Assessing the Value and Role of Seafood Traceability from an Entire Value-Chain Perspective

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Comprehensive REVIEWS in Food Science and Food Safety

Assessing the Value and Role of Seafood Traceability from an Entire Value-Chain Perspective

Brian Sterling, Martin Gooch, Benjamin Dent, Nicole Marenick, Alexander Miller, and Gilbert Sylvia

Abstract: The traceability practices and systems of 48 separate seafood businesses were assessed as part of an evaluation of 9 global seafood value chains (from catch to point of sale to the consumer). The purpose was to gain insights and provide knowledge about the impact of traceability on improving seafood industry business performance, including reducing waste, and enhancing consumer trust. In addition, the project developed and delivered a tool that can be used by stakeholders that are seeking to better understand the return on investment of implementation of traceability practices and solutions. Using structured and semistructured interviews of over 80 individuals, the research revealed that traceability is more highly valued by businesses, regardless of their size, if they engage more often in highly collaborative activities with their suppliers and customers. A survey in 5 nations about consumer perceptions with regards to seafood and the key factors influencing their purchasing decisions delivered insights into the discrete choices that consumers make when buying seafood products. The consumer survey data were incorporated into a "Discrete Choice Simulator" that others can use to compare and contrast the preferences of consumers in these countries and better understand what factors regarding traceability impact on their buying decisions. The research concluded with several recommendations for businesses, governments, and nongovernment organizations.

Keywords: seafood traceability, consumer survey, quality, return on investment

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Executive Summary

The Global Food Traceability Center (GFTC) is a public–private partnership program within the Institute of Food Technologists (IFT) and undertook this project with support from the Moore Foundation. The purpose of this project was to gain insights and provide knowledge about the impact of traceability on improving seafood industry business performance, including reducing waste, and enhancing consumer trust. In addition, the project developed and delivered a software tool that can be used by stakeholders that are seeking to better understand the return on investment (ROI) in implementation of traceability practices and solutions.

The project began with an extensive literature review, the results of which highlighted that effective food traceability can be viewed as an outcome of businesses possessing a disciplined, professionally managed approach to data gathering, retention, analysis, and collaboration, performed simultaneously at all points along the value chain. This strategic approach to traceability makes possible the creation of financially and environmentally sustainable food businesses and value chains, by providing the opportunity to create and retain a unique competitive advantage (Gooch and Sterling 2013).

The literature review also identified a definition of traceability that subsequently guided the research project: "the ability to access any or all information relating to that which is under consideration, throughout its entire life cycle, by means of recorded identifications" (Olsen and Borit 2013).

A team led by the GFTC then researched and identified the business case for traceability among businesses in the global seafood industry, including those involved in the capture/production, processing, and distribution levels, as well as in retail and foodservice. The research was conducted through direct interviews with 48 different businesses around the world in order to assess the reasons why "interparty" traceability systems were used to strengthen business performance and the impact of its implementation. (See Appendix A for details on factors used to help select these companies.)

The 2nd part of the research and analysis was identifying the attributes of specific seafood species and seafood products that most influence consumers' attitudes toward seafood and the impact of the attributes on their purchasing decisions. This included evaluating for which attributes associated with traceability consumers could be willing to pay. A 3rd-party market research company conducted the primary consumer research in 5 markets in which the businesses who participated in the research are involved: Canada, China, Germany, The Netherlands, and the United States.

Although not described in this report, the project also led to the development of software that allows businesses operating in

the seafood industry to calculate the ROI for their traceability investments.[1]

The literature review produced insights into the significant shifts that are occurring in the seafood industry and the factors driving those changes. For example, aquaculture and wild-caught seafood are 2 different sectors of the industry whose successes will continue to be impacted by challenges and opportunities unique to their respective sectors. These differences are foreseen to influence the extent to which traceability may be used to differentiate businesses and seafood products in the marketplace. The rapid growth of aquaculture and where aquaculture operations are located, along with rising demand for seafood (and other proteins) especially in developing nations, are notable drivers impacting the entire seafood industry. An example of a significant industry inhibitor is the growth of uncoordinated and nonharmonized policies and regulations being proposed around the world.

We found that previous research identified 4 different types of food value chains: Fragmented, Cooperative, Coordinated, and Collaborative. While a specific business or value chain may not always fit neatly into just one of the 4 categories, these category types helped researchers catalog how and why seafood businesses interact in a particular manner. The type also helped us to deduce which characteristics enhance a seafood business' ability to gain greater benefit from traceability practices and systems. This included clarifying the impact that information systems and communication have on commercial performance, and on other factors, such as the relationships that exist between businesses. (See Appendix B for details about the implications of the literature review.)

Insights from the literature review guided development of a strategy to engage with the international seafood industry during the primary research. The strategy guided development of a research process and methods that reflected value-chain analysis techniques. The literature review also led the researchers to decide that the actual seafood species encompassed by the research should be determined by the individuals and commercial businesses who championed the involvement of a value chain in which they operate. The justification for this decision came from the discovery that it would be more valuable to ground the primary research in a comparison of market-level forces such as aquaculture compared with wild-caught seafood, and factors associated with developed compared with developing markets, than to base the research on species only.

The primary research produced findings specific to the value chains investigated, many of which can be generalized to the global seafood industry. For example, it became clear that the more successful firms exhibited greater willingness than other companies to share information, and they had senior executives who considered the current research to be of value to their future success. Another generalized finding was that data used for traceability must be reliable and readily accessible. Achieving reliability and ready accessibility does not involve high cost; but it does require discipline and a core value regarding commercial transparency. And a general direct correlation was found to exist between the level of operational and strategic alignment that occurs between businesses and the value that they are able to derive from traceability.

The topics that we investigated during the primary research were:

1. Effect of interparty (between businesses) relationships on the willingness of companies to invest in traceability, exchange information, and share benefits from traceability;
2. Extent to which traceability and environmental sustainability affect retailer decisions on supplier selection, consumer attitudes, and purchasing behavior;
3. Degree to which traceability helps to reduce waste, lower the costs of ensuring food safety and quality, reconcile inconsistencies in information across the chain, reduce business risks/costs of food recalls, and enhance brand reputation; and
4. Barriers encountered during the development and implementation of a traceability system, and how they were addressed.

We found that distinct differences exist in the extent to which businesses and their value chains have benefited from traceability. Identified benefits included enhanced physical qualities of a product (for example, monitoring temperature history to manage freshness) and reduced costs (for example, shrinking inventory to reduce working capital). Traceability was also identified as an effective tool for managing and mitigating risks associated with individual enterprises (that is, maintaining tighter control of processes that impact food safety) and the wider industry (that is, eliminating the risk of sourcing illegal seafood).

Perhaps ironically, the more diffuse the role that traceability plays across businesses' operations and the more imbedded traceability is in businesses' management information systems, the more challenging it is for businesses to calculate its value through means such as ROI. From a cost-benefit perspective, this presents an important issue that impacts a business' ability to justify financial investment in traceability systems. The greater the benefit, the more ubiquitous traceability is across a business and along the value chain(s) in which it operates. Nevertheless, the more ubiquitous traceability is across business operations, the more difficult it is to quantify the benefits specific to traceability. Many of the respondents who participated in this study voiced this challenge. (See Appendix C for more quantitative analysis of the importance of traceability to the value chains.)

The consumer research component found distinct differences in the consumption habits of consumers residing in each of the 5 countries. While consumers exhibit a high degree of similar attitudes toward the seafood species researched, the most common packaging format and purchase channel differed significantly. These differences occurred at a national level and between species. Differences were also found in the relative importance of sustainability claims and verifications. Highlights from the consumer research are contained in the Section "Consumer Research."

From the consumer perspective, the relative importance and perceived value of factors relating to traceability, such as sustainability claims and species authentication, also differ notably by market and species. The overall findings from the study suggest that the foremost concern among consumers is quality, and that consumers seek "simple indicators" that can guide their purchasing decisions. The results of the research suggest that a significant proportion of consumers do not possess detailed knowledge about seafood. Therefore, consumers use simple surrogates, such as best-by and use-by dates, as indicators of freshness. It is not clear that the seafood industry appreciates this admittedly simplified tactic.

Another significant finding was that consumers view species authentication (the fish is actually what is advertised or labeled) as comparatively less important than verification that a seafood product was produced or harvested in a sustainable manner. This suggests that there may be a sizeable opportunity for businesses to capture value by differentiating their seafood products from

[1]The seafood financial decision support tool and instructions on its use may be accessed at https://seafoodtraceability.org/.

other brands by using traceability to verify sustainability-related attributes.

The implication of these findings is that there are commercial benefits and competitive advantages that seafood businesses can derive from implementing traceability practices and systems. Consumers are not clear about what traceability is, but they intuitively understand that the industry can do better in regards to demonstrating diligence with respect to safe food and sustainability practices. The desire among consumers for transparency continues to grow and shows signs of becoming a notable market driver.

While the impact of each of the implications differs by business and specific situations, the research findings helped inform 10 implications, some of which reinforced the findings of previous investigations of the seafood industry.

