U.S. CONSUMER PREFERENCES FOR SEAFOOD TRACEABILITY

by

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ABSTRACT

Americans are the second largest consumers of seafood globally but more than 90% of the seafood consumed is imported, causing the seafood supply chain to be long, opaque, and complex. This gives rise to several concerns such as intentional mislabeling, species substitution, illegal unreported and unregulated (IUU) fishing, unsustainable fishing practices and human rights violations in the seafood industry. Despite recent government mandates and initiatives such as the Seafood Import Monitoring Program (SIMP) as well as advocacy from industry and supply chain players, end-to-end information flows from harvest location to the table, remains a challenge. This is mainly due to lack of common harmonized Key Data Elements (KDEs), lack of interoperability, lack of global adoption of standards, and heterogenous systems. Traceability appears to provide a mechanism to alleviate these concerns through enabling information flows triggered by three major drivers of seafood traceability: producers, consumers and regulators. Of the three, consumers are perceived to have the least influence on traceability.

This paper investigates whether consumer preferences can drive seafood traceability. It also explores specific consumer characteristics and preferences for whole-chain traceability through direct survey, interviews with industry stakeholders and review of existing literature. The survey results show that consumer preferences play a lesser role as compared to other drivers, due to several exogenous reasons. However, further analysis shows that high propensity for traceability preferences may be influenced by high income levels, frequency of consumption and domicile habitats closer to urban and coastal areas in the U.S. Steps towards establishing an integrated, collaborative and inclusive approach to standardization of KDEs may help move the seafood traceability agenda forward.

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1. Introduction

1.1 Background

Seafood consumption has grown progressively since the 1950's. Global fish production peaked at about 171 million tons in 2016 (**Figure 1**), with that production evenly distributed between wild catch and aquaculture (FAO, 2018). The United States (U.S.) is the second largest consumer of seafood in the world. Fishing and seafood consumption in the United States increased in 2017 to 9.9 billion pounds (US$ 5.4 billion) annually, an increase of 3.6 percent from the year before. The seafood industry, which consists of fishing, seafood farming and processing sectors, forms a significant part of the U.S. economy. In 2016, the seafood industry contributed $100 billion to the U.S. GDP and supported 1.7 million jobs in the country (NOAA, 2017).

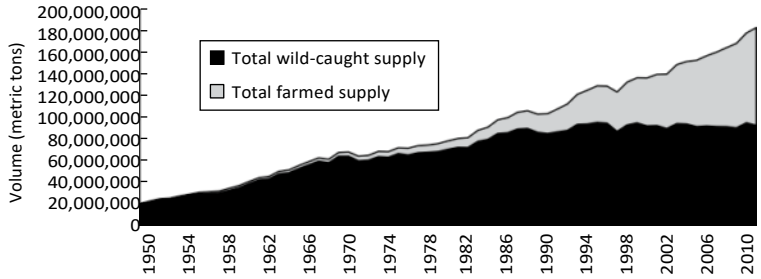


Figure 1: Volume of wild-caught and farmed seafood, 1950-2012. Source: FAO (2014)

In recent years, with increasing per capita income, more millennials entering the work force, and a greater focus on health and fitness, there is a shift to healthier, higher protein-based food. Seafood, a lean source of protein and essential nutrients, rich in Omega 3 and Omega 6 fatty acids, has been called "nature's super food" for its nutritional components (FAO, 2016).

The majority of seafood consumed in the U.S. today, between 85 to 95 percent is imported (NOAA, 2017). This lends a high level of opaqueness to the global seafood industry creating several

challenges such as: intentional species substitution, illegal unreported and unregulated (IUU) fishing, co-mingling of seafood species?, high incidence of foodborne illnesses, fraudulent labeling, unsustainable fishing practices and human rights violations. As a result, these issues threaten food safety and sustainability. The seafood supply chain's complexity is magnified due to the highly perishable nature of live and fresh seafood, proliferating product segments (wild-caught, aquaculture and processed across seafood products: fish, crustaceans and shellfish), ever-increasing tiers of diverse suppliers **(Figure 2),** and lack of seamless communication between them. There also exists a dearth of harmonized rules and globally accepted standards for seafood data attributes, which poses the biggest challenge in whole-chain transparency in the seafood industry. For example, it is possible for fishermen to legally sell Warsaw grouper, identified as a critically endangered species by the International Union for Conservation of Nature (IUCN), as simply "grouper," making it difficult to differentiate it from the 64 other fish that can be sold as grouper.

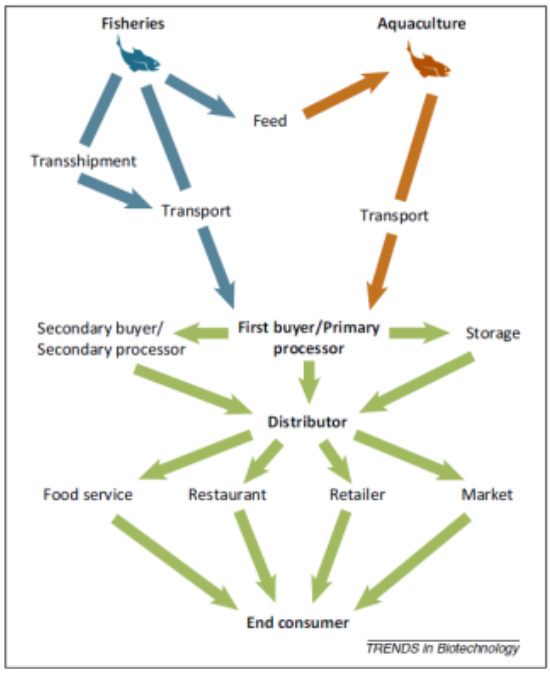


Figure 2: Schematic drawing of the seafood supply chain from producers to the end consumer.

1.2 Why Traceability?

Safety is an important quality attribute of seafood (FAO, 2018). Consumers' food safety perceptions influence their seafood consumption and purchase patterns. Some segments of consumers are increasingly demanding high standards of quality assurance and ascertainment that the fish they

purchase are produced sustainably and with quality certifications (Rahmaniya & Sekharan, 2017). These segments want to know more about where their fish originated from, who the suppliers are, whether they are sustainably farmed or caught and whether they are safe to feed their families. They want to gain trust about the safety and authenticity of the seafood they consume. In other words, the information flows surrounding the physical and financial flows of products have been gaining prominence. Transparency in end-to-end accurate, trusted, real time information as food moves through the supply chain can build trust with consumers (Mol, 2015).

Traceability does appear to provide a mechanism to alleviate these concerns through enabling structured information flows across the entire value chain (Bailey, Bush, Miller, & Kochen, 2016). However, the lack of consistent data standards, unharmonized global regulations, lack of interoperability between systems of record and lack of a common data vocabulary cause impediments in whole chain information flows (A. Naaum & Hanner, 2016). The Global Food Traceability Center (GFTC) lead the Interoperable Seafood Traceability Technology Architecture Project, with an aim to establish a harmonized, secure, interoperable seafood traceability system (Bhatt et al., 2016). It recommends a universal list of Key Data Elements (KDEs) at various product transformation touchpoints or Critical Tracking Events (CTEs) clustered by various drivers of traceability.

1.3 What is Driving Traceability?

Effective seafood traceability systems are dependent on various underlying drivers: (a) government regulation of seafood and its safety, (b) consumer-facing and brand aware supply chain actors, and (c) consumers who demand to know more about the credence attributes of their seafood (Bailey et al., 2016). Credence attributes are quality attributes which are desired by consumers. Consumers

have to rely on other sources such information on their products or other sources of information as media and word of mouth (Becker, n.d.). A recent transparency survey found that consumers want to see everything from a complete ingredient breakdown to sourcing information, with 94% of respondents saying they are likely to be more loyal to a brand that offers complete transparency (Label Insight, 2016). Information flow to consumers of seafood product characteristics like harvest date, quality, origin and processing information are communicated through product labeling and through chain of custody information systems via the retailer and product labeling. These "credence" attributes along with eco-labels and certifications, are difficult for consumers to obtain and are not a priority today. Consumer preferences are regarded as insignificant according to traceability literature. However, consumers could be a major driver of change in the behavior in the industry, far exceeding past-campaigns such as "dolphin-safe" tuna and bans on shark fin soup (Willette and Cheng, 2018).

1.4 Current Knowledge Gap

While there exists a significant literature examining consumer preferences for seafood and credence attributes, attitudes and beliefs related to U.S. seafood consumption, consumer preferences for traceable information and attitudes towards traceable KDEs are not well understood (Mol, 2015). Even with the recent U.S. regulations mandating comprehensive seafood import data, there still are open questions and gaps in that the information gathered does not specify unique attributes such as specific fishing methods, processing steps, scientific nomenclatures, and additional credence attributes (He, 2018). There is paucity of data or research about consumers' likeliness to engage in traceability and what motivates them to trace their products (A. Naaum & Hanner, 2016).

1.5 Research Objective and Summary

The goal of this paper is to understand the existing literature and the current research around seafood traceability from the perspective of drivers in general and consumer preferences, particularly in the U.S. It highlights consumer attitudes and perceptions associated with seafood buying behavior through direct survey, stakeholder interviews, and focus groups. It examines the influence of consumer preferences on traceability KDEs through statistical analysis, classification, clustering, data visualization and machine learning analysis. It answers the key questions: Do consumer preferences drive seafood traceability in the U.S.? What specific consumer characteristics, perceptions and attitudes spur high traceability KDEs? The paper further discusses the implications of the findings to the seafood industry stakeholders and recommendations to strengthen the value proposition and foster adoption of traceability systems.

This research paper is organized into 5 Sections. Section 2 summarizes a thematic representation of existing literature in this area. Section 3 explains the research methodology. The results and findings from the research are elaborated in Section 4 followed by discussion, recommendations and conclusion in Section 5.

2. Literature Review

The literature review was conducted in advance of the primary research to determine the needs and drivers of traceability. This chapter provides a synopsis of existing literature surrounding seafood traceability concepts, drivers of seafood traceability and consumer preferences towards traceability.

2.1 The Case for Seafood Traceability

When we think of seafood, we think of the fisher folk who catch or farm the fish, but there are many diverse global supply chain players, from the smallest fishermen and aquaculture farmers to processors, distributers, producers, manufacturers, and other intermediaries. Seafood has a particularly long, opaque, and complex journey as it travels through the global supply chain to the U.S., which causes challenges.

The global problem of Illegal, unreported and unregulated (IUU) fishing results in an estimated fishing loss of $10 billion to $23.5 billion per year, representing 11 to 26 million tons of seafood (Agnew et al, 2009). In the United States, IUU products account for $1.3 billion to $2.1 billion dollars of wild caught seafood imports (Pramod, Nakamura, Pitcher, & Delagran, 2014). Additionally, it also causes biodiversity loss and decreased food security (FAO, 2018). IUU has also been implicated in slave and human trafficked labor…. In 2014, a major investigation revealing brutal cases of slavery aboard fishing boats in Thailand caused international furor (Kelly A., 2018).

Seafood fraud, or intentional mislabeling of species name is rampant. For example, three recent DNA-based surveys of Los Angeles (California) restaurants found mislabeling rates of up to 52% when DNA results were compared with the U.S. Food and Drug Administration (FDA) list of acceptable market names and retail names. Results show that when scientific (Latin) species denomination is not mandatory, seafood labeling rules and controls are inadequate. Mislabeling in high-end grocery stores was also identified but at a slightly lower frequency (42%) than restaurants (Wilmette et al, 2017).

Average number of annual food product recall events by food, 2004-13

Food	Average 2004-13	Average 2004-08	Average 2009-13
Grain products	41.2	24.4	58.0**
Vegetable products	44.6	31.8	57.4
Fruit products	25.6	20.2	31.0
Dairy products	42.5	23.0	62.0*
Meat, poultry, and seafood products	77.3	57.0	97.6*
Nut products	53.2	19.2	87.2
Other food products	89.9	54.2	125.6**
Prepared foods and meals	58.0	38.6	77.4*
Baked goods	43.9	23.8	64.0*
Candy products	38.8	22.6	55.0
All food products	490.0	304.4	675.6**

Note: Asterisk (*) and double asterisk (**) indicate that the t-test of a difference in the means for 2004-08 and 2009-13 is significant at the 5- and 1-percent levels, respectively. A recall event is a recall announcement from a manufacturer or distributor and may include multiple recalled items.

Source: USDA, Economic Research Service calculations using U.S. Food and Drug Administration (FDA) and USDA, Food Safety and Inspection Service (FSIS) press releases, FSIS Recall Notification Reports, and FDA Enforcement Reports.

Figure 3: Average annual food recall events by food category, 2004-2013. Source: USDA

Mislabeling also allows contaminated fish products to enter the market. The average annual food recall events have increased by 71% from 2004-2008 to 2009-2013 (**Figure 3**). CDC (2015) reports that seafood caused about 36% of foodborne illnesses in the US in 2013. Seafood fraud and lack of traceability systems, account for damaging health effects. Even when some mechanisms exist for food safety assurance, there is lack of monitoring, transparency, trace-back and accountability in the seafood supply chain (Pramod et al., 2014).

Seafood is a highly perishable product, with a short shelf life. Even with expensive refrigerated storage and tanks, nearly 20% of seafood spoils before it reaches its end customer. For example, fishermen are often forced to accept low prices because of the obsolescence risk involved in holding out for a better price. At any point of time, the supply chain player holding the inventory is vulnerable to weather impacts and cold chain infrastructure conditions (Pramod et al., 2014). This power

equation can sometimes drive suppliers to resort to extreme measures—such as mislabeling product or purchasing illegal product or encouraging unsustainable fishing methods.

2.2 Seafood Traceability Concepts

2.2.1 What is traceability?

Traceability can be defined as "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" (Magera, Beaton, & Ecology Action Centre, 2009). It is the ability to track and trace product at every stage of the food chain, where the food came from (one step back) and where the food went to (one step forward). This is called the "one-up, one-down" system or OUOD. OUOD was part of a science-based minimum standards for preventive food safety practices, provide oversight and compliance through mandated inspections, respond effectively through mandatory food recalls, enhance record-keeping and establish a food product tracing system (FDA, 2017). In the seafood industry, Chain-of-Custody (CoC) provides a useful integrating framework for understanding efforts to reduce public health concerns surrounding the consumption of seafood. A traceability system which facilitates retrieval and access to information along a chain-of-custody is core concept to ensuring seafood supply chain transparency and risk mitigation (Yasuda & Bowen, 2006).

A traceability system should be able to (a) provide access to all properties of a food product; (b) provide access to all properties of a food product or ingredients in all its forms, in all links in the supply chain, not only on production batch level; and (c) facilitate traceability backwards and forwards (Olsen & Borit, 2018). Therefore, a comprehensive food traceability solution must have

the following characteristics: (a) unique identification of the food product at granular levels; (b) chronological registration of product information as it transforms or moves through the supply chain; (c) tracking and linking of all this registration information, so it forms a forward and backward trail; (d) harmonization and integration of this data as per global standards; and (e) transparency and communication of this information to achieve effective seafood traceability data governance.

Traceability can proactively provide a means for food safety and quality assurances by reducing the size and scope of recall (Bailey et al., 2016). Seafood traceability also may promote sustainable management of fisheries, which by itself is a global problem that challenges the balance of marine ecosystems and seafood supply for future generations. A survey of 9 global seafood producers identified greater commercial benefits of traceability when businesses more tightly integrate it into their value chains (Sterling et al., 2015). The benefits derived from traceability include improved supply chain management, reduced mislabeling and seafood fraud, regulatory enactments to deter IUU fishing such as import laws like those stipulated by the EU and FDA in the US, improved quality and better market differentiation.

2.2.2 Technology as an enabler of seafood traceability

The use of Information and Communication Technologies (ICT) has been leveraged widely to lower the information costs and improve the processes related to traceability such as (i) identification (ii) data capture (iii) data transfer and (iv) verification. Unique identification of the traceable unit is critical to traceability as it serves as the key link between the physical product and its associated information flow (Zhang & Bhatt, 2014). Business-to-business data capture and storage systems play a big role in the authenticity of traceable data. Enablement technologies such as RFID, barcodes, and EDI enabled supply chain players to seamlessly interchange data with one another as well as with

customers. This decade also saw the advent of the Blockchain. Blockchain or Distributed Ledger Technology (DLT) is a secure, shared, decentralized, distributed, immutable database architecture that maintains a continuously growing list of digitally verified updated records. This trustless, real-time updation and linking makes it near impossible to alter the data, as may be possible in a centralized system. Blockchain's potential benefits for the supply chain traceability include high level of trust, permanence of data, real-time accessibility of data and information, lack of a central controlling party, reduced transaction fees, paperless smart contracts, and an ability to swiftly track and trace records. Seafood mislabeling has been under increasing scrutiny due to DNA-based data verification methods. Since the late 2000s, DNA sequencing has emerged as a highly informative and reliable method for fish species verification. DNA technology has become more sophisticated with higher levels of accuracy, proliferating consumer awareness, updated legislation and better transparency (A. Naaum & Hanner, 2016).

