# Commercial and Recreational Allocation for Summer Flounder

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# Executive Summary

This work develops economic models for assessing the economic efficiency from allocation decisions made between the recreational and commercial fishing sectors for summer flounder along the Atlantic Coast of the United States. In this work, we rely on existing datasets to analyze economic welfare changes for commercial and recreational stakeholders having direct engagement fishing for summer flounder. Our work shows that

- The existing 60/40 commercial/recreational allocation is not suboptimal from an economic efficiency perspective
- Minor changes to a 60/40 allocation *in either direction* would most likely not lower the economic benefits received from the fishery

In the work, we note numerous caveats and will not list them again here. But any discussion or use of the results in this report must bear in mind the limitations of the models, the data, and the policy analysis. Even given these caveats, this work provides a useful metric for assessing the economic efficiency of various allocations across the commercial and recreational sectors for directly engaged stakeholders.

## Document Roadmap

Chapter 1 provides a broader introduction to this report. To motivate the empirical approaches taken in this report we present a small description of some historical data characterizing the commercial and recreational fisheries in Chapter 2. We develop economic models for the recreational (Chapter 3) and commercial (Chapter 4) sectors. In Chapter 5 we combine the recreational and commercial models for performing the allocation analysis, describe important caveats, and provide recommendations.

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# Chapter 1

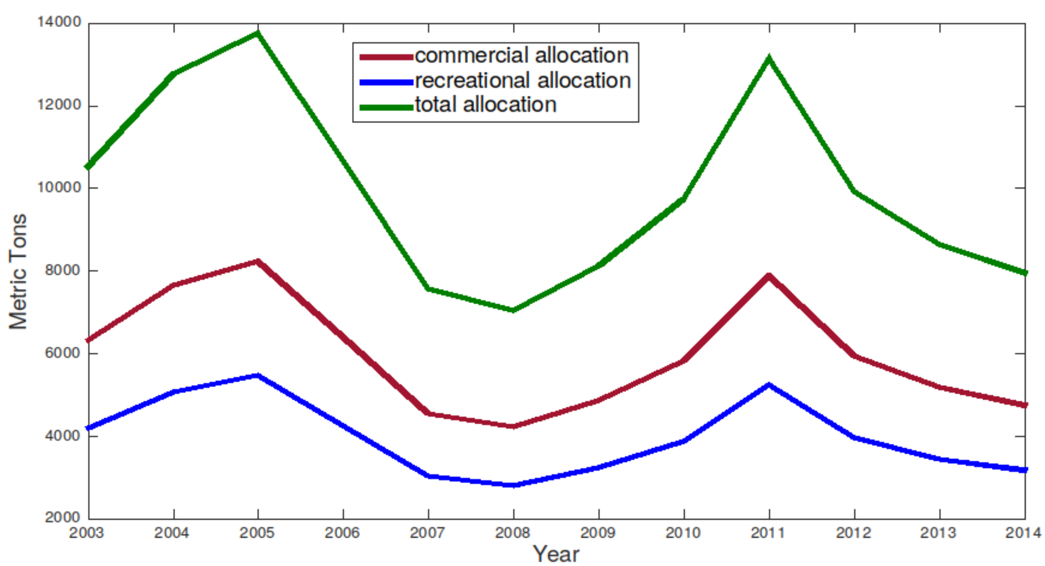
# Introduction

Summer flounder, also know as fluke, is an important commercial and recreational species, and are found in pelagic and demersal waters from the Gulf of Mexico through North Carolina, with larger concentrations in the mid-Atlantic and northwest Atlantic region. They spawn during the Fall and Winter along the continental shelf and they exhibit a strong seasonal inshore-offshore movement. They inhabit shallow coastal waters in the warmer months and then remain offshore during the colder months (MAFMC 2016). This strong seasonality is an important aspect of the commercial fleet, which consists of a winter offshore and a summer inshore fishery. The recreational fishery also responds to this seasonality with most directed summer flounder trips occurring during the warm summer months. The nature of the harvesting also requires management coordination because fishermen operate within both state (less than 3 miles offshore) and federal (3-200 miles offshore) waters.

The commercial and recreational landings for summer flounder were exceptionally high in the late 1970s through the 1980s, peaking at 26,100 metric tons in 1983. During the late 1980s and early 1990s the landings substantially decreased as the stock was overfished and a limited access fishery program was implemented. The first Fishery Management Plan (FMP) for summer flounder was conducted in 1988, shortly after the stock had been declared overfished Terceiro (2012). The management of the stock is conducted jointly by the Mid-Atlantic Fishery Management Council (MAFMC) and the Atlantic States Marine Fisheries Commission (ASMFC). Official policies are established by the National Marine Fisheries Service (NMFS). In 2012 the stock was declared rebuilt. The most recently published stock assessment for summer flounder was conducted in 2013. At that time it was concluded that the summer flounder stock was not overfished and that fishing mortality had decreased since 1997 (57th SAW 2013). However, in 2016 the summer flounder quota was reduced by 29% because of the observed overfishing in 2014 and the below-average recruitment rates observed in the year classes from 2010-2013 (MAFMC 2015). This reduction is part of a larger phase-in policy to reduce the total allowable catch over the coming years (MAFMC 2015). Therefore, the stock dynamics for summer flounder have recently undergone a substantial transition in the perception of overall health.

Under Amendment 2 (ratified in 1992) of the summer flounder FMP, the total allowable catch for summer flounder is divided between the commercial and recreational sectors. Currently, 60% of the total allowable catch is allocated to the commercial sector and 40% is allocated to the recreational sector. All allocations were based on historical catch rates observed between 1980-89. In addition, the commercial landings were further subdivided among the states that landed summer flounder based on their historical landings between 1980-1989 (Terceiro 2012). Sector allocations from 2003-2014 are illustrated in Figure 1.1 and are based on the limits reported on the MAFMC website.

Figure 1.1: Historical Recreational and Commercial Summer Flounder Allocations Plots




## 1.1 Allocation Analysis

To formulate a recommendation regarding the allocation of summer flounder across the commercial and recreational fishing sectors we will employ the equimarginal principal.

This method solely focuses on the economic impacts of the allocation, however distributional issues and social impacts may also be an important concern for policymakers (Edwards 1990). Given that one's value for summer flounder will depend on the current allocation of summer flounder to their respective sector, we account for this by calculating one's marginal value for a pound of summer flounder conditional on their current sector allocation. By equating marginal values between the commercial and recreational sectors we will be able to determine the sector allocations that maximize the total welfare.

Estimating the marginal value per a pound of summer flounder in the recreational sector utilizes a random utility model of site choice and follows an established literature discussed in Chapter 4. We develop a full model of recreational fishing along the Atlantic Coast and the model allows for mode, target, and species choice.

In order to estimate the marginal value per a pound of summer flounder in the recreation sector we use data from the NOAA Fisheries Office of Science and Technology's Marine Recreational Information Program. This data allows us to use better weighting methodology to improve our valuation models considerably (compared to the Marine Recreational Fisheries Statistics Survey Data). By linking policy changes to changes in expected catch in our model, we are able to develop measures of changes in the economic value of recreational fishing due to policy changes. Our measures are comparable to previous summer flounder studies (Gentner et al. (2010)) and Massey, Newbold and Gentner (2006)) and from our model we are able to develop marginal value estimates for a wide range of allocation possibilities.

Estimating the marginal value per a pound of summer flounder in the commercial sector has been traditionally approached from the consumer demand perspective (Carter et al. 2008; Gentner et al. 2010). However a limitation of this method is that it approaches it from a profit function perspective where harvest rates are a selection variable in a firm's profit maximization problem, whereas the modeling used to estimate recreational demand comes from a random utility model specification. The approach we elect to utilize in our modeling efforts utilizes the same random utility model foundation used in the recreational demand literature and combines it with fishery simulations to estimate the marginal values per a pound of summer flounder.

To estimate marginal value per a pound of summer flounder in the commercial fleet we will use observer data as well as trip level cost data from 2000 through 2014. The observer data contains detailed landings data for a sub-sample of the fleet operating off the east coast of the United States from Maine down to North Carolina. This includes the vessel's trip-level landings of summer flounder as well as all other species caught. The trip-level cost data contains detailed information on the costs vessels incurred during their fishing trips. These costs include fuel, food, bait, ice and other supply costs associated with the trip. Combining the information garnered from these two data sets we are able to construct expected profits from fishing in a particular location at a particular point in time and construct a fishery simulation to estimate marginal values.

## 1.2 Document Roadmap

To motivate the empirical approaches taken in this report, we next present a small description of some historical data characterizing the commercial and recreational fisheries. We focus our discussion on the data we will ultimately use for the analysis since numerous fisheries summaries exist elsewhere (e.g. Terceiro (2012))

To perform the allocation analysis, we develop parallel models in the recreation (Chapter 3) and commercial (Chapter 4) sectors. In the recreational chapter, we discuss conceptual issues relating to defining the recreational choice problems, implement these, and present estimation results for a behavioral model of summer recreational flounder fishing. We describe how we use the model results to develop and marginal value schedule for quota allocation changes and discuss caveats. In the commercial chapter, we develop a new way of analyzing the impacts of policies on commercial fishermen. The model uses a similar methodology to Chapter 3, but then uses this methodology to simulate fleet behavior when quota allocation changes. This allows us to measure changes in seasonal profits under various quota allocation levels, from which we derive the marginal value schedule for the commerical fishery.

In conclusion, we perform the allocation analysis, describe important caveats, and provide recommendations in Chapter 5

# Chapter 2

# Fishery Summaries

## 2.1 Commercial Fishery Summary

The commercial allocation, annual landings and annual value for summer flounder from 2000 through 2014 are illustrated in Table 2.1. The recent commercial allocations have been decreasing, however the market value has remained relatively stable. In 2014 the commercial landings for summer flounder were 4,941.2 metric tons, which is slight over the commercial allocation of 4,767.3 metric tons. This catch resulted in a value of $32,299,399. Between 2000 and 2014 the commercial allocation has not always been completely executed. This occurred in 2003, 2004, 2007, 2008, 2010 and 2013.

The commercial allocation is divided up among the states that harvest summer flounder. The state allocations are contained in Table 2.2. The states with the largest share of the summer flounder quota are North Carolina, Virginia, New Jersey and Rhode Island. The annual landings by state and year are contained in Table 2.3. The distribution of annual landings by state is similar to the percentages allocated to each state, which implies that no one state systematically executes lower than their percentage allocation.

## 2.2 Fisheries Data

The primary data set we utilize for our analysis is the fishery observer data. This data set contains detailed spatial production data, however only a small percentage of vessels are contained in the observer data. To investigate the robustness of this data set we will compare it to the vessel trip report (VTR) data that contains a larger percentage of the fleet activity. Because the VTR data does not contain detailed and sequenced spatial

Table 2.1: Annual Landings and Value for Summer Flounder

| Year | Commercial Allocation | Metric Tons Landed | Pounds Landed | Value |
|---|---|---|---|---|
| 2000 | 5,039.9 | 4,998.3 | 11,019,193 | 19,692,892 |
| 2001 | 6,480.4 | 4,860.6 | 10,715,630 | 17,331,869 |
| 2002 | 6,316.4 | 6,453.5 | 14,227,332 | 21,071,477 |
| 2003 | 6,341.2 | 6,499.2 | 14,328,181 | 23,188,120 |
| 2004 | 7,674,8 | 8,139.8 | 17,945,026 | 28,882,286 |
| 2005 | 8,246.3 | 7,749.1 | 17.083,575 | 30,118,259 |
| 2006 | 6,418.3 | 6,331,9 | 13,959,339 | 29,764,388 |
| 2007 | 4.549.5 | 4,445.5 | 9,800,522 | 23,848,565 |
| 2008 | 4,227.5 | 4,096.1 | 9,030,351 | 21,926,159 |
| 2009 | 4,871.6 | 4,896.6 | 10,795,138 | 22,358,627 |
| 2010 | 5,842.3 | 5,971.1 | 13,163,869 | 28,562,911 |
| 2011 | 7,883.4 | 7,218.0 | 15,912,725 | 31,775,642 |
| 2012 | 5,960.2 | 5,672.2 | 12,504,943 | 30,389,195 |
| 2013 | 5,189.1 | 5,395,3 | 11,894,588 | 28,613,558 |
| 2014 | 4,767.3 | 4,941.2 | 10,893,454 | 32,299,399 |

Table 2.2: State Allocations of Summer Flounder as a Percentage of Total Allocation

| State | Percentage SF |
|---|---|
| ME | 0.0476% |
| NH | 0.0005% |
| MA | 6.8205% |
| RI | 15.6830% |
| CT | 2.2571% |
| NY | 7.6470% |
| NJ | 16.7250% |
| DE | 0.0178% |
| MD | 2.0391% |
| VA | 21.3168% |
| NC | 27.4458% |

Table 2.3: Annual Landings by Year and State in Metric Tons

| Year | ME | MA | RI | CT | NY | NJ | DE | MD | VA | NC |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 3.1 | 357.9 | 772.2 | 112.2 | 368.3 | 838.3 | 5.6 | 0.0 | 1,001.0 | 1,536.1 |
| 2001 | 10.0 | 314.8 | 815.9 | 112.1 | 341.0 | 791.7 | 3.4 | 0.0 | 1,206.4 | 1,263.2 |
| 2002 | 0.2 | 457.9 | 1,037.1 | 161.8 | 477.6 | 1,091.8 | 1.2 | 0.0 | 1,347.3 | 1,873.0 |
| 2003 | 0.0 | 419.9 | 988.0 | 143.7 | 486.8 | 1,081.9 | 2.5 | 0.0 | 1,597.5 | 1,620.5 |
| 2004 | 0.1 | 541.0 | 1,399.1 | 184.2 | 723.2 | 1,192.9 | 3.4 | 119.1 | 1,771.8 | 2,197.3 |
| 2005 | 1.6 | 578.1 | 1,326.9 | 203.5 | 815.9 | 1,065.5 | 2.5 | 153.2 | 1,755.0 | 1,843.6 |
| 2006 | 0.0 | 417.5 | 963.1 | 143.6 | 553.3 | 1,079.5 | 1.6 | 112.4 | 1,250.5 | 1,806.0 |
| 2007 | 0.0 | 299.4 | 687.5 | 93.0 | 427.1 | 769.7 | 1.0 | 103.8 | 841.7 | 1,211.2 |
| 2008 | 0.0 | 292.4 | 668.3 | 100.1 | 388.4 | 698.9 | 0.6 | 94.4 | 750.1 | 1,091.6 |
| 2009 | 0.0 | 331.7 | 813.7 | 113.7 | 517.9 | 815.9 | 1.3 | 96.9 | 898.3 | 1,296.9 |
| 2010 | 0.0 | 386.4 | 1,038.5 | 139.9 | 618.5 | 982.2 | 0.8 | 118.6 | 1,175.8 | 1,501.9 |
| 2011 | 0.0 | 513.6 | 1,281.0 | 182.1 | 688.1 | 1,284.0 | 0.4 | 117.7 | 1,843.7 | 1,294.6 |
| 2012 | 0.0 | 404.4 | 1,092.9 | 143.1 | 561.5 | 1,029.1 | 0.4 | 75.0 | 1,869.8 | 494.5 |
| 2013 | 0.0 | 389.8 | 994.5 | 128.9 | 468.7 | 909.1 | 0.4 | 80.7 | 2,174.6 | 245.7 |
| 2014 | 0.0 | 315.7 | 932.1 | 115.0 | 378.1 | 828.5 | 0.8 | 117.4 | 929.4 | 1,320.8 |

behavior information we are unable to utilize it for our analysis. Table 2.4 contains information on the spatial distribution of effort within the VTR and observer data from 2012 through 2014, the last few years of our analysis. For the most part the spatial distribution of effort is similar across both data sets, however there a few sites where the rates of visitation are different.[1]

Table 2.4: Commercial Percentage of Effort by Year and Area

| | VTR Data | | | Observer Data | | |
|---|---|---|---|---|---|---|
| area_id | 2012 | 2013 | 2014 | 2012 | 2013 | 2014 |
| 464 | 0.15 | 0.11 | 0.21 | 0.46 | 0.04 | 0.29 |
| 465 | 0.03 | 0.05 | 0.05 | 0.00 | 0.16 | 0.00 |
| 511 | 0.01 | 0.02 | 0.01 | 0.00 | 0.12 | 0.00 |
| 512 | 0.80 | 0.99 | 0.68 | 0.62 | 0.37 | 0.00 |
| 513 | 3.39 | 5.49 | 5.30 | 4.29 | 3.17 | 5.59 |
| 514 | 8.03 | 6.50 | 5.41 | 16.75 | 8.39 | 13.64 |
| 515 | 2.95 | 3.57 | 3.95 | 5.36 | 3.64 | 8.67 |
| 521 | 7.37 | 9.51 | 7.76 | 8.72 | 9.36 | 6.12 |
| 522 | 8.55 | 6.90 | 6.27 | 10.74 | 10.51 | 7.57 |
| 525 | 2.20 | 1.80 | 2.78 | 2.47 | 2.27 | 0.92 |
| 526 | 2.23 | 3.29 | 1.71 | 0.36 | 1.42 | 0.77 |
| 533 | 0.00 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 |
| 537 | 9.53 | 11.02 | 11.64 | 9.28 | 7.61 | 17.11 |
| 538 | 1.23 | 1.12 | 1.47 | 1.81 | 1.18 | 0.00 |
| 539 | 5.32 | 5.95 | 4.99 | 4.09 | 6.62 | 5.64 |
| 561 | 2.25 | 1.97 | 1.10 | 2.02 | 0.94 | 0.72 |
| 562 | 3.26 | 2.09 | 2.31 | 1.09 | 1.31 | 0.53 |
| 611 | 2.29 | 2.73 | 2.32 | 1.26 | 4.08 | 1.20 |
| 612 | 4.95 | 4.60 | 5.45 | 4.95 | 6.54 | 0.48 |
| 613 | 8.07 | 7.53 | 10.02 | 4.70 | 7.05 | 2.22 |
| 614 | 0.92 | 1.17 | 0.89 | 0.19 | 1.07 | 0.00 |
| 615 | 7.14 | 6.23 | 4.78 | 0.94 | 1.76 | 1.01 |
| 616 | 4.38 | 4.26 | 6.55 | 11.29 | 9.90 | 15.18 |
| 621 | 2.30 | 1.78 | 2.27 | 1.67 | 3.08 | 0.96 |
| 622 | 3.45 | 2.53 | 1.84 | 3.19 | 4.57 | 6.70 |
| 623 | 0.21 | 0.05 | 0.15 | 1.01 | 0.18 | 0.29 |
| 625 | 1.22 | 1.03 | 0.66 | 0.00 | 0.16 | 0.00 |
| 626 | 0.90 | 0.71 | 1.32 | 1.18 | 2.65 | 1.88 |
| 627 | 0.01 | 0.02 | 0.03 | 0.15 | 0.16 | 0.00 |
| 631 | 1.40 | 1.07 | 0.53 | 0.07 | 0.21 | 0.00 |
| 632 | 0.24 | 0.23 | 0.18 | 0.51 | 1.13 | 0.00 |
| 635 | 1.24 | 1.84 | 3.46 | 0.79 | 0.14 | 0.77 |
| 636 | 0.06 | 0.15 | 0.19 | 0.03 | 0.22 | 1.59 |
| 701 | 0.09 | 0.33 | 0.21 | 0.00 | 0.00 | 0.05 |
| 702 | 0.01 | 0.02 | 0.01 | 0.00 | 0.00 | 0.10 |

