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The Role of Underutilized Fish in New England's Seafood System

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ABSTRACT

The global fisheries crisis has led to an increasing recognition for the need to relieve pressure on overfished, popular food fish stocks. Opportunities exist to shift consumer demand toward more sustainable choices, including fish that may be locally abundant. Attempts have been made to market underused fish (sometimes termed "trash fish") that represent more sustainable alternatives; however, it is unclear whether consumers will choose to purchase these more sustainable options, particularly if underused fish are also unfamiliar. Chapter 1 reviews existing research and current issues surrounding sustainable seafood and the recent shift toward local, abundant, undervalued species in New England's seafood market. This chapter also provides background on choice experiment surveys, a tool used to gauge consumer preferences. Next, Chapter 2 examines the role of underutilized seafood in New England's seafood system using a choice experiment survey to investigate consumer preferences for four underutilized species in the northwest Atlantic. The choice analysis examines consumer preferences for the attributes of marketed fish that influence consumers' buying decisions. Included in the study are pollock, silver hake, Atlantic mackerel, and spiny dogfish, all underused species promoted in Maine through the Gulf of Maine Research Institute's Out-of-the-Blue initiative. These species are abundant with stable populations in the Gulf of Maine, but have lower landings in relation to their target biomass than cod and haddock. Pollock, silver hake, and spiny dogfish are commonly used as substitutes for cod and haddock. My research finds that while New England seafood consumers prefer well-known species, there is room in the seafood system for underutilized fish, provided it is marketed effectively. Challenges for integrating new types of fish into New England's seafood market remain, as consumers still prefer overfished species and are generally unwilling to switch to species that they are unfamiliar with or perceive as lower quality. However, recognition and promotion of these underappreciated species is increasing, potentially leading to shifts in consumer preferences away from unsustainable, depleted stocks.

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CHAPTER 1: LITERATURE REVIEW

Overfishing and the Need for Change within Seafood Systems

Overfishing, one of the oldest and most pervasive forms of environmental damage caused by humans, has left many of the world's important food-fish stocks depleted or in steep decline (Jackson *et al.* 2001; Myers and Worm 2003). Though the United States boasts thousands of miles of coastline with the largest Exclusive Economic Zone of any nation, today the majority seafood consumed domestically is imported, traveling thousands of miles from the ocean to consumer's plates (McClenachan *et al*. 2014, Diana 2009). These globalized fisheries contrast with historical fishing practices in which fishers supplied fish to their community using small scale, sustainable harvest methods that conserved local fish populations (Campbell 2013). Today, coastal communities that once relied on their own region's fisheries now eat fish imported from the other side of the world (Diana 2009). Fisheries crashes have led to increasing recognition for the need for new, innovative ways to relieve pressure from the most overfished stocks and sustain ecosystems and fishers' livelihoods. To address some of these issues, a growing local seafood movement in the United States, similar to agriculture's "locavore" movement, attempts to find more sustainable markets for local fish, often supplying underutilized, underappreciated species, colloquially known as "trash fish" (Brinson *et al.* 2011).

Research related to overfishing and stock depletions focuses on two trends – crashes of food fish stocks and bycatch and waste of marine species – that may be addressed by local seafood movements and changes in consumption patterns. Fisheries crashes of popular, largely predatory fish species like cod, salmon, and tuna have led to a phenomenon called fishing down the food web in which humans target lower trophic level species after high trophic level fish have been removed from the ecosystem (Pauly 1998). Pauly *et al*. (1998) found that globally, the mean trophic level of fish caught in marine and inland areas fell from 3.3 to 3.1 and 3.1 to 2.8, respectively, between 1950 and 1994. Archaeological research suggests that fishing down the food web has occurred throughout the history of fishing (Reitz 2004). Humans' historical preference for high trophic level species and our history of unregulated, unsustainable take from the ocean has been a driving force behind these stock depletions (Mullon *et al.* 2005; Scheffer *et al.*

2005). Fishery crashes and fishing down our food web has led to forced preference shifts within seafood systems. For example, as the cod became overfished and eventually depleted in the northwest Atlantic in the early 1900s, fishers started targeting previously underused species, which consumers bought because the popular, favored choice was no longer available. The overexploitation of cod led to demand for and overfishing of lesser-valued species (Grasso 2008). Cod was generally the fish of choice in the classic English dish, fish and chips, but today the same dish is often prepared using spiny dogfish, which is often considered bycatch by American fishers (Kurlansky 1997; Bell 2014).

In some fisheries, bycatch makes up a greater portion of the catch than the target species (Alverson *et al.* 1994). Different kinds of bycatch include regulatory bycatch, in which fishers are not permitted to keep certain species based on current regulations, and economic bycatch, which includes undesired, often low trophic level species that have been historically unwanted by markets (Lobo *et al.* 2010). They are discarded, usually dead, because selling these fish is not economically feasible or profitable (Catchpole *et al.* 2005). Spiny dogfish, abundant in the Gulf of Maine, are commonly caught in ground fishing nets, but are discarded at sea because fishers are only paid an average of $0.14/lb for them (Bell 2014). The Food and Agriculture Organization estimated in that worldwide marine fisheries discard 7.3 million metric tons per year from 1992-2001 (Kelleher 2005). Many of these fish, though not landed do not reenter the ecosystem to reproduce.

Finding markets for bycatch can benefit ecosystems and economies. If a bycatch stock is healthy and can be marketed in place of target species, fishing pressure on target species may be reduced as consumers shift their preferences (Center for the Environment Fisheries and Aquaculture Science 2013). In New England's waters, abundant species like dogfish may inhibit cod recovery by competing for resources and preying on juveniles (Bundy and Fanning 2005). From an economic perspective, selling bycatch that would have been thrown overboard can create additional income for fishers struggling to make a living (Kaewnern and Wangvoralak 2005). Recently, with the rise of local seafood markets, bycatch and underutilized species are not just being discarded; they are finding their way into the market and onto consumer's plates (Pierce 2013).

Promoting Local Consumption Underutilized Seafood

Using a variety of methods, multiple types of local seafood initiatives address the problem of fisheries crashes and the potential of underused fish. An national organization, the Chef's Collaborative, actively promotes lesser known and underappreciated species of fish during Trash Fish Dinners, events featuring meals of low-valued seafood cooked by prominent chefs (McCandlish 2013). These dinners are often accompanied by lectures that educate diners about the importance of sustainable seafood. The Portland, Maine organization, the Gulf of Maine Research Institute (GMRI) partners with restaurants and universities in Maine, promoting pollock, Atlantic mackerel, spiny dogfish, silver hake, and Acadian redfish, species that the organization determined were underutilized in the Gulf of Maine. Sea to Table, based in North Carolina, provides a direct connection between small-scale fishermen and local chefs, which then supply consumers with fish from a short, transparent supply chain. The Northwest Atlantic Marine Alliance works with community-based fishermen on market and policy alternatives to protect the welfare of fishers and maintain healthy local ecosystems and fishing communities. These organizations include scientists, consumers, fishers, chefs, and fisheries managers who seek to foster strong relationships at every level of the supply chain.

Community Supported Fisheries (CSFs) are a new arm of the local food movement and represent a transition to historical method of distributing fish locally. Modeled after Community Supported Agriculture (CSA), the first CSF was formed in Port Clyde Maine in 2007 (Jenkins 2009). While the initial goal of the CSFs was to connect seafood consumers to fishers, thus shortening the supply chain and giving fishers better prices for their catch, ecological sustainability plays a key role in these organizations (McClenachan *et al.* 2014). The CSF model uses a direct marketing strategy in which consumers pay in advance for a share of a locally landed seafood (Witter 2012). Up-front payment decreases risk to fishers while community members receive a transparent supply chain; they know who catches their fish, how it was caught, and where it was caught (Brinson *et al.* 2011). Because consumers pay in advance of receiving their weekly or monthly share, CSFs have the opportunity to provide species

that are underrepresented in the traditional seafood market. Many of these species are caught as bycatch. Instead of discarding low-value fish, CSFs make them part of weekly shares and equip customers with recipes and instructions on how to prepare them (Miller 2012). This reduces waste, exposes customers to the diversity of locally available fish, and provides another source of income for fishers as they receive higher prices than they normally would for generally undesired fish (Brown 2012). Local seafood distribution operations often provide seafood on a smaller scale, which is inherently more sustainable than large-scale operations, which must often catch an unsustainable amount of fish in order to cover costs (Colby College Domestic Environmental Policy Group 2013).

