AN ABSTRACT OF THE THESIS OF

Brian Ahlers for the degree of Master of Science in Marine Resource Management presented on September 18, 2017.

Title: A Broader Overview and Investigation into Seafood Traceability Developments and the Current Landscape for the US West Coast Seafood Industry

Abstract approved:

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Seafood is one of the most diverse and highly traded natural resources worldwide. Widespread evidence of increased seafood fraud and IUU fishing has placed enormous pressure on industry and governments to determine the authenticity, safety, and sustainability of seafood. The recently established US National Ocean Council has addressed several gaps in the patchwork of seafood regulations and policies among US government agencies through new legislative and executive efforts. While many challenges still remain, both mandatory and voluntary adoption of traceability systems in the US and internationally reveal a trend toward increased seafood product traceability and supply chain transparency in seafood systems in the global north. To date, much of the traceability efforts on the seafood industry have been largely focused on downstream firms and policy. To address these gaps, we investigated the current landscape of perspectives from industry professionals across value chains in the largest seafood hub in the United States. Results from background interviews, discussions, and an online questionnaire reveal a general lack of awareness of the Seafood Import Monitoring Program (SIMP), increasing importance of traceability with firm complexity, and an overall positive perception for the effectiveness of traceability to address large pressures

and threats to the industry related to traceability. Unique characteristics regarding vertically integrated and larger firms were revealed, and small and upstream firms demonstrate a lack of traceability capacity over other firms. Whether market or regulatory driven, 92% of respondents to questionnaire agree or strongly agree that traceability is "here to stay." Given concerns of social, economic, and ecological sustainability, demand for seafood product information will likely continue to increase in seafood systems worldwide.

A Broader Overview and Investigation into Seafood Traceability Developments and the Current Landscape for the US West coast Seafood Industry

By
Brian Ahlers

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Science

Presented September 18, 2017

Commencement June 2018

Master of Science thesis of Brian Ahlers presented on September 18, 2017.

APPROVED:

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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request

Brian Ahlers, Author

ACKNOWLEDGEMENTS

Depending on the person, firm, or sector within the seafood industry, traceability takes on many meanings and can sometimes be a contentious subject given the regulatory implications. It is with enormous gratitude that I wish to thank my advisor, Dr. Gil Sylvia. With his ideas and connections he has developed over the course of his career, I was given access to a wide variety of people involved in the seafood industry to discuss the very messy and challenging issue of traceability. His consistent support, professional advice, undying passion, and wisdom regarding people, seafood systems, fisheries, and traceability has prepared me well beyond the needs of graduate research. I also wish to thank Dr. Michael Harte for all of his encouragement, professional advice, and general enthusiasm for the subject matter explored in our research. Both he and Dr. Christina DeWitt demonstrated a willingness to contribute to the research that was critical. There are a number of other individuals that I simply could not have carried out my research in their absence. Dr. Michael Morrissey and the Food Innovation Center were very helpful at recruiting and organizing our Portland Focus Group. I received exceptional assistance and feedback from Laura Anderson, Nancy Fitzpatrick, Dr. Mark Needham, and Mike Okoniewski on the design and implementation of our questionnaire in particular and I am grateful for their willingness to go above and beyond and make our research more aligned with the needs of the seafood industry. I would like to express my gratitude for the broader Hatfield Marine Science Center (HMSC) and community for awarding me the William Q. Wick and the Hannah-Jones Awards, and for providing a home base our Newport Focus Group and for our research. If it wasn't for Dr. Itchung Cheung in particular at the HMSC, I would not have had the opportunity to come to OSU to pursue my specific interests. I also wish to thank Dr. Flaxen Conway for awarding me the Dimmick and Laurel Scholarships, for always believing in me, and most importantly, for being one of the most encouraging and thoughtful individuals I have ever met. And of course, I owe the rest of the MRM/CEOAS faculty for their belief and support in the importance of the MRM program and the scientific rigor necessary to address to challenges and opportunities of tomorrow. This includes Robert Allen for all of his incredibly valuable professional advice, and Lori Hartline for her soups and for helping me navigate the larger OSU institution. I want to thank my friends and colleagues from the MRM community for the endless intellectual chats about social and environmental issues, the many laughs and communal soups, and their curiosity and sentiment about the world. I will miss them very much. Lastly, I wish to thank my parents and my partner Molly for their support and helping read over sections of my thesis when it mattered most. Because of all of these people, my heart, mind, and soul definitely grew from my time here at Oregon State University, and I am eternally grateful for the ups, downs, laughs, and opportunities to learn and challenge myself in ways I didn’t know were possible.

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Introduction

Background

Looking around an elementary school playground, you may see a circle of children playing a game of "telephone." Accurately relaying the initial phrase around the circle is highly unlikely even when the individuals are attempting to convey accurate information. The last person to receive the information looks to the first participant in the circle to validate their phrase. This process of individuals passing along information at several "checkpoints" can be extended to multiple businesses sharing product information along a supply chain, a challenge for many food system supply chains around the world.

Maintaining accurate information is difficult for seafood businesses. Like many commodities, seafood is highly globalized and has a relatively short shelf life. By it's very nature, seafood is highly perishable and requires a fair amount of processing and specialized handling. Every day that passes, degradation ensues, releasing aromas from biogenic amines, ammonia, and other compounds. Additionally, seafood is one of the globe's most diverse groups of commodities. Identification of products is remarkably complex compared to most other industries; The U.S. Food and Drug Administration's official "Seafood List" identifies 1,682 species by scientific name for the US market [1]. This is extremely high compared to almost any other food commodity.

Unlike agriculture, timber, banking, automotive, or pharmaceutical industries, the global seafood industry has faced unique challenges and arguably delayed "growing pains" associated with product validation, quality, safety, and sustainability [2]. Compared to terrestrially based agriculture, many of these species are highly mobile, often moving hundreds of miles in a day across geopolitical borders between nations, individual states or provinces, out on the high seas, or in the littoral zone, which collectively challenge the validation of catch origin and landings. Post harvest, products are processed from whole organisms into smaller parts, often multiple times, sometimes in multiple countries with different regulatory regimes and markets. Despite these challenges, people continue to consume a lot of seafood and global per capita consumption rate is around forty pounds per year [3]. And even if people do not directly consume seafood, it is globally ubiquitous and found in organic fertilizer, soil enhancements (e.g. fish emulsions), pet food, toothpaste, ice cream, and nutraceuticals (e.g. fish oils), to name a few.

For millennia, seafood has provided wealth and livelihoods to communities around the world. From before the Basque people's salting and drying of cod caught in Newfoundland to Norway (circa 1000 AD), to the first ever canning of seafood in early 19th century France, seafood has been traded around the world for a very long time. It has also been consumed for along time - middens a dozen feet thick can be seen in places around the world like the black abalone middens from the Chumash of the Channel Islands. Oceans have generated natural, social, and financial "capital" to communities around the world for centuries [4]. This history persists in our culture today. We are reminded of this with today's wild salmon runs in Bristol Bay, Alaska, coastal Maine residents celebrating their heritage at summertime seafood festivals, and people packing seafood restaurants along the waterfronts of Seattle, Cape Town, Lima, and other major cities and coastal towns around the world. Today seafood provides almost 20% of animal protein for 3 billion people, and nearly 1 billion rely on seafood as their primary source of animal protein [3]. Regardless of diet, lifestyle, or socioeconomic status, seafood is ubiquitous and the stewardship of this valuable resource demands our attention.

Given the demand for seafood and the tendency for humans to generally overexploit marine resources, it is imperative that markets are dynamic and help drive responsible extraction of fisheries resources. Providing accurate seafood information can generate valuable knowledge for businesses and improve the marketing and consumption of seafood in a global marketplace. By sharing accurate information, seafood businesses and consumers can make better decisions that improve their health, livelihoods, and "bottom lines." It can also support progress towards safe, and economically, ecologically, and socially sustainable seafood management.

These are some of the reasons seafood traceability and transparency have generated significant attention over the last few decades as a tool to address information needs for businesses, government, and consumers [5]. Traceability could potentially strengthen market mechanisms to improve the sustainability and legality of seafood. In addition to sustainability benefits, research suggests other benefits for companies that enlist in utilizing traceability information [6][2]. With rising pressure on seafood industry practices from non-government organizations (NGO's), consumers, news media outlets, and various tiers of government to address the threats to the quality, safety, and sustainability of seafood, the application of product traceability has been heralded as concept and tool to solve a variety of challenges and generate greater value to seafood firms [5–9].

The need for traceability driven solutions is likely to increase. From 2000 to 2011, seafood production increased in value from $60 billion to $120 billion and is continuing to increase [6]. In 2014 seafood represented approximately 6.7% of global protein consumption worldwide, which has increased steadily in recent decades [10]. Americans now consume approximately 15.5 pounds of seafood per capita annually, approximately

150% of the estimated US seafood consumption rate a century ago [11]. Roughly some 90% of that domestic consumption is imported, and evidence suggests the US government currently lacks the capacity, interagency collaboration, and enforcement to properly address deception, mislabeling, and uncertainty regarding the safety and legality of US seafood commerce [6,7,12,13].

As seafood demand continues to grow, doubt about the origins, handling, and sustainability of seafood imports has been reported, with some 20-32% of US seafood imports estimated to have originated from illegal, unreported, and/or unregulated (IUU) sources [14]. In a number of recent studies, DNA barcoding has revealed seafood mislabeling and potential fraud, exceeding 30% of retail product [15–18]. Consequently, efforts to regulate the legality and safety of seafood have been comprised and sustainability objectives underserved.

Regulatory and Policy Developments

Under the Bioterrorism Act of 2002 and the Food Safety and Modernization and Act of 2011 (FSMA), the Food and Drug Administration (FDA) inspects approximately 1-2% of seafood imports, and seafood firms must provide information pertaining to sources using the "one-up one-down" system within their respective supply chain [6,19]. Used in many countries around the world, the "one-up one-down" model is characterized as "each firm in the supply chain keeps a record containing the product identifiers and characteristics, from whom the product was received, and to whom it was sent" [2]. Highlighted in our National Ocean Policy and addressed in part by the IUU Fishing Enforcement Act passed in November of 2015, traceability intended to address IUU and seafood fraud. Although initially viewed as a regulatory burden, many firms have implemented traceability systems to improve operations that extend well beyond regulatory requirements [6,18,20]. Without any funding or support to industry, in December of 2016 the National Marine Fisheries Service (NMFS) determined their Final Rule requiring traceability information linking back to the vessel or farm for over 200 species currently imported, influencing approximately 40% of seafood markets in the United States [21]. Despite opposition and judicial process, this decision was recently upheld by a federal circuit court judge in Washington D.C.

Traceability Terminology

Beyond implications for increased regulatory data requirements, seafood traceability can incorporate other key data elements (KDE), such as weight, preservation techniques, time-temperature data, product handling, and geographic origin. Critical tracking events (CTE) are also important information, which are often site specific along the product chain-of-custody. In practice, both KDE, CTE, and other internal and external data are essential components to traceability along supply chains [6]. A comprehensive list of KDE's and CTE's and their rankings of importance can be found in Bhatt et al 2016 [2].

There are several definitions of traceability:

- the ability to systematically identify a unit of production, track its' location and describe any treatments or transformations at all stages of production, processing and distribution" [22].
- the ability to trace the history, application or location of an entity by means of recorded identifications
- the ability to assess any or all information related to that which is under consideration, throughout its entire life cycle, by means of recorded documentations [23].
- the recording of information as the product makes its way through the supply chain, and the ability to identify in real time where a product is and what processes it has undergone [5].
- the ability to follow a product back through these processes from the consumer to their origin [5].

These definitions overlap and for the purposes of this research, we developed a relatively simple and broad definition that encompasses the key underlying themes and features of traceability and traceability systems:

> a seafood information system and/or process that includes elements of **recording**, **storing**, and **sharing** of seafood product information within and amongst businesses, consumers, and other entities (e.g. government agencies, commodity and/or marketing associations) for the entire "life cycle" of a seafood product.

In this instance the term "life cycle" encompasses the entire duration of existence for a "renewable" biological life form both before and after mortality. To offer an example in the context of traceability, the "life cycle" of a wild salmon could begin from hatching in a redd, to harvest at maturity, all the way to the point-of-consumption in the market. This journey and the associated information would be fundamentally different for a wild caught organism, versus an aquaculture product that is produced in conjunction with human intervention.

Scope of the Research

Many traceability studies have focused on only one sector or component to value chains. Previous traceability studies focus on value chains [2,6,20,24–26], but fail to address the diversity of insights, perspectives, and attitudes of the seafood industry across several sectors. To address this gap in the current knowledge, this research examines the perspectives and attitudes of people and their associated firms and sectors through a value chain approach. Participants representing firms from harvest to point-of-sale were examined in the largest region of fisheries and aquaculture production along the West coast of the United States.

We selected the Pacific Northwest (PNW) for this study, and attempted to expand the study to the broader west coast of the United States. The US West Coast fisheries and broader seafood industry is arguably one of the top seafood hubs in the world, representing approximately 27% of total US seafood sales and supporting roughly over 278,000 jobs in Alaska, Washington, Oregon, and California in 2012 [27]. In Oregon alone, $500 million in personal income from over 1,700 vessels is brought into the state as a result of commercial fisheries [28].

This study was divided into three phases. Phase one began with a year-long process of extensive literature review; phase two was comprised of two major components involving background qualitative data collection, and phase included the design, implementation, collection, and analysis of quantitative data through an online questionnaire.

A broad range of sources were utilized in phase one for the literature review: *Comprehensive Reviews in Food Science and Food Safety, Current Opinion in Environmental Sustainability, Journal of Food Policy, Journal of Marine Resource Economics, PLOS One*, *Journal of Natural Resources*, *Journal of Ocean Coastal Management*, *Journal of Food Control*, *Marine Fisheries Review*, *Trends in Food Science and Technology*, *Journal of Marine Policy*, *Marine Pollution Bulletin*, *Frontiers in Ecology and the Environment*, and *the Journal of Food Science and Food Safety, Journal of Food Control, the Congressional Research Service, and the Government Office of Accountability*. For papers that were not available online, articles were obtained through Atlas Systems and the Oregon State University library website: http://osulibrary.oregonstate.edu/ill.

For the first component of phase two, fifteen semi-structured interviews were designed and conducted with members of businesses and organizations from key seafood hubs in the Pacific Northwest including Newport, Astoria, and Portland, OR, and Seattle and Olympia, WA. In the second component to phase two, two focus groups sessions were held in Newport and Portland, OR, using the same format. Meetings, objectives, and other components were a balance of a structured format and open discussion. We encouraged a thorough and lively discussion among participants. The questionnaire designed in phase three selectively targeted over 1000 potential subjects from the broader west coast seafood industry via a snowball technique. See chapter three (pg. 48) for more in depth explanation of methods.

In pursuing phases one, two, and three, the overarching objective of this study was to identify traceability concepts and issues that were important to members of the industry, and to analyze the level of agreement and/or disagreement and varying levels of importance for the concepts and issues that were investigated within a large segment of the west coast seafood industry.

Summary

Together with widespread attention on sustainability and illegal, unreported, and unregulated seafood (IUU), food safety regulations have been a significant driver of seafood product traceability. There has been considerable research centered on consumers, retailers, food service, and advocacy organizations in recent years. Research has examined many aspects of traceability developments and potential knowledge gaps remain regarding the insights of people closest to fisheries and seafood resources (see pg 49, Chapter 3). Our research is an attempt to contribute to the broader traceability dialogue from those that arguably depend on fisheries resources the most: the seafood industry. We believe their intimate understanding and knowledge could provide insights on current developments in the United States and internationally.

Whether regulatory or market-driven, we are at a pivotal moment where industry can, and arguably must, self-organize to address these multidimensional issues through collaborative business relations and information sharing practices. But given the regulatory and market drivers, is the seafood industry prepared for these challenges? What are the key issues for industry, and how does that align with external pressures? Does the industry feel the new requirements are necessary and being implemented effectively to address the current suite of challenges? The need to understand the current traceability landscape within the seafood industry could provide a path forward to understanding current impediments to traceability efforts, and identify potential models for success. This study offers a window into the general perceptions and attitudes of the West coast seafood industry regarding current and ongoing traceability developments, and could potentially offer a business case for increased capabilities in product traceability. The summary of results and analysis of this research will provide insights regarding attitudes, preparedness, and favorability of regulatory and market driven traceability. We hope these insights will be valuable for seafood firms and management and regulatory systems in the United States and abroad.

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Seafood traceability: a review of regulatory drivers in the United States and the global north

Abstract

Seafood is one of the most diverse and highly traded natural resources worldwide. Widespread evidence of increased seafood fraud and illegal, unreported, and unregulated (IUU) fishing has placed enormous pressure on industry and governments to determine the authenticity, safety, and sustainability of seafood. The current allocation of authority and responsibilities within and among the Food and Drug Administration, the National Marine Fisheries Service, Customs and Border Patrol, and other US government agencies reveals many gaps and challenges within the current US regulatory framework. A review of US seafood regulations and policies reveals several US government agencies have overlapping responsibilities, including inspections and enforcement both at sea and within the domestic supply chain. Because of the recommendations of the relatively nascent National Ocean Council, legislative, executive, and judicial actions have initiated a process for addressing seafood fraud and IUU fishing in foreign territories, on the high seas, and the United States. Critical questions remain about the current landscape of traceability preparedness within the industry, and whether new regulations will remove "bad actors" while protecting "good faith mistakes." The emergence of mandatory and voluntary traceability developments reveals a general trend toward increased seafood product traceability and supply chain transparency as a growing phenomenon in seafood systems in the global north.

Introduction

Seafood systems are complex and can be difficult to manage and regulate. Compared to terrestrially based agriculture, many marine finfish species are highly mobile, often moving hundreds of miles in a day across geopolitical borders before being harvested. Post-harvest, seafood products are often shipped around the world for processing and handled by numerous firms before point-of-sale. Given the historic exploitation of living marine resources and increasing demand for seafood worldwide, efforts to responsibly manage fishing activities have led to increased enforcement of seafood imports in many countries, especially in Europe and the United States. The United States has codified regulations to address illegal seafood commerce since the Lacey Act in 1900. In 2015, Americans consumed an average of 15.5 pounds of seafood per capita annually, which is 50% more than estimates from a century ago [29]. At present approximately 90% of seafood consumed is imported [30]. The US government currently lacks the capacity, collaboration, and enforcement to properly address uncertainty in the safety and legality of US seafood imports through inspections or supply chain audits [11]. Significant uncertainty with respect to the origin, handling, and sustainability of seafood imports are supported by evidence that 20-32% of US imported seafood product may be IUU [14]. In some cases, advances in DNA barcoding have retrospectively identified that over 30% of US seafood may be mislabeled and/or fraudulent depending on the species and sector of interest [18,31]. These findings illustrate a relatively opaque global seafood market, which undermines efforts and interests in the authenticity and sustainability of food products.

As a result of the Bioterrorism Act of 2002, the Food Safety and Modernization and Act of 2011 (FSMA), and other regulations, the Food and Drug Administration (FDA) inspects approximately 1-2% of seafood imports. Seafood firms must also provide information pertaining to "one-up one-down" [6]. Used in many countries around the world, the "one-up one-down" model is characterized as "each firm in the supply chain keeps a record containing the product identifiers and characteristics, from whom the product was received, and to whom it was sent" [2].

Seafood inspections occur under the US Customs and Border Patrol (CBP), the Food and Drug Administration (FDA), and the National Oceanic and Atmospheric Administration (NOAA) [13,19]. Despite these regulations, "one-up one-down" has arguably proven ineffective to address seafood fraud and IUU fishing [13]. Lead by the National Ocean Council (NOC), the IUU Fishing/Seafood Fraud Task Force (Task Force) was formed under executive memorandum by the Obama Administration in 2014 [32]. Incorporating twelve US government agencies, the Task Force was directed to address IUU and "seafood fraud that undermines the economic viability of U.S. and global fisheries, and deceives consumers about their purchasing choices." [13].

Despite a long history of legislation such as the Lacey Act of 1900 (LA), the Food, the Drug, and Cosmetic Act of 1938 (FDCA), and the Food Safety and Modernization Act of 2011(FSMA), government agencies have received enormous pressure from outside interest groups, the media, and consumers to overhaul and centralize their approach to seafood governance. This document provides an extensive review of previous, current, and impending US government regulations and policies pertaining to seafood imports and fraud, and elucidates the emergence of seafood traceability as a tool to improve supply chain transparency and regulatory compliance. Further discussion proposes questions regarding industry preparedness and considerations for the road ahead.

Methods

A review of United States seafood trade policies and regulations through primary literature was conducted using Google Scholar, and a Google search was conducted for secondary literature, white papers, internal documents, and gray literature. Given the interdisciplinary nature of our subject matter, a broad spectrum of journals were utilized in this review: *PLOS One*, *Journal of Natural Resources*, *Journal of Ocean Coastal Management*, *Journal of Food Control*, *Marine Fisheries Review*, *Trends in Food Science and Technology*, *Journal of Marine Policy*, *Marine Pollution Bulletin*, *Frontiers in Ecology and the Environment*, *Journal of Food Science and Food Safety, the Congressional Research Service, and the Government Office of Accountability*. Upon reviewing the literature, subject matter was classified thematically: government legislation, government regulations, economics, conservation initiatives, challenges, opportunities in the market, non-regulatory policies, non-government stakeholders, litigation, traceability, and other emerging issues within and outside the United States. For papers that were not available online, articles were obtained through Atlas Systems and the Oregon State University library website: http://osulibrary. oregonstate.edu/ill. Few articles or reports published prior to 2010 contributed to this review.

Pressures and Threats to US Seafood

Seafood Safety

Seafood safety has been the largest regulatory driver for traceability for many years [33]. According to the Center for Disease Control, 48 million people become sick from food contamination in general, and when compared to muscle foods, roughly 20% of those cases are from fish and shellfish consumption [34,35]. Under the FDCA of 1938, the FDA is responsible for ensuring the United States food supply is wholesome, safe, sanitary, and properly labeled, including imported products [36]. In 1997 over 60% of seafood consumed in the United States was imported; in 2010 it was 80%. Today ninety percent of U.S seafood consumption is sourced from imported product, placing great pressure on the FDA to uphold safety and human health obligations [30]. At present, the FDA largely relies on its seafood inspection program known as HACCP (Hazard Analysis and Critical Control Point). In addition to enforcing HACCP requirements, the FDA also coordinates with NOAA on seafood inspections, which will be discussed later in this review.

Seafood Fraud and Misrepresentation

Seafood fraud comes in many forms, and until now US regulations to deter fraudulent seafood imports have been largely ineffective. Deceptive labeling and marketing are two of the most common methods of skirting regulations. Often economically driven, these tactics including species substitution, origin, quantity, and quality, to name a few [12,13]. As defined by a 2009 report from the US Government Accountability Office, there are five common types of fraud: transshipping, over-treating, species substitution, short-weighting, and other mishandling [19]. Although the Food, Drug, and Cosmetic Act of 1938 has long prohibited "mislabeling" of food products, evidence suggests misrepresentation in both domestic and imported US seafood products. A recent global study revealed that one in five seafood samples were mislabeled, and similar figures have uncovered that 16% of products were misrepresented in the cities of San Francisco, Austin, and New York [15,37]. Another study found an average of 33% of seafood products to be mislabeled in the United States [18]. Among many other repeated studies, these findings demonstrate the inability for government agencies or the seafood industry to ensure the legitimacy, authenticity, and safety of relatively large proportions of the seafood products.

Transshipping was first officially recognized as a major threat to the management of seafood trade following a report on shrimp imports from China by way of Indonesia in 2005 [19]. To avoid the duties and fees incurred with US export laws, Indonesian companies transferred shrimp worth $6 million from China through Indonesia and labeled them as Indonesian product to avoid US duty requirements for shrimp shipped from China [19]. These practices of skirting regulations and fees often take place on the high seas outside of any Exclusive Economic Zone (EEZ); roughly 12% of the global annual commercial catch is caught in this area [38]. Out of the five forms of fraud, transshipment has perhaps gained the most media attention [39].

Another form of fraud is "over-treating," which is often conducted by adding water weight to misrepresent the quantity of product. This method of fraud is often accomplished through ice glazing frozen product or retaining water weight through use of chemicals (e.g. sodium tripolyphosphate) [12,19]. Species substitution is also a common form of fraud in which products are labeled as a higher value product, or mislabeled as a lower value product to avoid duties through the FDA. Whether conducted deliberately or accidentally, species substitution and incorrect labeling can often be a threat to human safety as well as misrepresent the authenticity of seafood products.

Short weighting is labeling products as weighing more than their actual weight and is a misrepresentation of the product value [19]. This problem has challenged government enforcement and has created problems for the industry. In 2009 the FDA re-introduced guidelines for ensuring proper weight and implemented severe penalties for short weighting including classification as a felony [12].