One of the biggest differences between traceability systems in wild caught seafood and that in farmed and other industries is the tracking of vessels on open water. For tracking pallets on land, the pre-existing technology tools and platforms follow a similar process. The two main methods for vessel tracking are Automatic Identification Systems (AIS) and Vessel Monitoring Systems. These methods can track the movement and locations of vessels, as well as identify the use of transshipment which allows vessels to stay at sea for indefinite periods of time. GPS and sensor technologies are part of Vessel Monitoring Systems (Lewis & Boyle, 2017).

There are several technology-enabled traceability case studies today in the seafood industry. The Gulf of Maine Research Institute (GMRI) in Portland, ME, in partnership with the industry's workers, is developing a smartphone app that can be used to track fish caught in the coastal waters of New England. The World Wildlife Fund (WWF) in New Zealand used a combination of radio

frequency identification (RFID) tags, quick response (QR) code tags and scanning devices to collect information about the journey of a tuna at various points along the supply chain (Visser & Hanich, n.d.). Blockchain's Digital Ledger Technology (DLT) is used for capturing and accessing traceability data. Fishcoin (**Figure 4**) is a blockchain based data ecosystem for the global seafood industry (Fishcoin, 2018). BumbleBee is commercial service that uses sensors across harvest location, processing centers and distribution centers. Consumers can access this information through Bumblebee's online tool (Meeks, K., 2016). Trace Register is another B2B application used by retailers to track, trace and communicate the traceability of their seafood. ThisFish and Gulf Seafood Trace provide dynamic two-way dialog between fishers and consumers to further democratize the information. Global Fishing Watch, a partnership between SkyTruth and Oceana and Google's new interactive technology platform that enables consumers to view global commercial fishing activity in near real-time, to encourage responsible fishing are other tools (Lewis & Boyle, 2017).

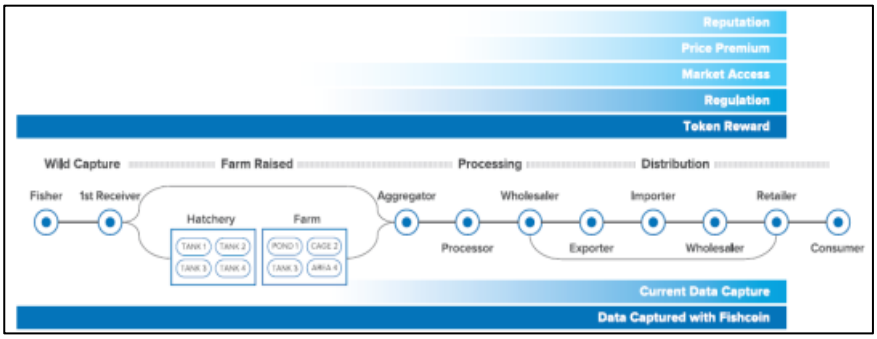


Figure 4: Schematic diagram of blockchain based seafood traceability. Source: Fishcoin, 2018.

2.2.3 Data Standards Related to Seafood Traceability

A standard can be defined as a set of minimum criteria that a food product must meet if it is to be suitable for human consumption, such as source, composition, appearance, freshness, permissible additives, and maximum bacterial content and guideline requirements for the distribution, labeling, manufacturing, packaging, processing and production of all types of food (Food Standard, 2019). The Food and Drug Administration (FDA) and GS1 are the most widely accepted standards setting

bodies in the seafood industry. The Food and Drug Administration (FDA) is responsible for assuring that foods sold in the United States are safe, wholesome and properly labeled. The Federal Food, Drug, and Cosmetic Act (FD&C Act) and the Fair Packaging and Labeling Act (FDA's Packaging and Labeling Standard) are the Federal laws governing food products under FDA's jurisdiction. Ever since the first barcode was scanned in 1974, GS1 has been a leader in supply chain visibility standards. GS1 published the GS1 Foundation for Fish, Seafood and Aquaculture Traceability Guideline in 2014 which was ratified in February 2019 (GS1, 2019).

The measure of traceability is the validation of the presence or absence of standard data attributes through the supply chain. Data attributes are classified into core attributes: regulatory attributes (e.g. country of origin); standards attributes (e.g. GS1 Master data); and credence data attributes (e.g. location of harvest). Unique identification of the smallest traceable unit is critical to traceability as it serves as the key link between the physical product and its associated information flow (Zhang and Bhatt 2014). There has been wide acceptance of the traceability concepts : 1. Critical Tracking Event (CTE), points where product is moved between premises or is transformed, or is determined to be a point where data capture is necessary to maintain traceability; 2. Key Data Elements (KDE), data required to successfully trace a product and its ingredients through all relevant CTEs. 3. External Traceability, assignment of a unique product identification number, batch / lot number, displaying it on the product or label and communicating forward and backward, linking information flow with physical flow of the product 4. Internal Traceability, establishment of a Unique Product Identifier, when the product undergoes ingredients' mixing, processing, transformation, reconfiguration or repackaging, linking the product with its original material input to maintain traceability (Bhatt et al., 2016). The seafood industry, NGOs and others have conducted research to identify and harmonize standard CTEs and KDEs along the seafood value chain. A global list of all recommended CTEs /

KDEs data model was compiled by FishWise (FishWise, 2017). Out of this global list, the most widely cited and relevant CTEs / KDEs data model ranked by importance was developed by the Institute of Food Technologies (IFT) in order to establish a global, secure, interoperable support system for seafood traceability (Bhatt et al., 2016). A full list of these recommended CTEs and KDEs is contained in **Appendix A.**

Standards establish harmonization of data in specific templates that encourage rapid adoption, interoperability and synchronization. Traceability can make it hard for illegal products from entering the supply chains if standardized harmonized data fields are made visible (Naaum and Hanner 2016). However, the problem with current data standards is a lack of acceptance of a common standardized "seafood attribute naming list." Different countries often have different seafood attribute lists and the use of standards is not prevalent. For instance, in different countries different names can be applied to the same species, or the same name can be applied to different species (Cawthorn et al., 2015). In addition, due to the multiple heterogenous proprietary systems of record, there is a lack of global interoperability which prevents global traceability to occur. Traceability, as it stands today, is an à la carte menu, where a company has to make multiple choices, for instance, on granularity, on whether to have referential integrity, on what data elements to record, on how to name and transmit them, on whether to use a standard, and on what standard(s) to use in that case, and so on (Borit and Olsen, 2016). This is due to the informational requirements, expectations and goals of different stakeholders that serves to *drive* seafood traceability.

2.3 Drivers of Traceability

A study of different characteristics of traceability systems reveal different purposes or drivers trigger different expectations in producers and consumers that do not always correspond to the traceability

system in use (Olsen & Borit, 2018). Seafood traceability's primary drivers can be understood through the scope and goals of traceability and informational flows in the value chains (**Figure 5**). They can be broadly organized into three main categories: (i) business or supply chain management-related traceability (ii) Regulatory-driven traceability for product verification and fraud prevention and (iii) Communication-derived voluntary traceability (Bailey et al., 2016).

GS1 identifies that the two main drivers for fish, seafood and aquaculture traceability are regulatory requirements and the need for greater transparency for businesses (Dean & Duckett, 2019). According to recent studies, consumer preferences as a driver was found to be not impactful. "Although the opportunities for consumers to engage in food traceability have increased since the mid-2000s, there is currently little data or research concerning which consumers are most likely to engage in tracing their products, what motivates them to trace, and what are their response rates when offered the opportunity to trace their products" (A. Naaum & Hanner, 2016). This section explains the characteristics of the 3 primary drivers: management, regulatory and consumer.

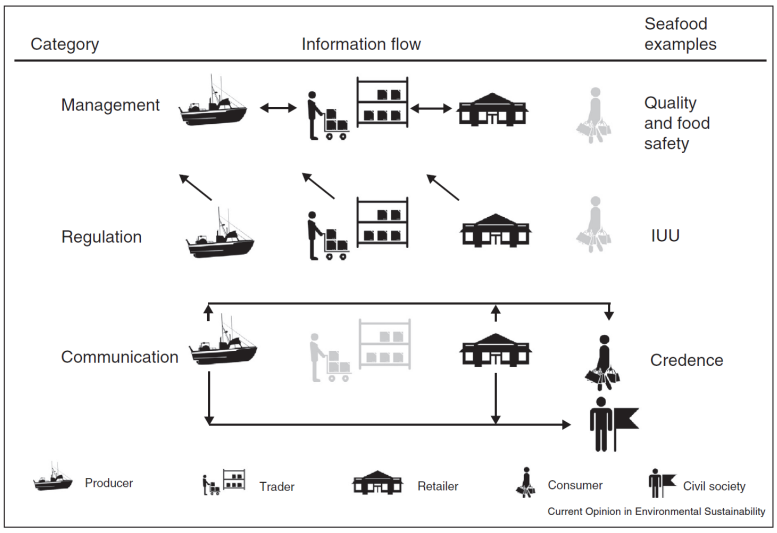


Figure 5: Seafood traceability information flows based on drivers

2.3.1 Management Driver

Management driven traceability is based on non-competitive goals such as supply chain efficiency, coordinating value chain activities through business to business (BTB) systems and managing

reputational risk by the business sector (Bailey et al., 2016). The business sector comprising supply chain players introduced seafood traceability to efficiently manage product recalls, manage their reputation, elongate shelf life and charge premium prices for the products (Bailey et al., 2016). Retailers are the primary supply chain player facing the consumer and are embracing traceability to build trust and loyalty with their customers. There are other players behind management drivers.

Ecolabels: With rising consumer awareness, seafood campaign ecolabels proliferated in the 1980s and 1990s. Ecolabels are "seals of approval" given to products that are deemed to have fewer negative impacts on the environment than similar products. The Marine Stewardship Council (MSC), the first seafood ecolabel launched in 1990, included a chain-of-custody certification to trace fish from the certified fishery of origin to the final point of sale. There are about 50 ecolabels and certifications related to seafood today such as Aquaculture Stewardship Council (2010) and Alaska Responsible Fisheries Management Certification (2011). Despite ecolabels, only a small fraction of global wild catch (<20%) and aquaculture product (<5%) are ever certified (Future of Fish, 2015).

Industry Organizations: Besides supply chain players, there are various industry and advocacy organizations (both for and not-for-profit) who protect the interests of their member organizations who are supply chain players such as retailers, seafood processing companies, distributors, etc.

Non-Governmental Organizations (NGOs): There are national and local NGOs with specific missions such as sustainability, protecting marine life, seafood safety, etc. Non-profits play an important role in moving forward initiatives and understanding of seafood traceability through guidelines and collaborative efforts (Lewis & Boyle, 2017).

Global Dialogue: The Global Dialogue on Seafood Traceability (the Dialogue) is an international business-to-business platform established to advance a unified framework for interoperable seafood

traceability practices. It is working to develop an internationally agreed list of KDEs to be associated with seafood products, and to establish standardized business practices for traceability.

2.3.2 Regulatory Driver

Government regulations are the key drivers behind seafood traceability compliance (Bhatt et al., 2016). There is a significant history of improving seafood traceability and labelling rules in the U.S. The Lacey Act (16 U.S.C. Section 3371–3378) of 1900, the primary law in the United States to discourage imports of illegally caught fish, was amended in 2008 to address illegal logging and imports and sale of counterfeit products. The Farm Security and Rural Investment Act of 2002 and Food, Conservation and Energy Act of 2008 established mandatory country-of-origin (COOL) labelling and sources of seafood. In June 2014, the White House released a Presidential Memorandum entitled "Establishing a Comprehensive Framework to Combat Illegal, Unreported and Unregulated Fish and Seafood Fraud" (He, 2018).

In early 2017, the US National Oceanic and Atmospheric Administration (NOAA) issued the Final Rule known as the Seafood Import Minoring Program (SIMP). SIMP mandated electronic submissions for import of at-risk priority species by US importers (NOAA, 2017). Furthermore, SIMP has the potential to synergize with other existing programs in the world such as the 2010 European Union (EU) IUU Regulation. Additionally, the Tuna 2020 Traceability Declaration that was signed at the United Nations Ocean Conference in June 2017 in which industry leaders have pledged that all tuna products will be traceable to the vessel and trip dates by 2020 (He, 2018).

Today, regulatory mandates are accompanied by advocacy by industry bodies, governmental agencies and non-governmental organizations (NGOs) to form the foundation of traceability data

governance for the seafood industry. Together they form the ecosystem for mitigating challenges and establishing standards, guidelines and common protocols for the seafood industry.

2.3.3 Consumer Driver

Communication or consumer driver are those that are triggered by information requirements of consumers or general public. Consumers, by virtue of social media, urbanization and obtaining higher levels of education are become more aware and concerned by what they are buying, how, where and when their seafood was harvested and produced (A. Naaum & Hanner, 2016). These concerns, along with higher quantity of imports in North America, have in turn triggered legislation and safety requirements throughout the seafood supply chain. There's a growing demand for traceability (Leal, Pimentel, Ricardo, Rosa, & Calado, 2015). A study in 2014 shows that two-thirds of US survey respondents preferred to buy food if they know the origins and 29% find local claims to be very or extremely important when making a purchasing decision (Food Business News, 2014).

A recent transparency survey found that consumers want to see everything from a complete ingredient breakdown to sourcing information, with 94% of respondents saying they are likely to be more loyal to a brand that offers complete transparency (Label Insight, 2016). Despite the numerous studies on consumer preferences for seafood and credence attributes related to U.S. seafood consumption, consumer preferences as a traceability driver and attitudes towards traceable KDEs is not well understood (Mol, 2015). An increase in consumers' awareness and a willingness to pay for sustainable practices will be key in driving Government regulations in traceability (He, 2018).

2.4 Gaps in Literature Review

The two primary cited drivers of seafood traceability are global regulatory mandates and retail sector (Bailey et al., 2016). Food safety concerns trigger global regulatory mandates and high sensitivity to reputation triggers retail sector driver. Regulatory mandates, standards and certification bodies and retailers drive the agenda to whole-chain traceability as well as consumer preferences. Other drivers such as safety, security and sustainability also need to be researched in depth (Borit & Olsen, n.d.).

Consumer preferences as a driver of traceability remains under-researched. With recent US regulations mandating comprehensive seafood import data, there still are open questions and gaps in that the information gathered does not specify unique attributes such as specific fishing methods, processing steps, scientific nomenclatures, and additional credence attributes. Additionally, substantial gap persists between informational requirements of the SIMP and COOL for seafood traceability. There exists room for government-mandated traceability rules to explore a more inclusive approach to integrate economic, environmental and social value judgements (He, 2018).

2.6 Thesis Objectives

The future of traceability adoption lies in designing and organizing systems in an integrated information flows aimed at sustainability governance, designed on globally operable standards, traceability drivers, data governance and transparency requirements which encourage adoption. This paper attempts to understand consumer preferences' role in seafood traceability. The insights and recommended Key Data Elements (KDEs) from the literature review has significantly contributed to the design and execution of primary research methods.

3. Methodology

This section describes the methodology utilized for the studying the influence of consumer preferences on seafood traceability. The methodology of the study followed this specific chronological order: literature review, study design and distribution, data collection and interviews, quantitative analysis including data scrubbing, data triaging and visualization analysis, discussions on implications on policy, business and consumers.

3.1 Study Design

A thematic analysis of available literature was used to inform the study design. Three components were used in the design of the study: (a) Primary research: Direct survey via questionnaire (b) Primary research: Interviews with industry stakeholders, retail stakeholders and focus groups from consumer respondents, and (c) Secondary research: Systematic thematic content analysis

3.1.1 Primary Research: Direct Survey

Direct Surveys are used to cover as many seafood consumers as possible. Seafood is still considered a luxury product. Demand for a luxury product rests on the following determinants of consumer attributes: population size and distribution; consumer income and distribution; consumer tastes and preferences; prices of other, related goods; availability of substitutes. (Engle, Quagrainie, & Dey, 2016). From the literature review and industry stakeholder interviews, the determinants of consumers' preferences towards traceability to be included in the study were income, education levels, gender, frequency of consumption, domicile habit, price and tastes.

$$Q_{dt} = f(I, T, E, G, F, P_d)$$

Q_{dt} = traceable KDEs; I = income; T = tastes and preferences; E = education levels; G = gender; F = frequency of consumption; H = domicile habitat; P_d = relative price of products.

Based on systematic literature review, a comprehensive KDE structure was obtained to evaluate consumer preferences. In order to prioritize brevity, only 15 questions were included. The questionnaire is enclosed in **Appendix B**. The questionnaire was designed to focus attention on 4 dimensions: seafood consumption patterns, socio-economic demographics, seafood purchase patterns and traceability data preferences.