We found that a number of common factors impacting on competitive advantage could be related to traceability, which allowed us to develop recommendations for how businesses can act upon the research findings. We also looked beyond the industry to recommend how governments and nongovernment organizations (NGOs) could balance the needs of their stakeholders with those of individual businesses in order to create a more sustainable industry.

For businesses, our recommendations are:

1. View Traceability from a Strategic Perspective

The research identified that the benefits of traceability are greater when businesses more tightly integrate traceability into their respective value chains, and their practices and systems.

2. Establish Purpose and Objectives before Selecting Technology

Knowing why traceability is needed and the benefits being sought allows decision making on which system is best suited to a particular business situation, reinforcing the ability to build on existing capabilities and resources.

3. Approach Traceability with Big Vision, Small Steps

Technology will not substitute for processes that are performed incorrectly. Therefore, it would not be wise to try to accomplish everything at once, or assume that the technology that is being implemented will produce the desired outcomes without changes also occurring among management and staff.

For governments, our recommendations are:

1. Enforce Legislation that Exists

A common theme that emerged in the research is that governments tend to develop new legislation and regulations to address an issue, often ahead of enforcing existing legislation and rules.

2. Enforce Legislation by Means that Produce the Intended Outcomes

Enforcement includes ensuring that regulations and legislation perform as intended, encouraging businesses to use traceability for business purposes.

3. Pursue International Consistency and Harmonization

The lack of international harmonization on policies and regulations creates weakness and limitations that are extremely difficult for individual businesses to address. It also increases the costs of traceability.

For NGOs, our recommendation is:

1. Engage in Constructive Dialogue

The attitudes that consumers express often differ from their actual shopping behavior. NGOs are encouraged to work with industry to influence changes in consumer behavior, as this is the most effective means of enabling and motivating changes in business behavior.

We also suggest areas for future research. Key areas to investigate include: deepening our understanding of how to use traceability to influence consumer behavior, further analysis of the financial impact of traceability on businesses, exploring the nature of traceability's effect on industry—NGO relationships, and how traceability can positively influence sustainable fisheries.

Purpose and Objectives

The seafood industry is experiencing significant change, with increased ecological concerns and environmental risks, evolving attitudes among consumers and industry stakeholders, changing consumer behavior, rising seafood demand, shifting market power, growing importance of aquaculture, concerns about seafood fraud, retail and foodservice demands driving increased investment, and increasingly stringent regulations pertaining to the supply and marketing of seafood. These are among the most notable factors impacting the seafood industry.

Information exchange plays an important role in enabling businesses to adapt to change, creates greater value for customers and consumers, and lessens the impact on the environment of business operations. Traceability is a key aspect of this exchange of information.

The research project that we review in this report had 2 purposes. The 1st was to identify the value of traceability from a commercial business case perspective. This was achieved by assessing the impact of "interparty" traceability systems on businesses performance from an entire value-chain perspective. The 2nd purpose was to identify the attributes that have the greatest influence on consumer purchasing decisions, and for which traceability-related attributes consumers might be willing to pay a premium. We clarified these attributes by conducting primary consumer research in 5 national markets in which the businesses who participated in the value-chain interviews and survey operate.

The objectives were to clarify how businesses are using "interparty" traceability systems to strengthen their competitive advantage from an entire product value-chain perspective, along with how and why they expected their use of "interparty" traceability to change in the next 5 years. This required the researchers to determine how traceability was being used by businesses operating at different points along the value chain and the nature of the benefits accrued. The researchers also needed to identify the relative impact of enterprise, industry, and socioeconomic drivers that are impacting the use of interparty traceability, along with the perceived and realizable value of traceability, from an entire value-chain perspective. This enabled recommendations to be developed into how businesses can increase competitiveness through the adoption of traceability systems, along with policies and programs that would enhance further adoption of traceability to enable the achievement of positive economic, financial, and environmental outcomes.

To achieve the objectives, the researchers asked specific questions of the individuals in the 48 businesses surveyed. The questions included issues such as:

- What is effective traceability, and how is it used?
- In which situations does traceability enable businesses to create financial value, and why?

Table 1–Overview of participating seafood product-value chains.

Chain	Species	Aquaculture or wild-caught	Country of production or capture	Country in which sold to consumers	Market type: retail or foodservice	Form in which sold to consumers
A	Cod	Wild	Iceland	The Netherlands	Retail	Fresh
B	Tuna	Wild	Fiji	The United States	Retail	Canned
C	Sardines	Wild	Canada	Canada	Retail	Canned
D	Tuna	Wild	Thailand	Canada	Retail	Canned
E	Salmon	Aquaculture	Faroe Islands	The United States	Retail and Foodservice	Fresh
F	Plaice	Wild	Iceland	Germany	Retail	Fresh
G	Shrimp	Aquaculture	Thailand	The United States	Retail	Frozen
H	Mahi mahi	Wild	Ecuador	The United States	Retail	Fresh
I	Tuna	Wild	Indonesia	The United States	Retail	Frozen

- To what extent is interparty traceability enabling businesses to increase their competitiveness and profitability (for example, by reducing costs and increasing revenue)?
- What is the consumer-recognized value that businesses consider in marketing their products? More specifically, how does perceived consumer value influence product development and markets in which businesses operate?
- What are the barriers and enablers that determine how businesses are able to utilize traceability to the greatest effect?

Methodology

The phases of this research project and the overall methodology are described below.

Literature review

In advance of the primary research, an extensive literature review was conducted to determine prior research into the commercial benefits and value of traceability. The research also sought to discover trends and drivers impacting the global seafood industry. The research delivered an extensive review to:

- Determine what had previously been completed in terms of analyzing the business case for traceability;
- Estimate the value that consumers perceive for traceability-related attributes in seafood;
- Quantify global seafood production, consumption trends, and the factors driving the trends; andDetermine methods previously used to analyze business operations and strategies from an entire value-chain perspective.

The insights from the literature review informed the development of the primary research methods and the design of the consumer research. The methodologies are summarized below. The substantial amount of information from the literature review was summarized in an issues brief, which was published by the GFTC in August 2014.[2]

Value-chain research

Value Chain Management Intl.[3] led the value-chain research. This element of the research involved interviewing and surveying 48 businesses operating within 9 separate seafood product-value chains. Individual respondents representing the participating businesses were those responsible for managing business activities such as procurement, operations, information technology (IT), marketing, sales, quality assurance, and sustainability. For larger businesses, individual respondents included executives accountable for various areas. For smaller companies, often an individual was responsible for a variety of areas.

Table 2–Consumer research sample.

Country	Number of respondents
The United States	500
Canada	400
Germany	400
The Netherlands	402
China	400

The 48 businesses who participated in the research included fishing fleets, aquaculture farms, primary processors, secondary processors, distributors, retailers, and foodservice operators. Except for 4 businesses, multiple respondents were interviewed for each business. The total annual revenues of the participating businesses ranged from US$190000 to over US$60 billion.

Table 1 provides details on the 9 product-value chains in which the businesses operate. For business confidentiality, the chains are identified only by alphabetical identifiers A through I. The information includes geographic location of the business, the primary seafood product species on which the research focused, the markets that each business supplies, and the format in which the species is marketed to consumers. Block diagrams illustrating each product-value chain and the information that each business deems important for traceability purposes are provided in Appendix D.

Participant selection. On the establishment of the GFTC and following the announcement of this study, a number of businesses expressed interest in participating in research into the value and role of traceability. Those discussions led to purposeful selection of businesses in 9 distinct product-value chains on the basis of their suitability to provide valuable commercial insights. Each business had made progress in integrating traceability into their activities, but had reached different stages. The businesses were also chosen because they represent global trade and in aggregate handle hundreds of seafood species. The businesses encompass the production and distribution of seafood sold to consumers in fresh, frozen, and canned form. This selection strategy ensured that the research produced sufficiently illustrative results that reflected the breadth of the seafood industry. It was not, however, the intention to develop a sampling scheme that would support statistically rigorous quantitative analysis across a representative subsample of the universe of chains or seafood companies.

The interviews were conducted in August and September 2014. A semistructured interview guide, including both closed and open-ended questions, was designed to collect detailed information on the characteristics of the businesses and opinions

[2]Enhancing Seafood Traceability Issues Brief, August 2014, may be downloaded at http://info.ift.org/download-the-seafood-traceability-issues-brief-and-comments.

[3]Value Chain Management Intl. (VCMI) is located in Oakville, Ontario, Canada and is dedicated to improving the profitability and competitiveness of commercial businesses through promoting and enabling the management of closely aligned value chains. Their global consulting team is located in Canada, Europe, Australasia, and comprises world leaders in value chain analysis, quality management, experiential management training, commercial-focused environmental sustainability, and value chain innovation. More information available at: vcm-international.com.

about traceability and its costs, benefits, and value for mitigating risks. Interview questions were based on the literature review and preliminary discussions with seafood industry representatives, NGOs, and academics. This ensured that standardized information was gathered systematically, although questions were also designed with sufficient flexibility to allow researchers to delve into greater detail as appropriate. The majority of interviews were conducted in person; the remainder occurred by telephone. One respondent provided information by e-mail only, however, due to scheduling conflicts. To encourage frank discussion and protect commercial interests, all responses were gathered and compiled anonymously. The interview guide and survey questions are provided in Appendix E.