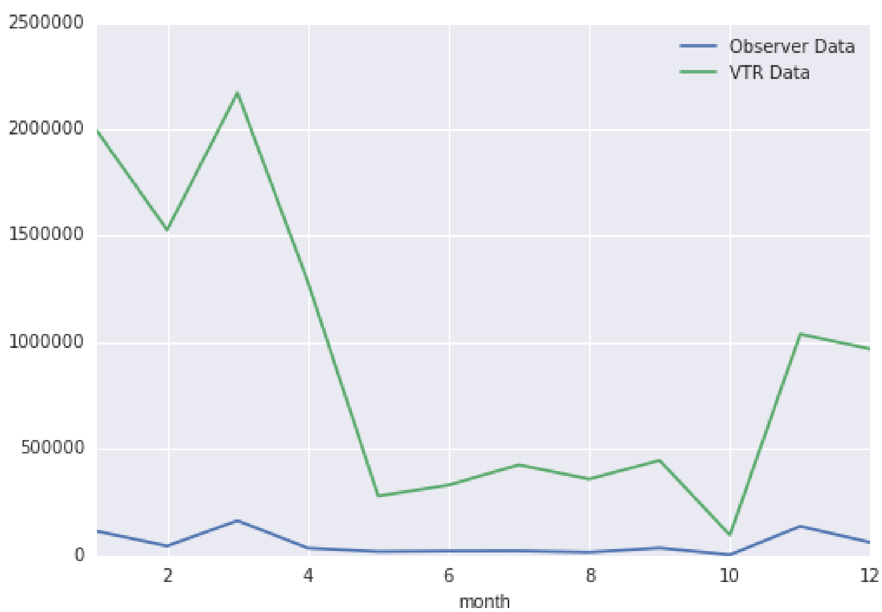
[1] VTR and Observer site selection by year are highly correlated (.754) for the period 2012-2014.

Table 2.1 contains information on the average daily, weekly and monthly price for summer flounder in 2014. The price for summer flounder is lower in the winter months, the time period when much of the summer flounder quota is landed, and higher in the summer months, the time period when landings are lower. Therefore, there does appear to be a correlation between the availability of summer flounder in the market and its ex-vessel price.

Figure 2.1: Summer Flounder Ex-Vessel Price (2014)


The seasonal variation in the catch of summer flounder is observed in Table 2.5 and Figure 2.2. The bulk of the summer flounder allocation is landed between the winter months of November through March. However, the sites visited differ between November and December and those fished from January through March. The predominate sites visited in November and December are 615, 616 and 621 with increased activity in site 537 in December. Site 537 is a highly fished site in January through March as well as sites 525 and 526. Fishing activity in the summer months is more spread out across the other sites, but little effort is spent fishing in the more highly visited winter sites. This pattern is a result of the seasonal migration patterns for summer flounder. The seasonal fishing patter figure, Figure 2.2, graphical illustrates the fishing patterns. Given that the observer data contains only a fraction of the total harvest observed in the VTR data the patters are not as evident. However, as will be illustrated in the upcoming sections of the report (see Figure 4.3) the seasonal patterns are similar to those observed in the VTR data.

Figure 2.2: Commercial Summer Flounder Catch By Month (2013)



## 2.3 Recreational Fishery Summary

In this section, we outline the important trends with respect to summer flounder catch, regulation, and participation by recreational anglers. Unless otherwise stated, all summary statistics in this section are obtained from *National Marine Fisheries Service* (2016). The summer flounder fishery is one of the largest and extensive recreational fisheries along the Atlantic Coast of the United States, if not the entire United States. For example, from North Carolina to Rhode Island in 2014 of the approximately 25 million recreation fishing trips 16.13% were primarily targeting summer flounder and 14.13% caught summer flounder.

### 2.3.1 Regulatory Background

There are three primary management policies set annually for limiting recreational harvest: Bag and Minimum Size Limits; and season limits. Tables 2.6 and 2.7 show the levels set for these management policies for the years 2009 and 2014, respectively.[2] Examining minimum size limits shows there is substantial variation across states. In 2009, Connecticut and New York anglers are required to release more fish (smaller than 21 and 19.5 inches respectively), whereas anglers further south in some states could keep fish as small as 15 inches in 2009 (North Carolina). In comparison, in 2014 there is somewhat more harmonization in Minimum Size Limits with a more stark North/South divide at New Jersey.

We see similar patters with respect to bag limits. In 2009 there was more heterogeneity than in 2014, with a similar North/South delineation around New Jersey, except that from New Jersey northwards (excluding Massachussetts), anglers were allowed to retain more summer flounder. We also see that seasons are more restricted in the Northern Regions of the study area, in particular in New York, New Jersey, and Connecticut.

What variation we do see in the policies are dependent on seasonal trends with respect to harvest (a function of both biological factors and angler decisions), and as we will see shortly, the majority of recreational harvest occurrs in New Jersey and New York. The net effect of the three policies enacted by managers is an annual harvest in the recreational sector, that is estimated because not every recreational trip is observed landing at the dock. The policies outlined in Table 2.7 lead to the mean total summer

[2]These data are supplied by the Mid-Atlantic Fisheries Management Council, data for years 2009-2014 are available from the authors.

flounder harvest of 7,398,558 pounds as reported in Table 2.8[3]

### 2.3.2 Historical Recreational Trends

The mean estimated catch, harvest, and pounds harvested are reported in Table 2.8.[4] Notice that catch has been declining while harvest and harvested pounds has been mostly increasing (from 2009-2014).

#### Catch Trends

Table 5.1 contains the detailed catch data by state and year that fleshes out the trends we saw in Table 2.8.[5] What stands out is the catch amounts from New York and New Jersey making these states a really important focus for management. This table also shows the percentage standard errors (% SE), which demonstrates the sizable amount of uncertainty associated with the state-level totals.

To visualize what has been happening with respect to catch, we have Figures 2.3a and 2.3b showing the declining catch trends by year (for New York and New Jersey) and mostly declining trends (for other states). With the exception of Connecticut and North Carolina, nearly every state is exhibiting declining total catch per year.

[3] It is also highly likely that polices with respect to other recreational species also impact summer flounder harvest, but for the purposes of this study we ignore this.

[4] It is important to note that the point estimates presented in this table are point estimates that have associated uncertainties associated with them. For example, total catch in 2014 has a +- error of 7.3%.

[5] By catch, we mean any fish caught whether harvested or released, comprised of what NMFS calls `A+B1+B2`.

Table 2.5: Commercial Summer Flounder Catch By Area and Month (Observer Data)

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 514 | 0.0 | 0.0 | 0.0 | 0.0 | 5.9 | 2.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 522 | 0.0 | 0.0 | 0.0 | 19.8 | 100.5 | 154.0 | 1012.0 | 76.0 | 0.0 | 95.0 | 0.0 | 0.0 |
| 525 | 24113.0 | 473.0 | 0.0 | 6441.2 | 162.0 | 502.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 526 | 40668.0 | 3545.0 | 16494.0 | 306.0 | 88.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 30.0 |
| 537 | 9015.0 | 19771.0 | 100426.4 | 15676.5 | 768.0 | 621.5 | 281.2 | 50.0 | 30.0 | 0.0 | 911.1 | 39775.9 |
| 538 | 0.0 | 0.0 | 0.0 | 4.1 | 45.1 | 132.0 | 504.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 539 | 1740.0 | 541.0 | 454.0 | 4711.9 | 813.5 | 1779.9 | 1390.7 | 804.0 | 658.0 | 268.0 | 4084.5 | 1568.2 |
| 561 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 43.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 562 | 322.0 | 0.0 | 0.0 | 0.0 | 14.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 10.0 |
| 611 | 0.0 | 0.0 | 0.0 | 735.9 | 1981.9 | 3180.2 | 2800.9 | 50.0 | 410.0 | 484.0 | 503.2 | 0.0 |
| 612 | 80.0 | 54.0 | 24.0 | 258.5 | 8686.1 | 8506.9 | 10202.5 | 6854.8 | 28120.2 | 481.0 | 18532.7 | 50.0 |
| 613 | 21814.0 | 9948.0 | 3960.0 | 204.3 | 2620.0 | 1210.5 | 986.1 | 1907.4 | 397.0 | 187.3 | 10574.6 | 311.0 |
| 614 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3076.0 | 2871.9 | 3378.3 | 3987.0 | 0.0 | 6.3 | 0.0 |
| 615 | 129.0 | 100.0 | 772.0 | 0.0 | 173.1 | 75.0 | 0.0 | 667.0 | 110.0 | 0.0 | 30506.4 | 355.0 |
| 616 | 14079.5 | 4396.5 | 26449.4 | 4756.8 | 1512.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 44707.1 | 17384.0 |
| 621 | 0.0 | 15.0 | 0.0 | 0.0 | 0.0 | 69.0 | 94.3 | 40.0 | 282.0 | 130.9 | 21015.5 | 184.0 |
| 622 | 199.0 | 3472.4 | 12814.5 | 293.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 41.6 | 0.0 |
| 623 | 69.0 | 726.0 | 4.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 625 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 77.0 | 0.0 | 0.0 | 0.0 | 1370.0 | 0.0 |
| 626 | 0.0 | 0.0 | 231.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1765.0 | 0.0 |
| 627 | 0.0 | 134.3 | 24.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1000.0 | 0.0 |
| 631 | 0.0 | 0.0 | 0.0 | 5.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 290.0 | 0.0 | 0.0 |

Table 2.6: Summer Flounder Recreational Regulations by State 2009

| State | Minimum Size (inches) | Possession Limit | Open Season |
|---|---|---|---|
| **Massachusetts** | 18.5 | 5 fish | July 1 – Aug. 13 |
| **Rhode Island** | 21.0 | 6 fish | June 17 – Dec. 31 |
| **Connecticut** | 19.5 | 3 fish | June 15 – Aug. 19 |
| **New York** | 21.0 | 2 fish | May 15 - June 15 and July 3-Aug. 17 |
| **New Jersey** | 18.0 | 6 fish | May 23 – Sept. 4 |
| **Delaware** | 18.5 | 4 fish | All Year |
| **Maryland:**<br>**Atlantic & Coastal Bays**<br>**Chesapeake Bay** | <br>18.0<br>16.5 | <br>3 fish<br>1 fish | April 15 - Sept. 13 |
| **Potomac River Fisheries Commission** | 16.5 | 1 fish | April 15-Sept. 13 |
| **Virginia** | 19.0 | 5 fish | All year |
| **North Carolina** | 15.0 in all waters except the following: 14.0 in Pamlico Sound[D], Albemarle Sound[E], and Browns Inlet South[F] (lat/log are listed below) | 8 fish | All Year |

A. **PAMLICO SOUND** - No person may possess flounder less than 14 inches total length taken from internal waters for recreational purposes **west of a line** beginning at a point on Point of Marsh in Carteret County at 35° 04.6166'N – 76° 27.8000'W, then running northeasterly to a point at Bluff Point in Hyde County at 35° 19.7000'N – 76° 09.8500'W. In Core and Clubfoot creeks, the Highway 101 Bridge constitutes the boundary north of which flounder must be at least 14 inches total length.

B. **ALBEMARLE SOUND** - No person may possess flounder less than 14 inches total length taken from internal waters for recreational purposes **west of a line** beginning at a point 35° 57.3950'N – 76° 00.8166'W on Long Shoal Point; running easterly to a point 35° 56.7316'N – 75° 59.3000' W near Marker "5" in Alligator River; running northeasterly along the Intracoastal Waterway to a point 36° 09.3033'N - 75° 53.4916'W near Marker "171" at the mouth of North River; running northwesterly to a point 36° 09.9093'N – 75° 54.6601'W on Camden Point.

C. **BROWNS INLET-SOUTH** – No person may possess flounder less than 14 inches total length in internal and Atlantic Ocean fishing waters for recreational purposes **west and south of a line** beginning at a point 34° 37.0000'N – 77° 15.000'W; running southeasterly to a point 34° 32.0000'N – 77° 10.0000'W.

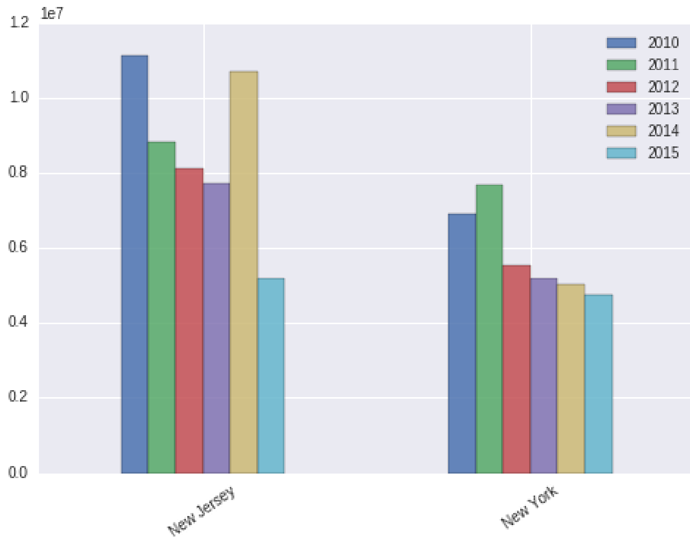
Table 2.7: Recreational Regulations by State 2014

| Region | State | Minimum Size (inches) | Possession Limit | Open Season |
|---|---|---|---|---|
| 1 | **Massachusetts** | 16 | 5 fish | May 22-September 30 |
| 2 | **Rhode Island** | 18 | 8 fish | May 1-December 31 |
| 3 | **Connecticut** | 18 | 5 fish | May 17- September 21 |
| | | 16 ( at 45 designated shore sites) | | |
| | **New York** | 18 | 5 fish | May 17- September 21 |
| | **New Jersey** | 18 | 5 fish | May 23- September 27 |
| | | 16 (1 pilot shore site) | 2 fish | May 23-September 27 |
| 4 | **Delaware** | 16 | 4 fish | January 1- December 31 |
| | **Maryland** | 16 | 4 fish | January 1- December 31 |
| | **PRFC** | 16 | 4 fish | January 1- December 31 |
| | **Virginia** | 16 | 4 fish | January 1- December 31 |
| 5 | **North Carolina** | 15 | 6 fish | January 1- December 31 |

Table 2.8: Total Recreational Catch, Harvest, and Pounds Landed (2010-2014)

| Year | Catch | Harvest | Pounds |
|---|---|---|---|
| 2010 | 23,721,520 | 1,501,465 | 5,108,357 |
| 2011 | 21,558,699 | 1,839,877 | 5,955,716 |
| 2012 | 16,528,040 | 2,272,135 | 6,489,675 |
| 2013 | 16,151,332 | 2,534,355 | 7,386,644 |
| 2014 | 19,455,661 | 2,459,205 | 7,398,558 |
| 2015 | 12,485,456 | 1,676,794 | 4,870,174 |

(a) New York and New Jersey




(b) Other Atlantic States

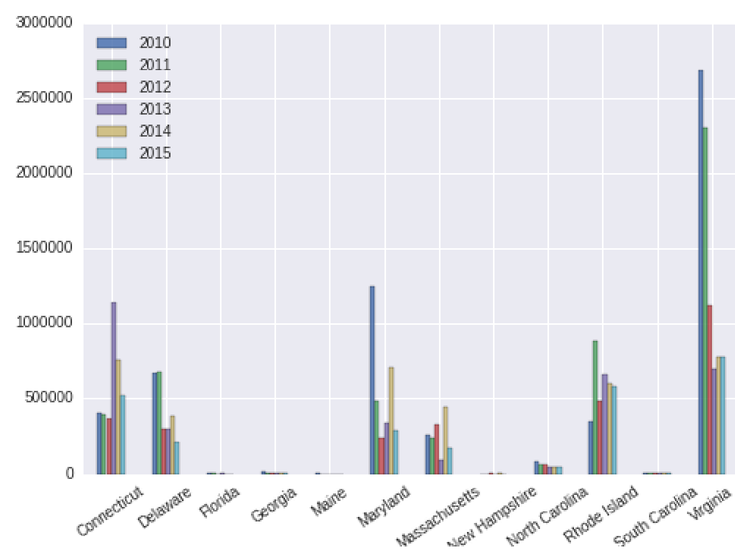



Figure 2.3: Total Recreational Catch (2010-2014)

### Harvest Trends

State level harvest for years 2010-2015 are reported in Table 5.2 and the data can be visualized in Figure 2.4a for New York and New Jersey and 2.4b for other Atlantic States. [6]

Despite seeing catch falling in nearly every state during the period 2010-2015, we see harvest increasing substantially in New Jersey (except for a really steep decline in 2015) and generally upward trends in nearly every state except North Carolina and Virginia. Examining regulatory changes in New Jersey from 2014 to 2015 reveal no real change in management with bag limits stable at 5, size limits unchanged at 18 inches, and season length virtually unchanged. We also see stable regulations for Virginia and North Carolina. We see a fairly large drop in trips to New Jersey and in Virginia from 2014 to 2015.