Other forms of misrepresentation often occur through preservation techniques. Tuna and other species are often treated with carbon monoxide (CO/TS) (a.k.a. "tasteless smoke") as a pigment fixative before freezing. Some companies deliberately do not indicate such handling practices which misrepresents perceived freshness, raising the products value and compromise retailer and consumer preference [13]. Under FDA regulations, all processed seafood treated with CO/TS must be labeled properly [40]. As many studies have concluded, consumers typically evaluate product quality though visual and olfactory assessments which become of limited use due to such practices [41]. Although the US Federal Trade Commission (FTC) serves to protect consumers against deception and fosters more informed choices for consumers, seafood presents several challenges beyond the capacity of the FTC outlined above [13]. As discussed later in this paper (pg. 50), designing and crafting regulations that adequately distinguish between deliberate and unintentional acts is very difficult.

Illegal, Unreported, and Unregulated Fishing (IUU)

IUU fishing products are often closely intertwined with industry practices and seafood fraud. Studies estimate anywhere from 68-85% of global commercial fish stocks have been fished up to their biological limits [10,42]. Amidst concerns of overfishing, attention on the legality and management of fisheries has increased, but the extent of IUU fishing has proven difficult to quantify. In 2012 the Department of Commerce (DOC) estimated \$10-\$23 billion dollars of economic loss annually worldwide due to IUU fishing [27]. Within the Pacific tuna fishery, a region often associated with IUU, studies estimate

$616 million in losses, including revenue for countries in the region generated from fees and reduced employment [33]. For the 2.3 million pounds of edible US seafood imports in 2011, Pramod et al (2014) estimated IUU imports at $1.3 to $2.1 billion. Calls for amendments to the LA have been made to address IUU in the United States [14].

Some examples of IUU fishing are summarized by violations of domestic or international laws and evading catch documentation, including unauthorized transshipments at sea, fishing without a license or quota, false reporting of catch, violating catch size or length, operating in areas closed to fishing, or using prohibited fishing gear or catch methods, and labor laws violations [43]. IUU practices can be associated with tax evasion, transnational crime, and slavery at sea [14]. Given 90% of all US seafood consumption is from imported product from the global south and many developed and developing countries around the world, IUU has become a major priority for the US government resulting in a plethora of new regulations discussed in further detail below.

U.S. Seafood Regulations

As a response to the challenge of transferring seafood products across and/or between various nation states, exclusive economic zones (EEZ), and/or the high seas, several major pieces of legislation have been codified to address seafood product legitimacy, safety, and sustainability within the US government framework. Under the Bioterrorism Act, requirements for "immediate prior sources and immediate subsequent sources" were established (aka one-up one-down policy), and under the Food Safety Modernization Act, requirements for contamination prevention were implemented [2]. Before these laws were established, however, traceability for seafood products was not explicitly required in the United States. Below is brief overview of seafood regulations as it relates to trade and transfer of seafood product (see Table 2.1).

Table 2.1. Timeline of major traceability related regulatory developments in the United States since 1900.

Date	Regulations	Description
1900	Lacey Act	Prohibits fish products taken or imported in violation of a foreign law or treaty [44]
1938	Food, Drug, and Cosmetic Act	Addresses rebranding of food, and sets guidelines for acceptable marketing names [12].
1946	Agricultural Marketing Act	Enabled fee-for-service inspection programs offered by government agencies [19].
2002	Bioterrorism and Safety Act*	Gives federal agencies the authority to establish requirements for "immediate prior sources… and subsequent recipients"[6]
2009	Country of Origin Labeling	Requires retailers to provide COO, farmed vs. wild product [12]. Put pressure on firms upstream to provide that info
2011	Food Safety and Modernization Act*	Focused more heavily on food contamination
2014	ITDS Executive Order	Collaboration between over 45 agencies to develop single portal data entry for firms, enhances efficiency [45]
2015	IUU Fishing Enforcement Act	Expanded the role of the Coast Guard and other agencies to enforce illegal fishing in the US EEZ and other countries
2018	Seafood Import Monitoring	Requires key data elements for over 200 species of imported products to the US, including vessel

+This regulation was upheld by a federal circuit court judge in June of 2017, leaving six months for industry compliance measures to be implemented. It begins effective January 1st, 2018.
*These regulations represent instances where "traceability" was codified or implemented explicitly.

U.S. Seafood Regulations – Trade and Import Laws

Passed in 1900, the Lacey Act (LA) (16 U.S.C. 3371-3378) addresses transport and trade of wildlife, making it illegal to "import, export, transport, sell, receive, acquire, or purchase" any wildlife that was "taken, possessed, transported, or sold in violation of the any law" in other countries, the United States, and American Indian Tribes, including finfish, mollusks, and other shellfish [44,46]. The LA is enforced by the US Fishing and Wildlife Service (FWS).

Reauthorized and amended in 2011, the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1857) states under Section 307 regarding "Prohibited Acts," it is illegal to "import, export, transport, sell, receive, acquire, or purchase in interstate or foreign commerce any fish taken, possessed, transported, or sold in violation of any foreign law or regulation" [47]. The MSA is mainly enforced by NOAA through the Department of Commerce (DOC) and by the Coast Guard with the Department of Defense (DOD). In addition to the LA and the MSA, a number of regional fisheries management agreements since 1950 led to US legislation including the Antarctic Living Marine Resources Convention Act of 1984 (16 U.S.C. 2431-2444) or Section 8 of the Tuna Convention Act of 1950 (16 U.S.C. 957), which collectively prohibit importation of illegal fish products into the United States [48][13]. These statutes are enforced by both NOAA and the US Coast Guard.

U.S. Seafood Regulations - IUU Fishing Regulations

Recent efforts to address IUU fishing through regulations involve vessel inspections while at sea or in port. Building on the United Nations Convention on the Law of the Sea (UNCLOS), in 2001 the United States signed the FAO International Plan of Action to Prevent, Deter, and Eliminate Illegal, Unreported, and Unregulated Fishing (IPOA), otherwise known as the Port State Measures Agreement. Although voluntary, 13 countries including the United States have ratified the agreement. As required, the US has developed a National Plan of Action (NPOA) to the IPOA agreement to increase capacity and enforcement of fishing laws in the United States, on the high seas, and with partner nation states who have shared regional fisheries management agreements (e.g. International Commission for the Conservation of Atlantic Tuna (ICCAT), Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR), and Inter-American Tropical Tuna Convention (IATTC)[49]. Additionally as part of the United States' NPOA, NFMS currently manages and updates a list of vessels known to participate in IUU fishing that is shared with partner nation states [49].

On November 5, 2015, as a result of the first recommendation from the Obama administration's Task Force on Combating IUU Fishing and Seafood Fraud (Task Force), Congress passed the IUU Fishing Enforcement Act, which strengthened fisheries enforcement mechanisms including the Tuna Convention Act of 1950, and agreements through the Antigua Convention [50]. Ultimately 12 fisheries statutes were amended to increase enforcement capacity to "stop illegal, unreported, and unregulated fishing" [50]. This law gives the Secretary of Homeland Security or the Secretary of Defense the authority to deny a vessel entry into a port within United States jurisdiction, authorizes the US Coast Guard officers to board vessels suspected of illegal fishing in the past three years, and imposes civil penalties and possible forfeiture of fishing vessels or fishing gear associated with IUU fishing activity [50]. This law increases the capacity and enforcement of IUU fishing within US jurisdiction. Given the broader complex US international policy arrangement with many other nation states, this jurisdiction includes several other countries, their respective EEZ's, and areas of high seas where appropriate.

While the IUU Fishing Enforcement Act increases authority to enforce legal wild capture fisheries practices at sea, there are many other legal considerations once seafood products are landed. Under the Lacey Act, civil violations are capped with a penalty of $10,000 USD, a misdemeanor. When a person knowingly violates the law, the cap is $100,000 USD, and for an organization, $200,000 USD. Penalties for felonies are up to $250,000 and $500,000 for individuals and organizations, respectively [44]. Inter alia regulatory shortcomings, enforcement mechanisms like civil penalties, clear forfeiture authority, and criminal fines and penalties need to be increased to properly deter fraud [13]. Despite the abovementioned fraudulent activities in section 4.1, many laws like the

LA or the Antarctic Living Marine Resources Conservation Act (ALMRCA) both have low civil penalty maximums, these penalties are often not effective deterrents of criminal acts [13].

U.S. Seafood Regulations - Inspections

In contrast to vessel inspections, once seafood is brought on land into the US market, the authority and subsequent regulations are fundamentally different in terms of accountability and process. Recent reports of substantial seafood mislabeling and other forms of fraud have caused greater scrutiny of seafood inspection laws and policies. Below is an overview of the current patchwork of interagency efforts regarding seafood inspections and current efforts to address those gaps.

The authority on seafood inspections are led by the Customs and Border Patrol (CBP) with the Department of Homeland Security (DHS), the National Marine Fisheries Service (NMFS) of NOAA, and the Food and Drug Administration (FDA) of the Department of Health and Human Services (DHHS). The authority, jurisdiction, and resources vary depending on the department, and overall inspection responsibilities are shared among agencies and departments. In addition to visual inspections, genetic and molecular techniques like DNA barcoding (i.e. using GenBank or Fish-BOL) and isotope analysis have drastically improved the inspection capabilities of industry firms, US government agencies, and NGO's [7,51]. Aside from US government agencies, advances in DNA barcoding have retrospectively identified a relatively high incidence of mislabeling of US seafood purchased at the retail and food service sectors – from 20% to nearly 60% depending on the species [18,31,37,52].

Customs and Border Patrol

Customs and Border Patrol (CBP) has a National Targeting and Analysis Group that deals with many cases of seafood fraud. Under the US Farm Security and Rural Investment Act of 2002, country-of-origin labeling COOL became required for retailers that sell seafood [7]. Unlike the FDA focused on safety and human health, the main goal for CBP is to enforce U.S. trade laws, although some food safety violations are uncovered. For all seafood imports, data is collected on type, value, and origin of seafood products, including assessment of Country of Origin Labeling (COOL) required for seafood imports [7]. COOL also requires farm or wild designation for fish and shellfish, however this is not required for processed food items [7]. The Task Force addressed concerns regarding the lack of CBP collaboration with other US government departments and agencies [13].

FDA Inspections – Human Health

Under the Food, Drug, and Cosmetic Act of 1938 (FDCA), The Bioterrorism Security Act (BSA) of 2002, and the FSMA of 2011 (FSMA), the FDA's main priority with respect to seafood inspections is human health. However, despite the FDA's focus on human health, seafood fraud violations are sometimes uncovered. From 2003-2008 the FDA incidentally identified economically motivated seafood fraud in 1% of seafood safety inspections [19].

As required by the Bioterrorism Act of 2002 and the Food Safety and FSMA, the Food and Drug Administration (FDA) inspects approximately 1-2% of seafood imports, and seafood firms must provide information pertaining to "one-up one-down" within their respective supply chain [6]. Since 1994 the FDA has used the Hazard Analysis Critical Control Point System (HACCP) to address food safety. While the goal of HACCP inspections is not to address economic adulteration, the program is relatively stringent, and requires seafood processors to develop and submit a plan to identify critical points where contamination can occur along with strategy for contamination mitigation [19]. Nevertheless, with longer supply chains in a globalized market, the focus on domestic supply and human health concerns has proven inadequate to fully address seafood fraud and IUU fishing.

To cite one example, in 2007 the FDA uncovered many cases of “pufferfish”, which contain tetrodotoxins harmful to human health that were labeled as “monkfish” [12]. To address these matters of high risk, the FDA keeps an “import alert list,” designed to inform field staff of potential issues and provides guidance with respect to prevalence of mislabeling (i.e. catfish and red snapper). Given 90% of seafood consumed in the US is imported, it is important to note that the FDA is limited in addressing seafood inspections of firms abroad. Out of 14,569 inspections conducted in 2008, only 61 were of foreign seafood firms [19]. Other issues of data accuracy remain. From 1993-2009, the FDA used the same species list despite 400 name changes of seafood products during that time. The recent passing of the Food Safety Modernization Act in 2011 has resulted in the largest expansion of FDA authority on food safety since the 1930’s [53]. As part of this expansion to address seafood product identification, in July of 2017, the FDA made considerable improvements to “The Seafood List,” now representing over 1,400 scientific names with common names and acceptable marketing names for the species listed [1].

NOAA Seafood Inspection Program – Economics, Labeling, and Safety

Since the Federal Agricultural Marketing Act of 1946, government agencies have had the authority to offer fee-for-service programs, mainly through the Seafood Inspection

Program (SIP). From a regulatory perspective, the issue of misrepresentation of seafood has been a concern for decades, even before the inception of NOAA in 1971. From 1988 to 1997, the NMFS and National Seafood Inspection Laboratory revealed that based on random selection of seafood vendors, 37% of fish and 13% seafood (shellfish, seaweed, etc.) products, were mislabeled [12].

In addition to the recently expanded vessel inspections at sea to address IUU products specifically, NMFS inspects seafood facilities through the SIP, which is available to "…vessel owners, processors, distributors, brokers, retailers, food service operators, exporters, importers, and those who have a financial interest in buying and selling seafood products…" [29]. In addition to the domestic FDA inspections program, the SIP inspects roughly 20% of domestic consumption and also inspects a limited amount of foreign facilities through a fee-for-service policy [13]. A GAO report in 2009 reported inspections of 375 domestic seafood firms, and 63 foreign firms.

In contrast to the human health focus for FDA inspections, NMFS inspects for economic integrity, labeling accuracy, and seafood safety through the SIP. In addition to the SIP, NOAA has the Quality Management Program (QMP), which applies HACCP principles to both food safety and economic fraud. In 2008, 202 domestic seafood companies were inspected. Under the QMP inspectors, weight is recorded before and after processing and species identification is verified through genetic and molecular techniques [19].

Interagency Collaboration and Conflict

The 2014 US Government response to address seafood fraud and IUU initiated via presidential memorandum solicited input from over 20 government agencies and departments [32]. This revealed an incredibly complex patchwork of regulations and policies to coordinate and enforce regulations and policies. US regulations and enforcement mechanisms lack appropriate penalties to deter fraud given the lack of interagency coordination required, these laws are difficult to enforce in practice.

The Magnuson-Stevens Fisheries Conservation and Management Act (MSA) "…prohibits import of fish taken in violation of foreign law..." [47]. However, lack of interagency cooperation within the DHS between US Immigration and Customs Enforcement (ICE), Homeland Security Investigations (HIS), and CBP has proven prohibitive to enforcement [13]. With the help of the IUU Fishing/Seafood Fraud Committee (FSFC) (formerly the Presidential IUU Fishing/Seafood Fraud Interagency Task Force) within the NOC, 15 recommendations were laid out in 2015 with specific plans of action across over a dozen agencies to allocate strategic responsibilities [13]. With respect to the DHS, the FSFC calls for expanded interagency information, and targets a number of these collaborative gaps in federal governance. The CBP's Commercial Targeting and Analysis Center (CTAC) collects valuable data that is now accessible for other agencies that can encounter seafood products [13,54].

The FDA, NMFS, and the CBP have different missions to fulfill and are under different departments in the United States government, each with their own laboratories, species list, and other methods of fulfilling their obligations [30]. However all agencies inspect seafood products as they are imported or shipped across seafood supply chains. While the FDA and CBP inspections are purely regulatory, the fee-for-service approach by NMFS has been criticized for potential conflict of interest given that private industry pays for inspection services which are also a critical arm of the seafood fraud enforcement mechanism in the United States [13].

Issues of redundancy for inspections of seafood facilities have long been an issue going back to 1974 and remain a challenge. In that year, the FDA and NMFS signed a memorandum of understanding to better coordinate (MOU) [30]. In 2007, the FDA inspected 104 seafood facilities that were also inspected by NOAA in that same year, and the FDA inspected 1,464 seafood operations that were not inspected by NOAA. In 2009 a revised MOU was signed to continue to improve efficiency of inspection resources and reduce duplicate inspections [30]. Issues of redundancy and information sharing with respect to species lists are still being addressed through legislative and executive actions due to IUU FSFC recommendations.

Current and Future Developments

Mandatory Product Traceability for US Imports

As part of the effort to improve enforcement, actions have already been taken to improve inspection of seafood imports and lay out mandatory traceability practices for the US seafood industry, most notably the Final Rule via executive order for the Seafood Import Monitoring Program. In response to recommendations 14 & 15 laid out by the Task Force in 2015, the IUU FSFC and NOAA recently announced in February of 2016 that they will be implementing traceability programs for over 200 species, and the NOC will soon be developing “minimum types of information required” for the purposes of traceability of these products. The species listed represent approximately 40% of the domestic market for consumption in the United States and are in part a result of a two public comment periods, including 25% of input from international stakeholders [21].

Some firms within the seafood industry view this announcement as a regulatory burden. some firms have implemented traceability as a tool to track their products regardless of impending government mandates [55]. On December 6, 2016, several US seafood companies led by the National Fisheries Institute and Alfa International Seafood, Inc. filed a lawsuit against the United States Government in response to the Final Rule regarding traceability requirements established by the Task Force in 2016. The plaintiff's complaint was that the mandatory traceability requirements would "…force seafood processors to adopt costly changes to the way in which seafood is processed, thereby significantly increasing the cost to the consumer" [56]. On June 22, 2017, a decision was made not to overturn the new traceability requirements. Because of this new ruling, new permitting, data recording, and recordkeeping for over 200 species of imported seafood products will be mandatory for seafood importers. More specifically, the new regulation would require the following key data elements (KDE): name of harvester, country of origin, license, scientific name, common name, gear type, when caught, where caught, wharf location, when landed, name of buyer, and importer proof of chain of custody. These new requirements for over 200 species becomes effective January 1, 2018 [57]. US importers are not required to share this information with businesses downstream in their supply chains.

Governments rely on customs data to monitor global commerce through a system called the International Harmonized Commodity Description and Coding System (HS). The US government manages HS codes through the Harmonized Tariff Schedule (HTS). Every type of commodity is assigned a series of numbers six to nine digits in length, describing a variety of attributes for a given product being imported into the United States. Currently 9.9% of the commodities in this system are at species level resolution [58]. If HS codes had increased data granularity, through proper training governments and customs officials around the world could provide improve traceability and transparency to address IUU Fishing and seafood fraud [59]. In the near future, this mechanism could enhance efforts for government agencies and customs officials to conduct mass balance validation of imported and exported product [59][60].

International Developments in Mandatory Seafood Regulations

In addition to the United States, other countries have established traceability requirements for seafood, most notably Japan and the European Union (EU). For EU countries, the "European Union Food Law and Hygiene Package" established "one-back, one-forward" data requirements to ensure product identification and labeling to ensure food safety standards. These regulations are coupled with the "European Union Rules to Combat Illegal, Unreported, and Unregulated Fishing," closing loopholes on unverified product which must be certified by the inspection agency.

Japan already had labeling requirements as required by the Japan Agricultural Standard (JAS), in 2007 Japan also passed the "Ordinance for the Enforcement of the Food Sanitation Act," the first legal requirement for storage of seafood traceability type information [2]. Largely driven by food safety concerns, Japan, Europe, and the United States and many other countries have implemented seafood traceability requirements. While most of the global north has ratcheted up traceability requirements, the Chinese government has not matched regulatory efforts.

China is the largest consumer of seafood globally, and the world's largest exporter of seafood [18,60]. From 2010-2014, Chinese food imports doubled in value, and from 2007-2008, mislabeling of Chinese food imports to the United States accounted for 22% of US food import violations [61,62]. According to the USDA Foreign Agricultural Service, 90% of U.S. seafood exports to China are "re-processed" or "secondarily processed" and sold to other nations, often back into the United States [60,63]. While there are many reasons for the rapid growth in China's seafood re-processing industry, trade regulations allowing tariff-free processing and re-export practices have incentivized exportation to China for processing [60]. The two main regulatory agencies in China related to seafood traceability: The China Inspection and Quarantine Bureau (CIQ) and China Customs Administration (CCA), are together tasked with food safety monitoring (CIQ) and import and export control (CCA). There is evidence that these two agencies do not have the capabilities to adequately control imports and exports of illegally sourced fish [60].

Voluntary Traceability Developments

While the US government has ramped up enforcement to mitigate illegal fishing at sea and more rigorous data requirements for over 40% of US seafood imports, many companies and organizations around the world have implemented voluntary product traceability practices both internally and externally through business-to-business traceability (BBT) [6,20]. With business efficiency and corporate social and environmental sustainability as the key drivers, many businesses have pursued voluntary traceability of product to improve reputation, increase shelf life, lower costs, and increase productivity [20]. For many companies, implementation of product traceability systems increased value to their business, and return on investment was achieved within a relatively short time frame [6]. To develop networks engaged in traceability solutions, government and non-government organizations (NGO) are developing public-private arrangements to implement and improve catch documentation and traceability systems (CDTS), particularly in the global south. The US Agency for International Development

(US AID), the Global Food Traceability Center (GFTC), and several other NGO's have initiated voluntary adoption of traceability technologies through programs such as the Global Dialogue on Seafood Traceability initiated in March of 2017 [33,64]. Nevertheless, many challenges remain including but not limited to improved catch documentation in the global south and other small-scale fisheries, and continued lack of interoperable and paralleled proprietary traceability systems [20]. How exactly the regulatory requirements and voluntary efforts will align to standardize and/or harmonize the current state of heterogeneous traceability systems is largely unknown [20]. As new regulations are introduced in the United States and around the world, organizations like GS1 and the International Organization for Standardization (IOS) have been and will continue play a pivotal role in future traceability developments.

Discussion

Consumers in the United States increasingly want to understand where their seafood comes from and are willing to pay more for this information [41,65]. A 2016 study of 1,000 registered voters found that 76% of US consumers would pay more for "legally caught and honestly labeled seafood [65]." This sentiment aligns with many of the recent decisions by the US federal government. Despite the formation of the NOC and efforts to streamline interdisciplinary and interagency collaboration, shortcomings regarding the capacity to ensure the authenticity, safety, and sustainability of seafood through traceability will likely continue to challenge public-private seafood governance.

Like many other issues addressed by the US National Ocean Policy, the trend towards more data, more collaboration, and increased enforcement and regulation seems fundamental to the actions of US agencies. As a result, the executive and legislative branch of the US government have responded with two regulations: IUU Fishing Enforcement Act and the Seafood Import Monitoring Program set to begin January 1, 2018. As part of this coordinated effort, several legislative and executive actions related to seafood have been issued to address several gaps in the regulatory framework.

Under the leadership of the NOC, the IUU FSFC has fostered improved agency and departmental collaboration. While recent executive and legislative actions have begun to address the issue, the current patchwork of government efforts between the FDA, NOAA, CBP, and others may limit efforts to resolve overlapping responsibilities, redundancy, and interoperability of data information systems. The International Trade Data System (ITDS) issued via Executive Order in 2014 is currently underway and involves the collaborative efforts of 47 US government agencies; this effort aims to provide a one-time, single portal for data requirements regarding the import and export of products, including seafood [45]. This interagency effort is designed to reduce costs for businesses and government, assist with real-time interagency decisions, and convert three paper-based government programs to an electronic format [66]. While this system should improve interoperability of data between agencies, the data will not be available to industry or the public [2].

In response to evidence of slave fishing, economic adulteration, illegally harvested products, and threats to human health and national food security, the US Government has joined the EU in launching a rigorous set of regulations that will impact the global seafood market. For example, the impending Seafood Import Monitoring Program alone is estimated to affect about 40% of the US market [57]. However, uncertainty about the effectiveness of future and proposed regulations to protect consumers and support industry remains. Depending on the type of seafood firm and their fundamental role in seafood systems, these recent and impending regulatory developments initiated by the US federal government may elicit a diverse array of perceptions and attitudes. What are the key challenges and opportunities for industry related to these regulatory developments? To date, these insights associated with traceability developments have not been explored and merit further investigation on the US seafood industry to highlight challenges and offer potential opportunities moving forward.

To address these gaps, our knowledge requires that we consider a number of questions. Is traceability currently an important component to seafood firms and their operations? Which components of traceability are most important and utilized by seafood firms? Does industry believe current and future traceability developments will effectively address the pressures and threats to the seafood industry? Will industry have ample time and resources to adapt to the upcoming changes? Are there certain types of seafood firms that are most prepared for future traceability developments? Which types of firms within the industry demonstrate collaborative businesses practices? Which firms will be "left behind"? What insights could contribute to improving the US regulatory environment? In consideration of these and other questions, future research on the seafood industry could better illustrate the current landscape of perceptions and attitudes surrounding traceability to foster potential solutions and a path forward.

Conclusion

Compared to financial, automobile, and other sectors in society, we are currently in the early stages of seafood traceability developments, and governments in the global north are ratcheting up requirements impacting many seafood companies around the globe. We are witnessing the proliferation of multiple proprietary traceability platforms to address market and regulatory demands [20]. It is unclear how traceability will evolve over the next twenty years. We assume there will be substantial progress in regulatory efforts regarding seafood safety and sustainability issues. Nevertheless, in twenty years how much of the world's fisheries will be under electronic data management systems, and how will that data be shared among industry firms, government, and consumers? How will the insights and industry perspectives influence traceability developments?

