Public Perceptions and Pesticides – A Case Study of the Willapa Bay Oyster Bed Spraying Permit of 2015

Ian L. Baker

A thesis

submitted in partial fulfillment of the

requirements for the degree of

Master of Marine Affairs

University of Washington

2016

Committee:

Edward H. Allison, Chair

Marc L. Miller

Program Authorized to Offer Degree:

School of Marine and Environmental Affairs

University of Washington

Abstract

Aquaculture has been identified as a way to meet increasing global seafood demands while wild-catch fishery production has been stagnant in recent years. In the United States, it may also be seen as a tool to balance the country's $11billion seafood trade deficit and continue to supply low-cost nutritious food choices. However, consumer concern for farmed seafood and environmental impacts has challenged traditional aquaculture practices and public support of its efforts. To better understand these concerns, this study analyzes the events and media surrounding one particular event that put the aquaculture industry in the spotlight. This incident was the 2015 application by local oyster growers to spray a new pesticide, the neurotoxin imidacloprid, on oyster beds in Willapa Bay, WA to control the populations of burrowing shrimp (Neotrypaea californiensis and Upogebia pugettensis) threatening the viability of their oyster farms. Elite interviews were used along with public comment and media coverage to identify the concerns of those supportive of and opposed to the issuance of the permit. Claims regarding the uncertainty of findings and historical disturbances of the bay were then analyzed with evidence from scientific literature as a way to support or refute their validity. Those opposing the permit were particularly concerned for non-target impacts, especially to salmon, which may not have been properly tested. Oyster growers and other supporters of the permit stress the need to control shrimp populations and cite human interference as a cause for the expanding shrimp populations. Six years of testing have been previously conducted on the efficacy and impacts of imidacloprid as a pesticide and studies

continue today. These studies illustrated that there was no confirmed risk of wider environmental damage, but that areas of uncertainty remained. Interviews conducted for this study demonstrate that concerns over these uncertainties still remain and shape the public opinion. This study finds that there is a distinct difference between the risk perceptions of the general public and those of the industry and administrative bodies. Objections to this spraying permit closely reflect global objections to aquaculture practices and demonstrate a disconnect between what is required by permit and what is deemed acceptable by some sub-sections the public in terms of environmental uncertainty and risk.

Public Perceptions and Pesticides: A Case Study of the Willapa Bay Oyster Bed Spraying Permit of 2015

Ian L. Baker

Chair of the Supervisory Committee:
Professor Edward H. Allison
School of Marine and Environmental Affairs

Table of Contents

Introduction

Americans have been told in recent years that their diets are not healthy enough. We eat too much high-fat protein while neglecting important micronutrients. “Eat more seafood,” say nutritionists and food media, it’s full of what you need with relatively low fat content. At the same time we face evidence that there is such a thing as eating more fish than is good for you. Studies and news articles are published regularly about the dangers of high mercury content in some fish. The USA already faces a yearly $11billion trade deficit in seafood (NOAA Fisheries n.d.), importing much more than we export and not meeting demands domestically. Our fisheries are producing at maximum sustainable yield, meaning it is not likely that we can produce more from our wild stocks. Aquaculture, or fish farming, has been a rapidly growing way to produce more seafood, but its growth has been relatively stagnant in the USA. I contend this is due in a large part to consumer perceptions of aquaculture negatively impacting demand. Prior studies by Mazur and Curtis (2006), Verbeke (2007), and others have demonstrated clearly that serious concerns about farmed seafood exist both in informed and uninformed consumers which may lead them to avoid these products.

This thesis explores some of the issues facing the continued production and growth of farmed seafood in the United States. Consumer perceptions of these products and the practices themselves appear to be generally negative, while also being minimally informed.

To examine these issues I studied media coverage, production statistics, and perception surveys and conducted interviews with key actors about the Pacific West Coast’s oyster aquaculture sector. The scope of this thesis covers a recent controversy in Willapa Bay,

Washington in which a pesticide, the neonicotinoid imidacloprid, was proposed as a control method against two species of burrowing shrimp *(Neotrypaea californiensis* and *Upogebia pugettensis)*. These native shrimp threatened the production of oysters in the bay by liquefying sea beds, causing oysters to sink and suffocate. Oyster growers in the area claimed their businesses would collapse if the shrimp infestation could not be controlled. Opposition to the use of this pesticide was concerned with environmental impacts to the bay and used media and consumer pressure to force the spraying permit's cancelation. Such heavy expectations for environmental protection and the quality of products have created a difficult market for aquaculture to grow in the United States. However, other less-regulated regions have seen significant growth in aquaculture production in recent years.

The health benefits of eating seafood are now becoming a set of well-documented and public facts. Major media outlets in recent years have been publishing articles centered on advice for how to increase seafood consumption and why it is important. Women's Health (Ansel 2011) published a piece titled *Eat More Seafood* which emphasized seafood, both fish and shellfish, as being a good source of micronutrients like omega-3, vitamins B and D, and providing protein with very low fat content. It specifically mentions farmed fish, calling it less flavorful than wild fish, but also raised in a pollutant-free environment. The Environmental Defense Fund (EDF 2016) has created a public information webpage echoing the idea that seafood has a high nutritional value while elaborating on what these benefits could mean for an individual including more seafood into their diet. The main benefit being a reduced risk of heart disease. The New York Times piece, *Lots of Reasons to Eat Fish*, (Brody 2014) brings up the

same nutritional benefits while trying to address everyday concerns about buying seafood such as what to buy and how to prepare it.

These media articles are supported by nutritional studies conducted in the past 15 years. An earlier study by the United States Department of Agriculture (USDA 2000) showed that the general public understands they have a poor diet, but only 23% of them have any interest in improving it. Studies like this may have started the dietary research and reporting that has led to the modern promotion of increased seafood intake. Since then, the USDA has published multiple *Dietary Guidelines for Americans*. The 2010 publication (USDA 2010) advises Americans to eat about 8 ounces of seafood per week, up from the (then) average rate of about 3.5 ounces per week. Since then, the 2015 (USDA 2015) publication has been released. It seems that adult intake of seafood has increased to roughly 4 ounces per week, but the USDA still advises increasing seafood consumption. Works by Ruxton et al. (2004) and McManus (2011) of the Centre of Excellence Science Seafood Health, along with others, help to support the nutritional claims made by organizations promoting an increased intake of seafood.

At the same time, people are being warned to not eat too much seafood (Harvard n.d.). Fish in the wild tend to accumulate contaminants that can be harmful to humans if ingested too often. Storelli (2008) examined the concentrations of heavy metals such as mercury, cadmium, and lead in wild seafood from the Mediterranean Sea. Levels of each contaminant varied by species and habitat which suggested bioaccumulation and the ingestion of environmental contaminants. Concern for human health was mentioned in closing, but was not the main focus of this paper. Another study by Han et al. (1998) made similar findings for seafood consumed in

Taiwan with the addition of finding trace portions of inorganic arsenic, which causes cancer in humans.