[6] Harvest is fish landed and is comprised of what NMFS calls `A+B1`, which is observed and reported harvest.

(a) New York and New Jersey

(b) Other Atlantic States

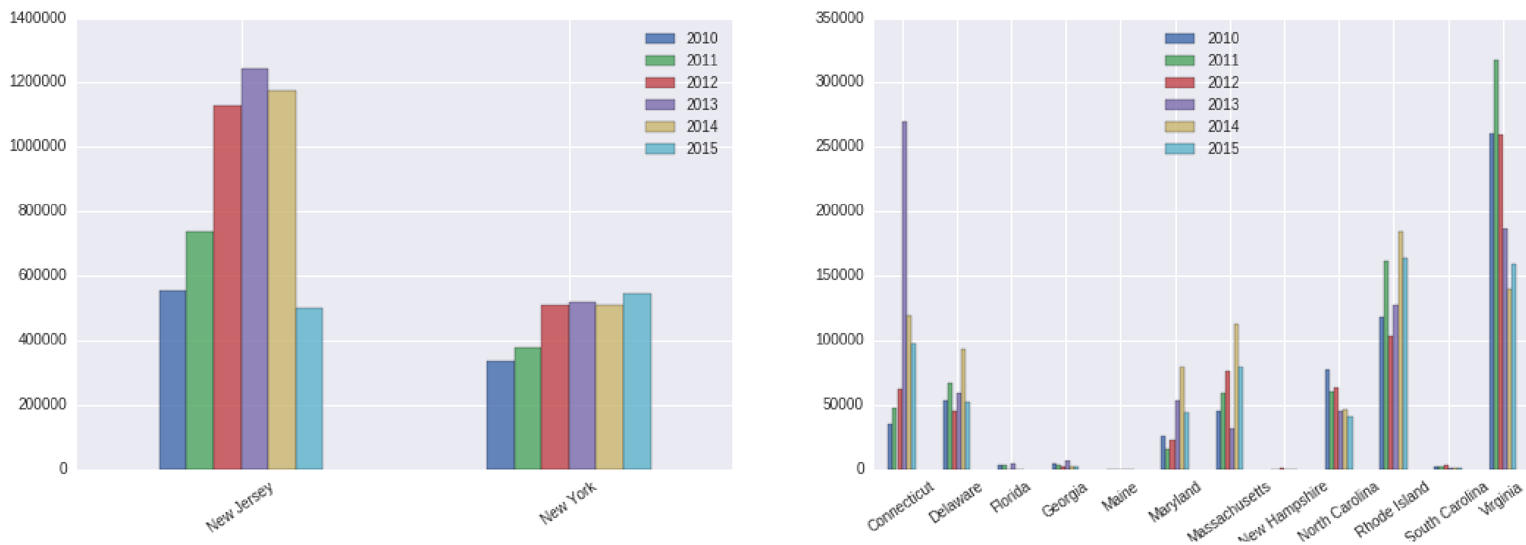
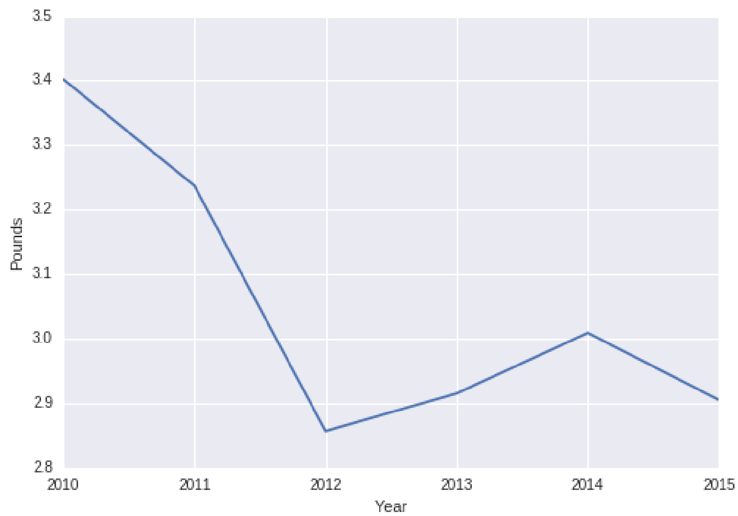



Figure 2.4: Total Recreational Harvest (2010-2014)

We see very similar trends in harvested weight in Figure 5.2. Averaging across states for a given year, the weight of the average fish harvested declined.[7] Figure 2.5 shows the average weight of summer flounder caught per year taken across all summer flounder catches, states, and waves. This average is influenced by biological factors (annual recruitment patters and the spatial distribution of fish), regulation (more stringent size limits will lower catch but increase the average size of this fish), and the spatial distribution of fishing (trips taken to states with lower size limits will tend to lower the average weight.).

Figure 2.5: Average Recreational Weight per Fish Landed by Year




[7]This number is absolutely a function of recreational regulations and should not be confused with the average summer flounder size.

### 2.3.3 Study Year: 2014

The recreation demand model in the next chapter uses data from year 2014, consequently, we focus on the 2014 data more here. From Table 2.9 we see New Jersey alone accounts for 47.80% of harvest and 48.78% of the pounds landed in the recreational fishery in 2014. New York and New Jersey combined account for 68.5% of harvest and 71.46% of pounds landed. The next largest states are Rhode Island, Connecticut, and Virginia (the ranking depend on if you examine numbers of fish caught or pounds landed).[8]

In Table 2.10, we see that the states of North Carolina and New Jersey have the largest number of trips (accounting for approximately 40% of the trips in our study area), followed by New York and Massachussetts. Within states, we see that a very high percentage of trips are directly targeting summer flounder in New York and New Jersey (28.53% and 36.86%, respectively), and in every state in the study area (except Massachussetts, Maryland, and North Carolina), summer flounder are targeted by more than 10% of trips.

In Table 2.10, we see similar patters with respect to trips harvesting summer flounder. In New Jersey, nearly one third of trips come back with summer flounder. For many other states (except Massachussetts, Maryland, and North Carolina), more than 10% of trips land summer flounder.

### 2.3.4 Catch Compositions

In other work not included here for the sake of brevity, we have examined catch compositions by state for

1. trips targeting summer flounder (based on reported `prim1` from the MRIP survey), in order to ascertain what other species are commonly caught with summer flounder on "summer flounder" trips by state.

2. trips not actively targeting summer flounder, but that caught summer flounder, in order to ascertain what other species are commonly targeted on trips that have non-targeted catch summer flounder.

We find that summer flounder is such a dominant species in recreational fishing and that it is quite common to find small game (e.g., striped bass and bluefish) and

[8]This table omits the states of Maine, New Hampshire, South Carolina, Georgia, and Florida since they are dropped from the analysis due to the relatively small amounts of summer flounder activity relative to the core study area.

bottom fish (e.g. sea basses and blackdrum) catch when summer flounder is targeted. Furthermore, it is common for targeters of small game and bottom fish to catch summer flounder. What wasn't common was mixes of summer flounder with big-game fish such as tuna or marlin.

Table 2.9: Total Recreational Summer Flounder Harvest and Harvested Weight 2014

| State | Harvest | % SE | Weight (lbs) | % SE |
|---|---|---|---|---|
| Connecticut | 119502 | 21.1 | 391168 | 20.1 |
| Delaware | 93029 | 15.8 | 227913 | 16.5 |
| Maryland | 79513 | 56.1 | 179313 | 56.0 |
| Massachusetts | 112840 | 41.1 | 238604 | 36.0 |
| New Jersey | 1175383 | 11.7 | 3608939 | 12.1 |
| New York | 509131 | 14.7 | 1677717 | 16.1 |
| North Carolina | 45708 | 20.2 | 67791 | 22.1 |
| Rhode Island | 184668 | 22.5 | 636207 | 22.7 |
| Virginia | 139431 | 15.3 | 370906 | 17.0 |

Table 2.10: Recreational Trips by State 2014

| | Total | | SF Directed | | SF Harvested | |
|---|---|---|---|---|---|---|
| State | Trips | % SE | Trips | % SE | Trips | % SE |
| Connecticut | 1364928 | 10.9 | 208154 | 20.8 | 188305 | 16.4 |
| Delaware | 867379 | 10.3 | 182728 | 10.0 | 128873 | 10.1 |
| Maryland | 2472802 | 6.8 | 219234 | 22.7 | 184802 | 22.8 |
| Massachusetts | 3397199 | 6.9 | 66630 | 29.3 | 78065 | 31.0 |
| New Jersey | 4868080 | 6.6 | 1794480 | 9.7 | 1513879 | 10.6 |
| New York | 3955151 | 7.1 | 1128222 | 9.7 | 1019136 | 9.9 |
| North Carolina | 4954073 | 5.3 | 884 | 59.0 | 41738 | 17.4 |
| Rhode Island | 1099260 | 10.3 | 147442 | 16.3 | 121575 | 14.3 |
| Virginia | 2182392 | 8.3 | 310947 | 9.2 | 278128 | 11.6 |

# Chapter 3

# Recreational Model

Our work closely follows previous work in the valuation of marine recreational fishing using recreational fishing data from the National Marine Fisheries Service. Unlike many previous studies using the Marine Recreational Fishing Statistics Survey (Bockstael, McConnell and Strand (1989), McConnell and Strand (1994), McConnell, Strand and Blake-Hedges (1995), McConnell, Strand and Blake-Hedges (1995), Hicks et al. (1999), Haab, Whitehead and McConnell (2001), and Haab et al. (2008)), our work uses the new Marine Recreational Information Program (MRIP). This data continues to support recreational valuation models like those estimated using MRFSS data, but includes more refined survey methodology enabling for better estimation accounting for on-site sampling (see Lovell and Carter (2014), Hindsley, Landry and Gentner (2011), and Gentner et al. (2010)) and uses the Marine Recreational Information Program survey data (hereafter MRIP). Taken together, the recreational valuation model presented here

- Accounts for on-site sampling and weights the statistical model appropriately
- Constructs a full choice structure of recreational fishing
  - Anglers not observed targeting summer flounder may still receive economic value from an allocation change
  - Anglers observed targeting summer flounder have many other species substitutes for targeting
- Estimates the WTP for summer flounder angling consistent with values observed in the literature (e.g. Massey, Newbold and Gentner (2006) and Gentner et al. (2010))

- Allows for the simulation of behavior and angler willingness to pay under different quota allocations.

## 3.1 The Choice Structure

It is important to note that our model considers choices *ex ante*, that is before any targeting or location decisions are made. This allows our model to capture angler choices over the full range of species they might catch. This feature of our model is important as summary data suggests that even those not directly targeting summer flounder may catch summer flounder and therefore, we develop a model that allows expected trip values to be influenced by a broad range of species.

Consistent with prior work in recreational fishing valuation (e.g. McConnell and Strand (1994), Gentner et al. (2010), and Hicks et al. (1999)) we model the choice of mode [shore, private/rental, party/charter], species group [small game, bottom fish, summer flounder][1], and fishing site (at the county level). Furthermore, we calculate site-specific quality measures (e.g. mean catch) per wave. Taken as a whole, the entire choice structure consists of **80 x 3 x 3 = 720** potential choice alternatives per observed trip in the data.

### 3.1.1 Species Groupings

To implement the choice structure, we had to make some aggregations over species. As shown by Haab et al. (2008), it isn't possible to include species-specific choice nodes for every (or even many) species, because for each choice node we must calculate expected catch for each site and wave. This places high data requirements and to overcome this problem, past studies (e.g. McConnell and Strand (1994) and Hicks et al. (1999)) have aggregated over many species for which there is insufficient data.

We employ the McConnell and Strand (1994) aggregation scheme shown in Figure 3.1, with two notable exceptions.[2].

1. Because we have (a) a policy interest in summer flounder and (b) summer flounder

[1]Other species groups such as big game, other flat-fish, non-specific targets are ommitted from our analysis based on our analysis of catch profiles for recreational trips involving summer flounder.

[2]The reader may notice some species listed which are rarely, if ever, caught in the study area. This is because McConnell and Strand (1994) examined the entire Atlantic seaboard as well as the panhandle of Florida. However, their species group assignment is valid for the study area as it embodies both biological characteristics and recreational fishing experience when categorizing species.

is one of the most targeted and caught species in the United States, we break summer flounder out of the flat fish group

2. After breaking summer flounder out of the flat fish group, we don't have enough data to include an "other flatfish" category, so all other flatfish are dropped for our analysis.

3. When conducting our species composition analysis, we found that there was virtually no overlap between McConnell and Strand's "big game" category and summer flounder, so it is dropped from the analysis.

Table 3.1: The McConnell Strand Species Groupings Employed in this Study

| | | |
|---|---|---|
| | **Small Game** | |
| Striped Bass | Bluefish | Jack |
| Pompano | Seatrout | Bonefish |
| Bonito | Snook | Red Drum |
| Barracuda | Mackerel | |
| | **Bottom Fish** | |
| Sandbar Shark | Dogfish Shark | Cat Shark |
| Sand Tiger Shark | Smooth Dog Shark | Carp |
| Catfish | Toadfish | Cod/Codfish |
| Pollack | Hake | Sea Robin |
| Sea Bass | Sawfish | Grunt |
| Kingfish | Mullett | Tautog |
| Butterfish | Nurse Shark | Brown Cat Shark |
| Porgy/Scup | Sheepshead | Pinfish |
| Snapper | Grouper | Perch |
| Black Drum | | |
| | **Flat Fish** | |
| Summer Flounder | Winter Flounder | Southern Flounder |
| Sole | Founders | |
| | **Big Game** | |
| Blue Shark | Tuna | Marlin |
| Thresher Shark | Great Hammerhead | Swordfish |
| Shortfin Mako Shark | Tiger Shark | White Shark |
| Smooth Hammerhead | Scalloped Hammer | Tarpon |
| Billfish | Sailfish | Dolphin |
| Cobia | Wahoo | |
| | **Other Fish** | |
| Herring | Eel | Skate |
| Puffer | Blacktip Shark | Requiem Shark |
| Dusky Shark | Atlantic Sharpnose | Bull Shark |
| Smalltail Shark | | |

### 3.1.2 Limiting the Choice Set Based on Distance

From the MRIP survey we have approximately 30,000 trips (in NC-MA in 2014) × 720 choice alternatives.[3] Past studies (e.g. McConnell and Strand (1994) and Hicks et al. (1999)) have limited the choice structure by only modeling single-day trips where the one way travel distance is less than 150 miles from the recreator's home. We use the NOAA Fisheries S&T distance files (these files calculate the distance from each intercepted angler's home to every coastal county within 150 miles), and therefore, we continue with past practices for limiting the choice structure to those sites within 150 miles of the respondents home. This necessarily eliminates all persons in the MRIP sample living far away (>150 miles) from their chosen site. Practically speaking, this reduces the size of the choice set from 720 to approximately 220 choices per individual in the intercept survey.

It is important to note that there are *very good* behavioral reasons for reducing the choice set in this way. Individuals on single-day angler trips are making decisions in a way consistent with our theoretical model. Multiple day trips (e.g. an angler from NC going to Maine who takes a marine fishing trip) are probably engaging in a plethora of other activities and this makes the link between travel cost and the resource we are valuing tenuous at best.

### 3.1.3 Summary Statistics Weighting

This study uses the MRIP data, which has information enabling proper weighting for summary statistics (e.g. mean catch of summer flounder per wave). Since strata are potentially over or under sampled in MRIPS, we use the supplied sample weights for calculating **any** summary statistic (e.g. average per site catch for summer flounder) in this study unless noted otherwise.[4]

### 3.1.4 Opportunity Cost of Time and the Price of the Trip

In the valuation of recreational resources, we need to link a non-market resource like trip quality (which for our case is catch) to a trade-off made by recreators. This study makes this link using the travel cost method. The choice set describes the trip quality along

[3]When we estimate the model, this would equate to 21.6 million rows of data

[4]We use the R Survey package for all summary statistics weighting in this chapter Lumley et al. (2004).

the coast and we construct the price of the trip as travel cost to each site $s$ for individual $i$ based on distance as follows:

$$tc_{is} = \$0.56 \times dist_{is}$$

where \$.56 is the federal reimbursable rate for 2014 per mile. In this study we don't have access to an economic add-on information for discerning what the literature terms "opportunity cost of time" (McConnell and Strand, 1981). Past studies using MRFSS data such as McConnell and Strand (1994) and Hicks et al. (1999) employed data for which there was a complementary economic add-on for discerning if the individual took time off work, without pay as a signal for whether the time spent traveling or on-site had costs to the individual by way of foregone wages. Gentner et al. (2010) also don't have an available economic add-on survey but does follow a similar methodology to ours. They however, approximate the "opportunity cost of time" using Census data. In our work we don't attempt the approximation and agree with Gentner et al. (2010) that our model presents a lower-bound estimate.

## 3.2 Random Utility Model of Recreational Site Choice

We assume an individual will choose species group $g$, mode $m$, and site $s$ by comparing the alternative specific utilities if it is the best one:

$$U(g,m,s) + \epsilon_{g,m,s} > U(i,j,k) + \epsilon_{i,j,k} \forall i \in G, j \in M, k \in S$$

where all species groups are denoted by $G$, all modes $M$, and all sites $S$. In this study we need to be able to alter landings (keep) of SF, so we calculate mean landings and release rates (numbers of fish) for each mode and site for summer flounder.

