

Health Risks and Gastronomic Rewards of Oyster Consumption in Washington State:

The Raw Facts

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**Abstract**

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Raw oyster consumption patterns and trends in Washington are assessed to inform the Washington State Department of Health (DOH) vibriosis risk assessment models. *Vibrio parahaemolyticus* is the primary naturally-occurring bacterium of concern and is associated with a number of raw oyster-related illnesses each year. As DOH moves to a risk-per-serving analysis in future risk assessment models, raw oyster data points like average serving size are highly relevant. With insight from local restaurateurs, oyster farmers and public health authorities, a raw oyster consumption survey was created and distributed at Seattle-area restaurants and seafood retailers and through social media outlets. Average raw oyster serving size, consumption frequency and other key data was collected from 502 participants during a seven month period from 2014 to 2015. A typical raw oyster consumer in Washington is in his or her early forties, eats seven raw oysters per sitting but does so only once every two months, and favors freshness and locality over affordability. Non-resident, male participants older than the average sample age

of forty-two were found to eat the largest quantities of raw oysters per sitting. The DOH can use these data to inform risk-per serving illness assessments on vibriosis, but possibly other pathogens associated with shellfish consumption as well. This study also offers a fresh perspective on seafood consumption data collection methodologies specific to the fine-dining sector.

## Table of Contents

<b>Introduction</b> .....	8
<i>Research Questions and Goals</i> .....	11
<i>Data Applications and Limitations</i> .....	11
<b>Methods</b> .....	14
<i>Key Informant Interviews</i> .....	14
<i>Identifying Study Partners</i> .....	15
<i>Survey Card Data Collection</i> .....	17
<i>Online Survey Data Collection</i> .....	19
<i>Analytical Approach</i> .....	21
<i>HSD Exempt Status</i> .....	23
<b>Results</b> .....	24
<i>Preliminary Assumptions</i> .....	24
<i>Survey Results</i> .....	25
<i>Demographic Comparisons of Total Sample</i> .....	44
<i>Demographic Comparisons of Serving Size Outliers</i> .....	50
<b>Discussion</b> .....	54
<i>Serving Size</i> .....	54
<i>Serving Size Outliers</i> .....	58
<i>Consumption Frequency</i> .....	61
<i>Preferred Times to Eat Raw Oysters</i> .....	62
<i>Purchasing Locations</i> .....	64
<i>Favorite Oyster Varieties and Types</i> .....	66
<i>Oyster Size Preference</i> .....	67
<i>Evaluating Raw Oyster Qualities</i> .....	67
<i>Participant Gender Ratio</i> .....	69
<i>Survey Exposure Challenges and Successes</i> .....	70
<i>Research Limitations</i> .....	72

<b>Conclusion</b> .....	73
<b>Appendices</b> .....	77
<b>Supplementary Figures</b> .....	82
<b>References</b> .....	93

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## Introduction

In recent years, raw oysters served on the half-shell have become a ubiquitous menu item at fine-dining restaurants across the U.S. (Wolf 2013). According to oyster growers this demand is a recent phenomenon. Island Creek Oysters, a company based in Duxbury, Massachusetts, has grown from roughly 50,000 oysters produced in 2001 to nearly 5 million produced last year (Wolf 2013). The Chesapeake Bay has seen an 806% increase in commercial oyster landings from 2006 to 2012 (Stewart 2014). Taylor Shellfish in Washington claims to have tripled its business in the last 10 years (Docter, pers. comm., 2015). As oyster farmer and trademark owner of the “Naked Cowboy” oyster variety, Chris Quartuccio told *Bloomberg Pursuits* magazine in 2013, “Everyone’s growing oysters,” these days to meet an incredible new demand for raw oysters in the US (Green 2013; Wolf 2013). “There’s a resurrection of oysters, it’s hard to keep up with it all,” remarked New York City chef and oyster bar veteran Kristof Zyzka (2013).

To date, there has been no formal research to quantify this trend and assess its public health implications. This data gap is proving detrimental to both public and private sector stakeholders. The food safety community and shellfish consumers are concerned about recent reports from the Center for Disease Control and Prevention (CDC) regarding increases in reported cases of *V. parahaemolyticus*-associated illnesses, or vibriosis (Scallan et al. 2011). While most foodborne illnesses are declining in the United States reports of vibriosis continue to increase despite an increase in harvest and temperature controls at the national and state level for shellfish harvest (CDC 2013). *V. parahaemolyticus* is temperature sensitive and as waters warm past a 10 degrees Celsius threshold, bacteria growth rate increases considerably (Desenclos et al. 1991). In addition to the potential for shellfish to be harvested with levels of bacteria that can cause illness immediately present in the tissues, without proper temperature control along the

supply chain there is potential for the bacterium to increase and cause illness post-harvest (Desenclos et al. 1991).

However uncertainties regarding the infectiousness of *V. parahaemolyticus* persist. It is unclear how many grams of *V. parahaemolyticus* transmit the illness and whether eating greater amounts of raw oysters would increase the chance of contracting vibriosis because epidemiological data does not match volunteer studies conducted by the Food and Agricultural Organization (2011). Food safety officials are seeking clarity on these issues to improve vibriosis illness mitigation (DePaola, pers. comm., 2015; Johnson, pers. comm., 2015).

“When ingested, *V. parahaemolyticus* causes watery diarrhea often with abdominal cramping, nausea, vomiting, fever and chills. Usually these symptoms occur within 24 hours of ingestion. Illness is usually self-limited and lasts 3 days.” (CDC 2013). The CDC considers severe vibriosis rare and in most cases treatment is not necessary (CDC 2013). Vibriosis has historically been underreported and underdiagnosed due to its mild symptoms but also due to challenges associated with properly conducting the lab tests (Scallan et al. 2011). Thus the actual number of vibriosis cases is considered to be much greater than the number of reported cases. The CDC relies on the Cholera and Other *Vibrio* Illness Surveillance Report (COVIS), a four-page checklist document for patients and their doctors to describe the illness and submit back to the CDC (CDC 2015). The COVIS system is meticulous in its details but is still a passive reporting tool that relies on the diligence of the patient. Efforts are being made to better inform the public of risks associated with consuming raw shellfish and laboratory capacity is also improving (Johnson, pers. comm., 2015). In Washington State, and now nationally as well, vibriosis is a notifiable condition and medical facilities are required to send samples to the state public health lab for confirmation testing (Vibriosis in Shellfish 2013).

The uncertainties surrounding vibriosis in Washington State are compounded by a fairly consistent number of reported cases in recent years. Despite an encouraging drop in reported cases in 2015 – possibly due to a new risk-based approach emphasized in the most recent DOH *V. parahaemolyticus* Critical Control Plan – illnesses remain well above 40 cases per year (Figure I-1) (Washington Department of Health 2015). Sporadic illnesses are still common in the warmer months despite the DOH’s best efforts (Figure I-2) (Johnson 2015).

A minimum research requirement for public health and environmental management purposes is to quantify the risk of exposure to pathogens by assessing the quantity of raw oysters consumed by an individual. This input into all models of food-borne disease risk assessment is unavailable for the Pacific Northwest – the largest oyster-producing region in the US (Aquaculture in the United States 2015). Existing input models are outdated and utilize consumption data from Florida (FDA 2005). Understanding regional raw oyster consumption patterns is essential for a meaningful risk-per-serving analysis.

Oyster growers share an interest in this research because they feel confident that their handling practices are not contributing to the increase in reported cases of vibriosis (Dewey, Docter, and Bloomfield, pers. comm., 2015). Instead they cite new users farther along the supply chain who are not familiar with handling raw shellfish as the primary catalyst for continued vibriosis challenges (Dewey, Docter, and Bloomfield, pers. comm., 2015). The Washington Shellfish Initiative reported that the shellfish industry in Washington State generates \$270 million towards the economy (2011). Vibriosis is not only a public health issue but an economic concern as well (Washington Shellfish Initiative 2011). Thus in addition to informing exposure risk for local consumers based on their raw oyster consumption rates, this study has the potential to elucidate these broader concerns.

### *Research Questions and Goals*

The goal of this study is to inform the DOH's process of regionalizing the U.S. Food and Drug Administration (FDA) *V. parahaemolyticus* risk assessment model by providing key data on raw oyster consumption in Washington. The research aims to answer the following questions:

- What is the average serving size of raw oysters?
- How often do consumers eat raw oysters?
- What time of year are consumers eating raw oysters?

Key considerations for evaluating the results include:

- What are the key demographics for raw oyster consumption in Washington?
- How can the answers to these and other consumer survey questions aid DOH and FDA in refinement of the risk assessment process?

### *Data Applications and Limitations*

Current vibriosis risk assessment models revolve around a risk per serving analysis (FDA 2005). Therefore raw oyster serving size data that is consistent with modern consumption trends is essential. However according to Dr. Angelo DePaola, a lead seafood microbiologist for the FDA and a key informant in this study, current data are outdated and poorly equipped to assess modern trends (Pers. comm., 2015). An oyster consumption study conducted through phone surveys in Florida in 1991 was used in the FDA *V. parahaemolyticus* risk assessment (Desenclos

et al. 1991). But in addition to being outdated and potentially irrelevant in a Pacific Northwest regional context, Desenclos et al. did not specify between raw or cooked oysters when conducting the surveys (1991). The average oyster serving size based on that study was 13 oysters (Desenclos et al. 1991). Most key informants within the shellfish industry believe 13 oysters is not an accurate raw oyster serving size (Docter, Dewey, Barrette, pers. comm., 2015). The primary objective of our research is to provide an accurate average serving size of raw commercially-harvested oysters in Washington.

While establishing a regionally-appropriate serving size is most applicable to regionalizing the FDA vibriosis risk assessment model, other relevant data points could be found with this study. Consumption frequency data, specifically how often the average consumer eats raw oysters, or at what times during the year they feel most inclined to eat raw oysters, may also prove informative for future vibriosis risk assessment. Other findings such as preferred oyster size and comparing freshness with other factors like price and place of harvest may be better suited to private sector stakeholder interests, but could serve an important purpose in future risk assessment studies, and were included in this study.

Washington-specific raw oyster consumption data collected in this study is immediately relevant for a new vibriosis risk calculator built by Dr. John Bowers and Dr. Angelo DePaola of the FDA (Interstate Shellfish Sanitation Conference 2015). This new calculator was recently reported at the 2015 Interstate Shellfish Sanitation Conference and is a tool available to states to meet the National Shellfish Sanitation Program's (NSSP) Guide for the Control of Molluscan Shellfish requirements for State Shellfish Authorities (i.e., the Washington DOH) to respond to shellfish related illnesses associated with *V. parahaemolyticus* (2015). The calculator is designed to be modified by states if and when region-specific data are available.

This study also aims to impact future revisions of Washington State's *V. parahaemolyticus* Control Plan (Washington Department of Health 2015). Laura Johnson and other health officials at DOH assisted with the design of this study specifically to allow future revisions to new risk-based approaches to vibriosis in the Washington Administrative Code (Pers. comm., 2015). The intention is to revise the current Control Plan to consider a risk-per-serving analysis. Hershman Marine Policy Fellowship recipient Hilary Browning developed a conceptual model of the Washington State risk assessment for *V. parahaemolyticus* in raw oysters which includes serving size as a key component to determining the risk of illness (Figure I-3) (2014).

Time and resource limitations were a factor during this study. Collecting data from all of Washington's raw oyster-eating demographics was not possible under the current study scope. Part of the challenge was constructing the survey and assembling participants for a food that is primarily consumed in restaurants, rather than bought in a retail setting. There were not comparable restaurant studies to emulate. Another aim of this study was to develop a framework for future studies both to expand the data set for risk assessment models, but also to inform other food systems studies on how to best collect data from the private restaurant sector. In lieu of Bowers and DePaola's vibriosis risk calculator, region-specific consumption data will become increasingly important and hopefully this study can offer a framework for data collection in other regions.

## Methods

We utilized three data collection methodologies in this study. We conducted a literature review of relevant survey methodologies, comparable restaurant studies, and recent *V. parahaemolyticus* findings to determine an appropriate analytical approach and to identify significant information gaps. Next, we interviewed key informants in this field, including foodborne illness experts, Washington oyster growers, Seattle area chefs and restaurateurs, to provide an important frame of reference for the literature review and the data to be collected. Finally we used survey methodologies in the form of survey cards and an internet survey tool which composed the bulk of the raw data collection needed to address the research questions.

### *Key Informant Interviews*

We conducted interviews with key informants before survey creation to effectively shape the periphery survey questions (those not directly pertaining to serving size) and to better understand the trajectory of the Washington State raw oyster industry over the last decade. In total, nine interviewees participated in this effort. They included three oyster growers, two industry informants, two vibriosis informants, and two Seattle-area chefs. These key informants were treated similarly to “elites” as defined by David Richards and J.M. Berry (1996, 2002). In a traditional interview:

“The investigator defines the question and the problem; he is only looking for answers within the bounds set by his presuppositions. In elite interviewing, as here defined, however, the investigator is willing, and often eager to let the interviewee teach him what the problem, the question, the situation, is – to the limits, of course, of the interviewer’s

ability to perceive relationships to his basic problems, whatever these may be.” (Richards 1996).

It was important to let key informants shape the interview and provide considerations and research strategies we may have overlooked. We used two lists of questions for the key informant interviews; one for restaurateurs and one for oyster growers (Appendix I). But true to Richards’ style, interviews were semi-structured to facilitate extra anecdotes that might be relevant but were not anticipated.

Initial interviews occurred in the Spring and Summer of 2014. One year later, in the final stages of the study, we conducted follow-up interviews to discuss the results and potential ramifications of the study findings. The interview format was again semi-structured, focusing on interviewee personal reactions to the results of each survey question. Interviewees were asked which results were most surprising to them and why, and which results were consistent with their pre-survey expectations. Lastly interviewees were asked to consider how the results might affect raw oyster consumers, the Washington raw oyster industry, and Washington public health policy.

### *Identifying Study Partners*

Before and after key informant interviews were conducted, restaurant, retail and oyster grower partners were identified as being potential collaborators in this study, meaning they would be willing to circulate our surveys to their customers. Collaborators allowed us to identify relevant raw oyster consumers in the Seattle area (their customers) and they legitimized our efforts by associating their brands with this study. Our only limiting criterion for choosing these business partners was that they sold live oysters for raw consumption in Washington. We constructed a preferred list of collaborators, in part based on perceived brand recognition –

aiming for the most respected restaurants, retailers and oyster farms in the area first, hoping they would provide access to the largest potential survey participant bases. We also intended to include casual dining, family-owned restaurants and retailers located outside of the Seattle metropolitan area in the greater Puget Sound region.

Our initial list of business partners to participate in this study included the following:

-Restaurants – Seattle-area restaurants (Elliot’s Oyster House; Ray’s Boathouse; Brooklyn Steak and Oyster House; Ballard Annex Oyster House; Dahlia Lounge, Seatown Seabar and Rotisserie; Etta’s; Anchovies and Olives; Chandler’s Crabhouse); Puget Sound restaurants not in the Seattle area (The Oyster House, Olympia WA; The Oyster Shack, South Bend WA; Xinh’s Clam and Oyster House, Shelton WA).

-Retailers – University Seafood; Mutual Fish; Uwajimaya; Seattle-area Quality Food Centers (QFC); Mike’s Seafood; Ekone Oyster

-Oyster Farms – Taylor Shellfish Farms; Hama Hama Oyster Company

Our final list of business partners that participated in this study included the following:

-Restaurants - Elliot’s Oyster House; Dahlia Lounge; Seatown Seabar and Rotisserie; Etta’s; Anchovies and Olives; Chandler’s Crabhouse

-Retailers – Hama Hama Oyster Company – Seattle farmer’s market locations

-Oyster Farms – Taylor Shellfish Farms; Hama Hama Oyster Company

-Other Partners – University of Washington, School of Marine and Environmental Affairs; NOAA Fisheries, Western Regional Center; *Women and Fish* (online blog); Seattle Farmers Market Association website

The Other Partners category was an example of opportunistic sampling (Cohen and Crabtree 2006). Towards the end of the sampling period colleagues at the University of Washington School of Marine and Environmental Affairs and NOAA Fisheries, Western Regional Center, circulated a link to the online survey through an email thread in a snowball sampling method (Goodman 1961). These are not oyster-selling establishments but we felt they added an important element to our data set – participants that are familiar with raw oysters and may be raw oyster consumers. This wasn't a strategy we expected to employ at the outset of data collection but we took advantage of the opportunity to boost the total sample over 500 responses.

#### *Survey Card Data Collection*

Survey cards appeared in two forms; Version 1 and Version 2. Both versions were first distributed in October 2014 and remained in circulation until May 2015 when data collection concluded. Version 1 was intended for distribution at seafood restaurants and retailers that sold raw oysters (Figure II-1). These cards were distributed to consumers at The Hama Hama Oyster Company Farm Store in Lilliwaup, Washington, and Hama Hama's two Seattle farmer's market stalls in the University District and Ballard neighborhoods. A small number of cards were also completed by students at the University of Washington's Seattle campus during an early survey

testing phase. Even though this was a location that obviously did not sell raw oysters, it only accounted for 15 surveys and participants were seen to be consistent with the expected survey population. A “t test” was conducted to test for significance before incorporating these 15 survey results.

The target sample for this version of the survey card was general seafood consumers, not necessarily raw oyster consumers. This intention is evident in the first question asking whether or not the survey participant eats raw oysters and why they made their decision (Figure II-1). The fill-in-the-blank nature of this question allowed for consumer input to be expressed, both in favor and in opposition to raw oyster consumption. Answers were displayed in a “word cloud” to emphasize buzzwords and display common themes (Figure II-2).

Survey card Version 2 was specifically designed for distribution at Chef Tom Douglas’ restaurants (Figure II-3). Chef Douglas hoped to promote his cookbook, *I Love Crab Cakes!*, in conjunction with the survey so he rewarded a signed copy of the cookbook to any customer who ordered six raw oysters and completed the survey card (Douglas and Lance 2006). Text describing the promotion and Chef Douglas’ logo was printed on the backside of this survey card version, when before on Version 1 the backside of the card had been left blank (Figure II-4). Under these circumstances, the “why or why not” question became irrelevant and instead we substituted a question regarding raw oyster consumption frequency (Figure II-3). Soon after the initial distribution of these cards and signed cookbooks we convinced Chef Douglas to award a cookbook to customers ordering any amount of oysters, not only those ordering at least six as the promotion initially entailed.

While we acknowledge that having two versions of this card jeopardized the consistency of our surveyed population, it was a necessary compromise. Chef Tom Douglas, whose

restaurants featured this second version of the survey card, was a major contributor to the size of the overall survey population. Bias was a concern but we were able to dissuade Chef Douglas from keeping the six oyster promotion and test for statistically significant variation. This was another “opportunistic sampling” method such that we made this sampling decision during the data collection process (Cohen and Crabtree 2006). “A flexible research and sampling design is an important feature of qualitative research, particularly when the research being conducted is exploratory in nature.” (Cohen and Crabtree 2006). Ultimately we chose to honor Chef Douglas’ survey question preference in order to maintain his partnership.

Both versions of the survey cards measured only 4 by 5.5 inches. The intention was to have the cards fit seamlessly into a restaurant bill envelope, or to be left on a retail counter near the register. In both instances a compact size was desirable to be discreet and provide minimal interference to the aesthetic of the restaurant table or seafood counter.

At Chef Douglas’ restaurants the study and the cards were introduced at the beginning of the meal in order to introduce the cookbook promotion. A heading paragraph on the cards was intended to provide the necessary information about the study and keep descriptions consistent for every card participant (Figure II-3).