Wild supplies of fish appear unable to keep up with increasing global demands. The UN estimated the world population to be 6.1 billion in year 2000, but is expected to grow to 8.9 billion by 2050 (UN 2004). From the 1960s to 2012, global per capita seafood consumption has risen from 9.9 kg to 19.2 kg per year (FAO 2014). Global fisheries have been stagnant since the 1990s, producing roughly 90 million tonnes of seafood per year (FAO 2014). In order to meet the growing demand, aquaculture production has become a rapidly growing, but controversial, business.

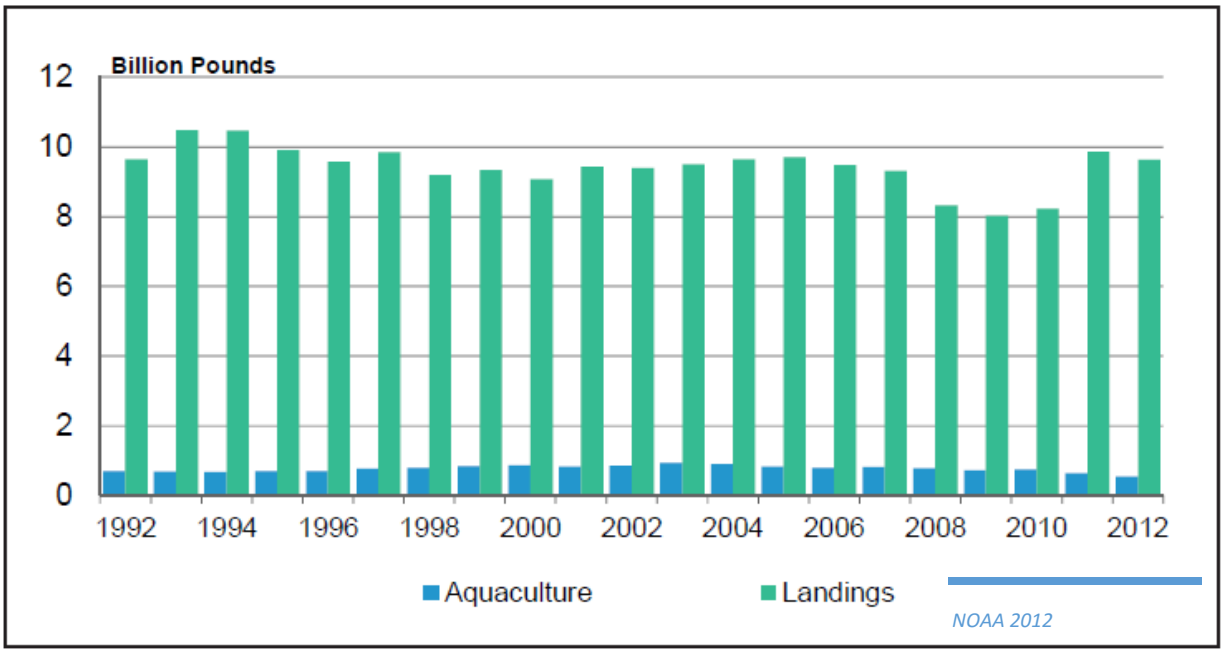
In 2012 aquaculture production made up 42 percent of global seafood production (FAO 2014), bringing in over 65 million tonnes of fish and shellfish. This production is up by 75 percent since just 2007. However, the vast majority of this growth has come from Asia, particularly China, and similar trends of growth are not as drastic in other parts of the world. While Asia produces 88.39 percent of global aquaculture products the Americas only produce 4.78% (FAO 2014), mostly provided by Latin American countries like Chile.

Slow aquaculture growth outside of China may be due, in part, to national customer perceptions of the industry and its products. Studies gauging these perceptions have found them to typically be negative. These perceptions come from pretty much all over the world and point towards a range of public objections to aquaculture practices. Studies have found negative public opinions to be influenced by environmental concerns (Mazur 2005; Mazur & Curtis 2006; DG Mare 2008; Robertson 2014; Feucht 2014), human health (DG Mare 2008;

Verbeke 2007; Feucht 2014) and nutritional concerns with the products (DG Mare 2008; Verbeke 2007), and distrust of science (Mazur 2005; Mazur and Curtis 2006). More common concerns found in studies demonstrate people's unfamiliarity with fish as a food. Shoppers at grocery stores just do not know how to prepare it or which fish they should be buying (New York Times 2014). Another common concern is the relative expensiveness of fish (Hicks 2008) compared to other protein sources. To some, fish is just not convenient to prepare (Olsen 2007).

The United States has been involved in aquaculture since the late 19th century. The earliest aquaculture operation in the US was a salmon hatchery in Alaska, established in 1872 (Arnason 2000). Ocean ranching, or hatchery farming, has become a widely practiced method for stock enrichment, but due to the difficulties involved in ownership rights of the fish once they are released at sea there has been very little privatization. Increasing demand for seafood while wild production remains stagnant (NOAA 2012) means the US has increasingly been forced to import larger volumes of fish from abroad. In 2011, the US's trade deficit for seafood reached over $11 billion (NOAA 2012). In the light of trade deficits and evidence of human rights violations in seafood and aquaculture production abroad (the Guardian 2014; EJF 2013; Barnhizer 2001), now is the time for the US to start making progress towards its own more sustainable aquaculture operations. Estimates of US aquaculture production show that the industry's growth is stagnant, averaging around 340,000 tonnes per year between 2006 and 2011 (NOAA 2012).

Volume of Domestic Commercial Landings and Aquaculture Production



Management strategies are already being formed and first steps have been taken towards expansion of US aquaculture. The Gulf of Mexico Fisheries Management Council has already released its final rule for the regulation of offshore aquaculture in the Gulf of Mexico (NOAA 2016). In the interest of sustainable growth, the final rule includes language regulating total allowable production volumes similar to wild fisheries Total Allowable Catch limits. It also discusses requirements for tagging and limits allowable species to those native to the Gulf of Mexico, reducing the potential dangers of escapement while improving data collection and monitoring. While the regulatory foundation for aquaculture growth is being implemented now, public acceptance of aquaculture products has not improved and may be a serious barrier to further expansion. In fact, older studies of public perception show higher acceptance of farmed seafood than more recent ones (Gempesaw 1995; Wright 2015).

Last year in Washington State, the negative perceptions of aquaculture came to a very public stage in a case involving shellfish growing in Willapa Bay. In this research, the case of Willapa Bay's shellfish growing industry is analyzed to determine what the public concerns are for aquaculture and how these concerns are formed. Through semi-structured, elite interviews with scholars, shellfish growers, and their objectors, perceptions and beliefs about the case are drawn out and examined using previous literature and media reports to help support the claims made. This study is conducted with the hope that illuminating these issues can help aquaculture grow into a more productive, sustainable, and publicly supported practice to meet our seafood demands.

Methods

This research was conducted qualitatively. Qualitative methods are more suited to meeting the goal of this thesis, which is to provide a clear description of the events and perceptions surrounding the controversial pesticide spraying on Willapa Bay oyster beds. "Qualitative research refers to the meanings, concepts, definitions, characteristics, metaphors, symbols, and descriptions of things." –Bruce Berg (1989, pg 3). In order to illuminate motives and public perceptions, contacts were selectively sampled to first ensure that no views or perceptions of any particular opinion were neglected.

