Economic and Ecological Opportunities of Bycatch in the New England Seafood Supply Chain

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Abstract

Bycatch is the unwanted portion of catch on a fishing vessel typically discarded at sea. The practice of discarding bycatch is well documented in global fisheries for increasing mortality, and exacerbating fish stock decline. With discard rates as high as 60% in some fisheries, bycatch reduction is a significant priority for improving financial and environmental sustainability. Fishery managers are seeking solutions to reduce bycatch waste through improved capture selectivity and discard reduction strategies. Some global fisheries have adopted discard bans to address these concerns, but results vary.

This research assessed the economic and ecological impacts of discards as applied to New England fisheries and the connected restaurant supply chains. In spreadsheet models, I collected menu data from New England restaurants to establish willingness to pay ranges for all commercially capture species from New England wild capture fisheries. These data demonstrate consumer preferences for a few species and a lack of interest in many others. These data were used to project total potential revenue for three stakeholders in the supply chain, fishers, processors and restauranteurs. I then estimated the effect discard reduction would have on marketable species mix availability, and subsequently stakeholder costs and revenues to answer the question, does ecological impact reduction require a decline in economic productivity for the supply chain.

In considering economic impacts, this research explored the potential for profitable utilization of many bycatch species and the inverse correlation of improving ecological impact and declining fishery profitability. Current costs and revenues were

compared to discard reduction simulations to assess impacts from changes in landed species volume. Given static total catch weight and historical market values, the results demonstrated low discard scenarios will move more low value species into the supply chain resulting in an overall decrease in industry revenue and profitability.

Under the conditions of the discard ban simulations, the total ecological impact on currently harvested fish species is reduced by up to 126 million pounds. The landed catch would include up to 106 million pounds of previously discarded fish of low economic value. As the discard ban becomes more rigorous, the total impact decreases and the total amount of low value species included in landings increases. This increase in lower value species has a negative impact on revenue for the entire sea food supply chain. The change in species mix decreases projected revenue for New England fisheries by as much as $150 million for the fishers and up to $1.19 billion for restaurants. However, this need not be reflected in declines in net revenue or profitability

The decline in revenue is rooted in the low initial value of the discard species. Discard species average $0.45 per pound at landing compared to the target species average of $1.86 per pound at landing. The low initial value impacts the final potential value generated through the supply chain, but is the low value driven by the supply chain or the end consumer? This reduction in revenue is the primary hurdle for the industry when attempting to reduce or eliminate the practice of economic discarding. Initiatives to reduce the ecological impact of the fishing industry on oceanic ecosystems should seek to increase popularity for underutilized species at the consumer level to increase demand and market value.

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Chapter I

Introduction

In 2012, fish accounted for 16.7 percent of global animal protein consumption at 19.2kg per person annually (FAO, 2014). Globally, wild capture marine fisheries produced 80 million tons of fish for human consumption, a 3% decline from 2010. With the human population increasing, food production will need to increase but most fisheries are currently fully exploited and 28% of global fisheries are exploited beyond biologically sustainable levels. Wild capture fisheries have leveled off or declined in total production over the past decade. However, the seafood industry continues to increase production of aquatic proteins through the development and expansion of aquaculture projects globally. Despite looming concerns about the long-term productivity of marine fisheries, the practice of discarding bycatch is prevalent. Bycatch is the unintended capture of non-target species during normal fishery operations. This practice compromises the stock health of commercial fisheries and the ecosystems they depend upon. (FAO, 2014).

Many methods of modern fishing and the equipment utilized in capture are not highly selective and consistently ensnare cohabitating species. The total resulting catch consists of a mix of target and non-target species. Much of the bycatch is edible and has some market value. Despite this, most is simply discarded at sea (Catchpole et al., 2014). The process of capture and release can cause significant trauma to the fish and much of what is discarded is injured or already dead. Those fish that are returned to the sea alive and intact are usually disoriented or impaired and are more susceptible to predation.

Mortality is the likely outcome for all discards. Specific mortality rates vary by species up to 80% with smaller species and crustaceans more likely to survive capture and release (Broadhurst, Suuronen, & Hulme, 2006).

In 2003, total global discards were estimated at 7.2million tons or 8% of the total catch, though verifiable data are limited and do not include illegal, unregulated or unreported fishing operations (Kelleher, 2005). In 2012, the total national average for discards in the United States was between 17% and 22% based on two separate surveys (Patrick & Benaka, 2013). The difference between the two surveys can be attributed to their reliance on estimates made from a small amount of verifiable data.

Bycatch is not only a systemic challenge for global fisheries, but this unsustainable practice of discarding bycatch species represents a missed economic opportunity for the seafood supply chain. It is financially inefficient to expend resources to capture a viable protein source, only to return it to the sea in search of more lucrative species. Due to high mortality rates of discarded bycatch, the practice has a specifically negative impact on population health for highly discarded species and may represent an obstacle to the long-term health of the oceans as it exacerbates stock decline and degrades overall ecosystem health. The waste of edible protein through discarding, needed to feed a growing population in an increasingly resource scarce environment, is neither an environmentally sustainable nor an ethical practice.

Diversification of consumer demand to bycatch fish species would alleviate some strain on overfished populations while simultaneously stimulating new revenue streams to offset the financial hardships experienced in many fishing communities. With a diffused demand, more species become economically viable and fishers be less likely to discard, resulting in a lower overall impact on biomass, and a reduction in days at sea and the impact the fishing industry has on the ocean. The practice of discarding continues due primarily to the perception that bycatch species have little or no market value and are therefore not an economically viable product for the seafood supply chain to capture and process. The value of discarded species can be extrapolated from the landing value of what amount of bycatch does go to market. This calculation has been produced before to reflect the single stage economic benefit possible by keeping normally discarded fish (Keledjian et al., 2014). However, what is unaccounted for is the value generated from the subsequent steps in the supply chain, for the seafood processor and the full-service restaurants which serve directly to the consumer.

Research Significance and Objectives

This research establishes a functioning model to forecast the economic opportunities for processors and restaurants of utilizing bycatch fishes. It also forecasts the impacts that changes in landed species mix will have on the entire seafood supply chain in New England. This model infers the possible change in total expected mortality associated with the current system of fishing operations. The assessment demonstrates the total potential value of underutilized species in a restaurant setting and provides incentives for the industry and regulators to improve efforts to promote consumer demand and limit waste of these species.

Initial efforts to diversify consumer demand will require investment in both direct financial industry support as well as in consumer education programs. This model can be utilized to show the benefits of public awareness campaigns and regulatory engagement in the market to derive the greatest value from what is now a wasted resource.

Background

Fishers will discard bycatch for a variety of reasons, but they fall into two primary categories: regulatory and economic.

Regulatory discards are unintentionally captured species which are not allowed to be legally sold and must be returned to the water. An attempt to sell any species that fall into this category will result in penalties from regulatory authorities. Sale of a species may be prohibited by regulation for the following reasons:

- The fisher has already exceeded his quota for capture of a particular species or multispecies group.
- The individual fish may not be the proper age, size or gender.
- The species may have no current quota or is protected by law
- The species may have been captured outside of legal fishing days or designated fishing areas.

Economic discards occur when fishers lack a strong enough financial incentive to take it to market. When this occurs, fishers will opt to dump these species back into the water in favor of more profitable ones. Species may become economic discards for the following reasons:

- Species are unpopular, with low consumer demand and therefore low market value. Demand is a result of cultural perception and taste preferences. Species perceived as undesirable by one community are frequently favored by another.

- Species which are difficult, labor intensive to process or prepare. Smaller species commonly fall into this category. Windowpane Flounder has a similar appearance and flavor to its larger relatives but is significantly smaller and yields little edible protein for a similar amount of processing effort. Processors will avoid it as the return on investment is lower. When processors are not willing to work with it restaurants will not have an opportunity to purchase it.
- Species are subject to high grading-- the lowest quality individual fish of the target species will be discarded in favor of higher quality ones of the same species. When a fisher has reached the maximum catch, fishing may continue in search or fresher and more profitable fish of the same species. (Catchpole, 2013).

Data Collection on Bycatch

Data on discards are collected from vessel reports generated by the crew on the fishing vessel. These reports are only considered verifiable if the vessel had an observer onboard at the time the discards occurred and were recorded. Observer programs place an auditor on a vessel to confirm the rates of capture and discarding. Though highly accurate, the observer programs are not widely used due to financial constraints and resistance from the industry. The low number of observers results in infrequent occurrence of verifiable results and overall reduced accuracy in estimates (Wigley, Blaylock, Rago, & Shield, 2012). Consequently, bycatch data is based heavily on estimates and its reliability is often called into question when used to make recommendations for quotas or industry regulation. The bycatch data used in this study was produced by the semi-annual NOAA bycatch evaluation which extrapolates estimates from a small sample of observer verified, and self-reported data.

Why Discards are a Problem

The per pound value of marketable bycatch is generally lower than that of target species; however, the practice of discarding bycatch is extremely common, resulting in millions of pounds of seafood being captured and returned to the water. Due to the scale of this practice, the financial impact is significant. The combined value of species discarded for regulatory and economic reasons in US fisheries are estimated to represent $4.2billion in missed economic opportunity (Patrick, et al., 2013).

The process of being captured by a commercial fishing operation can severely damage or kill a fish, even unintentionally. If a fish escapes with little physical damage it has still endured a highly stressful ordeal involving a rapid change in light, hydration and pressure, in addition to any physical trauma inflicted during the capture. Mortality caused beyond intended capture increases the negative impact on the stock health of specific species. Ecosystems can be further damaged if keystone species are disproportionately killed disrupting the food web. Protected species, which are not legally allowed to be captured, are nonetheless captured and may be unintentionally killed by a fishing operation at sea. This can be particularly harmful when bycatch includes females or juveniles. The reduction in opportunities for reproduction or juvenile recruitment compromises a species' ability to rebuild its population following a fishing season. When a species' population is fished or damaged beyond its ability to rebound, it will collapse.

