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THE SOCIAL ACCEPTABILITY OF SHELLFISH AQUACULTURE IN WASHINGTON

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THE SOCIAL ACCEPTABILITY OF SHELLFISH AQUACULTURE IN WASHINGTON

BY

KATIE RUBSTELLO

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE

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ABSTRACT

Domestic aquaculture continues to meet public resistance in the U.S. even though the U.S. imports a growing amount of farmed seafood. This study applies the normative evaluation approach to aquaculture in the South Puget Sound, Washington and uses data from an online survey to evaluate how local residents feel about two different types of shellfish aquaculture methods (rafts; bottom culture) in natural and developed settings. This study also evaluates public perceptions of the social and environmental impacts of shellfish aquaculture and examines how a farmed Atlantic salmon escape in Puget Sound in 2017 affected participant views of aquaculture. Findings revealed that Washington residents are overall accepting of both raft and bottom culture shellfish farms in natural and developed settings but are more supportive overall of bottom culture. Support for aquaculture depends on a moderation of farming intensity, as residents were more accepting of low to medium levels of raft and bottom culture. Respondents also felt that shellfish aquaculture had positive and negative impacts on local communities and the environment. They overwhelmingly agreed that aquaculture is good for the economy and a good nutritional option but had concerns about public access, use conflict, and local environmental disruption. These exploratory results can inform Washington aquaculture managers on how to engage the public with the impacts, risks, and methods of shellfish farms for better industry and community relations as shellfish aquaculture continues to grow in Washington coastal waters.

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Chapter 1

INTRODUCTION

Aquaculture is defined as the breeding, rearing, and harvesting of animals and plants in all types of water environments (NOAA, 2016). Shellfish farming mitigates the growing demand for seafood and also creates jobs, provides environmental benefits, and contributes to economic gains. Since the 1980s, the industry has become well established in the U.S. but has faced significant opposition and tough regulations and has struggled to grow to its capability (National Aquaculture Sector Overview, 2018). At the same time, the U.S. imports 90 percent of its seafood, half from foreign aquaculture, so that the U.S. seafood trade deficit was \$14 billion in 2016 (NOAA, 2016). There are some possible reasons for this economic trend including opposition stemming from complex environmental regulations, weak government advocacy, and opposition from various stakeholder groups (Chu et al., 2010). Public perceptions especially can influence the acceptance, investigation, and implementation of aquaculture (Flaherty et al., 2018). For this reason, many studies have begun to focus on the social conflicts surrounding aquaculture.

Studies have found that public perceptions of aquaculture stem from a variety of impacts of the aquaculture industry on local communities and ecological systems. First, consumers have health and safety concerns regarding farmed seafood products since the rearing of shellfish poses potential disease risks to humans (FAO, 2018). However, many new farms are often rejected because of social issues rather than environmental concerns (Banta and Gibbs, 2009). For one, communities often oppose government's taking of public marine spaces and granting that space to individuals for profit (Joyce and

Satterfield, 2010). The privatization of sea space can exclude community members from beaches or water access points and can hinder the rights practiced by First Nations (D'Anna and Murray, 2015). In general, aquaculture opposition stems from concerns about the allocation of beach tenures, conflict with commercial wild-capture fishers, and the aesthetic appearance of farms (Flaherty et al., 2018).

The future seafood supply will most likely come from aquaculture products so these conflicts over space and use cannot be ignored (Chu et al., 2010). Since public perceptions can affect how the government regulates the aquaculture industry, it is important to bridge the gap between society and U.S. policy so that aquaculture may have a chance to grow sustainably in the U.S. (Flaherty et al., 2018). However, there has been very limited community-level research about the public awareness of aquaculture and how the issues associated with its development are currently perceived (Flaherty et al., 2018). This study explores public perceptions of aquaculture development.

1.1 Recent Studies on Public Perceptions of Aquaculture

Several recent studies have investigated public perceptions of aquaculture. Two studies, Dalton et al (2017) and Dalton and Jin (2018), looked at public perceptions of shellfish aquaculture in Rhode Island (U.S) using mail surveys. Rhode Island was chosen as a study site because even though shellfish have been farmed in state waters for over a century, the public continues to strongly oppose industry activities (Dalton and Jin, 2018). Dalton and Jin (2018) looked at the attitudinal factors and personal characteristics that influence support for aquaculture. Overall, they found that key attitudinal factors affecting support include shellfish aquaculture's impacts on the local economy, its role as a nutritional food option, its effects on aesthetic qualities, and its interference with other

uses (Dalton and Jin, 2018). For example, participation in recreational activities on the water affected people's support for shellfish aquaculture. Respondents that participate in sailing and birding were less supportive of shellfish aquaculture than bicycle riders because birders and sailors are more likely to interact directly with aquaculture (Dalton and Jin, 2018). This is representative of Dalton and Jin's (2018) overall finding that support or opposition for aquaculture in Rhode Island is driven more by social than environmental impacts.

Dalton et al (2017) looked at the social carrying capacity of shellfish aquaculture in Rhode Island by using normative evaluations. Respondents were shown images of shellfish aquaculture at varying gear intensities in Narragansett Bay or a salt pond. Norm curves were then compared for groups by occupation based on their evaluation of different levels of shellfish aquaculture represented in the images. Overall, respondent support depended on the water body where aquaculture was occurring, the scale of the operation, and the way in which aquaculture was conducted (Dalton et al, 2017). Additionally, perceptions of aquaculture were also affected by factors including their occupation and whether they have water views from their residences or not (Dalton et al, 2017).

Studies on public perceptions of aquaculture have also been conducted outside of the U.S. To address social and cultural effects of aquaculture, D'Anna and Murray (2015) measured a British Columbia coastal community's perception of well-being to determine what is important to individuals and the community. Through interviews, participant-employed photography, and household surveys, they discovered that perceptions of aquaculture impacts have very subjective components varying from highly positive to

highly negative across environmental, economic, and experience dimensions (D'Anna and Murray, 2015). Like many other aquaculture studies, D'Anna and Murray (2015) found that more than half of their respondents thought shellfish aquaculture economically benefited local communities. However, respondents had many environmental concerns. For instance, 56% of respondents were uncertain about whether shellfish cleans the water (D'Anna and Murray, 2015). They were also uncertain about the effects to the coastal ecosystem, modifications to beaches, and the creation of plastic and other marine debris from aquaculture gear (D'Anna and Murray, 2015).

Apart from perceived impacts, they also found that a person's individual viewpoint of aquaculture would deter them from supporting a farm (D'Anna and Murray, 2015). This means the root of aquaculture governance and management issues is based on conflicts with local residents and activities in the area (D'Anna and Murray, 2015). D'Anna and Murray (2015) suggest that by understanding stakeholder values, preferences, and perceptions, stakeholders can better appreciate trade-offs of shellfish aquaculture and other coastal activities.

Another Canadian study by Flaherty et al. (2018) analyzed the public perceptions of shellfish and finfish aquaculture farms on both Pacific and Atlantic coasts of Canada. They found that respondents in this study believe that aquaculture has many positive and negative impacts. For instance, respondents believe that aquaculture is good for employment and the local economy, is a valid use of the coastline, and relieves pressure on wildlife. However, respondents did perceive negative impacts as well. For instance, respondents favored eating wild seafood due health and risk concerns from eating farmed

seafood (Flaherty et. al, 2018). Additionally, 35% think farming non-native species is an ecological concern (Flaherty et. al, 2018).

Another recent study looked at people's perceptions of the positive and negative impacts of aquaculture around the world. Froehlich et al (2017) looked at headlines with the text 'aquaculture,' 'marine aquaculture,' and 'offshore aquaculture' in a variety of media sources such as newspapers, blogs, or journals. To evaluate public response to these articles, they collected the comment sections and noted the types of concerns people had and recorded whether the comment about aquaculture was positive or negative. They found that in the U.S., negative comments about aquaculture focused on environmental concerns and were linked with terms like 'wildlife' and 'oil' (Froehlich et al, 2017). This shows how U.S. citizens continue to be weary of aquaculture and environmental risks.

This study explores public perceptions of aquaculture associated with seafood preferences and attitudes toward aquaculture impacts and risks in the state of Washington (U.S.).

1.2 History of Washington aquaculture

Washington has an expansive coastal zone and has the ecological capacity for both shellfish and finfish aquaculture. When it gained statehood in 1889, Washington's aquatic lands became state-owned, which makes how the state manages aquaculture unique to other states that farm shellfish (Ryan, 2017). For instance, aquaculture in Washington is managed by the state but responsibilities are split between departments. The Washington Department of Natural Resources leases tidelands for shellfish aquaculture and the amount of acreage provided by the state to a farmer is based on a percentage of production that a farmer can reach in a year (Washington Sea Grant, 2015).

In order to obtain a permit, a farm requires approval from the Washington Department of Health, Washington Department of Fish and Wildlife, and the U.S. Army Corps of Engineers (C.M. Ryan et al., 2017). The state still manages the shoreline with the Shoreline Management Act (SMA) of 1971. According to the SMA, “alterations of the natural condition of the shorelines” of Washington are “priority for single-family residences and their appurtenant structures, ports, shoreline recreational uses.” Priority will also be given to “an economic development element” for “projects of statewide significance” that are “particularly dependent on their location on or use of the shorelines of the state,” (Washington State Legislature, 1971). The SMA establishes Washington shorelines as working waterfronts, recreational spaces, and residential areas (Ryan, 2017). In this way, aquaculture, as a water dependent commercial activity that benefits the state’s economy and provides jobs for many local Washington residents, is a shoreline priority.

In the state overall, aquaculture makes up 2,100 acres of the state-owned aquatic lands, most of those leasing being in the tidelands (Washington State Department of Natural Resources, 2019). Washington DNR’s Aquatics Districts collect fees off of these leases based on the standards set out in the 1984 Aquatic Lands Act to protect the environment and public access from private, economic actions (Washington State Department of Natural Resources, 2019). The Revised Code of Washington 79.90.495 maintains that “if state-owned aquatic lands are used for aquaculture production or harvesting, rents and fees shall be established through competitive bidding or negotiation,” (Aquaculture Leasing Statutory and Regulatory Framework). Revenue from these leases are used by the state for the management and protection of the state-owned

aquatic lands and granted to the Aquatic Lands Enhancement Account (ALEA) to help protect and improve these aquatic lands (Washington State Department of Natural Resources, 2019).

Since the late 1800s, Washington has been a leading U.S. producer of farmed bivalves and the shellfish industry added \$184 million to the state's economy in 2010 (Access Washington, 2013). Washington was also the first state to launch a Shellfish Initiative in 2011 in collaboration with government agencies, non-government agencies, the shellfish aquaculture industry, and local tribes (Washington Governor Jay Inslee). The Initiative's goal is to promote clean-water commerce, promote and expand the shellfish aquaculture industry, and create jobs (Washington Governor Jay Inslee). Although the state government has invested its resources to promote shellfish aquaculture, the aquaculture industry continues to face challenges.

For example, a finfish aquaculture incident in August 2017 changed the future of the aquaculture industry in the state. Washington has the largest open-water salmon farming industry in the nation and is the only state on the Pacific coast to have open-water salmon farming as Alaska, California, and Oregon have either banned it or never had it to begin with (Mapes, 2017). However, following the escape of half the 305,000 farmed Atlantic salmon from Cooke Aquaculture Pacific pens in Puget Sound, Governor Jay Inslee and the Commissioner of Public Lands issued a moratorium of any new or pending permits for fish farming in the state (Mapes, 2017). At present, Washington legislators have passed a bill to phase out non-native finfish farming in Washington marine waters to protect native salmon species (State of Washington, 2018).

