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Citizen Preferences for Marine Environmental Policy

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CITIZEN PREFERENCES FOR MARINE ENVIRONMENTAL POLICY

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A THESIS

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Thesis Advisors: Dr. Keith S. Evans & Dr. Caroline L. Noblet

An Abstract of the Thesis Presented
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The growing global population, combined with increased land use, has emphasized the demand for sustainable ocean management strategies. Among suggestions for these strategies is a closer examination of the visual impact that aquaculture sites may have on coastal homes, as well as perception and preferences on coastal issues including coastal hazards, impacts of development, and marine debris. Maine's unique and extensive history, as well as geographic location makes it an ideal setting to study these vital coastal issues, as well as to assist decision makers with informed options for management and policy.

This research explores various coastal usages and issues to determine what role visual impacts and perceptions may play on coastal communities in Maine. Empirical methods utilized include 1) viewshed analysis and semi-log hedonic pricing framework in order to capture information regarding impacts that view of marine aquaculture may have on coastal home prices; and 2) various survey instruments including logistic regression to explore perceptions concerning ocean and coastal priority areas; to determine what characteristics may be associated with

different levels of awareness of policy-relevant knowledge; and to investigate the relationship between perception of and preference for Maine coastal and ocean issues.

Results from our semi-log hedonic pricing model suggest that visibility of aquaculture may have mixed impacts on coastal housing markets depending on geographic region, as well as how view of aquaculture enters our models. For Casco Bay, visibility of aquaculture shows no statistically significant impacts in base model and alternate model 2, and positive impacts in alternate model 1(entering the model as an aquaculture view dummy indicator). Damariscotta also shows no statistically significant effects in base model and alternate model 2, while conveying positive effects on housing prices in alternate model 1. View of aquaculture conveys no statistically significant effects in Penobscot Bay in base model or alternate model 1 but conveys positive and significant effects in alternate model 2. We find that omission of visibility may lead to omitted variable bias. These results also suggest that we may be missing additional indicators associated with aquaculture (noise, smell, etc.). The research completed from our models is a critical step towards the end objective to inform policy makers and stakeholders of social costs related to future site selection for sustainable marine aquaculture.

Results from our survey data suggest that participating Maine coastal citizens who agreed or strongly agreed with the perceived statements regarding current ocean and coastal conditions prioritized these areas as outlined in the Maine Coastal Program. Additionally, certain situational factors such as trust in science, belief in climate change, and perception of ocean health may be important predictors of knowledge and preferences. Overall, we found that participants who have an awareness of the situational factors listed above are more likely to support coastal zone priority areas enacted by the Maine Coastal Plan that promote effective marine planning and protection.

DEDICATION

For Earth's most valuable creations without voices of their own;

For women in STEM fields around the world, breaking glass barriers and persisting;

For my darling husband, who supported me and pushed me through every challenge, who fed me and took me to the movies, who believed in me;

For my grandfather (PopPop), whose voice, encouragement, and love still guides me;

For the ocean that calls me;

For my mother, a strong female, who was forced to drop out of high school at a young age, worked her way through her 20s living in her car, got her GED, became general manager of a super market chain, and had three children who adore her. Losing you was the most difficult struggle I have ever had to face. Thank you for teaching me to be fierce.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

AQ - aquaculture

CZMA – Coastal Zone Management Act

CZMP - Coastal Zone Management Program

DEM – Digital Elevation Model

DMR – Department of Marine Resources

GIS – Geographic Information Systems

HPM – hedonic pricing model

LiDAR - Light Detection and Ranging

LPA – limited purpose aquaculture

MCP – Maine Coastal Program

MWTP – marginal willingness to pay

NOAA – National Oceanic and Atmospheric Administration

PUC – Public Utilities Commission

SEANET – Sustainable Ecological Aquaculture Network

STD – standard aquaculture

CHAPTER 1

INTRODUCTION

1.1 Background

As the population increases, the number of coastal residents has grown substantially in the last few decades, prompting coastal managers and policy makers to examine the impacts of ocean and coastal utilization on the ecosystem as well as coastal economies. Resource managers are evaluating the ways that coastal areas are currently used to meet the demands of the increasing population (CIESIN, 2007; NOAA, 2016; Factsheet: People and Oceans, 2017). These changes require us to rethink policy that considers all members of these coastal communities and that addresses current, multiple, interacting uses. There is a growing importance for individuals to care about coastal and ocean issues including aquaculture, marine debris, impacts of development, coastal hazards, public access, wetlands, and ocean resources (Steel, Smith, Opsommer, Curiel, & Warner-Steel, 2005; Maine Coastal Program, 2015). To achieve sustainable ocean usage, coastal users including citizens and stakeholders must be well informed. Failure to capture the level of citizen perceptions and knowledge of current ocean issues and policy may have consequences in attempting to achieve environmental objectives (Gelcich, Buckley, Pinnegar, Chilvers, Lorenzoni, Terry, & Duarte, 2014).

1.2 Purpose of the Research

This research examines the idea of coastal preferences and perceptions of multiple, interacting coastal issues. Coastal homeowners may have preferences for proximity and visual line of sight of aquaculture, how close their home is to public access, and level of water quality. Additionally, the relationship between the level of awareness coastal residents have for coastal issues, such as marine debris, wetlands, coastal hazards, etc. and their priority levels for those issues is examined. Research to assess preference choices, as well as perceptions is vital to developing sustainable management practices and policies. Viewshed impacts of aquaculture have not been thoroughly addressed in literature. Further, although perceptions research has been completed on the national level, little attention has been given to local and regional specific attitudes and situations, which can encourage the most optimal environmental policies (Schwab, 1988). The two studies provided in this thesis attempt to capture citizen preferences and explore the mechanisms which may affect these preferences.

Our first study explores the viewshed impacts of aquaculture on coastal home values. The main aim of this research is to provide further insight into the mechanisms with which aquaculture may impact coastal real estate prices. The research question explored is whether line of sight to marine aquaculture (specifically shellfish aquaculture) has an impact on coastal residential real estate prices.

Our second study investigates the relationship between awareness of policy-relevant knowledge concerning ocean and coastal priority areas; determines what housing, demographic, and social characteristics may be associated with higher levels of regional coastal and ocean awareness of policy-relevant knowledge relating to oceans; and examines the relationship between perception of and preference for Maine coastal and ocean issues.

1.3 Thesis Organization

This thesis is divided into two studies that examine preferences for specific marine and coastal issues. Chapter 2 uses data for Maine coastal home sales between 2012 and 2014 in conjunction with aquaculture siting data provided by the Maine Office of GIS to examine the marginal impacts of aquaculture viewshed on house values in coastal Maine. Chapter 3 incorporates survey data received by Maine coastal residents to 1) investigate perceptions of policy-relevant knowledge concerning ocean and coastal priority areas; and 2) determine what characteristics, including perceptions, may be associated with higher levels of regional coastal and ocean awareness and preference.

CHAPTER 2

EXPLORING VISUAL IMPACTS OF MARINE AQUACULTURE ON COASTAL RESIDENTIAL REAL ESTATE PRICES

2.1 Introduction

Resource managers are currently evaluating the ways that coastal areas are used to meet the demands of the increasing population (CIESIN, 2007; NOAA, 2016; Factsheet: People and Oceans, 2017). With limited land and freshwater, more decision makers are depending on the oceans to provide additional food (NOAA, 2016). Aquaculture is expected to play a major role in fish production and consumption in the decades to come (FAO, 2016). The National Oceanic and Atmospheric Administration (NOAA) intends to grow aquaculture by 50% in the United States from 2016 to 2020 (NOAA, 2016). To meet this goal, the Department of Commerce has expanded support of aquaculture research, as well as opportunities for U.S. seafood farming in the ocean (Love, Gorski, & Fry, 2017). As aquaculture growth becomes more widespread, it is important to address citizen preferences in addition to grower preferences for site selection, as well as determine the type of role they play in the communities of coastal residents whom they impact. This information can help assist policymakers in advocating for the best use of our coastal waters, and best placement of our resources within them.

Although the marine aquaculture industry and related partners are working diligently to emphasize the positive impacts of marine aquaculture, negative perceptions of the aquaculture industry remain a major concern, particularly for coastal communities, homes, and economies near where aquaculture facilities are located (Knapp & Rubino, 2016; Lapointe, 2013). Stated and revealed preference methods have been utilized in efforts to examine impacts of aquaculture (Murray & D’Anna 2015; Fairbanks 2016; Evans, Chen, & Robichaud, 2017). Most recently, research completed by Evans et al. (2017) suggest that the presence of marine aquaculture within a 2-mile buffer of a coastal home in Maine can impact house pricing depending upon region.

The next step, and the focus of this paper is exploring line of sight as a mechanism through which aquaculture may impact coastal real estate prices. Research on wind turbine development indicates that proximity does not provide a full representation of all the impacts of living near a turbine (Lang, et al. 2014). Effects of a specific proximity indicator may also contain the impacts of viewshed of that variable. There has been recent increased interest in capturing the effects of visibility of environmental attributes using the hedonic pricing model (HPM) (Lang et al., 2014; Klaiber, Abbot, & Smith, 2017). One of the major concerns for increased marine aquaculture facilities is that these operations change the view of the natural coastal landscape and therefore, can negatively impact the location where they are placed both for residents and visitors (SAO, 2016). There is additional risk for multiple or density related aquaculture operations, which may further reduce the aesthetic appeal of a location; thus, potentially decreasing an area's economic value through decreased tourism and money spent on other coastal activities (dining, recreation, etc.), as well as potentially decreasing property values (Lapointe, 2013).

Despite the importance of viewshed in aquaculture siting decisions, to date only a few studies have tackled this key issue (Perèz, Telfer, & Ross, 2010; Falconer, Hunter, Telfer, & Ross, 2013). The current research topic addresses this important research question by incorporating a line of sight (LOS) indicator into a log-linear hedonic pricing model (HPM) in effort to investigate viewshed impacts on coastal residential real estate prices in Maine. A Boolean viewshed model is utilized through ArcGIS to extract viewshed information for coastal homes in three regions in Maine. The data extracted from this viewshed analysis is incorporated into HPM to estimate the impact of line of sight on coastal homes in Maine. Given the results from Evans et al, (2017a), as well as previous studies completed on viewshed impacts it is suspected that the effects of marine aquaculture line of sight on coastal housing real estate has varied impacts across regions (Perèz, Telfer, & Ross, 2010; Falconer et al.,2013; Hindsley et al., 2013; Yamagata, Murakami, Seya1, & Tsutsumi, 2013; Cavailhès, 2009; Sandar & Polasky, 2009; Lang, et al., 2014; Hoen, Wiser, Cappers, Thayer, & Sethi, 2011; Gibbons, 2015).

Maine's unique coastline and marine resources provide opportunities for coastal communities to engage in a spectrum of working waterfront industries. Within this spectrum, the aquaculture sector plays a major role (Davis, 2017). This analysis utilizes single family home sales from 2012-2014 in the coastal areas of Maine including Casco Bay, Damariscotta River Region, and Penobscot Bay. Geocoded homes are spatially and temporally linked with aquaculture lease sites within a 2-mile buffer of the home. Information was extracted through GIS analysis regarding lease tract characteristics that include acreage of each site, distance from the centroid point of the site, how many sites are present for each home within the distance buffer, as well as how many sites can be seen by the housing point within the buffer. This information, as well as additional housing structural, neighborhood, and environmental characteristics are inserted as the "bundle" of goods for each home and are used to recover marginal values consumers place on this characteristic (Taylor, 2003).

Model results suggest evidence of mixed impacts where there is distinction of proximity to marine aquaculture versus the visibility of marine aquaculture on those same homes. However, our base and alternate models, as well as the way in which line of sight enters these models need additional refinement for these results to be used for informing coastal decision-makers.

2.2 Background

Aquaculture, although historically practiced since 2000-1000 B.C (Rabanal, 1988) is a relatively new growing field in the US, especially coastal aquaculture sites that are near residential homes. Marine aquaculture has been around for over two centuries and has had laws in place since the early 1900s (Schauffler, 2013). The process of private citizens and companies obtaining aquaculture leases, including standard and limited purpose aquaculture (LPA) for the culture of marine fish, shellfish and plants, dates to the 1970s.

According to Sea Grant Maine, Maine has some of the strictest aquaculture regulations and monitoring requirements in the world (Torosyan, 2003). The state of Maine has regulations regarding the establishment of aquaculture leases. These regulations are presented in Chapter 2 of the Department of Marine Resources Regulations (InforME, 2016) and include a pre-application meeting and scoping session, a notice to landowners within 1,000 feet of the proposed lease, proposed site marking, notice of lease application and hearing, department site review, a prehearing conference, a formal lease application, and hearing process. Additionally, the state of Maine has noise, light, and visual impact standards in place to mitigate assumed impacts on coastal communities (Maine State Planning Office, 2006). Lease application hearing processes are opportunities to present evidence and provide testimony regarding proposed aquaculture sites. These are attended by stakeholders, members of the DMR, and agency, as well as public representatives, and are a chance to gain knowledge about the proposed site, voice any concerns, or ask questions.

> Visual Impact Applicability. "… The size, height, and mass of buildings and equipment used at aquaculture facilities shall be constructed so as to minimize the visual impact as viewed from the water…All buildings, vessels, barges, and structures shall be no more than one story and no more than 20 feet in height from the water line. Height shall be measured from waterline to the top of the roof or highest fixed part of the structure or vessel…"

Figure 1. Excerpt from Chapter 2 of Maine's Department of Marine Resources (DMR) aquaculture regulations. These address the visual impact limitations for marine aquaculture in the state of Maine (Department of Marine Resources, 2013).

During our study area time frame, 2012-2014, Maine had approximately 283 aquaculture tracts in production, playing a major part in the coastline industry (Davis, 2017). Despite its role in coastal industry, aquaculture, and its relationship with coastal communities is mixed. Research completed by Evans et al. (2017) shows that proximity to marine aquaculture can have positive, negative, and not statistically significant effects depending on location. However, there may be other confounding variables (sight, smell, noise, etc.), that, when omitted from our model, can lead to incorrect coefficient estimates in hedonic price equations and skewed conclusions on marginal impacts for specific attributes (Paterson & Boyle). Visibility of aquaculture could be an important determinant of housing preference and therefore is the focus of our research.

The main aim of this research is to provide further insight into the mechanisms with which marine aquaculture may impact coastal real estate prices. The research question explored is whether LOS of marine aquaculture (specifically shellfish aquaculture) has an impact on coastal residential real estate prices. From prior visibility impact assessments, as well as previous proximity to aquaculture research conducted by Evans et al. (2017), we expect mixed effects of visibility depending on region.

2.3 Literature Review

Hedonic pricing models (HPM) are commonly used to extract marginal impacts of environmental characteristics including: water quality (Walsh, 2009), pollution (Evans, Athearn, Chenc, Bell, & Johnson, 2017b), proximity to and viewshed of wind turbines (Lang et al., 2014), landscape ecosystem services (Klaiber et al., 2017), contaminated land cleanup benefits (Haninger, Ma, & Timmins, 2017), wildfire effects (Garnache & Guilfoos, 2018), etc. More recent studies also consider spatial and temporal factors in housing prices (Herath & Maier, 2010). In estimating the implicit price of housing characteristics, including environmental amenities, sales price is considered a function of the property's neighborhood, spatial and environmental characteristics Taylor, 2003; Earnhart, 2002).

Attempts to capture visibility effects using hedonic pricing models commonly utilize discrete visibility variables (dummies), or distance measurements as proxies for the value of views (Hindsley et al., 2013). Prior to the expansion of GIS techniques, field research techniques were utilized to collect viewshed characteristics. Benson., Hansen, Schwartz, & Smersh (1998) conducted a personal inspection of potential view properties sold over an eleven-year period to estimate the value of the ocean view amenity on sales prices of single-family residential homes. Lang et al. (2014) performed site visits to 1,354 properties within two miles of a turbine and rated the view of the landscape into one of five categories. Their results suggest that the view of the turbine had no statistical impact on property values.

While "site visit" viewshed methods provided initial insight into the effects line of sight has on residential properties, these approaches to capture views in the hedonic property function have distinct limitations (Hindsley et al., 2012). These include the cost and time required for surveyors to perform the field work necessary to capture this viewshed indicator, which may limit the sample size for the hedonic framework.

Increasingly, researchers use remote sensing methods to capture viewshed characteristics (Cavailhes et al., 2009; Bin et al., 2008; Morgan & Hamilton, 2011). Geographic Information Systems (GIS) technology provides data relevant to housing, neighborhood, and spatial characteristics (Falconer et al., 2013). Over time, this technology has become increasingly precise in deriving areas of visibility from given areas and is considered an important tool used to describe spatial characteristics of an environment (Hindsley, Hamilton, & Morgan, 2013). This capability provides us with a unique opportunity to capture a property's view using Light Detection and Ranging (LiDAR) data in a GIS environment and use that information in hedonic modeling techniques. (Morgan & Hamilton, 2011).

Successful implementation of viewshed techniques are seen in a range of diverse studies and are essential for providing neighborhood and environmental attributes commonly used to evaluate environmental amenities in the HPM (Falconer et al., 2013). Numerous studies have examined the issue of viewshed impacts on housing property values within the hedonic framework. However, these studies typically focus on valuing natural environmental landscape features such as ocean views (Benson et al., 1998), green space views (Yamagata, Murakami, Seya1, & Tsutsumi, 2013), and other various landscape attributes (Hindsley et al., 2013; Cavailhès, 2009; Sandar & Polasky, 2009). Some research has been conducted on the effects of viewshed between home prices and non-environmental attributes. The effect of the view of wind turbines on residential housing properties has been studied (Lang et al., 2014; Hoen et al., 2011; Gibbons, 2015) with varied effects; showing both no statistical impact, and large negative impacts on local house prices. Paterson & Boyle (2002) used GIS to develop variables to signify effects of land features in hedonic models of residential housing prices. Their research explored the effect that view has on property prices, as well as investigated the omission of visibility variables that may lead to omitted variable bias.

Although viewshed research has been used to indicate whether certain geographic locations are suitable for future sea cage as well as land-based aquaculture operations. (Perèz, Telfer, & Ross, 2010; Falconer et al., 2013), few research efforts have been conducted on the actual effects that view of marine aquaculture may have on housing prices. Coupling results from viewshed technology with a hedonic pricing model may provide information necessary to make future siting decisions.

Research conducted on wind turbines suggest that changes to natural settings such as ocean view may be varied. While Gibbons (2015) suggests that visibility of wind turbines decreases residential housing values, Lang (2013) and Hoen et al., (2014) found that wind turbines have no statistically significant negative impacts on the prices of residential real estate. Vyn (2018) argues that wind turbines negatively impact property values in those areas that face negative opposition to wind turbine development, while those in municipalities that are largely unopposed to wind turbine development are not significantly impacted. Walls, Kousky, & Chu (2002) performed research on impacts of land type covers on residential housing properties in Missouri over a 24-year period. Using GIS-based viewshed analyses for each property, they found mixed effects of viewshed for different types of land.

In summary, results for views of natural amenities are mixed, with some studies finding positive values for amenities, some finding negative impact, and others finding no statistically significant impact.

2.4 Study Area

Variation in geographic coverage across coastal properties is vital to observe the visual impact of aquaculture on coastal homes (Evans et al., 2017). We select three regions in coastal Maine, a state known for its aquaculture industry, to meet these important criteria. Penobscot Bay, Damariscotta River Region, and Casco Bay differ in coastal usage, as well as cultural comfortability and history with the aquaculture industry. A dataset of single-family home sales was provided by the Maine Multiple Listing Service (MLS) and encompasses real estate data from January 2012 to December 2014. Data were subset to transactions within our three study areas (Casco Bay, Penobscot Bay, and Damariscotta River Region) and examined to ensure "arms-length" criteria were met for housing sales and structural features, and that unobserved housing features that could not be validated are dropped from the dataset (Lang et al., 2014; Taylor, 2017). Total count in our three study areas are 5,664, 1,351, and 1,660 observations for Casco Bay, Damariscotta River Region, and Penobscot Bay, respectively.

Our three study areas differ in terms of coastal economy, recreation and tourism, and opportunities for aquaculture development (Evans et al., 2017). Casco Bay is considered one of the busiest regions in Maine and is known for its abundant working waterfront rich with coastal resources (Portland: Geography and Climate, 2017; MaineRivers.org, 2017). For over three centuries this area has been used for marine activities, including fishing, commerce, and shipping (Needelman, 2018; PortlandMaine.gov, 2016). The Damariscotta River region, just north of Casco Bay, produces most oysters grown in Maine (Damariscotta River Association, 2016; Evans et al., 2017). The Damariscotta River is also the site of the first official aquaculture lease and has a vast culture and history steeped in aquaculture. Mild temperatures help to make Damariscotta a desired location for growing shellfish in Maine (InforME, 2016). Penobscot Bay, located northeast of Damariscotta, is also known for its lobster and fishing industry, as well as ecotourism opportunities (Penobscot Bay, 2017).

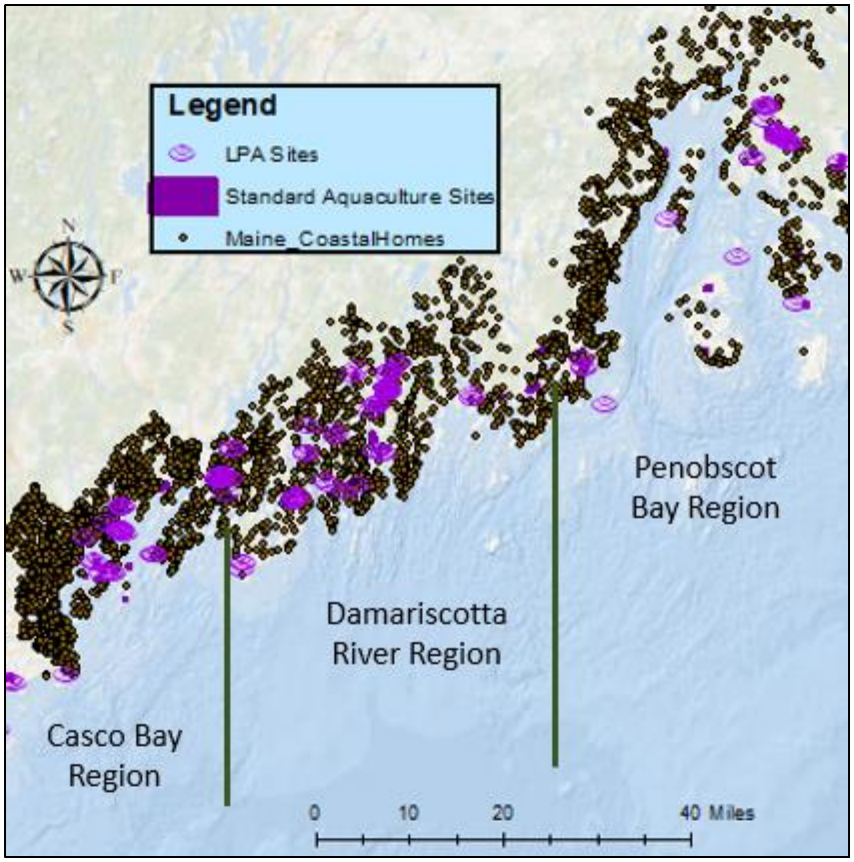

Figure 2. Study area for analysis. Penobscot Bay (N = 1,660), Damariscotta River Region (N = 1,351), and Casco Bay (N = 5,664)

2.5 Research Methods

We employ a hedonic pricing model (HPM) to examine the impact of visual impacts on the sale prices of coastal residential homes in the state of Maine (Rosen, 1974). An individual's choice of a house and its sales price implies an observable and implicit choice over that house's structural (size of the house, number of bathrooms/beds, etc.), neighborhood (crime rate, quality of schools, etc.), and environmental attributes (ocean views, water quality, etc.), as well as their implicit prices (Lang et al., 2014; Taylor, 2017). As such, estimated implicit prices (marginal values) for these characteristics (including environmental amenities) can be extracted through regression analysis. Several assumptions are commonly used in hedonic model estimation including: buyers and sellers have full information regarding the price and characteristics of the houses in the market; there exists a large market; there is only one house purchase by one buyer at a time; no influence on the market price through actions taken by either individual buyers or sellers; and prices move to equilibrium to balance supply and demand. Through modeling and estimating the implicit prices of housing attributes using hedonic framework, we can estimate the average value that buyers place on amenities of interest (Lang et al., 2014; Evans et al., 2017).