Seafood regulations and policies continue to expand in the global north, and as cited by Freidman (2017), it will be important to enable flexibility in the legal framework to properly distinguish between "good faith mistakes" and "bad faith actors" [67]. This will be difficult, however. To the extent possible, careful and creative policymaking that includes industry's knowledge and day-to-day insights will be critical. Whether the new onslaught of regulatory solutions will allow for this flexibility in uncertain, but these efforts must incentivize good behavior, and preclude "bad actors" from exploiting the patchwork of regulations and government agencies tasked with upholding seafood governance. Many challenges remain. However, both mandatory and voluntary adopted traceability systems in the US and internationally will continue to address the authenticity, safety, and social, economic, and ecological sustainability of seafood.

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Seafood traceability: perspectives, attitudes, and insights across value chains of the US West coast seafood industry

Abstract

Seafood traceability has been perceived as a tool to address recent pressures and impending regulatory demands on the United States seafood industry. Traceability research efforts have focused on downstream firms and regulatory drivers, and to address gaps in current research, we investigated the current landscape of varying attitudes, perspectives, and level of importance from industry professionals across value chains in the largest seafood hub in the United States. Supported by background interviews and semi-formal focus groups, an online questionnaire targeting west coast seafood professionals reveal a general lack of awareness of the Seafood Import Monitoring Program (SIMP), variation for perceived importance of traceability features was statistically significant when compared to value chain characterization and size of firms represented by respondents. Overall compatibility of data was the least importance feature of traceability according to respondents in aggregate. Depending on value chain characterization and size of firms represented, perception of future developments varied. Respondents indicated an overall positive perception for the potential effectiveness of traceability to address IUU and seafood fraud. In general on average, compared to respondents representing smaller firms that were single sector and/or associated with wild capture fisheries, larger firms that were vertically integrated and/or associated with aquaculture were generally more knowledgeable, prepared, and had a higher perceived importance of traceability. Whether market or regulatory driven, a large majority of respondents acknowledge traceability as a phenomenon that is “here to stay.”

Introduction

Given concerns of social, economic, and ecological sustainability, demand for seafood product information has driven rapid change in markets and regulations across an already diverse, complex, and globalized seafood system. For over a decade "traceability" has been touted as a critical concept and a mechanism to address a wide array of challenges and opportunities for fisheries, aquaculture, and other seafood related companies along the entire supply chain [5]. There is pressure from environmental and non-government organizations, consumers, and the media to address a broad range of issues, including the safety, quality and sustainability of seafood. DNA barcoding studies have revealed significant issues related to mislabeling and seafood fraud of domestic and imported seafood products from harvest to point-of-sale [16,18,31,39,41,65,68–71]. Accurate, transparent, and traceable product origin, identification, and other key data elements (KDE) are essential components for upholding human health, tackling economic fraud, avoiding consumer deception, and other potential benefits for firms and their value chains [6,12]. Despite the requirements laid out in the Bioterrorism Act of 2002 and the continued efforts stemming from the Food Safety and Modernization Act of 2011, evidence suggests that both the US federal government and industry often lack the capacity and ability to ensure the authenticity, safety, and sustainability of products [13,19,30]. In response to these shortcomings, the US government has responded through legislative and executive actions recommended by the IUU Fishing/Seafood Fraud Committee (FSFC) (Illegal, Unreported, and Unregulated) assembled through the National Ocean Council (NOC) [12,43].

The new Seafood Import Monitoring Program (SIMP) requires US seafood importers to collect and provide a new set of product information for over 200 species of imported product effective January 1, 2018 [56,57]. This is a major leap in regulatory requirements issued by the US government regarding traceability type information (Table 3.1). The new data requirements for US importers must be linked to the original vessel or farm associated with harvest and/or production, however, US importers are not required to share that information with other firms or the public.

Table 3.1. Timeline of major traceability related regulatory developments in the United States since 1900.

Date	Regulations	Description
1900	Lacey Act	Prohibits fish products taken or imported in violation of a foreign law or treaty [44]
1938	Food, Drug, and Cosmetic Act	Addresses rebranding of food, and sets guidelines for acceptable marketing names [12].
1946	Agricultural Marketing Act	Enabled fee-for-service inspection programs offered by government agencies [19].
2002	Bioterrorism and Safety Act*	Gives federal agencies the authority to establish requirements for "immediate prior sources… and subsequent recipients"[6]
2009	Country of Origin Labeling	Requires retailers to provide COO, farmed vs. wild product. Put pressure on firms upstream to provide that information [12]
2011	Food Safety and Modernization Act*	Focused more heavily on food contamination
2014	ITDS Executive Order	Collaboration between over 45 agencies to develop single portal data entry for firms, enhances efficiency [45]
2015	IUU Fishing Enforcement Act	Expanded the role of the Coast Guard and other agencies to enforce illegal fishing in the US EEZ and other countries
2018	Seafood Import Monitoring Program*+	Requires key data elements for over 200 species of imported products to the US, including vessel

+This regulation was upheld by a federal circuit court judge in June of 2017, leaving six months for industry compliance measures to be implemented.
*These regulations represent instances where "traceability" was codified or implemented explicitly.

The United States imports approximately 90% of total seafood consumption and is the second largest consumer of seafood in the world. New requirements will create challenges for producers in the global south and other export regions, and for buyers, retailers, restaurants, and other firms in the United States [20,29]. Cost of record keeping alone associated with SIMP has been estimated around 53 million USD [72].

There are many benefits to traceability. It serves to reduce operating costs, increase productivity, increase efficiency, reduce contamination risk, and increase competitive advantage [6,73]. Others benefits include enhanced product quality, improved inventory controls, and decreased risk of IUU products [6,24]. As regulatory requirements mount in the global north, seafood companies around the world increasingly pursue traceability voluntarily beyond regulatory compliance [2,6,20]. In Sterling et al (2015), seafood firms indicated that traceability brought value to their individual firm and to partner firms within their respective value chains. In fact, traceability was viewed as an effective way to generate over eight realized benefits, including improved product quality, product recalls, inventory tracking, food safety, customer service, and increased ability to meet consumer demand, and verify date and location of harvest [6]. To date much of the traceability research and dialogue have been largely focused on downstream firms (e.g. retail, food service, chefs, end consumers), consumer transparency, and regulatory drivers [7,20,55,58,74]. Consumer choice and regulatory compliance are critical elements of the broader traceability dialogue. Discussed below, our study aims to address potential knowledge gaps regarding current traceability related practices and perceptions within seafood firms across value chains.

Scores of publications related to "seafood traceability" were reviewed that examine the status of government regulations and enforcement mechanisms [5,7,12,58,75,76], IUU and fraud and mislabeling [37,52,77,78], and genetic and molecular techniques in species identification and technological advancements [16,17,31,51,79,80]. Additionally, many of these studies have focused on only one seafood sector or component to value chains. Previous traceability studies focus on value chains [2,6,20,24–26], but failed to address the insights, perspectives, and attitudes of the seafood industry across multiple seafood sectors. "Sectors" pertains to different firms or "nodes" that have distinctive roles within value chains, including production (e.g. wild capture fisheries), processing, distribution, or food service (e.g. restaurants), to name a few. To address this gap in the current knowledge, this research examines the perspectives and attitudes of people and their associated firms and sectors through a value chain approach. Participants representing firms from harvest to point-of-sale were examined in the largest region of fisheries and aquaculture production along the West coast of the United States. One of the top global seafood hubs, this region represents nearly a third (27% in 2012) of total US seafood sales and typically supports over a quarter million fisheries and seafood jobs in Alaska, Washington, Oregon, and California [27].

Value chain characteristics are a critical consideration to understanding capacity and opportunities for traceability [6]. This research builds off these previous insights, utilizing a value chain approach to investigate a series of questions and offers a window into the perceptions and practices of those that are most closely tied to seafood resources. We ascertain this provides a unique opportunity to identify potential problems, solutions, and possible explanatory factors associated with the challenges and opportunities for firms, their sectors, and the regional industry as a whole.

The following research questions were pursued:

1) How important are traceability system components and traceability type information to respondents? Which components and information are most important, and how does this differ between firms and sectors?
2) Do firms demonstrate traceability in practice within their organization? What are the varying perspectives and attitudes regarding traceability challenges?
3) At present, what is the relative level of preparedness for the anticipated regulatory and market driven traceability developments at present and in the future? Which types of firms and/or sectors are better equipped than others for these developments?
4) Are respondents in favor of increased government regulations, and how does perception of regulatory requirements differ across sectors, sizes of firms, location, and other demographics?
5) What are the general perceptions of benefits and costs to individual firms, across value chains, and to the broader industry according to respondents?
6) How do seafood firms view the importance of traceability and traceability type information for supporting transparency and consumer choice?

7) What are current status of general information sharing and communication between firms and sectors within the sample population?
8) Do current and impending regulatory requirements and broader traceability developments effectively address the pressures and threats to the safety, quality, and sustainability of seafood in the future? How does this differ between sectors?

Methods

This research was conducted through a mixed-method design, using qualitative techniques to prioritize and "validate" the design of the quantitative questionnaire. Primary and secondary literature were reviewed for Phase one. After phase one, employees, contractors, and/or owners of seafood firms and/or organizations were asked to participate in phases two and three of the research which are summarized in detail below. Participants generally represented positions of leadership and authority within seafood businesses or supporting organizations. Initial participants were selectively sampled based on already established relationships with Oregon State University.

Phase One: Review of Primary and Secondary Literature

Phase One incorporated a comprehensive literature review on seafood traceability through primary literature, secondary literature, white papers, internal documents, and gray literature. Key topics from the review were identified to inform the design of the qualitative and quantitative data collection processes in Phases Two and Three, respectively. For a more comprehensive literature review, please see Chapter 2, "Seafood traceability: a review of regulatory drivers in the United States and the global north".

Phase Two: Semi-Structured Interviews and Focus Groups - Qualitative

Semi-structured interviews and semi-formal focus groups were conducted from July to September 2016 aiming to develop a background understanding of regional industry perspectives, and to identify and prioritize key traceability concepts and issues for research in phase three. Qualitative data were obtained through twelve, semi-structured, ninety-minute background interviews with fifteen representatives from the seafood industry. To the extent possible, interview participants represented small, medium, and large firms from Oregon and Washington, and included sectors from regional value chains from firms representing harvest to point-of-sale (e.g. wild capture fishermen, aquaculture, processors, wholesalers, distributors, retail, restaurants, and industry organizations). Participants were contacted based on pre-existing relationships with the Coastal Marine Experiment Station, the Seafood Laboratory, and Oregon State University more broadly.

Interview discussion questions investigated general perceptions regarding seafood product traceability as a tool to address safety, quality, and sustainability of products, the role of government versus the market, and future expectations of traceability developments. See Table 3.24 for interview and focus group outlines. Participants shared their opinions from their perspective as members of the regional seafood industry. Members of the research team captured observations through field notes. Qualitative data from field notes were classified into fourteen themes for further investigation (Table 3.25).

Building on the interviews, two semi-formal focus groups were designed and conducted with twelve members of the regional seafood industry, each lasting approximately two hours. Two groups of five and seven individuals were held in Portland and Newport, Oregon, respectively. Semi-formal focus groups were designed to facilitate guided discussion on key priority traceability issues as highlighted from the literature as well as the individual interviews. The Newport Group was more representative of "upstream" value chain members of the regional industry (e.g. harvest, processing, etc.), and the Portland Group was more representative of "downstream" members (e.g.

distribution, retail, food service). The core objective of the two semi-formal focus groups was to identify perspectives, attitudes, potential discrepancies and/or consensus among participants as they relate to current and emerging seafood product traceability issues, summarized in Table 3.25. To ensure alignment among participants, general background information was provided on traceability drivers, challenges, opportunities, regulations, trade issues, technologies, and other information [81]. Observations were recorded through field notes and classified into primary, secondary, and tertiary topics (see Table 3.25, Appendix A).

Phase two provided background information helpful in identifying primary, secondary, and tertiary topics to conduct Phase Three. As part of phase three, these topics and the literature review in phase one informed the overall design and scope of the electronic questionnaire discussed below.

Phase Three: Online Questionnaire – Quantitative

Fourteen primary, secondary, and tertiary themes were identified and informed the design of a thirty question online questionnaire. Before electronic implementation of the questionnaire, the questionnaire was beta tested with a select group of ten industry professionals representing a wide array of sectors and sizes and businesses (Qualtrics, Provo, UT, 2013) (see questionnaire, Appendix B). The questionnaire was designed for owners, employees, and/or contractors of firms representing sectors of seafood value chains along the West coast of the United States, including Alaska, Washington, Oregon, and California (see Table 3.2 for firm classifications). Prior to beginning the questionnaire, all participants were presented a modified definition of seafood product traceability drawing upon universal themes from five existing definitions (see Table 3.3):

"Seafood traceability is defined as a seafood information system and/or process that includes elements of recording, storing, and sharing seafood product information within and amongst businesses, consumers, and other entities."

Table 3.2. Firm classifications of respondents used in the analyses.

Sector/Firm Classification	First Aggregation[1]	Second Aggregation[2]
Harvester- Wild Caught (WC)	WC*	Upstream[3]
Harvester- Aquaculture (AQ)	AQ*	Midstream[4]
Primary Processor	Processor*	Downstream[5]
Secondary Processor	"Midstream" Sectors*	Vertically Integrated[6]
Importer	Retail or Food Service*	
Wholesaler	Multiple, upstream, wild (M-U,WC)	
Exporter	Multiple, upstream, farmed (M-U,AQ)	
Distributor	Multiple, midstream (M-M)	
Retail Small	Multiple, downstream (M-D)	
Retail Large	Vertically integrated[6]	
Food Service		
Other Food Service		
Direct Sale		
Other Supporting Organization		

[1]Given the low sample size in some categories, this series of value chain characterizations was used for several analyses.
[2]In some analyses, this was further aggregated into "upstream," "downstream," and "vertically integrated." In these instances, "midstream" was classified as "downstream."
[3]One to four sectors selected, included wild caught or aquaculture production, and no point-of-sale sectors selected.
[4]One to four sectors involving distribution, export, import, or wholesale
[5]One-four sectors including at least one point-of-sale sector and no harvest or processors selected.
[6]Five ore more sectors selected, with at least one from upstream, midstream, and downstream.
*Respondents selected only one sector out of all classifications provided (n=85). All others respondents indicated two or more sectors as part of their firm.

Table 3.3. Traceability definitions from the literature. For the participants in this study, the definition above (pg. 54) was suitable given the varying levels of education and prior knowledge of traceability issues.

Traceability definitions
The ability to systematically identify a unit of production, track its' location and describe any treatments or transformations at all stages of production, processing and distribution" [22]*
The ability to trace the history, application or location of an entity by means of recorded identifications
The ability to assess any or all information related to that which is under consideration, throughout its entire life cycle, by means of recorded documentations [23].
The recording of information as the product makes its way through the supply chain, and the ability to identify in real time where a product is and what processes it has undergone [5].
The ability to follow a product back through these processes from the consumer to their origin [5].
The ability to follow or study out in detail, or step by step, the history of a certain activity or process

*This definition was adopted by EC Regulation 178/2002 established by the European Parliament [73].

Phase Three: Participant Recruitment

Through the snowball technique employed in this research, 120 initial participants were recruited electronically via email from a personal database and with the assistance of regional commodity associations, public records requests through state agencies, state Sea Grant organizations, and food service associations. Initial respondents were issued a personalized pre-notification letter, and repeated contacts were made within short time intervals to assist with survey implementation [82].

Consistent with a snowball technique, these initial research subjects served as "knowledge of insiders" and were utilized to increase our recruitment efforts [83]. Upon being contacted, these individuals were solicited to a) take the online questionnaire and b) forward the questionnaire to their colleagues, fellow members of their supply chains, or other members of the seafood industry within the geographic and demographic scope of the research.

To prevent duplicative responses, questionnaires were password protected and provided only to those contacted directly or via knowledge insiders. To the extent possible, the questionnaire asked questions to ensure verification of eligibility and preclude participants not suitable for the study (e.g. non-industry members).

Phase Three: Survey Design and Data Collection

Data from completed surveys were collected via email in June and July of 2017. Most questions used a four-point scale via Likert scales (e.g. 1="not important", 4-"extremely important"; 1="strongly disagree", 4="strongly agree") and gathered continuous data. Some questions were structured as dichotomous and/or binary variables (e.g. yes or no). Categorical data were collected on respondents' reported gender, age, geographic location, firm size (by average annual revenue), number of species, level of education completed, number and type of sectors involved, and professional roles of respondents within firm or organization (e.g. CEO, quality control, vessel captain, aquaculture manager, etc.). Overall questionnaire results were provided to respondents upon request, and participants were provided project hat in exchange for their time. Table 3.26 (Appendix A) summarizes variables measured in the online questionnaire and explored in this paper.

Phase Three: Data Analyses

Building on the value chain approach, questions were used to “scaffold” traceability concepts throughout the questionnaire and measured variables in four tiers: individual firm, across value chain(s), broader industry, and end consumers. Chi-square, and ANOVA tests were employed to evaluate the statistical significance and strength of associations between categorical, dichotomous, and continuous data.

To address the research questions at hand, several variables were aggregated into dichotomous or categorical variables and recoded accordingly for subsequent analyses. New dichotomous variables were computed for education (e.g. college, no college), age (e.g. under 50 years, over 50 years), and number of species handled (5 species or less, more than 5).

To understand interactions between variables compared to the numbers and sectors selected and represented by the respondents, data were recoded accordingly (e.g. single sector, multiple sectors (two to four), five or more sectors). Responses to sector classifications were likewise recoded and aggregated into “upstream,” “midstream,” downstream,” and “vertically integrated” sector classifications to broadly characterize the firm within the value chain. While previous research has identified "vertically integrated" as firms that are "involved with transactions or processes at more than one node in the supply chain…" [84], this study took a narrower definition: five sectors (e.g. nodes) or more and at least one sector from harvest and/or processing ("upstream" firms), at least one from distribution, wholesale, import/export ("midstream" firms), and at least one from point-of-sale firms ("downstream" firms). A summary of these variable aggregations is provided in Table 3.2.

Factor analyses were conducted on continuous scale variables via Principal Components Factor Analysis (PCA). Consistent with standard PCA methodology, responses to scalar variables that were statistically significant were aggregated through computation of new indices based on means of responses [85]. Prior to computation of these indices, consistency of scales measuring general perceptions and attitudes were examined using Chronbach alpha reliability coefficients (>.65). These groups included attitudes towards traceability challenges, potential benefits to individual firms, across value chains, and the broader industry, the role of government, importance of traceability features, and general outlook on future traceability developments.

K-Means cluster analyses were conducted to evaluate trends among respondents, and each cluster was computed into a new categorical variable accordingly. Cluster analyses were employed to examine variation, interactions, and relatedness between and among responses related to traceability features, attitudes towards information for consumer transparency, and attitudes regarding the future. Table 3.27 in Appendix A provides a summary of computed variables from data aggregations, PCA, and K-Means Cluster analyses.

We assumed survey responses were of normal distributions and that respondents were representative of the general population (e.g. individuals involved in the west coast seafood industry). To indicate the strength and nature of relationships and/or differences between variables, effect sizes were calculated for chi-squared tests involving dichotomous variables (Cramer's V), categorical variables (Phi, ϕ), and ANOVA tests (eta, η). Strength of the associated variance between variables was reported with language consistent with Vaske ("minimal," "typical," "substantial") (2013) [85]. Questionnaire responses of "not applicable," "not sure," and missing values were removed to allow for statistical analyses. All statistical analyses were conducted in SPSS 22.0 for Mac [86]. For the purposes of this study, "organization," "business," and "firm" are all referred to as "firms." Response rate could not be quantified given the snowball technique used to recruit participants.

Results

Data Summary

185 surveys were received electronically from individuals averaging 51 years of age and representing seafood firms from sectors based within coastal states of the USA (AK, WA, OR, CA, and HI) (Figure 3.1). Individuals were 74% male, 26% female, with 78% residing in the states of Oregon and Washington alone. 42% of respondents classified themselves as CEO, president, or company owner, and ages of respondents ranged between 20 and 90 years, with most respondents over 50 years of age. Overall, respondents were well educated and perceived themselves as relatively knowledgeable of

traceability concepts and issues; 91% indicated they had either a high level or moderate level of understanding of traceability. 62% of respondents reported a bachelor's degree or higher for highest level of education completed. No statistical significance was found between size of firm and value chain characterization of firm. For the purposes of this study, "value chain characterization" indicated whether the respondent's firm was single sector vs. multiple and/or vertically integrated, and which sectors were represented in the practices of any firm represented by each respondent. See Table 3.4 for a summary of demographic characteristics of all respondents to the online questionnaire. Frequency of types of firms are summarized in Figure 3.2.

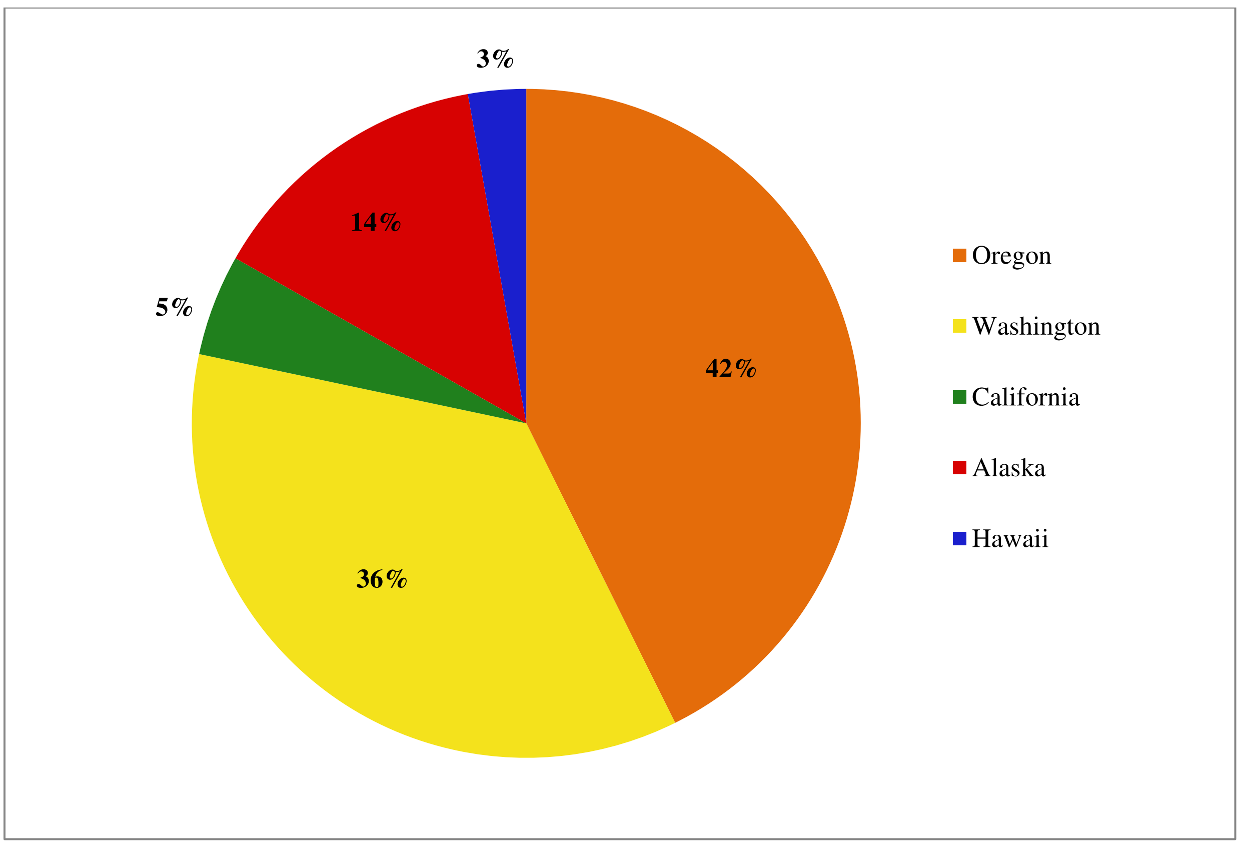

Figure 3.1 Geographic location of respondents' based on where firm or organization resides in US states along the west coast (n=143).

Table 3.4 Demographic characteristics of survey respondents (*N*=183). Values are shown as percentages within each firm category along the top row. Parenthetical values are counts.