"Sustainable" Seafood: Perceptions and Misconceptions

When buying groceries, taste and price are often at the forefront of a shopper's mind. But with the introduction of sustainable food initiatives and seafood labeling programs, consumers have another factor to consider when buying food: sustainability. While consumers are increasingly aware of the social and environmental implications of food production, the focus has been on agriculture; seafood has recently entered social movements toward sustainable seafood. The advent of seafood labeling, seafood watch lists, and public commitment to seafood sustainability by companies like Whole Foods represents an interest in giving consumers sustainable choices. Today, seafood guides that provide consumers with information regarding the sustainability of individual species are common (Jacquet *et al.* 2009). The Marine Stewardship Council (MSC) certifies healthy fisheries that use sustainable fishing practices provide fishermen with adequate job security. In order to maintain certification, fisheries must continually meet science-based standards of sustainable fishing practices and traceability.

In addition to MSC labels, seafood suppliers are now using other labels, like the Monterey Bay Aquarium's Seafood Watch and Blue Ocean Institute (BOI) Sustainable Seafood Choices that tell consumers which species are sustainable and which are unsustainable due overfishing of the target stocks or other environmental impacts. These seafood labels have been found to accurately represent fisheries that are more sustainable than average. Out of 45 MSC certified stocks, 74% were above biomass levels that would produce a maximum sustainable yield, compared to only 44% of 179 uncertified

stocks (Gutiérrez *et al.* 2012). Thus, many see eco-labels, which inform consumers and add transparency to the supply chain, as a step in the right direction

Although eco-labels attempt to increase supply chain transparency, labeling efforts have been criticized for several reasons, in particular their tendency to focus attention on large-scale fisheries. Much of the seafood that Whole Foods currently provides is MSC certified. But while the MSC promotes the best environmental choice in seafood, some scientists and activists believe that financial incentives and the economic value of an MSC certification have led to a shift toward certification of large-scale, industrialized fisheries that are not in fact sustainable (Gulbrandsen 2009). Little evidence exists that these labeling efforts have been successful at halting the decline of the world's fish stocks (Goyert *et al.* 2010; Jacquet *et al.* 2010). A study commissioned by the Monterey Bay Aquarium, which run's Seafood Watch, found that the distribution of these seafood pocket guides did not bring changes to the seafood market or a decline in overfishing (Gulbrandsen 2009).

As consumer awareness for seafood sustainability rises, financial incentives that accompany eco-friendly labels have been associated with seafood fraud and mislabeling, a rising problem in the world's seafood industry (Jacquet and Pauly 2007). Seafood fraud makes it difficult for consumers to make sustainable choices, as the names of undesirable fish species are often swapped for ones that are more profitable and more sustainable. Labeling a fish as something more sustainable or more desirable takes advantage of consumers who may be willing to pay more for specific species. Using DNA testing, an Oceana study found that 33% of more than 1,200 sample of seafood from 674 outlets in 21 states were mislabeled, between 2010 and 2012 (Oceana 2013). Mislabeling misleads consumers about the actual state of the marine environment as it maintains the appearance of a healthy supply of popular fish species despite severe overfishing. Customers may be unwittingly consuming species that pose health risks or are at risk due to stock declines (Oceana 2012). Though seafood labeling programs seek to increase seafood traceability and transparency in the supply chain, they also provide financial incentives for suppliers to make the supply less transparent (Miller and Mariani 2010)

Initiatives to shorten the supply chain from boat to plate provide an alternate way of raising awareness for sustainably harvested seafood. Connections within communities

fostered by these groups actively promote transparency in the supply chain. The simplest way to avoid illegal fish and buy sustainable ones is to build community relationships and purchase locally caught fish (Figure 1). As supply chains grow in length and become increasingly fragmented, it has become difficult to determine from where seafood sold in grocery stores and restaurants originate. With roughly 90% of America's fish imported, it is almost impossible to track where and how the fish was caught (NOAA 2013b). Pramod *et al.*(2014) estimated that 20-32% of the imported fish that Americans consume originates from illegal fishing or unreported catches. Without transparent fishing practices and traceability of a product from boat to plate, consumers have no way of avoiding illegal or unsustainable products, since illegal products often enter supply chains at the processing stage.

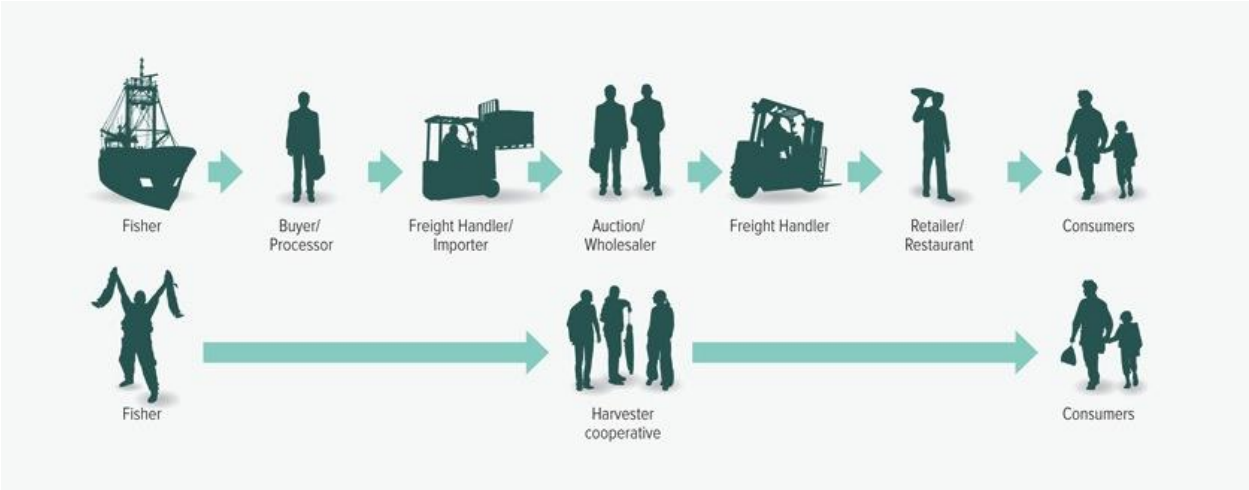

Figure 1. A theoretical map of the distribution chain for industrial seafood products and Community Supported Fisheries (Nelson *et al.* 2013).

Preferences for Local and Sustainable Food

Pertinent to research on the role of underutilized seafood are consumer preferences for local and sustainable food. To date, most research on local food preferences examines consumer preferences for agricultural products. These studies highlight important attributes of food that are used to gauge consumer seafood preferences. A study about public perceptions of local food and farming in the United Kingdom showed that while many consumers are interested in locally grown produce, a smaller portion of the population actively seeks out and regularly buys local food. Weatherell *et al.* (2003) performed semi-structured discussions to obtain qualitative data

on perceptions of food. The main priorities of respondents when choosing food were price, convenience, ease of preparation, and access, all attributes that are applicable to seafood. In addition to the qualitative data, the researchers developed a questionnaire addressing respondent's priorities when choosing food. The top three priorities were taste, freshness, and health. Though each type of data collection yielded different results both methods found that local production was one of the least important attributes.

Studies in Tennessee and South Carolina also showed that locally produced food, while preferred by some consumers, is not top priority for many. Eastwood *et al.* (1987) found that consumers in Tennessee had little preference for produce grown in state. However, research does demonstrate changing preferences and an increased appreciation for local food as well as geographic differences in preference (Eastwood *et al.* 1987; Carpio and Isengildina-massa 2009). Carpio and Isengildina-massa (2009) found that 60% of Indiana consumers were likely to purchase and consume locally produced foods. Additionally, studies show a rise in consumer interest in local foods reflected by growth of farmer's markets, which provide fresh and local produce (Carpio and Isengildina-massa 2009).

Seafood Preference Analyses

Though food preference literature is primarily terrestrial-based, the advent of aquaculture and sustainable seafood labeling has led to increased study of seafood preferences. To explore seafood preference, researchers have used market-based surveys and analyses to determine stated preference for seafood, consumer buying practices, and willingness to pay for different types of seafood. These studies also include demographic data as social and economic factors may impact preference and purchasing behavior (Kalberg *et al.* 2013).

Studies in the early 1990s explored consumer preference for seafood based on catch methods and quality. Halbrendt *et al.* (1991) investigated buyer attitudes toward farm-raised, hybrid striped bass. The researchers used a market survey that was mailed to seafood wholesalers, retailers, and restaurants. Respondents rated seven finfish attributes – quality, fresh/frozen, fish size, size uniformity, product form, seasonality, and price – based on importance of the attributes in purchasing decisions. The investigators found

that all market levels reported quality as being the most important attribute of fish. For the retail and wholesale market levels, purchase price, and fresh versus frozen were the next two most important attributes, with fresh fish as the preferred choice.