Initial data collection began with media reports based on key phases, locations, and actors found in previous articles. The Seattle Times (Westneat 2015) and The Oregonian (AP 2015a, 2015b) produced a series of articles on this topic from which initial search terms were gathered. Following these key terms led to the original article published in Bloomberg Business (Donahue 2015) which seems to be the catalyst for the subsequent explosion of coverage on the topic, locally. Organizations mentioned in articles were further used as search terms to clarify positions and motives. Selective sampling of contacts was conducted so as to allow for representative views from both sides of the debate, those opposed to and in favor of the pesticide spraying permit. Several contacts with known views on the issue were first selected for each side, opposing or advocating for pesticide use, followed by experts whose views were unknown before conducting the interview. Throughout the media search, other actors' names were collected and used to form the basis for a contact list.

Contact with potential interviewees was made first through email, then any other way possible. Alternative methods included telephone calls, web address comment submission, and social media outreach to individuals or organizations that could have contact with them. Contacts that did not respond within several days had additional reminder emails sent to them. Reminders continued until contact was made or, in some cases, the deadline for data collection was reached.

All interviewees were given authority to choose times and places to meet. In-person interviews were prioritized, but not always possible. Often for the sake of convenience or inability to travel, contacts chose to participate through long-distance interviews. Long-distance methods included telephone and video conferencing interviews. Contacts local to the Seattle area were generally interviewed in-person while those farther away or with heavy work schedules opted for a long-distance interview. Six interviews were conducted in total, half of which were held in-person. A total of sixteen potential contacts were approached, but two declined while the others were unresponsive.

The interviews were conducted in a semi-structured, elite method so as to allow for a flexibility in questioning while allowing interviewees to operate as a teacher on their expert topic. Dexter (2006, pg 18) defines an 'elite' as "any interviewee…given special, non-standard treatment." He specifically elaborates to say that these 'elites' are given range to define structure the account of the situation as they see fit. This is precisely what I have done in my interviews when I ask interviewees *why* the situation turned out the way it did and what the real issue is. Statistical analysis was never intended to be part of the methods, so semi-structured interviews were ideal to pursue newly-arising lines of questions in order to understand the

complete view of each contact while following potential leads. Initial lists of interview questions were written up for each individual contact. These initial questions were based on their involvement in media reports, expertise as it related to pesticides or shellfish growing, and their own interpretations of the events around the topic. Unique topics that arose in response to these initial questions were pursued to the extent of the interviewee's confidence. Names of other actors were also recorded during interviews to use as further search terms or additional contacts through a modified snowball sampling method (Biernacki and Waldorf 1981).

Transcripts of interviews were written up and used for analysis content. Interviews were recorded on two devices to assure no loss of data while the researcher conducted the interviews. In transcribing, dialogue was edited to remove meaningless repetition and grammatical omissions which, in life, are often edits made subconsciously by a listener (Malcolm 1990). Each interviewee provided personal insights and reasons to back up their position in regards to pesticide spraying in the bay. These insights were compiled and used as the basis for scientific literature review. In addition to illustrating the different viewpoints about this contentious issue, this paper will seek to evaluate the evidence provided that has formed the basis of interviewees' stances on the issue.

Oyster Farming in Willapa Bay and its Challenges

Willapa Bay is a relatively large estuary in southwest Washington's Pacific County, just north of the Washington-Oregon border and the mouth of the Columbia River. It has 3 deep channels, however most of the bay is a mud flat at low tide (Banas 2004). It is the first bay north of the Columbia River estuary and the setting for major public debate in recent years over the application of pesticides to control a native pest for the shellfish growers. "We've got 5, 6, 7 generations of farmers here who have been farming since 1849, farming oysters," says a researcher working with the growers.