### *Online Survey Data Collection*

The second half of the data set was collected through an online survey that expanded the scope of the in-person survey cards. It included all the questions featured on both versions of the survey cards and added several new questions (Appendix II). Due to time constraints, space limitations on the cards, and considerations for the aesthetic of the restaurant meal experience,

the survey cards were limited in scope and length. The online survey was distributed to customers outside of restaurants and seafood retail stores and was more flexible. Five additional questions were added to provide broader insight for *V. parahaemolyticus* risk assessment models (Appendix II).

Consumers were exposed to the online survey through a variety of formats. The primary distribution channels were through social media outlets of Seattle-area restaurants. Elliot's Oyster, Chandler's Crabhouse, Anchovies and Olives and the Taylor Shellfish Farms restaurants opted to share the online survey through social media instead of distributing the survey cards at their brick-and-mortar establishments. Seatown Seabar and Rotisserie, Dahlia Lounge and Etta's advertised the online survey in addition to distributing survey card Version 2. Hama Hama Oyster Company primarily advertised the online survey, but also distributed survey card Version 1 at its Seattle-area farmer's market stalls. Social media outreach consisted of a brief post on relevant Facebook or twitter pages, usually reposted multiple times through the data collection period. This method generated the majority of the online survey results.

Other ways in which the online survey was advertised to potential participants were through a direct email thread and through a local radio program. The email thread was addressed to [sma-all@uw.edu](mailto:sma-all@uw.edu), which is an email group composed of all University of Washington, School of Marine and Environmental Affairs students and staff, past and present. Those on this email thread were encouraged to initiate a snowball sampling style (Goodman 1961) by forwarding the link to any Washingtonians who might be inclined to take the survey, regardless of oyster preference. This resulted in the survey being re-forwarded through another email chain at the NOAA Fisheries Western Regional Center office. The radio promotion consisted of a brief interview on KLAY Tacoma during a program called *Dine Northwest*. I was interviewed about

my academic career and this study specifically. I was able to explain where and how interested listeners could take the online survey.

The online survey tool used to create the survey and collect the feedback was a development cloud based survey tool designed by SurveyMonkey Inc. We chose a basic “Beta” design that provided a relatively limited initial analysis of the data but allowed for data to be exported to a CSV file for further analysis. SurveyMonkey includes an IP address blocking function which prohibits the same user from taking the survey multiple times. We also asked online participants if they had completed a survey card, either Version 1 or 2, prior to taking the online survey in order to avoid measurement error.

### *Analytical Approach*

Having few existing studies to compare, we examined each polling method and individual result independently in order to assess the effectiveness and accuracy of each tool and data point. We measured data accuracy by comparing results with the few relevant existing studies (Desenclos et al. 1991; Lowther et al. 2010), but also with our initial expectations based on information collected during the key informant interviews. Statistically testing the significance of differences in means for serving size and consumption frequency; the only two consumption questions to appear on both survey cards and the online survey, allowed us to draw more applicable conclusions. After data collection we re-interviewed the key informants and recorded their impressions of the final results (Table 1).

All data were collected into a CSV file and analyzed using Microsoft Excel. We displayed totals for each survey question graphically for easy comparison. We generated world

clouds for Question 1 of survey card Version 1 and the online survey, Question 4 of the online survey and Question 6 of the online survey to illustrate fill-in-the-blank responses (Figure II-2, Figure II-5 and Figure II-6).

We calculated averages for serving size, consumption frequency, and participant age. We also considered averages for the independent variables place of residence, age, and gender. For place of residence we compared averages for Washington State residents to non-Washington State residents. For age we separated participants into 10-year segments (30-39 year olds, 40-49 year olds, for example), but also grouped into three larger segments (19-39 year olds, 40-59 year olds, 60 years and older) for effective Chi-square testing. For gender we compared averages for men and women.

Pearson's Chi-Square test was used to determine if the distribution of frequency or serving size was significantly different between gender (men and women), place of residence (Washington residents and non-Washington residents) and age categories (the three larger segments described above). Similar to how we grouped participant age into three categories, we grouped serving size into three categories for Chi-square testing. The three serving size categories were 1-5 raw oysters, 6-11 raw oysters, and 12 or more raw oysters. Additionally we conducted a "t-test" to examine population means between survey cards and the online survey in order to determine if the data was similar enough to compare together. The t-test also served as a general assessment of the data collection process.

We also used these three independent variables (gender, place of residence and age) to examine outlying serving size data points. Participants who indicated they eat 18 or more raw oysters per sitting were measured as outliers and examined separately. But for a more robust analysis we included all consumers indicating they eat 12 or more raw oysters per sitting to this

outlier group. As described earlier, an illness-triggering dosage of *V. parahaemolyticus* is currently unclear, but consumers eating 12 or more raw oysters per sitting may be exposing themselves to higher loads of *V. parahaemolyticus* bacteria which could potentially place them at greater risk of vibriosis. Aligning demographic trends with these higher consumption rates could prove valuable to future risk-per-serving assessment models.

Finally, after determining age to be a statistically significant factor on average serving size, we conducted a multiple regression analysis to determine if the age of men and women and that of non-Washington residents and Washington residents was contributing to average serving size differently. This was accomplished by separating male participants, female participants, non-WA resident participants and WA resident participants into two groups each – those younger than the age of 41 and those older than 41. Relevant values were reported in Tables and “box and whisker plots” were constructed to illustrate the eight subgroups.

*University of Washington Human Subjects Division (HSD): Determination of Exempt Status*

We applied for exempt status to be approved for survey data collection in accordance with federal regulations 45 CFR 46.101/21 CFR 56.104. We applied on two separate occasions. The first application was approved on August 5<sup>th</sup>, 2014, under application #47747, which encapsulated the parameters of the survey card methods and distribution. When the online survey method was added early in 2015, we re-applied for exempt status (application #49221), and were approved again on February 26, 2015.

As per our application, key informants and study partners were named in this paper only after permission was granted on an individual request basis.

## Results

### *Preliminary Assumptions*

To assess the accuracy of our survey results, we established our preliminary assumptions for each survey question. These assumptions were mostly drawn from our key informant interviews because of the limited available literature on raw oyster consumption records. We also considered references that described commercial oyster industry growth in Washington (Washington Shellfish Initiative 2011; Docter pers. comm., 2015). However an understanding of recent oyster industry growth was not a concrete correlation to specific raw oyster consumption statistics. Thus we relied on the advice from our key informants to develop the following preliminary assumptions:

*Percentage of survey participants that eat raw oysters:* 90% yes, 10% no. This is an expected ratio of survey participants – not seafood consumers or patrons of the restaurants and retailers which offered the survey. We expect most participants to be taking the survey because they do indeed eat raw oysters.

*Average Raw Oyster Serving Size per sitting:* 4-5 raw oysters per sitting. For this expected range we considered Taylor Shellfish Farms point-of-sale (POS) data from their Seattle restaurants, which indicated 3.8-4.5 raw oysters per sitting was the serving size average. This range did not consider shared oyster plates or customers at Taylor Shellfish Farms restaurants that chose not to eat raw oysters at all, so we expected a slightly higher serving size average from our survey results.

*Average Raw Oyster Consumption Frequency:* We expected 4-7 times a year to be most commonly reported.

*Preferred time of year to eat raw oysters:* Equal representation in all seasons with a slight decline in summer. Holidays and special occasions will be selected by 25% of the participants.

*Typical buying location for raw oysters:* We expected restaurants to be the most popular buying location. This question was not asked on the in-restaurant survey cards to avoid bias.

*Favorite type of raw oysters:* Expectations were that only about 33% of participants would answer ‘yes’ and specify.

*Preferred raw oyster size:* We expected 2.5 to 3 inches to be the range of preference.

*Importance of certain considerations when buying raw oysters:* We expected Freshness to be most important, followed by Price then Place of Harvest and Time of Year, in that order.

*Average Age:* This was difficult to anticipate because of the different survey methods involved in our data collection. We expected the online survey to attract a younger average participant age than the survey cards.

*Gender Ratio:* We expected a 50/50 ratio of men and women.

*Place of Residence:* We expected most of the non-resident participants to access the study via survey cards whereas the online survey would be more accessible to Washington residents who are more likely to be following our restaurant and farm partners on social media.

\*See Table I-1 for all “Expected” and “Observed” results.

### *Survey Results*

In total, 502 survey responses were collected across all survey methods. The survey cards yielded 239 responses (48% of the total sample). 209 of the survey cards (42% of the total sample and 87% of all survey cards) came from Chef Tom Douglas’ restaurants. All surveys taken at his restaurants were Version 2 of the survey cards (Figure II-3). Survey card Version 1

was distributed equally between UW campus outlets and Hama Hama Farmer's market stalls, yielding a total of 30 responses (6% of the total sample and 13% of survey cards) (Figure II-1).

263 (52% of the total sample) of the 502 survey responses came from the online survey. Of these online participants, 224 specified exactly where they found the online survey. 61 indicated they found the survey via a direct email invitation. 140 indicated they found the survey through various social media outlets. The remaining 23 participants indicated they found the online survey through another source in the form of a blog or website that reposted the survey link independently and without request by our research group.

Question 1 – “Do you eat oysters on the half shell (raw)? Why or why not?”

This question appeared on Version 1 of the survey card and on the online survey.

Our primary aim with question 1 was to capture candid fill-in-the-blank responses to illustrate the Washington consumer schema of raw oysters. This was best captured in a word cloud (Figure II-2). Word association ranged from positive – “Delicious”, “Sustainable”, “Nutritious” – to negative – “Gross”, “Booger”.

Most participants do eat raw oysters on the half shell (raw), which aligned with our expected outcome (Table I-1). For survey card Version 1, 80% said Yes and 20% said No. For the online survey 86% said Yes and 14% said No.

It is important to note that it was not the intent of this question or this study to determine the percentage of raw oyster consumers amongst the total Washington population. The initial aim was to measure how many raw oysters a typical consumer was eating in one

serving. We aimed to collect word association feedback to illustrate the raw oyster consumer schema for this region (Figure II-2).

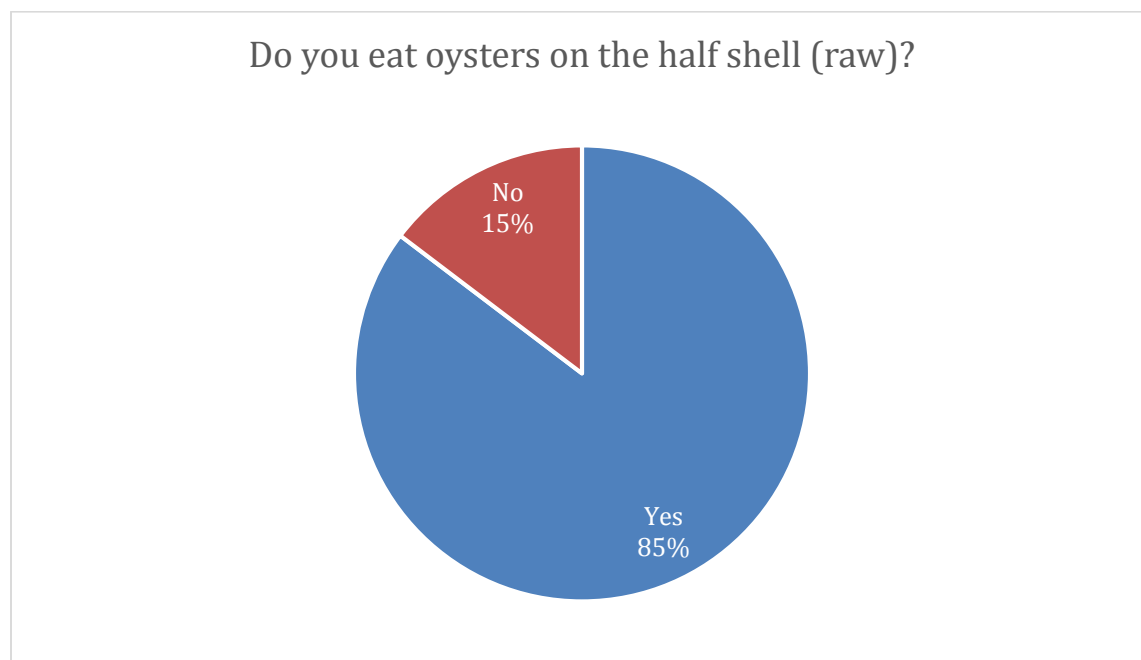


Figure III-1. Displays ratio of survey participants that eat raw oysters compared to those that do not. These totals do not represent the oyster consuming population in Washington compared to all consumers, just the proportion in our sample of oyster restaurant patrons, seafood retail customers, and fans of oyster-related websites and social media pages.

Question 2 – “How many raw oysters do you personally eat in one sitting?”

This question appeared on all versions of the survey.

Serving size, the data point seen as most important to vibriosis risk assessment by DOH and FDA, was measured on both versions of the survey cards and the online survey. Results were separated between cards and the online survey to more easily identify statistically significant differences between collection methods. The distributions for both methods look

similar, with both having a mode of 6. The average serving size for survey card participants was 6.81 raw oysters and the average serving size for online participants was 7.88 raw oysters. Combining all responses between both survey methods yielded an average serving size of 7.32 raw oysters. These results were higher than was initially expected from our key informant interviews (Table I-1).

Participants that ate more than 12 raw oysters per serving were asked to specify exactly how many they ate. In addition to numerical responses, answers sometimes included explanations or qualifying statements. For example, 21% of these fill-in-the-blank responses mentioned price as a prohibiting factor to eating more raw oysters per serving.

The online survey received more responses considered to be statistical outliers (serving size > 17.5 raw oysters) which served to raise the average serving size for the online survey above that of the survey cards in a statistically significant total. This significance was determined by conducting a two-sample “t-test” using the standard test statistic of  $p = 0.05$ . Our null hypothesis ( $H_0$ ) was that there was no significant difference between the survey card set and the online survey set. The resulting  $p$  value of 0.01 when comparing average serving sizes between these sets allowed us to reject this null hypothesis and conclude that there was a significant statistical difference between set A and set B. When removing the outlying data points from both sets,  $p = 0.38$ , and grouping both sets for one total comparison was possible under these conditions.

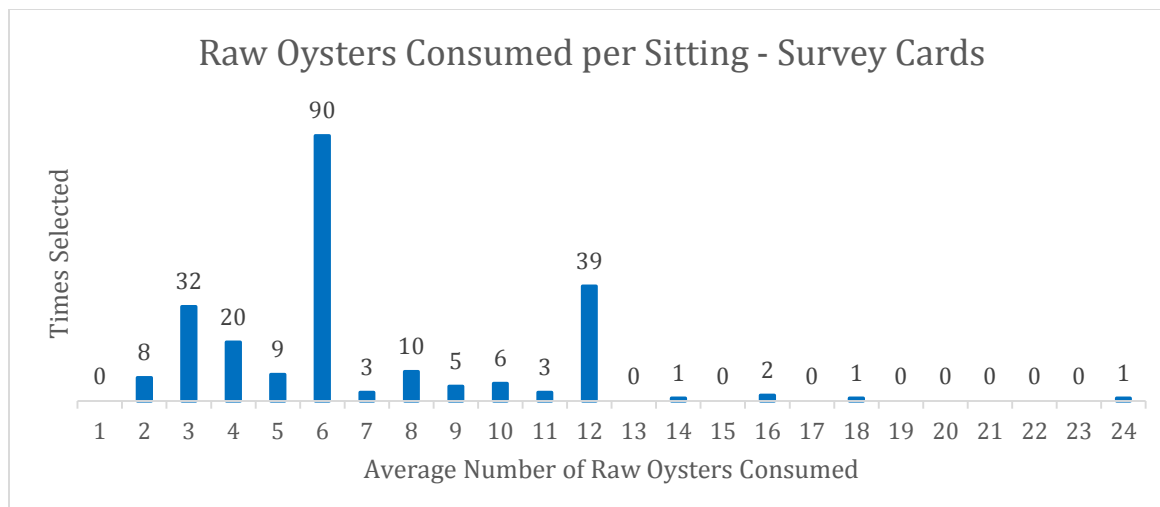


Figure III-2. Serving size data for survey cards Version 1 and 2. Average serving size = 6.81 raw oysters per sitting with all data points included. Average serving size without outliers (>17.5 raw oysters) = 6.68 raw oysters per sitting. The mode = 6. A “t test” conducted to measure significant differences between the first 50 participants at Chef Tom Douglas’ restaurants who took the survey with an emphasis on ordering 6 oysters specifically, and the remaining participants, yielded  $p = 0.57$ , proving concerns of survey bias were not present in these results.

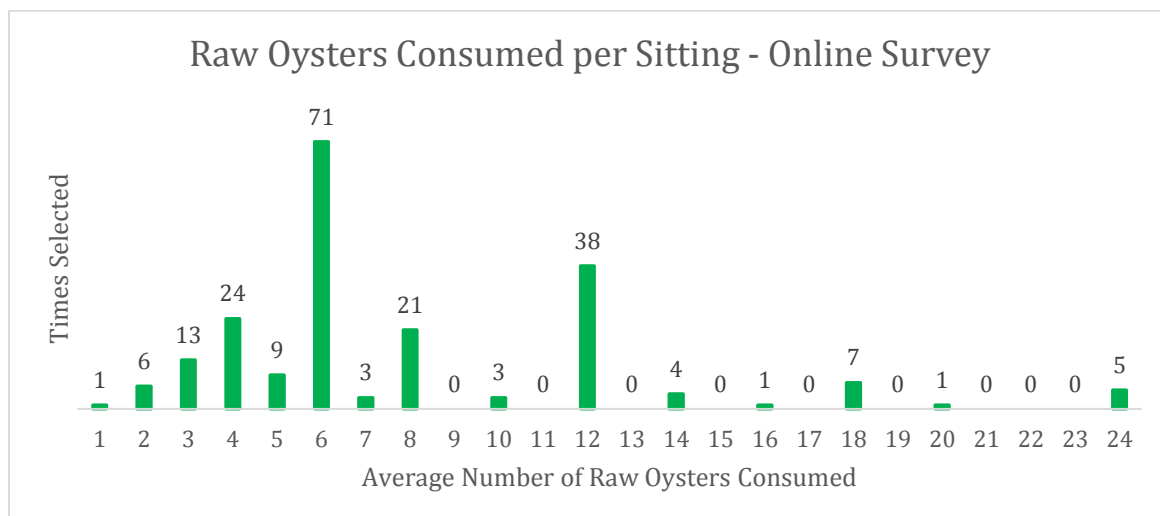


Figure III-3. Serving size data for the online survey. Average serving size = 7.88 raw oysters per sitting with all data points included. Average serving size without outliers (>17.5 raw oysters) = 7.09 raw oysters per sitting. The mode = 6. The greater presence of outlying data points was the main contributing factor to these averages being greater than those seen in the survey card data.