The data gathered during the interviews were analyzed using thematic content analysis. This involves a systematic review across a data set, in this case the interviews and survey results, to find repeated patterns. The themes used were known enablers and barriers to value-chain management in practice, which were derived from the value-chain management literature and previous analyses conducted by the Value Chain Management Centre (now Value Chain Management Intl.).[4] Quantitative analysis using baseline statistics (means, modes, median, and range) was conducted using data from the closed questions to help evaluate differences in patterns of responses based on key variables: for example, the position of the company in the market channel or the classification of the chain based on the qualitative analysis. Box and whisker plots, bar charts, tables, and various visual techniques were used to present key results.

Consumer research

Ipsos Agriculture and Animal Health[5] designed, implemented, and analyzed an in-depth quantitative study to determine and illustrate how specific seafood attributes drive shoppers' propensity to purchase, and their willingness to pay for attributes relating to traceability and selection, using discrete choice and conjoint analysis. The study was implemented through Ipsos' global *iSay* panel. The sample was drawn from primary household grocery shoppers who had eaten shrimp, tuna, or salmon in the previous 3 months, at home or in a restaurant, and were likely to purchase the same in the following 4 months. As shown in Table 2, the survey was conducted in 5 countries (Canada, China, Germany, The Netherlands, and the United States).

The demographic breakdown of respondents is shown in Table 3.

The survey investigated consumption patterns for shrimp/prawns, tuna, salmon, mahi mahi/dorado/dolphinfish, and sardines. The survey then took respondents through a discrete choice exercise focusing on shrimp/prawns, tuna, and salmon. The product formats studied were fresh, frozen, and canned. The survey asked respondents to make a series of choices between 2 products with different configurations of the following attributes:

- Production method (none, wild, farmed) verification;
- Species verification (with, without);
- Sustainability certification (none, manufacturer or retailer, independent 3rd party, government)
- Verification of critical dates (none, best-before, best-before plus packaging)
- Price relative to the current market price (−25%, current price, +10%, +25%).

The choices made in these comparisons then provided the data for modeling choices that would typically be expected in each of the 5 markets, and ultimately determining the "choice share" any given combination is expected to achieve.

The output of this activity was a *Discrete Choice Simulator* which provides a user-friendly interface from which a user can select any 2 configurations of product attributes, to determine the economic value of any attribute as well as any specific level within an attribute. The GFTC has decided to make this simulator available by request to interested users.

Literature Review Summary

In advance of the primary research, an extensive literature review was conducted to determine prior research into the commercial benefits and value of traceability. The research also sought to determine trends and drivers impacting the global seafood industry. Selected highlights from the literature review that specifically relate to the primary research are presented below. In addition, the "Enhancing Seafood Traceability Issues Brief" produced by IFT following completion of the literature review is downloadable at http://info.ift.org/download-the-seafood-traceability-issues-brief-and-comments.

Highlights

Seafood is a dominant sector in the global food industry and remains one of the fastest growing protein sources consumed worldwide. The industry has a history of food safety and environmental practices that has recently raised concerns among consumers, regulatory agencies, and NGOs. While businesses and the industry are addressing these concerns, the industry is undergoing significant transition due to changing global demographics (shift in demand from developed to developing nations), economic factors (explosive growth of aquaculture), as well as environmental issues (sustainability, and illegal, unreported, unregulated [IUU] fishing).

Companies recognize that transparency and traceability are critical to brand equity, risk mitigation, food safety, and consumer confidence. Yet, global trade and complex value chains make it difficult to consistently identify the origin and history of many seafood products. Seafood often moves very long distances, in and out of multiple ports, and changes hands among various brokers, wholesalers, processors, and retailers before reaching the consumer (Waage and Kraft 2013; Pramod and others 2014).

Reducing value-chain risks and global competition to source seafood that is not from IUU sources are rapidly increasing the need for processors, distributors, and retailers of seafood to manage their sourcing policies more effectively than previously. At the same time, policymakers are recognizing that "bait to plate" seafood traceability is a key tool to achieving sustainable fisheries, combating illegal fishing, and ensuring food security. From both commercial and public policy perspectives, improved seafood traceability has become a top priority. At this time, only a fraction of wild-caught fish products can be sufficiently traced to meet these growing demands for transparency.

The following sections provide concise insights into issues found to be affecting the performance of the seafood industry and the potential for traceability to mitigate or reduce businesses' exposure to risk, reduce waste, enhance consumer trust, and increase business efficiencies. We also describe what the term traceability means in the context of this project.

[4]For further details on this methodology, see Boyatzis (1998) and Johnson (2010).

[5]Ipsos is Canada's leading survey-based marketing research firm, with offices in 86 countries. More information available at www.ipsos.ca.

Table 3–Consumer research demographics.[6]

		United States (%)	Canada (%)	Germany (%)	The Netherlands (%)	China (%)
Age	25 to 34 y	21	22	22	13	34
	35 to 49 y	32	32	32	37	39
	50 to 75 y	46	46	46	50	27
Gender	Female	78	86	60	68	63
	Male	22	14	40	32	37
Children in the household	44	30	30	30	77	
Household income	Low	42	28	30	24	32
	Medium	32	39	27	23	41
	High	21	20	26	31	27
	DK/Prefer not to answer	5	13	16	22	0

Background

Production trends. In the last decade, the most significant trend affecting the seafood industry has been the rapid rise in aquaculture. Global aquaculture production increased from 40 million tons (MT) in the year 2000 to almost 90 MT in 2012 (FAO 2013). During this time, production from wild-capture fisheries (both inland and marine) slowly rose from about 81 MT to approximately 90 MT per year. Aquaculture now accounts for 50% of all seafood produced globally.

Capture fisheries production is highly consolidated. China was the largest producer of seafood from capture fisheries from 2000 to 2012, contributing 18% of total catch (FAO 2013). The 10 countries which produce the greatest amount of seafood represented 59% of total capture fisheries production in 2012.

Consumption. Fish are an important source of good quality protein, are relatively low in fat and may also be a good source of iodine. Consumption of all types of seafood has increased 17% in the last decade, rising from an average global consumption per capita of 15.8 kg in 2000 (round weight equivalent), to 18.5 kg in 2009 (FAO 2013). Consumption has increased in all areas of the world, with some individual country exceptions. Consumption of seafood in Asia, Europe, North America, and Oceania is relatively high, with average consumption in 2009 of 20.6, 21.9, 24, and 26 kg/capita, respectively (FAO 2013). Consumption in Africa (9.5 kg/capita) and South America (9.7 kg/capita) is relatively low.

Global trade. The total global value of imported and exported seafood products doubled during the period 2000 to 2011, from approximately $60 billion to over $120 billion. A slight decrease in seafood trade was observed in 2008 to 2009, which reflected the global economic crisis; however, there has been subsequent recovery.

China led the world in export value of fish and seafood in 2011, with approximately 13% of the total global share, valued at $17.2 billion. The top 10 exporting countries accounted for 52% of the total global value.

Frozen shrimp and prawns were the top export in 2011, valued at $9.2 billion. Frozen fish fillets ($5.1 billion), fresh or chilled Atlantic salmon ($4.8 billion), and canned tuna ($2.5 billion) were important exports in terms of value. A key nonhuman consumption export was fishmeal, prepared from either whole fish or fish parts, representing a value of almost $4 billion in 2011.

Retail sector. The retail sector is exerting more influence in the global seafood market by increasingly committing to responsible sourcing practices. Sustainability concerns have risen throughout the seafood industry as the impact of industry watchdog lists (such as Greenpeace's CATO report) are felt and requests for 3rd-party certifications have become more prevalent. For example, a survey of the European seafood market indicated that 95% of consumer respondents wanted more information on how to make sustainable seafood choices (Seafood Choices Alliance 2007). This focus on sustainable sourcing is also a key development in the European and North American markets (Seafood Choices Alliance 2008).

Drivers affecting seafood consumption/purchasing. Seafood consumption per capita per day has increased since the early 1960s, specifically in the consumption of invertebrates and freshwater fishes (Kearney 2010).

The main drivers of consumer behavior relating to the purchasing and consumption of seafood relate to issues concerning nutrition and health, freshness of product, the country of origin, and a desire for variety. Negative factors affecting the purchase of seafood include: perceptions that it is expensive and inconvenient to prepare; lack of consumer confidence in choosing and preparing unfamiliar species; questions about food safety, and concerns about ecological sustainability. Furthermore, some consumers do not find seafood as satisfying or filling as other meats.

What is traceability?

