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Behaviors and Perceptions of Environmental Decision Making: the Role of Information Dissemination Through Public Disclosures and Labels

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BEHAVIORS AND PERCEPTIONS OF ENVIRONMENTAL DECISION MAKING:

THE ROLE OF INFORMATION DISSEMINATION THROUGH

PUBLIC DISCLOSURES AND LABELS

By

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Environmental decision making may be influenced by information and how this information has been disseminated. By recognizing that information needs to be salient to the individual (Cash et al., 2003; Cash, Borck, & Patt, 2006), tailored and framed to the individual (Pelletier & Sharp, 2008), and recognizing that the information must be presented in a way that the individual is ready and able to accept the information (Teisl, Rubin, & Noblet, 2008) all serve as a means to improve the effect information has on environmental decision making. Through this work, two studies of contextual examples of how information dissemination affects environmental decision making are presented.

The first study seeks to learn about how safety information disclosures affect the perception of risk. Coastal water quality may be threatened by natural and human process; it is important to understand how coastal water users perceive the risk to human health associated with these threats (Hlavsa et al., 2011; Lewis & Miller, 2016). I use data collected by the New England Sustainability Consortium's (NEST) Safe Beaches & Shellfish Project 2015 mail survey conducted in Maine and New Hampshire on coastal residents (Fox et al., 2017). I investigate how information through public disclosures at either beaches or shellfish harvesting areas influence risk perceptions associated with entering the water (or eating shellfish) under an advisory or closure. Further, we test to see if the frames of marine environment

or public health may be more appropriate to communicate information to the public and how it influences risk perception. The findings suggest that disclosures of poor coastal water quality at these areas do not influence risk perception nor do specific messages appear to alter risk perceptions.

The second study seeks to better understand consumer information seeking behavior and use of product labels for aquaculture products and how these behaviors change when the heterogeneity in preferences is considered. Despite aquaculture's stance as a rapidly growing sustainable food technology, public opinion about aquaculture is still relatively unformed (Murray et al., 2017). Labeling of aquaculture products is an opportunity to provide information that is salient and messages that bridge the gap between the individual and the information presented on labels at the time of purchase (Cash et al., 2003, 2006; Pelletier & Sharp, 2008; Teisl et al., 2008). We use data from a 2017 national survey collected by the Sustainable Ecological Aquaculture Network (SEANET) Human Dimensions Team to capture behaviors and perceptions of aquaculture. To approach our unique problem, audience segmentation methods are employed to introduce heterogeneity in our sample based on a suite of covariates that fundamentally separates individuals into groups by their attitudes and impressions of aquaculture and investigate how aquaculture label seeking behavior on products changes across groups of individuals. Findings suggest that, while public opinion remains unformed, three types of individuals exist: interested skeptics, status quo, and information seekers. It is found that the different types of individuals all tend to seek information slightly differently, providing a frame for the aquaculture industry to tailor information so that it may be more salient to the individual at the time of purchase (Cash et al., 2006; Pelletier & Sharp, 2008).

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CHAPTER 1

INTRODUCTION

1.1. Introduction

Information is a vital component of the decision-making process. With relevant information about some subject or matter, individuals can form opinions, perceptions, beliefs, and attitudes that can then turn to actionable behavior. A growing body of work studies the role of information in environmental decision making. The current study builds and expands on this previous literature by identifying challenges faced by individuals making environmental decisions using varying information.

At the heart of this research is a set of articles that inform us about information and its role with individuals. Cash et al. (2003; 2006) note three components that must be present in disseminated information in order for it to have an effect on individuals: (1) scientifically credible, (2) legitimate, and (3) salient to the individual. The third aspect is of importance to the current study as it approaches the effect of information and its interaction with the individual in an economic scope. Information saliency is the idea that the piece of information is presented in a manner or at a time that is more likely to be accepted and retained by the individual. This is in opposition to what is called the "loading-dock approach" in that information is simply presented with no effort to link this information to the individual.

To further the idea of saliency, message tailoring serves as a way to increase the likelihood that the information will be retained by the individual. Pelletier and Sharp (2008) suggest that information should be framed it in a way that encourages autonomy:

> *"Tailoring messages according to proposed processes underlying behaviour change (i.e., being aware of a problem, deciding what to do about it, and implementing a behaviour) should make messages more effective by progressively increasing the level of self-determined motivation of the targeted population"* (Pelletier & Sharp, 2008, pg. 215).

Teisl et al. (2008) note the importance of the union between the individual and the information. At the time that the information is presented, the individual must be willing to accept the information. The authors note that there may be characteristics of the individual, specifically environmental attitudes, that may influence behavioral expectations.

The crux of this research is the combination of these aspects; for information to influence environmental decision making, the information must be both salient and tailored to the individual in accordance with the individual's environmental characteristics. It is with this foundation that this research tackles two contextual examples of environmental decision making presented by information dissemination.

1.2. Purpose and goal of the research

The unique attribute of this thesis work is that it presents two independent studies that seek to inform environmental decision making. Information dissemination is a key component of policy making, scientific research, and industry expansion. The two studies contained herein are but two exemplars of the challenges faced when conveying information to the public.

The first context is the protection of public health and deterrence of risky activities through public disclosures. This poses several challenges in that the information must be tailored to a mass audience on-site and directly impacts public health. The first study attempts to answer two important research questions: (1) how do risk disclosures affect risk perception? and (2) is there an environmental or societal frame that strengthens public disclosure messaging so that the information is more apparent and salient to the individual?

The second exemplar is understanding varied information seeking behavior of food labels due to heterogeneous preferences for a food technology, here, aquaculture. The unique aspect of this study is that while the information is available to the public, people may interpret the information differently. Through the example of aquaculture labeling, this work attempts to address the research questions: (1) what drives individuals to seek information on labels about a food technology? and (2) do we better understand this behavior with the introduction of heterogenous preferences?

1.3. Thesis outline

The remainder of the thesis will be divided into two studies on the effect information has on environmental decision making and a brief discussion. Chapter 2 presents a study that took place in 2015 in coastal Maine and New Hampshire. This section focuses on the effect that public disclosures of poor coastal water quality has on the perceived risk of (1) swimming at a beach under advisory due to poor coastal water quality; and (2) eating shellfish from a closed harvesting area due to poor coastal water quality. Chapter 3 presents a study from a national survey conducted in 2017 on the perception, attitudes, and behaviors associated with aquaculture. This section focuses on what drives individuals to seek information about aquaculture on labels and how this may change when we consider the heterogeneous nature of aquaculture perceptions. Chapter 4 concludes with lessons learned from this research and what it may mean moving forward.

CHAPTER 2

TAKING THE RISK: FACTORS INFLUENCING CITIZEN RISK PERCEPTION UNDER BEACH AND SHELLFISH ADVISORIES AND CLOSURES

2.1. Introduction

Coastal zones drive regional economies and enhance the quality of lives in its surrounding areas. However, coastal water quality may be threatened by both natural and human processes (Mallin, Williams, Esham, & Lowe, 2000). Both recreational coastal waters (Hlavsa et al., 2011) and shellfish harvesting areas (Lewis & Miller, 2016; NSSP, 2015) are impacted by poor coastal water quality. One of the impacts from the threats is closures to either recreational beach waters or shellfish harvesting areas due to poor coastal water quality. These pollution closures affect a variety of people like coastal recreational users and the tourism industry, coastal homeowners, commercial harvesters, and so on (Evans, Athearn, Chen, Bell, & Johnson, 2016; Parsons et al., 2009). It is important to understand how beach visitors and shellfish consumers perceive the risk to human health associated with these threats. Our study expands the literature of coastal management by providing insight into (1) how safety information disclosures at recreational beaches and shellfish harvesting areas affect the perceived risk of poor coastal water quality and (2) how priming through frames of public health and marine environment affect the risk perception of poor coastal water quality.

One aspect of an individual's risk perception may be influenced by the information they have about the risk. While studies show that the availability of safety information on the risks of an action change the pursuit of the activity (Verbeke, Frewer, Scholderer, & Brabander, 2007), other work suggests that risk perception is a poor indicator of risk behavior and that safety information aimed at altering risk perception will have little, if any, effect on risk behavior (Rundmo, 1997). These inconsistent results may be due to the need for information to be incorporated at a level that affects decision making. To do this, the information must be salient, credible, and have scientific legitimacy of the message to serve as a link between information and knowledge (Cash et al., 2003, 2006).

It is expected that once an individual obtains the relevant safety information of some given risk, perception of the risk should increase as the risks are made apparent. The decrease of risk perception following awareness of information about the risk may be considered irrational behavior. This may stem from safety information being either overlooked or from newer and less relevant safety information standing out more so than older but more critical information, creating a conflict between new and prior knowledge of the risk (Kollmuss & Agyeman, 2002; Loewenstein, Sunstein, & Golman, 2014). Alternatively, some people may simply have low risk perception in that they know what the risk is, but are seemingly unaffected by it; the probability of the risk occurring to them is perceived to be low (Sharot, Korn, & Dolan, 2011). The issue may lie in a failure of information salience. Take for example the perception of risk in extreme events (i.e. low probability, high damage) like natural disasters where risk perception and risk severity are linked (Slovic & Weber, 2002; Weinstein, 2000). This allows a focus on two competing, yet related, ideas: a failure of information in that individuals do not process safety information in the intended way or a failure of rationality in part because individuals do not believe in the risk associated with the safety information.

The opportunity cost of retrieving safety information includes both time and effort of an individual (Kaminski, Bell, Noblet, & Evans, 2017). While some work suggests that individual information seeking behavior may be more prone to sacrifice legitimacy of information for both difficulty of accessibility and time it takes to retain the information (Weiler, 2004), the utilization of avenues that are more salient and efficient in reporting safety information in a conversant manner remains a viable way to mitigate risky actions (Wahlberg & Sjoberg, 2000).

Safety information can come in a variety of mediums such as information that is sought out by the individual and information disclosures that are presented to the individual. Previous work on information seeking behavior regarding risks of water quality have shown that individuals who are more exposed to the risk are more likely to seek out safety information about the activity (Kaminski et al., 2017). This relies on the individual actively seeking out the safety information as opposed to the safety information that is presented to them in the form of a disclosure of poor coastal water quality at a beach or a shellfish harvesting area (EPA, 2017; NSSP, 2015). A downfall to disclosures, however, is that the message may not have as large of an effect as the providers of the safety information would intend (Loewenstein et al., 2014). It is important then to understand how disclosures regarding poor coastal water quality affect the risk perception of individuals to inform disclosure messaging for both beach-goers and shellfish consumers alike. Furthermore, understanding risk perception can be used to help misinformation from being spread and promote public health through efforts in a communication framework.

While we know that framing effects can be used to influence behavior, it is still unclear whether dissimilar frames affect different pathways of perceived risk involving environmental aspects of consumption and exposure. The literature on framing effects notes that structural variation of information affects cognition, thus respondents may react differently to the same facts depending on how they are presented (Kahneman, 2003; Kühberger, 1998) and this interpretation of information may be used to guide personal decision making (Thaler & Sunstein, 2008) and public policy (Amir & Lobel, 2017). Important to our research, previous work notes framing as an effect in decision making with natural resources, ranging from uncertainty (Brugnach, Dewulf, Henriksen, & van der Keur, 2011), to energy preferences (Noblet et al., 2015), to allocation of coastal water funds (Evans, Noblet, Fox, Bell, & Kaminski, 2017), to contingent valuation (Green, Jacowitz, Kahneman, & McFadden, 1998).