These legislative developments leave space for the shellfish aquaculture industry to grow. However, some members of the public are united in opposition against the growth and current operations of shellfish farms. One such organization, The Coalition to Protect Puget Sound, aims to voice public concerns about industrial aquaculture and its impacts and turn those concerns into policy and regulations (Coalition to Protect Puget Sound). This study aims to understand what shellfish aquaculture impacts are most concerning to Washington residents.

In order to evaluate Washington perceptions, this study addresses the following research questions:

1. How do residents in Washington feel about different levels of aquaculture in South Puget Sound?
2. How do different groups of people perceive possible impacts of shellfish aquaculture?
3. How do residents perceive native versus non-native species in local waters?
4. Did the farmed Atlantic salmon escape impact resident perceptions of shellfish aquaculture?

1.3 Understanding Opposition (and Support) using Social Carrying Capacity

One way to better understand social opposition (or support) of aquaculture is through social carrying capacity. Social carrying capacity is the level of use that exceeds acceptable environmental and social impacts in terms of satisfaction, acceptability, desirability, and preference (Dalton et al., 2017). It is important to understand local social dynamics associated with aquaculture farms since over 50% of the human population lives within about 60 miles of the coast and there will be an increase in competition for

coastal resources (Byron et al., 2011). The academic literature has explored ecological impacts of aquaculture yet less attention has been given to the impacts on residents, coastal users, and other stakeholders despite social impacts often having greatest influence on industry growth (Dalton et al., 2017). This lack of extensive academic literature on the social carrying capacity of aquaculture and the social acceptability of different methods of growing seafood represent a policy gap that hinders the continued growth of the aquaculture industry in the U.S.

However, this gap in knowledge might be due to the fact that social carrying capacity of aquaculture is so difficult to understand. Social carrying capacity can be highly variable in the same region because each individual in a community has a different background that affects how they view their local waterways (Gibbs, 2009). For instance, as Gibbs (2009) suggests, a commercial fisher may be more favorable to industry in waterways while a retiree or city commuter might expect tranquility in their backyards. Support for aquaculture can also vary depending on the current economic state of the region. Strong economic growth tends to correspond with low aquaculture support, while more difficult economic times lend to increased support of the industry (Gibbs, 2009). Also, some communities are still distrusting of small aquaculture operations because they believe shellfish farmers will try to gain acceptance in the community by starting out small and then expanding their farms (Gibbs, 2009). At the same time, some farmers hope that while expanding their own operations they are simultaneously stretching the social carrying capacity of the community as well (Gibbs, 2009). These varying factors in each community make it difficult to claim a universal social carrying capacity. Therefore,

it is important to look at a variety of stakeholders to understand what factors are influencing their attitudes.

Social carrying capacity has been studied in various forms. One study by Manning et al. (1999) evaluated crowding norms in Acadia National Park following concerns of increasing bicycle use on historical carriage roads. The study presented participants with 19 images of carriage roads with various levels of pedestrian and recreational activities and asked them to rate the crowd levels from acceptable to unacceptable. Participants were shown an image of an empty road, then an image with a few bikers and pedestrians, then an image with more bikers and pedestrians until the final image showed bikers and pedestrians filling the road. The participants were then asked which levels of visitor use the National Park Service should ultimately allow in the park area (Manning et al., 1999).

The study found that there was less variance in the visual approach (Manning et al., 1999). The visual images would be easier for participants, either visitors or local residents, to agree upon and would be more predictive when evaluating social carrying capacity. Manning et al. (1999) advises future studies using the visual approach to include a wide range of use levels to eliminate bias and low variance in responses. This study will build upon the visual methods described in Manning et al. (1999) by portraying a wide range of use levels in images of aquaculture farms to understand public acceptance of various levels of shellfish aquaculture.

1.4 Applying Social Norm Curves to Shellfish Aquaculture in US West Coast

This study extends Dalton et al.'s (2017) normative evaluation study of shellfish aquaculture in Rhode Island to the U.S. west coast. Flaherty et al. (2018) compared how

the communities on the Pacific and Atlantic coasts of Canada differed in their perceptions of aquaculture and found differences based on location. This study is interested to see how communities on the Pacific coast of the U.S. also differ from communities on the Atlantic coast using the same methods. It will also expand on the methods used in Dalton et al. (2017).

The Dalton et al. (2017) study found that respondent support varied with the intensity of the aquaculture operations. For instance, visible equipment such as a vessel is more likely to face opposition than sites without vessels covering the same amount of space (Dalton et al., 2017). However, the Dalton et al. (2017) study only analyzed one type of aquaculture method. This study further varies levels of farming methods, background settings, and recreational use. In order to understand what specifically deters people from supporting different types of farms, it is important to vary the different types of aquaculture methods such as above water rafts and bottom culture to see if aesthetics or perceived intensity play a factor in the public's perceptions of aquaculture farm development.

This study uses a normative evaluation approach to investigate the social acceptability of shellfish aquaculture in Puget Sound (Washington state). An electronic survey of Puget Sound residents was conducted to examine how different farm, recreational, and environmental factors affect people's support of aquaculture. Examples of factors varied include the farm size, methods to grow shellfish (rafts and bottom culture), and the levels of human activity near the site (house development and recreational use). Residents' characteristics that can influence levels of support for

aquaculture (e.g., seafood consumer preference; proximity of residence to waterfront) are also examined.

CHAPTER 2

METHODOLOGY

2.1 Study area

This study was conducted in coastal communities around Puget Sound, Washington (Fig 1).

Fig. 1 Map of local areas of Puget Sound, Washington
Created by: Katie Rubstello, URI, 2019

Puget Sound is one of the three main sites in this Pacific Northwest state where commercial shellfish aquaculture operations have greatly increased in the past few years (Center For Food Safety, 2016). Puget Sound cultivates a variety of species: Manila clams, mussels, Geoduck clams, Pacific oysters, Eastern oysters, and Kumamoto oysters (Washington Sea Grant, 2015). In South Puget Sound, there are 27,520 acres of tideland and 4,748 of those acres farm shellfish, accounting for 17.3% of the shoreline (Coalition to Protect Puget Sound Habitat and Paul H. Garrison and Betty N. Garrison v. Pierce County, Darrell de Tienne and Chelsea Farms, LLC). In 2013, the South Sound was the top-producing region with 37% total production and almost 58% of the total value (Washington Sea Grant, 2015). There are also social interests in Puget Sound. For

instance, counties surrounding Puget Sound are some of the few counties in Washington in which residents live year round on saltwater waterfront properties (Hudson, 2016).

South Puget Sound is specifically of interest because of its diverse use, presence of endangered species, local environmental advocacy, and its proximity to tribal lands.

Puget Sound is a diverse region split into north, central, and south. Central Puget Sound is home to the large port city of Seattle. However, the surrounding coastal cities of north and south sound are smaller with a diverse level of industry (Table 1).

Table 1. Demographic information of Washington cities and towns surveyed
Sources: State of Washington 2018 Population Trends; United States Census Bureau; University of Washington, Tacoma; Everett WA; Forbes; City of Shelton

Town	Size *land area mi ²	Population *2018 state estimate	Industry
Bremerton	28.41	41,500	Defense Tourism
Everett	33.45	111,200	Technology Aerospace
Gig Harbor	5.95	10,320	Education Healthcare Social Assistance
Lacey	16.06	50,170	Government
Olympia	17.8	52,490	Government
Shelton	5.76	10,140	Logging and Lumber Aquaculture

For instance, Olympia is the capital of Washington and the government and government services employ 25% of all the workers in the surrounding Thurston County area including the city of Lacey (Thurston Regional Planning Council). Nearby is the industrial city of Shelton, the smallest represented in this survey. It was founded around lumber and the lumber mill is still a strong industry in the area as well as the aquaculture industry (City of Shelton, 2017).

Some cities in this survey also represent the naval presence in Washington. Bremerton harbors the Puget Sound Naval Shipyard and Bremerton Annex of Naval Base Kitsap, which both have an economic and political presence in the area (Forbes). Everett, the northern most Puget Sound city in this survey, used to be a mill town built on wood-based industries like many western Washington cities, but is now a commercial seaport and naval station (Everett WA). It also houses The Boeing Co.'s manufacturing complex, which draws numerous aerospace and technology companies to the area (Economic Alliance Snohomish County).

2.2 Data collection

This study utilized an online survey to reach residents in Washington state. We also partnered with Qualtrics, an online survey company, to recruit a sample of Washington residents through a survey panel. Qualtrics handled all recruiting and administered the surveys that we designed. Qualtrics electronically sent participant responses to the research team.

An online survey was chosen for this study because of its many advantages to the research team and survey participants. First, an online survey allowed us to survey a population from across the country. Also, the cultural understanding of computer technology has improved along with the computers and Internet connections themselves (Dillman, 2009). The 2017 Washington Census Bureau reported that 91.4% of households had a computer (The United States Census Bureau). Therefore, an electronic platform makes more sense for a society that has become more reliant on and at ease with technology.

Also, an advantage of this particular method is the ease of showing high quality visual representations of the subject matter to participants (Robson and McCartan, 2016). This is especially important for participants who are not familiar with shellfish aquaculture or cannot visualize certain methods. Manning et al. (1999) compared presenting information to survey participants with numeric and visual methods and found that there was less variance in responses among respondents with the visual based approach than the numeric approach. To overcome distance and present participants with images necessary to create social norm curves, the online survey was the best method for this study.

The survey had several parts (see Appendix A). The first part of the survey used images to evaluate the participant's attitudes towards different levels of shellfish aquaculture in a coastal setting. Similar to Dalton, et al. (2017), our images represented an unidentifiable area in South Puget Sound to which the viewer can relate. The images vary different aquaculture methods such as above water operations (rafts) and bottom culture (posts). The backgrounds are also varied to present a natural landscape (Fig. 2 and 4) versus a developed area including recreational users and residential houses (Fig. 3 and 5). The respondents were asked to evaluate the images using a 7-point likert scale with 1=Very Unacceptable to 7=Very Acceptable

Fig. 2 Shellfish aquaculture rafts in a natural setting

Fig. 3 Shellfish aquaculture rafts in a developed setting

Fig. 4. Shellfish bottom culture (posts) in a natural setting

Fig. 5 Shellfish bottom culture (posts) in a developed setting

The second part of the survey asked about respondent's attitudes toward social and environmental impacts of aquaculture as well as what participants think about Washington aquaculture management and potential policies. The third part asked about participant seafood preferences and whether they were familiar with the farmed Atlantic salmon escape in Puget Sound. The fourth and final part of the survey asked demographic questions of participants and their relationship with the shoreline and coastal waters. These answers allowed us to group participants by individual characteristics.

2.3 Data analysis

Qualitative analysis of social norm curves was used to evaluate respondent reactions to the different scenarios of aquaculture development. A social norm curve (Fig. 6) shows the average acceptability ratings of groups of respondents for an activity at different levels of use. The highest point of the curve presents the optimal (or preferred) condition (Manning et al., 1999). The minimum acceptable condition is where the norm curve crosses the neutral (or zero) point of the acceptability scale (Manning et al., 1999). All points above the neutral point, or line of minimum acceptability, represent what respondents see as the acceptable conditions and below the neutral point are what the respondents have deemed the unacceptable conditions (Manning et al., 1999). In this study, the x-axis represents increasing levels of aquaculture development for rafts or bottom culture (Figures 2-5) and the y-axis represents the mean level of acceptability on the 7-point likert scale.

Fig. 6 Hypothetical norm curve (Source: Manning, 1999)

We also compared the means for various respondent groups. First, we compared means for which respondents were more or less tolerant of particular farming methods in

natural or developed settings. Then we compared means for how respondents perceive possible positive and negative social and environmental impacts of shellfish aquaculture in Washington. Finally, we compared means by respondent demographics including seafood preferences, whether the respondent participates in activities on the shoreline or coastal waters, how close they live to the shoreline, gender, city, and whether the respondent had heard of the farmed Atlantic salmon escape. These means were then visually represented on social norm curves to better understand how different respondent preferences compared with other respondents by group.