It was designed and coded using the software Qualtrics. Qualtrics is a subscription software for collecting and analyzing data for research and surveys. Qualtrics' features such as Display Logic, Skip Logic, Randomization and Recoding helped in eliminating non-US residents (3 questions), non-consumers of seafood, reducing bias, coding for future statistical analysis and accurate data collection. The questionnaire was kept anonymous – no names, contact information or IP address were gathered to avoid social environment bias. The questionnaire was hosted on Qualtrics but was redirected from www.bitly.com which helped in confirming US residency using geographic country-level IP functionality. Bitly's user interface is in Appendix C. The following two URLs were used for distribution in order to assess response rates for distribution to professional and social connections separately: bit.ly/myseafood and bit.ly/aboutmyseafood. The questionnaire was live on Qualtrics between March 23rd, 2019 and April 12th, 2019 for data collection. Questionnaire distribution methodology include email campaign within the US, academic community, and seafood NGO partners. Both selective and snowball sampling methods were used. Various social media tools such as Facebook, LinkedIN, Twitter and group applications were used.

The questionnaire focuses on eliciting preferences on traceability from a skewed sample of US population. The skewness was caused due to online nature of the survey which targeted respondents with smartphones as well as the distribution to existing and known contacts in the researcher's business and social circles. It leaned towards affluent, educated population who are perceivably more aware of food safety, regulatory mandates and are more discerning about their consumption. This skewness helps in narrowing down attitudinal preferences as more educated and affluent respondents consume more seafood.

3.1.2 Primary Research: Stakeholder Interviews

An semi-structured open-ended interview guide was prepared to focus on three sub-segments of interviewees (i) US retailers and retail stakeholders such as Kroger, Ahold Delhaize, Walmart, Food Marketing Institute (FMI) and FishCoin (ii) Industry, Standards and Regulatory stakeholders such as Food and Drug Administration (FDA), GS1, Wildlife Fund (WWF), Global Dialogue on Seafood Traceability, Gulf of Maine Research Institute and National Fisheries (ii) Consumer focus groups comprising graduate students, industry veterans and working professionals. The interviews were kept informal and open-ended. They were conducted over video conferencing with WebEx with occasional telephonic conferencing. Nine interviews were conducted, and 3 in-person focus group meetings were held. The interviews helped triage qualitative information and arrive at inferences and explanations of the resulting data.

3.1.3 Secondary Research: Thematic Content Analysis

In addition to the foundational literature review in Chapter 2, a further systematic review of specific literature was conducted to understand consumer preferences and attitudes pertaining to the seafood industry. Recent research papers from 2005 onwards with the keywords "seafood traceability" and

“consumer preferences” were searched. A total of around 50 documents were reviewed to assess regulatory, standards, technology and processes implications for seafood industry. Thematic Analysis methodology was applied to various reports, publications and research papers from industry associations, governmental organizations and ecolabel certification bodies. Details of these are described in the References section.

Added to the scope of the content review, the results of previous surveys, current use cases for seafood traceability and existing expansive body of literature related to seafood traceability KDEs were studied. The previous surveys conducted in seafood traceability taken into the scope of secondary research include: (i) A national survey of 2700 US households on food traceability, HarvestMark, 2007 (A. Naaum & Hanner, 2016) (ii) a North American survey of 302 consumers, ThisFish, 2014 (A. Naaum & Hanner, 2016). (iii) 2096 U.S. grocery shoppers on seafood purchasing preferences, Food Marketing Institute (FMI), 2019. (iv) 5-country survey including 500 U.S. respondents to study seafood attributes that drive purchase and their willingness to pay (WTP) for attributes relating to traceability (Sterling et al., 2015).

3.2 Analysis Methods

3.2.1 Quantitative Analysis

Data emerging from the questionnaire was scrubbed to remove redundancies, incomplete entries and non-US responses. After cleaning and imputing the data, a quantitative analysis of results was conducted. Statistical summary, classification tree, clustering and data visualization techniques were used in the quantitative analysis. Statistical summary metrics such as mean, median, standard

deviation and correlation analysis were used on Microsoft Excel to gauge the relevance of the data. Appropriate machine learning and advanced analytics techniques were selected.

Classification trees predict a discrete category (the class) using numerical or categorical input variables. They provide comprehensible predictors where there are many variables which interact in complicated, nonlinear ways. To compute the classification tree, we start with a single node, and then look for the binary distinction which gives the most information about the class. This process is repeated, continuing the recursion until there is a stopping criterion or maximum number of branches. To prune the tree, the maximum number of levels used is three. Pruning is the process of removing the unnecessary structure from a decision tree, effectively reducing the complexity to combat overfitting.

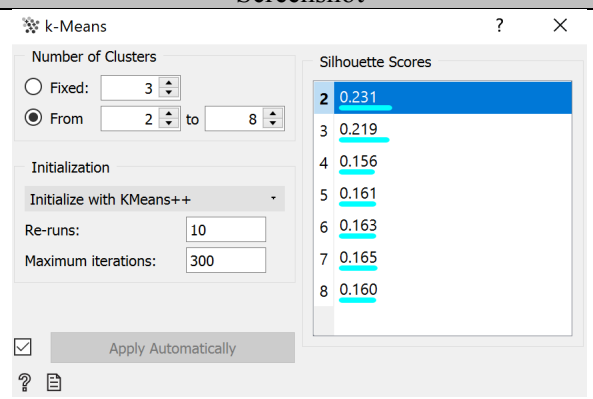
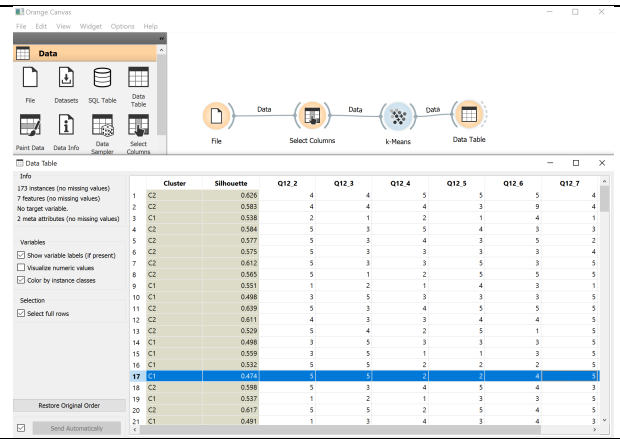
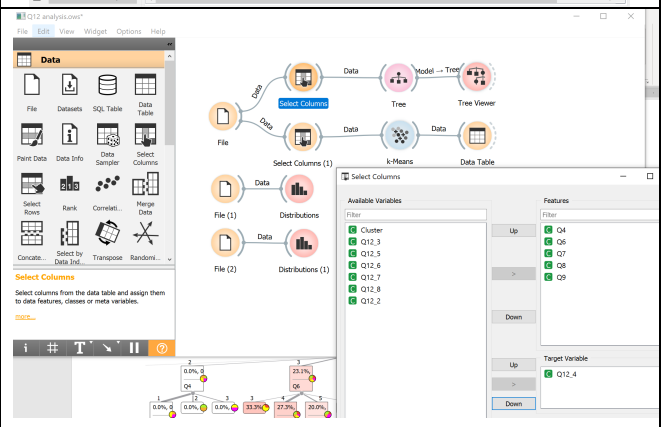
Clustering is an unsupervised learning algorithm, used to partition the data into groups such that observations within a cluster are related to each other. A k-means clustering algorithm was used. K-means finds k clusters such that the total pairwise distance between each observation and its closest cluster centroid is minimized. K-means analysis helped in grouping respondents' characteristics into High Traceability (C1) or Low Traceability (C2) clusters. Orange machine learning software was used for classification and clustering. Orange is an open source machine learning and statistical analysis software. The clusters were used to detect patterns in consumer preferences based on specific features such as income, education, domicile, seafood consumption habits and gender of respondents.

The analysis and data visualization software used for this purpose were Qualtrics statistical engine, Tableau Desktop, Tableau Prep, Orange and Microsoft Excel.

3.2.2 Machine Learning Detailed Methodology

This sub-section explains the methodology of cluster analysis, Principal Component Analysis (PCA) and classification tree through machine learning. Taking the responses for Q12: Seafood Purchasing Factors, the steps are depicted in **Table 1, Figure 3.1** and **Table 2**.

3.2.2.1 K-Means Clustering

Steps	Methodology	Screenshot
1	After loading the cleaned data set into Orange, the relevant columns (all answer variables) are selected. K-Means widget helps calculate the optimum number of clusters iteratively.	
2	K-Means assigns each row to a cluster (C1 or C2) using Silhouette Scores. This column is appended onto the data set to form a new data set. This data is reloaded onto the Orange Canvas.	
3	Distribution widgets uses the new clustered data sets as inputs. To find out what demographics attitudes explains most about the cluster or specific response variable, that variable is selected as Target.	

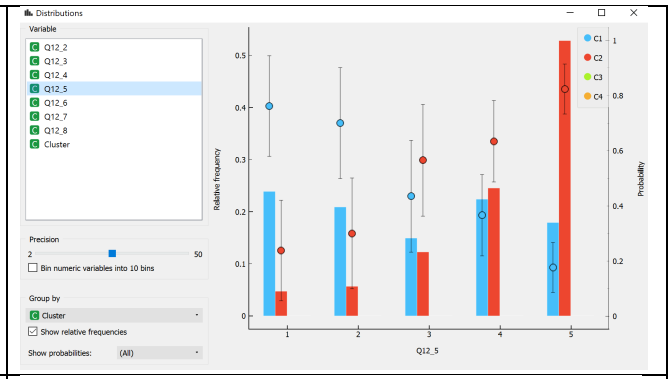
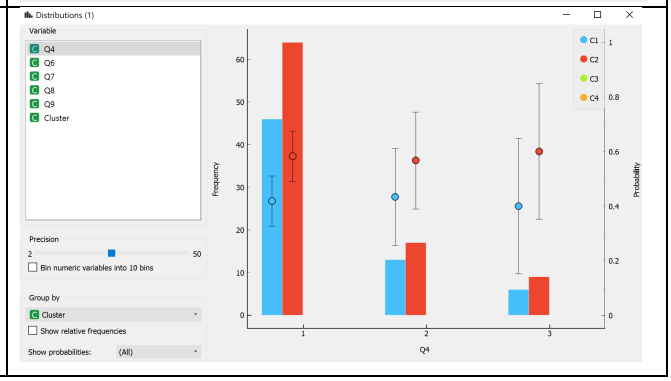
4	This distribution shows that C2 ranks Wild Caught (12-5) the highest (very important to them). The graph also the probability bar, ranking C1 cluster's as 0.40.	
5	We can obtain patterns on the entire cluster sets. Frequency of Consumption is an important characteristic of respondents in cluster C2.	

Table 1: k-Means Clustering Methodology

3.2.2.2 Principal Component Analysis (PCA)

A PCA analysis of both clusters C1 and C2 depict a 70% explained variance for Area Under the Curve (AUH). This AUH curve and explained variance of 70% shows a high significance of distinctness of clusters.

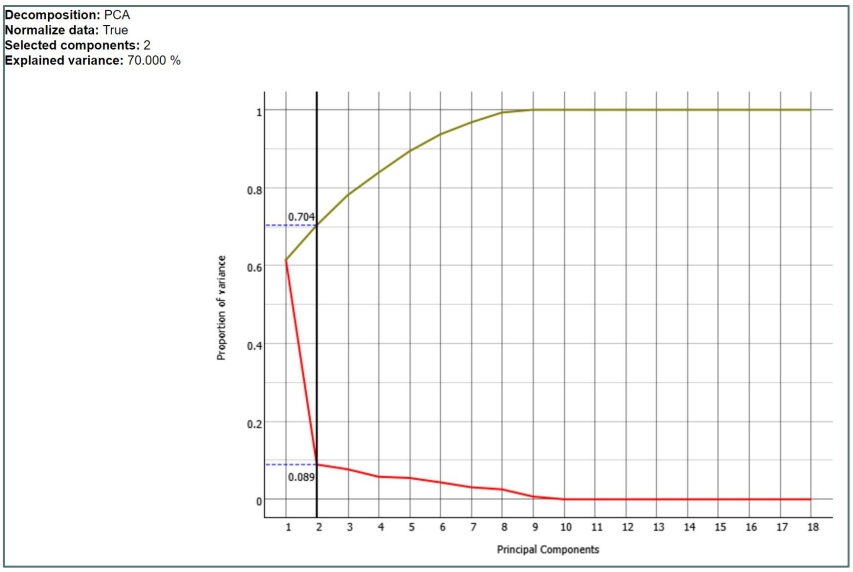


Figure 6: Principal Component Analysis of Clusters

3.2.2.3 Classification Tree

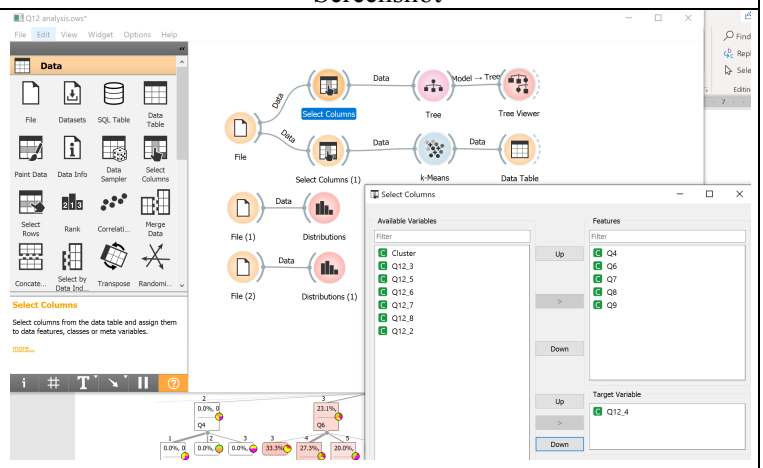
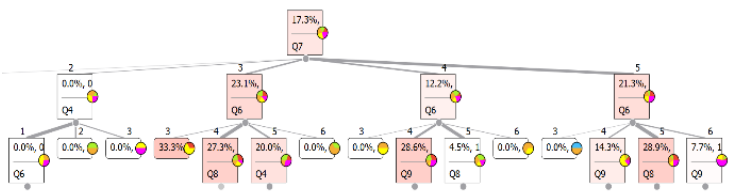
Steps	Methodology	Screenshot
1	The cleaned data is fed into Orange. Select Columns widget help to assign all features as variables. The Tree widget creates the Classification Tree.	
2	The Tree Viewer widget shows the distinctive feature which can split the entire data set. It is Q7 (income levels), followed by Q6 (education).	

Table 2: Classification Tree Methodology

Section 4 elucidates the results and inferences of the consumer preferences research, overlaid with qualitative data gathered from the interviews and focus groups.

4. Results

This chapter describes the respondents' profile and explains the results of the survey, stakeholder interviews and systematic literature review, broken out in broad themes.

4.1 Respondents' Profiles

Figure 7: Respondents' demographic information

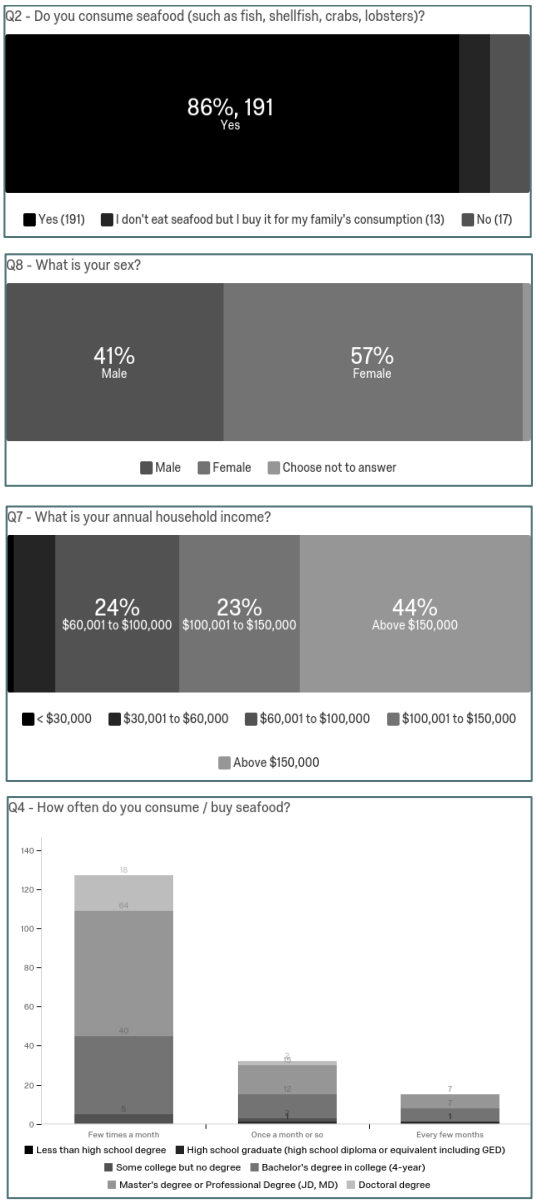


Figure 8: Demographics by education levels

The total number of clicks on *bit.ly/myseafood* and *bit.ly/aboutmyseafood* was 282 respondents, out of which international clicks and duplicates were purged. The final respondents' count for the survey was 225 within the United States, out of which 17 were respondents who did not consume seafood and were eliminated. The final analyses included 208 valid responses.