The literature on consumptive and exposure risk perception is still an expanding body of work. Growing concerns of safety and quality surrounding food risk perception, varying from disease outbreak (Setbon, Raude, Fischler, & Flahault, 2005), product origin (Fonte, 2002), and public health concerns (Sparks & Shepherd, 1994), pose a threat to food industries. Studies have suggested that while negative communication of food safety demotivates the consumption behavior of the food in question, behavioral and attitudinal components also serve as primary influences (Lobb, Mazzocchi, & Traill, 2007). Studies regarding the experience of specific food illnesses suggest that an event resulting in sickness has a negative cognitive influence that may increase the perception of risk (Parry, Miles, Tridente, & Palmer, 2006). Related, perception of risk due to exposure to an unsafe environment relies more on seeking and incorporating safety information on the potential hazards (I. H. Langford, Georgiou, Bateman, Day, & Turner, 2000). Studies suggest that improvement of water quality and the marine environment is important to reduce the risk of waterborne illness (Machado & Mourato, 2002; Wade et al., 2006). Effects of public health and marine environment frames may serve as a tool to improve messaging of environmental decision making (Pelletier & Sharp, 2008).

Understanding how risks are perceived and how knowledge about the risk is translated into actionable behavior will provide an opportunity for policy makers and researchers to mitigate these risks by conveying safety information that is salient to consumers (Cash et al., 2003, 2006). This work seeks to inform risk communication effects associated with poor coastal water quality by means of beach waters and shellfish consumption and offer methods that seek to deter citizens from engaging in dangerous activities through risk perceptions associated with poor coastal water quality (i.e., entering the water at a beach under advisory; consuming shellfish from a closed harvesting area). Through this work, we seek to explain two research questions to expand the literature of coastal management: (1) how do disclosures of poor coastal water quality at either recreational beaches or shellfish harvesting areas affect the risk perception of becoming ill from either swimming in the water or consuming shellfish harvested from that area, respectively? and (2) if framing has an effect on the risk perception of poor coastal water quality, which frame out of *public health* and *marine environment* is the most effective?

To find evidence for an answer to these research questions, we employ a fractional logit model. We find that both seeing a disclosure of poor coastal water quality at either a beach or shellfish harvesting area or the framed issue of public health or marine environment have no effect on the perception of risk in our hypothetical scenario. The lack of effect from disclosures and from the framed issue indicate a need for further work into risk communication.

2.2. Methodology

2.2.1. Study area

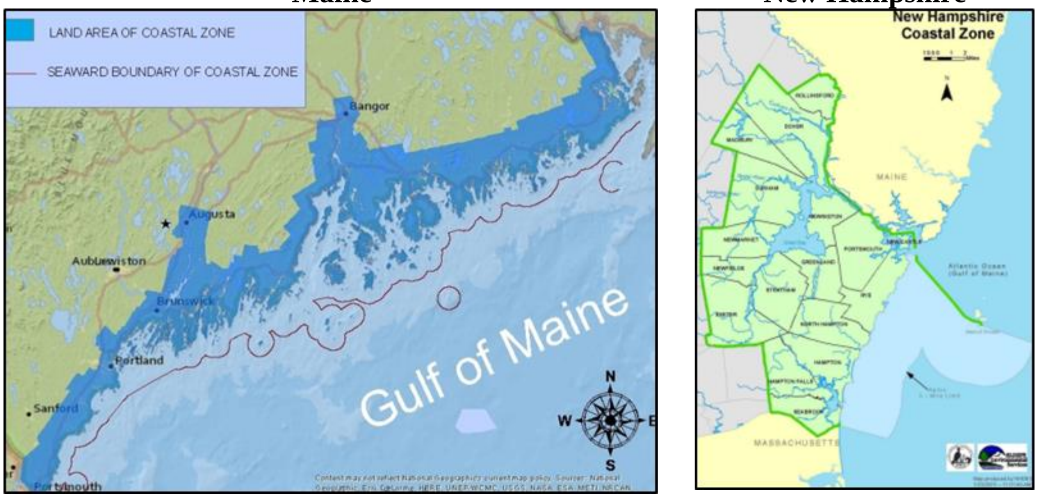
A unique characteristic of this study is the comparison of neighboring New England states – Maine and New Hampshire. While both states are subject to federal regulation of shellfish harvesting and sale (NSSP, 2015), the states differ in beach regulation for advisories and closures (EPA, 2017). Maine takes a decentralized approach through the Maine Healthy Beaches program, putting responsibility on beach managers (state and local) to test the coastal waters based on levels of bacteria and beach conditions. Staff of Maine Healthy Beaches then coordinate all the lab interpretation of the samples and engage with the local managers about the results. Once these measurements have been calculated, it is up to the beach manager if an advisory or closure is posted ("Maine Healthy Beaches," 2017). New Hampshire takes a centralized approach through the Department of Environmental Services Beach Program. Samples of the coastal water are taken and checked for bacterial contaminants. Once past a certain threshold, an advisory is posted advising not to go into the water, though not forbidden. In some cases, the beach manager may choose to close the beach ("New Hampshire Department of Environmental Services," 2017).

2.2.2. Survey administration

We used data from a two-round mail survey employed in August 2015 to randomly selected coastal zone residents of 146 coastal towns in Maine and 37 coastal towns in New Hampshire (Fox et al., 2017). The survey included a $1 incentive for participation (Dillman, Smyth, & Christian, 2014) (Figure 2.1.). Of the 4,000 surveys that were distributed, we received 1,176 for a response rate of 32.9% (427 undeliverable). Not all surveys were returned complete, thus a subset of 769 respondents who answered all questions in this study are used (subset response rate = 21.5%). Comparison of the demographics of this subset sample with the adult population revealed that our sample is comprised of more males, is more educated, has a higher income, and is older than the general adult population in our study area (Table 2.1.).

Figure 2.1.: Sample area of Maine and New Hampshire's coastal zones used for survey administration

Maine **New Hampshire**



Coastal zone images taken from (Fox et al., 2017)

Table 2.1.: Comparison of Maine and New Hampshire sample of survey respondents against 2010-2014 American Community Survey

	Maine (N=541)		**New Hampshire (N=228)**	
	Sample	**Census**	**Sample**	**Census**
Gender (Male)	59.1%	49.0%	54.8%	49.5%
Education (HS or above)	97.2%	91.6%	99.1%	92.3%
Median income	$62,500	$48,804	$87,500	$64,916
Median age	57.5	43.2	54.9	41.5

Table modified from Evans et al. (2017)

The survey questionnaire included questions about coastal areas, coastal water quality, behaviors associated with beach activities or seafood consumption, coastal water quality protection programs, and opinions on policy issues. Consistent with our research objectives, we administered the survey using 6 versions. These versions varied based on the combinations of exposure pathway (i.e., shellfish, beach), health frame (i.e., public health or marine environment), and state institutional references (i.e., Maine and New Hampshire). We revised the question wording and artwork appropriately by version to demonstrate the impact of varying information on decision making (Figures 2.2. and 2.3.).

Through a randomized distribution of surveys, we find a roughly even split between beach and shellfish version of the survey at the aggregate level and within the states sampled. A larger proportion of the survey respondents were from Maine, consistent with survey administration. Though there is roughly an even total split of marine environment and public health, we recognize that slightly more respondents from Maine received the marine environment issue and slightly more respondents from New Hampshire saw public health (Table 2.2.).

Figure 2.2.: Example question text used in survey to display how the health frame was employed

"Please think about coastal water quality in terms of «ISSUE Pt. 1» including the «ISSUE Pt. 2». In your opinion how would you rate the coastal water quality in these New England states and Canadian Provinces?"

ISSUE Pt. 1/ISSUE Pt. 2 was replaced with either (1) public health/safety of swimming in the water and shellfish harvesting from flats and waters or (2) marine environment/health of plants and animals

Table 2.2.: Summary of respondents by state, version, and frame
N=769

	Total	**Maine**	**New Hampshire**
	100% (769)	70.4% (541)	29.7% (228)
Natural pathway			
Beach	49.7% (382)	49.2% (266)	50.9% (116)
Shellfish	50.3% (387)	50.8% (275)	49.1% (112)
Induced frame			
Marine environment	49.8% (383)	52.7% (285)	43.0% (98)
Public health	50.2% (386)	47.3% (256)	57.0% (130)

2.2.3. Data

2.2.3.1. Dependent variable

Respondents provided our dependent variable, the likelihood of getting sick from 0-100% (rescaled to 0-1), when faced with one of two risk scenarios (Figure 2.3. and 2.4.).

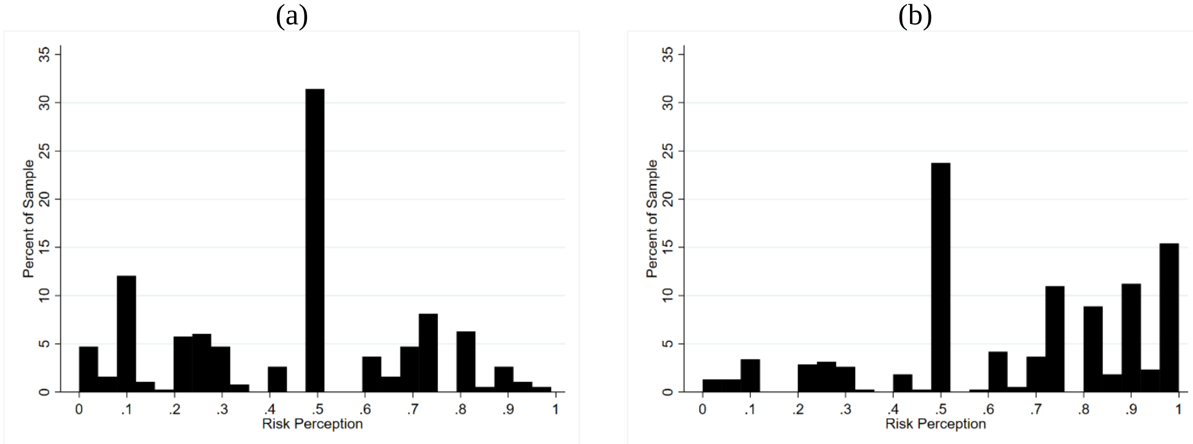
Figure 2.3.: Artwork and question text for risk perception scenario by version of survey with response format[1]

Beach	Shellfish
	
If a beach has an advisory recommending that people not to enter the water, and a person like yourself enters the water, in your opinion how likely is it that this person gets sick?	*If a shellfish area is posted as closed, and a person like you eats shellfish from this area, in your opinion, how likely is it that this person will get sick?*

Enter a number between 0 (definitely will not get sick) and 100 (definitely will get sick).
___%

Figure 2.4.: Distributions of risk perception by (a) beach and (b) shellfish

(a) (b)



To explain a respondent's stated perceived risk, we employ variables that may capture a priori knowledge, perceptions, familiarity with, and efforts to seek safety information about the risk (Table 2.3.). While no respondent in the beach version stated that they were 100% confident that they would become ill, 56 (14.62%) of respondents in the shellfish version stated they were 100% confident that they would get sick. Of those who had no risk perception (0% chance of becoming ill), the beach version contained 10 (2.62%) and the shellfish version contained 2 (0.52%). Furthermore, the respondents who stated that there was a 50% probability of becoming sick were 119 (31.15%) for the beach version and 91

[1] Note to reader: The definition of risk perception differs from Slovic et al. (1980) in that I am only able to account for perceived likelihood of risk and not risk severity.