Management Strategies to Minimize Discards

A variety of solutions have been put forward globally to address the issue of bycatch and discards: again, if numbers not further used, or logical progression of use, then bullets preferred

- Selective fishing gear: This solution seeks to reduce or eliminate the issue of unintended capture by preventing non-target species for becoming ensnared or by allowing a path to escape. Requirements for gear type regulation or modification to improve selective capture have had a positive impact on bycatch reduction in several fisheries. This strategy does not alleviate fishing pressure on highly popular target species (Sardà, Coll, Heymans, & Stergiou, 2013).
- Selective fishing grounds: This solution seeks to avoid specific locations completely or during certain times of the year when non-target species are known to be present in significant numbers. Fishing grounds may be closed to fishers when non-target species are migrating through or are known to be breeding grounds or habitats of non-target species.
- Multi species quotas: This solution takes a more holistic fishery management approach and seeks to develop codependent quotas for multiple cohabitating species. Multi-species quota strategies are unique to individual fisheries with variable consideration given to volumes of bycatch. In a multispecies management scenario, fishers must adhere to catch limits of several species simultaneously. In the event the catch limit for one species is reached, the unmet quotas for the other species in the fishery will be voided. (Patrick et al., 2013).

- Discard ban: This solution seeks to prohibit all discards in specific fisheries. In 2012, the European Union, under its Common Fisheries Policy, enacted a discard ban on ground fisheries. On January 1, 2015 a similar ban was enacted for pelagic fisheries. This strategy is intended to approach fisheries management holistically and utilize the total catch, resulting in a more efficient use of resources through a balanced and reduced ecological impact (Condie, Grant, & Catchpole, 2014). This decision is not unprecedented, though it is the broadest application of the strategy to date. Other countries have enacted discard bans but have limited the breadth of the policy to individual fisheries. Discard bans have been implemented for specific fisheries in Iceland, The Faroe Islands, Canada, New Zealand and Alaska.
    - Discard bans have also incentivized the fishing industry to invest in technological development to make fishing gear more selective and improve the total value of the catch through the reduction of undesired species capture.

U.S. and New England Fisheries Management

Fisheries management regulations in the United States are based on recommendations made by the National Oceanic Atmospheric Association. NOAA is tasked with assessing species stock health and ensuring the sustainable harvest of all commercial species. Data is drawn from the Vessel Trip Reports or Dealer Reports but can only be truly verified through an observer program. The most recent bycatch report assembled for the New England fisheries by NOAA contains only 10% observer verified data and uses statistical models to estimate the total bycatch numbers (Wigley et al., 2012). The report assessed 14 managed species groups captured by 55 fishing fleets designated by target species and gear type in New England. The NOAA report estimated discard rates range from nearly 0% to 60% depending on which fishing fleet was examined. Accurate total bycatch for all New England fisheries is unknown but estimates are in the millions of tons. The data is primarily utilized as an indicator for which fleets are expected to have the highest discard rates (Wigley et al., 2012). Research continues to be conducted on the subject though conflict of opinion is rampant between the scientific, fishing and political communities as to the best course of action. This conflict is fueled by the questionable accuracy of stock assessments and the economic needs of the fishing community.

Commercial fisheries in New England have decreased by 15% since 2003 (FAO, 2014). In 2013 ground fishing catch limits were significantly reduced to preserve the viability of many ground fish species populations. This reduction in allowable catch prevented many boats from participating in the fishery. In 2014, the fishery was declared a disaster and $32.8 million in disaster relief funding was distributed to support the fishing community (NOAA, 2014). During this period, the practice of economic discarding continued.

Bycatch Markets

There are a few existing efforts to popularize bycatch and develop markets for the oft-discarded species. Motivations for participation in this effort are both economic and ecologically driven. The US shrimp fisheries in the Caribbean have one of the highest bycatch percentages in the nation with a rich diversity of underutilized species being captured along with the target species (Keledjian, 2014). Instead of simply discarding it, entrepreneurs have taken the bycatch and created a market demand through restaurants and retail outlets to utilize the total catch.

Establishing a robust market demand for underutilized species could provide supplementary economic opportunity for struggling New England fisheries. There are some examples of bycatch use in New England but the potential of total catch utilization and its impact on the marketplace and fisheries ecosystems has not been quantified. My study estimates discards of eight species and calculates the potential value to the New England seafood supply chain.

Research Questions, Hypotheses and Specific Aims

This project reviewed the supply and demand relationship through the estimated availability and market value of discarded bycatch and the consumer's willingness to pay.

My thesis research addressed the following questions: Is taking bycatch species to market more economically and ecologically advantageous than discarding them?

What is the total financial impact of a no-discard scenario on the New England seafood supply chain?

What is the potential value of discards to the New England seafood supply chain?

At what level of demand would underutilized species be considered desirable catch based on their menu price?

My main hypotheses with respect to these research questions include the following predictions:

1. Under a wide range of catch volumes and market prices, many bycatch species are profitable to exploit
2. Because of environmental benefits, unprofitable bycatch species merit public subsidy to make them profitable for buyers
3. Underutilized species can become financially viable with an investment to drive consumer demand

Specific Aims

To examine these hypothesis, I addressed these specific aims:

1. Quantify existing and potential supply of eight edible bycatch species and the volumes at which they are captured.
2. Quantify potential value of total catch to supply chain stakeholders by species.
3. Quantify average logistical costs of utilizing total catch in the supply chain from landing to consumer.
4. Estimate economic impacts of discard reduction scenarios by examining changes in the percentages of species landed based on capture and discard estimates.
5. Determine financial thresholds for achieving positive economic impact through bycatch utilization.
6. Explore application of investment in building demand for low value species to achieve a positive outcome in Skate, Summer Flounder and Spiny Dogfish.

Chapter II

Methods

In order to analyze the potential value of discarded New England bycatch species as they pass through the supply chain and the economic impact they may have on the industry, I first estimated three metrics: 1) supply of target species and potential supply of bycatch species, 2) demand for target species and bycatch species on at the consumer level, and 3) values and costs associated with landing, processing and selling bycatch species. Collection of these data, understanding of the restaurant supply chain, and estimates of variables used in analysis was importantly advised by my 20 years in the restaurant industry, including eight working with Legal Seafoods in Boston.

I analyzed the supply chain from landing to restaurant to determine average costs for utilizing target and non-target species based on industry standards for logistical costs, processing yields and viable profit margins.

I established a restaurant financial business model based on industry standards for projecting food cost and menu pricing. On a species by species basis, cost sensitivity analysis was used to demonstrate the expense and potential value each species represents to the restaurant model.

Total value was determined by establishing a willingness-to-pay range per species based on listed sale prices at restaurant operations. When no menu pricing was available, species were assigned pricing from like species with available pricing. Pricing data for restaurants were taken from a sample of 415 restaurants in New England self-designating as seafood restaurants with menus available online through Opentable.com from January 1 to June 31, 2017. Multiple data points on each sample were collected, and included genre of cuisine, location, price tier, species offered on menu from New England fisheries, and price of those seafood entrees.

Demand was determined by the frequency of menu appearances a species had across the sample of restaurants. These data were used to benchmark demand thresholds for sustainable pricing against which economic discard was compared for investment goal setting. Demand was also multiplied by mean menu price to determine the menu influence a single species had over the menus in the sample. Menu influence indicates perceived desirability and is a factor in future menu decisions. It.is determined through the combination of mean price point and frequency of appearance on restaurant menus. A species with a low mean price point which appears infrequently on menus will have low menu influence and will not be often included in future menus. A species with a high mean price point that is frequently on menus will have high menu influence and will often be selected to include in future menus.

The combination of mean restaurant plate value and fisheries bycatch volume of available product was used to accurately estimate the potential value per species and total revenue for the entire industry.

A summary is provided of the steps in data collection and analysis (Table 1).

Fisheries Data

Landing data was collected from the National Oceans Economics Program (NOEP) fisheries data for fleets operating in the managed fishing territory defined as

Table 1. Research design: data collection and analysis.

Determine volume of fish, landed and discarded by species and percentage	Review data sets from NOAA and NOEP on landings and estimated discard ratios and volumes of all species captured by the 55 fleets under New England fisheries management.
Determine baseline logistical cost to supply chain from capture to sale.	Review industry practices and determine costs of handling from landing to consumer.
Determine value per species and total revenue for supply chain	Review landing pricing data from NOEP Collect data on a sample of online restaurant menus. Assess current pricing for species at: • Auction • Processor • Restaurant • Consumer
Simulate reduced discard scenarios	Based on NOAA discard ratio data, determine what the species volumes mix will be for the same total landing weight as previous year under discard reduction scenarios
Simulate economic impact	Based on pricing for each species, assign total value of the species and industry under discard reduction scenarios
Simulate biomass impact	Compare total mortality under discard reduction scenarios

New England for 2004-2016 (National Oceans Economics Program, 2017). This database compiles total annual volumes of landed species and revenue generated by the capture of listed species. The program was founded through a grant from NOAA to provide social and economic time-series data for valuing the oceans and coastal zones. NOEP tracks economic and demographic trends along the coast and coastal oceans, providing a scientific foundation for studying coastal management and marine policy.

Landing values from NEOP per lb for each species were extrapolated from total revenue divided by total landed weight. Daily pricing of fish at auction fluctuates through the year, influenced by weather, seasonality, demand and other variables. Annual figures provide a relevant mean.

These data were used to establish trends in landings and value at auction for commonly discarded species. These auction value data are the foundation for determining value of discards through the seafood supply chain. Additionally, the trends provide context for price projection for future sales to establish strategies for promotion of underutilized species to a self-sustaining price position in the market.

Discard Data

Discard data were collected from the NOAA report *2014 Discard Estimation, Precision, and Sample Size Analyses for 14 Federally Managed Species Groups in the Northeast Region* (NOAA, 2014). These estimates are based on data voluntarily accumulated in capture logs maintained by the crew of participating fishing vessels. The log data is verified by an observer on the vessel when available. Data are then analyzed to estimate average bycatch discarding across the New England Fishing fleet. Data are stratified by geography, time of year, target species and gear type to extrapolate bycatch discard volume estimates specific to each fishery. Discard estimates were analyzed by species and compared to the calculated total market value of landed volumes to determine potential value for the entire supply chain for each species.

There is discard data for all commercial wild capture species though most are discarded at relatively low numbers. The majority of discards occur within a few species. This research focused on the three species with the highest discard volumes represented in the 2014 NOAA survey: Skate, Spiny Dogfish and Summer Flounder. Due to the particularly high frequency with which these species are unintentionally captured and discarded, they would have the greatest economic impact on the seafood supply chain in a total discard ban scenario.