In determining how each of these characteristics, including visual characteristics influence price, we must decide on the functional form of the hedonic price model. For our purposes we use semi-log functional form in which[1]:

$$\ln P_{ijt} = \alpha_0 + \Sigma\beta_i x_i + \varepsilon$$

Where x_i is the estimated coefficient for all variables of interest in that bundle. Where $\frac{\partial P}{\partial x_i} = \beta_i P$; the implicit marginal price for the environmental attribute Although there are no clear guidelines for the correct functional form for the hedonic price function, research completed by Cropper, Deck, & McConnell (1988) suggest that simpler functional forms such as the semi-log are better at recovering marginal values in the presence of unobserved housing characteristics and therefore, will be used in our research.

[1] Functional form adopted from Taylor (2017)

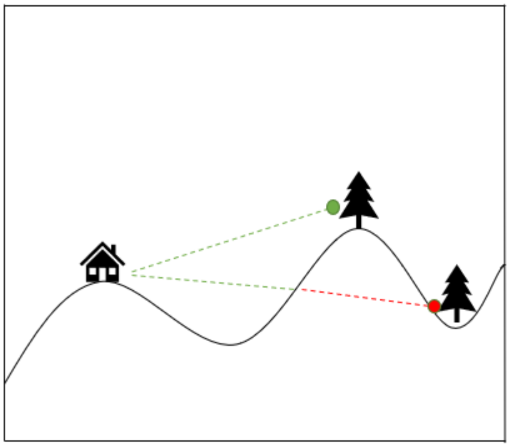

Figure 3: Concept behind line of sight model (adapted from Cavailhes, 2009). GIS line of sight models attempt to extract sight information from the observer (house) to the target (trees). Anything along the green line is visible by the target. Anything along the red line is not.

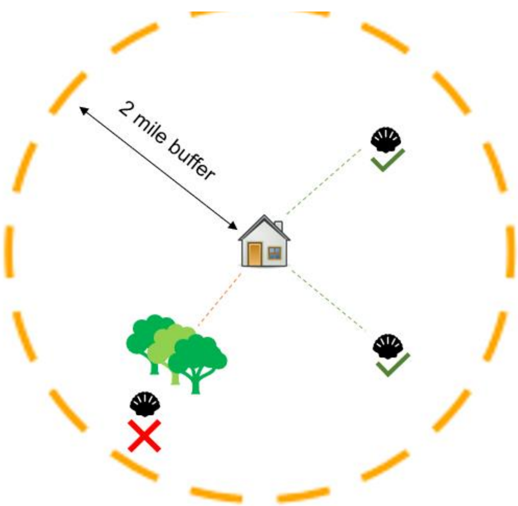

Figure 4. Conceptual Model of Aquaculture Line of Sight Model in GIS. Sight lines are constructed between each house and each shellfish aquaculture site. Line of Sight is performed to determine visibility along each line. The value 0 signifies the observer not being visible, while 1 signifies visibility. This information was utilized to construct a line of sight variable for each home to each aquaculture site within our study.

Since our research is focused on whether view of aquaculture is capitalized into the market for housing, estimates of the marginal implicit prices (sign, magnitude, and statistical significance) are suitable measures to use and can provide interesting insights regarding the importance of viewshed to coastal residents (Taylor, 2017).

We utilize geographic information systems (GIS) technology and employ Maine Office of GIS Digital Elevation Model (DEM) raster data to identify visibility between an observation point (individual home) and target (aquaculture site) (Figure 3). To extend research completed by Evans et al. (2017), only those marine aquaculture features (Limited Purpose Aquaculture (LPA) and Standard Aquaculture sites) within a 2-mile distance of the sample area coastal homes were tested.

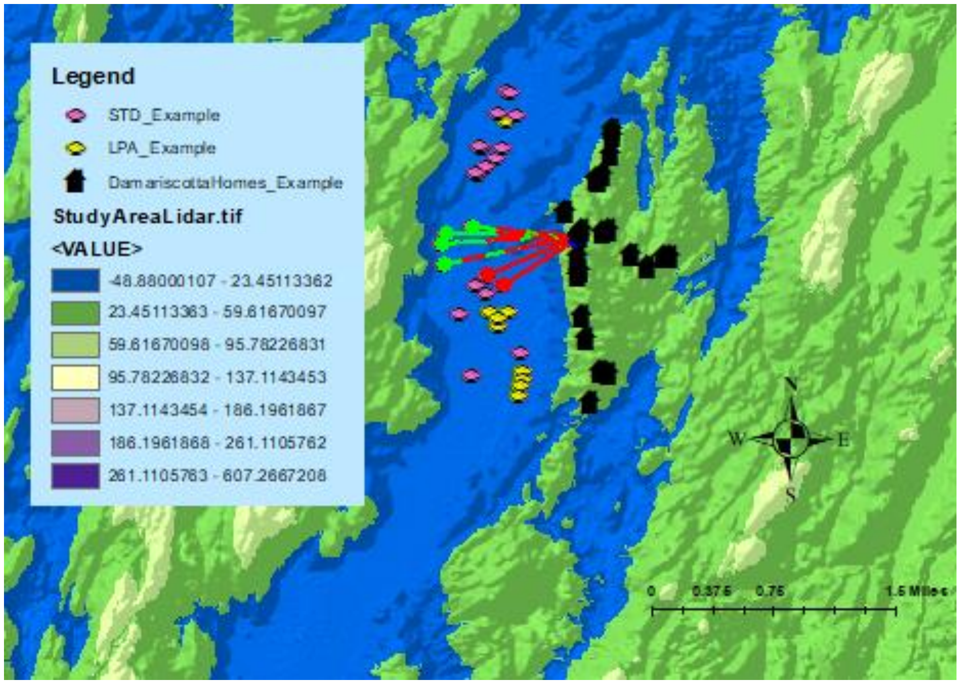

Figure 5. Line of sight example of sample home in Damariscotta River Region. Sight lines connect observation points (houses) to target points (aquaculture tract sites). The line of sight capability was used to determine visibility along each of the target points to observation points within a 2-mile buffer. Red endpoints indicate no visibility between observer and target; Green endpoints indicate visibility between observer and target. Table results signified a Boolean indicator 1 for visibility and 0 for no visibility. Viewshed analysis was completed for all houses and aquaculture sites in all three study regions. Results from this analysis were utilized to construct a line of sight indicator vector for each home to each site within the study.

The two parameters used for estimating visibility of aquaculture sites are (1) height for point of observation and height for point being observed. Observation height was assigned at 1.8 meters (height of eyesight for the average human observer) and was based on previous viewshed work completed by Cavailhes (2009) and Zanon (2015). The target height of Limited Purpose Aquaculture sites in Maine was assigned 0.762 meters. This number was determined through information listed on Maine's Chapter 2 Limited Purpose Aquaculture (LPA) License Program (2013) regarding gear description. Equipment utilized for aquaculture can vary from floating bags and tray racks to bottom cages (DMR, 2014). Since there are no strict requirements regarding the height for LPAs, the most conservative height of 2.5 feet, or 0.762 meters was utilized to account for shellfish rafts (typically used in shellfish aquaculture, the primary form of aquaculture in our study areas). The LPA height provided above was also utilized for Standard and Experimental Aquaculture Leases that fall under the shellfish category. Standard Aquaculture leases also include several finfish leases in the state of Maine. Standard leases have a required height maximum of 20 feet, or 6.096 meters. This is the maximum height that buildings, vessels, and barges can be assigned from the water line (DMR, 2014). Since finfish leases tend to use larger equipment, leases that fall under this category are assigned the conservative 6.096m target height.[2] The binary variable obtained from the viewshed analysis is incorporated in the vector of structural, neighborhood, and environmental housing attributes relevant to the HPM.

2.5.1 Housing Characteristics

In general, most property value studies include many explanatory factors which divide into three main categories: structural, neighborhood, and environmental (Taylor, 2003; Earnhart, 2002). The features included within each of these categories is presented in Table 1. We have attempted to identify prominent household characteristics to minimize omitted variable bias.

Table 1. Prominent structural, neighborhood, and environmental features commonly used in HPM, and those applied in our research.

Structural Features	Applied	Neighborhood Features	Applied	Environmental Features	Applied
Number of Bathrooms	✓	School District	✓	Water Based Features	✓
Interior Space	✓	City Center (post office, airport, etc.)	✓	Land Based Features	
Lot Size	✓	Socioeconomic indicators	✓	Air Features	
Age of Structure	✓	Level of Crime			
Style					
Number of Bedrooms					

*Features used in HPM model based on Taylor (2003) and Earnhart (2002)

[2] While there are Atlantic Salmon and Cod aquaculture sites in Maine, none were within a 2-mile buffer zone of our coastal homes. Therefore, this study is focused on shellfish aquaculture impacts.

Table 2. Summary statistics for housing structural, neighborhood, and locational characteristics.

		Casco Bay (N = 5,664)		**Damariscotta River Region (N =1,351)**		**Penobscot Bay (N = 1,660)**	
Variable Name	**Units**	**Mean or % (if 0/1)**	**SD**	**Mean or % (if 0/1)**	**SD**	**Mean or % (if 0/1)**	**SD**
Structural Characteristics of the House							
Sales price	$1,000s	337.72	278.33	303.66	289.76	289.67	319.00
Lot size	Acres	1.07	4.84	3.81	9.05	3.06	7.10
Living area	Ft^2	2037.45	978.64	1899.60	957.71	1900.39	987.7
Bathrooms	Number	2.00	0.85	1.93	0.85	1.94	0.87
Age	Years	60.25	45.49	66.71	62.84	72.00	56.89
Cabin	% (0/1)	0.55%	--	1.63%	--	1.60%	--
Winter Sale	% (0/1)	16.14%	--	17.91%	--	17.15%	--
Neighborhood Characteristics of the House							
Median household income	$1000s	65.40	17.67	55.61	73.00	48.88	11.27
Seasonal	%	6.16	9.83	26.86	17.56	22.02	15.43
Hospital Indicator	% (0/1)	42.45%	--	12.66%	--	18.75%	--
Per Student Expenditure	$1000s	13.83	0.70	14.49	17.01	15.51	2.86
Locational Characteristics of the House							
Waterfront Home	% (0/1)	4.89%	--	14.36%	--	8.40%	--
Distance to Water	Miles	1.00	1.29	0.64	1.04	0.74	1.08
Near Government Access Point	% (0/1)	39.41%	--	28.35%	--	31.70%	--
Elevation of House	100s Ft	4.20	0.61	0.96	1.48	1.26	0.96
Waterview	%	18.90	20.70	23.80	20.32	25.67	19.03
Prohibited/Restricted Water Quality	%	12.36	15.49	10.75	12.61	11.34	9.84
Coastal Aquaculture Characteristics							
Features		Count	Acreage	Count	Acreage	Count	Acreage
Aquaculture tracts, Present (2MI)	Number, Acres	60	69.35	89	190.84	55	100.24
Aquaculture tracts, Line of Sight (2MI)	Number, Acres	52	52.42	78	161.01	41	72.92
AQ Seen vs Present (Variation) (2MI)	%	14.8%		17.2%		13.1%	

*Notes: Monetary data points within the set were adjusted using the New England CPI with 2017 as a base year, to reflect the real price monetary values. (CPI-All Urban Consumers, 2018) (Evans, et al., 2017b)

Structural Features: Structural housing characteristics utilized in our research include number of *baths, lot size, living area, age,* and a *cabin* indicator dummy to signify seasonal property. Additionally, a *winter sale* characteristic was also obtained, since it is possible homebuyers who purchased a home in the winter may not be aware of lease sites currently in the waters near them and/or there is less communication for proposed sites in the winter. Winter months were labeled as those falling within the months of December, January, or February (0,1 indicator).

Neighborhood Features: Neighborhood characteristics were compiled using a variety of different resources and databases. *Median household income* was compiled using a Maine 2010 decennial dataset originally constructed by Evans and Robichaud (2017). *Student expenditure* data was compiled using a list of per pupil expenditures for all school districts in the state of Maine[3]. Percent of *seasonal homes* was developed using the census data from this region as a measure of percent seasonal homes of the available housing stock. This control is intended to capture the differences in areas with part-time residences. Data on *hospital locations* (signifies access to urban amenities) was pulled from Maine E911 address data from Maine Public Utilities Commission (PUC).

Environmental Features: Environmental category features were compiled using ArcGIS technology. A *waterfront* indicator was obtained via the "select by location" GIS feature to identify (using 0/1 indicator) homes considered to be in shoreland zones ("…within 250 feet of the highwater line of any pond over 10 acres, any river that drains at least 25 square miles, and all tidal waters and saltwater marshes…" (Maine Home Connection, 2017)).

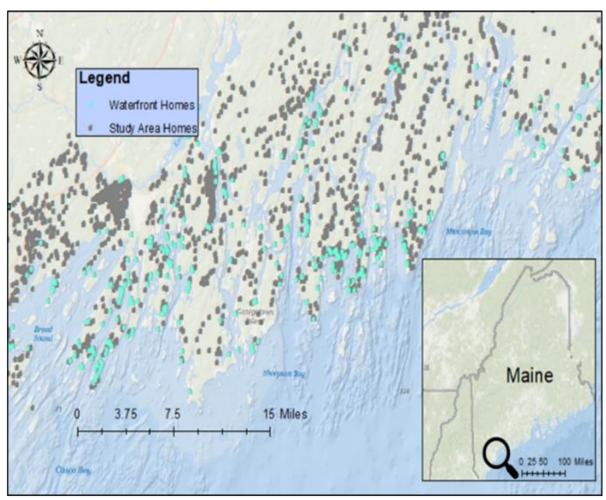

Figure 6. Maine selection of waterfront homes. In Casco Bay (above), homes were selected and assigned a "1" indicator if they were within 250 feet of the Maine coastline.

[3] In our models school district income is a proxy for school quality while household income is a proxy for spatial differences in census tracts

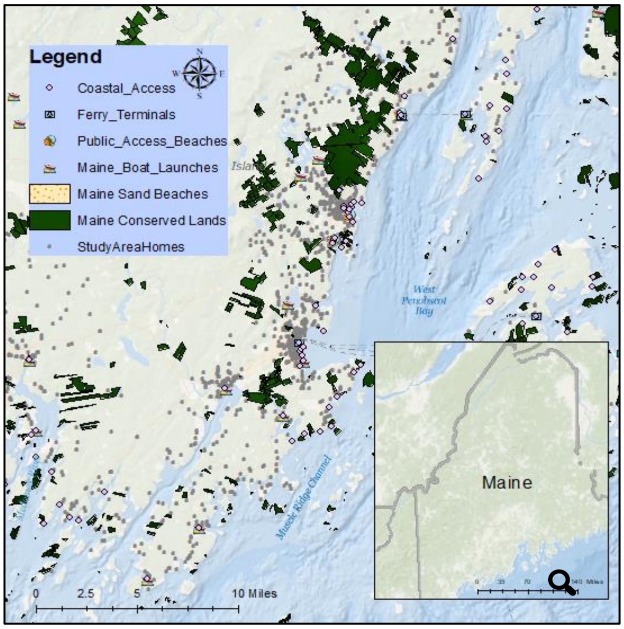

Figure 7. Maine government access points. These include coastal access, ferry terminals, public access and sand beaches, boat launches, and conservation land were collected for Penobscot Bay (above); Homes were selected and assigned a

2017 Shellfish NSSP Classification data was used (and checked against the 2014 data to ensure this was an adequate measure) to control for *water quality* in our model. The percentage proportion of a two-mile buffer zone containing prohibited or restrictive water quality was calculated as a proxy for water quality (Devoe, 2019). In Maine, marine aquaculture lease sites are prohibited anywhere within 1,000 feet from any government managed beach, conservation land, boat ramp, ferry terminal, or other coastal public access point. Therefore, *government access* data was gathered from Maine Office of GIS, Maine Healthy Beaches, and Evans & Robichaud (2017). The "select by location" feature linked each home in the sample area to the closest coastal access site and an indictor (0,1) was assigned to those homes within a thousand feet of a government managed area (Halsted, 2018a; Halsted, 2018b; Devoe, 2019; DMR, 2018; Devoe, 2018; DMR, 2018; Maine Healthy Beaches Program, 2018; US Harbors Tide & Weather Network, n.d.; US Harbors Tides, Weather and Local Knowledge, 2015)

Distance to water and waterfront indicators may not necessary capture all the relevant features of "perceived exposure" that have an impact on the sales price of a coastal home

(Taylor, 2017). Therefore, data was also gathered to determine proportion view of water (*waterview)* by coastal homes in tease out additional impacts of coastal activities. While waterfront signifies a house is within the distance required to be considered waterfront, additional geographic features may be present that would allow the house more or less of certain coastal visual amenities... A two-mile buffer zone was built around each home to calculate the percentage of water located within two miles of it (Cavailhès et al., 2009). Any homes that did not include water within the 2-mile buffer zone were assigned "0."

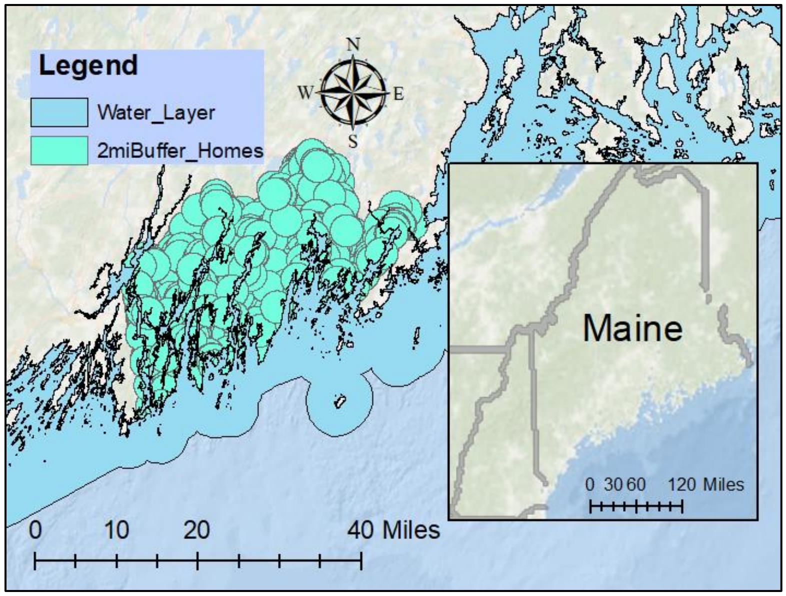

Figure 8. Two-mile buffer zone to indicate proportion of water around homes in Damariscotta River Region

In addition to the above environmental control variables, data regarding distance to aquaculture tract and area of each aquaculture tract was gathered to construct aquaculture controls and indexes for our model. *Aquaculture distance* information was also used to determine which aquaculture sites were present (*near*) within a specified distance from a coastal home. Viewshed data (to construct the aquaculture *seen* variable) was extrapolated via ArcGIS using the sample coastal home dataset, LPA and STD aquaculture tract data and LiDAR data from the Maine Office of GIS.

2.5.2 Base Model: Distance Weighted Acreage Aquaculture Index

When investigating the average effect of visual impacts of aquaculture, it is useful to think about four states of the world: 1) aquaculture is neither present, nor seen; 2) aquaculture present but not seen; 3) aquaculture is seen and not present (not possible in our data with a two-mile buffer) and 4) aquaculture is present and seen. At its' basic form, our HPM also needs to address line of sight in the model, as well as all areas of potential correlation with regards to aquaculture.

Consistent with Evans et al. (2017) techniques, two aquaculture indexes were created based on 1) presence of aquaculture lease, and 2) line of sight, to capture the aggregate effect of the characteristics of density (count) of tracts within 2-mile buffer, area of the tract, and distance between tract and coastal home. These index variables are represented by distance weighted acreage for each present aquaculture tract and each visible aquaculture tract. This equates to the area for each present tract area divided by distance[4]:

$$\text{DWA\_Present}_i = K_i \sum_{k \in A_i^{Present}} \frac{a_{ik}}{d_{ik}};$$

$$\text{DWA\_Seen}_i = K_i \sum_{k \in A_i^{Seen}} \frac{a_{ik}}{d_{ik}};$$

where K_i signifies the number of marine aquaculture tracts, a_{ik} represents the acreage of each tract near home i, d_{ik} represents distance of each aquaculture tract to home i, $A_i^{Present}$ signifies the

[4] Aquaculture presence and sight index adopted from Evans et al (2017a).

set of active tracts present within 2-mile buffer of house i, A_i^{Seen} signifies the set of active tracts present and seen within 2-mile buffer of house i.[5]

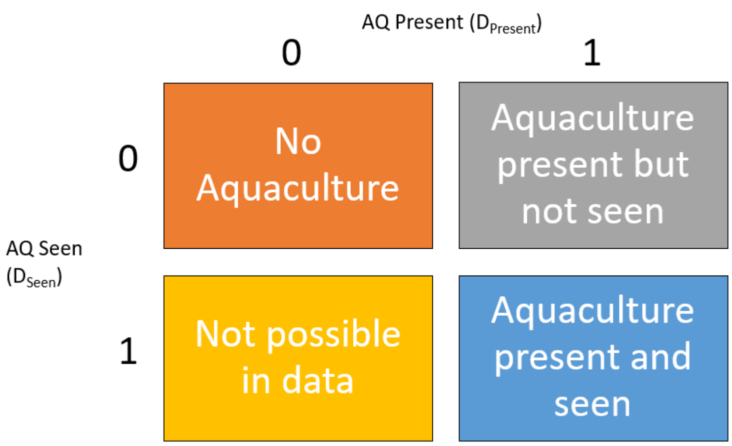

Figure 9. The four states of the world when exploring the presence and viewshed of aquaculture. While investigating impacts for the presence of aquaculture is an important first step; this variable is absorbing all other impacts associated with the leases (smell, noise, presence, etc.) Our goal is to extract the confounding influence that aquaculture line of sight impacts may have on aquaculture sites.