(23.76%) for the shellfish version. This indicates that either there is a large portion of our sample who are either quite uncertain about the outcome or have systematically anchored their response to 50% (Manski & Molinari, 2010).

2.2.3.2. Explanatory variables

Two binary variables are used to provide evidence for the research questions. The first is whether the respondent has seen a disclosure at either a recreational beach or a shellfish harvesting area depending on which version of the survey was received. It is made apparent to the respondent that closure indicates that the water quality has reached an unsafe level of contaminants. To test for framing effects, we control for which version of the survey the respondent received (Table 2.3.).

We control for information seeking behavior about either water quality at beaches in the respondent's home state or the safety of eating seafood, consistent with prior work (Kaminski et al., 2017). The belief that scientists to provide reliable information is included to control for variation in the saliency of these disclosures, as disclosures are posted after scientific evidence shows a certain level on contamination in the water at either beaches or shellfish harvesting areas (Cash et al., 2003, 2006; EPA, 2017; NSSP, 2015). Further controls include past sickness from either swimming at a coastal beach in the respondent's home state or to eating shellfish[2], ratings of home state water quality, risk preference, and a related risky behavior (Cohen, Etner, & Jeleva, 2008; Rabin & Thaler, 2001). The risky behavior varied between version with frequency of swimming in coastal waters after a heavy rainfall being used in the beach version and frequency of eating raw shellfish/meat being used in the shellfish version. These, along with risk preference, are used to control variation in risk perception (Slovic, 1987). Lastly, demographics are included as well as state for the beach version only (Table 2.3.). State is included in the beach version only as federal regulations prevent a difference in state policy between Maine and New Hampshire for shellfish closures but the state policy for beach closures do vary (EPA, 2017; NSSP, 2015).

[2] It is noted to the respondent that the sickness caused by shellfish consumption is not due to an allergic reaction.

Table 2.3.: Descriptive statistics for dependent and explanatory variables

Variable	Description	Mean Std. Dev. Beach (N=382)	 Shellfish (N=387)
Dependent variable			
RISK	Likelihood of getting sick from either entering the water at a beach under an advisory or eating shellfish from a closed harvesting area due to poor coastal water quality (0-1)	0.447 0.255	0.655 0.272
Explanatory variables			
- Disclosure and frame			
DISCLOSURE	Seen beach advisory or seen shellfish closure due to poor coastal water quality = 1; Otherwise = 0	0.291 0.455	0.563 0.497
ISSUE	Public health = 1; Marine environment = 0	0.518 0.500	0.486 0.500
- Information attributes			
SEEK_INFO	Sought safety information about water quality at coastal beaches or sought safety information about seafood consumption = 1; Otherwise = 0	0.181 0.385	0.320 0.467
RELIABLE	Scientists provide reliable information (Disagree = 1; Agree = 7)	5.202 1.322	5.098 1.286
- Personal characteristics			
PAST_ILLNESS	Gotten sick from swimming at coastal beach or from consuming shellfish = 1; Otherwise = 0	0.010 0.102	0.109 0.311
HOME_WQ	Rating of home state water quality (Poor = 1; Excellent = 7)	3.673 0.787	3.734 0.712
RISK_PREFERENCE	Respondent generally avoids taking risks (Disagree = 1; Agree = 7)	4.631 1.661	4.651 1.608
RISK_BEHAVIOR	Stated frequency of either swimming at a beach after heavy rainfall or consuming raw (Never = 1; Often = 7)	2.492 1.637	2.395 1.798
- Sociodemographics			
STATE	New Hampshire = 1; Maine = 0	0.304 0.460	- -
MALE	Male = 1; Otherwise = 0	0.584 0.494	0.574 0.495
EDU	Education (Categorical from 0-11 years = 1 to Postgraduate = 5)	3.620 1.084	3.685 1.084
INC	Household income (1000USD)	86.865 56.065	6.636 1.975
AGE	Age (years)	56.817 14.935	56.625 14.631

2.2.4. Statistical model

Given the nature of the dependent variable, a fractional logit model is employed following Papke and Wooldrige (1996)[3]. A fractional logit model is unique in that it can handle proportional data [0,1], is differentiable which allows interpretation of marginal effects, and can be specified using a logit probability. Given the focus of this work is on policy relevance, model interpretation will take the form of sign and significance, though numeric coefficients and marginal effects are presented[4]. The log-likelihood of the function take the form of equation 2.1 (Papke & Wooldridge, 1996) where y_i is the dependent variable, X_i is a suite of covariates used in the model, β is the related coefficients, and $G(X_i\beta)$ takes the logit functional form of equation 2.2:

$$lnL = \sum_{i=1}^{N} y_i \, ln[G(X_i\beta)] + (1 - y_i) \, ln[1 - G(X_i\beta)] \qquad (2.1)$$

$$G(X_i\beta) = \frac{e^{X_i\beta}}{1 + e^{X_i\beta}} \qquad (2.2)$$

2.3. Results

The results for both versions of the survey are shown in Table 2.4. Columns 1 and 2 show the coefficients and marginal effects respectively of the fractional logit model on the beach version of the survey. Columns 3 and 4 show the coefficients and marginal effects respectively of the fractional logit model on the shellfish version of the survey.

2.3.1. Beach

It is suggested by the data that the statistically significant impacting factors to risk perception of becoming ill from swimming in coastal waters under an advisory of poor coastal water quality is risk preference, risk behavior, identifying as male, and age squared. If a respondent has a higher aversion to

[3] A more appropriate model would be a zero-one-inflated beta regression (Ferrari & Cribari-Neto, 2004; Ospina & Ferrari, 2009, 2012) that is extended to account for the mass at 0.5. However, the data are quite limited in both sample size and those who stated 0 or 1 which would produce unruly and uninterpretable standard errors.

[4] Note to reader: a marginal effect in a fractional logit model is interpreted as with a unit increase in the explanatory variable, there will be a percentage change in the dependent variable corresponding to the coefficient. This is not discussed in the paper as "risk perception" and statements like "a change in X increases/decreases risk perception by Y%" is ambiguous and does not provide any additional benefit to policy making.

risk, the average response of the risk perception of becoming ill after swimming in coastal waters where an advisory is in place due to poor coastal water quality increases. Related, there is a negative effect on risk perception from those who engage in a similar risky activity. Both of the two previous results follow basic theory of risk perception (Slovic, 1987). Identifying as male decreases the average perception of risk, consistent with previous work (Harris, Jenkins, & Glaser, 2006). Though the effect is buried in zeros, age squared negatively impacts risk perception suggesting that risk perception increases with age until a certain point where it begins to decrease. Both seeing a disclosure at the beach and the framed issue have no statistical impact on risk perception (Table 2.4.).

2.3.2. Shellfish

From the results of the shellfish model, it is found that both seeking relevant safety information and having a higher belief that scientists provide reliable information both increase risk perception. This is unsurprising as those who seek information about a risk and trust in the source are aware of a similar risk and may have a higher perception of said risk. Getting sick from shellfish in the past has the largest effect on risk perception of eating shellfish harvested from an area of poor coastal water quality. This suggests that those who have gotten sick from shellfish consumption may have a much higher risk perception than those who have not. Both risk preference and risk behavior have an effect on risk perception in that those who avoid risk have a higher perceived risk and those who engage in similar risky activities have a lower perceived risk, consistent with prior work (Slovic, 1987). Identifying as male and age have a negative effect on risk perception (Harris et al., 2006). Both seeing a disclosure at the shellfish harvesting area and the framed issue have no statistical impact on risk perception (Table 2.4.).

Table 2.4.: Coefficients and marginal effects of fractional logit model for the (1) beach and (2) shellfish versions of the survey

Version	**Beach (N=382)**		**Shellfish (N=387)**	
	Coefficient Std. Err.	**Margins Std. Err.**	**Coefficient Std. Err.**	**Margins Std. Err.**
Explanatory variables				
- Disclosure and frame				
DISCLOSURE	-0.093 -0.116	-0.022 -0.028	0.033 -0.122	0.007 -0.026
ISSUE	0.033 -0.108	0.008 -0.026	0.085 -0.119	0.018 -0.025
- Information attributes				
SEEK_INFO	0.011 -0.139	0.003 -0.034	0.408*** -0.136	0.087*** -0.029
RELIABLE	-0.014 -0.042	-0.003 -0.01	0.131*** -0.05	0.028*** -0.011
- Personal characteristics				
PAST_ILLNESS	0.436 -0.356	0.106 -0.086	0.570** -0.222	0.121*** -0.047
HOME_WQ	-0.05 -0.07	-0.012 -0.017	-0.111 -0.087	-0.024 -0.018
RISK_PREFERENCE	0.082*** -0.031	0.020*** -0.008	0.074* -0.041	0.016* -0.009
RISK_BEHAVIOR	-0.062* -0.033	-0.015* -0.008	-0.126*** -0.034	-0.027*** -0.007
- Sociodemographics				
STATE	-0.147 -0.115	-0.036 -0.028	- -	- -
MALE	-0.234** -0.112	-0.057** -0.027	-0.418*** -0.123	-0.089*** -0.026
EDU	-0.003 -0.052	-0.001 -0.013	-0.013 -0.069	-0.003 -0.015
INC	-0.001 -0.001	0.000 0.000	0.000 -0.001	0.000 0.000
AGE	0.024 -0.020	0.006 -0.005	-0.048* -0.025	-0.010* -0.005
AGE^2	-0.000* 0.000	-0.000* 0.000	0.000 0.000	0.000 0.000

2.4. Discussion

We began this study with two research questions in mind: (1) how do disclosures of poor coastal water quality at either recreational beaches or shellfish harvesting areas affect the risk perception of becoming ill from either swimming in the water or consuming shellfish harvested from that area respectively and (2) if framing has an effect on the risk perception of poor coastal water quality, which frame out of *public health* and *marine environment* is the most effective? From the results of the data, we find evidence that seeing a disclosure of poor coastal water quality at either a beach or a shellfish harvesting area has no effect on risk perception of becoming ill from either swimming while the advisory is posted or consuming shellfish harvesting from a closed area. We further find no effect of framing between public health and marine environment on risk perception.

This study is limited by several factors that future work may seek to relieve. First, a follow up question to ascertain confidence in the response of risk perception may provide insight into certainty. Second, a reconstruction of the question, perhaps to a purely ordered Likert-scale response, may reduce the variability in risk perception for ease of analysis. Third, disclosure awareness for both pathways are framed in a way that asked respondents to only respond if they had seen or heard of a closure/advisory due to poor coastal water quality. A question before this to gauge monitoring activity would provide more insight into awareness of the protection of public health through these monitoring efforts. Fourth, the statistical methods were constrained by the data. A zero-one-inflated beta regression with an extension to analyze the mass at 0.5 would provide a richer analysis. However, the data were both small in sample size and had a relative lack of those who reported levels or risk perception at 0 and 1. This would cause portions of the model to be uninterpretable. Further research should seek to explore methods to incorporate rounded responses into the estimation process (e.g., 25%, 50%, 75%, and so on) (Manski & Molinari, 2010). Lastly, an expansion of type of risk may further inform the risk perception literature. While this risk perception variable focuses only on the risk to personal health, an expansion to marine health, recreation industry, and public health are avenues of future research.