Processing Costs and Revenue Estimates

Once a fish has been landed, before it gets to the consumer, it commonly passes through auctions and open markets to the second tier of the seafood supply chain, consisting of processors and distributors. Processors will transport, store, fabricate and distribute the catch, incurring costs while doing so. Costs are passed on to the next tier in the supply chain, restaurants. Restauranteurs are capable of side stepping the second tier and doing business directly with auctions or the actual fishers. In this situation, they assume the costs of transportation and processing the fish. Costs are less predictable in this scenario, but this is not common and so not explored in this analysis.

Processing costs were determined based on industry standard averages for yields, costs and margins derived from information shared by Ipswich Shellfish Group, one of the wholesalers and distributors of sea food in New England. Business costs fluctuate daily throughout the year, influenced by multiple variables and individual business models. However, the competitive nature of the market keeps vendors in close proximity.

During the processing stage in the supply chain, a whole fish will be butchered into premium filets. The processing of a whole fish into a filet reduces the usable weight and increases the cost per pound of the protein. Premium filets will be priced in direct correlation to the yield ratio of the whole fish. Additional usable protein may be collected from a fish and used in a variety of other markets and industries. That product is not accounted for in this research and the results are focused exclusively on the premium yield. Spiny Dogfish and Summer Flounder have an average premium yield of 38%. Skate has an average premium filet yield of 26%.

To determine cost and value of fish as it moves through the processing tier of the seafood supply chain, a spreadsheet analysis was performed to establish a trend for Skate, Summer Flounder and Spiny Dogfish for the period 2004-2016. Total pounds of fish landed and average price per pound were taken from the NOEP data set for each year. Cost of processing was estimated at an additional $0.20 per pound per whole fish. The fabrication yield is then applied to the total weight, 38% for Summer Flounder and Spiny Dogfish, and 26% for Skate. Additional costs for overhead and margin are estimated at $0.60 per pound of premium filet. The total revenue for the processor is calculated as the sum of premium filet yield, processing, overhead and margin. The final price per pound is the initial cost to restaurants.

Restaurant Cost and Revenue Estimates

Restaurant costs and revenues were determined based on a range of industry standard targets for food cost, based on my experience in the industry in the Boston area. Costs can vary depending on stability of supply, menu strategy and individual business models but the long-term success of a restaurant depends on its ability to reliably achieve these targets. It is common across all levels of restaurant service models to set a food cost target between 20% and 40%. In this research, I establish four tiers of food cost at 20%, 25%, 33% and 40% to assess outcomes across the full range of costing possibilities.

To manage food cost a restaurant must model and establish plate costing. Plate cost is determined by combining the volumes and cost of all ingredients required to complete a single dish for service. It is industry standard for the protein to carry the greatest single cost of any ingredient included in the dish. The percentage of plate cost assumed exclusively by the protein will vary based on chef preference, preparation and protein cost. With a highly expensive protein, a chef will look to reduce cost on other items to stay within the food cost target and keep the menu price tolerable for guests. For this research the protein is assumed to represent 50% of total plate cost. Menu price is estimated in this research as a direct correlation to ingredient cost and the food cost targets of 20%, 25%, 33% and 40%.

Total potential revenue is determined based on projected menu prices multiplied by available portions of each species. This research also includes the total revenue potential of discards sold at average listed menu price for comparison.

Discard Ban Estimates

Once value per species was established through menu pricing estimates, the total value of discards within the fishery could be estimated. These data served as the baseline discard scenario. I also simulated the impact of a change in discard policy. The different scenarios assumed a static total capture weight and price per pound per species based on 2014 landing data from the NOEP. The simulation tested a 0 to 100% reduction in economic discards at 10% increments.

Using existing species capture data and values determined through this research, a per species value and total industry revenue was determined under the simulated scenarios.

Menu Pricing Data for Bycatch Species

Species were selected to be included in this study based on data from the NEOP which lists all commercially landed species based on geographic designation and market name. For the geographic area designated at New England, the NEOP included all commercially captured species in the coastal waters between Maine and Rhode Island. In total, 115 different commercially captured species designations were listed by common names for New England. These 115 species were placed into columns on the data sheet and pricing was listed for each menu data point in the corresponding meal period designation and menu row for each menu in the sample.

This research focused on species caught in New England fisheries, but other international sources exist for many of the species captured and sold in New England. The disclosure of capture location was not reliably included in menus in the sample menus, so the point of origin was not included in the data collection. This fact is not impactful to the initial of consumers' willingness to pay analysis. The goal of the research was to show current market value at the consumer level, which due to lack of transparency on restaurant menus, isn't heavily influenced by point of origin. Restaurants may be offering species which are caught locally but also caught internationally. Haddock, cod, tuna and swordfish are examples of this. Though there is often no way of determining the origin of the species listed on the menu, the willingness to pay continues to be relevant as the consumer makes decisions based upon perceived value of species itself and not its origin.

Menu Data

This research was based on collecting menu pricing data to draw a sample of price points across restaurant industry segments, thereby identifying pricing ranges for each species of aquatic protein captured in New England fisheries. The collection of this data occurred between January and June of 2017. Menus were sampled through OpenTable.com, an online reservation website used by a variety of independent and chain restaurant companies.

Restaurant sample section. Restaurants were selected for this menu audit when located in the geographic area designated as New England and self-categorized as a seafood restaurant. This was done to increase the odds of finding New England caught fish species on the menu and reduce the number of restaurants with no relevant data. A total of 415 Restaurants met these criteria.

Menus were accessed electronically either from the Opentable.com website itself or via a link to the restaurant's homepage. Pricing information was collected for each species clearly identified on the menu. Species offered in combination in dishes were excluded from the sample data.

When selected for analysis, the following basic information was captured: name, address, price point and genre. This data was recorded in a table with columns for the commercially captured New England fish species.

Restaurant were excluded from the sample when 1) they did not have a menu available online, 2) did not offer New England caught fish species on their menu or 3) did not provide pricing on the menu. Of the 415 restaurants sampled, 82 were excluded for failing to meet the data criteria; 333 menus were analyzed, and 1790 species specific menu pricing data points were collected.

Price point. The price point is a scale of 2-4 designed by Opentable.com to give a relative assessment of expected meal price. A restaurant with a 2 designation is expected to charge an individual diner less than $30 for a meal. A restaurant with a 3 designation is expected to charge an individual diner between $30 and $50 for a meal. A restaurant with a 4 designation is expected to charge an individual diner more than $50 for a meal. This data is informative when analyzing the range of menu pricing for the same species across the data set.

Meal period. There are three menu category segments which impact pricing based on portion size and traditional pricing expectations from diners. These menu categories consist of: 1) Appetizers, which typically consist of a smaller portion, 2) Lunch, which frequently offers smaller portions and or lower pricing, and 3) Dinner, which will offer the largest portions at the highest prices. Pricing for these segments were collected separately for each species where necessary to increase pricing range accuracy based on portion size and meal period. These data were used exclusively to demonstrate popularity of species, but due to the variability in pricing strategy and portion sizing, was not suitable for other analysis.

Portion size. Protein portion sizes vary based on species used, the restaurant concept and meal periods. For this analysis, confirmed meal period portions were defined as follows:

appetizers were estimated at 4 oz, lunch portions were estimated at 6 oz and dinner portions were estimated at 8 oz. For analysis of the potential costs and values of discarded bycatch as it passed through the supply chain from landing to processing to restaurant to consumer, pricing for 8 oz dinner portions was used exclusively to represent the greatest potential value possible.

Representation. Where menus did not use exact naming conventions to differentiate within a species category such as Hake, which includes Silver Hake, White Hake, Red Hake and Silver/Red Hake, data points were combined based on the general name used. In this instance, menu data collected combined all Hake varieties to demonstrate popularity and a range of acceptable pricing associated with Hake. This is justified as the names used in wholesale fish markets will change to occasionally include specific details about the species or list them all under the general category. From a restaurant perspective, there is no legal requirement to list specifics beyond the common name for the species used. As another example, Flounder is the general name used to describe five specific species, Windowpane, Witch, Winter, Summer and Yellowtail, which once processed and prepared as a meal will be difficult to differentiate between. Through the process of consolidation, the original 115 species designated in the NOEP data set was condensed to 92 verifiably different wild capture species.

Chapter III

Results

The results from this analysis fall into three sections. The first section details the value of total discards in the New England fishery and the potential value of those species at auction. These results establish the basis for projections of the potential value of discard species through the seafood supply chain to include fishers, processor and restaurant operations. Specific focus is given to Summer Flounder, Skate and Spiny Dogfish which are the three most highly discarded species in the New England fisheries. These results are used as the foundation for the second section which extrapolated the economic and ecological impacts an array of discard ban scenarios would have on the New England seafood supply chain. The third section is a review of the survey results from the menu sample taken of New England seafood restaurants. These data establish popularity as well as pricing ranges which are used as a bench mark for likelihood to purchase and willingness to pay. The benchmarks for market sustained species are used to establish pricing goals for commonly discarded species suitable for similar culinary application.

Fisheries Data – Landings and Discards

Total species volume landed in 2014 was 643 million pounds which generated $1.2billion in revenue for the fishing industry at an average of $1.86 per pound of landed fish. Economic discards in 2014 were estimated to be 126million pounds. Based on 2014 average auction pricing (NOEP, 2014), the potential value of total discards was

$57million for an average of $0.45 per pound of fish (Table 2). The combined landed and discard totals equal a total capture volume of 769 million pounds at a potential value of $1.257billion. Total estimated economic discards represented 16.4% of the total capture and 4.5% of the total potential value.

Table 2. Estimated discard totals and potential value to fishers, 2014.

Species	Discards (pounds)	2014 auction $/#	Total $
Flounder Windowpane	1,630,000	$ 0.57	$ 929,100.00
Flounder, Winter	551,000	$ 1.97	$ 1,085,470.00
Flounder, Witch	227,000	$ 2.49	$ 565,230.00
Flounder, Yellowtail	488,000	$ 1.12	$ 546,560.00
Flounder, Summer	2,800,000	$ 3.60	$ 10,080,000.00
Haddock	980,000	$ 1.14	$ 1,117,200.00
Hake, OS Silver	14,000	$ 0.97	$ 13,580.00
Hake, Red	1,700,000	$ 0.38	$ 646,000.00
Hake, Silver	1,870,000	$ 0.70	$ 1,309,000.00
Hake, White	257,000	$ 1.39	$ 357,230.00
Monkfish	258,000	$ 2.35	$ 606,300.00
Acadian Redfish	981,000	$ 0.55	$ 539,550.00
Scup	1,070,000	$ 0.60	$ 642,000.00
Black Seabass	1,040,000	$ 3.28	$ 3,411,200.00
Spiny Dogfish	21,650,000	$ 0.21	$ 4,546,500.00
Skates	90,410,000	$ 0.34	$ 30,739,400.00
Totals	125926000	$ 0.45	$ 57,134,320.00

Economic Opportunity of Significant Discard Species

Total discards estimated in the 2014 NOAA survey included 17 species totaling 126 million pounds in discards. To assess the potential value of these discards from landing through the supply chain, data were analyzed through a spreadsheet model (Table 4). The model included industry standard costs and revenue targets for landing, processing and restaurant operation models. Of the 17 species in the NOAA survey, only 10 were included in the model as they were considered to have significant discard volumes, defined as >250,000 pounds. These 10 species represent 122 million lb of the total discard volume worth $45.1 million to fishers. Potential revenue for processors equaled $90.9 million. Potential restaurant revenue ranges from $355 million at the low end to $1.96 billion on the high end.