Food traceability can have many definitions. A useful definition proposed by Olsen and Borit (2013) is "the ability to access any or all information relating to that which is under consideration, throughout its entire life cycle, by means of recorded identifications." The GFTC uses this definition in discussions and consultations.

Regardless of whether traceability systems are fully implemented throughout an entire value chain, it is the system itself and the rigor with which it is applied that ultimately determine the product traceability capabilities of individual businesses (Clarke 2009).

Effective food traceability can be viewed as an outcome of businesses that have a disciplined, professionally managed approach to data gathering, retention, analysis, and collaboration at all points along the value chain. Effective traceability enables the creation of financially and environmentally sustainable businesses and value chains, by providing the opportunity to create and retain a unique competitive advantage (Gooch and Sterling 2013).

Food safety is tied to traceability and has become an increasingly growing concern among consumers. Consumer attitudes have been negatively impacted by issues such as bovine spongiform encephalopathy (BSE) and high-profile incidents of food adulteration and foodborne illness. The commercial food industry has been forced to evolve to regain consumer trust; traceability is an important tool in this effort. The risk of food safety incidents, zoonotic disease outbreaks, or the presence of contaminants can threaten both the quality and safety of food. The food industry has addressed food protection, food hygiene, safety, and quality through the introduction of management systems such as Hazard Analysis and Critical Control Points (HACCP) and standards of the Intl. Organization for Standards (ISO9001). Leading businesses

[6]See http://www.ift.org/gftc.aspx for the complete consumer research report and analysis.

have ingrained traceability into many of these and other standards over the last decade.

The primary aim of traceability in food value chains has been to facilitate regaining or strengthening consumer trust by preventing or restricting the spread of food safety incidents (Pang and others 2012). Traceability systems were originally designed as auditing processes to allow a food product to be traced back to its production facilities in the event of a health and safety incident. In contrast to systems such as HACCP, which are designed to prevent problems from occurring, or quality assurance testing protocols, which are designed to detect problems in products before they reach consumers, traceability systems were typically designed to work retrospectively. This does not mean, however, that traceability does not have more proactive capabilities.

To be an effective tool, traceability needs to be viewed from this prospective stance. Traceability systems can benefit businesses and entire sectors, from a production, marketing, and value-chain management perspective. The quantitative benefits associated with traceability include protection of public health, improved trade, strengthened sustainability practices, reduced recall scope, increased consumer trust, and quality assurance and value-chain efficiencies (McEntire and Bhatt 2012).

It is important to note that the existence of a traceability system itself does not guarantee that a product is traceable throughout an entire food chain. In this research, we found that systems mainly reinforced or supported business practices intended for other business benefits. For example, recording vessel information is used for billing and payment activities, but also can serve to show the origination of a catch (traceability).

Another important characteristic we found is that the more collaborative businesses became, the more that their respective (and disparate) systems were used to manage information at the individual business level for mutual benefit. Systems that become more interoperable are able to comply with open standards and rapidly changing market demands. This implies that partners can benefit even more if they have uniform standards for the data that they use for the purpose of traceability.

Traceability systems can be considered in 2 categories: internal and external systems. Internal traceability systems, common in the seafood industry, allow companies to trace what is happening within their own operations. External (or value chain) traceability systems are more rare and require more complex information-sharing practices and systems that allow one to trace what happens to a product through all parts of the value chain, or a portion of the value chain external to the business entity (Magera and Beaton 2009).

Applying traceability

Van Dorp (2002) describes a traceability system from the perspective of information management, which includes 3 layers: item coding (the physical layer), information architecture (information layer), and planning and control (the control layer).

Traceability systems vary from simple, paper-based records to complex electronic data systems which can include software, barcodes, handheld readers/scanners, and radio frequency identification (RFID) tags. In this research project, we found all these types of recording tools. Regardless of the way data are collected, stored, and shared, traceability is only effective when the information transmitted along the chain is reliable and standardized (McEntire and others 2010; Nga 2010).

According to Buchanan and others (2012), the main elements of traceability include:

- *Definition of traceable entities*. External traceable entities may include trade units (items), logistics units (pallets), or shipments. Internal traceable entities may include batches (lots). Uniform definitions are essential to interoperability.
- *Unique identification of traceable entities*. Examples include GS1 coding, RFID tracking, or labels that can be scanned by a machine or read by a human. Uniqueness is key so that there is no ambiguity about which specific product entity (an item, box, pallet, and so on) is being considered.
- *Key data elements (KDEs)*. Recording and storing relevant information about the product or entity.
- *Critical tracking events (CTEs)*. Steps in the value chain at which data (KDEs) need to be collected.

Effective traceability

Effective traceability in a food value chain relies on the ability to identify the product in all its forms, and the sources of input materials, as well as being able to conduct backward and forward tracking using recorded information to determine the specific location and life history of the product. For this to happen, a traceability system must have the following properties (Olsen and Borit 2013):

- Ability to provide access to all properties of a food product, not only those that can be verified analytically;
- Ability to provide access to the properties of a food product or ingredient in all of its forms, at all of the places in the value chain, not only at the product batch level;
- Ability to facilitate traceability both backward and forward;
- Be capable of being based on systematic recordings of these properties.

In practice, this means that a unit identification system or numbering scheme must be present; without it, the goals of a traceability system cannot be achieved. Gooch and Sterling (2013) reported that the following benefits should be considered the goals of a well-designed traceability system (Samarasinghe and others 2009):

- *Market Benefits*. Traceability is often a requirement in order to access regulated environments seafood. It also provides the information needed for making decisions about new product development and new consumer demands.
- *Strengthened Quality and Safety Management*. An effective traceability system strengthens food safety management capabilities by providing the data needed to follow the seafood as it is processed through its lifecycle.
- *Reduced Cost of Production*. When traceability is an outcome of having effective information and communication systems, the data can be used to reduce working capital costs while offering the opportunity for more rapid investment payback.
- *Enhanced Product Recall*. Effective traceability systems help companies reduce their business risk by providing the information they need to overcome a crisis promptly and effectively and regain "normal business operations" and consumer confidence.

Drivers of seafood traceability

The identification, origin, and history of seafood products are made more difficult by globalization of trade and the lack of

international information standards (Thompson and others 2005). This raises concerns from the retail and foodservice sectors and consumers about the safety of their seafood supplies. Whether the impact of traceability on the seafood industry is perceived as positive or negative will depend on the potential market benefits and the design, management, and marketing of traceability concepts (Thompson and others 2005).

The destination market for many seafood products plays an important role in driving businesses and companies to adopt traceability. The market influence on traceability can be tied to regulatory requirements specific for the exportation of products to market destinations, health and safety regulations, consumer demand for various "certified" products, and the business' own desire for product differentiation. Seafood traceability systems are being implemented to address consumer attitudes relating to sustainability, meet regulatory requirements, address market demands, and improve production and management practices (Thompson and others 2005; Hanner and others 2011).

Costs and benefits of effective traceability

Stakeholders are divided when it comes to determining what is the greatest benefit attributed to improved traceability practices. Some argue that the benefits to safety and public health are deemed to be the most substantial. Others argue that by applying traceability to management of value chains, additional business or industry-level benefits are more significant. As indicated above, some of the business benefits include the ability to recall products effectively, increase access to new markets, capture added value by improved supply/value chain management, and substantiate sustainability claims (Nga 2010; Sparling and Sterling 2011; McEntire and Bhatt 2012).

The costs compared with benefits issue is of particular concern to smaller operations, many of whom do not have the resources required to purchase and implement a full traceability system (Greene 2010). While larger operations may see the cost of implementing traceability systems as future investment, smaller operations may view it as a financial liability (McMorris 2010). For this reason, simple and effective business-case tools can help these smaller businesses develop their own payback (ROI) calculations.

A key point that many businesses miss, when assessing the costs for traceability, is they already have in place many of the systems and practices necessary for traceability. They have them in place for food safety and production efficiencies. In these instances, the existing information need only be accessed and used differently to support traceability (Gooch and Sterling 2013).

In summary, and as shown in Figure 1, the 3 key areas of business benefits associated with effective traceability are:

1. Delivering business (operational) efficiencies that lower costs;
2. Opening company-level competitive advantage in new markets or to new customers; and
3. Mitigating market and operational risks faced by the company.

In the Section "Value-Chain Analysis," we discuss in more detail these main groups of benefits of traceability, and areas of best practice, for the chain structures we found. We found that best practice traceability is associated with practices and systems that produce benefits in all 3 areas, as well as delivering compliance with regulations. Therefore, as shown in Figure 1, "best practice" is the area where the 3 benefit circles intersect.