Despite this set of limitations, this work is still critical for the protection of public health against these risks by seeking to provide information that will improve risk messaging to make the information more salient for both residents and tourists alike (Cash et al., 2003, 2006). Communication of risks through disclosure awareness can be an effective avenue of mitigating the risk introduced from entering water at a coastal beach under advisory. A challenge moving forward with this communication is that while 29% of the respondents have seen a beach advisory, it did not affect the perception of risk for poor coastal water quality at the beach. This leaves room for an improvement in communication of beach monitoring, even when the beach currently has safe conditions, to help convey the risks of coastal waters despite low reported illnesses from either Maine or New Hampshire coastal beaches (Dorevitch et al., 2012; Fleisher & Kay, 2006; Hlavsa et al., 2011). Experiences of past sickness, either through the respondent or a family member, may provide a framework for communication in reporting that the illness, be it epidemiological, GI, or related, can be contracted by anyone. Policy makers and researchers alike should seek to improve communication of these advisories in a manner that improves the awareness levels of monitoring and that improves the messaging to increase risk perception when an advisory is posted.

Previous studies in a similar setting have shown that those who engage in recreational activities are more likely to seek out safety information (Kaminski et al., 2017). While this allows for a tailoring of information based on recreational activity (Pelletier & Sharp, 2008), disclosures are subject to a more general audience as they are publicly displayed (Loewenstein et al., 2014). Communication campaigns that display not only safety information but also monitoring efforts at coastal beaches may improve both disclosure awareness and state and local government responsibility/effectiveness in protecting coastal water. However, this should be approached with caution as a boomerang effect may exist when an advisory is posted; a posted advisory may cause curiosity in the risk and tempt beachgoers to still enter the water (Hart, 2013; Ringold, 2002). While some mobile phone applications are already in place to inform citizens about water quality in Maine ("Beaches in Maine," 2017), social media presence in both states may aid in this endeavor. Furthermore, the state of Maine has existing state sponsored programs that help report disclosures and promote communication of the risks involved during a beach closure ("Maine Healthy Beaches," 2017). To the author's knowledge, no such programs exist in the state of New Hampshire, though this may be due in part to the relative lack of coastline. These programs can provide a viable method in risk mitigation for beaches under an advisory due to poor coastal water quality.

A further measure of mitigation of risk at beaches arises when beach monitoring policies in Maine and New Hampshire are taken into consideration. In Maine, there is a more decentralized approach to water quality monitoring at the beach. While this provides localized benefits of regulation, the decision to post an advisory is subject to the local beach manager ("Maine Healthy Beaches," 2017). In contrast, New Hampshire takes a more centralized approach to water quality regulation at beaches. Once water quality has reached a certain threshold, an advisory is posted, though the beach is not closed. The public may still enter the water at their free will unless the local beach manager decides to firmly close the beach and close the parking to the beach ("New Hampshire Department of Environmental Services," 2017). An update in this policy may further mitigate any risk associated with poor coastal water quality at beaches in both states. For both states, a more rigid policy *requiring* local beach managers to both monitor water quality at these beaches and *close* the beach is an avenue for policy revision to aid in risk mitigation.

It is found that there is a higher awareness of shellfish harvesting closures, reported illness levels, and information seeking behavior for the shellfish pathway. Despite this, there is a no effect of seeing a disclosure with the perception of risk from eating shellfish from a closed harvesting area. This may suggest that the disclosure at the shellfish harvesting areas may not be effective in conveying risks. It may be the case then that an information gap exists in the risks associated with contaminated shellfish consumption. This anomaly, however, may be attributed to the lack of exposure to this risk due to the enforceable policies currently in place regarding shellfish products (NSSP, 2015). Despite this, recreational shellfish harvesting and the cottage industry still pose a threat to consumption of shellfish from closed harvesting areas. Policy makers and researchers alike should seek to improve communication of the risks of contaminated shellfish products and continue to enforce, if not expand, policies regarding shellfish harvesting flat closures to ensure the protection of public health.

While this research investigates the impact of point-of-contact signs, other factors may be influencing risk perception such as societal norms (e.g., actions of other beachgoers) (Cialdini et al., 1998; Elster, 2007) or ascription of responsibility for the protection of coastal water quality by state or federal organizations (Genius et al., 2005; Kontogianni et al., 2003). Managers of these natural resources should work to understand all facets of what may be directly, or indirectly, influencing risk perception with the goal to deter risky activity for the protection of both public health and the marine environment.

CHAPTER 3

AQUACULTURE'S X AMERICAS: AUDIENCE SEGMENTATION AND INFORMATION SEEKING BEHAVIOR REGARDING AQUACULTURE PRODUCTS

3.1. Introduction

The Food and Agriculture Organization (2016) states that as of 2014, the aquaculture (henceforth AQ) industry accounts for 44.1% of global aquatic animal (primarily finfish and shellfish) production. AQ sea vegetable production, such as seaweed and algae, has nearly tripled over the past 20 years. Since the late 2000's, Asian AQ production has exceeded Asian wild-capture fisheries. There has also been an upward trend in AQ within Africa and the Americas; despite this trend, there is still a considerable gap before AQ production in other continents grows beyond capture fisheries (FAO, 2016, pp. 18-22). The United States depends on imports to satiate domestic demand for seafood and sea vegetables (FAO, 2016, pp. 54), though this may be attributed to re-exportation of AQ products for processing (Knapp & Rubino, 2016; NOAA, 2016). US AQ is a viable alternative to US wild-capture fisheries and sea vegetable supply (FAO, 2016) and may provide domestic economic benefits to low-income fishing communities (Pérez-Sánchez & Muir, 2003). It is critical, then, to understand domestic citizen beliefs and perceptions about AQ to improve marketing strategies, increase domestic purchase and consumption of AQ products, and build AQ acceptance as a sustainable food technology.

Yale's study entitled *Global Warming's Six Americas: 2009* revolutionized how information about climate change and greenhouse gas emissions is conveyed. Given that different types of individuals retain different types of information, Leiserowitz and colleagues (2009) suggest that groups of individuals and the way they perceive global warming may be discovered through individual characteristics using latent class analysis. These characteristics include 36 variables relating to beliefs, perceptions, political leaning, actions, and other attributes that define the individual. The authors find that within the general population, six different classifications emerge from the data, which they labeled: alarmed, concerned, cautious, disengaged, doubtful, and dismissive. Once these classes are discovered, insight into environmental issues and actions may be separated for a much deeper and richer analysis of climate change perception. Furthermore, this audience segmentation allows for information to be catered and communicated in a way that is specific to the individuals' beliefs about the subject of climate change (Leiserowitz et al., 2009). Through latent class analyses and other segmentation methodologies, heterogeneity is introduced to provide a more robust set of results. Here we recognize the potential for heterogeneity in AQ opinions that provides a foundation for investigation of how perceptions of AQ may differ across groups of people. I expand upon previous studies that examine heterogeneity in seafood preferences (Hanson, Rauniyar, & Herrmann, 1994; Nguyen, Haider, Solgaard, Ravn-Jonsen, & Roth, 2015; K. K. Quagrainie & Engle, 2006) by investigating how information seeking amongst these groups differs, specifically label seeking behavior on AQ products.

A US survey that captured attitudes, behaviors, and perceptions associated with AQ revealed that public opinion remains relatively unformed at the national level, suggesting a gap between AQ industry products, practices, and impacts and consumer knowledge (Murray et al., 2017). This gap between the general population and the AQ industry may be relieved through information distribution. Information salience has been shown to be a crucial competent of actionable knowledge (Cash et al., 2006). While seafood labels serve to disseminate product information, segmentation of the population by beliefs and perceptions about AQ allows content to be catered thereby improving information saliency. This presents an opportunity for studying the impacts of varying AQ information (e.g. marketing, safety, health) on labels that is more salient to different segments of individuals and prompts two important research questions: (1) In the context of AQ products, what is driving label seeking behavior? and (2) does introducing heterogeneity improve our understanding of this behavior?

Understanding AQ label seeking behavior is one of many pieces needed to help shape public opinion. By gathering baseline information on current perceptions of AQ and label information seeking behavior, there will be a better understanding of opportunities to influence future behaviors. This work seeks to inform information diffusion, food technology acceptance, and labeling efforts of the AQ industry. Armed with the robust literature of various AQ perceptions, this work seeks to expand the AQ literature through comparative audience segmentation methodologies paired with models that explain what is driving label seeking behavior of AQ products.

I employ (1) a latent class logit model and (2) a cluster analysis using Ward's method interacted with a logit model to better understand what is driving label seeking behavior. Given a lack of solidified public opinion about AQ in the US and a relative lack of variance in public perceptions, the comparative methodologies introduce heterogeneity through both statistical means (latent classes) and by means of groupings in squared Euclidean space (clusters). It is found that, given a lack of convergence for the latent class logit model, the cluster analysis provides a more suitable method for introducing heterogeneity into the sample. Three clusters are found to exist within the sample, which I label: interested skeptics, status quo, and information seekers. Through the model, those who seek information on seafood country of origins, sustainable harvesting, areas known for high quality seafood, and certifications are more likely to seek AQ information on labels. Yet, a model ran on the homogeneous sample may still be appropriate due to potentially uniform opinions.

3.2. Background

3.2.1. Perceptions of aquaculture

Given the variety of products that AQ can yield, the economic, social, and environmental impacts and perceptions of the industry will vary (D'Anna & Murray, 2015; Hall & Amberg, 2013; Naylor et al., 2000). For example, despite the perception of AQ as environmentally intrusive (Naylor et al., 2000), the production of shellfish can actually provide benefits to the environment as they improve water quality through filter-feeding (Shumway et al., 2003). This implies that information regarding beliefs and perceptions of AQ may vary depending on what information an individual has obtained or been exposed to (e.g., media, labeling, safety or production) about the industry.

For AQ to expand as an industry and meet domestic seafood demand in the United States, it is important to understand how perceptions about AQ are influenced as citizen opposition can hinder industry growth (Knapp & Rubino, 2016). Measuring stakeholder and citizen support of AQ may help bridge the gap between AQ industry products, practices, and impacts and consumer knowledge and is crucial for understanding perceptions, support, and perception of risks relating to AQ (Chu et al., 2010; Mazur & Curtis, 2006).

Awareness and knowledge of AQ play a significant role in its acceptance and support by consumers (Aarset et al., 2004; Chu et al., 2010; Gempesaw II, Bacon, Wessells, & Manalo, 1995; Mazur & Curtis, 2008) despite a trend of low levels of knowledge of other food technologies (Frewer et al., 2011). This implies that disseminating legitimate and salient information is important for increasing support of AQ. Several information characteristics have been shown to influence the perception of AQ. Mazur and Curtis (2006) find that stakeholders and households alike trust in science despite being skeptical about government organizations and the AQ industry. Building trust in both government organizations and the AQ industry while conveying scientific information at a level salient to individuals remains a challenge for AQ producers (Aarset et al., 2004; Mazur & Curtis, 2006).

Bergfjord (2009) finds that producers in the AQ industry are typically concerned with product price drops (impacting profit), regulation of the industry, and disease amongst their product. This is relatable to consumers being concerned about affordability, policy affecting AQ, and food safety. Additional economic, social, and environmental concerns are raised when considering the support of AQ including pollutants, fishery pressure, diet and health, and ecosystem invasion (Chu et al., 2010; Gempesaw II et al., 1995; Naylor et al., 2000). Understanding these concerns will help to mitigate the perception of risk related to AQ and increase support of the industry.