Ignoring subscripts indexing individuals, we have for summer flounder the utility at each site $k$ and mode $j$:

$$\begin{aligned} U(SF,j,k) = &\beta_{tc}TC_k + \beta_{lnm,k}log(M_k) \\ &+ \beta_{SH}(mode_j == SHORE) \\ &+ \beta_{PR}(mode_j == PRIVATE/RENTAL) \\ &+ \beta_{SF,K}\sqrt{Keep_{SF,j,k}} + \beta_{SF,R}\sqrt{Release_{SF,j,k}} \end{aligned} \tag{3.1}$$

For the other two species, we have similar specifications. For example, for bottom fish the utility at each site $k$ and mode $j$:

$$\begin{aligned} U(BT,j,k) =& \beta_{tc}TC_k + \beta_{lnm,k}log(M_k) \\ &+ \beta_{SH}(mode_j == SHORE) \\ &+ \beta_{PR}(mode_j == PRIVATE/RENTAL) \\ &+ \beta_{BT}\sqrt{Catch_{BT,j,k}} \end{aligned} \tag{3.2}$$

Following normal conventions on assumptions about site, mode, and species specific errors ($\epsilon$), we can model the probability that an individual chooses $g$ (species), $m$ (mode), and $s$ (site) as

$$P(d^i_{g,m,s}|\beta, \mathbf{X}) = \frac{e^{U(g,m,s)}}{\sum_{l\in G}\sum_{m\in M}\sum_{k\in S} e^{U(l,j,k)}}$$

Using likelihood contributions like this for each individual, we define the log-likelihood function using the Weighted Exogenous Sample Maximum Likelihood Estimation (WESMLE) approach that accounts for on-site sampling (see Lovell and Carter (2014) and Manski and Lerman (1977)),[5]

$$LL(\mathbf{d}|\beta, \mathbf{X}) = \sum_{i\in N}\sum_{g\in G}\sum_{m\in M}\sum_{s\in S}\frac{Q_s}{H_s}d_{igms}logP(d^i_{g,m,s}|\beta, \mathbf{X})$$

where the weight ($\frac{Q_k}{H_k}$) is comprised of

$$Q_k = \frac{T_k}{T}, H_k = \frac{s_k}{S}$$

and where $d_{igms}$ is equal 1 if individual $i$ chooses alternative $[g, m, s]$ and $T_k$ are total (population) trips taken to site $k$, $T$ are total trips (across all sites), $s_k$ are sampled trips from site $k$ and $S$ is the survey sample size.[6].

## 3.3 Estimation Methods

We experimented with using classical maximum likelihood techniques for estimating the model but due to the size of the dataset, we resorted to using Bayesian Sampling techniques for recovering the posterior distribution of our parameters by constructing Monte

[5] We didn't attempt a nested estimation of this model.

[6] Using Monte-Carlo techniques generating toy data consistent with the MRIP data collection method (where sites are over and under sampled), we found the WESMLE to out-perform the choice-based sampling weight approach outlined in Haab and McConnell (2002)). These results are unreported but available from the authors.

Carlo Markov Chains. From Bayes Rule, the posterior of our parameters ($P(\beta|\mathbf{d}, \mathbf{X})$) is

$$P(\beta|\mathbf{d}, \mathbf{X}) \propto P(\mathbf{d}|\beta, \mathbf{X})P(\beta|\beta^0)$$

where $P(\mathbf{d}|\beta, \mathbf{X})$ is the likelihood function where $P(\beta|\beta^0)$ are our priors on the model parameters. In this work we assume flat priors (any real numbered parameter vector is equally likely based on our prior knowledge), making our posterior

$$P(\beta|d^i_{g,m,s}, \mathbf{X}) \propto P(\mathbf{d}|\beta, \mathbf{X})$$

consequently, when we use sampling techniques to sample from the posterior distribution of parameters, we are sampling exactly from the distribution of parameters that maximizes the likelihood. When constructing our markov chain, we used the weights employed by WESMLE to account for on-site sampling. Sampling from the posterior in this way allows us to construct the distribution of our parameter estimates directly and all inference (e.g. parameter estimates and standard errors) are self weighting.

We implemented this approach in Python using the `pymc3` package (Salvatier, Wiecki and Fonnesbeck, 2016) employing the "No U-turn Sampler" (Hoffman and Gelman, 2014). This package is capable of very fast sampling when likelihood functions are computationally expensive.

## 3.4 Results

Summaries of the posterior distribution of the parameters are reported in Table 3.2.[7] Note that our Monte Carlo Markov Chain is comprised of 1000 samples (after burn-in) from the posterior distribution of the parameters. We summarize these samples in this table. We report the mean, the standard deviation (analogous to standard errors), and various percentiles. Looking at the parameters, we can see that the the 99% confidence intervals never overlap zero. For example, for travel cost ($\beta_{tc}$), the 99% confidence interval is [-.101449,-.096878]. P-values (not shown) for each of these variables shows these are all significant at the 5% (and 1%) levels. We also see that the dummy variables on mode (normalizing on party charter) are positive and roughly equal. This indicates that anglers are more likely to choose something besides party/charter trips.

All of the parameters are also of the expected sign. The travel cost coefficient is negative, the aggregation term ($\beta_{lnm}$) correcting for the number of sites in each county

[7]Recall that in our specification, catch rates (and keep rates for summer flounder) enter in square root form.

is positive. All of the catch coefficients for each of our species/species groups are also positive. Note that in relative terms, the bottom fish has the smallest mean estimate, whereas summer flounder is the highest (landed). Summer flounder landed ($\beta_{sf,land}$) is significantly higher than summer flounder caught and released ($\beta_{sf,rel}$). This indicates that while anglers might enjoy catching summer flounder and releasing them, they are much happier keeping landed summer flounder.[8]

Figure 3.1 summarizes our results visually for five separate Monte Carlo Markov Chains (we construct 5 so we can test that the chains have converged, which they have based on the Geweke (Geweke, 2005) and Gellman-Rubin tests (Gelman et al., 2014)). In the left pane we see for each parameter the marginal distribution. These can be viewed like a histogram. For example, the probability mass for $\beta_{tc}$ is centered around -.9995 and the bulk of the samples are in the approximate range [-.102,-.0975]. In the right hand pane we have the trace plot for the Markov Chain sampling process where the x-axis is the sample number. Notice these "flat-line" trace plots show that the sampler is moving around the posterior space near the model parameters that maximize the likelihood function and visually confirm convergence.

## 3.5 Welfare Estimation

The standard welfare calculation (defined as compensating variation (CV)) for a change in policy affecting site-specific variables from $\mathbf{x}^0$ to $\mathbf{x}^1$ for individual $i$ is defined as:

$$CV(\mathbf{x}_i^0 \rightarrow \mathbf{x}_i^1) = \frac{log\left(\sum_{i \in S} e^{\mathbf{x}_i^0 \beta}\right) - log\left(\sum_{i \in S} e^{\mathbf{x}_i^1 \beta}\right)}{\beta_{tc}} \tag{3.3}$$

This gives us the mean compensating variation *per trip*.[9]

### 3.5.1 Modeling Policy Changes

For our purposes, all $\mathbf{x}_i$'s will remain as observed in the data from year 2014, except for landings and released historical catch averages for summer flounder. Note that by assumption the allocation policy

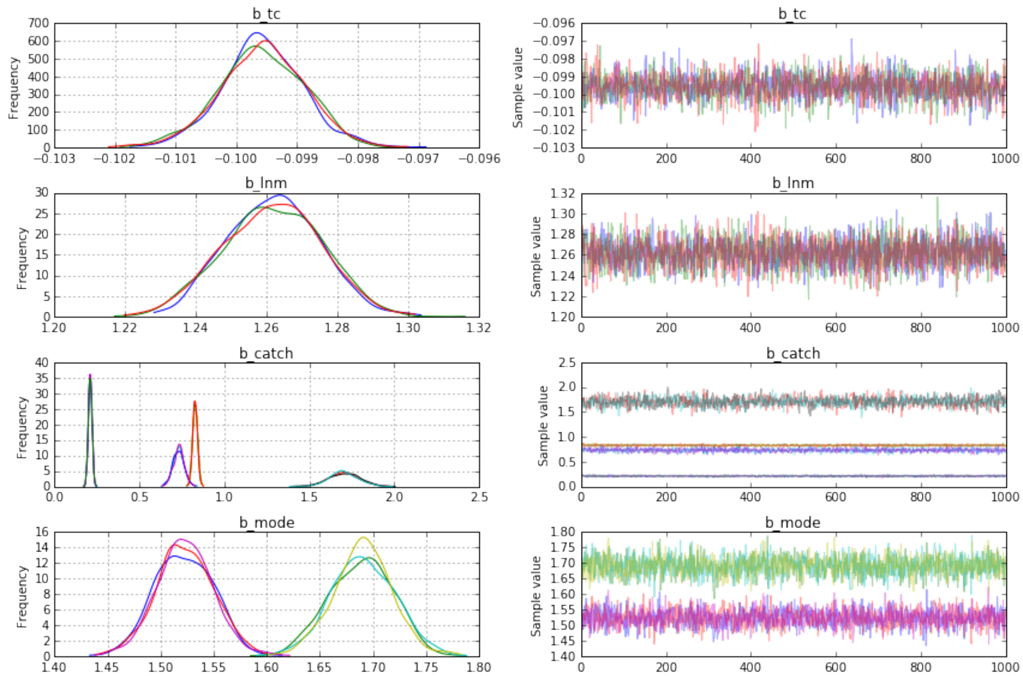
[8]It bears mentioning again that all of the catch rate variables included in the model are calculated from *sample weighted* MRIPS data that accounts for the problems with on-site sampling.

[9]Recall that since there is no economic add-on in 2014, the results presented in this section are lower bound estimates.

Table 3.2: Recreational Random Utility Model Estimates

| | $\beta_{tc}$ | $\beta_{lnm}$ | $b_{bt}$ | $\beta_{sg}$ | $\beta_{sf,land}$ | $b_{sf,rel}$ | $\beta_{pr}$ | $\beta_{sh}$ |
|---|---|---|---|---|---|---|---|---|
| Mean | -0.099572 | 1.261703 | 0.210776 | 0.828308 | 1.704043 | 0.730967 | 1.522743 | 1.690098 |
| Std Dev | 0.000687 | 0.013695 | 0.010831 | 0.014509 | 0.087752 | 0.032410 | 0.027029 | 0.029306 |
| min | -0.102108 | 1.216995 | 0.169941 | 0.777885 | 1.384343 | 0.628437 | 1.433269 | 1.584659 |
| 0.5% | -0.101449 | 1.227577 | 0.184025 | 0.789383 | 1.471976 | 0.647675 | 1.454465 | 1.614740 |
| 2.5% | -0.100980 | 1.235180 | 0.189104 | 0.799830 | 1.531269 | 0.665325 | 1.469813 | 1.631867 |
| 5% | -0.100733 | 1.238977 | 0.192635 | 0.804790 | 1.561199 | 0.677568 | 1.479011 | 1.640069 |
| 50% | -0.099575 | 1.261834 | 0.210678 | 0.828181 | 1.702743 | 0.731825 | 1.522283 | 1.690711 |
| 95% | -0.098457 | 1.284005 | 0.228427 | 0.852046 | 1.850422 | 0.784601 | 1.566065 | 1.736475 |
| 97.5% | -0.098255 | 1.287781 | 0.231412 | 0.856292 | 1.877102 | 0.796230 | 1.574819 | 1.747441 |
| 99.5% | -0.097822 | 1.296705 | 0.238011 | 0.865643 | 1.932048 | 0.815577 | 1.593135 | 1.765785 |
| max | -0.096878 | 1.315996 | 0.250116 | 0.877409 | 2.004679 | 0.841560 | 1.621508 | 1.788339 |

Figure 3.1: Recreational Random Utility Model Posterior Distribution Plots




- Does not alter expected total catch (combined keep and release)[10]
- Does alter the distribution of expected total catch between keep and release categories.

Pre-policy expected Keep and Release rates for summer flounder at site $s$, mode $m$ is $Keep^0_{SF,s,m}$ and $Release^0_{SF,s,m}$. Following the policy change (for example giving the fraction $\Delta$ more Keep to recreational anglers) Keep and Release change to

$$Keep^1_{SF,s,m} = Keep^0_{SF,s,m} \times (1 + \Delta) \tag{3.4}$$

$$Release^1_{SF,s,m} = Release^0_{SF,s,m} - \Delta \times Keep^0_{SF,j,k} \tag{3.5}$$

Note that: $Keep^1_{SF,s,m} + Release^1_{SF,s,m} = Keep^0_{SF,s,m} + Release^0_{SF,s,m}$.

To make this more concrete, consider summer flounder landings and release averages in the Table 3.3, before (denoted as Policy 0) and after (Policy 1) a 10% increase in summer flounder landings at some site. Under policy 1, more of the released fish are allowed to be kept. So the way we model the policy, total catch (combined catch and

[10]This analysis doesn't consider cases where total recreational and commercial TAC *and* allocations are changed. Consequently, we can think of the Welfare estimation as from a 2014 baseline and TAC.

release) is unchanged, but the policy alters the distribution of that total between catch and release categories.

Table 3.3: Example Policy Impacts on Catch and Keep Rates

| Policy | Total Catch | Landings | Release |
|---|---|---|---|
| 0 | 5 | 3 | 2 |
| 1 | 5 | 3.3 | 1.7 |

Equation 3.3 is the compensating variation for angler $i$ on an intercepted trip. Since angler $i$ is part of the on-site sample, she might be over or under-represented compared to a population based random sample. Taking the simple mean across all $CV_i$'s gives us an incorrect mean welfare effect. Consequently, we again used R's Survey package and the provided MRIP weights to calculate a weighted and correct mean $CV$. We have to do this for *every* allocation rule under consideration. We also sample from our posterior parameter values to calculate these weighted $CV$'s for a wide range of likely parameter vectors. In the end, we are able to construct confidence intervals around our mean $CV$ estimate.[11]

### 3.5.2 Aggregation to Population

Once we have recovered the correct mean compensating variation per trip, we perform aggregations to project our estimates into total economic values and total economic values per pound. Since policies impact the distribution of catch between kept and released summer flounder, we perform the following simple steps in our analysis for computing the totals described in our results below.

1. For a $\Delta\%$ change in quota, change every expected catch and keep rate for summer flounder as described above.

2. Using this change calculate CV as described above

3. From the NOAA Fisheries website, we know the total harvested summer flounder and total weight harvested (along with standard deviations) for each state.

[11]In addition to our uncertainty about parameter estimates, our confidence intervals also include uncertainty associated with 1) total landings and 2) summer flounder weight per fish.

Draw randomly from each states distribution and sum for total harvest and total harvested weight.

4. For the $\Delta\%$ change in quota, scale total harvest and total harvested weight.

5. Calculate changes in compensating variations and changes in quota allocations across each subsequent quota allocation[12]. We then approximate the marginal value for the region between each policy step $t$ and $t+1$ as $MWTP_{t+1} = \frac{TWTP_t - TWTP_{t+1}}{Landings_t - Landings_{t+1}}$ and for graphing purposes center at the mid-point between the two quota amounts $\frac{Landings_t - Landings_{t+1}}{2}$.

Note that this method explicitly assumes

1. that what fishermen value *ex ante* is exactly what will be observed with respect to aggregate harvests and weights *ex post*.

2. that landings will be consistent with quota levels.

### 3.5.3 Results

In Table 3.4 we show compensating variation for divergences from the 2014 quota allocation baseline. So a change in quota of 50,000 means that +50,000 more pounds are given to the recreational sector for total harvest of 7,398,558 + 50,000 pounds of fish. A negative change in quota is taking pounds away from the recreational sector. In Table 3.5 we calculate the marginal willingness to pay for quota allocation levels (rather than changes in quota as in Table 3.4). In Table 3.5 we also report quota allocation levels in metric tons for more direct comparison to the commercial chapter.

Based on estimation available from NOAA National Marine Fisheries Service, the total summer flounder harvested weight (in the study region) in 2014 was 7,398,558. Consequently, in our analysis, we consider a 100% reduction and 100% increase to the summer flounder recreational allocation.

Notice that as quota approaches zero, the required total compensating variation gets larger (more negative) at a non-linear rate. This is consistent with what economists call "diminishing marginal returns" and supports intuition about how fishermen value summer flounder quota: the less quota the angler community has, the higher the relative

[12]In our work, we examine the following quota changes: -100%, -80%, -60%, -40%, -20%, -5%, +5%, +20%, +40%, +60%, +80%, +100% relative to the *observed* 2014 landings

value a pound of quota. Conversely, if we increase quota to the recreational sector, the angler community benefits, but the incremental benefit for a pound of quota enjoyed by the community is less than the first pound of quota they receive.

Figures 3.2 and 3.3 show visually the total economic value and the marginal value, respectively, of quota for the recreational sector. In Figure 3.2 at a quota change of 0 pounds, Compensating Variation is zero. In Figure 3.2, we see that doubling the recreation quota leads to a gain in economic value for recreational anglers of approximately $20 million per year. By contrast, reducing the recreational sector leads to a loss in economic value of approximately $35 million per year.[13]

We see similar patterns in Figure 3.3. For very small quota allocations in the recreational sector, the value per pound of summer flounder is approximately $10. As quota is increased, the value per pound declines (this is due to diminishing marginal returns as discussed above), so that after a doubling of recreational quota, the value per pound is approximately $2.

It should be noted that in both of these figures, the confidence intervals flare out from the Change in Pounds Allocated at 0 (for Figure 3.2) and for Pounds Allocated at approximately 7.4 million pounds (for Figure 3.3) because both of these points represent the baseline observed levels in 2014. As we move further from that baseline, the uncertainty of our estimated economic values increase.

[13]While the model can be used for analyzing these large swings in quota relative to 2014, we are more confident in our model for analyzing smaller quota changes.