This distance weighted acreage aquaculture index (DWA) was developed and utilized for several of the models below as proxies for the presence and view of aquaculture. This house specific measure of aquaculture was originally developed by Evans et al. (2017) to account for the spatial arrangement of leases with different scales of production.

Evans' et al. (2017) presence distance weighted acreage index multiplied by the count of aquaculture leases present for each house represents the impact that the presence of aquaculture may have on housing prices. Although presence was captured using this approach, the presence variable is also absorbing all the other impacts associated with the leases (smell, noise, presence, etc.), and absorbing correlation with other leases in the same water. Because unseen aquaculture sites are also present, the coefficient measures a mix of presence, line of sight, and other spillover effects of aquaculture. Since we are interested in viewshed as a mechanism through which aquaculture

[5] Although an aquaculture site may be present in the 2-mile buffer zone, the elevation and geographic location of the home determine if the aquaculture is within line of sight.

affects property prices, we want to extract that potentially confounding influence. We therefore modify Evans' et al (2017) equation to reflect the viewshed impacts of aquaculture.

Our base equation is:

$$\ln P_{ijt} = \beta_0 + \beta_1 x_i + \beta_2 DWA\_Present_i + \beta_3 DWA\_Seen_i + \delta_j + \delta_t + \varepsilon_{ijt}$$

Where $\ln P_{ijt}$ is the log price of a house, x_i is a bundle of housing characteristics, $DWA\_Present_i$ is the distance weighted acreage for aquaculture present within 2 miles of each house, DWA_Seen_i is the distance weighted acreage for aquaculture sites seen by houses within a 2-mile buffer.

This base equation encompasses the distance weighted acreage indexes for present leases, as well as those that are present and seen (impacts of the aquaculture itself being there). It is important to note that while previous research by Evans et al. (2017) was completed using aquaculture sites (some containing multiple tracks), our research handled leases differently and treated all sites that were not joined as "tracts." All tracts that shared layer space, were additions of prior tracts, or were directly adjacent to each other were joined using the union feature in GIS. The aquaculture site data used in this analysis was provided directly through contacts at the Maine Department of Marine Resources (DMR). Knowledge regarding expiration, activation, and termination dates was updated by this staff as of June 2018. Outlined below are two alternate approaches in which aquaculture presence and view enters our model.[6]

[6] We also ran a third alternate model in attempt to better capture variation between aquaculture present within the 2-mile buffer and aquaculture that is present and seen within the buffer. However, this model significantly decreased our observations, therefore reducing power of our model. Results from this alternate model are available upon request.

2.5.3 Alternate Approach 1: Capturing Line of Sight Impacts through Dummy Variables

Dummy variables are used in regression models to account for factors that may change across observations (Hill, Griffiths, Judge, & Reiman, 2001). These variables allow for flexibility in the estimated responses to changes in environmental conditions. Dummy, or binary variables take one of two values, 1 or 0, to indicate the presence or absence of a characteristic. In the case of the HPM, a dummy variable can be utilized to indicate whether a desirable neighborhood, structural, or environmental characteristic is present for observations within the study sample. In our first alternate approach to determine impacts of line of sight, we develop two dummies to signify if aquaculture is present (0,1) and if aquaculture is present and seen from the home (0,1). Consistent with Lang et al.'s (2014) techniques, two aquaculture dummy variables created based on 1) presence and 2) line of sight in effort to capture the aggregate effect of the lease on the coastal home.

$$D_{Near} = \begin{matrix} 1 \text{ if aquaculture is present} \\ 0 \text{ if aquaculture is not present} \end{matrix}$$

$$D_{Seen} = \begin{matrix} 1 \text{ if aquaculture is seen} \\ 0 \text{ if aquaculture is not seen} \end{matrix}$$

Incorporating these two dummy variables in our regression model, we obtain the following equation:

$$\ln P_i = \beta_0 + \beta_1 x_i + \beta_2 D_{Present} + \beta_3 D_{Seen} + \delta_j + \delta_t + \varepsilon_{ijt}$$

Where P_{ijt} is the sales price of housing unit i in neighborhood j at time t. X_i includes structural, neighborhood, and environmental characteristics of home i. $D_{Present}$ represents a dummy variable equal to 1 if aquaculture is present within a 2-mile buffer zone of the house. D_{Seen} represents a dummy variable indicating aquaculture that is seen from the house. δ_j and δ_t are municipality and sales-year fixed effects to capture any localized demographic changes or year to year variation in sales conditions. This equation encompasses the presence of aquaculture, as well as the extracted viewshed mechanism which may also have an impact on housing prices. Since our dependent variable is the natural log of sales price, then the interpretation of our coefficient estimate is the approximate percentage change in price when the characteristic in question is present.

2.5.4 Alternate Approach 2: Capturing Line of Sight Impacts through Interaction Variables

The second alternate approach recalls the four possible scenarios for a home observation. We account for these scenarios by using our aquaculture dummies to signify $D_{Present}$ (aquaculture is present, some are seen, and some are not), D_{Seen} (aquaculture is both present and seen), and add a new dummy, D_{NO} (aquaculture is present, but not seen). We then interact these dummies with the aquaculture near and aquaculture seen distance weighted acreage indexes.

Our equation is below:

$\ln P_{ijt} =$

$$\beta_0 X_i + \underbrace{\beta_1 D_{Present_i}}_{\text{AQ Present}} + \underbrace{\beta_1 (D_{NO_i})\text{DWA\_Present}_i}_{\text{Only AQ Present}} + \underbrace{\beta_2 (D_{Seen_i})\text{DWA\_Present}_i}_{\text{Mix of AQ Present and Seen}} + \underbrace{\beta_3 (D_{Seen_i})\text{DWA\_Seen}_i}_{\text{Only AQ that are both Seen and Present}} + \delta_j + \delta_t + \varepsilon_{ijt}$$

Where $D_{Present}$ signifies homes that have at least one aquaculture site present in a 2-mile buffer zone of their house; $(D_{NO_i})\text{DWA\_Present}_i$ represents an interaction term between only those homes with aquaculture present, and the distance weighted acreage index for those sites; $(D_{Seen_i})\text{DWA\_Present}_i$ is an interaction between homes that are present and seen (with some seen and some not; and $(D_{Seen_i})\text{DWA\_Seen}_i$ representing an interaction between only those homes that have both aquaculture in the 2-mile buffer zone and can be seen by those homes.

Table 3. Casco Bay region parameter estimates across all three log-linear HPM models. Base Model: captures line of sight impacts for aquaculture presence and line of sight for all observations; Alt Model 1: captures line of sight impacts through dummy variables; and Alt Model 2: captures line of sight impacts through interaction variables. Robust standard errors are in parenthesis. Parameter estimates for municipality can be found in Appendix B. Parameter estimates for year fixed effects are available upon request.

Casco Bay	Base Model		Alternate Model 1		Alternate Model 2	
	(N = 5,664)		(N = 5,664)		(N = 5,664)	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Coastal Aquaculture Characteristics						
Aquaculture Count Presence DWA Interaction	-0.528	0.702	-	-	-	-
Aquaculture Count Seen DWA Interaction	10.33	6.688	-	-	-	-
Aquaculture tracts, Present (2MI) Dummy	-	-	**-0.023*** **	0.005	-	-
Aquaculture tracts, Line of Sight (2MI) Dummy	-	-	**0.067*** **	0.016	-	-
Aquaculture Present	-	-	-	-	**-0.071*** **	0.013
Aquaculture Present, not seen	-	-	-	-	-0.333	.779
Mix of Aquaculture present and seen	-	-	-	-	0.289	1.357
Only aquaculture present and seen	-	-	-	-	10.635	7.261
Control Variables: Coastal Locational Characteristics of the House						
Waterfront Home	**0.395*** **	0.028	**0.390*** **	0.027	**0.393*** **	0.028
Distance to Water (miles)	**-0.025*** **	0.000	**-0.028*** **	0.000	**-0.033*** **	0.000
Distance to Water^2(miles)	**0.000*** **	0.000	**0.000*** **	0.000	**0.000*** **	0.000
Near Government Access Point	-0.002	0.010	-0.003	0.010	-0.004	0.010
Elevation of Home (100s feet)	**0.446*** **	0.000	**0.458*** **	0.000	**0.500*** **	0.000
Waterview	**0.006*** **	0.001	**0.006*** **	0.001	**0.006*** **	0.001
Prohibited/Restricted Water Quality	0.000	0.001	0.000	0.001	-0.001	0.001

Table 3 Continued

Control Variables: Structural Characteristics of the House						
Lot size (100s acres)	**0.798*****	0.001	**0.809*****	0.002	**0.813*****	0.002
Living area (1000s ft^2)	**0.258*****	0.000	**0.259*****	0.000	**0.258*****	0.000
Bathrooms	**0.139*****	0.011	**0.139*****	0.008	**0.139*****	0.011
Age	**-0.003*****	0.000	**-0.003*****	0.000	**-0.003*****	0.000
Age^2	**0.000*****	0.000	**0.000*****	0.000	**0.000*****	0.000
Cabin	-0.110	0.083	-0.101	0.081	-0.099	0.082
Winter Sale	**-0.044*****	0.012	**-0.044*****	0.012	**-0.045*****	0.012
Control Variables: Neighborhood Characteristics of the House						
Median household income ($10,000s)	**-0.251*****	0.000	**-0.244*****	0.000	**-0.241*****	0.000
Seasonal	**0.023*****	0.003	**0.027*****	0.003	**0.025*****	0.003
Hospital Indicator	**0.441*****	0.020	**0.437*****	0.019	**0.453*****	0.020
Per Student Expenditure($1,000s)	**0.741*****	0.000	**0.735*****	0.000	**0.732*****	0.000
Measures of Fit						
AIC	2626.469		2589.784		2599.412	
BIC	2832.367		2795.682		2818.594	

*Table adapted from Evans et al. (2017)

*** p<0.01, **p<0.05, *p<0.1

Table 4. Damariscotta river region parameter estimates across all three log-linear HPM models. Base Model: captures line of sight impacts for aquaculture presence and line of sight for all observations; Alt Model 1: capture line of sight impacts through dummy variables; and Alt Model 2: capture line of sight impacts through interaction variables. Parameter estimates for municipality can be found in Appendix B. Parameter estimates for year fixed effects are available upon request.

Damariscotta River Region	Base Model (N = 1,351)		Alternate Model 1 (N = 1,351)		Alternate Model 2 (N = 1,351)	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Coastal Aquaculture Characteristics						
Aquaculture Presence DWA Interaction	**0.115****	0.048	-	-	-	-
Aquaculture Seen DWA Interaction	0.101	0.111	-	-	-	-
Aquaculture tracts, Present (2MI) Dummy	-	-	0.004	0.004	-	-
Aquaculture tracts, Line of Sight (2MI) Dummy	-	-	**0.016****	0.008	-	-
Aquaculture Present	-	-	-	-	-0.006	0.039
Aquaculture Present, not seen	-	-	-	-	**0.137****	0.063
Mix of Aquaculture present and seen	-	-	-	-	**0.103***	0.056
Only aquaculture present and seen	-	-	-	-	0.130	0.133
Control Variables: Coastal Locational Characteristics of the House						
Waterfront Home	**0.360*****	0.044	**0.361*****	0.044	**0.359*****	0.044
Distance to Water (miles)	**-0.003*****	0.000	**-0.001*****	0.000	**-0.002*****	0.000
Distance to Water^2(miles)	**0.000****	0.000	**0.000****	0.000	**0.000****	0.000
Near Government Access Point	-0.003	0.033	-0.004	0.033	-0.004	0.033
Elevation of Home (100s feet)	**-1.969*****	0.001	**-1.969*****	0.001	**-1.970*****	0.001
Waterview	**0.008*****	0.001	**0.008*****	0.001	**0.008*****	0.001
Prohibited/Restricted Water Quality	0.001	0.002	0.001	0.002	0.001	0.002

Table 4 Continued

Control Variables: Structural Characteristics of the House						
Lot size (100s acres)	**1.372*** **	0.002	1.372***	0.002	**1.374*** **	0.002
Living area (1000s ft^2)	**0.240*** **	0.000	0.241***	0.000	**0.242*** **	0.000
Bathrooms	**0.236*** **	0.034	**0.236*** **	0.034	**0.237*** **	0.034
Age	**-0.004*** **	0.001	**-0.004*** **	0.001	**-0.004*** **	0.001
Age^2	**0.000*** **	0.000	**0.000*** **	0.000	**0.000*** **	0.000
Cabin	-0.005	0.140	-0.006	0.140	-0.004	0.140
Winter Sale	-0.022	0.037	-0.023	0.037	-0.022	0.037
Control Variables: Neighborhood Characteristics of the House						
Median household income ($10,000s)	**-7.312*** **	0.000	**-7.290*** **	0.000	**-7.304*** **	0.000
Seasonal	**0.075***	0.044	**0.075***	0.044	**0.075***	0.044
Hospital Indicator	**-8.953*** **	0.447	**-8.920*** **	0.456	**-8.945*** **	0.461
Per Student Expenditure($1,000s)	**-1.818*** **	0.002	**-1.821*** **	0.000	**-1.817*** **	0.000
Measures of Fit						
AIC	1926.653		1926.72		1928.529	
BIC	2129.789		2124.643		2136.873	

*Table adapted from Evans et al. (2017)

*** p<0.01, **p<0.05, *p<0.1

Table 5. Penobscot Bay parameter estimates across all three log-linear HPM models. Base Model: captures line of sight impacts for aquaculture presence and line of sight for all observations; Alt Model 1: captures line of sight impacts through dummy variables; and Alt Model 2: captures line of sight impacts through interaction variables. Parameter estimates for municipality can be found in Appendix B. Parameter estimates for year fixed effects are available upon request.

Penobscot Bay	Base Model		Alternate Model 1		Alternate Model 2	
	(N = 1,660)		(N = 1,660)		(N = 1,660)	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Coastal Aquaculture Characteristics						
Aquaculture Presence DWA Interaction	**-3.89****	1.85	-	-	-	-
Aquaculture Seen DWA Interaction	3.900	4.300	-	-	-	-
Aquaculture tracts, Present (2MI) Dummy	-	-	**-0.019***	0.011	-	-
Aquaculture tracts, Line of Sight (2MI) Dummy	-	-	-0.04	0.043	-	-
Aquaculture Present	-	-	-	-	-0.071	0.053
Aquaculture Present, not seen	-	-	-	-	-0.206	1.614
Mix of Aquaculture present and seen	-	-	-	-	**-5.611****	2.331
Only aquaculture present and seen	-	-	-	-	**11.160***	6.077
Control Variables: Coastal Location Characteristics of the House						
Waterfront Home	**0.468*****	0.051	**0.465*****	0.050	**0.468*****	0.050
Distance to Water (miles)	**-0.044***	0.000	**-0.043***	0.000	**-0.047***	0.000
Distance to Water^2(miles)	**0.000****	0.000	**0.000****	0.000	**0.000****	0.000
Near Government Access Point	**0.122*****	0.028	**0.124*****	0.028	**.122*****	0.028
Elevation of Home (100s feet)	-0.450	0.001	-0.451	0.001	-0.432	0.001
Waterview	**0.009*****	0.001	**0.009*****	0.001	**0.008*****	0.001
Prohibited/Restricted Water Quality	-0.001	0.003	-0.001	0.003	-0.001	0.003

Table 5 Continued

Control Variables: Structural Characteristics of the House						
Lot size (100s acres)	**1.966*** **	0.003	**1.973*** **	0.002	**1.940*** **	0.003
Living area (1000s ft^2)	**0.194*** **	0.000	**0.196*** **	0.000	**0.193*** **	0.000
Bathrooms	**0.255*** **	0.032	**0.254*** **	0.0213	**0.258*** **	0.032
Age	**-0.005*** **	0.001	**-0.005*** **	0.001	**-0.005*** **	0.001
Age^2	**0.000*** **	0.000	**0.000*** **	0.000	**0.000*** **	0.000
Cabin	**0.315* **	0.18	**0.314* **	0.113	**0.322* **	0.178
Winter Sale	-0.006	0.034	-0.007	0.034	-0.007	0.034
Control Variables: Neighborhood Characteristics of the House						
Median household income ($10,000s)	**-0.558** **	0.000	**-0.658** **	0.000	**-0.653* **	0.000
Seasonal	**0.173*** **	0.069	**0.189*** **	0.070	**0.189*** **	0.069
Hospital Indicator	**2.700*** **	0.974	**2.910*** **	0.976	**2.910*** **	0.977
Per Student Expenditure($1,000s)	**-1.017** **	0	**-1.112*** **	0.000	**-1.108*** **	0.000
Measures of Fit						
AIC	2526.402		2534.434		2522.261	
BIC	2753.814		2761.846		2760.503	

*Table adapted from Evans et al. (2017)

*** p<0.01, **p<0.05, *p<0.1

2.6 Results

Tables 3, 4, and 5 (above) display results from each of the four models across Casco Bay, Penobscot Bay, and the Damariscotta River Region. These results allow us to compare how each model specification is impacting each location.

The structural, neighborhood, and environmental characteristic control variables performed as expected with regards to sign and significance in all three models. *Water quality* did not test significant in any regions, most likely since aquaculture sites require certain water quality standards to be met. Therefore, we have little variation in our dataset. *Near government access* point dummy indicator was significant and positive in our Penobscot Bay model. This is expected due to Penobscot Bay's reputation in ecotourism and convenient location near state parks and sanctuaries. One would expect that homes within a buffer zone of these government access points would demand a higher premium than homes outside of it. *Winter sale* proxies tested negative and significant in the Casco Bay area. A reason for this could be due to the increased urban presence coinciding with more individuals moving in the summer months. *Hospital* had mixed negative and positive large impacts on housing prices. This is most likely due to the small number of 911 centers, and little variation between houses near and far from them. The *Cabin* variable was significant in the Penobscot Bay model, and this makes sense due to the increased use or purchase of seasonal homes in these regions with a reputation for tourism.

2.6.1 Base Model: Accounting for Aquaculture Presence and Line of Sight through DWA Interaction

Our presence of aquaculture results suggest variation in the impact on housing prices across Casco Bay, Damariscotta Region, and Penobscot Bay. We do not find indication of any impact in Casco Bay, while there is statistically significant evidence for Damariscotta Region and Penobscot Bay. These results use the same presence of aquaculture index built by Evans et al. (2017) and match their results for presence of aquaculture across all regions. After controlling for structural, neighborhood, and other marine environment characteristics, the line of sight aquaculture index is not significant in Casco, Damariscotta, or Penobscot regions. This suggests that the view of aquaculture may not be considered an amenity or disamenity in either of these three areas.

2.6.2 Alternate Model 1: Capturing Line of Sight Impacts through Dummy Variables

Alternate model 1 yields different results for presence of aquaculture, which was not significant in our base model. While the presence of aquaculture in Casco Bay tested significant and negative at the 2-mile level; sight of aquaculture tested significant and positive.[7] Presence in Damariscotta was insignificant, but sight of aquaculture tested significant and positive at the 5% level. Again, this is inconsistent with our results from our base model, in which line of sight was not significant. Like results for our base model, the dummy variable representing view of aquaculture was not significant for the Penobscot Bay region, though presence was significant and negative in both models.

2.6.3 Alternate Model 2: Capturing Line of Sight Impacts through Interaction Variables

The relationship with aquaculture in this model is varied with the indicator of aquaculture presence having no significant relationship with the coastal homes in Penobscot Bay; a significant, positive relationship with coastal homes in Damariscotta, and a significant, negative relationship with the sale price of coastal homes in Casco Bay. Our aquaculture index interaction with presence only (no *seen*) convey a positive and significant relationship with housing prices in

[7] These results do not match intuition and are further explored in the discussion section of this chapter.

Damariscotta. Those with a mix of AQ present and seen convey statistically significant positive relationship with housing prices in Damariscotta River region and a strong negative relationship with housing prices in Penobscot Bay. Effects of presence and line of sight of aquaculture are varied (only AQ *seen*), with no effect in Casco or Damariscotta areas, while having a strong positive relationship with housing prices in Penobscot Bay.

2.7 Discussion

Our results in all models robustly test and confirm the hypothesis that effects of marine aquaculture line of sight on coastal housing real estate has varied impacts across regions. Through observing the p-value of the F test, all models test significant and fit the data well. Prior research completed by Evans et al. (2017) argues no presence impacts in Casco Bay, significant and negative impacts in Penobscot Bay, and significant and positive impacts in Damariscotta. While the base model is most like the research conducted by Evans et al (2017) and confirms the aquaculture presence results in Penobscot, Damariscotta, and Casco Bay; Akaike information criterion and Bayesian information criterion suggest that alternate model 1 fits our data better and therefore, may be of higher quality relative to the other models (StataCorp, 2013). Our results from this model show that, while line of sight has no statistically significant impacts in Penobscot region, it conveys a significant and positive relationship with coastal housing prices in Casco Bay and Damariscotta. This could have something to do with the relative magnitude of aquaculture in this urban working waterfront compared to the larger commercial fishing ships, docks, recreational boats that are constantly on the water. In Damariscotta, justification could involve the rich history and culture of aquaculture in the area. Differences between viewshed impacts on Casco and Damariscotta versus Penobscot may also have something to do with the perception that urbanites and suburbanites have regarding view of aquaculture or marine amenities in general (Mogush, Krizek, & Levinson, 2016). Urban house buyers in Casco Bay near Maine's "working waterfront" may value marine activity viewshed differently than rural house buyers in Penobscot. An interesting expansion of this research topic would be to determine impacts that other marine uses have on the Casco Bay region, and its' "working waterfront," compared to those in the more rural areas of Damariscotta and Penobscot Bay. We may also want to address additional marine use variables, such as docks, transportation and fishing boats and ships, etc., that may be important factors of controlling for bias induced by omitted variables. It is unclear how the values of these results might be affected by omitted variable bias. Further research will need to explore the counterintuitive significant negative aquaculture presence results against the significant and positive aquaculture viewshed results. This could be due to a number of reasons including lack of variation in the dataset, model misspecification, or omitted variable bias. Interestingly, Walls, Kousky, and Chu (2013) also find similar mixed results during their research on visibility versus proximity impacts of various topography on residential housing prices. While values tested positive for proximity to forested areas, results conveyed negative values for viewshed of forest land. Additionally, although proximity tested positive for grassy recreational lands, visibility had no statistically significant impacts.

As Paterson & Boyle (2002) argue, visibility measures are important determinants of price. It is important to examine what impacts visibility may have and to determine if the omission of this variable leads to omitted variable bias (Paterson & Boyle, 2002). When alternate model 1 models are run for the three regions utilizing only the presence indicator dummy, proximity to aquaculture in Damariscotta now appears to have a positive significant effect on home prices. This is different than our original alternate model 1 conclusions where present is not significant, but line of sight is. This result leads us to believe that without the line of sight indicator, our Damariscotta coastal environment aquaculture related variables could suffer from omitted variable bias. Once these effects are accounted for, proximity to aquaculture becomes insignificant. Additionally, these results show that aquaculture visibility may play a valuable, positive role in certain coastal communities. It is important to also note that although proximity to aquaculture becomes significant in Damariscotta, estimated coefficients for housing characteristics are stable across specifications, suggesting that visibility variables in our models are independent to structural characteristics (Paterson & Boyle, 2002). When alternate model 1 models are run for the three regions including only the visual indicator dummy, the results are congruent with original model results: significant and positive for Damariscotta, not significant for Penobscot, and significant and positive for Casco Bay. However, coefficient results are smaller in Casco Bay, and larger in Damariscotta. The differences above are probably attributable to either proximity to aquaculture or view of aquaculture's conflation of the other's effects. These results also suggest that we may be missing additional indicators associated with aquaculture (noise, smell, etc.), and should therefore tread carefully prior to using these results for any coastal management decisions.