Several sociodemographic characteristics, like gender, income, and age have been shown to affect AQ product consumption (Gempesaw II et al., 1995) as well as AQ perceptions. For example, Mazur and Curtis (2006) show that higher education and identifying as female are both correlated with an increase of concern regarding environmental issues associated with AQ. Further, previous studies have shown that coastal distance affects consumption of certain AQ products (e.g., those who live close to the coast are more likely to consume AQ oysters more frequently) (Gempesaw II et al., 1995), but communities value the AQ farms higher as they provide community income and employment (Katranidis, Nitsi, & Vakrou, 2003). Personal habits such as frequency of seafood purchase and consumption must also be considered as they positively affect interest in and support of AQ (K. Quagrainie, Hart, & Brown, 2008), though the preference of wild-caught over AQ seafood has been shown to negatively affect AQ product consumption (Hall & Amberg, 2013).

Previous studies have measured the effect on AQ perceptions by proximity to coast or by nondomestic products (Chu et al., 2010; Gempesaw II et al., 1995) as the economic, environmental, and social impact will differ for communities closer to AQ sites (Evans et al., 2017; Mazur & Curtis, 2008). Though freshwater AQ production currently makes up the majority of the United States' AQ market (NOAA, 2017), coastal communities are impacted by a growing marine AQ industry due to the shared water use on the coast (Primavera, 2006). Additionally, there is evidence of a relationship between the tourism industry and AQ as these areas rely on coastal zones as a portion of their economy (Freeman et al., 2012). This implies that further investigation of perceptions and support of AQ production based on spatial impacts is necessary for the healthy expansion of AQ production.

3.2.2. The role of aquaculture labels

The use of information via labels involves two crucial aspects: (1) the direct information provided by the label and (2) the individual's readiness to use and/or accept the information. In multiple studies, Cash et al.[5] (2003, 2006) notes the importance of saliency in effective dissemination of information. This is furthered by Pelletier and Sharp (2008), who suggest that message "tailoring and framing" may provide more certainty in behavior altering information. The bridging of the inherent gap between information and the individual is an important step in information communication as noted by Teisl et al. (2008) and will aid in the endeavor to match label attributes to latent consumer preferences. This gap may be more difficult to close with the aforementioned trend of low levels of knowledge in food technologies (Frewer et al., 2011). Through labeling efforts, search attributes (i.e., information the individual may obtain before purchasing a product; generally visible) may help bridge this gap despite issues that may persist from experience attributes (i.e., information the individual may obtain after experiencing a product) and

[5] Full author list between Cash et al. (2003) and (2006) vary despite having the same first author. Please see citation for respective author list and credit.

credence attributes (i.e., asymmetric information that is difficult for the individual to obtain) (M. R. Darby & Karni, 1973).

Food labels and certifications serve to disseminate information about a product, its quality, origin, and other factors to consumers. These can take the form of eco-labels (C. L. Noblet & Teisl, 2015; Teisl, Roe, & Hicks, 2002; Teisl et al., 2008), organic labeling (Janssen & Hamm, 2012; McCluskey & Loureiro, 2003), origin of product (Loureiro & McCluskey, 2000; van Ittersum, Candel, & Meulenberg, 2003), farm raised vs. wild caught (Brayden et al., 2018), and so on. Another potential service that food labels can offer is the mitigation of perceived risk of a new food technology, such as AQ, at the time of purchase by providing some measure of certification, product origin, if it was sustainably harvested, or other credence attributes not readily available to the consumer otherwise. It is critical then to recognize the importance of labeling and certifications' influence on the consumer's label information seeking behavior to help bridge the gap between search behaviors and credence attributes and their effect on the consumer.

The US currently requires method of production labeling for fish and shellfish (USDA, 2017). Food labeling on AQ products represents a form of targeted product information that may relieve pressure on the consumer by providing credence attributes (e.g., sustainability, environmental impact, health, etc.) to increase acceptance as a food technology. While local labels on farmed seafood has been shown to resonate more than non-local foods for consumers (Davidson, Pan, Hu, & Poerwanto, 2012; Fonner & Sylvia, 2015), the boundary of where local foods become non-local is still questionable (Darby et al., 2008). Other efforts for labeling include "organic" farm-raised salmon, which has shown to have similar effects of price premiums as "organic" agriculture products have (Ankamah-Yeboah et al., 2016) despite a lack of a formal definition of "organic" AQ (Aarset et al., 2004; USDA, 2016). Further, studies regarding organic labeling show that trust in the certification may play a critical role at the time of product purchase (Janssen & Hamm, 2012; Nuttavuthisit & Thøgersen, 2017). While a number of studies look at the effect of similar forms of AQ labeling (Brayden et al., 2018; Roheim, Sudhakaran, & Durham, 2012), areas not commonly associated with AQ (e.g. inland states) may result in a lack of any effect from AQ labeling (Quagrainie et al., 2008).

Labels that distinguish wild-caught from farm raised have been shown to influence both the willingness to pay and preference for seafood products. Roheim, Sudhakaran, and Durham (2012) show that seafood consumers have a preference for wild-caught as opposed to certified farm raised seafood which has been shown by other studies to negatively affect AQ product consumption (Hall & Amberg, 2013). This suggests that current labeling for AQ products may need improvement to encourage consumer purchases (Gaviglio & Demartini, 2009).

3.3. Methodology

3.3.1. Survey administration and sample

An online survey was employed and administered by GfK International through the KnowledgePanel from 13 January to 28 January of 2017 with a pre-test taking place shortly before from 27 December to 29 December of 2016 (Dillman et al., 2014). The KnowledgePanel is an online panel of 55,000 members hosted by GfK that represent the US population (GfK, 2018). The participants were selected using probability sampling of addresses and are notified by either (1) email or (2) visiting their KnowledgePanel account. The total sample consisted of N=1,210 completed surveys (N=2,125 surveys were sent with a response rate of 56.9%). Each respondent received compensation for their time to take the survey through a point system on their KnowledgePanel account. A follow-up email was sent on the third fielding day with a final reminder sent on day ten of fielding (Murray et al., 2017).

The respondents were asked 40 questions regarding AQ (both marine and freshwater) perceptions, knowledge, and attitudes designed by an interdisciplinary team of academic researchers working in the field of economics, journalism, and communication. Categories of questions included (1) seafood consumption and information seeking behavior, (2) preferences for marine use, (3) awareness of AQ, (4) AQ consumption and product origin knowledge, (5) AQ in the news, (6) perceptions of AQ, and (7) governance and AQ (Murray et al., 2017).

The time to complete the survey varied widely amongst the sample. While the median time is reasonable at 24 minutes, the mean time is 637.1 minutes (s.d.=2,087.7) with the shortest time being 2 minutes and the longest survey time at 19,004 minutes (13.2 days). The survey was originally designed to take 20 minutes with some expected variance due to reading speed. Though message framing experiments were included in the survey design, they are not presented in this study. Therefore, only a lower bound of 10 minutes is placed on the survey time to remove respondents who may have not thought through the carefully designed questionnaire. This reduces the sample of completed surveys to N=1,124.

To ensure the sample is consistent, those who did not answer variables used throughout this study were dropped (Final N=1,002). Comparison to the 2012-2016[6] American Community Survey 5-Year Estimates shows that our sample is more educated, has a higher median income, and a higher median age (Table 3.1.).

Table 3.1.: Comparison of sample of survey respondents against 2012-2016 American Community Survey

	Sample (N=1,002)	**Census**
Gender (Male)	49.3%	49.2%
Education (HS or above)	93.3%	87%
Median income	$67,500	$55,322
Median age	55	37.7

Geographical locations of respondents consisted of 18.4% in the Northeast[7], 21.7% in the Midwest[8], 35.5% in the South[9], and 24.5% in the West[10]. Most of the sample lived in either (1) a one-family detached house in a metropolitan area (60.0%), (2) an apartment in a metropolitan area (14.8%) or (3) a one-family detached house in a non-metropolitan area (11.9%).

[6] As the survey was administered in January of 2017, changes in census sociodemographics (2016) are assumed to not be substantially different.
[7] Northeast US states: ME, NH, VT, MA, RI, CT, NY, NJ, and PA
[8] Midwest US states: OH, IN, IL, MI, WI, MN, IA, MO, ND, SD, NE, and KS
[9] South US states: DE, MD, DC, VA, WV, NC, SC, GA, FL, KY, TN, AL, MS, AR, LA, OK, and TX
[10] West US states: MT, ID, WY, CO, NM, AZ, UT, NV, WA, OR, CA, AK, and HI

3.3.2. Segmentation methods

3.3.2.1. Latent class logit model

Latent class logit models (LCLMs) can be employed when there is unobserved heterogeneity in the sample with a binary choice variable. Our dependent variable is binary and represents information seeking of AQ labels (1=Yes; 0=No). LCLMs estimate a conditional choice probability alongside a probability estimate of latent class membership. The conditional logit choice probability is formed from an individual i chooses the alternative j from a set of alternatives k conditional on belonging (probability) to latent class g. The probability of success is based on a set of observables X_{ij} (Equation 2.1). The class probability is determined from a multinomial logit where the probability of an individual π_{ig} of belonging to a class is determined by another set of observable variables z_i (McLachlan & Peel, 2000) where $0 \leq \pi_{ig} \leq 1$ and $\sum_{g=1}^{G} \pi_g = 1$ (Equation 2.2). The unconditional choice probability then takes the form following Train (Equation 2.3) (2009):

$$P_{ij|g} = \frac{e^{\beta_g X_{ij}}}{\sum_k e^{\beta_g X_{ik}}} \quad for\ g = 1, \dots, G \qquad (2.1)$$

$$\pi_{ig} = \frac{e^{\gamma_g z_i}}{\sum_g e^{\gamma_g z_i}} \qquad (2.2)$$

$$P_{ij} = \sum_{g=1}^{G} \pi_{ig} P_{ij|g} \qquad (2.3)$$

The number of classes can be either determined by some a priori information or determined for best-fit by the model itself through the Akaike information criterion (AIC) as LCLMs are expectation-maximization algorithms (Louviere et al., 2000; Train, 2009).

3.3.2.2. Cluster analysis (CA) using Ward's method with logit model

Like the LCLM, cluster analysis (CA) is a form of audience segmentation methodology based on a set of observable variables that determine membership to a cluster of individuals. Unlike the LCLM, CA membership is not probabilistic through statistical modeling but rather determined by some algorithm involving Euclidean distance or squared Euclidean distance. Many forms of clustering algorithms exist that have different sets of criteria for cluster membership and are useful in their own right (e.g. k-means, single link, complete link, k-modes, etc.). Ward's method is of particular interest as it seeks to minimize the variance within a cluster through recursive algorithms of the sum of squared errors (Ward, 1963). This is a form of hierarchical cluster analysis that begins with each observation being in its individual cluster. Clusters are then formed by selecting a merge that will lead to the smallest increase in deviation from the centroid of the cluster. Clusters can then be aggregated through Gower's dissimilarity coefficient to establish a workable number of clusters (i.e. not entire sample) that is more comparable to the number of classes in the LCLM (Gower & Legendre, 1986).