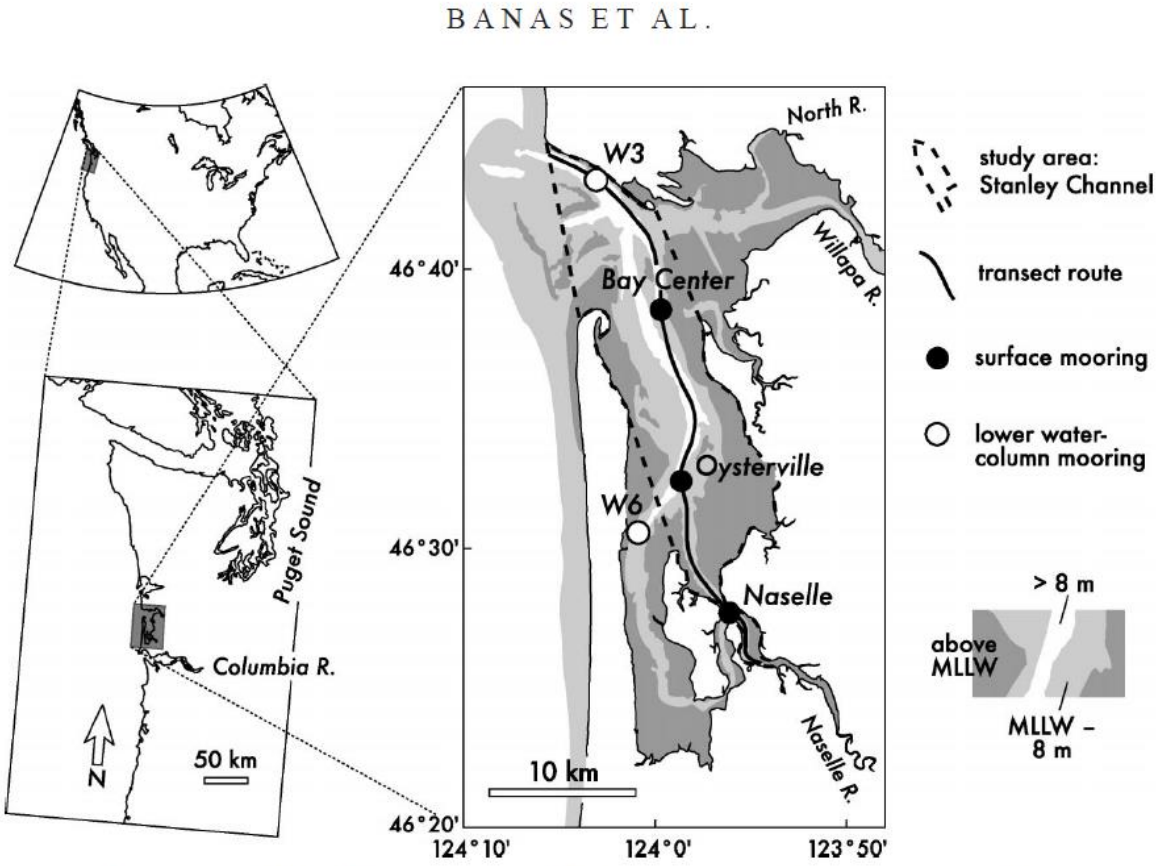
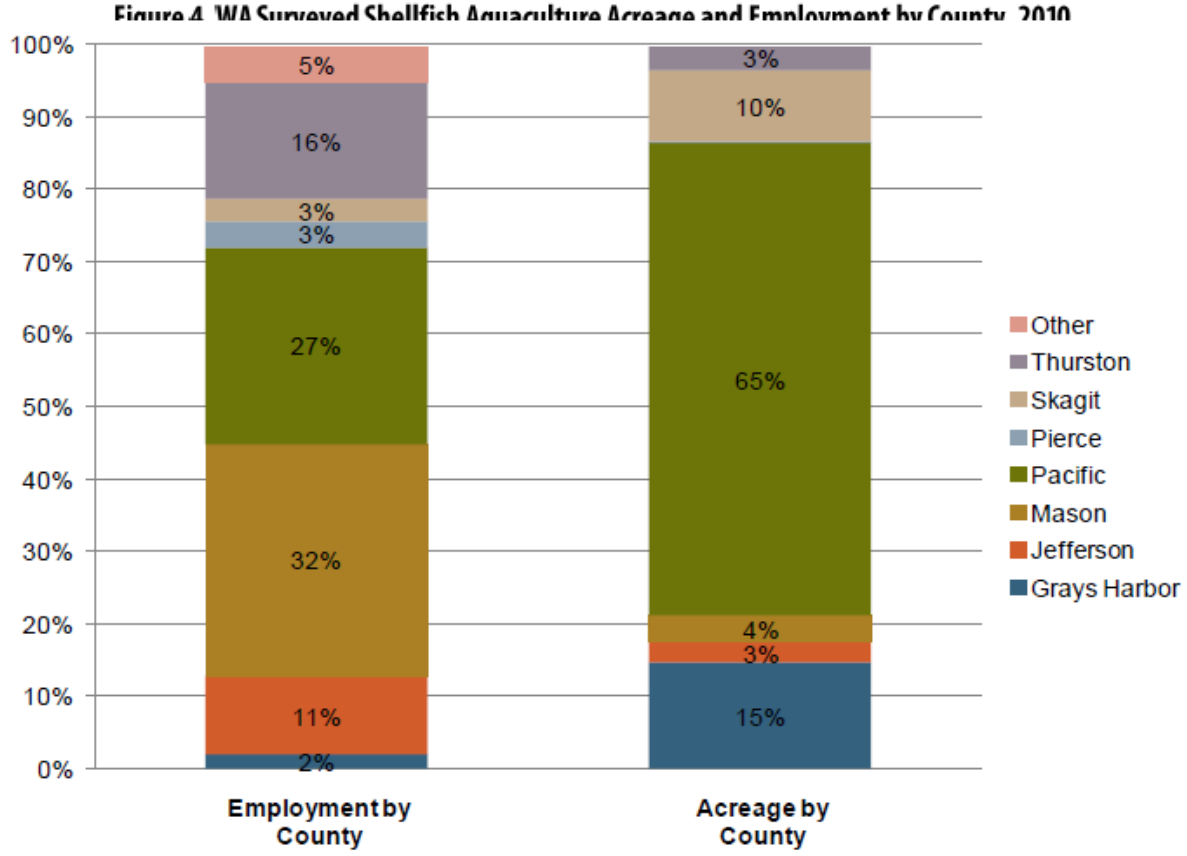


FIG. 1. Maps of Willapa Bay, the Pacific Northwest coast, and North America. Mooring locations and the axial transect route are indicated.

One in four oysters consumed in the United States is grown in Willapa Bay, claim Willapa's oyster growers (Wing 2016). Washington State produced over 8 million pounds of oysters in 2010 (Northern Economics 2013) and the industry contributed over $70million in revenue for harvesters and processors (WDFW 2008). Compared to the national oyster production of the same year at over 36 million pounds (NOAA 2012), worth an estimated $111million, it would seem the growers' claims are not far off. Pacific County has over 17,000 acres of commercial shellfish farming land and makes up over 58% of the total shellfish farming acreage in Washington (Northern Economics 2013). Pacific County's aquaculture employs an estimated 27% of those working in aquaculture in Washington State (Northern Economics 2013) with 30 farmers employing roughly 500 people total (Stratton 2016).



The oysters grown in Willapa Bay are a non-native species, the Pacific oyster. They were imported from Japan after the native species, the Olympia oyster, was harvested to near extinction (Donahue 2015). This has been a point of contention for the public, the idea that chemicals are being used to control native shrimp for the production of non-native oysters. Oyster growing can take several forms, such as hanging bags and trellis lines, however Willapa Bay is far too shallow in most of its range to allow these techniques. For this reason, oyster farming in the bay is conducted in a bed culture style, meaning oysters are grown on the floor of the bay in the mud. Of further hindrance to off-bottom techniques is the fact that burrowing shrimp make it nearly impossible for any kind of support pole to remain upright in the liquefied mud (Hiss 1986). This prevents even the minimal infrastructure needed for net bags and trellis cultivation from being functional.

Starting in the 1940s a new pest began to cause serious trouble for the shellfish growers (WA DoE 2015a). Two species of burrowing shrimp (ghost shrimp, *Neotrypaea californiensis* and mud shrimp, *Upogebia pugettensis*) saw a large population explosion which coincided with an El Niño year out in the Pacific Ocean. One grower described the damages caused by the shrimp: "When the shrimp totally take over an area, the ground gets so soft you can't even have crews walk on it." In large numbers, these shrimp liquefy the mud, causing oysters growing there to sink in and suffocate. Oyster growers in the bay turned to carbaryl, a widely used agricultural pesticide at the time, as a means of controlling the shrimp. It was first identified as a potential control method in the 1960s by public fisheries agencies and received continued authorization from the WA Department of Ecology over the years (WBGHOGA 2006).

> "The industry was panicked and as they looked for a solution, it was the Department of Fisheries at the time that came to them and suggested carbaryl. That's what the industry relied on from, I think, 1963 on." – Willapa Bay shellfish grower

Use of carbaryl to treat the mudflats continued until 2003. The Willapa Bay/Grays Harbor Oyster Growers Association was forced to come to a settlement with the Washington Toxics Coalition[1] when they appealed the Growers Association's carbaryl spraying permit on grounds of environmental damage and human health risks (Schreder 2003). This settlement began the ten year phase-out of carbaryl spraying and the shellfish industry's search for a new solution to their pest problems.

> "They looked at many different options. They tried a number of natural control methods like clove oil. They were not successful. They tried direct mechanical approaches like crushing and seismic work. Even fresh water was tried but it doesn't work out on the mud flats. Imidacloprid[2] was the thing that would allow them to best control the shrimp and was less toxic than carbaryl." – NOAA Aquaculture coordinator

> "We tested everything, chemical and mechanical. Everything on the 25B[3] list, the so-called 'natural chemicals', things like cinnamon and cayenne pepper, citric acid… You name it, we threw it at these shrimp. At the end of the day, the only thing that showed any promise was imidacloprid, another pesticide widely used throughout the world, but not in a marine environment." – Willapa Bay shellfish grower

[1] From watoxics.org: "Washington Toxics Coalition uses groundbreaking research, top-notch advocacy, in-depth grassroots organizing, and high-quality consumer information to help create a healthier and just world by promoting safer products, chemicals, and practices, and a healthier future for the next generation."
[2] Imidacloprid was identified as a highly-effective, widely used agricultural pesticide similar to the way in which carbaryl was initially identified.
[3] Outlined in the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA 1996), compiled by the Environmental Protection Agency (EPA).