Table 3.4: Total Compensating Variation for Recreational Sector by Quota Change from 2014 Observed Landings

| Change in Quota (Pounds) | Change in Quota (Metric Tons) | Lower 95% CI | Mean CV | Upper 95% CI |
|---|---|---|---|---|
| -7,398,558 | -3,356 | -40,518,534 | -35,025,888 | -29,756,109 |
| -5,918,846 | -2,685 | -23,569,401 | -20,433,425 | -17,564,884 |
| -4,439,135 | -2,014 | -15,833,755 | -13,835,185 | -11,959,676 |
| -2,959,423 | -1,342 | -10,236,713 | -8,653,824 | -7,318,248 |
| -1,479,712 | -671 | -4,795,840 | -4,045,957 | -3,366,934 |
| -369,928 | -168 | -1,112,268 | -983,208 | -835,250 |
| 369,928 | 168 | 779,031 | 955,284 | 1,111,872 |
| 1,479,712 | 671 | 3,190,313 | 3,732,857 | 4,464,099 |
| 2,959,423 | 1,342 | 6,199,854 | 7,412,389 | 8,448,261 |
| 4,439,135 | 2,014 | 8,971,631 | 10,746,294 | 12,733,040 |
| 5,918,846 | 2,685 | 11,953,536 | 13,915,225 | 16,191,597 |
| 7,398,558 | 3,356 | 14,331,487 | 16,972,007 | 20,119,153 |

## 3.6 Caveats

As with any model, we make assumptions and simplifications over very rich economic and biological systems in order to distill important impacts due to policy changes in the fishery. Below we list the major caveats with our work:

1. This analysis focuses *only* on recreational fishermen and ignores changes in economic value in related sectors (e.g. party/charter owner operator profits, bait and tackle shop profits, etc.) that can be solely attributed to summer flounder quota changes. Consequently, this means the estimates presented here are *lower bound estimates*.

2. As discussed previously, our estimates ignore the opportunity cost of time and again means we are providing *lower bound estimates*. We discuss this in more detail in the following section where we present our preferred model.

3. Our analysis *does not* account for changes in trips due to quota changes. We might imagine that as quota is lowered trips decrease (via bag, seasonal restriction, bag and size limit changes, etc.). We hold trips constant at 2014 observed levels. This again means that our estimates are *lower bound* estimates.

Table 3.5: Marginal Willingness to Pay by Quota Allocation

| Quota (Pounds) | Quota (Metric Tons) | Lower 95% CI | Mean CV | Upper 95% CI |
|---|---|---|---|---|
| 739,856 | 336 | 6.02 | 9.86 | 14.02 |
| 2,219,567 | 1,007 | 2.03 | 4.46 | 6.93 |
| 3,699,279 | 1,678 | 1.91 | 3.50 | 5.40 |
| 5,178,991 | 2,349 | 2.22 | 3.11 | 4.13 |
| 6,473,738 | 2,936 | 2.17 | 2.76 | 3.37 |
| 7,398,558 | 3,356 | 2.31 | 2.62 | 2.92 |
| 8,323,378 | 3,775 | 2.01 | 2.50 | 3.08 |
| 9,618,125 | 4,363 | 1.66 | 2.49 | 3.38 |
| 11,097,837 | 5,034 | 0.86 | 2.25 | 3.80 |
| 12,577,549 | 5,705 | 0.39 | 2.14 | 3.91 |
| 14,057,260 | 6,376 | -0.35 | 2.07 | 4.52 |

4. When altering expected catch and release of summer flounder as described in Section 3.5.1, we assume that there is some combination of bag, size limit, and season limit that could be changed to meet quota goals. Whether this tends to push our estimate towards an upward or lower bound is unknown.

## 3.7 Discussion

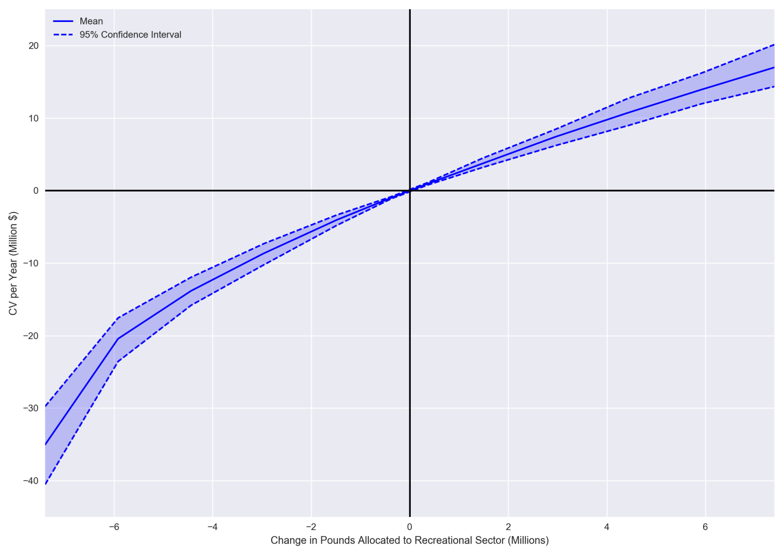
Despite the limitations of our work mentioned in the above section, the provided estimates are a very defensible *lower bound* estimates for the change in economic value associated with quota changes in the Summer Flounder Fishery. Table 3.6 lists several other studies and point estimates for marginal values associated with summer flounder.

To compare the results, it is important to note that all of the values per pound reported in Table 3.6 except ours, calculate a +1 fish change in expected catch *at each site for all trips.* Consequently, the policy change examines a case where every summer flounder trip probably catches and keeps an additional summer flounder. This change is much larger in magnitude than any considered in this study[15]. The most comparable estimate we produce to either Gentner et al. (2010) or Massey, Newbold and Gentner

[14] Calculated by dividing +1 fish estimate ($4.22) by 2.77 (Average weight of summer flounder used by (Gentner et al., 2010)). Also uses a sample of Maryland anglers who fished and not NOAA Fisheries MRIP data.

[15] 4,061,024 trips (MRIP estimated Summer Flounder directed trips along the Atlantic Coast) $\times$ + 1 fish $\times$ 2.77 pounds per fish = 11,249,036 additional pounds of recreational harvest.

Figure 3.2: Recreational Total Change in Economic Value



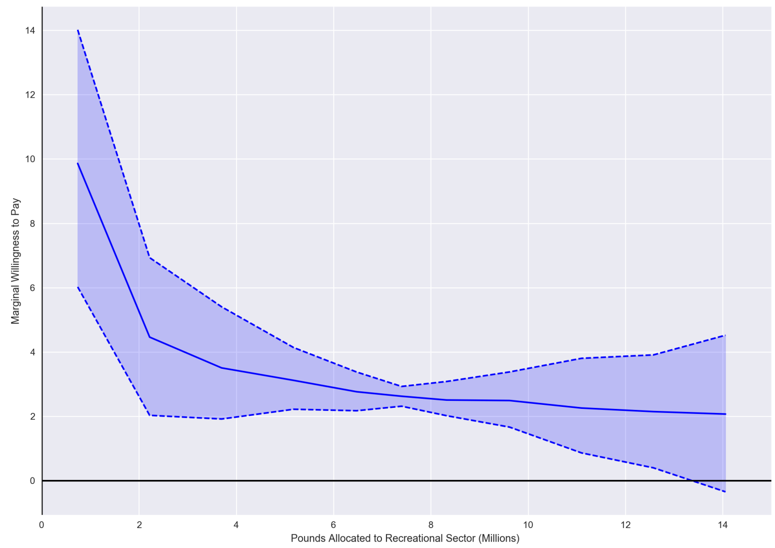

(2006) is $2.07 which corresponds to an allocation of an additional 7.4 million pounds of recreational quota.

Due to data constraints we were unable to estimate a model that fully accounts for the travel cost of recreation trips because a lack of data precluded us from accounting for the opportunity cost of time. It is well known and an established finding in the recreation demand literature that failing to include the opportunity cost of time in recreation demand models will bias welfare results (Bockstael, Strand and Hanemann (1987)). Examining the results in Gentner et al. (2010), they find that after using their opportunity cost of time correction, their economic value estimate was approximately 1.85 times higher for their preferred model.[16] Since we don't have access to data allowing us to include time in the construction of travel costs, we perform a benefits transfer by applying Gentner et al. (2010) scaling ratio to our estimates to approximate the results we would have found given complete data.[17] After applying the benefits transfer

[16]From Table 5.15 page 59.

[17]There is a well established literature on benefits transfer and the conditions under which it is a valid technique to use, particularly in a random utility model context (Parsons and Kealy (1994)). Given that both our study and Gentner et al. (2010) are using the same data (except for the including travel cost), the same study region, and the same modeling technique the literature shows benefits transfer to yield reliable estimates for welfare measures ((Parsons and Kealy (1994)).

Figure 3.3: Marginal Willingness to Pay Time Costs Excluded



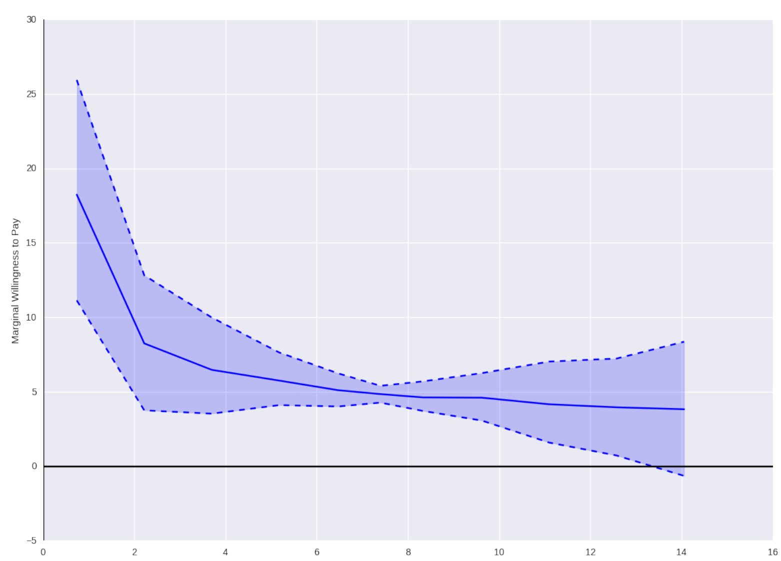

to approximate a situation where the opportunity cost of time had been included in our model, the marginal willingness to pay would have resided in the range [$18.24 to $3.83] depending on the quota level being analyzed. Consequently, our preferred marginal williness to pay estimates include the opportunity cost of time and are given in Figure 3.4 and are calculated by scaling either Figure 3.3 or the values in Table 3.5 by 1.85.

Our results show that the recreational summer flounder fishery is extremely valuable notwithstanding our caveats above. Furthermore, our results clearly show that this value responds to allocation decisions made by managers and responds in ways that we think is reasonable: when recreational anglers don't have very much quota they value an additional pound of quota more than if the sector had lots of quota. However, even as sector allocations for the recreational sector get large (relative to observed catches in 2014), they continue to have high value per pound for summer flounder.

Table 3.6: A comparison of Summer Flounder Valuation Estimates

| Study | Mean Value per Pound | Opportunity Cost of Time | Weighting | Nested |
|---|---|---|---|---|
| Current Study | $9.86 - $2.07 | Not Included | Yes | No |
| Gentner et al. (2010) | $3.48 | Included | No | Yes |
| | $2.38 | Not Included | No | Yes |
| | $1.45 | Included | No | No |
| | $0.80 | Not Included | No | |
| | $0.99 | Included | Yes | No |
| | $0.53 | Not Included | Yes | No |
| Massey, Newbold and Gentner (2006)[14] | $1.59 | Unknown | Unknown | No |

Figure 3.4: Marginal Willingness to Pay (Time Costs Included)



# Chapter 4

# Commercial Model

Our analysis of the commercial sector substantially differs from the previous work that has been conducted on sector allocation Gentner et al. (2010), Carter, Agar and Waters (2008). However, the modeling structure closely follows the empirical methodology used in our analysis of the recreational sector as the random utility model is the foundation McFadden (1978). Our modeling efforts consist of four distinct steps that allow us to estimate the marginal value per a pound of summer flounder within the commercial sector. In the first stage we estimate trip-level costs for the trawl fleet targeting summer flounder. In the second stage we estimate a site choice model for vessels that caught summer flounder between 2000 and 2014. In our third stage we combine the trip-level cost estimates with site choice estimates to simulate fleet activity and the execution of the summer flounder fleet allocation. Lastly, using a convolution method we estimate the marginal value per a pound of summer flounder by determining the incremental profits earned when the allocation is increased for the commercial summer flounder fleet. In the following description we divide up each estimation step and discuss them in more detail.

## 4.1 Estimating Trip Costs

The first step in our analysis was estimating the expected trip-level costs using the trip-level cost data from 2000 through 2014. This data has been collected by the Social Sciences Branch (SSB) of the NMFS Northeast Fisheries Science Center on an annual basis as part of Northeast Fishery Observer Program's (NEFOP) data collection efforts Das (2013). The data are obtained either through the direct observation of the observer or through interviewing the vessel captain. The data used to construct our expected costs is a subset of the broader data set constructed by the NEFOP as it focuses on just those vessels who have landed summer flounder between 2000 and 2014 and are trawl vessels. Therefore, our estimation techniques and data utilized are slightly different from those used by Das (2013).

Given the narrowly defined subset of vessels that we elected to use in our analysis we extracted the tons of ice, the price of ice, the gallons of fuel purchased, the fuel price, costs incurred for vessel damages, general supply costs, food costs, water costs and bait costs from the NEFOP cost data to construct a total trip level cost. We also extracted information on the number of crew members employed, the month and year of harvest, vessel characteristics (i.e., gtons, hp, hold, length), the vessel's state, the steam time on the trip and the number of hauls conducted on the trip. This data was used to estimate a log-log ordinary least squares regression for trip-level costs. The covariates used to explain the total trip level costs included year fixed effects, month fixed effects, vessel-state fixed effects, vessel capital (i.e., vessel characteristics), crew, steam time, days fished and hauls conducted. The parameter estimates from our regression are contained in Table 4.1.

The regression results indicate that trip-level costs were the lowest in the early 2000s, which is most likely driven by the substantially lower fuel costs during this time period. Costs are also lower during the months of August and October which roughly corresponds with the seasonal fishing patterns within the summer flounder fishery. Vessels fishing from Connecticut, Maryland, New York and Rhode Island have lower trip level costs. This roughly corresponds with the areas that have the largest concentration of summer flounder. The fixed inputs that increase trip level costs are the vessels length and gross tonnage, whereas their horsepower and hold capacity have little impact on costs. As far as the variable inputs of production, the larger the crew size the higher the costs, but the second order effect is negative. Steam time also increases the trip-level costs but again the second order term is negative. The number of days increases the trip-level costs at an increasing rate and lastly, the number of hauls increases costs but at a decreasing rate.

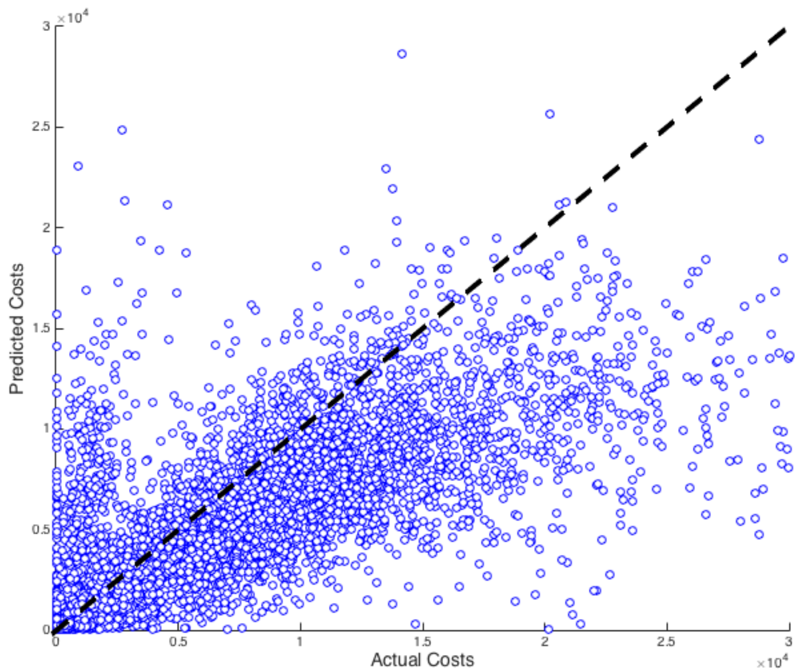
Using these parameter estimates we will estimate the expected costs per a haul within our simulation. Given the need for an accurate profile of costs we plot the actual and expected costs resulting from our regression estimates in Figure 4.1. In general our predicted trip-level costs are closely in line with those observed in the trip cost data. However, our estimates do tend to underestimate the expected trip level costs. This can be easily observed by noting that clustering of the data in Figure 4.1 below the 45-degree

Table 4.1: Trip-Level Cost Estimates

| Parameter | Estimate | Parameter | Estimate | Parmeter | Estimate |
|---|---|---|---|---|---|
| Constant | -0.0457 | February | -0.0858 | New York | -0.4056*** |
| | (0.7732) | | (0.0916) | | (0.1472) |
| Year 2000 | -0.6720*** | March | 0.0151 | North Carolina | 0.0253 |
| | (0.1996) | | (0.0918) | | (0.1783) |
| Year 2001 | -0.7971*** | April | 0.0024 | Rhode Island | -0.3363*** |
| | (0.1894) | | (0.1000) | | (0.1343) |
| Year 2002 | -0.3774** | May | -0.0509 | ln(length) | 0.8328*** |
| | (0.1798) | | (0.0927) | | (0.2516) |
| Year 2003 | -0.2969* | June | -0.0830 | ln(gtons) | 0.2952*** |
| | (0.1703) | | (0.0894) | | (0.0897) |
| Year 2004 | -0.4045** | July | -0.1384 | ln(hp) | 0.0197 |
| | (0.1596) | | (0.0854) | | (0.0724) |
| Year 2005 | 0.0972 | August | -0.2273*** | ln(hold) | 0.0076 |
| | (0.1541) | | (0.0876) | | (0.0244) |
| Year 2006 | 0.2378 | September | -0.1249 | ln(crew) | 0.2631** |
| | (0.1610) | | (0.0903) | | (0.1268) |
| Year 2007 | 0.1946 | October | -0.1713* | ln(crew)*ln(crew) | -0.0659*** |
| | (0.1597) | | (0.0893) | | (0.0704) |
| Year 2008 | 0.3645** | November | -0.0655 | ln(steam) | 0.3362*** |
| | (0.1598) | | (0.0882) | | (0.0673) |
| Year 2009 | -0.2033 | Connecticut | -1.7158*** | ln(steam)*ln(steam) | -0.0746*** |
| | (0.1553) | | (0.1972) | | (0.0212) |
| Year 2010 | 0.1628 | Maine | 0.2317 | ln(days) | 0.7823*** |
| | (0.1583) | | (0.1620) | | (0.1060) |
| Year 2011 | 0.3049* | Maryland | -1.0701*** | ln(days)*ln(days) | 0.1319*** |
| | (0.1582) | | (0.1826) | | (0.0524) |
| Year 2012 | 0.1211 | Massachusetts | 0.0894 | ln(hauls) | 0.7095*** |
| | (0.1598) | | (0.1299) | | (0.0707) |
| Year 2013 | 0.1334 | New Hampshire | -0.1484 | ln(hauls)*ln(hauls) | -0.1407*** |
| | (0.1593) | | (0.1724) | | (0.0224) |
| January | -0.1165 | New Jersey | -0.0608 | | |
| | (0.0888) | | (0.1365) | | |
| | Number of Obs. | | 13,667 | | |
| | Adjust. $R^2$ | | 0.4064 | | |

line. Although this does introduce a bias into our simulation results, as long as this bias permeates all of the trips within the simulation this will not introduce a substantial bias to our marginal valuation estimates. This will become more evident in our discussion of the simulation results.