Following the cluster analysis through Ward's method, a logit model will be employed that includes the model interacted with all but one cluster that will be used as a reference group. Using notation similar to the form in the LCLM, the model will be estimated as a logit model following Train (2009) interacted with a dummy variable D_{ig} for each cluster $g = (1, \dots, G)$ conditioned on membership in that cluster with the exclusion of one cluster to avoid the dummy variable trap (Equation 2.4):

$$P_{ij} = \sum_{g=1}^{G-1} D_{ig} P_{ij|g} \qquad (2.4)$$

This form is useful in several ways in that it (1) allows for a comparable AIC to the LCLM, (2) puts observation in discrete groups as opposed to a probability of belonging to a class, and (3) has a stronger chance of convergence given a lack of variability in the segmentation variables[11]. Once the model has been iterated until the groups (latent classes or clusters) no longer converge, the AIC will allow for selection of which methodology provides the best fit for introducing heterogeneity into the sample through either (1) latent classes from a latent class logit model or (2) clusters using Ward's method of minimum variance.

[11] Recall that a national survey in early 2017 revealed that public opinion remains relatively unformed at the national level (Murray et al., 2017) which may impede on convergence of statistical models.

3.3.3. Data

3.3.3.1. Segmentation variables

Latent class and cluster membership will be determined by the same suite of 8 covariates (henceforth *segmentation variables*). These are determined by previous studies' assessment of AQ perceptions, attitudes, and beliefs. Summary statistics, shorthand variable names that will be used in the results tables, and variable descriptions can be found in Table 3.2.

The first segmentation variable is binary and will represent the individual's label seeking behavior of seafood production. This option was only shown to those who stated that they actively seek out information in the form of asking or looking for a label at the time of purchase. Most of the options for what kind of information will be used in the logit model, however this option will be used for segmentation purposes. Open ended responses were accepted if the respondent selected "other" for information seeking. These open-ended responses were recoded as "production method" if the respondent states responses including wild-caught, farm-raised, or some combination of the two.

The second segmentation variable is a created binary variable adapted from information insufficiency and information sufficiency threshold measures risk information seeking and processing model (Yang, Rickard, Harrison, & Seo, 2014). Respondents were asked to estimate their *current knowledge* of AQ on a 0-100% scale, where 0% means knowing nothing and 100% means knowing everything they can possibly know about the topic (i.e., information insufficiency). Following this, respondents were asked to estimate how much they think they *need to know* about AQ on the same scale (i.e., information sufficiency threshold). This allowed for the creation of a binary variable where 1 denotes the respondent believes they should know more than they currently do and 0 otherwise.

For determination of the reference group for the CA and to avoid the dummy variable trap, the cluster who did not seek or sought the least amount of production information and those who did not want to know more or wanted to know the least about AQ were chosen as the reference group. This decision would allow the results of those who would be seeking information to be shown in the logit model results.

The next six variables are all composite variables (arithmetic mean) using factor analysis and Cronbach's alpha reliability coefficient (α). This technique allows the researcher to see if a set of Likert-scale questions was answered in a similar way with a reliability equal to α following Gliem and Gliem (2003). Each variable was based on a set of questions asked to the respondent, pertaining to support for AQ (α=0.920), feelings about information dissemination (i.e., source credibility) from (1) government officials (α=0.846), (2) university scientists (α=0.857), and (3) AQ industry representatives (α=0.830)[12] (Mazur & Curtis, 2006; Roosen et al., 2015), trust in science (α=0.865) (Langford & Georgiou, 1998), and the belief that there is a gap between society and the environment (α=0.731) (Dietz, Stern, & Guagnano, 1998). Full text for each composite variable, as well as factor loading, can be found in Table 3.3.

Table 3.2.: Descriptive statistics for variables used for class and cluster membership
N=1,002

Variable	**Description**	**Mean Std. Dev.**
L_PRODUCED	When viewing a seafood label, what information do you look for? (How the seafood is produced =1; Otherwise=0)	0.229 0.420
AQ_KNOW_MORE	Level of desired AQ knowledge is higher than level of stated AQ knowledge=1; Otherwise=0	0.816 0.387
SUPPORT	Measures of support for AQ [C] (Strongly Disagree=1; Strongly Agree=6) (α=0.920)	3.801 1.010
FEEL_GOV	Feelings about information dissemination from government officials [C] (Positive=1; Negative=6) (α=0.846)	3.911 1.019
FEEL_SCI	Feelings about information dissemination from university scientists [C] (Positive=1; Negative=6) (α=0.857)	3.098 0.818
FEEL_REP	Feelings about information dissemination from AQ industry representatives [C] (Positive=1; Negative=6) (α=0.830)	3.792 0.889
TIS	Measures of trust in science [C] (Strongly Disagree=1; Strongly Agree=6) (α=0.865)	4.032 0.700
ENV_SOC_GAP	Belief that there is a gap between society and the environment [C] (Strongly Disagree=1; Strongly Agree=6) (α=0.731)	3.724 0.808

[C] Denotes that the variable is a composite variable. Composite variables are made by taking the arithmetic average of the questions used in factor analysis. Corresponding Cronbach's alpha is included in parentheses.

[12] The scale for the last question for government officials, university scientists, and AQ industry representative was flipped as it was inversely related to the other questions in the set. This is shown in Table 3.3 as "good" attributes are shown on the left and "bad" attributes are shown on the right except for the last option where "biased," a bad attribute, is on the left and "unbiased," a good attribute, is on the right.

Table 3.3.: Question text for composite variables created with factor loadings and Cronbach's alpha reliability coefficient
N=1,002

		Factor Loading
Variable	**SUPPORT**	
Question	For each statement below, please indicate how likely you are to engage in the following.	
1	Support policies that fund research on aquaculture.	0.830
2	Support policies that expand aquaculture operations in the U.S.	0.829
3	Support policies that expand aquaculture operations outside of the U.S.	0.708
4	Buy aquaculture products.	0.803
5	Look for aquaculture products when I purchase seafood.	0.815
6	Seek more information on aquaculture.	0.781
7	Learn more about the issues surrounding aquaculture.	0.786
	Cronbach's alpha reliability coefficient (α)	0.920
Variable	**FEEL_GOV**	
Question	**Government officials** are a possible source of information about aquaculture. Considering what you know, please click on the number between the two phrases that best describes your feelings about information from **government officials**.	
1	Can be trusted vs. Cannot be trusted	0.893
2	Is accurate vs. Is inaccurate	0.895
3	Is fair vs. Is not fair	0.909
4	Tells the whole story vs. Does not tell the whole story	0.821
5	Is biased vs. Is unbiased ^{RC}	0.151
	Cronbach's alpha reliability coefficient (α)	0.846
Variable	**FEEL_SCI**	
Question	**University scientists** are a possible source of information about aquaculture. Considering what you know, please click on the number between the two phrases that best describes your feelings about information from **university scientists**.	
1	Can be trusted vs. Cannot be trusted	0.913
2	Is accurate vs. Is inaccurate	0.913
3	Is fair vs. Is not fair	0.926
4	Tells the whole story vs. Does not tell the whole story	0.822
5	Is biased vs. Is unbiased ^{RC}	0.167
	Cronbach's alpha reliability coefficient (α)	0.857

Table 3.3. continued

Variable	FEEL_REP	
Question	**Aquaculture industry representatives** are a possible source of information about aquaculture. Considering what you know, please click on the number between the two phrases that best describes your feelings about information from **aquaculture industry representatives**.	
1	Can be trusted vs. Cannot be trusted	0.903
2	Is accurate vs. Is inaccurate	0.917
3	Is fair vs. Is not fair	0.922
4	Tells the whole story vs. Does not tell the whole story	0.830
5	Is biased vs. Is unbiased [RC]	0.023
	Cronbach's alpha reliability coefficient (α)	0.830

Variable	TIS	
Question	Please indicate the extent to which you agree or disagree with the following statements.	
1	Scientists can raise our standard of living.	0.710
2	Results from scientific research are sometimes unreliable. [RC]	0.238
3	Scientist have improved the safety of our food supply.	0.728
4	Scientists produce unbiased information.	0.639
5	Scientists provide reliable information	0.818
6	I feel scientific research often goes too far. [RC]	0.464
7	I fear the potential impacts of scientific research. [RC]	0.400
8	Scientists do important work.	0.709
9	I trust scientists who study the safety of the food we eat.	0.802
10	I trust scientists who study how we use the environment.	0.763
	Cronbach's alpha reliability coefficient (α)	0.865

Variable	ENV_SOC_GAP	
Question	What is your general opinion about the state of the environment? For each statement below, please tell us how you feel:	
1	We worry too much about the future of the environment, and not enough about prices and jobs today. [RC]	0.465
2	People worry too much about human progress harming the environment. [RC]	0.501
3	Almost everything we do in modern life harms the environment.	0.678
4	Nature would be at peace and in harmony if only human beings would leave it alone.	0.573
5	Any change humans cause in nature -- no matter how scientific -- is likely to make things worse.	0.603
6	Economic growth always harms the environment.	0.622
	Cronbach's alpha reliability coefficient (α)	0.731

[RC] Indicates the variable was reverse coded to match sign of factor loading

3.3.3.2. Model variables

The logit model will be determined by a suite of 13 variables. These are determined by previous studies' assessment of label information seeking behaviors, personal characteristics, and socio-demographics. Summary statistics, shorthand variable names that will be used in the results tables, and variable descriptions can be found in Table 3.4.

The dependent variable represents an individual who states they have actively looked for information on AQ products by reading labels or packaging information on AQ products. Previous work has shown the importance of information and how individuals accept it (Cash et al., 2003, 2006; Pelletier & Sharp, 2008; Teisl et al., 2008) as well as the role of label information at the time of purchase (Janssen & Hamm, 2012; Nuttavuthisit & Thøgersen, 2017), making this variable of industry interest as consumer decision to engage in this behavior is key to AQ acceptance. Variables capturing stated seafood consumption patterns, types of information seeking behavior, benefit/risk perception of AQ, and socio-demographics are employed to better understand what influences this label seeking behavior for AQ products.

Information seeking behavior all stem from a single multiple-choice question. This information unique in that it captures different forms of label information sought by the individual. The various types of information actively sought include (1) country of origin, (2) sustainably harvested, (3) if the product is local, (4) originates in a state or area known for high quality seafood, and (5) if the product is certified by the Marine Stewardship Council (MSC) or other certifying entity. Insight into how these forms of information seeking may influence AQ label information seeking behavior will provide some signal of how to properly frame AQ information on labels. For example, if those who seek if the product was sustainably harvested are more likely to seek AQ information on labels, then the AQ industry may be more prone to frame their AQ information in a suitability scope.

The variable for coastal state was created based on the state where the respondent lived in. This is used alongside living within 50 miles of the coast as respondents who lived in states where the AQ industry is more active (e.g. coastal Northeast states, Alaska, coastal Northwest states, and so on) may be more prone to seek AQ information on labels not because they live within 50 miles of the coast but rather because the AQ industry represents part of the state's economy. Other socio-demographic controls include categorical education level, household income, age, and age squared.