Demographic characteristics	WC[1] (n=33)	AQ[2] (n=16)	Processor[3] (n=20)	Mid[4] (n=9)	Food Service or Retail[5] (n=33)	M-U, WC[6] (n=14)	M-U, AQ[7] (n=7)	M-M[8] (n=19)	M-D[9] (n=10)	Vertically Integrated[10] (n=22)
Age (Mean, std)	(53.48, 13.12)	(48.46, 15.97)	(53.71, 13.57)	(47.12, 13.93)	(48.50, 15.29)	(53.75,12.08)	(54, 7.54)	(52.63, 9.16)	(50.67, 10.61)	(46.67, 13.27)
Range	20-74	22-70	30-72	27-65	26-90	30-71	45-65	35-64	33-64	24-71
Gender										
Male	67 (16)	54 (7)	82 (14)	67 (4)	73 (19)	83 (10)	83 (5)	100 (16)	67 (6)	67 (12)
Female	33 (8)	46 (6)	18 (3)	33 (2)	27 (7)	17 (2)	17 (1)	0 (0)	33 (3)	33 (6)
Location										
OR	59 (13)	0 (0)	47 (8)	16.7 (1)	68 (15)	46 (5)	33 (2)	25 (3)	44 (4)	27 (4)
WA	23 (5)	77 (10)	18 (3)	33 (2)	23 (5)	46 (5)	67 (4)	50 (6)	33 (3)	47 (7)
AK	0 (0)	15 (1)	6 (5)	0 (0)	5 (1)	0 (0)	0 (0)	17 (2)	0 (0)	0 (0)
CA	18 (4)	8 (1)	30 (5)	33 (2)	5 (1)	9 (1)	0 (0)	0 (0)	11 (1)	27 (4)
HI	0 (0)	0 (0)	0 (0)	17 (1)	0 (0)	0 (0)	0 (0)	8 (1)	11 (1)	0 (0)

[1]Wild caught harvester or fisherman
[2]Aquculture harvester
[3]Combined "primary" and "secondary" processors. Represents only one sector selected.
[4]Combined "Wholesaler/Importer/Exporter/Distributor. Represents only one sector selected.
[5]Combined "Retail-Large," "Retail-Small," "Restaurants," and other food service. Represents only one sector selected.
[6]Combined respondents that selected multiple sectors tied to wild caught production.
[7]Combined respondents that selected multiple sectors tied to aquaculture production.
[8]Respondents that selected 2-4 sectors that didn't include any firms involved in production (harvest) *and* point-of-sale sectors.
[9]Respondents that selected 2-4 sectors that included any downstream firms (food service, retail (small or large), or direct sale).
[10]Vertically integrated was for respondents that had to include at least one sector from harvest, mid value chain, and point-of-sale firms. Also had to have 5 or more sectors selected by respondents.

Table 3.4, Continued.

Demographic characteristic	WC (n=33)	AQ (n=16)	Processor (n=20)	Mid (n=9)	Food Service or Retail (n=33)	M-U, WC[6] (n=14)	M-U, AQ[7] (n=7)	M-M[8] (n=19)	M-D[9] (n=10)	Vertically Integrated [10] (n=22)
High school/equivalent	21 (5)	0 (0)	12 (2)	17 (1)	4 (1)	0 (0)	0 (0)	6 (1)	0 (0)	11 (2)
Some college, no degree	25 (6)	0 (0)	12 (8)	17 (1)	24 (6)	25 (3)	17 (1)	6 (1)	45 (4)	22 (4)
Trade/tech/vocational	0 (0)	0 (0)	0 (0)	0 (0)	4 (1)	0 (0)	0 (0)	19 (3)	0 (0)	0 (0)
Associate degree	13 (3)	17 (2)	6 (1)	0 (0)	12 (3)	0 (0)	0 (0)	0 (0)	0 (0)	6 (1)
Bachelor's degree	25 (6)	58 (7)	41 (7)	50 (3)	36 (9)	67 (8)	67 (4)	31 (5)	22 (2)	44 (8)
Master's degree	4 (1)	17 (2)	17 (3)	17 (1)	16 (4)	8 (1)	17 (1)	31 (5)	22 (2)	17 (3)
Professional degree	13 (3)	8 (1)	0 (0)	0 (0)	4 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Doctorate degree	0 (0)	0 (0)	12 (2)	0 (0)	0 (0)	0 (0)	0 (0)	6 (1)	11 (1)	0 (0)
Species Handled/Managed										
0 to 5	74 (17)	77 (10)	30 (5)	17 (1)	15 (4)	17 (2)	50 (3)	6 (1)	22 (2)	39 (7)
6 to 15	26 (6)	23 (3)	30 (5)	50 (3)	27 (7)	25 (3)	0 (0)	25 (4)	33 (3)	17 (3)
16-30	0 (0)	0 (0)	6 (1)	0 (0)	31 (8)	17 (2)	17 (1)	25 (4)	22 (2)	17 (3)
31-50	0 (0)	0 (0)	18 (3)	17 (1)	15 (4)	17 (2)	17 (1)	31(5)	11 (1)	6 (1)
50+	0 (0)	0 (0)	18 (3)	17 (1)	12 (3)	25 (3)	17 (1)	13(2)	11 (1)	22 (4)
Traceability Knowledge										
None	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Very Little	24 (8)	6 (1)	5 (1)	11 (1)	12 (4)	14 (2)	0 (0)	0 (0)	0 (0)	0 (0)
Moderate	61 (20)	56 (9)	40 (8)	56 (5)	55 (18)	29 (4)	43 (3)	32 (6)	50 (5)	50 (11)
High	15 (5)	38 (6)	55 (11)	33 (3)	33 (11)	57 (8)	57 (4)	68 (13)	50 (5)	50 (11)
Role within firm[1]										
CEO/Pres/Owner	26 (6)	50 (6)	35 (6)	67 (4)	42 (10)	8 (1)	67 (4)	50 (8)	56 (5)	53 (9)
Other	74 (17)	50 (6)	65 (11)	33 (2)	58 (14)	92 (11)	33 (2)	50 (8)	44 (4)	47 (8)

[1]Role within firm represents respondent selections to role within their company. 42% were of the CEO/President/Owner, one of over twenty

Importance of traceability to firms

To address the first research question of the study, we set out to understand the level of importance of key traceability features and key data elements (KDE) identified by respondents. A K-Means Cluster analysis was conducted, identifying three groupings of respondents that demonstrated distinct and statistically significant differences in their perceived level of importance for key traceability features. Borrowing from terminology from Sterling at al (2015), we assigned the terms "fragmented," "cooperative," and "collaborative" to characterize the three clusters regarding perceived importance of traceability features for individual firms (Table 3.6)[6].

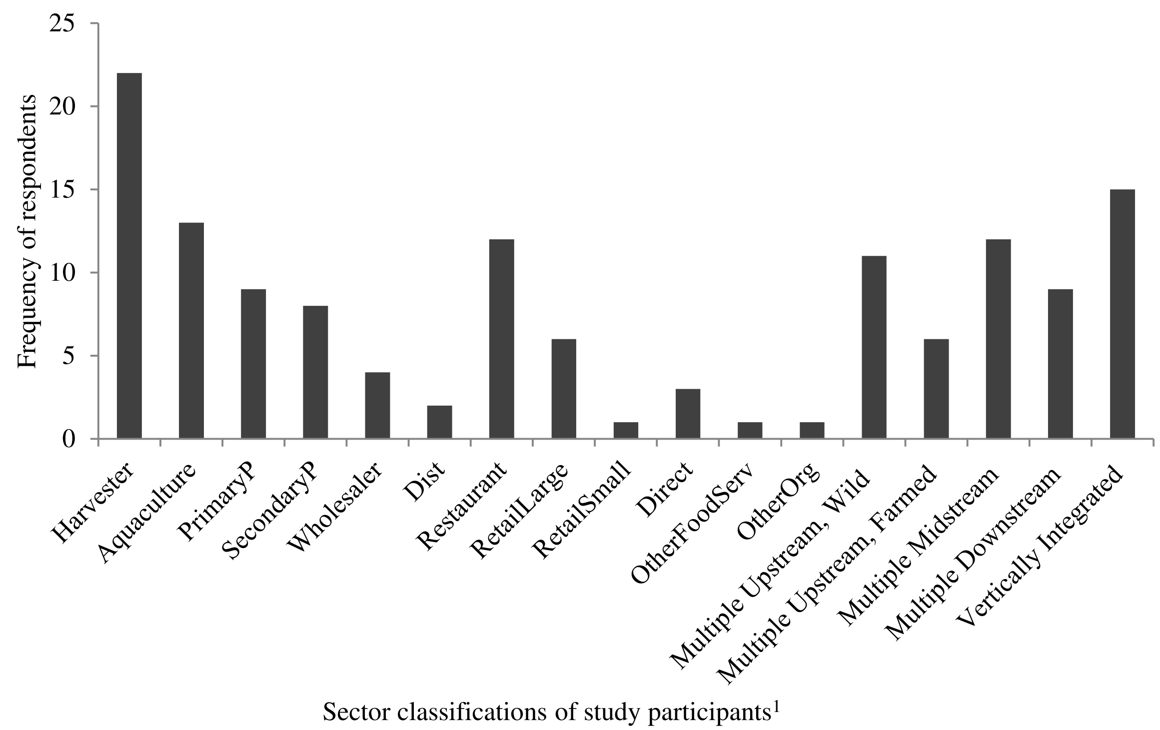

Figure 3.2. Frequency of sectors selected by respondents. Respondents that selected multiple sectors were classified as multiple upstream (wild and farmed), midstream, downstream, or vertically integrated (n = 185).

[1]Respondents that work for firms that involve more than one sector were classified differently, beginning with "multiple" or "vertically integrated.

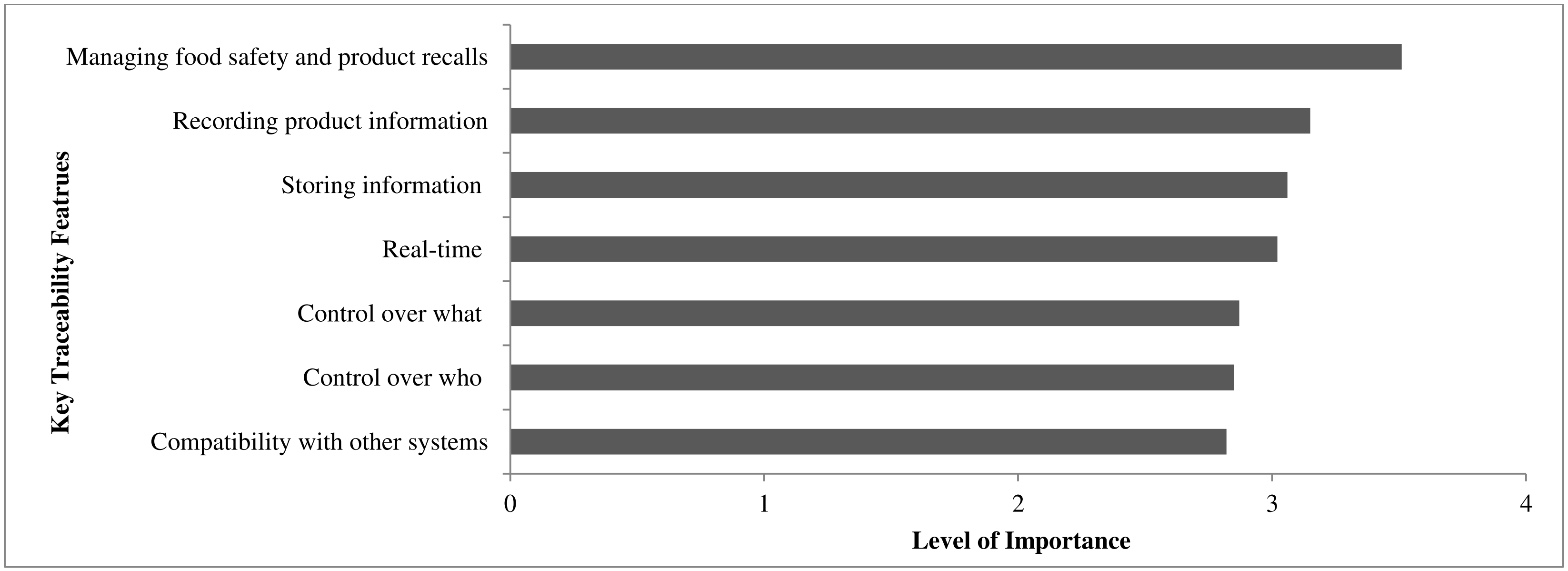

Figure 3.3 Mean average level of importance of key traceability system features across all respondents. Items were coded on a 4-point scale of 1= “not at all important” ; 4 = “extremely important”).

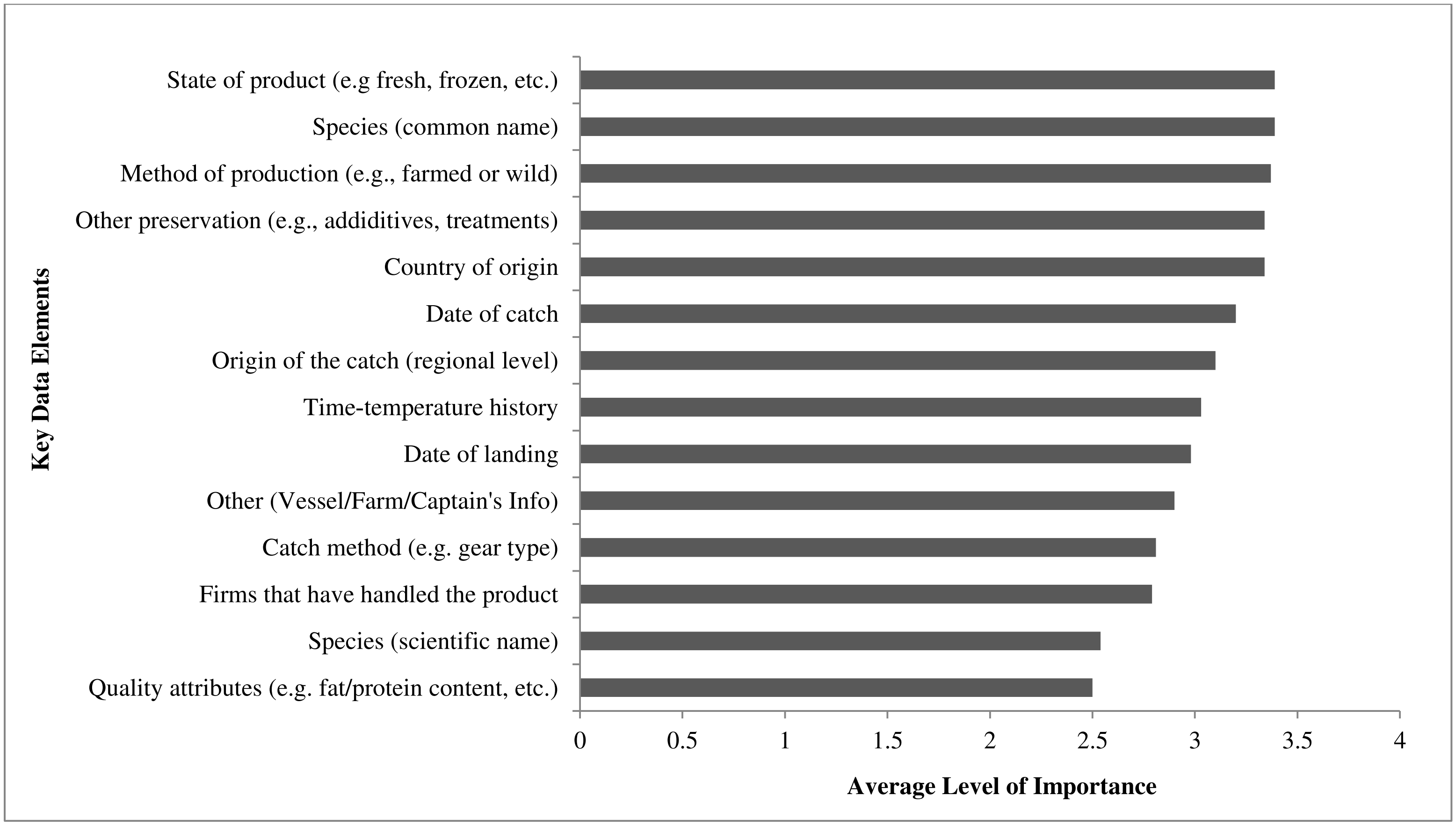

Figure 3.4 Mean average level of importance of KDE's key to firms represented by respondents and used for traceability (1= "not at all important"; 4 = "extremely important").

Means scores for clusters 1 through 3 had mean importance scores of between 1.68 and 2.36, 2.58 and 3.53, and 3.53 and 3.85 across all key traceability features, respectively.

A PCA of the seven continuous variables gauging importance of traceability features identified statistical significance, and an index was computed based on mean responses to seven variables across all respondents. For the remainder of this paper, this is referred to as the "key features index" (KFI). A set of variables measuring perceived importance of key data elements (KDE) to individual firms was also statistically significant and computed into an index, "KDE index." Unlike the inherent features of traceability (e.g. recording, storing, etc.) address with the KFI, KDE's are specific to the information used as part of the traceability process (e.g. catch method, catch origin, date of landing, etc.). For the KDI, KDE, and other indices generated via PCA, see Table 3.7. For all PCA, reliability tests were conducted for all indices to remove any potential variables that were above Chronbach alpha values.

Building on the PCA and subsequent factors identified among responses to twenty-six variables, we selected the KFI and tested for relatedness with a suite of demographic and categorical variables measured in the questionnaire. In comparing the KFI (Factor 2 in Table 3.7) with the size of firm (average annual revenue), geographic location, number of species handled or managed, number of sectors represented by respondent's firm, and the broader value chain characterization, we employed several one-way's and found statistical significance with substantial (size of firm), typical (location, sector diversity, and firm characterization), and minimal (number of species) effect sizes for the relationships examined. The association between KFI and age was not statistically significant as evidenced in Table 3.9.

Table 3.6. Cluster analysis of respondent's perceived importance of traceability features and KDE's, and attitudes towards future traceability developments.

	Cluster Centers[1]				
	Cluster 1	Cluster 2	Cluster 3	F value	Eta (η) effect size
Importance of key features	n=22	n=78	n=55		
Recording	fragmented	coordinated	collaborative	121.505	0.784
Managing	fragmented	coordinated	collaborative	56.620	0.653
Compatibility	fragmented	coordinated	collaborative	86.780	0.730
Storing	fragmented	coordinated	collaborative	79.059	0.714
Control What	fragmented	coordinated	collaborative	78.147	0.712
Real Time Info	fragmented	coordinated	collaborative	49.009	0.626
Control Who	fragmented	coordinated	collaborative	65.388	0.680
Importance of KDE's	n=46	n=58	n=55		
Country of Origin	fragmented	coordinated	collaborative	14.487	0.396
Production Method (wild or farmed)	fragmented	coordinated	collaborative	23.156	0.478
Species (common name)	fragmented	coordinated	collaborative	10.604	0.346
Species (scientific name)	fragmented	coordinated	collaborative	24.444	0.488
Origin of Catch (region)	fragmented	coordinated	collaborative	73.580	0.697
Date of Catch	fragmented	coordinated	collaborative	80.522	0.713
Date of Landing	fragmented	coordinated	collaborative	64.502	0.673
Catch Method (gear type)	fragmented	coordinated	collaborative	45.101	0.605
State of Product (fresh, frozen, etc.)	fragmented	coordinated	collaborative	38.812	0.576
Other Preservation or additives	fragmented	coordinated	collaborative	41.622	0.590
Quality Info	fragmented	coordinated	collaborative	15.375	0.406
Time-Temp Info	fragmented	coordinated	collaborative	37.789	0.571
Businesses Involved	fragmented	coordinated	collaborative	69.253	0.686
Attitudes about future developments	n=30	n=31	n=45		
"Here to stay"	pessimistic	mixed	optimistic	5.159	0.302[2]
Harm to small business	pessimistic	mixed	optimistic	47.819	0.694
IUU will decrease	pessimistic	mixed	optimistic	61.135	0.737
"Best practices" will be rewarded	pessimistic	mixed	optimistic	24.923	0.571
Costs will outweigh benefits	pessimistic	mixed	optimistic	15.598	0.482
Prices will increase for consumers	pessimistic	mixed	optimistic	58.927	0.730

[1]All one-way ANOVA's were statistically significant,
[2]With the exception of traceability is "here to stay," every variable and subsequent relationships tested had a substantial effect size.

Table 3.7 Principal components factor analysis of twenty-eight continuous variables featured in questionnaire.

Attitudes and Level of Importance	Factor Loadings[1]				
	Factor 1: Challenges*	Factor 2: Key features**	Factor 3: Gov Favorability**	Factor 4: Benefits to value chains*	Factor 5: Negative outlook*
Difficulty in managing and tracking "lots", batches, cartons, and/or packages	0.86				
Interoperability of data systems	0.84				
Cost of human data entry (e.g. transfer from paper records to electronic)	0.84				
Cost of required technologies	0.80				
Data security	0.71				
Co-mingling of raw material (e.g. individual products mixed together)	0.63				
Business culture is not supportive	0.59				
Storing product information (including paper documents)		0.84			
Control over who receives product information		0.81			
Recording product information (including paper records)		0.80			
Control over types of product information to be shared		0.77			
Compatibility with your internal business information system		0.75			
Managing food safety and product recalls		0.64			
Accessing product information in real time		0.57			
Current government regulations should be strengthened by requiring additional information to be shared along the supply chain			0.84		
Current gov regulations are sufficient (Reverse coded)			0.83		
Point-of-sale businesses must provide info beyond current regulations			0.62		
Only the market should dictate traceability developments (reverse coded)			0.61		
Traceability improves inventory management				0.53	
Traceability improves product safety				0.86	
Traceability improves product quality				0.76	

Table 3.7 Continued.

Attitudes and Level of Importance	Factor Loadings[1] Factor 1: Challenges*	Factor 2: Key features**	Factor 3: Gov Favorability**	Factor 4: Benefits to value chains*	Factor 5: Negative outlook*
Traceability improves product turnover				0.52	
Traceability reduces waste				0.49	
Government should not require any form of seafood traceability					0.74
Traceability will significantly increase the prices for consumers					0.69
Proposed federal traceability requirements will disproportionately harm small over large firms					0.68
Eigenvalue	8.23	4.60	3.72	1.95	1.65
Percentage (%) of total variance explained	13.77	13.54	11.49	8.46	7.10
Cumulative percentage (%) of total variance	13.77	27.31	38.80	47.26	54.36

[1]Combined principal components factors analysis with Varimax rotation. Only factors with eigenvalues >1 and items with factor loadings >.40 were retained in the final factor structure (Tabachnick and Fidell 1996).
*Items coded on 4-point scales of 1 = “strongly disagree” to 4= “strongly agree”.
**Items coded on 4-point scales of 1 = “not at all important” to 4 = “extremely important”.

These results provide statistical evidence that the variation of importance of traceability features associated with size of firm, number of species, number of sectors involved, and geographic location. In fact, clear evidence that KFI increases with firm size is demonstrated below in Table 3.10 on pg 71. This finding compliments our evidence that importance of traceability varies statistically with the number of sectors, illustrated in Figure 3.5. A closer look at relatedness between KFI and geographic region in Table 3.8 reveals the lowest mean KFI value for Alaska and Oregon (2.78 and 2.95, respectively), suggesting these two regions perceive traceability with lower importance on average than respondents in other regions surveyed. It is important to note, however, that a chi-squared analysis of respondent firm location compared with value chain characterization of firm was statistically significant with a substantial effect size, suggesting a disproportionate representation of firms within each region of the study (p=.007; Phi= .672)(Table 3.8).

Had geographic location not been statistically significant compared to value chain characterization, we would suspect there to be no association between these two variables.

For respondents that indicated only one sector, average KFI values for aquaculture production (3.28) was higher over wild capture (2.72), and processors had the second highest mean KFI value for single sector firms represented (3.18). Among respondents who selected more than one sector, KFI was generally higher for "upstream" sectors, and again aquaculture was higher compared to wild capture production. In fact, multi-sector aquaculture production ranked the highest of all sector characterizations (3.61), suggesting firms that both produce and process farmed seafood within sample population have the highest perceived importance for traceability features on average. Respondents that were vertically integrated demonstrated a relatively high average KFI value as well (3.14). These results suggest aquaculture, processors, and firms involving multiple sectors and/or vertically integrated had a higher level of perceived importance for key traceability features consistent with the literature review and/or phase two of this study. Using a regression analysis to compare with age and one-way ANOVA to compare with gender, findings were not statistically significant when associated with KFI values ($R= .014$; $p=.995$).

In the questionnaire respondents selected the type of sector(s) represented by firm, and clear evidence suggested a statistically significant association between the importance of traceability and number of sectors within firm as shown in Figure 3.5. A one-way ANOVA test was conducted to evaluate the strength and statistical significance of this relationship and found a typical strength of association ($p<.001$; $\eta=.328$). To investigate this relationship further at the individual sector level, we employed an ANOVA test to identify potential relatedness between the key features index and individual sectors

Table 3.8. Chi-squared test for relatedness between broader value chain characterization and geographic location of respondents' firm.

	Value Chain Characterization													
	WC	AQ	Processor	Mid	Food Service or Retail	M-U, WC	M-U, AQ	M- M	M-D	Vertically Integrated	Total	X^2 value	p-value	Phi (ϕ) effect size
Geographic Location	22	13	17	6	22	11	6	12	9	15	133	60.09	0.007	0.672
Oregon	13	0	8	1	15	5	2	3	4	4	55			
Washington	5	10	3	2	5	5	4	6	3	7	50			
California	0	2	1	0	1	0	0	2	0	0	6			
Alaska	4	1	5	2	1	1	0	0	1	4	19			
Hawaii	0	0	0	1	0	0	0	1	1	0	3			

Table 3.9 One-way ANOVA comparing relatedness between value chain characterization and key features index (KFI), age, and benefits to firm.