Historical Economic Opportunity of Significant Discard Species

Among the commonly discarded species, two represent the greatest volume, Skate and Spiny Dogfish. Combined they represent 112 million lb of economic discards. The historical performance of these two species does not align with the industry trends as a whole and consequently present little incentive for supply chain stakeholders to utilize them.

Skate. In 2014 over 90.4 million lb of skate were captured and discarded and only 19.6 million lb landed. The auction value for these species is well below the average for the entire fishery and has remained low over the past 12 years. Landing numbers have also been in decline. Numbers from 2010 are unusual and I could find no explanation for the incongruent figures. The combination of a consistent low value and declining landing numbers indicate low demand for the species. These low numbers occur despite the fact that skate wing is listed on menus at an above average price (Table 5). A likely explanation is that skate requires advanced skill to prepare for restaurant diners and may only appear in more refined operations that appeal to a smaller more affluent and adventurous clientele. The challenges of working with the product would exclude the majority of mid-level restaurant operations.

Spiny Dogfish: In 2014 10.35 million lb of dogfish was landed and 21.6 million lb was discarded. Since 2004 landings of dogfish have increased but auction pricing has remained flat (Table 6). The combination of increased landing with stagnant pricing indicates that there is no popular demand and that this species is a commodity product. New England fishers are likely selling to foreign markets and industrial applications. There was no documented menu presence in the menu sample and a comparable species was used for a menu pricing example. Dogfish is most easily used in a fried application and the analog menu pricing was based on haddock when used in similar fashion.

By comparison, the value trend of the New England fishery has been consistently trending in a predictable direction. Since 2004, the average price per lb at auction of fish landed in the New England fishery has nearly doubled, increasing from $1.13 to $2.23 while the total landed volume has declined by 17% (Table. 3). This combination of opposing trends indicates a steady demand for sea food products.

Table 3. New England fishery historical value.

Year	Pounds	Revenue	$/#
2004	716,409,983	$811,667,782	$1.13
2005	683,506,389	$970,247,785	$1.42
2006	752,458,168	$954,283,576	$1.27
2007	583,381,668	$903,471,441	$1.55
2008	600,986,923	$811,338,840	$1.35
2009	646,875,585	$782,170,184	$1.21
2010	577,818,115	$957,844,259	$1.66
2011	624,640,641	$1,109,313,720	$1.78
2012	664,243,459	$1,191,362,543	$1.79
2013	636,415,553	$1,163,449,099	$1.83
2014	643,137,170	$1,201,256,673	$1.87
2015	598,815,281	$1,238,119,260	$2.07
2016	594,998,906	$1,325,936,481	$2.23

Table 4. 2014 stakeholder value estimates for major discard species.

Capture	Flounder, Yellowtail	Flounder, Summer	Haddock	Hake, Silver	Hake, Red	Hake, White	Acadian Redfish	Scup	Skates	Spiny Dogfish
tal landed pounds (millions)	3.71	3.00	10.04	12.75	1.08	4.13	10.08	8.93	19.63	10.35
tal discarded pounds (millions)	0.49	2.80	0.98	1.87	1.70	0.26	0.98	1.07	90.41	21.65
tal Captured pounds (millions)	4.20	5.80	11.02	14.62	2.78	4.39	11.06	10.00	110.04	32.00
rcentage discarded	12%	48%	9%	13%	61%	6%	9%	11%	82%	68%
ice per pound	$ 1.01	$ 3.26	$ 1.03	$ 0.64	$ 0.34	$ 1.26	$ 0.50	$ 0.60	$ 0.30	$ 0.19
tal discard value (millions)	$ 0.49	$ 9.13	$ 1.01	$ 1.20	$ 0.58	$ 0.33	$ 0.49	$ 0.64	$ 27.12	$ 4.11
Discards Processing Costs and Value										
st of Processing +$0.20/lb	$ 1.21	$ 3.46	$ 1.23	$ 0.84	$ 0.54	$ 1.46	$ 0.70	$ 0.80	$ 0.50	$ 0.39
emium yield price 38% (26% for Skate)	3.18	9.11	$ 3.24	$ 2.21	$ 1.42	$ 3.84	$ 1.84	$ 2.11	$ 1.92	$ 1.03
emium price mark up +$0.60/lb	$ 3.78	$ 9.71	$ 3.84	$ 2.81	$ 2.02	$ 4.44	$ 2.44	$ 2.71	$ 2.52	$ 1.63
scard value to Processors (millions)	$ 0.70	$ 10.33	$ 1.43	$ 2.00	$ 1.31	$ 0.44	$ 0.91	$ 1.10	$ 59.31	$ 13.38
Discard Restaurant Costs and Value										
z portions yielded (millions)	0.37	2.13	0.74	1.42	1.29	0.20	0.74	0.81	68.71	16.45
st per 8oz portion	$ 1.89	$ 4.85	$ 1.92	$ 1.41	$ 1.01	$ 2.22	$ 1.22	$ 1.35	$ 1.26	$ 0.81
ate Cost = Protein Cost x 2	$ 3.78	$ 9.71	$ 3.84	$ 2.81	$ 2.02	$ 4.44	$ 2.44	$ 2.71	$ 2.52	$ 1.63
enu price 40% FC model	$ 9.46	$ 24.26	$ 9.59	$ 7.03	$ 5.05	$ 11.11	$ 6.11	$ 6.76	$ 6.31	$ 4.07
oss Profit Dollars	$ 5.68	$ 14.56	$ 5.76	$ 4.22	$ 3.03	$ 6.66	$ 3.66	$ 4.06	$ 3.78	$ 2.44
tal revenue (millions)	$ 2.11	$ 30.98	$ 4.29	$ 5.99	$ 3.92	$ 1.32	$ 2.73	$ 3.30	$ 260.05	$ 40.14
enu price 33.3% FC model	$ 11.35	$ 29.12	$ 11.51	$ 8.43	$ 6.06	$ 13.33	$ 7.33	$ 8.12	$ 7.57	$ 4.88
oss Profit Dollars per serving	$ 7.57	$ 19.41	$ 7.67	$ 5.62	$ 4.04	$ 8.88	$ 4.88	$ 5.41	$ 5.05	$ 3.25
tal revenue (millions)	$ 2.82	$ 41.31	$ 5.72	$ 7.99	$ 5.22	$ 1.76	$ 3.64	$ 4.40	$ 346.73	$ 53.52
enu price 25% FC model	$ 15.14	$ 38.82	$ 15.35	$ 11.24	$ 8.08	$ 17.77	$ 9.77	$ 10.82	$ 10.09	$ 6.51
oss Profit Dollars per serving	$ 11.35	$ 29.12	$ 11.51	$ 8.43	$ 6.06	$ 13.33	$ 7.33	$ 8.12	$ 7.57	$ 4.88
tal revenue (millions)	$ 4.23	$ 61.96	$ 8.57	$ 11.98	$ 7.83	$ 2.63	$ 5.46	$ 6.60	$ 520.09	$ 80.28
enu price 20% FC model	$ 18.92	$ 48.53	$ 19.18	$ 14.05	$ 10.11	$ 22.21	$ 12.21	$ 13.53	$ 12.62	$ 8.13
oss Profit Dollars per serving	$ 15.14	$ 38.82	$ 15.35	$ 11.24	$ 8.08	$ 17.77	$ 9.77	$ 10.82	$ 10.09	$ 6.51
tal revenue (millions)	$ 5.64	$ 82.61	$ 11.43	$ 15.98	$ 10.44	$ 3.51	$ 7.28	$ 8.80	$ 693.46	$ 107.04
erage Menu Price from Sample	$ 23.54	$ 18.00	$ 20.58	$ 24.00	$ 21.00	$ 27.50	$ 24.85	$ 26.75	$ 25.95	$ 14.82
oss Profit Dollars per serving	$ 19.76	$ 8.29	$ 16.74	$ 21.19	$ 18.98	$ 23.06	$ 22.41	$ 24.04	$ 23.43	$ 13.19
tal Potential Revenue at Listed Menu	$ 7.36	$ 17.65	$ 12.47	$ 30.11	$ 24.52	$ 4.56	$ 16.69	$ 19.55	$ 1,609.70	$ 217.09

Table 5. 2004 – 2016 stakeholder value estimates – skate.

ice per pound	$ 0.16	$ 0.18	$ 0.21	$ 0.24	$ 0.18	$ 0.20	2.79	$ 0.25	$ 0.23	$ 0.30	$ 0.30	$ 0.20	$ 0.19
rcentage change from 2004	12%	0%	4%	12%	-19%	-98%	41%	-41%	-56%	-42%	-42%	-48%	
% Premium yield cost to Restaurant	$ 1.38	$ 1.46	$ 1.58	$ 1.69	$ 1.46	$ 1.54	$ 1.50	$ 1.73	$ 1.65	$ 1.92	$ 1.92	$ 1.54	$ 1.50
ate Cost = Protein x 2	$ 1.98	$ 2.06	$ 2.18	$ 2.29	$ 2.06	$ 2.14	$ 2.10	$ 2.33	$ 2.25	$ 2.52	$ 2.52	$ 2.14	$ 2.10
tal revenue (millions)	$ 87.72	$ 80.19	$ 96.36	$ 96.85	$ 102.22	$ 77.03	$ 12.90	$ 60.33	$ 59.07	$ 50.18	$ 64.39	$ 54.52	$ 48.68
tal revenue (millions)	$ 105.26	$ 96.22	$ 115.63	$ 116.22	$ 122.66	$ 92.44	$ 15.48	$ 72.39	$ 70.88	$ 60.22	$ 77.26	$ 65.42	$ 58.41
tal revenue (millions)	$ 140.35	$ 128.30	$ 154.18	$ 154.96	$ 163.54	$ 123.25	$ 20.64	$ 96.52	$ 94.51	$ 80.29	$ 103.02	$ 87.23	$ 77.88
tal revenue (millions)	$ 175.44	$ 160.37	$ 192.72	$ 193.70	$ 204.43	$ 154.07	$ 25.80	$ 120.65	$ 118.14	$ 100.37	$ 128.77	$ 109.03	$ 97.35

