Spring 2020

A Resource Management Analysis of Olympia and Pacific Oysters in Puget Sound

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A RESOURCE MANAGEMENT ANALYSIS OF OLYMPIA AND PACIFIC OYSTERS IN PUGET SOUND

A Thesis

Presented to

The Graduate Faculty

Central Washington University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

Cultural and Environmental Resource Management

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by

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June 2020

CENTRAL WASHINGTON UNIVERSITY

Graduate Studies

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ABSTRACT

A RESOURCE MANAGEMENT ANALYSIS OF OLYMPIA AND PACIFIC OYSTERS IN PUGET SOUND

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Beginning with the 1848 California Gold Rush, populations of Olympia oysters (*Ostrea lurida*) were nearly decimated by overharvest and water pollution in Puget Sound. To fill the market demand for oysters, Pacific oysters (*Crassostrea gigas*) were introduced from Japan in the early 1900s. Since then, Pacific oysters have become the most common species sold by shellfish growers in the Pacific Northwest due to their hardiness and fast growth. Olympia oysters have subsequently become the focus of many restoration projects in Puget Sound in attempts to regrow populations. Paradoxically, Pacific oyster shells are often used in restoration projects as substrate for the Olympia oysters to settle on.

This study aimed to explore the different management practices of Olympia and Pacific oysters in Puget Sound through a common pool resource management framework. Semi-structured interviews and free-listing activities were conducted with eleven different stakeholders including oyster growers, restoration project managers, shellfish biologists, health department employees, and researchers between June and August 2019. Interview questions covered a broad range of topics, compiling a baseline of information for future research projects.

After analyzing interviews, several notable themes emerged regarding oyster restoration and harvesting. The first being that the market is a direct result of the combination of the history of Puget Sound, selfhood, and harvest and territoriality; next, restoration and monitoring practices result from the laws, institutions, partnerships, funding, and volunteer efforts; and finally, that the future of the industry is shaped largely by the ecology of oysters, surrounding pollution, health, and climate change.

The free-listing exercises that took place revealed the most imminent threats to oysters according to those interviewed. The category of threat most frequently brought up was water pollution and water quality, followed by climate change effects. The research resulted in several clear management recommendations for restoration work on Olympia oysters in Puget Sound. Most importantly, a clear set of metrics needs to be established and agreed upon by each of the groups that are independently working to restore oyster habitats in the area.

ACKNOWLEDGMENTS

First, I would like to thank my thesis chair, Dr. Rodrigo Rentería for all of the guidance and help throughout the research and writing processes. I would also like to thank my other committee members, Dr. Pat McCutcheon and Dr. Hope Amason for helping me with my proposal and final product.

I am very grateful to all of the research participants in the study for taking the time to speak with me. I received so much insight from each interview that I could have never learned from simply reading papers alone. I would also like to thank everyone who did not participate in interviews, but who referred me to others who were able.

Next, I am thankful for the Samish Indian Nation and the American Indian Graduate Center for the generous scholarships and opportunities I have received throughout my education. This research was also supported in part by the School of Graduate Studies and Research at Central Washington University in Ellensburg, Washington. I received their Graduate Student Summer Fellowship which was used to pay for my travel expenses associated with conducting interviews. Without this funding, I could not have effectively finished my research.

Finally, I would like to thank my friends and family for being so supportive and helping to keep me motivated for the past two years, and throughout my entire educational journey.

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INTRODUCTION

Oysters are vital members of aquatic ecosystems around the world, aiding in the creation of habitats for a variety of aquatic species, protection of shorelines from erosion, and filtration of toxins from bodies of water, among other important ecosystem functions (Coen et al. 2007; Grabowski et al. 2012). Unfortunately, anthropogenic activities in the past century, such as overharvesting and pollution, have contributed to declining oyster populations worldwide to the point where they are now at 15% of their historic levels (Beck et al. 2011). For this reason, oyster management practices represent an important element of many intertidal conservation efforts around the world.

Mirroring this global trend, in the Pacific Northwest, the Olympia oyster (*Ostrea lurida*), the endemic species of the region, was nearly extinct by the 1980s, after being over-exploited following the 1849 California Gold Rush, and further harmed by pollution in the 1900s. This early industry boom was followed by pollution from pulp mills in local oyster habitats (Dumbauld et al. 2011). In an attempt to increase oyster production, Pacific Oysters (*Crassostrea gigas*) were introduced from Japan in the early 1900s, and quickly became the most widely-grown and eaten species in the Pacific Northwest, due to their fast growth (Dinnel 2016; Ruesink et al. 2006).

Currently, efforts are being made by many different organizations to enhance oyster habitats and expand the dwindling populations of Olympia oysters. In the process, they have become part of the local imaginary of the Pacific Northwest; an unquestionable

component of the regional seafood scene and its distinctive *merroir* flavor (this term is based on the *terroir* flavors of wine, meaning that their flavors are based on place, adapted to the French word “mer” meaning “sea”). Anchored to an intense tourist-based market, oyster production and conservation sometimes align, sometimes not. The preservation, creation or destruction of oyster beds emerges then as a fundamental aspect of the conservation of these species, and commercial production, bracketed within issues like inter-tidal urbanization, pollution and the increasingly tangible effects of climate change. Based on the above, an analysis of oyster management practices in the Puget Sound constitutes an urgent matter. The Common Pool Resource Management framework proposed by Ostrom et al. (2002) was found to be most applicable due to the complex relationships that exist surrounding oysters in the region.

As a member of the Samish Indian Nation, my interest in resource management began as a child, when I first learned about the use of clam gardens by my ancestors. We are taught by our Elders that our lives depend on the Salish Sea and the seafood that grows there. We learn "our table is set when the tide is out" very early. I was shown a shell midden in the San Juan Islands by the natural resource manager of my tribe and intrigued by the way the layers echo the hundreds and thousands of years of my tribe's existence. I chose to research oysters in Puget Sound both because of my own interests, and because of the work my tribe has done restoring clam and oyster beds in Fidalgo Bay. Initially, I was most interested in hearing the perspectives from tribal elders; though found that I was unable to do so, likely due to limitations in time, funding, and recruitment method. Because of these difficulties, I chose to shift my focus to the management practices of the oyster that my family has ties to for hundreds of years, the

Olympia oyster, as well as the introduced species that has heavily influenced the Pacific Northwest, the Pacific oyster.

Problem

The Puget Sound region of Washington is home to a complex system of interactions between people and oysters. For thousands of years, indigenous people utilized the only native species of oyster in the Pacific Northwest, the Olympia oyster as a food source (Price 2018, Croes et al. 2007). In the late 1800s, a series of laws were enacted that sold both tidelands and tribal lands to settlers in the Pacific Northwest. These acts gave newcomers to the area prime land to begin shellfish farming operations. Some of the shellfish farms that were subsequently started on these lands are still in business today (Hanson, Barry. Interview with author. Shelton, June 17, 2019). As a common pool resource, the incorporation of oysters into private property regimes often times resulted in social tensions for access, making Olympias a classic example of the Tragedy of the Commons (Hardin 1968). The market demand for Olympia oysters was far more than could be sustainably harvested, causing massive declines in populations. I argue however, that this model is an oversimplification of the true story.

The commercialization of Olympia oysters for mass-consumption led to the introduction of a new species in the early 1900s, the Pacific oyster. The introduction of the Pacific oyster brought new ecological effects, such as invasive predators to Puget Sound. In more recent times, however, oysters have become a delicacy for the wealthy, and are now sold on the half shell at a number of high-end oyster bars all over the northwest (Gordon, Blanton, and Nosho 2003; Taylor Shellfish Farms 2018). As a result,

commercial shellfish farms are increasingly growing the Olympia oyster to sell at these restaurants, with a single oyster priced at over three dollars in some restaurants (Taylor Shellfish Farms 2018).

Current oyster production areas in the Puget Sound correspond to traditional Native American harvesting grounds; echoing a territorial displacement with many social and ecological consequences. Due to the seizure and sale of tidelands in the 1890s, many former harvesting grounds for indigenous peoples have been privatized. Populations of native Olympia oysters were nearly decimated, as were the harvesting rights of tribes. After years of court battles, several tribes now have rights to harvest shellfish on their traditional lands, and are aiding in the recovery of the oysters.

To aid in the recovery of Olympia oyster populations, many attempts at restoring habitat are currently being conducted in the Pacific Northwest by various local nonprofit groups and government agencies (Figure 1). As restoration managers, commercial producers, and recreational harvesters compete for access to scarce, non-polluted Puget Sound oyster grounds, different structural conflicts are rendered visible. For example, while most oyster harvesters, restoration scientists, and shellfish biologists can agree that clean water is an incredibly important factor for oyster habitat, others who operate outside the oyster industry, such as dairy farmers and septic system owners, contribute to runoff that make harvesting oysters impossible at times.

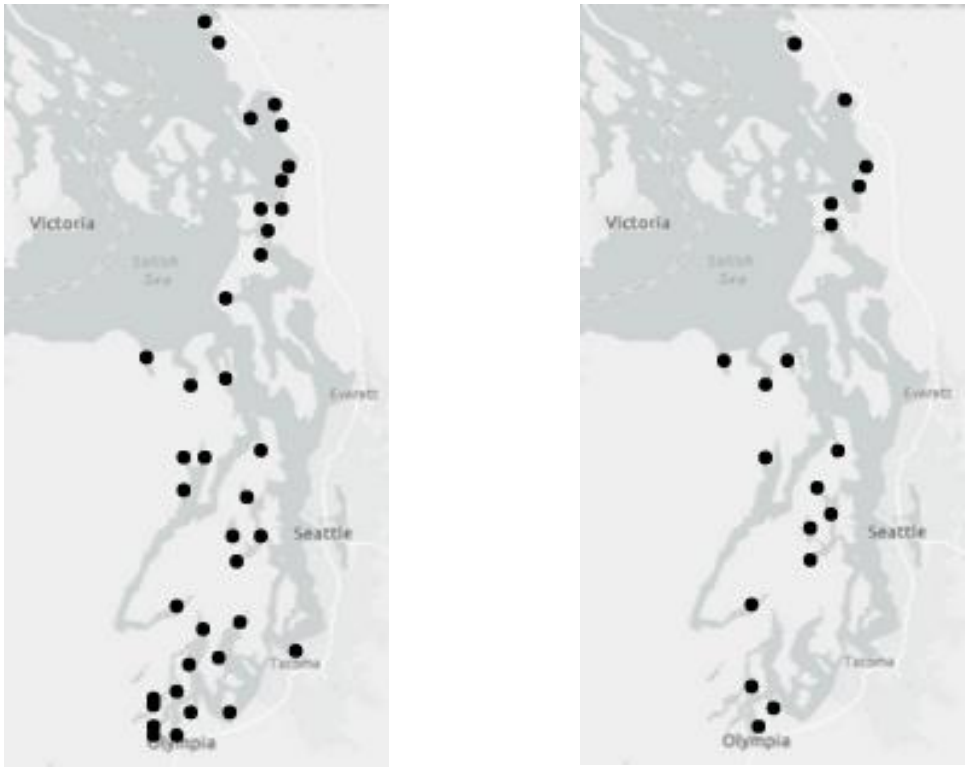

Figure 1: Black dots represent historic locations of Olympia oyster beds in Puget Sound (left), and current restoration sites (right). Map created by Liliana Kaeding. Data points from DeWeerdt 2019.

Despite the long history of oysters playing an important role in the lives of many people in the Pacific Northwest, a review of the literature showed no social or cultural analysis around oyster management practices, neither historically nor contemporarily. The literature instead only briefly mentions the California Gold Rush-era and Indigenous people in passing, almost entirely ignoring the current culture surrounding oyster management (Price 2018, Dinnel 2016, Dumbauld et al. 2011). Many papers have been published recently regarding the economic (Grabowski et al. 2012), and ecological (Dumbauld and McCoy 2015) aspects of oysters, as well as political ecologies of oysters in other regions (Deason et al. 2014, Lau and Scales 2016), or other marine species (Breslow 2014, Ryan et al. 2017), but a resource management analysis of oysters in Puget

Sound has not yet been written. Due to the complex roles of the commercial industry, restoration projects, and other stakeholders, an analysis of these management practices is necessary to understand these relationships that are centered around the native Olympia oyster.

The management of oysters has been explored around the world, including countries as far as Taiwan and Brazil, though much of the research has been conducted in in Chesapeake Bay, located between Maryland and Virginia. Oyster management is generally conceptualized as a Tragedy of the Commons problem, or a critique of the theory (Strand, Lipton, and Buss 1990; Poirine 2003; Arnold 2015; Liu, Kao, and Chen 2015). The Tragedy of the Commons theory states that individuals using a shared resource will exploit the resource and work in their own best interests, eventually depleting an open-access resource. Oysters have traditionally been common pool resources, as they are relatively easy to harvest and hard to restrict access on public lands. More recently, however, as aquaculture expands worldwide, the beds are grown on private property and use is restricted.

Despite the many (rightful) criticisms that Garret Hardin's work has received, his theory of the Tragedy of the Commons could potentially be applied to the case of Olympia oysters in Puget Sound in the mid-1800s to the mid-1900s. If one considers Olympia oysters as common pool resources, their overexploitation was a result of lack of regulation, according to Hardin's theory. Robbins (2012) discusses the degradation and marginalization thesis, that states that certain natural resources will be overexploited and depleted as a response to high demand in the markets, which leads to poverty and thus

more overexploitation, building on the work of Hardin (1968). Because the harvest of Olympia oysters was not regulated at the time, the demand for the small endemic oysters in markets in California drove a higher than sustainable harvest, exploiting their populations for many years. Harvesters were not incentivized to preserve populations due to the lack of formal regulations and lack of private property at the time, though the indigenous institutions that had previously regulated oyster beds. Note, however, that there is no evidence suggesting that prior to the 1848 California Gold Rush, populations were degraded by the indigenous populations. Quite to the contrary, oyster harvesting seemed to have been part of larger food systems for many coastal Native Populations. However, while the Tragedy of the Commons Theory may have help explained the degradations and almost complete disappearance of Olympia Oysters during the Gold Rush period, it does not currently apply to oyster management conditions in Puget Sound.

While Hardin's 1968 theory of Tragedy of the Commons argues that government control and private property regimes help to better regulate resources such as oysters, Ostrom et al. (2002) argue that these types of ownership may actually have the opposite effect. They argue that government management may lead to the rejection of indigenous institutions that have been in place for long periods of time, even making their stewardship illegal. In turn, the government may be unable to effectively monitor the resources in a way that helps to regulate them, leading to users exploiting the resource for their own benefit anyway (Ostrom et al. 2002). Indigenous institutions may have helped regulate the harvest of Olympia oysters, prior to as well as after the California Gold Rush.

In this context, this research hypothesizes that oyster management in Puget Sound represent a successful, if imperfect, Common Pool Resource governance model—following Ostrom's work—where formal and informal social norms and regulations (i.e. institutions) articulate in sustainable fashion the simultaneous commercial use and conservation of oysters in the region. Similarly, many of the same challenges that Common Pool Resource Management models experience worldwide, are present here. Many of the tidelands in Washington State are privately owned for instance, complicating access to important oyster beds—while perhaps protecting them. In contrast, other tidelands are public, with recreational harvesters allowed to take eighteen oysters per person at open beaches (Washington Department of Fish and Wildlife 2020). The 2.5-inch size requirement for oysters essentially eliminates Olympia oysters from harvest, meaning that Pacific oysters are generally the only species available for recreational harvests. Instead, Olympia oyster populations are being restored. Therefore, this research aims to conceptualize a new framework through which to consider oyster management. The major challenges for managing common pool resources that Ostrom (2002) lists are all relevant to this research, nonetheless. These challenges include considering the social and historical contexts that surround a resource, understanding that institutions are constantly changing and evolving, and finally, developing methods for managing common pool resources more effectively.

Purpose

The purpose of this study is to create a resource management documentation and analysis of Olympia and Pacific oysters in Puget Sound. By conducting a thorough

literature review and semi-structured interviews with various stakeholders, the following research objectives were met: 1) analyzing the historical production of oysters in Puget Sound, with special emphasis on treaties and court cases relevant to shellfish production; 2) conducting an ethnographic survey of contemporary oyster management practices among different stakeholders; 3) producing a resource management analysis of oyster realities in Puget Sound; 4) proposing alternative management practices capable of ensuring more socially equitable and ecologically sustainable outcomes.

In order to meet the objectives of this study listed above, the following four research questions were asked. 1) What is the historical context of oyster production and consumption in the Puget Sound? 2) How are oysters grown in the Puget Sound managed by different stakeholders? 3) What social, economic, legal, political and ecological factors affect current patterns of management, production and consumption of oysters in the Puget Sound? 4) What are the different perceptions of the future—oyster related—for these stakeholders?

Significance

This research is significant for several different reasons. First, a critical analysis of oyster management practices in the Puget Sound was conducted for the first time, systematizing key information. Both oyster restoration projects and the commercial industry were explored, as they often share similar goals and work cooperatively. An analysis of management practices can help to create a baseline upon which further research can be conducted.

Second, priorities and motivations that define different stakeholders' roles were better understood after conducting interviews around Puget Sound. Stakeholders were asked a variety of questions regarding their own involvement with oyster management, in an attempt to better understand the position of each group in relation to the industry as a whole. These were identified to help analyze the current management policies in place to determine if they are fair and beneficial.

Third, a cultural dimension was added to the economic, ecological and political analysis of the oyster industry. A thorough review of the literature revealed that there have been no previous studies conducted in Puget Sound regarding oysters that aim to evaluate the role of stakeholders. Describing the roles of each actor brings relevance to academic articles about the economic and ecological impacts oysters have on communities. In addition, this research connects the history of oyster harvesting in the region to the present-day management of both Olympia and Pacific oysters in Puget Sound.