	Value Chain Characterization												
Continuous Variable	WC	AQ	Processor	Mid	Food Service or Retail	M-U, WC	M-U, AQ	M- M	M-D	Vertically Integrated	F value	p-value	Eta (η) effect size
Key features index	2.72	3.28	3.18	3.00	2.89	3.22	3.61	2.98	2.91	3.14	2.34	.017	.352
Age of respondent	54.25	48.46	53.71	47.17	48.50	53.75	54.00	52.63	50.67	46.67	.790	.630	-
Benefits to Firm													
Prod efficiency[1]	2.69	3.00	2.00	2.17	2.63	2.36	2.00	2.47	1.63	2.38	3.089	.002	.441
Risk mgmt	3.25	3.38	3.06	3.00	3.35	3.33	3.00	3.22	2.78	3.20	.780	.635	-
Market access	3.14	3.15	3.00	2.86	3.09	3.17	2.50	2.78	3.00	3.06	.581	.811	-

[1]This variable is defined and discussed in greater detail later in this paper.

Table 3.10 One-way ANOVA comparing relatedness between size of firm and Factors 2 and 4 by average annual revenue (USD). Strength of relatedness was substantial between variables (η>.371).

	Size of Firm								
Factors	Fewer than $50,000	Greater than $50,000, fewer than $99,999	Greater than $100,000, fewer than $1,000,000	Greater than $1,000,000, fewer than $5,000,000	Greater than $5,000,000, fewer than $100,000,000	Greater than $100,0 00,000	F value	p-value	Eta (η) effect size
KFI	2.57	2.90	2.86	3.03	3.24	3.444	4.494	<.001	.384
Benefits Across Index[1]	3.44	3.15	3.05	2.90	2.79	2.888	2.621	.028	.319

[1]This variable is defined and discussed in greater detail later in this paper.

Table 3.11 One-way ANOVA comparing relatedness between geographic location of where respondent resides as an employee, contractor, or owner of firm and key features index and KDE Index.

	Location of Respondent's Firm							
Continuous Variable	Oregon	Washington	California	Alaska	Hawaii	F value	p-value	Eta (η) effect size
KFI	2.95	3.15	3.39	2.78	3.83	3.71	0.007	0.323
KDE Index	2.04	1.97	2	2.24	2	.328	.859	

Table 3.12 One-way ANOVA comparing relatedness between Factors 2 and 4 from Table 3.7 compared with number of species (dichotomous) handled, sold, and/or managed by firm.

	Number of Species				
Factors	5 or less	More than 5	F value	p-value	Eta (η) effect size
Key Features Index	2.96	3.19	4.657	0.033	0.179
Benefits Across Index[1]	3.01	2.78	4.570	.034	.188

[1]This variable is defined and discussed in greater detail later in this paper.

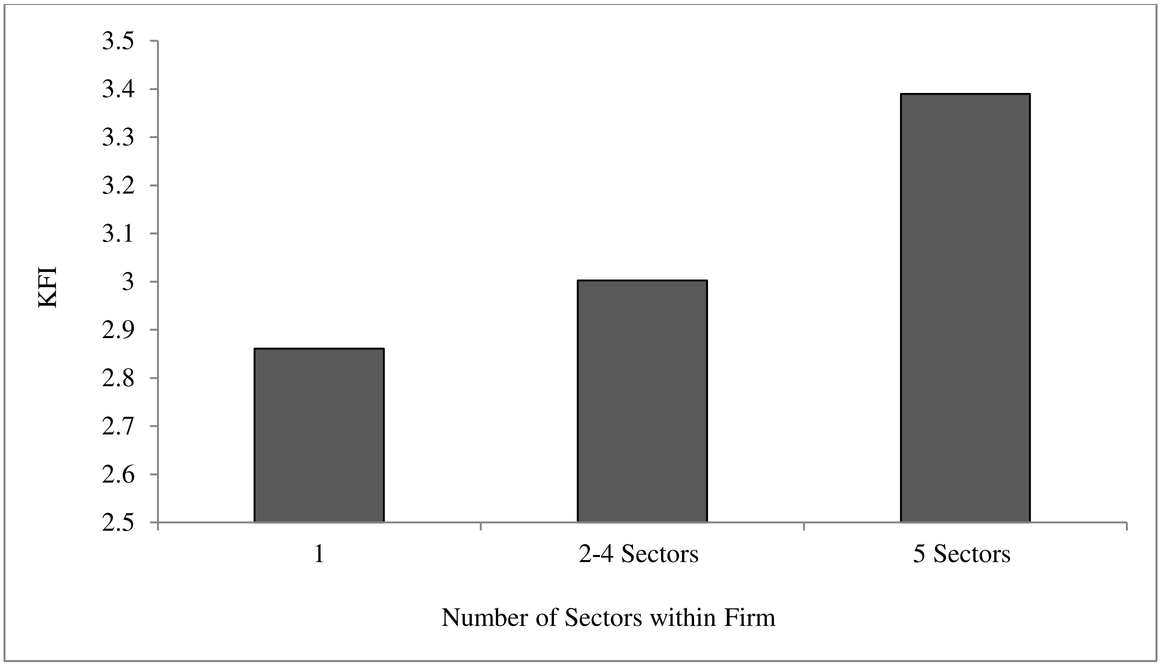

Figure 3.5 Number of sectors in relation to KFI (n=159). Based off mean responses, index (KFI) was an aggregation of variables measuring importance of key features of traceability systems highlighted in the questionnaire. One-way ANOVA yielded statistical significance between variables and typical effect size ($F=8.513$; $p<.001$; $\eta=.315$)

characterizations summarized in Table 3.9. Associations between the KFI and aggregate value chain characterization of firm were not statistically significant (p=.484) (e.g. upstream, downstream, vertically integrated). Nevertheless, the significant finding and directionality in the relationship between number of sectors and perceived importance of traceability is a key finding that merits further discussion later in this paper.

In addition to the perceived importance of key traceability system features from respondents, we investigated the perceived level importance of key data elements (KDE) or "traceability type information" to the firms represented by respondents. Respondents indicated importance (extremely important or very important) of traceability type information in the following order: common name, state of product (e.g. fresh, frozen, dried, etc.), production method (farmed vs. wild), preservation method (e.g. carbon monoxide, triphosphates, etc.), and date of catch as the top five key data elements for traceability of their products within their firms (n=59)(see Figure 3.6 below). Furthermore, three clusters were discovered through K-Means Cluster analysis that identified three groups of individuals that demonstrated fragmented (n=48), coordinated (n=56), and collaborative (n=55) firm practices with regards to KDE. Results of cluster analysis are summarized in Table 3.6.

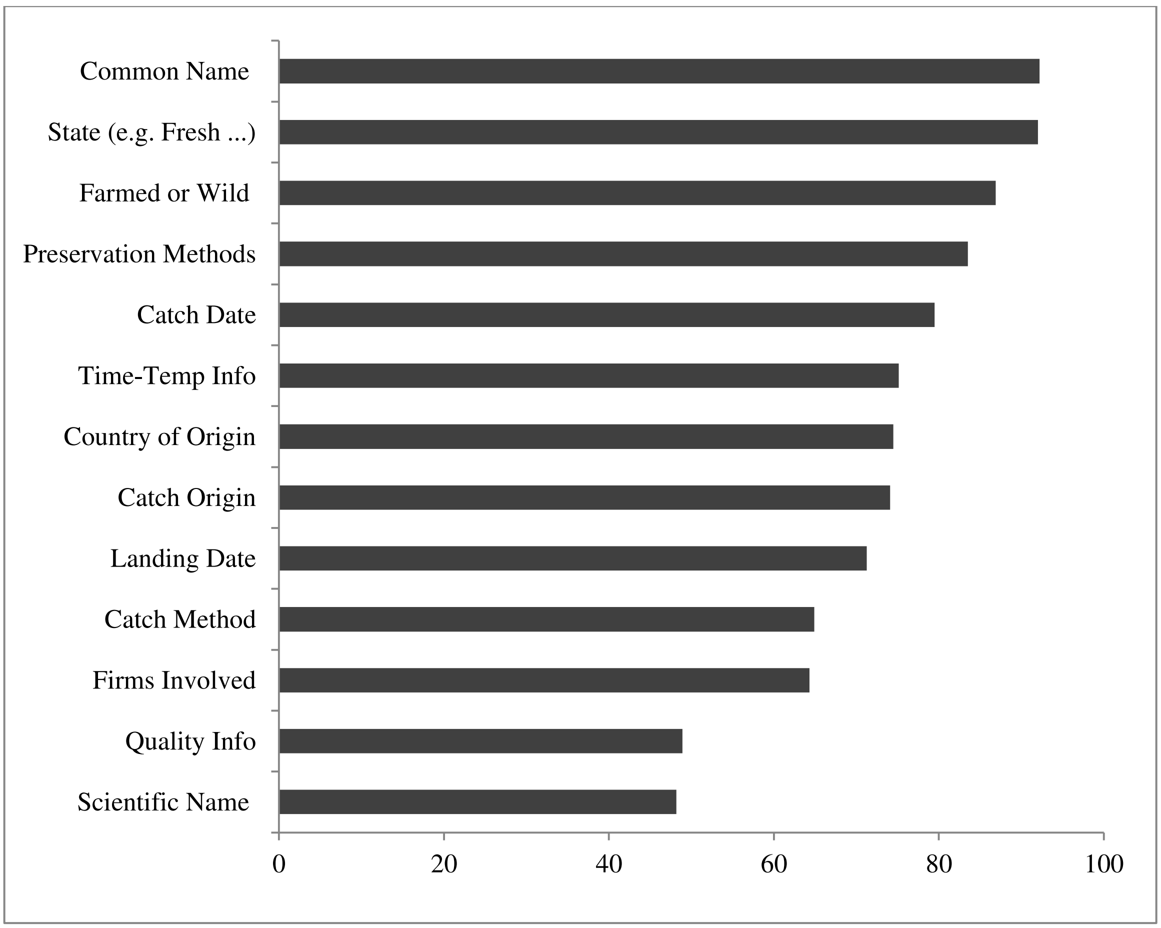

Figure 3.6 Importance of traceability type information (key data elements) for all respondents that indicated the information was either "very important" or "extremely important" to their firm. Reported numbers were measured as a percentage of total responses for each category of information (n=59).

Traceability in Practice and Inherent Challenges

After establishing varying levels of perceived importance of traceability, further inquiry into traceability activities within each firm was measured. Respondents responded to their reported usage of key traceability features in their firm consistent with the same features included in the KFI (“yes,” “no,” and “not sure”). A series of one-way ANOVA tests comparing the importance of key traceability features with the usage of said features was statistically significant across all variables with typical effect sizes summarized in Table 3.13 below. These findings provide evidence that respondents’ perceived importance and usage of traceability features are consistent, a key component to the findings of this study.

Table 3.13 One-way ANOVA of reported usage of key traceability features in practice compared to perceived importance of key traceability features to respondents. Results were significant in every category.

	Usage of Key Traceability Features				
Importance of Key Traceability Features[1]	Yes	No	F value	p-value	Eta (η) effect size
Recording capabilities	3.24	2.52	19.924	<.001	0.315
Storing capabilities	3.13	2.57	9.516	.002	0.225
Compatability[2]	3.16	2.33	31.287	<.001	0.425
Control over what	3.11	2.44	20.275	<.001	0.349
Control over who	3.03	2.00	7.965	.005	0.218
Managing food safety	3.59	3.23	5.274	.023	0.175
Real time capabilities	3.25	2.70	17.518	<.001	0.322

[1] Respondents answered questions on a Likert scale 1= “not important”; 4=“extremely important.”

To add to our understanding of whether firms utilize traceability features in practice, we sought to understand attitudes and perspectives related to the key challenges firms face regarding the use of traceability. PCA revealed relatedness in responses to seven variables measuring agreement and/or disagreement regarding traceability related challenges for respondents and their firms (see Table 3.7). One variable was removed as it exceeded the Chronbach alpha parameter (“business culture not supportive”). Consequently as a result of the PCA, a new index was computed based on six variable means. When tested against broader value chain characterization via one-way ANOVA, statistical significance was determined with a typical effect size ($p<.001$; $\eta=.316$), suggesting the perceptions of traceability challenges are associated with characterization of firms within their value chain(s). Mean responses for traceability challenges were less than three for all categories, suggesting respondents strongly disagreed or disagreed on average regarding the issues highlighted that create challenges regarding traceability. Firms that were considered vertically integrated had the lowest mean value of 1.74, suggesting the challenges presented were of least concern compared to other sectors characterizations. This and other results are summarized in Table 3.14.

Table 3.14 One-way ANOVA's for Factors computed from Table 3.7 and compared to aggregate value chain characterization.

	Aggregate Value Chain Characterization[1]						
PCA Indices	Upstream	Midstream	Downstream	Vertically Integrated	F value	p-value	Eta (η) effect size
Government Favorability	2.82	2.31	2.60	2.46	6.046	.001	.316
Negative outlook	2.35	2.72	2.45	2.34	2.948	.035	.256
Traceability challenges	2.23	2.17	2.55	1.74	2.793	.043	.260
Benefits Across Index	2.96	2.72	2.99	3.21	2.826	.042	.261

[1] See Table 3.2 for definitions of "upstream," "midstream," "downstream," and "vertically integrated."

Preparedness for Traceability Developments

With new market forces and regulatory requirements, this study sought to evaluate the general level of preparedness for traceability developments within our sample population. We assumed those reported awareness of SIMP and those who also demonstrated moderate or high levels of knowledge of traceability concepts and issues were suitable indicators of overall preparedness for current and impending market and regulatory developments among respondents. To evaluate knowledge of respondents, we compared traceability knowledge with firm size and value chain characterization, which were both significant with substantial effect sizes ($p<.001$, $\phi = .516$; $p=.03$, $\phi=.410$, respectively). In general, larger firms and more downstream or vertically integrated firms appeared more knowledgeable compared to smaller firms and more upstream firms as shown in Table 3.15. General level of self-reported knowledge of traceability concepts and issues were relatively high. When compared to the three clusters of respondents categorized as fragmented, coordinated, and collaborative based on importance of traceability, knowledge of traceability issues was statistically significant. More collaborative respondents demonstrated the largest proportion of respondents indicating a high level of traceability knowledge overall. Our findings provide evidence that larger firms, firms containing multiple sectors, and firms that are vertically integrated are more collaborative and knowledgeable of traceability concepts and issues.

Table 3.15 Chi-squared test comparing traceability knowledge with size of firm and value chain characterization.

	Knowledge of Traceability							
	None	Very little	Moderate	High	Total	X^2 value	p-value	Phi (ϕ) effect size
Firm Size (annual, USD)	0	13	75	61	149	39.731	<.001	0.516
Less than 50,000	0	1	10	2	13	-	-	-
Less than 50 K, more than 100 K	0	2	8	4	14	-	-	-
Less than 100 K, more than 1 M	0	3	22	6	31	-	-	-
Less than 1 M, more than 5 M	0	7	24	15	46	-	-	-
Less than 5 M, more than 100 M	0	0	9	18	27	-	-	-
Less than 100,000,000 M	0	0	2	16	18	-	-	-
Value Chain Characterization[1]	0	17	89	77	183	30.797	0.030	0.410
Cluster- Trace Features	0	22	78	55	155	13.378	.010	.294
1 – Fragmented	0	4	6	3	13	-	-	-
2 – Coordinated	0	11	43	17	71	-	-	-
3 – Collaborative	0	7	29	35	71	-	-	-

[1]See Table 3.9 to see associated firm characterizations.

Although a majority of respondents reported a moderate or high level of traceability knowledge, 71.6% of respondents indicated they were not aware of new impending mandatory federal traceability requirements for over 200 species of imported product effective January 1, 2018 (n=148). A relatively high percentage of firms involved in importation reported they were not aware of the new requirements (52.6%, n=19). This is a particularly interesting finding given the direct relevance to firm that directly import and regulatory implications in January of 2018. Importers will be required to provide traceability information to the federal government as part of SIMP, and will not be required to share this information with consumers or other businesses. Overall, these findings suggest a general lack of regulatory awareness for the new impending SIMP regulation. This is particularly noteworthy for importers given the specific legal obligations of importers as part of the new SIMP framework. To account for knowledge of traceability related to regulatory awareness we employed a chi-squared test comparing traceability knowledge and awareness of new regulation; traceability knowledge appeared to increase with awareness of new regulation and was statistically significant with a typical effect size (Table 3.17) ($p<.001$, ϕ =.346).

To ascertain what types of firms were more prepared over others, we employed a chi-squared test comparing firm size and regulatory awareness and found statistical significance and a typical effect size ($p<.001$, ϕ =.347). As illustrated in Figure 3.7, we discovered that larger firms generally demonstrated a greater awareness of the new regulatory requirements for imported seafood, particularly firms that gross over five million in sales on average annually (USD). These results and the number of sectors involved was statistically significance with a minimal effect size ($p=.043$; ϕ =.215)(see Table 3.17). Broader firm value chain characterization, however, was not significant when tested ($p=.085$). No statistical significance was found for regulatory awareness when associated and tested against age, gender, education, and geographic location.

In the interest of understanding preparedness, the questionnaire screened for general knowledge of traceability issues. When compared with professional roles within firms (CEO/President/Owner vs. other role), respondent awareness of new regulations was significant after a chi-squared test (p=.004, Cramer's V =.486). When compared to sector diversity (1, 2 to 5, more than 5 sectors), regulatory awareness was also significant, with a typical effect size (p=.043, Cramer's V =.215). These results suggest people of higher authority within their firm are more knowledgeable of regulatory developments, and firms with a more complex set of sectors are also more likely to demonstrate greater awareness of the new SIMP regulations.

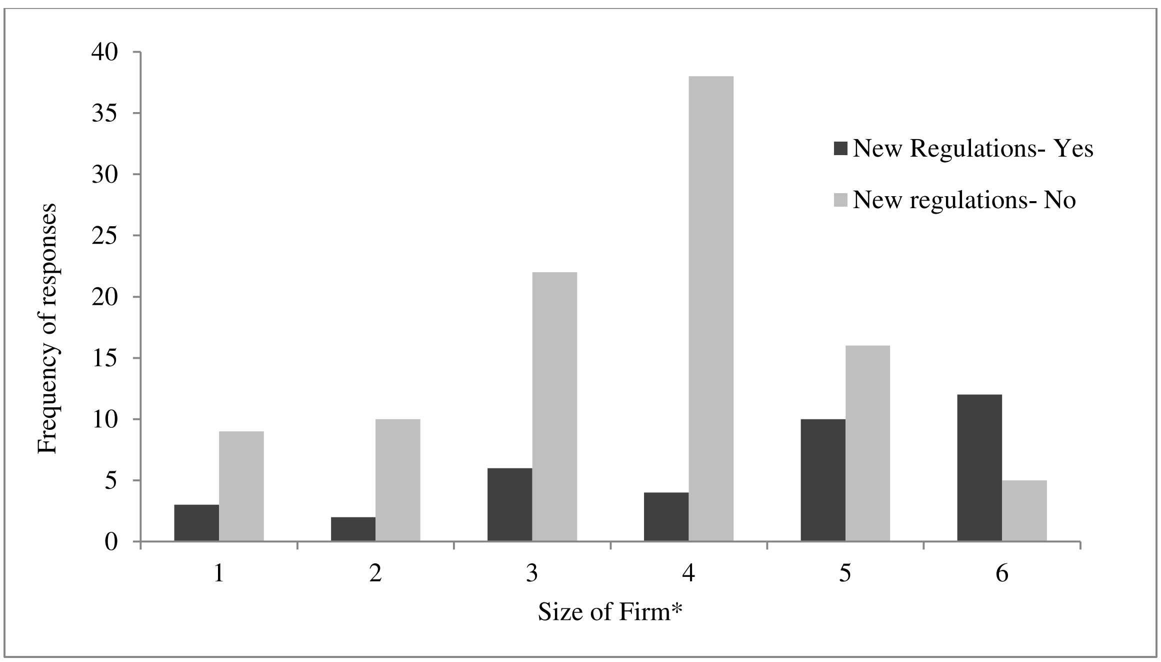

Figure 3.7 Frequency of responses from participants that indicated they were aware ("yes") or not aware ("not") in comparison with size of firm (average annual revenue, USD) (n=137). Strength of associations between variables was typical (ϕ =.433).
*Size of firm was coded as the following (USD): 1= fewer than 50,000 2= greater than 50,000, fewer 100,000 3= greater than 100,000, fewer than 1,000,000 4= greater than 1,000,000, fewer than 5,000,000 5= greater than 5,000,000, fewer than 100,000,000 and lastly, 6= greater than 100,000,000 USD.

Table 3.17 Comparison of firm size and number of sectors with awareness of new federal regulations.

Categorical Variable	Awareness* Yes	No	Total	X^2 value	p-value	Phi (ϕ) effect size
Sector Diversity	39	97	136	6.28	.043	.215
Single sector	11	49	-	-	-	-
2-4 sectors	15	30	-	-	-	-
5 or more sectors	13	18	-	-	-	-
Size of Firm (USD)	37	100	137	25.739	<.001	.433
Less than 50,000	3	9	-	-	-	-
Less than 50 K, more than 100 K	2	10	-	-	-	-
Less than 100 K, more than 1 M	6	22	-	-	-	-
Less than 1 M, more than 5 M	4	38	-	-	-	-
Less than 5 M, more than 100 M	10	16	-	-	-	-
Less than 100,000,000 M	12	5	-	-	-	-
Knowledge of traceability issues	42	106	148	17.765	<.001	.346

*Awareness of new SIMP regulations (1 = "yes" 2 = "no" 3= "not sure"). Responses of "not sure" were removed along with missing values to conduct statistical analysis.

Perception of the Role of Government

While many respondents were not aware of the new regulatory requirements, half of overall respondents (50.8%) indicated they "strongly disagree" or "disagree" with the notion that current government traceability regulations are sufficient, suggesting a large proportion of respondents perceive that more regulatory oversight is needed related to traceability. Associations between firm location in value chain and level of agreement that current regulations are sufficient ("strongly disagree or "disagree") were statistically significant via chi-square test with a typical effect size summarized in Figure 3.8 ($p<.001$, ϕ =.293). This provides evidence that "upstream" firms (any response indicating four sectors or less that includes wild capture and/or aquaculture production) are in relatively strong agreement that no new traceability regulations are necessary. The index of favorability for increased government oversight from the PCA (Table 3.7) compared across aggregate value chain characterization suggests that upstream firms have a more positive outlook on the role of government to address issues within the industry. This might suggest that upstream firms are more likely to be satisfied with existing regulations, and therefore have a more positive outlook regarding the role of government. Depending on how this is interpreted, these two findings could likewise be in conflict.

Unlike upstream firms associated with harvest and processing, most of downstream firms (4 or less that does *not* include any form of production or processing) and vertically integrated firms disagreed that current regulations are sufficient. No significance in associations were found in comparing regulatory awareness for firm value chain characterization, age, gender, or geographic location (p=.085, .818, .269, .608, respectively).

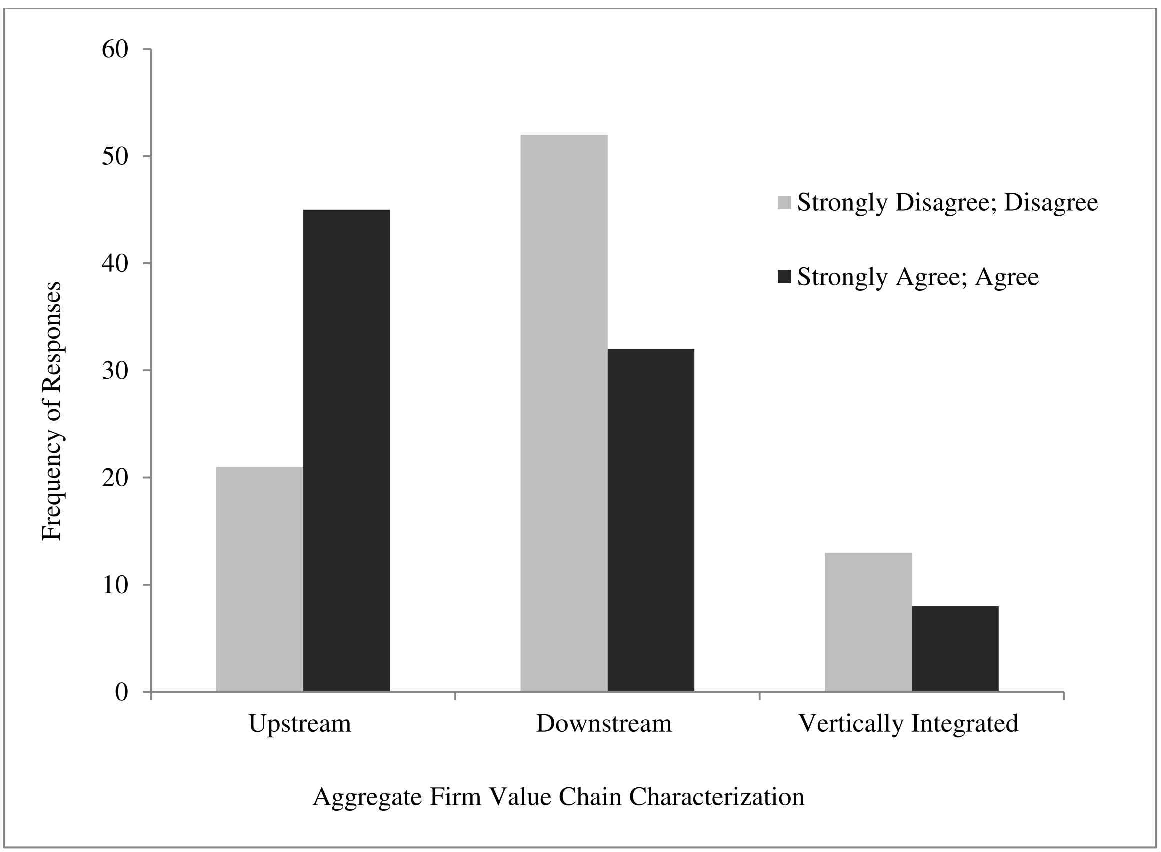

Figure 3.8 Frequency of responses from participants that indicated they were is general agreement or disagreement that current traceability regulations are sufficient (n=171).