Table 3.4.: Descriptive statistics for variables used in logit model
N=1,002

Variable	**Description**	**Mean Std. Dev.**
Dependent variable		
LABEL_AQ	Have you ever actively looked for information about aquaculture or aquaculture products by reading labels or packaging information on aquaculture products? (Yes=1; No=0)	0.224 0.417
Explanatory variables		
- Information seeking (When viewing a seafood label, what information do you look for?)		
L_COUNTRY	What country the seafood is from=1; Otherwise=0	0.323 0.468
L_SUST_HARV	If the seafood is sustainably harvested=1; Otherwise=0	0.187 0.390
L_LOCAL	If the seafood is from a local area=1; Otherwise=0	0.198 0.398
L_HQ	If the seafood is from a coastal area or state known for high quality seafood products=1; Otherwise=0	0.216 0.411
L_CERTIFIED	If the seafood is certified by the Marine Stewardship Council (MSC) or other certifying entity=1; Otherwise=0	0.067 0.250
- Personal characteristics		
FREQ_CONSUME	Frequency of seafood consumption (Never=1; Less than once per month=2; Once per month=3; Once per week=4; Daily=5)	3.012 0 .985
BENEFITS_RISKS	Stated measure of risks and benefits of AQ (Risks strongly outweigh the benefits=1; Benefits strongly outweigh the risks=5)	3.433 0.914
- Sociodemographics		
HOME_WITHIN_COAST	Own or rent a home within 50 miles of the coast=1; Otherwise=0	0.308 0.462
COASTAL_STATE	Lives in a coastal state=1; Otherwise=0	0.597 0.491
EDU	Education (Categorical from less than high school=1 to bachelor's or higher=4)	2.947 0.951
INC	Household income (1000USD)	86.956 62.123
AGE	Age (years)	51.545 16.872

3.4. Results

3.4.1. Preferred model

The AIC output for both model specifications can be found in Table 3.5. The latent class logit model (LCLM) had difficulty converging with the introduction of heterogeneity. The model did not converge after 15,000 iterations and would only converge if the Newton-Raphson tolerance level was removed[13] [14]. As such, the results of the LCLM are compromised as the model would not properly converge.

From the AIC output for the cluster analysis (CA), 5 groups produced the lowest AIC suggesting the best model fit. However, one of the remaining clusters in the model only consisted of N=25 which would have produced unrealistic and uninterpretable standard errors. The model results for the CA will be presented for 3 clusters as it produced the next lowest AIC with heterogeneity introduced[15]. Though this AIC is higher than working under the assumption of homogeneity, literature backing varying degrees of AQ perceptions provides a robust story for the acceptance of this increase in AIC for the introduction of heterogeneity. Of importance is the lack of convergence for the CA beyond 4 clusters. This, along with the non-convergence of the LCLM, strengthen earlier claims of an unformed public opinion and may be due in part to this lack of variance (Murray et al., 2017). To ensure validity of difference among the 3 clusters, a simple one-way ANOVA was employed revealing all variables in the segmentation portion of the model are statistically different at the 0.05 confidence level. Additionally, all sociodemographic variables used as controls in the logit model are tested using a simple one-way ANOVA. It is found that all sociodemographics are not statistically different except for education ($p < 0.01$).

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[13] The default Newton-Raphson tolerance level is set to a default of $gH^{-1}g' < 1e\text{-}5$. This was iteratively relaxed until the tolerance level had to be removed for convergence.
[14] Given the lack of convergence, a simple latent class analysis was performed using the same variables to alleviate computational strain yielding similar results of non-convergence.
[15] It should be carefully noted that the "best" model following criteria of the lowest AIC would be the homogeneous model. However, the aim of this research is the change in model once heterogeneity is introduced. The homogenous model will be briefly discussed in the discussion.

Table 3.5.: AIC for (1) latent class logit model and (2) cluster analysis using Ward's method and a logit model for first 7 classes or clusters.

	LCLM	CA
1	832.53	832.53
2	805.04[1]	956.34
3	787.01[1]	898.43
4	798.90[1]	913.03
5	NNS	869.15^
6	NNS	873.77[1]
7	817.54[1]	887.55[1]

Note: *NNS* denotes that the Hessian is not negative semidefinite. [1]Model did not converge after 15,000 iterations and was reran with the tolerance for the scaled gradient is turned off. Reference group for CA was chosen based on which group (1) sought the least amount of information of seafood production and (2) wanted to know the least about AQ. This was done as these were those who label efforts may have the least effect on. ^ Sample split non-reference group was N=25 causing overly large s.e. 3 cluster group was chosen due to this.

3.4.2. Cluster analysis and logit model

Descriptive statistics for the segmentation variables are shown in Table 3.6. with Table 3.7. showing the box plots of the non-binary segmentation variables to determine characteristics of the clusters. Descriptive statistics for the logit model variables are shown in Table 3.8.

Cluster 1 (C1) does not seek information of seafood production methods, but believes they should know more about AQ. While C1 has a higher level of support for AQ compared to C2, C1 has the lowest reported perceived credibility of information from government officials, university scientists, and AQ industry representatives. With relatively high levels of trust in science and belief in a gap between society and the environment, C1 will be referred to as *interested skeptics*.

C2 has low reported levels of seeking production methods for seafood and no members of this cluster believe they should know more about AQ. Further, C2 has the lowest level of support for AQ, trust in science, and belief in a societal-environmental gap. Their feelings toward all three source of information dissemination falls between C1 and C3 aside from university scientists which is ranked the highest of all clusters. Due to their lack of desire to know more about AQ and the low levels of support and trust in science, C2 will be referred to as *status quo*. For the purpose of the analysis and to avoid the dummy variable trap, *status quo* will be used as the reference group in the logit model.

All members of C3 seek information of seafood production methods and believe they should know more about AQ. C3 has the highest levels of support for AQ, feelings about information dissemination from government officials and AQ industry representatives, and belief in a societal-environmental gap with relatively high levels of feelings about information dissemination from university scientists and trust in science. Consequently, C3 will be referred to as *information seekers*.

Table 3.6.: Descriptive statistics for variables used for cluster membership by cluster
N=1,002

	Mean Std. Dev.		
Cluster	**Interested Skeptics (N=614)**	**Status Quo (N=184)**	**Information Seekers (N=204)**
L_PRODUCED	0.000 0.000	0.136 0.344	1.000 0.000
AQ_KNOW_MORE	1.000 0.000	0.000 0.000	1.000 0.000
SUPPORT	3.819 0.962	3.466 1.198	4.046 0.883
FEEL_GOV	3.842 0.957	4.010 1.081	4.032 1.126
FEEL_SCI	3.034 0.763	3.314 0.905	3.094 0.862
FEEL_REP	3.738 0.864	3.836 0.911	3.915 0.933
TIS	4.079 0.689	3.833 0.710	4.070 0.698
ENV_SOC_GAP	3.746 0.823	3.554 0.793	3.810 0.759

Table 3.7.: Box plots of non-binary variables used in segmentation by cluster

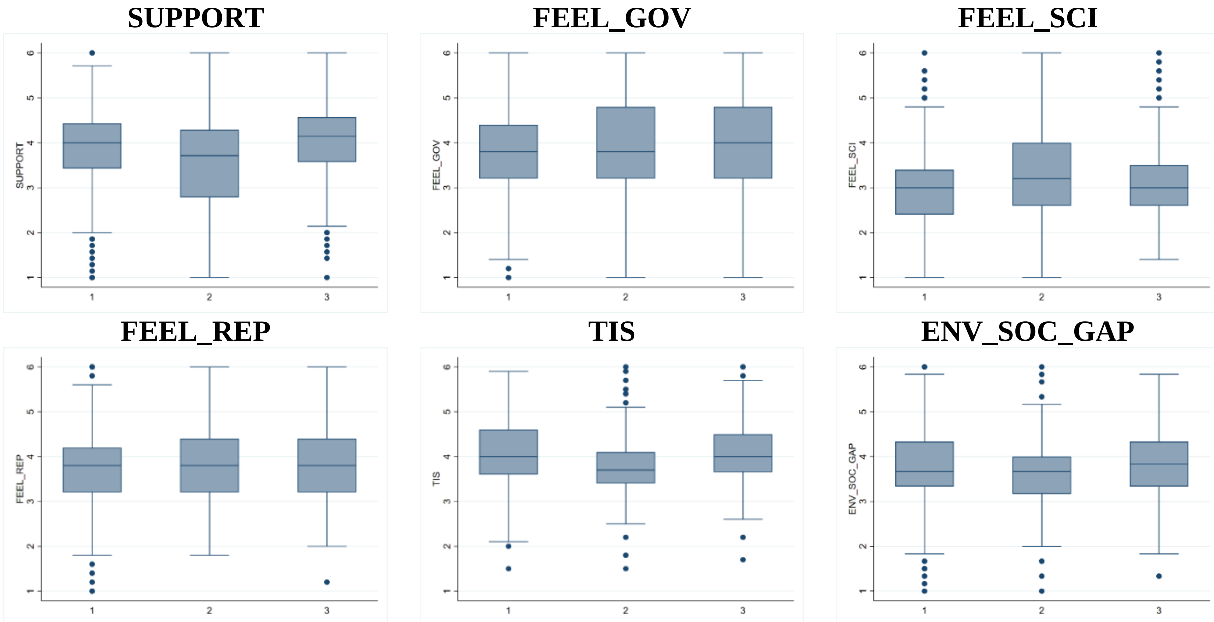

Table 3.8.: Descriptive statistics for variables used in logit model by clusters
N=1,002

	Mean Std. Dev.		
Cluster	**Interested Skeptics (N=614)**	**Status Quo (N=184)**	**Information Seekers (N=204)**
Dependent variable			
LABEL_AQ	0.147 0.354	0.174 0.380	0.500 0.501
Explanatory variables			
- Information seeking			
L_COUNTRY	0.213 0.410	0.196 0.398	0.770 0.422
L_SUST_HARV	0.096 0.295	0.130 0.338	0.510 0.501
L_LOCAL	0.127 0.333	0.168 0.375	0.436 0.497
L_HQ	0.127 0.333	0.174 0.380	0.520 0.501
L_CERTIFIED	0.028 0.164	0.060 0.238	0.191 0.394
- Personal characteristics			
FREQ_CONSUME	2.932 0.977	2.772 1.062	3.471 0.778
BENEFITS_RISKS	3.510 0.835	3.375 1.000	3.255 1.029
- Sociodemographics			
HOME_WITHIN_COAST	0.314 0.465	0.288 0.454	0.309 0.463
COASTAL_STATE	0.617 0.486	0.582 0.495	0.549 0.499
EDU	2.922 0.935	2.804 0.989	3.152 0.937
INC	87.987 62.803	83.003 59.689	87.420 62.372
AGE	51.466 17.275	49.929 16.267	53.240 16.088

Results of the logit models are shown with coefficients in Table 3.9. and marginal effects in Table 3.10. Marginal effects will be used for the primary results and discussion as they measure changes in the predicted probabilities of AQ label information seeking behavior. It is found that both the interested skeptics and information seekers are roughly 15% and 13% (respectively) more likely to seek AQ information on labels if they also tend to look for information about country of origin. Consistent with the notion of needing reassurance, the interested skeptics are more likely to seek AQ information on labels if they seek information regarding high quality seafood producing areas or states and if the seafood has been certified by roughly 10% and 16% (respectively). For information seekers, those who seek information of the sustainable harvesting of seafood are roughly 10% more likely to seek AQ information of labels. No other effects are found regarding information seeking.

Frequency of seafood consumption has an unsurprisingly positive effect on AQ information seeking on labels. Results from demographics yield little significant results aside from living 50 miles from a coast for interested skeptics, household income for information seekers, and age for both. Living within 50 miles of a coast and age squared has a positive effect and age has a negative effect on seeking AQ information on labels for interested skeptics. Household income and age squared has a positive effect on seeking AQ information on labels for information seekers.