Additionally, all models suffer from lack of variation in the dataset. Figure 10 displays the low variation in all three areas with respect to those that have no aquaculture present versus those that have aquaculture present versus those that are also within line of sight of aquaculture.

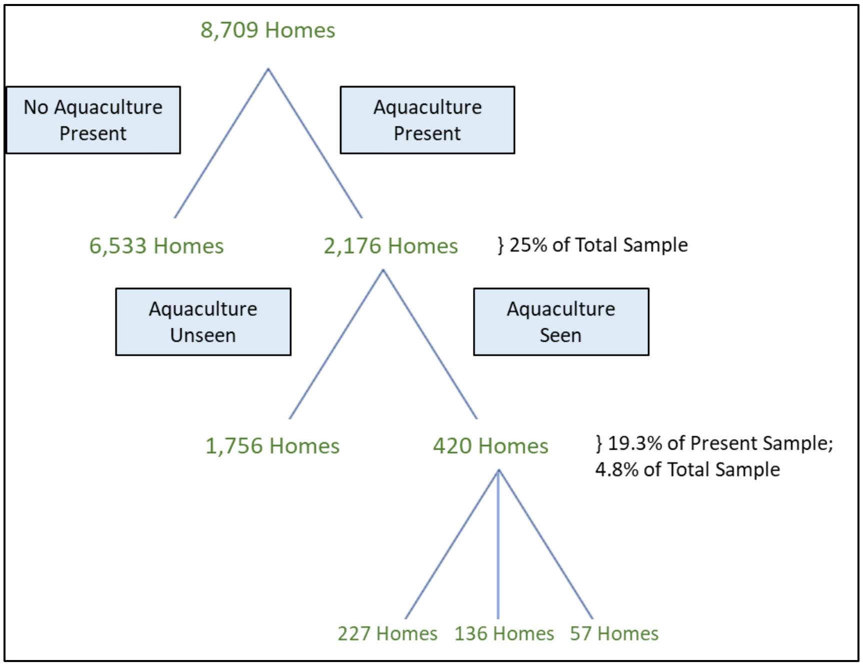

Figure 10. Lack of variation across households in Coastal Maine. Out of 5,664 homes in Casco Bay, only 227 of them account for those that are within a 2-mile presence of aquaculture and are in line of sight of aquaculture. Out of 1,351 homes in Damariscotta, only 136 homes meet this criterion. In Penobscot Bay, 57 homes out of 1,660 are present and within line of sight of a 2-mile buffer zone for marine aquaculture.

An additional limitation of our dataset concerns the Maine Multiple Listing Service (MMLS) data. After the data was cleaned to ensure “arm’s length” transactions, a random sample of 100 observations was retrieved to check accuracy, and a percentage of error of 51% was calculated based on the number of homes that had at least one field that did not match information provided on real estate sites such as Zillow.com, Realtor.com, or Trulia.com. For the purposes of research we still err on the side of using MMLS data, consistent with the 2012-2014 attributes of the home. We spent considerable time and effort ground truthing the data, but we recognize the limitations of this dataset and therefore, will not overemphasize precision of our results.

There were 32 observations (primarily in Hancock County) from the original study area that were not covered by the LiDAR elevation data provided through the Maine Office of GIS. We worked directly with the Maine Office of GIS to discuss the missing LiDAR collection, but unfortunately the collection has not reached delivery stage yet. There is elevation data available at a coarser resolution from the National Elevation Dataset. However, the resolution is different and therefore the results of the analysis would not be directly comparable to those using the LIDAR data. Therefore, these 32 homes were removed from the dataset.

Determining viewshed is a computer-intensive procedure with a long processing time. ArcGIS must detect and review every point along the lines of a polygon. Due to time constraints, we opted to use centroids for each of the standard aquaculture lease polygon data. To capture all variation due to the presence of obstacles such as trees, garages, etc., future work might entail site visits to properties listed within the housing transaction dataset and within two miles of an aquaculture site (Lang et al., 2013). Visibility of an aquaculture sight could then be rated in categories based on viewshed proportion.

Additionally, with the recent increase in applying spatial statistics to hedonic modeling, future research might incorporate the use of machine learning techniques, such as the random forest method, as an alternative to hedonic pricing modeling techniques (Ceh, Kilibarda, Lisec, & Bajat, 2018). Research exists that argues that machine learning techniques may perform higher than other methods and convey better sales price predictions.

The hedonic model suggests that the implicit price of the amenity of interest is equivalent to the individual homeowner's marginal willingness to pay (MWTP) for that specific characteristic (Taylor, 2017). When used in environmental contexts, this tool model provides researchers with knowledge regarding the importance of magnitude of different environmental amenities. Our research is focused primarily on determining whether viewshed of aquaculture sites are capitalized into the market for housing. However, once a final model is specified, we should extract the implicit price of the amenity (viewshed of aquaculture) to determine the average homeowner's marginal willingness to pay (MWTP) for this view (Taylor, 2017). For the semi-log hedonic functional form, the MTWP for the aquaculture viewshed attribute can be achieved by the taking a partial derivative with respect to the attribute of interest. Interpretations for these results describe the average marginal impacts on the house price for a change in aquaculture viewshed attribute for all the lease sites that are within the distance buffer around the home[8].

While we attempted different ways in which viewshed of aquaculture entered the semi-log functional form for the hedonic price function, next steps would also include attempting different specifications to model this relationship. While there is research arguing for the use of semi-log to recover marginal values (Cropper, 1988), regression diagnostics run on our models suggest misspecification.[9] Research by Kuminoff, Parmeter, & Pope (2010) argue the box-cox form provides a more flexible framework. Evans et al. (2017) uses the box-cox transformation on sales price to take advantage of this flexibility and assist in the selection of model specification.

The end goal through this research is to address the impacts (if any) of aquaculture on coastal communities. Coastal managers in Maine are currently considering issues such as water quality, size, location, species, and discharge when examining aquaculture siting decisions

[8] It is important to note here that, when determining MWTP, statistical significance versus economic significance will both need to be addressed

[9] Specification link test for single-equation models and Ramsey reset test were performed to test for model misspecification.

(Department of Marine Resources, 2013). Our model will allow for visual and proximity effects on coastal communities to also be examined. Exploring the mechanisms through which aquaculture impacts coastal communities can serve to increase adoptability and acceptability of marine aquaculture and continue Maine's projected path as one of the nation's leaders in sustainable aquaculture.

CHAPTER 3

EXPLORING PERCEPTIONS OF, AND PREFERENCES FOR MARINE COASTAL ISSUES

3.1 Introduction

Since ancient civilization, mankind has depended on the ocean for food, transportation and space (Hoagland & Ticco, 2001). This vital source of food, energy, and life interacts daily with 356,000 kilometers of coastline which one third of the human population inhabits (Martínez et al., 2007). Approximately 84% of the world's countries have a coastline, and these areas are highly utilized for work, food, and recreation. The economic, cultural, and environmental significance of these areas lead to the necessary protection of them, especially due to the continued overuse. The number of coastal residents has grown substantially in the last few decades, prompting coastal managers and policy makers to examine the impacts of increased pressure on coastal space, ocean resources, and marine ecosystems on coastal economies. Changes in ecosystems, landscapes and species can result in consequences including changes in economic revenue for these areas. The sea is directly and indirectly impacted by threats such as pollution, climate change, acidification, invasive species, ocean floods, storms, sea-level change, and coastal erosion (Field et al., 2013; Rudd, 2017). These impacts can have serious consequences on quality of life and property, as well as marine ecosystem services. Understanding the perspectives of residents on coastal issues can provide insight to policy makers, managers, and stakeholders on how to best combat degradation and implement accepted practices.

While an individual's perceptions (interests, social values, experiences, and interpretation of an issue) are not unbiased, individuals can have strong beliefs regarding these matters that they can view as their own personal truths (Jefferson et al., 2015; Munhall, 2018). It is important that we consider these “subjective” beliefs as they can have direct consequences on environmental sustainability and conservation efforts (de Groot and de Groot, 2009).

Public perceptions research, particularly what community members perceive to be threats towards the marine environment, is vital to understanding regional ocean and coastal priorities; and employing informed and accepted science, policy, and management decisions (Carlton & Jacobson, 2013; Gelcich & O'Keeffe, 2016; Gelcich et al., 2014). Objectives for this research are to:

1) Investigate perceptions of ocean and coastal priority areas for Maine
2) Determine what characteristics may be associated with higher levels of regional coastal and ocean awareness and preference
3) Determine causal relationships between perceptions of current ocean and coastal issues, and personal characteristic of respondents in determining preference for marine planning and protection

Achieving the above objectives will help us identify to what extent perception and understanding of coastal sea issues play a role in preference. This knowledge may help to improve management of our coastal zone, as environmental awareness is deemed to be essential to environmental sustainability (Chung-Ling Chen, 2015). To capture this baseline data, we administered a survey of Maine coastal residents in January of 2019.

3.2 Background

To understand public awareness and attitudes towards marine environmental issues, survey studies are most often used (Hynes, Norton, & Corless, 2014; Steel et al., 2005, Cervantes & Espejel, 2008; Belden & Stewart and American Viewpoint, 1999; Arnold, 2004, Chen & Tsai, 2015; Blasiak, Yagi, Kurokura, Ichikawa, Wakita, & Mori, 2015; Gelcich et al., 2014)

While most of current research is focused on surveys at the national level, it is important to understand regional differences (Shwom, Dan, & Dietz, 2008). A challenge to utilizing national surveys to examine environmental issues is that the national level may ignore differences between regions or states. Geographic location and regional social environment can play an important role in community support for specific policies, as well as influence people's beliefs and attitudes (Shwom, et al., 2008; Schwab, 1988). Just like an environmental policy that is correct in one region is unlikely to be correct in all, national survey data may not accurately reflect specific regional differences in perceptions and preferences for environmental issues. Surveying at a regional level can assist state and local governments to advocate for and apply the most optimal environmental policies depending on the regional specific attitudes and situations.

In addition to the need for surveys at a regional level, many marine perception studies have been limited to specific species groups, such as whales or coral (Järvi, 2016; Made, Hamzah, & Herdi, 2016; Johnson & Jackson, 2015; Sea Web, 2004), specific issues, such as fisheries, aquaculture, climate change, marine protected areas, or ocean acidification (Steel et al., 2005; Shwom, 2008; Whitmarsh & Palmieri, 2008; Spence, Pidgeon, & Pearson, 2018; Kotowicz, Richmond, & Hospital, 2017; Frisch, Mathis, Kettle, & Trainor, 2015), or specific target audiences, such as fishers or divers (Made et al., 2016; Johnson & Jackson, 2015).

Understanding public awareness regarding marine coastal issues is vital to comprehending the complex relationship between people and the ocean (Gelcich et al., 2014). Researchers Jefferson, McKinley, Capstick, Fletcher, Griffin, & Milanese (2015) highlight the demand for, and benefits of public perceptions research in marine conservation issues to understand people's relationship with the sea and the issues which affect it. To promote sustainable coastal usage, more needs to be understood about perceptions and knowledge gap of current coastal and ocean issues, research, and policies (Steel et al., 2005). Results from research on perceptions can be used to better understand acceptance levels of existing marine policy, to assess the degree to which communities have preference for certain marine management strategies, and to incorporate preferences into more widely recognized policies (Bennett, 2016; Gelcich et al., 2010; Gelcich, et al., 2005).

Recent research efforts argue that our relationship with the coastal and marine environment, as well as our knowledge, beliefs, trust in science and government, and educational status can all influence perception of how we see coastal and ocean issues (Easman, Abernethy, & Godley, 2018; Visser et al., 2003; Hynes et al., 2014; Steel et al., 2005; Belden et al., 1999; Arnold, 2004; Daigle et al., 2016; Gelcich & O'Keeffe, 2016). Research has shown that the public are often unaware of the threats facing the marine environment as well as what is being done to sustainably manage them. Several national studies have attempted to examine the public awareness, attitudes, and perceptions to the marine environment using public surveys. Hynes et al. (2014) used results from a nationwide survey in Ireland to investigate the concerns and preferences of individuals towards the marine environment. Although results from the survey in Ireland revealed moderate levels of knowledge pertaining to current ocean and coastal issues, frequency distributions and multivariate regression model research completed by Steel et al. (2005) in the Pacific Northwest of the United States revealed low levels of policy-relevant knowledge concerning ocean and coastal issues. The Ocean Project emphasizes the public's low awareness as the greatest threat to marine areas (Belden et al., 1999)

Given the multi-use nature of our coast line, as well as the collective perception of the coastal hazards it faces, the development and implementation of successful mitigation strategies require public acceptance (Noblet, Evans, Fox, Bell, & Kaminski, 2017). Prior literature has unveiled various perceptions of marine issues and involvement, depending on country and current knowledge of policies. Literature specific to United States perception research suggests a relationship between respondents' view of marine issues, and their overall awareness of policies. However, this is at a national level. Therefore, it will be interesting to examine this relationship at a state level, with regulations and policies specific to the state of Maine.

3.3 Study Area

Maine is a unique area in that, the coastal zone contains nearly half of its developed land and residents (MCHT, 2012). Maine has one of the largest coastlines in the United States with over 5,400 miles of mainland and shoreline (Maine Coastal Plan, 2015).

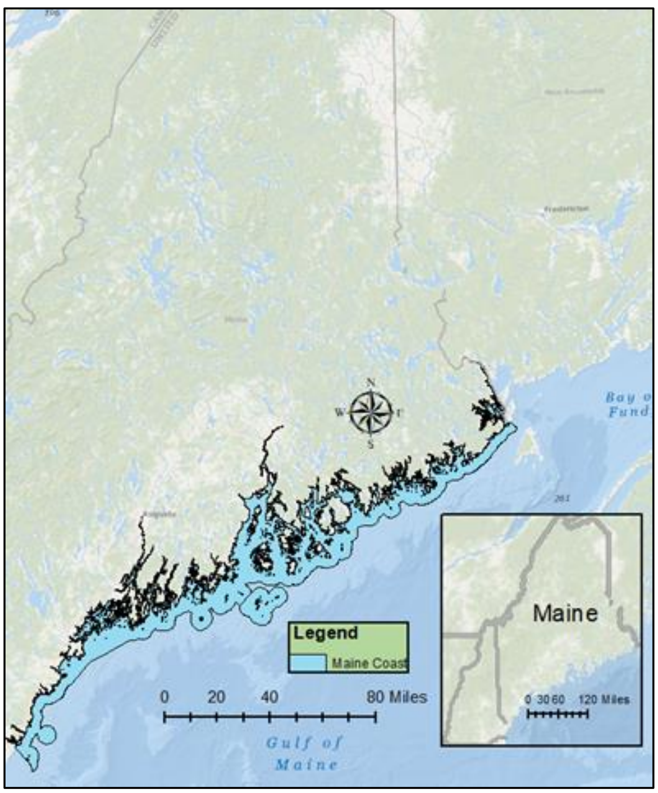

Figure 11. Map of Survey Area – Coastal Maine.

Between 2007 and 2025, the number of coastal residents in the Gulf of Maine is projected to increase by 600,000 individuals (Schauffler, 2013). More than 50% of residents living in the Gulf of Maine are part of the coastal communities that help to drive Maine's economy. To ensure healthy ecosystems, while providing economic benefits to those who live and travel to coastal communities in Maine, sustainable coastal practices, management techniques, and solutions must be coordinated and implemented. It is imperative that perceptions and preference research be completed to develop sustainable decision-making practices.

Coastal Maine provides a unique study area, geographically, ecologically, and economically. In addition to having one of the most thriving coastal ecosystems, an estimated 10% of Maine's population is currently working for ocean related industries such as fishing, eco-tourism, etc. (USFWS, 2005; NOAA, 2013a). Coastal Maine's vast array of ecosystem services and economic benefits allow it to continue to flourish while maintaining a reputation known for its vibrant tourism, working waterfront, and coastal communities (Johnson, O'Neil, Rizk, & Walsh, 2014). Despite Maine's successes with its 5,408 miles of coastline, it faces several long-term threats including warming waters, overfishing, invasive species; as well as short term threats including habit degradation, and gear entanglement (Maine Coastal Program, 2015; Johnson et al., 2014).

Maine is one of 36 states and territories that participate in the National Coastal Zone Management Program (CZMP) (Maine Coastal Program, 2015). The program is a voluntary partnership between the federal government and U.S. coastal and Great Lakes states and territories authorized by the Coastal Zone Management Act (CZMA) of 1972 to address national coastal issues. The program is administered by the National Oceanic and Atmospheric Administration's (NOAA) Office for Coastal Management. Maine's Coastal Program (MCP) was approved by NOAA in 1978 and develops priority levels and management strategies for the nine coastal issues highlighted in the CZMA (InforME, 2016). Research conducted by the MCP (2015) highlights the following key themes:

- The threats of ocean acidification, rate of sea level rise, pollution run-off, land-based development and its impacts on wetlands and fishery resources, erosion, invasive species, and poor water quality

- The importance for coastal access to Maine residents, businesses, and tourists and concern for improvements to public access, as well as the improved public education materials and coastal access guide
- The growing aquaculture industry's ability to foster economic growth in coastal Maine
- The importance of addressing marine debris, as well as the consistent or decreased general debris amount over the last five years

Due to Maine's large coastal community and business population, Maine's vulnerability to these hazards, as well as resiliency efforts and management strategies need to be addressed.

3.4 Survey Design, Administration, and Participants

3.4.1 Survey Design

Our study considers Maine coastal citizens to be the prime benefactors from the provision of coastal services in the categories listed under the Maine Coastal Program (MCP) [10], keeping in mind that it is possible that individuals who neither live in nor visit Maine benefit from the addressing of these coastal issues.

We asked Maine coastal resident participants to rate their agreement/disagreement with 17 statements adapted from the MCP Strategic Outlook (2015) regarding coastal issues on a Likert-type scale and one open-ended question regarding their perception of coastal issues in Maine (adapted from Gelcich et al., 2014) (**Appendix F**). Likert scale questions are useful in social surveys and were utilized in effort to measure attitudes, awareness, trust levels, etc., regarding coastal priority issues in the state of Maine (Subedi, 2016). Participants rated each item

[10] Our sample frame, the list from which the sample units are chosen should match the study population, but this is rarely the case. Since our survey sample does not perfectly match the study population, generalization from the survey sample can only be made to our sample frame.

on a five-point scale where 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree.

These statements were based on current trends for “hot topic” coastal and ocean issues. We centered responses for this survey around the four primary “high” priority areas from the 2015 MCP Strategic Outlook: coastal hazards, wetlands, ocean resources, and cumulative and secondary impacts of development. Additionally, we added questions concerning coastal issues, marine debris, aquaculture, and public access. Though marine debris and aquaculture are currently considered “low” priority areas by the MCP Strategic Outlook, these two issues are currently considered key priority areas on a national level. Public access is considered a medium priority area for the state of Maine. Only about 12% of Maine’s shoreline is publicly owned (Duff, 2016). MCP (2015) noted the demand that Maine communities have for public access improvements. Therefore, it was determined public access should be represented. Categories for perception and preference Likert-scale questions are explained in further depth below. The study sample was also asked to rate their level of familiarity with the MCP. The MCP applies priority levels to each of the nine coastal priority areas based on their research and five-year objectives. These levels are determined through examining present as well as past research involving the nine priority areas, as well as meetings with private and state agencies to determine priorities and develop strategies (Maine Coastal Program, 2015). While the current process is vital to identifying and mitigating coastal issues, it is imperative to also capture the level of citizen perceptions and knowledge of current ocean issues and policy, since communities are ultimately the decision makers when electing officials to represent these policies. Participants were asked to respond with their level of agreement for the following Likert statements regarding the prioritization of the following MCP Strategic Outlook (2015) marine planning and protection issues:

- Reducing threats/risk to public health from storms & climate change
- Improving and expanding state-level planning for how we use our coast
- Protecting, restoring and enhancing wetlands
- Expanding the aquaculture industry
- Eliminating or reducing marine debris
- Providing more public access to the shore
- Addressing impacts associated with land development and other stressors

Additionally, participants were asked to respond with their level of agreement for 17 Likert scale statements regarding topics addressed in the MCP Strategic Outlook (2015).

In addition to the above Maine coastal priority preference and perception questions, survey questions examined also include:

- *Level of trust for science such as reliability, bias, aims, and improvements accomplished due to science*
- *Belief in global climate change including the level with which it is occurring and the causes of it*
- *Level of trust for various coastal and ocean decision makers including businesses, charities, and local/state/Nationwide decision makers*
- *A range of sociodemographic and household characteristic control questions including age, education status, years living in Maine, frequency of time spent in ocean recreation, access to the ocean, etc.*
- *Open ended question regarding topics that come to mind when respondents think of Maine's ocean and coastline environmental issues (respond via a textbox) (adapted from Gelcich et al, 2014)*

The complete survey with questions can be found in **Appendix F.**

Table 6. Citizen Perception of Current Ocean and Coastal Issues. Priority levels were determined through research conducted by the 2015 Maine Coastal Plan

Maine Coastal Program (MCP) Key Topic Area	How area is defined via Coastal Zone Enhancement Program (CZEP)	Classification of area according to MCP	Classification of area according to Majority of Maine Coastal Survey Respondents
Ocean Resources	*"Planning for existing and potential new uses in coastal waters, including consideration of marine resources (species and habitats), cultural/historic resources, water quality, sand and gravel deposits, dredging, etc. (Maine Coastal Program, 2015)."*	High Priority	High Priority (67% of Respondents)
Cumulative and Secondary Impacts of Coastal Development	*"Addressing impacts associated with land development and other stressors (Maine Coastal Program, 2015)."*	High Priority	High Priority (81% of Respondents)
Wetlands	*"Protection, restoration, or enhancement of the existing coastal wetlands base, or creation of new coastal wetlands (Maine Coastal Program, 2015)."*	High Priority	High Priority (81% of Respondents)
Coastal Hazards	*"Eliminating or reducing threats to public health, safety and welfare from storms, climate change, erosion, etc. (Maine Coastal Program, 2015)."*	High Priority	High Priority (67% of Respondents)
Public Access	*"Attain increased opportunities for public access, taking into account current and future public access needs, to coastal areas of recreational, historical, aesthetic, ecological, or cultural value access to the coastal shore (Maine Coastal Program, 2015).*	Medium Priority	Medium Priority (39% of Respondents)
Aquaculture	*The facilitating farming/cultivation of aquatic organisms such as fish, shellfish and plants (Maine Coastal Program, 2015)."*	Low priority	Medium Priority (40% of Respondents)
Marine Debris	*"Eliminating or reducing trash and other refuse in coastal waters or on shorelines."*	Low priority	High Priority (78% of Respondents)

3.4.2 Survey Administration

The questionnaire was published online in January 2019 under the title "SEANET Coastal Community Survey." The study sample (n=6,000) was randomly selected from a mailing list of coastal residents purchased through Maine Multiple Listing Service, a database provider. Participants from 130 coastal communities in Maine were mailed a notice letter that explained the goals and the voluntary nature of the survey project. Participants were provided a Survey ID, which allows them to access the survey, helps mitigate for duplicates in the analysis, and is used to determine non-response. To increase survey response, participants were offered the opportunity to enter a raffle drawing for $50 upon completion of the survey. To minimize non-response, a reminder postcard was sent to all participants two weeks later. Some surveys were returned as undeliverable resulting in a survey sample of 5,502 households. The survey had a response rate of 4.93% (271/5,502). Out of the 271 survey respondents, 201 completed the survey for a completion rate of 74.20%. However, not all participants responded to all questions, and therefore our analysis focuses on the 187 participants who completed all sections. This low response rate limits our ability to generalize the information gathered through this survey, however we are still able to provide insight into part of Maine's coastal population.