2.4 Limitations

There are some limitations for the methods used in this study. First, this study used a third party to recruit respondents. We cannot make any determinations about how Qualtrics recruited the respondents or what incentives respondents had for taking the survey. Also, presenting the participants with visuals in this study may bias responses. For instance, a respondent could be influenced by the order in which photographs are presented and reveal a set of norms that may have been reversed if the order were different (Manning et al, 2002). However, this study presented respondents with a wide variety of images in a random order to help eliminate this potential bias.

CHAPTER 3

RESULTS

3.1 Summary of Participants

This study surveyed 105 people within the Puget Sound area. Of the respondents, 73.3% were female. Age ranged from 18 to 86 years old with the average age being 42.48 years old. Respondents were on average somewhat educated with 32.4% having a minimum of at least some college experience. Only 5.7% either had an advanced graduate degree while 5.7% had some high school. Most participants were scattered around the Puget Sound area with the majority residing in Everett, Olympia, and Bremerton. 57% of respondents do not own their places of residence and 42.8% of people have only lived in their place of residence for 1 to 3 years.

Fig. 7 Map of cities surveyed in Puget Sound, Washington
Created by: Katie Rubstello, URI, 2019

The income brackets of the respondents were more diverse. For example, 21.9% of respondents had household incomes of \$50,000 to \$74,999, while 15.2% had a household income of \$35,000 to \$49,999, and 15.2% had a household income of \$100,000 to \$199,999. The most frequently reported occupations of respondents were homemakers, retired, or unemployed. Of those that indicated that they had a job, office worker or administrator was the most common occupation.

Table 2. Summary of respondents

Variable	Total Sample (n)	Mean or Highest Frequency Category
Age	104	42.48
City	105	Everett
Education	105	32.4% some college
Gender	104	73.3% female
Income	105	\$50,000 to \$74,999
Occupation	96	Homemaker
Own/rent residence	105	57% rent

3.2 Reactions to aquaculture development scenarios and social norms curves

Social norm curves for two types of shellfish aquaculture (rafts; bottom culture) in two different settings (developed; natural) were qualitatively compared for all respondents. Respondents are on average less tolerant of rafts in a developed setting than any of the other types of aquaculture, including rafts in a natural setting, bottom culture in a developed setting, and bottom culture in natural setting. Of the four norm curves, only the curve for raft aquaculture in a developed setting crossed the minimum level of acceptability (=4). As seen in Fig. 8 (a), respondents found 10 rafts in a developed setting to be unacceptable. As a group, respondents find low levels of bottom culture in both natural and developed settings to be most acceptable.

Fig 8 (a) Social norm curves for different levels of raft aquaculture development in natural v. developed settings

Fig 8 (b) Social norm curves for different levels of bottom culture in natural v. developed settings

The means were compared by stated level of agreement (agree, neutral, disagree) for each of the 16 impacts for both raft and bottom culture in natural and developed settings (Table 3). These results show that respondents agree the most positive impact of shellfish aquaculture is that it is *good for Washington's economy*. The negative impact that respondents agreed with the most is that shellfish aquaculture *pollutes the water*.

Table 3. Means of shellfish aquaculture impacts (n=105)
(1=strongly agree to 5= strongly disagree)

	<i>Impact of Shellfish Aquaculture</i>	<i>Mean</i>
<i>Negative impacts</i>	Pollutes the water	3.47
	Displaces wild harvest operations	3.32
	Impinges on rights of tribes	3.26
	Negative impacts on boat navigation/safety	3.25
	Competes with endangered species	3.23
	Threatens marine vegetation	3.14
	Interferes with public access	3.07
	Spoils natural coastal view	3.05
	Displaces recreational harvest	3.05
<i>Positive impacts</i>	Enhances the scenery	3.28
	Improves water quality	3.03
	More environmentally friendly than finfish	3.01
	Reduces wild harvest operations pressure	2.72
	Important to the cultural landscape	2.53
	Healthy seafood option	2.27
	Good for WA's Economy	1.88

Respondents expressed a variety of attitudes toward the positive and negative social and environmental impacts of shellfish aquaculture (Table 4).

Table 4. Number of participants responding to statements related to shellfish aquaculture social and environmental impacts (Percentage of those responding to that question shown in parentheses)

	Agree	Neither	Disagree
Environmental			
<i>Positive</i>			
Improves water quality (n=97)	26 (24.8%)	46 (43.8%)	25 (23.8%)
More friendly than finfish (n=87)	43 (41%)	39 (37.1%)	5 (4.8%)
<i>Negative</i>			
Competes with endangered species (n=93)	21 (20%)	35 (33.3%)	37 (35.2%)
Threatens marine vegetation (n=95)	26 (24.8%)	31 (29.5%)	38 (36.2%)
Social			
<i>Positive</i>			
Healthy nutrition option (n=101)	68 (64.8%)	23 (21.9%)	10 (9.5%)
Important to culture (n=101)	63 (60%)	21 (20%)	17 (16.2%)
<i>Negative</i>			
Spoils view (n=104)	34 (32.4%)	32 (30.5%)	38 (36.2%)
Interferes with public access (n=101)	33 (31.4%)	28 (26.7%)	40 (38.1%)

3.3 Social norm curves by perceived impacts of shellfish aquaculture

3.3.1 Positive environmental impacts

Social norm curves were compared by stated level of agreement (agree, neutral, disagree) for each of the four environmental impacts for both raft and bottom culture in developed settings. (See Appendix A for social norm curves associated with social impacts). Respondents who do not think that shellfish aquaculture *improves water quality* (n=25) seemed less tolerant of aquaculture development than those who thought it improved water quality or thought it had no effect on water quality. For instance,

respondents who think it *does not improve water quality* found raft aquaculture unacceptable at all levels of development (Fig 9a). For bottom culture, they found all levels to be acceptable except for the highest level of bottom culture, 15 posts (Fig 9b). Those that think shellfish aquaculture *improves water quality* (n=26) found all levels of raft and bottom culture development to be acceptable. Similar to those that think shellfish aquaculture *improves water quality*, respondents that were *neutral* (n=46) found all levels of bottom culture to be acceptable (Fig 9b). However, they did not find the maximum level of raft development, 10 rafts, to be acceptable (Fig 9a).

Fig 9 (a) Social norm curves for different levels of raft aquaculture for whether shellfish aquaculture improves water quality

Fig 9 (b) Social norm curves for different levels of bottom culture for whether shellfish aquaculture improves water quality

Table 5. Means and standard deviations compared for different levels of rafts and bottom culture for natural and developed settings for whether shellfish aquaculture improves water quality (Standard deviations shown in italics)

Improves Water Quality		Natural					Developed				
		2	4	6	8	10	2	4	6	8	10
Rafts	Improves	4.73 <i>2.011</i>	5.19 <i>1.415</i>	5.27 <i>1.614</i>	4.69 <i>2.112</i>	4.15 <i>2.344</i>	5.23 <i>1.557</i>	5.08 <i>1.623</i>	4.85 <i>1.642</i>	4.54 <i>2.121</i>	4.27 <i>2.089</i>
	Neutral	5.33 <i>1.634</i>	5.2 <i>1.641</i>	5.2 <i>1.529</i>	4.67 <i>1.687</i>	4.61 <i>1.983</i>	4.8 <i>1.821</i>	4.65 <i>1.689</i>	4.43 <i>1.747</i>	4.04 <i>1.885</i>	3.91 <i>2.031</i>
	Does Not Improve	4.36 <i>1.846</i>	4.32 <i>1.6</i>	4.04 <i>1.567</i>	4.2 <i>2.062</i>	3.76 <i>2.385</i>	3.84 <i>2.035</i>	3.36 <i>1.868</i>	3.08 <i>1.605</i>	3.36 <i>2.099</i>	3.64 <i>2.361</i>
		3	6	9	12	15	3	6	9	12	15
Bottom Culture	Improves	5.23 <i>1.818</i>	5.5 <i>1.364</i>	5.62 <i>1.203</i>	4.58 <i>1.963</i>	4.42 <i>2.266</i>	5.58 <i>1.579</i>	5.62 <i>1.359</i>	4.81 <i>1.877</i>	4.5 <i>1.838</i>	4.54 <i>2.005</i>
	Neutral	5.37 <i>1.691</i>	5.2 <i>1.708</i>	5.22 <i>1.576</i>	4.43 <i>1.996</i>	4.2 <i>2.217</i>	5.07 <i>1.806</i>	5.2 <i>1.628</i>	4.39 <i>1.77</i>	4.15 <i>2.022</i>	4.2 <i>1.928</i>
	Does Not Improve	4.28 <i>2.072</i>	4.84 <i>1.772</i>	4.44 <i>2.329</i>	4.28 <i>2.072</i>	3.64 <i>2.215</i>	4.68 <i>2.096</i>	4.84 <i>1.908</i>	4.16 <i>1.993</i>	4.04 <i>2.071</i>	3.72 <i>2.151</i>

Respondents were also asked whether they think shellfish aquaculture is more environmentally friendly than finfish aquaculture. Those that think shellfish aquaculture is *more environmentally friendly than finfish aquaculture* (n=43) found bottom culture and raft aquaculture to be acceptable at all levels of development. Only five people think shellfish aquaculture is *not more environmentally friendly than finfish aquaculture*, which likely explains the atypical norm curve for this group of respondents. For instance, these

five respondents found eight rafts unacceptable but were accepting of 10 rafts (Fig 10a). They were much more accepting of bottom culture and never dropped below the level of minimum acceptability (Fig 10b). Those that were *neutral* (n=39) found both rafts and bottom culture unacceptable after medium development. This group seems less tolerant of shellfish aquaculture development than the other two groups who either agreed or disagree with the statement that shellfish aquaculture is more environmentally friendly than finfish aquaculture.

Fig 10 (a) Social norm curves for different levels of raft aquaculture for whether shellfish aquaculture is more environmentally friendly than finfish aquaculture

Fig 10 (b) Social norm curves for different levels of bottom culture for whether shellfish aquaculture is more environmentally friendly than finfish aquaculture

Table 6. Means and standard deviations compared for different levels of rafts and bottom culture for natural and developed settings for whether shellfish aquaculture is more environmentally friendly than finfish aquaculture (Standard deviations shown in italics)

More environmentally friendly than finfish aquaculture		Natural					Developed				
		2	4	6	8	10	2	4	6	8	10
Rafts	Is more friendly	4.84	4.98	5.12	4.88	4.65	4.58	4.49	4.21	4.19	4.37
		1.889	1.711	1.451	1.867	2.277	2.026	1.932	2.007	2.085	2.149
	Neutral	4.87	4.92	4.67	4.13	4	4.56	4.41	4.08	3.82	3.44
		1.75	1.44	1.691	1.765	2.013	1.729	1.758	1.612	1.998	1.971
	Is not more friendly	4.4	5.2	4.6	5	3.4	6	4.2	4.6	3.8	5
		2.191	1.789	2.302	2.449	2.608	1.414	2.168	1.817	2.387	2
		3	6	9	12	15	3	6	9	12	15
Bottom Culture	Is more friendly	5.37	5.4	5.58	4.88	4.65	5.05	5.47	4.58	4.49	4.49
		1.662	1.545	1.622	1.892	2.137	1.902	1.453	1.88	2.109	2.028
	Neutral	4.69	4.77	4.79	4	3.69	4.82	4.9	3.97	3.64	3.82
		1.935	1.693	1.689	1.919	2.19	1.76	1.744	1.799	1.814	1.89
	Is not more friendly	5.2	6.2	3.8	5	4	6.2	5.2	5.8	5.4	4.4
		1.483	0.837	2.683	1.871	2.828	0.837	2.049	1.304	1.14	2.191

3.3.2 Negative environmental impacts

We also asked respondents to evaluate shellfish aquaculture's negative environmental impacts. Those that think shellfish aquaculture *does not compete with endangered species* (n=37) found all levels of rafts and bottom culture to be acceptable. Respondents that are *neutral* (n=35) were accepting of all levels of raft aquaculture (Fig

11a) and of bottom culture up to 12 posts (Fig 11b). Respondents that think shellfish aquaculture *competes with endangered species* (n=21) were less tolerant of shellfish aquaculture than the other two groups. For instance, they did not find rafts beyond medium development (greater than six rafts) to be acceptable (Fig 11a). For bottom culture, they dropped below the minimum level of acceptability at 12 posts but were willing to accept the highest level of bottom culture, 15 posts (Fig 11b).