Anderson and Bettencourt (1993) found that seafood preferences varied between two sets of consumers, buyers for expensive restaurants and individuals who buy seafood at fish markets. Restaurant customers were not used as respondents because preferences for seafood in restaurants may be affected by other factors such as the overall composition of a dish and the ambiance of the restaurant. The researchers used a conjoint choice experiment to investigate preferences of two different consumer types for fresh and frozen salmon. Both restaurant buyers and fish market buyers reported preferring fresh salmon to frozen salmon, but fish market buyers placed more value on the color and appearance of the fish. These findings make sense given that the form in which the end-user sees the fish is important and differs between these two consumer types. Consumers shopping at fish markets see the raw product whereas diners received cooked fish. There were also differences in the type of salmon preferred by each group of consumer. Buyers for seafood restaurants preferred seasonally available species of salmon, compared to fish market buyers who preferred specific species that were available year round. The importance of price also differed for each market segment. The study suggests that expensive seafood restaurants use price as an indicator of quality, preferring to buy fish that are more expensive (Anderson and Bettencourt 1993).

Similar attributes were used in both studies, including species, price, origin, catch method, availability, color, quality, form, minimum order quantity, and fresh vs. frozen. Unlike the Halbrendt *et al.* (1991), Anderson and Bettencourt (1993) compared multiple species of fish in varied product forms. These studies suggest that in certain situations, other attributes such as quality, price, and product form may also influence buy decisions. While these studies provide important feedback on consumer preferences, they do not employ revealed preference of consumers, which uses observed purchasing behavior and would more accurately demonstrate consumers' tastes.

Demographics may also play a role in seafood preference. Researchers at the University of Kentucky performed a choice experiment to compare seafood preferences across four states. In the experiment the attributes used were: 1) catch method (wild

caught versus farm raised, fresh/frozen); 2) origin (imported versus domestic); 3) price. Like other studies, they did not compare species. The investigators found that geographic location played a major role in seafood preference. Consumers in Hawaii, a coastal state, demonstrated a higher marginal willingness to pay for wild-caught tuna and salmon ($5.48/lb and $2.50/lb) than consumers in Kentucky ($-3.14/lb and $-1.18/lb), who were willing to pay more for previously frozen fish (Hu 2013; Kalberg *et al.* 2013). Other studies have found other demographic factors such as household size, income, race, and urbanization play a role in seafood preference (Cheng and Capps 2013).

Seafood Preferences and Eco-labeling

Recent seafood preference studies focus on eco-labeling and the impact of environmental concerns on buying behavior. As the demand for seafood has increased in concert with declining fisheries, the demand for eco-labeled seafood has increased (Goyert *et al.* 2010). Goyert et al. (2010) investigated the costs and benefits of a Marine Stewardship Council label to Maine's lobster fishery and its lobstermen. It was hypothesized that MSC certification may increase demand for lobsters but may also put undue pressure on the fishery, which would be forced to meet the standards of the label every year. The researchers found that half of the lobstermen they interviewed were in favor of the certification. However, they also found that only 36% of consumers that participated in the survey would be willing to pay more for eco-labeled lobster. While an MSC certification may highlight the fishery's sustainable practices, the researchers posit that it may not in fact help lobstermen, as certification does not guarantee an increased market.

Researchers in the United Kingdom performed a choice experiment similar to Halbrendt *et al.* (1991) and Anderson and Bettencourt (1993). Jaffry *et al.* (2004) used similar attributes, with the addition of 'certification' and 'certifier,' referring to the organization that provided a seafood label. The questionnaire used in the study was broken into five sections: 1) factors that affect food choice; 2) fish and fish product purchasing behavior; 3) a choice experiment; 4) general purchase choices; 5) socio-economic and demographic variables. Respondents were asked to choose between several seafood products – fresh, chilled cod fillets, fresh, chilled salmon steaks, tinned tuna,

frozen fish fingers, smoked haddock fillets, and frozen prawns. Sustainability and quality certification was found to have a positive impact on product choice. While both eco-labels positively influenced consumer preference, sustainable certifications had a greater effect on consumers than quality certifications.

A study in 2006 used a choice experiment to evaluate consumer preference for seafood based on taste and the presence or absence of an eco-label (Johnston and Roheim 2006). Previous studies have used consumer stated preference to estimate willingness to pay for eco-labeled seafood, suggesting that some consumers were willing to pay a premium for eco-labeled and presumably sustainable seafood (Johnston *et al.* 2001). The research focused on consumer choices among different types of seafood in the presence of eco-labels using the variables species, price, and presence or absence of a 'No Overfishing' eco-label. While respondents stated that they were willing to pay more for eco-labeled seafood, the results of the choice experiment showed that consumers were unwilling to sacrifice taste for the presence of an eco-label.

Benefits and dangers to fish stocks of marketing underutilized seafood

Marketing underutilized fish is only a partial solution to overfishing and stock depletions. A sustainable seafood system requires abundant and diverse supplies of fish, fishers with access to those fisheries, and business models that support the first two elements, as well as effective management (Alden 2011). Marketing underutilized seafood can play a role as consumers and the market have the power to influence how seafood is harvested and what is available (Olson *et al.* 2014). An influx of sustainable seafood into the market can also supplement existing management, which though necessary, does not always lead to rebuilt stocks. For example, despite a drastic cut to cod quotas in the Gulf of Maine, Georges Bank, and Newfoundland, where a moratorium on commercial cod fishing was issued in 1992, cod stocks have not rebounded (Schrank 2005).

Fisheries cannot afford a total switch from popular species to underutilized species, unless we first protect fish stocks. If a complete transition to currently under or un-marketed species occurs without proper safeguards for fish stocks, overfishing will continue (Pauly 1998). Before the 1930s, the seafood industry shunned the abundant

Acadian redfish, however "processors found that redfish were adaptable to new food technology, and harvests rose as freezing techniques enables a widespread distribution if the frozen product around the country" (NOAA 2014). However, the population crashed by the mid-1950s as redfish could not withstand the heavy fishing pressure. While the life history characteristics (long life spans and low reproductive rates) makes Acadian redfish susceptible, its fishing history highlights the importance of proper management as well as catch diversity, which could alleviate threats to species susceptible to overfishing.

Underutilized Seafood in the Gulf of Maine

Though cod and haddock remain the faces of New England fishing, the region is home to many potentially marketable fish. Because cod and haddock are severely overfished (B/B_{msy}[1] = 0.19_{cod}, $0.59_{haddock}$), markets for different, underutilized species are currently emerging. This study includes four northwestern Atlantic species, pollock, spiny dogfish, silver hake, and Atlantic mackerel, promoted by GMRIs Out-of-the-Blue initiative. As mild, white, flaky fish, hake, dogfish, and pollock are often used as substitutes for cod and haddock, making them ideal fish to begin to take pressure off overfished stocks. Underutilized fish represent an opportunity for Maine and New England to diversify its seafood market, which currently leans on the lobster fishery for 80% of its value (Steneck *et al.* 2011). Diversifying New England's fishery is essential for its future sustainability as it would reduce pressure on overfished stocks, reduce the possibility of a crash within the lobster fishery, and provide fishers with income that would have gone to waste along with discards of low-value species (Alden 2011).

[1] B/B_{msy} is used by NOAA to quantify the status of fish stocks. B = the biomass of all the fish in a specific stock. B_{msy} = the biomass that enables a fish stock to deliver a maximum sustainable yield than can be harvested without reducing the population (NOAA 2013a). B/B_{msy} >1 indicates a healthy stock.

CHAPTER 2: CONSUMER PREFERENCE FOR UNDERUTILIZED FISH IN NEW ENGLAND

Introduction

Global fisheries crashes have led to the need for new, innovative ways to sustain both marine ecosystems and fishing communities (Witter 2012). Likewise, recognition for the need to reduce bycatch and other waste associated with fishing has prompted calls to create markets for discarded species that are consumable but are not currently marketed due to issues of scale and perceived consumer preference (Alverson *et al.* 1994; Leviton 2013). To address these issues, a growing local seafood movement in the United States has begun to market abundant and underutilized species to local consumers in the hopes of diversifying local fisheries, taking pressure off of overfished stocks, and increasing community interest in sustainable fisheries (Brinson *et al.* 2011; Olson *et al.* 2014; McClenachan *et al.* 2014). From an economic perspective, selling species that would have been discarded can create additional and alternative sources of income for fishers without increasing strain on the ecosystem (Kaewnern and Wangvoralak 2005). Once consumers gain appreciation for these species, their values may increase, benefiting fishers who catch them. Marketing underutilized fish falls under the greater sustainability goal of fisheries diversification, which may increase both ecological and economic sustainability by spreading fishing effort more broadly across the ecosystem, reducing the trophic level of landed fish, and providing security to local fishermen (Alden 2011).