Average time taken to complete the survey was 18 minutes. Respondents were offered a choice to complete the survey on their computer, phone, or tablet (all required internet). Respondents were assured names would be confidential and not associated with their responses.

3.4.3 Survey Participants

Of the surveys submitted, highest response rates were from Portland (26), South Portland (25), and Brunswick (19). Our sample is slightly more male, is more educated, has a higher income, and is older than the general adult coastal population of Maine.

Table 7. SEANET Coastal Community Survey Respondents Descriptive Statistics Compared to 2010 Census Data.

	Maine Coastal Respondents (N = 187)	2010 Maine Coastal Census Data
Gender (% females)	47.8%	51.2%
Education (HS or above)	100%	93%
Median Income	$87,000	$51,068.5
Median Age (Years)	51	47.2

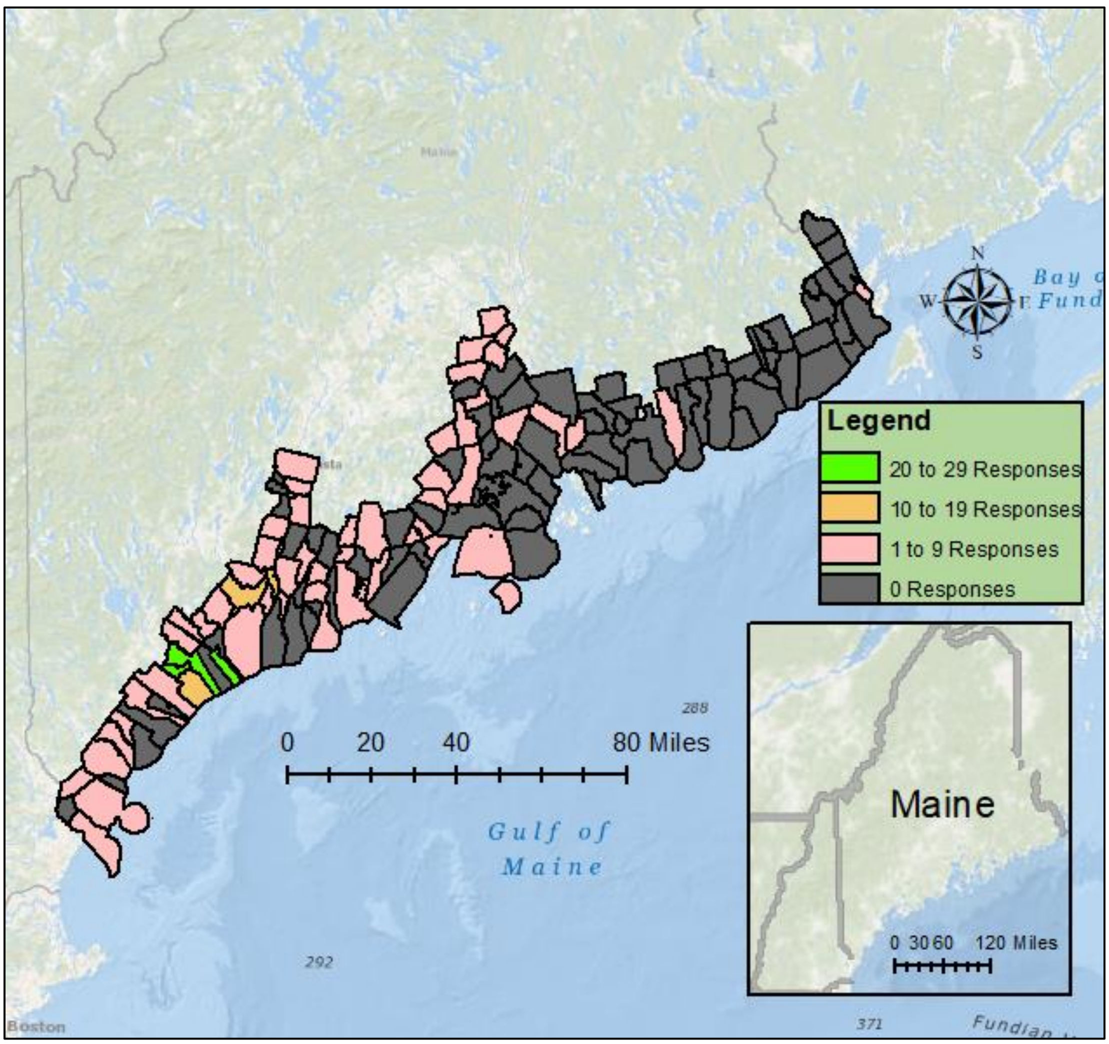

Figure 12. Maine Coastal Towns represented in Survey Sample Administration (N = 5,502).

Data collection was performed in January and February of 2019. On average, respondents have lived in Maine for about 13 years. Only a small percentage (0.5%) of respondents are seasonal residents, and most of the participants (94.6%) own their house. Roughly a fourth of the participants (27.2%) can see and/or access the ocean from their residence. Respondents seem quite engaged in Maine’s coastline, with nearly half of them (45.3%) engaging in recreation at least once a week, and 7.9% of them making a living from the sea in positions such as waterfront dining, marine biology, boat repair, recreational and professional fishing, ecotourism, artistry, and marine publication. Most respondents (85%) agree that global climate change is happening with over half of them (57%) agreeing climate change is caused by human activities and only 2% agreeing that climate change is caused only through natural changes in the environment.

3.5 Data Analysis

We analyzed the survey response data with R, Stata, and Excel. Our inferential statistics include chi-square tests of distribution differences, cross-tabulation, and frequencies. Analysis on causal relationship between respondent perceptions and preferences for coastal issues and coastal issue management for specific priority areas are analyzed using factor analysis and logit regression (**Appendix D, E**)

R software was used to create a word cloud, which provided a visual representation of responses to the survey question, “When you think about Maine's ocean and coastline, what are the three most important environmental issues that come to mind?” The term “pollution” shows up the most frequently (64 times) with “water” and “warming” close behind.

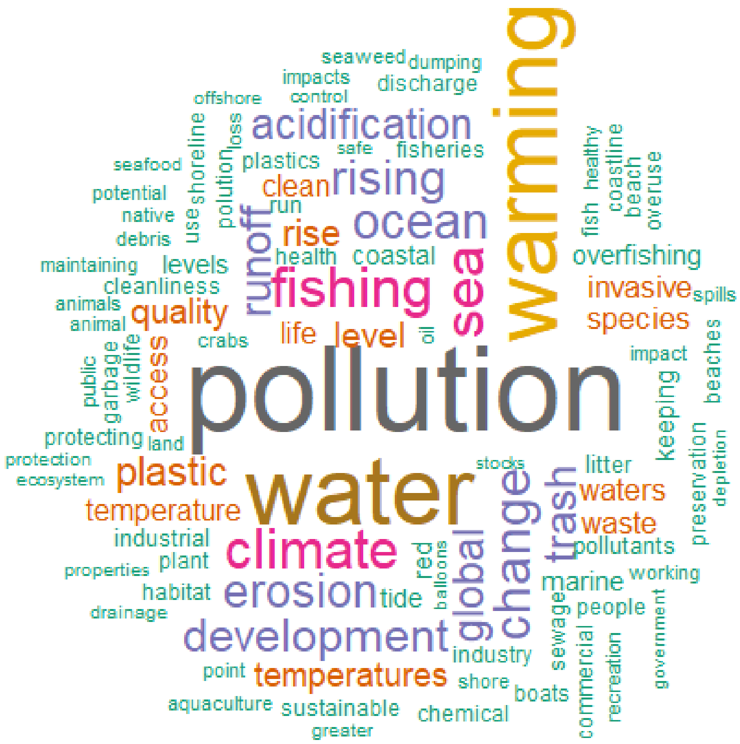

Figure 13. Word cloud displaying top responses for the most important Maine coastal issues.

Participants responded to 17 Likert scale statements rating their level of agreement with various statements pertaining to seven of the nine ocean and coastal issues outlined by the CZMA and MCP. Using factor analysis, these statements were then grouped into six variables to determine their relationship (if any) with individual preference for coastal priority. Although the nature of this analysis was exploratory, we had some preconceived notions about what statements might relate in terms of broader issues at hand. Individually, the responses to these questions are specific to the coastal issue they highlight. However, taken together, they can provide a more comprehensive measure of awareness of coastal/ocean issue findings in the state of Maine. This is what we desire to understand

Of these 17 statements, all those concerning wetlands, coastal hazards, ocean resources, and cumulative and secondary development impacts loaded into an overall *health of the ocean* variable[11]. Gelcich et al. (2014) argues that there are many factors that affect marine ecosystems at any given time. In our analysis, we observe combined effects of multiple coastal stresses

[11] Ocean_Health and Trust_Sci composite variables were constructed using factor analysis. For more information regarding this effort, see Appendix C

wetlands, cumulative development impacts, coastal hazards, and ocean resources as a comprehensive ocean health problem. Therefore, these issues were factored into an overall health of the ocean composite variable. Aquaculture, public access, and marine debris statements were assessed separately. Logistic regression was used to model the relationships between the categorical coastal issue preferences variable and a set of independent variables.[12]

[12] More on logistical regression and results can be found in Appendix D

3.6 Results and Discussion

Likert scale stacked bar charts pertaining to relevant Maine Coastal Policy preference and perception questions are listed below. The y-axis presents the Likert statement provided. The x-axis provides the proportion of surveyed participants that responded.

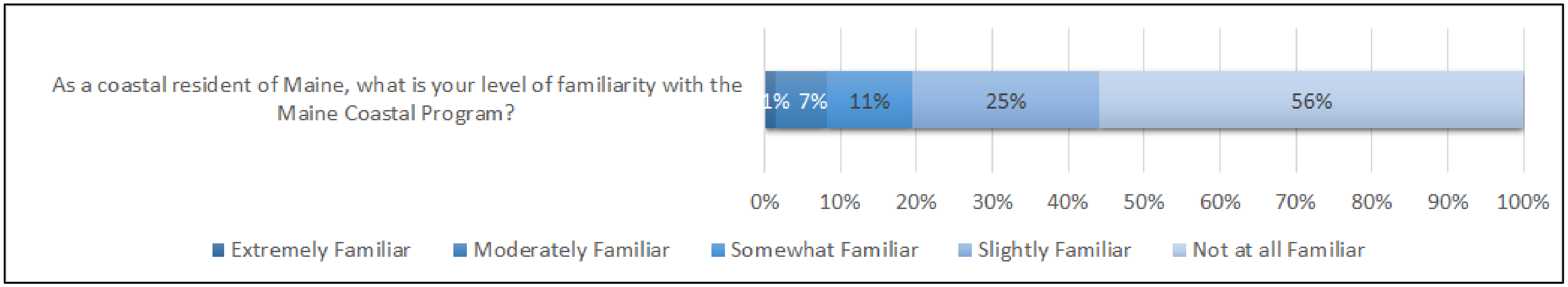

Figure 14. Familiarity of Maine Coastal Program. Most respondents are not familiar with the Maine Coastal Program.

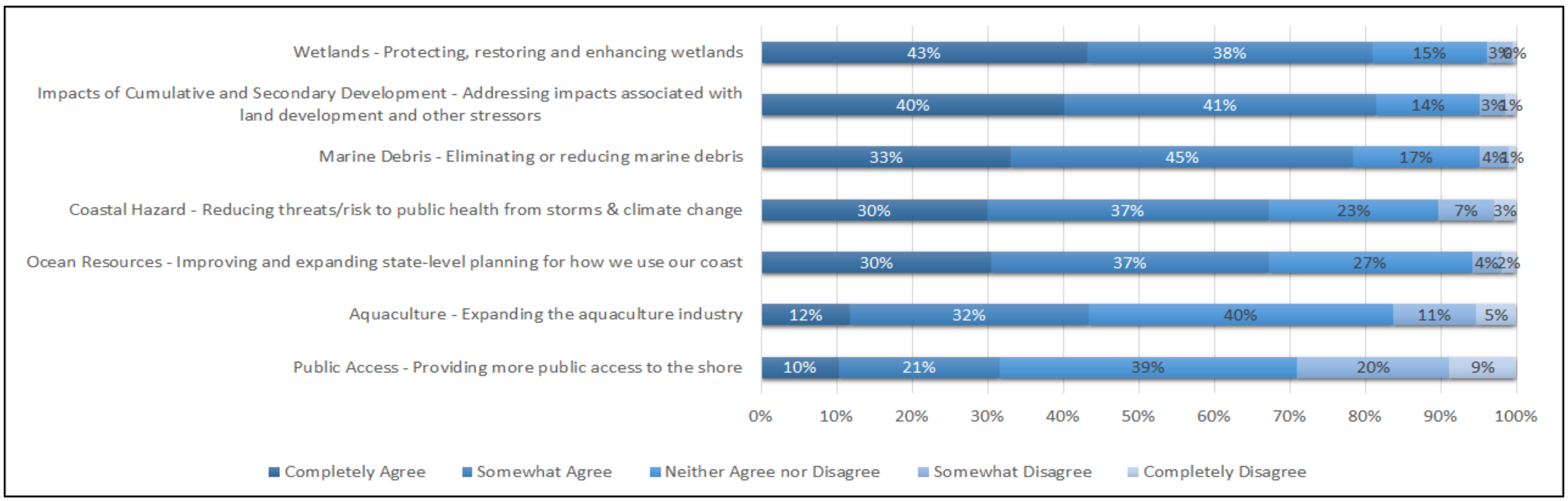

Figure 15. Preferences for seven of the coastal priority areas.

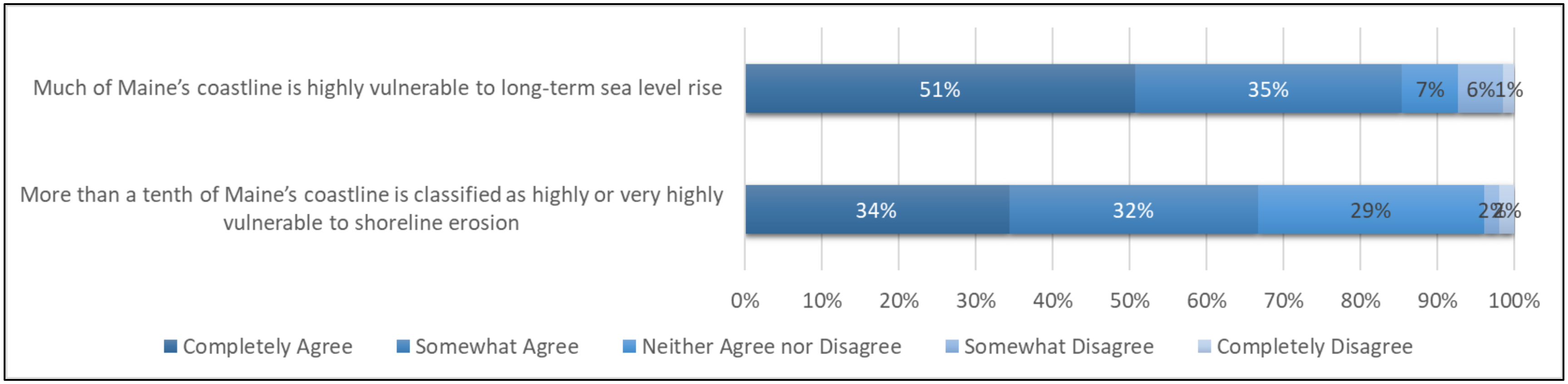

Figure 16. Perception of coastal issue statements related to Coastal Hazards MCP priority area.

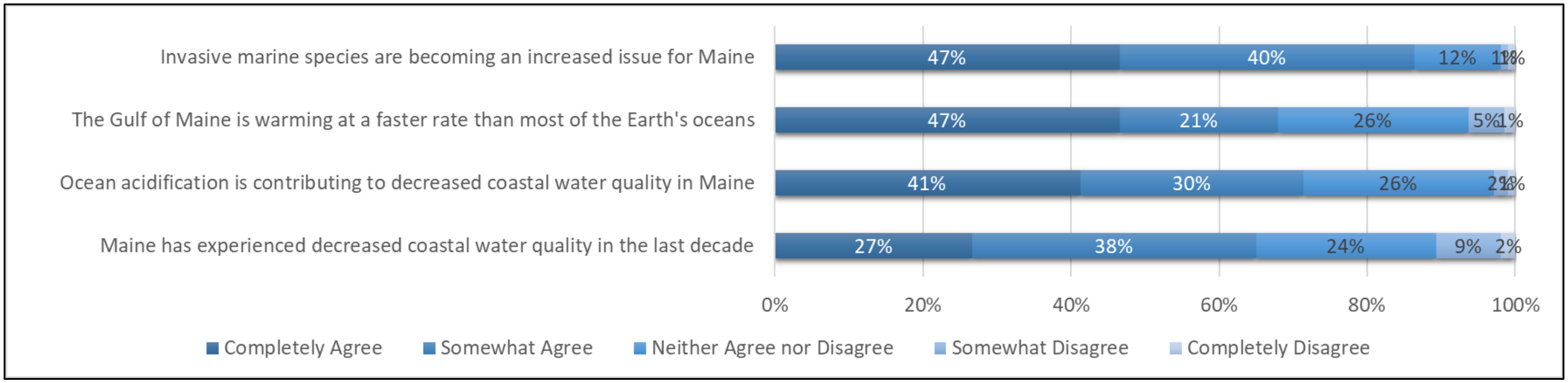

Figure 17. Perception of coastal issue statements related to Ocean Resources MCP priority area.

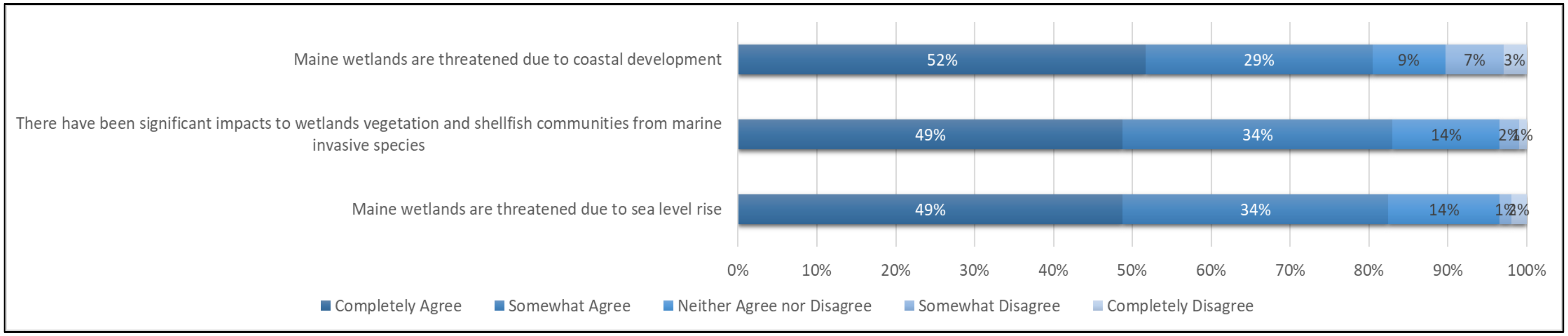

Figure 18. Perception of coastal issue statements related to Wetlands MCP priority area.

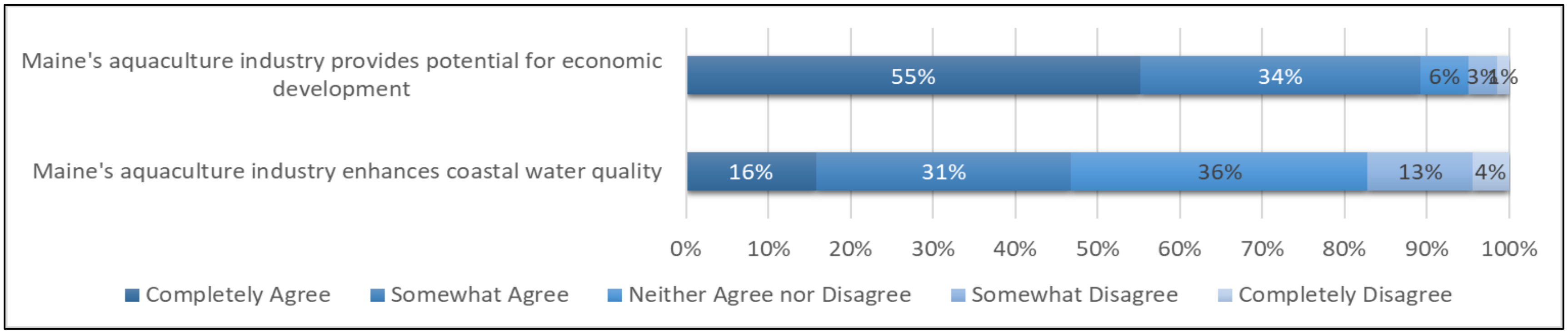

Figure 19. Perception of coastal issue statements related to Aquaculture MCP priority area.

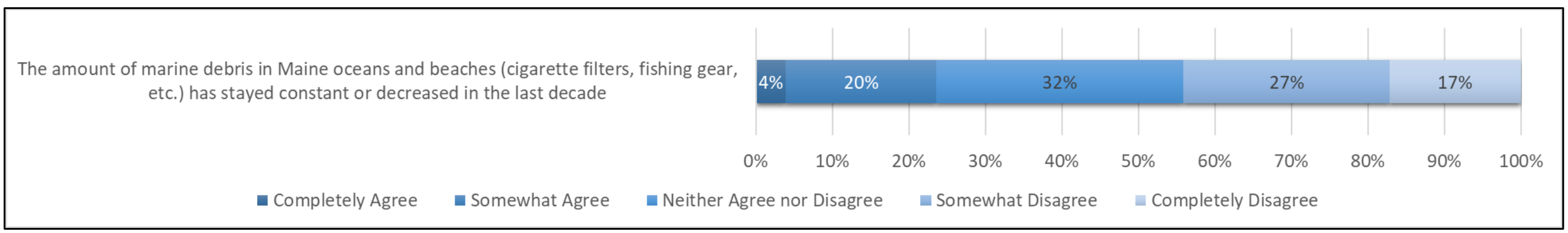

Figure 20. Perception of coastal issue statements related to Marine Debris MCP priority area.