Fig 11 (a) Social norm curves for different levels of raft aquaculture for whether shellfish aquaculture competes with endangered species

Fig 11 (b) Social norm curves for different levels of bottom culture for whether shellfish aquaculture competes with endangered species

Table 7. Means and standard deviations compared for different levels of rafts and bottom culture for natural and developed settings for whether shellfish aquaculture competes with endangered species (Standard deviations shown in italics)

Competes with Endangered Species		Natural					Developed				
		2	4	6	8	10	2	4	6	8	10
Rafts	Competes	4.57 <i>1.748</i>	4.52 <i>1.537</i>	4.33 <i>1.56</i>	3.67 <i>1.853</i>	3.9 <i>2.343</i>	4.33 <i>1.958</i>	4.1 <i>1.947</i>	3.67 <i>1.77</i>	3.57 <i>2.087</i>	3.38 <i>2.312</i>
	Neutral	4.91 <i>1.9</i>	4.97 <i>1.524</i>	5.03 <i>1.248</i>	4.43 <i>1.754</i>	3.8 <i>2.26</i>	4.63 <i>1.734</i>	4.57 <i>1.501</i>	4.31 <i>1.641</i>	4 <i>1.847</i>	4.17 <i>1.886</i>
	Does Not Compete	5.3 <i>1.648</i>	5.32 <i>1.564</i>	5.41 <i>1.674</i>	5.27 <i>1.694</i>	5.05 <i>1.747</i>	5.22 <i>1.813</i>	4.86 <i>1.932</i>	4.68 <i>1.916</i>	4.51 <i>2.036</i>	4.51 <i>2.063</i>
Bottom Culture	Competes	4.67 <i>2.058</i>	4.57 <i>1.805</i>	4.52 <i>1.965</i>	3.95 <i>2.061</i>	3.76 <i>2.278</i>	4.52 <i>2.089</i>	4.71 <i>1.793</i>	4 <i>1.897</i>	3.95 <i>2.085</i>	4.19 <i>2.25</i>
	Neutral	5 <i>1.732</i>	5.17 <i>1.403</i>	5.2 <i>1.694</i>	4.14 <i>1.865</i>	3.83 <i>2.242</i>	5.26 <i>1.738</i>	5.14 <i>1.593</i>	4.34 <i>1.731</i>	3.97 <i>1.871</i>	3.94 <i>1.939</i>
	Does Not Compete	5.51 <i>1.627</i>	5.76 <i>1.517</i>	5.46 <i>1.609</i>	5.16 <i>1.772</i>	4.81 <i>2.066</i>	5.38 <i>1.605</i>	5.65 <i>1.438</i>	4.86 <i>1.873</i>	4.7 <i>1.942</i>	4.65 <i>1.814</i>

Norm curves for whether shellfish aquaculture threatens marine vegetation were also visually compared. Respondents that think shellfish aquaculture *does not threaten marine vegetation* (n=38) were accepting of all levels of rafts and bottom culture. Respondents that think shellfish aquaculture *threatens marine vegetation* (n=26) were much less tolerant of development. For raft aquaculture, they dropped below the minimum level of acceptability after two rafts (Fig 12a). For bottom culture, they

dropped below the minimum level of acceptability after nine posts (Fig 12b).

Respondents that are *neutral* (n=31) were accepting of development up to six rafts (Fig 12a). They were a little more tolerant of bottom culture as they found all levels of development acceptable except for 12 posts (Fig 12b).

Fig 12 (a) Social norm curves for different levels of raft aquaculture for whether shellfish aquaculture threatens marine vegetation

Fig 12 (b) Social norm curves for different levels of bottom culture for whether shellfish aquaculture threatens marine vegetation

Table 8. Means and standard deviations compared for different levels of rafts and bottom culture for natural and developed settings for whether shellfish aquaculture threatens marine vegetation (Standard deviations shown in italics)

Threatens Marine Vegetation		Natural					Developed				
		2	4	6	8	10	2	4	6	8	10
Rafts	Threatens	4.77 <i>1.818</i>	4.46 <i>1.581</i>	4.42 <i>1.579</i>	4 <i>1.811</i>	3.35 <i>2.262</i>	4.12 <i>1.925</i>	3.81 <i>1.855</i>	3.54 <i>1.726</i>	3.5 <i>1.903</i>	3.42 <i>2.139</i>
	Neutral	5.03 <i>1.816</i>	5 <i>1.549</i>	5.1 <i>1.446</i>	4.19 <i>1.973</i>	4.19 <i>2.242</i>	4.97 <i>1.741</i>	4.71 <i>1.596</i>	4.48 <i>1.63</i>	3.94 <i>2.032</i>	3.94 <i>2.112</i>
	Does Not Threaten	4.71 <i>1.887</i>	5.21 <i>1.63</i>	5.05 <i>1.8</i>	5.29 <i>1.691</i>	5 <i>1.86</i>	4.61 <i>1.966</i>	4.42 <i>1.981</i>	4.21 <i>1.919</i>	4.21 <i>2.158</i>	4.13 <i>2.146</i>
		3	6	9	12	15	3	6	9	12	15
Bottom Culture	Threatens	4.85 <i>2.13</i>	4.54 <i>1.702</i>	4.42 <i>1.858</i>	3.92 <i>2.058</i>	3.62 <i>2.08</i>	4.85 <i>2.13</i>	4.73 <i>1.867</i>	4.08 <i>1.719</i>	3.81 <i>1.96</i>	3.62 <i>1.981</i>
	Neutral	4.87 <i>1.803</i>	5.1 <i>1.64</i>	5.23 <i>1.765</i>	4.35 <i>1.976</i>	3.74 <i>2.323</i>	4.87 <i>1.91</i>	5.13 <i>1.607</i>	4.16 <i>1.881</i>	3.9 <i>2.022</i>	4.1 <i>2.166</i>
	Does Not Threaten	5.18 <i>1.753</i>	5.55 <i>1.519</i>	5.39 <i>1.603</i>	4.92 <i>1.836</i>	4.89 <i>2.153</i>	5.24 <i>1.601</i>	5.42 <i>1.553</i>	4.74 <i>1.899</i>	4.61 <i>1.98</i>	4.63 <i>1.866</i>

3.4 Social norm curves by seafood preferences

Another part of this study focused on respondents' seafood preferences. Only four respondents answered that they never eat seafood and six answered that they don't eat seafood in general. We combined these two response groups. Those that *never eat seafood* (n=10) found all levels of raft aquaculture to be acceptable but dropped below the minimum level of acceptability for the highest level of bottom culture development (Fig 17b). Conversely, respondents that *occasionally eat seafood* (n=59) found all levels of bottom culture acceptable but felt that higher levels of raft development were unacceptable (Fig 17a). Respondents that *often eat seafood* (n=36) followed a similar trajectory as those who *occasionally eat seafood*. For instance, they were very tolerant of all levels of bottom culture but felt less positive about the highest level of bottom culture development (Fig 17b). This group also found all levels of raft development acceptable except for the highest level of development, 10 rafts (Fig 17a).

Fig 13 (a) Social norm curves for different levels of raft aquaculture for how often respondents eat any kind of seafood

Fig 13 (b) Social norm curves for different levels of bottom culture for how often respondents eat any kind of seafood

Table 9. Means and standard deviations compared for different levels of rafts and bottom culture for natural and developed settings for how often respondents eat any kind of seafood (Standard deviations shown in italics)

How often do you eat any kind of seafood?		Natural					Developed				
		2	4	6	8	10	2	4	6	8	10
Rafts	Never	3.8	4.5	4.4	4.2	4.1	4.7	4.5	4.3	4.2	4.8
		<i>2.098</i>	<i>1.354</i>	<i>1.265</i>	<i>1.814</i>	<i>2.47</i>	<i>1.767</i>	<i>1.179</i>	<i>1.418</i>	<i>1.751</i>	<i>1.814</i>
	Occasionally	4.8	4.85	4.92	4.59	4.46	4.44	4.31	4.1	3.93	3.8
		<i>1.75</i>	<i>1.574</i>	<i>1.601</i>	<i>1.821</i>	<i>2.12</i>	<i>1.725</i>	<i>1.715</i>	<i>1.678</i>	<i>1.929</i>	<i>2.032</i>
	Often	5.44	5.42	5.19	4.78	4.14	4.97	4.67	4.42	4.11	3.94
		<i>1.647</i>	<i>1.574</i>	<i>1.687</i>	<i>1.944</i>	<i>2.113</i>	<i>2.077</i>	<i>2.138</i>	<i>2.103</i>	<i>2.252</i>	<i>2.254</i>
		3	6	9	12	15	3	6	9	12	15
Bottom Culture	Never	3.6	4.4	4.3	3.8	3.6	4.4	4.3	4.6	4	3.6
		<i>1.897</i>	<i>1.776</i>	<i>2.163</i>	<i>2.348</i>	<i>2.413</i>	<i>2.119</i>	<i>2.003</i>	<i>2.011</i>	2	2.271
	Occasionally	4.95	5.12	5.08	4.64	4.59	4.9	5.15	4.41	4.24	4.41
		<i>1.823</i>	<i>1.641</i>	<i>1.654</i>	<i>1.845</i>	<i>2.102</i>	<i>1.807</i>	<i>1.54</i>	<i>1.693</i>	<i>1.888</i>	<i>1.913</i>
	Often	5.67	5.5	5.36	4.44	3.75	5.58	5.5	4.56	4.31	4.06
		<i>1.549</i>	<i>1.444</i>	<i>1.641</i>	<i>2.006</i>	<i>2.234</i>	<i>1.628</i>	<i>1.577</i>	<i>2.049</i>	<i>2.122</i>	<i>2.042</i>

We also explored how gender affects respondent seafood consumption. Only one male *never eats seafood* while nine females indicated that they *never eat seafood* (Fig 14). This male respondent had a high level of acceptability for each gear type while the females were much less tolerant. For instance, females hovered around the minimum level of acceptability before dropping below at 12 posts (Fig 14b). For those that *occasionally eat seafood*, females were less tolerant of raft aquaculture than males falling below the minimum level of acceptability at six rafts while males found all levels of rafts acceptable (Fig 15a). However, females and males were nearly identical in their responses to bottom culture and were accepting of all levels of posts (Fig 15b).

Finally, we compared females and males that *often eat seafood*. Only seven males indicated that they *often eat seafood*, which explains the variability in the male norm curves. However, these males that *often eat seafood* are less tolerant of shellfish

aquaculture than females that often eat seafood. For instance, females never drop below the minimum level of acceptability for either gear type while males fell below the minimum level of acceptability at nine rafts (Fig 16a). Furthermore, males were much less tolerant of bottom culture finding no levels of posts acceptable (Fig 16b).

