundfish fishery. Using treatment Group 1 takes a wide view of who comprises the potential source of leaked effort. Finding a significant difference-in-differences estimator for a Group 1 model run could be taken to indicate a watershed change in how the fishing population targets New England and Mid-Atlantic species as a result of the Sector Program.

Group 2 fishermen are a subset of Group 1; Group 2 includes only those individuals who enrolled in a sector, thereby contributing their catch history (PSC) to the sector's collectively managed ACE. Total enrollment across 17 sectors in 2011 was 819 individuals. In keeping with the idea that sector management creates opportunities to expand fishing activity beyond New England groundfish – by virtue of increased flexibility to catch groundfish over the entirety of the fishing season – one would expect to see a stronger positive increase in Mid-Atlantic fishery participation in Group 2 models relative to Group 1 models. If difference-in-differences estimates are significant for Group 2 but not for Group 1, one could infer that sector management altered Mid-Atlantic fishing effort for participating individuals, but not the entirety of the fishing community that lands New England-managed species.

Group 3 fishermen are a subset of Group 2, including those individuals who reap the financial benefits of their sector's collective catch but do not actively fish their own allotted share. The number of inactive sector members was 448 in 2011. Idled in New England fisheries by their sector managers, inactive sector members might have the greatest opportunity to redirect effort into Mid-Atlantic fisheries. Some of these fishermen may have been idled because their vessels are less efficient or because they had a lesser desire to continue fishing. This possibility cuts against the likelihood of a positive treatment effect. Nevertheless, holding fishing skill and vessel efficiency constant, treatment Group 3 should show the strongest, most positive increase in Mid-Atlantic fishery participation. That said, the many ways that substitution can unfold leads to some ambiguity in predictions, and the lack of a single definitive theoretical basis for defining treatment is another reason to consider multiple definitions of treatment.

In an ideal experiment, treatment and control groups would be the same in every way except for their levels in the outcome variable of interest. In such a case, the difference in the mean outcome level between the treatment and control groups would provide a confident measure of the effect of being in the treatment group. The multitude of unobservable factors affecting pounds and value of landings make it impossible to control for every factor that explains the difference in outcome levels between treatment and control. Weather, local product demand, and the strength of the overall economy as it impacts the opportunity cost of a fisherman's time are just a few examples of these unobservable factors that are not reported in commercial fisheries data. Difference-in-differences estimation is an appropriate strategy for this case because it compares the relationship between trends in outcome levels over time for treatment and control groups. The identifying assumption of this strategy is that, in the absence of treatment, the *difference* in the treatment and control groups' outcome levels – explained by omitted unobserved factors – remains the same over time. This first-stage difference describes the relationship between the underlying trends in treatment and control group fishing effort prior to policy implementation.

We use an ordinary least squares (OLS) regression-based differences-in-differences estimator with fixed-effects. A regression model is superior to the mean differencing estimation in its ability to control for variation in outcomes that are attributable to time period effects that are independent of the observational unit and time-independent effects. Effects that are invariant across time periods would include the essential differences between fishermen, such as relative access to capital, skill level, relationships with buyers, or experience. Fixed-effects models provide valid estimates of outcomes even if the unobserved, time-independent individual effects are correlated with other regressors. As with other OLS models, conditional exogeneity is required. This means that, after controlling for observable and unobserved factors that differentiate one individual in the sample from another, the expected value of the residual error is zero (Hayashi 2000, p.7).

Each calendar year was subdivided into three seasonal periods, or trimesters (January-April; May-August; September-December), creating 18 time periods within the time series. Including a dummy variable as a regressor for each portion of the year absorbs the effect of time-specific aggregate landings shocks that would be correlated across individuals in a certain period, regardless of the year. Controlling for seasonal variation is particularly important when analyzing fisheries because harvest patterns vary significantly in response to stock movements, spawning seasons, weather, regulatory restrictions, market conditions, and intense derby periods in regulated open access fisheries. A vector of year dummy variables is also included to control for variation in outcomes that are unique to a given year but affect all individuals equally. Including year and seasonal effects in a fixed-effects model effectively yields individual-specific time trends. We also include a linear time trend for the trimester-year combination. This time trend absorbs any monotonic changes in catch or value over the entire time period.[4] The fixed effects differences-in-differences models used are of the form:

$$Y_{ipy} = \beta D_{ipy} + \theta T_{py} + \gamma_p + \delta_y + \alpha_i + \varepsilon_{ipy} \qquad \text{(Eq. 1)}$$