Some important demographic information (**Figure 7**) of the 208 respondents are (a) 41% were male and 57% were female (2% did not want to answer this question). (b) 44% of the respondents' family income is $150,000 per annum (very-high-income earners), followed by 23% in high-income bracket, followed by 24% median-income earners. Other seafood surveys have found similar patterns arriving at a conclusion that higher income respondents consume more seafood (Naaum, Amanda & Hanner, Robert, 2016). Frequency of consumption (**Figure 8**) was interestingly highly

represented in the respondents' pool. Over 72% (127 respondents) consumed a few times a month, followed by 18% (32 respondents) who consumed once a month or so and 9% (15 respondents) stated that they are infrequent consumers of seafood. Section 4.2 explains the inferences from the results and analyses of the survey, overlaid by the excerpts from the stakeholder interviews in 7 broad themes.

4.2 Findings and Analysis

4.1.1 Qualitative findings from stakeholder interviews and focus groups

The stakeholder interviews conducted along with systematic literature review revealed the following overall themes.

Supply Chain Stakeholders	Fresh produce, meat and seafood is why people come to stores. In a world of homogenous products, our biggest differentiator is our reputation to stock fresh food.
	In retail, being the first to woo and retain customers is very important. Traceability enables brand and reputation management and ensures customer loyalty.
Non-Governmental Stakeholders	Regulations do not encourage aquaculture. There are ambiguous ocean zoning rules for commercial and recreational fishing, and this results in illegal fishing. Consumers are not aware of these challenges. No one cares to educate them.
	Retailers are consumer-facing. They own the most responsibility to educate the consumers so they can safely purchase more.
	Seafood is not consumed as much as other protein in the US. Consumers are not sure how to safely store them and prepare them. They would rather eat seafood at restaurants
Regulatory Stakeholders	Traceable label implies that (it) is a responsibly and sustainably sourced seafood. Policies help in implementation.
	As the value of imports increase, the regulations are becoming more stringent as it concerns public health and safety.

	It is easier to impose restrictions on supply chain imports; but it is hard to implement traceability controls on domestic products.
Consumers	Rather than worry about our seafood's journey and provenance, we just shop at <retailer> where we know they validate the authenticity of our seafood.
	Certifications and date packed are useful information we look for.
	We do not prepare seafood at home since we are not sure if we should freeze or not (prior to cooking). We like seafood but we only eat seafood at restaurants.

Table 3: Supply Chain Stakeholders Interviews

4.1.2 Consumers consumption and purchasing patterns

Price and wild caught seafood are the primary attributes that attract shoppers across all income levels and education levels (**Figure 9**). Wild caught is perceived to be "healthy" and sustainable compared to farmed seafood. While high-income and high-consumption consumers prefer high traceability data to other categories, including 100% traceable labels, middle-income consumers are sensitive to price. Domicile habitat is also an influencer (**Figure 10**), showing that urban / suburban consumers have a high preference for traceability. Females stand out with registering higher number of preferences while purchasing seafood. Consumers also prefer trusted certified seafood with Marine Stewardship Council (MSC) as the first choice (**Figure 11**).

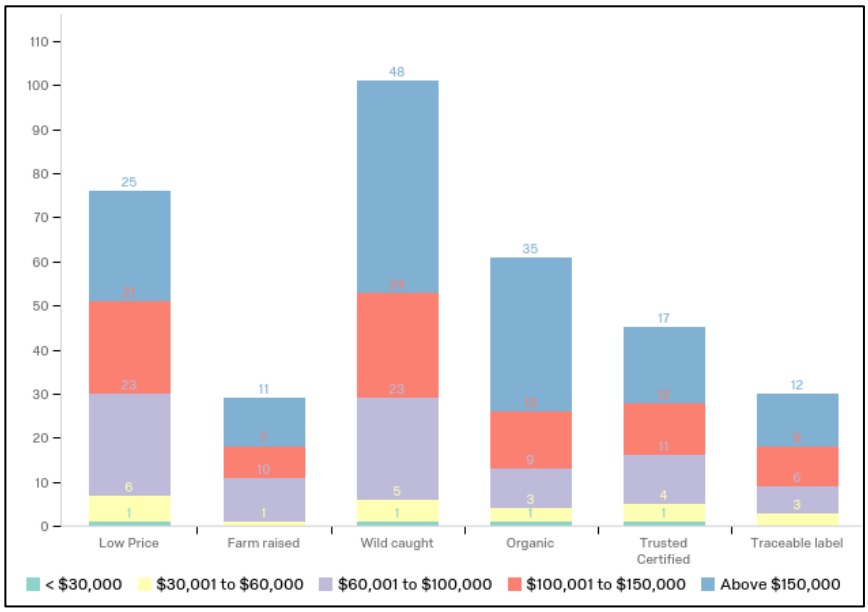


Figure 9: Result - Consumers' purchasing factors by income levels

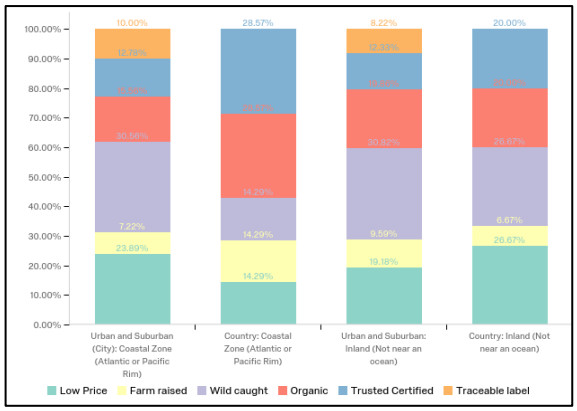


Figure 10: Result – Consumers' purchasing factors by domicile habitat

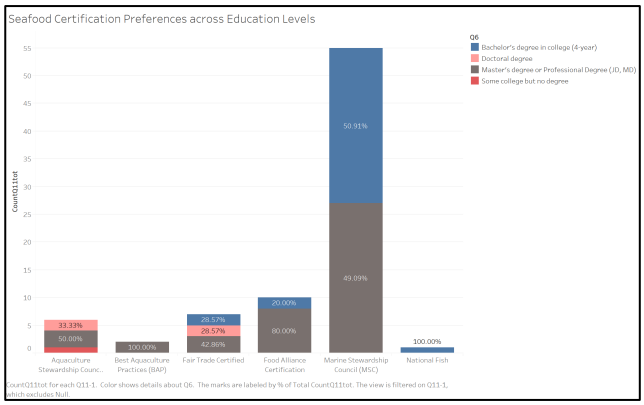


Figure 11: Result - Certification preferences across education levels

4.1.3 Seafood consumption patterns

Respondents who are more highly educated show a greater consumption preference for seafood (**Figure 12**). This could be due to the perceived health benefits of seafood. Educated consumers also show a preference for higher traceability KDEs for seafood. An interesting finding is that masters and professional degree holders are the highest consumers of seafood. Doctoral degree holders do not consume as much, thereby their preferences do not influence traceability as much.

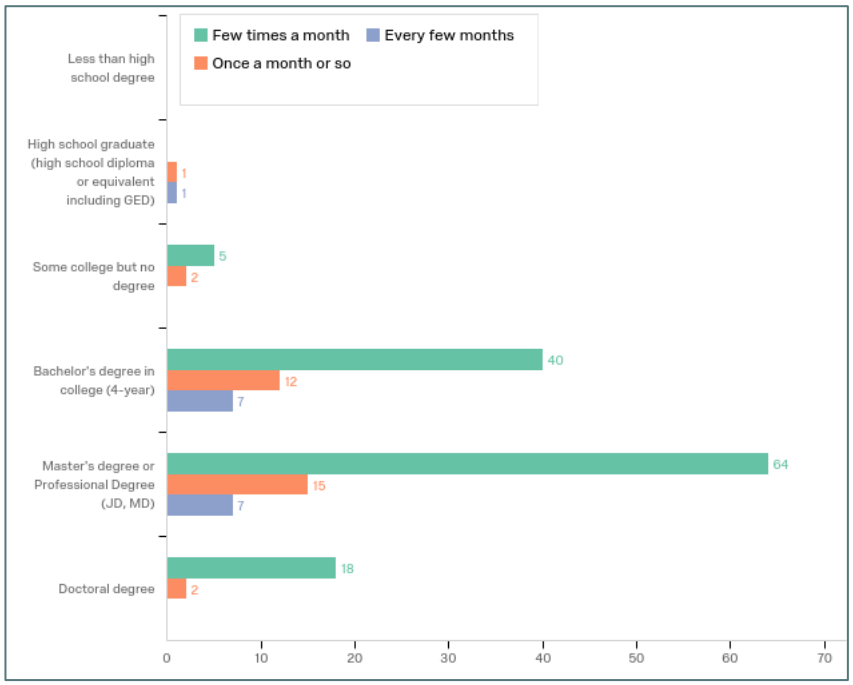


Figure 12: Result - Consumption patterns by frequency of consumption

4.1.4 Consumers prefer freshness of seafood

Consumers are concerned about most about freshness and safe refrigeration of seafood, followed by authenticity of seafood producers' certifications. "Freshness" of seafood received the highest number of votes. In fact, the preference for freshness of food is far ahead of the other factors and features prominently across all income and education levels (**Figure 12 and Figure 13**).

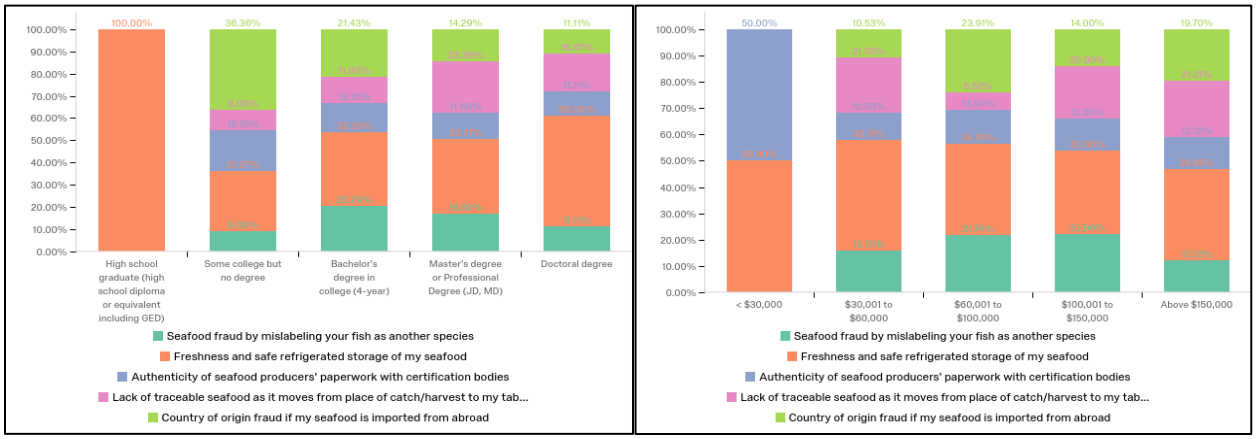


Figure 13: Result - Consumer concerns per education and income levels

4.1.5 What makes consumers trust seafood authenticity?

Results show (**Figure 14**) that women are more discerning consumers. More men prefer low price for seafood, while almost twice the number of women choose wild caught, organic, trusted certified and traceable label and brand. Women also showed more preference towards High traceability (**Figure 15**) such as for real-

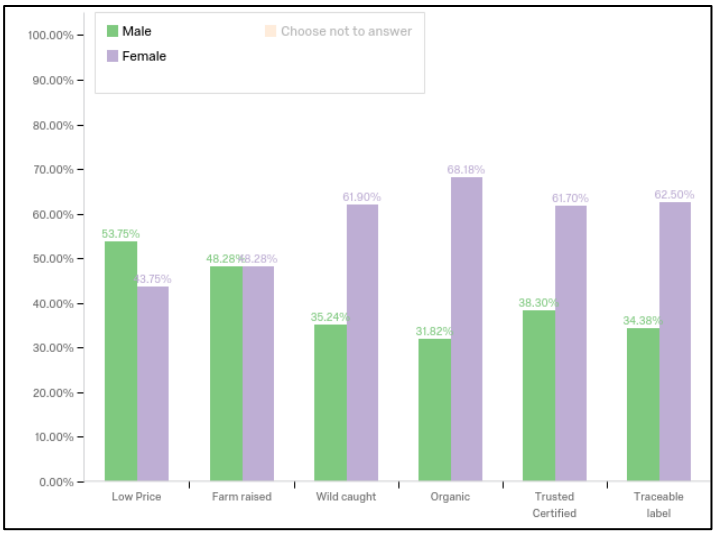


Figure 14: Result - Seafood trust by gender

Figure 16: Result - Seafood Trust Factors per education levels

time date and time stamps for whole chain traceability, processing methods, vessel and temperature information. When asked to rank three traceability KDEs: Sensor and GPS data (High), Legal & Certification Stamps (Medium) and Trustworthy Brand (Low), the most distinct pattern in preferences is seen amongst education levels (**Figure 16**). The more educated the consumers are, the more they seemed to rank high traceability attribute such as sensor and GPS based catch location. Consumers who do not have a

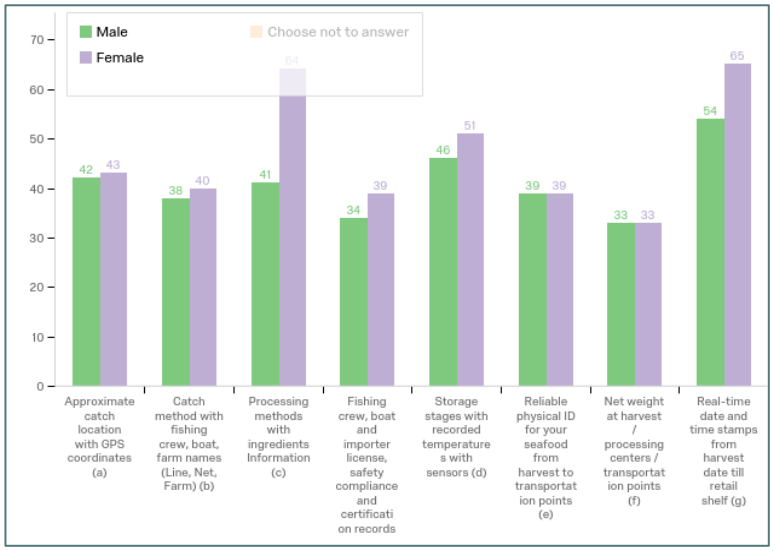


Figure 15: Result - High traceability preferences by gender

college degree tended to be less discerning and ranked trustworthy brand as most preferable. An interesting finding is that legal compliance and certification were not highly valued attributes by advanced degree holders. It can be inferred that as education and awareness levels increase,

more accurate high traceability information about the seafood supply chain is preferred.

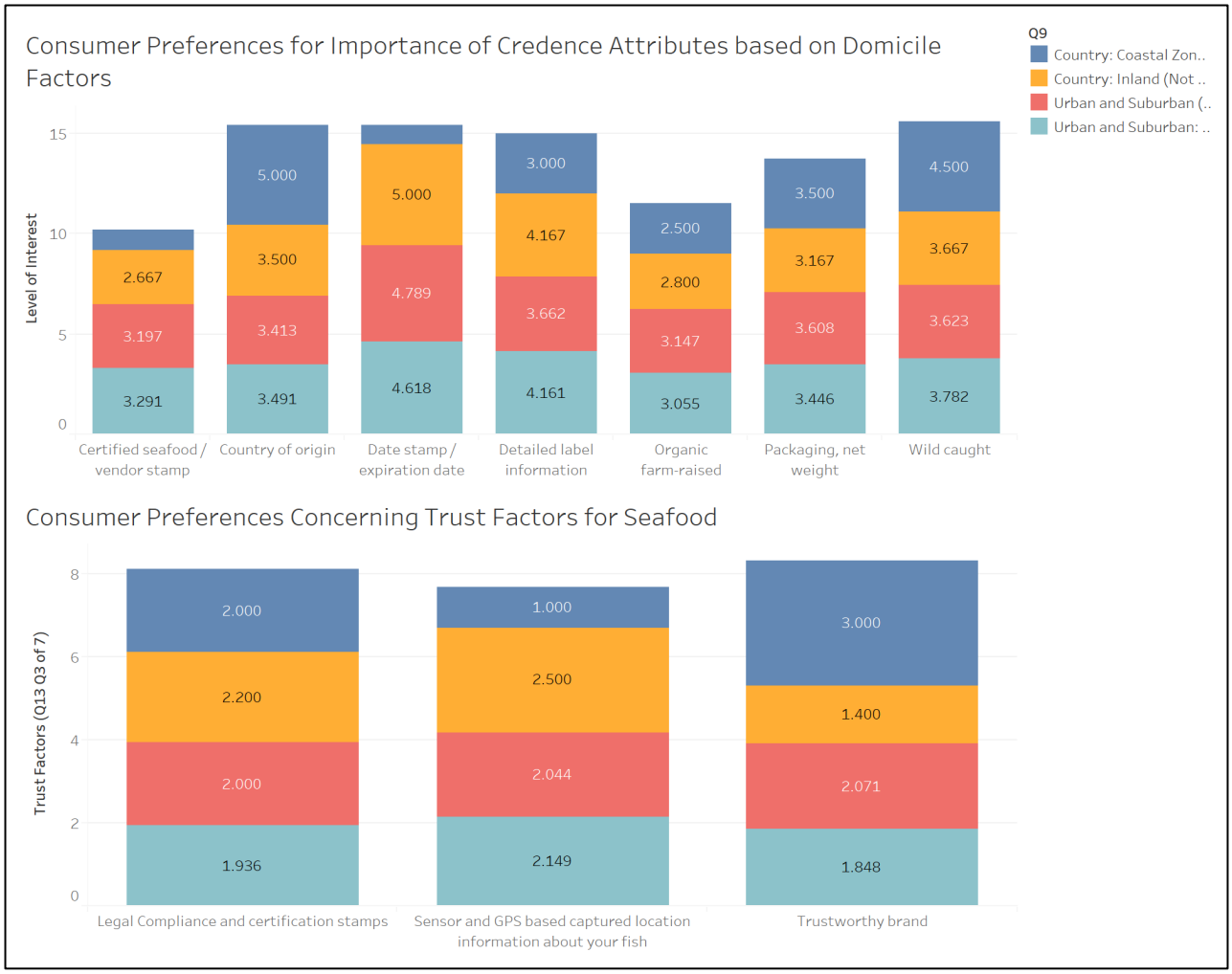


Figure 17: Result – Seafood Trust Factors per domicile habitat

Consumer preferences for credence attributes were found to differ according to domicile habitat (**Figure 17**). Consumers living in coastal and urban / suburban regions show a higher propensity to prefer High traceability. Non-coastal inland-living consumers seem to prefer seafood expiration date (Low traceability).