Table 3.9.: Logit model coefficients for estimating seeking behavior of AQ labels by clusters with reference group (status quo)
N=1,002

	Coefficient Std. Err.		
Cluster	**Interested Skeptics (N=614)**	**Status Quo (N=184)**	**Information Seekers (N=204)**
- Information seeking			
L_COUNTRY	**1.122***** **-0.345**		**0.951**** **-0.393**
L_SUST_HARV	0.607 -0.373		**0.728**** **-0.346**
L_LOCAL	-0.195 -0.356		-0.238 -0.354
L_HQ	**0.726**** **-0.354**		-0.165 -0.342
L_CERTIFIED	**1.231**** **-0.578**		-0.420 -0.418
- Personal characteristics			
FREQ_CONSUME	**0.341**** **-0.143**		**0.516***** **-0.194**
BENEFITS_RISKS	0.054 -0.138		-0.234 -0.149
- Sociodemographics			
HOME_WITHIN_COAST	**0.595**** **-0.302**		0.031 -0.392
COASTAL_STATE	-0.144 -0.297		-0.056 -0.352
EDU	0.048 -0.144		0.194 -0.187
INC	-0.002 -0.002		**0.005*** **-0.003**
AGE	**-0.096***** **-0.028**		**-0.065** **-0.041**
AGE^2	**0.001***** **0.000**		**0.001*** **0.000**

Table 3.10.: Logit model margins for estimating seeking behavior of AQ labels by clusters with reference group (status quo)
N=1,002

Cluster	**Interested Skeptics (N=614)**	**Margins Std. Err. Status Quo (N=184)**	**Information Seekers (N=204)**
Explanatory variables			
- Information seeking			
L_COUNTRY	**0.149***** **-0.045**		**0.126**** **-0.051**
L_SUST_HARV	0.080 -0.049		**0.097**** **-0.045**
L_LOCAL	-0.026 -0.047		-0.032 -0.047
L_HQ	**0.096**** **-0.047**		-0.022 -0.045
L_CERTIFIED	**0.163**** **-0.076**		-0.056 -0.055
- Personal characteristics			
FREQ_CONSUME	**0.045**** **-0.019**		**0.068***** **-0.025**
BENEFITS_RISKS	0.007 -0.018		-0.031 -0.020
- Sociodemographics			
HOME_WITHIN_COAST	**0.079**** **-0.040**		0.004 -0.052
COASTAL_STATE	-0.019 -0.039		-0.007 -0.047
EDU	0.006 -0.019		0.026 -0.025
INC	0.000 0.000		**0.001*** **0.000**
AGE	**-0.013***** **-0.004**		-0.009 -0.005
AGE^2	**0.000***** **0.000**		**0.000*** **0.000**

3.5. Discussion

This study began with important research questions: what is driving label seeking behavior of AQ products and does introducing heterogeneity improve our understanding? From the AIC output, it is found that the homogenous sample yields the lowest AIC, suggesting that through this methodology, clustering weakens the model, further backing the claim that public opinion is unformed about AQ (Murray et al., 2017). Though this is the case using that criteria, the robust literature of AQ perceptions suggests something different; perceptions about AQ products vary greatly and should be treated as such (e.g. D'Anna & Murray, 2015; Hall & Amberg, 2013; Naylor et al., 2000). This may be due in part to AQ perceptions of certain AQ products (e.g., environmental impact of AQ salmon perceptions versus AQ oyster perceptions). For posterity, however, the results of the homogenous sample are shown in Table 3.11. The results are consistent with the information seeker cluster in that those who seek the country or origin or if the seafood is sustainably harvested are more likely to seek AQ information of labels. What is gained from the CA is the insight into what is driving AQ information seeking on labels by interested skeptics, the largest cluster and, arguably, the cluster that may be affected most by information and message tailoring of AQ information (Pelletier & Sharp, 2008; Teisl et al., 2008)

These results are of interest to the researchers, the AQ industry, and policy makers alike. From a methodological point of view, this study was limited in that convergence of the LCLM was an issue. This convergence issue may be relieved given a larger sample size with higher levels of variability. Given this issue, heterogeneity was still introduced through other means to capture a richer analysis than a homogenous sample would offer. This provides methods for researchers, both academic and industry, to introduce variability in perceptions through other means given barriers of convergence.

However, this lack of variability implies that perhaps public opinion of AQ as an industry (i.e. not by individual products and for both marine and freshwater AQ) may not be formed yet (Murray et al., 2017) or that the topic of AQ is not as controversial other issues (e.g. Leiserowitz et al., 2009). This lack of formation of public opinion may be remedied through labeling efforts. The AQ industry should seek to frame information about AQ through (1) country of origin, (2) the sustainability of the industry, (3) if the AQ product is farmed in an area known for high quality seafood, and (4) if the product is certified. The last frame is of temporal significance as the AQ industry is currently working with policy makers to finalize the certification process for organic AQ (Aarset et al., 2004; USDA, 2016). Previous work has shown the effect of organic labeling (Janssen & Hamm, 2012; McCluskey & Loureiro, 2003) with some work specifically focusing on the effect of organic labeling on AQ products (Brayden et al., 2018).

Though the certification in the current study is given by the Marine Stewardship Council or "some other certifying entity," the actual effect of organic labeling on US AQ products is still unknown as it has not been formalized. This provides a critical opportunity for the AQ industry to work with policy makers as organic labeling may provide information to bridge the gap between the information on the product and the *interested skeptics* (Teisl et al., 2008). The closure of this gap may not only help the public form an opinion about the AQ industry, but help the AQ industry thrive to provide economic benefits to coastal communities (Pérez-Sánchez & Muir, 2003) and be accepted as a food technology.

Future studies should seek to use this information to expand the literature on AQ consumer perceptions and purchase decisions. This will provide a more definitive response to the effect of label seeking efforts and message tailoring on the AQ industry. Furthermore, coastal communities that would economically benefit from an expansion of the marine AQ industry may consist of those that also rely on coastal tourism (e.g. coastal New England, Alaska, West Coast, etc.). Though the endeavor would prove to be difficult, an impact of AQ expansion on tourism in these areas would provide more insight into the cooperation amongst these two industries to supply the greatest economic, environmental, and societal benefits to these areas. Lastly, this analysis focused on AQ as a single entity with no differentiation between marine and freshwater AQ perceptions. Regional differences may exist regarding preferences between these two types of AQ and should be considered for future research.

Table 3.11.: Homogenous logit model coefficients and marginal effects for estimating seeking behavior of AQ labels

N=1,002

	Coefficient Std. Err.	**Margin Std. Err.**
- Information seeking		
L_COUNTRY	1.455***	0.184***
	-0.217	-0.025
L_SUST_HARV	0.860***	0.109***
	-0.222	-0.027
L_LOCAL	0.050	0.006
	-0.230	-0.029
L_HQ	0.183	0.023
	-0.224	-0.028
L_CERTIFIED	0.030	0.004
	-0.309	-0.039
- Personal characteristics		
FREQ_CONSUME	0.601***	0.076***
	-0.115	-0.014
BENEFITS_RISKS	-0.028	-0.004
	-0.096	-0.012
- Sociodemographics		
HOME_WITHIN_COAST	0.246	0.031
	-0.214	-0.027
COASTAL_STATE	0.030	0.004
	-0.206	-0.026
EDU	0.132	0.017
	-0.105	-0.013
INC	0.000	0.000
	-0.002	0.000
AGE	-0.006	-0.001
	-0.033	-0.004
AGE^2	0.000	0.000
	0.000	0.000

CHAPTER 4

CONCLUSIONS

This research focuses on the need for influential information to be both salient and tailored to the individual; this is especially important in environmental decision-making scenarios. The purpose of this thesis was to find evidence to answer four research questions regarding information and environmental decision making.

Chapter 2 sought to answer (1) how do disclosures of poor coastal water quality at either recreational beaches or shellfish harvesting areas affect the risk perception of becoming ill from either swimming in the water or consuming shellfish harvested from that area respectively and (2) if framing influences the risk perception of poor coastal water quality, which frame (out of public health and marine environment) is the most effective, if any? The study revealed no evidence of a disclosure effect on the behaviors of (a) entering the water a beach under an advisory due to poor coastal water quality or (b) consuming shellfish from a shellfish harvesting area closed due to poor coastal water quality. Furthermore, altering the frame of the survey between *marine environment* and *public health* had no effect on risk perception. This suggests that current information dissemination at these locations may require improvements as closures and advisories are an indication of increased risk that individuals fail to recognize. To ensure that this information is salient, tailored to the audience, and is an accord with the audience's environmental characteristics, a field test (e.g., in-person and on-site surveys about the communication of public disclosures) may be best suited for the protection of public health.

Chapter 3 sought to answer (1) what is driving label seeking behavior surrounding aquaculture products and (2) does introducing heterogeneity improve our understanding? The use of national marine and freshwater aquaculture survey data makes the results of this study unique by measuring perceptions of *aquaculture* as a single industry as opposed to separating them by product produced (e.g. marine salmon pens, freshwater tilapia, etc.). What we find from the introduction of heterogeneity in aquaculture label-seeking information is that three groups of individuals exist: interested skeptics, status quo, and information seekers. Using status quo as a reference group, it is found that interested skeptics tend to look for aquaculture information on labels if they also search for (1) country of origin of the product, (2) if the seafood came from an area or state known for high quality seafood, and (3) if the seafood product was certified. Information seekers tend to look for aquaculture information on labels if they also search for (1) country of origin and (2) if the seafood product was sustainably harvested. Despite these results that provide the aquaculture industry with information about how to tailor information on labels to be salient to the individual, the homogenous model still outperformed the heterogenous model providing further evidence that national opinions about aquaculture as an industry is unformed (Murray et al., 2017).

There is a plethora of challenges that environmental information dissemination faces; only two exemplars were investigated in this thesis. Results from Chapter 2 provide insight into whether public health information is influential in altering risk perception, with the aim to deter citizens from dangerous and risky activities. Continued testing of disclosure efforts by managers of natural resources that are subject to some risk is key to understanding if information is influencing risky decisions.

Results from Chapter 3 provide both modeling and policy insights. First, improvements in understanding preferences and perceptions is made through introducing heterogeneity into modeling efforts. The current work extends the literature by not isolating a particular product but rather a nation's perceptions of the industry as a whole. Second, the research assists policy makers in their challenge of realizing cooperation between the aquaculture industry and the economy, environment, and society, and the aquaculture industry as they work to improve and solidify their position as a sustainable food technology.

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BIOGRAPHY OF THE AUTHOR

Jordan Ross Anthony was born in Evansville, IN on December 9, 1991. In 2010, Ross became an Eagle Scout and graduated from Central High School. Ross attended the University of Evansville and graduated in the winter of 2014 with a double major in economics and international studies and a double minor in mathematics and Russian studies. While a student at UE, Ross was an active member of Sigma Alpha Epsilon and worked at Showplace Cinemas, a local movie theater. Following his undergraduate career, Ross began to work at MSW●ARS Research as a project manager.

Aside from his academic life, Ross has several hobbies. An avid musician, he has taught himself seven different instruments, regularly plays and writes music, and has a dangerously expensive collection of vinyl records. Ross enjoys the outdoors, having backpacked and skied most of his life. Additionally, he is an avid hockey and New Jersey Devils fan.

Ross enrolled in the School of Economics at the University of Maine in 2016 and took on a research assistantship under Dr. Caroline L. Noblet. Throughout his time at UMaine, Ross worked on multiple projects outside the scope of this research and both presented and attended a plethora of conferences at the state, regional, and national level. Ross is a candidate for the Master of Science degree in Resource Economics & Policy from the University of Maine in May 2018.