Table 6. 2004 – 2016 stakeholder value estimates – spiny dogfish

Landing	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total
unds of fish landed (millions)	1.42	2.23	4.23	3.45	4.92	7.39	8.70	12.52	16.61	7.85	10.35	8.39	15.03	1[illegible]
ice per pound	$ 0.17	$ 0.20	$ 0.25	$ 0.23	$ 0.28	$ 0.23	$ 0.21	$ 0.21	$ 0.20	$ 0.15	$ 0.19	$ 0.16	$ 0.22	[illegible]
tal landed value (millions)	$ 0.24	$ 0.45	$ 1.06	$ 0.79	$ 1.38	$ 1.70	$ 1.83	$ 2.63	$ 3.32	$ 1.18	$ 1.97	$ 1.34	$ 3.31	$ 2
nding change from 2004 (millions)		0.81	2.81	2.03	3.50	5.97	7.28	11.10	15.19	6.43	8.93	6.97	13.61	
rcentage change from 2004		57%	198%	143%	246%	420%	513%	782%	1070%	453%	629%	491%	958%	
ice change %		18%	25%	-8%	22%	-18%	-9%	0%	-5%	-25%	27%	-16%	38%	
Processing														
st of Processing +$0.20/lb	$ 0.37	$ 0.40	$ 0.45	$ 0.43	$ 0.48	$ 0.43	$ 0.41	$ 0.41	$ 0.40	$ 0.35	$ 0.39	$ 0.36	$ 0.42	
% Premium yield	$ 0.97	$ 1.05	$ 1.18	$ 1.13	$ 1.26	$ 1.13	$ 1.08	$ 1.08	$ 1.05	$ 0.92	$ 1.03	$ 0.95	$ 1.11	
emium price mark up +$0.60/lb st to Restaurant	$ 1.57	$ 1.65	$ 1.78	$ 1.73	$ 1.86	$ 1.73	$ 1.68	$ 1.68	$ 1.65	$ 1.52	$ 1.63	$ 1.55	$ 1.71	
emium price change from 2014 %		5%	13%	10%	18%	10%	7%	7%	5%	-3%	3%	-2%	8%	
tal value to Processors (millions)	$ 0.85	$ 1.40	$ 2.87	$ 2.27	$ 3.48	$ 4.86	$ 5.55	$ 7.99	$ 10.43	$ 4.54	$ 6.40	$ 4.93	$ 9.74	$ 6
lue Change from 2014		65%	238%	167%	310%	473%	554%	841%	1128%	434%	653%	481%	1047%	
Restaurants														
z portions available	0.74	1.16	2.20	1.79	2.56	3.84	4.52	6.51	8.64	4.08	5.38	4.36	7.82	[illegible]
st per 8oz portion	$ 0.79	$ 0.83	$ 0.89	$ 0.87	$ 0.93	$ 0.87	$ 0.84	$ 0.84	$ 0.83	$ 0.76	$ 0.81	$ 0.77	$ 0.85	
ate Cost = Protein x 2	$ 1.31	$ 1.38	$ 1.49	$ 1.45	$ 1.56	$ 1.45	$ 1.40	$ 1.40	$ 1.38	$ 1.27	$ 1.36	$ 1.29	$ 1.42	
enu price 40% FC model	$ 3.29	$ 3.45	$ 3.72	$ 3.61	$ 3.89	$ 3.61	$ 3.50	$ 3.50	$ 3.45	$ 3.18	$ 3.39	$ 3.23	$ 3.56	
oss Profit Dollars per serving	$ 1.97	$ 2.07	$ 2.23	$ 2.17	$ 2.33	$ 2.17	$ 2.10	$ 2.10	$ 2.07	$ 1.91	$ 2.04	$ 1.94	$ 2.14	
tal revenue (millions)	$ 2.43	$ 4.00	$ 8.19	$ 6.48	$ 9.95	$13.89	$15.86	$22.82	$ 29.80	$12.96	$18.27	$14.09	$ 27.82	$ 18
enu price 33.3% FC model	$ 3.94	$ 4.14	$ 4.47	$ 4.34	$ 4.67	$ 4.34	$ 4.21	$ 4.21	$ 4.14	$ 3.81	$ 4.07	$ 3.88	$ 4.27	
oss Profit Dollars per serving	$ 3.16	$ 3.31	$ 3.58	$ 3.47	$ 3.74	$ 3.47	$ 3.37	$ 3.37	$ 3.31	$ 3.05	$ 3.26	$ 3.10	$ 3.42	
tal revenue (millions)	$ 2.91	$ 4.80	$ 9.83	$ 7.78	$11.94	$16.67	$19.03	$27.38	$ 35.76	$15.55	$21.93	$16.91	$ 33.39	$ 22
enu price 25% FC model	$ 5.26	$ 5.52	$ 5.96	$ 5.78	$ 6.22	$ 5.78	$ 5.61	$ 5.61	$ 5.52	$ 5.08	$ 5.43	$ 5.17	$ 5.70	
oss Profit Dollars per serving	$ 4.47	$ 4.69	$ 5.07	$ 4.92	$ 5.29	$ 4.92	$ 4.77	$ 4.77	$ 4.69	$ 4.32	$ 4.62	$ 4.39	$ 4.84	
tal revenue (millions)	$ 3.88	$ 6.40	$13.11	$10.38	$15.92	$22.22	$25.37	$36.51	$ 47.68	$20.74	$29.23	$22.55	$ 44.51	$ 29
enu price 20% FC model	$ 6.57	$ 6.90	$ 7.45	$ 7.23	$ 7.78	$ 7.23	$ 7.01	$ 7.01	$ 6.90	$ 6.35	$ 6.79	$ 6.46	$ 7.12	
oss Profit Dollars per serving	$ 5.78	$ 6.07	$ 6.56	$ 6.36	$ 6.85	$ 6.36	$ 6.17	$ 6.17	$ 6.07	$ 5.59	$ 5.98	$ 5.69	$ 6.27	
tal revenue (millions)	$ 4.85	$ 8.00	$16.38	$12.97	$19.90	$27.78	$31.71	$45.64	$ 59.59	$25.92	$36.54	$28.18	$ 55.64	$ 37
tal potential value based on Menu ice Avg of Similar Preparation: $14.82	$10.94	$17.19	$32.60	$26.59	$37.92	$56.95	$67.05	$96.48	$128.00	$60.50	$79.76	$64.66	$115.83	$ 79

Discard Reduction Simulations

The simulations test the range of impact changes in laws governing discards would have on the economics of the sea food supply chain and the incidental fish mortality caused by the practice of discards.

For 2014 the fish landed was 643 million lb (Table 6) and the total estimated discards equaled 126 million lb. The equals a total capture of 769 million lb. In this simulation, the total landing weight remained constant as the simulation approached closer to a zero-discard scenario. Consequently, the total capture decreased until it was equal to the total landing 643 million lb. A total ban on discards with a static landing weight would yield a 16.4% reduction in total fish mortality for both target and non-target species (Table 7).

Simulation example 1: 100% discard reduction scenario. In the discard reduction scenarios, the total landings of the fishery remained equal to the 643million pounds of fish landed in 2014 with a discard rate of 0%. In this discard reduction scenario, with a static total landed weight, species typically discarded represented 16.4% percent of the capture or 105.4 million lb. This would reduce landings of target species by an equal amount. With the addition of the discard species, the total value of the catch changes to reflect the value of the landed species. The economic discards are valued at an average of \$0.45/lb. versus the target species of \$1.87/lb. In a static landed weight scenario, the change in capture mix would mean a net reduction of \$150 million in landed value for 2014.

At the processor level, the change landed species mix and the corresponding value represents a decline of $364 million in processor value for 2014. At the restaurant level, the changed in landed species mix and the corresponding value represents a decline of $1.19 billion of potential revenue.