Where *i* denotes an individual fisherman, *p* denotes a time period, *y* denotes a year, Y_{ipy} is the outcome level for individual *i* in time period *p* and year *y*, D_{ipy} takes the value of 1 for treated

[4] We cannot include period-year dummy variables as they would be perfectly co-linear with the treatment variable.

individuals in time period *p* and year *y* and 0 for control, T_{py} is a linear time trend for the period-year combination, γ_p are time period dummies, δ_y are year dummies, $+\alpha_i$ are individual fixed-effects and ε_{ipy} is the error term which is assumed to be independent across different fishermen, but allowed to be correlated for different period observations for the same fisherman. The estimated value of β is interpreted as the differences-in-differences estimator. The models were run with both POUNDS_{ipy} $VALUE_{ipy}$ as the dependent variable.

The critical identifying assumption in a difference-in-differences model is that in the absence of treatment, trends in outcomes between the treated and control groups would have been parallel. To test the validity of this identifying assumption, we conduct falsification tests for all outcomes that have statistically significant treatment effects. To do this we drop all post-treatment data (years 2010 and beyond) and redefine 2008 as the proxy "treatment" year. Thus, data from 2006 and 2007 are considered "pre-treatment" and data from 2008 and 2009 are considered "post-treatment." The exact same difference-in-differences models are run on these data. Since there was actually no treatment during this entire period, if the identifying assumption holds, we should observe no statistically significant treatment effect.

Defining the scope of "Mid-Atlantic fisheries" is critical to conducting policy-relevant model runs. The MAFMC directly manages 13 marine species under seven FMPs. Twelve of these species are listed in Table 3, and the last is short-finned squid, which does not appear in the aggregate NMFS database for landings by gear (so was excluded from the table). Short-finned squid landings do appear in our micro-level database and can be used in the analysis. The broadest possible definition of Mid-Atlantic fisheries thus includes all 13 species. Running models across the aggregated species landings and revenues, using each of the three previously defined treatment groups, in turn, provides a region-wide look at altered activity patterns in the

Mid-Atlantic. This aggregate-level analysis is the main test of our hypothesis that the Sector Program induced spillover into the Mid-Atlantic.

We also consider model runs for individual species or combinations of species. We base these runs on identifying likely candidates for spillovers. The number of individual fishermen included in a single model run is always large, with a minimum of 519 and a maximum of 2,559. As discussed above, the appeal of fishing for Mid-Atlantic species to New England fishermen could stem from geographical stock distributions that straddle management regions, the amount of overlap in fishing seasons, ease of permit access for Mid-Atlantic species, similarity of the product market, or the similarity between the type of gear used on New England groundfish and identified Mid-Atlantic species. In addition to using information in Tables 1 and 3, these attributes were assessed based on information available from NMFS and Northeast Fisheries Science Center (NEFSC) (NOAA 2012, NEFSC 2006) as well as personal communication with MAFMC staff (Seagraves 2012).

The following considerations were made when paring down the full roster of Mid-Atlantic species to eight species of special interest. New England groundfish species are primarily targeted with bottom and mid-water trawl gear. Landings data on surfclams and ocean quahogs was reasonably excluded given the specialized nature of the shellfish dredging fishery. Tilefish was excluded because the small number of active fishermen and low entry-pressure has created a de facto ITQ fishery. Bluefish is excluded because it is a low-value fishery that is mainly prosecuted with hook-and-line gear. Black sea bass is excluded because over 40% of species landings are taken with pot fishing gear and commercial landings are heavily outweighed by recreational fishing (NOAA 2012). Using each of the three treatment groups in turn, the model was run to determine effects on aggregated pounds and landed value outcomes for the eight remaining species: summer flounder, scup, spiny dogfish, long-finned squid, short-finned squid, Atlantic mackerel, butterfish, and monkfish.