Perceived costs and benefits to firm and value chain(s)

Previous research has struggled to quantify realized benefits and costs associated with seafood traceability [6]. While this study was not able to quantify or provide these specific figures (or potential Return on Investment (ROI)), perception of the distribution of potential benefits and costs was tested for associations with firm characterizations (e.g. sector, size, etc.).

Three potential benefits to individual firms were previously identified in the literature and discussed in the background work. Attitudes towards traceability's ability to increase these potential benefits (production efficiency, risk management, and market access) for individual firms were measured and compared to firm value chain characterization using a one-way ANOVA for each potential benefit. Production efficiency was statistically significant with a substantial effect size ($p=.002$; $\eta=.441$), however risk management and market access were not significant. These results are illustrated in Table 3.9. No other significance was found with other demographics or categorical variables regarding responses to production efficiency, risk management, and market access, and therefore we were unable to demonstrate any relationships regarding benefits to individual firms.

Factor 4 from the PCA incorporated a suite of variables measuring perceived benefits across value chain (see Table 3.14). We employed a one-way ANOVA to compare this index to firm size and value chain characterization and found statistical significance for both relationships with typical effect sizes ($p=.042$; $\eta=.261$). Upon further examination, "vertically integrated" had the highest mean value (3.21), which was significantly higher than perceived benefits for upstream, midstream, and downstream firm characterizations. This suggests respondents representing vertically integrated firms generally agree or strongly agree that traceability generates benefits across their value chain(s). This and other unique attitudes and insights associated with vertically integrated firms merit further discussion later in this paper.

The general attitudes of respondents regarding allocation of benefits and costs across value chains were tested in association with value chain characterization via chi-squared test, which was statistically significant for costs with a typical effect size ($p=.035$, $\phi = .396$). In five out of six size classes of firms, the notion that traceability costs are disproportionately allocated to downstream firms was selected the least. According to our sample of respondents' general perception, this finding demonstrates near consensus that downstream firms do not face the "brunt" of traceability costs. For firms grossing less than an average of five million (USD) in annual sales, majority of respondents generally suggested that costs are distributed equally across value chains. This changed for larger firms (more than five million USD); in fact, respondents appeared to indicate they believed downstream firms generally received higher costs associated with traceability than other members of the value chain. These results are summarized in Table 3.18.

General attitudes towards consumer transparency

In response to evidence and growing demand for more accessible product information from consumers, this study investigated the insights regarding the increasingly important issue of consumer demand, and collective consumer choice as a driver for traceability changes in the market. In this light, we sought out to understanding the importance of traceability type information for the purposes of sharing with consumers at point-of-sale, and how that information should be communicated from the industry's perspective. Most respondents indicated "yes" to the following sets of information to be shared with consumers: country of origin (83%), common

Table 3.18 Chi-square tests comparing perceived allocation of costs and benefits and value chain characterization.

Allocation	Size of Firm By Average Annual Revenue: Less than $50,000	Greater than $50,000, less than $99,999	Greater than $100,000, less than $1,000,000	Greater than $1,000,000, less than $5,000,000	Greater than $5,000,000, less than $100,000,000	Greater than $100,000,000	Total	X^2 value	p-value	Phi (ϕ) effect size
Benefits	9	13	26	41	25	18	132	11.323	0.333	0.293
1=upstream[1]	0	1	5	3	6	0	15	-	-	-
2=downstream[2]	4	6	11	20	12	11	64	-	-	-
3=equal dist[3]	5	6	10	18	7	7	53	-	-	-
Costs[4]	8	12	25	38	24	17	124	19.426	0.035	0.396
1=upstream	2	4	5	14	12	10	47	-	-	-
2=downstream	1	1	7	8	9	1	27	-	-	-
3=equal dist	5	7	13	16	3	6	50	-	-	-

[1]Benefits favor upstream firms
[2]Benefits favor downstream firms
[3]Benefits are equally distributed across value chains
[4]Same selections, but for allocation of traceability costs across value chains rather than benefits

Name (87%), production method (wild vs. farmed) (81%), state of product (fresh, frozen, prev. frozen, or dried) (76%), and origin of the catch (60%). With the exception of two types of information (Time-temp info and firms involved in handling the product), the large majority of respondents indicated that label or signage at point-of-sale was the preferred method of communicating all types of information. Figure 3.9 illustrates respondent preference for what types and how seafood product information should be shared with consumers.

Some evidence suggests that traceability will help consumers become more informed; which it turn brings value to firms across the entire value chain. To examine the varying perceived benefit across value chains, a K-Means cluster analysis was conducted across a suite of variables measuring preference for transparency of product information to consumers. Three clusters were identified summarized by preference for no transparency, some transparency, and full transparency. The results of this analysis are summarized in Table 3.19.

Building off these clusters identified in Table 3.19, a one-way ANOVA test was employed to examine relatedness of these clusters with the perception of consumer education as a potential benefit across the value chain for firm represented by respondent. Statistical evidence suggests respondents that favored full transparency perceived improved consumer education as a potential net benefit across the value chains associated with their firm.

While this outcome is to be expected, further investigation revealed more than half of responses associated with upstream firms were in favor of full transparency of traceability information to consumers (52%), and midstream firms had the highest

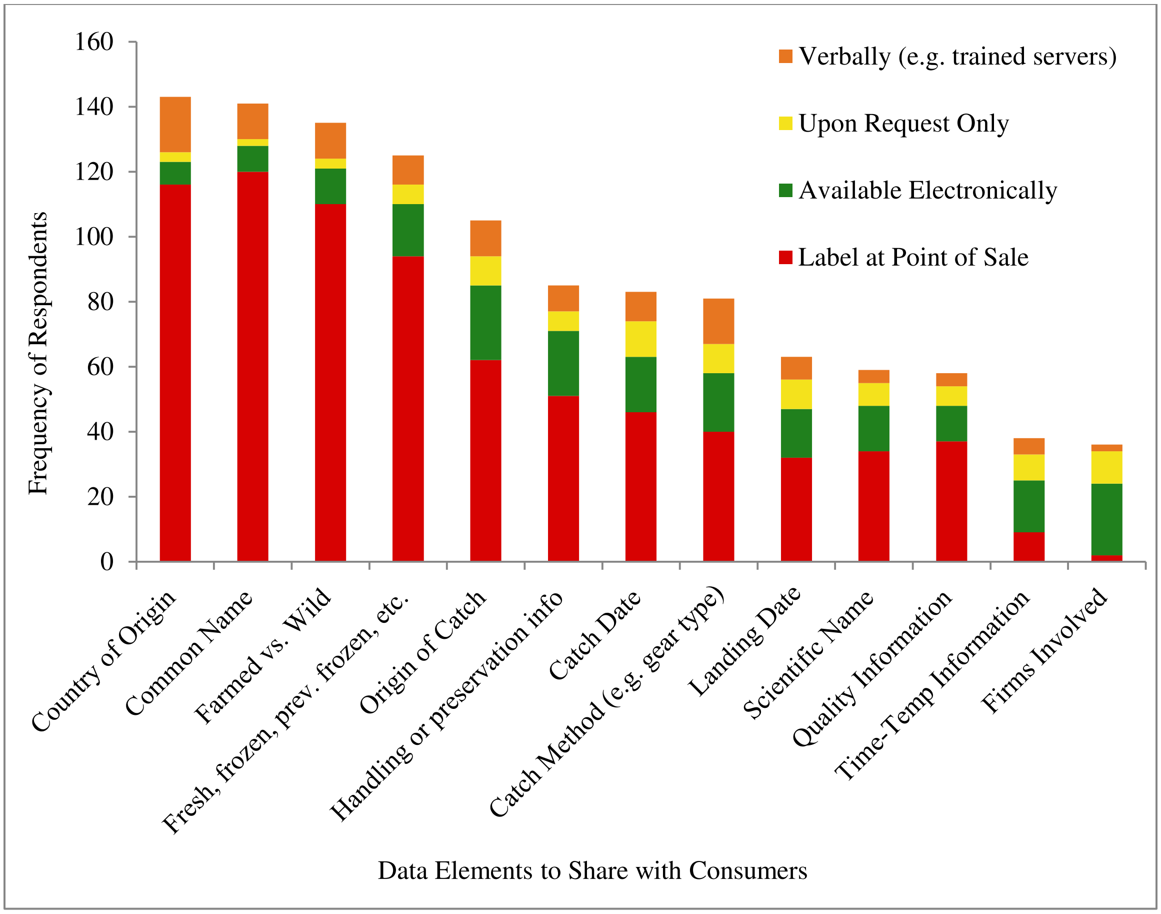

Figure 3.9 Frequency of responses indicating the types of information that should be shared with consumers, and how that information should be shared.

Table 3.19 Cluster analysis of preference for information to be made available to consumers at point-of-sale. This concept it also known to many as "consumer transparency."

	Final Clusters[1]				
	Cluster 1	Cluster 2	Cluster 3	X^2 value	Cramer's V
Info for consumers	n=68	n=91	n=35		
Country of origin	No transprcy	Some transprcy	Full transprcy	180.642	0.965
Farmed vs. Wild Caught	No transprcy	Some transprcy	Full transprcy	159.738	0.907
Species (common name)	No transprcy	Some transprcy	Full transprcy	126.914	0.809
Species (scientific name)	No transprcy	Some transprcy	Full transprcy	57.592	0.545
Origin of the catch (regional)	No transprcy	Some transprcy	Full transprcy	88.039	0.674
Date of catch	No transprcy	Some transprcy	Full transprcy	64.361	0.576
Date of landing	No transprcy	Some transprcy	Full transprcy	84.497	0.66
Catch method (e.g. gear type)	No transprcy	Some transprcy	Full transprcy	90.183	0.682
State (e.g. fresh, prev. frozen)	No transprcy	Some transprcy	Full transprcy	110.978	0.756
Preservation or additives	No transprcy	Some transprcy	Full transprcy	79.510	0.64
Quality attributes	No transprcy	Some transprcy	Full transprcy	28.168	0.381
Time-temperature history	No transprcy	Some transprcy	Full transprcy	66.702	0.586
List of businesses involved	No transprcy	Some transprcy	Full transprcy	58.469	0.549

[1]All chi-squared tests were statistically significant with substantial effect sizes for all variables.

Table 3.20 One-way ANOVA comparing three clusters with perceived benefit of consumer education across the value chain.

Benefits from Traceability	Final Clusters - Consumer Transparency[1] Minimal transparency	Some transparency	Full transparency	F value	p-value	Eta (η) effect size
Consumer education	2.20	3.19	3.34	7.194	<.001	0.299

[1]Clusters were identified as part of cluster analyses summarized in Table 3.19.

proportion of responses indicating preference for a moderate amount of transparency ("some transparency") (35%). Respondents associated with midstream, downstream, and vertically integrated firms appeared to favor a more moderate approach to transparency illustrated in Table 3.21. In comparison with previous research, this finding that most fisherman, aquaculture, and processors generally preferred full transparency of traceability type information to consumers is surprising. Relatedness between consumer transparency clusters and gender, age, firm size, and geographic location was not statistically significant.

Table 3.21 Chi-squared test of three clusters compared to aggregate firm characterization.

	Final Clusters - Consumer Transparency[1] Minimal transparency	Some transparency	Full Transparency	Total	X^2 value	p-value	Phi (ϕ) effect size
Aggregate Firm Characterization	14	84	62	160	16.392	0.012	0.320
Upstream	6	22	32	60	-	-	-
Midstream	5	29	7	41	-	-	-
Downstream	1	22	16	39	-	-	-
Vertically Integrated	2	11	7	20	-	-	-

[1]Clusters were identified as part of cluster analyses summarized in Table 3.19.

Inter-communication between sectors

Evidence has shown certain sectors of the seafood industry are particularly fragmented compared to other industries [6]. This study attempted to get a broad perspective regarding industry communications, and the frequency of communication among industry sectors within our sample population. Respondents reported frequency of correspondence (e.g. in person, email, phone, text, etc.) with different sectors for the purposes of sharing information. We assumed that one potential surrogate for collaboration was communication from one sector to another.

According to all responses, primary processors and wild capture fishermen receive the most communications from members of the industry than any other sector. Respondents indicated the top five sectors they communicate with over the course of a year are processors, harvesters (WC), wholesalers, distributors, and secondary processors. Despite anecdotal evidence and discussion of fragmented intercommunications between seafood firms identified in previous studies, our aggregate results illustrated in Figure 3.10 suggest most communications between sectors occur quite frequently (at least once a week to daily). According to respondents, processors and wild capture fisheries require the most correspondence and communication.

Frequency of correspondence with various sectors classifications and firm size (by average annual revenue) was significant via Chi-square test for six sectors including end consumers, with typical and substantial strength of interaction (see Table 3.22). With the exception of the largest firms (over $100,000,000 in annual revenue), respondents indicated they communicate with processors (primary and/or secondary) and wild capture harvesters the most out of all sector classifications. Relationships between frequency of correspondence and gender, age, number of species, and other demographics were not statistically significant.

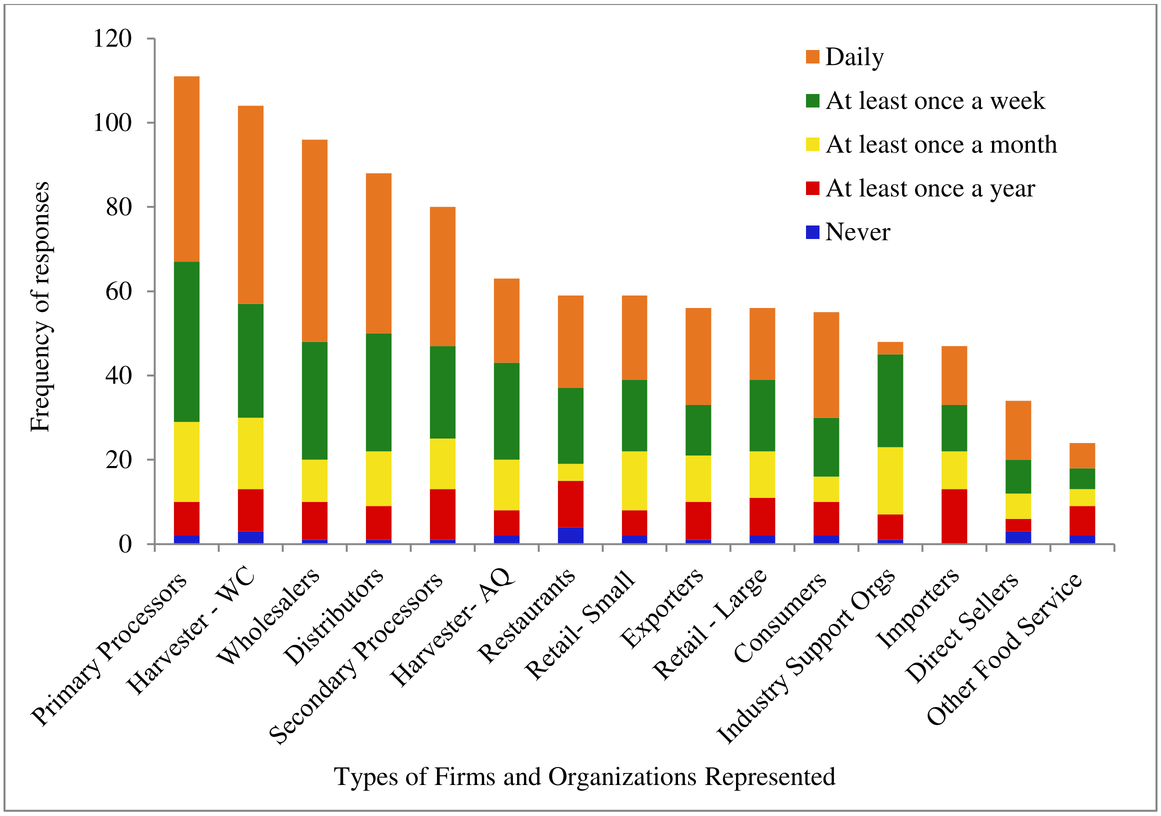

Figure 3.10 Frequency of responses indicating how often individual respondents communicate with various sectors to conduct business. "Communication" was defined as exchange of information in person, over the phone, texting email, or other automated information transfer

In the seafood industry, information sharing occurs in several ways both formal and informal. An inquiry into information sharing arrangements between respondents' firms and their partner firms in value chains revealed a relatively heterogeneous representation of arrangement practices (voluntary upon request, voluntary and routine, and routine through contractual arrangements). Overall 96% of respondents implied they knew the information sharing arrangements established between their firm and partner firms, and could articulate what type of arrangements they had across all sectors. These results are summarized in Figure 3.11. No statistical significance was found with contractual arrangements and other variables tested (size of firm, firm characterization, gender, age, and knowledge of traceability).

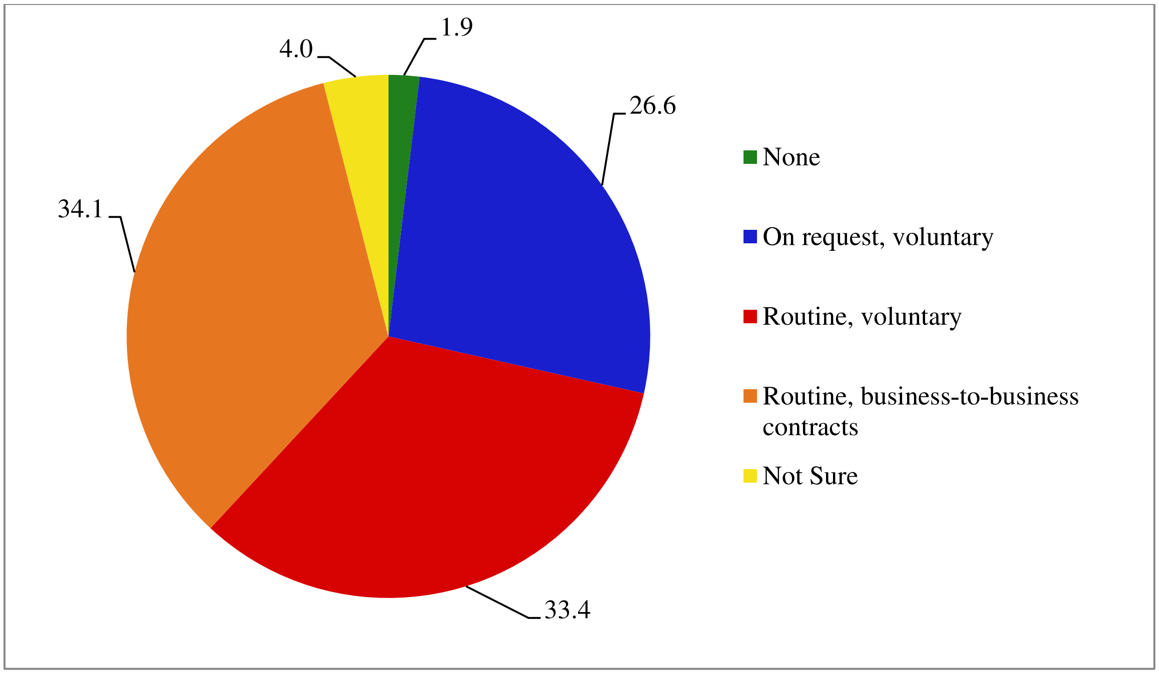

Figure 3.11 Percentage of respondents' information sharing arrangements with partner business in value chains.

Future Developments: Where is this all headed?

Whether regulatory or market driven, almost all (92.2%) of respondents indicated they either "agree" or "strongly agree" that traceability developments are "here to stay." In this vein, we examined the perceived effectiveness of new traceability developments (regulatory or market driven) at addressing the key pressures and threats to the seafood industry identified in phases one and two of the study. In aggregate, most of respondents indicated they "agreed" or "strongly agreed" future developments in traceability would decrease illegitimate practices (73.7%) (e.g. fraud and IUU), and that future traceability developments will help incentivize "best practices" in the industry (82.9%).

To examine these "hot button" issues, we employed a one-way ANOVA test to compare attitudes regarding future issues across value chain characterizations. The

Table 3.22 Frequency of correspondence with each sector or organization categorization across firm sizes.

	Size of Firm By Average Annual Revenue									
Frequency of Correspondence[1]	Less than $50,000	Greater than $50,000, less than $99,999	Greater than $100,000, less than $1,000,000	Greater than $1,000,000, less than $5,000,000	Greater than $5,000,000, less than $100,000,000	Greater than $100,000,000	Total	X^2 value	p-value	Phi (ϕ) effect size
Wild Capture	8	9	21	24	17	14	93	39.608	0.006	0.653
Aquaculture	1	3	4	20	17	12	57	1.906	0.110	
Primary Proc.	10	7	15	29	24	15	100	35.657	0.017	0.597
Secondary Proc.	3	6	10	16	21	15	71	30.364	0.064	
Wholesale	6	5	8	32	22	13	86	36.270	0.014	0.649
Export	1	1	2	14	17	13	48	52.982	0.000	1.051
Import	1	2	2	8	14	15	42	16.198	0.369	
Distribution	3	5	11	26	18	16	79	31.361	0.051	
Restaurant	3	3	12	11	13	12	54	24.511	0.221	
Retail - Large	1	5	9	11	12	13	51	10.911	0.949	
Retail - Small	2	5	10	14	11	10	52	33.837	0.027	0.807
Direct Sale	1	5	10	6	5	5	32	24.322	0.229	
Other Food Serv.	1	5	10	6	5	5	32	22.836	0.297	
Consumers	6	3	13	13	10	6	51	35.188	0.019	0.831

[1]Respondents answered with the following options: 1=none, 2=at least once a year, 3=at least once a month, 4=at least once a week 5=daily

The level of agreement and disagreement that IUU will decrease, best practices will be rewarded, and the market alone should dictate future developments were all statistically significant with substantial effect sizes. When compared across value chain characterizations, all other variables measuring attitudes about the future were not statistically significant. These findings demonstrate a substantial strength of association about two issues important issues identified by the seafood industry, government, and other interest groups. Likewise, on average, results demonstrated that aquaculture sector (1.91) disagreed the most over any other value chain characterization shown in Table 3.23, suggesting strong attitudes about the need for role of government in future traceability needs (n=13). Mid value chain firms (only one sector selected) had the highest average levels of agreement with the notion that traceability will decease IUU and reward "best practices" (3.50 and 3.40, respectively), although these sample sizes were only six and five, respectively. See Table 3.14 for summary of results for future traceability outlook.

Attitudes about future traceability developments were measured across several variables, and three clusters were generated representing "pessimistic," "mixed," and

Table 3.23 Variables measuring perceptions and attitudes of future traceability issues in relation to value chain characterizations.

	Value Chain Characterizations											
Future Traceability Outlook	Wild caught	Farmed	Processor	Mid[8]	Food Service or Retail	M-U, WC	MU-AQ	M-M	M-D	Vertically Integrated[10]	F value	p-value	Eta (η) effect size
"Here to stay"	3.35	3.08	3.19	3.67	3.38	3.17	3.67	3.38	3.22	3.44	0.778	0.637	
Harm to small business	2.65	2.73	3.07	3.00	2.39	2.43	2.67	2.87	3.33	2.88	1.357	0.216	
IUU decrease	2.95	2.42	2.53	3.50	3.27	2.91	2.80	2.67	2.43	2.94	3.277	0.001	0.436
"Best practices" rewarded	3.19	2.91	2.81	3.40	3.46	3.18	3.00	2.75	2.67	3.38	2.578	0.009	0.396
Costs outweigh benefits	2.62	2.44	3.13	2.67	2.57	2.67	3.00	2.87	3.11	2.71	1.148	0.335	
Market should dictate future	2.41	1.92	2.93	2.50	2.41	2.18	2.50	2.67	3.33	2.44	2.589	0.009	0.398
Prices increase for consumers	2.55	2.27	3.00	2.83	2.48	2.40	3.00	2.71	3.00	2.50	1.421	0.187	

“optimistic” attitudes among three statistically significant groups of responses (Table 3.7). Responses of individuals from cluster one demonstrated pessimistic attitudes and tended to disagree that future traceability developments will adequately address IUU and fraud, and reward best practices; likewise, this cluster indicated they agreed that prices would increase for consumers and small firms would disproportionately be harmed over large firms. Cluster two comprised of more neutral, mixed attitudes about the future, where traceability would indeed harm small firms and raise prices, but it likewise tended to agree that IUU and fraud would be addressed and best practices would be incentivized. Cluster three (optimistic) respondents tended to disagree that prices would increase, and that small firms would be harmed. Additionally, these respondents held a favorable view of the ability of traceability to decrease illegitimate practices, and that good actors would be rewarded. Collectively, all three clusters seemed in general agreement that traceability was “here to stay” with a mean response of 3.03 or higher for all three clusters. See Table 3.6 for summary of results from the K-Means Cluster Analysis.