Figure 4.1: Predictive Accuracy for the Trip-Level Cost Estimates




## 4.2 Random Utility Model

The random utility model has been extensively used in the fishery economics literature focused on spatial discrete choices Curtis and Hicks (2000), Hicks and Schnier (2008), Haynie, Hicks and Schnier (2009), Holland and Sutinen (1999), Holland and Sutinen (2000) and Smith and Wilen (2003). Assuming that there are $N$ different sites that a fisherman can select from, they will select location $i$ in time period $t$ if the utility of selecting location $i$ exceeds the utility they can derive from all other locations. This is expressed as,

$$U(i,t) + \epsilon_{i,t} > U(j,t) + \epsilon_{i,t} \forall j \in N$$

The error structure $\epsilon_{i,t}$ is assumed to be known by the decision agent (the fisherman) but not by the researcher. Ignoring the subscripts indexing locations and time the utility specification we utilize for our model is,

$$\begin{aligned} U(i,t) =& \gamma_i + \beta_1 Distance + \beta_2 SF_{Catch} + \\ & \beta_3 BSB_{Catch} + \beta_4 SCUP_{Catch} + \\ & \beta_5 Other_{Catch} + \beta_6 No_{Choice} + \epsilon \end{aligned} \tag{4.1}$$

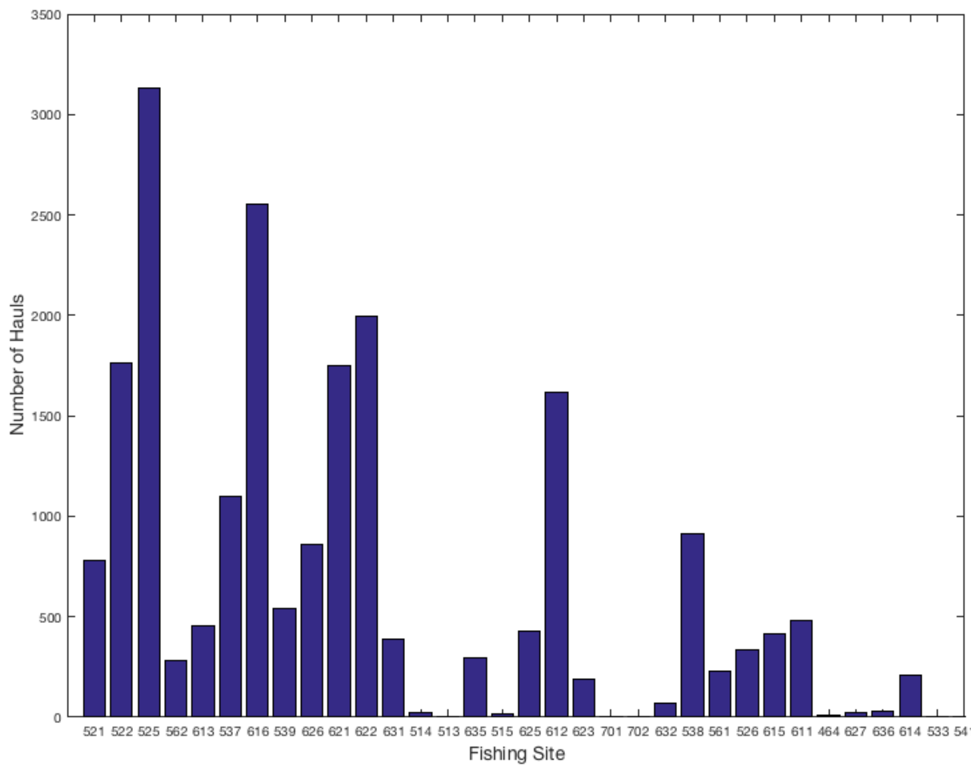
In this model $\gamma_i$ are site specific constants to control for site-specific factors that are unobserved in our data set, but that drive site choice selection. The use of these alternative specific constants have proven to be exceptionally valuable in the fishery economics literature (Timmins and Murdock (2007), Smith (2005) and Hicks, Horrace and Schnier (2012)). *Distance* is the expected distance that a vessel will travel from the current location to all other potential locations. Within the data set on a vessel's first haul we calculated the distance using their home port as the point of origination. $SF_{Catch}$ is the expected summer flounder catch that a fisherman will obtain if they visit the site in question in the current time period. $BSB_{Catch}$, $SCUP_{Catch}$ and $Other_{Catch}$ are similar variables constructed for black sea bass, scup and all other species landed. All expected catch calculations are constructed using a 60-day lag of the observed catch earned in the respective locations [1]. We elected to partition out black sea bass and scup from the other species as these two species are jointly managed with summer flounder. The variable $No_{Choice}$ is a dummy variable that indicates whether or not a location has not been visited within the past 60-days (the time window used for the catch expectations). This helps to control for temporal variations in the sites that vessels fish, which is important given the seasonal trends that exist within this fishery.

To estimate our model we use observer data from 2000 through 2014. To ensure that we are capturing vessels that caught summer flounder during this time period we restrict the sample to trawl vessels that landed summer flounder during this time period. There were 33 distinct 3-digit NFMS zones that were fished by vessels during this time. Figure 4.2 plots a histogram of the number of hauls that were conducted in each of these sites within our sample. The top five most visited sites were locations 525, 616, 622, 621 and 522. The data set consists of 2,337 unique fishing trips and 20,900 unique hauls.

The parameter estimates from our random utility model are contained in Table 4.2. The parameter estimates are consistent with the site visitation rates. The highest

[1] We explored the use of alternative lagged time framings (i.e., 30-day, 60-day, 90-day, 180-day, 1-year) and our results were relatively robust to alternative specifications

Figure 4.2: Histogram of Hauls per a Site




valued site is location 525, which is also the most visited site, and the other highly visited sites (i.e., 616, 622, 621 and 522) have high site-specific constants. The sites with low visitation rates (i.e., 701 and 702) have negative site-specific constants that are consistent with our expectations. We only estimate 30 site-specific constants in our model because three of the sites had exceptionally small visitation rates and we set their site-specific constants to zero. The other parameter estimates are also consistent with our expectations. The coefficient on expected distance traveled is negatively and highly significant [2]. The expected catch coefficients indicate that a higher expected summer flounder catch as well as black sea bass catch increases the probability that a vessel will fish in a given location, whereas a high expected catch for all other species reduces the probability that one will fish in a given location. The expected catch for scup did not influence the site visitation probability. Lastly, the coefficient on $No_{Choice}$ indicates that

[2]The distance variable was scaled by 1000 miles

vessels are less likely to visit a location that they have not visited in the past 60-days. The parameter estimates from this regression provides the foundation for the simulation model that will be discussed in the upcoming section.

## 4.3 Simulation Model

The simulation model utilizes the parameter estimates to simulate fleet activity and the execution of the total allowable catch within the commercial fishery sector. The simulation is a multi-step process that invokes different elements of existing policy limitations and seasonality to reflect the true fleet activity within the fishery. Each step is discussed in detail below.

*Step One*: We initialize the current total allowable catch to the commercial sector. Within the simulation we initialize the allocation at 1,000 metric tons and increase it by 1,000 metric tons until the allocation reaches 24,000 metric tons. Although 24,000 metric ton is substantially higher than recent allocations, it is near the peak catche levels observed in the 1980s and it is reasonable to assume that it is highly unlikely that future allocations will ever reach that level.

*Step Two*: We take a random draw from the parameter distribution resulting from the random utility model. The random draw uses the parameter estimate vector as well as the variance covariance matrix for the estimates to generate a new parameter vector. This is conducted to ensure that our parameter estimate draws reflect the underlying parameter distribution.

*Step Three*: We randomly draw a fishing trip from the observer data and use the parameter vector from *Step Two* to predict the site visitation probabilities for each haul on the randomly drawn trip. The estimated probabilities are calculated using the following equation

$$P(i,t) = \frac{e^{U(i,t)}}{\sum_{j \in N} e^{U(j,t)}}$$

This estimated probability surface is then multiplied by the expected catch rates, $SFExp_{i,t}$ (estimated using 60-day lags) at each location in time period $t$, $P(i,t) * SFExp_{i,t}$, and then is summed up across all locations, $Catch_t = \sum(P(i,t) * SFExp_{i,t}$, to determine the expected catch in time period $t$. These expectations are also estimated for black sea bass as well as scup.

Table 4.2: Random Utility Model Site Choice Estimates

| Parameter | Estimate | Parameter | Estimate | Parmeter | Estimate |
|---|---|---|---|---|---|
| Site 521 | 2.0442*** | Site 635 | -0.5788** | Site 464 | -2.0776*** |
| | (0.1496) | | (0.2162) | | (0.5861) |
| Site 522 | 3.0940*** | Site 515 | -0.6407 | Site 627 | -2.4724*** |
| | (0.1537) | | (0.4107) | | (0.3190) |
| Site 525 | 3.5658*** | Site 625 | 0.0261 | Site 636 | -2.1976*** |
| | (0.1547) | | (0.1763) | | (0.2817) |
| Site 562 | 1.4981*** | Site 612 | 0.6767*** | Site 614 | 0.0069 |
| | (0.1664) | | (0.1563) | | (0.1670) |
| Site 613 | 0.6517*** | Site 623 | -1.0422*** | Distance | -0.0338*** |
| | (0.1495) | | (0.1678) | | (0.0003) |
| Site 537 | 1.6887*** | Site 701 | -1.5556*** | SF Catch | 0.707e5*** |
| | (0.1427) | | (0.3606) | | (0.073e6) |
| Site 616 | 1.8001*** | Site 702 | -0.9233** | BSB Catch | 0.811e5*** |
| | (0.1465) | | (0.3437) | | (0.287e6) |
| Site 539 | 0.0431 | Site 632 | -1.2967*** | SCUP Catch | 0.039e5 |
| | (0.1510) | | (0.2327) | | (0.035e6) |
| Site 626 | 0.8498*** | Site 538 | 1.0285*** | Other Catch | -0.062e5*** |
| | (0.1687) | | (0.1463) | | (0.011e6) |
| Site 621 | 0.9726*** | Site 561 | 1.2662*** | No Choice | -2.2604*** |
| | (0.1647) | | (0.1705) | | (0.0946) |
| Site 622 | 1.4854*** | Site 526 | 0.8241*** | | |
| | (0.1574) | | (0.1546) | | |
| Site 631 | -0.2938 | Site 615 | 0.0588 | | |
| | (0.1947) | | (0.1586) | | |
| Site 514 | -2.1053*** | Site 611 | 0.1855 | | |
| | (0.3988) | | (0.1521) | | |
| Number of Obs. | | | 20,900 | | |
| Log Likelihood (parameters=0) | | | -73,077 | | |
| Log Likelihood (estimates) | | | -17,417 | | |

*Step Four*: We reduce the allocation of summer flounder to the commercial fleet by the $Catch_t$ to determine the remaining allocation of summer flounder. In addition, we set the total allowable catch of black sea bass to 2.5 million pounds and the total allowable catch for scup to 22 million pounds. If the catch for either or these species exceeds this allocation the expected catch is set to zero to reflect that they must be discarded.

*Step Five*: We calculate the expected revenue from each haul using the following formula $Rev_t = \sum(P(i,t) * (SFRevenues_{i,t} + BSBRevenues_{i,t} + SCUPRevenues_{i,t} + OtherRevenues_{i,t})$.[3] To account for the costs incurred on the trip we subtracted the expected costs from fishing that trip using our cost estimates (see Table 4.1) discussed earlier to get a profile of trip-level profits.These profits were then added up for all fishing activity that occurred within the simulation to determine the fleet wide profits for the given allocation of summer flounder.

*Step Six*: We determine whether or not the current aggregate catch of summer flounder for the fleet has exceeded the allocation and if it has not we return to *Step Two* until the allocation of summer flounder is exhausted.

The above mentioned six steps represent the core of the simulation, which we refer to as *Model One*, however additional complexities have been added to make the simulation more realistic. The additional features are summarized below.

### 4.3.1 State Allocations for Summer Flounder, Black Sea Bass and Scup

The commercial fleets allocation of summer flounder is further subdivided among the states that harvest summer flounder. This is also true for the allocations of black sea bass and scup. Given this, we added these constraints to our second simulation model, *Model Two*. The state allocations we used for each of the three species are indicated in Table 4.3.

In order to incorporate the state allocations into the simulation model we tracked the catch of summer flounder (SF), black sea bass (BSB) and scup through the simulation. In the case that state allocation for summer flounder was exceeded we removed all vessel-trips originating from that state in *Step Three* of the simulation. This way only those vessel-trips that were eligible to fish for summer flounder, per the state allocation rules,

[3] Revenue expectations are calculated using a 60-day lag.

Table 4.3: State Allocations for Summer Flounder, Black Sea Bass and Scup

| State | Percentage SF | Percentage BSB | Percentage SCUP |
|---|---|---|---|
| ME | 0.0476% | 0.1210% | 0.5000% |
| NH | 0.0005% | 0.0000% | 0.5000% |
| MA | 6.8205% | 21.5853% | 13.0000% |
| RI | 15.6830% | 56.1894% | 11.0000% |
| CT | 2.2571% | 3.1537% | 1.0000% |
| NY | 7.6470% | 15.8232% | 7.0000% |
| NJ | 16.7250% | 2.9164% | 20.0000% |
| DE | 0.0178% | 0.0000% | 5.0000% |
| MD | 2.0391% | 0.0119% | 11.0000% |
| VA | 21.3168% | 0.1650% | 20.0000% |
| NC | 27.4458% | 0.0249% | 11.0000% |

were eligible for random selection. If a states allocation for black sea bass or scup were exceeded, we still allowed for the vessel-trip to be selected in *Step Three*, but we zeroed out the catch of the species that had already exceeded its state allocation limit.

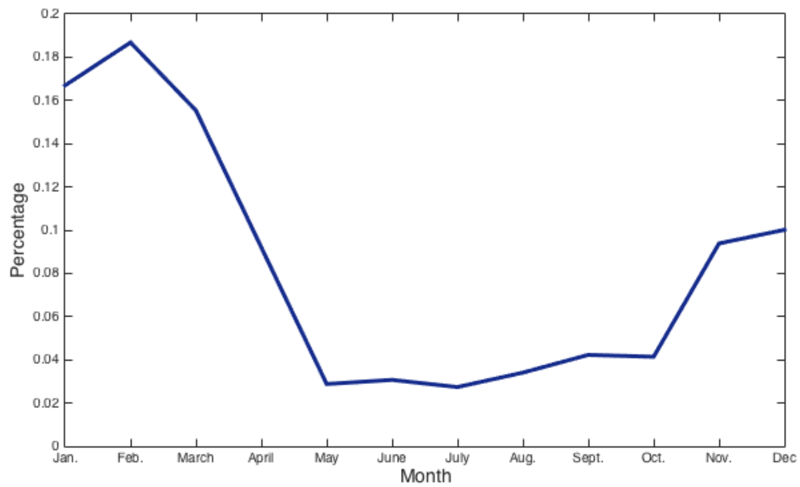
### 4.3.2 Seasonal Patterns in Fishing Behavior

The summer flounder fishery is a seasonal fishery will a large percentage of the catch occurring in the winter months. Figure 4.3 graphically illustrates the average percentage of the landings that occurred by month within the observer data. It is clear that a bulk of the catch arises in the months of November, December, January, February and March. Given that we are randomly generating a vessel-trip from the set of all vessel-trips, we added a seasonal constraint to the model that ensures that the simulated fleet behavior mirrors the temporal distribution of catch within the fishery. This was achieved by altering our *Step Three* by first randomly sampling a month from the distribution illustrated in Figure 4.3 and then randomly selecting a vessel-trip from within that month.