Table 7. Discard reduction simulation

Capture	No Reduction	10% Reduction	20% Reduction	30% Reduction	40% Reduction	50% Reduction	60% Reduction	70% Reduction	80% Reduction	90% Reductin	10
tal landed pounds (millions)	643	643	643	643	643	643	643	643	643	643	
rget species landed pounds (millions)	643	632	622	611	601	590	580	569	559	548	
card species landed pounds (millions)	0	11	21	32	42	53	63	74	84	95	
card species discarded pounds (millions)	126	113	101	88	76	63	50	38	25	13	
tal Capture	769	756	744	731	719	706	693	681	668	656	
rget species value per pound	$ 1.86	$ 1.86	$ 1.86	$ 1.86	$ 1.86	$ 1.86	$ 1.86	$ 1.86	$ 1.86	$ 1.86	$
card species value per pound	$ 0.45	$ 0.45	$ 0.45	$ 0.45	$ 0.45	$ 0.45	$ 0.45	$ 0.45	$ 0.45	$ 0.45	$
tal catch value (millions)	$ 1,196	$ 1,181	$ 1,166	$ 1,151	$ 1,137	$ 1,122	$ 1,107	$ 1,092	$ 1,077	$ 1,062	$
r pound average	$ 1.86	$ 1.84	$ 1.81	$ 1.79	$ 1.77	$ 1.74	$ 1.72	$ 1.70	$ 1.68	$ 1.65	$
Discards Processing Costs and Value											
st of Processing +$0.20/lb	$ 2.06	$ 2.04	$ 2.01	$ 1.99	$ 1.97	$ 1.94	$ 1.92	$ 1.90	$ 1.88	$ 1.85	$
emium yield price 38%	5.42	5.36	$ 5.30	$ 5.24	$ 5.18	$ 5.12	$ 5.06	$ 5.00	$ 4.93	$ 4.87	$
emium price mark up +$0.60/lb Cost Restaurant	$ 6.02	$ 5.96	$ 5.90	$ 5.84	$ 5.78	$ 5.72	$ 5.66	$ 5.60	$ 5.53	$ 5.47	$
lue to Processors (millions)	$ 1,471	$ 1,432	$ 1,394	$ 1,356	$ 1,319	$ 1,282	$ 1,246	$ 1,210	$ 804	$ 1,140	$
Discard Restaurant Costs and Value											
z portions yielded (millions)	488.68	488.68	488.68	488.68	488.68	488.68	488.68	488.68	488.68	488.68	
st per 8oz portion	$ 3.01	$ 2.98	$ 2.95	$ 2.92	$ 2.89	$ 2.86	$ 2.83	$ 2.80	$ 2.77	$ 2.74	$
ite Cost = Protein Cost x 2	$ 6.02	$ 5.96	$ 5.90	$ 5.84	$ 5.78	$ 5.72	$ 5.66	$ 5.60	$ 5.53	$ 5.47	$
enu price 40% FC model	$ 15.05	$ 14.90	$ 14.75	$ 14.60	$ 14.44	$ 14.29	$ 14.14	$ 13.99	$ 13.84	$ 13.68	$
oss Profit Dollars	$ 9.03	$ 8.94	$ 8.85	$ 8.76	$ 8.67	$ 8.58	$ 8.48	$ 8.39	$ 8.30	$ 8.21	$
tal revenue (millions)	$ 4,413.55	$ 4,368.98	$ 4,324.42	$ 4,279.85	$ 4,235.28	$ 4,190.72	$ 4,146.15	$ 4,101.58	$ 4,057.01	$ 4,012.45	$
enu price 33.3% FC model	$ 18.06	$ 17.88	$ 17.70	$ 17.52	$ 17.33	$ 17.15	$ 16.97	$ 16.79	$ 16.60	$ 16.42	$
oss Profit Dollars per serving	$ 12.04	$ 11.92	$ 11.80	$ 11.68	$ 11.56	$ 11.43	$ 11.31	$ 11.19	$ 11.07	$ 10.95	$
tal revenue (millions)	$ 5,884.74	$ 5,825.31	$ 5,765.89	$ 5,706.47	$ 5,647.04	$ 5,587.62	$ 5,528.20	$ 5,468.77	$ 5,409.35	$ 5,349.93	$
enu price 25% FC model	$ 24.08	$ 23.84	$ 23.60	$ 23.35	$ 23.11	$ 22.87	$ 22.63	$ 22.38	$ 22.14	$ 21.90	$
oss Profit Dollars per serving	$ 18.06	$ 17.88	$ 17.70	$ 17.52	$ 17.33	$ 17.15	$ 16.97	$ 16.79	$ 16.60	$ 16.42	$
tal revenue (millions)	$ 8,827.10	$ 8,737.97	$ 8,648.83	$ 8,559.70	$ 8,470.57	$ 8,381.43	$ 8,292.30	$ 8,203.16	$ 8,114.03	$ 8,024.89	$
enu price 20% FC model	$ 30.11	$ 29.80	$ 29.50	$ 29.19	$ 28.89	$ 28.59	$ 28.28	$ 27.98	$ 27.67	$ 27.37	$
oss Profit Dollars per serving	$ 24.08	$ 23.84	$ 23.60	$ 23.35	$ 23.11	$ 22.87	$ 22.63	$ 22.38	$ 22.14	$ 21.90	$
tal revenue (millions)	$ 11,769.47	$ 11,650.63	$ 11,531.78	$ 11,412.93	$ 11,294.09	$ 11,175.24	$ 11,056.40	$ 10,937.55	$ 10,818.70	$ 10,699.86	$

Simulation example 2: 50% discard reduction scenario. Total landings of the fishery were also set to equal 643 million pounds of fish, but with a discard rate of 8.2%. In this discard reduction scenario with a static total landed weight, species typically discarded would represent 8.2% percent of the capture or 53.18 million lb. This would reduce landings of target species by an equal amount. With the addition of the discard species, the total value of the catch changes to reflect the value of the landed species. The economic discards are valued at an average of $0.45/lb versus the target species of $1.87/lb In a static landed weight scenario, the change in capture mix would mean a net reduction of $75 million in landed value for 2014.

At the processor level, the change landed species mix and the corresponding value represents a decline of $189 million in processor value for 2014.

At the restaurant level, the changed in landed species mix and the corresponding value represents a decline of $594 billion in potential revenue.

Simulation example 3: 20% discard reduction scenario. Total landings of the fishery is again equal to 643million pounds of fish, now with a discard rate of 13.1%. In this discard reduction scenario with a static total landed weight, species typically discarded would represent 3.3% percent of the capture or 21 million lb. This would reduce landings of target species by an equal amount. With the addition of the discard species, the total value of the catch changes to reflect the value of the landed species. As in all scenarios, the economic discards are valued at an average of $0.45/pound versus the target species of $1.87/pound. In this static landed weight scenario, the change in capture mix would mean a net reduction of $30 million in landed value for 2014.

At the processor level, the change landed species mix and the corresponding value represents a decline of $77 million in processor value for 2014.

At the restaurant level, the changed in landed species mix and the corresponding value represents a decline of $237.5 billion of potential revenue.

Menu Survey Results

A sample of 415 restaurant menus were taken during data collection phase of the project. Of the 415 menus samples, 333 menus contained complete data relevant to this research. Each menu was reviewed for the 92 verifiably different species from the condensed NOEP data set. A total of 1790 menu entries of New England wild capture fishery products or same species of undeclared origin were recorded (Table 8).

Table 8. Menu survey data.

Menu survey data	
New England Restaurants on Open Table	11058
New England Restaurants identified as Seafood focused	415
New England Restaurants that met sample criteria	333
Total number of species in NE wild fisheries designated by NOEP	115
Total number of specifically identifiable species	102
Total number of species on menus sampled	40
Total number of entries of seafood offerings	1790

Menu Pricing

Menu pricing for total lunch entrees ranged from a high of $33.00 for scallops to a low of $8.00 for Haddock (Figure 1). Menu pricing for all sampled dinner entrees ranged from a high of $45 for Yellow Fin Tuna to a low of $11.75 for Haddock. Average menu pricing for lunch entrees ranged from a high of $18.82 for Yellowfin Tuna to a low of $14.82 for Haddock. Average menu pricing for dinner entrees ranged from a high of $31.09 for Atlantic Halibut to a low of $18.00 for Summer Flounder.

Menu Price Range

The range of pricing on menus varied significantly even within the same species (Figure 2). This fluctuation is driven by the individual businesses and the decision being made by operators on what to offer and at what price. The significance of these wide ranges indicates that willingness to pay is elastic, and based on my experience in the restaurant industry, value perception is often more heavily influenced by factors such as ambiance, preparation and service than merely the core protein on the dish. An item like tuna, which has a relatively high mean menu price for the dinner portion at $28, was still recorded to be offered as low as $17. Conversely, a species like Summer Flounder, which is often an economic discard and has a relatively low mean menu price at $18, was also listed on menus as high as $32 for a dinner entrée.

Aquaculture salmon was included for menu price comparison. Though not a wild capture species, farmed salmon was the most common species of fish represented in the menu sample and provides a relevant point of reference for a consumer's willingness to pay for seafood. Farmed Salmon had an average dinner price of $24.06 with a max price of $40.95 and a minimum price of $14.79. The expansive range of pricing on farmed Salmon can be at least partially explained by the value perception associated with point of origin. Farmed salmon from Chile is commonly perceived as being of lower value than Salmon from aquaculture operations in the North Atlantic, like those from Scotland or the Faroe Islands.

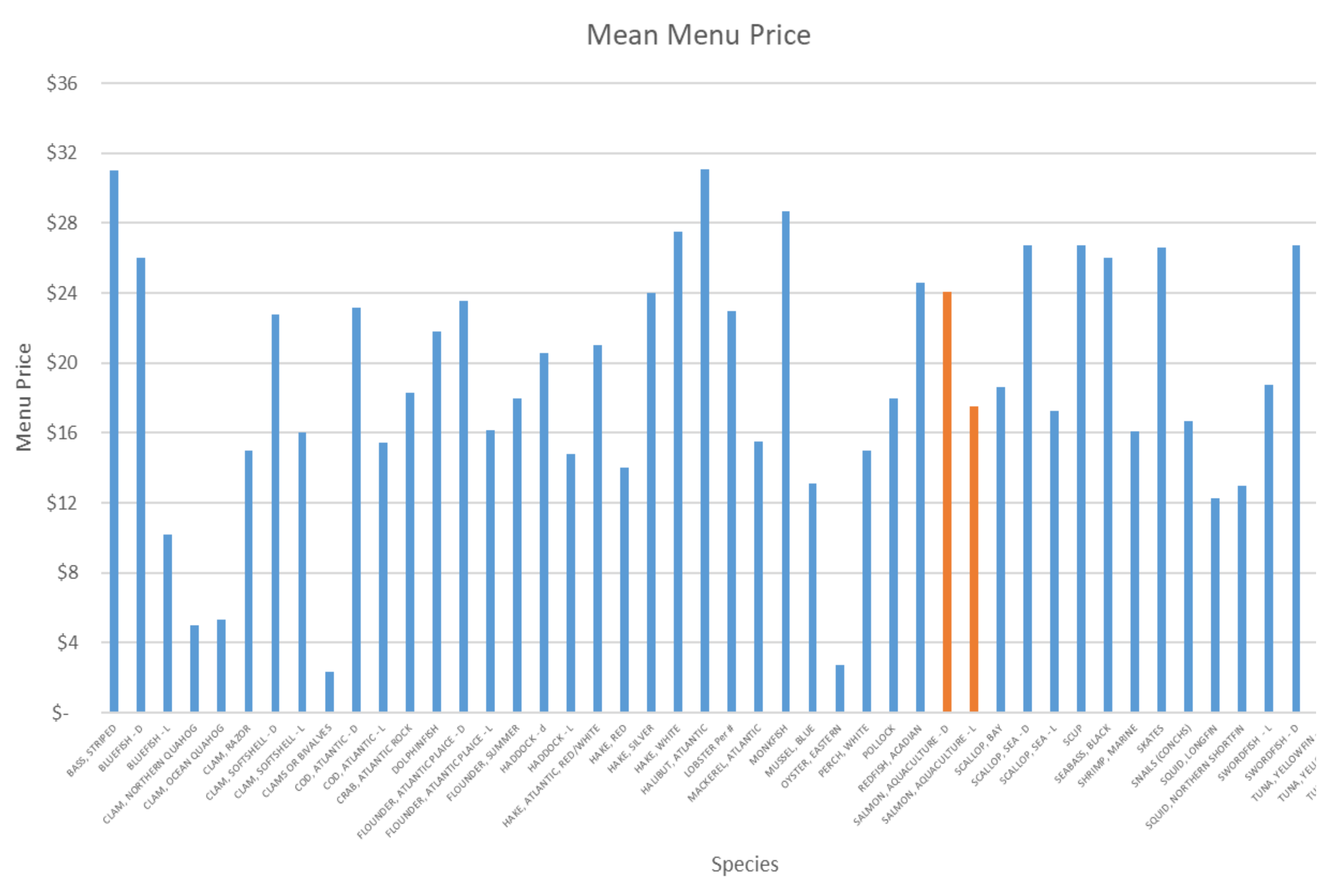

Figure 1. Mean menu price of seafood species.