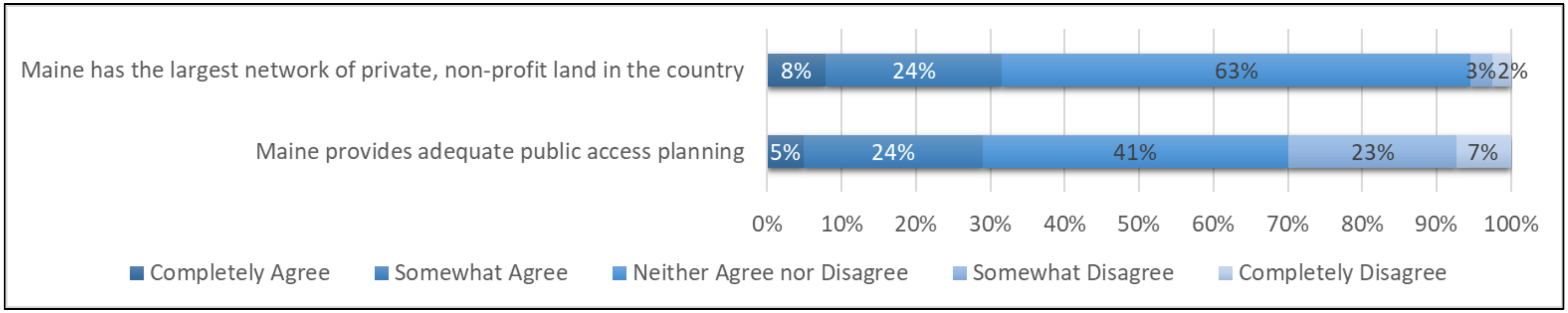

Figure 21. Perception of coastal issue statements related to Public Access MCP priority area.

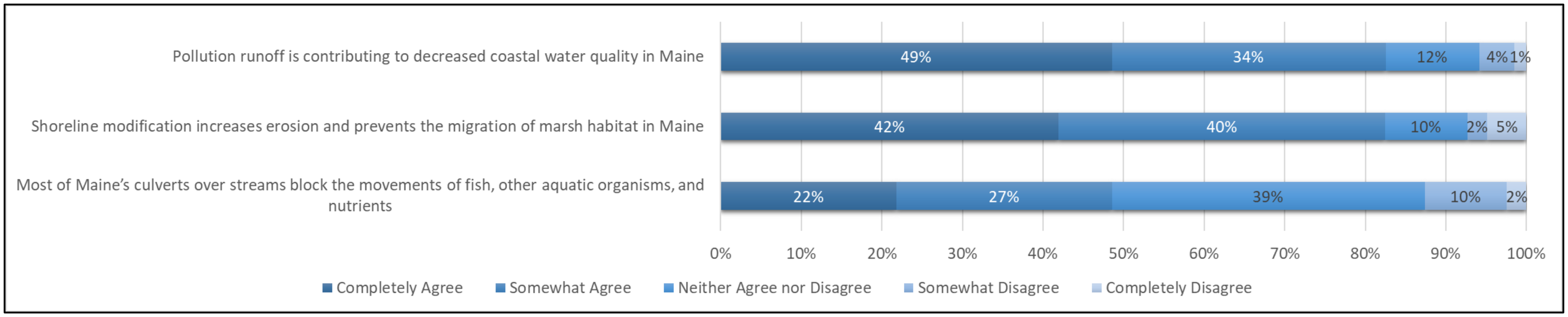

Figure 22. Perception of coastal issue statements related to Cumulative and Secondary Impacts of Development MCP priority area.

As **Figure 15** displays the top three "priority" areas from the seven provided for the coastal program are wetlands, cumulative and secondary impacts of development, and marine debris. While the first two are deemed "high priority" areas by the MCP, marine debris is considered a "low-priority" area. However, on a national and global level, recent attention has been focused on marine litter, plastics particularly, and the growing impacts it has on the marine environment and coastal communities. In fact, Wright and Henson (2017), when ranking the top ten most pressing environmental issues, place plastics in the ocean at number one. Greg Stone, Chief Scientist for Oceans, Conservation International puts it at second for the top five biggest threats facing our oceans (Stone, 2014). Wetlands was the highest priority area for coastal managers by respondents. This is somewhat expected, and in line with what the MCP outlines (Maine Coastal Program, 2015). Approximately one fourth of Maine (5 million acres) is considered wetland, and are an integral part of Maine's natural resources, ranging from inland peatlands to salt marshes and mudflats along the coast (Armstrong, n.d). Changes in land use due to urban and agricultural development including fishing and farming communities, harvesting, air/water pollution are contributing factors in wetland loss. Dahl (1990) estimated that Maine has lost about a fifth of its wetlands over the last two hundred years. That wetlands are the highest priority area by respondents offers insight on the current perception of this coastal issue.

3.6.1 Coastal Issue Perception and Relationship with Preferences and Perception

Coastal Hazards: 67.15% of those surveyed felt that threats/risk to public health from storms & climate change (coastal hazards) should be at either high or highest priority levels for coastal managers. Reasons for this could include the belief by most respondents (81%) with the MCP Strategic Outlook (2015) statements that Maine's coastline is highly vulnerable to long-term sea level rise (81%) (from cross tabulation results), as well as that more than a tenth of Maine's coastline is highly vulnerable to erosion (77.15%). Regression results confirm that there exists a positive relationship between individuals who agree that the coastline faces these threats and the likelihood of considering coastal hazards to be a high priority area. Since most of Maine's population lives near the coastline, these individuals may observe the effects of sea level rise, flooding, and erosion, and therefore, may be more apt to adopt management strategies to address this issue (Schmitt, n.d.). Analysis also revealed that those who agreed more with the stated ocean health perception, trust in science, and engagement in recreation activities, were more likely to agree that coastal hazards was a high priority area.

Ocean Resources: Like coastal hazards, 67.15% of all those surveyed also placed improving and expanding state-level planning for how we use our coast (coastal resources) at either high or highest priority levels (Figure 17). This matches the MCP in terms of preference placement, and also parallels MCP in terms of agreeance with concerns related to this issue. The majority of respondents that agree with this high priority placement also believe the MCP Strategic Outlook (2015) statements that 1) Maine has experienced decreased coastal water quality in the last decade (72.73%); 2) Ocean acidification is contributing to decreased coastal water quality in Maine (84.7%); 3) The Gulf of Maine is warming at a faster rate than most of the Earth's oceans placed coastal resources (77.1%) and 4) Invasive marine species are becoming an increased issue for Maine (71.88%).

Similar to coastal hazards, these effects are felt firsthand by coastal communities, and therefore, this group of individuals may be more aware of the detrimental impact of climate change, invasive species, etc. (Schmitt, n.d.). Additionally, Maine's fisher and coastal economy may directly feel the economic impacts of non-native species in the form of costs and damages from fouling of equipment, impacts to fishery or aquaculture resources, and recreational impacts

(Pappal, 2010). On average, those who agreed more with the stated ocean health perception and engagement in recreation activities were more likely to identify ocean resources as a higher priority area.

Wetlands: A majority of those surveyed (80.89%) placed protecting, restoring and enhancing wetlands at either high or highest priority levels. Some of the influence of this preference level could be due to the strong agreeance from these respondents in line with MCP Strategic Outlook (2015) statements that wetlands are threatened by sea level rise (94%), coastal development (96.23%), and invasive species (88%). While coastal wetlands only represent about 3% of the state of Maine, they are a vital part of coastal communities, as is evident from the importance respondents place on this coastal area as well as their awareness surrounding threats to coastal wetlands (Dahl, 1990). Similar to perception of ocean resources and hazards, wetlands awareness could stem from coastal communities witnessing first-hand the impacts of climate change and development impacts. In fact, regression analysis conveyed that those who believe in climate change are roughly five times more likely to prioritize wetlands as a high or highest priority area. Those who agreed that there was an overall decline in the health of the ocean are six times more likely to prioritize wetlands.

Aquaculture: 43.35% of all those surveyed placed expanding the aquaculture industry (aquaculture) at either the high or highest priority levels. This attitude may be explained by the opportunity for Maine aquaculture to provide potential economic development, as a majority (60.71%) of the people who agreed with prior MCP Strategic Outlook (2015) statements about Maine's aquaculture industry and economic development placed aquaculture at either high or the highest priority level. Positive relationships between economic development opportunities and prioritization of aquaculture are confirmed by regression analysis (**Appendix E**). Further, a positive view of aquaculture may also stem from awareness of two significant aquaculture project developments in mid-coast Maine (Hamilton, 2018). Although not marine aquaculture, these facilities continue the push for Maine to become a major player in aquaculture in the United States. Coastal communities may recognize this growth and see it as potential for job and economic growth. The more respondents agree that Maine's aquaculture industry enhances coastal water quality, the more likely they are to support aquaculture as a high priority area. While inferential statistics show that most respondents do not disagree that aquaculture enhances coastal water quality, our research aligns with the MCP in that more outreach and education should be encouraged to communicate water quality improvements achieved through shellfish aquaculture (Maine Coastal Program, 2015).

Marine Debris: Most respondents (78%) placed eliminating or reducing marine debris (Marine Debris) in the high or highest priority preference (Figure 20). Roughly 91.8% of those that placed reducing marine debris at a high or highest priority level strongly disagreed with the MCP Strategic Outlook (2015) statement that the amount of marine debris in Maine oceans and beaches (cigarette filters, fishing gear, etc.) has stayed constant or decreased in the last decade. This information gained from inferential statistics and cross tabulation shows a mismatch in the research completed by the MCP and the awareness of marine debris issues by our respondents. Possible reasons for this include the fact that, while marine debris as a local and regional issue may have decreased, as a global issue marine debris has been accelerated in recent years and is projected to continue to increase exponentially (Parker, 2015). In addition to the physical increase of marine debris in our coastal waters, awareness for this debris has also grown exponentially in the last decade. This awareness could be impacting the perception of respondents and thus, impacting their preference levels for coastal managers to place high priority on marine debris. Analysis reveals an inverse relationship between those that believe marine debris is getting better and identifying marine debris as a high priority area for coastal managers. There is a positive relationship between those that agree that Maine's ocean health is in decline and those that display preference for marine debris.

Public Access: 31.52% of all those surveyed placed providing more public access to the shore at either the high or highest priority levels. This matches the MCP label for Public Access as a medium priority area. From those individuals that placed public access at a higher priority level, 22.22% strongly agree that Maine provides adequate public access planning and 31.25% strongly agree that Maine has the largest network of private, non-profit land in the country. This conveys the importance of other coastal areas by stakeholders and networked state agencies. It is interesting to see the alignment of coastal community respondents with these ocean management collaborators. Additionally, Maine has aided in the form of research grants, monitoring assistance, and educational materials for coastal access. It is possible these materials may assuage individuals' concerns regarding ocean public access. About 32% of respondents can either see or access the beach from their house so it is also possible that, for a large proportion of respondents, this is not an issue. Analysis shows that those that agree more that Maine provides adequate public access planning are less likely to consider public access as a high priority area. Public access is one of only two preferences that do not appear to have a relationship with perception of the overall health of the coastal environment. This could be due to the belief that access is not impacted by the health of the ocean. However, research suggests this may not be the case. Growth in private shorefront properties may close off public access in attempts to mitigate coastal hazards (Schauffler, 2013). It may be worth exploring the issue of public access and its relationship with the health of Maine's coastline in future research.

Cumulative and Secondary Impacts of Development: Most respondents (81.38%) agree with the MCP Strategic Outlook (2015) statement that addressing impacts associated with land development and other stressors should be classified as a high/highest priority area (Figure 22). This could be since these respondents that place this area as a higher priority agree with MCP (2015) that 1) most of Maine's culverts over streams block the movements of aquatic organisms and nutrients (88.89% of respondents); 2) pollution runoff is contributing to decreased coastal water quality (92%); and 3) shoreline modification increases erosion and prevents the migration of marsh habitat (94.19%). On average, those that agree more with the stated ocean health perception are more likely to agree that impacts of development are a high priority area. This is understandable since impacts of development may compromise the ecosystem services such as water quality, wetlands, mitigation of erosion, and migration of marsh habitat (Maine Coastal Program, 2015; Schauffler, 2013). Regression results confirm that those who perceive negative effects of ocean health are five times more likely to view cumulative and secondary impacts of development as a higher priority area. Additionally, those who convey trust in scientific research and results are three times more likely to agree that impacts of development should be listed as higher priority. An interesting conflict may be present here between those that acknowledge environmental consequences of development and/or those that acknowledge economic benefits of development.

3.7 Discussion

As evidence above suggests, there is a clear relationship between an individual's perceptions of each of the ocean issues, and those corresponding preferences. On average, there exists a significant positive relationship between those that agree with coastal perceptions related to coastal hazards, ocean resources, wetlands, aquaculture, and impacts of development and their preference level for those coastal issues. Alternatively, there exists a significant inverse relationship between those that agree with the stated coastal perceptions regarding marine debris and public access. On average, the people who agree with these statements are less likely to view marine debris as a higher coastal priority. This makes sense given the fact that statements regarding marine debris and public access are positive and discuss the optimistic evidence for these coastal issues (Marine Debris statement: The amount of marine debris in Maine oceans and beaches (cigarette filters, fishing gear, etc.) has stayed constant or decreased in the last decade; Aquaculture statement: Maine's aquaculture industry provides potential for economic development).

Respondents consider pollution to be the biggest issue when it comes to the marine environment. Public access is an important issue and most respondents seem to agree that Maine provides adequate public access. However, this issue lacks urgency. This is in line with the Maine Coastal Program's (MCP) rating of public access as a medium priority area. Aquaculture on the other hand seems to be a more important, or preferred issue for respondents than as prioritized in the MCP. The MCP places it at low priority level, while respondents feel it is a medium priority area. It may be interesting to examine this discrepancy at further length. Perception of marine debris as it pertains to the state of Maine was spread evenly, yet its preference remains relatively high among respondents. Again, further research may examine the role that media, national priority levels, beliefs, and other influencers may have on this preference rating.

It is worth noting the interesting causal analysis results of preferences for aquaculture. Marine aquaculture has been present within the coastal waters of Maine since the 1800s and has had laws governing fish and shellfish culture date back to 1905 (InforME, 2016). From 2007 to

2017, the total economic impact of aquaculture increased from $50 million to $137 million dollars (Aquaculture Research Institute, 2016). As aquaculture growth becomes more widespread, it is important to address citizen preferences for site selection, as well as determine if they provide a negative or positive role in the communities of coastal residents whom they impact. While most respondents agree aquaculture provides potential for economic development, they are hesitant to agree that aquaculture enhances water quality. Recommendations for future objectives for the MCP could be to address this issue through education, outreach, etc. and determine if that perception changes through awareness campaigns.

Additionally, in nearly all the logit models (except for preference for aquaculture and public access), perception of health of the ocean has an important relationship with how individual's prioritize management of ocean and coastal issues. On average, the more likely individuals are to think the health of the ocean is in decline (through factors such as erosion, water quality, rising seas, ocean acidification, etc.), the more adamant they are about making coastal issues a priority such as coastal hazards, ocean resources, wetlands, marine debris, and impacts. In the case of wetlands, if the respondent feels the health of the ocean is in decline, they are nearly 6.5 times more likely to rank wetlands as a "high" priority issue. This says a lot regarding how big of a role perception can play in determining importance of these issues of individuals. None of the models display declining preference rankings due to higher health of the ocean concerns. Trust in Science also has a positive relationship with preference for coastal issues. In nearly half of the models, those who have a higher trust in scientists and the work that they do at least double their odds of highly prioritizing coastal issues. In the case of development impacts preferences, higher trust in science tripled the odds of an individual considering developing impacts a high priority area for coastal managers.

While the results above are promising in the areas of perceptions research as a means of conveying to coastal managers the level of importance of a variety of coastal issues, it is important to also recognize that the exploratory nature of our model, and the limitations it currently has. First, since we are working with a convenience sample, we need to be careful not to generalize our results to a wider population (Brewer & Ley, 2013). Furthermore, we recognize that behavioral intentions may not translate into actual behavior. However, our results highlight how perception of various ocean issues, climate change, and trust interact with preferences. Additionally, Maine has the highest percentage of secondary homes in the United States (Schauffler, 2013). Future research may involve inclusion of seasonal residents to ensure they have a voice. One of the largest issues in environmental survey research is that respondents may have little familiarity with the issues being considered (Dietz & Stern, 1995). Although the Coastal Zone Management Act has been around since 1972, and the MCP was established in 1978 with partnership of local, regional, and state agencies, over half of coastal Maine respondents had not heard of it. A next step in this research, as well as improving communication and awareness regarding ocean and coastal issues would be to provide relevant information regarding the program, to reduce uncertainty in making perception choices (Shwom, 2008).

While not addressed in this research, work completed by Schroeder (1992) and Gelcich et al. (2014) suggest that 1) the type of network that respondents get news from, as well as 2) the level of trust for various coastal and ocean decision makers can also play important roles in priority for ocean management. Personal experience and awareness alone may not necessarily fully account for level of concern of respondents. Additionally, spatial differences may exist in the gathering and use of information regarding the Maine coast. Therefore, features should be addressed utilizing zip code data from respondents to account for urban versus rural variation.

Our study suggests that an individual’s beliefs and awareness may factor into their desire to prioritize marine issues. Some of the results presented may be of interest to Maine marine conservation and education programs (Arnold, 2004). Limitations in survey length reduced the nine issues outlined in the CZMA and MCP to seven issues. Two additional priority areas, 1) Energy and Government Siting and 2) Special Area Management Plans are also referenced in the CZMA, as well as MCP’s Plan. Additional preference and perception research should include all nine issues, as well as additional statements researchers can use to frame awareness in terms of multiple impacts. Information from this survey is important to help Maine coastal communities, stakeholders, and organizations that manage marine issues, including the Maine Department of Agriculture, Conservation and Forestry, and the Department of Marine Resources understand what coastal priorities individuals have, and what may influence how they frame those priorities, especially if this research is conducted every time the MCP Strategic Outlook is updated (Lotze, Guest, O'Leary, Tuda, & Wallace, 2018). Being that Maine is a coastal state part of the nation-wide Coastal Zone Management Program (CZMP), preferences and perceptions might also be useful in regional and national discussions with partner coastal states in determining how best to approach and prioritize these issues.

To meet the demands of coastal communities in Maine, there should be encouragement for the growth of consensus-based approaches to managing resources (Anderson, 2000). Collaboration between stakeholders, government officials, and resource managers that includes community perceptions and preferences can assist with developing widely adopted and accepted coastal management solutions.

CHAPTER 4

CONCLUSIONS

With the forecasted exponential population increase, aquaculture is expected to play a major role in fish production and consumption, both in short- and long-term sustainable food source goals (FAO, 2016). The United States is currently considered to be one of the top countries for marine aquaculture potential (Kapetsky et al., 2013). As aquaculture growth becomes more widespread, it is important to address citizen preferences for the attributes associated from site production, as well as determine if they provide a negative or positive role in the communities of coastal residents whom they impact. This information can help assist policymakers in advocating for the best use of our coastal waters, and best placement of our resources within them. The aquaculture community is working with a wide range of industry and government partners to find acceptable and effective ways to incorporate sustainable aquaculture, including through wild and farmed local seafood strategies, education for positive environmental impacts, and emphasizing gear intended to mitigate viewshed and recreational conflicts with aquaculture (Knapp & Rubino, 2016).

Our research provides insightful information regarding the knowledge and preference of widely acknowledged coastal and marine issues. However, we must show caution when understanding how this research may translate into development of policy solutions (Kittinger et al., 2013). Further research is required to help identify additional characteristics that may be related to marine coastal issue perceptions. Examining the role that media may play in the perception of these issues is an area for future research (Schroeder, 1992). The relationship between society and the sea is vital to balancing the intricate web of sustainable human existence. The major challenge facing us today is managing the use of this area, so that future generations can enjoy the same benefits and services we do today. Through engagement with coastal residents, ocean and coastal leaders in policy, research, and management can gain valuable insight into the public relationship with marine environments, thereby able to better align managerial and policy priorities with public demand (Gelcich, et al., 2014; Field et al., 2013).

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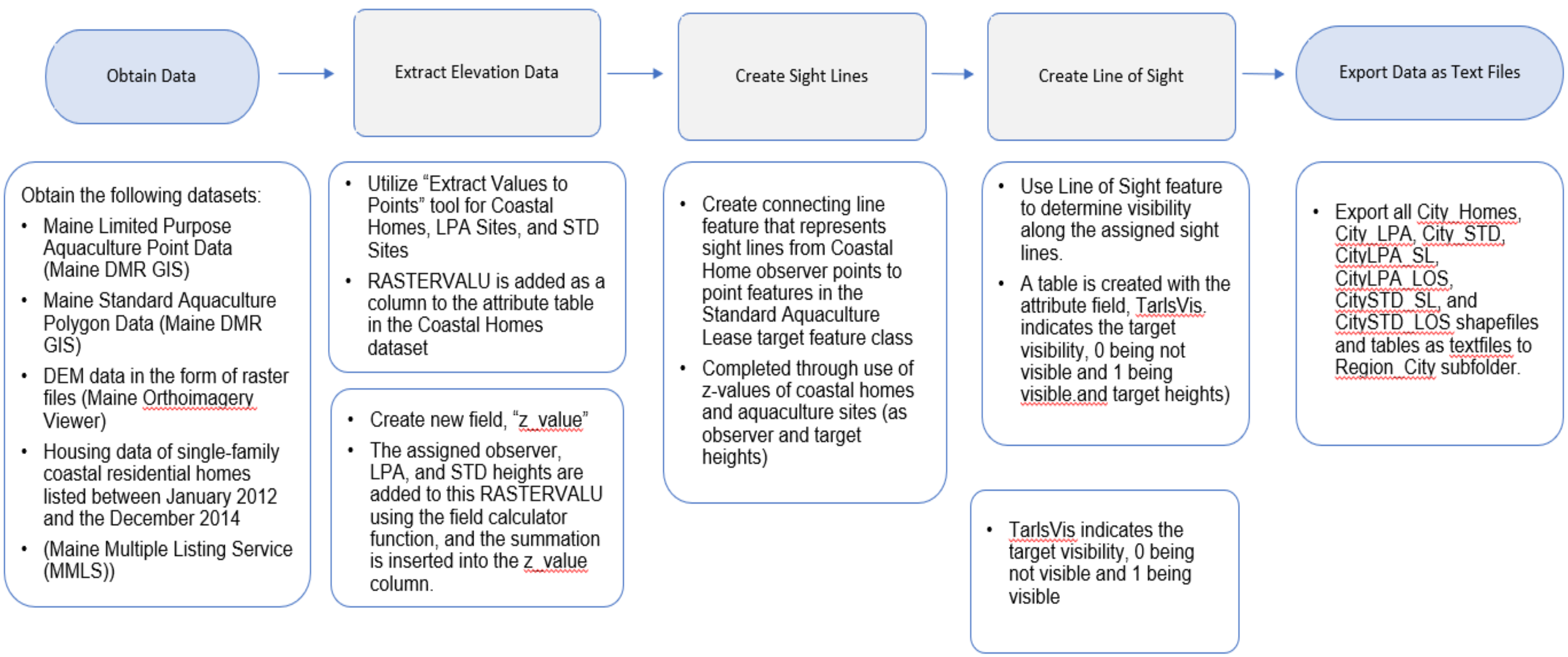
APPENDIX A: Conceptual Model for Viewshed Analysis

Figure 23. Conceptual Model for Viewshed Analysis



APPENDIX B: Parameter Estimates per Municipality

Table 8. Fixed effect impacts of Casco Bay, Damariscotta River Region, and Penobscot Bay based on log-linear HPM.