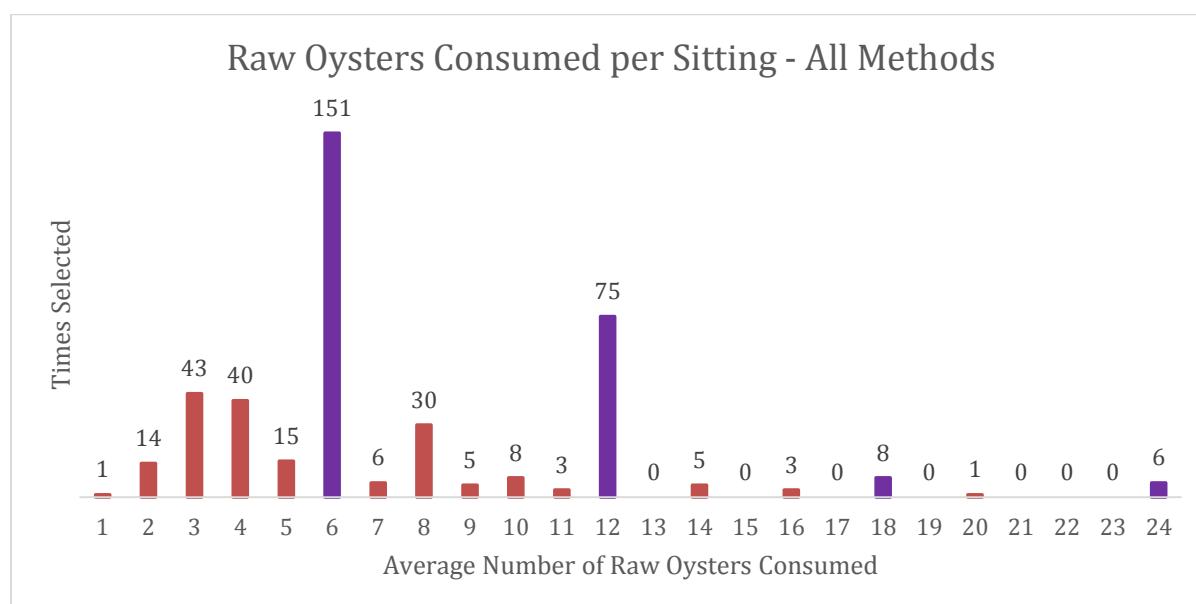


Figure III-4. Serving size data for all survey methods. Average serving size = 7.32 raw oysters per sitting with all data points included. Average serving size without outliers (>17.5 raw oysters) = 6.84 raw oysters per sitting. The mode = 6. Columns in purple highlight the spikes in raw oyster consumption at factors of 6, which reflects typical oyster sales units, but also reflects consumer preference.

Question 3 – “How often do you eat raw oysters?”

This question appeared on Version 2 of the survey card and on the online survey

Raw oyster consumption frequency was another important data point for vibriosis risk assessment. However our results did not deviate from our preliminary assumptions (Table I-1). Across all survey methods the mode was 4-7 times a year, equating to raw oyster consumption about once every 2 months during a typical year.

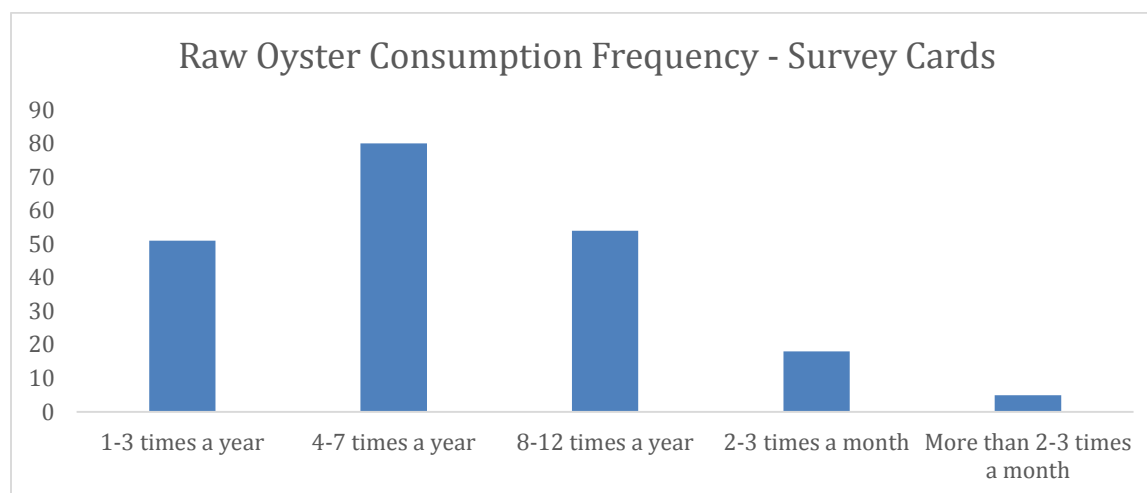


Figure III-5. Raw oyster consumption frequency distribution for survey card Version 2. Like the online survey results, the mode = 4-7 times a year. 1 being equal to “1-3 times a year”, and 5 being equal to “More than 2-3 times a year”, the average frequency = 2.25.

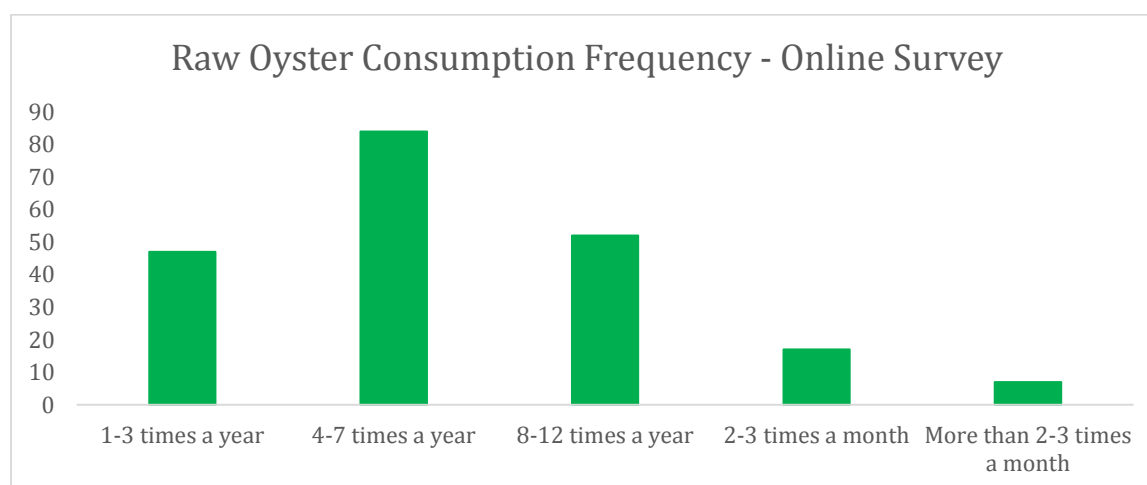


Figure III-6. Raw oyster consumption frequency distribution for the online survey. Like Version 2 of the survey cards results, the mode = 4-7 times a year. 1 being equal to “1-3 times a year”, and 5 being equal to “More than 2-3 times a year”, the average frequency = 2.29.

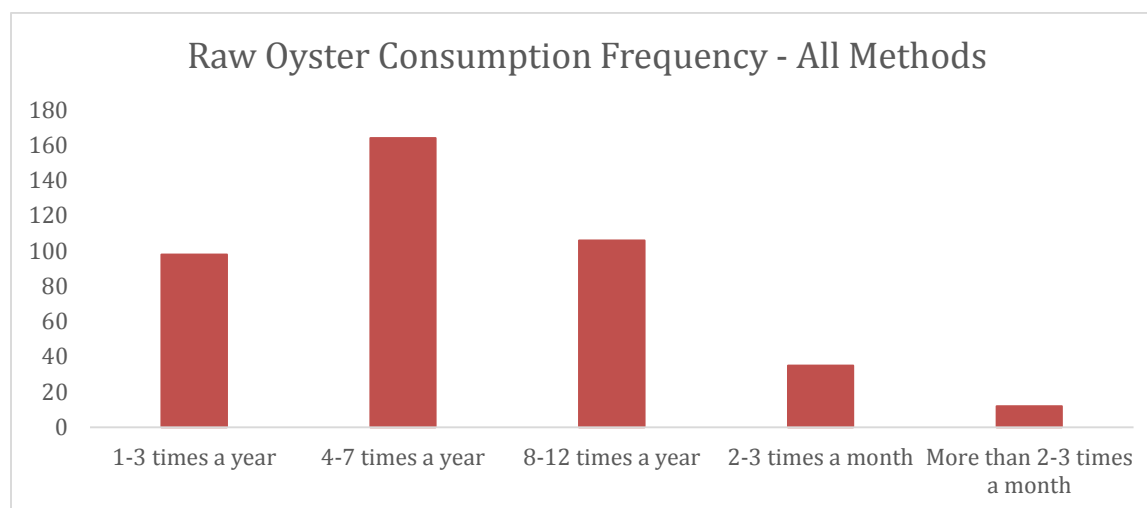


Figure III-7. Raw oyster consumption frequency distribution for all survey methods. The mode = 4-7 times a year. 1 being equal to “1-3 times a year”, and 5 being equal to “More than 2-3 times a year”, the average frequency = 2.27.

Question 4 – “Are there certain times during the year when you prefer to eat raw oysters?”

*(Please check all that apply)*

This question only appeared on the online survey.

Observed results pertaining to preferred oyster consumption times of the year matched our expected results (Table I-1). The decline in summer matches seasonal reported vibriosis illness data (Figure I-2) and depicts an aversion to eating raw oysters during this time of year. Because of restaurant and oyster grower partners having a sensitivity to survey questions that explicitly ask about foodborne illness, we did not ask survey participants *why* they skipped

summer. Thus it is unclear if this result is due to knowledge regarding vibriosis risk, oyster spawning, or another factor. Contradictory to this result are testimonials from Washington oyster growers and restaurateurs that describe the summer months as the busiest raw oyster sales month of the year, with the exception of December (Docter, Hauch, Spaulding, pers. comm., 2015).

The 47 participants who selected the answer choice “Holidays or other specific times” were asked to specify. Their responses were displayed in a word cloud (Figure II-5). A few respondents (6, 13% of the group that selected ‘Holidays and other specific times’) expressed times of year when they look to *avoid* raw oysters. These responses were not clearly expressed in the word cloud. “Months with no R”, and “Don’t eat in summer” were two examples of these avoidance responses.

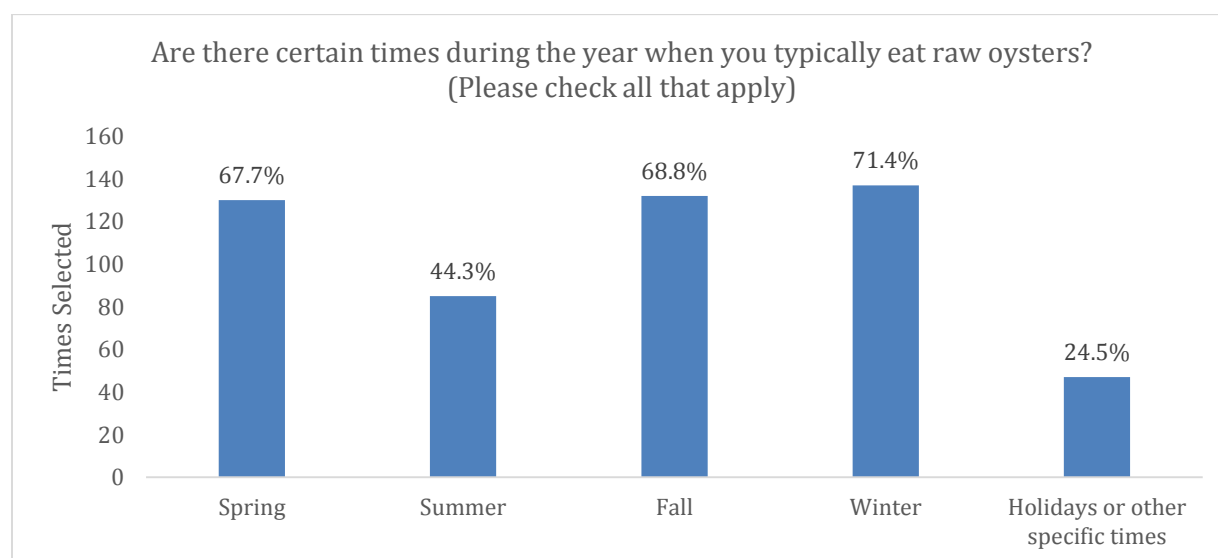


Figure III-8. Temporal preferences for raw oyster consumption by season with an option to specify specific occasions when raw oyster consumption typically occurs. Participants were allowed to check all categories that apply, thus the listed percentages describe the percentage of

participants that included that answer in their checklist. The aversion to summer compared to other seasons possibly reflects vibriosis risk awareness, but contradicts seasonal sales information.

Question 5 – “Where do you typically buy raw oysters?”

This question only appeared on the online survey.

This observed result matched the expected result that restaurants would be the most popular buying location for raw oyster consumption (Table I-1). The word choice “buy” was carefully used instead of “where do you typically eat raw oysters” because we wanted to only capture commercial oyster consumers. If the word choice was “eat” and a consumer answered “at home” as their preferred location, then those meals at home could include recreationally harvested oysters or commercially harvested oysters

If participants did want to describe recreational harvest as their primary raw oyster source, they were able to do so by selecting “Other Locations”. Participants that selected this answer choice were asked to specify the location. 20 of the 36 participants who selected “Other Locations” (56%) explained that they buy them directly from the oyster grower or from the farm. 10 of the 36 participants (28%) said they harvest their own recreationally.

While most participants did indicate they preferred to buy raw oysters at restaurants (66%), serving size outliers (those who consumed 18 or more raw oysters per sitting) were less likely to buy raw oysters at restaurants (only 40%). There were not enough outlier responses to effectively test for statistical significance in this result, however (n=15).

Only one participant reported typically buying raw oysters online. Among the study partners Hama Hama Oyster Co. sells their oysters and other products online and it was at their request that we included this answer choice for Question 5.

It is important to note that we did not ask this question on the survey cards, only on the online survey. Bias could be introduced if a consumer was answering this question at a restaurant or seafood retailer.

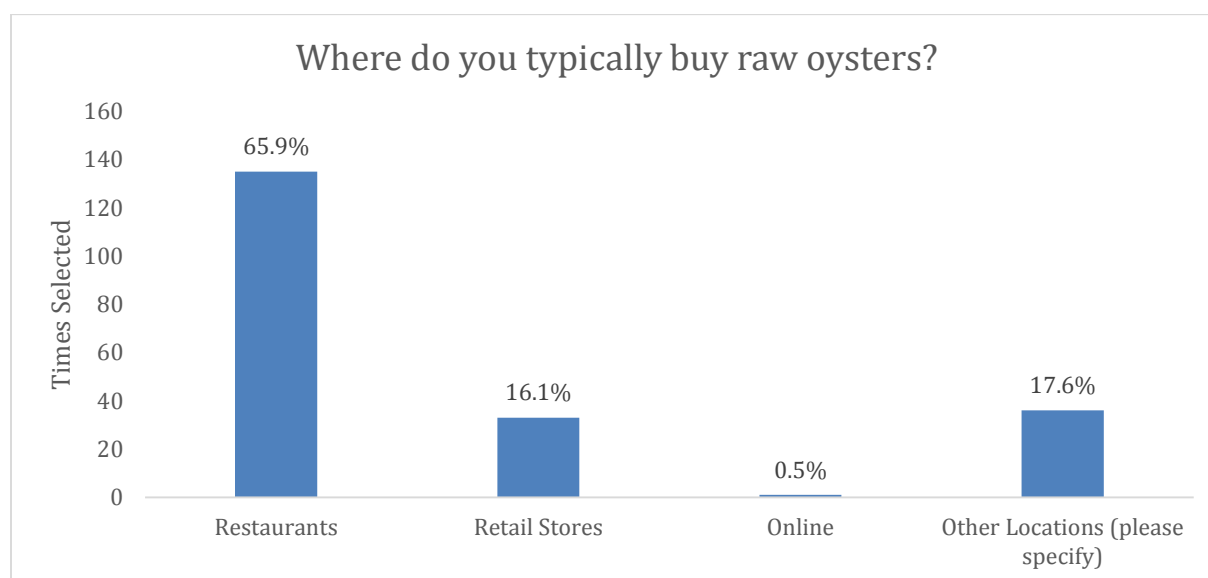


Figure III-9. Typical buying locations for raw oysters. A majority of participants selected restaurants, and indeed the 66% total could be considered even greater because some of the 18% who specified other locations described restaurants as one of multiple typical buying locations.

Question 6 – “Do you have a favorite type of oyster?”

This question only appeared on the online survey

This observed result was different than our expected result, with more participants indicating they have a specific favorite raw oyster type than was initially assumed (Table I-1). Participants that selected answer choice “Yes” were asked to specify the type. 29 of the 101 (19%) participants that answered “Yes” mentioned “Kumamoto” oysters, marking the most popular oyster type in this survey. Overall the answers included a wide array of oyster types locally grown in the Pacific Northwest, such as Hama Hama, Kusshi and Fanny Bay oysters. Other answers mentioned geographical areas of preference, such as “Puget Sound”, “Hood Canal” or “Atlantic Coast”. All answers were displayed in a word cloud (Figure II-6).

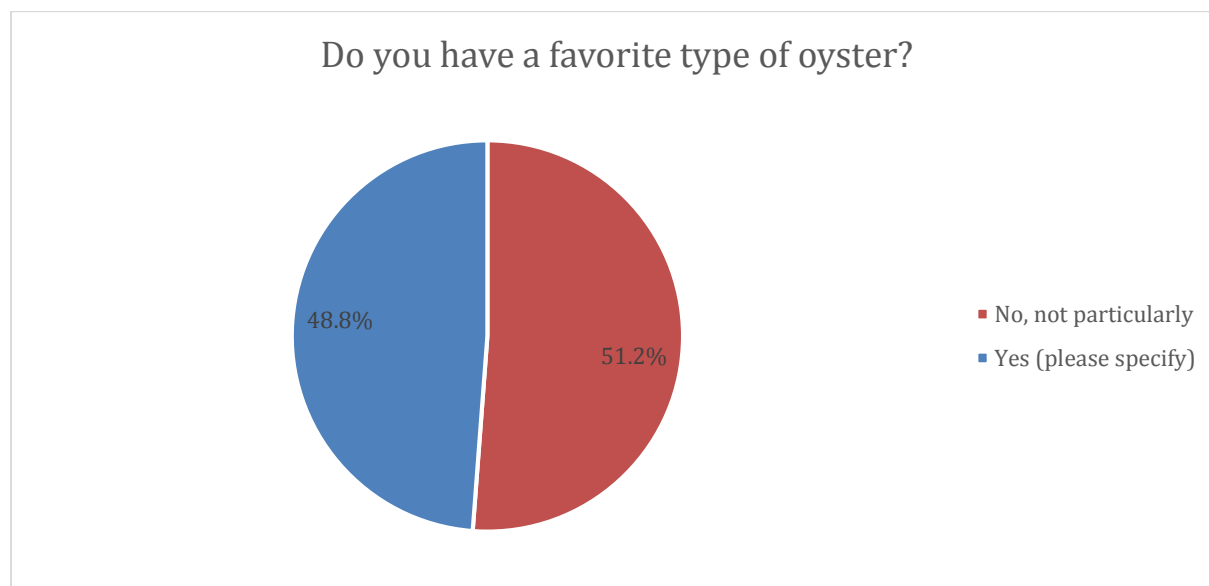


Figure III-10. Proportion of participants that indicated they have a favorite type of raw oyster compared to those that do not particularly have a singular preference. Results were displayed in a word cloud to easily illustrate the diversity of responses from those that selected “Yes (please specify)” (Figure II-6).

Question 7 – “What size oyster do you prefer to eat raw, on the half-shell?” (*Measurements are from the oyster’s hinge to the bill, which is its length, not its width*)

This question only appeared on the online survey.

Expected and observed results closely matched for this question (Table I-1). The industry standard for commercial oysters intended for raw consumption in Washington is typically around 3 inches, which matches the most popular choices of Extra Small and Small in this result (Docter, pers. comm., 2015). Oyster growers were particularly interested in the results of this question to reinforce these aesthetic standards. This result could vary considerably in other regions of the country that feature different oyster varieties, growing conditions, preparation methods and consumer preferences.