Noting that susceptibility to redirected effort varies across species according to the factors mentioned above, the three-treatment approach was applied to landings data for each of six Mid-Atlantic species in isolation. The model runs used data on summer flounder, scup, long-finned squid, Atlantic mackerel, butterfish and monkfish. Spiny dogfish and short-finned squid were dropped, having been identified as primarily incidental bycatch species. Table 4 summarizes the total number of fishermen targeting different groups of Mid-Atlantic species and how many vessels are in treatment and control groups. Across models, the control group remains unchanged. This group corresponds to Mid-Atlantic fishermen who never (in sample) have landed any of the sector species. Moving from Treatment Group 1 (all vessels with catch records of sector species) to Treatment Group 2 (enrolled sector members) raises questions about whether some of the what we count in Treatment Group 1 and exclude from the control group are, in fact, Mid-Atlantic fishermen who have had some incidental landings of sector species. In other words, we can be confident that all fishing vessels in Treatment Groups 2 and 3 are treated with the Sector Program, but it is possible that some fishermen in Treatment Group 1 should actually be in the control group. By excluding these fishermen altogether in model runs with Treatment Groups 2 and 3, we believe that our experimental design errs on the side of being conservative.

Results

We estimate models for each of the three treatment group definitions (3 groups), both pounds landed and dollar value (2 groups), and all eight vulnerable species plus five individual species or combinations of species (6 groups) for a total of 36 models (3 x 2 x 6). All statistical significance is based on standard errors that are clustered at the fisherman level. Table 5 summarizes the treatment effects for all model runs, significance, and results of falsification tests. Full results are in the (reviewer's) appendix (to be archived online with URL).

For all species combined, we find evidence of quantity spillovers in Treatment Group 3 that passes a falsification test. The interpretation is that the Sector Program caused inactive sector members to increase their landings of Mid-Atlantic species by 1,296 pounds per trimester relative to Mid-Atlantic fishermen. The Group 2 pounds treatment effect is significant but fails the falsification test. For dollar value, the Group 2 result is significant and passes the falsification test; the Sector Program caused enrolled sector members to increase the dollar value of their catches of Mid-Atlantic species by $5,050 per trimester relative to Mid-Atlantic fishermen. The Group 3 result is not statistically significant, and neither pounds landed nor dollar value is significant for Group 1 (all fishermen who have ever caught New England groundfish in sample).

Turning to individual species, Atlantic mackerel is statistically significant for pounds and value in all three treatment definitions. However, only the results for dollar value and Treatment Group 1 passes a falsification test. Mackerel is caught almost exclusively with otter trawl and thus is a good substitute for groundfish species on the basis of gear, but it is a relatively weak market substitute. The passing of the falsification test for Treatment Group 1 but not for the other definitions raises questions about the treatment definitions; eliminating fishermen who have caught groundfish but who did not enroll in a sector leads to the weaker results. One possibility is that the formation of sectors caused groundfish fishermen in the common pool to intensify fishing for other species. This is not implausible given that mackerel is a high-volume and low-value fishery. It might be that fishing vessels best equipped to compete in a high-volume environment were less interested in joining a sector.

A similar mechanism could explain statistically significant Treatment Group 1 results that pass falsification tests for long-finned squid and butterfish. Like mackerel, squid is a high-volume and low-value species caught predominantly with otter trawl. Butterfish, which is also low-value, is caught mostly as bycatch in the squid fishery. In the sample period, there was no directed butterfish fishery. So, it is not surprising that its treatment effects track mostly with those of squid, though it is clear from Table 3 that butterfish is also caught with some other gears and thus as bycatch in other fisheries.

The results for monkfish are all negative, but only two results are statistically significant, and none pass falsification tests. In other words, there is no evidence that the Sector Program caused decreases in monkfish landings for New England fishermen relative to Mid-Atlantic fishermen.

The combination of summer flounder and scup is statistically significant for pounds and dollars in Treatment Groups 1 and 2, and the Treatment Group 2 results pass falsification tests. Both of these species are strong candidates for spillover on the basis of gear and market substitutability. As such, it is not surprising that the Sector Program caused spillovers for enrolled sector members. The question is why the statistical results do not show the same for inactive sector members (Treatment Group 3). The results are positive and of similar magnitude to the Treatment Group 2 results, but lack statistical significance. One possibility is simply that inactive sector members have less profitable vessels, and it is more profitable for them to idle their vessels and allow active sector members to catch both the allocation of groundfish and some of the Mid-Atlantic spillover. We do not observe ownership structure, but it is certainly a theoretical possibility that an individual owning two vessels with different efficiencies could choose to idle one to maximize profits across the two.