## 4.4 Construction of Marginal Values

For each of the different summer flounder allocations we conducted 40 different simulations. This allows us to construct confidence intervals on our estimates of the marginal value per a pound of summer flounder. To calculate the marginal value we estimated

Figure 4.3: Seasonal Pattern for Summer Flounder Harvest




the following equation

$$\text{Marginal Value}_k = (Profit_k - Profit_{k-1})/(1000 * \text{Metric Ton})$$

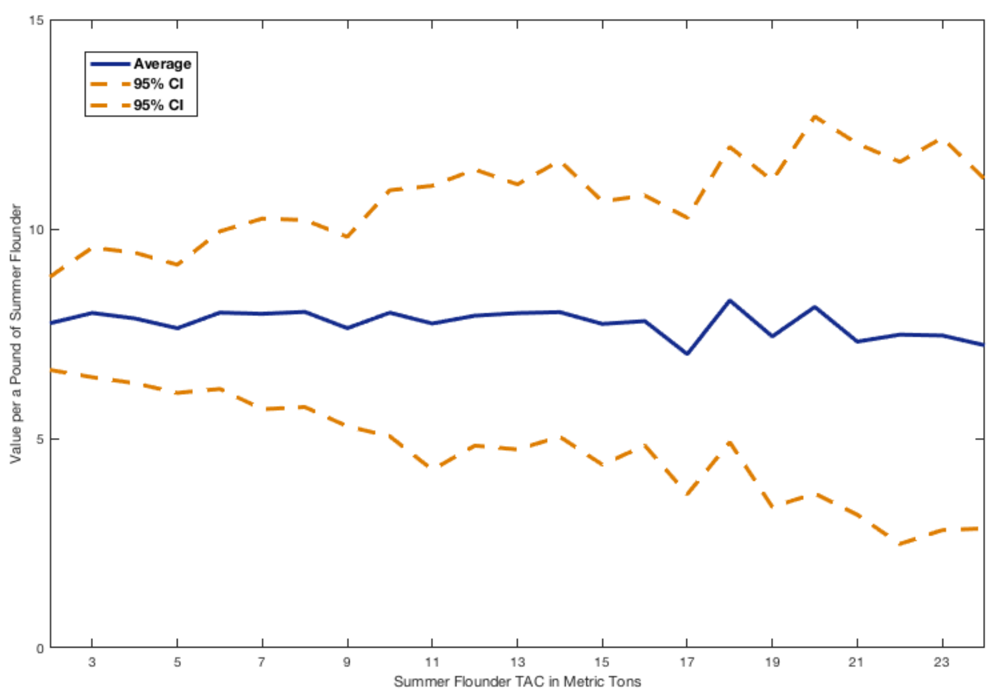
where, Marginal Value$_k$ is the marginal value when one increases the allocation of summer flounder to allocation level $k$, $Profit_k$ is our estimate of fleet profits when the allocation is $k$ and $Profit_{k-1}$ is the estimated profit prior to the increase in the allocation from level $k-1$ to $k$. Given that our unit of increase is 1,000 metric tons, we divide the difference in the change in profits by the incremental change in pounds landed to get a marginal value per a pound of summer flounder. Since we have 40 different simulations for each level of $k$, through the convolution of all 40 at one level of $k$ with the 40 observed at level $k-1$ we obtain 1,600 different comparisons. These 1,600 comparisons allow us to construct 95% confidence intervals by dropping the top and bottom 40 estimates of Marginal Value$_k$.

One important feature of the marginal value calculations is that they are derived from the total profits that a vessel earns while fishing. This is the sum of all species landed and not just summer flounder. Therefore, although the ex-vessel price for summer flounder ranges between two and four dollars it is possible that the marginal value for summer flounder can exceed this value. This is because summer flounder is a complement in production. When a vessel targets summer flounder they also catch other species that have market value. Therefore, the marginal value of summer flounder is not only the value they derive from summer flounder but also the additional value they derive from the other species that are caught in conjunction with targeting summer flounder. This is an important feature of the simulation because if one reduces the allocation of summer flounder to the commercial fleet it will also impact the revenue flows that they derive from the other species that they would have caught if they were able to target more summer flounder. The following subsections discuss the results from the three different models estimated.

### 4.4.1 Marginal Values - Model 1

*Model 1* is the simplest of the models we estimate. This model does not utilize state limits for summer flounder, black sea bass or scup and it does not invoke any seasonality. This model only uses the allocations of the three different species as the binding constraints on the simulation. The mean marginal value for each incremental increase in the allocation of summer flounder as well as the 95% confidence intervals are illustrated in Table 4.4 and graphically illustrated in Figure 4.4.

Figure 4.4: Marginal Value Estimates for Model 1




The results from *Model 1* illustrate that the average marginal value for summer

Table 4.4: Marginal Values for Model 1

| Allocation (MT) | Mean | Lower 95% CI | Upper 95% CI |
|---|---|---|---|
| 2,000 | 7.7478 | 6.6333 | 8.8544 |
| 3,000 | 7.9936 | 6.4596 | 9.5542 |
| 4,000 | 7.8628 | 6.3183 | 9.4333 |
| 5,000 | 7.6284 | 6.0852 | 9.1440 |
| 6,000 | 8.0014 | 6.1807 | 9.9411 |
| 7,000 | 7.9734 | 5.6971 | 10.2457 |
| 8,000 | 8.0192 | 5.7484 | 10.2113 |
| 9,000 | 7.6299 | 5.2897 | 9.8110 |
| 10,000 | 8.0000 | 5.0497 | 10.9225 |
| 11,000 | 7.7414 | 4.2516 | 11.0279 |
| 12,000 | 7.9279 | 4.8275 | 11.4178 |
| 13,000 | 7.9896 | 4.7374 | 11.0630 |
| 14,000 | 8.0131 | 5.0389 | 11.6264 |
| 15,000 | 7.7321 | 4.3741 | 10.6578 |
| 16,000 | 7.7991 | 4.8314 | 10.7978 |
| 17,000 | 7.0100 | 3.6677 | 10.2632 |
| 18,000 | 8.2934 | 4.9092 | 11.9560 |
| 19,000 | 7.4332 | 3.3640 | 11.1518 |
| 20,000 | 8.1377 | 3.6841 | 12.6815 |
| 21,000 | 7.3097 | 3.1786 | 12.0338 |
| 22,000 | 7.4763 | 2.4800 | 11.5981 |
| 23,000 | 7.4557 | 2.8114 | 12.1705 |
| 24,000 | 7.2222 | 2.8514 | 11.1849 |

flounder ranges from around $7 to $8.3 a pound. The confidence intervals for the estimates increase as the quota allocation increases. At the lowest quota allocation, 2,000 metric tons, the 95% confidence interval is between $6.63 and $8.85. At the highest quota level, 24,000 metric tons, the 95% confidence interval is between $2.85 and $11.18. The current allocation to commercial sector has been hovering between 8,000 and 13,000 metric tons. In this range the average marginal value is between $7.63 and $8.01 and the 95% confidence intervals are between $5.75 and $10.21 at 8,000 metric tons and $4.73 and $11.06 at 13,000 metric tons.

### 4.4.2 Marginal Values - Model 2

*Model 2* augments *Model 1* by incorporating the state allocation constraints. This implies that once a given state has reached their allocation of summer flounder we no longer allowed vessels from that state to target summer flounder. If vessels reached their allocation of black sea bass and scup we did allow them to continue targeting summer flounder, but we did not allow them to retain any of the black sea bass or scup for sale (i.e., we zeroed out the revenue flow from the species). The results from this simulation are contained in Table 4.5 as well as Figure 4.5.

The results illustrate that incorporating the state allocation constraints lowered the marginal value per a pound of summer flounder by approximately 28%. Therefore, the state allocation constraints are a significant contribution to our simulation model. The average marginal values for *Model 2* range from slightly over $5 to just slightly under $6 a pound, with the values gradually decreasing as the allocation of summer flounder increases. The 95% confidence intervals range from between $5.20 and $6.72 at the lowest allocation, 2,000 metric tons, to between $2.33 and $8.04 at the highest allocation level, 24,000 metric tons. The current allocation to commercial sector has been hovering between 8,000 and 13,000 metric tons. In this range the average marginal value is between $5.35 and $5.84 and the 95% confidence intervals are between $4.16 and $7.44 at 8,000 metric tons and $4.03 and $7.55 at 13,000 metric tons. These are lower than the values observed under *Model 1*.

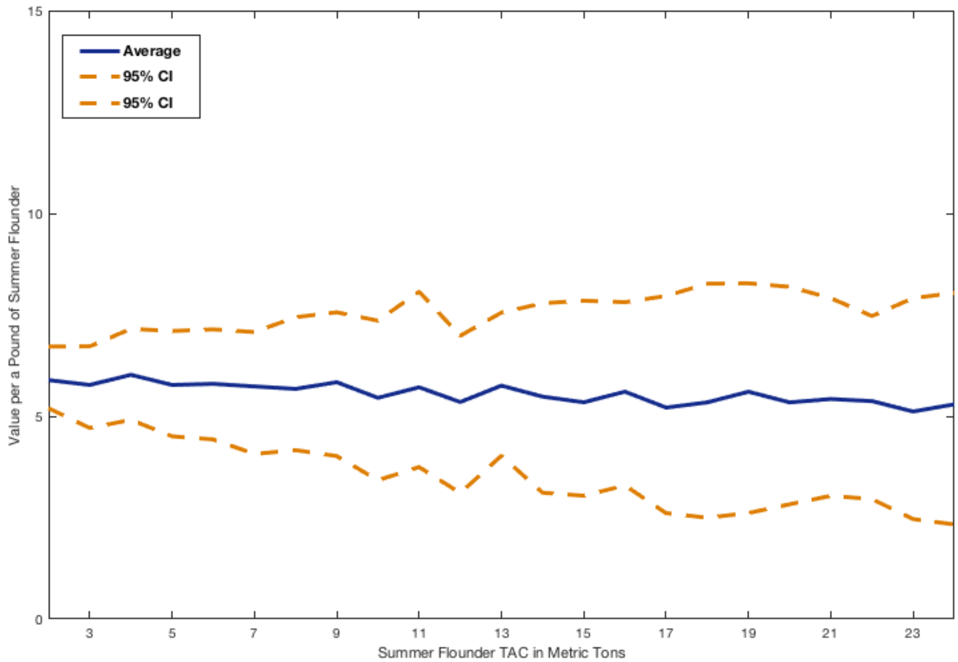
### 4.4.3 Marginal Values - Model 3

*Model 3* builds on *Model 2* by incorporating seasonality in the execution of commercial allocation. Using the distribution of landings in Figure 3 we first randomly drew a month from this distribution and then a vessel trip as well as ensuring that the trip met the state

Table 4.5: Marginal Values for Model 2

| Allocation (MT) | Mean | Lower 95% CI | Upper 95% CI |
|---|---|---|---|
| 2,000 | 5.8912 | 5.1979 | 6.7163 |
| 3,000 | 5.7719 | 4.7107 | 6.7222 |
| 4,000 | 6.0203 | 4.9100 | 7.1536 |
| 5,000 | 5.7723 | 4.5051 | 7.1005 |
| 6,000 | 5.7984 | 4.4274 | 7.1405 |
| 7,000 | 5.7344 | 4.0708 | 7.0750 |
| 8,000 | 5.6742 | 4.1642 | 7.4412 |
| 9,000 | 5.8385 | 4.0181 | 7.5617 |
| 10,000 | 5.4538 | 3.4214 | 7.3554 |
| 11,000 | 5.7139 | 3.7474 | 8.0717 |
| 12,000 | 5.3493 | 3.1078 | 6.9818 |
| 13,000 | 5.7539 | 4.0262 | 7.5545 |
| 14,000 | 5.4830 | 3.1144 | 7.7844 |
| 15,000 | 5.3437 | 3.0401 | 7.8483 |
| 16,000 | 5.6057 | 3.2938 | 7.8103 |
| 17,000 | 5.2131 | 2.6121 | 7.9651 |
| 18,000 | 5.3416 | 2.4983 | 8.2667 |
| 19,000 | 5.6042 | 2.6154 | 8.2773 |
| 20,000 | 5.3415 | 2.8286 | 8.1890 |
| 21,000 | 5.4241 | 3.0384 | 7.9107 |
| 22,000 | 5.3730 | 2.9580 | 7.4693 |
| 23,000 | 5.1163 | 2.4650 | 7.9103 |
| 24,000 | 5.2927 | 2.3330 | 8.0395 |

Figure 4.5: Marginal Value Estimates for Model 2



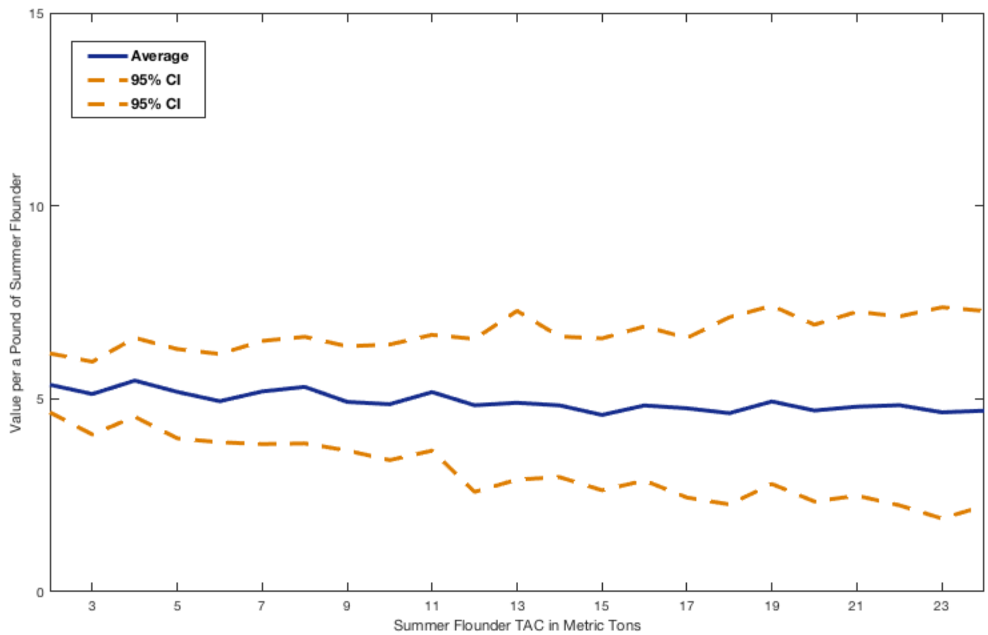

allocation constraints. This seasonality allowed the execution of the sector allocation to mirror the actual distribution of harvest observed within the sector. The results from the simulation are illustrated in Table 4.6 and Figure 4.6.

The results from *Model 3* generate slightly lower marginal value estimates than those observed in *Model 2*. This is reasonable because we have constructed the simulation so that it mimics the seasonal inshore-offshore patterns within the fishery. The average marginal value ranges from \$5.5 to around \$4.6 per a pound of summer flounder, with the marginal values decreasing as the allocation to the sector increases. The 95% confidence intervals range from between \$4.65 and \$6.18 at the lowest allocation, 2,000 metric tons, to between \$2.22 and \$7.28 at the highest allocation level, 24,000 metric tons The current allocation to the commercial sector has been hovering between 8,000 and 13,000 metric tons. In this range the average marginal value is between \$4.83 and \$5.31 and the 95% confidence intervals are between \$3.84 and \$6.61 at 8,000 metric tons and \$2.91 and \$7.28 at 13,000 metric tons. These estimates are approximately \$0.63 lower than *Model 2* and around \$2.82 per a pound lower than *Model 1*. Given that *Model 3* most closely follows the seasonal harvesting trends as well as the state allocation constraints, the

Table 4.6: Marginal Values for Model 3

| Allocation (MT) | Mean | Lower 95% CI | Upper 95% CI |
|---|---:|---:|---:|
| 2,000 | 5.3647 | 4.6499 | 6.1764 |
| 3,000 | 5.1244 | 4.0759 | 5.9617 |
| 4,000 | 5.4723 | 4.5370 | 6.5790 |
| 5,000 | 5.1795 | 3.9753 | 6.2888 |
| 6,000 | 4.9376 | 3.8741 | 6.1608 |
| 7,000 | 5.1906 | 3.8274 | 6.4999 |
| 8,000 | 5.3084 | 3.8437 | 6.6055 |
| 9,000 | 4.9202 | 3.6601 | 6.3619 |
| 10,000 | 4.8595 | 3.4107 | 6.4060 |
| 11,000 | 5.1734 | 3.6569 | 6.6575 |
| 12,000 | 4.8325 | 2.5880 | 6.5516 |
| 13,000 | 4.8965 | 2.9068 | 7.2792 |
| 14,000 | 4.8295 | 2.9711 | 6.6132 |
| 15,000 | 4.5819 | 2.6307 | 6.5645 |
| 16,000 | 4.8280 | 2.8806 | 6.8749 |
| 17,000 | 4.7540 | 2.4417 | 6.5781 |
| 18,000 | 4.6277 | 2.2631 | 7.1122 |
| 19,000 | 4.9304 | 2.7936 | 7.4110 |
| 20,000 | 4.6968 | 2.3390 | 6.9201 |
| 21,000 | 4.7958 | 2.4909 | 7.2562 |
| 22,000 | 4.8346 | 2.2409 | 7.1341 |
| 23,000 | 4.6497 | 1.8990 | 7.3699 |
| 24,000 | 4.6912 | 2.2228 | 7.2767 |

Figure 4.6: Marginal Value Estimates for Model 3




results from this model are our preferred estimates of the marginal value per a pound of summer flounder.

### 4.4.4 Caveats

As with any empirical study, there are limitations to our analysis. These limitations are a result of the modeling conducted as well as the available data we have used to conduct our analysis. Listed below are the major caveats with our work:

1. The data used in our analysis relies on the observer data set. This data set captures only a small portion of the total summer flounder landings. Although the observer data does closely align with the vessel trip reports it is important to note its limited coverage. The vessel trip report data can not be used in our analysis because it does not contain detailed and sequenced spatial behavior. Therefore, the observer data is the best available data set for our analysis.

2. Our analysis is a short run analysis of the commercial fleet. In our model the price of summer flounder is not endogenous and we do not account for the free entry and

exit of fishermen within the summer flounder fishery. These factors may result in different results, but the data does not allow us to investigate these factors.

3. Our analysis does not account for the localized depletion within the fishery. As the quota increased, and more fishing occurs one might expect that the cost per a haul increases.

# Chapter 5

# Allocation Analysis and Recommendations

We conclude with our allocation analysis, which examines for a particular quota level the marginal benefits (or marginal willingness to pay) for each sector if an additional unit of quota was allocated to them. Following the equimarginal principle, we examine allocation levels where each sector's marginal benefit for the last quota unit allocated to them is equalized. Economists call this optimal because once we have established the optimal allocation, any other allocation necessarily lowers total economic benefits in the fishery.[1]

## 5.1 Allocation Analysis

The earlier chapters clearly demonstrate that both sectors benefit when quota is allocated to them. In this section, we compare these marginal benefits to examine

1. How the current allocation (60% Commercial and 40% recreational) compares to the optimal allocation

2. The quota allocation change that could increase economic benefits in the fishery

Both the commercial and recreational methodologies produce marginal value estimates that show what the sector is "willing to pay" for an additional unit of quota. We combine the marginal value estimates from Model 3 in the commercial Chapter 4

[1]This is a strong statement and we note the caveats to our work mentioned in this chapter and elsewhere in the document.