Casco Bay	**Base Model (N = 5,664)**		**Alternate Model 1 (N = 5,664)**		**Alternate Model 2 (N = 5,664)**	
	Coef.	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**
Control Variables: Spatial Characteristics						
Brunswick	**-0.599*** **	0.025	**-0.591*** **	0.025	**-0.601*** **	0.025
Cape	**1.180*** **	0.061	**1.147*** **	0.062	**1.146*** **	0.062
Chebeague	**-4.21*** **	0.321	**-4.379*** **	0.315	**-4.284*** **	0.319
Cumberland	0.071	0.029	**0.047*** **	0.029	**0.084*** **	0.029
Falmouth	**0.792*** **	0.045	**0.767*** **	0.046	**0.794*** **	0.045
Freeport	**0.569*** **	0.035	**0.551*** **	0.035	**0.563*** **	0.035
Harpswell	**-0.366*** **	0.114	**-0.501*** **	0.109	**-0.468*** **	0.113
Long	**-1.383*** **	0.226	**-1.639*** **	0.216	**-1.489*** **	0.223
Phippsburg	-0.158	0.115	-0.307	0.112	**-0.261** **	0.114
Portland	0	(omitted)	0	(omitted)	0	(omitted)
South	0	(omitted)	0	(omitted)	0	(omitted)
West	0	(omitted)	0	(omitted)	0	(omitted)
Yarmouth	0	(omitted)	0	(omitted)	0	(omitted)

*** p<0.01, **p<0.05, *p<0.1

Table 8 Continued

Damariscotta River Region	Base Model		Alternate Model 1		Alternate Model 2	
	(N = 1,351)		(N = 1,351)		(N = 1,351)	
	Coef.	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**
Control Variables: Spatial Characteristics						
Arrowsic	**9.696*****	0.476	**9.665*****	0.477	**9.685*****	0.477
Boothbay	0.601	0.902	-0.626	0.907	-0.594	0.908
Boothbay Harbor	**2.890*****	0.838	**2.839*****	0.840	**2.895*****	0.841
Bremen	**-15.903*****	1.849	**-15.865*****	1.865	**-15.892*****	1.865
Bristol	-2.037	1.488	-2.048	1.500	-2.036	1.495
Cushing	**-7.078*****	0.786	**-7.074*****	0.793	**-7.068*****	0.797
Damariscotta	0	(omitted)	0	(omitted)	0	(omitted)
Edgecomb	**8.423*****	0.543	**8.377*****	0.543	**8.422*****	0.543
Friendship	**-9.216*****	1.433	**-9.210*****	1.446	**-9.205*****	1.450
Georgetown	1.156	1.206	1.110	1.211	1.164	1.211
Newcastle	**-3.539*****	0.360	**-3.529*****	0.368	**-3.534*****	0.367
Nobleboro	**-2.813*****	1.024	**-2.813*****	1.032	**-2.811*****	1.029
South Bristol	0.488	1.694	-0.539	1.707	-0.483	1.702
Southport	**8.999*****	1.760	**8.926*****	1.767	**8.999*****	1.763
Thomaston	**-3.823*****	0.313	**-3.812*****	0.315	**-3.817*****	0.313
Waldoboro	**-11.871*****	0.430	**-11.837*****	0.431	**-11.861*****	0.440
Westport Island	**3.773*****	1.114	**3.736*****	1.122	**3.773*****	1.118
Wiscasset	**-12.666*****	0.406	**-12.634*****	0.404843	**-12.649*****	0.418
Woolwich	0	(omitted)	0	(omitted	0	(omitted)

*** p<0.01, **p<0.05, *p<0.1

Table 8 Continued

Penobscot Bay	Base Model (N = 1,660)		Alternate Model 1 (N = 1,660)		Alternate Model 2 (N = 1,660)	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Control Variables: Spatial Characteristics						
Brooklin	**-3.322****	1.359	**-3.628*****	1.363	**-3.681*****	1.372
Brooksville	**3.922*****	1.442	**4.206*****	1.444	**4.222*****	1.456
Camden	**3.188*****	1.047	**3.432*****	1.051	**3.457*****	1.059
Castine	1.273	0.807	**1.488***	0.811	**1.478***	0.824
Deer Isle	**-0.260***	0.152	**-0.272***	0.152	**-0.293***	0.153
Islesboro	**12.258****	5.172	**13.469****	5.189	**13.563****	5.234
Lincolnville	**1.263*****	0.434	**1.3645*****	0.435	**1.364*****	0.440
North Haven	**12.237****	5.158	**13.492*****	5.177	**13.578*****	5.224
Northport	**-1.855****	0.760	**-1.999*****	0.762	**-2.017*****	0.764
Orland	**-2.985*****	1.075	**-3.214*****	1.079	**-3.255*****	1.084
Owl's Head	-0.025	0.191	0.011	0.193	0.002	0.195
Penobscot	**-0.748****	0.367	**-0.784****	0.371	**-0.818****	0.370
Prospect	**1.103****	0.672	**1.261***	0.675	**1.290***	0.680
Rockland	**2.163*****	0.819	**2.292*****	0.820	**2.330*****	0.822
Rockport	**1.688***	1.026	**1.986***	1.032	**1.987***	1.050
Saint George	**-2.550****	1.145	**-2.822****	1.150	**-2.835****	1.157
Searsport	**1.360****	0.676	**1.529****	0.679	**1.546****	0.685
Sedgwick	**0.642*****	0.179	**0.658*****	0.181	**0.655*****	0.178
South Thomaston	**1.073*****	0.387	**1.137*****	0.402	**1.151*****	0.386
Stockton Springs	0	(omitted)	0	(omitted)	0	(omitted)

Table 8 Continued

Stonington	0	(omitted)	0	(omitted)	0	(omitted)
Verona Island	0	(omitted)	0	(omitted)	0	(omitted)
Vinalhaven	0	(omitted)	0	(omitted)	0	(omitted)

*** p<0.01, **p<0.05, *p<0.1

APPENDIX C: Survey Statements as Predictor Variables

Table 9. Predictor Variables assessed in a survey of attitudes regarding ocean and coastal issues.

Survey Statement	Type of Response
Home Setting	
Can you see or access the ocean from the address to which this survey was mailed, or another property you own? (Check all that apply)	Multiple choice (multiple answer)
How many people, including yourself, live in your household?	Open-ended
Experience/awareness	
As a coastal resident of Maine, what is your level of familiarity with the Maine Coastal Program? (Select one answer)	Scale from 1 (not at all familiar) to 5 (extremely familiar)
How often do you visit or spend time interacting with Maine's coast? (Select one answer)	Scale from 1(two or more times a week) to 5 (Never)
Do you or does anyone in your household make a living from the sea? (Select all that apply)	Multiple choice (multiple answer) and open-ended
How often do you engage in recreational activities on the coast of Maine?	Multiple choice (single answer)
Perception (Statements Adapted from MCP Strategic Outlook (2015))	
Maine has experienced decreased coastal water quality in the last decade	Scale from 1 (completely disagree) to 5 (completely agree)
Ocean acidification is contributing to decreased coastal water quality in Maine	
The Gulf of Maine is warming at a faster rate than most of the Earth's oceans	
Invasive marine species are becoming an increased issue for Maine	
Most of Maine’s culverts over streams block the movements of fish, other aquatic organisms, and nutrients	
Pollution runoff is contributing to decreased coastal water quality in Maine	
Shoreline modification increases erosion and prevents the migration of marsh habitat in Maine	
Maine wetlands are threatened due to sea level rise	
Maine wetlands are threatened due to coastal development	
There have been significant impacts to wetlands vegetation and shellfish communities from marine invasive species	
Much of Maine’s coastline is highly vulnerable to long-term sea level rise	
More than a tenth of Maine’s coastline is classified as highly or very highly vulnerable to shoreline erosion	
Maine's aquaculture industry provides potential for economic development	
Maine's aquaculture industry enhances coastal water quality	
The amount of marine debris in Maine oceans and beaches (cigarette filters, fishing gear, etc.) has stayed constant or decreased in the last decade	
Maine provides adequate public access planning	
Maine has the largest network of private, non-profit land in the country	

Table 9 Continued

Preference (Statements Adapted from MCP Strategic Outlook (2015))	
Reducing threats/risk to public health from storms & climate change	Scale from 1 (lowest priority) to 5 (highest priority)
Improving and expanding state-level planning for how we use our coast	
Protecting, restoring and enhancing wetlands	
Expanding the aquaculture industry	
Eliminating or reducing marine debris	
Providing more public access to the shore	
Addressing impacts associated with land development and other stressors	
Trust in Local, State, and national ocean and coastal decision makers; trust in science	
Charities, non-profit, voluntary citizens' groups	Scale from 1 (complete distrust) to 5 (complete trust)
Business and industry	
Town/local decision-makers	
State decision-makers	
Nationwide decision-makers	
Science can raise our standard of living	
Results from scientific research are sometimes unreliable	
Scientists have improved our coastlines	
Scientists produce unbiased information	
Scientists provide reliable information	
I feel scientific research often goes too far	
I fear the potential impacts of scientific research	
Scientists do important work	
I trust scientists who study how we use the coast	
Belief in climate change	
Global climate change is happening	Scale from 1 (completely disagree) to 5 (completely agree)
Global climate change is caused by human activities	
Global climate changes is only caused by natural changes in the environment	
Global climate change is caused by an equal combination of human activities and natural changes in the environment	
Demographics	
How do you identify yourself? (Select one answer)	M/F/O
What year were you born? (please write 4-digit number for year)	Open-ended
What year did you purchase your home? Please type the year in the four-digit format (19XX, or 20XX).	
Indicate your current status (Check all that apply)	Multiple choice (allow multiple answers)
What is the highest level of education you have completed? (Select one answer)	Multiple choice (allow single answers)

*Adapted from Murray & D'Anna (2015).

APPENDIX D: Factor Analysis Summary

Exploratory factor analysis was utilized to investigate interactions between and group perceived marine ecosystem impacts as well as belief in science in terms of multiple, rather than isolated, impacts (Gelcich, 2014). In the social sciences, factor analysis is usually applied to variables that are highly correlated and can be thus accounted for by a smaller number of factors (Kline, 2014). Factor loadings are the strength of the correlations of a variable with a factor. Our goal is to identify groups within our scales and classify them according to any relationships between them. The first step in our process of factoring is separate the statements we think are trying to answer the same question, otherwise known as those that are highly correlated with each other (TIBCO Software Inc., 2019). While we use exploratory factor analysis, we wish to analyze the Likert-scale results as attitudes towards climate change, trust in decision makers, trust in science, and coastal perception. Therefore, we organize the Likert-scale data for factor analysis into the following groups:

a. Trust in Science – 9 Likert scale statements
b. Coastal Perception – 17 Likert Scale Statements
c. Trust in Coastal/Ocean Decision Makers – 5 scale statements
d. Belief in Global Climate Change – 4 Likert scale statements

Factor analysis was performed using principle components factoring and factors were rotated for better interpretation (Torres-Reyna, 2010). Via literature by Yong and Pearce (2013), we used Kaiser's criterion to determine how many factors to retain (above eigen value of 1) (Kaiser, 1960). We viewed factor loadings to determine relationships between sets of variables (Yong and Pearce, 2013). All the Trust in Science and 12 of the 17 Coastal Perception variables factored into 2 composite variables, *Trust in Science* and *Ocean Health*. Belief in Climate Change and Trust in Decision Makers did not factor. Next, we calculate internal consistency reliability or coefficient alpha (Cronbach's alpha). Our reliability coefficients should be at least .70. We repeat for each factor.

Table 10. Question text for composite variables created with factor loadings and Cronbach's alpha reliability coefficient (N =187).

		Factor Loading
Variable	**Ocean Health**	
Question	As a coastal resident of Maine, what is your level of agreement with the following statements? (Select one answer for each statement) Please refer to the following definition as you complete this question.	
1	Maine wetlands are threatened due to sea level rise	.80
2	Pollution runoff is contributing to decreased coastal water quality in Maine	.75
3	There have been significant impacts to wetlands vegetation and shellfish communities from marine invasive species	.75
4	Shoreline modification increases erosion and prevents the migration of marsh habitat in Maine	.73
5	The Gulf of Maine is warming at a faster rate than most of the Earth's oceans	.72
6	Ocean acidification is contributing to decreased coastal water quality in Maine	.72
7	Maine wetlands are threatened due to coastal development	.69
8	Much of Maine's coastline is highly vulnerable to long-term sea level rise	.68
9	Maine has experienced decreased coastal water quality in the last decade	.64
10	Invasive marine species are becoming an increased issue for Maine	.64
11	More than a tenth of Maine's coastline is classified as highly or very highly vulnerable to shoreline erosion	.58
12	Most of Maine's culverts over streams block the movements of fish, other aquatic organisms, and nutrients	.55
	Cronbach's alpha reliability coefficient	**.90**
Variable	**Trust_Sci**	
Question	Please indicate the extent to which you agree or disagree with each of the following statements (Select one answer for each statement)	
1	Scientists provide reliable information	.84
2	I trust scientists who study how we use the coast	.83
3	Scientists produce unbiased information	.76
4	Scientists do important work	.75
5	Science can raise our standard of living	.71
6	I feel scientific research often goes too far*	.70
7	Scientists have improved our coastlines	.67
8	I fear the potential impacts of scientific research*	.58
9	Results from scientific research are sometimes unreliable*	.57
	Cronbach's alpha reliability coefficient	**.86**

*Table adapted from Anthony (2018)

*indicates statement was reverse coded to match sign of factor loading

APPENDIX E: Logit Model - Discreet Choice Method Summary

Logistic regression was utilized to model the probability of an individual labeling a coastal issue as “high priority” given the values of coastal, climate, and science perceptions, as well as personal and housing characteristics variables, which can be categorical or numerical (Foltz, 2015a). The Stata command “logit” fits maximum likelihood models with binary dependent variables coded as 0/1 (Statacorp, 2013).

We use the formal model:

$$L_i = log\frac{p(x_i)}{1-p(x_i)} = \beta_0 + \beta_1 x_i$$[13]

The goal of logistic regression is to estimate p for a linear combination of the independent variables. Estimate of p is p-hat, $\hat{p}$. Our dependent variable is dichotomous (1 or 0). Marine preferences are coded “1” for high priority area (scored 4,5 in Likert scale) and “0” for all others (neither high nor low priority area to lowest priority area). It is a binary, mutually exclusive variable, meaning respondents either agree the specific marine issue is a high priority area, or they do not. We want to know the odds of an individual having a perception of 4 or 5 for a coastal priority area also prefer that issue.

We can use the odds ratio information in our logistic model to understand the relationship (if any) between the predictor and response variables (Minitab, 2019). We can also get a sense of the size and direction of this relationship. This interpretation uses the fact that the odds of an individual preference for certain coastal issue p, are divided by the probability of individual preferences for a certain coastal issue are not 1 (1-p). Therefore the odds of an individual preference are p(preference/p(not preference) and assumes that the other predictors remain constant (Minitab, 2019; Foltz, 2015b). The greater the log odds, the more likely the reference

[13] Model adapted from Gujarati & Porter (2008) and Foltz (2015)

event is. Stata results display the odds ratio, which represents the odds of Y = 1(an individual chooses high preference of coastal issue) when x (the individual's perception of a coastal issue) increases by 1 unit (Torres-Reyna, n.d). When the odds ratio is greater than one, then the odds of Y = 1 increase. When the odds ratio is less than 1, the odds of Y = 1 decrease. For example, the odds ratio for ocean health in our ocean resources model is 3.620. This means, that the odds of Y=1 (ocean resources as a high priority) for ocean resources preferences increases by 3.620 units for each additional level of perception. The positive relationship means that as perception "increases," the odds of preference for that coastal issue increases.

Future work in our research would involve us to use the below equation for $\hat{p}$ to substitute our coefficients in the equation. This will give us the probability that an individual prefers a certain coastal issue, given their perception, housing, and personal characteristics.

Solving for $\hat{p}$ provides us with the estimated regression equation,

$$\hat{p} = \frac{e^{\beta_0+\beta_1 x_i}}{1+e^{\beta_0+\beta_1 x_i}}$$

Table 11. Descriptive Statistics for Variables used in Logit Model.

Variable	Description	Mean	Standard Deviation
Dependent Variable			
Preference Coastal Hazard	Reducing threats/risk to public health from storms & climate change (scale with 1 = lowest priority to 5 = highest priority)	3.838	1.031
Preference Ocean Resources	Improving and expanding state-level planning for how we use our coast (1-5 scale)	3.897	0.949
Preference Wetlands	Protecting, restoring and enhancing wetlands (1-5 scale)	4.196	0.854
Preference Aquaculture	Expanding the aquaculture industry (1-5 scale)	3.335	1.003
Preference Marine Debris	Eliminating or reducing marine debris (1-5 scale)	4.054	0.863
Preference Public Access	Providing more public access to the shore (1-5 scale)	3.039	1.090
Preference Cumulative and Secondary Impacts of Development	Addressing impacts associated with land development and other stressors (1-5 scale)	4.152	0.889

Table 11 Continued

Explanatory Variables			
	Perception Characteristics		
Health of the Ocean Perception	Factored composite variable focused on overall health of ocean from multiple stresses including ocean resources, coastal hazards, wetlands, and cumulative and secondary development impacts (scale with 1 = completely disagree with to 5 = completely agree with)	4.095	0.661
Aquaculture Perception 1	Level of agreeance that Maine's aquaculture industry provides potential for economic development (1-5 scale)	4.379	0.861
Aquaculture Perception 2	Level of agreeance that Maine's aquaculture industry enhances coastal water quality (1-5 scale)	3.409	1.041
Aquaculture Familiarity	Level of familiarity with aquaculture in Maine. 1 signifies no familiarity to 4 which signifies have heard of and seen aquaculture	1.748	0.973
Marine Debris Perception	Level of agreeance that the amount of marine debris in Maine oceans and beaches (cigarette filters, fishing gear, etc.) has stayed constant or decreased in the last decade (1-5 scale)	2.662	1.096
Public Access Perception 1	Level of agreeance that Maine provides adequate public access planning (1-5 scale)	2.966	0.979
Public Access Perception 2	Level of agreeance that Maine has the largest network of private, non-profit land in the country (1-5 scale)	3.315	0.764
	Personal Characteristics		
Familiarity of the Maine Coastal Program	Familiarity with Maine Coastal Program (scale with 1 = not at all familiar to 5 = extremely familiar)	1.730	1.008
Trust in Science	Factored composite variable focused on overall trust of scientists, work they do, and their results (scale with 1 = completely distrust to 5 = completely trust)	4.009	0.656
Belief in Climate Change	Climate Change Indicator (0,1), to indicate a belief in climate change	0.931	0.254
Living from the Sea	If individual or someone in the house makes living from sea (0,1)	.079	0.270
Access to the Sea	If individual can see or access ocean from their home (0,1)	.317	0.466
Coastal Recreation	How often individual interacts with sea (scale from daily = 5 to never = 1)	2.597	0.873
Years in Home	Years that an individual has owned their current residence (years)	5.821	8.644
	Sociodemographics		
Female	Female = 0; Otherwise = 1	.4705882	0.500
Education	Education (scale from 0-11=1 to postgraduate = 5)	4.347	0.683
Age	Age (years)	51.935	14.079

*Table adapted from Anthony (2018)

Table 12. Logit Model Odds Ratio for determining relationship between perception of and preferences for specific coastal issues.

	Odds Ratio Standard Error						
Variable	Preference Coastal Hazards	Preference Ocean Resources	Preference Wetlands	Preference Aquaculture	Preference Marine Debris	Preference Public Access	Preference Impacts
FAMILIARITY_MCP Familiarity with Maine Coastal Program (categorical with 1 = not at all familiar to 5 = extremely familiar)	1.006 0.211	0.903 0.187	1.027 0.285	0.826 0.167	**0.675*** 0.148	0.922 0.195	1.346 0.374
AQUACULTURE_1 Level of agreeance that Maine's aquaculture industry provides potential for economic development (1-5 scale)	0.671 0.183	1.092 0.270	1.159 0.402	**1.645*** 0.440	0.796 0.256	0.977 0.249	0.571 0.210
AQUACULTURE_2 Level of agreeance that Maine's aquaculture industry enhances coastal water quality (1-5 scale)	1.130 0.223	1.081 0.216	0.745 0.211	**2.493**** 0.552	1.345 0.314	1.207 0.244	0.863 0.225
AQUACULTURE FAMILIARITY Level of familiarity with aquaculture in Maine. 1 signifies no familiarity to 4 which signifies have heard of and seen aquaculture	1.109 0.221	0.819 0.157	0.778 0.196	0.976 0.201	1.298 0.315	1.061 0.771	1.046 0.276
MARINEDEB_1 Level of agreeance that the amount of marine debris in Maine oceans and beaches (cigarette filters, fishing gear, etc.) has stayed constant or decreased in the last decade (1-5 scale)	0.949 0.175	0.975 0.173	**1.542*** 0.397	1.095 0.195	**0.585***** 0.120	1.125 0.515	1.107 0.279
PUBACCESS_1 Level of agreeance that Maine provides adequate public access planning (1-5 scale)	1.045 0.212	1.058 0.206	0.742 0.214	**1.370*** .262	0.970 0.204	**0.506***** 0.103	1.005 0.265

Table 12 Continued

PUBACCESS_2 Level of agreeance that Maine has the largest network of private, non-profit land in the country (1-5 scale)	0.893 0.226	1.115 0.275	1.010 0.345	0.681 0.164	0.799 0.212	1.053 0.266	1.295 0.423
HEALTH_OCEAN Factored composite variable focused on overall health of ocean from multiple stresses including ocean resources, coastal hazards, wetlands, and cumulative and secondary development impacts	**2.316**** 0.944	**3.620***** 1.442	**6.402***** 3.628	1.517 0.598	**2.154*** 0.894	0.602 0.232	**5.257***** 2.976
TRUST_SCIENCE Factored composite variable focused on overall trust of scientists, work they do, and their results	**2.655***** 0.957	0.992 0.338	1.635 0.768	1.225 0.447	0.931 0.359	**2.134**** 0.761	**3.079**** 1.506
CLIMATECHANGE_D Climate Change Indicator (0,1), to indicate a belief in climate change	**4.928*** 4.631	0.938 0.736	**5.397*** 5.394	0.271 0.225	2.289 1.840	6.355 7.485	1.089 0.940
FEMALE Female = 0; Otherwise = 1	1.735 0.649	0.808 0.291	0.939 0.460	**0.463**** 0.166	1.384 0.561	1.116 0.405	1.297 0.629
EDUCATION Education (Categorical from 0-11=1 to postgraduate = 5)	0.970 0.275	0.719 0.206	0.678 0.268	0.944 0.265	0.665 0.215	0.780 0.227	1.255 0.447
YEARS_HOME Years that they've owned their current residence (years)	0.987 0.022	0.995 0.025	1.003 0.035	1.034 0.039	0.987 0.033	0.981 0.020	1.005 0.030
ACCESS_SEA If individual can see or access ocean from their home	1.184 0.516	1.032 0.442	0.522 0.307	1.238 0.507	1.503 0.714	1.846 0.770	0.682 0.380
LIVING_SEA If individual or someone in the house makes living from sea (0,1)	0.706 0.480	0.522 0.346	0.868 0.772	1.824 1.262	1.004 0.728	1.902 1.348	0.783 0.690

Table 12 Continued

RECREATION_COAST How often individual interacts with sea (Categorical from daily = 5 to never = 1)	**2.031*** 0.835	1.712 0.679	0.794 0.443	1.129 0.451	1.127 0.492	1.880 0.749	0.492 0.266
AGE Age (years)	1.005 0.014	1.030** 0.015	**1.036*** 0.020	1.011 0.0142	0.016	1.022 0.014	1.012 0.019
Prob>chi2	0.000	0.005	0.000	0.000	0.053	0.010	0.000
Pearson Goodness of fit Test	0.331	0.089	0.863	0.390	0.064	0.307	0.407

*Table adapted from Anthony (2018)

APPENDIX F: SEANET Coastal Community Survey

SEANET Coastal Community Survey

Thank you for considering participating in the SEANET Coastal Community Survey. On the next page you will be asked to enter your unique survey ID. This information can be found on your survey letter. Survey IDs are only used for bookkeeping purposes.