4.1.6 Marginal premium for traceability

When blind surveyed as to willingness to pay $1 per attribute displayed, catch location (36%) stands out as the most desired attribute and catch method (27%) is second, followed by processing methods with ingredients information (20%).

A breakdown per education and income levels as see in **Figure 18** show Catch location and processing methods are already implemented in traceability today as Country-of-Origin (COOL) Labeling. While this is not an absolute indication of consumers' willingness-to-pay (WTP), there's a clear preference for traceability attributes demanded by consumers.

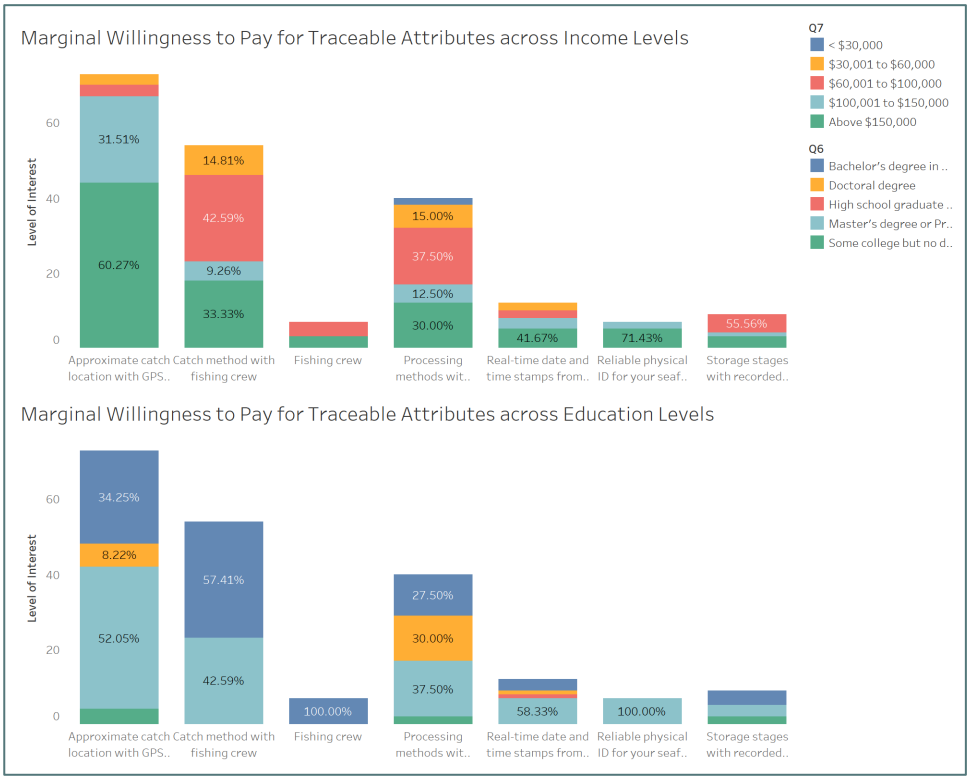


Figure 18: Result - Marginal premium for traceable attributes across education levels

4.1.7 Consumer demographics plays a role in traceability preferences

The location KDE-wise breakdown (**Figure 19**), processing centers rank highest at 31%, with distributor / retailer information second at 24%, followed by packaging facility information at 23%.

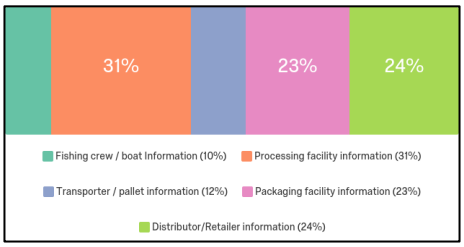


Figure 19: Result - Location KDE preferences

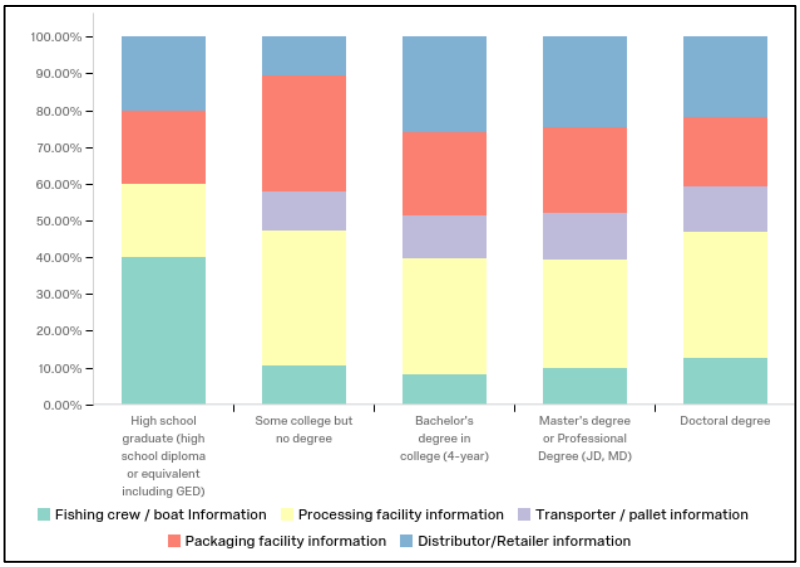


Figure 20: Result - Location KDEs by education levels

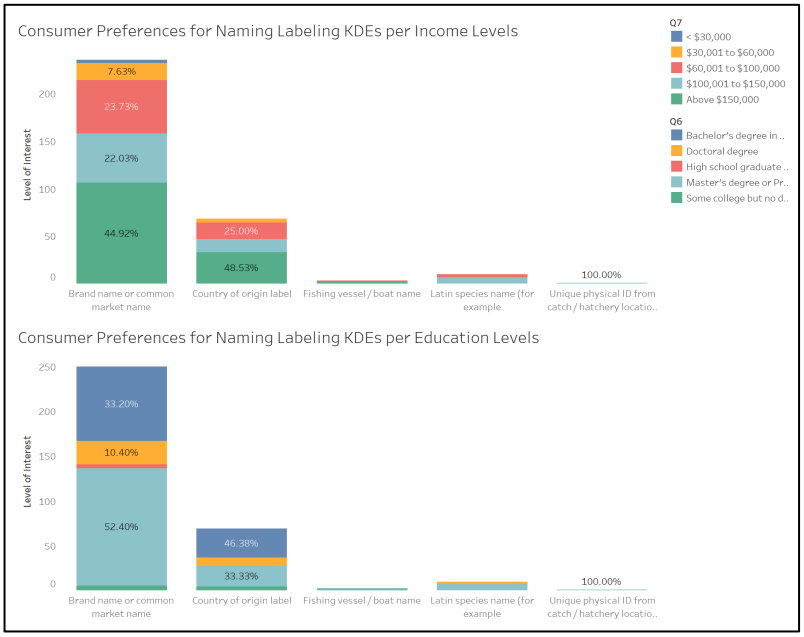


Figure 21: Result - Naming KDEs per income levels

Fishing crew information and transporter / pallet information are at 10% and 12% respectively, which is expected, considering that these are more managerial KDEs. Respondents largely prefer similar KDEs, regardless of education levels (**Figure 20**).

In seafood industry, brand or common name is common labeling attribute, however it is subject to fraudulent practices and species substitution, which using the Latin species name prevents. However, results demonstrate (**Figure 21**) that seafood name fraud has not permeated down to all consumers. However, Latin species name is preferred by respondents with advanced degrees. Additionally, only the advanced degree holders demand unique physical IDs and fishing vessel name, showing that as education levels advance, seafood awareness increases, leading to higher demand for traceability.

4.1.8 Premium prices on traceable seafood

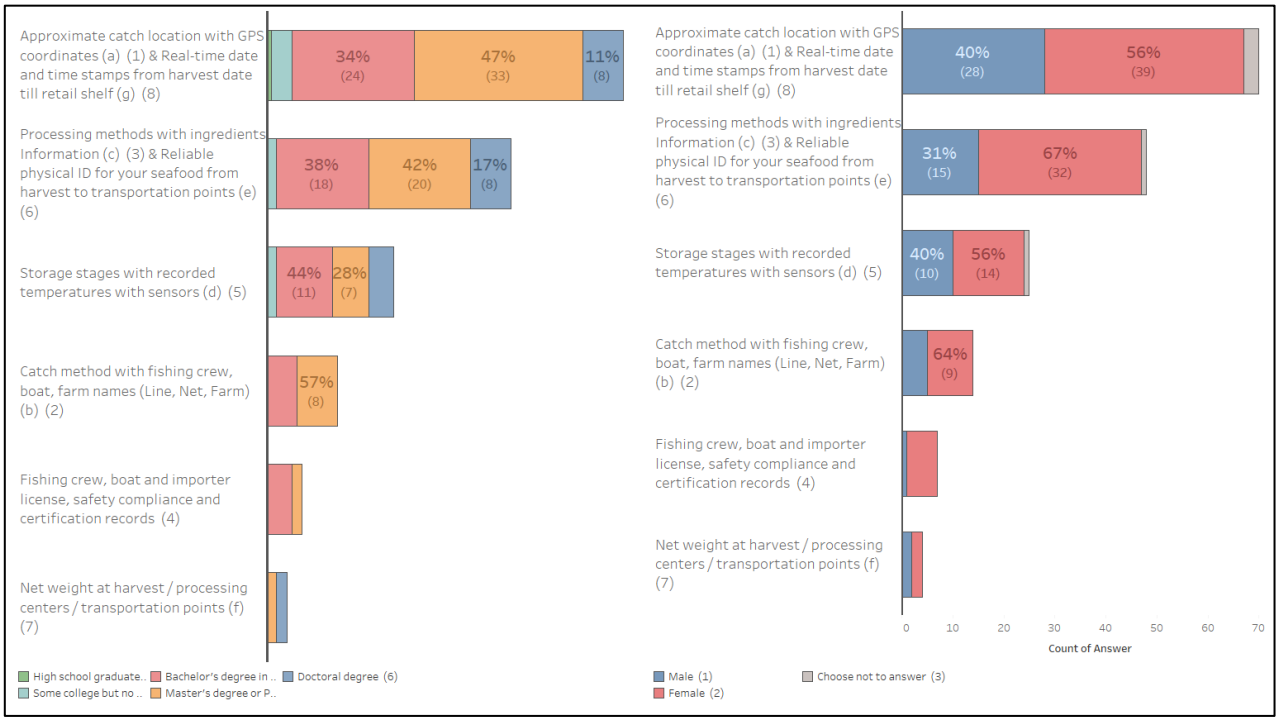


Figure 22: Result - High traceability preferences by education levels and gender

Consumers who care about their seafood quality and traceable data are shown to be generally willing to pay premium prices for their seafood. The results of the survey for full real-time traceability information with GPS and sensors (High traceability), Country-of-Origin, vessel and processing center information (Medium traceability) and certified with expiry date (Low traceability) shows that consumers who are educated (Bachelors and above) show preferences for and willingness to pay for High traceability KDEs (**Figure 22**).We can also see that consumers' preferences for traceability increase in proportion with education levels linearly. We can infer that as more education, wealth and income levels rise, there will be more demand for high traceability.

Results **(Figure 23 and Figure 24)** demonstrate that consumer preferences for traceability are well correlated across education levels and income levels. Cross tabulating the results further on the basis on frequency of consumption

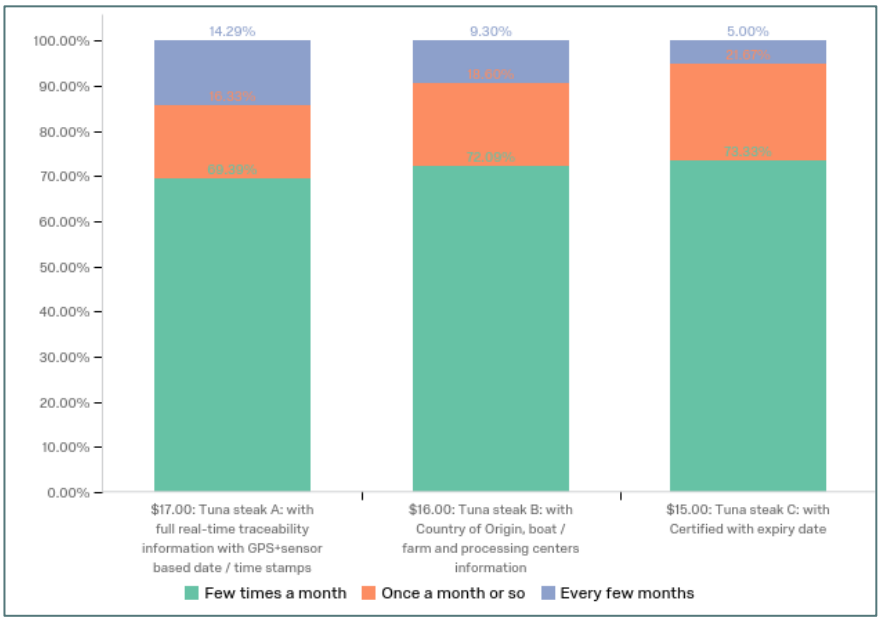


Figure 25: Frequency of Consumption

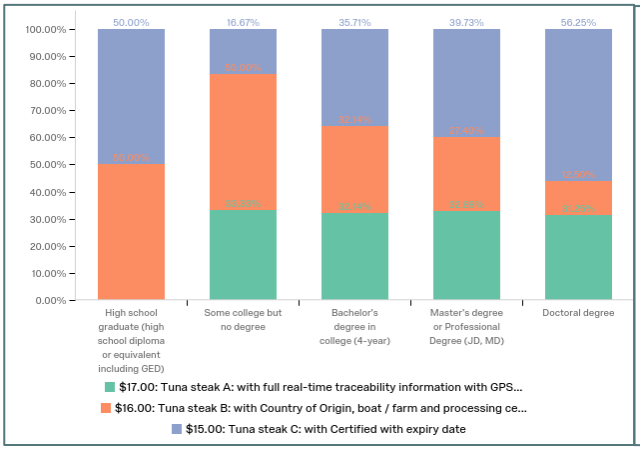


Figure 24: Result - Education levels

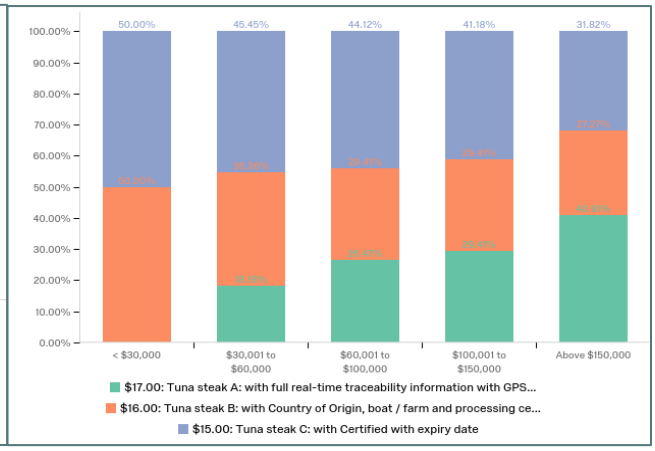


Figure 23: Result - Income Levels

Figure 25 shows that frequently consuming population (Few Times a Month) care more about traceability. It can be summarized that consumers get more educated or become more affluent, they consume more seafood and care more about traceability, including willing to pay a premium for High traceability KDEs.