Finally, this research is important for facilitating constructive dialogue amongst the different actors. Knowing the motivations behind protecting native species while simultaneously farming the introduced species of oyster may aid government agencies in creating cooperative management practices among different stakeholders (Zaferetos 2004). Interviewing people with various interests, such as tribal shellfish biologists and families who own shellfish farms, may help them gain recognition in an arena where they are often left out of the conversation. Having equitable policies helps to ensure that restoration projects and commercial interests are not at odds.

Methods

The methods are presented here to guide the literature review and results in the next several chapters. Understanding the current and historical management practices of oysters in Puget Sound requires a series of steps. The methods and techniques used for this study mirror the four objectives outlined in the introduction. The majority of the research process is based on the steps detailed in Bernard 2006. The research process began by examining relevant oyster production practices, both present and historical, and laws and court decisions through the lens of resource management. Then, the Institutional Review Board (IRB) process was completed according to Central Washington University guidelines (Central Washington University). Then 11 interviews were conducted with relevant stakeholders. Next, factors affecting oyster production and restoration were analyzed using coding techniques, and finally a resource management analysis based on the information gathered throughout my research was written.

Recruitment

Before data collection began, approval was obtained by the Human Subjects Review Council (HSRC) at Central Washington University to ensure that the data collection of my study was ethical and safe for participants. Next, contact information was obtained online through shellfish grower lists, company websites, government contact information pages, and tribal websites. Every commercial grower in Puget Sound listed on the Department of Health's list of certified commercial shellfish companies was

contacted, as well as many Marine Resource Committees, and government officials. Some participants were also identified through snowball sampling described in Deason et. al (2014), meaning that each person interviewed was asked if they knew of others who might be helpful in the research. Individuals identified by participants were contacted following the interview. Potential participants were then emailed more detailed information about the study and were asked if they would be willing to participate at their convenience.

Data Collection

In total, 11 semi-structured interviews were conducted between June and September of 2019. Ten of the interviews took place in person, and one was conducted by phone. The length of each interview varied by person, ranging from only 15 minutes to several hours. Of the 11 interviews, nine were recorded, based on the approval of the participants. A six-digit code number was assigned to the notes and recordings of each interview to protect the identities of the participants, as required by the HSRC. In notes and transcriptions, all participants are referred to by their code numbers. A code sheet with code numbers and corresponding names was kept separately from all data in a safe location.

During the interviews, participants were initially asked questions regarding their professions in relation to oysters, including questions about how long they have been involved, and their role. Next, they were asked about other groups they have collaborated with, and some of their observations over time about the oysters in Puget Sound. A list of several open-ended questions was created prior to the first interview. Some questions

were tailored slightly to match the expertise of the person being interviewed, or omitted if they were not relevant to that specific participant. The questions that were asked are listed in Appendixes A, B, and C.

In addition, participants were asked to do a short free-listing exercise at the end of the interview. Each person was asked to list the five laws or regulations that they believed to have the most significant impact or importance for their occupation in relation to oysters. Next, they were asked to list the five biggest threats to oysters, as perceived by the individual. Answers were ranked in order from most to least important. Finally, at the end of the interview, as previously stated, participants were asked if they knew other people who may be willing to be interviewed. If so, contact information was exchanged, and these newly identified potential participants were also contacted using the methods above.

In one instance, participant observation was conducted. Due to time restrictions, however, the experience was limited to one day, during business hours. No oyster harvesting was observed due to the summer season, but various sites were visited to check the growth of oysters. The harvest of clams was observed during this time instead. Other aspects of the commercial industry, such as the facilities used for cleaning and packing the oysters and other shellfish were observed.

Because the number of interviews conducted was small, data was supplemented with websites and newspaper articles from the shellfish industry, tourism magazines, and restaurants. Webpages used in this study were initially identified through a web search. Searches such as “Olympia oysters Puget Sound,” and “Seattle oysters” were used to find

relevant newspaper and magazine articles discussing the narratives surrounding oysters, and restaurant and farm store websites were visited to examine the language used on menus surrounding oysters. These webpages were then used to conduct an analysis of the narrative of oysters in Puget Sound.

Data Analysis

Interviews were transcribed after they were conducted using the recordings. Next, the text of the interviews was coded using ethnographic methods outlined in Vivanco (2016). Interviews were read through multiple times, each time identifying common themes within and between interviews. Eventually, more than twenty categories were identified in total across all of the interviews. The same process was repeated for several newspaper and magazine articles in order to create an analysis of the narrative told about Olympia oysters by the media. The identified themes were then used to create an analysis of the results.

Limitations

During the data collection period there were several difficulties to obtaining interviews. These reasons include time and funding limitations, safety issues, and sampling method. The result was a smaller sample size than anticipated, and no true participant observation could be conducted. Each of these barriers are discussed below.

First, the interview period for the study was only ten weeks, lasting from June through August 2019. In this relatively short time span, it was difficult for me to form relationships and trust that would normally be gained during long periods of ethnographic

fieldwork. Instead, most potential participants were emailed a few times with details of the study. If they had availability, we met in person for an interview. The short time frame did not allow for much flexibility regarding participants' schedules, and time to plan and return for follow up interviews. Because of events such as summer vacations, and Canoe Journey, many potential participants sent auto-reply emails explaining they would be out of their offices for several days. These people were contacted again upon their return, but in many cases, they did not respond. The overlap with Canoe Journey during the summer may have also excluded many tribal members from participating in the research.

In addition, much of oyster harvesting, especially with smaller companies, is done late at night during winter when the tides are low, not in summer months (Hanson, Barry. Interview with author. Shelton, June 17, 2019). Therefore, the oyster harvest did not occur during the time frame of the data collection. Some observation of clam harvesting did occur during the daytime in one instance, though the methods are not exactly the same (Hanson, Barry. Interview with author. Shelton, June 17, 2019). The beaches oyster harvesting is conducted on also tend to be secluded, so for my own safety, participant observation of oyster harvesting was not conducted for this study.

The sampling method also likely had an impact on the people who responded and eventually participated in the interview process. Most participants were identified through email, meaning that those who use email less or not at all were likely excluded from the study entirely. Email was identified as the simplest way to contact potential participants because phone numbers and street addresses were not always available.

While email seemed to work well for those working in government positions, the response rate for other groups, such as tribal members, was significantly lower. No recreational harvesters could be identified and contacted, as none were known by the researcher, and oysters are generally not harvested by the public during summer due to health concerns.

Given more time and funding, more interviews could be conducted. Unfortunately, due to the short time frame of a master's program, and COVID-19 concerns, more data could not realistically be collected. Despite the difficulties, the interviews that were conducted still provided insightful information regarding oyster management practices in Puget Sound, and did not hinder the ability to create a meaningful analysis. A variety of stakeholders were still able to be interviewed, creating a solid foundation for future research projects, and resulting in the analysis that follows.

CHAPTER II

A HISTORY OF OYSTERS IN PUGET SOUND

This chapter centers my analysis of oyster practices in the Puget Sound area within its historical context, describing the social and ecological transformations that resulted in contemporary management practice. In this context, the chapter provides a literature review of the uses of oysters by indigenous peoples in Puget Sound. The gap in the literature regarding this relationship will also be addressed, as little is known about the Olympia oyster prior to the arrival of settlers in the 1800s. Lastly, the chapter will describe treaties, laws, and court decisions that have dramatically influenced the oyster industry to give context to the current state of affairs.

Native American Use of Oysters

The scholarly literature offers very few references on the relationship between indigenous peoples and oysters. In the sections that follow, this relationship will be described using the information that is available, beginning with the limited archeological record. During a phone conversation with an archaeologist, he stated that Olympia oysters are rarely preserved in archaeological sites due to their thin shells and small size. There is then a large gap in the known history, beginning again in the early 1800s, as settlers began to arrive on the west coast. Finally, laws and court decisions affecting harvesting rights will be discussed, as they continue to affect the rights of indigenous people in Washington State.

Coast Salish people and Olympia oysters have a long history in the Pacific Northwest. Shell middens, large piles of discarded mollusk shells, are evidence that indigenous people have been harvesting and eating oysters (and many other shellfish species) for over three thousand years in Puget Sound (Croes et al. 2007; Gordon, Blanton, and Nosho 2003; Barber et al. 2015). Few academic sources, however, focus on the relationship between indigenous people and oysters in the region (Belcher 1985; De Denaan 2013). According to one anthropologist, shellfish were often ignored in the ethnographic records in the Pacific Northwest in favor of salmon, despite their role as an important food source (Belcher 1985). The best source of information regarding shellfish is found in books, either written by those directly involved in the oyster industry, or books written about these people. In her biography, "Katie Gale: A Coast Salish Woman's Life on Oyster Bay," Llyn De Denaan describes the oyster industry in the late 1800s, through the lens of a Native American woman who lived in southern Puget Sound, near Olympia, Washington.

Before the Bush and Callow Acts were passed, Native American women were often in charge of harvesting the oyster beds, and sold the oysters directly to markets in town (De Denaan 2013). According to De Denaan (2013), these women and their families had a "monopoly on oyster picking, culling, and trading until the 1878 arrival" of white settlers who changed laws regarding ownership of tidelands (113-14). Many lived in float houses on the water because they could avoid owning property and living on reservations and could harvest oysters and other shellfish directly off them (De Denaan 2013). Then, they would trade the shellfish for dried goods in town, or sell baskets full of oysters for up to 25 cents (De Denaan 2013; Steele 1957). As settlers

moved to Washington State, however, they began to take over the oyster industry. Eventually, many indigenous people were no longer able to sell oysters to markets directly (De Denaan 2013). Instead, Native people became shellfish harvesters for the businessmen who settled in the area.

There is an old adage among the Coast Salish tribes in the Pacific Northwest that states "when the tide is out, the table is set for dinner" (Lummi Natural Resources Department). Growing up, I heard this phrase often at tribal events, as we were served fresh clams and salmon. I was also told stories by tribal elders that shellfish used to grow so abundantly around Puget Sound that one could simply walk along the beach and pick buckets full off the beach. Harvesting Olympia oysters straight off the tidelands is likely not feasible for many people at this point, however many tribes do retain harvest rights, which will be discussed in depth in the next section.

Today, at least thirteen tribes around Washington have licenses to grow and sell oysters commercially (Washington State Department of Health 2018). Oysters grown by tribes tend to be Pacifics, and are served at tribal events, or grown for subsistence of members. According to one tribal shellfish biologist, "the underlying motivation is to maintain long term populations of shellfish resources for the benefit of the tribal community, and it has the side effect of increasing it for the general public in the region as well" (Rhodes, Brad. Interview with author. Skokomish, August 21, 2019). In addition, at least ten tribes are actively working to restore Olympia oyster beds. The majority of the tribes with commercial licenses are the same tribes working to restore

Olympia oysters. Clearly, these tribes have connections with shellfish that could be explored more, if relationships with elders can be established.

Though the historic range of the Olympia oyster spanned from present-day Alaska through Baja California, Mexico, a review of the literature revealed that there is almost no information regarding the relationship between indigenous people and the native oyster outside of the Puget Sound region. The Digital Collections of the University of Washington was searched for archival information, though no records were found regarding the oysters outside of Washington State.

Treaties, Laws, and Court Decisions

There are a variety of treaties, laws, and court decisions, many of which were enacted in the 1800s, that continue to affect the indigenous people in Washington today. In this section, the treaties of Point Elliott, Point No Point, and Medicine Creek, as well as the Dawes General Allotment Act of 1887, the Bush and Callow Acts are discussed to provide context for the displacement of tribes in the Puget Sound area. The 1921 Anti-Alien Land Act further provides evidence for displacement, but in this case, for Japanese immigrants. Finally, the state of the current shellfish industry in regards to tribes is explained by the Rafeedie Decision and Commercial Shellfish Grower's Settlement.

In the mid-1850s, the Governor of the Washington Territories, Isaac Stevens rushed to sign numerous treaties with many different tribes, ceding land to the United States. Three of these treaties, the Treaty of Medicine Creek, the Treaty of Point No Point, and the Treaty of Point Elliott, took nearly all coastal areas from tribes in the Puget

Sound region (Figure 2) (Northwest Indian Fisheries Commission 2016d). Some of the signatory tribes were granted reservations and eventually federal recognition in exchange for the land, while many others were not. Each of the tribes that signed the treaty were granted the right to hunt and fish on their "usual and accustomed grounds." The phrasing of these treaties became important again in the 1980s and 1990s, with the Boldt and Rafeedie decisions, discussed later. The signing of these treaties allowed for the passage of other property laws more than thirty years later, to encourage settlement of the state.

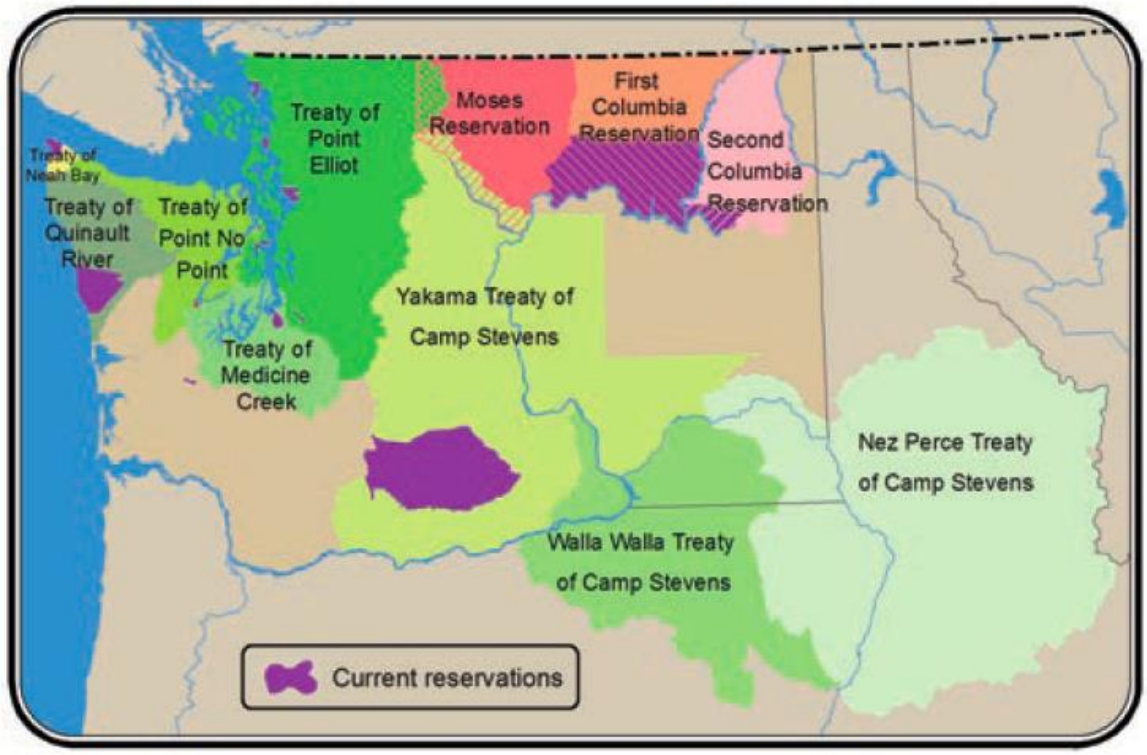

Figure 2: Map of ceded lands in Washington State as a result of treaties signed by Isaac Stevens. The lands ceded by the Treaty of Point Elliott, Treaty of Medicine Creek, and Treaty of Point No Point completely surround Puget Sound. Current reservations shown in purple. Lynn et al. 2013.

In the late 1800s, a series of bills were passed that granted property to those willing to work the land. The Dawes General Allotment Act of 1887 divided up reservations into private property; giving land, as well as citizenship, to indigenous people. There was a catch, however; the individuals were required to assimilate into white society and give up their culture (National Archives; De Denaan 2013). They were also required to farm the land, something that many of them could not do, due to either desert land, or lack of money or knowledge required to begin the agricultural process (National Archives). The unclaimed land was then made available to white settlers in the area. In 1895, the Bush Act and the Callow Act were created by Washington State legislators. The Bush Act allowed for individuals to buy up to 100 acres of tidelands at $1.25 per acre from the state. Oyster cultivation was the only activity allowed on this land in order to encourage the growth of the industry in the state (National Archives). The Callow Act had similar wording and goals, though less than 2% of the 47,000 acres of tidelands were sold under this act (Solomon 2002). The lands that were sold under these acts in Skagit, Island, Snohomish, and Thurston counties is documented by the Department of Natural Resources, and shown in Figures 3 and 4.