Fig 14 (a) Social norm curves for different levels of raft aquaculture for females and males that never eat seafood

Fig 14 (b) Social norm curves for different levels of bottom culture for females and males that never eat seafood

Fig 15 (a) Social norm curves for different levels of raft aquaculture for females and males that occasionally eat seafood

Fig 15 (b) Social norm curves for different levels of bottom culture for females and males that occasionally eat seafood

Fig 16 (a) Social norm curves for different levels of raft aquaculture for females and males that often eat seafood

Fig 16 (b) Social norm curves for different levels of bottom culture for females and males that often eat seafood

We also asked respondents if it is important to them where their seafood comes from. Respondents that indicated it *is important where their seafood comes from* (n=76) were accepting of all levels of bottom culture development (Fig 17b). They were also accepting of rafts except for the highest level of raft development (Fig 17a). Respondents that are *neutral* (n=17) followed almost an identical trajectory to those that care where their seafood comes from. For example, this group found all levels of bottom culture development acceptable (Fig 17b), but they also fell below the minimum level of acceptability at the highest level of raft development (Fig 17a). The respondents that indicated it is *not important where their seafood comes from* (n=5) found only the lowest level of raft development acceptable (Fig 17a). For bottom culture, they were accepting of all levels but unexpectedly most accepting of the highest level of development (Fig 17b).

Fig 17 (a) Social norm curves for different levels of raft aquaculture for whether it is important to respondents where their seafood comes from

Fig 17 (b) Social norm curves for different levels of bottom culture for whether it is important to respondents where their seafood comes from

Table 10. Means and standard deviations compared for different levels of rafts and bottom culture for natural and developed settings for whether it is important to respondents where their seafood comes from (Standard deviations shown in italics)

Is it important to me where my seafood comes from?		Natural					Developed				
		2	4	6	8	10	2	4	6	8	10
Rafts	TRUE	5.07 <i>1.66</i>	5.13 <i>1.561</i>	5.08 <i>1.573</i>	4.78 <i>1.852</i>	4.3 <i>2.191</i>	4.51 <i>1.8</i>	4.43 <i>1.85</i>	4.17 <i>1.893</i>	4.03 <i>2.091</i>	3.87 <i>2.119</i>
	FALSE	4.2 <i>2.168</i>	3.6 <i>0.894</i>	3.4 <i>1.517</i>	3.6 <i>1.949</i>	3.4 <i>2.302</i>	4.6 <i>2.302</i>	3 <i>1.581</i>	3.4 <i>1.14</i>	3.2 <i>1.304</i>	3.6 <i>3.13</i>
	Neutral	4.88 <i>2.027</i>	5 <i>1.696</i>	5.12 <i>1.654</i>	4.41 <i>1.734</i>	4.53 <i>1.972</i>	5.06 <i>2.076</i>	4.94 <i>1.819</i>	4.65 <i>1.693</i>	4.29 <i>1.896</i>	4.18 <i>1.811</i>
		3	6	9	12	15	3	6	9	12	15
Bottom Culture	TRUE	5.32 <i>1.675</i>	5.3 <i>1.566</i>	5.24 <i>1.632</i>	4.61 <i>2.007</i>	4.41 <i>2.24</i>	5.24 <i>1.719</i>	5.36 <i>1.503</i>	4.46 <i>1.928</i>	4.26 <i>2.062</i>	4.22 <i>2.004</i>
	FALSE	4.2 <i>1.643</i>	5.4 <i>0.894</i>	4.4 <i>2.408</i>	5 <i>1.225</i>	3.6 <i>2.702</i>	4.6 <i>1.949</i>	4.4 <i>1.517</i>	5 <i>2.121</i>	4.6 <i>1.949</i>	5.2 <i>1.789</i>
	Neutral	4.82 <i>2.069</i>	5.06 <i>1.676</i>	5.35 <i>1.412</i>	4.53 <i>1.546</i>	4.18 <i>1.741</i>	4.76 <i>1.954</i>	5.18 <i>1.704</i>	4.65 <i>1.272</i>	4.47 <i>1.586</i>	4.47 <i>1.772</i>

Respondents were also asked if they prefer to eat wild-caught or farm-raised shellfish. Those that have *no preference* (n=52) were accepting of raft and bottom culture

development at all levels. Those that *prefer wild-caught shellfish* (n=39) were only accepting of low levels of aquaculture development. For instance, they found raft development acceptable up to six rafts (Fig 18a) and bottom culture development acceptable up to nine posts (Fig 18b). The few that *prefer farm-raised shellfish* (n=5) were surprisingly the least tolerant group of shellfish aquaculture development. For instance, they did not find any levels of raft development acceptable (Fig 18a). However, they were more tolerant of bottom culture and only dropped below the minimum level of acceptability at 15 posts (Fig 18b).

Fig 18 (a) Social norm curves for different levels of raft aquaculture for whether respondents prefer to eat wild-caught or farm-raised shellfish

Fig 18 (b) Social norm curves for different levels of bottom culture for whether respondents prefer to eat wild-caught or farm-raised shellfish

Table 11. Means and standard deviations compared for different levels of rafts and bottom culture for natural and developed settings for whether respondents prefer to eat wild-caught or farmed shellfish (Standard deviations shown in italics)

Prefer to eat...		Natural					Developed				
		2	4	6	8	10	2	4	6	8	10
Rafts	Wild-caught shellfish	5.21 <i>1.436</i>	4.79 <i>1.559</i>	4.72 <i>1.589</i>	4.15 <i>1.885</i>	3.46 <i>2.063</i>	4.51 <i>1.833</i>	4.21 <i>1.838</i>	3.85 <i>1.829</i>	3.46 <i>1.958</i>	3.28 <i>2.012</i>
	Farm-raised shellfish	5 <i>2.345</i>	5 <i>2.236</i>	4.6 <i>2.074</i>	4.2 <i>1.924</i>	4.6 <i>2.074</i>	3.8 <i>2.588</i>	3.2 <i>2.168</i>	3.6 <i>2.074</i>	3.4 <i>2.302</i>	3.2 <i>2.168</i>
	No preference	4.87 <i>1.92</i>	5.23 <i>1.567</i>	5.27 <i>1.598</i>	5.06 <i>1.765</i>	5.02 <i>1.945</i>	4.77 <i>1.864</i>	4.73 <i>1.838</i>	4.58 <i>1.786</i>	4.48 <i>1.995</i>	4.4 <i>2.098</i>
		3	6	9	12	15	3	6	9	12	15
Bottom Culture	Wild-caught shellfish	5.05 <i>1.685</i>	5.03 <i>1.564</i>	4.77 <i>1.677</i>	3.79 <i>1.949</i>	3.59 <i>2.245</i>	5.15 <i>1.725</i>	4.95 <i>1.589</i>	3.87 <i>1.852</i>	3.46 <i>1.833</i>	3.51 <i>1.89</i>
	Farm-raised shellfish	5.4 <i>2.51</i>	5 <i>2.345</i>	4.4 <i>1.817</i>	4.4 <i>2.191</i>	4.4 <i>2.408</i>	4.8 <i>2.387</i>	4.6 <i>2.191</i>	4 <i>1.732</i>	4.4 <i>2.408</i>	3.6 <i>2.074</i>
	No preference	5.29 <i>1.764</i>	5.46 <i>1.488</i>	5.62 <i>1.523</i>	5.21 <i>1.637</i>	4.83 <i>2.007</i>	5.15 <i>1.775</i>	5.58 <i>1.419</i>	5 <i>1.704</i>	4.9 <i>1.85</i>	4.96 <i>1.804</i>

3.5 Social norm curves by demographic groups

Respondents were asked whether they participate in recreational activities along the Puget Sound shoreline or coastal waterways. Those that *participate in activities* (n=54) were accepting of all levels of raft and bottom culture development. Respondents that *don't participate in activities* (n=51) were less tolerant. For raft development, this group fell below the minimum level of acceptability at six rafts (Fig 19a) and for bottom culture development, at nine posts (Fig 19b).

Fig 19 (a) Social norm curves for different levels of raft aquaculture for whether respondents participate in recreational activities

Fig 19 (b) Social norm curves for different levels of bottom culture for whether respondents participate in recreational activities

Table 12. Means and standard deviations compared for different levels of rafts and bottom culture for natural and developed settings for respondents participate in activities (Standard deviations shown in italics)

Do you participate in activities?		Natural					Developed				
		2	4	6	8	10	2	4	6	8	10
Rafts	Yes	5.19 <i>1.854</i>	5.39 <i>1.618</i>	5.24 <i>1.636</i>	4.96 <i>1.913</i>	4.57 <i>2.142</i>	5.11 <i>1.755</i>	4.76 <i>1.863</i>	4.65 <i>1.885</i>	4.31 <i>2.109</i>	4.28 <i>2.141</i>
	No	4.65 <i>1.707</i>	4.61 <i>1.429</i>	4.67 <i>1.532</i>	4.25 <i>1.73</i>	4.04 <i>2.116</i>	4.16 <i>1.848</i>	4.12 <i>1.74</i>	3.78 <i>1.616</i>	3.71 <i>1.879</i>	3.59 <i>2.002</i>
		3	6	9	12	15	3	6	9	12	15
Bottom Culture	Yes	5.69 <i>1.576</i>	5.61 <i>1.583</i>	5.44 <i>1.755</i>	4.87 <i>1.864</i>	4.3 <i>2.237</i>	5.67 <i>1.59</i>	5.74 <i>1.592</i>	5 <i>1.801</i>	4.65 <i>1.954</i>	4.46 <i>1.891</i>
	No	4.41 <i>1.846</i>	4.73 <i>1.511</i>	4.75 <i>1.598</i>	4.1 <i>1.972</i>	4.12 <i>2.179</i>	4.47 <i>1.826</i>	4.61 <i>1.443</i>	3.92 <i>1.719</i>	3.8 <i>1.898</i>	3.94 <i>2.073</i>

We also asked respondents how far they live from the Puget Sound shoreline.

Those that live closest in proximity to the shoreline, *can see the shore from house* (n=8)

or *can walk* (n=26), were accepting of all levels of raft and bottom culture development.

Conversely, respondents that live further from the shoreline were less tolerant of shellfish

aquaculture development. Respondents that *can bike* (n=19) or *have to drive* (n=52) found high levels of raft and bottom culture development to be unacceptable. For example, respondents that *can bike* dropped below the minimum level of acceptability at 10 rafts (Fig 20a). They were more tolerant of bottom culture finding all levels acceptable up to the highest level of development (Fig 20b). Similarly, respondents that *have to drive*, found raft development acceptable up to six rafts (Fig 20a). For bottom culture, they were not accepting of eight or twelve posts yet found the highest level of development, 15 posts, acceptable (Fig 20b).