Overall, there is evidence that the Sector Program causes some spillovers into the Mid-Atlantic, but the evidence is not consistent across different ways of defining the treatment group, pounds versus dollars, and species groups.

Discussion

There are at least four possible implications of our findings that the New England Sector Program caused some spillovers into Mid-Atlantic fisheries. First, potential efficiency gains from the Sector Program in New England may have been offset at least partially by efficiency losses in the Mid-Atlantic. It is important to note that we did not test this hypothesis directly, but our results are consistent with this unintended consequence. Because the Mid-Atlantic species included in our model are regulated with fishery-wide total allowable catches (TACs), aggregate landings are reasonably viewed as zero-sum. Fish caught by redirected Sector Program fishing vessels are fish that are not caught by Mid-Atlantic fishermen, assuming the TACs bind. Even if TACs do not bind, within-season stock effects could cause cost increases for Mid-Atlantic fishermen as a result of Sector Program effort redirection. Our results are not necessarily cause for grave concern because we do not find positive treatment effects consistently across all treatment group definitions, outcome variables, and ways of aggregating species. It could be that efficiency losses from spillovers are not large enough to warrant the costs of controlling them. We did not explore this question, which suggests a direction for future research.

Second, there may be opportunities for regions like the Mid-Atlantic to address spillovers proactively before a policy change in an adjacent region. The use of sideboard limits in Alaska essentially attempts to deal with spillovers before they occur. In several instances, the North Pacific Fishery Management Council has restricted groups of vessels that participate in one catch share-managed fishery from expanding their aggregate level of retained catch in another fishery beyond the proportion that they harvested during a qualifying period.[5] Vessels without sideboard exemptions are prohibited from directed fishing in the spillover fishery once they reach their collective participation limit. The Mid-Atlantic chose not to pursue such an approach despite full knowledge of the coming sector program in New England. A reasonable question is whether the efficiency gains would have justified the cost of administering such a program in the Mid-Atlantic.

Third, a more radical approach would be full and complete creation of catch shares for all federally managed fisheries that do not already have catch share programs. Such programs might be a mix of individual transferable quotas, sectors, other forms of cooperatives, and territorial use rights in fisheries (TURFs), but would aim to undo residual open-access incentives in U.S. fisheries. Although changes of this sort would almost certainly be politically infeasible in the current policy climate, theoretically they would create high barriers to entry for fishing effort that might spillover from one region to another. As such, a radical policy change like this might avoid regional spillovers within the United States. The sentiment echoes that of calls to design climate policy that is all encompassing, i.e. to “think globally, act globally” (Wiener 2007). Still, broad formation of catch shares in U.S. fisheries could produce unintended consequences. Excess fishing capital might enter unregulated high-seas fisheries, be sold and exported to countries with less tightly controlled fisheries, or create more pressure from the domestic recreational sector by expanding the supply of charter vessels. Moreover, a policy change like this in developing

[5] NPFMC fisheries with sideboards include: the American Fisheries Act (AFA) pollock fishery, the Crab Rationalization Program, the Central Gulf of Alaska Rockfish Program, and the “Amendment 80” Fishery (Bering Sea/Aleutian Islands non-pollock trawl catcher/processors).

countries raises questions about the impacts of fisheries reform on the poor that rely on open-access conditions as part of a livelihood strategy that blends fishing and non-fishing income (Liese, Smith, and Kramer 2007; Wilen 2013).

Lastly, spillovers may reflect complex livelihood strategies within fisheries that single-species management fails to acknowledge. In this sense, spillovers from a policy change may be no different from effort redirection in response to fluctuations in fish stocks or market conditions. Managers would need to know not just if spillovers were occurring, but whether they had negative efficiency consequences. Supposing that there were not efficiency losses, the management implications are very different from those described above. Managers in this case might have a stake in facilitating, not limiting, opportunities to redirect effort. Single-species TACs might be replaced by value-based IFQs (Turner 1996) or some form of portfolio management (Sanchirico, Smith, and Lipton 2008). These ideas, though discussed in the economics literature, have yet to emerge as practical policy proposals.