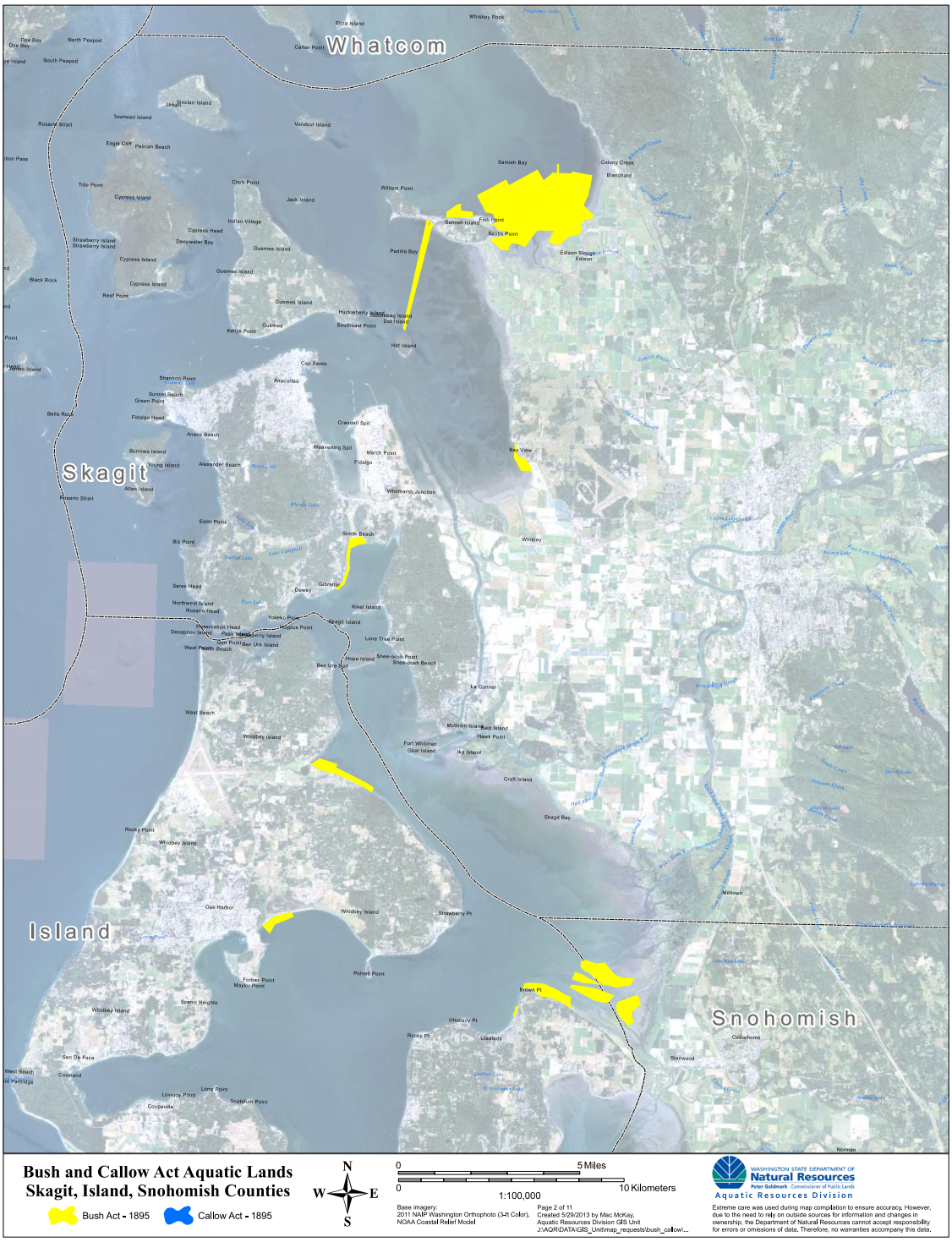

Figure 3: Land sold under the Bush and Callow Acts in Skagit, Island, and Snohomish Counties. Department of Natural Resources 2020.

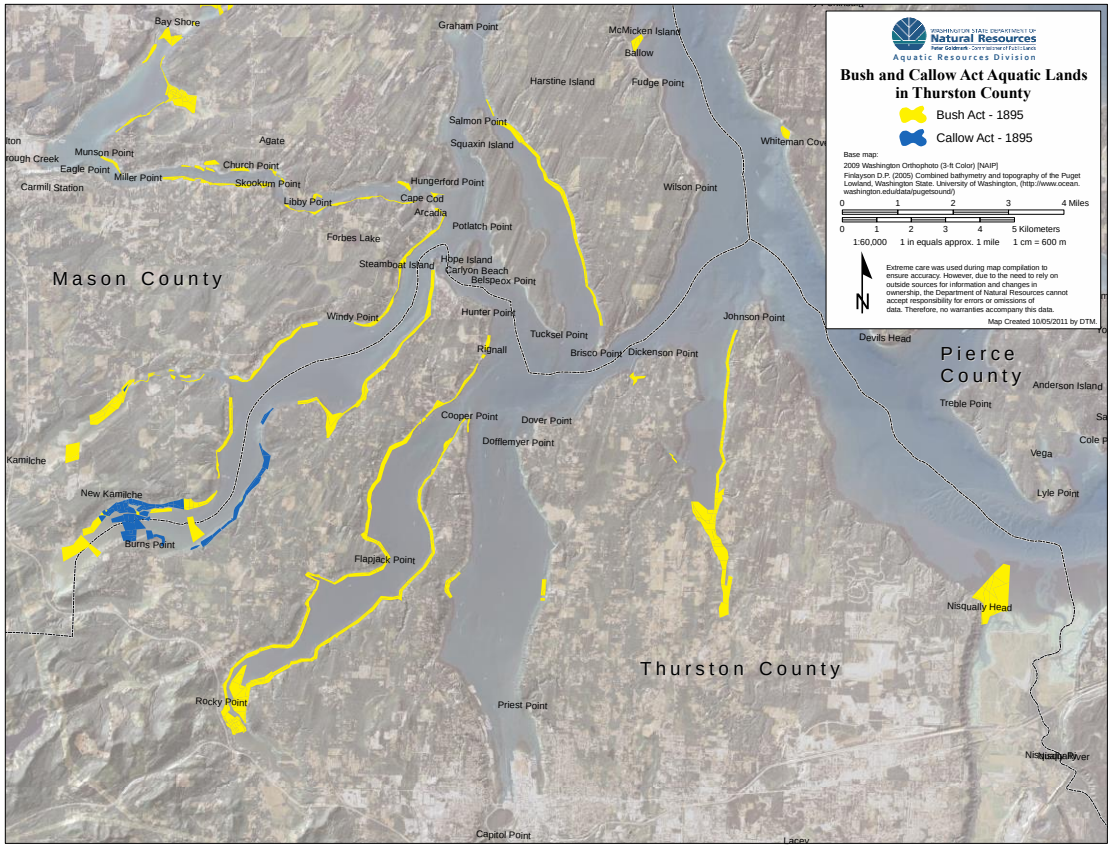

Figure 4: Land sold under the Bush and Callow Acts in Thurston County. Department of Natural Resources 2020.

Nearly a hundred years after the Bush and Callow Acts were passed into law, in 1994, a federal district court judge named Edward Rafeedie ruled that tribes had rights to half of all shellfish on “usual and accustomed grounds,” meaning that any naturally occurring beds on public or private tidelands could be cultivated by the fifteen treaty tribes in Washington state (Northwest Indian Fisheries Commission 2016a). The tribes with shellfish harvesting rights are: Jamestown S’Klallam, Lower Elwha Klallam, Lummi, Makah, Muckleshoot, Nisqually, Nooksack, Port Gamble S’Klallam, Puyallup,

Skokomish, Squaxin Island, Suquamish, Swinomish, Tulalip, and Upper Skagit (Northwest Indian Fisheries Commission 2016c).

In 2007, the treaty tribes worked with commercial shellfish growers to come to an agreement regarding the Rafeedie decision. The agreement included three important points: first, tribes would leave $2 million worth of shellfish on commercial growers' beds. Second, growers would invest $500,000 over ten years to improve public tidelands. Finally, a $33 million trust was established for the tribes to purchase and improve tidelands for which only they would have access (Northwest Indian Fisheries Commission 2016a). Financial support for this program was secured through various state and federal funds (Northwest Indian Fisheries Commission 2016a). In addition, Harmon (1998) describes how cultural identities have changed over time in indigenous populations, sometimes creating legal problems for tribes about various issues, such as fishing rights and shellfish harvesting rights. In some cases, tribes have been accused of not being the same people that their ancestors once were, and their rights are called into question (Harmon 1998).

In 1921, the Anti-Alien Land Act was passed in Washington. The act prohibited anyone except for U.S. Citizens from owning any land in the state (Gordon, Blanton, and Nosho 2003). The law also allowed for the state to seize land from non-citizens and auction it off to legal citizens (Gordon, Blanton, and Nosho 2003). The legislation was passed due to anti-Japanese sentiment, which coincided with the introduction of Pacific oysters to the Pacific Northwest (Gordon, Blanton, and Nosho 2003). Japanese landowners who had begun to grow Pacific oysters in Washington State, were essentially

barred from their interests in the oyster industry (Gordon, Blanton, and Nosho 2003). Some returned to Japan and continued their businesses by selling Pacific oyster seed to Washington companies (Gordon, Blanton, and Nosho 2003).

The tidelands used for shellfish harvesting have continued to be a contentious topic of debate in Washington. Anderson (1999) analyzes the rights of tribes to harvest shellfish on private lands and uses the Rafeedie ruling as a case study. The Rafeedie ruling or decision confirmed treaty-reserved rights for tribes to harvest naturally occurring shellfish on any tidal lands within the set area, regardless if the land was private or public property (Anderson 1999). Tribes were allowed up to half the shellfish harvest from their usual and accustomed places, an extension of the famous Boldt decision that upheld the fishing rights of tribes (Northwest Indian Fisheries Commission 2016b). The decision specifically excluded tidelands cultivated for commercial purposes (Northwest Indian Fisheries Commission 2016b).

The Commercial Shellfish Growers Settlement is another important document that was a result of the Rafeedie decision (Northwest Indian Fisheries Commission). This agreement involved the seventeen treaty tribes in Puget Sound working with commercial shellfish growers to create a workable solution for all parties involved. The three major provisions listed in the document were supported by state and federal funding (Northwest Indian Fisheries Commission 2016a). First, tribes agreed to leave $2 million worth of oysters in their natural beds for commercial growers each year; Next, the growers agreed to $500,000 worth of shellfish restoration projects over ten years; Finally, a $33 million

trust was established for tribes to enhance natural shellfish beds (Northwest Indian Fisheries Commission 2016a).

Conclusion

In summary, tribes around Puget Sound have been connected to Olympia oysters for at least three thousand years, according to the archaeological record. Traditional shellfish harvesting grounds were ceded to the Washington Territory in 1855 under the treaties of Point Elliott, Point No Point, and Medicine Creek. Access to shellfish beds for tribes were further limited by the privatization of tidelands under the Bush and Callow Acts of 1895. Tribes were not fully able to use their shellfish harvesting rights granted under the treaties until 1994, when Judge Rafeedie upheld these rights. Due to the territorial displacements and conflicts that have occurred around the region regarding both tribes and oysters, Puget Sound was chosen for the study area.

CHAPTER III

STUDY AREA AND ECOLOGY OF OYSTERS IN PUGET SOUND

The study area for this research is the Puget Sound region and the connecting waters to the north (Figure 5). This area includes Hood Canal, South Puget Sound, Central Puget Sound, the Whidbey Island basin, as well as Padilla Bay, Samish Bay, and Bellingham Bay to the north (Harmon 1998). I have specifically chosen this region for my study because of its rich history of commercial oyster production beginning in the mid-1800s, in which both white settlers and Native American people were involved (Steele 1954; Gordon et al. 2003; De Denaan 2013). Objectives one through four can be met using this area due to the ecological and cultural history, that continue into the present day. There are also dozens of commercial shellfish companies operating in the Puget Sound region, several of which are owned by tribes (Washington State Department of Health 2018). In addition, there are many restoration projects around Puget Sound. Ten years ago, only 155 acres were recorded to have Olympia oysters, out of the nearly 10,000 acres of oyster beds there used to be (Haight 2019).

Figure 5: The study area, Puget Sound. Modified from the Washington State Department of Health Commercial Shellfish Map Viewer (2020).

The average monthly temperatures in Puget Sound range from about 7 degrees Celsius in January, the coldest month, to 15 degrees Celsius in August, the warmest

month (Moore et al. 2016). These numbers were higher than normal from 2014 to 2016, however, during an event known as “The Blob” (Moore et al. 2019). “The Blob” was an extremely large mass of water that stretched between Alaska and Mexico, with temperatures up to seven degrees warmer than normal (Cornwell and Doughton 2015). During this time, shellfish harvests were abnormally affected by biotoxins, likely due to the warm water (Cornwell and Doughton 2015). In 2018, these numbers were again higher than normal, with the exception of a cold spell from late February through March (Moore et al. 2019).

Water temperature is extremely important for oysters, as they can only breed under certain conditions. Previous studies demonstrated that oysters needed water at least 12.5 degrees Celsius to brood but recently, Olympia oysters in northern Puget Sound were demonstrated to spawn at two degrees cooler than that in tidal lagoons (Barber et al. 2016). These results are thought to be a local adaptation to colder water (Barber et al. 2016). In addition to breeding, water temperature is correlated with vibriosis and biotoxins. While neither affect the oysters, there are health consequences for eating raw shellfish during warmer months. These health concerns will be discussed more in depth in the Contemporary Issues section.

Habitat Requirements for Oysters

The ideal conditions for oysters in relation to the conditions in Puget Sound must be examined in order to understand the limitations of growing oysters. Olympia oysters are considered more “finicky” while Pacific oysters are generally considered to be much hardier. Olympia oysters can be found in bays in habitats with gravel, mud, or shell

substrates, with salinity levels around 25 parts per thousand around Puget Sound (Lindsay and Simons 1997; Puget Sound Restoration Fund 2019). Historically, Olympia oyster beds were concentrated around Hood Canal, South Puget Sound, Bellingham Bay, and Padilla Bay.

In addition, Olympia oysters require moderate water temperatures, ranging between 5 degrees (winter months) and 23 degrees Celsius in summer (Lindsay and Simons 1997). By contrast, Pacific Oysters can survive in a slightly wider range of temperatures, between 4 and 24 degrees Celsius (Pauley et al. 1988). Oysters also require specific temperatures to begin spawning in warmer months. Despite the obvious commercial benefits of growing Pacific oysters, such as fast growth, recent evidence suggests that Olympia oyster embryos may be able to withstand ocean acidification better than Pacific oysters (Waldbusser et al. 2016). Their resilience is likely due to their slower rate of shell building and calcification in juveniles (Waldbusser et al. 2016). Olympia and Pacific oysters are, however, both affected by ocean acidification in later stages of development (Waldbusser et al. 2016). Both species have similar salinity requirements and are sensitive to the low salinity that occasionally occurs in bays in the Puget Sound region following high periods of precipitation (Lindsay and Simons 1997; Pauley et al. 1988).

Ecology of Oysters

To better understand the state of the oyster industry and restoration projects, it is first necessary to explain what contributions oysters make to the ecosystem, the impacts of introducing a nonnative species, as well as the differences between Olympia and

Pacific oysters. Knowing these differences helps in understanding the motivations behind growing each species in the commercial industry, as well as the importance of restoration projects. Much of the literature regarding oysters in Puget Sound is focused on their ecology, and will be addressed in this section.

General Ecosystem Functions

Oysters are classified as bivalve mollusks, meaning that they have two shells connected by a hinge (Couch and Hassler 1989). Oysters provide a variety of functions and ecosystem services in estuarine habitats. They begin life as small organisms that float in the water, eventually attaching to a surface where they grow together with other oysters and create reefs, similar to coral reefs (NOAA Fisheries 2019). Oyster reefs provide several services to both the environment and humans including: filtering and cleaning the water of nutrients and phytoplankton, as oysters are filter feeders; protecting the shoreline from erosion by creating a barrier from waves; creating habitat for fish and other marine organisms, such as crabs and shrimp; as well as providing food and jobs for people worldwide (Coen et al. 2007; Grabowski et al. 2012; NOAA Fisheries 2019). In 2012, the total services provided by oysters were estimated to be valued between $10,000 and $100,000 per hectare per year, depending on the location of the reef and types of services included in the estimate (Grabowski et al. 2012).

Oysters are considered autogenic ecosystem engineers, meaning that they use their own structures to create and modify their habitats, called reefs or beds (Jones et al. 1994). Up to 85% of the total oyster reefs worldwide have been lost since the 1880s due to anthropogenic activities, and up to 99% of these habitats have been lost in some

regions of the United States (Beck et al. 2011; Grabowski et al. 2012). At times, overharvesting was the main cause, though pollution has increasingly become a major cause for this destruction, as shorelines develop, and coastal populations grow. These drastic decreases in oyster populations mean that many of the services listed above that they provide to their ecosystems have also been lost. Therefore, restoration efforts are being conducted around the world, and are focused on expanding populations.

Olympia Oysters

The historic range of Olympia oysters extended from the coast of southern Alaska through Baja California, though are currently found only between Gale Passage, British Columbia and Bahía de San Quintín, Mexico (Couch and Hassler 1989; Gillespie 2000). Evidence suggests there are five isolated populations along the west coast that are genetically distinct from one another, which may affect the potential of oysters from these other populations to be used as broodstock for restoration projects (Pritchard et al. 2015; Stick 2011). Olympia oysters are relatively small compared to what many recognize as oysters, rarely getting more than 2.5 inches in length when fully grown, which is the size required for recreational harvesting (Couch and Hassler 1989). Their small size and slow growth time may have contributed to their overharvesting, as a gallon of shucked Olympias takes about 2,400 individuals (White, Ruesink, and Trimble 2009).

Olympia oysters reproduce in the summer months, generally from about May until August (Couch and Hassler 1989). Spawning requires specific water temperatures, between 13 and 16 degrees Celsius (Couch and Hassler 1989). Olympia oysters are less resilient to extremes in cold and heat than other species of oysters (White, Ruesink, and

Trimble 2009). One shellfish grower described them in this way: “Olympias are very susceptible to too hot of weather or too cold of weather, or sedimentation so they’re more finicky. Predators like oyster drills love Olympia oysters because they’re a pretty thin shelled oyster. If you have many drills on the beach you can lose your crop” (Brewer, Dennis. Interview with author. Union, August 14, 2019).