Fig 20 (a) Social norm curves for different levels of raft aquaculture by proximity to the Puget Sound shoreline

Fig 20 (b) Social norm curves for different levels of bottom culture by proximity to the Puget Sound shoreline

Table 13. Means and standard deviations compared for different levels of rafts and bottom culture for natural and developed settings for how far respondents live from the Puget Sound shoreline (Standard deviations shown in italics)

Approximately how far do you live from the Puget Sound shoreline?		Natural					Developed				
		2	4	6	8	10	2	4	6	8	10
Rafts	See shoreline from house	5 <i>1.069</i>	4.75 <i>1.832</i>	5.13 <i>1.356</i>	4.75 <i>2.252</i>	3.88 <i>2.588</i>	4.63 <i>1.685</i>	4.5 <i>2</i>	4.63 <i>2.066</i>	4.75 <i>2.121</i>	4.38 <i>2.2</i>
	Can walk	5 <i>2.117</i>	4.96 <i>1.708</i>	4.81 <i>1.744</i>	4.65 <i>1.788</i>	4.15 <i>2.185</i>	5.08 <i>1.875</i>	4.69 <i>1.692</i>	4.38 <i>1.699</i>	4.12 <i>1.946</i>	4.04 <i>2.218</i>
	Can bike	5 <i>1.886</i>	5.53 <i>1.429</i>	5.26 <i>1.593</i>	5 <i>1.633</i>	4.42 <i>2.036</i>	4.47 <i>1.896</i>	4.47 <i>1.954</i>	4.16 <i>1.864</i>	4.11 <i>1.997</i>	3.95 <i>2.013</i>
	Have to drive	4.85 <i>1.719</i>	4.88 <i>1.517</i>	4.9 <i>1.6</i>	4.44 <i>1.924</i>	4.42 <i>2.127</i>	4.5 <i>1.873</i>	4.31 <i>1.853</i>	4.12 <i>1.833</i>	3.83 <i>2.065</i>	3.83 <i>2.093</i>
		3	6	9	12	15	3	6	9	12	15
Bottom Culture	See shoreline from house	5.5 <i>1.309</i>	5.63 <i>0.916</i>	5.5 <i>1.069</i>	5 <i>1.604</i>	4.63 <i>1.923</i>	5.5 <i>1.414</i>	5.63 <i>0.744</i>	5.5 <i>1.309</i>	5 <i>1.604</i>	4.88 <i>1.959</i>
	Can walk	5.31 <i>1.692</i>	5.38 <i>1.856</i>	5.35 <i>1.875</i>	4.62 <i>1.813</i>	4.08 <i>2.382</i>	5.27 <i>1.845</i>	5.62 <i>1.722</i>	4.73 <i>1.888</i>	4.62 <i>1.92</i>	4.46 <i>1.816</i>
	Can bike	5.37 <i>1.978</i>	5.11 <i>1.629</i>	5.16 <i>1.772</i>	4.47 <i>1.806</i>	4.11 <i>1.997</i>	5.47 <i>1.744</i>	5.32 <i>1.734</i>	4.95 <i>1.649</i>	4.58 <i>1.924</i>	3.84 <i>1.74</i>
	Have to drive	4.77 <i>1.885</i>	5.04 <i>1.559</i>	4.9 <i>1.695</i>	4.37 <i>2.133</i>	4.25 <i>2.265</i>	4.79 <i>1.851</i>	4.87 <i>1.585</i>	4.02 <i>1.852</i>	3.81 <i>2</i>	4.12 <i>2.166</i>
		3	6	9	12	15	3	6	9	12	15

This study sampled respondents from a variety of cities in the Puget Sound area. Of the 13 cities, only six are represented in this section because they of their greater sample sizes. Respondents from *Bremerton* (n=18) were accepting of raft development up to four rafts (Fig 21a). They were more tolerant of bottom culture and indicated that all levels of development were acceptable (Fig 21b). Respondents from *Gig Harbor* (n=11) also found all levels of bottom culture acceptable (Fig 21b) as well as all levels of raft development except for eight rafts (Fig 21a). Conversely, respondents from *Everett* (n=22) found all levels of raft aquaculture acceptable (Fig 21a) and were accepting of all levels of bottom culture except for 12 posts (Fig 21b). Respondents from *Lacey* (n=11) also found of all levels of bottom culture acceptable (Fig 21b). They were accepting of raft development up to six rafts and then they indicated a low tolerance for the higher

levels of development (Fig 21a). *Olympia* (n=18) had the most tolerant respondents finding all levels of raft and bottom culture development acceptable. Respondents from *Shelton* (n=9) were the least tolerant group. They found all levels of raft development unacceptable (Fig 21a) and were only accepting of the lowest levels of bottom culture development (Fig 21b).

Fig 21 (a) Social norm curves for different levels of raft aquaculture by city

Fig 21 (b) Social norm curves for different levels of bottom culture by city

This study also investigated the relationship between the recent escape of farmed-Atlantic salmon in Washington State and how this event may have affected participant views of native versus non-native species and shellfish farming versus finfish farming in Puget Sound. Respondents that were *familiar* with the incident (n=27) found all levels of raft and bottom culture to be acceptable. Respondents that were *unfamiliar* with the incident (n=68) were less tolerant dropping below the minimum level of acceptability at low to medium levels of development. For raft aquaculture, they only found up to six rafts acceptable (Fig 22a). For bottom culture, they found all levels of development acceptable except for 12 posts (Fig 22b).

Fig 22 (a) Social norm curves for different levels of raft aquaculture by those familiar with farmed Atlantic salmon escape

Fig 22 (b) Social norm curves for different levels of bottom culture by those familiar with farmed Atlantic salmon escape

Table 14. Means and standard deviations compared for different levels of rafts and bottom culture for natural and developed settings for whether respondents are familiar with the farmed Atlantic salmon escape (Standard deviations shown in italics)

Familiar with the farmed Atlantic salmon escape		Natural					Developed				
		2	4	6	8	10	2	4	6	8	10
Rafts	Familiar	5.3 <i>1.66</i>	5.52 <i>1.282</i>	5.26 <i>1.655</i>	4.93 <i>1.752</i>	4.63 <i>1.984</i>	5.19 <i>1.733</i>	4.89 <i>1.739</i>	4.63 <i>1.822</i>	4.44 <i>1.928</i>	4.3 <i>2.072</i>
	Not familiar	5.3 <i>1.829</i>	5.4 <i>1.075</i>	5.4 <i>1.075</i>	4.8 <i>1.687</i>	4.2 <i>2.044</i>	5.1 <i>1.524</i>	4.7 <i>1.16</i>	4.6 <i>0.843</i>	4.6 <i>1.075</i>	4.4 <i>1.43</i>
		3	6	9	12	15	3	6	9	12	15
Bottom Culture	Familiar	5.37 <i>1.548</i>	5.7 <i>1.103</i>	5.48 <i>1.451</i>	4.63 <i>1.884</i>	4.37 <i>2.221</i>	5.85 <i>0.989</i>	5.63 <i>1.334</i>	5.15 <i>1.634</i>	4.78 <i>1.672</i>	4.52 <i>1.827</i>
	Not familiar	5.1 <i>1.853</i>	5.6 <i>1.506</i>	5.6 <i>1.174</i>	5.1 <i>1.449</i>	5.1 <i>1.853</i>	5.1 <i>1.663</i>	5.5 <i>1.434</i>	5.1 <i>1.663</i>	4.7 <i>1.767</i>	4.8 <i>1.549</i>

CHAPTER 4

DISCUSSION

Overall, participants in this study were generally accepting of shellfish aquaculture. This study compared two types of settings (natural; developed) and found that high levels of aquaculture development tend to be least acceptable to respondents across all groups. This study also compared how respondents perceive different gear types (rafts; bottom culture) and found that bottom culture tends to be more acceptable to respondents than surface level raft aquaculture. Even groups that generally believe that an aquaculture farm spoils the natural, coastal view are still accepting of low levels of rafts and bottom culture.

Respondents also indicated that they think shellfish aquaculture has positive social and environmental impacts. In terms of social impacts, the majority of respondents believe shellfish aquaculture is a healthy nutritional option for human consumption, is an important part of Washington's cultural landscape, does not spoil the natural, coastal view, and does not interfere with public access. Also, respondents overwhelmingly agreed that shellfish aquaculture is good for Washington's economy. This aligns with the Flaherty et al, 2018 study in Canada in which respondents on the east and west coasts of the country believed that aquaculture is good for employment and the local economy.

For environmental impacts, respondents also believe shellfish aquaculture is more environmentally friendly than finfish aquaculture, does not compete with endangered species, and does not threaten marine vegetation. Many respondents commented in the

survey that they were accepting of aquaculture as long as it does not harm local wildlife or the environment. One respondent said that any type of aquaculture is “good in moderation so long as the population of the wildlife doesn’t suffer because of it.” This call for moderation supports this study’s findings that respondents are overall much more accepting of low to medium levels of shellfish aquaculture.

Another respondent echoed this sentiment saying, “I hope this study seeks to improve Puget Sound ecosystems while finding balance in providing for human populations.” One other respondent also hopes that shellfish farming continues as long as it is done “without harming the environment.” Therefore, balance of practice and careful regard for Washington’s marine life and natural resources seem important to Washington coastal residents. This follows a similar trend as the Froehlich et al, 2017 study in which they found that U.S. participants were more focused on environmental concerns than participants from other countries surveyed.

4.1 Seafood preference has little impact on tolerance for aquaculture development

The majority of respondents in this study eat seafood. Those that eat seafood also overwhelmingly care where their seafood comes from but most respondents have no preference between wild or farmed shellfish. However, respondents with a preference overwhelmingly prefer wild-caught versus farm-raised shellfish. These findings somewhat support the seafood literature that has found wild-caught is favored because people generally believe it tastes better, is healthier, and safer to eat than farmed seafood (Flaherty et. al, 2018). Brayden et al. (2018) found that wild-harvest products are not universally preferred, as only 53% of participants preferred wild-harvest products, but consumers tend to have less of an aversion to farmed shellfish than finfish. The Brayden

et al. (2018) results also revealed that respondents had a strong preference for products produced in their home state, which aligns with our study's results that people generally care where their seafood comes from. Further research in Washington could look at how residents feel about local seafood and if their support for aquaculture changes based on consumer access to locally grown shellfish.

The results do not show that people who eat seafood are generally more tolerant of shellfish aquaculture than those that don't eat seafood. Even respondents that prefer farm-raised shellfish were not overwhelmingly supportive of aquaculture but were even less supportive of aquaculture development than respondents that prefer wild-caught shellfish or have no preference. While these results are surprising, there could be a couple explanations. For one, the sample of people who *never eat seafood, prefer farm-raised shellfish*, and indicated that it is *not important to them where their seafood comes from* are very small in this survey. Also, it's possible that people who support the farming of shellfish in general simply do not want those farms to be in their local waters.

Additionally, when we compared female and male responses for how often they eat seafood, we found mixed results. For instance, females were overall much less tolerant of shellfish aquaculture. However, males who *often eat seafood* were less tolerant of bottom culture than females who *often eat seafood*. This variation might be due to the low representation of males in this study. Future studies can expand on how gender influences respondent perceptions of shellfish aquaculture and preferences for seafood.

4.2 Proximity from shoreline impacts tolerance for aquaculture development

Results show that people who live further away from the shoreline are less tolerant of high levels of aquaculture than people that can see or easily access the

shoreline from their homes. However, these results may not be representative of all water view residents in Puget Sound since only eight participants living near the shoreline have water views. Nevertheless, these trends are a departure from the Dalton et. al, 2017 Rhode Island study. In Rhode Island, residents with water views were statistically significantly less tolerant of the highest level of development than non-water view residents (Dalton et. al, 2017). A reason for this difference could be the terrain of the two states. In the Rhode Island study, the measure “proximity to the shore” was used to distinguish between residents living along the shoreline and those living inland. Due to Rhode Island’s flatter terrain, if a respondent indicated that they could see the shore from their house, it likely meant they lived directly on the water. However, in Washington, the terrain is more mountainous so if respondents indicate they can see the shore from their house that does not necessarily mean that the shoreline is very accessible. Therefore, Washington residents who can see the water from their house may actually live a significant distance from the water and may not have the same kind of relationship with the shoreline in their backyard.

However, it could also be that people who live closer to the shoreline are more invested in shoreline and coastal activities than other residents. For instance, waterfront residents may have better access to community information about local shoreline activities and be more prone to participating in local meetings to express their opposition (or support) for industry activities near their homes. It’s also possible that respondents that *can bike* or *have to drive* could have different conceptions of what the shoreline should be opposed to those that live close to it. For example, people who can’t see the

shoreline every day may go there to escape human development and expect to see only natural views. This is an area for future study.

4.3 Geographic distribution impacts tolerance for aquaculture development

There was also a difference in perceptions of aquaculture based on geographic distribution of respondents in this study. The more northern cities, such as Bremerton, Everett, and Gig Harbor had generally positive reactions to aquaculture development. Also, residents from Olympia were also accepting of all levels and types of aquaculture development. This could be because there are no aquaculture farms in the waters near Olympia, so residents are not highly exposed to aquaculture conflicts.