Interest in the role underutilized fish in sustainable seafood systems is on the rise within academic and conservation communities, as well as with chefs and fishers (Miller 2012; GMRI 2013). For example, since 2008 the Northwest Atlantic Marine Alliance (NAMA) holds an annual Seafood Throwdown, in which local chefs compete in a cooking competition featuring locally caught seafood. The Chefs Collaborative, a national non-profit network of chefs, hosts Trash Fish Dinners, which feature well-known, local chefs preparing meals using several underused species. Seafood suppliers like Red's Best in Massachusetts and Sea to Table in North Carolina makes underutilized species available to chefs across the country while providing fishers with fairer prices (Future of Fish 2014). Other efforts to diversify demand include Community Supported Fisheries (CSFs), which use a direct marketing strategy to connect consumers to fishers

and provide a direct route for the fish from boat to plate. CSFs often expose shareholders to underused seafood in order to reduce fisheries discards and provide better prices to fishers (McClenachan *et al.* 2014). While there are localized efforts to promote these underutilized, sustainable fisheries, it is unclear if consumers in larger markets will choose to purchase these species, which may be unfamiliar and perceived as less desirable.

New England is an ideal place to examine issues of consumer choice and fisheries sustainability because of a long history of overfishing and current local initiatives to diversify fisheries and market underutilized stocks. Atlantic cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) remain two of the highest value New England finfish, and are currently overfished in the Gulf of Maine (Table 1). However, other species like pollock (*Pollachius virens*), Atlantic mackerel (*Scomber scombrus*), spiny dogfish (*Squalus acanthias*), and silver hake (*Merluccius bilinearis*) have healthy stocks, and local efforts exist to create markets for these species. For example, the Gulf of Maine Research Institute (GMRI) partners with restaurants and universities to promote the consumption of these species, which they have assessed to be underutilized, based on their small percentage of allowable catch harvested, and sustainable, based on strong management and high biomass relative to the defined management target (B/Bmsy). A low ex-vessel price, but higher price in foreign markets further indicates that these species are marketable as they are in demand in other parts of the world (GMRI 2013).

Here, I measure consumer preferences for underutilized species in New England in order to gain insight into their marketability, and by extension, the ability of these efforts to improve fisheries sustainability through consumption of underused species and reduction of fishing pressure on overfished stocks. I also examine the relationship of underused fish in relation to other attributes of seafood, including origin of catch, sustainability label, and price to gain insight into how these attributes drive consumer preference.

Table 1. The six species included in the analysis and their current stock status (as measured by B/Bmsy), ex-vessel price per pound, and the most recent landings (NOAA 2013a,c). B/Bmsy values >1 indicates a healthy stock.

Species	B/B_{MSY} – Gulf of Maine (2013)	$/pound – Maine (2012)	Maine landings – metric tons (2012)
Atlantic cod	0.19	2.50	223.4
Haddock	0.59	2.23	25.6
Pollock	2.15	0.95	23.8
Silver hake	1.02	0.47	102.9
Atlantic mackerel	3.57	0.34	18.9
Spiny dogfish	1.03	0.20	1,206.3

Methods

Choice experiments

This study uses a choice experiment survey to examine consumer preferences for underutilized fish in New England. Choice experiments are based on Lancaster's (1966) theory that consumers derive utility not just from singular goods, but from their characteristics. Therefore, choice experiments are stated preference tools that examine consumer preference for goods based on multiple attributes. Stated preference differs from revealed preference in that respondents make realistic but hypothetical decisions; investigators do not observe real consumer buying behavior. In choice experiment surveys, respondents choose their preferred option from several hypothetical but realistic choices that include the attributes important to the product. Typically, these attributes have multiple levels, which create realistic variation among options. Choice experiments estimate the value that consumers place on good and their attributes and identify the combinations of attributes and levels that consumers prefer (Dissanayake and Ando 2014).

Experimental design

The choice experiment used in this analysis presented respondents with opportunities to express preferences for six fish marketed in New England's seafood

system: four abundant, underutilized and two popular, overfished species. Respondents were presented with choices between two seafood products and asked to indicate which they would buy. These choices included the following five attributes: fish species, origin of catch, price, eco-label, and the inclusion of a recipe upon purchase of the fish. Each attribute included different levels to determine how consumers' value individual attributes differently (Table 2).

Atlantic cod and haddock are mild, white, flaky groundfish. Pollock and silver hake are also white flaky fish that are often used as substitutes for cod and haddock. Spiny dogfish is a small schooling shark species often used in place of cod in fish and chips in the United Kingdom. Atlantic mackerel is rich, oily fish. Because one of the aims of the study was to gauge the familiarity of respondents with each fish included in the survey, descriptions of the fish were not supplied to respondents. Each of these fish can be caught in the Gulf of Maine or Iceland, which was reflected by origin of catch labels. For price, each label represented one of three possible price levels (low, medium, and high), which were constrained to a range of current and feasible prices found in supermarkets for each species (Table 2, Table 3). Eco-labels were based on possible actual possibilities, so they varied across species. Recipes for the fish were also provided to respondents. Hypothetical but realistic seafood labels were created with one level of each attribute represented on each label (Figure 2, Table 2). Each choice set contained two seafood labels and a third option of choosing neither fish. In each choice situation, respondents were also given the opportunity to describe why they made each choice. Preferences for fish species were derived from a comparison between estimated willingness to pay and the mid-range price of each fish offered in the choice experiment survey (Table 3).

Table 2. Attributes and levels for the choice experiment survey.

Attribute	Attribute Levels
Species	1. Pollock 2. Atlantic mackerel 3. Silver hake 4. Spiny dogfish 5. Haddock 6. Cod
Origin Label	1. Caught in US 2. Caught in Iceland 3. Caught in the Gulf of Maine
Eco-Label	1. Best Choice (Pollock, Atlantic mackerel, spiny dogfish) 2. Good alternative (Silver hake, haddock, Atlantic cod caught in Iceland) 3. Avoid (Atlantic cod caught in Gulf of Maine or US) 4. No Label (all six species)
Price	1. High 2. Medium 3. Low
Preparation	1. Recipe included on label 2. Recipe not included on label

Table 3. Price ranges of spiny dogfish, Atlantic mackerel, silver hake, cod, and haddock based off of current prices of fish in supermarkets.

	Spiny dogfish	**Atlantic mackerel**	**Pollock**	**Silver hake**	**Cod**	**Haddock**
Low	$3.99	$3.99	$5.99	$8.99	$8.99	$8.99
Medium	$5.99	$5.99	$8.99	$11.99	$11.99	$11.99
High	$8.99	$8.99	$11.99	$14.99	$14.99	$14.99

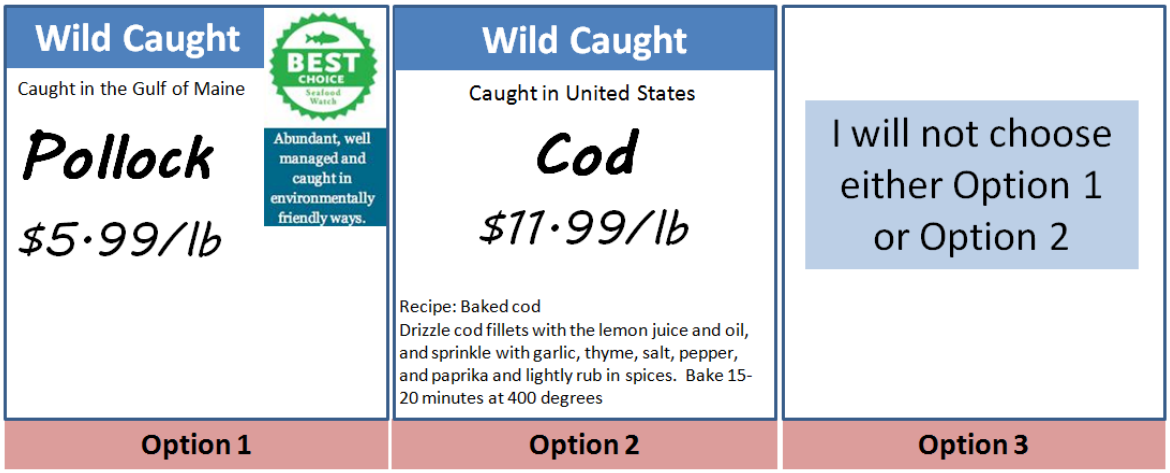

Figure 2. Hypothetical seafood labels presented to consumers in the choice experiment. All labels contain one level of each of the five attributes: species, price, presence of a sustainability label, origin of catch, and presence of a recipe.