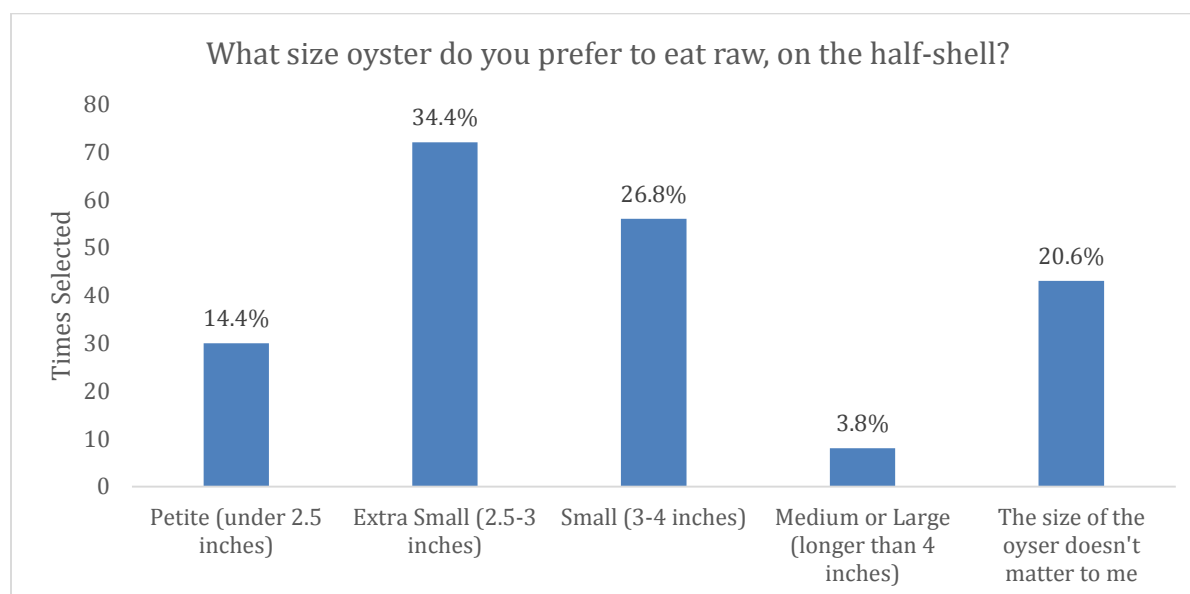


Figure III-11. Size preferences for raw oysters, measured in oyster length, not width. The preferred range of 2.5-4 inches matches most oysters produced for raw consumption in Washington State but may be different for other regions of the country.

Question 8 – “When choosing raw oysters, how important are the following considerations?” (1 meaning not important at all, 5 meaning extremely important)

This question only appeared on the online survey.

The expected result did not fully match the observed result for this question (Table I-1). While Freshness was most valued, Price was least valued but had been projected as the second most important consideration for raw oyster consumers.

Valuation for Question 8 was totaled from a one-five Likert Scale such that a selection of “1” represented “not important at all” and a selection of “5” represented “extremely important” (Maurer, Todd and Pierce 1998). 97% of participants indicated Freshness was either 4, “very important” or 5, “extremely important” (Table III-1). Conversely only 22% of participants indicated Price was either 4, “very important” or 5, “extremely important” (Table III-1).

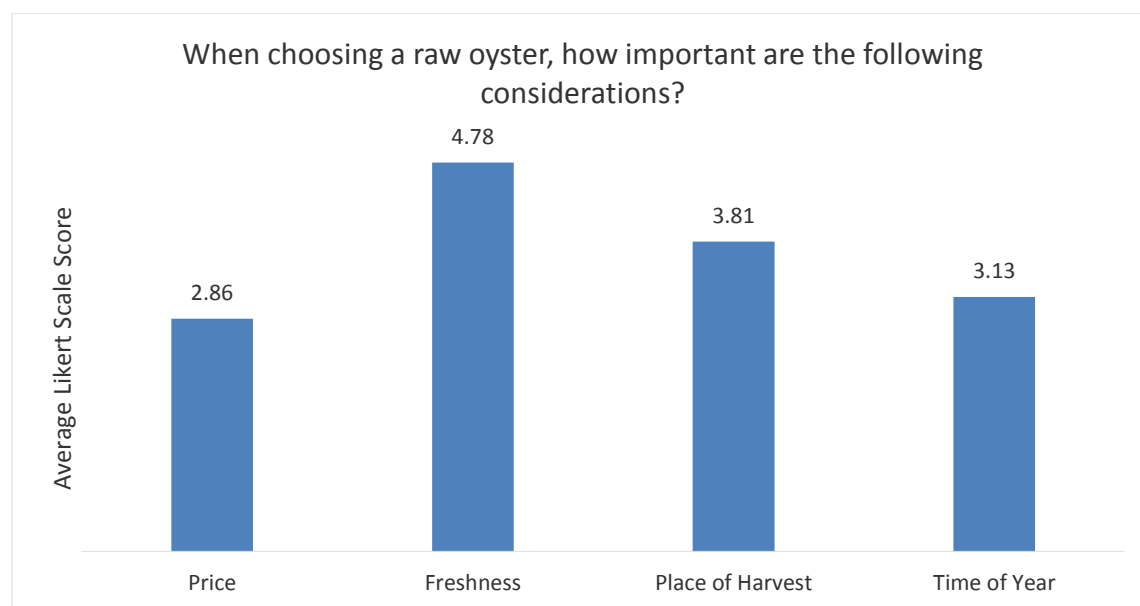


Figure III-12. Relative importance of four considerations, Price, Freshness, Place of Harvest and Time of Year, when buying raw oysters. These results illustrate a pronounced valuation of freshness and other factors pertaining to raw oyster quality over price (Table III-1).

Question 9 – “What is your date of birth?” (*sorry, you must be at least 18 years of age to participate*)

This question appeared on all versions of the survey

The average age of the total sample matched our expected result, but the expected difference in average age between online survey participants and survey card participants was not present in the observed results (Table I-1). The average age for survey card participants was 42 (mean = 42.49), and the average age for online survey participants was 41 (mean = 41.06). Together the total sample age was 41 (mean = 41.80). All ages were calculated on June 26<sup>th</sup>, 2015.

Minors were not counted for any version of this survey and a small disclaimer explained this at the beginning of each survey. The age range of our participants was 19 to 91.

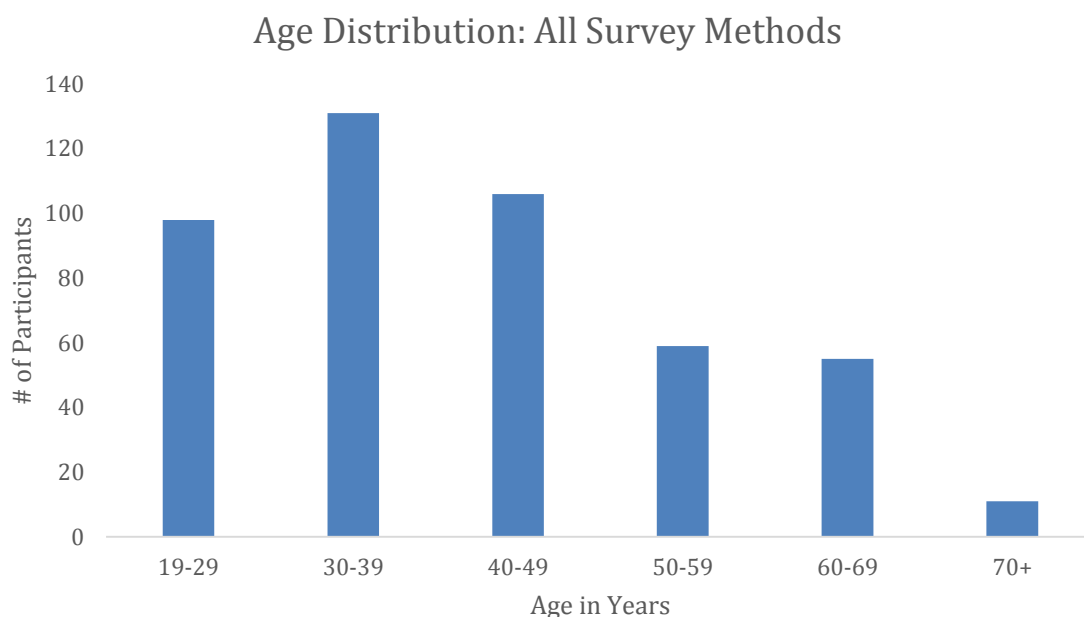


Figure III-13. Age distribution of all survey participants. The mode age range was 30-39 but the average age was 41. Minors were not polled in this study. The youngest participant was 19 and

the oldest participant was 91. Average age of survey card participants was 42 and the average age of online survey participants was 41

Question 10 – “What is your gender?”

This question appeared on all versions of the survey.

The gender distribution did not match our expectations (Table I-1). More women took this survey than men, and one online participant selected “Other” and explained, “I am an oyster”. 51% of survey card participants were men, while 49% were female. But the online survey ratio was much less balanced, with only 37% men and 63% women. Average gender distribution for both methods together was 44% men and 56% women.

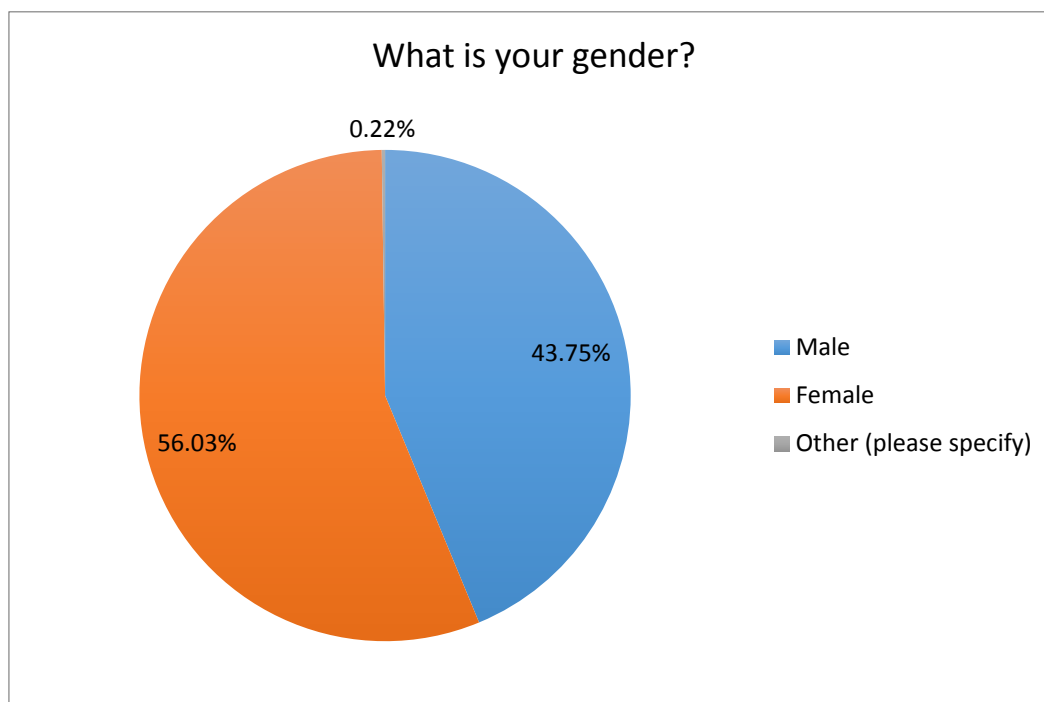


Figure III-14. Gender distribution for all survey methods. An unexpected majority of women in the online survey (63%) contributed to the ratio displayed here.

Question 11 – “What is your place of residence?”

This question appeared on all versions of the survey.

Locals, or residents, are defined as survey participants that indicated their current place of residence is in Washington State. Tourists, or non-residents, are defined as survey participants that indicated their current place of residence is anywhere outside Washington State. The ratio of non-residents compared to Washington residents was similar to our expected results (Table I-1).

Most Non-resident participants were polled via survey cards at Chef Douglas’ Seattle-area restaurants. 51% of Survey Card Version 2 participants were non-residents, 17% of Survey Card Version 1 were non-residents, and only 12% of Online Survey participants were non-residents.

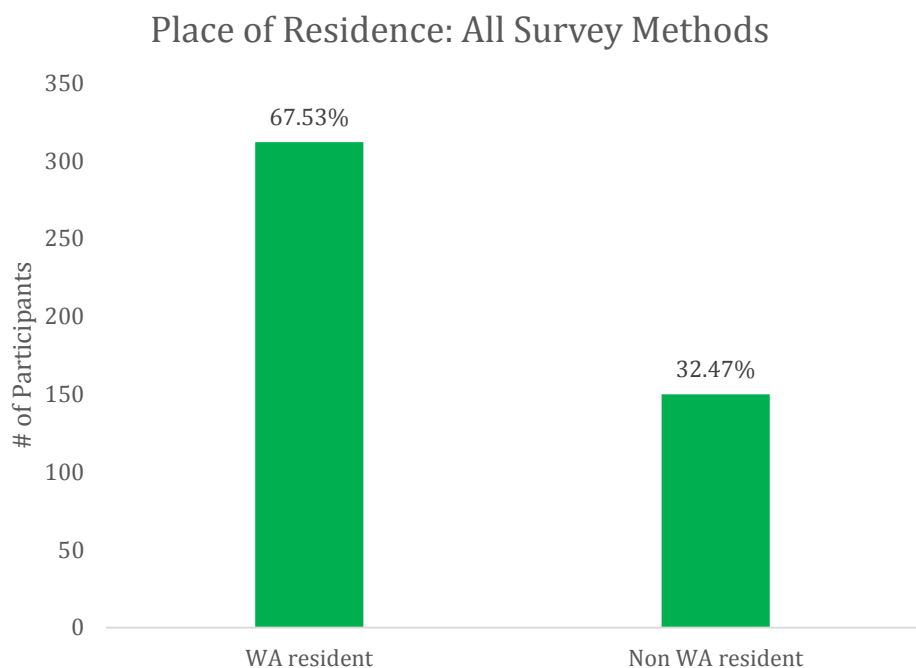


Figure III-15. Ratio of WA residents and non-residents for all survey methods. Most non-resident participants were polled at Chef Douglas’ Seattle restaurants via survey card Version 2.

#### Question 12 – “Where did you hear about the online survey?”

This question only appeared on the online survey.

This question was not related to raw oyster consumption but did serve to give us a snapshot of the reach of our online survey and our dissemination methods. Social media pages for restaurant and oyster grower partners were intended to be the primary medium for online survey data collection, and that emphasis is present in these results. Responses collected via email threads and other methods were sometimes unintended, resulting from an unknown participant reposting the online survey link on a blog or in an email. We expected a degree of survey distribution randomness.

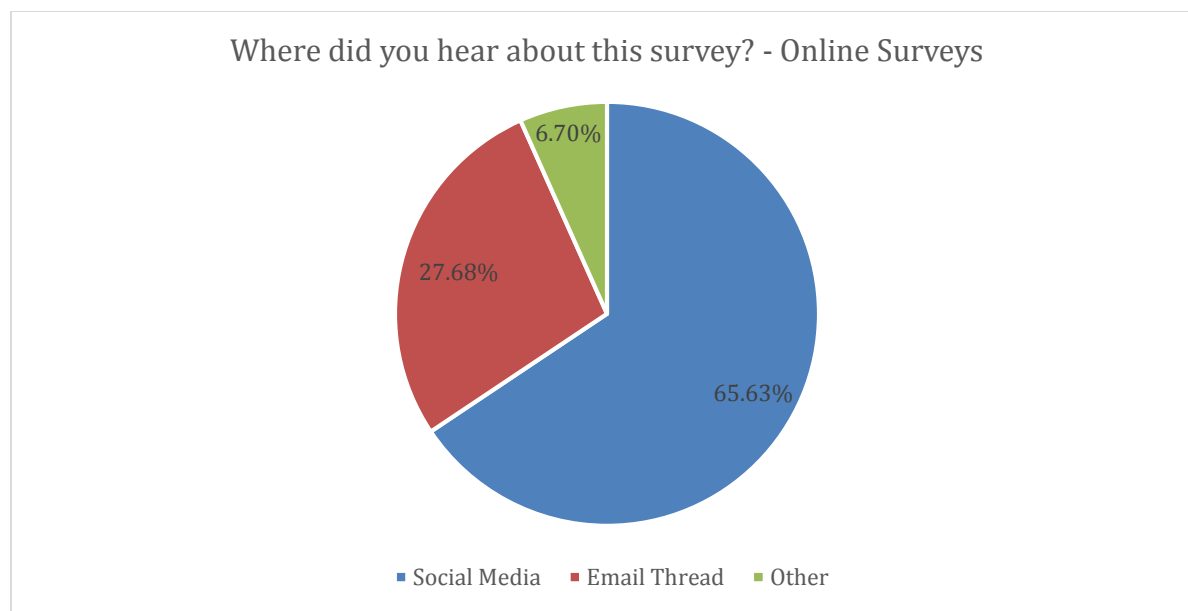


Figure III-16. A pie chart depicting online survey access points. An email thread was intentionally started but was re-sent and mostly distributed without the help of our researchers. Similarly the “Other” sources refer to blogs or other websites that reposted the online survey link without our request. The *Eat Ballard* Facebook page, for example, reposted the survey link after seeing it on one of our five original partner pages without our request (Oyster Survey 2015).

Question 13 – “Did you complete a Washington Raw Oyster Consumer Survey Card at a Seattle-area restaurant or seafood retail location in the past few months?” (*The cards have been in circulation since October, 2014*)

This question only appeared on the online survey.

This question aimed to ensure participants that completed a survey card did not get counted twice for overlapping questions if they also took the online survey. Only 3 participants answered yes (1% of the online sample), and their responses were adjusted appropriately when generating our results.

### *Demographic Comparisons of Total Sample*

Demographic variables, place of residence, gender and age were considered specifically for average serving size and average consumption frequency data. Serving size and consumption frequency received the most responses (n=438 and n=416, respectively) and are particularly relevant to vibriosis risk assessment considerations.

Non-residents, men, and participants older than the average age of 41 were seen as consuming more raw oysters per serving than their counterparts, Washington residents, women, and participants younger than 41. The average serving size disparity was most present in the age distribution, with 19-29 year olds averaging 6.30 raw oysters per serving and 60-69 year olds averaging 9.06 raw oysters per serving.

Conducting Chi-square tests to assess the significance of these variables on average serving size yielded  $p = 0.11$  for place of residence,  $p = 0.06$  for gender and  $p = 0.0007$  for age. To calculate the significance of age we regrouped the age categories from six groups into just three (ages 19-39, 40-59 and 60 and older).  $P$  values for place of residence and age were close to the test standard test statistic of 0.05, but still greater than this value, suggesting there is not a statistically significant effect from these two independent variables on serving size. Age however yielded a  $p$  value much lesser than 0.05, suggesting consumer age has a statistically significant effect on average serving size.

Non-residents and men continued the trend of greater consumption with the frequency data, eating raw oysters more often than Washington residents and women. For age however this

trend of the older generation eating more than younger consumers did not continue with the frequency results.

Chi-square tests to assess significance of these independent variables on consumption frequency yielded  $p = 0.19$  for place of residence,  $p = 0.71$  for gender and  $p = 0.34$  for age. None of these  $p$  values were greater than the test statistic of 0.05 and therefore do not have statistically significant effects on average consumption frequency.