During interviews, a restoration manager gave a detailed account of the necessary conditions that Olympias need to survive and reproduce, emphasizing the preferred species for the native oyster.

> Well, they have optimal survival growth in probably the +2 to -2 in the tidal range. They’re more sensitive to temperature extremes than the Pacific oyster. They of course don’t like to be buried in mud so you have to pick sites carefully so they don’t get silted in and buried. It appears that they do best when they are routinely dewatered during low tide. For instance, our original seed plot at the trestle was in standing water at low tide, just kind of a pool area, and they did very well there growing but what happens when the shell substrate that they like to settle on oyster shell is in that environment, everything else attaches to that area like barnacles bryzoa, and those cover the shells and make it difficult for the oyster to settle on. But if they are dewatered during low tide, that controls the other organisms in the habitat. Olympia oyster also prefer to settle on oyster shell but they will also settle on clam shells, rocks, wood, metal, but they really like oyster shell, and they kind of seek that out. (Lewis, Peter. Interview with author. Anacortes, June 25, 2019)

Pacific Oysters

Pacific oysters grow up to three times larger and faster than Olympias, generally harvested at around three inches in length, though they can grow much larger if left in the tidelands for a longer period of time, as shown in Figure 6 (Pauley et al. 1988).

Figure 6: Juvenile Pacific oyster (left) and adult Olympia oyster (right) near Shelton, Washington. Photo by Liliana Kaeding, June 2019.

In addition, Pacifics are considered hardier than Olympias, with their ability to survive in a wider range of water temperatures (Ruesink et al. 2006). Today, the Pacific oyster has become the dominant species on the West Coast of the United States in terms of numbers grown commercially. The species has also been attributed with increased productivity in estuaries in Washington State (Ruesink et al. 2006). Pacific oysters can grow to market size up to three times as quickly as Olympia oysters despite their larger size, making them more desirable for aquaculture (Ruesink et al. 2006). According to a study conducted in Willapa Bay, Washington, Pacific oysters are currently harvested at nearly four times the rate of the maximum historical Olympia oyster yield (Ruesink et al.

2006). One tribal shellfish biologist even considers Pacifics to be naturalized at this point: "If we were to just stop altogether, cultivating Pacific oysters, I don't see them going anywhere. I think that they've effectively established their own wild stocks, wild populations, and I think as long as we're not completely destroying their habitat they'll be just fine on their own" (Knight, Lauren. Interview with author. Blyn, August 15, 2019).

Pacific oysters were introduced to Washington in the early 20th century from Japan, with estimates of the exact year ranging from 1902 to 1919, depending on the source. During this period, several invasive species came attached to the shells of the Pacific oysters, including harmful oyster drills, which drill into the shells of small oysters and consume them (Dinnel 2016). These invasive species continue to have detrimental effects on ecosystems in Washington State today. Pacific oysters are much larger than Olympia oysters, and quickly became favored by oyster growers and consumers alike. Pacific oysters grow up to three times larger and faster, and are considered hardier than the Olympia, with their ability to survive in a wider range of water temperatures (Ruesink et al. 2006).

Olympia oysters require moderate water temperatures, ranging between 5 degrees (winter months) and 23 degrees Celsius in summer (Lindsay and Simons 1997). By contrast, Pacific Oysters can survive in a slightly wider range of temperatures, between 4 and 24 degrees Celsius (Pauley et al. 1988). Oysters also require specific temperatures to begin spawning in warmer months. Despite the obvious commercial benefits of growing Pacific oysters, such as fast growth, recent evidence suggests that Olympia oyster embryos may be able to withstand ocean acidification better than Pacific oysters

(Waldbusser et al. 2016). Their resilience is likely due to their slower rate of shell building and calcification in juveniles (Waldbusser et al. 2016). Olympia and Pacific oysters are, however, both affected by ocean acidification in later stages of development (Waldbusser et al. 2016). Both species have similar salinity requirements, and are sensitive to low salinity that occasionally occurs in bays in the Puget Sound region following high periods of precipitation (Lindsay and Simons 1997; Pauley et al. 1988).

Ecological Effects of Pacific Oysters

Non-native species can have severe consequences for the existing ecosystems, and Pacific oysters are no exception. When Pacific Oysters were introduced, several other species of invertebrates and algae were introduced by "hitchhiking." This term means that the organisms were attached to the shells of the introduced oysters, or to the bottoms of the ships that brought them (Wonham and Carlton 2005). One of these species, the Japanese oyster drill (*Ocinebrellus inornatus*), is extremely damaging to Olympia oysters, and can have strong negative impacts on their populations (Figure 7) (Peter-Contesse and Peabody 2005. Olympia oysters are easy targets for the oyster drills due to their relatively thin shells and small size. While the commercial industry tried to supplement already declining oyster populations with a new species for their own harvests, the Pacific oyster appears to have contributed instead to the increased damage of the Olympia oyster in Washington State. Removal of oyster drills is both time-consuming and labor intensive, and some restoration efforts may be hindered by their presence (Grason and Buhle 2016). The oyster drills are, therefore, both ecologically and economically damaging. Fortunately, the spread of oyster drills is mainly limited to

human activities, as they emerge from their egg casings crawling on land, rather than being broadcast into the water, so their spread is slow (Grason and Buhle 2016).

Figure 7: Egg capsules of Japanese oyster drills, found near Shelton, Washington. Drill pictured on far right. Photo by Liliana Kaeding, June 2019.

Some argue that Pacific oysters have not been all bad for the environment, as they still aid in filtering water of harmful nutrients and algal blooms, despite their status as an invasive species (Gottlieb and Schweighofer 1996). Coen et al (2007), however, say that introduction of Pacific oysters specifically for improving water quality is not a good idea. They argue that the effects of oysters on water quality have not been properly quantified, the scale that would be required to produce those effects have not been discussed, and the

introduction of an invasive species is risky for the ecosystem as a whole (Coen et al. 2007).

Olympia oysters continued to be overharvested for many years, with almost no regard for the sustainability of the practice; oyster shells were also not returned to the beach after harvest (Kincaid 1928). As laws were passed encouraging the cultivation of tidelands in the state, this trend continued further. Eventually, Olympia oysters were no longer enough to satisfy the markets. New species such as the Virginica (Crassostrea virginica) were introduced to Washington waters, though did not survive, and did not become an important player in the oyster industry in Puget Sound until much later (Gordon, Blanton, and Nosho 2003).

Contemporary Issues

Currently, the number of Olympia oysters in Puget Sound is only a fraction of the historic populations. Many of the problems that used to exist historically, such as overharvest, are no longer much of an issue, but other threats, such as pollution, are only increasing. Increased urbanization and shoreline development have led to increased pollution, and decreased habitat availability. Privatizing the tidelands in Washington State changed the way that oysters were being harvested, and limited the industry to those who could buy them, leading to multigenerational family businesses, many of which are still in business today. People are now consuming huge amounts of raw oysters, with the potential for health risks caused by bacteria and biotoxins.

Harvest areas

Today, there are 110 individual commercial shellfish growing areas in the state, which represents about 370,000 acres (Nelson, Stephen. Interview with author. Tumwater, July 18, 2019). Harvest areas today are largely in the same areas as the historic locations of Olympia oyster beds. This overlap is due to the specific habitat requirements that oysters have, as well as the locations of the private tidelands in Washington where much of the commercial industry takes place (Figure 8). The tidelands that were ideal for oysters were sold under the Bush and Callow Acts, which continue to influence the oyster industry today, as these lands were often passed down through families. There are, however, certain locations where oysters can grow, but cannot be harvested for human consumption due to pollution. For example, in October 2018, about 6,000 pounds of oyster shells were placed in Elliott Bay in Seattle (Morrow 2018). The purpose of this project was to help clean the water, and restore the native oyster beds to the area (Morrow 2018). The oysters were not, however, intended to be eaten.

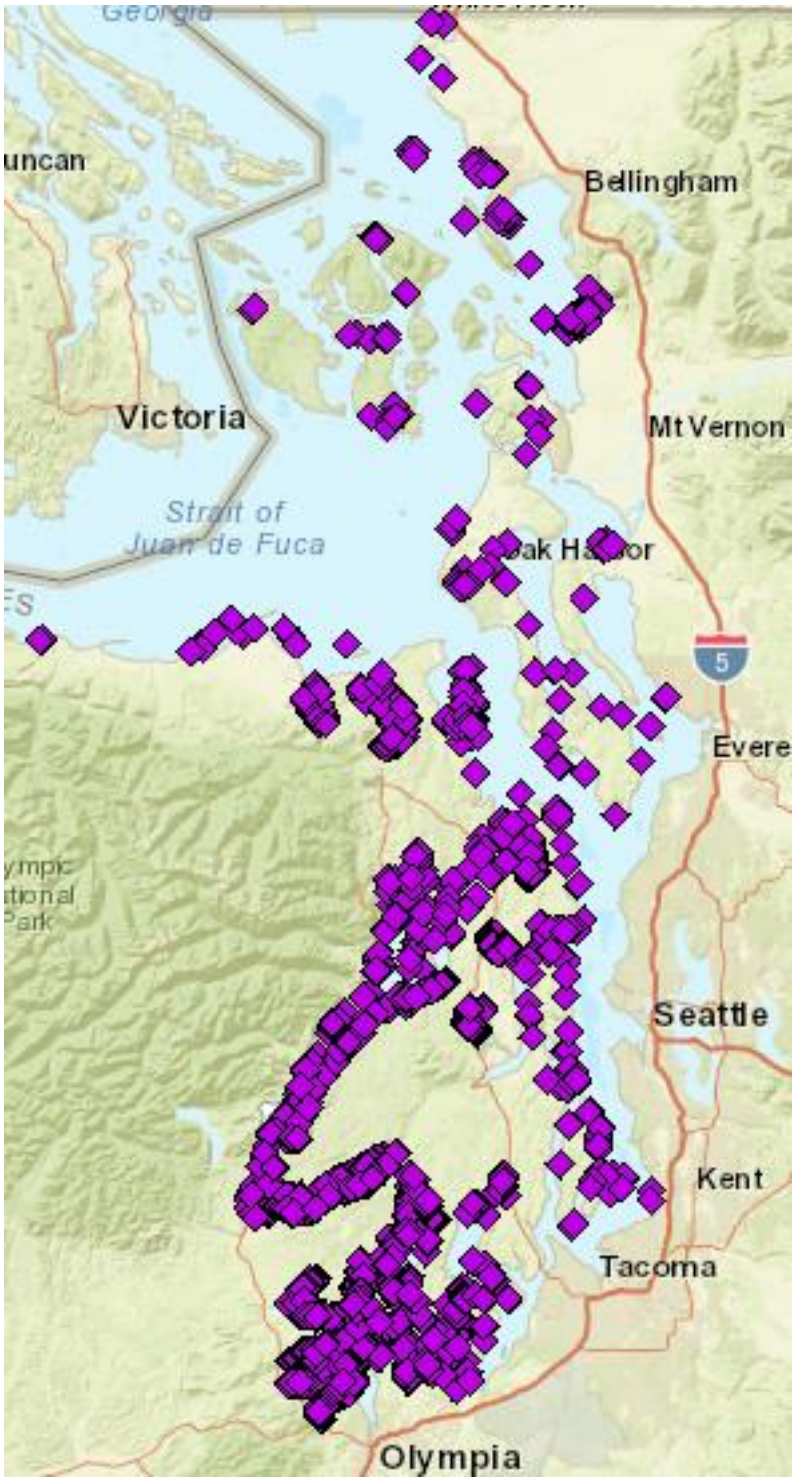

Figure 8: Purple diamonds represent commercial harvest sites around Puget Sound. Modified from Washington State Department of Health Commercial Shellfish Map Viewer.

The Port of Seattle Senior Environmental Program Manager Jon Sloan was quoted saying “People fertilize their lawns. There is industrial stuff to get in there. These filter feeders actually take those contaminants out of the water and incorporate them into their biomass. That's one reason we really don't want people eating these oysters. They are illegal to harvest. No urban oyster is really safe to eat, but they do a fantastic job of cleaning up the environment” (Morrow 2018). The oysters placed in Elliott Bay were placed there with the specific goal of providing filtration services in the water. Sloan’s statement was confirmed by a Washington State Department of Health official, who said that some areas are not suited for shellfish harvesting due to the way they have been developed, and mentioned Elliott Bay as one of these areas (Nelson, Stephen. Interview with author. Tumwater, July 18, 2019).

Washington is the largest producer of shellfish in the United States, adding $184 million to the state’s economy, and 2,710 jobs in 2010 (Washington State Shellfish Initiative). More than three-quarters of the value of the state’s aquaculture comes from areas within the study area, including North, South, and Central Puget Sound, Hood Canal, and the Strait of Juan de Fuca (Washington State Shellfish Initiative). The Pacific oyster is the largest share of aquaculture production in the state (Washington State Shellfish Initiative). Currently, shellfish aquaculture is the second largest employer in Mason County, Washington which includes Shelton, the location of all three oyster companies that were interviewed (Pacific Coast Shellfish Growers Association 2020).

Pollution

Water pollution from pulp mills date back as far as the 1860s, according to some records (White, Ruesink, and Trimble 2009). Nearly one hundred years ago, in 1927, a pulp mill opened in Shelton, Washington. Sulfite waste liquor discharged from the pulp mill led to a major decrease in Olympia oyster populations in southern Puget Sound (White, Ruesink, and Trimble 2009). Pulp mills are no longer a problem, though increased population density near growing areas comes with its own set of problems. Pollution from agricultural runoff and sewage and septic systems have become another major concern as populations grow in Washington State (Nelson, Stephen. Interview with author. Tumwater, July 18, 2019; Brewer, Dennis. Interview with author. Union, August 14, 2019; Hart, Walter. Interview with author. Shelton, August 21, 2019). Skagit County was named as a place where rivers are polluted as a result of runoff from dairy farms.

Vibriosis

There are several types of illnesses, diseases, and biotoxins that affect either oysters, or humans consuming oysters that are currently considered problems in Puget Sound. These include vibriosis, herpesvirus, and shellfish poisoning. All of these can cause problems for the commercial industry, by affecting their ability to harvest and sell shellfish to their markets, and consumers, who often prefer to eat raw oysters on the half shell.

Vibriosis is a disease that affects humans caused by the bacteria Vibrio parahaemolyticus (PSEMP Marine Waters Workgroup 2018). The bacteria causes

intestinal problems in humans, as well as headaches and fevers, with symptoms lasting up to four days (Washington State Department of Health 2018). Cases tend to be mild, though occasionally result in hospitalization (Washington State Department of Health 2018). Vibriosis is generally caused by the consumption of raw shellfish, including oysters on the half shell, because the bacteria lives in saltwater, and can be killed by cooking (PSEMP Marine Waters Workgroup 2018). The bacteria is able to proliferate best when water temperatures are high.

From 2014 to 2017, the water temperatures in Puget Sound were abnormally high, resulting in several cases of vibriosis in the state (PSEMP Marine Waters Workgroup 2018). Oftentimes, shellfish cannot be harvested for human consumption during periods of high temperatures, resulting in economic losses for commercial shellfish companies, as well as beach closures (Washington State Department of Health 2018). With climate change, it is possible that these more extreme temperatures will become more common in the waters of Puget Sound. Because Pacific oysters withstand variable temperatures better than Olympia oysters, Pacific oysters may be the only viable option for shellfish farmers under these conditions.

Biotoxins

Marine biotoxins are another concern for oyster growers, humans who eat them, as well as the Department of Health. These neurotoxins are produced during harmful algal blooms, and bioaccumulated by filter feeders such as oysters (Lummi Natural Resources Department. 2019). Biotoxins cannot be destroyed by cooking, unlike vibriosis, so if they are detected, oyster harvest must be stopped and the beaches must be

closed immediately for public safety (Washington State Department of Health). In Washington state, there are three types of biotoxins: paralytic shellfish poisoning, amnesic shellfish poisoning, and diarrhetic shellfish poisoning. As their names imply, they cause paralysis, short term memory loss, and diarrhea, respectively (Lummi Natural Resources Department. 2019).

Herpesvirus

In recent years, Ostreid herpesvirus 1 (OsHV-1), also known as Pacific Oyster Mortality Syndrome (POMS) has become a major threat to Pacific oysters all over the world, and especially in Europe, Australia, and New Zealand (Ugalde et al. 2018; Pernet et al. 2019). Herpesvirus is not a threat to humans, but has been reported to cause mortality in as many as 87% of the oysters in Tasmania, Australia, and up to 100% in France (Ugalde et al. 2018). As of writing, herpesvirus has not yet reached Puget Sound, but has infected oysters in Tomales Bay in Northern California (Burge 2017; Segarra et al. 2010). Based on data collected during the interviews, Ostreid herpesvirus 1 is a very real concern for oyster growers and shellfish biologists in Puget Sound looking toward the future (Knight, Lauren. Interview with author. Blyn, August 15, 2019).

Conclusion

This chapter has shown the complex habitat requirements of oysters in Puget Sound, and the issues that currently affect the management of them. As urban development increases stress in coastal environments, pollution becomes more of a concern for oyster growers, as unclean water can close beaches for harvest. As climate

change alters the temperature and water of these coastal environment, the health of both humans and oysters become at risk. As both Native American tribes and Washington's private sector are simultaneously interested in conserving and commercializing different species of oysters in Puget sound, it is evident that oyster management is of utmost importance. The following chapter documents some of the voices in charge of oyster management and production in Puget sound, using quotes from the interviews that were conducted.