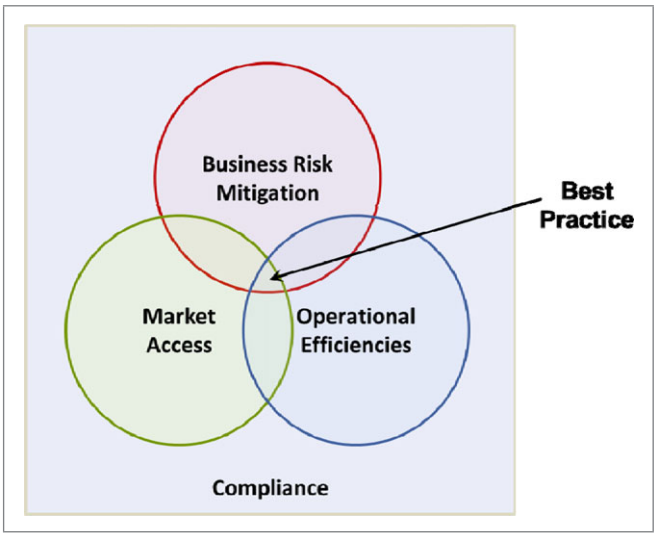


Figure 1–Key benefits and best practice.

Role of traceability technology

Historically, the aim of traceability in food value chains has been to prevent or restrict the spread of food safety incidents (Pang and others 2012). As such, traceability is usually part of a reactive process and has not been used as much to address business opportunities, nor to identify and manage business issues beyond compliance with regulations. Innovative technologies can be used to make traceability faster, more reliable, more cost-effective, and to capture data proactively for use to commercial advantage (Huang and Yang 2009; Gooch and Sterling 2013).

Since the 1950s, the physical capacity for catching, processing, and moving seafood around the world has dramatically risen. However, this increase in physical capacity has not been matched by the use of digital information management. Most of the practices used in the international seafood industry, including those related to traceability, continue to be manual, with a reliance on paper-based tools (FutureofFish.org 2014). The recognition that modern IT and digital records can add value for the customer, while simultaneously reducing the costs of producing a product or service, has revolutionized the role of information management in organizations (Porter and Millar 1985). This project found that taking advantage of electronic systems and information is restricted to those seafood companies who already tend to be leading-edge users of technology to support business decision making.

In the seafood industry, there is a lack of uniform requirements or standards for information gathering and sharing that are needed for traceability. This causes businesses to form one-to-one data exchanges with their suppliers and customers, which in turn drives up costs and the opportunity for errors. This lack of interoperability is significant and inhibits the collaboration of businesses along the value chain. It leads to increased business risks and costs and inhibits rapid, reliable response in the event of an emergency. Lack of interoperability weakens businesses' ability to partner with other members of their value chain to increase their competitiveness, reduce waste, implement sustainable business practices, and innovate to meet changing market demands.

In other words, lack of uniform requirements leads to loss of interoperability which, in turn, makes seafood value chain

traceability impractical. The outcome is lower business profitability, reduced industry viability, and questionable decision making which can impact long-term sustainability of resources.

Using value-chain analysis to quantify benefits

The argument above clarifies the link in how traceability plays an important role in effective management of fisheries (wild-caught and aquaculture) and other operations along the seafood value chain, although few seafood business case studies have been specifically conducted on traceability. Many of the researched studies are at a micro level relating to specific issues such as food safety or technology solutions. Few have analyzed the role and impact of traceability from a proactive commercial standpoint in the context of specific businesses and situations. With analyses to date, it is unclear what changes in uniform technical requirements are needed, and what the potential impact on the global seafood industry is. The impact of cultural, structural, scale, and production factors in each sector on value of traceability was also unclear.

The lack of knowledge about international standard practices for collecting or sharing traceability information relates to regulations and use of technology. There are numerous certification programs and software platforms to support traceability, but they are not necessarily compatible with each other. This incompatibility limits the overall and potential impact of traceability on the industry. Similarly, while there are examples of industry innovators, they are few in number. Advocates of change in the seafood industry appear to be isolated and unable to impact the industry at large. The seafood industry could be compared to the railway networks of the past, in which different companies would use dissimilar track sizes within the same region.

From the literature review, we concluded that businesses and society can expect to realize many benefits from improved seafood traceability. Improvement in traceability processes, as part of sound value-chain management, is critical to the long-term sustainability of the seafood industry. However, only a few published studies were able to quantify these benefits.

Identifying commercial benefits. Process mapping for traceability in food value chains is an approach used to clarify at which points along the value chain the information that is necessary to maintain full traceability is lost. Process mapping also enables a determination of how information is used by the participating businesses to create value for customers and consumers (Banterle and Stranieri 2008a,b).

Cost-benefit analysis is an important means of determining an appropriate course of action, whether that be using existing capabilities more effectively or upgrading technological or management capabilities to achieve predetermined opportunities in the most cost-effective manner possible. Cost-benefit analysis requires researchers to connect business-level inputs and outputs with the role and benefits of traceability and information systems (Banterle and Stranieri 2008a,b; Donnelly and Olsen 2012).

A framework for evaluating the capabilities and determining factors of value chains was developed by the Value Chain Management Centre (now Value Chain Management Intl.). The framework is summarized in Table 4. The framework classifies chains into 4 categories on the basis of the degree of collaboration that exists between the businesses comprising the value chain. The process is based on analyzing both the semistructured interviews and survey results of the businesses in the value chain, to look for evidence of:

- Alignment and misalignment, in particular whether those in the value chain strategically adopt an entire chain perspective, the nature of their market orientation, their experience and approach to addressing operational barriers (data integrity, different requirements from multiple suppliers, and customers), and also the extent to which they pursue the opportunities afforded by traceability
- Behavior that builds or reflects trust, commitment, and sharing of benefits
- Objectives and outcome relating to traceability, especially legal compliance, risk mitigation, driving performance, and competitive advantage.

Summary

The literature review showed that the seafood industry is increasingly global and complex in nature. The review also highlighted that, while traceability is becoming an increasingly important management tool and being made a mandatory requirement by governments, there remain notable gaps in the practices and data required to achieve and enforce traceability. This results in a lack of transparency and informed insights, which has the potential to negatively impact the ability of businesses to adapt in an increasingly dynamic industry.

A major cause of this lack of transparency is that international standard requirements for collecting and sharing traceability information do not exist in the seafood sector (Borit and Olsen 2012). For example, a majority of the North American industry maintains internal traceability and the "one up/one down" external traceability model. Legislation in the European Union is more stringent, requiring certifications for seafood imported into the EU in an attempt to restrict IUU fishing practices. This variance in requirements is a cause for concern for those who offer their seafood products on the global market.

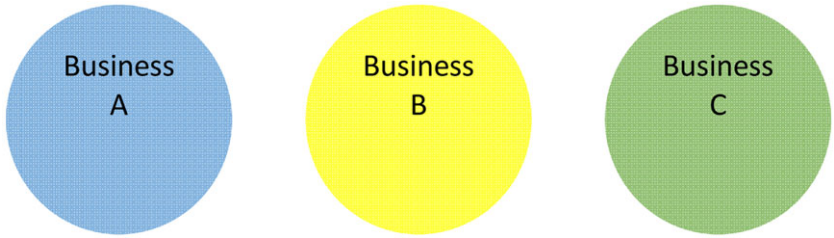
Although China is the major player in seafood processing, there is lack of publicly available and transparent data creating concerns about other aspects of production and processing. Furthermore, fish exported to China can be reexported after processing as "Product of China," regardless of its original source (Roheim 2008). Traceability data for other regions, such as Japan, specific EU nations, Australasia, and developing countries are lacking.

The review also revealed that there is a noticeable lack of business case studies regarding traceability in the seafood sector. Few researchers take a total systems approach to investigating the role and value of traceability. The examples of business case studies that exist are typically limited to a single species or sector, which negatively affects the transferability of findings to other situations (Donnelly and Olsen 2012). Furthermore, investigations generally focus on how information collected through improved traceability systems improves operations and does not extend to how this information or the technology systems can benefit public health during trace-back investigations. For example, the speed with which records can be accessed and provided to regulatory agencies is seldom mentioned (McEntire and Bhatt 2012). This is problematic as the primary drivers for the implementation of traceability systems have been from the public safety sector, rather than from a business point of view (Pang and others 2012). Little information was found to exist that businesses can use to objectively evaluate the appropriateness of traceability systems and their applicability in real-world settings.

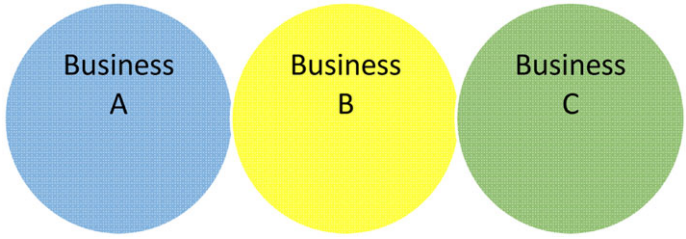
In light of these findings, subsequent phases of the research sought to establish a strategic foundation upon which further research can be conducted to better understand what is required in

Table 4–Classification of Value Chains.[7]

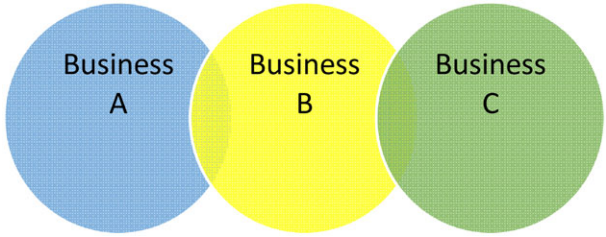
Fragmented Value Chain: Transactional trading comprising a series of short-term, unique interactions. Because information is withheld, price, volume, and quality are the only factors used in decisions. Accordingly, relationships are more adversarial and distrusting; and without the ability to pool intercompany knowledge and other resources, the chain struggles to adapt to changing market demands and new technology.