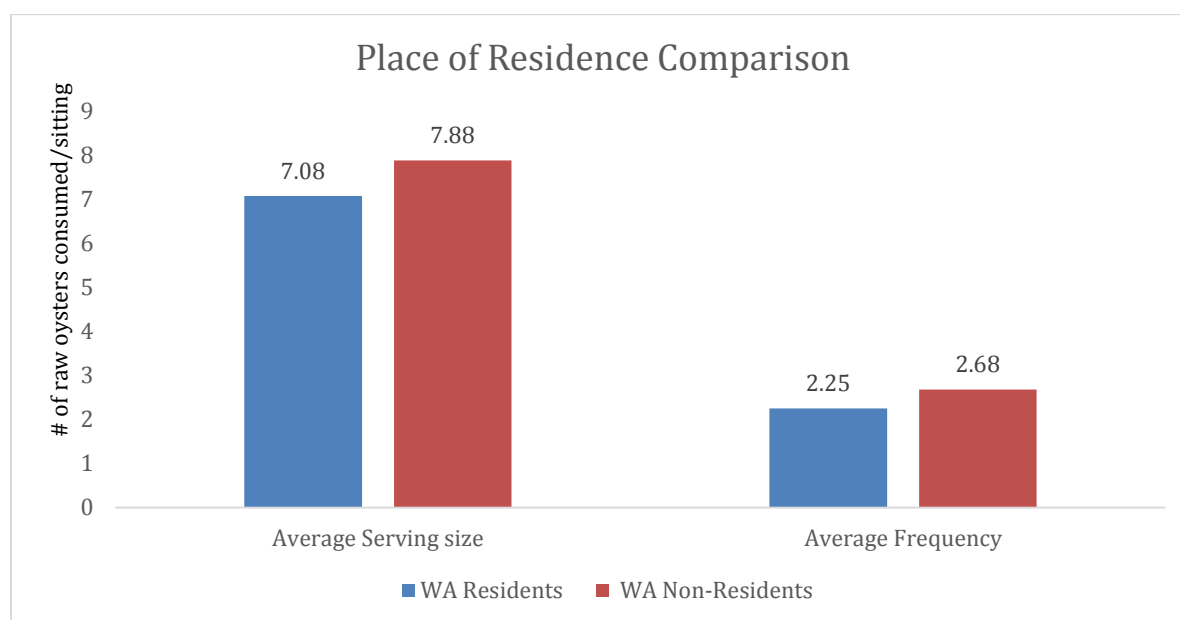


Figure III-17. A comparison of average serving size and average consumption frequency of raw oysters for residents and non-residents of Washington State. Non-residents were seen to eat more raw oysters, and eat them more often, than their WA-resident counterparts. However neither difference in average proved to be statistically significant ( $p = 0.11$  for serving size and  $p = 0.19$  for consumption frequency).

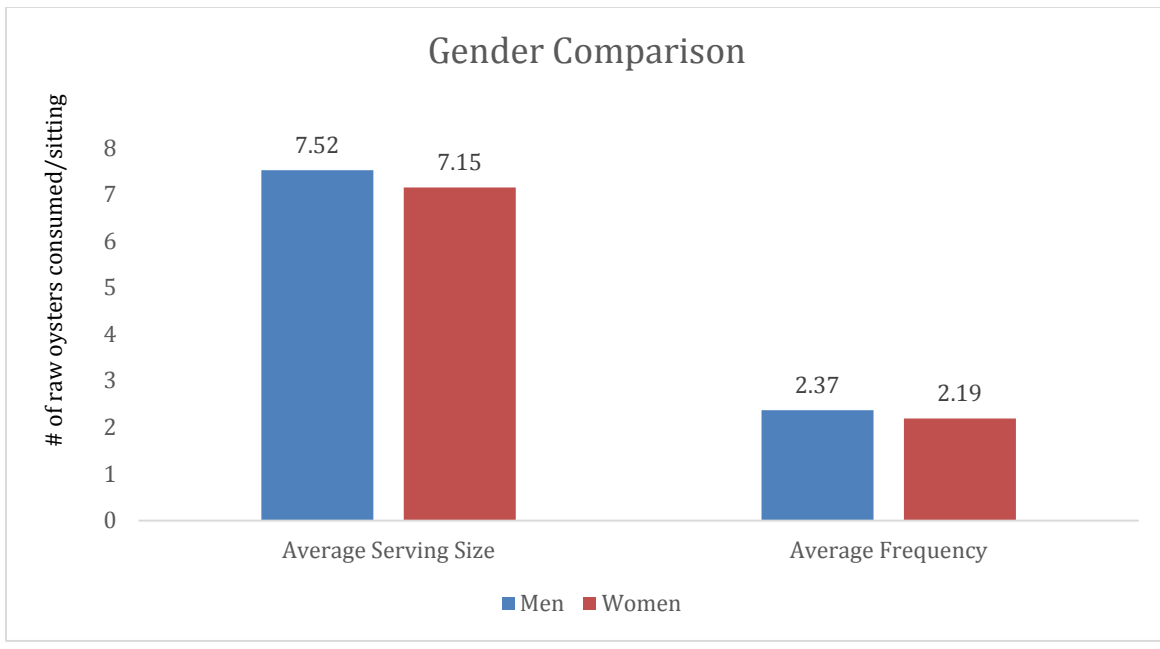


Figure III-18. A comparison of average serving size and average consumption frequency of raw oysters for men and women. Men were seen to eat more raw oysters, and eat them more often, than their female counterparts. However neither difference in average proved to be statistically significant ( $p = 0.06$  for serving size and  $p = 0.71$  for consumption frequency).

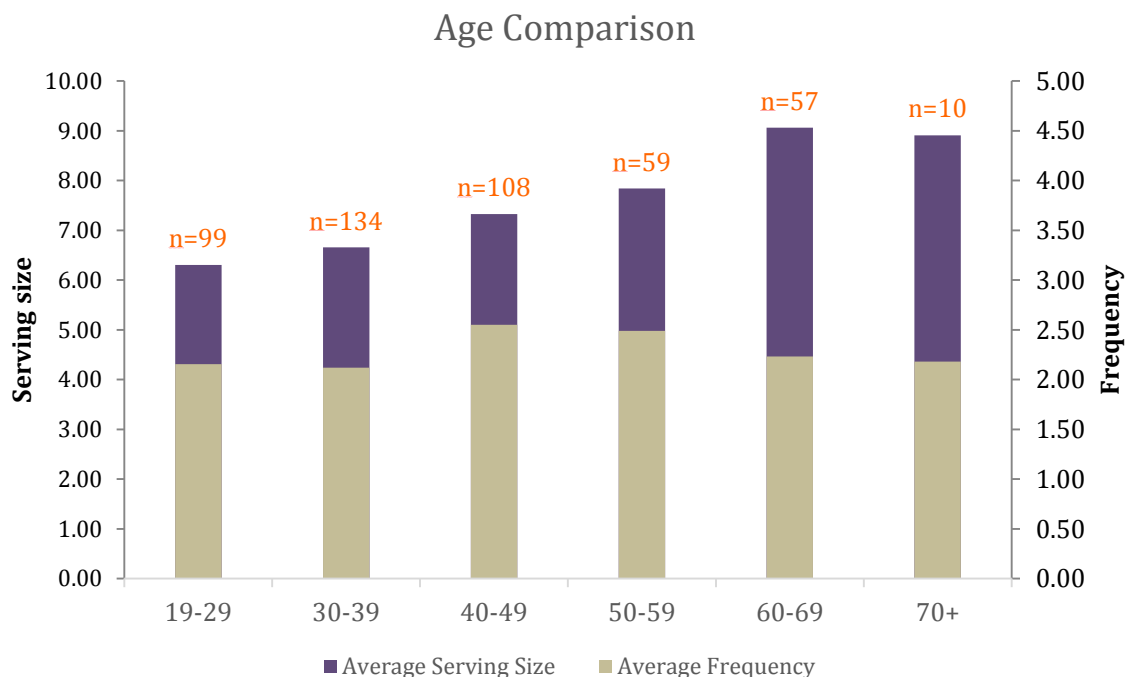


Figure III-19. A comparison of average serving size and average consumption frequency of raw oysters separated into six age groups. Purple bars measure average raw oyster serving size for each ten-year age group. Beige bars measure average raw oyster consumption frequency for each ten-year age group such that 1 equates to “1-3 times a year” and 5 equates to “More than 2-3 times a month”. Orange “n” values display the number of participants in each age group. Older participants (older than 41) were seen to eat more raw oysters than their younger counterparts. Average frequency however was more static. Differences in serving size averages proved to be statistically significant ( $p = 0.0007$ ). Differences in consumption frequencies did not prove to be statistically significant ( $p = 0.34$ ).

After identifying age as a statistically significant contributing factor to average serving size we examined the interactions of gender and place of residence on age in a multiple regression analysis to hone our understanding of this significant age result. We separated male and female participants into two groups each; those ages 41 or younger and those ages 42 or

older. We did the same with non-residents and WA residents. The results were displayed in “box and whisker plots”.

Male participants ages 41 and younger had an average serving size of 6.27 raw oysters. Female participants ages 41 and younger had an average serving size of 6.87 raw oysters. Male participants ages 42 and older had an average serving size of 8.18 raw oysters. Female participants ages 42 and older had an average serving size of 7.58 raw oysters.

Non-resident participants ages 41 and younger had an average serving size of 6.67 raw oysters. WA resident participants ages 41 and younger had an average serving size of 6.68 raw oysters. Non-resident participants ages 42 and older had an average serving size of 8.56 raw oysters. WA resident participants ages 42 and older had an average serving size of 7.50 raw oysters.

The multiple regression analysis did not yield any evidence of a statistically significant interaction between age and gender or age and place of residence (in all models,  $p > 0.05$ ). As age increased we observed the difference in oyster consumption between men and women and non-residents and WA residents gets smaller, however not to a significant degree. The differences in serving sizes do not vary between groups such that male and non-resident participants generally ate more raw oysters per serving than female and WA resident participants in our total sample, and these trends persisted in these age-separated subgroups. The similarities in our “box and whisker plots” illustrate this result.

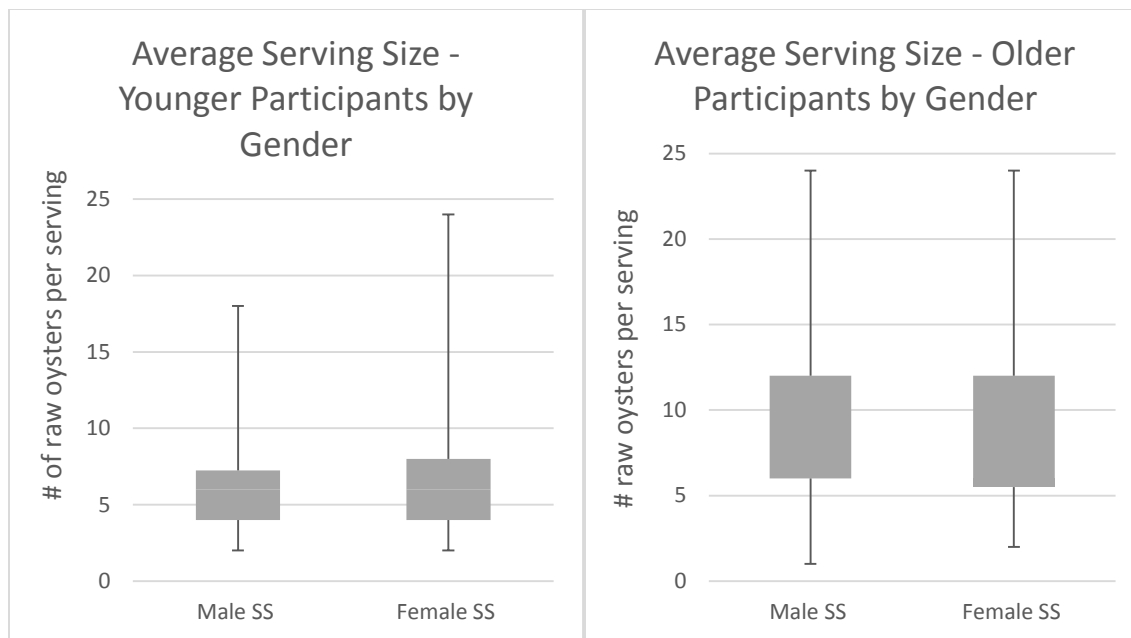


Figure III-20. Box and Whisker plots displaying the interaction of age and gender on average serving size. The left graph displays male and female participant serving sizes for ages 41 and younger. The right graph displays male and female participant serving sizes for ages 42 and older. Using these serving size subgroups in a multiple regression model, we did not find any evidence of an interaction between age and gender ( $p > 0.05$ ).

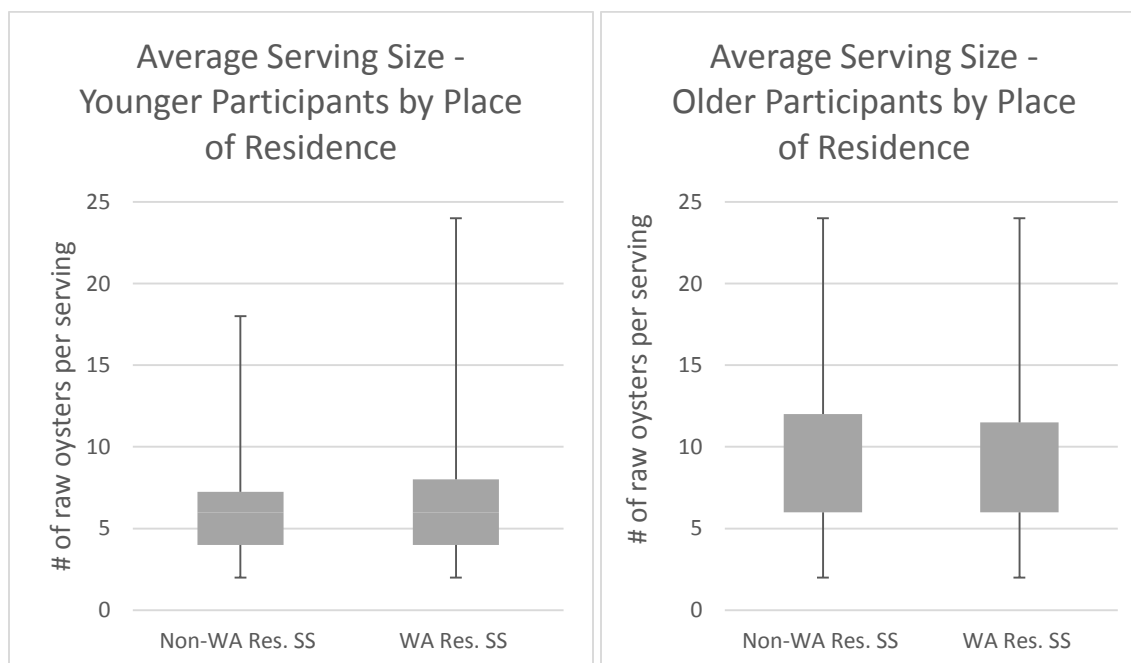


Figure III-21. Box and Whisker plots displaying the interaction of age and place of residence on average serving size. The left graph displays non-resident and WA resident participant serving sizes for ages 41 and younger. The right graph displays non-resident and WA resident participant serving sizes for ages 42 and older. Using these serving size subgroups in a multiple regression model, we did not find any evidence of an interaction between age and place of residence ( $p > 0.05$ ).

#### *Demographic Comparisons of Serving Size Outliers*

A closer look at outlying serving size data points was necessary because consumers eating the greatest quantities of raw oyster per sitting are potentially consuming the highest *V. parahaemolyticus* bacteria loads and may be at greater risk of vibriosis. Statistically, an outlying data point in our serving size set was calculated to be any serving size of 18 or more raw oysters per sitting. But under these parameter  $n = 15$ , which was not a representative sample of our 438 total serving size responses. Thus we decided to include all responses that indicated an average serving size of 12 or more raw oysters, resulting in  $n = 97$ . We also chose this range because it was double our total mode of 6 raw oysters per sitting, and because raw oysters are often sold by units of 6 and an analysis that included serving sizes of 12 raw oysters would be of greater relevance than one that began at 13 raw oysters, for example.

Again we chose to separated results into the three independent variable categories; place of residence, gender and age.

Survey card participants were split evenly between residents and non-residents (non-residents accounted for 51% of the survey card responses), but 61% of the survey card participants who indicated they eat 12 or more raw oysters per sitting were non-residents. Similarly non-residents accounted for only 12% of online survey responses, but 17% of the

online participants who eat 12 or more raw oysters per sitting were non-residents. A Chi-square test to assess the significance of place of residence in this outlier serving size analysis yielded  $p = 0.12$ . This value is greater than the test statistic of 0.05, proving there is no statistically significant effect of place of residence on serving size in this outlier group.

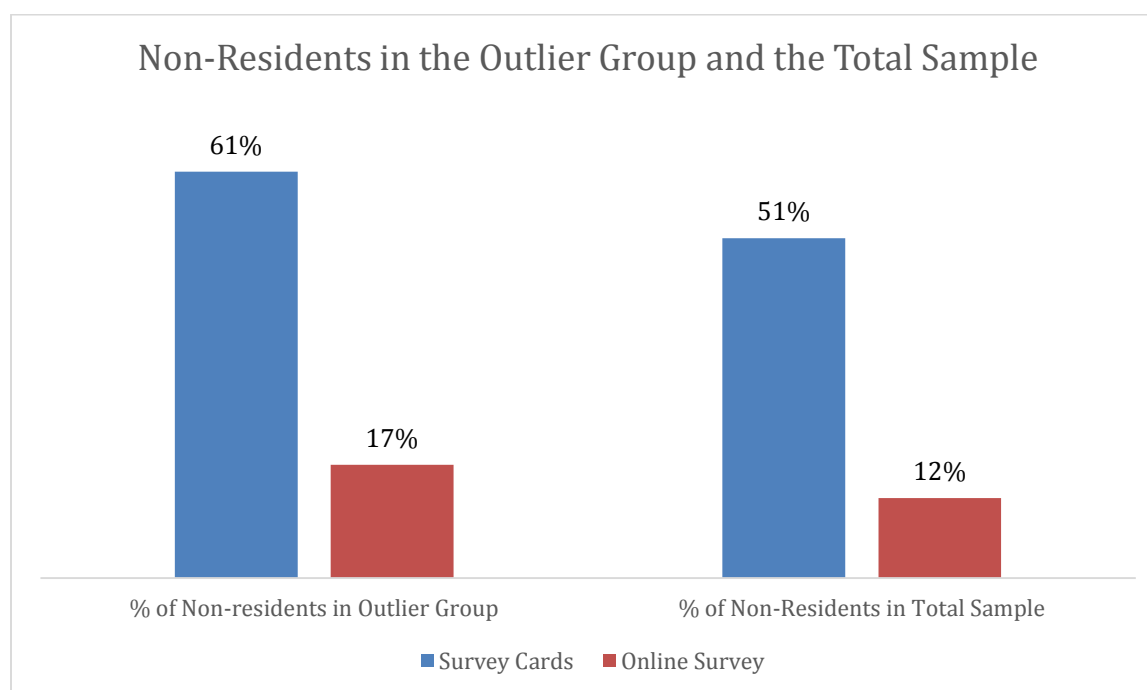


Figure III-22. Comparison of WA resident and non-resident average raw oyster serving size in the outlier group and the total sample, separated by survey method. In each method, non-residents were more present in the outlier group than in the total sample, but this difference was not proven to be statistically significant ( $p = 0.12$ ).

Survey card participants were split evenly between men and women (men accounted for 51% of the survey card responses), but 55% of the survey card participants who indicated they eat 12 or more raw oysters per sitting were men. Similarly men accounted for only 36% of

online survey responses, but 39% of the online participants who eat 12 or more raw oysters per sitting were men. A Chi-square test to assess the significance of gender in this outlier serving size analysis yielded  $p = 0.052$ . This value is equal to the test statistic of 0.05, proving there is a statistically significant effect of gender on serving size in this outlier group.