Testing for new control methods continued through the ten year phase-out period including efficacy tests for imidacloprid. Imidacloprid is a neurotoxin of the neonicotinoid family which blocks specific receptors in the brains of target species. This blockage causes respiratory failure in the individuals and often results in death. In late 2014, the shellfish growers began the application process to gain a National Pollution Discharge Elimination System (NPDES) permit to spray imidacloprid in Willapa Bay (WGHOGA 2014). On April 16, 2015 the State of Washington Department of Ecology formally approved the Oyster Growers' permit which would go into effect one month later (WA DoE 2015b).

However, the permit would not last that long. Days after the permit was announced, a series of media articles would be published, calling public attention to the new permit and inciting a mass public outcry against the oyster growers who would spray chemicals on their crops. "Our emails, and phones, and social media lit up that morning after people read that article," said the Willapa Bay shellfish grower. What started with a single article in the Bloomberg (Donahue 2015) spread very quickly to local media sources. This article, titled *Washington State Turns to Neurotoxins to Save Its Oysters*, discussed imidacloprid's potential ties to Colony Collapse Disorder in detail, the dying off of bee colonies around the world linked to the neonicotinoid family of pesticides (vanEngelsdorp 2006). It also mentions a label on commercially available imidacloprid which reads 'Do not apply directly to water,' a label which the oyster grower interviewed for this study contends is misinformation.

> "It's one of the most widely used chemicals, but it says right on the label 'not for use in water'. The reason for that is that Bayer CropSciences, the group that registered that chemical for use, only registered it for terrestrial use. They didn't apply for it to be used in water. So they, on the label, have that saying. It wasn't that it was bad for use in water, just that their registration wasn't for it. The registration that the growers pursued was specifically for that, use in water, but the media didn't report that." – Willapa Bay shellfish grower

The Seattle Times quickly published the reactions of local chefs (Clement 2015). They chose to distance themselves from pesticide use and threaten to not buy from any growers participating in the imidacloprid spraying permit. Environmental impacts and the safety of customers eating shellfish grown with pesticides were the major concerns of the chefs interviewed. A local chef and restaurateur interviewed for this study said "… it's more about conservation and that it's a more natural way to provide seafood." A University of Washington professor and member of the Regional Aquaculture Center Program summed up the media articles by saying: "From what I understand, it just took a couple of well-known chefs in Seattle speaking out to get the industry worried."

Shortly after, The Oregonian published its own article focusing on other issues with the permit (Associated Press 2015). NOAA and U.S. Fish and Wildlife both wrote letters to Washington's Dept. of Ecology during the permit's comment period to put forth their own concerns. These concerns focused on potential off-target species impacts and lack of data to conclude that impacts will be minimal (WA DoE 2015a). They were specifically concerned with potential impacts to green sturgeon, an endangered species living in Willapa Bay, and that impact studies were conducted on its cousin species the white sturgeon which is not endangered. It also repeated another major concern of the original Bloomberg article which, more than any other issue, seemed to fuel the public's outrage against the permit. That issue was a warning on commercially available imidacloprid reading "Do not apply directly to water."

> "That Saturday, the Willapa Growers Association had an emergency meeting to decide what to do. They talked about three different options: going ahead with the spray program (which they had the permits to do), keep the permits and not spray, or withdraw the permits. With each of those options, the media attention diminished… On Sunday they made a request to the Director of Ecology to withdraw the permit. A press release was sent out that Sunday and the media coverage immediately died out." – Willapa Bay shellfish grower

The permit for the Willapa Bay/Grays Harbor Oyster Growers Association to spray imidacloprid on the tide lands was officially revoked on May 4, 2015, eleven days before the permit ever went into effect (WA DoE 2015c). Many of the opponents of spraying framed their objections in terms of environmental damages and human health risks, yet the permit made it through a year's worth of application process and six years of testing. The Department of Ecology didn't cancel the permit due to evidence of harm, rather it was suspended by the growers themselves under the weight of public and media pressure. In the next section, I will elaborate more on the public's major objections while looking to academic literature to support these claims. I will also discuss the potential impacts of the media's framing of this issue.

Discussion

In this section, I will be elaborating on a few of the key issues that came up during analysis. These issues seem particularly important to understanding the entire set of events surrounding the spraying permit and its cancelation. Claims brought forth by interviewees were evaluated with evidence from scientific studies in the literature. The intent of this section is to clarify the factuality of these concerns and claims for the audience and anyone wishing to pursue this discussion.

Impacts of damming the Columbia River

Throughout my interviews with contacts, this theory was proposed several times. The theory is that the damming of the Columbia River may have contributed to the rapid population growth of the burrowing shrimp in Willapa Bay. My shellfish grower contact summarized the theory as follows:

> "The best explanation I can think of that's been hypothesized is the damming of the Columbia River. Prior to the dams, the river would flood and there would be major fresh water events. The river would put huge volumes of fresh water out into the ocean and, through the longshore drift, that fresh water would come into Willapa Bay and Grays Harbor and those bays would turn fresh. So fresh that the old timers talked about how everything would die. Clams would die, eel grass would die, crabs would die. It would basically reset the bay's ecology to zero and it would have to start all over. Presumably that would have the same effect on these shrimp." – Willapa Bay shellfish grower

If this theory is correct, it would mean that humans are partially responsible for the pests plaguing the shellfish industry in Willapa Bay. A University of Washington professor had a similar view:

> "My understanding is that some of the problem comes from the changes in freshwater flows into Willapa Bay. It's been allowing shrimp to invade places they wouldn't have been able to tolerate with higher freshwater flows into the bay." – UW Professor and Regional Aquaculture Center Program member

This theory is supported by several works in the literature. Studies have found that damming a river can reduce the flow of freshwater into estuaries, especially during peak flow times (Weitkamp 1994). Other studies have demonstrated the same conclusions by observing changes in shellfish growth rates and distributions before and after dam construction (Rodriguez 2001; Shöne 2003). Finally, a study by Patten and Norelius (2016) found that the burrowing shrimp have a high tolerance for fresh water in short periods. Exposure to fresh water would have to last much longer than 72 hours to be impactful as a control method since the study showed that even in a 50% dilution of freshwater:saltwater, only half of the shrimp tested actually died and dilution rates of that level would be nearly impossible in practice. However Weitkamp's (1994) study indicated peak flow periods for the Columbia River to last for several months, increasing the likelihood of impacts on the shrimp populations. This demonstrates that even though shrimp are tolerant of freshwater for short periods of time, natural exposures were much longer in duration and evidence of their short-term tolerance does not disprove this flow regime change hypothesis.