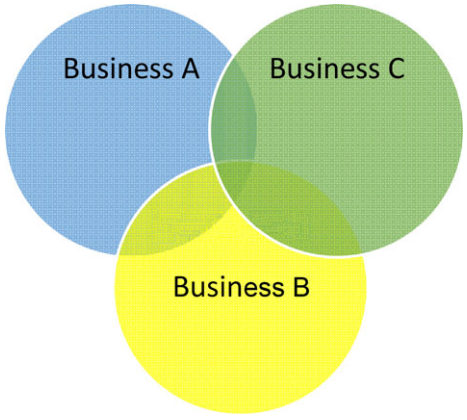
Cooperative Value Chain: Businesses pursue medium-term operational support. The extent to which this evolves into strategic coordination will depend upon the compatibility of the culture of different businesses, as well as external environmental business factors.



Coordinated Value Chain: Businesses share complementary objectives, attitudes, and leadership styles, and the benefits of mutual commitment to each other are recognized. This leads to at least some businesses adopting strategically aligned structures and perspectives.



Collaborative Value Chain: Long-term strategic alignment exists, based on sharing resources and/or developing capabilities which deliver mutual benefits. This requires transparency and businesses to possess compatible cultures, vision, and leadership, creating conditions for investment in relationship-specific products, services and assets. While significant rewards can result, there are also risks associated with this interdependence.



developing a seafood industry that is truly sustainable from economic and environmental perspectives.

Value-Chain Analysis

This section presents results from the analysis of data produced from the interviews conducted with respondents from the 48 participating businesses. Section "Overall analysis" presents aggregated results from across all 9 value chains. Section "Comparisons of Cooperative, Coordinated, and Collaborative Chains" contrasts results between each of the value-chain participants. Analysis allowed creation of a fuller picture of the comparative benefits of traceability, on the basis of value-chain classification category.

[7]Adapted from Value Chain Management Centre (2012).

Overall analysis

General perspectives. *Business/company characteristics*. Of the businesses surveyed, downstream[8] businesses were generally much larger in terms of annual sales and number of employees (Figure 2).[9] There was also significant variation in these metrics

[8]Throughout this section, *upstream* refers to the firms that engage in any wild capture, aquaculture, or primary processing. *Downstream* refers to firms that engage in distribution, secondary processing, and retail activities. Twenty-two of the participating firms are upstream and 26 are downstream.

[9]When reading a box and whisker plot, the box represents the middle 50% of the data, from the 25th to the 75th percentile. The median is represented by the line that separates the box in half. The mean is represented as a "+." The minimum and maximum values are represented by the ends of the whiskers.

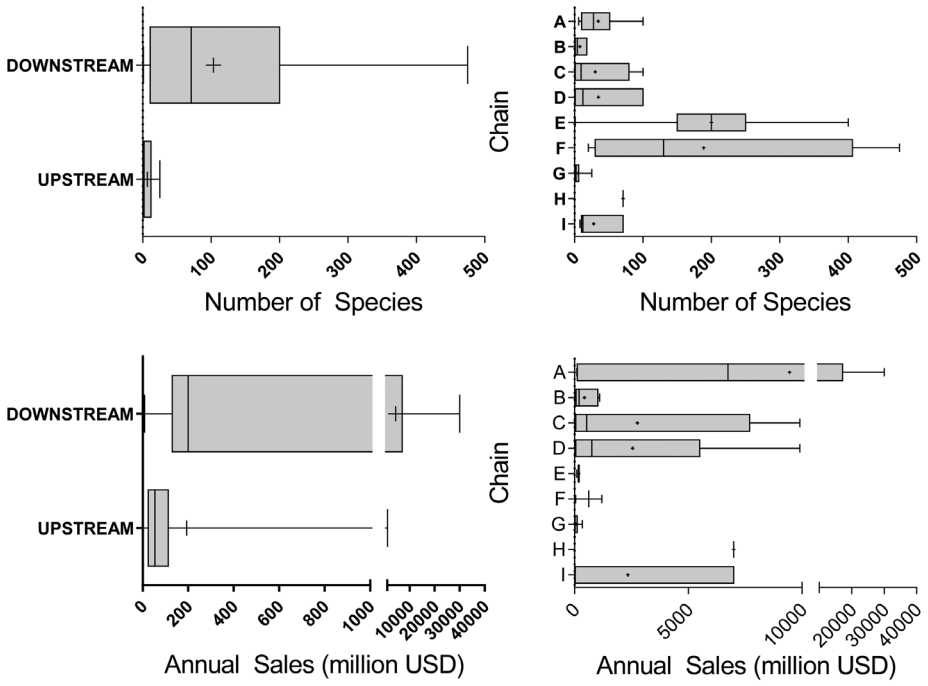


Figure 2–Box and whisker plots of the annual sales and number of fish and seafood species which individual businesses handled. Of the 48 firms in the study, all are represented in the Number-of-Species graphs, while 44 offered annual sales information.

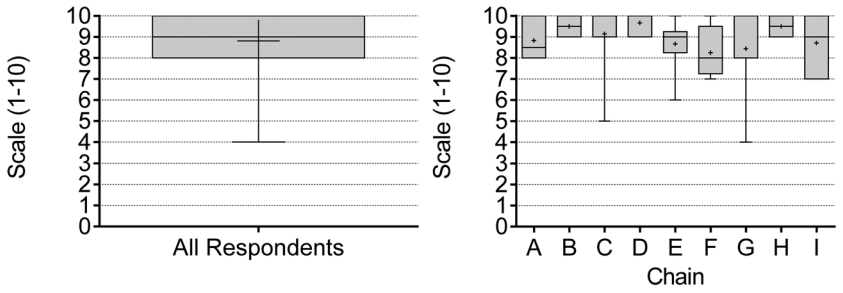


Figure 3–The importance of traceability to business success for all respondents and value chains (1 = completely unimportant, 10 = extremely important). A total of 47 of 48 respondents provided a response.

between chains due to the fact that some chains contained large retail corporations in the downstream end, while other retail outlets in other chains were much smaller.

Of the businesses surveyed, there was an extremely high correlation (more than 0.90) between the businesses in the downstream section of the value chain and the businesses having annual sales greater than $100 million. It was therefore not possible to untangle the effect of company size from effects stemming from the position of the company in the value chain. Thus, throughout this report the analysis for upstream businesses is roughly synonymous for small businesses (those with sales less than $100 million per year), and the analysis for downstream businesses is roughly synonymous for large businesses (those with sales greater than $100 million per year).

The majority of businesses implemented their current traceability system within the last 8 years; 92% of businesses use an all-electronic system or combination of paper and electronic. In addition, many traceability systems are integrated with a business enterprise resource planning (ERP) such as SAP (a major brand of enterprise software).

Importance of traceability. A consistently strong message that transcends the company size, and its location in the value chain, is that businesses believe that traceability systems are extremely important to the success of their business (Figure 3).

While traceability is of similar importance to both downstream and upstream firms, its importance to downstream firms is higher when consideration of certain species and their source are included. For example, some of these distributors and retailers were particularly concerned about the ability to trace seafood sourced geographically far from the final market destination (such as tuna and shrimp sourced from Southeast Asia and sold to European and North American markets), as well as products carrying ecolabels such as "dolphin safe." The KDEs that were of the highest importance to firms in the study reflected this concern. Catch/process *date* and catch/process *ID* were the 2 most important KDEs from a traceability perspective, with approximately 70% and 60% of firms indicating they were critical to their businesses, respectively.

Traceability attitudes. Most businesses adopt traceability systems voluntarily. When asked for a statement that most closely reflects

Figure 4–Box and whisker plots showing the percentage of employees trained and the number of traceability training hours per year per employee undertaken by upstream compared with downstream businesses.

their opinion, approximately 80% of businesses said that "*traceability is a necessary cost of business in order to reduce exposure to business risks.*" Approximately 65% of businesses indicated that "*traceability enables us to manage our business more successfully than otherwise possible.*" More than 50% of respondents indicated that traceability is essential for fostering relationships with their downstream clients, such as consumers and retailers. Less than 30% of businesses indicated that traceability was forced on them by 3rd parties, such as ecolabelers, and less than 40% indicated that traceability was mandated by regulation.