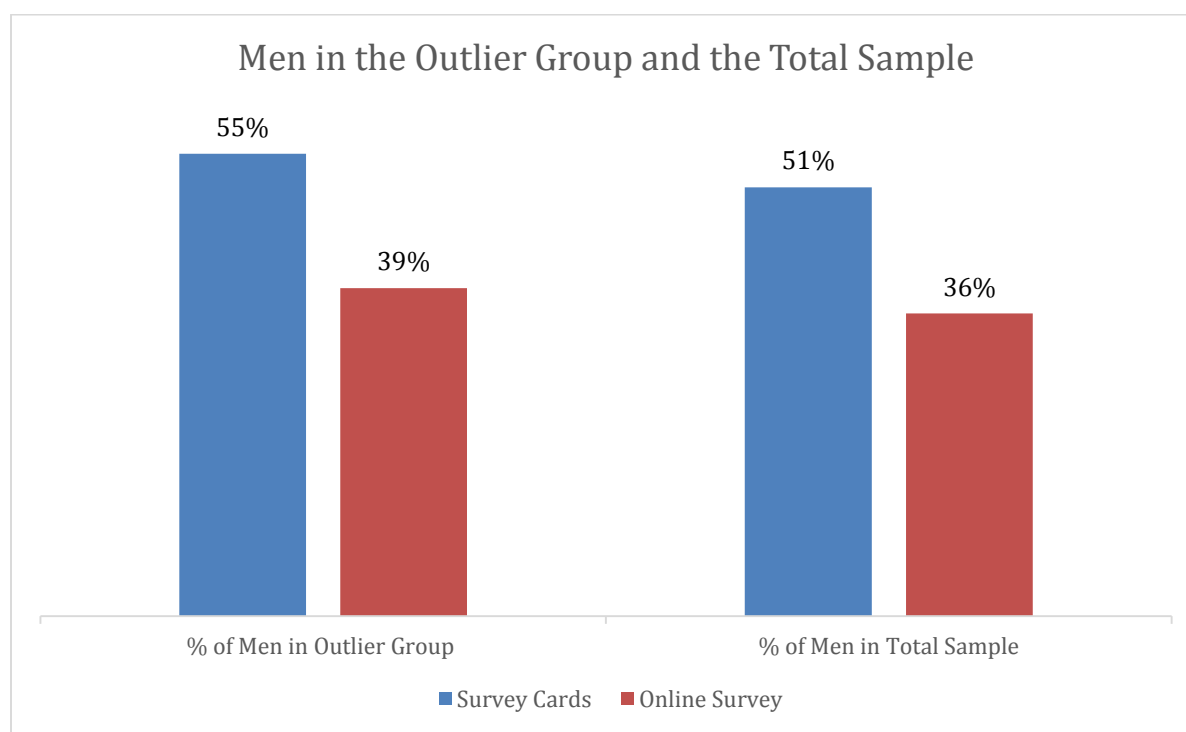


Figure III-23. Comparison of male and female average raw oyster serving size in the outlier group and the total sample, separated by survey method. In each method, men were more present in the outlier group than in the total sample. This difference was proven to be statistically significant with a  $p$  value nearly equal to the test statistic ( $p = 0.52$ ).

Average age of survey card participants was very similar to that of online participants (Figure III-13). Participants older than the total sample average age of 41 accounted for 42% of total survey card responses but accounted for a greater percentage of outlier response at 51%.

Similarly these older participants only accounted for 41% of total online survey responses but 45% of outlier online serving size responses. A Chi-square test to assess the significance of age in this outlier serving size analysis yielded  $p = 0.01$ . This value is greater than the test statistic of 0.05, proving there is a statistically significant effect of age on serving size in this outlier group.

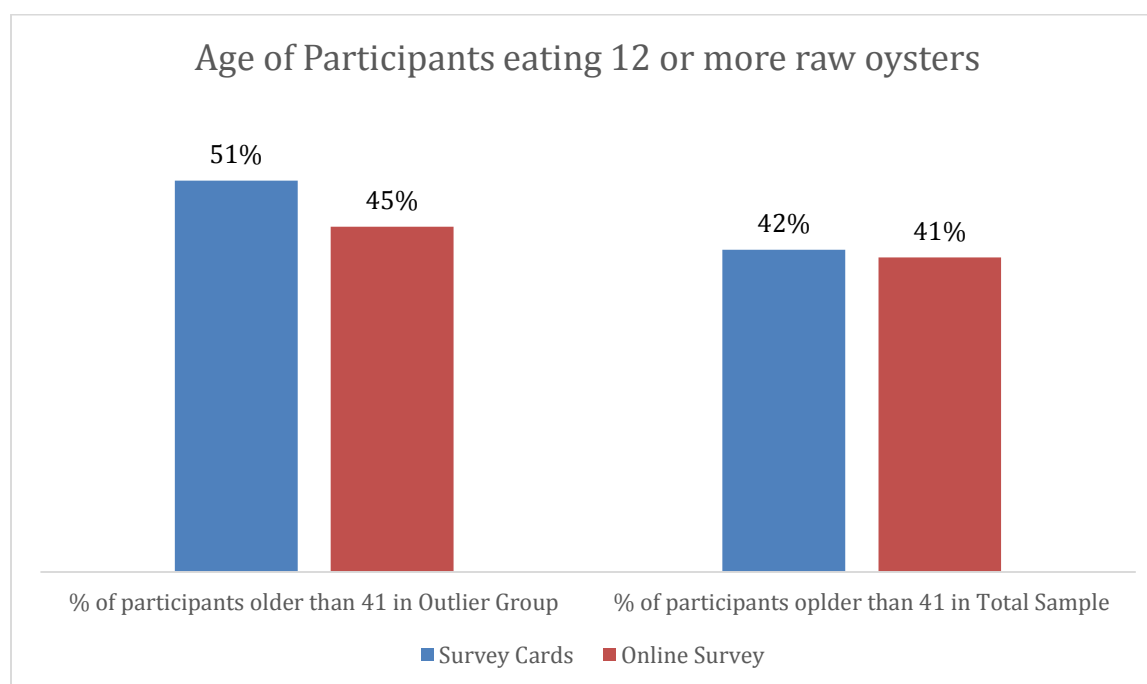


Figure III-24. Comparison of older (>41 years old) and younger ( $\leq 41$  years old) participant average raw oyster serving size in the outlier group and the total sample, separated by survey method. In each method, older participants were more present in the outlier group than in the total sample. This difference was proven to be statistically significant with a  $p$  value greater than the test statistic of 0.05 ( $p = 0.01$ ).

## Discussion

### *Serving Size*

All average serving sizes, for individual demographics, specific survey methods, and the entire sample, were greater than initially expected (Table I-1). We expected 6 oysters to be considered a sharable size by two diners, rather than a single serving size. However the mode of our total sample was 6 by a considerable margin (61% of all survey participants). If consumers chose to eat more than 6 raw oysters, they often ate 6 more raw oysters, totaling one dozen, and so on in factors of 6 (Figure III-4). This pattern is likely related to restaurant menus and seafood retailers that usually sell oysters in half-dozen increments.

Initially there was concern that the in-restaurant survey cards were skewing serving size answers to reflect 6 oysters too often. Chef Tom Douglas, whose restaurant customers accounted for most of the survey card responses, attached a promotion to the survey that incentivized participants to order 6 raw oysters specifically. According to servers at Dahlia Lounge, if a customer ordered 6 raw oysters and took the survey they would be rewarded with a free cookbook. We anticipated this concern and convinced Chef Douglas to remove the 6-oyster requirement for the free cookbook. But there were approximately 50 survey responses collected under the half-dozen oyster promotion conditions. These first 50 participants had an average serving size of 6.67 raw oysters. The remaining participants at Tom Douglas' restaurants had an average serving size of 6.96 raw oysters. The cookbook promotion did not seem to significantly skew serving size responses when comparing these averages ("t test" yielded  $p = 0.57$ ).

Similar concerns were raised when speaking with Austin Docter and Bill Dewey of Taylor Shellfish Farms. Dewey wondered if a degree of "boastfulness" was affecting some

participants, causing them to indicate a greater average raw oyster serving size (Pers. comm., 2015). Social psychologists would refer to this as a result of “social desirability bias” which is common to questionnaire surveys (Sjöström, Ove and Holst 2002; Phillips and Clancy 1972; Holden 2010). Social desirability bias arises when survey participants answer in accordance with a favorable view of reality and themselves instead of a critical consideration of facts (Holden 2010). Instead of taking a moment to critically consider an *average* raw oyster serving size across multiple meals, perhaps some participants selectively recalled occasions when they ate 12 or more raw oysters and proudly answered in accordance with those memories and not with a more representative average of all other raw oyster eating memories.

Docter specifically expressed skepticism towards an average serving size of 6 raw oysters (Pers. comm., 2015). Taylor Shellfish Farms’ Seattle restaurants report a serving size between 3.8 and 4.5 raw oysters per sitting despite their best efforts to sell as many raw oysters as possible (Docter pers. comm., 2015). Taylor Shellfish Farms restaurants are specifically focused on selling shellfish and raw oysters, thus it would be expected that their serving size data would be accurate or possibly a bit higher than the state average. However these restaurants calculate average raw oyster serving size by dividing *all* customers by the number of raw oysters sold (Docter pers. comm., 2015). Thus the few customers at Taylor Shellfish Farm restaurants that do not eat raw oysters with their meal are incorrectly contributing to the average, leading to a lower overall average. Furthermore there is no way of measuring specifically how many raw oysters each individual at the table ate – a complication that arises when raw oysters are shared. Regardless of these potential inaccuracies of POS data, our reported average serving size range of 6.84 to 7.32 raw oysters may be high and warrants further consideration (Figure III-4).

Discrepancies in average serving sizes between survey cards (predominately completed in restaurants) and the online survey were present in the results and warrant careful consideration (Figure III-2, Figure III-3). Perhaps participants at restaurants were associating their responses to the number of raw oysters they had just consumed during that meal. It would be difficult to imagine a response of 18 or more raw oysters per sitting at a Tom Douglas restaurant where oysters average \$3.50 apiece (Dhalia Lounge Dinner Menu 2015). But on a computer in a setting away from a restaurant, answering the online survey privately, it might be more conceivable that a participant would recall their most extravagant raw oyster eating experience and be compelled to answer higher than in a restaurant setting.

While most online participants indicated they usually buy raw oysters at restaurants (66%), 34% indicated they usually buy oysters elsewhere for home consumption (Figure III-9). Oysters bought in a retail setting or harvested recreationally are considerably cheaper per oyster than those offered at restaurants, which would allow this 34% of participants to afford to eat raw oysters in greater numbers. Only 40% of serving size outliers indicated they typically buy raw oysters at restaurants compared to this total average of 66%, suggesting that price may be an important restriction on greater raw oyster consumption per sitting. Survey card participants were not asked this buying location question because of space limitations on the cards, but also because the location of survey completion could lead to biased responses.

Taylor Shellfish Farms preferred the online survey to in-restaurant survey cards at their Seattle restaurants. A direct comparison between survey cards and online surveys from the same private company source may have illuminated the discrepancy between the POS serving size data and that of this study, as well as the discrepancy in average serving size between survey methods. Future studies should consider comparing responses from multiple survey methods

from one company or restaurant chain to better assess the serving size discrepancies found in our results (Figure III-2, Figure III-3).

A noteworthy distinction in serving size was found between Washington residents and non-residents that took the survey. Non-resident consumption averaged nearly one full raw oyster more per sitting than did local resident consumption (7.88 for non-residents compared to 7.08 for WA residents) (Figure III-17). This distinction was surmised by most key informants but had never been confirmed (Docter, Barrette, Douglas, pers. comm., 2015). It suggests non-residents visiting Washington may be doing so on vacation or may not have the chance to return again soon and want to take full advantage of local flavors by eating large amounts of raw oysters and other foods with less regard to price and normal eating habits than a local resident might employ. Despite the Chi-square results showing a lack of statistical significance, non-resident raw oyster consumers should be monitored in future assessments. Non-residents eating large amounts of raw oysters and returning to their home states or countries to report vibriosis is a complicated public health concern.

Studies suggest that on average, men eat more than women, and this distinction is exacerbated in mixed gender social situations (Allen-O'Donnell et al. 2011; Bublitz et al. 2013). Allen-O'Donnell et al. found that when men eat in the presence of women, they consumed 200 more calories on average than when women were not present (2011). Similarly women ate fewer calories on average when men were present during the meal (Allen-O'Donnell et al. 2011). These findings are particularly relevant for raw oyster consumption because of the social nature of this particular food. Raw oysters are meant to be shared and are typically featured as an appetizer on restaurant menus. Nearly all of our survey card participants were participating while dining at a restaurant (87%) and 66% of online survey participants indicated they typically

buy raw oysters at restaurants (Figure III-9). This majority of our sample typically eats raw oysters in social settings where Allen-O'Donnell et al's findings may be particularly relevant. Like place of residence, vibriosis risk assessment should consider gender as a meaningful variable influencing average raw oyster serving size, despite the statistical insignificance ( $p = 0.06$ ).

The independent variable that proved to most significantly affect average serving size was age ( $p = 0.0007$ ). While we calculated this  $p$  value by combining our decadal age groups into three, twenty-year age groups, the result reflects our age comparison graph which shows that nearly every subsequent ten year age group ate more raw oysters on average than the last (with the exception of 70+ participants eating less than 60-69 participants) (Figure III-19). Public health officials might take note of this result because more serious cases of vibriosis are more likely to be reported and require hospitalization in those that have chronic illnesses or are immunocompromised; conditions typically associated with the elderly (FAO and WHO 2011).

When splitting participant gender and place of residence into two age subgroups (young and older than our total sample average age of 41) and employing a multiple regression analysis, a statistically significant interaction was not present ( $p > 0.05$ ) (Figure III-20, Figure IUU-21). This result suggests age is a constant factor on average serving size across all gender and place of residence subgroups. As participant age increased, raw oyster serving size averages increased similarly.

### *Serving Size Outlier Analysis*

In a risk-per-serving analysis where grams of each meal are measured and considered for risk thresholds, serving size outliers represent consumers at the greatest risk of illness. Such consumers are potentially eating bacteria loads twice or even three times greater than our mode of 6 raw oysters per serving. While statistically outliers were defined as responses of 18 or more raw oysters per serving, we expanded the outlier analysis to include all responses of 12 or more raw oysters per serving in order to inform a greater proportion of the Washington consumer population.

Chi-square tests proved gender and age to be statistically significant contributors to average serving size amongst this outlier group (Figure III-23, Figure III-24). While place of residence did not prove to be as statistically significant, it did yield a considerable correlation ( $p = 0.12$ ) and showed a clear gap between Washington residents and non-residents (Figure III-22).

Oyster prices could possibly explain why younger consumers are eating fewer oysters per sitting than older consumers. Presumably older consumers have more disposable income and may not be restricted by raw oyster prices. However this consideration could be countered by Seattle's new, young, and highly salaried IT community (Parkhurst 2015). While price was shown to be less important to survey participants than freshness or place of harvest when buying raw oysters, it was still a relevant factor for many survey participants. 21% of participants who indicated they eat more than 12 raw oysters mentioned price as a prohibiting factor. Considering price sensitivity was an unprompted response to that survey question, this rate is noteworthy. It also reflects the lower rate of restaurant buying location preference for outliers referenced earlier (40% of outliers prefer buying raw oysters at restaurants compared to nearly 66% for the total sample). Participants who eat 12 or fewer raw oysters per sitting were not able to answer a fill-in-the-blank about their choice. Because there were only 15 responses of 18 or more raw oysters

per serving we could not effectively test for statistical significance of this buying location difference. Future studies should expand on these preliminary findings.

The same explanation for higher non-resident serving sizes in the total sample might also explain the large presence of non-residents in the outlier group. Tourists are less likely to be restricted by price or normal eating habits than residents, especially when consuming a food famously associated to the region, such as raw oysters in the Pacific Northwest. Certainly non-resident serving size outliers are a pertinent consideration for vibriosis risk assessment. DOH must be aware of consumers that eat raw oysters and then potentially leave Washington State to report illness elsewhere. Vibriosis lab testing capacity is a limitation already discussed, and while labs are not necessarily better suited to test for vibriosis here in Washington than other states or countries, different regional reporting structures and the separation between epidemiological staff, retail inspection staff and other personnel can cause complications and irregular reporting (Johnson, pers. comm., 2015). Furthermore the CDC tracks vibriosis illness based on the residence of the ill person, adding another factor to location of the meal, the location of the lab facility where the individual was tested, and the location where the oysters were harvested (Johnson, pers. comm., 2015). The ill person, the lab, the restaurant and the oyster itself could potentially all come from different states.

A greater proportion of male participants in the outlier group may be explained by socially impactful eating environments described by Allen-O'Donnell et al. (2011). Social desirability bias could also be an important consideration in this result as perhaps more male participants felt subconsciously motivated to record higher consumption averages than did female participants. This assertion requires a sociological analysis beyond the scope of this study, but it is worth noting for future research.

### *Consumption Frequency*

Responses from both versions of the survey indicated that 4-7 times a year is the most typical raw oyster consumption frequency for survey participants (mode = 2, 39% of responses) (Figure III-7). Only 11% of participants said they eat raw oysters more than once a month. Most key informants agreed that 4-7 times a year seemed like an accurate average temporal scale for average raw oyster consumption in Washington (Table I-1).

Average consumption frequencies were also similar between independent variables and Chi-square testing reflected this statistical insignificance (Figure III-17, Figure III-18, and Figure III-19). These similar averages may be indicative of the national demand for raw oysters. An assumption that Washington residents eat raw oysters more often because they live in the state that produces more commercial oysters than anywhere else is incorrect based on these results (Figure III-17). Washington shellfish enjoys a premium reputation nationally and abroad. Wild Edibles, a major seafood wholesaler based in New York City sources nearly half of its raw oyster inventory from Washington State (Martin, pers. comm., 2015). Similarly Taylor Shellfish Farms' only sells about 10% of its live oysters in Washington State (Docter, pers, comm., 2015). Seattle restaurateur, Tom Douglas, explained that he has had to reevaluate his raw oyster sourcing as local producers have become too expensive (Pers. comm., 2015). These factors suggest that living in Washington may not allow for greater exposure to affordable or even higher quality raw oysters compared to other regions of the country. It is possible that Washington residents are eating less raw oysters today than in previous years if Chef Douglas' testimony reflects a broader trend. This could mean raw oyster prices have increased and

availability has actually decreased for Washingtonians over the years, thus deterring higher consumption.

If consumers are not eating raw oysters at frequencies greater than anticipated, then industry growth must be attributed to other factors. This suggestion supports the higher average serving size result. Another consideration may be the proportion of consumers eating oysters. With considerably more restaurants offering raw oysters today than in previous years it is logical to surmise that there is a greater number of raw oyster consumers (Green 2013; Wolf 2013). Key informant interviews support this assertion. A final consideration should be the supply restriction on Gulf of Mexico wild oysters after the Deepwater Horizon oil spill that reportedly destroyed between four and eight billion oysters (US Department of Justice 2011).

Washingtonians do enjoy recreational access to oysters and shellfish not available in other parts of the country, and indeed shellfish harvesting has been a cherished activity for generations in the Puget Sound. But this access advantage is not reflected in our consumption data. With these considerations, plus the fact that Washington-grown oysters are increasingly sold out of state, an assumption that Washington residents eat more raw oysters simply because they live nearby is misguided. Again though, a timescale comparison would be needed to confirm this assertion.

### *Preferred Times to Eat Raw Oysters*

*V. parahaemolyticus* is a temperature sensitive bacterium and outbreaks have always been associated with warmer months (Figure I-2) (Johnson 2015). There is clearly an understanding among consumers that summer is not an ideal time to eat raw oysters in

Washington, but it is unclear as to why they feel this way. As water temperatures rise Washington oyster harvests are restricted to mitigate *V. parahaemolyticus* growth. Some growers have been known to raise their prices during these times, perhaps deterring consumers in the process (Hauch, pers. comm., 2015). The “r” month folk wisdom that advocates for oyster eating *only* in months that are spelled with at least one “r” may also be a factor for some consumers (McGough 2013). Oysters spawn in the summer months, meaning they are historically less full, flavorful, and texturally pleasing when temperatures rise (McGough 2013). With the advent of triploid oysters that do not spawn the “r” month rule is becoming obsolete, but possibly still influential to consumption habits (Hollier 2014). Certainly some consumers are also aware of the heightened vibriosis risks associated with eating raw oysters harvested in warmer waters.