Factor 5 was identified and calculated through PCA (Table 3.7), and the relationship between general negative outlook (Factor 5) and aggregate value chain characterization (“upstream,” “mid-value chain,” “downstream,” and “vertically integrated”) was statistically significant with a typical strength of interactions (See Table 3.13)(p=.035, ϕ =.256). Compared to other aggregate firm characterizations, midstream firms (e.g. distributors, wholesalers, importers, exporters with 4 sectors selected or less) appeared to have the highest mean level of agreement (2.72) that the future outlook will have negative outcomes (n=36). Overall on average, this finding suggests that these respondents had the greatest concern that costs of traceability may outweigh benefits to firms, costs may generally go up for consumers, new developments may disproportionately harm small firms over large firms, and that government should not provide any form of regulatory requirements. We likewise tested for relatedness between firm size and future outlook variables, and each association was not statistically significant ($p = 0.646, 0.377, 0.189, 0.092, 0.964, 0.08, 0.726$).

Discussion

Our results identified varying attitudes, perspectives, and insights on the level of favorability and preparedness for current and impending regulatory and market driven traceability developments within a sample population of west coast seafood industry professionals.

Importance of traceability in practice

Analysis suggested that traits especially integrated, larger, more diverse firms demonstrated more "collaborative" practices based on the perceived importance of traceability features, traceability information (KDE's), and the usage of traceability features in practice. Our findings establish clear evidence that importance of traceability generally increases with size of firm, number of sectors involved, and for selected sectors (Table 3.10; 3.12). This reaffirms previous work that traceability in practice is more common for vertically integrated firms [84]. As supported by the findings of this work, larger firms were generally more vertically integrated – as suggested in other studies, these firms likely have access to more resources to develop or subcontract the traceability architecture necessary to achieve product custody outcomes [6].

This study confirms the unique and critical role of processors in value chains. Respondents representing all sectors and sizes of firms selected processors indicated communicate with primary processors the most and the most often, supporting the critical importance of this node in value chains (Table 3.22). Previous studies on US fisheries have reported that traceability of products are often “lost” at the processor level [87]. In the background qualitative work of this study, processors (and catcher-processor vessels) in particular likewise cited some of the greatest challenges (and opportunities) with maintaining product traceability. Whether it’s high volume or multiple, high value species, as illustrated by the traditional “hourglass model,” processors are faced with a relatively high level of complex issues, including traceability. Meeting new regulatory requirements will be costly for this sector in particular. As shown in Table 3.18, 38% of respondents indicated they thought more upstream firms would bare the greatest proportion of costs associated with implementation of traceability. While this study did gather information on species and average annual revenue, it did not gather information on total product volume of firms. In order to understand the full scope of challenges, including processors, this information should be analyzed in future work. Considerable research is needed to understand the key lessons from processors. Technological advancements will be critical given the information demands processors face compared to other sectors.

Knowledge and preparedness for traceability

Although a large majority of respondents reported a moderate or high level of knowledge regarding traceability concepts and issues, over 70% were not aware of the SIMP, set to begin effective January 1, 2018. Given the Final Ruling was announced in

December of 2016 and a high profile lawsuit filed ensued throughout winter and spring of 2017, this is somewhat surprising. Whether NOAA and the US federal government have fallen short of their outreach obligations, or the seafood industry doesn't communicate effectively with regulatory authorities is largely unknown.

Larger firms and more downstream and/or vertically integrated firms generally demonstrated a higher level of knowledge, awareness, and preparedness for developments in traceability. Anecdotally and based on the background qualitative work for this study, these results appear consistent with the industry. We postulate that larger and point-of-sale firms typically have greater access to supporting organizations, associations, and other resources, they regularly interface with the public, and they handle larger volume (and more potential risk) as part of their business model.

Vertical Integration: what's the secret?

One of the most interesting findings for this study was the unique set of characteristics for vertically integrated firms (n=21) compared to other aggregate value chain characteristics (downstream, midstream, upstream, or vertically integrated). These respondents strongly disagreed with the concept that certain challenges make traceability difficult (mean of 1.74). They also demonstrated a more positive outlook, and had the second lowest mean response in favor of government oversight on traceability issues (2.46). Respondents who identified 5 or more sectors as components to their firm (n=36) indicated the greatest "perceived importance of traceability" and traceability type information. Additionally, the 12% of respondents that represented firms grossing over 100 million (USD) annually (n=18) indicated the largest mean KDI (Table 3.10), supporting the notion that large, multi-sector, and vertically integrated firms generally value traceability and believe it's an extremely important component to their firm, as it touches upon several critical components to their business operations and core objectives.

The concept of vertical integration has been a concept of substantial interest in food systems and seafood in particular with regards to traceability [5,6,84]. With traceability, each node in the value chain must make decisions on the information that is collected, stored, and shared [5]. Unlike small businesses that are often more fragmented, vertical integration also often comes with more "top-down" decision- making that can direct the decisions of multiple sectors making traceability more feasible. Previous studies have noted the innate cooperative behavior of vertically integrated firms; these firms generally demonstrate increased consumer knowledge and production efficiencies, improve quality and safety of products, and enable faster responses to internal challenges [5,88]. By their very nature compared to small firms, vertically integrated companies handle more volume, and therefore require and utilize more information to avoid risk, achieve regulatory compliance, and achieve efficiency. The findings from this study are consistent with broader analysis of food systems.

Midstream firms (distributors, wholesalers, exporters, importers) generally unfavorable attitudes regarding government oversight of traceability. In fact, these firms had the lowest mean value (2.31) out of all value chain characterizations of firms regarding government favorability. Additionally, these firms reported the lowest mean response to perceived benefits across value chain(s) (2.72), demonstrating general disagreement that traceability benefits all supply chain players. As defined in this study, middle value chain firms are not directly associated with production or point-of-sale processes, which may reflect a lack of understanding between different or willingness to implement on the complexities necessary to market traceability product. are often perceived as more averse to traceability implementation given their unique role in value chains. To our knowledge, this has not been explored in the literature to date and merits further investigation.

Government Oversight

Given the high favorability of government oversight (even increased government oversight beyond current regulations) among fishing and aquaculture producers evidenced in this study, it would appear upstream and smaller firms are looking to government to assist with these efforts. It is possible these small firms are not involved with imported product and simply sell locally or naturally however. Nevertheless, the US government (led by NOAA) has certainly put forth a robust effort to provide the support or framework by rolling out several regulations, including the SIMP beginning January 1, 2018 for imported product. Interestingly, the firms that see the greatest importance of traceability (e.g. large, diverse, integrated, processing sector) have pushed back the most on these impending traceability regulations. We postulate that, for these firms, the costs associated with compliance and avoiding risk of noncompliance are potentially highest for these sectors and types of firms.

One sector most in favor of government involvement was the aquaculture sector. Both individual aquaculture producers (n=13) and multi-sector firms involving aquaculture production (n=6) had the highest KFI values for value chain characterizations, 3.28 and 3.61, respectively (Table 3.10). Although a relatively small sample size, the higher value supports the notion that perceived importance of traceability increases with number of sectors and with firms producing farmed products. The aquaculture sector likewise was the only sector that had a mean score of 3.0 or higher indicating perceived production efficiency benefits for individual firms generated from traceability. For many years, the aquaculture industry has worked closely with the FDA and other authorities to tackle unique seafood safety risks associated with aquaculture products (e.g. *vibrio* with oysters). Certainly as aquaculture continues to expand in the United States and globally, we anticipate the demand for government partnerships and oversight to increase.

Potential Response Bias

While a suite of valuable findings and insights were uncovered as part of this investigation, respondents were sampled via a modified snowball technique, and therefore the findings of this study are not necessarily representative of the broader US west coast industry and/or seafood industry [89]. The findings of this study only demonstrate potential associations between variables and among group of participants that were sampled. Participants were nonrandom and the sample population was subject to sampling error. Sampling error could not be evaluated given the lack of census data. Similarities can we drawn between the findings of this study and the broader west coast seafood industry, however these comparisons cannot be considered representative [90]. With the exception of our initial wave of participants associated with the snowball technique, the full extent of individuals that were invited to participate in our survey is largely unknown, therefore, nonresponse error could not be evaluated [85].

Furthermore, given the substantial effect size and significance between geographic location of firms represented by respondents and value chain characterization

(Table 3.9), our analysis suggests a potential disproportionate representation of sectors along the US west coast. Given the volume of production in Washington and Alaska alone compared to Oregon and Washington, this is not surprising [29]. Within the study sample, for example, 78% of respondents indicated their firm resided in Oregon or Washington, no aquaculture firm was represented from the state of Oregon, and 50% of food service and/or retail resided in the state of Oregon. These examples illustrate potential biases when interpreting the data, and that the results of this study may not be generalizable to the region, and perhaps most importantly, other regions. Nevertheless, geographic location had no significance in virtually all analyses in this study other than value chain characterization. Other studies have also found no statistical significance of geographic location regarding the perceived benefits and value of traceability across value chains [6].

Another form of potential bias was related to the role of participants within the firms they represented. A substantial percentage of participants (40.6%) were generally working in positions of leadership and authority (e.g. CEO, president, managing director, etc.) within seafood businesses or supporting organizations, and were selectively sampled based on already established relationships with the research team. We acknowledge the disproportionate representation of upper management over lower management could result in potential bias related to surveys across a more diverse representation of industry job responsibilities.

Suggestions for further research and other considerations

This study supports the growing consensus regarding the favorability and perceived importance of traceability especially to vertically integrated and larger firms in the seafood industry. Many companies, particularly small and medium sized firms and upstream firms, may not have resources to comply with traceability regulations or demands from the market. The findings of this study demonstrate a substantial lack of awareness for new regulations. Moving forward, it is critical that government agencies pursue due diligence to notify and educate seafood firms regarding the new requirements as they will undoubtedly impact a large proportion of the market (40% according to NOAA) [57].

This study likewise noted differences in perceptions and attitudes between wild capture and aquaculture firms. The current “one-size-fits-all” approach to the broader traceability dialogue may be a challenge in the future. How can industry accommodate the unique regulatory requirements for the aquaculture industry, and maintain the pace of traceability enhancements required for aquaculture? Aquaculture products are generally much easier than wild capture products to maintain validation and safety of products and other traceability objectives given there are non-migratory and managed with multiple human interventions through their life cycle. Moving forward, we anticipate the interface between downstream firms, the aquaculture industry, and the wild capture industry to be fundamentally different and will operate at two different “speeds” in the movement towards improved traceability.

Whether regulatory or market driven, the big question is will the broader industry collectively be able to move forward at the same pace? Given the general discrepancy in the preparedness and importance of traceability features and traceability information identified in this study, the pace of adoption will vary by sector and firm. There will certainly be winners and losers. Our results suggest that small and medium size firms, and wild capture firms may be more reluctant to change. What is the relative feasibility for these firms to participate in the growing movement to implement, enhance, and expand global seafood developments in traceability? Without consolidating, can these separate smaller and medium sized entities collaborate and/or interact with larger, perhaps more vertically integrated firms involved in seafood commerce? The proposed solution by many experts is interoperability [2,91].

Recent efforts to provide a path forward offer lessons from finance, travel, produce, and healthcare industries; these lessons rest heavily on computerized systems and on interoperable, global seafood traceability architecture [26]. Studies have long identified interoperability as one of the largest challenges to sharing data and information with fisheries and food systems [2,26]. Nevertheless in this study, respondents in aggregate demonstrated that the “compatibility” of data systems was the least important feature of traceability systems (Figure 3.3). Given the recent emphasis of compatibility and/or and “interoperability” in seafood traceability research, this finding highlights different sentiments between industry members and traceability researchers, and may reflect a discrepancy in thinking about traceability concepts and issues. Nevertheless, respondents that were generally more knowledgeable of traceability concepts and issues expressed an even stronger importance for traceability

This study identified several subgroups and sections of the US west coast regional seafood industry that, at present, have a negative outlook on future traceability development. However according to the individuals sampled in this research, the large majority of industry agrees that IUU and seafood fraud will decrease and best practices will be rewarded because of future regulatory and market driven traceability developments. One thing appears certain according to industry: traceability is "here to stay."

Conclusion

Our findings demonstrate that many firms are not prepared for market and regulatory driven traceability developments, but generally agree it is a growing phenomenon. Whether more fragmented and less knowledgeable firms will be able to adapt, comply, and expand their traceability capacities soon without outside assistance or resources is largely unknown. As strategies for improved interoperability of firms within seafood systems offer a path forward for regulatory compliance and better industry collaboration, our research identifies a diverse range of traceability knowledge, practices, and preparedness for the future. This reality raises many questions regarding the feasibility of US companies for keeping pace with the current regulatory and market traceability drivers. Questions surrounding who pays for the proposed future traceability architecture, and whether government can distinguish between good faith actions and bad faith mistakes must undoubtedly be resolved moving forward.

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Appendix A – TABLES

Table 3.24. Outline for semi-structured background interviews and semi-formal focus groups. Focus group were comprised of five individuals in Newport, Oregon, and seven individuals in Portland, Oregon.

Question Topic	Sub-questions/topics
Introduction	*a. Participant name(s)* *b. Position in the organization* *c. Experience in the seafood industry*
General Mission of Business or Organization	*a. Scope of your mission for business/org?* b. *Describe your types of seafood products?*
Information Sharing	*a. Describe some key seafood information you typically want, need, will not share, and limitations to information*
General perspectives- Traceability	*a. Do traceability systems add value, benefits, or costs?* *b. Do you have a system? How much do you know?* *c. What are some conditions for traceability, in your opinion?* *d. Limitations to traceability (barriers to traceability)*
Role of government	*a. Who is most vulnerable to the new traceability requirements?* *b. Who are the winners and losers?* *c. Who is MOST responsible for fraud, IUU, seafood safety, etc.?* *d. Limitations to increased government oversight*
Thoughts on broader value chain	*a. Potential benefits of traceability to users in the value chain* *b. Information flow within the value chain* *c. Benefits to users in the value chain* *d. Information flow within the value chain* *e. What information are you most concerned about (slippery slope)?* *f. Does it bring value back benefits to your business?*
More on information systems	*a. How does it work?* *b. Major issues, roadblocks?* *c. Next step?*
Traceability Drivers	*a. What are the key drivers to traceability?* *b. NGO's, government, consumers, industry?*
The Future	*a. Regulatory* *b. Market issues / market driven* *c. Influence of technology* *d. Are consumers' needs change in the future?*

Table 3.25 Primary, secondary, and tertiary topics identified from qualitative field notes. Semi-structures interviews and two semi-formal focus groups successfully highlighted the key traceability issues at this juncture.

Primary	Secondary	Tertiary
Access to information	Data Security, misrepresentation and misuse (e.g. shelf life), permissions	"Millennials" will continue to request more access to information; government oversight
Traceability type information	Proprietary information, consumer information, internal information, and B-to-B information	Proprietary information, consumer information, internal information, and B-to-B information Species ID, price, catch method, COO, product state, river system, nutrition information, origin of catch, captains names, date of catch, time/temp info
Internal vs. external	Regulatory compliance, consumer facing, business-to-business	Many firms are still paper based
Potential barriers	Partitioning catch and species	Commodity fisheries vs. high value fisheries, welfare and poverty concerns might take precedence
Perception of Government	Government in general, impending regulations	Legal authority not clear, lack of government resources to enforce laws
Traceability architecture	Paper based (basic) vs. ERP system technologies (advanced)	Open source, cloud technologies and/or portals
Production method	Wild capture vs. aquaculture	Migratory vs. sedentary, differing safety requirements, farmed is easier overall
Public perception	Consumer education, marketing, retaining the culture	Technological and social limitations to informing the public
Key drivers for traceability	Regulatory vs. market demand	Safety and quality are most critical moving forward
Potential benefits	Production/operational, improved business relationships, competitive edge, marketing	Waste reduction, transparency, logistics and management, cost recovery, competitive advantage, increased marketing capacity, consumer education
Potential costs	Human error, database software, increase labor costs, improved monitoring	Costs may disproportionately harm small firms and processors
Societal factors	Demographics, global market forces	Consolidation and vertical integration
Relationships	Level of collaboration, information sharing, client retention	Traceability can help engender trust
Perception of the future	"Winners and losers," vision for the future	Small businesses are more vulnerable, domestic production may increase, IUU and fraud, traceability is "here to stay"

Table 3.26. Name, description, and scale of variables used in the traceability questionnaire.

Name	Description	Scale
SeafoodBusiness	Indicates elligability and involvement in the industry	Dichotomous 1= "yes;" 2=no;" 3="not sure;"
NoGov	Scenario with no government involvement with traceability	ordinal: 1="strong disagree,"; 2= "disagree;" 3="agree;" 4="strongly agree" 6="not applicable; 7="don't know;"
SomeGov	Current government requirements are sufficient	ordinal: 1="strong disagree,"; 2= "disagree;" 3="agree;" 4="strongly agree" 6="not applicable; 7="don't know;"
MoreGov	Future impending regulations are an effective approach moving forward	ordinal: 1="strong disagree,"; 2= "disagree;" 3="agree;" 4="strongly agree" 6="not applicable; 7="don't know;"
EvenMoreGov	More regulations needed on top of current and impending regs	ordinal: 1="strong disagree,"; 2= "disagree;" 3="agree;" 4="strongly agree" 6="not applicable; 7="don't know;"
PerceptionGov	Enabled respondents to share their additional thoughts	Open ended response
Knowledge	Degree of knowledge of traceability	Ordinal: 1="none;" 2="some;" 3="moderate;" 4="extremely knowledge"
Countryof Origin	Level of importance of traceability information, country of origin	ordinal: 1="not important,"; 2= "somewhat important;" 3="important;" 4="critically important" 6="not applicable; 7="don't know;"
Production Method	Level of importance of traceability information, (e.g. wild or farmed)	ordinal: 1="not important,"; 2= "somewhat important;" 3="important;" 4="critically important" 6="not applicable; 7="don't know;"
Species Common	Level of importance of traceability information, common name	ordinal: 1="not important,"; 2= "somewhat important;" 3="important;" 4="critically important" 6="not applicable; 7="don't know;"
Species Science	Level of importance of traceability information, scientific name	ordinal: 1="not important,"; 2= "somewhat important;" 3="important;" 4="critically important" 6="not applicable; 7="don't know;"
CatchOrigin	General origin of the catch	ordinal: 1="not important,"; 2= "somewhat important;" 3="important;" 4="critically important" 6="not applicable; 7="don't know;"
CatchDate	Date of harvest	ordinal: 1="not important,"; 2= "somewhat important;" 3="important;" 4="critically important" 6="not applicable; 7="don't know;"
LandingDate	Date product was brought to shore	ordinal: 1="not important,"; 2= "somewhat important;" 3="important;" 4="critically important" 6="not applicable; 7="don't know;"

Table 3.26, Continued.

Name	Description	Scale
CatchMethod	Gear used, (e.g. fixed gear, longline, trawler)	ordinal: 1="not important,"; 2= "somewhat important;" 3="important;" 4="critically important" 6="not applicable; 7="don't know;"
ProductState	Fresh, frozen, dried, etc.	ordinal: 1="not important,"; 2= "somewhat important;" 3="important;" 4="critically important" 6="not applicable; 7="don't know;"
OtherPres	Preservation techniques (e.g. carbon monoxide)	ordinal: 1="not important,"; 2= "somewhat important;" 3="important;" 4="critically important" 6="not applicable; 7="don't know;"
Quality	general product quality	ordinal: 1="not important,"; 2= "somewhat important;" 3="important;" 4="critically important" 6="not applicable; 7="don't know;"
TimeTemp	Records of temperature at various times when being shipped	ordinal: 1="not important,"; 2= "somewhat important;" 3="important;" 4="critically important" 6="not applicable; 7="don't know;"
Businesses	Firms involved	ordinal: 1="not important,"; 2= "somewhat important;" 3="important;" 4="critically important" 6="not applicable; 7="don't know;"
Recording	Key features ; recording info	ordinal: 1="not important,"; 2= "somewhat important;" 3="important;" 4="critically important" 6="not applicable; 7="don't know;"
Managing	Key features ; managing seafood safety	ordinal: 1="not important,"; 2= "somewhat important;" 3="important;" 4="critically important" 6="not applicable; 7="don't know;"
Compatibility	Key features; interoperability between systems	ordinal: 1="not important,"; 2= "somewhat important;" 3="important;" 4="critically important" 6="not applicable; 7="don't know;"
Storing	Key features; data storage, including paper	ordinal: 1="not important,"; 2= "somewhat important;" 3="important;" 4="critically important" 6="not applicable; 7="don't know;"
ControlWhat	Key features; control over what information is being shared	ordinal: 1="not important,"; 2= "somewhat important;" 3="important;" 4="critically important" 6="not applicable; 7="don't know;"
RealTime	Key features; information offered in near real time	ordinal: 1="not important,"; 2= "somewhat important;" 3="important;" 4="critically important" 6="not applicable; 7="don't know;"
ControlWho	Key feordinall over who receives information	ordinal: 1="not important,"; 2= "somewhat important;" 3="important;" 4="critically important" 6="not applicable; 7="don't know;"
RecordingUse … RealTimeUse*	Indicates whether this component is utilized in their firm operations	Dichotomous 1= "yes;" 2=no;" 3="not sure;"

Table 3.26, Continued.

Name	Description	Scale
RecordPercent … RealTimePercent*	Percentage of products subject to this traceability component	Ordinal: 1-10 (e.g. 1 = 10% of product, 8 = 80%)
Comingling	Key traceability challenge; mixing of multiple fishes into one salmon burger in the plant	ordinal: 1="strong disagree,"; 2= "disagree;" 3="agree;" 4="strongly agree" 6="not applicable; 7="don't know;"
GovReg	Key traceability challenge; government regulations	ordinal: 1="strong disagree,"; 2= "disagree;" 3="agree;" 4="strongly agree" 6="not applicable; 7="don't know;"
BusCulture	Key traceability challenge; business culture not supportive	ordinal: 1="strong disagree,"; 2= "disagree;" 3="agree;" 4="strongly agree" 6="not applicable; 7="don't know;"
LotDifficulty	Key traceability challenge; difficulty in tracking lots	ordinal: 1="strong disagree,"; 2= "disagree;" 3="agree;" 4="strongly agree" 6="not applicable; 7="don't know;"
HumanCost	Key traceability challenge; cost of more human labor	ordinal: 1="strong disagree,"; 2= "disagree;" 3="agree;" 4="strongly agree" 6="not applicable; 7="don't know;"
TechCost	Key traceability challenge; technology necessary is too expensive	ordinal: 1="strong disagree,"; 2= "disagree;" 3="agree;" 4="strongly agree" 6="not applicable; 7="don't know;"
Inter-operability	Key traceability challenge; different data systems sharing information	ordinal: 1="strong disagree,"; 2= "disagree;" 3="agree;" 4="strongly agree" 6="not applicable; 7="don't know;"
DataSecurity	Key traceability challenge; security of product information	ordinal: 1="strong disagree,"; 2= "disagree;" 3="agree;" 4="strongly agree" 6="not applicable; 7="don't know;"
Prod Efficiency	Potential benefit; production efficiency	ordinal: 1="strong disagree,"; 2= "disagree;" 3="agree;" 4="strongly agree" 6="not applicable; 7="don't know;"
RiskMan	Potential benefit; risk management	ordinal: 1="strong disagree,"; 2= "disagree;" 3="agree;" 4="strongly agree" 6="not applicable; 7="don't know;"
MarketAccess	Potential benefit; increased access to the market	ordinal: 1="strong disagree,"; 2= "disagree;" 3="agree;" 4="strongly agree" 6="not applicable; 7="don't know;"
HarvesterComms … OtherComms*	Indicates if communication with this sector occurs	Dichotomous 1= "yes;" 2=no;" 3="not sure;"

Table 3.26, Continued.