4.1.9 Cluster and Classification Tree Analyses

Using cluster analysis, as described in Section 3.2.2, the ideal number of clusters using k-means clustering technique was determined to be 2 with a silhouette score of 0.520. The two clusters are 1. High Traceability Preferred Respondents (C1) and 2. Low Traceability Preferred Respondents (C2). Applying classification tree algorithm (**Figure 26**), both clusters show income levels as an overwhelming dividing factor for consumer preferences towards traceability. The second order split for Low Traceability cluster, C1, is explained most by education levels and gender, as seen in Section 4.1.5. For High Traceability cluster, C2, the second largest contributing factors are frequency of consumption at 90.5%, followed by urban and coastal U.S. residents at 85.7%.

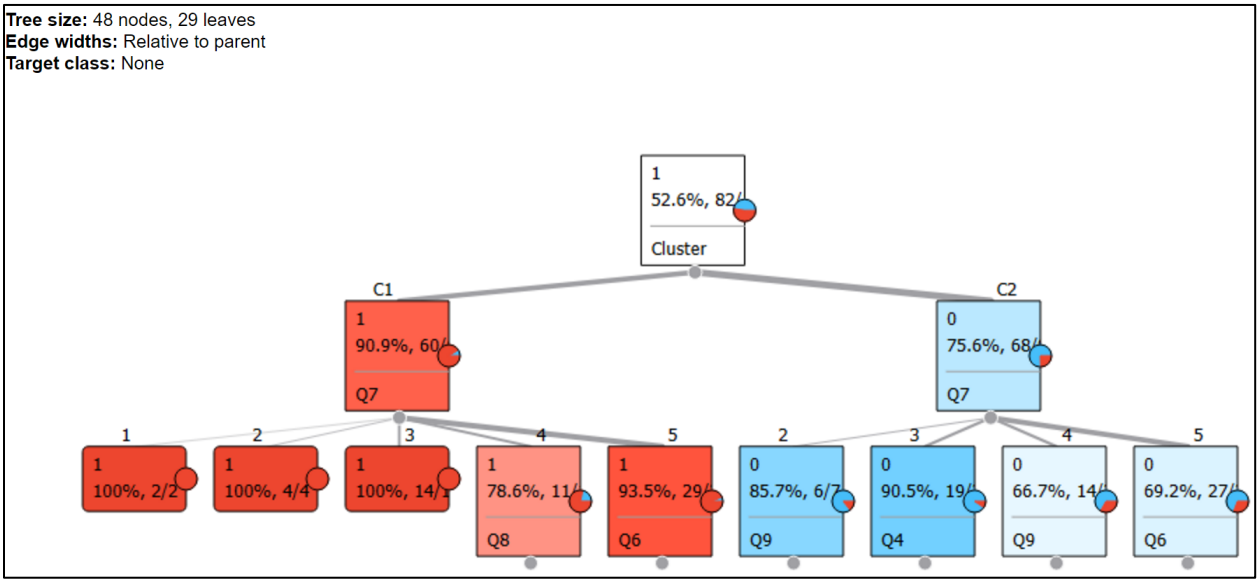
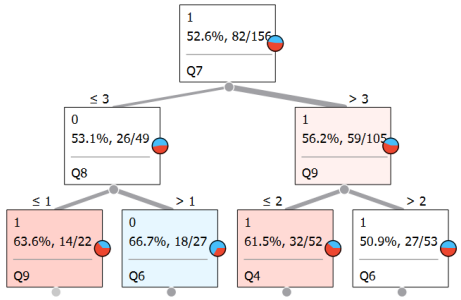
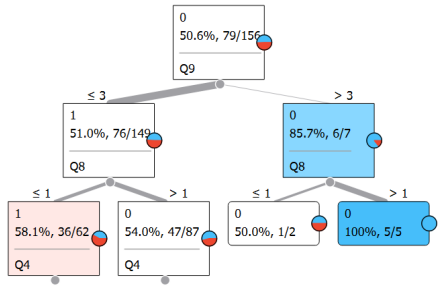


Figure 26: Classification Tree

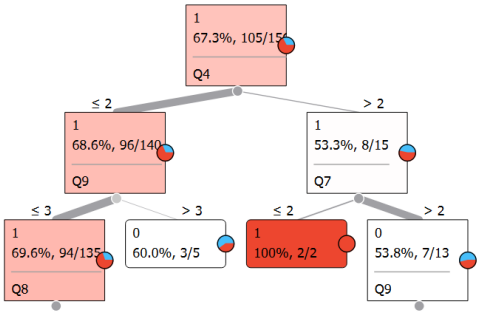
Further insights are obtained from classification trees of high traceability attributes (**Table 4**).



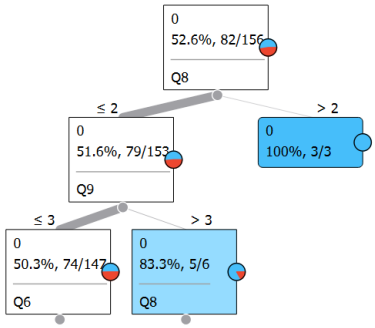
1. Approximate Catch Location with GPS



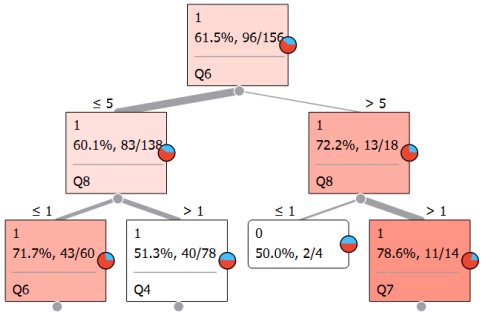
2. Fishing crew, vessel, method (line, net, farm)



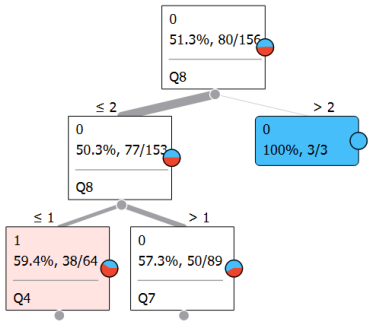
3. Processing methods with ingredients



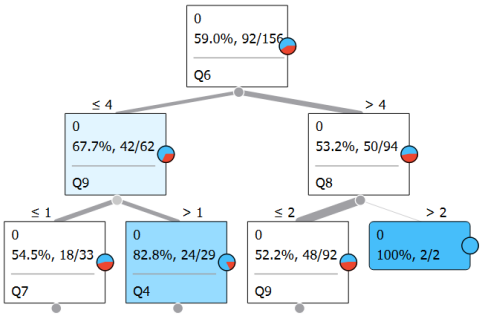
4. Storage stages with temperature sensors



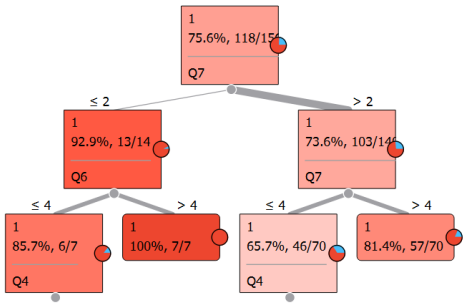
5. Unique Physical ID from harvest to retail



6. Net Weight at harvest, processing, retail nodes



7. Real-time date and time stamps at all nodes



8. Vessel / Crew compliance and certification

Table 4: KDE-wise Classification Trees

Respondents were asked if they were willing to pay $1 for high traceability attributes. The classification trees for attributes (KDEs) in **Table 4** shows highest confidence intervals (approximately 60% and above) for (1) Catch location with GPS; (3) Processing methods with ingredients; (5) Unique physical ID across all nodes; (7) Real-time date and time stamps across all nodes; and (8) Fishing vessel, crew compliance and certifications. Interestingly, the binary distinguishing features which give us most information about the attribute are: A. Annual Household Income (Q7); and B. Education Levels (Q6); followed by C. Frequency of Consumption (Q4). At the branch levels, D. Domicile Habitat (Q9) follows the front runners closely.

Figure 27 shows that as education and income levels rise, higher seafood traceability is preferred. The socio-economic group who preferred high traceability most (C1) was master's degree holders and professionals, who also earned the most. Doctoral degree holders showed a lower income level than master's degree holders and professionals and their preference for traceability is lower. Complementary studies to this research are included in Appendix C. Chapter 5 leverages these insights to discuss perspectives and implications.

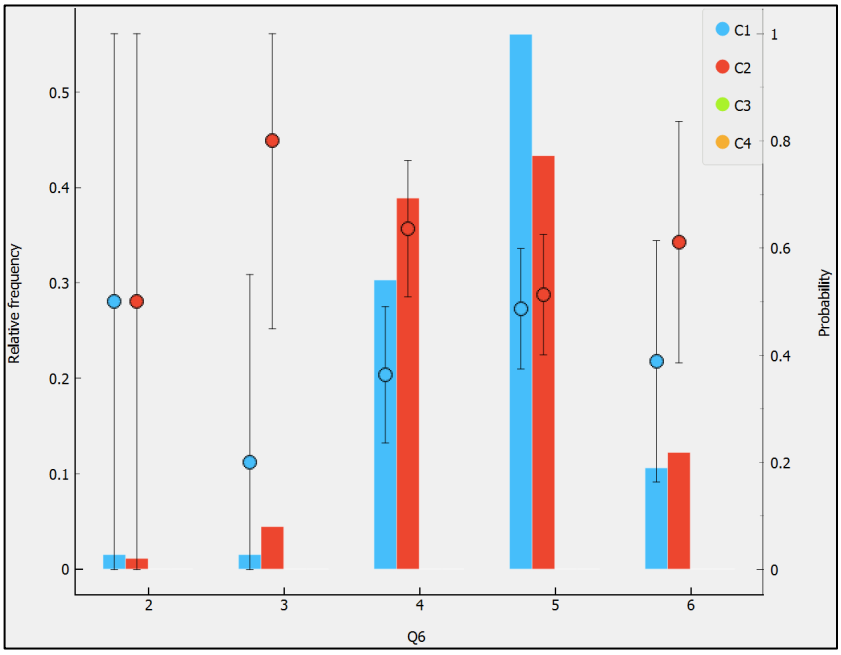


Figure 27: Result - Cluster and Probability Analysis

5. Discussion

This section serves to consolidate all the findings from interviews with stakeholders in the seafood industry, inferences from the consumer preferences research and valuable insights from the systematic literature review and thematic analysis.

5.1. Perspectives

5.1.1 Key inferences from research

Research shows that there is a high preference for traceability attributes amongst affluent consumers who also consume seafood more frequently. Seafood ranks as the least consumed protein in the U.S as seen by other studies in **Appendix C** (Mintel, 2018). Even though salmon prices fell by nearly 70% between 1980 and 2007 making salmon more of a staple product than a high-priced luxury product (Engle et al., 2016), seafood consumption still follows the demand patterns of a luxury product. Some reasons for this are (a) price rationalization of seafood is not yet known to the population who would otherwise switch from other sources of protein (b) there is lack of knowledge about seafood species and preparation methods, and (c) it is still considered a staple of the rich. Therefore, it may be inferred that affluent consumers consume seafood more frequently and largely prefer seafood traceability.

Perceived freshness of seafood as seen in Section 4.1.4 is an influencer of seafood consumption. This likely derives from the perishability of seafood as compared to other products. Consumers linked traceability of seafood with proper labeling of their seafood (48% likelihood) and with fresher seafood (44% likelihood). It is worth exploring the labeling attributes that recall “freshness” in the minds of the consumers. Urban and coastal consumers have a high preference for traceable KDEs as

shown in Section 4. Country / inland respondents showed a higher preference for farm-raised due to their perception of wild caught fish from the ocean traveling longer distances to retailers' shelves, impacting its freshness. Findings from qualitative interviews and focus groups demonstrated that the attributes related to real-time date and time stamps are indeed linked to freshness. This data matches with the results of survey responses sent to 1,118 consumers by ThisFish in 2014 (A. M. Naaum & Hanner, 2015). This, along with other studies contained in Appendix C, also show a partiality for health benefits, low price and wild caught seafood.

The higher preferences for certified seafood and brand as depicted in 4.1.1, it demonstrates that retailers are in fact a primary driver of seafood traceability. Retailers seem to have a substantial influence in consumers' seafood purchase decisions. Retailers are also are the final node of physical flow to the consumer. They benefit from educated empowered consumers in terms of higher sales of seafood. Retailers understandably have tweaked their marketing campaigns to target women shoppers. As more women and higher-income consumers shop in stores, they tend to prefer high traceability. Interestingly, the results in Section 4.1.5 also revalidate that women prefer higher traceability KDEs, nearly twice that of men.

Consumers still prefer brand name or common market name such as "grouper" for *Epinephelus nigritus* and "Atlantic salmon" for *salmo salar*, which perpetrates species substitution fraud by mid-chain players. ThisFish compared the results for a survey of 3,004 Americans conducted by National Public Radio (NPR) in 2012 (A. M. Naaum & Hanner, 2015), with strikingly similar findings. It is clear that much of the current findings with regards to seafood challenges - such as Latin species name being more authentic and aquaculture being more sustainable - are not permeating to the general public. Aquaculture or farm raised product is not even being debated as a sustainable solution (Van Holt, Weisman, Käll, Crona, & Vergara, 2018). Consumers who prefer traceable KDEs were

more than twice as likely to eat seafood more than four times a month and were twice as likely to consider sustainability important. It can be summarized that consumers get more educated or become more affluent, they consume more seafood and care more about traceability, including willing to pay a premium for High traceability KDEs.

5.1.2 Recommendations for seafood traceability drivers

Research shows that educated and affluent consumers who consume seafood more frequently demand more information and place higher value on traceability. As seafood consumption increases, so does public awareness of the associated nutritional and environmental issues related to seafood mislabeling. Success stories of labeling accuracy do exist. For instance, it was found that mislabeling of cod in Irish supermarkets declined from 34% to 0% after extensive media coverage raised public awareness. Mislabeling in fishmongers in Europe drop to below 5% as a result of improved reporting requirements for suppliers and processors (Wilmette et al., 2017). A key difference between these successes and others that did not meet expectations was the focus on engaging the general public in monitoring efforts to promote seafood awareness and literacy among consumers more broadly. This highlights the need for an integrated, comprehensive, local-scale strategy that engages the seafood community in developing solutions to educate consumers and the general public.

Two cases in point for local seafood community development are: (a) Los Angeles Seafood Monitoring Project (LASM), composed of stakeholders from local universities, seafood restaurants, non-profit organizations as well as local, state and federal government agencies, aims to eliminate seafood mislabeling using a two-tiered approach. First, it seeks to clarify ambiguity in government labeling requirements that result in mislabeling by proposing revisions to the FDA-approved "Seafood List." Second, it conducts blind sampling and DNA barcoding to monitor fish that the

wholesales sell to restaurants, in collaboration with seafood restaurants in the region. (b) The Gulf of Maine Research Institute (GMRI) is dedicated to the resilience of the Gulf of Maine ecosystem and the communities that depend on it. GMRI's seafood program partners with the supply chain players that form each link of the supply chain: with fishermen, sea farmers, dealers, processors, retailers and restaurant owners to test and implement technologies and processes to increase the use of regional seafood, raise consumer awareness of seafood and empower seafood purchases and increase the overall sustainability of the seafood ecosystem.

Regulatory authorities, media, global organizations and NGOs together have more strength to implement a coordinated campaign to spread public awareness about the benefits, practices and issues related to seafood consumption. However, this research overall, the results of the interviews and other studies demonstrate that the link between consumer preferences for traceability and seafood purchases overall is slim. But, dividing into two clusters, C1 and C2 which explains more about the consumers who do and do not care about traceability, we are able to garner more information. There may be a multitude of reasons for C1 or the cluster where demand for traceability is low. Many consumer choices are constrained, as a result of choices made by others several steps earlier in the supply chain. Other reasons may be that the current seafood system masks the seafood choices via substitution of source fisheries and species (Van Holt et al., 2018). Van Holt (2018) suggests that in such a case, educating the consumer as a sole strategy may not move the needle. It may require exploration into whether educating the mid-level supply chain actors and others in a position to influence the public such as media and universities can have a bigger impact. If true, the attitudinal change amongst mid-level supply chain players can go far in influencing and strengthening the impact of consumer preferences as a driver for transparency. Transparency builds trust; trust increases seafood purchases, which, in turn, reinforces traceability and transparency.

Seafood traceability systems are an essential part of informational governance, where value chain information flows between industry, regulatory and/or consuming actors depending on various underlying drivers. Among the three drivers of traceability, communication or consumer-facing traceability (CFT) is the most complicated, as there may be more obstacles due to localization, design and heterogeneity of traceability systems. Its impact is inconsistent due to high level of differentiation in global markets, purchase patterns and demographics. An integrated approach to harmonize KDEs with an understanding of drivers will reinforce traceability and sustainability governance (Mol, 2015).