The implications discussed above are not perfectly overlapping. The possibility that spillovers are just part of a larger economic context for fishing behavior suggests that no action is necessary, but it also begs the question of why some spillover effects actually passed falsification tests. Supposing that spillovers are enough of a problem to warrant a policy action, one type of action—e.g., a complete allocation of catch shares—would negate the need for another type of action—e.g. a network of sideboards.

The notion of spillovers as livelihood raises philosophical questions about how to define the treatment and control group in our context. Already, we chose to exclude many fishermen from the control group because they had caught some sector species even if these catches were truly incidental (Table 4). Scheld and Anderson (2014), focusing on a very different question from ours, find aggregate gains of $30 million from the Sector Program. However, they actually include gains in Mid-Atlantic fisheries in their tally (increased revenue in the Mid-Atlantic for Sector Program fishermen relative to counterfactual Mid-Atlantic revenues for Sector Program fishermen). If we take our individual vessel-level revenue result for all enrolled Sector Program fishermen with eight species ($5,050), multiply by three (to move from tri-mester to annual), and then multiply by number of Sector Program vessels (518), the result is roughly $7.8 million, a magnitude sufficiently large to question whether some of the gains in Scheld and Anderson (2014) were offset by spillovers. It could be that some of what they are counting as gains are, in fact, transfers from the Mid-Atlantic fishermen, whereas some of what we imply are efficiency losses are, in fact, gains from better market timing that the Sector Program fishermen are able to exploit. Even if all of the spillovers that we find are net losses that offset gains from the Sector Program, the net effect combing our results with Scheld and Anderson (2014) is a $22.2 million revenue increase due to the Sector Program. Overall, our results are not an indictment of catch shares, but they suggest that there are possible ways to improve performance through some coordination across regions and a taking a broader view of fisheries than the single-species focus of most current management institutions.

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Table 1. New England Groundfish Landings in 2009

Fishery	Pounds	Value ($)	Price ($/lb.)	Otter Trawl Pounds	Gillnet Pounds	Other Pounds	Not Coded Pounds	Total Coded Pounds	Otter Trawl Coded Gears	Gillnets Coded Gears	Other Coded Gears
Cod	19,442,875	24,846,605	1.28	4,094,820	6,289,209	1,207,489	7,851,357	11,591,518	35%	54%	10%
Haddock	12,233,976	12,945,104	1.06	4,231,480	251,247	378,197	7,373,052	4,860,924	87%	5%	8%
Plaice	3,040,214	3,853,125	1.27	1,482,549	125,134	19,755	1,412,776	1,627,438	91%	8%	1%
Winter Flounder	4,703,928	7,824,370	1.66	1,260,068	133,372	342,657	2,967,831	1,736,097	73%	8%	20%
Yellowtail Flounder	3,435,682	4,606,270	1.34	1,158,562	144,443	114,293	2,018,384	1,417,298	82%	10%	8%
Pollock	16,020,335	9,762,477	0.61	5,472,406	5,604,208	45,371	4,898,350	11,121,985	49%	50%	0%
Hake (Silver, Red, and White)	15,466,145	9,055,847	0.59	6,000,691	855,854	41,427	8,568,173	6,897,972	87%	12%	1%
Redfish	3,097,815	1,501,659	0.48	965,860	156,294	494	1,975,167	1,122,648	86%	14%	0%
Total	77,440,970	74,395,457	0.96	24,666,436	13,559,761	2,149,683	37,065,090	40,375,880	61%	34%	5%

Note:

Data from National Marine Fisheries Service Commercial Fisheries Statistics, http://www.st.nmfs.noaa.gov/commercial-fisheries/index

Table 2. New England groundfish sectors, membership, and geographical distribution by home port

2011 Groundfish Sectors	Enrolled Members	Home Port States
Georges Bank Fixed Gear	96	MA
Northeast Coastal Communities	28	MA, ME, NJ
Port Clyde Community Groundfish	39	ME
Sustainable Harvest	124	CT, MA, ME, NH, NJ, NY, RI
Tri-State	19	MA, NC, NJ
Northeast Seafood Coalition II	83	MA, ME, NH
Northeast Seafood Coalition III	93	MA, ME
Northeast Seafood Coalition IV	41	MA
Northeast Seafood Coalition V	32	CT, MA, NJ, NY, RI
Northeast Seafood Coalition VI	21	MA, NJ, NY, RI
Northeast Seafood Coalition VII	20	MA, RI
Northeast Seafood Coalition VIII	20	NJ, VA
Northeast Seafood Coalition IX	60	MA, RI
Northeast Seafood Coalition X	51	MA
Northeast Seafood Coalition XI	46	ME, NH, NJ
Northeast Seafood Coalition XII	11	ME, NH
Northeast Seafood Coalition XIII	35	CT, MA, NY, RI