Figure 4.6 (the preferred model) with the marginal value schedule from the recreation Chapter 3 Figure 3.4 (also the preferred estimate). In order to do this, we assume a grand total allowable catch of 8,000 Metric Tons (as that was the approximate TAC level in 2014 and the last year of data included in our models) and imposed the following constraint on the commercial and recreational sectors:

$$Harvest_{Recreational} + Harvest_{Commercial} = 8000$$

This allows us to solve for one sector's harvest as a function of the other. The commercial harvest can be written as

$$Harvest_{Commercial} = 8000 - Harvest_{Recreational}$$

Using these constraints we combine the marginal value schedules for each sector in Figure 5.1. Note that in the figure, we use the preferred models from both the recreational and commercial sectors.

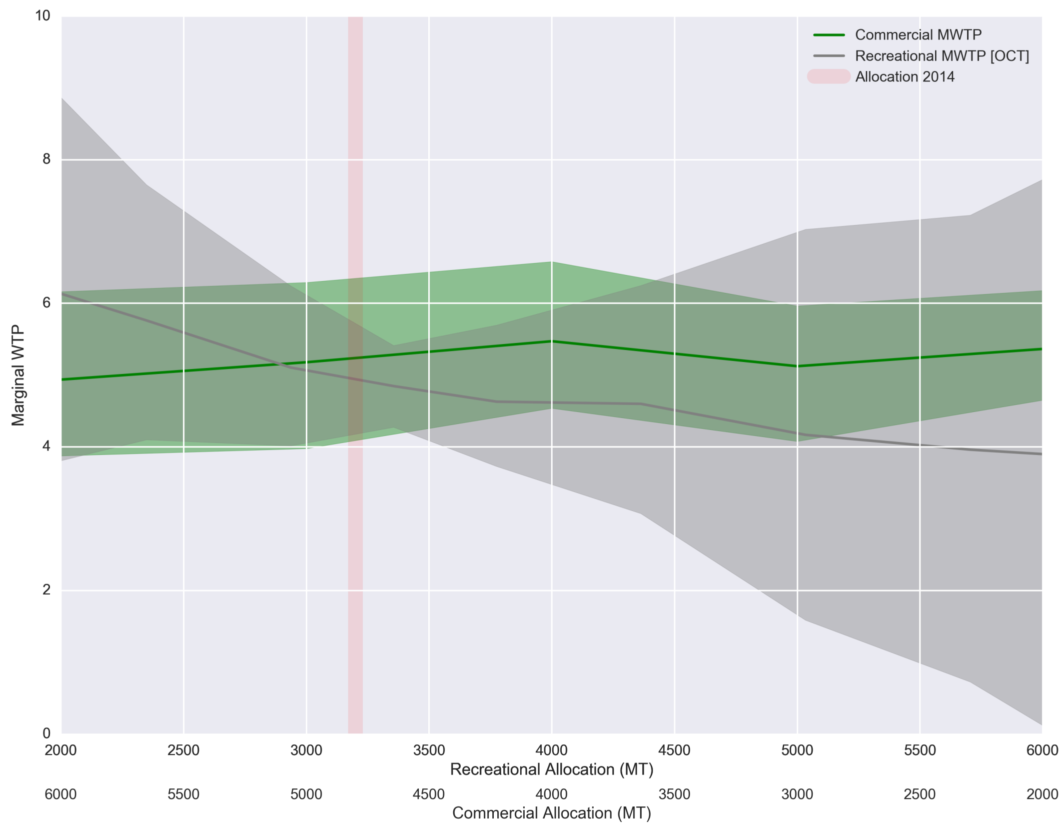
This figure shows, that once the 95% confidence intervals are included, there is no clear-cut difference in marginal value schedules for a wide swath of quota allocation levels between 2000 and 6000 metric tons. Once the uncertainty is factored into the equimarginal analysis,

- The current allocation can't be said to be sub-optimal since stakeholders directly engaged in summer flounder fishing have a very similar "Willingness to Pay" for an additional pound of fish in the neighborhood of the current allocation.
- Modest changes from the current allocation would most likely not lower benefits in the fishery.
- Large changes severely limiting one sector over another would most likely lower benefits in the fishery.

### 5.1.1 Caveats

The aforementioned analysis hinges on a number of key assumptions and we want to make clear some that we think are quite important to note alongside our main results. Besides the caveats broken down by sector and listed below, we also acknowledge additional caveats that impact the overall analysis:

Figure 5.1: Marginal Benefits of Quota by Sector




- Both the commercial and recreational models use *past* fishing outcomes to characterize fishing quality for each of the sites in the spatial fishing model. Since past fishing outcomes are a product of past management and ecological conditions the quality measures we use may not fully capture the current quality expectations that is important for characterizing fishermen's preferences. However, since the models require fishing quality expectations that are spatially detailed, we have no choice but to use past fishing data for characterizing current expectations.

- As pointed out by Holzer and McConnell (2014), the equimarginal principle (that we use for allocation above) reaches an efficient allocation when property rights can be attached to the resource. We don't have that in this case, since once allocations occur for each sector an open access fishery ensues. We note this important caveat and argue that we can't do better without a *per-fisherman* participation model for both sectors and models of preference heterogeneity.

- Neither sector model allows for localized biological depletion.
- Due to the timeliness of producing the research we were forced to work off of the year 2014 as the baseline.

**Recreation Caveats**

1. By focusing on angler behavior, we ignore any other changes in consumer or producer surplus in the recreation sector that is *due to quota changes in the summer flounder fishery* such as losses/gains in profits at bait shops and boating repair and supply businesses. This means we are tending to underestimate the marginal value schedule for the recreation sector.

2. Our adjustment above in Figure 5.1 to account for the opportunity cost of time is an estimate of what the complete model might look like. In a sense, we are performing a benefits transfer with all of the issues that accompany it. We think it is a reasonable approximation since both studies examine the same resource, use the same data, and employ similar methods.

3. Our methods do not account for changes in participation and numbers of trips due to policy changes. Consequently, we are tending to underestimate the marginal value schedule for the recreational sector.

**Commercial Caveats**

1. The benefits accruing to commercial anglers occur in the *short-run*, since an extensive literature (see Grafton et al. (2006) for a brief overview) has shown that exogenous changes in profitability in regulated open access fisheries are often driven to low levels as commercial vessels try to out-compete each other to catch the fleet quota. Consequently, we would expect the marginal value schedule in 5.1 to decline over time.

2. Like the recreation analysis, this study only focuses on at-sea commercial behavior and ignores any changes in consumer and produce surplus in the commerical sector *solely due to quota changes* such as boating and dock services, and losses in consumer surplus for consumers of summer flounder. Consequently, we are tending to underestimate the marginal value schedule for the commercial sector.

### 5.1.2 Recommendations

Deciding the sector allocation of summer flounder between the commercial and recreational sectors is an impactful policy decision that alters the welfare of these respective sectors. In our analysis we have focused on making conservative recommendations regarding sector allocation because each of the models developed in our analysis possess important caveats and limitations that are relevant to policy. Although, the methods and data used are the best available we have made a concerted effort to acknowledge the limitations of our efforts and its efficacy for public policy. Given our results, there are a number of short-run implications of our analysis.

In the short-run, we don't see any statistical difference between the marginal value schedules of the two sectors using the preferred set of results. This suggests that the current sector allocations conform with our results. Although the mean estimates for the commercial sectors marginal valuation lie below those within the recreational sector when the recreational allocation is below approximately 2,700 metric tons, the confidence intervals for both sectors overlap. This indicates that our results provide little empirical support for altering the current allocation. Our results also suggest that modest changes in allocation *in either direction* would most likely not lower the economic benefits in the fishery. Large changes that severely restricted one sector over another would most likely lower the economic benefits in the fishery.

Our results can not be used to inform any long-run policy analysis as both sectors are likely to change their behavior should the existing allocation change. On the recreational side our results ignore any changes that may arise in related sectors (i.e., party/charter owners, bait and tackle shops, etc..) and changes in recreational effort that could impact their marginal valuation. On the commercial side our results do not address any changes in the prevailing market (i.e, ex-vessel prices), fleet behavior (i.e, entry and exit), or in related sectors should the allocation to the commercial sector change. Consequently, based solely on the equimarginal analysis performed here with accompanying caveats, we do not recommend changing the quota allocation as the marginal value schedules (Figure 5.1) are nearly equalized at the current allocation level.

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# Appendix

Table 5.1: Total Recreational Summer Flounder Catch by State (2010-2015)

| | | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| Connecticut | Catch | 408103.0 | 391627.0 | 368752.0 | 1135976.0 | 757270.0 | 522428.0 |
| | % SE | 23.1 | 29.7 | 22.8 | 14.6 | 20.7 | 22.2 |
| Delaware | Catch | 672223.0 | 682321.0 | 298917.0 | 296722.0 | 385462.0 | 207777.0 |
| | % SE | 14.6 | 16.6 | 16.6 | 12.2 | 12.2 | 14.1 |
| Maryland | Catch | 1250666.0 | 487883.0 | 236175.0 | 333283.0 | 710356.0 | 288387.0 |
| | % SE | 33.9 | 22.8 | 33.2 | 14.4 | 32.6 | 24.3 |
| Massachusetts | Catch | 259869.0 | 240958.0 | 326079.0 | 93176.0 | 449391.0 | 168620.0 |
| | % SE | 56.3 | 22.6 | 24.1 | 19.1 | 47.0 | 20.7 |
| New Jersey | Catch | 11117078.0 | 8832808.0 | 8111333.0 | 7705212.0 | 10688470.0 | 5174878.0 |
| | % SE | 8.9 | 10.1 | 10.9 | 12.3 | 11.8 | 9.0 |
| New York | catch | 6905742.0 | 7671293.0 | 5521735.0 | 5184731.0 | 5033970.0 | 4732687.0 |
| | % SE | 11.6 | 10.4 | 11.8 | 13.0 | 10.4 | 11.5 |
| North Carolina | Catch | 79184.0 | 61629.0 | 63505.0 | 45469.0 | 47026.0 | 40561.0 |
| | % SE | 13.0 | 16.3 | 17.0 | 17.0 | 19.7 | 23.1 |
| Rhode Island | Catch | 348766.0 | 885522.0 | 484903.0 | 654975.0 | 601986.0 | 576822.0 |
| | % SE | 17.3 | 23.8 | 17.2 | 35.1 | 21.3 | 20.9 |
| Virginia | Catch | 2679889.0 | 2304658.0 | 1116641.0 | 701788.0 | 781730.0 | 773296.0 |
| | % SE | 13.4 | 17.6 | 15.3 | 14.9 | 10.7 | 23.7 |

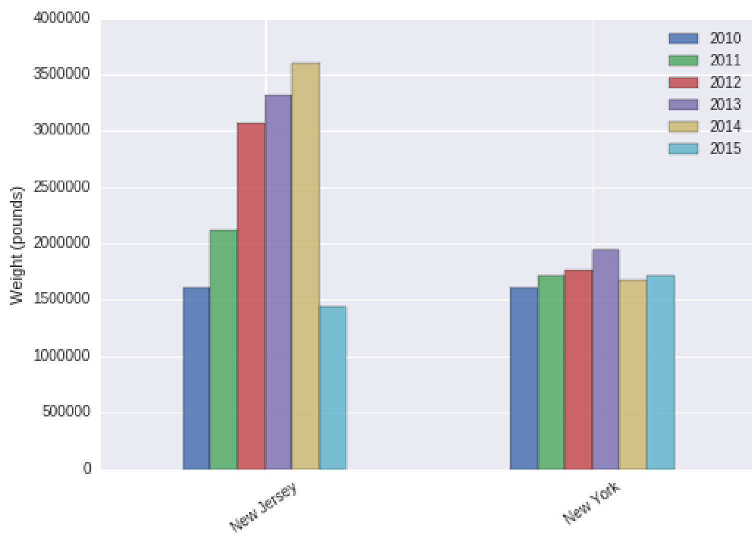
Table 5.2: Total Recreational Summer Flounder Harvest by State (2010-2015)

| | | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| Connecticut | Harvest | 35028.0 | 47071.0 | 62501.0 | 269650.0 | 119502.0 | 97215.0 |
| | % SE | 30.7 | 33.9 | 41.5 | 18.7 | 21.1 | 28.9 |
| Delaware | Harvest | 53512.0 | 66820.0 | 45474.0 | 58279.0 | 93029.0 | 51450.0 |
| | % SE | 18.2 | 21.9 | 23.7 | 13.7 | 15.8 | 13.9 |
| Maryland | Harvest | 25215.0 | 15347.0 | 22617.0 | 53180.0 | 79513.0 | 44437.0 |
| | % SE | 35.7 | 44.8 | 32.2 | 22.1 | 56.1 | 27.9 |
| Massachusetts | Harvest | 45156.0 | 58372.0 | 75803.0 | 31228.0 | 112840.0 | 79109.0 |
| | % SE | 48.0 | 36.8 | 34.1 | 26.1 | 41.1 | 34.5 |
| New Jersey | Harvest | 552401.0 | 736848.0 | 1130407.0 | 1244432.0 | 1175383.0 | 497482.0 |
| | % SE | 13.7 | 13.0 | 11.8 | 14.6 | 11.7 | 11.1 |
| New York | Harvest | 334491.0 | 376198.0 | 509123.0 | 518016.0 | 509131.0 | 543278.0 |
| | % SE | 16.8 | 16.3 | 17.2 | 16.0 | 14.7 | 11.2 |
| North Carolina | Harvest | 77157.0 | 60422.0 | 63135.0 | 44941.0 | 45708.0 | 40561.0 |
| | % SE | 13.2 | 16.6 | 17.1 | 17.2 | 20.2 | 23.1 |
| Rhode Island | Harvest | 118455.0 | 161125.0 | 103102.0 | 127713.0 | 184668.0 | 164028.0 |
| | % SE | 33.0 | 31.3 | 32.9 | 25.8 | 22.5 | 24.9 |
| Virginia | Harvest | 260050.0 | 317674.0 | 259973.0 | 186916.0 | 139431.0 | 159234.0 |
| | % SE | 15.2 | 19.0 | 16.9 | 31.7 | 15.3 | 25.0 |

Table 5.3: Total Summer Flounder Harvested Weight (Pounds) for Atlantic States (2010-2015)

| | | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| Connecticut | Pounds | 132013.0 | 186834.0 | 191119.0 | 888906.0 | 391168.0 | 346179.0 |
| | % SE | 31.3 | 35.0 | 39.2 | 18.5 | 20.1 | 29.4 |
| Delaware | Pounds | 159976.0 | 182733.0 | 141935.0 | 159185.0 | 227913.0 | 114638.0 |
| | % SE | 18.1 | 22.4 | 24.6 | 13.9 | 16.5 | 14.7 |
| Maryland | Pounds | 91834.0 | 55686.0 | 61514.0 | 108690.0 | 179313.0 | 103613.0 |
| | % SE | 38.3 | 46.7 | 33.1 | 21.7 | 56.0 | 31.7 |
| Massachusetts | Pounds | 137611.0 | 202665.0 | 175110.0 | 64365.0 | 238604.0 | 146532.0 |
| | % SE | 44.4 | 51.6 | 32.6 | 27.9 | 36.0 | 27.5 |
| New Jersey | Pounds | 1614357.0 | 2116951.0 | 3063723.0 | 3316971.0 | 3608939.0 | 1442827.0 |
| | % SE | 14.0 | 13.2 | 11.8 | 14.3 | 12.1 | 11.0 |
| New York | Pounds | 1612298.0 | 1718121.0 | 1760650.0 | 1954821.0 | 1677717.0 | 1708882.0 |
| | % SE | 16.8 | 17.4 | 17.3 | 17.2 | 16.1 | 11.7 |
| North Carolina | Pounds | 111539.0 | 100543.0 | 101642.0 | 70874.0 | 67791.0 | 64065.0 |
| | % SE | 13.4 | 16.0 | 17.0 | 17.3 | 22.1 | 23.5 |
| Rhode Island | Pounds | 458873.0 | 511544.0 | 335506.0 | 371948.0 | 636207.0 | 600597.0 |
| | % SE | 31.3 | 29.0 | 36.7 | 24.8 | 22.7 | 27.9 |
| Virginia | Pounds | 789856.0 | 880639.0 | 658476.0 | 450884.0 | 370906.0 | 342841.0 |
| | % SE | 15.0 | 18.8 | 17.2 | 31.2 | 17.0 | 23.9 |

(a) New York and New Jersey




(b) Other Atlantic States

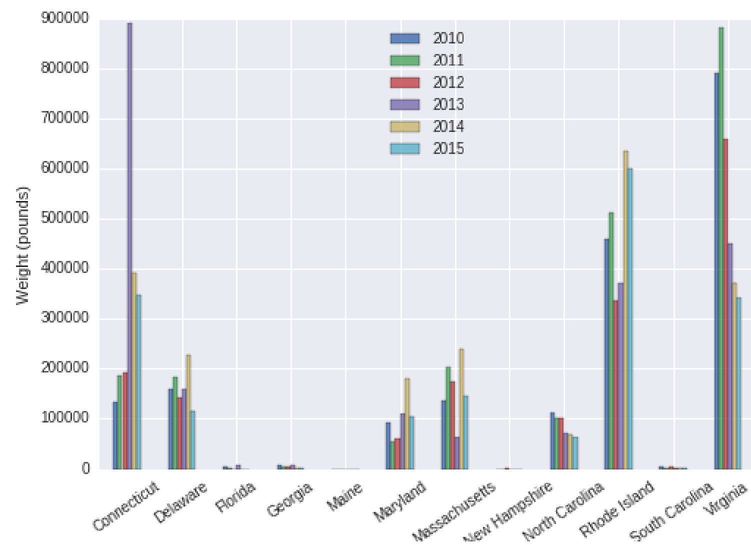



Figure 5.2: Total Recreational Harvested Weight (Pounds) (2010-2014)