This leads me to question the state of Willapa Bay as an ecosystem. It seems the public imagines a Willapa Bay that is separate from reality. Comments made on the Willapa spraying permit during its public comment period suggest that a large portion of the people active in political and environmental management discussions think of Willapa Bay as a natural

ecosystem (DoE 2015a). A local chef told me: “My gut instinct… is that these burrowing shrimp, that are native pests, are a natural way for these beaches to get rotations.” The growers themselves advertise the bay as a pristine, pure, and perfect environment as a way to market their products (Goose Point 2012; Willapa Oysters 2004).

> “The vibrant and pristine coastal-plain estuary of Willapa Bay, known for its highly productive ecosystem and abundance of farmed oysters, has supported more than a century of shellfisheries.” – Goose Point Oysters

Meanwhile, the media has painted an imaginary world for their readers by repeatedly describing the growers’ pest control methods as a way to wipe out the native burrowing shrimp populations (Clement 2015; Associated Press 2015; Donahue 2015). In reality it seems that Willapa Bay hasn’t been a natural ecosystem since the 1950s, when its seasonal freshwater flows from the Columbia River started to be blocked by dam construction. Or even before that, in the late 1800s, when shellfish growers first started to actively plant oysters in the tidelands rather than simply collecting them from wild populations. A foreign species of Pacific oysters, brought over from Japan, was used to replace the native stocks of Olympic oysters which had been harvested to near extinction in the region (Donahue 2015). In reality, Willapa Bay is a novel ecosystem (Hobbs 2006), one that has been highly modified by human activities in a way that even the native species no longer interact as they once did. Willapa Bay is a working waterfront. People grow food there to make a living, but the public has forgotten

that, in favor of an imagined untouched and pristine wilderness. News of this new pesticide spraying permit simply shook the people from their dreams.

Uncertainty in Science

Mazur and Curtis (2006), while investigating public perceptions of aquaculture in Australia, found that alongside environmental concerns the public also expressed a significant distrust in science and research which displayed aquaculture in a positive light. Scientists and politicians that held these views were perceived by the public to benefit from the promotion of aquaculture and they were generally dismissed.

> "Many interviewees believed there were substantial inadequacies in the knowledge and decision-making frameworks used in aquaculture planning and management, including approaches to managing a range of uncertainties and risks associated with the industry" – Mazur and Curtis (2006)

Gentzkow and Shapiro (2006) found that people tend to consider sources of information to have a higher quality when these reports agree with the consumer's prior expectations. My research indicates similar feelings of distrust and focus on uncertainties in the public about the Willapa Bay spraying permit.

> "I think that, as is the case with a lot of EISs, there was a certain license taken with reaching conclusions based on a flimsy evidentiary base… Clearly, some of the studies that really should have been done, had not been. So, I guess I would argue that the evidentiary base was inadequate to reach the conclusions that were reached." – Organic scientist[4]

[4] Title given to reflect interviewee's expertise in organic and sustainable agriculture. Affiliated with the Organic Trade Association and formerly with the Center for Sustainable Agriculture and Natural Resources.

Concerns brought forth by the public made during the spraying permit's comment period also indicate a certain distrust in the testing and certification process. Many of the comments still opposed the spraying permit with concerns that had already been addressed in the six years of testing conducted by the industry and the Department of Ecology (DoE 2015a). Large organizations like the Coalition to Protect Puget Sound Habitat and the World Temperate Rainforest Network opposed the permit over concerns for local bee colonies that had already been studied and addressed. There were also comments by individuals concerned with lack of monitoring or integrated management strategies even though the permit itself discusses these strategies in its description of the proposed action (pg 1-2) and impact mitigation chapters (pg 1-7)(DoE 2015a). One comment from the Xerces Society[5] (pg F-15) summed up the general opposition to science: "The draft EIS has not provided sufficient information regarding the possible risks of imidacloprid." The major concern seems to be that during six years of testing, the real dangers of spraying hadn't been tested. The organic scientist interviewed for this study was asked what studies they thought needed to be conducted to show that imidacloprid isn't as harmful as everyone fears:

> "They'd have to do multi-year studies on the levels in the sediment based on a known application rate. They'd have to do studies of the levels within the estuary and how the tidal movements effected the levels within the estuary. They'd have to figure out some way to determine at what levels does imidacloprid screw up the neural system that salmon and steelhead use to spawn." – Organic scientist

[5] Mission from xerces.org: "The Xerces Society is a nonprofit organization that protects wildlife through the conservation of invertebrates and their habitat. Established in 1971, the Society is at the forefront of invertebrate protection worldwide, harnessing the knowledge of scientists and the enthusiasm of citizens to implement conservation programs."

Comments made on the permit echo this scientist's concern for salmon. The safety of salmon in the Northwest is a very serious issue for the people. Commercial fishing for salmon in Washington generated about $20million in 2006, excluding treaty harvest, while revenue generated by all recreational fishing in Washington is estimated to be $392million (WDFW 2008). It is no wonder the people are protective of this natural resource. A consolidation of research study by Compliance Services International[6] (CSI 2013) addressed many of the concerns brought up by the public. In response to salmon and other off-target fish concerns, concerns for fish impacted unintentionally by the use of pesticides, the Department of Ecology directly quotes this study in a longer form as follows:

> "Imidacloprid has low toxicity to fish regardless of test species or duration. Toxicity studies on species that are resident in Willapa Bay and Grays Harbor indicate relatively low sensitivity to this product and reflect the results found with surrogate test organisms." – CSI 2013, pg 26

These studies based this conclusion on uptake rates of fish through their gills, dermally, and orally. The study further goes on to find that potential for bioaccumulation is low (pg 39), the pesticide degrades rapidly (pg 22), and potential for unintended drift is very low with the right application method and formula (pg 10) (CSI 2013). While these concerns have already been addressed in studies, they persist in the general public. The public's acceptance of science

[6] Compliance Services International (CSI) are a regulatory consultancy agency focusing on regulatory and environmental challenges.

has been shown to be quite high, however a sizable minority appears to always object regardless of how much information they receive (SRI 2014, pg 34).

Conclusions

My research into the case of Willapa Bay's 2015 oyster bed spraying permit has shown that public opposition to this event falls within the categories of environmental and human health concerns and reflect global concerns for aquaculture practices. The largest concerns come from environmental risks and unforeseen impacts that have yet to be tested. Although much of the public appears to be supportive of science overall, there is always a non-trivial sub-section of the population that is distrusting. The shellfish growers chose to withdraw their spraying permit when faced with public opposition even though they claim the shrimp could potentially ruin all growing in the bay. A cost-benefit, business decision that limited damages to company and industry image such as this may further fuel public distrust of the growers' and the DoE's objectives.

Another potential explanation for the vocal public and media opposition to this permit is a difference in risk perceptions between the public and the industry. The opposition may not explicitly doubt the science and figures behind the conducted studies, but instead they doubt the thresholds for potential impact at which the DoE has deemed to be acceptable. None of the research conducted stated that there was no risk, or that there would be no impacts. Indeed, the collection of studies assembled by Compliance Services International (CSI 2012) acknowledges the risks of predation on the poisoned shrimp or exposure to the pesticide of fish through their gills, but concludes that the impacts are temporary and generally non-fatal.