In contrast, residents from Shelton had more negative responses to aquaculture development, particularly at higher levels of aquaculture intensity. Shelton is close in proximity to Olympia but the two cities have very different experiences with aquaculture industry activities. For instance, local Shelton waters have many aquaculture farms including controversial geoduck farms that have generated many lawsuits. Geoduck farms differ from other farms represented in this survey because Washington has been expanding its commercial nearshore geoduck production to meet Asian market demands and farms now encompass 200 acres of privately owned tidelands in the Puget Sound (Washington Department of Natural Resources). It is no surprise then that over the years, geoduck aquaculture in the Puget Sound, which is gear and labor intensive, has created social and legal tensions among stakeholders (Ryan et al., 2017). Additionally, one Shelton resident stated that she lives “five miles from Taylor Shellfish,” the largest U.S. producer of shellfish aquaculture headquartered in Shelton. Therefore, residents in

Shelton are much more exposed to aquaculture and farm conflicts than those in other communities in South Puget Sound so it's possible their negative perceptions are influenced by these external factors.

4.4 Farmed Atlantic salmon escape had an impact on tolerances for aquaculture development

From these results, we can infer that the farmed Atlantic salmon escape did not have a negative impact on how residents in Puget Sound perceive shellfish aquaculture in local waters. This finding was surprising as we expected more people would have heard of the escape and that those with knowledge of the escape would have a much higher perception of aquaculture risks. We expected this because recent and local catastrophes leave negative, lasting impressions on coastal communities (e.g., Froehlich et. al, 2017). For instance, public attitudes of offshore aquaculture and offshore development in general were very negative in the Gulf coast following the Deep Horizon spill in 2010 (Froehlich et. al, 2017). Therefore, we expected a similar trend of negative opinion of farmed non-native species and aquaculture in general to follow the escape of the Atlantic salmon. However, there did not seem to be a relationship.

One respondent who had not heard of the Cooke escape offered her own concern regarding native species. She said that Washington should “prevent introducing invasive species that may harm the natural ecosystems.” Like many others in this survey, this respondent is very concerned about the Puget Sound ecosystem in general and it is not specific to the Atlantic salmon escape. Another possible explanation might be that those who are familiar with the escape are more attune to environmental news and issues and are therefore more familiar and comfortable with the idea of aquaculture. Those that are

not as aware of environmental issues may be unfamiliar with aquaculture and, therefore, are less comfortable with waters being farmed in general.

Another respondent who had heard of the Cooke escape did offer some insight into why respondents might know of this farming disaster yet continue to support aquaculture. This person commented: “I approve in general but the Cooke incident shows the need for care/oversight.” Therefore, perhaps the assumption that the Cooke escape would deter people from certain types of aquaculture was flawed. Instead, the escape may have inspired the public to demand more from the industry rather than have a complete ban of its practice. Additionally, different risks are involved with raising finfish than shellfish so it is possible that respondents were able to entirely remove the finfish aquaculture issues from shellfish aquaculture in general.

Studies have found that the greater the perceived risk, the less acceptable the aquaculture industry and government’s planning and management activities will be (e.g., Mazur and Curtis, 2008). The literature suggests that industry transparency, concern for public interest in environmental protection, and public involvement in the industry will only help aquaculture managers as they advocate for aquaculture expansion (e.g., Chu et al., 2010). Following the farmed Atlantic salmon escape, Washington managers could be transparent about what went wrong at this particular farm, what policies are in place to prevent another escape incident, and why managers are less concerned with non-native, farmed shellfish in local waters than non-native, farmed finfish.

4.5 Implications of this study on Washington aquaculture management

Based on the results in this study, farmers that are looking to establish a new farm should consider that local residents of South Puget Sound seem more tolerant of higher

levels of bottom culture than they are of surface water operations. This means that larger bottom culture farms that harvest species such as oysters, clams, and quahogs are more likely to receive public support than the same size of farms with mussel rafts. This may have to do with the fact that aesthetics can affect public support for aquaculture farms. Other studies of aquaculture operations in Puget Sound have found that residents report noise and light pollution from farms and garbage spreading from farming sites onto beaches (e.g., Ryan et al., 2018). Ryan et al. (2018) also found that some people believe the beauty and pristine quality of Puget Sound should be persevered. Since rafts are larger and more visible to the general public than bottom culture on tidelands, residents could be more opposed to the aesthetic qualities of rafts than bottom culture operations.

In regards to impacts of shellfish aquaculture, respondents overwhelmingly agreed that shellfish aquaculture has a positive impact on Washington's economy. Therefore, if managers are promoting shellfish aquaculture in Puget Sound, they do not necessarily need to push an economic message. Instead, managers could focus on the impacts of aquaculture on wildlife and the Puget Sound ecosystem since many respondents indicated in their comments that these particular impacts are most important to them. They could also focus on other water uses such as wild harvest operations, recreational boat paths, tribal use, and public access, since some respondents expressed a negative opinion of aquaculture impacts on these particular uses, which is similar to the findings in Dalton and Jin (2018). One respondent said: "I very much disapprove of the way Washington State handles these issues particularly with regard to their ferry usage in our waterways." Another respondent had concerns about public access, saying she is "not against aquaculture as long as it is minimal and not disruptive to the beauty of Puget

Sound and that access to the beaches of Puget Sound remains a reality for the general public.”

Respondents also expressed having a lack of information about aquaculture. One respondent from Everett commented: “I believe the state can do more to promote aquaculture. We do not hear much about it.” Another respondent thought this study was “informative, as it showed me what the floating docks and random pylons I've seen in our waters over the years really are.” They did not express resistance to the idea of aquaculture but curiosity towards its practice. These comments show that industry transparency and more communication about aquaculture practices in general would be beneficial for Washington residents if the state continues to increase farming activities. This shows that Washington’s Shellfish Initiative has more work to do in the promotion of aquaculture and making a connection with coastal residents.

Managers could also make sure there are positive environmental messages that calm resident fears of water pollution and the threat to endangered species and marine vegetation as these were the highest environmental concerns for respondents. Pollution in the Puget Sound is generally a concern to Washington residents because of the potential impacts on the health of beloved endangered species such as Orcas and salmon. One respondent addressed this pollution concern saying, “The Puget Sound is highly polluted and does not necessarily provide the healthiest aquaculture.” Therefore, while residents might agree that shellfish aquaculture is a positive practice, they may not think the Puget Sound is the right place for farms. For this reason, managers could discuss water quality issues in Puget Sound when promoting shellfish aquaculture.

4.6 Limitations and Further Research

While this study has insight for Washington managers and shellfish growers, there are some limitations that must be considered. First, there could be some issues associated with using a sample provided by Qualtrics. The Qualtrics sample seemed to have a high number of people without jobs, which may be because they have more free time to participate in Qualtrics surveys. The sample size was also biased towards females. Females made up over 50% of the population in seven of the twelve cities sampled (U.S. Census Bureau, 2017). However, the female population never rose above 56%, which makes this study's sample population of 73.3% female not representative of the gender distribution in Puget Sound. A future study could try to diversify the gender sample. Also, this study would have benefited from having more water view residents who may have more interaction with aquaculture and have different interests associated with activity in local waters than those that live further from the shoreline. Future studies could recruit participants using another sampling method than that used by Qualtrics and target a more representative sample of residents.

The sample population provided by Qualtrics was only 105 participants out of a population of 461,154. With a confidence interval of plus or minus 5%, our sample should have been more than double in size to be better representative of the southern Puget Sound population. For our study, the small sample sizes in some groups created volatility in the social norm curves (eg Figure 18). Overall, we cannot be sure that opinions and attitudes towards aquaculture in this study are representative of all South Puget Sound residents due to the sampling methodology employed by Qualtrics.

This study was qualitative in nature exploring trends in public perceptions and how different groups feel about aquaculture in Washington. A future study could expand

these results and explore a more quantitative approach. Future research could also extend this study to understand more about external factors influencing resident attitudes. For instance, this study showed a considerable divide between gender perceptions of aquaculture, as females were more tolerant of aquaculture than males. This is a departure from environmental literature in which females are more attuned to risks than males (Mazur and Curtis, 2008). For aquaculture, this means that females also focus on the negative aspects of farming activities and potential risks of farmed seafood (Mazur and Curtis, 2008). It would also be interesting to further explore Washington residents' perceptions of risk.

Another surprising finding in this study was that so many respondents had not heard of the Cooke farmed Atlantic salmon escape. In order to understand how to reach people about environmental issues, it would be interesting to explore what sources people get their news from and if they follow environmental news. There is also greater opportunity to expand on attitudes of shellfish versus finfish aquaculture since Washington recently banned finfish aquaculture after the Atlantic salmon escape incident (Ryan, 2018). A future study could extend the use of social norms and apply it to how people perceive different levels of finfish aquaculture development since this study did not directly ask about finfish aquaculture.

One study could explore whether residents think the ban of finfish aquaculture is good for Washington. Since many residents think aquaculture is good for the economy but also think protecting local wildlife and the environment is important, the study could explore how people understand and rationalize this policy decision. It could also explain to residents that more non-native oysters are raised in Washington waters rather than the

native, Olympic oyster, which many people may not know. Then, instead of just asking residents if Washington should raise only native species, the study could ask if Washington should focus on reintroducing the Olympic oyster and phasing out the non-native oysters. Then the study could look at social norm curves for whether prefer the native or non-native oyster.

Further studies could also expand on people's relationship with seafood and their concept of raising native or non-native species. In this study, the sample size was very small for people who did not eat seafood or care about where their seafood comes from. A future study could explore why Washington residents eat a lot of seafood as well as why they care where their seafood comes from.

CHAPTER 5

CONCLUSION

Aquaculture farms have been met with public resistance in the U.S. as the industry grows to keep up with human demand. This study surveyed Washington residents in the Puget Sound area and examined levels of acceptability for various levels of different methods of shellfish aquaculture in Puget Sound using social norm curves. Findings revealed that balance and moderation is key to public support of a shellfish farms in southern Puget Sound waters. Respondents in this study are overall accepting of both raft and bottom culture shellfish farms in natural and developed settings. However, respondents are more accepting of bottom culture overall than they are of raft aquaculture. Nevertheless, respondents still find lower levels of raft aquaculture acceptable. Therefore, Washington managers and shellfish farmers are more likely to have public support if the farms are smaller with low to medium levels of development and if farmers use bottom culture practices.

The results of this study show that if Washington wants to be a leader in the U.S. shellfish aquaculture industry, there is room to improve on public communication. For instance, the majority of participants in this study had not heard of the most recent major environmental disaster in Puget Sound, the 2017 farmed Atlantic salmon escape from Cooke Aquaculture Pacific net pens. Additionally, many participants expressed unfamiliarity with aquaculture in general. Participants overwhelmingly agreed that

aquaculture is good for the economy and a good nutritional option but had concerns about public access, use conflict, and local environmental disruption.

Future studies can expand upon the use of social norm curves to determine how residents feel about shellfish and finfish aquaculture in general. The use of social norm curves could extend to how residents feel about harvesting the oceans in general and how they perceive the state of fisheries or fish populations in general. This could give managers insights into how residents feel about shellfish harvesting activities and what methods they find acceptable. There is also further opportunity to build upon the understanding of how people receive their news or what types of groups seek out environmental information to guide managers in improving their communication about the industry for possibilities of future aquaculture development in local coastal waters.