Name	Description	Scale
HarvesterTime … Consumer Time*	Indicates how often communication occurs; across sectors	ordinal: 1="never,"; 2= "once a year;" 3="once a month;" 4="once a week" 5= "daily;" 6="not applicable; 7="don't know;"
HarvesterInfoShare … Consumer Share*	Beyond gov regs, information sharing arrangements w/ each sector, if any	ordinal: 1="none,"; 2= "upon request only, voluntary;" 3="routine, voluntary;" 4="routine, business-to-business, voluntary;" 5= "not sure;"
CoOriginCon … BusinessesCon*	Info transparent to consumers	Dichotomous 1= "yes;" 2=no;" 3="not sure;"
COOComms ... Businesses Comms*	How info should be communicated to consumers	ordinal: 1 = "Label/Sign at point of Sale;" 2 = "Available electronically (e.g. QR code, website);" 3 = "Upon request Only;" 4 = "Verbally (e.g. trained servers/ staff);" 5 = "Other;"
Turnover	Potential benefit; increased turnover	ordinal: 1="strong disagree,"; 2= "disagree;" 3="agree;" 4="strongly agree" 6="not applicable; 7="don't know;"
Inventory	Potential benefit; Enhanced inventory tracking	ordinal: 1="strong disagree,"; 2= "disagree;" 3="agree;" 4="strongly agree" 6="not applicable; 7="don't know;"
Waste	Potential benefit; waste reduction	ordinal: 1="strong disagree,"; 2= "disagree;" 3="agree;" 4="strongly agree" 6="not applicable; 7="don't know;"
ProdQuality	Potential benefit; increased quality	ordinal: 1="strong disagree,"; 2= "disagree;" 3="agree;" 4="strongly agree" 6="not applicable; 7="don't know;"
ProdSafety	Potential benefit; safety issues	ordinal: 1="strong disagree,"; 2= "disagree;" 3="agree;" 4="strongly agree" 6="not applicable; 7="don't know;"
ConEducation	Potential benefit; consumers will become more educated	ordinal: 1="strong disagree,"; 2= "disagree;" 3="agree;" 4="strongly agree" 6="not applicable; 7="don't know;"
CostsAcross*	Perception of cost allocation in value chain	categorical: 1="benefits primarily impact “upstream” members;" 2="benefits primarily impact “downstream” members;" 3="Generally there are equal distribution of benefits to all supply chain members;" 4="not sure;"
Benefits* Across	Perception of benefit allocation in value chain	categorical: 1="benefits primarily impact “upstream” members;" 2="benefits primarily impact “downstream” members;" 3="Generally there are equal distribution of benefits to all supply chain members;" 4="not sure;"
FutureStay	Traceability is "here to stay" regardless of regs	ordinal: 1="strong disagree,"; 2= "disagree;" 3="agree;" 4="strongly agree" 6="not applicable; 7="don't know;"
FutureHarm	Traceability will disproportionately harm small businesses	ordinal: 1="strong disagree,"; 2= "disagree;" 3="agree;" 4="strongly agree" 6="not applicable; 7="don't know;"

Table 3.26, Continued.

Name	Description	Scale
FutureIllegitimate	Future illegitimate production and handling practices will decrease	ordinal: 1="strong disagree,"; 2= "disagree;" 3="agree;" 4="strongly agree" 6="not applicable; 7="don't know;"
FutureReward	Traceabiity will help reward "best practices"	ordinal: 1="strong disagree,"; 2= "disagree;" 3="agree;" 4="strongly agree" 6="not applicable; 7="don't know;"
Futurebenefits	Costs will be higher than relative to benefits	ordinal: 1="strong disagree,"; 2= "disagree;" 3="agree;" 4="strongly agree" 6="not applicable; 7="don't know;"
FutureMarketNeeds	Future traceability develops should only be market driven and not regulatory	ordinal: 1="strong disagree,"; 2= "disagree;" 3="agree;" 4="strongly agree" 6="not applicable; 7="don't know;"
FuturePrice	Cost to consumers will increase significantly	ordinal: 1="strong disagree,"; 2= "disagree;" 3="agree;" 4="strongly agree" 6="not applicable; 7="don't know;"
Regulation	Awareness of SIMP	Dichotomous: 1= "yes;" 2=no;" 3="not sure;"
Species	Number of species handled by firm	ordinal: 1="1-5,"; 2= "6-15;" 3="16-30;" 4="31-50" 5="50+;" 6="not applicable; 7="don't know;"
CurrentRole	Role within firm	Categorical: 1="CEO/President/Owner;" …(24 classifications)
Location	Location where respondents works for their firm	categorical: 1="Oregon;" 2="Washington;" 3="Alaska;" 4="California;" 5="other" 6="not sure;"
Age	age in years	continuous
Education	Level of formal education	nominal: 6 = "Some high school, no diploma;" 7 = "High school graduate, diploma or the equivalent (for example: GED);" 8 = "Some college credit, no degree;" etc.
Gender	How do respondent describe themselves	categorical: 1="male;" 2="female;" 3="transgender;" 4="I do not identify as male, female, or transgender"
CompanyType	Indicates which sectors the firm represents	Dichotomous: 1= "yes;" 2=no;" 3="not sure;" for each sector (select all that apply)
CompanySize	Size of firm	1= "< $50,000" 2 = " > $50,000 and $99,999" 3 = "> $100,000 and < $1,000,000" 4 = "> $1,000,000 and < $5,000,000" 5 = "> $5,000,000 and < $100,000,000" 6 = "> $100,000,000"

*Variables were assessed contingent on previous selections, across multiple sectors and/or information selections.

Table 3.27 New variables computed from aggregations, cluster analyses, and/or factor analyses (PCA).

Name	Description	Scale
Sectordiversity	Number of sectors selected	Continuous
Sectordiversity_ dichotomous	Single sector; multiple sectors	dichotomous: 1="one;" 2="multiple"
Education_ dichotomous	Split into two categories	dichotomous 1 = "associates Degree or less;" 2 = "more than an associates degree"
Age_dichotomous	Split into two categories	dichotomous: 1="50 yrs or less;" 2="Over 50 yrs"
CurrentRole_ dichotomous	Split into two categories	dichotomous: 1="CEO/president/owner;" 2="Other"
MarketDrivenReversed	Reverse coded to align with PCA	See "FutureMarketNeed," Table 3.26
FutureRewardReversed	Reverse coded to align with PCA	See "FutureReward," Table 3.26
SomeGovReversed	Reverse coded to align with PCA	See "SomeGov," Table 3.26
Attitudes_traceability_ challenges	Index computed on general attitudes towards traceability challenges within firm; PCA	continuous: based on means of four variables: HumanCost,TechCost,Interoperability,DataSecurity
Importance_of_ traceability_features	Index computed on perceived importance of traceability features to firm; PCA	continuous: means of six variables: Recording,Managing,Compatability,Storing,ControlWhat,ControlWho
Negative_outlook	NoGov,FuturePrice,FutureHarm,FutureCosts	continuous: means of six variables: NoGov,FuturePrice,FutureHarm,FutureCosts
CompanyType_ Aggregate	three categories	categorical: 1="upstream," 2="midstream" 3="downstream;"
CompanyType_ Aggregate_plus	two categories	categorical: 1="upstream;" 2="downstream;"

Table 3.27, Continued.

Name	Description	Scale
Benefits_within_index	Index computed on perceived benefits to firm; PCA	continuous: based on means of two variables: RiskMan,MarketAccess; PCA
Benefits_across_index2	Index computed on perceived benefits across value chain; PCA	continuous: based on means of three variables: Turnover,Inventory,Waste; PCA
Benefits_across_index3	Index computed on perceived benefits across value chain; PCA	continuous: based on means of two variables: ProdQuality,ProdSafety; PCA
Benefits_industry_index4	Index computed on perceived benefits to broader industry; PCA	continuous: based on means of three variables: FutureReward,FutureIllegitimate,ConEducation; PCA
three_group_keytracefeatures	Three clusters identified regarding perceived importance of key traceability features	categorical: based on means of seven variables: Recording Storing Compatability ControlWhat ControlWho Manage RealTime; K-Means Cluster
three_group_traceability_ usage	Three clusters identified regarding usage of key traceability features within their firm	categorical: based on means of seven variables: RecordingUse StoringUse CompatabilityUse ControlWhatUse ControlWhoUse ManageUse RealTimeUse; K-Means Cluster
Importer_dichotomous	Two categories	Seperated importers from non-importers
Species_dichotomous	Two categories based on number of species handled	dichotmous; 1="5 or fewer;" 2="Greater than 5;"
four_group_transparancy	Four clusters identified regarding perception of future developments	categorical: based on means of seven variables: FutureStay FutureHarm FutureIllegitimate FutureReward FutureCosts FuturePrice; K-Means Cluster

Appendix B – QUESTIONNAIRE

1) Are you involved (e.g. as an employee, owner, or contractor) in a seafood business/organization that serves a role in seafood production, supply, and/or other industry support (e.g., commercial fisheries, aquaculture, processing, distribution, retail, food service, industry association, marketing association, commodity commission, management organization, etc.)?

- ○ Yes
- ○ No
- ○ Not sure

2) Thinking broadly, please indicate the extent you agree or disagree with the following statements regarding the role of government in requiring and managing product traceability.

	Strongly disagree	Disagree	Agree	Strongly agree	Not applicable	Don't Know
Government should not require any form of seafood traceability	○	○	○	○	○	○
The current traceability regulations are adequate (e.g., "one-up, one-down", country of origin)	○	○	○	○	○	○
Current government regulations should be strengthened by requiring additional information to be shared along the supply chain	○	○	○	○	○	○
Point-of-sale businesses must increase traceability information provided to consumers beyond current regulations	○	○	○	○	○	○

3) Any other comments regarding the role of government and requirements for managing for product traceability?

4) Please select the choice that BEST represents your general level of knowledge with respect to seafood traceability concepts and issues.

- ◯ None
- ◯ Very little
- ◯ Moderate
- ◯ High

5) Which of the following sectors BEST describes your seafood business/organization. If you participate in more than one (e.g. as an employee, owner, contractor), please indicate all categories that apply.

- ☐ Harvester/fisherman – wild capture
- ☐ Aquaculture (e.g shellfish, finfish, seaweed)
- ☐ Primary processor
- ☐ Secondary processor (e.g. value-added, portioning, and other activities beyond initial processing)
- ☐ Wholesaler
- ☐ Exporter
- ☐ Importer
- ☐ Distributor
- ☐ Restaurant
- ☐ Retail - grocery store
- ☐ Retail – "boutique vendor" (e.g fish shop, farmers market)
- ☐ Direct marketer (e.g. direct to consumers, not retailer)
- ☐ Other food service institution (e.g. hospital, school, etc.)
- ☐ Affiliated organization (e.g. industry association, marketing association, commodity commission, management organization)

- Other sectors/organizations (please specify) ____________________
- Other sectors/organizations (please specify) ____________________
- Not Sure

6) Out of your multiple selections, select the primary business function that typically represents the largest portion of your revenue or income compared to other business functions. **Please refer to this selection for the remainder of questions regarding your business/organization**.

- Harvester/fisherman – wild capture
- Aquaculture (e.g shellfish, finfish, seaweed)
- Primary processor
- Secondary processor (e.g. value-added, portioning, and other activities beyond initial processing)
- Wholesaler
- Exporter
- Importer
- Distributor
- Restaurant
- Retail - grocery store
- Retail – "boutique vendor" (e.g fish shop, farmers market)
- Direct marketer (e.g. direct to consumers, not retailer)
- Other food service institution (e.g. hospital, school, etc.)
- Affiliated organization (e.g. industry association, marketing association, commodity commission, management organization)
- Other sectors/organizations (please specify) ____________________

○ Other sectors/organizations (please specify) ________________________________

○ Not Sure

7) How important are the following types of traceability information for your business/organization?

	Not at all important	Slightly important	Very important	Extremely important	Not Applicable	Don't Know
Country of origin	○	○	○	○	○	○
Method of production (e.g., farmed or wild)	○	○	○	○	○	○
Species (common name)	○	○	○	○	○	○
Species (scientific name)	○	○	○	○	○	○
Origin of the catch (area of the ocean or regional level)	○	○	○	○	○	○
Date of catch	○	○	○	○	○	○
Date of landing	○	○	○	○	○	○
Catch method (e.g. gear type)	○	○	○	○	○	○
State of product (fresh, frozen, or previously frozen)	○	○	○	○	○	○
Other preservation methods	○	○	○	○	○	○

Quality attributes	○	○	○	○	○	○
Time-temperature history	○	○	○	○	○	○
Businesses that have handled the product	○	○	○	○	○	○
Other (please specify)	○	○	○	○	○	○
Other (please specify)	○	○	○	○	○	○
Other (please specify)	○	○	○	○	○	○

9) For your business/organization, how important are the following key features of traceability systems?

	Not at all important	Slightly important	Very important	Extremely important	Not applicable	Don't Know
Recording product information (including paper records)	○	○	○	○	○	○
Storing product information (including paper documents)	○	○	○	○	○	○
Compatibility with your internal business information system	○	○	○	○	○	○
Control over types of product information to be shared	○	○	○	○	○	○
Control over who receives product information	○	○	○	○	○	○
Managing food safety and product recalls	○	○	○	○	○	○
Accessing product information in real time	○	○	○	○	○	○

10) Does your business/organization currently use these features as part of your traceability efforts?

	Yes	No	Not Sure
Recording product information (including paper records)	○	○	○
Storing product information (including paper documents)	○	○	○
Compatibility with your internal business information system	○	○	○
Control over types of product information to be shared	○	○	○
Control over who receives product information	○	○	○
Managing food safety and product recalls	○	○	○
Accessing product information in real time	○	○	○

11) Based on each of the traceability features you currently use, over the course of a year, what percentage of the volume of the seafood products that you handle would you classify as being regularly subject to these traceability practices?

Recording product information (including paper records)	
Storing product information (including paper documents)	
Compatibility with your internal business information system	
Control over types of product information to be shared	
Control over who receives product information	
Managing food safety and product recalls	
Accessing product information in real time	

12) For your business/organization, to what degree do the following issues create barriers for using traceability?

	No barriers	Some barriers	Many barriers	Significant barriers	Not applicable	Don't Know
Co-mingling of raw material (e.g. individual products mixed together)	○	○	○	○	○	○
Government regulations	○	○	○	○	○	○
Business culture is not supportive	○	○	○	○	○	○
Difficulty in managing and tracking "lots", batches, cartons, and/or packages	○	○	○	○	○	○
Cost of human data entry (e.g.	○	○	○	○	○	○

transfer from paper records to electronic)						
Cost of required technologies	○	○	○	○	○	○
Incompatible data systems	○	○	○	○	○	○
Data security	○	○	○	○	○	○
Other (please specify)	○	○	○	○	○	○
Other (please specify)	○	○	○	○	○	○

13) Please indicate your level of agreement and/or disagreement with the following statements regarding your business/organization. Traceability systems help produce net benefits as a result of...

	Strongly disagree	Disagree	Agree	Strongly agree	Not Applicable	Don't Know
increasing production efficiency	○	○	○	○	○	○
improving risk management	○	○	○	○	○	○
increasing market access	○	○	○	○	○	○

14) As an individual employee, owner, and/or contractor in your business/organization, which of the following sectors do you conduct businesses with? Select all that apply.

- ☐ Harvester/fisherman – wild capture
- ☐ Aquaculture producer
- ☐ Primary processor
- ☐ Secondary processor (e.g. value-added, portioning, and other activities beyond initial processing)
- ☐ Wholesaler
- ☐ Exporter

- ☐ Importer
- ☐ Distributor
- ☐ Restaurant
- ☐ Retail – grocery story
- ☐ Retail – "boutique vendor" (e.g fish shop, farmers market)
- ☐ Direct marketer
- ☐ Other food service institutions (e.g. hospital, school, etc.)
- ☐ Affiliated organization (e.g. industry association, marketing association, commodity commission, management organization)
- ☐ Consumer
- ☐ Other sectors/organization ____
- ☐ Other sectors/organization ____
- ☐ Not sure

15) How often do you communicate (e.g. in person, by phone, text, or email) with people from the sectors you selected in the previous question?

	Never	At least once a year	At least once a month	At least once a week	Daily	Don't Know
Harvester/fisherman – wild capture	○	○	○	○	○	○
Aquaculture producer	○	○	○	○	○	○
Primary processor	○	○	○	○	○	○
Secondary processor	○	○	○	○	○	○
Wholesaler	○	○	○	○	○	○
Exporter	○	○	○	○	○	○

Importer	○	○	○	○	○	○
Distributor	○	○	○	○	○	○
Restaurant	○	○	○	○	○	○
Retail – grocery story	○	○	○	○	○	○
Retail – "boutique vendor" (e.g fish shop, farmers market)	○	○	○	○	○	○
Direct marketer	○	○	○	○	○	○
Other food service institutions (e.g. hospital, school, etc.)	○	○	○	○	○	○
Affiliated organization	○	○	○	○	○	○
Consumer	○	○	○	○	○	○
Other sectors/organization	○	○	○	○	○	○
Other sectors/organization	○	○	○	○	○	○
Not sure	○	○	○	○	○	○

16) Aside from government requirements, please select the information sharing arrangements that occurs with the sectors you selected previously.

	None	On request, voluntary	Routine, voluntary	Routine, business-to-business contracts	Not Sure
Harvester/fisherman – wild capture	○	○	○	○	○
Aquaculture producer	○	○	○	○	○
Primary processor	○	○	○	○	○
Secondary processor	○	○	○	○	○
Wholesaler	○	○	○	○	○
Exporter	○	○	○	○	○
Importer	○	○	○	○	○
Distributor	○	○	○	○	○
Restaurant	○	○	○	○	○
Retail – grocery story	○	○	○	○	○
Retail – "boutique vendor" (e.g fish shop, farmers market)	○	○	○	○	○
Direct marketer	○	○	○	○	○
Other food service institutions (e.g. hospital, school, etc.)	○	○	○	○	○
Affiliated organization	○	○	○	○	○

Consumer	○	○	○	○	○
Other sectors/organization	○	○	○	○	○
Other sectors/organization	○	○	○	○	○
Not sure	○	○	○	○	○

17) Which of the following types of product information should be made available to consumers? Select all that apply.

- ☐ Country of origin
- ☐ Method of production (e.g., farmed or wild)
- ☐ Species (common name)
- ☐ Species (scientific name)
- ☐ Origin of the catch (area of the ocean or regional level)
- ☐ Date of catch
- ☐ Date of landing
- ☐ Harvest method (e.g. gear type)
- ☐ State (e.g. fresh, frozen, or previously frozen)
- ☐ Other handling (e.g. carbon monoxide, etc.)
- ☐ Quality attributes (e.g. "freshness," % fat content, nutrition, etc.)
- ☐ Time-temperature history
- ☐ List of all businesses that have handled the product
- ☐ Other (please specify) ____
- ☐ Other (please specify) ____

☐ Other (please specify) ____

18) For each of the types of product information you selected above, what is the BEST method for communicating this information to consumers?

	Label/Sign at point of Sale	Available electronically (e.g. QR code, website)	Upon request Only	Verbally (e.g. trained servers/ staff)	Other
Country of origin	○	○	○	○	○
Method of production (e.g., farmed or wild)	○	○	○	○	○
Species (common name)	○	○	○	○	○
Species (scientific name)	○	○	○	○	○
Origin of the catch (area of the ocean or regional level)	○	○	○	○	○
Date of catch	○	○	○	○	○
Date of landing	○	○	○	○	○
Harvest method (e.g. gear type)	○	○	○	○	○
State (e.g. fresh, frozen, or previously frozen)	○	○	○	○	○
Other handling (e.g. carbon monoxide, etc.)	○	○	○	○	○
Quality attributes (e.g. "freshness," %	○	○	○	○	○

fat content, nutrition, etc.)					
Time-temperature history	○	○	○	○	○
List of all businesses that have handled the product	○	○	○	○	○
Other (please specify)	○	○	○	○	○
Other (please specify)	○	○	○	○	○
Other (please specify)	○	○	○	○	○

19) Across your entire supply chain(s) (not just within your business), please indicate your level of agreement and/or disagreement with the following statements. Generally speaking, traceability...

	Strongly disagree	Disagree	Agree	Strongly agree	Not applicable	Don't Know
improves product turnover	○	○	○	○	○	○
improves inventory management	○	○	○	○	○	○
reduces waste	○	○	○	○	○	○
improves product quality	○	○	○	○	○	○
improves product safety	○	○	○	○	○	○
improves consumer education	○	○	○	○	○	○
Other (please specify)	○	○	○	○	○	○

Other (please specify)	◯	◯	◯	◯	◯	◯

20) Indicate to the extent to which you agree or disagree for the following statements regarding the relative distribution of costs traceability across your entire supply chain(s?

◯ Costs primarily impact "upstream" members (i.e. producers, processors, fish farms, etc.)

◯ Costs primarily impact "downstream" members (i.e. wholesalers, retailers, restaurants, etc.)

◯ Generally there are equal distribution of costs to all supply chain members

◯ Not sure

21) Indicate to the extent to which you agree or disagree for the following statements regarding the relative distribution of benefits of traceability across your entire supply chain(s)?

◯ Benefits tend to favor "upstream" members (i.e. producers, processors, farms, etc.)

◯ Benefits tend to favor "downstream" members (i.e. wholesalers, retailers, restaurants, etc.)

◯ Generally there are equal distribution of benefits to all supply chain members

◯ Not sure

21 Thinking about the future of traceability, please indicate the extent to which you agree or disagree with the following statements:

	Strongly disagree	Disagree	Agree	Strongly agree	Not Applicable	Don't Know
Whether driven by market or regulatory needs, some form of traceability is "here to stay"	◯	◯	◯	◯	◯	◯
Proposed federal traceability requirements will disproportionately harm small businesses compared to large ones	◯	◯	◯	◯	◯	◯

Traceability will decrease illegitimate production and seafood handling practices	○	○	○	○	○	○
Traceability will help reward “best practices”	○	○	○	○	○	○
Traceability will increase business costs relative to benefits	○	○	○	○	○	○
Beyond current seafood safety requirements, the growth of traceability should only be driven by market needs	○	○	○	○	○	○
Traceability will significantly increase the price of seafood for consumers	○	○	○	○	○	○

22) New proposed federal regulations for imported seafood products require a "core" set of information to be traced to the US importer, including name of harvester, country of origin, license, scientific name, common name, gear type, when caught, where caught, wharf location, when landed, name of buyer, and importer proof of chain of custody. Compliance for this "core" information under these new requirements for over 200 species becomes effective January 1, 2018. (Importers are not required to share this information with businesses downstream supply chain). Are you aware of these new requirements under the proposed federal regulations?

○ Yes

○ No

○ Not sure

23) On average, roughly how many seafood species does your business/organization handle/manage/support over the course of a year?

○ 0-5

○ 6-15

- 16-30
- 31-50
- 50+
- My business/organization does NOT handle/manage/support seafood products either directly or indirectly

24) Roughly speaking, what is the average annual revenue (e.g. sales) of your seafood business/organization?

- Less than $50,000
- Between $50,000 and $100,000
- Between $100,000 and $500,000
- Between $1 Million and $5 Million
- Between $5 Million and $100 Million
- More than $100 Million
- Not Sure

25) Approximately how many years have you been in the seafood business? Please type in below.

26) How would you describe your current role in your seafood business/organization? Please select the answer that best represents your primary responsibility.

- Management (CEO/President/Partner/Owner/Managing Director)
- Category Manager
- Administration
- Operations
- Sales/Marketing
- Private Label Program Director/Manager

- Commercial Director
- Menu Planner/Chef
- Plant/Factory Management
- Logistics/Warehouse/Distribution
- Quality Control/Quality Management
- Manufacturer/Processor
- Technical/Operation Management
- Product Development/ R & D
- Engineer
- Buyer/Purchasing Ingredients
- Buyer/Purchasing Equipment/Services/Packaging Supplier
- Buyer/Purchasing Foodservice
- Supplier
- Vessel - Skipper
- Vessel - Deck Hand
- Line worker
- Server
- Aquaculture Farm Manager
- Other ____

27) Where is your seafood business/organization located? Select one below.

- Oregon

- Washington
- Northern California
- Alaska
- Other ____

28) What is your age? Please enter in number of years below.

29) What is your highest degree or level of education you completed?

- Some high school, no diploma
- High school graduate, diploma or the equivalent (for example: GED)
- Some college credit, no degree
- Trade/technical/vocational training
- Associate degree
- Bachelor's degree
- Master's degree
- Professional degree
- Doctorate degree

30) How would you describe yourself? Note, this question is required to be worded in this manner.

- ◯ Male
- ◯ Female
- ◯ Transgender
- ◯ I do not identify as male, female, or transgender

Conclusion

When I first began my investigation into seafood traceability research, I was fascinated by the overall concept. After two years of research in this subject, my intrigue and understanding of such an interdisciplinary field of research has expanded well beyond what I thought was possible. Diving into socioeconomic research on the seafood industry perspectives has instilled an intimate understanding of how and why people operate in certain ways within seafood businesses and the challenges of regulatory constraints. I have developed a deep admiration for the creativity, innovation, and innate drive of many individuals within the industry to solve problems and work together. By it's very nature the ocean is always changing what it provides, and it will continue to provide jobs and nutritious food for people and communities.

From this research I learned that small is beautiful, and large is efficient. There's a lot of current dialogue that favors small over large businesses, and as we dig deeper, economic sustainability merits efficiencies that are sometimes difficult for smaller businesses to obtain. The careful balance of ecological, economic, and social sustainability weighs heavily on "good "science and sound decision making. In today's world we often operate in silos, and it was a privilege to understand the day-to-day jobs of seafood industry professionals and to better understand their story. As industry, government, and the broader scientific community aims to work together to solve problems, applied social science research will hopefully continue to maintain trust between industry and scientists, and elucidate some truths about seafood systems that will help generate new solutions.