Table 5: Potential impact of traceability on information governance based on traceability drivers

Table 1

Potential impact of traceability on sustainability governance and level of required negotiation for different categories of traceability drivers [28] and information flows [18••]

Category and stage	Information flow	Level of negotiation	Impact on sustainability governance
Management	Between value chain actors	Low	Low
Regulation	From value chain actors to regulators	Medium	High
Communication	From value chain actors to consumers	High	Unknown

Consumer preferences' impact is relatively unknown, and research shows low demand for traceability, at least amongst the less affluent, infrequent consumers (cluster C1). The higher demand for traceable KDEs among the highly educated and aware consumers shows that with rise in education, awareness, income levels and seafood consumption, consumer preferences' role as a driver will only gain in prominence. Better understanding of all drivers and factoring them in traceability implementations will result in better adoption rates. Rate of adoption is a function of standardized process definition of common interoperable data elements, collected authentically on a consistent trusted repository, with ability to disseminate the right information to the right stakeholders at the right time with continuous improvement to meet the changing drivers of traceability and updated needs of value chain actors.

5.1.3 Traceability as an informational governance tool

Traceability does appear to provide a mechanism through which information can be channeled between producers, consumers and regulators (Mol, 2015). Traceability systems are a form of informational governance. They provide a structured channeling of information flows within the entire value chain (Bailey et al., 2016). To summarize, the steps to establish a universally adoptable seafood data governance are: (i) an understanding of what is driving whole-chain traceability, (ii) the scope and goals of traceability, (iii) globally accepted standardized seafood attribute naming list, (iv) a universal list of harmonized rules and stakeholders, and (v) accountable integrated approach to establish a global interoperable harmonized seafood traceability data governance framework.

While seafood traceability initiatives outlined in Section 2 have made significant advances in KDE definitions of traceability, global common standards are still needed to form a common interoperable vocabulary. These standards will eventually set the foundation for regulatory mandates (by global governmental organizations) and managerial initiatives (by supply chain actors) calibrated to consumer-driven data needs. The Global Dialogue, as discussed in Section 2.3.1, is currently working to come up with data standards that might pave the way for standardization and creation of a common KDE vocabulary that meets minimum needs of all actors and has a robust informational governance roadmap.

5.1.4 Common Interoperable Key Data Elements (KDEs) vocabulary

It all begins with data thinking. There are many considerations to factor in due to the global nature of seafood, variety of species fished / harvested, supply chain actors, drivers, accessibility to technology, seafood legislation and industry practices of seafood companies. The goal is to establish globally harmonized agreed-upon key data elements (KDEs), which are technologically interoperable across all traceability systems to facilitate business-to-business interchange, data

verification, standardization and data governance. While a great deal of coordination, negotiation and collaboration is needed to arrive at a common harmonized data foundation, the next step forward would be a minimum viable Global KDE list with a clear accountable value chain actor which meets global requirements, such as Catch / Harvest Location (Actor: Fishing Vessel) or Country of Origin Labeling (Actor: Processing Location). Accountability cannot be delegated to the supply chain actor but can be effected through regulatory mandates and incentivization.

5.1.5 Integrated approach to traceability

A comprehensive understanding of drivers, benefits and potential impact on sustainability governance along with additional research can pave the way to creating a framework for establishing common KDEs prioritizing from [i] to [iv] (**Figure**). The KDEs in [i] such as Country-of-Origin Labeling (COOL) as shown by research at the intersection of all three drivers, Managerial, Regulatory and Consumer, would be part of minimum viable KDE list. KDEs that fall in [ii], [iii] and [iv] regions can be global and/or local. KDEs that fall within a single driver, such as Managerial, Consumer OR Regulatory are local-scale KDEs which are incorporated into or layered into the framework at a country or specific industry level. This integrated approach may spur better adoption of the KDEs by all stakeholders.

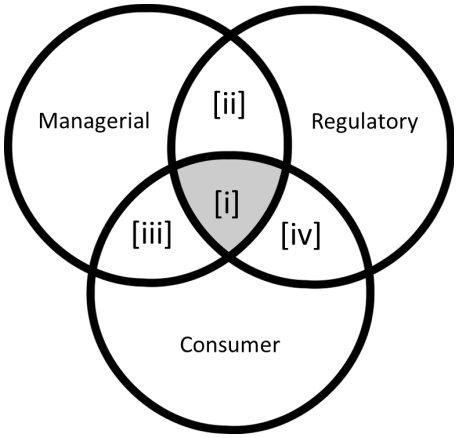


Figure 28: Intersection of all drivers

5.1.6 Managerial Implications

Traceability will likely gain traction with a comprehensive education which includes supply chain players along with consumers to alleviate species substitution and other illegal practices. To be able to do that, all supply chain actors need to be identified and integrated into working groups.

Supply chain players stand to gain the most as seafood consumption increases. As seafood consumption increases, it will drive more traceability implementations, as a reinforcing loop. Traceable products result in more accurate demand forecasting and require a shorter re-order period. Traceability is especially beneficial for wild-caught products where the supply chain is opaque, prone to seasonality and not readily responsive to retail demand. Educating consumers about the benefits of aquaculture results in better inventory management, less wastage, fresher products and a significant impact on sustainability. Enhanced reliability and regularity in supply of farmed product should enable producers to negotiate better prices as well (Engle et al., 2016).

Table 6: Integrated approach combining drivers for seafood traceability

Value Chain Category*+	Management Transparency	Regulatory Transparency	Communication Transparency
Information Flows*+	Between value chain actors	Between value chain actors to regulators	Between value chain actors to consumers
Example: Information Flows*	Total quality management	EU tracking and tracing system	Eco-labels, certifications
Example: Players	Seafood retailers, Grocery Manufacturers' Association (GMA), Food Marketing Institute (FMI), National Fisheries Institute, GS1	FAO, NOAA, U.S. FDA, State Department, U.S. Agency for International Development (USAID), United Nations' Port State Measures Agreement (PSMA)	NGOs such as World Wildlife Fund (WWF), Conservation Alliance, Gulf of Maine Research Institute, Global Fishing Watch, Global Dialogue on Seafood Traceability
Sustainable Governance Impact+	Low	High	**Low**
Accountable (A) KDEs (example)	Net Weight, Processing Ingredients	Harvest Location, Latin Series Name	Unique Physical ID, Processing Methods
Voluntary (V) KDEs (example)	Pallet Identifier, Storage Temperatures	Fishing method (Line, Net, Farm), Processing locations	Certification & CoC Status, Vessel Name
* Based on different categories of drivers (Coff et al. 2013) & information flows (Mol, 2015); + Based on sustainable governance impact (Bailey et al, 2016)			

Retailers can better target specific consumer demographic segments to educate, promote and upsell seafood. Affluent consumers (earning over $150,000 or between $60,000 to $100,000 per year, but

not those earning between $100,000 to $150,000 per year), graduate and professional degree holders and urban and coastal population have highest propensity to consume more seafood. The role of mandatory labels is to ensure essential information reaches consumers. Voluntary labels providing desirable information to consumers can command premium pricing for seafood (Alfnes, Chen, & Rickertsen, 2018). Since more than 96% of seafood is purchased instore, seafood is a potential lever for retailers to increase footfall into stores (FMI, 2018). Seafood retailers recognize the importance of seafood traceability, use it to track performance against their sustainable seafood commitments and have used it for branding and reputation management. For instance, Target and the Midwest grocery chain Hy-Vee, Albertsons Companies, Ahold Delhaize Group's U.S. Hannaford and Food Lion stores, Whole Foods and Kroger have all made commitments to reach 100% traceable seafood. We have seen from survey results that retailers wield a lot of power and influence over traceability. Retailers coming together to agree and standardize on educating and standardizing attributes with consumers and upstream supply chain actors would move the needle forward for whole-chain traceability.

5.1.7 Policy Implications

In seafood traceability implementations, Government mandates are the most effective driver and play a major part in adoption. Government policies needs to be continuously calibrated taking into consideration changing market trends, key drivers and transient global trade. Other impactful drivers such as climate change and sustainability needs to be understood better. Consumers wrongly assume that wild caught is better 'quality' than aquaculture. Aquaculture in fact is more sustainable since it increases supply of fresh seafood without straining the wild stocks while bringing positive economic impact to organized farming sector (Brayden, Noblet, Evans, & Rickard, 2018). Future policy

regulations aimed at promoting farm raised seafood traceability will help raise its perception in the minds of the consumers which in turn will save our oceans and reduce US dependence on imports.

While SIMP certainly raises the bar on electronic traceability records by importers, it falls short of performing an effective task of informing local consumers in its current form. Pushing towards a more transparent and accountable system will efficiently facilitate data collection, sharing and analysis amongst all relevant value chain actors, and lead to full traceability that can significantly impact the way people treat food and co-exist within the sustainable eco system (He, 2018). Seafood industry is similar to pharmaceutical industry in terms of complex supply chain and high incidence of imports, high level of counterfeiting, need for whole chain traceability and stringent regulations by FDA. Seafood could take a page out of the pharmaceutical playbook to better implement traceability. Traceability through technology takes significant investment. As the largest importer of seafood in the world, United States policy mandates in favor of traceability will go a long way in improved seafood supply chain visibility.

5.1.8 Consumer Implications

The primary aim of traceability in food supply chains has been to alleviate food insecurity, regain or strengthen consumer trust by preventing foodborne illnesses from following the food from provenance to the table and ensure safe food for the world population. If consumers are aware of what to look for in labels and can make informed purchases, we are closer to the goal. Prevention is the best cure.

There are three primary stakeholders who are more accountable than others for consumer-facing traceability (CFT): Governments, supply chain players and the media. Mid-level and consumer-facing players such as wholesalers, distributors and retailers play an important part in ensuring that

the best practices and information flows are accurate. Governments have a critical role in issuing traceability mandates as it affects the safety of its citizens. Media's role is vital in informing consumers, such as the "Save the Dolphin" campaign in 1990s, where the media played a large role in the global boycott of tuna after the televised video of cruelty to dolphins during tuna fishing was revealed. There are success stories of labeling accuracy increasing in some seafood sectors. For instance, mislabeling of cod declined from 34% to 0% in supermarkets in Ireland after extensive media coverage raised public awareness (Mariani et al. 2015). Likewise, rates of mislabeling in traditional markets and by fishmongers in Europe have dropped precipitously to <5% as a result of improved reporting requirements for suppliers and processors (Mariani et al. 2015). A key difference between these successes and other studies that fell short was the focus on engaging the general public in monitoring efforts to promote seafood awareness and literacy among consumers more broadly (Naaum and Hanner 2015).

5.2 Conclusion

Traceability in the seafood industry in the US is fraught with many challenges due to its diverse complex supply chain, high incidence of imports, consumer perception about seafood, lack of awareness of drivers, lack of interoperability and common data vocabulary between supply chain actors, consumers and global legislation. There has been a litany of recent initiatives: new policy changes with the introduction of SIMP, collaborative advocacy and standards establishment with Global Dialogue, retailer commitments to 100% traceable seafood, industry and NGO global initiatives which include advocacy and local-scale community organization. But the present policy and managerial transparency do not factor in consumer preferences due to its perceived lack of influence on seafood traceability governance.

The survey results show there is some weightage of consumer preferences on seafood traceability KDEs, compared to policy and managerial drivers, however it is not big enough to influence standards and global practices. There may be several reasons for this, such as constraints in the purchasing ability of consumers, too many middlemen who wield influence over supply of seafood and deliberate masking of awareness about seafood's challenges. Additional contributing factors may be lack of awareness of the benefits of traceability implementations in the mid-supply chain, a lack of clear accountability and the general dearth of payment mechanisms for traceability. The results go on to show demographic and social characteristics of consumers that drive traceable behavior and specific KDEs in various consumer segments that are perceived as more important. It also emphasizes that as consumers become more educated, more aware of the industry challenges and consume more seafood, the demand for traceability is bound to increase and so will their influence on what data is needed. This will lead to better adoption of standardized KDEs and sustainable practices by all stakeholders in the seafood supply chain.

5.3 Limitations

There are several limitations to this study. Firstly, the study was restricted to the US seafood industry. Since the goal of the seafood traceability is to reach global interoperable harmonized, studying the influence of consumer preferences as a driver would be useful in all countries. This would also enable easier global adoption in the future.

Due to paucity of time, the interviews and focus group meetings were fewer than average. Interviewing more diverse supply chain players such as ecolabel certification bodies, local government and non-government organizations and traceability enabling companies would add more

richness to the findings. In addition, the survey was conducted with a small sample size. A larger sample size may be more representative of universal preferences and attitudes. With higher budgets, survey distribution to a more diverse sample such as rural, inland, less affluent consumers and ethnic communities would generate more insights. Although this study provides detailed information on individual-level consumer preference and to some extent, a willingness to pay a premium for high traceability data, it does not cover Willingness to Pay (WTP). However, WTP may not actually reflect consumers' actual behavior.

5.4 Future research

With growth in consumer and public transparency needs, there is a new research agenda to mix these two forms of transparency with management and regulatory transparency (Mol, 2015). Global advocacy and action groups exist for traceability mandates. The more inclusive it is of the cohort of stakeholders and traceability drivers, the more complete and more futuristic will be the global standards. Future research to identify major current and future drivers (such as sustainability) and take into consideration the universal list of stakeholders would be a step in the right direction. Research in the pursuit of a global industry-wide integrative approach to harmonizing interoperable mandatory KDEs and recommended KDEs, with accountability assigned to value chain actors for data capture, storage and dissemination of the KDEs at each node of the value chain would be key. The seafood industry will certainly benefit from global harmonized traceability practices, data governance and traceability implementation practices that eventually will build trust and increase seafood consumption in America.

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Appendix A

Key Data Elements (KDEs) list (Bhatt et al., 2016) from IFT's publication: Project to Develop an Interoperable Seafood Traceability Technology Architecture

Table 1–CTEs and KDEs that occur throughout value chain. A, B, and C represent the importance ranking of the CTE.

CTEs and KDEs that occur throughout value chain	Rankings		
CTE	A	B	C
CTE type	X		
CTE ID	X		
Event owner	X		
Date and time	X		
Event location	X		
Item ID type	X		
Item ID	X		
Batch/lot/serial number	X		
Quantity	X		
Unit of measure	X		
Batch/lot relevant due date	X		
Activity type	X		
Activity ID	X		
Supplier name	X		
Trading partner location	X		
Temperature		X	X
Specific product attributes		X	X

Table 2–CTE/KDEs for wild harvest.

CTE	KDE		Rankings A	Rankings B	Rankings C
Point of harvest					
Wild capture					
	Latin species name		X		
	Common or market name		X		X
	Catch location		X	X	X
		FAO major fishing zone	X		
		Country of catch	X		
		Region	X		
		Management authority	X		
		Stock	X		
	Landing date			X	X
	Time of harvest				
	Vessel info				
		Flag of fishing vessel		X	
		Name of fishing vessel	X	X	X
		Captain name		X	
		Home port		X	X
		IMO	X	X	
	Fishing method		X		X
	Total weight of catch			X	
	Certification status and chain of custody code			X	X

Table 3–CTE/KDEs for farm raised.

CTE	KDE		Rankings A	Rankings B	Rankings C
Point of harvest					
Farm					
	Farmed location				
		Farm name or processor name	X	X	
		Country of farming	X		
		Region of farming (or address)	X	X	X
		GPS coordinates		X	X
	Country of origin labeling (COOL)		X		
	Production method		X		
	Fishmeal KDEs				X
	Feed company name			X	
	Feed ingredients			X	X
	Hatchery name			X	
	Source information for wild fish feed		X		
	Catch area		X		
	Flag of fishing vessel			X	
	Name of fishing vessel			X	
	Fishing gear		X		

Table 4–KDEs for CTEs of retained bycatch, trans-shipment, shipping and receiving, transportation, port/landing, processing stages, primary/secondary, and distribution.

CTE	KDE	Rankings A	Rankings B	Rankings C
Retained bycatch				
	Species	X		
	Stock			X
	Size of Bycatch		X	
	Quantity of Bycatch		X	
	Date and Time of Bycatch		X	X
	Location of Bycatch	X		
	Catch Certificate/License	X		
Trans-shipment				
Shipping and receiving				
	Was the Product Trans-shipped?	X		
	Tonnage Trans-shipment		X	X
	IMO Number of Catch Vessel and Carrier		X	X
	Identity of Receiving and Shipping Vessels	X	X	
	Date and Time of Transfer	X	X	
	Location of Transfer	X	X	
	Species or Common Name	X	X	
	Quantity	X	X	
	Lot, Batch of Shipment Number	X	X	
Transportation				
Port/landing				
	Location Landed	X	X	
	Date Landed		X	
	Identity of Vessel	X		
	Event Owner	X	X	
	Species, Stock, Size	X		
	Catch Certificate of License Number		X	
	Quantity of Fish		X	
Processing stages				
Primary and secondary				
	Species	X		
	Dates and times received	X	X	X
	Location received	X	X	
	Weight	X		
	Lot number	X		
	Batch code	X		
	Dates and times shipped	X	X	
	Name of processor/packing plant	X		
	Pallet identifier	X		
	Supplier		X	
	Customer		X	
Distribution				
	Product	X		
	Weight	X	X	
	Container/seal number	X	X	
	Pallet identifier	X	X	
	Lot number/batch number/serial number	X		
	Pallet identifier	X	X	
	Dispatch date	X	X	
	Receiving date	X	X	
	Transport companies	X	X	
	GTIN code/UPC code	X		
	Quantities	X		

Appendix B

Direct Survey Questionnaire

Seafood Consumer Preferences Survey: What Matters Most to You? [MIT Research Project]

Start of Block: Informed Consent

Q1

Welcome to the Seafood Consumer Preferences research study!