APPENDIX A: SUPPLEMENTAL NORM CURVES

Fig 23 (a) Social norm curves for different levels of raft aquaculture for whether shellfish aquaculture is a healthy nutritional option

Fig 23 (b) Social norm curves for different levels of bottom culture for whether shellfish aquaculture is a healthy nutritional option

Fig 24 (a) Social norm curves for different levels of raft aquaculture for whether shellfish aquaculture is important to the cultural landscape

Fig 24 (b) Social norm curves for different levels of bottom culture for whether shellfish aquaculture is important to the cultural landscape

Fig 25 (a) Social norm curves for different levels of raft aquaculture for whether shellfish aquaculture spoils the natural coastal view

Fig 25 (b) Social norm curves for different levels of bottom culture for whether shellfish aquaculture spoils the natural coastal view

Fig 26 (a) Social norm curves for different levels of raft aquaculture for whether shellfish aquaculture interferes with public access

Fig 26 (b) Social norm curves for different levels of bottom culture for whether shellfish aquaculture interferes with public access

Fig 27 (a) Social norm curves for different levels of raft aquaculture by gender

Fig 27 (b) Social norm curves for different levels of bottom culture by gender

APPENDIX B: COPY OF SURVEY

Social Carrying Capacity of Shellfish Aquaculture in South Puget Sound Washington

Welcome to my survey about shellfish aquaculture in Washington.

I am a graduate student at the University of Rhode Island and this research is being conducted as part of my master's thesis.

The purpose of this survey is to better understand how people perceive shellfish aquaculture in Washington, specifically in South Puget Sound. There are 4 parts to this survey:

Part 1) You will evaluate images of shellfish aquaculture

Part 2) You will rate your range of agreement/disagreement with statements about aquaculture and WA management in general

Part 3) You will be asked about your seafood preferences

Part 4) You will be asked about your own activities and relationship to WA coastal waters

Thank you for your participation! Your answers are very helpful in helping me collect data for my research.

Click the arrow below to be taken to the consent form.

Consent Form

You are being asked to take part in a research study. The purpose of the research is to better understand how people perceive shellfish aquaculture in Washington. Anyone who is 18 years or older is eligible to participate. Please read the following before agreeing to be in this study. If you agree to be in this study, it will take you approximately 15-20 minutes to complete the survey. You will be asked to evaluate images of shellfish aquaculture farms with varying levels of aquaculture intensity and answer questions about your views of aquaculture in Washington overall. There are no known risks, benefits or compensation. Your responses will be strictly anonymous. The survey will not ask for any identifying information. The responses may be used for scholarly purpose and aggregate data may be shared or published. This survey is completely voluntary. You may refuse to take part in the study at any time without affecting your relationship with the investigators of this study or the University of Rhode Island (URI). Your decision will not result in any loss of benefits to which you are otherwise entitled. You have the right to not answer any single question, as well as to withdraw completely from the survey at any point during the process. Additionally, you have the right to request that the researchers not use any of your responses. You have the right to ask questions about this research study and to have those questions answered by me before, during or after the research. If you have any questions about the study at any time feel free to contact me at krubstello@my.uri.edu or my advisor, Tracey Dalton from the Department of Marine Affairs at the University of Rhode Island (URI), at dalton@uri.edu. Additionally, you may contact the URI Institutional Review Board (IRB) if you have questions regarding your rights as a research participant. You may also contact the IRB if you have questions, complaints or concerns that you do not feel you can discuss with the investigators. The University of Rhode Island IRB may be reached by phone at (401) 874-4328 or by e-mail at researchintegrity@etal.uri.edu. You may also contact the URI Vice President for Research and Economic Development by phone at (401) 874-4576. If you would like to keep a copy of this document for your records, please print or save this page now. You may also contact the researcher to request a copy. By clicking below to be taken to the survey, you indicate that you are 18 years or older, have read and understood the above, and volunteer to participate in this study.

- ☐ Agree
- ☐ Disagree

What is your age? _____

What is your primary residence?

- ☐ City _____
- ☐ State _____
- ☐ Zip code _____
- ☐ How many years have you lived in this home? _____
- ☐ Do you own this home? (Yes/No) _____

Part 1

The following 10 images show varying intensities of mussel aquaculture. Each image will have a mussel raft used in farming mussels and some images will represent various uses of WA coastal waters.

Tell us what you think about each of these settings showing possible scenarios of shellfish aquaculture farms. For each setting, SELECT ONE RESPONSE on a scale of 1 to 7 where 1=Very Unacceptable to 7=Very Acceptable.

Very
unacceptable

☐ 1

☐ 2

☐ 3

☐ 4

☐ 5

☐ 6

Very
acceptable

☐ 7

Very
unacceptable

☐ 1

☐ 2

☐ 3

☐ 4

☐ 5

☐ 6

Very
acceptable

☐ 7

Very
unacceptable

☐ 1

☐ 2

☐ 3

☐ 4

☐ 5

☐ 6

Very
acceptable

☐ 7

Very
unacceptable

☐ 1

☐ 2

☐ 3

☐ 4

☐ 5

☐ 6

Very
acceptable

☐ 7

Very
unacceptable

☐ 1

☐ 2

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Very
acceptable

☐ 7

Very
unacceptable

☐ 1

☐ 2

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☐ 6

Very
acceptable

☐ 7

Very
unacceptable

☐ 1

☐ 2

☐ 3

☐ 4

☐ 5

☐ 6

Very
acceptable

☐ 7

Very unacceptable Very acceptable

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7

Very unacceptable Very acceptable

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7

Very
unacceptable

☐ 1

☐ 2

☐ 3

☐ 4

☐ 5

☐ 6

Very
acceptable

☐ 7

The following 10 images show varying intensities of oyster aquaculture in the tidal zone. Each image will have oyster posts used to mark where the farm is.

Tell us what you think about each of these settings showing possible scenarios of shellfish aquaculture farms. For each setting, SELECT ONE RESPONSE on a scale of 1 to 7 where 1=Very Unacceptable to 7=Very Acceptable.

Very
unacceptable

☐ 1

☐ 2

☐ 3

☐ 4

☐ 5

☐ 6

Very
acceptable

☐ 7

Very
unacceptable

☐ 1

☐ 2

☐ 3

☐ 4

☐ 5

☐ 6

Very
acceptable

☐ 7

Very
unacceptable

☐ 1

☐ 2

☐ 3

☐ 4

☐ 5

☐ 6

Very
acceptable

☐ 7

Very
unacceptable

☐ 1

☐ 2

☐ 3

☐ 4

☐ 5

☐ 6

Very
acceptable

☐ 7

Very
unacceptable

☐ 1

☐ 2

☐ 3

☐ 4

☐ 5

☐ 6

Very
acceptable

☐ 7

Very
unacceptable

☐ 1

☐ 2

☐ 3

☐ 4

☐ 5

☐ 6

Very
acceptable

☐ 7

Very
unacceptable

☐ 1

☐ 2

☐ 3

☐ 4

☐ 5

☐ 6

Very
acceptable

☐ 7

Very
unacceptable

☐ 1

☐ 2

☐ 3

☐ 4

☐ 5

☐ 6

Very
acceptable

☐ 7

Very
unacceptable

☐ 1

☐ 2

☐ 3

☐ 4

☐ 5

☐ 6

Very
acceptable

☐ 7

Very
unacceptable

☐ 1

☐ 2

☐ 3

☐ 4

☐ 5

☐ 6

Very
acceptable

☐ 7

Part 2

For each statement, SELECT ONE RESPONSE on a scale of 1 to 5 where 1=Strongly Disagree and 5=Strongly Agree:

I think shellfish aquaculture...

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	I Don't Know
is good for WA's economy	☐	☐	☐	☐	☐	☐
pollutes the water	☐	☐	☐	☐	☐	☐
has negative impacts on navigation and boat safety	☐	☐	☐	☐	☐	☐
is an important part of the cultural landscape	☐	☐	☐	☐	☐	☐
enhances the scenery	☐	☐	☐	☐	☐	☐
displaces wild harvest operations	☐	☐	☐	☐	☐	☐
is more environmentally friendly than finfish aquaculture	☐	☐	☐	☐	☐	☐
spoils the natural coastal view	☐	☐	☐	☐	☐	☐

For each statement, SELECT ONE RESPONSE on a scale of 1 to 5 where 1=Strongly Disagree and 5=Strongly Agree:

I think shellfish aquaculture...

	Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree	I Don't Know
improves water quality	☐	☐	☐	☐	☐	☐
threatens marine vegetation	☐	☐	☐	☐	☐	☐
displaces recreational shellfish harvest	☐	☐	☐	☐	☐	☐
competes with endangered species	☐	☐	☐	☐	☐	☐
reduces environmental pressures from wild harvest operations	☐	☐	☐	☐	☐	☐
provides a healthy option for meeting people's nutritional needs	☐	☐	☐	☐	☐	☐
interferes with public access	☐	☐	☐	☐	☐	☐
impinges on rights of tribal communities	☐	☐	☐	☐	☐	☐

I think...

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	I don't know
There is too much aquaculture in Puget Sound	☐	☐	☐	☐	☐	☐
There should be more aquaculture in Puget Sound	☐	☐	☐	☐	☐	☐
Public involvement and opinion is valued by the state agency (WA Department of Natural Resources) responsible for managing aquaculture	☐	☐	☐	☐	☐	☐
The WA Department of Natural Resources is trustworthy	☐	☐	☐	☐	☐	☐

WA state should enact policies to make sure...

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	I don't know
all farm-raised seafood is native to WA water	☐	☐	☐	☐	☐	☐
aquaculture farms only raise shellfish, not finfish	☐	☐	☐	☐	☐	☐
Aquaculture activities include a mix of products (shellfish, finfish, kelp)	☐	☐	☐	☐	☐	☐

Part 3

Are you familiar with the Cooke Aquaculture Atlantic salmon escape in the Puget Sound in August 2017? (Select one)

- ☐ Yes
- ☐ No
- ☐ Not sure

How often do you eat any kind of seafood?

- ☐ Never
- ☐ Occasionally
- ☐ Often
- ☐ I don't eat seafood

It is important to me where my seafood comes from.

- ☐ True
- ☐ False
- ☐ Neither true nor false
- ☐ I don't eat seafood

I prefer to eat...

- ☐ Wild-caught shellfish
- ☐ Farm-raised shellfish
- ☐ No preference
- ☐ I don't eat seafood

Part 4

The following questions ensure that all groups are fairly represented in the research study. All answers are anonymous and confidential.

Approximately how far do you live from the Puget Sound shoreline?

- ☐ I can see the shoreline from my home
- ☐ I can walk
- ☐ I can bike
- ☐ I have to drive (Please enter the number of miles you need to drive to get to the shoreline from your home:) _____

Do you participate in recreational activities along WA's shoreline or coastal waterways?
(Check one)

- ☐ Yes
- ☐ No

Which activities do you participate in? (Check all that apply)

- ☐ Swimming
- ☐ Kayaking
- ☐ Paddle boarding
- ☐ Sunbathing/ relaxing
- ☐ Birding
- ☐ Motor boating
- ☐ Sailing
- ☐ Recreational fishing
- ☐ Bicycle riding
- ☐ Wind surfing
- ☐ Hiking
- ☐ Shellfish harvesting
- ☐ Other _____

Have you participated in shellfish aquaculture planning or management? (Check one)

- ☐ Yes
- ☐ No

Do you belong to any community organizations (Check one)

- ☐ Yes
- ☐ No

What is your primary occupation? _____

What is your second job (if applicable) _____

What is your gender? _____

What is the highest level of school that you completed? (Check one)

- ☐ Less than high school
- ☐ Some high school
- ☐ Completed high school or GED
- ☐ Some college
- ☐ Associate's degree
- ☐ Bachelor's degree
- ☐ Graduate or advanced degree

What is your annual household income before taxes (check one)?

- ☐ Less than \$15,000
- ☐ \$15,000 to \$24,999
- ☐ \$25,000 to \$34,999
- ☐ \$35,000 to \$49,999
- ☐ \$50,000 to \$74,999
- ☐ \$75,000 to \$99,999
- ☐ \$100,000 to \$199,999
- ☐ \$200,000 or more

Comments

Please use this section to comment on this study or to give your input on Washington's waters, state agencies, or views on aquaculture in general

You have reached the end of the survey. Click the right arrow below to record your answers and complete the survey. Thank you for your responses!

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