Employee traceability training. Ninety-four percent of the responding firms indicated that they train at least some of their employees in the use of traceability, although only 33% train all of their employees. Upstream businesses were more likely to train all of the employees but were also more likely to have fewer employees. Businesses that train their employees in traceability do so for an average of 7.5 h per year (Figure 4). Interestingly, while upstream businesses train a higher percentage of their employees than downstream businesses, they spend fewer hours training them—a mean of 4 h per year per employee compared with 14 h for downstream businesses. This may be due to greater reliance on direct supervision and mentoring by upstream businesses. The 1st and 2nd most cited methods of training were internal company workshops (50%) and mock recalls (40%).

Of the 48 firms, 45 train their employees in traceability. Of these, 28 offered information regarding the percentage of employees trained, and 16 offered information regarding the number of training hours per employee. A Mann-Whitney U test was performed to test for differences.[10] While the differences in the percentage of employees trained between upstream and downstream firms were not significant, the differences in the number of training hours per employee were significant at the $P < 0.1$ level.

Implementation challenges. Approximately 35% of respondents reported that no significant challenges were faced during implementation. While a similar percentage reported challenges arising from their immediate environment (that is, budgetary, technical), the most common implementation challenges were caused by difficulties arising from other businesses in the value chain (44% of respondents indicated this challenge). This suggests that benefits of traceability are likely to be higher when members of a value chain are closely aligned, rather than fragmented.

Traceability costs. More than half of the respondents were not in a position to know or share a financial understanding of their firm's traceability system. They were therefore unable to accurately estimate implementation and maintenance costs. Of those businesses that did respond, most provided costs for the larger information system (for example, Information Communication Technology [ICT] or Enterprise Resource Planning [ERP]) since traceability systems were embedded within the system. Results revealed that implementation costs were larger than maintenance costs. However, as a percentage of annual sales, large businesses (those with annual revenues of over $100 million) incurred implementation costs that were on average lower than maintenance costs, and proportionately small, at 0.01% and 0.03%, respectively. Small businesses (those with annual revenues of less than $100 million) spent on average 1% of annual sales to implement a traceability system, but an average 3% to maintain the system. This result suggests that smaller businesses, therefore, spent a significantly higher proportion of earnings (10 times higher) than large businesses on implementing and maintaining their traceability system. However, because only a handful of small companies responded to this question, the result should be considered preliminary.

Expectations. Before implementing their current traceability system, the median firm[11] *expected* that the system would enable them to make better and more informed business decisions, and scored a 7 on a scale of 1 to 10. After the system was implemented, the *benefits* of the traceability system were scored higher; the median had risen to approximately 8 of 10.

Seventy-five percent of businesses showed a positive change in opinion from before implementation to after implementation of their traceability system, indicating that the benefits of implementing a traceability system surpassed their expectations. In addition, a Wilcoxon-signed rank test was conducted to evaluate the differences among firms in their expectations and their postimplementation opinions. The positive change in opinion was statistically significant at the $P < 0.05$ level.

Benefits of traceability. The types of benefits that businesses derive from the use of a traceability system are widespread. Based on a Likert scale (1 = not effective, 5 = extremely effective), respondents were asked to evaluate the effectiveness of their traceability system for generating benefits in 27 categories. Figure 5 shows the mean score for all respondents, as well as the breakdown of high (a score of 4 or 5), medium (a score of 3), and low (a score of 1 or 2) overall.

The 7 highest scoring benefits in order of rank were "increase quality," "improve product recalls," "improve inventory tracking," "improve food safety," "improve customer service," "respond to

[10]Throughout this section of the report, statistical tests comparing means are conducted for selected questions. Because of the low number of respondents ($N < 49$), statistical power is relatively low.

[11]Median firm means the company in the sample in which half the firms score higher, and half lower. Median is being used instead of the mean since the mean may not be "representative" if there are very skewed or boundary results (for example, a very large firm compared to most firms, or a few extremely low or high scores).

Figure 5–Possible benefits of traceability and the mean response of businesses when asked how effective their traceability system has been at addressing each possible benefit. The proportion of high, medium, and low scores for each benefit are shown. The probabilities to the left of each benefit category indicate the proportion of businesses responding out of a possible total of 48. Those not responding either did not respond, or indicated "no knowledge," or "not applicable."

consumer demand," and "verify harvest date and location." Fourteen benefits scored a 3 or 4, and 6 benefits scored below 3. The 6 lowest scoring benefits, by rank from the bottom, were "reduce input cost," "reduce administration costs," "increase margins," "increase revenue," "develop pricing models," and "increase productivity." We noted that low scores were also associated with a lower number of individual responses.

To evaluate the responses more strategically, benefits were grouped according to whether they tend to: (1) drive company-level efficiencies, (2) provide company-level competitive advantage, or (3) mitigate market and operational risks faced by the firm. All 3 were key benefits identified in the literature review.

Benefits: driving efficiency. The literature review indicated that traceability systems can be used to drive company-level efficiency, in areas such as reducing input and administration costs, reducing waste and pilferage, and increasing revenue. Figure 6 shows how upstream and downstream businesses ranked the effectiveness of their traceability system to capture efficiency benefits. The overall average score for this category of potential benefits was 3.0, indicating that traceability systems were moderately effective at increasing company-level efficiency. The highest ranked benefits in this category were related to reducing waste and pilferage, while the lowest ranked benefits of a traceability system were related to reducing company-level input and administration costs. More than 60% and 47% of respondents indicated that their traceability system was "not at all effective" at reducing input costs and administration costs, respectively. On average, downstream businesses ranked the ability of their traceability system to effectively increase company-level efficiency a half a point lower than upstream businesses.

Benefits: competitive advantage. Figure 7 shows potential benefits related to increasing a company's "competitive advantage" in the market. The highest scoring benefit categories included increasing product quality, responding to consumer and customer demand, and the ability to verify product characteristics such as catch date and location. More than 80% of respondents ranked the ability of their traceability system to generate these benefits as high (4 or 5 on the Likert scale). Ninety-five percent of upstream businesses and 78% of downstream businesses stated that their traceability system allowed them to effectively increase product quality.

The overall average score was 3.8, implying that businesses believe that their traceability system was highly effective at increasing competitive advantage. Similar to the "driving efficiency" category, upstream businesses ranked the ability of their traceability system to increase their competitive advantage higher than downstream businesses.

Benefits: mitigating risks. Among the 3 categories of benefits, "mitigating risks" generated the highest mean benefits scores (4.0). Businesses indicated believing that their traceability system is highly effective at improving food safety, reducing product recalls, and improving inventory tracking (Figure 8). This group of benefits was also ranked as high by a significant proportion of respondents (more than 75%). Again, upstream businesses scored the benefits higher than downstream businesses.

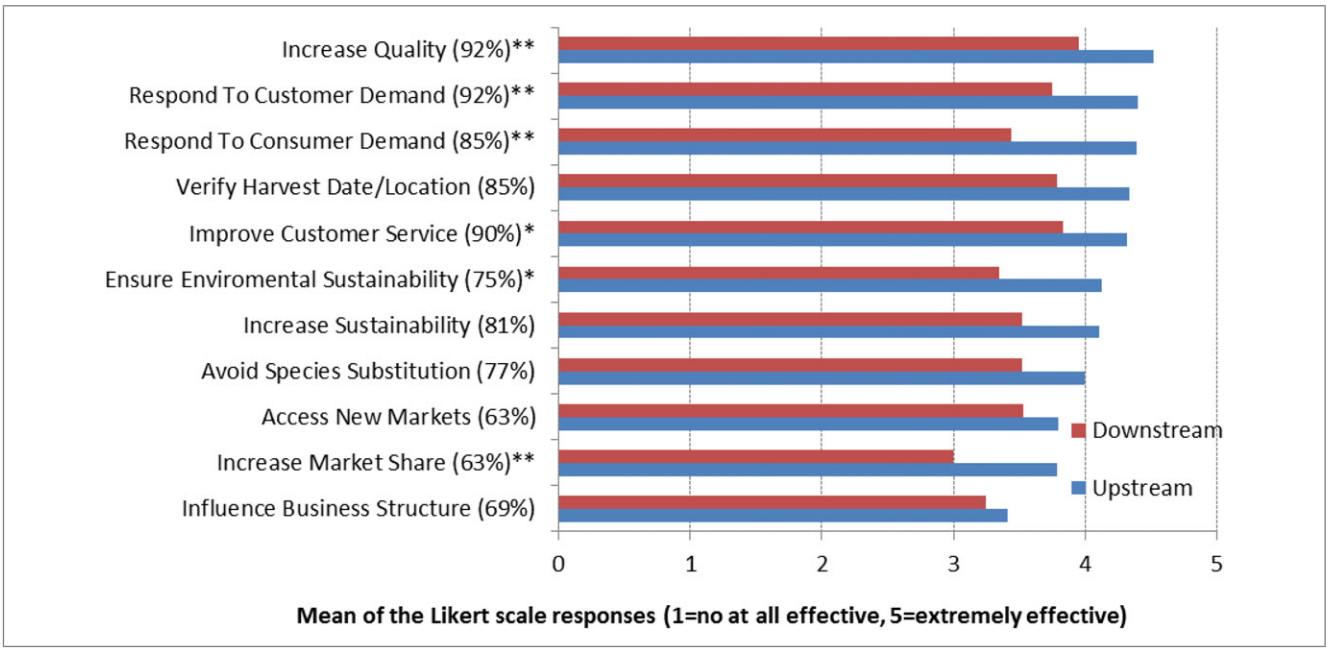


Figure 6–The mean of responses for both upstream and downstream businesses on "effectiveness" of a company's traceability system in generating benefits that "drive efficiency."[12]