We did not directly ask about oyster-related foodborne illnesses in this survey. The structure of Question 4 did not provide an opportunity for respondents to clarify why summer is an avoidable time of year for many consumers. Our foodservice research partners did not want to be involved with a study asking specific foodborne illness questions because they feared survey participants might begin to associate their products and establishments with vibriosis. But more fundamentally we did not ask about summer aversion because at the outset of data collection we were not aware of this observed response. The data collection for this study was designed to focus on serving size and other consumption trends, not illness. This may be an area where future research that explores these seasonal perceptions further would be informative to the public health community.

This aversion to raw oysters in the summer months may not corroborate with sales numbers from Seattle seafood restaurants and Washington oyster farms. A few raw oyster-

serving restaurants in the Seattle area, both involved and not involved with this study, have described an increase in sales during warmer months, seemingly in contradiction to our results for Question 4. Ray's Boathouse, a restaurant not involved with the surveys but willing to comment on their raw oyster sales, explained that their fall and winter raw oyster sales are substantially less than those totaled during the summer (Hauch, pers. comm., 2015). Similarly Austin Docter of Taylor Shellfish Farms said, "in general, all three summer months [June, July and August] are busier than any other months, with the exception of December when everyone is out shopping." (Pers. comm., 2015). Docter reaffirms this summer preference for raw oyster consumers and touches on the popularity of raw oysters during the holidays, which is reflected in our word cloud for Question 4 (Figure II-5). "Longer days, more time to sit outside, more weekend excursions," are important considerations for consumers when selecting raw oysters (Docter, pers. comm., 2015). These factors seem to outweigh the summer aversion depicted in our results.

### *Purchasing Locations*

We did not poll survey card participants on their preferred purchasing locations. Almost all survey cards were completed at a restaurant, which would have introduced bias into these results. This purchasing location analysis only pertains to online survey responses.

Industry testimony suggested the majority of raw oyster sales occur in restaurants and the results from the online survey support this claim (Table I-1) (Figure III-9). The premise of this study was based around the expectation that most commercially-harvested raw oysters are purchased in a restaurant setting and only surveying retail customers would not be representative

of the raw oyster-consuming population in Washington State. Our results support this premise (Figure III-9).

There was a notable segment of participants that indicated they bought raw oysters directly from farms. 13% of the online participant group indicated oyster farms as the preferred buying location in the optional fill-in-the-blank section of Question 5 (Figure III-9). Although a small portion of the total sample, oyster farm purchases accounted for 75% of the fill-in-the-blank answers given. In comparison only 3% of the total population said they typically eat raw oysters that they harvested recreationally – a low number, but this survey was designed for commercial raw oyster consumption and not to quantify recreational oyster harvests.

In the outlier data analysis we noticed that only 40% of raw oyster consumers who consume 18 or more raw oysters per serving indicated they usually buy raw oysters at restaurants. This percentage was lower than the overall sample average of 66% (Figure III-9). Buying raw oysters in retail settings or harvesting them recreationally lowers the cost per oyster and seems to encourage more consumption per sitting. Thus if buying locations change significantly, more consumers could be at greater risk of vibriosis.

For both public health officials and restaurateurs this result confirms a previous understanding that restaurants are a main venue for raw oyster consumption. A point of contention unique to raw oyster consumption in restaurants is the “variety plate” of raw oysters. Today commercial oyster farmers distinguish their products from those of their competitors on the basis of terroir or rather *merroir* (Martell 2011). Similar to wines, oysters are said to take the taste of the place they are grown. The nutrient flow in the water, like the mineral composition in the soil of a vineyard, subtly alters the taste of a raw oyster (Martell 2011). To feature these taste differences many restaurants now offer a “variety plate” of raw oysters with a piece or two from

each of a number of different oyster farms. Consumers get to compare each oyster on the plate and feel more involved in the meal and the farm-to-table narrative. From a public health perspective, the variety plate presents a complicated challenge in investigating the source of an illness. If a consumer contracts vibriosis, there is no method for determining which oyster on the variety plate led to the illness. A possible benefit of outlying oyster consumers eating raw oysters more often at home or from self-harvest is that tracking their illness source would likely be simpler than in this variety plate scenario.

#### *Favorite Oyster Varieties and Types*

We did not expect nearly half of the online participants to specify a favorite type of raw oyster (Figure III-10) (Table I-1). This is another data point that would be interesting to measure in other markets and over time to compare with our results this year in Washington.

There was a mix of geography and brand preferences amongst participants that answered “Yes” in Question 6, but brand recognition was the dominant theme. This question only appeared on the online survey, so there was no interference with specific restaurant menus and favorite oyster type – if a survey card participant had just ordered Kumamoto oysters with a meal, he or she might be swayed to indicate those oysters are his or her favorite. Bias could also exist through the setting in which a participant found the online survey – if an online participant found the survey on Hama Hama’s Facebook page he or she might be inclined to answer in favor of their oyster varieties.

This data likely will not inform vibriosis risk assessment, but it does tell oyster growers that half of their customers may be selecting oysters based on the name on the menu rather than

the product itself. It is not clear if these consumers would avoid eating raw oysters altogether if their preferred brand or variety was not on the menu, but such considerations are certainly relevant with this result in mind.

### *Oyster Size Preferences*

The size of the oyster was a factor for 79% of online survey participants (Figure III-11). There was a distinct preference for smaller oysters, with only 4% of participants indicating they preferred oysters longer than 4 inches. The most popular size was Extra Small (2.5-3 inches) and indeed this reflects raw oyster sales - most commercial oysters grown in Washington are around 3 inches in length (Docter, James, pers. comm., 2015).

This question has important risk assessment applications. Current vibriosis risk assessment models are based on risk per oyster analyses measured by converting the number of raw oysters consumed to grams, which then informs the potential bacterial load of the meal (FDA 2005). Illness risk increases as total weight of raw oysters consumed increases. DOH determines average weights for different oyster sizes, meaning a larger oyster preference could significantly alter recommendations (Browning 2014). According to Dr. DePaola the average oyster size statistic is second in importance only to average serving size in informing current vibriosis risk assessment models (Pers. comm., 2015).

### *Evaluating Raw Oyster Qualities*

When anticipating important factors for raw oyster consumers, perceived Freshness was important to respondents, with a weighted average of 4.78 on our 1-to-5 Likert Scale (Figure III-12). But the dramatically lower weighted average of 2.86 for Price was not expected (Figure III-12). (Table I-1).

Most key informants we interviewed before collecting our survey data felt that the industry was nearing a critical juncture with oyster prices and that would be reflected in this result (Table I-1). Bill Dewey of Taylor Shellfish Farms was concerned that an economic bubble should have burst when raw oyster prices reached three dollars apiece (Pers. comm., 2014). “Who in their right mind would pay three dollars for an oyster, we thought.” (Dewey, pers. comm., 2014). But these results suggest customers are willing to pay a premium for a fresh, local product harvested at peak season. Raw oysters prices may be more elastic than expected and demand may be sustained with prices even higher than the three dollar industry standard.

These findings will not directly inform foodborne illness risk assessment models but they do highlight a relevant consumer premium on freshness. Oyster growers we interviewed were quite defensive about raw oyster illnesses reports by local media, explaining that, “when someone gets sick from an oyster, it is front page news in the Seattle Times. But I bet someone in Washington also got sick from a hamburger that same day, but we don’t hear about that story.” (Bloomfield, pers. comm., 2014). Raw seafood instills a heightened level of uneasiness in American consumers, and indeed there are life-threatening risks involved with eating any kind of raw animal-based protein. But compared to salmonella which has an annual incidence rate of 15.2 reported cases per 100,000, vibriosis had an incidence 0.28 reported illnesses per 100,000 in 2010 (Salmonella: Technical Information 2015; Newton et al. 2012). An important caveat is that more consumers eat chicken, eggs, and other animal proteins that can carry salmonella in greater

amounts and in greater frequencies than raw oysters, and are thus exposing themselves to salmonella far more often than to *V. parahaemolyticus*. But this comparison shows that the perceived risk of eating raw oysters may not match actual risk, and consumer perception is a powerful incentive.

It would be interesting to examine consumer perception towards low-priced raw oysters to see if they distrusted a product solely because of the price point. But our participants' valuation of freshness should be noted in this study to reiterate the sensitivity of illness associations in the consumer raw oyster schema.

#### *Participant Gender Ratio*

The gender distribution in this study was unusual in that 63% of the online survey participants were women (Figure III-14). It is unlikely that this imbalance is representative of the broader Washington raw oyster consumption community because the in-restaurant survey cards yielded an equal ratio of male and female participants. The online survey was re-posted by the blog *Women and Fish* and was distributed around the University of Washington School of Marine and Environmental Affairs student body, which has more female students than male. However these two samples should not have skewed the online survey gender ratio as drastically as is seen, so the discrepancy is difficult to explain.

Some studies suggest women are more responsive to surveys than men, and online surveys have proven to be a sampling method that particularly represents this difference (Smith 2008). An online survey gender response test was conducted on San Jose State University faculty in 2008 and found the response rate of females to be 36% compared to just 24% for men.

Statistical analysis proved this difference to be significant ( $p < .001$ ). Similar studies should be considered in determining future raw oyster consumption research methodologies. To date there has been no correlation between *V. parahaemolyticus* illness and gender (DePaola, pers. comm., 2015).

### *Survey Exposure Challenges and Successes*

Despite our best efforts, it was exceedingly difficult to distribute survey cards because most restaurateurs disliked the idea of having them presented during the meal. The cards were designed to be minimally intrusive and easy to complete in a few seconds. Yet most restaurants were unwilling to disrupt the aesthetic of the meal in any way. This certainly was one of our concerns from the beginning of this study because most restaurants that serve raw oysters fall into a highly sophisticated “fine-dining” category that provide a premium product at higher price points. Restaurateurs felt these cards might appear “tacky” or as if the customers were being given “homework” at the table. (Docter, pers. comm., 2015). Taylor Shellfish Farms’ restaurants were not able to distribute survey cards but they were extremely cooperative with other aspects of this study and particularly interested in our results.

Only one restaurateur agreed to distribute survey cards: Chef Tom Douglas. We hoped Chef Douglas’ reputation and partnership would attract other restaurateurs to the survey cards, especially since he joined our efforts relatively early into the data collection process. However this was not the case and it seemed more challenging to attract additional restaurant partners once survey card Version 2 was in circulation. The willingness of other Seattle restaurants to

engage was contingent on their competitors, such that they chose not to participate if another major player already distributed survey cards.

The online survey was created after the survey cards failed to reach a representative population in the greater Seattle area. Online survey results doubled the participant population and provided responses on additional questions not featured on the survey cards. The online survey could have had a broader reach if more restaurants and seafood retailers were successfully recruited, but it still succeeded in expanding the total population to a sufficient size.

Results from Question 12, “*How did you hear about this survey?*” showed the online survey was accessed by a variety of participants from multiple sources (Figure III-16). Social media posts were the most efficient data collection method because they yielded the most results but also because it placed the recruiting effort on our private sector participants. Yet by directly involving private companies we may have skewed the results for questions regarding oyster size and brand preferences.

With the help of just six social media users: Tom Douglas Restaurants, Ethan Stowell Restaurants, Elliot’s Oyster House, Chandler’s Crabhouse, Hama Hama Oyster Farm and Taylor Shellfish Farms, we were able to generate 263 total online survey responses and attract other websites and social media outlets to our survey. The *Eat Ballard* Facebook page, for example, reposted the survey link after seeing it on one of our five original partner pages without our request.

The 61 responses collected via the email thread, as described by “Other Partners” in our methodologies, were more than originally anticipated. This was probably because those emailed were either already aware of the study or were particularly interested in seafood studies and

marine affairs (the survey was emailed to the regional NOAA Fisheries offices). For this reason the success of the email thread should be considered somewhat unusual and not expected with future studies of this kind. Instead future studies should review and expand upon the success of the social media outreach strategy.

### *Research Limitations*

Overall this study accumulated a substantial survey population size with which relevant conclusions could be drawn on raw oyster consumption statistics and trends. Destination restaurants outside the city, located in coastal and Puget Sound areas, and in Eastern Washington, were not surveyed and would have added an interesting perspective to the data set. Additionally only two oyster farms, Hama Hama Oysters and Taylor Shellfish Farms, directly participated with survey distribution. Participation from oyster farms in Grays Harbor or Pacific counties would have been a welcome addition. It would have also allowed for intrastate comparisons.

It was not feasible in the scope of this study, but it would have been interesting to poll all Seattle consumers, not solely raw oyster consumers or patrons of seafood restaurants. There was no perspective gained about the proportion of raw oyster consumers among total seafood consumers, or the total population in Washington, and there was no measurement of how that number has changed over time. Both results would certainly be relevant to public health officials and private sector stakeholders.

## Conclusion

The primary goal of this study was to provide information to DOH on average raw oyster serving size for oysters consumed in Washington. Our results displayed a much higher average serving size than initially expected and some key informants questioned these findings (Figure III-4). Taylor Shellfish Farms restaurant POS data found their average raw oyster serving size to be between 3.80 and 4.50 raw oysters per sitting in a dining environment that adamantly encourages raw oyster consumption (Docter, pers. comm., 2015). Yet in all of our survey formats and demographics we found the average serving size to be greater than 6 raw oysters per sitting.

The key distinction between Taylor Shellfish Farms' POS data and our results is that the former records raw oyster sales while the latter measures consumer perception. POS data are based on sales per receipt, not sales per customer. It fails to capture individual consumption of shared menu items. A plate of raw oysters is typically shared and almost always featured as an appetizer on restaurant menus. Our survey was designed to fill this information gap by polling each consumer specifically and disregarding any sales data that could be misleading. The wording of our serving size question was meticulously crafted for this aim.

Perhaps the distinction between our findings and Taylor Shellfish Farms' POS findings is better viewed as a range of possible answers than discouraging evidence against either data set. The correct raw oyster serving size probably lies somewhere between 4.50 and 6.84 raw oysters – somewhere between the sales receipt and a consumer's perception of their own dining habits.

Vibriosis risk assessment can be conducted effectively within this serving size interval by incorporating this study's other findings to hone our understanding of a typical raw oyster

consumer. For example, consumers in Washington eat raw oysters approximately once every two months, which did not surprise any of our key informants (Figure III-7) (Table I-1). This demands consideration of the higher end of the serving size interval because oyster industry growth may be a reflection of consumers eating more raw oysters per sitting. It also suggests that more people are consuming Washington-grown raw oysters than previously expected. If serving size is not the explanation for industry growth, then new consumers may be the answer. Indeed non-resident raw oyster consumers in the outlier serving size group were a key contributor to increasing the serving size average in this study (Figure III-22). Non-residents were also found to eat raw oysters slightly more often than Washington residents (Figure III-17). Perhaps this non-resident demand is related to recent declines of Gulf of Mexico oysters in the wake of the 2010 Deepwater Horizon oil spill which resulted in the loss of 240 to 508 million pounds of edible oyster meat (US Department of Justice 2011). Local and national vibriosis risk assessments will need to consider an inter-regional perspective for today's raw oyster consumers..

While the image of a typical Washington raw oyster consumer is quite diverse, both from the perspective of place of residence and from the 19 to 91 age range in our sample, there were some noteworthy consistencies in our results to make helpful generalizations. Freshness was paramount to all consumers in this survey, outclassing price by two full points on average on a 1-to-5 Likert Scale (Figure III-12) (Table III-1). Place of Harvest and Time of Year were also more important to consumers than Price when selecting raw oysters (Figure III-12) (Table III-1). This result shows oyster growers and restaurant owners that raw oysters are a considerably more price-elastic product than our key-informants originally thought (Table I-1). It also may serve to illustrate how critical a safe product is to raw oyster consumers, if a correlation between

freshness and safety can be determined. This study was unable to delve deeper into that association but a majority of survey participants expressed an aversion to raw oysters in the summer months, which may have reflected a combination of concerns such as taste and texture, but certainly involved illness considerations as well. Effective illness risk assessment is particularly important for raw oysters because it must protect this fragile consumer schema.

Another helpful generalization is that consumers plateau their raw oyster consumption around factors of six oysters (Figure III-4). Purple columns in Figure III-4 highlight these consumption thresholds at which consumers usually stop eating. However if consumers choose to continue eating raw oysters past six pieces, they usually eat another half dozen, and continue in factors of six until the biggest appetites are satisfied at twenty-four raw oysters (Figure III-4). Oysters are often sold by the dozen in a retail setting, and many menus feature raw oysters priced with the best value at half-dozen increments which surely contributed to this trend. Effective risk assessment from a risk-per-serving analysis should focus around these factors of six. Comparing the foodborne illness risk of twelve raw oysters relative to six raw oysters would be impactful.

If there is evidence that twelve or more raw oysters represents a higher illness risk than six or fewer raw oysters, we can be assured that most consumers do not venture into the double-digits per sitting. But those who do are typically men (although equal amounts of female consumers were shown to eat exactly twelve oysters) over the age fifty. Additionally these older male consumers are usually non-residents. Chi-square testing proved age to be the most significant of these three independent variables on affecting average serving size (Figure III-19). A multiple regression analysis showed age to be a constant contributor to higher average serving sizes across all other demographics for gender and place of residence, not solely male and non-

resident participants (Figure). Older consumers of any food are more likely to be immunocompromised than younger counterparts. Our findings related to consumer age should be incorporated in vibriosis risk assessment models to mitigate risks for these sensitive populations.

Comprehensive raw oyster consumption data collection can be accumulated in a relatively short time frame with minimal resources. We were concerned that a product consumed predominantly in privately owned, fine-dining restaurants would be complicated to measure, and indeed it was challenging to partner with multiple restaurateurs willing to participate with in-restaurant survey cards. But with only a handful of initial relationships we were able to disseminate our online survey to a broad range of participants and user groups, collecting a representative sample size for effective results. No previous study of this kind existed for raw oysters or any similar food product consumed in these restaurant settings. Our relative success should be an encouraging example for future studies. The ability of our findings to have immediate public health benefits has proven that more information can and should be collected from the private restaurant sector for future risk assessment purposes.

## Appendix I

### QUESTIONS FOR CHEFS AND RESTAURATEURS:

\*\*to all applicable questions, consider your answer in the scope of 5 to 10 years. For example in question #1, in addition to how many oysters you buy and sell now, consider if this amount has changed over the past 10 years. Please elaborate on any such changes.

1. -How many oysters do you buy for raw consumption each week/month? (may be easier to estimate on different time scales for different chefs)
2. -How many oysters are served per plate? If oysters are ordered by the piece at your restaurant, how many pieces would you say you sell on average per order?
3. -Based on your observations, what type of customers are ordering raw oysters? Men, women, young people, older people, minorities, tourists? Etc.
4. -Based on your observations, what would be the typical serving size for one customer eating raw oysters in your restaurant(s)?
5. -What times during the year are raw oyster sales highest and lowest at your restaurant? Or is there even a major difference?
6. -What percentage of your raw oysters on your menu come from farms here in Washington?
7. -Has raw oyster popularity changed in recent years in your opinion? How has it changed in your restaurant, your menu?
8. -What do you think raw oyster demand will look like in 5 years, and what factors will most influence change?
9. -What else do you think is important for me to consider when studying raw oyster consumption in Washington?