The information that you provide in this survey is confidential. Individual responses will not be reported.

You are invited to participate in a research project conducted by the Sustainable Ecological Aquaculture Network at the University of Maine. Our collaborative research team led by Dr. Caroline L. Noblet, Dr. Keith S. Evans and graduate students Olga Bredikhina and Amy Bainbridge is working to learn about how you view alternatives for Maine coasts, including your view of aquaculture. You must be at least 18 years of age to participate in this study.

What Will You Be Asked to Do? If you decide to participate, please visit the website listed at the bottom of this letter to complete a survey. Answering these questions may take up to 20 minutes. Examples of questions include: Have you heard of, or seen, any marine aquaculture in Maine?; Have you ever consumed Maine aquacultured seafood?

Risks Except for your time and inconvenience, there are no risks to you from participating in this study. By completing the survey questions, you are giving your consent to participate in this study.

Benefits While this study will have no direct benefit to you, this research may help us learn more about the opinions and behaviors of Maine citizens.

Compensation To compensate you for your time, upon completion of the survey, **you may choose to be entered into a raffle for one of multiple $50 gift cards**. At the end of the survey you will see information on how to access an online portal that will collect information for raffle entry. This information will be recorded separately from your survey responses.

Confidentiality Your name will not be on any of the documents. The information you provide in response to the survey questions will be treated with professional confidence and will only be used for research purposes. These data will only be published in a summarized form, so your individual responses will never be revealed or shared with anyone outside the research team. Survey codes are only used for the purpose of sending reminder materials to those who do not respond. An electronic key linking participant information to data will be stored using software that provides additional security and destroyed on September 1, 2019. We will store the data gathered in a secure electronic database at the University of Maine; it will be deleted on September 2, 2023.

Voluntary Your participation is voluntary and you may choose to skip any question though please note that information about the survey raffle is located at the end of the survey. Your completion of the online survey tells us you have read and understood the information above and agree to be a part of the study.

Contact Information If you have any questions about this research, you may contact our research team at 207.835.1844 (or email mainecoastalresidentsurvey@gmail.com) If you have any questions about your rights as a research participant, please contact the Office of Research Compliance, University of Maine, 207.581.1498 or 207.581.2657 (or e-mail umric@maine.edu).

○ Yes, I agree with the terms outlined (1)

End of Block: Survey Introduction

Start of Block: Section 1: Citizen Perception of Current Ocean and Coastal Issues

Q1 This section presents questions regarding current ocean and coastal issues. Your feedback will be helpful in understanding public perceptions and preferences for ocean and coastal priority areas.

Q2 How often do you visit or spend time interacting with Maine's coast? (Select one answer)

- ○ Two or more times per week (1)
- ○ A few times a month or more (2)
- ○ Once or twice a month (3)
- ○ Once or twice a year (4)
- ○ Never (5)

Q3 Please think about coastal water quality in terms of the marine environment including the health of plants and animals. In your opinion, how would you rate the coastal water quality in Maine?

	Poor (1)	Fair (2)	Good (3)	Very Good (4)	Excellent (5)
Maine Coastal Water Quality (1)	○	○	○	○	○

Q4 When you think about Maine's coastline, what are the three most important environmental issues that come to mind?

- ◯ Environmental Issue 1 (1) ____
- ◯ Environmental Issue 2 (2) ____
- ◯ Environmental Issue 3 (3) ____

End of Block: Section 1: Citizen Perception of Current Ocean and Coastal Issues

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Start of Block: Introduction to Choice Experiment

We are interested in how coastal features influence housing choices among Maine residents. In the following, you will be presented with 3 choice scenarios where you will be asked to select among 4 possible coastal home lots. Please go to the next page to begin a choice experiment.

End of Block: Introduction to Choice Experiment

Start of Block: Final Coded experiment

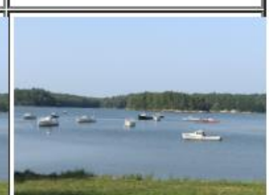
Q5
Suppose you needed to leave your current home and are moving into a new housing development in your current city/town. You have already picked out the model home and are now selecting a home lot. The four home lots that you are considering are located within the same housing development but near different coastal features and are associated with different monthly payments.

As Maine's coastline continues to develop, coastal features near home lots may change over time. The expected change in ocean views and the number of years before these changes occur are shown for each lot. For some lots, there may be no change in view (denoted below). While there is information available on how coastal development will impact these lots over the next 15 years further changes beyond this are not known. The monthly payments shown below represent monthly mortgage payments assuming a 15-year mortgage. Differences in monthly payments across home lots reflect anticipated changes in ocean views.

Considering the four alternatives, which would you choose?

Please click on a picture to enlarge it, and then click again to shrink it.

Q6

	HOME LOT A	HOME LOT B	HOME LOT C	HOME LOT D
Current type of coastal usage	Aquaculture	Undeveloped	Coastal fishing	Undeveloped
Current view				
Years in current view	10	15	10	5
Future type of coastal usage	Undeveloped	Aquaculture	Undeveloped	Coastal fishing
Future view				
Monthly payments	$2,300	$1,800	$1,200	$1,200

○ Home Lot A (1)

○ Home Lot B (2)

○ Home Lot C (3)

○ Home Lot D (4)

Q7 Please, explain why you chose this house lot

____

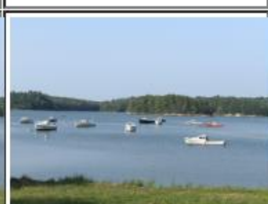
End of Block: Final Coded experiment

Start of Block: Choice scenario 2

Q8 Now suppose you are considering four different home lots. Again, these home lots are all located in the same housing development but differ in ocean views and monthly payments.

Considering the four alternatives described below, which would you choose?
Please click on a picture to enlarge it, and then click again to shrink it.

Q9

	HOME LOT A	HOME LOT B	HOME LOT C	HOME LOT D
Current type of coastal usage	Undeveloped	Coastal fishing	Coastal fishing	Coastal fishing
Current view				
Years in current view	10	15 (no change in view)	5	15
Future type of coastal usage	Aquaculture	Coastal fishing	Aquaculture	Undeveloped
Future view				
Monthly payments	$2,300	$1,800	$1,200	$1,200

○ Home Lot A (1)

○ Home Lot B (2)

○ Home Lot C (3)

○ Home Lot D (4)

Q10 Please, explain why you chose this house lot.

____

End of Block: Choice scenario 2

Start of Block: Choice scenario 3

Q11 Finally, suppose you are considering four different house lots. Again, these house lots are all located in the same housing development but differ in ocean views and monthly payments.

Considering the four alternatives described below, which would you choose?
Please click on a picture to enlarge it, and then click again to shrink it.

Q12

	HOME A	HOME B	HOME C	HOME D
Current type of coastal usage	Aquaculture	Aquaculture	Undeveloped	Coastal fishing
Current view				
Years in current view	15	10	15 (no change in view)	15 (no change in view)
Future type of coastal usage	Undeveloped	Coastal fishing	Undeveloped	Coastal fishing
Future view				
Monthly payments	$2,300	$1,800	$1,800	$1,200

◯ Home lot A (1)

◯ Home lot B (2)

◯ Home lot C (3)

◯ Home lot D (4)

Q13 Please, explain why you chose this house lot.

____

End of Block: Choice scenario 3

Start of Block: Maine Coastal Program

Q14 This section presents questions regarding your familiarity with the Maine Coastal Program, as well as your preferences for coastal issues. Your feedback will be helpful in understanding public perceptions and preferences for ocean and coastal priority areas.

Q15 As a coastal resident of Maine, what is your level of familiarity with the Maine Coastal Program? (Select one answer)

	Not at all Familiar (1)	Slightly Familiar (2)	Somewhat Familiar (3)	Moderately Familiar (4)	Extremely Familiar (5)
Maine Coastal Program (1)	◯	◯	◯	◯	◯

Q16 As a coastal resident of Maine, what is your level of agreement with the following statements? (Select one answer for each statement) Please refer to the following definitions as you complete this question.

Pollution runoff - water from rain or melting snow containing pollutants from fertilizers, pet, and yard waste that drains into a body of water

Ocean acidification - chemical changes in the ocean as a result of carbon dioxide emissions
Coastal development - changing how a coastal area is used, from a natural or semi-natural state to a different purpose such as agriculture or housing

	Completely Disagree (1)	Somewhat Disagree (2)	Neither Agree nor Disagree (3)	Somewhat Agree (4)	Completely Agree (5)
Maine has experienced decreased coastal water quality in the last decade (6)	○	○	○	○	○
Ocean acidification is contributing to decreased coastal water quality in Maine (2)	○	○	○	○	○
The Gulf of Maine is warming at a faster rate than most of the Earth's oceans (18)	○	○	○	○	○
Invasive marine species are becoming an increased issue for Maine (19)	○	○	○	○	○
Most of Maine’s culverts over streams block the movements of fish, other aquatic organisms, and nutrients (20)	○	○	○	○	○

Pollution runoff is contributing to decreased coastal water quality in Maine (21)	○	○	○	○	○
Shoreline modification increases erosion and prevents the migration of marsh habitat in Maine (22)	○	○	○	○	○

Page Break

Q17 As a coastal resident of Maine, what is your level of agreement with the following statements? (Select one answer for each statement) Please refer to the following definition as you complete this question.

Erosion - the loss of coastal lands due to the removal of sediments or bedrock from the shoreline
Coastal development - changing how a coastal area is used, from a natural or semi-natural state to a different purpose such as agriculture or housing
Wetlands - areas where water covers the soil, or is present either at or near the surface of the soil all year or for different periods of time during the year

	Completely Disagree (1)	Somewhat Disagree (2)	Neither Agree nor Disagree (3)	Somewhat Agree (4)	Completely Agree (5)
Maine wetlands are threatened due to sea level rise (1)	○	○	○	○	○
Maine wetlands are threatened due to coastal development (2)	○	○	○	○	○
There have been significant impacts to wetlands vegetation and shellfish communities from marine invasive species (3)	○	○	○	○	○
Much of Maine's coastline is highly vulnerable to long-term sea level rise (5)	○	○	○	○	○
More than a tenth of Maine's coastline is classified as highly or very highly vulnerable to shoreline erosion (7)	○	○	○	○	○

Page Break

Q18 As a coastal resident of Maine, what is your level of agreement with the following statements. (Select one answer for each statement)Please refer to the following definitions as you complete this question

Aquaculture - growing seafood for human consumption
Marine debris - any human made solid material that is abandoned into the marine environment
Culvert - a tunnel carrying a stream or open drain under a road or railroad

	Completely Disagree (1)	Somewhat Disagree (2)	Neither Agree nor Disagree (3)	Somewhat Agree (4)	Completely Agree (5)
Maine's aquaculture industry provides potential for economic development (1)	○	○	○	○	○
Maine's aquaculture industry enhances coastal water quality (2)	○	○	○	○	○
The amount of marine debris in Maine oceans and beaches (cigarette filters, fishing gear, etc.) has stayed constant or decreased in the last decade (3)	○	○	○	○	○
Maine provides adequate public access planning (4)	○	○	○	○	○
Maine has the largest network of private, non-profit land in the country (5)	○	○	○	○	○

Page Break

Q19 How should Maine coastal managers prioritize each of the following marine planning and protection issues? (Select one answer for each statement)
Please refer to the following definitions as you complete this question.

Pollution runoff - water from rain or melting snow that contains pollutants from fertilizers, pet and yard waste and drains into a body of water.
Ocean acidification - chemical changes in the ocean as a result of carbon dioxide emissions
Coastal development - changing how a coastal area is used, from a natural or semi-natural state to a different purpose such as agriculture or housing
Aquaculture - growth of seafood for human consumption
Marine debris - any human-made solid material that is abandoned into the marine environment
Wetlands - areas where water covers the soil, or is present either at or near the surface of the soil all year or for different periods of time during the year

	Lowest Priority (1)	Low Priority (2)	Moderate Priority (3)	High Priority (4)	Highest Priority (5)
Reducing threats/risk to public health from storms & climate change (1)	○	○	○	○	○
Improving and expanding state-level planning for how we use our coast (2)	○	○	○	○	○
Protecting, restoring and enhancing wetlands (3)	○	○	○	○	○
Expanding the aquaculture industry (4)	○	○	○	○	○
Eliminating or reducing marine debris (5)	○	○	○	○	○
Providing more public access to the shore (6)	○	○	○	○	○
Addressing impacts associated with land development and other stressors (7)	○	○	○	○	○

Q20 Coastal and ocean policy decision-making occurs at multiple levels: local, state, and national. Please select stars below to indicate the level of trust you have for different coastal and ocean decision-makers. (1 indicates complete distrust, 5 indicates complete trust)

Charities, non-profit, voluntary citizens' groups (1)	☆	☆	☆	☆	☆
Business and industry (2)	☆	☆	☆	☆	☆
Town/local decision-makers (3)	☆	☆	☆	☆	☆
State decision-makers (4)	☆	☆	☆	☆	☆
Nationwide decision-makers (5)	☆	☆	☆	☆	☆

Page Break

Q21 Please indicate the extent to which you agree or disagree with each of the following statements (Select one answer for each statement)

	Completely Disagree (1)	Somewhat Disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Completely Agree (5)
Science can raise our standard of living (1)	○	○	○	○	○
Results from scientific research are sometimes unreliable (2)	○	○	○	○	○
Scientists have improved our coastlines (3)	○	○	○	○	○
Scientists produce unbiased information (4)	○	○	○	○	○
Scientists provide reliable information (5)	○	○	○	○	○
I feel scientific research often goes too far (6)	○	○	○	○	○
I fear the potential impacts of scientific research (7)	○	○	○	○	○
Scientists do important work (8)	○	○	○	○	○

I trust scientists who study how we use the coast (9)	○	○	○	○	○
Global climate change is happening (10)	○	○	○	○	○
Global climate change is caused by human activities (11)	○	○	○	○	○
Global climate changes is only caused by natural changes in the environment (12)	○	○	○	○	○
Global climate change is caused by an equal combination of human activities and natural changes in the environment (13)	○	○	○	○	○

Page Break

Q22 How often do you access the following sources to get news or news headlines concerning coasts and oceans? By news, we mean information about events and issues that involve more than just your friends or family.

	Never (1)	Rarely (2)	Sometimes (3)	Most of the Time (4)	Always (5)
Get news from a U.S. newspaper (e.g., The New York Times, Denver Post) – in print, on the newspaper website, or through an app (1)	○	○	○	○	○
Get news from an international (non-U.S.) newspaper (e.g., The Guardian) – in print, on the newspaper website, or through an app (2)	○	○	○	○	○
Get news from live radio or a podcast (3)	○	○	○	○	○
Watch television news (e.g. local news or ABC World News, NBC Nightly News , or CNN, The FOX News cable channel, MSNBC) (4)	○	○	○	○	○

Get news from a social networking site (e.g., Facebook, Twitter, etc.) (5)	○	○	○	○	○

End of Block: Maine Coastal Program

Start of Block: Maine Coastal Usage

Q23 This section presents questions regarding Maine coastal usage. Your feedback will be helpful in understanding public perceptions of and preferences for the way Maine's coast is used.

Q24 In your opinion, **how is** Maine's coast **currently used**? Please replace the zeros with numbers to indicate what percentage of the Maine coast is used for each of the following categories. Please make sure all responses total 100%.

Food production (aquaculture, fisheries, etc.) : _______ (1)
Energy production : _______ (2)
Tourism and recreation : _______ (3)
Private residences/development : _______ (4)
National Park, State Park, Nature Reserve, etc. : _______ (5)
Nothing/unused : _______ (6)
Other (please specify) : _______ (10)

Total : ________

Q25 In your opinion, **how do you want** Maine's coast **to be used**? Please replace the zeros with numbers to indicate what percentage of the Maine coast you want to be used for each of the following categories. Please make sure all responses total 100%.

Food production (aquaculture, fisheries, etc.) : ________ (1)
Energy production : ________ (2)
Tourism and recreation : ________ (3)
Private residences/development : ________ (4)
National Park, State Park, Nature Reserve, etc. : ________ (5)
Nothing/unused : ________ (6)
Other (please specify) : ________ (10)

Total : ________

End of Block: Maine Coastal Usage

Start of Block: Aquaculture Operations

Q26 This section presents questions regarding familiarity with Maine's marine aquaculture operations, as well as understanding of and preferences for coastal priority areas. Your feedback will be helpful in understanding public perceptions of and preferences for ocean and coastal priority areas.

Q27 Have you heard of, or seen, any marine aquaculture operations? (Select one answer)

- ○ Yes, I have heard of them (1)
- ○ Yes, I have seen them (2)
- ○ Yes, I have heard of them and seen them (4)
- ○ No, I have not heard of, or seen them (3)

Skip To: End of Block If Have you heard of, or seen, any marine aquaculture operations? (Select one answer) = No, I have not heard of, or seen them

Q28 Where have you seen, or heard of, marine aquaculture operations? (Select all answers that are true)

- ▢ Maine (1)
- ▢ United States, outside of Maine (2)
- ▢ Outside of the United States (3)

End of Block: Aquaculture Operations

Start of Block: Demographic Questions

Q29 We would like to know a little bit about you for statistical purposes. All your answers to the survey are treated as confidential. However, we need this information to be able to compare your responses with other Mainers. We thank you again for participating in this survey.

Q30 How do you identify yourself? (Select one answer)

- ○ Female (1)
- ○ Male (2)
- ○ Other (3)

Q31
What year were you born? (please write 4 digit number for year)
Ex: 19XX, 20XX

____

Q32 Indicate your current status (Check all that apply)

- ☐ Student (1)
- ☐ Unemployed (2)
- ☐ Employed part-time (3)
- ☐ Employed full-time (5)
- ☐ Homemaker/stay at home parent (6)
- ☐ Retired (7)

Q33 What is the highest level of education you have completed? (Select one answer)

- ○ Some high school, or less (1)
- ○ High school graduate or GED (2)
- ○ Some college (3)
- ○ College graduate (Bachelor's degree or equivalent) (4)
- ○ Postgraduate degree (Master's, Doctorate, Law, or other advanced degree) (5)

Q34 What was your total household income before taxes for the last year? (Select one answer)

- ◯ Less than $10,000 (1)
- ◯ $10,000 - $14,999 (2)
- ◯ $15,000 - $24,999 (3)
- ◯ $25,000 - $34,999 (4)
- ◯ $35,000 - $49,999 (5)
- ◯ $50,000 - $74,999 (6)
- ◯ $75,000 - $99,999 (7)
- ◯ $100,000 - $149,999 (8)
- ◯ $150,000 - $199,999 (9)
- ◯ More than $200,000 (10)

Q35 Do you own or rent your current home?

- ◯ I own my current house (1)
- ◯ I rent my current house (2)

Skip To: Q37 If Do you own or rent your current home? = I rent my current house

---

Q36 What year did you purchase your home? Please type the year in the four-digit format (19XX, or 20XX).

____

Q37 How many years have you lived in Maine? (Select one answer)

- ○ <1 year (1)
- ○ 1-5 years (2)
- ○ 6-10 years (3)
- ○ 11-15 years (4)
- ○ 16-20 years (5)
- ○ >20 years (6)

Q38 Is the address to which this survey was mailed a year-round or seasonal residence? (Select one answer)

- ○ Year-round residence (1)
- ○ Seasonal residence (2)

Q39 Can you see or access the ocean from the address to which this survey was mailed, or another property you own? (Check all that apply)

- ☐ Yes, I can see the ocean from this residence (1)
- ☐ Yes, I can access the ocean from this residence (2)
- ☐ Yes, I can see the ocean from another owned property (3)
- ☐ Yes, I can access the ocean from another owned property (4)
- ☐ No, I can neither see nor access the ocean from any of my property (5)

Q40 How many people, including yourself, live in your household?

________ Number of children (less than 18 years old) (1)
________ Number of adults (18 years old and older) (2)

Q41 Do you or does anyone in your household make a living from the sea? (Select all that apply)

- ☐ Yes I make a living from the sea (What do you do?) (1) ____
- ☐ Someone in my household makes a living from the sea (What do they do?) (2) ____
- ☐ No, but I live in a community that relies on the sea for most livelihoods (3)
- ☐ No (4)

Q42 How often do you engage in recreational activities on the coast of Maine?

- ○ Daily (1)
- ○ Weekly (2)
- ○ Once a month (3)
- ○ Rarely (4)
- ○ Never (5)

Q43 Please indicate where you may be on the scales below by sliding the weight from 1 - 7.

Very liberal					Very conservative		
0	1	2	3	4	5	6	7

Socially, I consider myself ()	
Fiscally, I consider myself ()	

End of Block: Demographic Questions

Start of Block: Thank you for your assistance!

Q44 Thank you for taking the time to tell us about your experiences, opinions, and preferences. In the space below, please feel free to share any additional comments you may have. Please click the arrow below to ensure your survey responses are recorded.

____

____

____

____

____

End of Block: Thank you for your assistance!

BIOGRAPHY OF THE AUTHOR

Amy Bainbridge was born in Pittsburgh, Pennsylvania in 1987. She was raised in Pittsburgh and graduated from Northgate High School in 2005. She attended The Ohio State University and graduated in 2009 with a Bachelor's degree in English. She moved to Florida and entered the University of Central Florida Economics undergraduate program and graduated in 2015 with a Bachelor's degree in Economics. She moved to Maine and attended the University of Maine Economics program in the fall of 2017. After receiving her degree, Amy will be joining The Balmoral Group, an economics & engineering firm, to begin her career as a resource economist. Amy is a candidate for the Master of Science degree in Resource Economics & Policy from the University of Maine in May 2019.