CHAPTER IV

DATA ANALYSIS

Based on purposive and snow-ball sampling recruitment strategies, 11 stakeholders were interviewed in the summer of 2019. Interviewees included three people in the oyster industry, three people from government agencies, two restoration project managers, two tribal shellfish biologists, and one researcher. Those interviewed from the shellfish industry were from three companies in South Puget Sound. Two of those from government workers were from the Washington State Department of Health, and one from the Washington Department of Fish and Wildlife. The restoration project managers were from the Jefferson County Marine Resources Committee, and the Skagit County Marine Resources Committee. The tribal shellfish biologists represented the Jamestown S'Klallam tribe and the Skokomish tribe.

The interviews conducted during the summer of 2019 resulted in nearly seven hours of recordings, as well as approximately eight more hours spent with stakeholders that were not recorded, yet extensive notes were taken to help contextualize and triangulate information. The recordings, once transcribed, held more than seventy-three pages of content (35,000 words). In addition, more than two hundred photos were taken at the various interview locations. For the purposes of this paper, and based on ethical considerations articulated in my Internal Review Board Human Subjects Research and consent form (study number 2019-067) each participant was assigned a pseudonym to maintain anonymity when they are quoted.

Data Analysis

Dr. Renteria and I coded for emergent categories. More than twenty categories resulted salient during coding. The categories identified during interviews that were considered most relevant to this research were classified into three broad clusters: 1) those that affect the market, 2) those pertaining restoration and monitoring, and 3) issues that continue to affect oysters in Puget Sound. Each of the categories are organized primarily in relation to the ecology of Olympia and Pacific oysters, which have at least some influence on almost every category. For instance, the speed of their growth determines which species is more widely available for the markets (Pacific); the Olympia's preference for oyster shell as a substrate requires old Pacific oyster shells from commercial growers; and finally, it is possible that in the future, Olympia oysters may be more resilient to oyster acidification than Pacific oysters. The categories will each be discussed in depth, emphasizing the quotes obtained during the interviews to best represent the issues.

The cluster Markets represents an outcome of the relationships between processes related to the crafting and maintenance of a sense of self, oysters harvesting times, regulations and methodologies in the context of specific territorialities and the history of Puget Sound; similarly, the Restoration and Monitoring practices and projects cluster is dependent on established and contested laws, partnerships, funding, and volunteer work that different institutions make possible; finally, a number of Issues are present in the future of oysters in the Pacific Northwest, influenced by health challenges, increasing

pollution, and the threat of climate change. Each of these relationships are demonstrated in Figure 9.

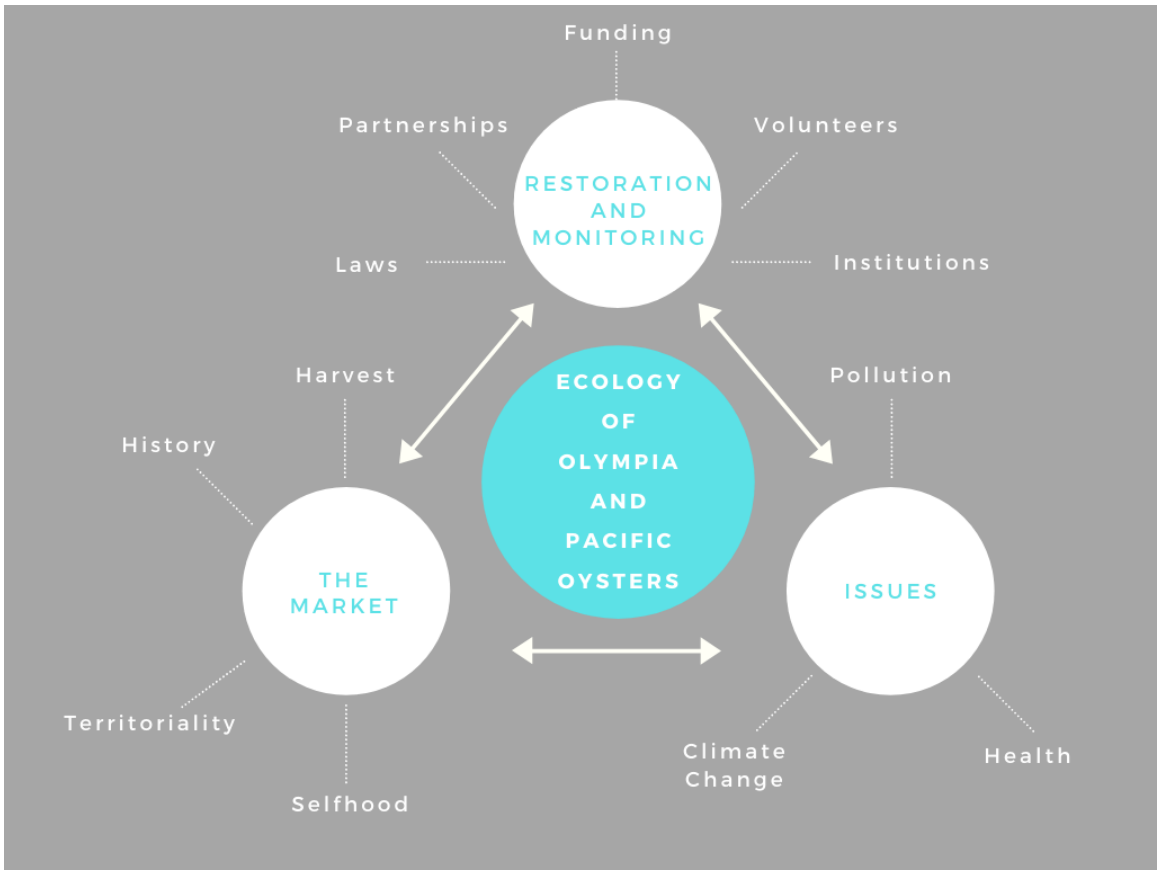

Figure 9: Conceptual map of the categories identified during interviews. Created by Liliana Kaeding using Canva.

While there are many ways that these categories could have been arranged into themes, after carefully analyzing patterns and relationships, the arrangement shown was determined to be the most useful for explaining the concepts presented. This conceptual map is simplified for clarity, but many of the categories could be shown to overlap, or be included in multiple clusters. For example, the distinction between the shellfish industry and the restoration projects even becomes blurred in some cases, as several companies

are involved with both, working to maintain water quality and donating shell as substrate for Olympia oysters to settle on.

The Market for Oysters

In Puget Sound, the market for oysters is influenced by a variety of factors, including the history of the region, the identities and sense of self in relation to oysters created by this history, the harvesting practices taking place, and the different forms of territoriality that articulated said harvesting. To understand the way oysters occupy an important commercial niche in the region, it is necessary to understand the history of Puget Sound. Prior to Washington becoming a state, Native American women harvested oysters off the beach and sold them in towns around Puget Sound (De Denaan 2013). The treaties signed by tribes in the 1850s then displaced many of these women, allowing for newcomers to the area to buy these lands. The Bush and Callow Acts of 1895 created a formal oyster industry that specialized in growing and harvesting Olympia oysters, then shifted to Pacific oysters as the need arose. Each of these treaties and laws continue to influence the species of oysters grown to this day, and the locations that are available for harvest. In addition, many growers have continued their family businesses for several generations, also influencing the availability of the native oyster, the Olympia, as commercial growers can choose which species to grow. Many consider oyster harvesting a way of life, and in turn the self is constructed and molded over time.

Territoriality

Beginning in the 1890s, land use laws allowed settlers to buy tidelands to begin growing and harvesting shellfish. These laws, specifically the Bush and Callow Acts, created a territorial displacement for the indigenous people already occupying those areas and harvesting oysters. In South Puget Sound, Eld Inlet, Hammersley Inlet, Oakland Bay, Skookum Inlet, South Bay, and Totten Inlet were rich with oyster beds, according to E.N. Steele, an early oyster farmer; in North Puget Sound, oysters were most abundant in Quilcene Bay and Samish Bay (Steele 1957). Data collected in 2013 shows that South Puget Sound continues to be the largest aquaculture producer of shellfish in the state (Washington Sea Grant 2015).

Land allocation laws continue to affect the ways that Washington tribes relate to oysters to this day. Growing up, oysters were never one of the foods we ate at tribal events. My tribe, Samish, does not have access to shellfish harvesting rights due to a clerical error in the 1960s by the Bureau of Indian Affairs, despite being signatories to the Treaty of Point Elliott. Rosie Cayou-James, a Samish elder, recalled that her grandfather used to harvest Olympia oysters in the 1890s in Fidalgo Bay; that area was turned into an oyster farm by settlers soon after (DeWeerdt 2019). Eventually, the populations of Olympia oysters were nearly lost in this area. In present times, Fidalgo Bay has been the site of a restoration project for nearly twenty years.

Currently, access to land is one of the major barriers to restoration work, according to project managers (Lewis, Peter. Interview with author. Anacortes, June 25, 2019; Foster, Cindy. Interview with author. Port Hadlock, July 28, 2019). Access to

appropriate tidelands is not always available, as many of the ideal restoration locations are privately owned, or already being used for commercial shellfish operations. Those involved with restoration projects must often work with landowners or companies to gain access to these important sites. One site in particular on Fidalgo Bay was named as a location where access had to be granted by a company (Lewis, Peter. Interview with author. Anacortes, June 25, 2019). Other locations identified as restoration sites, with varying levels of success, include: Skagit Bay, Drayton Harbor, Chuckanut Bay, Discovery Bay, Quilcene Bay, Dabob Bay, Sequim Bay (Lewis, Peter. Interview with author. Anacortes, June 25, 2019; Knight, Lauren. Interview with author. Blyn, August 15, 2019). Other sites identified as potential restoration sites include: Padilla Bay, Samish Bay (Lewis, Peter. Interview with author. Anacortes, June 25, 2019).

Today, much of the oyster industry is still concentrated in the areas that Steele identified more than 60 years ago in both North and South Puget Sound. The three oyster growers interviewed, who make up only a small fraction of the total growers in Washington State, each had businesses within these regions, and some even mentioned Steele's book as a resource for me to read. Several shellfish companies continue to operate on lands that were purchased by their family members under the Bush and Callow Acts of 1895.

There are four Marine Resource Committees (MRCs) that operate at the county level involved with oyster restoration projects: Clallam, Jefferson, Skagit, and Whatcom (Northwest Straits Commission 2020). Each of these counties represent areas where Olympia oysters were once abundant, but due to overharvesting and pollution, are now

scarce in wild populations. Marine Resource Committees are groups of volunteers who work toward specific marine conservation goals, organized within the Northwest Straits Marine Conservation Initiative (Northwest Straits Foundation 2020). These four MRCs are working to enhance Olympia oyster populations and their habitats, and improve water quality. While the MRCs are doing important restoration and enhancement work, their work is limited by the arbitrary boundaries of the counties themselves. These boundaries lead to a separation in restoration efforts, as each county coordinates their own restoration efforts.

Harvest

For many companies, the Pacific oyster is the main crop being grown and sold each year. Nearly everyone interviewed agreed that Pacific oysters are faster and easier to grow than most other species of oyster, and do not have as specific of habitat requirements. Many companies choose not to grow the Olympia oyster at all. They are more difficult to grow, and more susceptible to predators such as oyster drills. In some locations, such as the Seattle area, the commercial industry cannot operate at all due to high levels of pollution caused by intense urbanization. In addition, harvesting Olympias is a specialized skill and is more time consuming because they are harder to identify and see, as they look similar to small Pacific oysters. There are small patches of them around South Puget Sound, but there have not been big enough populations to harvest for 6-8 years (Hanson, Barry. Interview with author. Shelton, June 17, 2019).

While Olympia oysters are more difficult to grow than Pacifics, some companies still choose to grow them for their own personal reasons. For one company, Olympias are

a tradition. As one of the largest shellfish companies, they have more flexibility to grow more species than smaller growers do. “I guess part of the reason we grow so many different species in part is to have some diversity for the markets. And then the other part of the Olympia oyster is kind of more of a historical thing. That’s what my family started growing so I guess it’s more of a legacy thing than anything else” (Hart, Walter. Interview with author. Shelton, August 21, 2019). This company has been growing and harvesting Olympias for nearly 100 years and continues the tradition to this day. Another grower with a small company chooses to grow native oysters because “Olympia’s are more a labor of love for me, so I’m experimenting with different ways of raising them now that we don’t have dikes and we couldn't get the permits to even build dikes anymore” (Brewer, Dennis. Interview with author. Union, August 14, 2019). Because of the habitat requirements of Olympia oysters, growing them without dikes becomes more difficult and time consuming. These two companies had their own methods for growing these oysters that differed from one another.

Sense of Self

For commercial growers, the oyster industry is, in some way, a construction of the self. While only three growers were interviewed, their answers mirrored each other. Each discussed their families’ multigenerational history of growing and harvesting oysters in Puget Sound, their connection to the Olympia and Pacific oysters, and their motivations for continuing in the business. Two of the three men interviewed stated that their children are also continuing their business by working in the industry, in some capacity (Hart,

Walter. Interview with author. Shelton, August 21, 2019; Brewer, Dennis. Interview with author. Union, August 14, 2019).

Some growers choose to harvest oysters for other reason other than to sustain their livelihoods—perhaps related to what being an oyster farmers means to them socially or historically, articulating specific senses of self: "And there's no absolute need, money-wise, to do it, but I want to pass on the business to our daughters and keep the ground in cultivation. But the oyster business, I think you'll hear from many, it's a way of life. It keeps me physically, mentally, and socially active" (Brewer, Dennis. Interview with author. Union, August 14, 2019). This shellfish grower does not require the income, and stated later in the interview that he and his wife use nearly all of the income from their business for shellfish related events and trips.

One grower has been around oysters his entire life, even describing his earliest memory: "I grew up on a shellfish farm in Totten Inlet. In fact, my first memory is falling out of a boat when my dad was working with Olympia oysters, so I've been all my life, and my family has been farming shellfish here since 1890" (Hart, Walter. Interview with author. Shelton, August 21, 2019). Clearly this family has ties to the shellfish industry for several generations and holds significance to their concept of the self. As he continued his family's legacy, his sense of self continued to form over time, shaped around the oyster industry. In this context, the relation that some people have to Oysters in the Puget Sound goes beyond monetary interest; that said however, the oyster market in the Pacific Northwest represents a fundamental economic and regional asset.

The Market

The oyster industry in Washington is one of the largest in the country, supporting over 3,200 jobs and generating $270 million per year (Sreenivasan 2012). Pacific oysters make up the largest share of the market, at 38% of both gross weight and revenue of shellfish produced in Washington State, as of 2013; these percentages represent nearly 8.8 million pounds of oysters, and $35 million dollars (Washington Sea Grant 2015). Many of these oysters wind up in restaurants in Seattle, including the three Taylor Shellfish oyster bar locations.

The market for oysters is affected by multiple factors. The demand for half shell oysters requires that oysters can be grown quickly and individually. Therefore, Pacific oysters are grown by nearly every company, due to their fast growth and ability to survive in many locations. In addition, the demand for oysters drives the industry. Some favor certain flavors from specific specialty species that are not as widely grown in Washington state, such as the Olympia and Kumamoto oysters.

The market has shifted considerably since the early days of the oyster industry, in the 1800s. Originally, Olympia oysters were the only species that were commercially viable in the Pacific Northwest, before Pacifics were introduced to the Pacific Northwest. Whereas the market used to be for shucked oysters, the demand in the market has changed considerably, and now is nearly all for half shell oysters (Hart, Walter. Interview with author. Shelton, August 21, 2019; Brewer, Dennis. Interview with author. Union, August 14, 2019). One oyster grower recalled a neighbor who once sold a large quantity of shucked Olympia oysters to the restaurant at the top of the Space Needle

during the 1962 World's Fair (Brewer, Dennis. Interview with author. Union, August 14, 2019). Now, nearly all the oysters at restaurants in Seattle are sold on the half shell (Figure 10).

Figure 10: Oysters on the half shell at Taylor Shellfish Farms restaurant. Photo from yelp.com

Oysters are famous for their "*merroir*" flavor, taking on the unique flavor of where they are grown (Taylor Shellfish Farms 2018). Olympia oysters are known for their unique metallic flavor (Cox 2017). At high end oyster bars and restaurants in Seattle, oysters on the half shell can vary greatly in price depending on the species, and the location the oyster is grown. At Taylor Shellfish Farms, Olympias are three dollars each, while Pacifics are slightly less expensive (Taylor Shellfish Farms 2018). Each species is listed with their growing location and price (Taylor Shellfish Farms 2018). At

the Brooklyn, however, in downtown Seattle, oysters on the half shell are offered with beer and wine pairings, as well as on their own (The Brooklyn 2017). The menu lists the flavor for each type, the scientific name for each oyster, as well as the location they were grown, and the method of growing that was used (The Brooklyn 2017). Listing these details may be indicative of the reputation of oysters as luxurious foods in the Pacific Northwest.

Conclusion

The market is heavily influenced by the history of Puget Sound, territoriality, sense of self from growers, and finally, the harvest. The history of Puget Sound, including multiple treaties and the Bush and Callow Acts, influenced the ability of settlers to become shellfish growers in the region. These lands continue to be used as commercial shellfish beds today. Many of these businesses have been passed down from generation to generation, and continue to influence the species of oysters that are grown. Olympia oysters are sometimes grown for legacy reasons, as they were the original species harvested by the company, and are a part of the sense of self of some growers. The ease of growing Pacific oysters, however, has made them the most common species in markets around the world.