Demographic survey

Since consumer characteristics may affect purchasing decisions made by respondents (Darby *et al.* 2006), a demographic survey was conducted that asked respondents to indicate pre-tax household income, the presence of children in the family, and their zip code, which was used to determine the proximity of their primary residence to the coast. In order to learn more about motivations for purchasing fish, the survey portion of the questionnaire also consisted of questions related to respondents' seafood buying practices (frequency and location of purchase), which were used to identify additional patterns within the choice experiment data. Respondents were asked about the importance that they place on each of the five attributes used in the choice experiment: species/taste, price, sustainability label, origin of catch, and knowledge of preparation. The choice experiment data were broken down into subsamples based on respondents' answers to survey questions about seafood buying practices and stated values for seafood attributes. The survey was placed after the choice experiment so that it would not introduce bias to the choice experiment.

Survey Implementation

The choice experiment and survey was web-based and promoted using social media outlets (Twitter and Facebook), as well as word-of-mouth. Local organizations, including the Gulf of Maine Research Institute, the Penobscot East Resource Center, Sea

to Table, the Chefs Collaborative, and the New England Aquarium, helped to promote the survey among their followers. While the respondents to the questionnaire were not chosen at random and are not representative of all seafood consumers in New England, the survey was designed to focus on consumers who were informed about the problems of sustainability. Therefore, the results cannot be generalized to the whole population of New England seafood consumers since these are people that may be most willing to buy underused species; however, my assumption was that informed consumers are most likely to start a shift toward underused species so this represents a "best case" scenario for willingness to purchase underutilized stocks.

Analysis

The choice experiment design was generated following standard practice in choice experiment modeling using SAS Macro (Kuhfeld 2010). The design achieved a 100% D-efficiency[2]. A block design was created where the 36 choice sets were separated in blocks of six choice profiles, giving six unique surveys containing six questions each. The process yielded 1,812 individual choice question observations. A multinomial mixed logit was used to estimate consumer willingness to pay for goods, which assumes that consumers' preferences are heterogeneous. The coefficient estimates for the mixed multinomial logit (MMNL) model cannot be interpreted directly (Carlsson *et al.* 2003; Hensher *et al.* 2003; Dissanayake and Ando 2014). Therefore, following the standard practice in the literature, I calculate the average marginal willingness to pay (WTP) in each attribute, *i*, by dividing the coefficient estimate for each attribute with the coefficient estimate for the payment term, as given in

$$MWTP_i = \frac{\beta_i}{\beta_{cost}}$$

Here, I present a main effects (no interactions) specification in the equation

[2] D-efficiency is the most common criterion for evaluating linear designs. D-efficiency minimizes the generalized variance of the parameter estimates given by D = det [V(X,β)1/k] where V(X, β) is the variance-covariance matrix and k is the number of parameters. Huber and Zwerina (1996) identify four criteria (orthogonality, level balance, minimum overlap, and utility balance) which are required for a D-efficient experiment design.

$$V_{ni} = \beta_{1n}X_{fish-species} + \beta_{3n}X_{price} + \beta_{4n}X_{origin\_of\_catch} + \beta_{5n}X_{sustaianbility\_label} + \beta_{6n}X_{presence\_of\_recipe}$$

Data were analyzed using the mixlogit command in STATA for the MMNL specifications. WTP estimation was conducted in STATA using the mixed logit model created by Hole (2013). The model estimation is located in the appendix.

In addition to analysis of the entire respondent sample, analyses were run on subsamples of the respondents. Subsamples included previous exposure to underused fish (respondents who had and had not previously purchased at least one underused fish species), distance from the coast (> and < 50km), children in the family (presence or absence), and annual household income (≥ and < $100,000 per year).

Results

Demographic survey

Each of the six different survey versions was taken at least 45 times, receiving at least 14% of the responses, which ensured that each of the 36 choice profiles was included in the final analysis. In total, 336 responses were received, 302 of which were included in the analysis (90%). Responses were discarded if respondents reported that they did not buy fish to cook and eat at home or if they lived outside of the region of interest (New England and New York). Of the included responses, 63% were from Massachusetts, 26% were from Maine, and the remaining 11% were from New York, Connecticut, New Hampshire, Vermont, and Rhode Island. Based on respondents' reported zip codes, 53% live within 50km of the coast. Forty seven percent reported household incomes of >$100,000 per year and 73% of respondents reported having children. The majority of respondents reported buying fish frequently, with 43% at least once a week and 42% at least once a month. Only 6% reported buying fish at least once every two months, while 9% reported buying fish less than once every two months. The majority of respondents purchase their seafood in grocery stores (56%), though the locations in which consumers reported buying seafood were diverse, with 15% reporting that they purchase fish from local Community Supported Fisheries, 11% from local fish markets, and 9% from farmer's markets. Many respondents reported buying fish from

more than one type of supplier. Comments revealed that a few respondents catch their own fish, purchase fish directly from fishers, or eat fish that is given to them by friends.

Out of the six species used in the choice experiment, 78% of respondents reported one of the two overfished species as their preferred fish. Forty-four percent of respondents selected haddock and 34% selected cod. Three percent of respondents preferred pollock, 3% preferred silver hake, and no respondents reported preferring spiny dogfish, while 16% responded that they had no preference among the six fish. Though the majority of respondents preferred the two overfished and generally more popular fish species, 61% reported having previously purchased at least one of the underutilized species. Of the five attributes, taste, origin, and knowledge of preparation were most valued by respondents. Seventy-five percent of respondents reported that taste was of high importance when buying fish, with the presence of sustainability labels and price of lesser importance (Figure 3). Only 14% of respondents reported that price was of high importance when purchasing fish; 12% of respondents reported that sustainability label was of high importance when purchasing fish.

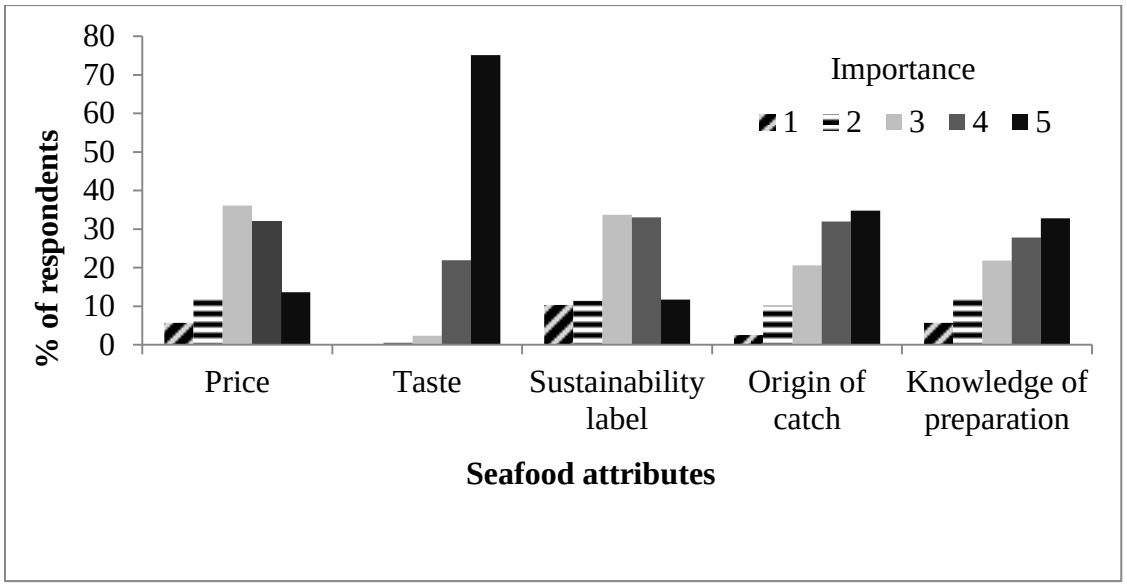

Figure 3. Respondent valuation of attributes included on choice experiment seafood labels. 1 = low importance, 5 = high importance.