We are interested in understanding your preferences for purchasing and consuming seafood (fish, shellfish, crustaceans such as crabs and lobsters). You will be presented with information relevant to seafood attributes and asked to answer some questions about it. Please be assured that your responses will be kept completely confidential and anonymous. This survey is for academic research purposes and your input is valuable. It will contribute to useful research on food safety / sustainability and earn you some good karma!

The study should take you around 4-6 minutes to complete. If you are interested in receiving a copy of the final report, please feel free to fill in your email at the end of the survey. Your participation in this research is voluntary. You have the right to withdraw at any point during the study, for any reason. If you would like to contact the Principal Investigator, Sunitha Ray, Graduate Student in Supply Chain Management program at MIT, Cambridge, MA to discuss this research, please e-mail sunithar@mit.edu. Thank you for your time!

By clicking the button below, you acknowledge that your participation in the study is voluntary, you are 18 years of age or older. Please note that this survey will be best displayed on a laptop or desktop computer, rather than a mobile device.

○ I consent, begin the study (1)

○ I do not consent, I do not wish to participate (2)

Skip To: End of Survey If Q1 = 2

Q2 Do you consume seafood (such as fish, shellfish, crabs, lobsters)?

○ Yes (1)

- ○ I don't eat seafood but I buy it for my family's consumption (2)
- ○ No (0)

Skip To: End of Survey If Q2 = 0

Q3 Which U.S. state do you call home?

▼ Alabama (1) ... I do not reside in the United States (0)

Skip To: End of Survey If Q3 = 0

Q4 How often do you consume / buy seafood?

Few times a month (1)

Once a month or so (2)

Every few months (3)

End of Block: Informed Consent

Start of Block: Block 1

Q6 What is the highest level of school you have completed or the highest degree you have received?

- ○ Less than high school degree (1)
- ○ High school graduate (high school diploma or equivalent including GED) (2)
- ○ Some college but no degree (3)
- ○ Bachelor's degree in college (4-year) (4)
- ○ Master's degree or Professional Degree (JD, MD) (5)
- ○ Doctoral degree (6)

Q7 What is your annual household income? [if you are currently a student, what was it before?]

- ○ < $30,000 (1)
- ○ $30,001 to $60,000 (2)
- ○ $60,001 to $100,000 (3)
- ○ $100,001 to $150,000 (4)
- ○ Above $150,000 (5)

Q8 What is your sex?

- ○ Male (1)
- ○ Female (2)
- ○ Choose not to answer (3)

Q9 How would you describe where you live in the USA?

- ○ Urban and Suburban (City): Coastal Zone (Atlantic or Pacific Rim) (1)
- ○ Country: Coastal Zone (Atlantic or Pacific Rim) (2)
- ○ Urban and Suburban: Inland (Not near an ocean) (3)
- ○ Country: Inland (Not near an ocean) (4)

End of Block: Block 1

Start of Block: Block 2

Q10 Q1 of 7: Which of the following do you look for when purchasing seafood? (Check all that apply).

- ○ Low Price (1)
- ○ Farm raised (2)
- ○ Wild caught (3)
- ○ Organic (4)
- ○ Trusted Certified (5)
- ○ Traceable label (6)

Display This Question:

If Q10 = 5

Q11 Since you like Certified seafood, please choose the certifications that you typically look for on the label:

- ○ Marine Stewardship Council (MSC) (1)
- ○ Aquaculture Stewardship Council (ASC) (2)
- ○ Food Alliance Certification (3)
- ○ Best Aquaculture Practices (BAP) (4)
- ○ Fair Trade Certified (5)
- ○ National Fish (6)

Q12 Q2 of 7: How important are the below for you while purchasing seafood? (Click on the star: 1 for Not at All Important; 5 for Most Important)

- Detailed label information (2) ☆ ☆ ☆ ☆ ☆
- Packaging, net weight (3) ☆ ☆ ☆ ☆ ☆
- Organic farm-raised (4) ☆ ☆ ☆ ☆ ☆
- Wild caught (5) ☆ ☆ ☆ ☆ ☆
- Country of origin (6) ☆ ☆ ☆ ☆ ☆
- Date stamp / expiration date (7) ☆ ☆ ☆ ☆ ☆
- Certified seafood / vendor stamp (8) ☆ ☆ ☆ ☆ ☆

Q13 Q3 of 7: Which of the below factors would make you trust your seafood purchases the most? (Please rank in order of importance with 1 being the most Important and 3 being least important)

_____ Sensor and GPS based captured location information about your fish (3)

_____ Trustworthy brand (1)

_____ Legal Compliance and certification stamps (2)

End of Block: Block 2

Start of Block: Block 3

Q14 Q4 of 7: What name attributes would you prefer on the label when buying seafood? (check all that apply).

○ Brand name or common market name (1)

- ○ Country of origin label (2)
- ○ Latin species name (for example, 'salmo salar' for Atlantic Salmon) (3)
- ○ Fishing vessel / boat name (4)
- ○ Unique physical ID from catch / hatchery location to your table (5)

Q15 Q5 of 7: What location attributes would you like to know on your food's journey from "ocean to table"? (Check all that apply)

- ○ Fishing crew / boat Information (1)
- ○ Processing facility information (2)
- ○ Transporter / pallet information (3)
- ○ Packaging facility information (4)
- ○ Distributor/Retailer information (5)

Q16 Q6 of 7: If any of the following attributes appeared on the product label and added $1 each to your price, which one(s) would you choose? (Please rank in order of importance with 1 being the Least Important and 5 being Most Important)

- Approximate catch location with GPS coordinates (a) (1) ☆ ☆ ☆ ☆ ☆
- Catch method with fishing crew, boat, farm names (Line, Net, Farm) (b) (2) ☆ ☆ ☆ ☆ ☆
- Processing methods with ingredients Information (c) (3) ☆ ☆ ☆ ☆ ☆

- Fishing crew, boat and importer license, safety compliance and certification records (8) ☆ ☆ ☆ ☆ ☆
- Storage stages with recorded temperatures with sensors (d) (4) ☆ ☆ ☆ ☆ ☆
- Reliable physical ID for your seafood from harvest to transportation points (e) (5) ☆ ☆ ☆ ☆ ☆
- Net weight at harvest / processing centers / transportation points (f) (6) ☆ ☆ ☆ ☆ ☆
- Real-time date and time stamps from harvest date till retail shelf (g) (7) ☆ ☆ ☆ ☆ ☆

Q17 Q7 of 7: Given the below sample product, which product would you buy?

○ $17.00: Tuna steak A: with full real-time traceability information with GPS+sensor based date / time stamps (1)

○ $16.00: Tuna steak B: with Country of Origin, boat / farm and processing centers information (2)

○ $15.00: Tuna steak C: with Certified with expiry date (3)

Q18 Thank you. If you would like a copy of the full report when it's complete, enter your email below (optional):

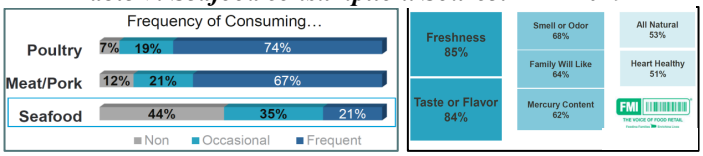
_____

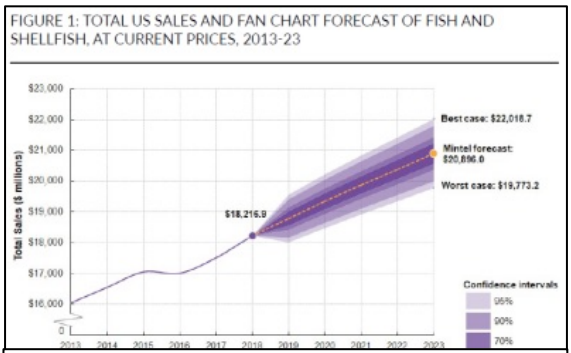
End of Block: Block 3

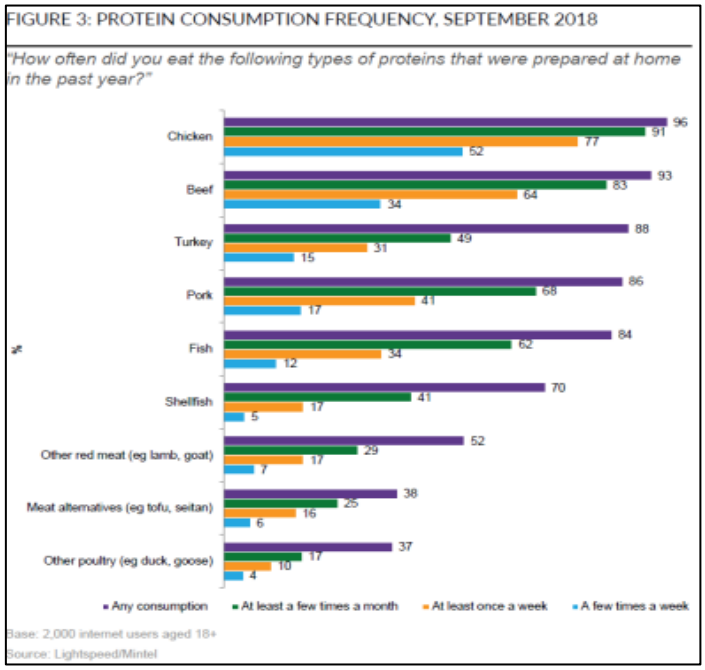
Appendix C

Surveys, charts and data collection conducted by other organizations that are complementary to the research conducted for this paper. Bitly user screen is also displayed.

Table 7: Seafood consumption. Source: FMI 2019







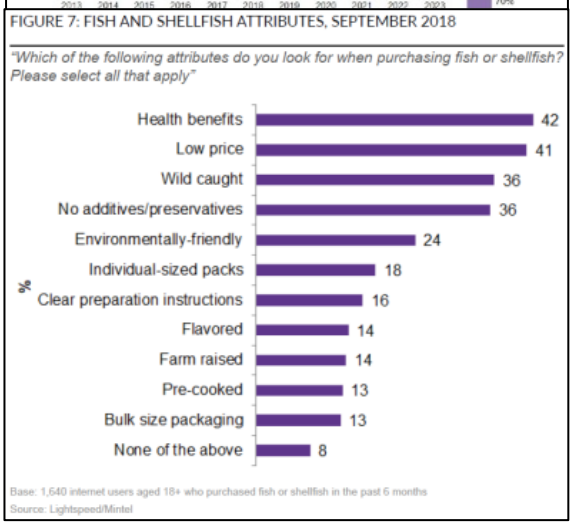
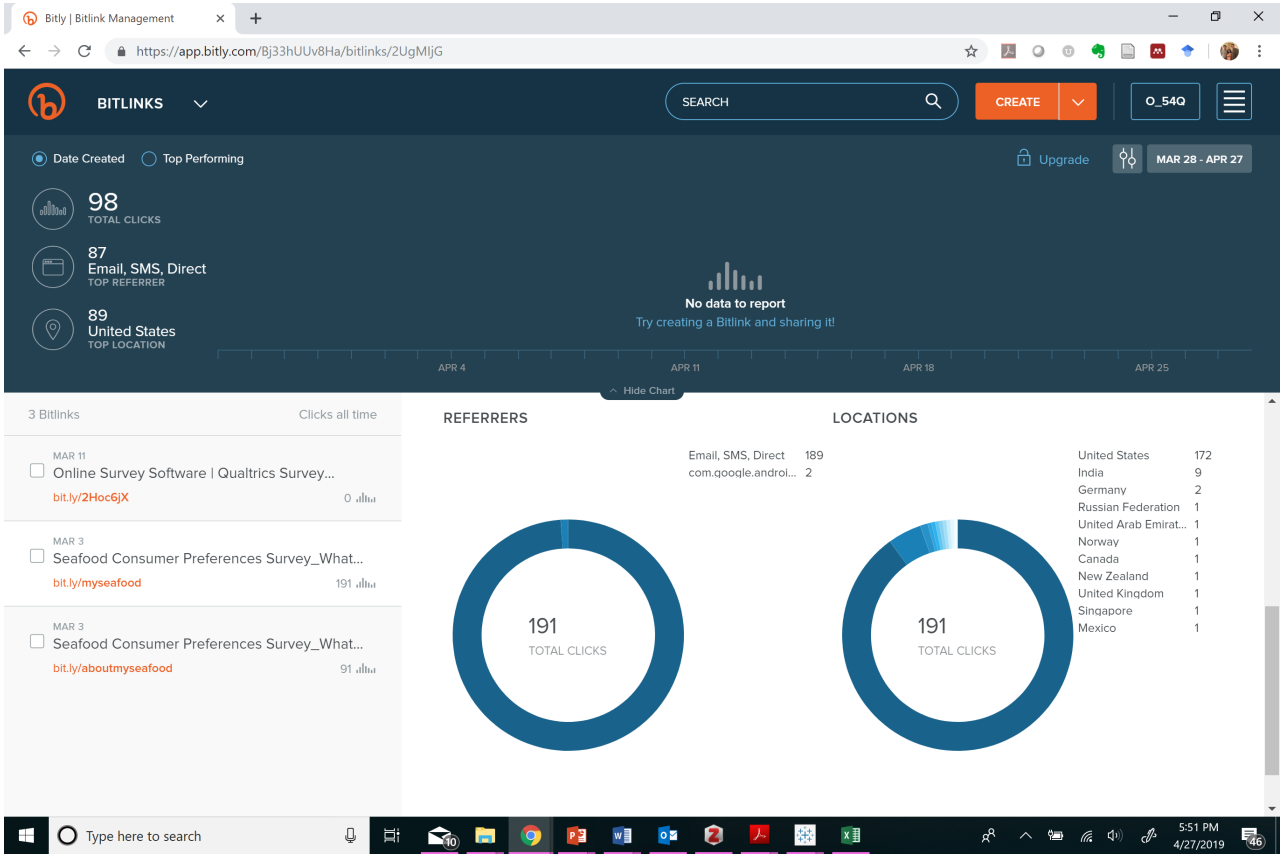


FIGURE 4: PROTEIN OCCASIONS, SEPTEMBER 2018

"During which occasions/seasons have you eaten the following proteins in the past year? Please select all that apply."

	Chicken %	Turkey %	Red meat %	Fish %	Shellfish %	Meat alternatives %
For breakfast	13	11	19	7	5	13
For lunch	63	42	47	40	29	34
For dinner	87	67	83	73	71	45
As a snack	22	13	14	12	17	17
At a party	34	17	31	16	32	14
At a barbecue	53	11	54	12	16	9
At a restaurant	62	23	62	50	58	29
At work	23	11	16	9	7	12
In the winter	61	46	56	44	41	27
In the summer	64	31	58	49	51	29
In the spring	61	31	54	44	43	27
In the fall	61	57	55	43	40	27
Other	2	5	4	3	4	16

Base: 1,917 internet users aged 18+ who have eaten a listed protein in the past year
Source: Lightspeed/Mintel


Bitly | Bitlink Management
https://app.bitly.com/Bj33hUUv8Ha/bitlinks/2UgMIjG
BITLINKS
SEARCH
CREATE
O_54Q
Date Created
Top Performing
Upgrade
MAR 28 - APR 27
98
TOTAL CLICKS
87
Email, SMS, Direct
TOP REFERRER
89
United States
TOP LOCATION
No data to report
Try creating a Bitlink and sharing it!
APR 4
APR 11
APR 18
APR 25
Hide Chart
3 Bitlinks
Clicks all time
MAR 11
Online Survey Software | Qualtrics Survey...
bit.ly/2Hoc6jX
0
MAR 3
Seafood Consumer Preferences Survey_What...
bit.ly/myseafood
191
MAR 3
Seafood Consumer Preferences Survey_What...
bit.ly/aboutmyseafood
91
REFERRERS
Email, SMS, Direct 189
com.qooqle.androi... 2
191
TOTAL CLICKS
LOCATIONS
United States 172
India 9
Germany 2
Russian Federation 1
United Arab Emirat... 1
Norway 1
Canada 1
New Zealand 1
United Kingdom 1
Singapore 1
Mexico 1
191
TOTAL CLICKS
Type here to search
5:51 PM
4/27/2019