Contrary to what we initially anticipated, the burgeoning oyster industry, far from been antagonistic or detrimental to conservation efforts, actually seems to be in alignment with restoration goals. There seems to be productive collaboration between conservation goals and the market. Oysters, regardless of their role in either restoration or the commercial industry, benefit from clean water. Therefore, different stakeholders, despite

their different goals, are motivated to work together to achieve these goals. In addition, piles of discarded and dried shells may be taken from shellfish farms, and used as substrate for Olympia oysters to settle on. In this way, commercial growers benefit the restoration efforts that are being conducted.

Restoration and Monitoring as a Result of Laws, Institutions, Funding, Volunteers, and Partnerships

Restoration work is the main way through which Olympia oyster populations are rebounding in the Pacific Northwest. To make restoration projects possible, there must be several factors that align. For many projects, funding and volunteers are the main limiting factor. There must also be access to appropriate tidelands, and laws that allow for restoration work to be done at a site. Finally, there must be institutions that can cooperate to meet a common goal, and work to create laws that are conducive to this type of work. Each of these factors helps to influence and shape the way that restoration projects can be conducted in the state, and partially determines the success of the restoration.

Funding and Volunteers

Funding was identified by participants in interviews multiple times as one of the limiting factors for restoration. According to one shellfish biologist:

> Funding is very politically driven. And politics are driven by constituents and what their concerns are so as long as people in the community express an interest in restoration and the importance of restoration as it pertains to oysters, or shellfish, then yes, I think there will continue to be funding for it. But if that interest dissipates, then no, there won't be funding. (Knight, Lauren. Interview with author. Blyn, August 15, 2019).

Funding for shellfish restoration projects, as in many fields, is not guaranteed each year, and is dependent on grants. Restoration projects require volunteers for monitoring when funding is not available. For the Fidalgo Bay site, the large number of retirees in Anacortes help to keep these projects running. “Most of the work in terms of monitoring, probably 90% plus has been done by volunteers so that doesn’t require anything, so we haven’t even had a budget line item for the MRC for quite a few years...It’s just a matter of getting the volunteers out and counting...I don’t think I've ever come up short” (Lewis, Peter. Interview with author. Anacortes, June 25, 2019). While that project had success finding volunteers, not all of the work can be done by crowdsourcing. Some require experienced shellfish biologists, such as those overseen by the Department of Fish and Wildlife.

> Funding, the main one. Funding, staffing, we do not have anywhere near the funding and staff to address all the disease prevention issues that we have to deal with. Olympia oyster restoration, we are responsible for it and we oversee it in the state, we’re responsible for the species. We have to rely on entities outside of the agency to accomplish a lot of the work. (Webb, Brian. Interview with author. Port Townsend, August 15, 2019).

In addition to funding, shellfish restoration projects need volunteers willing to help with the monitoring aspects. Some restoration projects, such as the one in Fidalgo Bay, rely almost entirely on volunteer work. Volunteers may also help drastically reduce the budget required for monitoring sites for years after the initial oyster cultch or substrate is distributed.

Restoration projects also lead to a construction of the self. Volunteers spend many hours, of their time monitoring oyster beds (Figure 11). In addition, according to one project leader, the volunteers enjoy working on restoration projects. “One, it’s interesting to engage the public when it comes to oysters and I think that’s one of the advantages of restoration, they’re learning something about oysters but they’re also doing something that they feel is helping the environment” (073119).

Figure 11: Jefferson County Marine Resources Committee volunteers spreading shells in Discovery Bay. Photo taken from Jefferson County Marine Resources Committee website, 2020.

Laws

Many different laws were discussed as important to the restoration process, the commercial industry, and the government agencies. Many of the laws concerning clean water were ranked as important for each of the three types of stakeholders mentioned above. Some laws, such as the Endangered Species Act to protect critical habitat, were more limited to the realm of restoration, and did not affect the commercial industry as

much. Finally, laws regarding equipment, labor, and human health were mentioned mainly by commercial growers.

The laws that were cited as important for restoration projects differed slightly from those mentioned by other groups. Restoration projects require access to land, and permits regarding critical habitat---all aspects related to territoriality issues expressed in the previous sections. One project leader described the laws that affected her work, and the challenges they present: “And I would say the major hurdles are the logistics of permits, that’s probably the major one. And access to a site. And the other big one is not being able to do restoration areas where there’s eelgrass, even though in nature, Olympia oysters and eelgrass might coexist” (Foster, Cindy. Interview with author. Port Hadlock, July 28, 2019). Eelgrass is considered an indicator of the health of estuarine ecosystems in Puget Sound, and is closely monitored and protected at the federal level under the Endangered Species Act of 1973 and Magnuson-Stevens Act, and at the state level by the Growth Management Act (Valdez et al. 2016; Goehring, Gaeckle, and Brandt 2015). Aquaculture is considered a potential threat. While restoration projects are potentially less damaging to eelgrass than aquaculture, restoration may still fall under aquaculture, and permission for these projects can be denied (Foster, Cindy. Interview with author. Port Hadlock, July 28, 2019).

Access to land was another issue discussed several times for restoration of oyster beds. Another problem is “having the right tidelands available. Washington State, probably somewhere around 70% of the tidelands were sold to private parties so the government can’t just go and do restoration on private tidelands” (Webb, Brian.

Interview with author. Port Townsend, August 15, 2019). The tidelands in Washington State were sold to private individuals in the late 1800s, and continue to be privately held today, under the Bush and Callow Acts. For the public tidelands, these are limited further by the availability of tidelands not covered in eelgrass.

In many restoration projects, Pacific oyster shells are placed in tidelands to create substrate for Olympias to settle on. The shell that is used often comes from shellfish companies around Puget Sound (Lewis, Peter. Interview with author. Anacortes, June 25, 2019; Hanson, Barry. 2019. Interview with author, June 17). Before shells can be transferred, however, they must first obtain a Shellfish Transfer permit, and have been out of water for several months to avoid spreading invasive species and disease (Figure 12) (Washington Department of Fish and Wildlife 2020).

Figure 12: Pile of Pacific oyster shell drying out. Photo by Liliana Kaeding, June 2019.

The commercial industry must adhere to standards from a variety of different government agencies, including federal, state, and local governments. These standards include many health, environmental, and labor regulations. Laws that affect commercial shellfish growers will be discussed in detail in the following paragraphs.

Laws regarding construction of dikes on tidelands were discussed multiple times throughout interviews. To increase production in South Puget Sound in the early twentieth century, Olympia oysters were cultivated using a system of dikes, which were terraces created on the tidelands that allowed the oysters to be covered with water at low tides (Steele 1957). The water that pooled on each level protected the oysters from

extreme temperature variations. The dikes were huge investments for growers at the time, costing nearly four thousand dollars an acre, and taking years to complete (Steele 1957). Construction began in the 1910s, continuing for more than fifteen years (Peter-Contesse and Peabody 2005). The U.S. Army Corps of Engineers no longer issues permits for dikes, meaning that the huge system that was once built over a span of several decades is now falling into disrepair (Figure 13) (Hanson, Barry. Interview with author. Shelton, June 17, 2019). Oyster growers have had to find other ways to grow the native oyster, which require more effort. For this reason, some producers choose not to, or are unable to, grow Olympia oysters anymore.

Figure 13: Tidelands that were once diked for Olympia oyster harvest near Shelton, Washington. Photo by Liliana Kaeding, June 2019.

The Washington State Department of Health oversees the Shellfish Sanitation program. They follow the rules outlined in the Washington Administrative Code 246-282, called the Sanitary Control of Shellfish. The Washington Administrative Code (WAC) establishes requirements for those who grow and harvest shellfish, as well as other activities including processing, transporting, and selling shellfish (Sanitary Control of Shellfish). These rules aim to ensure that the commercial shellfish industry is taking necessary precautions to keep the public safe when consuming raw shellfish. WAC 246-282 also includes provisions for dealing with *Vibrio parahaemolyticus*.

The Department of Health is also concerned with classifying shellfish growing areas. Areas where shellfish growing is always permitted are called "approved" areas. An approved classification means that the area does not have shoreline pollution impacts and can generally be harvested at any time. Other classifications include "conditionally approved," "prohibited," and "restricted" (Figure 14). Conditionally approved areas sometimes meet the requirements of an approved area, but sometimes has issues. Restricted areas do not meet the water quality standards based on thirty samples collected over a period of up to five years. Harvesters are allowed to take shellfish from these areas, and move them to an approved area to purge for up to two months, but due to the difficulties of this process, most choose not to do this. Finally, restricted areas mean that harvesting is not allowed at all. These classifications are permanent, though are reevaluated. In addition, there are emergency closures for beaches in case unexpected events happen, such as an oil spill or heavy rainfall. A Department of Health official discussed the regulations surrounding water quality in the state. Multiple institutions must

work together to correct pollution problems in the state when shellfish areas are impacted.

> Washington probably has the most significant water quality program in the nation. We have laws that require local governments and agencies to respond when we have shellfish downgrades based on non-point pollution. They have to do certain things if we downgrade an area, like create basically a closure response plan that says what they're going to do and how they're going to try to fix these things. (Nelson, Stephen. Interview with author. Tumwater, July 18, 2019).

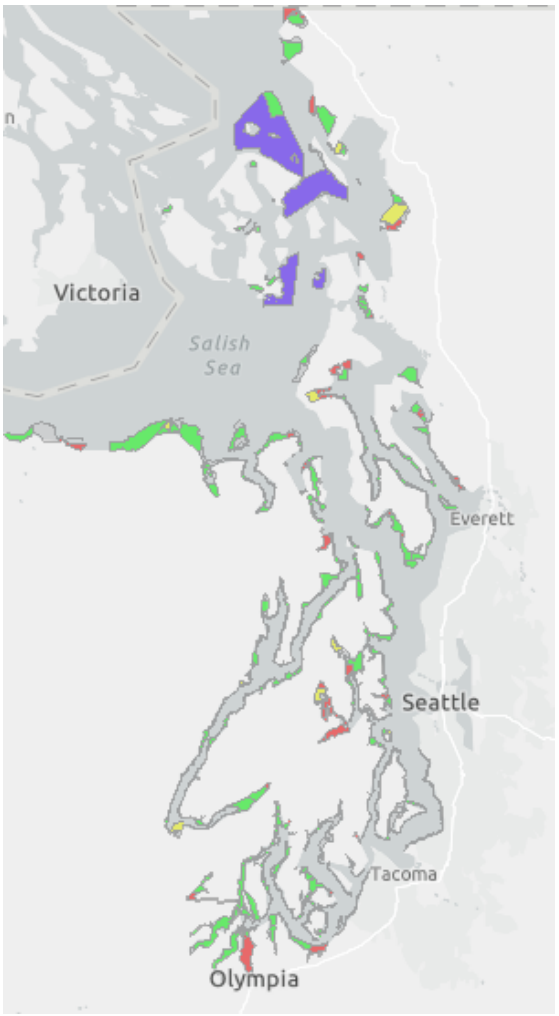

Figure 14: Commercial shellfish growing areas. Green areas are approved, yellow areas are conditionally approved, red areas are prohibited, and purple areas are restricted. Gray areas are unclassified. Modified from the Washington State Department of Health Commercial Shellfish Map Viewer.

Institutions

Each of the laws listed above must be enforced by an institution. For this reason, agencies such as the Washington State Department of Health, Washington Department of Fish and Wildlife, Washington Department of Natural Resources, Washington State Department of Ecology, are all necessary to ensure rules and laws are followed appropriately. These agencies issue permits, monitor water quality, and work together to both ensure the safety of humans consuming oysters, and protect the ecosystem. Other federal government agencies identified in various capacities include the United States Food and Drug Administration, United States Army Corps of Engineers, National Marine Fisheries Service, United States Fish and Wildlife, Environmental Protection Agency, National Oceanic and Atmospheric Administration, United States Forest Service, and the United States Department of Agriculture.

In addition to the agencies that create regulations, there are also many organizations involved in restoring Olympia oyster populations. These include several Marine Resource Committees representing coastal counties such as Skagit, Clallam, Whatcom, and Jefferson counties. The Northwest Straits Commission oversees these Marine Resource Committees, and is a state agency. The Puget Sound Restoration Fund, a nonprofit organization, may be the single biggest group currently working to restore oyster habitats.

Tribes are another set of groups who work to both restore Olympia oyster beds, in cooperation with Marine Resource Committees and other organizations. As mentioned in the History of Olympia oysters in Puget Sound, at least ten tribes are currently working

on restoration projects, including Jamestown S'Klallam and Skokomish, whose shellfish biologists were interviewed. In many cases, the tribes also raise Pacific oysters for commercial and subsistence purposes. At least thirteen tribes have commercial licenses.

Partnerships

After coding the interviews, one of the most prevalent themes identified was partnerships and cooperation. Almost unanimously, shellfish growers, government officials, tribal shellfish biologists, and restoration project leaders agreed that partnerships with each other are necessary for a variety of reasons. These partnerships are made up of local and state government agencies, tribes, shellfish growers, researchers, and private landowners. The most common reasons mentioned for creating partnerships include a need for funding of projects, expertise of Olympia oyster habitat, access to restoration sites, protection of water quality, enforcement of laws, among others.

First, Olympia oysters need substrate to settle on. Restoration projects may focus on adding appropriate substrate to habitats so that the native oysters are not smothered by mud and silt. According to several interviewed, they prefer oyster shell over other materials used for restoration, such as ceramic tiles or rocks (Lewis, Peter. Interview with author. Anacortes, June 25, 2019). Because restoration organizations are not involved in the commercial industry, their access to shell is limited by their partnerships with shellfish companies. Therefore, those attempting to restore habitats must work closely with shellfish growers near them to obtain the shell that has been dried on land for several months, in accordance with transport laws. In this way, the commercial industry and restoration projects are not at odds with each other, but rather cooperating to achieve

similar goals. Both groups are working to restore native oyster habitats in the Pacific Northwest, though their motivations may be different.

Perhaps one of the most surprising partnerships mentioned was between the Skagit Marine Resources Committee and the Shell refinery near Fidalgo Bay in Anacortes, Washington (Lewis, Peter. Interview with author. Anacortes, June 25, 2019). While one would not normally assume that an oil refinery could hold an active role in restoration projects, they provided access for the Marine Resource Committee to work on projects (Lewis, Peter. Interview with author. Anacortes, June 25, 2019). The access allows for more tidelands to be available for restoration. The cooperation between these unlikely partners is the type that is required for large-scale oyster restoration in Puget Sound. No instances were discussed during interviews where access was blocked to tidelands, though it can be assumed that this occurs regularly, as access to sites was mentioned as a barrier to restoration.

Restoration and Monitoring

There are a variety of restoration projects currently being conducted in Puget Sound by various entities, including the state and local governments, tribes, and nonprofit organizations. There is also cooperation between each of these projects that are focused on restoring habitat and aiming to expand wild populations of Olympia oysters. A Fish and Wildlife shellfish biologist clearly spelled out the goals of their restoration projects: "The approach we take is to do restoration to the point where we have established a self-sustaining, natural population of Olympia oysters. In other words, simply defined as they no longer need human assistance to maintain themselves and also increase their

distribution, presence" (Webb, Brian. Interview with author. Port Townsend, August 15, 2019). When asked if there are any areas that qualify as restored, under his definition, his response was "Sequim Bay I would say is close to that point. Fidalgo Bay in Skagit County is another place that essentially is at that point. Could walk away and not do anything more and their mollusk observations are going to persist, and continuing to expand" (Webb, Brian. Interview with author. Port Townsend, August 15, 2019).

A Department of Health official discusses the successes of upgrading areas to be approved for shellfish harvesting. He states that the restoration program, which aimed to restore 10,000 acres by 2020 was successful, even though the current total of 5,700 seems far from the goal. Part of this is due to a several thousand-acre downgrade in 2011 in Samish Bay due to discharge from one of the rivers that feeds into the bay.

> I would go to our restoration program, when we talk about that 10,000 acre goal, we're at 5,700. It doesn't look like a success but I would say our restoration program in whole is an incredibly successful program. And when I talk about our restoration program, I mean the web that we have. Not only the people here in the office but our local, state partners, our tribal partners, everybody that works on projects out there, the shellfish protection districts, the NEP program, everything to improve water quality. It's been incredibly successful. We've had some growing areas upgraded that, those upgrades took 25 years to obtain and the counties and the state kept working at it and working at it, and the water quality finally improved, and it was millions of dollars to get there but we were able to upgrade the area so I think that's a really good success. (Nelson, Stephen. Interview with author. Tumwater, July 18, 2019)

In addition, he lists the partnerships formed as part of the restoration program. These are crucial to the work being done, as the projects require partnerships for having the necessary workforce, funding, and cooperation. The Department of Health must

coordinate with other state agencies, such as the Department of Fish and Wildlife, tribal communities, and many others.

Conclusion

In conclusion, restoration and monitoring projects are not possible without the help of other institutions, volunteers, partnerships, and funding, and must abide by the many laws that are in place to protect habitats. These institutions range from state and local government agencies, to nonprofit organizations, to tribes, to the commercial industry. Each of these groups cooperate with one another to meet their shared goals, such as improved water quality and restored oyster beds. Because funding is politically driven, and not guaranteed, some restoration projects rely on volunteers to help reduce costs and increase public awareness. Finally, these groups work to follow or change laws to better fit the needs of all stakeholders involved. Some of the most pressing issues facing restoration projects include the uncertainty that arises from factors such as pollution, disease, and climate change. Looking toward the future, most of the stakeholders agreed that more work needs to be done to protect oyster populations from these threats.

Issues: Ecology, Pollution, Health, Climate Change, and the Future

The ecology of Olympia and Pacific oysters means that their health is dependent on clean water and appropriate habitat, including firm substrate. Pollution and climate change affect their health, as well as human health, as they can lead to the prevalence of

harmful disease and bacteria. Each of these issues will affect the future of the oysters because they are stressors that are difficult to predict far into the future.