Choice experiment

Respondents were willing to pay more the mid-range market price for cod (+$6.01) and haddock (+$10.97) (Table 4). Pollock was the only underused species for which respondents were willing to pay more than the mid-range price. Respondents were not willing to pay more than the mid-range price for silver hake (−$2.74), Atlantic mackerel (−$2.09), and spiny dogfish (−$8.08).

Origin of catch as well as specificity on the origin label was also important to respondents (Figure 4a). Consumers in New England prefer Gulf of Maine caught fish to foreign fish, with an estimated willingness to pay for Gulf of Maine caught fish of $8.14/lb, as compared to $4.12/lb for fish with the label "Caught in the US." Willingness to pay for sustainability labels was lower than marginal willingness to pay for catch origin (Figure 4b). Respondents were only willing to pay $2.09/lb for fish labeled "Best Choice" by the Monterey Bay Aquarium's Seafood Watch. The values for the "Good Alternative" ($ –2.81/lb) and "Avoid" ($ –13.57/lb) sustainability labels were both negative, showing a stated aversion to less sustainable seafood.

Table 4. Estimated WTP for haddock, cod, pollock, silver hake, Atlantic mackerel, and spiny dogfish relative to mid-range prices for each used in the choice experiment.

Species	**Estimated WTP ($/lb)**	**+/− of mid-range prices**
Haddock	22.96	+10.97
Cod	18.00	+6.01
Pollock	14.22	+5.23
Silver hake	9.25	−2.74
Atlantic mackerel	$3.90	−2.09
Spiny dogfish	-2.52	−8.08

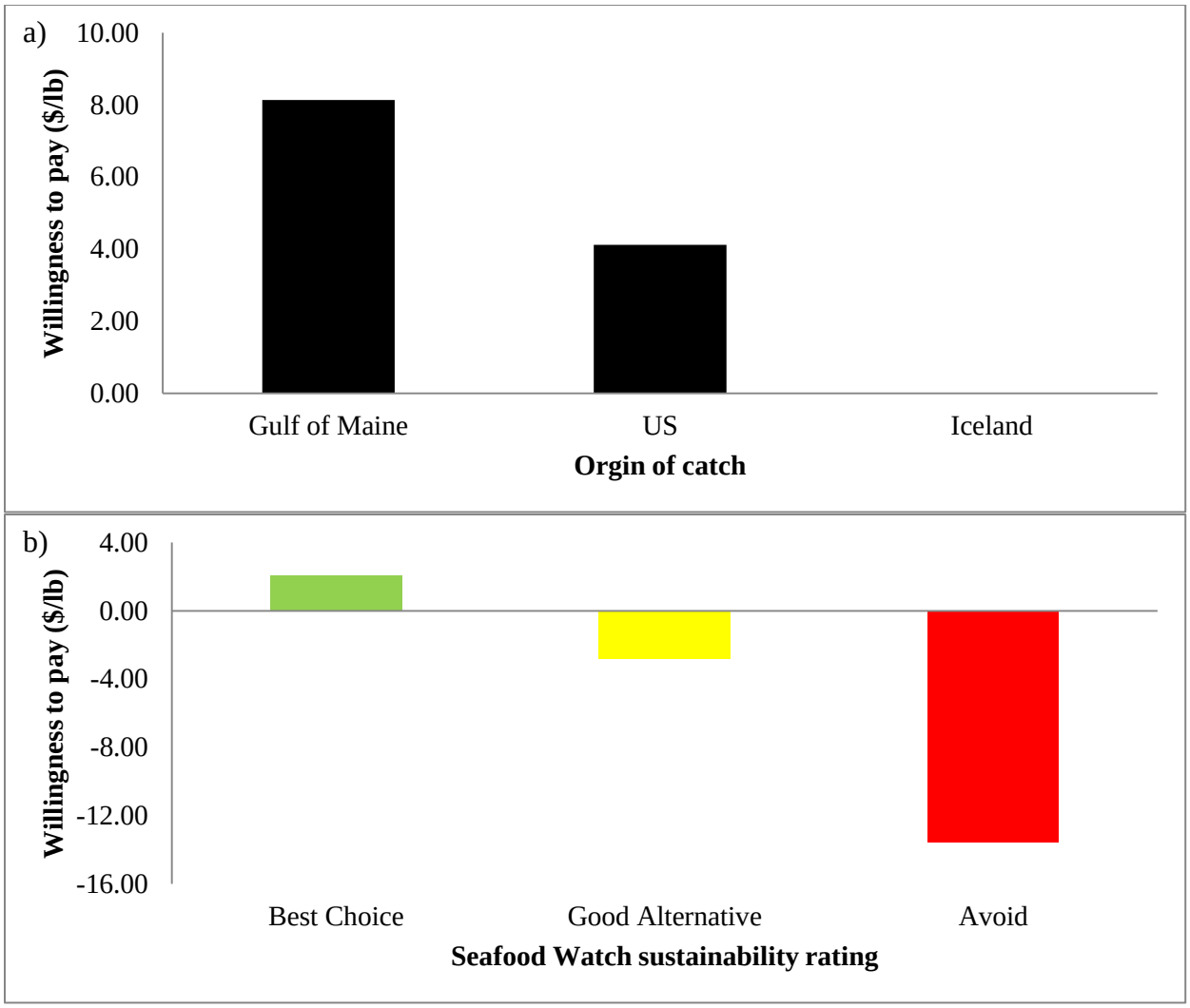

Figure 4a, b. Estimated willingness to pay for origin of catch and Monterey Bay Aquarium Seafood Watch Sustainability labels.

In addition to the attributes included in the choice experiments, characteristics of consumers and buying practices played a role in preferences. Previous exposure to underutilized species increased respondents' willingness to pay for each species. Respondents who reported having previously purchased at least one of the four underutilized species were willing to pay more than the mid-range price for pollock ($16.61/lb), silver hake ($12.21/lb), and Atlantic mackerel ($7.98/lb) than respondents who had never bought an underutilized species (Figure 5). The differential between WTP and mid-range price for cod and haddock was higher for respondents who had not previously bought an underused species (+$17.30/lb for haddock, +$9.61/lb for cod) than

respondents who had purchased at least one underused fish (+$11.14/lb for haddock, +$4.22/lb for cod).

I did not find any demographic differences among respondents. There was not statistical difference in respondents' willingness to pay for any of the attributes between respondents within 50km and further than 50km from the coast; those from families with children and those from families without children; or those whose household income was $100,000 per year or more and those whose household income was less than $100,000 per year.

Table 5. Estimates of WTP for haddock, cod, pollock, silver hake, Atlantic mackerel, and spiny dogfish relative to mid-range prices used in the choice experiment. Grouped by respondents who had and had not previously purchased at least one underutilized fish species.

Species	**Estimated WTP ($/lb) – had previously bought underused fish**	**+/− of mid-range prices**	**Estimated WTP ($/lb) – had not previously bought underused fish**	**+/− of mid-range prices**
Haddock	23.13	+11.14	29.29	+17.30
Cod	16.21	+4.22	21.60	+9.61
Pollock	16.61	+7.62	5.13	−3.86
Silver hake	12.21	+0.22	4.65	−7.34
Atlantic mackerel	7.98	+1.99	−4.96	−10.95
Spiny dogfish	4.21	−1.78	−16.72	−22.71

Stated preference results from the questionnaire corresponded with stated preference results from the choice experiment. Respondents who stated that eco-labels were important when buying fish were willing to pay more for a Seafood Watch "Best Choice" sustainability rating ($6.60/lb) and showed a greater aversion to the "Good Alternative" and "Avoid" ratings than those who reported that they did not find eco-labels important. Additionally, respondents who reported that they valued eco-labels in the questionnaire were willing to pay more for Gulf of Maine caught fish ($12.18/lb) than respondents who reported that they did not value eco-labels ($9.30/lb). Respondents who found origin of catch to be of great importance were willing to pay substantially more

($11.82/lb) for Gulf of Maine caught fish than respondents who did not find origin of catch to be important ($2.96/lb).