Table 3. Mid-Atlantic Fisheries Landings in 2009

Fishery	Pounds	Value ($)	Price ($/lb.)	Otter Trawl Pounds	Gillnet Pounds	Other Pounds	Not Coded Pounds	Total Coded Pounds	Otter Trawl Coded Gears	Gillnets Coded Gears	Other Coded Gears
Whitefish											
Summer Flounder	10,430,771	21,581,799	2.07	6,286,293	114,129	937,118	3,093,231	7,337,540	86%	2%	13%
Scup	7,870,465	6,075,339	0.77	2,117,178	0	1,227,346	4,525,941	3,344,524	63%	0%	37%
Black Sea Bass	1,614,382	4,404,751	2.73	325,145	6,556	853,748	428,933	1,185,449	27%	1%	72%
Golden Tilefish	1,987,317	4,457,145	2.24	4,663	0	657,942	1,324,712	662,605	1%	0%	99%
Other Seafood											
Monkfish	18,873,932	19,172,676	1.02	3,364,083	7,455,965	1,501,492	6,552,392	12,321,540	27%	61%	12%
Atlantic Mackerel	29,975,463	6,375,267	0.21	26,830,346	6	583,676	2,561,435	27,414,028	98%	0%	2%
Butterfish	990,073	632,757	0.64	378,773	49,774	50,464	511,062	479,011	79%	10%	11%
Longfin Squid	19,847,227	18,106,368	0.91	7,834,463	0	258,022	11,754,742	8,092,485	97%	0%	3%
Bluefish	6,441,298	2,533,036	0.39	404,078	3,863,855	507,583	1,665,782	4,775,516	8%	81%	11%
Surfclam	45,986,208	30,928,637	0.67	0	0	40,880,938	5,105,270	40,880,938	0%	0%	100%
Ocean Quahog	12,969,390	8,748,296	0.67	0	0	12,969,390	0	12,969,390	0%	0%	100%
Spiny Dogfish	1,300,711	361,273	0.28	190,804	335,794	245,044	529,069	771,642	25%	44%	32%
Total	158,287,237	123,377,344	0.78	47,735,826	11,826,079	60,672,763	38,052,569	120,234,668	40%	10%	50%

Notes:

Data from National Marine Fisheries Service Commercial Fisheries Statistics, http://www.st.nmfs.noaa.gov/commercial-fisheries/index

Shortfin squid is also managed by the Mid-Atlantic Council but does not appear in the aggregate landings-by-gear data for 2009.

Table 4. Number of Individual Fishermen Included in Each Species Aggregation Analysis

Species	Number of Species	Total Individual Fishermen	Control	Treat 1	Treat 2	Treat 3
Complete Mid-Atlantic Species Roster	13	2559	1211	1348	523	165
High-vulnerability Effort-Receiving Species	8	2380	1058	1322	518	163
Long-finned Squid	1	586	128	458	173	54
Atlantic Mackerel	1	555	81	474	221	54
Butterfish	1	519	103	416	146	44
Monkfish	1	1679	588	1091	480	141
Scup	1	898	315	583	162	55
Summer Flounder	1	1253	523	730	244	72
Scup/Summer Flounder Combined	2	1451	642	809	261	79

Table 5. Treatment Effect Model Results

Species	Treatment Definition Group 1		Group 2		Group 3	
Pounds						
All Species	1,226.6		16,330.5	*	1,296.0	*,+
Atlatntic Mackerel	61,241.0	*	68,594.3	*	45,171.8	*
Butterfish	481.9	*,+	789.4	*,+	24.5	
Longfin Squid	2,335.7	*,+	(2,356.5)		865.0	
Monkfish	(531.0)	*	(941.4)	*	(543.2)	
Summer Founder + Scup	916.8	*	3,611.9	*,+	3,052.5	
Value						
All Species	$ 1,041		$ 5,050	*,+	$ 3,305	
Atlatntic Mackerel	$ 10,162	*,+	$ 9,638	*	$ 6,422	*
Butterfish	$ 233	*,+	$ 326	*	$ 45	
Longfin Squid	$ 5,030	*,+	$ 5,152	*	$ 1,737	
Monkfish	$ (400)		$ (506)		$ (1,237)	
Summer Founder + Scup	$ 1,785	*	$ 4,409	*,+	$ 4,428	

Notes:

Standard errors clustered at the individual vessel level.