### QUESTIONS FOR OYSTER GROWERS AND INDUSTRY KEY INFORMANTS:

\*\*to all applicable questions, please also answer in terms of change in the last 10 years. For example, in question #1 please indicate how many oysters you sell currently, but also explain how that number has changed over the last 5 to 10 years.

1. -How many oysters does Hama Hama sell for raw consumption each week/month/year? (whatever timescale you prefer)
2. -What percentage of sales are for raw consumption, compared to sales for products meant for cooked preparations?
3. -Where (geographically), and to what establishments, are most of your live oysters sold? Restaurants, retailers (percentages)? Do you think your answer would be similar to other oyster farmers in Washington? Why or why not?

4. -What percentage of your live oysters is sold in state? Where do you sell the rest?
5. -Do you think raw oyster consumption in Washington has changed in the last 5, 10, 20 years? If so, how?
6. -Has the way you run your business changed in the last 1, 5 or 10 years? How so?
  - >For example, has your farming and harvesting techniques changed?
  - >have you marketed your business differently?
  - >Do you feel you are targeting a new consumer base?
7. -In your opinion, what is the biggest challenge for WA oyster farmers going forward?
8. -Over saturation – what are your thoughts? Do you think it exists in the commercial oyster industry here in WA? How does it affect veteran WA farmers like yourself? Do you think it benefits consumers?
9. -What is one aspect, one reality of the WA oyster industry that consumers do not understand, that you think they should understand?
10. -What would you personally like to learn from this study?
11. -What other thoughts do you have about raw oyster consumption in Washington and its evolution in recent years?

## Appendix II

WASHINGTON RAW OYSTER CONSUMER SURVEY – ONLINE VERSION

The School of Marine and Environmental Affairs at the University of Washington is partnering with the Washington Department of Health to conduct a consumer survey in order to better understand your tastes and preferences for raw oysters here in Washington. Please take a moment to answer the following questions:

1. Do you eat oysters on the half shell (raw)? Why or why not?

(Please circle one and briefly explain) Yes – No

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*[Skip logic will be employed here – if they answer “no” then the survey will skip them to the final demographic questions.]*

2. How many raw oysters do you personally eat in one sitting?

(Please circle one, or explain)

1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10 – 11 – 12 – Other:

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3. How often do you eat raw oysters? (Please circle one)

1 to 3times a year – 4 to 7times a year – 8 to 12times a year – 2 to 3times a month – More than 2 to 3times a month

4. Are there certain times during the year when you typically eat raw oysters? (Please circle all that apply)

Spring – Summer – Fall – Winter – Holidays (please explain)\_\_\_\_\_

Other times not listed (please explain)

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5. Where do you typically buy raw oysters?

Restaurants – Retail Stores – Other (please explain)\_\_\_\_\_

6. Do you have a favorite type of oyster?

No, not particularly – Yes (please explain)\_\_\_\_\_

7. What size oyster do you prefer to eat raw, on the half-shell?

(Measurements are from the oyster's hinge to the bill, which is its length, not its width)

(Please circle one)

Petite (under 2.5 inches) – Extra Small (2.5-3 inches) – Small (3-4 inches) – Medium or Large (longer than 4 inches) –The size of the oyster doesn't matter to me

When choosing a raw oyster how important are the following considerations:

8. Price? (Please circle one)

Not important at all – Not very important – Moderately important – Very important – Extremely important

9. Freshness? (Please circle one)

Not important at all – Not very important – Moderately important – Very important – Extremely important

10. Place of harvest? (Please circle one)

Not important at all – Not very important – Moderately important – Very important – Extremely important

*[If they answered "no" to the first question then they will skip ahead to this point in the survey:]*

What is your date of birth? mm\_\_\_\_\_ dd\_\_\_\_\_ yyyy\_\_\_\_\_

What is your gender (Please circle one)

Male   Female   Other (please  
specify)\_\_\_\_\_

Place of Residence: City\_\_\_\_\_ State \_\_\_\_\_ Zip  
Code\_\_\_\_\_

Thank you so much for your participation. If you are interested in learning more about this study or sharing more of your experiences eating raw oysters in Washington, please leave us your email address:

Email address: (*voluntary*)

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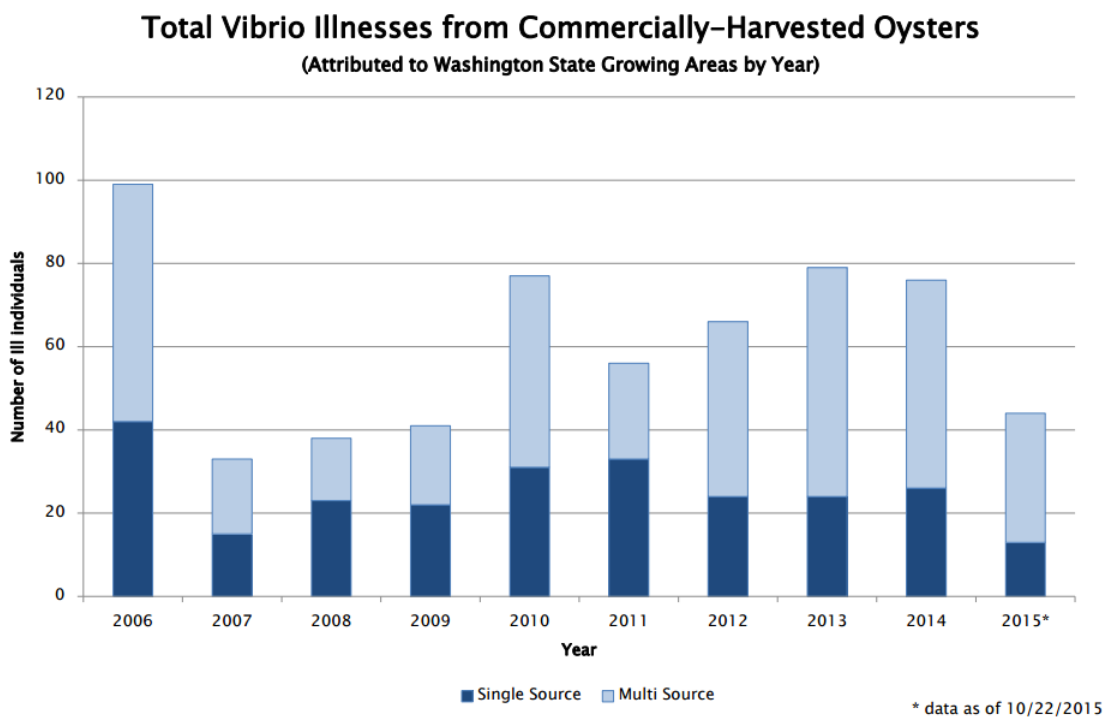


Figure I-1. Reported cases of vibriosis associated with Washington-grown oysters from 2006 to 2015. While the reported cases have been relatively consistent in this nine-year span, the rate of illness has perhaps decreased when considering oyster industry growth during this same time period. The decrease from 2014 to 2015 is possibly a reflection of the new DOH *V. parahaemolyticus* critical control plan that uses a risk-based approach. DOH aims to reduce these reported cases even further as a risk-per-serving analysis becomes more feasible. (Washington Department of Health 2015).

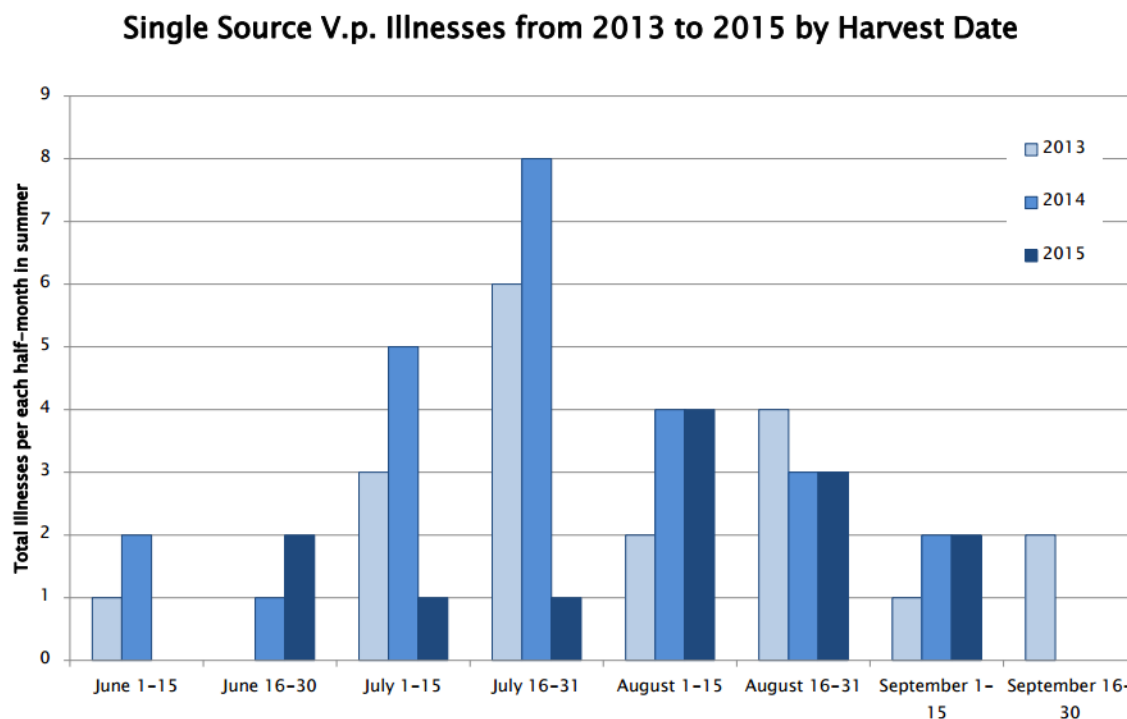


Figure I-2. *V. parahaemolyticus* illness reports from 2013 to 2015 in Washington State. It illustrates the temperature sensitivity of *V. parahaemolyticus* and its tendency for illnesses to occur from oysters harvested in the summer months. This data may reflect results from Survey Question 4, but seems to contradict key informant testimony regarding raw oyster sales which are understood to be at their peak during the summer months. (Washington Department of Health 2015).

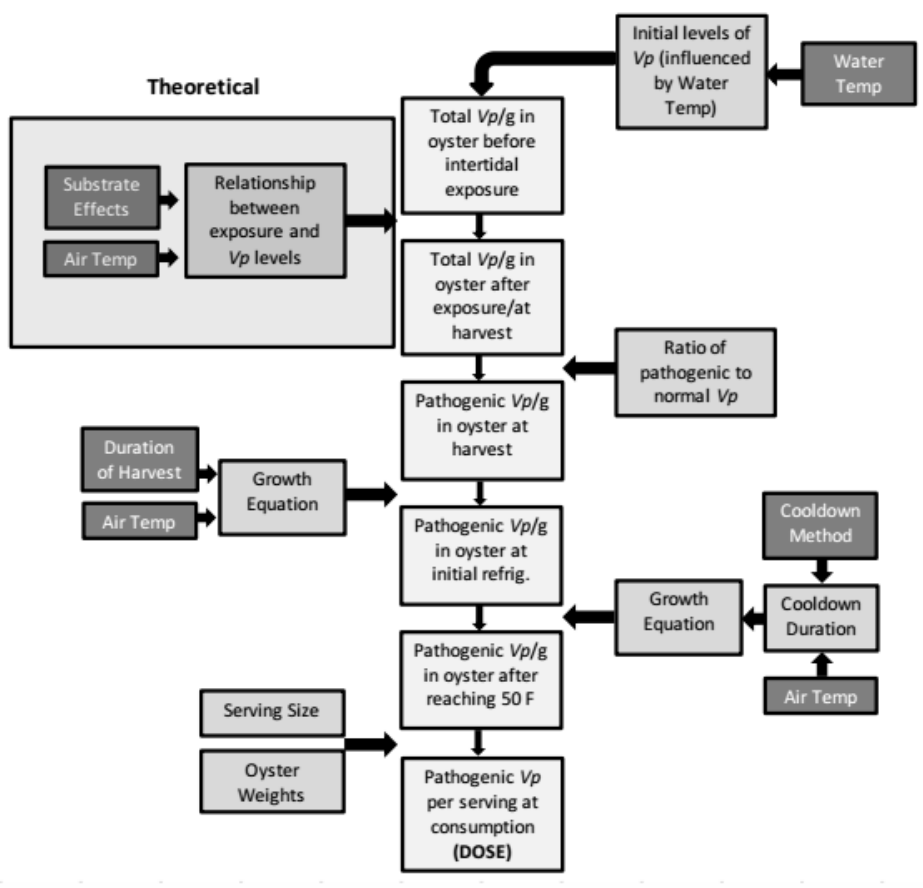


Figure I-3. Conceptual model of the WA State risk assessment for *V. parahaemolyticus* in raw oysters designed. Dark grey boxes indicate user input values; medium grey boxes indicate data; and light grey boxes represent levels of *V. parahaemolyticus* in oyster tissue at various stages of the supply chain. (Browning 2014).


<p><b>WASHINGTON RAW OYSTER CONSUMER SURVEY</b></p> <hr style="width: 10%; margin-left: 0;"/> <p>The School of Marine and Environmental Affairs at the University of Washington is conducting a consumer survey in order to better understand your tastes and preferences for raw oysters here in Washington. Please take a moment to answer the following questions:</p> <p>Do you eat oysters on the half shell (raw) and why or why not? (Please circle one and briefly explain) <b>YES NO</b></p> <p>_____</p> <p>_____</p> <p>If you do eat raw oysters, how many do you personally eat in one sitting? (Please circle one, or explain)</p> <p><b>1 2 3 4 5 6 7 8 9 10 11 12 OTHER:</b> _____</p> <p>What is your date of birth? <b>mm</b> _____ <b>dd</b> _____ <b>yyyy</b> _____ (Sorry, you must be at least 18 years of age to participate)</p> <p>What is your gender? (Please circle one) <b>MALE FEMALE OTHER</b> (please specify) _____</p> <p>Place of Residence: <b>CITY</b> _____ <b>STATE</b> _____ <b>ZIP CODE</b> _____</p> <p><b>Thank you so much for your participation.</b> If you are interested in completing our full survey please email us at: <a href="mailto:uwoystersurvey@gmail.com">uwoystersurvey@gmail.com</a>. We would greatly appreciate your insight!</p>	<p><b>W</b> SCHOOL OF MARINE &amp; ENVIRONMENTAL AFFAIRS UNIVERSITY of WASHINGTON College of the Environment</p>
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Figure II-1. Survey Card Version 1. This version of the survey card was distributed at seafood retailer stores, seafood farmer's market stalls, and around University of Washington's Seattle Campus. This version was designed specifically to collect fill-in-the-blank consumer feedback from seafood consumers who may or may not choose to eat raw oysters in order to build a word cloud representative of the raw oyster schema.




Figure II-2. Results from survey Question 1 are displayed in a word cloud. The size of the words are proportionate to the number of times they appeared in the fill-in-the-blank answers. In addition to positive words like “delicious”, “sustainable” and “delicious”, negative words like “gross” and “booger” also appeared in the word cloud, illustrating the polarizing nature of raw oysters in the schema of our surveyed population.

## **WASHINGTON RAW OYSTER CONSUMER SURVEY**



SCHOOL OF MARINE & ENVIRONMENTAL AFFAIRS  
UNIVERSITY of WASHINGTON  
College of the Environment



The School of Marine and Environmental Affairs at the University of Washington is conducting a consumer survey in order to better understand your tastes and preferences for raw oysters here in Washington. Please take a moment to answer the following questions:

How many raw oysters do you personally eat in one sitting? *(Please circle one, or explain)*

**1 2 3 4 5 6 7 8 9 10 11 12 OTHER:** \_\_\_\_\_

How often do you eat raw oysters? *(Please circle one)*

**1-3 TIMES A YEAR 4-7 TIMES A YEAR 8-12 TIMES A YEAR 2-3 TIMES A MONTH MORE THAN 2-3 TIMES A MONTH**

What is your date of birth? **mm** \_\_\_\_\_ **dd** \_\_\_\_\_ **yyyy** \_\_\_\_\_  
*(Sorry, you must be at least 18 years of age to participate)*

What is your gender? *(Please circle one)*

**MALE FEMALE OTHER** *(please specify)* \_\_\_\_\_

Place of Residence: **CITY** \_\_\_\_\_ **STATE** \_\_\_\_\_ **ZIP CODE** \_\_\_\_\_

**Thank you so much for your participation.** If you are interested in completing our full survey please email us at: [uwoystersurvey@gmail.com](mailto:uwoystersurvey@gmail.com). We would greatly appreciate your insight!

Figure II-3. Survey Card Version 2 (front side). This version of the survey card was designed specifically for distribution at Chef Tom Douglas' Seattle-area restaurants. Unlike Version 1, this version was only given to customers who already ordered raw oysters. The first question from Version 1 became redundant and was instead replaced by a question measuring raw oyster consumption frequency.



Figure II-4. Survey Card Version 2 (back side). Chef Tom Douglas requested that this cookbook promotion be added to the backside of the survey cards distributed at his restaurants. His intention was to encourage participation in the survey while increasing raw oyster sales and promoting his new cookbook simultaneously.





<b>Preliminary Assumptions</b>		
Question	Expected	Observed
<i>1. Do you eat oysters on the half shell (raw)?</i>	90% yes, 10% no.	85% yes, 15% no
<i>2. How many raw oysters do you personally eat in one sitting?</i>	4-5 raw oysters	6.84-7.32 raw oysters
<i>3. How often do you eat raw oysters?</i>	4-7 times a year	4-7 times a year
<i>4. Are there certain times during the year when you prefer to eat raw oysters?</i>	Fall, Winter, Spring equal, Summer less popular	Fall, Winter, Spring equal, Summer less popular
<i>5. Where do you typically buy raw oysters?</i>	Restaurants	Restaurants
<i>6. Do you have a favorite type of oysters?</i>	33% yes, 67% no	48.8 yes, 51.2 no
<i>7. What size oyster do you prefer to eat raw, on the half-shell?</i>	2.5 to 3 inches	2.5 to 3 inches
<i>8. When choosing raw oysters, how important are the following considerations?</i>	Order of importance: Freshness, Price, Place of Harvest, Time of Year	Order of importance: Freshness, Place of Harvest, Time of Year, Price
<i>9. What is your date of birth?</i>	Online survey younger than Survey Cards, total average age = 40	Online survey equal age with Survey Cards, total average age = 41
<i>10. What is your gender?</i>	50% men, 50% women	36.4% men, 63.1% women
<i>11. What is your place of residence?</i>	33% non-resident, 67% WA resident	32.47% non-resident, 67.53% WA resident

Table I-1. Preliminary assumptions matrix capturing our expected results after the literature and key informant interview process in the middle column, and observed results after data collection in the far right column. Notable unexpected results include questions 2, 6, 8, and 10.

	Not Important At All	Not Very Important	Moderately Important	Very Important	Extremely Important	Total	Weighted Average
Price	23 (11.17%)	43 (20.87%)	94 (45.63%)	32 (15.53%)	14 (6.80%)	206	2.86
Freshness	1 (0.48%)	0 (0.00%)	5 (2.40%)	31 (14.90%)	171 (82.21%)	208	4.78
Place of Harvest	3 (1.46%)	15 (7.28%)	57 (27.67%)	74(35.92%)	57 (27.67%)	206	3.81
Time of Year	21 (10.34%)	48 (23.65%)	59 (29.06%)	34 (16.75%)	41 (20.20%)	203	3.13

Table III-1. This table shows responses to Question 8 from the online survey: “When choosing a raw oyster, how important are the following considerations?” Participants rated each of the 4 indicators (Price, Freshness, Place of Harvest, and Time of Year) on a 1-5 Likert Scale aligning with “Not Important at All” to “Extremely Important”.

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