Respondent comments

Price, taste, and familiarity of the species were the most common attributes mentioned in comments provided by respondents (Table 4). Respondents chose Option 3, the "Neither" option in 18% of the choice situations. In total, there were 366 comments recorded explaining decisions made during the choice experiment. Many comments revealed that respondents chose not to buy fish because they deemed the labeled price too expensive based on the levels of the other attributes on the label. Overall, respondents commented that their preferred fish was locally caught and contained a "Best Choice" sustainability rating. However, unfamiliarity with an underused species led many respondents to choose Option 3 and often overrode the desire for local or sustainable products. Even if all the other attributes on the label were preferred, several respondents stated that they were unwilling to purchase a fish that they did not know how to prepare, had never heard of, or had never knowingly tasted. Respondents also reported that they would prefer to buy an unfamiliar species at restaurants or independent seafood markets (Figure 5).

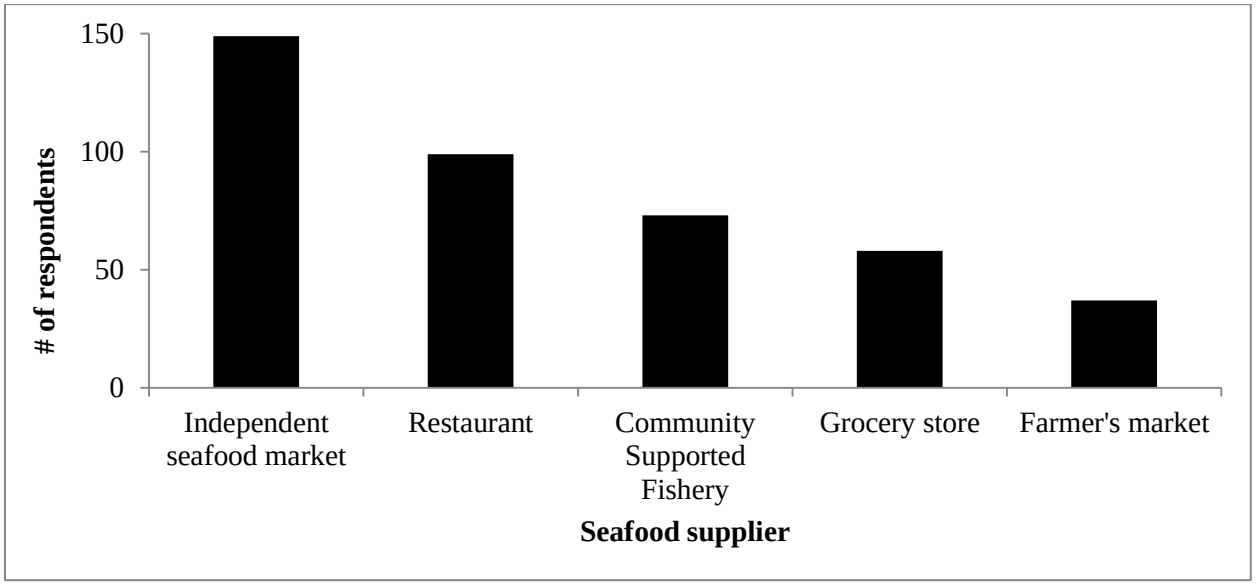

Figure 5. Preferences for seafood supplier when buying unfamiliar seafood.

Comments reflect a high level of education on the topic of sustainable seafood. Respondents were aware cod is overfished and that locally caught fish is often more sustainable than imported, foreign seafood. Respondents expressed concern about the labeling organization, commenting that it "was not the preferred label for information." In concert with the choice experiment data, respondents wanted as much information as possible on the origin of catch, preferring to see "more information other than 'Caught in the US' because it [did not tell them] where the fish was caught" (Table 6).

Table 6. Respondent explanations of their decisions in the choice experiment.

Explanations of purchasing decisions
I don't like the taste of Pollock and I don't buy cod because I know it has been over-fished.
I have never bought either hake or dogfish and prefer to buy only fish I am familiar with
I would not purchase silver hake due my unfamiliarity with the species as well the distance it has traveled and the high price. I would not choose spiny dogfish, as I am also unfamiliar with the species. The name is unappealing. The price is good, but makes me wonder why so inexpensive.
I don't like the "concerns of health of habitat" [in the explanation of the "Good Alternative" seafood label] for the haddock and would not pay 11.99/lb for cod.
I would be more likely to try the dogfish if I had it prepared by someone who knows how to cook it well first - maybe out in a restaurant. Also, Seafood Watch is not a preferred label for information for me. Rather than expensive imported haddock, I would by local pollock, flounder, or redfish.
I don't know what hake is. I know that dogfish has recently been in the news as fish likely to replace cod as it is plentiful but can't get past the name.
I choose fish that is caught locally and sustainably, and less risky health-wise. I didn't choose dogfish because it is not a personal preference and may be very high in heavy metals. I really like hake, but Iceland is too far away.
I'm not interested in New England groundfish because there is so little left.
I really would prefer local, sustainably harvested fish. I'd rather eat tofu (seriously) than eat a fish too high up the food chain, not sustainably harvested, or flown in from another country (thinking about a carbon footprint there).
I like seeing more information other than "caught in US" because it does not tell me where the fish was caught (Gulf of Maine, Narragansett Bay, Block Island Sound, Gulf of Mexico, Pacific Northwest, etc…)

Discussion

The results of the choice experiment and the survey suggest that even well-informed New England seafood consumers prefer the historically popular and overfished species to underutilized species pollock, silver hake, spiny dogfish, and Atlantic mackerel. This result suggests continued demand for overfished stocks and a lack of support for diversification within New England's fisheries. However, the data also show that consumer preferences are flexible given the right set of circumstances. Because consumers who had previously purchased one of the underutilized species were willing to pay more for each of the underused fish, efforts to introduce underutilized species to consumers may shift preferences toward less valued species. Comments from respondents imply that being more familiar with the underused species would influence their decisions, making them more likely to try "trash fish." Since previous exposure to a fish increased the likelihood that a respondent would choose to purchase it, effective promotion of underused fish is most likely to be successful if it starts with suppliers. These results provide evidence that restaurants, independent seafood markets, CSFs, and organizations such as the Chefs Collaborative and the Gulf of Maine Research Institute that are currently promoting consumption of a diverse array of seafood may ultimately be successful in their efforts.

This research used affluent respondents who showed a relatively high level of education on the topic of sustainable seafood and currently represent the target demographic for underused seafood marketing strategies and campaigns. However, demographics did not significantly alter preferences for any of the attributes in the choice experiment.

The results of the choice experiment suggest a preference for specificity with respect to origin of catch, as indicated by the fact that respondents strongly favored local fish caught in the Gulf of Maine to fish labeled as caught in the US more generally, or caught in Iceland. Supplying and marketing local seafood fish may increase consumer willingness to purchase an underused fish despite other unfavorable attributes, such as unfamiliarity with the species. Survey results positively correspond with the current "locavore" movement and research that shows a growing interest in local food, evinced by the growing number of farmer's markets in the United States as well as the rise of

Community Supported Fisheries in the last five years (Carpio and Isengildina-massa 2009; Witter 2012). While locally caught fish may positively influence consumer decisions, sustainability labels have less of an influence on seafood buying decisions. These results concur with previous results that consumers are not strongly affected by positive labels (Johnston and Roheim 2006). I also find that negative seafood labels deter consumers from buying unsustainable fish. But in order for consumers to be deterred they must be made aware of all sustainability ratings, not just the positive ones.

Though underused fish may be abundant and may alleviate some pressure on overfished stocks, caution must be used in the shift toward underutilized fish. Each of the underused fish included in this study has experienced a stock crash within the last 50 years (NOAA 2013c). Silver hake landings increased drastically in the late 1960s, prior to the implementation of increased catch restrictions; foreign fleets depleted United States Atlantic mackerel stocks in the 1970s; the abundance of pollock dropped below sustainable levels in early 1990s; spiny dogfish stocks fell below minimum sustainable levels in 1998. Other species such as Atlantic halibut, monkfish, and Acadian redfish, food fish species that have transitioned form undesirable to desirable species, have crashed due to increased fishing pressure. Fishers and consumers in the northwest Atlantic considered halibut to be a worthless bycatch species prior to the 1840s. However, halibut's "robust migration, improved transportation, consumer tastes, corporate decision-making, market capitalism, advance in refrigeration, and the physical nature of the fish itself – in terms of reproduction and product preservation – all contributed to its trajectory from worthlessness to a commodity" between 1840 and 1880, which lead to near commercial extinction for the fish (Grasso 2008: pg. 67).

In the fishing industry, one of the dangers has been and continues to be over-valuing, over-targeting, and the depletion of certain species. Diversity in the fishery and demand for seafood is essential for a sustainable marine food system. These crashes and subsequent recoveries, made possible by large quota cuts that removed these fish from the market, highlight the importance of adequate management in addition to market and community-based conservation strategies.