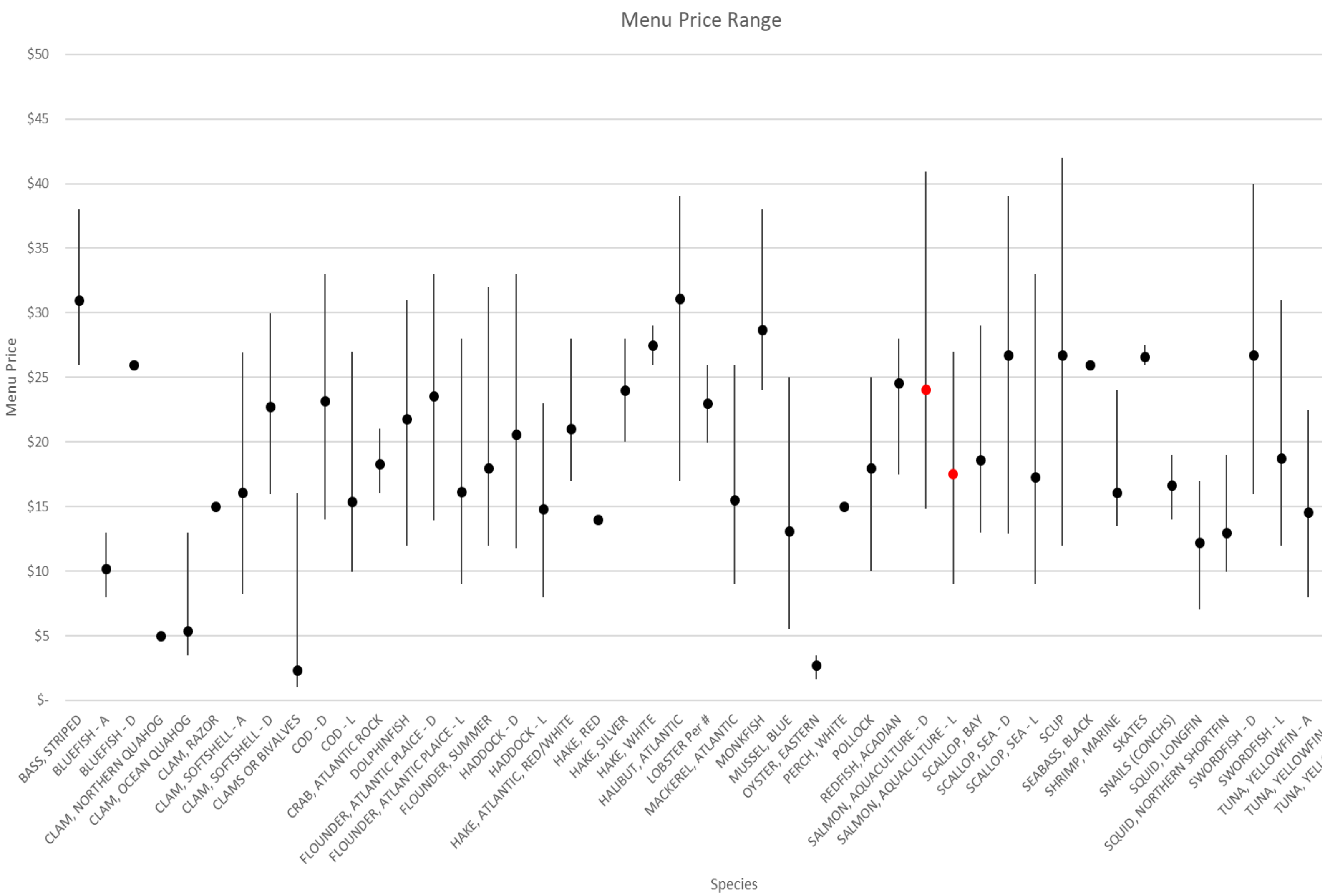

Figure 2. Menu price range of seafood species.

Popularity

Species were determined to be popular based on the frequency with which they appeared on restaurant menus. Of the species commercially captured more than half made no appearance on the menus sampled (Table 9).

Table 9. Species not represented in the menu sample.

No Menu Representation			
AMBERJACK	DORY, AMERICAN JOHN	LEATHERJACKETS	SHARK, SHORT MAKO
BLOODWORMS	EEL, AMERICAN	MACKEREL, CHUB	SHARK, SMOOTH DOGFISH
BONITO, ATLANTIC	EEL, CONGER	MACKEREL, SPANISH	SHARK, SPINY DOGFISH
BUTTERFISH	ESCOLAR	MENHADEN,	SILVERSIDES
CLAM, ARC, BLOOD	FLOUNDER, WINDOWPANE	OYSTER, EUROPEAN	SKATE, LITTLE
CLAM, JACKKNIFE	FLOUNDER, WINTER	PERIWINKLES	TAUTOG
CLAM, SURF	FLOUNDER, WITCH	SEA CUCUMBER	TILEFISH, BLUELINE
CRAB, BLUE	FLOUNDER, YELLOWTAIL	SEA RAVEN	TILEFISH, GOLDEN
CRAB, GREEN	FLOUNDER, FOURSPOT	SEA URCHINS	TUNA, ALBACORE
CRAB, HORSESHOE	GOOSEFISH	SEAROBINS	TUNA, BIGEYE
CRAB, JONAH	HAKE, OFFSHORE SILVER	SHAD, AMERICAN	TUNA, BLUEFIN
CRABS, GEN	HERRING, ATLANTIC	SHAD, HICKORY	TUNA, LITTLE TUNNY
CROAKER, ATLANTIC	HERRINGS	SHARK, DOGFISH	WAHOO
CUNNER	KING WHITING	SHARK, LONG MAKO	WEAKFISH
CUSK	LAUNCES	SHARK, PORBEAGLE	WHELK, CHANNELED
			WHELK, KNOBBED

Of the species commercially captured in New England fisheries, 40 made appearances in the menu samples. Of these 40 species, five made up 57.5% of total appearances. The top five most common menu items of wild species across all meal periods were Yellowfin Tuna with 254 menu appearances, Scallops with 251 menu appearances, Haddock with 219 menu appearances, Mussels with 171 menu appearances, and Cod with 134 menu appearances (Table 10). As point of comparison, farmed Salmon made 316 menu appearances.

Table 10. Species represented in menu sample.

Menu Representation		
TUNA, YELLOWFIN	254	14.19%
SCALLOPS	251	14.02%
HADDOCK	219	12.23%
MUSSEL, BLUE	171	9.55%
COD	134	7.49%
OYSTER, EASTERN	123	6.87%
SWORDFISH D	105	5.87%
CLAM, SOFTSHELL - A	83	4.64%
CLAMS OR BIVALVES	82	4.58%
SQUID, LONGFIN	81	4.53%
FLOUNDER, PLAICE	67	3.74%
SWORDFISH L	33	1.84%
HALIBUT, ATLANTIC	30	1.68%
MONKFISH	16	0.89%
DOLPHINFISH	14	0.78%
BLUEFISH	13	0.73%
CLAM, OCEAN QUAHOG	13	0.73%
SALMON, WILD	12	0.67%
BASS, STRIPED	11	0.61%
POLLOCK	11	0.61%
SQUID, NORTHERN SHORTFIN	9	0.50%
SCALLOP, BAY	8	0.45%
SHRIMP, MARINE	6	0.34%
FLOUNDER, SUMMER	4	0.22%
MACKEREL, ATLANTIC	4	0.22%
REDFISH, ACADIAN	6	0.34%
SKATES	4	0.22%
CRAB, ATLANTIC ROCK	3	0.17%
HAKE, ATLANTIC, RED/WHITE	3	0.17%
SNAILS (CONCHS)	3	0.17%
HAKE, SILVER	2	0.11%
HAKE, WHITE	2	0.11%
LOBSTER Per #	2	0.11%
PERCH, WHITE	2	0.11%
ALEWIFE	1	0.06%
CLAM, ATLANTIC JACKKNIFE	1	0.06%
CLAM, NORTHERN QUAHOG	1	0.06%
HAKE, RED	1	0.06%
SEABASS, BLACK	1	0.06%

Menu Influence

The combination of pricing and popularity determine the menu influence of a particular species (Figure 3). This is indicated by menu value, the product of mean menu pricing and the frequency with which a species appeared on menus in the sample. A species with a high frequency of occurrences on menus but a low menu price will be a less desirable target species than one with both a high frequency of occurrences and a higher price point. Species with low menu presence and low cost have proven to provide little incentive for members of the seafood supply chain to use. In instances where an item is uncommon and low cost, the individual business owner is making a conscious decision to take a risk on a product for reasons other than obvious financial success.

Red Hake is a good example of this. The single offering of Red Hake on any menu in this study is by Turner's Seafood in Salem. This business is known for having a strong direct connection to the fishing community and caters to aficionados of New England Seafood who would see the value in an underutilized species. Razor Clams is another which is singularly offered by Island Creek Oyster Bar in Boston. This business is run in conjunction with the Island Creek Oyster farm which has a strong reputation for environmental stewardship and providing specialty and often overlooked local bi-valve species. These businesses are making menu decisions supportive of their brand identity as specialists and activists instead of aligning with prevailing financial philosophy.

The two major discard species analyzed in this research, Skate and Spiny Dogfish, have little or no menu influence as a result of low popularity and low market value

(Figure 2). By comparison, farmed Salmon is the most influential of all species documented in the menu sample.