Ecology of Oysters

The different ecologies of Olympia and Pacific oysters leads to their different management practices, and requires specialized knowledge for both growing and restoration. One oyster grower described Olympia oysters as more “finicky” than Pacific oysters, confirmed by a restoration manager, who stated that very few people have the knowledge of how to properly grow Olympias.

As evidenced throughout interviews with restoration project leaders and oyster growers, Olympia oysters require firm substrate, and prefer oyster shells to settle on. Interestingly, despite the Pacific oyster being an invasive species, their shell is often utilized for restoration efforts around Puget Sound. Even though their introduction to the Pacific Northwest further harmed Olympia oyster populations by introducing invasive predators, such as oyster drills, their shells are now being used to help grow populations in restoration projects.

Pollution

Pollution is a concern for anyone harvesting oysters. As evidenced by the comments of a Department of Health official, major risks to water quality are posed by a variety of human activities around Puget Sound:

> Certainly, shoreline development and onsite septic systems, management of those. Farms, agriculture, specifically the dairies and cattle farms, things that produce

> manure that can have runoff. Boater waste, still, even though we have the no discharge zone, still an issue. Wastewater treatment plants, and then the sustainable funding for pollution identification and correction programs. (Nelson, Stephen. Interview with author. Tumwater, July 18, 2019).

Some also expressed concern for the amount of plastic in the water used for production of oysters, including a restoration manager and a tribal shellfish biologist (Hart, Walter. Interview with author. Shelton, August 21, 2019; Rhodes, Brad. Interview with author. Skokomish, August 21, 2019). According to the shellfish biologist, the plastic used in aquaculture can break loose from the operation and end up floating around as pollution in the water (Rhodes, Brad. Interview with author. Skokomish, August 21, 2019). Other sources of plastics are problems for shellfish too. A recent study shows that microplastics were found in the majority of razor clams and Pacific oysters collected from Oregon beaches. Out of 245 animals tested, only two contained no traces of microplastics (Baechler et al. 2020). Plastics are especially troubling in marine environments as they do not degrade, and can disrupt coastal environments far from the source (Liu, Kao, and Chen 2015).

Health

Human health is a major concern for those who harvest and consume oysters. While oysters can be processed and cooked, the half shell market is currently most popular in restaurants. Oysters on the half shell are raw, and therefore humans who consume them are susceptible to harmful bacteria, such as vibrio.

> "Vibrio doesn't affect the oysters themselves in terms of the health of the oyster. It makes humans sick, it's a foodborne illness. Vibrio grows faster when it's warm...You have to be very very careful on how you handle the oysters because if you keep them out of cool conditions, if you keep their temperature up too long,

> that vibrio can divide and grow rapidly, then to concentrations when humans eat it, it gets us real sick. Though you can kill vibrio by cooking it. So it's really mostly a concern for the half shell market, it's not a concern for people who are shucking and processing and cooking the oyster." Knight, Lauren. Interview with author. Blyn, August 15, 2019).

In addition to Vibrio, biotoxins are another risk to humans who eat shellfish, caused by harmful algal blooms, typically during warmer months, especially summer. Unlike Vibrio, however, biotoxins cannot be destroyed by cooking (Knight, Lauren. Interview with author. Blyn, August 15, 2019; Lummi Natural Resources Department 2019). Once consumed, there is no cure to biotoxins, which can cause diarrhea, memory loss, and paralysis, depending on the type (Lummi Natural Resources Department 2019). Risk to humans may increase with climate change, as waters warm and harmful algal blooms happen more often and last for longer periods of time. According to the Lummi Natural Resources Department, "blooms are already occurring earlier in spring and later in fall and larger blooms are increasing the toxicity of shellfish to lethal levels" (2019). When biotoxins are present, beaches must be closed immediately for harvest, affecting both public and commercial harvests (Figure 15). The thorough monitoring conducted by the Washington Department of Health is vital for the safety of those who eat shellfish. There are approximately 275 public access beaches for oyster harvest in Washington State, spanning thirteen coastal counties, in addition to the 110 commercial growing areas (Nelson, Stephon. Interview with author. Tumwater, July 18, 2019; Washington Shellfish Trail 2019).

Figure 15: Toxic shellfish sign near Anacortes, Washington. Photo taken by Liliana Kaeding, March 2019.

Climate Change

Climate change was identified as another potential threat to oysters, for multiple reasons. Climate change may contribute to a number of issues that affect oysters, including habitat loss from sea level rise, warming ocean temperatures, and ocean acidification. In addition, the Olympia and Pacific oysters may react differently to these changes, according to recent studies (Waldbusser et al. 2016). Corrosive waters make the formation of oyster shells difficult in the first two to three days of their lives (Sreenivasan 2012) The calcium carbonate used to build their shells can dissolve in highly corrosive waters, something that does not happen when the pH is higher; larvae die within two days when this occurs (Sreenivasan 2012).

Climate change may result in changes to the waters oysters live in, such as becoming more acidic. According to a tribal shellfish biologist, these changes may have several different effects: "Another threat to oysters...definitely changes in climate that's resulting in changes in water chemistry. That's definitely going to be a big threat to oysters. If waters in fact do become more corrosive then we could have dramatic declines in the populations" (Knight, Lauren. Interview with author. Blyn, August 15, 2019). Warming temperatures may also be directly linked to major declines in oyster populations:

> And warming temperatures, in fact there was just a study that came out, I think it was from somewhere in France...they had several decades worth of monitoring data on oyster populations and they were able to link the decline of oyster populations to...actual increased temperature in the water. So how that's going to impact our oysters here is a little bit of an unknown but it's definitely a potential threat. (Knight, Lauren. Interview with author. Blyn, August 15, 2019).

In addition, warming temperatures may impact the prevalence of diseases. “Slight increases in temperature also increases the risk of disease becoming a huge issue” (Webb, Brian. Interview with author. Port Townsend, August 15, 2019). Warmer temperatures increase the risk of humans becoming sick with vibriosis, or a biotoxin resulting from a harmful algal bloom. Therefore, climate change and its effects of warming waters and ocean acidification may have major negative impacts that could hinder the harvest of oysters for human consumption, as well as harm or even kill the oysters themselves.

The Future

The future of oysters in Puget Sound is dependent on a variety of factors, including the ecology of oysters, water quality, human and oyster health, and climate change. Although the future is still unknown for all oysters in Puget Sound, those involved with Olympia oyster restoration projects are optimistic about the survival of the native species. A shellfish biologist for the Department of Fish and Wildlife believes that in the future, oyster restoration projects will continue to increase, and be more successful. “I think that especially with the momentum we’ve gained with the recent knowledge we’ve garnered on Olympia oysters, I see it just increasing, restoring more locations, more rich, more numbers. Yeah, the only limiting factors is restoration costs dollars” (Webb, Brian. Interview with author. Port Townsend, August 15, 2019). Funding is again cited as the limiting factor for restoration projects, meaning that there must continue to be interest in these projects, and restoring the health of aquatic ecosystems must remain a priority.

One oyster grower said that the future was uncertain for the industry he had spent his life working in. He believes that in one hundred years, the oyster industry will likely be doomed, but may be sustainable for the next twenty or thirty years, for many of the reasons stated in previous sections. He is hopeful that with advancing science in the fields of genetics and carbon removal that some improvements could be made. He also believes that climate change is a major issue, stating that Americans and the government need to change their mindsets and take action.

In agreement with the oyster grower above, a researcher at the University of Washington described ploidy manipulation as an important tool for hatcheries to help safeguard wild populations (Carey, Sean. Interview with author. Seattle, August 29, 2019). Triploid oysters possess three, instead of the regular two, sets of chromosomes, making them unable to spawn. Because these oysters are infertile, they do not expend energy on their reproductive system, meaning that they are able to grow larger and faster than diploids (Hollier 2014). In addition, the triploid oysters are then marketable during summer months, as they do not spawn during this period when diploid oysters become nearly inedible (Hollier 2014).

In addition to the uncertain future of the oyster industry, lack of continuous labor was mentioned as another increasing problem. Despite offering competitive wages and benefits, two oyster growers stated they could not find enough workers to employ each season, stating that people were unwilling to put in the hard work required for harvesting oysters (Hanson, Barry. Interview with author. Shelton, June 17, 2019; Hart, Walter. Interview with author. Shelton, August 21, 2019). Therefore, the development

of new harvesting methods that are less labor intensive or more efficient may become necessary in the very near future (Hart, Walter. 2019. Interview with author, August 21).

Despite the uncertainty however, there is hope, as the commercial shellfish industry is generally considered sustainable. A Department of Health official stated that he believes the oyster industry works hard to ensure they can keep harvesting.

> I don't know what that's going to do over time, I'm not an expert in that and I hesitate to guess what might happen, but overall, big picture, I think the shellfish growers in our state are very responsible. They understand the importance of water quality, they understand parts of a sustainable farm and there's a lot of them that work hard to make sure that's happening. (Nelson, Stephen. Interview with author. Tumwater, July 18, 2019).

So while there is uncertainty regarding climate change and oyster growth, there are also systems in place to maintain standards of water quality and human health that may help to ease these impacts. There are both economic and ecological incentives for oyster growers to work collaboratively with government agencies, tribes, and restoration managers for a future of sustainability.

The future of oysters in Puget Sound is uncertain, and will be impacted by several factors. Climate change and its effects, such as ocean acidification and warming temperatures are already beginning to impact oysters around the world and have been shown to cause disease and mortality in oysters. The slower growth of Olympia oysters may help them better survive the impacts of climate change, compared to Pacific oysters. While pollution is regulated in Puget Sound, the rapid expansion of population may continue to affect the water quality, and therefore the ability to harvest and eat oysters safely. Human health also plays a major factor in oyster harvesting, as bacteria and

biotoxins are major concerns for those who eat them. There are many different opinions on what the future will look like for oysters, and only time will tell.

Free Listing Exercise- Threats to Oysters

During interviews, participants were asked to list what they perceive to be the three to five biggest threats to oysters. Twenty different types of threats were listed during this exercise, and these answers were condensed into nine different categories. A total of 41 responses were given among the eleven participants. Water pollution and water quality were identified as the most major and immediate threats to oysters, mentioned 12 times in total (Figure 16). The category of pollution and water quality included the general mention of pollution, septic systems, agricultural runoff, boater waste, wastewater treatment plants, stormwater, and plastics.

Next, climate change and its effects were listed eleven times during the exercise. This threat included categories such as ocean acidification, warming water temperatures, and climate change in general. The rest of the categories were discussed significantly less. Shoreline development and habitat loss were grouped together and mentioned five times total. Herpesvirus, a threat that currently affects only Pacific oysters, was listed four times. Vibrio, a threat only to humans who consume raw oysters was listed three times. Next, smothering by mud was listed, and grouped with those who said lack of proper sediment was a threat, for a total of three. Two participants were concerned about the current political climate, such as tariffs being imposed on international markets including China, a huge buyer of shellfish products. There were also two mentions of predators, including oyster drills which can harm Olympia oysters.

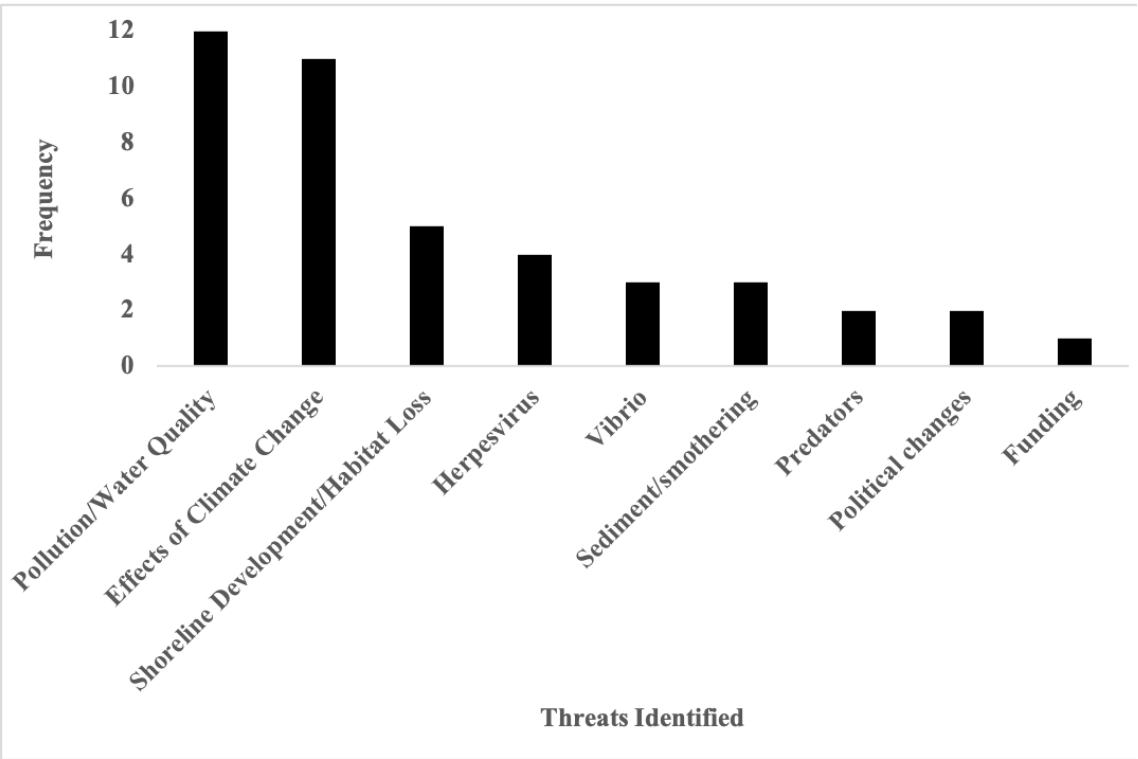

Figure 16: The number of times major threats to oysters were identified during the free-listing exercise.

Finally, having a secure source of funding was listed by a restoration manager, who was concerned for the future of these projects. Participants were asked to list the threats to oysters to better understand problems that are the most crucial for their survival. Pollution and climate change were both mentioned by nearly everyone, meaning that those with knowledge of oysters find these problems to be urgent and critical. Management practices will no doubt be influenced by these two threats in the future, in both the commercial and restoration sectors. While each threat is listed independently, many of the issues presented above are actually interrelated, and could be incorporated into the issues cluster of the conceptual map.

Hipster Oysters: Oysters in Media

Oysters, as a commodity, play an important role in the Pacific Northwest imaginary. After Salmon and berries, oysters are a quintessential element of Seattle's food scene. Restaurants like the Walrus and the Carpenter in Ballard, Taylor Shellfish and Coastal Cuisine in Capitol Hill and Elliott's oyster house in West Seattle, represent the upscale version of a city-large appetitive for oysters, which are also commercialized or offered in many lower income culinary locations in the International district or the touristic corridors of the city like Pike Place Market. There are at least eighteen oyster bars in Seattle, though there are likely many more restaurants that also serve oysters in the surrounding areas (Clement and Vinh 2017; Vermillion and Saez 2018).

In addition to these culinary considerations, the way the Olympia oysters are portrayed in the media is important in terms of analyzing which issues receive attention at a regional level and which ones do not—and therefore, to track the flow of resources. Articles on this subject are written frequently and many seem to frame the oyster the same way, as making a comeback. Olympia oysters have been the subject of many articles in the news in the past few years, each with titles suggestive of large-scale population growth. With articles named "The Tiny but Mighty Olympia Oyster Regains a Foothold in Washington Waters," and "Why the Olympia Oyster is Primed for a Comeback," the oysters are clearly being brought to the public's attention (Cox 2017; Doughton 2019). The articles highlight the restoration efforts to bring the population numbers back up around the Pacific Northwest, and the flavors the oysters bring to restaurant menus (Cox 2017; Doughton 2019). Cox discusses his experiences eating

Olympias at oyster bars in Manhattan, San Francisco, and finally Olympia, Washington (Cox 2017). There seems to be a disconnect between those who work on oyster restoration projects, and those who write about the comeback of oysters for the restaurant business. One shellfish biologist in charge of Olympia oysters in the state stated during his interview that he is working to save the Olympia oyster for environmental purposes, not for the commercial industry (Webb, Brian. Interview with author. Port Townsend, August 15, 2019).

One author, however, does acknowledge that the restoration efforts may not be for the purposes of eating Olympia oysters, stating "Ecological and gastronomic goals could eventually intersect, giving more people a chance to experience a forgotten part of our culinary heritage" (Doughton 2019, para. 13). In this case, Doughton recognizes that the restoration efforts are for ecological purposes, not for human consumption. In this way, the narrative told in this article seems to be more accurate, in relation to the interviews conducted.

An article written in 2003 also frames Olympia oysters in a more realistic light, compared to the results of the interviews. While the article is titled "The Olympia Oyster, a Tasty and Nearly Extinct Little Morsel," the content tells a slightly different story. The article begins by explaining restoration, projects in Puget Sound, then discusses the oyster industry. Blake discusses that oysters were gaining popularity, though Olympias made up only a small portion of the market because of the difficulty of growing them, and the small amount of meat on them (Blake 2003). The benefits of bringing back the oyster, according to the article, lie in revitalizing tribal cultures and cleaner water in Puget

Sound, rather than the availability of oysters in restaurants as the authors of other articles argue (Blake 2003).