A desire to protect what is perceived to be a natural, pristine ecosystem appears to be a driving force for those concerned for the environment. The industry may have brought this struggle upon themselves through their branding practices. It is also possible that the public

was jarred into remembering their inherent disapproval of pesticide use in farming by the string of media articles published on the topic. Whatever the cause, there is research to suggest that Willapa Bay has long since become a novel ecosystem, created by the damming of the Columbia River and the active farming practices of a non-native oyster species going on in the bay. Rather than being a business venture to protect profits, the pesticide spraying practices may be seen as an adaptive strategy by the local growers to combat an ecosystem that is shifting due to human interference.

Further study into this topic would benefit from closer examination of media influence. Tone of media coverage on the topic may have impacts on public attitude, relative availability of information, and responses from the industry. Although public comment played a role in the growers' choice to cancel their permit, the degree of negative media coverage appeared to be the driving force.

The degree of uncertainty may have caused much of the backlash against the spraying permit in 2015, but Willapa oyster growers are renewing their application for the imidacloprid permit (Johnson 2016; Wing 2016; Pulkkinen 2016). Expanding research to include the worrying uncertainties of the previous permit may help improve perceptions of spraying if impacts are found to be negligible.

For Americans to reach the recommended intake of seafood by the USDA, they will need to nearly double the amount of seafood each individual eats. Achieving this goal is intended to improve the health of individuals, but will require severe increases in either seafood production or imports to the country. Seafood produced abroad rarely meets the environmental

expectations that U.S. consumers place on domestically produced seafood, however it can be produced much cheaper. If the U.S. is to avoid increasing its already $11billion seafood trade deficit while avoiding overfishing our wild stocks to extinction, domestic aquaculture must increase production in the future. Environmental concerns and regulatory constraints have made it difficult for a small industry to get a single pesticide spraying permit and implies even more significant barriers to more intensive aquaculture practices such as the expansion of marine net-pen farming.

Works Cited

- Ansel K. 2011. *Eat More Seafood*. Women's Health. (web). <http://www.womenshealthmag.com/beauty/seafood-recipes>
- Arnason R. 2000. *The Economics of Ocean Ranching: Experiences, Outlook, and Theory*. A report for the Food and Agriculture Organization.
- Associated Press. 2015, May 2. *Neurotoxic pesticide OK'd for Willapa Bay oyster beds, despite concerns*. The Oregonian, retrieved from www.oregonlive.com.
- Associated Press. 2015, May 3. *Pesticide pray plan for Willapa Bay oyster beds canceled after public expresses concerns*. The Oregonian, retrieved from www.oregonlive.com.
- Banas N., B. Hickey, P. MacCready, and J. Newton. 2004. *Dynamics of Willapa Bay, Washington: A Highly Unsteady, Partially Mixed Estuary*. American Meteorological Society. 34: 2413-2427.
- Barnhizer D. 2001. Trade, Environment and Human Rights: The Paradigm case of Industrial Aquaculture and the Exploitation of Traditional Communities. In D. Barnhizer (ed.) *Effective Strategies for Protecting Human Rights*. Aldershot: Ashgate Dartmouth.
- Berg, B. 1989. *Qualitative Research Methods for the Social Sciences*. 4th ed. Allyn & Bacon. Needham Heights, MA.
- Biernacki P. and D. Waldorf. *Snowball Sampling: Problems and Techniques of Chain Referral Sampling*. Sociological Methods Research. 10: 141-164.
- Brody J. 2014. *Lots of Reasons to Eat Fish*. The New York Times. (web). <http://well.blogs.nytimes.com/2014/08/18/picking-apart-objections-to-eating-fish/>
- Clement B. 2015. *Chefs 'horrified' by plan to spray pesticide on oyster beds*. The Seattle Times. (web). <http://www.seattletimes.com/life/food-drink/plan-to-put-neurotoxin-on-oyster-beds-distresses-restaurants/>
- Compliance Services International. Study by: B. McGaughy et al. 2013. *Risk Assessment for Use of Imidacloprid to Control Burrowing Shrimp in Shellfish Beds of Willapa Bay and Grays Harbor, WA*. Lakewood, Washington.
- Dexter L.A. 2006. *Elite and specialized interviewing*. ECPR Press. Colchester, UK.
- DG Mare. Study by: Ernst and Young. 2008. *Image survey on the perception of fishery and aquaculture products*. DG Mare.
- Donahue B. 2015, April 24. *Washington State Turns to Neurotoxins to Save Its Oysters*. Bloomberg, retrieved from www.bloomberg.com.
- vanEngelsdorp D. 2006. *Colony Collapse Disorder Preliminary Report*. Mid-Atlantic Apiculture Research and Extension Consortium (MAAREC) – CCD Working Group.
- Environmental Defense Fund. (n.d.). *The benefits of eating fish*. (web). <http://seafood.edf.org/benefits-eating-fish>
- Environmental Justice Fund (EJF). 2013. *Sold to the Sea – Human Trafficking in Thailand's Fishing Industry*.

- Feucht Y. and K. Zander. 2014. *Consumers' knowledge and information needs on organic aquaculture.* Thusnen Institute of Market Analysis, Bundesallee.
- Food and Agriculture Organization of the United Nations. 2014. *The State of World Fisheries and Aquaculture*. United Nations, Rome.
- Gempesaw C., J. Bacon, C. Wessells, and A. Manalo. 1995. *Consumer Perceptions of Aquaculture Products*. American Journal of Agricultural Economics. 77; 5: 1306-1312.
- Gentzkow M. and J. Shapiro. 2006. *Media Bias and Reputation*. Journal of Political Economy. 114;2: 280-316.
- Goose Point Oysters. (n.d.). *Meet the Nisbet's of Willapa Bay*. (web). <http://goosepoint.com/about/>
- Han B.C., W.L. Jeng, R.Y. Cheng, G.T. Fang, T.C. Hung, and R.J. Tseng. 1998. *Estimation of Target Hazard Quotient and Potential Health Risks for Metals by Consumption of Seafood in Taiwan*. Environmental Contamination and Toxicology. 35 (4): 711-720.
- Harvard School of Public Health. (n.d.). *Fish: Friend or Foe – fears of contaminants make many unnecessarily shy away from fish*. (web). <http://www.hsph.harvard.edu/nutritionsource/fish/>
- Hicks D., L. Pivarnik, and R. McDermott. 2008. *Consumer perceptions about seafood – and Internet survey*. Journal of Foodservice. 19: 213-226.
- Hiss J. 1986. *Fish and Shellfish Resources of Willapa Bay of Interest to the Shoalwater Tribe*. U.S. Fisheries and Wildlife Service.
- Hobbs, R. 2006. *Novel Ecosystems: theoretical and management aspects of the new ecological world order*. Global Ecology and Biogeography. 15; 1-7.
- Hodal K., C. Kelly, and F. Lawrence. 2014. *Revealed: Asian slave labour producing prawns for supermarkets in US, UK*. The Guardian.
- Johnson, G. 2016. Kiro 7. *Willapa Bay oyster growers renew request to use pesticides*. (web). <http://www.kiro7.com/news/willapa-bay-oyster-growers-renew-request-use-pesti/40011716>
- Malcolm J. 1990. *The Morality of Journalism*. Forward from *The Journalist and the Murderer*. Vintage, reprint edition.
- Mazur N., H. Aslin, and I. Byron. 2005. *Community Perceptions of Aquaculture: Final Report*. Australian Bureau of Rural Sciences.
- Mazure N. and A. Curtis. 2006. *Risk Perceptions, Aquaculture, and Issues of Trust: Lessons from Australia*. Society and Natural Resources: An International Journal. 19: 791-808.
- McManus, Alexandra and Newton, Wendy. 2011. Seafood, nutrition and human health: A synopsis of the nutritional benefits of consuming seafood, Curtin University of Technology, Centre of Excellence for Science, Seafood & Health (CoESSH).
- NOAA. 2012. *Fisheries of the United States, 2012*.