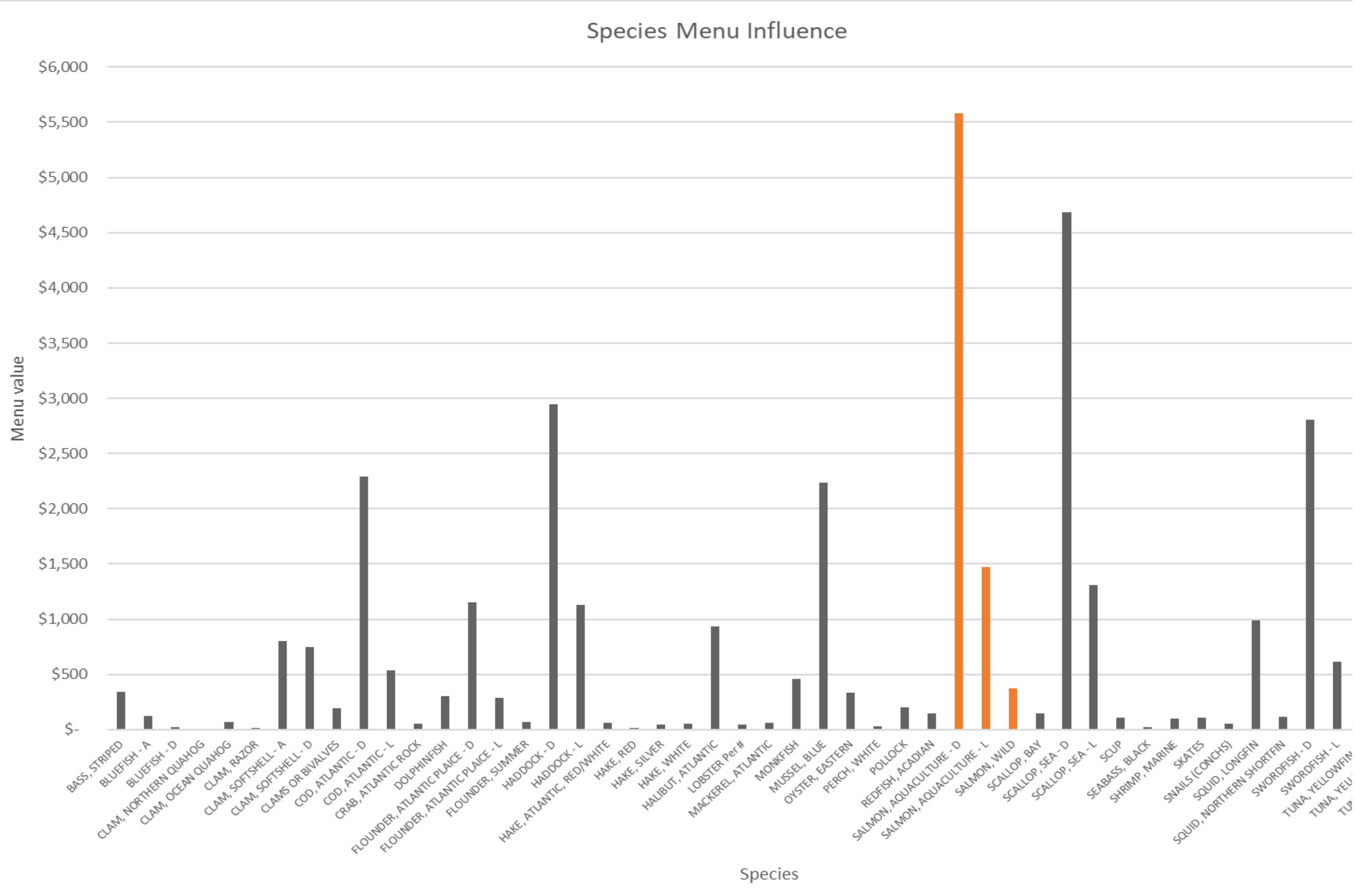

Figure 3. Species menu influence.

Chapter IV

Discussion

This research sought to reveal the root causes for the practice of economic discarding in the New England fishing industry, which persists despite evidence illustrating the damage it causes to the near and far term health of the fishery. The broad explanation is that the system of economic incentives for fishermen causes them to behave against the best interest of the resource upon which they depend. The economic and ecological waste inherent in capturing and discarding species which may be utilized as a viable source of inexpensive protein is perpetuated by a market failure. As the resource is depleted it becomes more valuable and increases the incentives to exploit it. Other viable species maintain their status of low economic value and the cultural perception of low value reduces demand further.

Impacts of Discards and Discard Reduction Strategies

The economic impact of banning all discards in the simulation scenarios showed that a total ban on discarding would flood the catch with low value species and cause a significant decline in the total revenue generated through the supply chain. This total discard ban would reduce catch value to the fishers by $150 million. The trade-off is that total fish mortality would be reduced by 126 million lb. of all species regardless of value. What is the positive impact of 126 million lb. reduction in fish mortality?

The current market conditions do not take into consideration long term impacts of fishing operations. The value placed on species today is not reflective of the true costs that current fishing practices have on the ecosystem. If exploitation occurs today at a level which causes a decline in future productivity permanently, those captured fish now bear the cost of every fish not captured moving forward. If the 2016 NE fishery generated $1.3 billion in revenue just at landing, what is the cost to supplement that industry if fisheries collapse and productivity falls by a significant percentage?

Beyond fishers, the second and third tier businesses depending on those products are vulnerable to revenue decline as well. A restaurant with a client base accustomed to eating a particular species at a particular price may stop coming if the species price increases significantly or is no longer available.

Instead of low value species attracting new consumers based on similar flavor and texture at a value proposition, the market continues to reward the focused utilization of a few landed species. Despite the 17% decline in productivity between 2004 and 2016 in the New England fishery, total revenue of the industry has increased by 39%.

The price gap between target and non-target species has widened and grows increasingly difficult to span. Education and marketing campaigns to drive demand may be effective to combat the cultural assignments of quality vs low-quality species. A greater willingness of consumers to try and regularly purchase an underutilized species would naturally increase value and correspondingly adjust the incentives for fishers to land previously discarded species.

Some parallels can be drawn to monocultures in the agricultural sector, where the logistics of that industry are largely tailored to the production, transportation and processing of corn and soybeans. Equipment, processing and consumers have been accustomed to producing and consuming a single product in massive quantities, and the prospects of making an adjustment to a more complicated and diversified system is undesirable. Restaurant operators already track hundreds of business-impacting variables and commodity ingredients, so attempting to make a system more complex is unappealing without a provable and tangible benefit. They would hesitate to take on a species that may have variable availability, short supply, poor name recognition complex preparation needs or a negative guest perception.

This risk is more tolerable at small operations where control of the product and execution are limited to a few items. In a small operation, the financial risk may also be lower as the supply needed will be smaller and there is greater ability to adjust in the moment if necessary. The larger an operation becomes the less likely it is to take a risk on a lesser known species or one with limited availability. At an increased size, an operation loses some agility and execution fidelity. Large scale operators are less likely to make the time and resource investment to acquire and implement a new dish unless they know it will be successful.

Market Influencers

Point of origin becomes relevant in discussions of influencing market pricing when locally caught species supply is low but an alternate supply is available from another location. This variable delays a market correction. Even though supply may decline locally, pricing does not increase due to international supply. If a discard ban was applied, the importation of regionally popular species from fisheries outside of New

England will disguise the lack of local species availability and suppress a rise in menu cost. This suppression will delay a natural market correction. The international supply will suppress financial incentives for consumers to regularly purchase underutilized species they have generally avoided or not been offered in the past. This will also challenge the viability of alternative species fisheries as the price on their capture will be slow to appreciate. Even with financial assistance, the time line to realize a return on investment may be too long for new fisheries to remain fiscally cogent.

Menu Strategies

Menu pricing was rigid in this research, and not explored in calculations. However, with a nearly limitless number of ingredient combinations available, a chef has great flexibility to interchange ingredients and manipulate costing. Additionally, a properly engineered menu is a balance of high and low-cost items working in concert to achieve the financial goals of the business. Each item on a menu plays a role and price isn't always the primary consideration. Menu items can serve different purposes, like to attract guests, speed the pace of service, provide a value, show off, establish culinary credibility or make a statement. This means the same items may be priced differently from business to business without significant change in the dish components. The differing models of high volume vs fine dining are a good example. A guest will understand that the higher price on the menu in a fine dining restaurant is also representative of the service and ambiance of the business not merely a reflection of the cost of the food.

Research Limitations

This research was limited by the accuracy of the estimated discard ratios and mortality rates presented by the NMFS and other research. Additionally, it assumed all species are equally valuable in the ecosystem and that total mortality is a relevant measure for managing a fishery. When assessing the market potential of species, this research only considered premium pricing for product sent to restaurants. It does not consider the markets for processed and canned applications, nor does it account for the non-human consumption or industrial application markets.

This research also does not allow for an increased total weight of catch due to the availability of underutilized species. Nor did this analysis account for the continued improvement of selective fishing gear, which could reach a level of selectiveness sufficient to change the capture ratios and retain only the most valuable species on the market. I also assumed static pricing and demand for the variety of species and did not account for value adjustments in the market place driven by supply and demand. However, the model lends itself to be manipulated to adjust for this in follow up research.

Questions for Further Research

Under a discard ban scenario, how would pricing for underutilized species change given the greater availability of the low value species and a decreased availability of the high value species?

What level of investment in education would be sufficient to improve public perception of underutilized species enough to establish a demand capable of driving landing price to a self-sustaining level?

Assuming fishing operations are exclusively responsible for the decline of productivity in New England fisheries over the last 12 years, what is the true cost of overfishing today if discard practices don't change and the decline continues?

Conclusions

The issues surrounding the ecological and economic viability of the New England fishery are complex and highly interwoven. Implying that fishers are only at fault and should just land all caught species is a gross over simplification of the challenges of bycatch and the market forces at work. If fishers had the economic incentives to retain total catch, they would. That incentive must be supported by demand from the consumers and if consumers have a choice and an ability to pay they will not be incentivized to alter preferences. The true cost of highly popular New England caught species is somewhat disguised as less expensive international supply or farmed species suppress menu prices and keep the consumer value perception low.   However, in the interest of protecting the health of fish stocks and the aquatic ecosystem which supplies the seafood, a regulatory intervention to correct the market failure may be necessary to prevent an irreversible collapse.

Taking full advantage of the discarded bycatch species is possible but would require an adjustment in how the industry handles those species and more significantly an adjustment in the dining preferences of consumers.

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