CHAPTER V

DISCUSSION

The purpose of this study was to explore the historical and contemporary management practices of Olympia and Pacific oysters in Puget Sound. Throughout the research process, a variety of stakeholders were interviewed regarding their roles and perspectives about the oysters. Each of the research questions (restated below) were answered in semi-structured interviews. The first question aimed to address the historical context of oyster production and consumption in Puget Sound. The second question asked how the oysters in Puget Sound are grown and managed by different stakeholders. Third, the ways that social, economic, legal, political, and ecological factors affect current patterns of management, production, and consumption of oysters in Puget Sound. Finally, the different perceptions of the future for these stakeholders, in relation to oysters was determined. This research has revealed that oyster management in Puget Sound follows the Common Pool Resource Management model described by Ostrom et al., where social norms and regulations converge to create a sustainable commercial harvest and oyster restoration projects.

According to Breitburg et al. (2000), commercial production of oysters and restoration efforts are generally considered to be in conflict with each other. They argue that these goals actually align with each other and can be used to create better outcomes for both interests (Breitburg et al. 2000). The data collected for this thesis confirms the ideas stated in the paper, that restoration efforts to restore oyster reefs can eventually help the commercial industry increase their yield. For example, both restoration efforts and commercial productions require adequate substrate in proper habitat for oysters to grow

and reproduce (Breitburg et al. 2000). As shown throughout the interviews, partnerships in Washington State already exist to address these common goals, and are required for success for both parties.

One of the main takeaways from the interviews was the importance of partnerships and cooperation between stakeholders. Overall, everyone interviewed agreed that the many partnerships required for the oyster industry and oyster restoration have been cooperative. No major conflicts were reported between any of the groups interviewed. The only issues that were discussed were on the individual level, mainly regarding failure to comply with regulations. The goals of the commercial industry and restoration projects were not found to be in conflict with one another, and instead, actually complemented each other. Many of the concerns for oyster growers, such as clean water and disease prevention, were shared by restoration managers, and government agencies alike. These partnerships are vital for the protection of oysters and their habitats in the future, and are a unique tool that can be used to help properly manage the resources in Puget Sound.

In addition, the listing exercise revealed the major threats to oysters, including Olympias and Pacifics, as perceived by the individuals interviewed. After categorizing the many different answers, into broader themes, the two that were discussed in nearly every interview included water quality and pollution, and climate change and its effects. Because these results were gathered from experts in a variety of positions regarding oyster management, one can conclude that these threats affect oyster harvesting, oyster restoration projects, as well as human health. The need to maintain good water quality

along shorelines is vital for the harvest of oysters for the market, as well as the health of the ecosystems. In addition, the unknown effects of climate change produce uncertainty for those working to restore oyster beds, as well as for the future of the oyster industry. Therefore, these effects, including ocean acidification and warming temperatures should be mitigated as much as possible. In reality, there is no clear solution to this growing worldwide problem at this time.

There are three main clusters identified throughout the research. Each of the clusters identified are complex, with several different factors that influence each other. In addition, the three clusters do not exist in isolation. Each of the clusters overlaps one another and could be organized in many different ways. The clusters were chosen in an attempt to organize and simplify the complicated and sometimes contradicting responses from interviews. The first theme is the history of oysters in Puget Sound underlying the self, harvest, and territoriality. History, selfhood, harvest, and territoriality result in the market. The next cluster relates laws and institutions to funding and volunteers and restoration and monitoring. In this case, the underlying connection is partnerships. Finally, the ecology of oysters is directly affected by pollution, which in turn affects the health of both oysters and humans. These factors are also affected by climate change, leaving an uncertain outlook for the future. Importantly, I found I was able to articulate all the concepts and considerations through Hardin and Ostrom's theoretical debate on the commons—and their practical implications for their management and sustainability.

Oysters are generally considered to be a common pool resource. Hardin's Tragedy of the Commons (1968), however, oversimplifies the issues surrounding these resources,

as it does not account for the historical and social contexts. Ostrom et al. (2002) argue that norms and institutions actually manage the local regulation of common pool resources better than government or private property regimes, which disrupt the indigenous institutions that were formerly in place. In addition, governments rarely expend the resources necessary to monitor to ensure that they are not being overexploited. In the case of Puget Sound, this argument seems to be true. Currently, oysters are managed collaboratively between many different stakeholders, though during the period that tidelands became privately and government owned, populations of Olympia oysters declined drastically.

For those in the commercial sector, much of their business continues to be influenced by the history of the region, their own sense of self, and territoriality. When Olympia oyster populations declined drastically from overharvesting and pollution, Pacific oysters were introduced to the market in Puget Sound. Only recently have Olympia oysters been managed in ways that help to grow their populations, such as the many restoration projects being undertaken. While privatization of lands helped to slow the overharvest of Olympia oysters, part of their resurgence can be attributed to the market demand for the native species, and the role they play in the legacies of the companies. Shellfish producers have joined restoration efforts as well, as they are able to play a role by donating discarded oyster shell to be used as substrate.

Just as the commercial industry can be helpful in oyster restoration projects, so can other institutions. Local organizations and volunteers are often responsible for conducting restoration and monitoring projects. These efforts are necessary as funding

can be limited and difficult to obtain, unless there is public interest and involvement. Partnerships are created as a result of all of these efforts because they require the work of many different state and local agencies, and help from the commercial industry as well. Each of these institutions has similar worries about issues, such as water quality, meaning that they are in agreement on many of the same issues, even though one might guess their goals are at odds.

Many of the issues that affect oysters, including pollution, disease, and climate change are worries for all stakeholders involved. Because the issues affect each of these groups, they are able to work together to try to solve some of the problems, such as water quality in Puget Sound. Due to their partnerships, they are handling the commons problem in a way similar to that described in Ostrom et al. 2002.

Management Recommendations

After conducting and analyzing interviews with 11 different stakeholders, a few management recommendations emerged. First, among those involved with Olympia oyster restoration projects, several stated that there is no single metric to be able to assess the success of restoration projects in Washington. There is not one single organization that oversees all projects in Puget Sound. Instead, there are several smaller groups, including government and nonprofit organizations. According to one restoration project leader, some Marine Resource Committees are overseen by the Northwest Straits Commission, while others work under the Puget Sound Restoration Fund:

> I think the challenges of restoration have to do with trying to be consistent. I was talking with someone this morning, like what do we measure? What does Skagit

> measure? What does Clallam measure? Because we're all these mostly independent entities, we're all taking this slightly different approach. The same with the Restoration Fund. Each person is looking at a different aspect but in order to see what progress we're making, it would be nice to have some sort of consistent metrics that we're all using, and there isn't really a good coordinating structure to allow that to happen. We're trying to do it a little bit within the Northwest Straits but we're completely separate from what other entities might be doing for restoration. (Foster, Cindy. Interview with author. Port Hadlock, July 28, 2019).

Despite the many partnerships that are involved in restoration projects, there is no unifying entity for all of Puget Sound that helps bring these many smaller projects together. A shellfish biologist for a tribe had nearly identical statements to be made about the lack of metrics in Washington, adding that data cannot be easily compared between projects if the same data points are not being collected:

> Washington State, we haven't even decided what metrics we should all be looking at to determine, I mean this is my understanding, I think lots of people have ideas of what the best metrics are to look at to determine if restoration is successful but what we don't have is a common consensus. So what a lot of people who are carrying out restoration efforts may not be aligning the metrics in which they're measuring. That's a bit problematic from a scientific point of view. I think to really be able to understand what is success in terms of restoration, we need to have common metrics that we're all collecting data on and comparing it Puget Sound wide. So I think there's still some work to be done to really hone in on exactly what it means for a restoration project to be successful, and to have some common goals there. (Knight, Lauren. Interview with author. Blyn, August 15, 2019).

Here, the scientific process is also brought up as a reason to use similar metrics. There is a need to accurately replicate data for restoration projects so that similar methods can be used when there are high success rates.

Coen and Luckenbach (2000) suggested this same need for oyster restoration criteria in South Carolina and Virginia. They recommended monitoring sites for the long term to see how oyster populations grow and develop into reefs (Coen and Luckenbach

2000). While their work was published twenty years ago, their recommendations have yet to be followed, at least in Washington State. In western Europe, the beginning stages of oyster restoration projects are being conducted. Stakeholders there have formed the Native Oyster Restoration Alliance, and have created the Berlin Oyster Recommendation, a document outlining the restoration process and common goals uniting different members (Pogoda et al. 2019). A similar group could be formed in Washington State to create a joint effort among many different partners.

Interestingly, there is a document outlining universal restoration metrics for Olympia oysters. In 2007, an analysis of 1,035 oyster restoration sites in the Chesapeake Bay found that nearly half of the sites did not have clear goals, nor a long-term monitoring project in place (Baggett et al. 2014). As a result, a committee of restoration scientists formed to create the Oyster Habitat Restoration: Monitoring and Assessment Handbook. The handbook created a clear set of metrics that can be applied universally to oyster restoration projects, as well as optional metrics that can also be used as needed. One of the goals for the project was to create recommendations specifically for the Olympia oyster, to allow for comparisons of projects on different scales (Baggett et al. 2014). The recommendations included measuring: "(1) reef areal dimension; (2) reef height; (3) oyster density; and, (4) oyster size-frequency distributions" for every restoration project (Baggett et al. 2014). In addition, they recommended that water temperature, salinity, and dissolved oxygen also be monitored (Baggett et al. 2014). While these recommendations have been written and published by these researchers, there is currently no single unifying body in place to implement these standards in all restoration projects in Washington State, as discussed above. (Foster, Cindy. Interview

with author. Port Hadlock, July 28, 2019; Knight, Lauren. Interview with author. Blyn, August 15, 2019).

One of the Marine Resource Committee members stated that the Jefferson County MRC was currently in the experimental phase of restoration. A Department of Fish and Wildlife biologist, however, said that his agency had moved beyond that phase as they had already gained the specific set of knowledge and methods required for Olympia oyster restoration. Because there is no set of common metrics, or common knowledge between restoration projects for best methods, a better system of communication needs to be created so that all restoration projects can share the information they have. Whether communication be established through one large unifying organization or written guides, multiple interviews made clear that there are many different organizations and agencies working toward the same goal with different ideas of how to get there. The web of partnerships is already in place between many groups in Puget Sound, but the final step for all groups to have the same information regarding Olympia oyster restoration has not yet been taken.

In addition to the creation of a common set of metrics and open lines of communication, another possible management strategy is to create equitable management plans for the many different stakeholders involved in the oyster industry. Political pluralism, the concept that power is distributed between various political and non-governmental groups, has been previously shown to work in Skagit County, regarding land use on the Swinomish reservation (Zafaretos 2004). In addition, the current projects organized by the Puget Sound Restoration Fund and the Northwest Straits Commission

are following this model by including tribes, local government, commercial shellfish farms, and other organizations. Because of the success of these projects in the Puget Sound region, similar methods could be applied to other environmental situations around the country. Alternatively, these same methods could be applied to other oyster restoration and management projects around the world, and similar results could be expected.

Research Considerations: Future Directions

As mentioned previously, there were multiple factors limiting the number of interviews that could be conducted, including time and funding. In addition, many smaller companies do not harvest oysters during the summer months due to warmer temperatures that can result in diseases in humans, such as vibrio (Knight, Lauren. Interview with author. Blyn, August 15, 2019). Despite the difficulties, 11 interviews were conducted, a full day was spent on an oyster farm, and websites and interviews were analyzed using a coding system outlined in Bernard (2006). The data collected thus far presents a starting point for future research to be conducted, including grounds for a doctoral dissertation. Many more interviews should be conducted to ensure multiple viewpoints, and ethnographic fieldwork should be conducted to gain a deeper understanding of the people who care about oysters.

Next, those interviewed represented some, but not all, of the possible stakeholders. There are several stakeholders involved in the oyster industry that were not interviewed, for a variety of reasons. First, no tribal members were interviewed. Two shellfish biologists for tribes were interviewed, though their views cannot represent the

perspectives of those with cultural ties to a traditional food source. There are also a large number of tribes in the Puget Sound region, so there are likely many different views on the subject of oysters. Next, no distributors or restaurants were contacted. While these may be important perspectives regarding the market for oysters and for creating a political ecology, they were determined to be outside the realm of resource management by the researcher. Finally, no recreational harvesters were interviewed. Public beach access is more limited for oyster harvesting during the summer due to threats of disease with warmer weather (Washington Department of Fish and Wildlife 2020). Also, while some beaches may be open according to the Department of Health, they may be closed seasonally by the Department of Fish and Wildlife to keep populations from being devastated (Washington Department of Fish and Wildlife 2020; Washington State Department of Health 2020). In addition, tides must be at appropriate heights to be able to harvest shellfish. For this reason, the time frame for identifying and interviewing recreational harvesters was very limited and was not able to be accomplished during this research.

The research conducted in this master's thesis sets the stage for many future research projects. This research aimed to create a baseline for the current industry, including identifying relevant actors and their roles within oyster management. However, due to time and funding constraints, more in-depth research was not feasible for this project. Future research questions could focus and expand on a variety of topics identified by this initial set of interviews. These topics may be centered around volunteers, the market, recreational harvest, tribal use of oysters, and any of the conflicts that may be involved with these different sectors.

One possible research question involves the identities and motivations of the volunteers for oyster restoration projects. Understanding who volunteers for these projects could potentially help expand recruitment efforts, or affect the way organizations advertise their volunteer positions. Because volunteers are critical to the monitoring aspect of many projects, this research could potentially benefit the non-profit agencies working to restore oyster habitat. A different research project could examine sources of funding for restoration projects. The research could discuss the organizations who receive and disburse funding, the ways the funding is used, and if the market contributes to those projects. Another researcher could ask if the markets and restoration efforts are working toward the same goal, or if there are tensions between them. In this research, interviewees representing restoration interests explained that their intentions were to restore oysters for ecological reasons; those from shellfish companies stated that Olympia oysters were mainly grown for legacy purposes, to carry on a tradition of their family business. Therefore, there could be conflicts in these motivations, even though both groups are working to restore Olympia oyster populations.

In addition, a much more thorough analysis on the media portrayal of Olympia oysters could be produced using a coding process similar to that used to analyze interviews in this research. There are hundreds of articles about the native oyster published in webpages, newspapers, and magazines from the past twenty years or so. Comparing the stories that are told through these outlets to the stories told by growers and restoration managers would be interesting. The identified threats and challengers may or may not be similar, and the stated reasoning for restoration projects may also produce

similarities and differences. The media narrative told regarding the most pressing issues for the industry may also be different than the ones told by shellfish producers.

The information presented in this thesis provides a brief summary of the complexities of Olympia and Pacific oyster management in Puget Sound. An in-depth analysis of all of the intricacies was not feasible for a single master's thesis. This research instead serves as a starting point for future projects. The research presented here represents a view of only ten weeks into a small part of the commercial oyster industry and the many restoration projects that are being conducted in multiple counties. In all likelihood, responses for each question will change based on the challenges of a given year. This thesis gives a very broad overview of some of the different management practices and many restoration projects being conducted around Washington State for both Pacific and Olympia oysters. Given enough time and funding, multiple ethnographies could be produced for each of the questions raised above, providing more in-depth cultural knowledge of these topics.

Often overlooked or undervalued, I hope these pages make evident the immense complexity, richness, and challenges of focusing our attention in these quiet bivalve's social and ecological networks—where they play a fundamental role as actors of the Pacific Northwest. Much work remains to be done. I hope the present work inspires future generations of scholars to continue this conversation. Lewis Carroll's The Walrus and the Carpenter would certainly agree.

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APPENDIXES

Appendix A: Sample Interview Questions for Shellfish Growers

Initial Questions	**Follow-up Questions**
What is your role in the oyster industry?	How long have you been in this position? What does this position entail?
What types of oysters do you grow?	Why do you grow these species? Which species is the most profitable? Why do you think that is? Which species is the most popular? Why do you think that is? Is there an advantage to one species over the others?
Are the same growing methods used for each species?	How do they differ? Have these methods changed over time?
Is your company involved in any restoration projects?	In what capacity? Who do you work with?
Which laws must your business follow?	Do these laws help or hurt your business?
How has the oyster industry changed since you've been involved in it?	What do you think caused these changes?
What direction do you see the industry going in the future?	What do you think will cause these changes?
List 3-5 major threats to oysters.	Dependent on response.

Appendix B: Sample Interview Questions for Government Agencies

Initial Questions	**Follow-up Questions**
What is your role regarding oyster management?	How long have you been in this position? What does this position entail?
What types of projects are currently being done?	Where are these being conducted? What is being done?
Do you work with other groups?	Which organizations/ institutions/ tribes/ companies are involved? Is there any conflict between groups?
What successes have the projects had?	Dependent on response.
What problems have the projects had?	Dependent on response.
Which laws must your restoration projects follow?	Do these laws affect your ability to conduct these projects?
How have restoration projects changed since you've been involved with them?	What do you think caused these changes?
What direction do you see these projects going in the future?	What do you think will cause these changes?
Do you think more needs to be done to protect oysters?	Why or why not?
List 3-5 major threats to oysters.	Dependent on response.

Appendix C: Sample Interview Questions for Restoration Project Managers and Tribal Shellfish Biologists

Initial Questions	**Follow-up Questions**
What is your role regarding oyster restoration?	How long have you been in this position? What does this position entail?
What types of projects are currently being done?	Where are these being conducted? What is being done?
Do you work with other groups?	Which organizations/ institutions/ tribes/ companies are involved? Is there any conflict between groups?
What successes have the projects had?	Dependent on response.
What problems have the projects had?	Dependent on response.
Which laws must your restoration projects follow?	Do these laws affect your ability to conduct these projects?
How has the oyster industry changed since you've been involved in it?	What do you think caused these changes?
What direction do you see these projects going in the future?	What do you think will cause these changes?
Do you think more needs to be done to protect oysters?	Why or why not?
List 3-5 major threats to oysters.	Dependent on response.