* significant at the 5% level, and + passes falsification test.

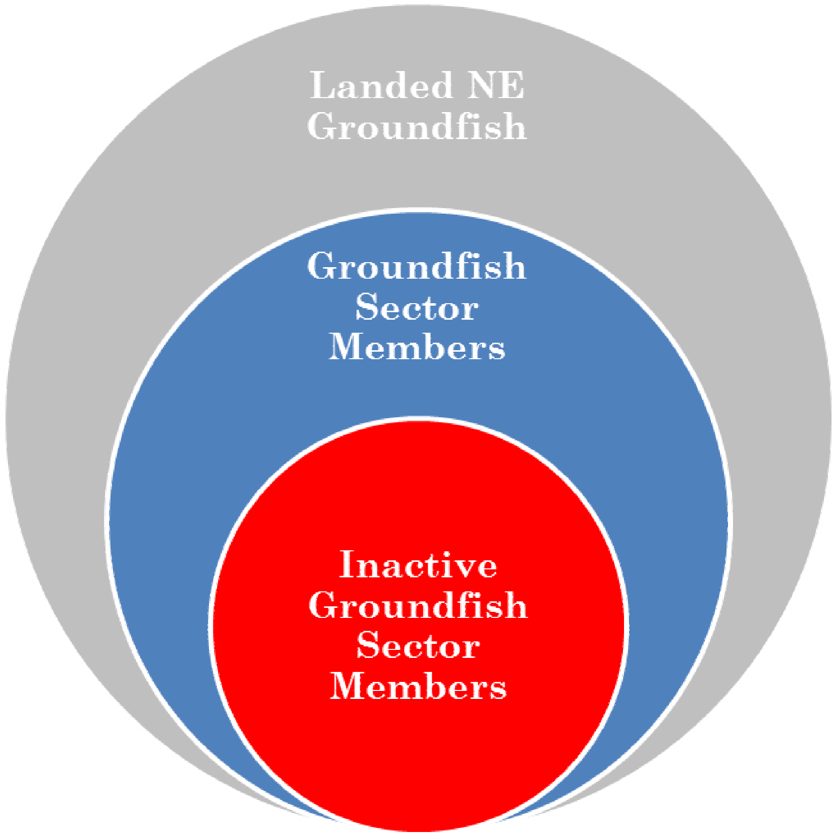

Figure 1. Three Definitions of the Treatment Group

Reviewer's Appendix – All treatment effect results (all 36 model runs)

Results in gray indicate that the estimates are statistically significant at the 5% level and pass the falsification test.

Species	All	All	All	All	All	All
Treatment Definition	1	1	2	2	3	3
Dependent Variable	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Result or Falsification Test	Results	Falsification	Results	Falsification	Results	Falsification
Treatment Estimate	122.6	-4425.9	16330.5	8929.3	12969	4101.4
Treatment Standard Error	2902.1	3456.1	3604.6	4148.5	3917.7	3434.1

Species	Atlantic Mackerel	Atlantic Mackerel	Atlantic Mackerel	Atlantic Mackerel	Atlantic Mackerel	Atlantic Mackerel
Treatment Definition	1	1	2	2	3	3
Dependent Variable	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Result or Falsification Test	Results	Falsification	Results	Falsification	Results	Falsification
Treatment Estimate	61241	46240.9	68594.3	35336.3	45171.9	19981.3
Treatment Standard Error	18854.4	21106.6	17329	10161.7	11503.5	6252.8

Species	Butterfish	Butterfish	Butterfish	Butterfish	Butterfish	Butterfish
Treatment Definition	1	1	2	2	3	3
Dependent Variable	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Result or Falsification Test	Results	Falsification	Results	Falsification	Results	Falsification
Treatment Estimate	481.9	-159.7	789.4	227.2	24.5	-193.8
Treatment Standard Error	139.9	131.1	216.7	163.1	396.2	531.7