- NOAA. 2016. *Fisheries of the Caribbean, Gulf, and South Atlantic; Aquaculture; Final Rule*. 50 CFR Parts 600 and 622. Vol. 81, No. 8; 1762-1800.
- NOAA Fisheries. *Aquaculture in the United States*. (web) <http://www.nmfs.noaa.gov/aquaculture/aquaculture_in_us.html>
- Northern Economics. 2013. *The Economic Impact of Shellfish Aquaculture in Washington, Oregon, and California*. Pacific Shellfish Institute.
- Olsen Svein, Joachim Scholderer, Karen Brunso, and Wim Verbeke. 2007. *Exploring the relationship between convenience and fish consumption: A cross-cultural study*. Department of Social Science and Marketing, Norwegian College of Fishery Science, University of Tromso. 49: 84-91.
- Patten K. and S. Norelius. 2016. *2015-2016 Progress report Washington Department of Fish and Wildlife Burrowing Shrimp Research in Willapa Bay*. WSU Long Beach Research Extension Unit. Long Beach, Washington.
- Pulkkinen, L. 2016. Seattle Pi. *Oyster farmers burned by pesticide backlash aim to spray*. (web). <http://www.seattlepi.com/local/article/Oyster-farmers-burned-by-pesticide-backlash-aim-6752004.php>
- Robertson A. and V. Comfort. 2014. *Public perceptions of New Zealand's aquaculture industry*. Ministry for Primary Industries.
- Rodriguez C., K. Flessa, D. Dettman. 2001. *Effects of Upstream Diversion of Colorado River Water on the Estuarine Bivalve Mollusc Mulinia coloradoensis*. Conservation Biology. 15: 249-258.
- Ruxton C. H. S., S. C. Reed, M. J. A. Simpson, and K. J. Millington. 2004. The health benefits of omega-3 polyunsaturated fatty acids: a review of the evidence. Journal of Human Nutrition and Dietetics. Volume 17; Issue 5, 449-459.
- Schöne B.R., K.W. Flessa, D.L. Dettman, D.H. Goodwin. 2003. *Upstream dams and downstream clams: growth rates of bivalve mollusks unveil impact of river management on estuarine ecosystems (Colorado River Delta, Mexico*). Estuarine, Coastal and Shelf Science. 58: 715-726.
- Schreder E. 2003. *Carbaryl Use in Willapa Bay and Grays Harbor to End*. Alternatives. Washington Toxics Coalition. Volume 22, No. 3.
- Social Research Institute. 2014. Report by: S. Castell et al. *Public Attitudes to Science 2014*. Department for Business, Innovation, and Skills.
- Storelli M.M. 2008. *Potential human health risks from metals (Hg, Cd, and Pb) and polychlorinated biphenyls (PCBs) via seafood consumption: Estimation of target hazard quotients and toxic equivalents*. Food and Chemical Toxicology. 46: 2782-2788.
- Stratton E. 2016, March 22. *Life on the Half Shell: Aquaculture dominates farming on Willapa Bay*. Chinook Observer, retrieved from www.chinookobserver.com.
- United Nations Department of Economics and Social Affairs. 2004. *World Population to 2300*. United Nations, New York.

- United States Department of Agriculture. 2000. *Beliefs and Attitudes of Americans Toward Their Diet*. Center for Nutritional Policy and Promotion.
- United States Department of Agriculture. 2010. *Dietary Guidelines for Americans 2010*. Center for Nutritional Policy and Promotion.
- United States Department of Agriculture. 2015. *Dietary Guidelines for Americans 2015*. Center for Nutritional Policy and Promotion.
- Verbeke W., I. Sioen, K. Brunso, S. DeHanauw, and J. Van Camp. 2007. *Consumer perception versus scientific evidence of farmed and wild fish: exploratory insights from Belgium.* Aquaculture International. 15: 121-136.
- Washington Department of Fish and Wildlife. 2008. *Economic Analysis of Non-treaty Commercial and Recreational Fisheries in Washington State*. Prepared by: TCW Economics.
- Washington State Department of Ecology. 2015a. *Final Environmental Impact Statement Control of Burrowing Shrimp using Imidacloprid on Commercial Oyster and Clam Beds in Willapa Bay and Grays Harbor, Washington*. Olympia, Washington. Pub. Number 15-10-013.
- Washington State Department of Ecology. 2015b. *National Pollution Discharge Elimination System Waste Discharge Permit No.WA0039781*. Olympia, Washington.
- Washington State Department of Ecology. 2015c. *Termination of National Pollution Discharge Elimination System Permit Number WA0039781*. Olympia, Washington.
- Washington Toxics Coalition. (n.d.). *About Us*. (web). <http://www.watoxics.org/about>
- Weitkamp L. 1994. *A Review of the Effects of Dams on the Columbia River Estuarine Environment, with Special Reference to Salmonids*. US Department of Energy.
- Westneat D. 2015, April 28. *Disbelief over state plan to spray neurotoxin into oyster beds*. The Seattle times, retrieved from www.seattletimes.com.
- Willapa Bay/Grays Harbor Oyster Growers Association. 2006. *Fact Sheet for NPDES Permit No. WA0040975*. Prepared for WA Department of Ecology.
- Willapa Grays Harbor Oyster Growers Association. 2014. *Fact Sheet for NPDES Permit No. WA0039781*. Prepared for WA Department of Ecology.
- Willapa Oysters. (n.d.). *Growing Oysters*. (web). <http://willapa-oysters.com/grsh.html>
- Wing J. 2016. *Willapa Bay Oyster Farmers Ask State Again For Permission To Use Neurotoxin*. KPLU 88.5. (web). <http://www.kplu.org/post/willapa-bay-oyster-farmers-ask-state-again-permission-use-neurotoxin>
- Wright J. 2015. *Consumer survey explores farmed, wild seafood perceptions*. Global Aquaculture Alliance. (web). <http://advocate.gaalliance.org/consumer-survey-explores-farmed-wild-seafood-perceptions/>
- Xerces Society. (n.d.). *Mission*. <http://www.xerces.org/mission/>