Underused species have proven marketable as evidenced by demand for pollock and dogfish in Europe. However, current domestic marketing strategies are not effective

or non-existent, and underutilized fish struggle to gain a foothold in the United States (Bell 2014). More research investigating consumer preferences and effective marketing strategies is needed to assess the impact that the market can have on the sustainability and conservation of food fish stocks. Future research could also focus on a more representative range of New England's seafood consumers and could encompass a wider geographical range, including more species.

CONCLUSION

In this thesis, I examine a voluntary shift in seafood preferences that aims to divert demand for iconic, overfished species like cod by promoting, sustainably harvested, underused species of fish. As New England's fisheries continue to face growing pressures and depleting stocks, effective management and alternative forms of conservation like market-based strategies are crucial. The fisheries crisis is complex and involves a number of players, from fishers who struggle to make a living on the ocean and fisheries regulators who set regulations to consumers who demand certain types of fish and seafood sellers who are only willing to supply the most popular species. In the fishing industry, anthropogenic problems such poverty are often at odds with ecological function and conservation, and drive crises like overfishing and fisheries collapse. The New England fishery, which involves an undiversified seafood market and a fast growing local, sustainable seafood movement that promotes underused species, has the potential to continue to provide fishers with a way of life that has sustained them for centuries. Diversity is the key for both fishers and the fish they target.

Chapter 1 reviewed the current research focused on consumer seafood preferences. It discussed growing consumer awareness surrounding issues of sustainability but showed that demand has been slow to shift toward sustainable, local food. Current sustainable seafood labeling programs attempt to promote sustainably caught seafood and educate consumers about fisheries conservation. However, it is still unclear whether Marine Stewardship Council or Seafood Watch eco-labels effectively influence seafood consumers or positively affect the world's fisheries. The rise of Community Supported Fisheries and a local seafood movement, has demonstrated that there are ways to promote sustainable seafood other than sustainability labels. Consumers appreciate relationships with their seafood providers as well as transparent supply chains, which seafood eco-labels do not always provide. CSFs and sustainable seafood organizations like Sea to Table and the Gulf of Maine Research Institute show that marketing strategies may be part of the solution to the current fisheries crisis. Promotion of underutilized species has proven successful, albeit on a small scale.

Additionally, chapter 1 briefly examines the history of fisheries crashes in Maine, which provide cautionary lessons for the future of New England's seafood market. While

stringent management helped rebuild many of Maine's food fish stocks that became popular after cod stocks crashed, that crashes occurred provides evidence that unless managed correctly stocks could crash again. Previous stock depletions should make the fishing and seafood community more wary of overexploiting a specific fishery as New England has done with cod, haddock, and Atlantic halibut.

Chapter 2 of this thesis uses a survey to study attitudes and preferences for seafood consumption and demonstrates that while cod and haddock remain favorites of New England seafood consumers, there is room for underused species in the market. Consumers are willing to transition from overfished species to underused, low-value seafood given that the right set of attributes accompanies those fish. Consumers see fish as a bundle of attributes, including species/taste, price, origin of catch, and sustainability label, with some attributes of higher value to consumers than others. Additional characteristics of fish not used in the choice experiment include the type of seafood purveyor and the customer's familiarity with the species. While price, origin of catch, and a predisposition to buy certain types of fish influence consumer decisions, one of the most important factors deterring respondents from choosing the underutilized species was unfamiliarity with the fish.

Unfamiliarity with underused species is a problem that may be addressed through effective marketing and can be seen as an opportunity for the fishing industry. Respondents reported that they preferred fish caught locally, in the Gulf of Maine and were more willing to buy an unfamiliar fish at restaurants and independent seafood markets than supermarkets. With these buying preferences in mind, seafood suppliers should be able to tailor a supply of underused seafood that meshes with consumer preferences. Once seafood suppliers provide an opening in the market for underutilized fish, fishers will be able to profit from catches that would have otherwise gone to waste. As fishers and suppliers take advantage of New England's diverse seafood options, consumers will begin to realize that these underutilized species are not "trash fish" but food fish that are good alternatives to historically popular species.

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APPENDIX

Model and Estimation

The standard multinomial logit model, which has been used extensively for analyzing discrete choice models assumes that the respondents are homogeneous with regard to their preferences (the βs are identical for all respondents). This assumption is often invalid. Therefore, following the recent literature, I use a mixed multinomial logit model (MMNL) that incorporates heterogeneity of preferences (Carlsson *et al.* 2003; Hensher *et al.* 2003; Dissanayake and Ando 2014). Assuming a linear utility, the utility gained by person *q* from alternative *i* in choice situation *t* is given by

$$U_{qit} = \alpha_{qi} + \beta_q X_{qit} + \varepsilon_{qit}$$

where X_{qit} is a vector of non-stochastic explanatory variables. The parameter α_{qi} represents an intrinsic preference for the alternative (also called the alternative specific constant). Following standard practice for logit models we assume that ε_{qit} is independently and identically distributed extreme value type I. We assume the density of β_q is given by $f(\beta \mid \Omega)$ where the true parameter of the distribution is given by Ω. The conditional choice probability of alternative *i* for individual *q* in choice situation *t* is logit[1] and given by

$$L_q(\beta_q) = \prod_t \frac{\exp(\alpha_{qi} + \beta_q X_{qitq})}{\sum_{j \in J} \exp(\alpha_{qj} + \beta_q X_{qjt})}.$$

The unconditional choice probability for individual *q* is given by

$$P_q(\Omega) = \int L_q(\beta) f(\beta \mid \Omega) d\beta$$

Mixlogit Regression table

	Mixlogit - all	Mixlogit – previous underused fish purchase	Mixlogit – no underused fish purchase
Mean			
fish_pollock	2.915***	4.591***	0.788
	(0.455)	(0.664)	(1.034)
fish_mackerel	0.800*	2.207***	-0.761
	(0.421)	(0.576)	(0.741)
fish_hake	1.895***	3.375***	0.714
	(0.416)	(0.579)	(0.887)
fish_dogfish	-0.516	1.165**	-2.565**
	(0.523)	(0.576)	(1.007)
fish_haddock	4.706***	6.395***	4.492***
	(0.488)	(0.753)	(0.946)
fish_cod	3.689***	4.482***	3.313***
	(0.515)	(0.734)	(0.977)
recipe_incl	0.0210	-0.214	0.675**
	(0.148)	(0.189)	(0.306)
origin_GoM	1.668***	2.306***	1.556***
	(0.219)	(0.322)	(0.427)
origin_US	0.844***	1.218***	0.852**
	(0.170)	(0.255)	(0.333)
label_BC	0.428*	0.519*	-0.802
	(0.240)	(0.305)	(0.696)
label_GA	-0.577**	-0.343	-1.040**
	(0.254)	(0.395)	(0.425)
label_AV	-2.781***	-2.963***	-4.455***
	(0.585)	(0.760)	(1.373)
price1	-0.205***	-0.276***	-0.153**
	(0.0335)	(0.0472)	(0.0635)
Standard Deviation			
fish_pollock	2.308***	-1.649***	6.270***
	(0.389)	(0.462)	(1.233)
fish_mackerel	3.046***	3.731***	4.301***
	(0.384)	(0.622)	(1.024)
fish_hake	0.928*	0.892	2.724***
	(0.503)	(0.803)	(1.016)
fish_dogfish	3.423***	3.062***	4.317***
	(0.764)	(0.497)	(1.260)
fish_haddock	1.972***	2.623***	1.779***
	(0.403)	(0.399)	(0.480)
fish_cod	2.198***	-2.718***	2.471***

	(0.414)	(0.672)	(0.704)
recipe_incl	0.994*** (0.222)	-0.260 (0.332)	0.962*** (0.364)
origin_GoM	1.426*** (0.278)	1.461*** (0.330)	1.562*** (0.484)
origin_US	0.382 (0.301)	-0.938*** (0.306)	-1.238*** (0.480)
label_BC	1.620*** (0.424)	-1.417*** (0.361)	3.941*** (1.245)
label_GA	1.192*** (0.443)	-1.651*** (0.552)	1.929*** (0.596)
label_AV	-1.420 (1.085)	1.476* (0.858)	8.016*** (2.694)
price1	0.164*** (0.0188)	0.213*** (0.0287)	0.193*** (0.0343)
Observations	5434	3329	2105
Log lik.	-1477.3	-853.1	-551.5
Chi-squared	452.1	272.7	240.3

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$