Species	Loligo	Loligo	Loligo	Loligo	Loligo	Loligo
Treatment Definition	1	1	2	2	3	3
Dependent Variable	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Result or Falsification Test	Results	Falsification	Results	Falsification	Results	Falsification
Treatment Estimate	2335.7	-1398.4	-2356.5	3512	865	2271.6
Treatment Standard Error	1133.4	2479.4	2220.3	2383	3578.8	3631.6

Species	Monkfish	Monkfish	Monkfish	Monkfish	Monkfish	Monkfish
Treatment Definition	1	1	2	2	3	3
Dependent Variable	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Result or Falsification Test	Results	Falsification	Results	Falsification	Results	Falsification
Treatment Estimate	-531	-714.8	-941.4	-1200.4	-543.2	-968.9
Treatment Standard Error	149	190.1	215.2	275.3	368.4	494.1

Species	Summer Flounder and Scup	Summer Flounder and Scup	Summer Flounder and Scup	Summer Flounder and Scup	Summer Flounder and Scup	Summer Flounder and Scup
Treatment Definition	1	1	2	2	3	3
Dependent Variable	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Result or Falsification Test	Results	Falsification	Results	Falsification	Results	Falsification
Treatment Estimate	916.8	-1264.3	3611.9	-393.4	3052.5	361.5
Treatment Standard Error	304.3	337.3	806.9	643.6	2001.3	1500.6

Species	All	All	All	All	All	All
Treatment Definition	1	1	2	2	3	3
Dependent Variable	Value	Value	Value	Value	Value	Value
Result or Falsification Test	Results	Falsification	Results	Falsification	Results	Falsification
Treatment Estimate	1040.5	-2749.4	5050	1226.5	3304.5	-867.5
Treatment Standard Error	748.2	791.4	1324	1230	2543.1	2450.3

Species	Atlantic Mackerel	Atlantic Mackerel	Atlantic Mackerel	Atlantic Mackerel	Atlantic Mackerel	Atlantic Mackerel
Treatment Definition	1	1	2	2	3	3
Dependent Variable	Value	Value	Value	Value	Value	Value
Result or Falsification Test	Results	Falsification	Results	Falsification	Results	Falsification
Treatment Estimate	10162.2	3896.6	9638.2	3903.1	6422	2037
Treatment Standard Error	3109	2548.8	2410.7	1268.4	1646.1	805.2

Species	Butterfish	Butterfish	Butterfish	Butterfish	Butterfish	Butterfish
Treatment Definition	1	1	2	2	3	3
Dependent Variable	Value	Value	Value	Value	Value	Value
Result or Falsification Test	Results	Falsification	Results	Falsification	Results	Falsification
Treatment Estimate	233.4	-93.1	325.8	233.1	45.4	-24.6
Treatment Standard Error	87.2	84.6	117.2	101	223	254.6

Species	Loligo	Loligo	Loligo	Loligo	Loligo	Loligo
Treatment Definition	1	1	2	2	3	3
Dependent Variable	Value	Value	Value	Value	Value	Value
Result or Falsification Test	Results	Falsification	Results	Falsification	Results	Falsification
Treatment Estimate	5060	332.3	5151.9	5040.5	1737.4	2011.7
Treatment Standard Error	1413.9	1889.8	2155.5	1943.4	3775	3397

Species	Monkfish	Monkfish	Monkfish	Monkfish	Monkfish	Monkfish
Treatment Definition	1	1	2	2	3	3
Dependent Variable	Value	Value	Value	Value	Value	Value
Result or Falsification Test	Results	Falsification	Results	Falsification	Results	Falsification
Treatment Estimate	-399.8	-1200	-506.4	-1569.9	-1236.6	-1442.8
Treatment Standard Error	272.9	305.2	451.1	481.2	839.5	863.4

Species	Summer Flounder and Scup	Summer Flounder and Scup	Summer Flounder and Scup	Summer Flounder and Scup	Summer Flounder and Scup	Summer Flounder and Scup
Treatment Definition	1	1	2	2	3	3
Dependent Variable	Value	Value	Value	Value	Value	Value
Result or Falsification Test	Results	Falsification	Results	Falsification	Results	Falsification
Treatment Estimate	1785	-1546.3	4408.5	430.4	4428.1	-470.2
Treatment Standard Error	417.4	517.3	918	913.3	2272.3	2789