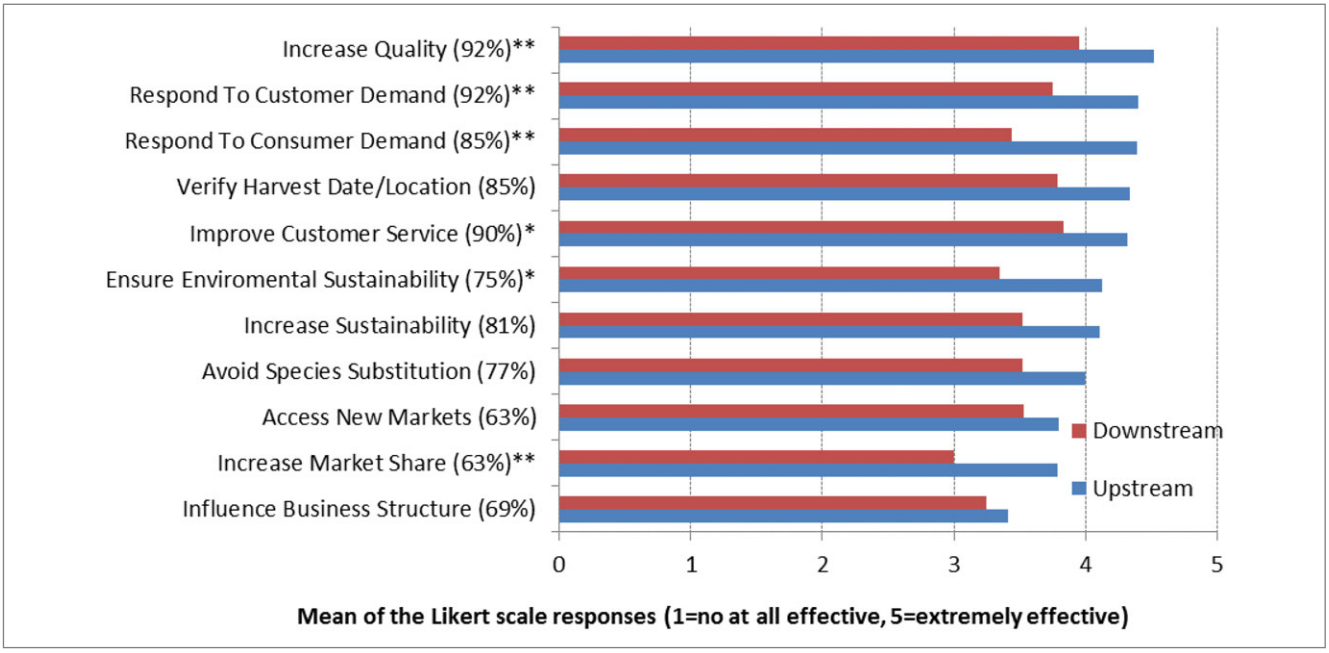


Figure 7–The mean of responses for both upstream and downstream businesses on effectiveness of a company's traceability system in generating "competitive advantage" benefits.[13]

While businesses are exposed to many different kinds of risks that have a substantial influence on business decisions, traceability systems were generally reported to be effective in helping to mitigate 2 types of risk: market and operational. Market risks are those that potentially impact a company's input costs and/or output prices and revenue. Operational risks are those that could potentially impact how a company conducts its business.

In addition, risks can be categorized by whether they are controllable (that is, the source of the risk is "inside" the value chain), or uncontrollable (that is, their source is "outside" of the value

[12]The percentages of the 48 participants that responded are shown in parentheses. Among those who did not respond, some indicated "no knowledge" or "not applicable." ** indicates that the difference in opinion between upstream and downstream firms is significant at the $P < 0.05$ level, * indicates significance at the $P < 0.1$ level (2 sample t test used).

[13]Response rate of a total of 48 possible respondents shown in parentheses. Among those who did not respond, some indicated "no knowledge" or "not applicable." ** indicates the difference in opinion between upstream and downstream firms is significant at the $P < 0.05$ level, * indicates significance at the $P < 0.1$ level (two-sample t-test used).

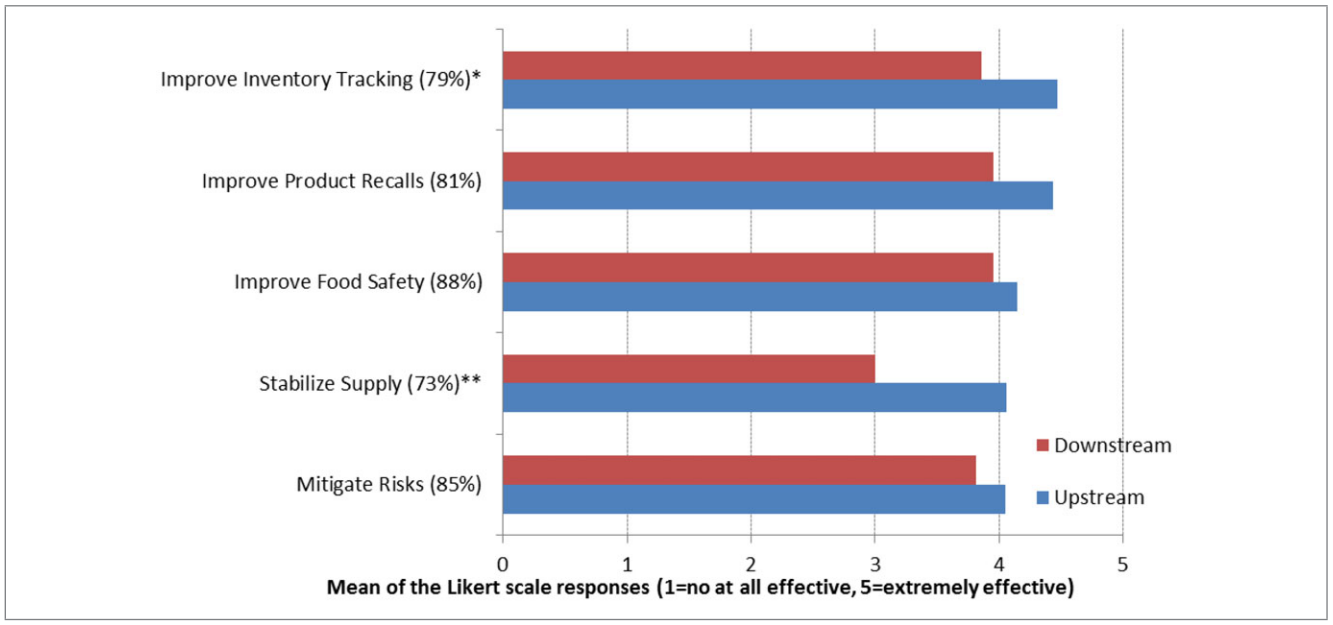


Figure 8–The mean of responses for both upstream and downstream businesses on effectiveness of a company's traceability system in "mitigating risks."[14]

chain). Table 5 shows the broad categories of market and operational risks and their most likely source.

Respondents were asked to score each type of risk according to its influence on shaping their business decisions. Figure 9 and 10, respectively, show the 10 highest ranked risks that, on average, impacted the ability of upstream and downstream companies to conduct business. Upstream businesses were most concerned about risks that would impact their ability to provide a consistent, high-quality supply of fish to downstream businesses, such as the availability of fish at the source, and the product's origin, date of harvest, and species name. There was less variation in the level of influence between factors among downstream respondents.

Figure 11 shows the distribution of the mean rankings of business' influence of "inside" (controllable) and "outside" (uncontrollable) risks on business decisions. Although the differences in mean rankings for controllable and uncontrollable risks were not statistically significant, businesses may be more influenced by risks that are within the control of their market chain.

Although businesses were exposed to many different kinds of risks that influence decision making, it appears that traceability systems were generally perceived as effective in helping to mitigate these risks. Figure 12 illustrates how upstream and downstream businesses ranked the ability of their traceability system to address both market and operational risks.

Although not statistically significant, on average, upstream businesses expressed greater confidence in the ability of their traceability system to help mitigate both market and operational risks, with a median rating of 8 of 10 in both categories. Downstream businesses expressed moderately high confidence in the ability of their traceability system to address both types of risk, with a median score of 7.

Generally, the businesses in the study said that they receive most of the requisite information they need to make effective business decisions. There are exceptions. Product temperature history, as well as the date and location of harvest are important pieces of information that respondents indicated were not available approximately 40% of the time. Information on labor practices was also commonly unavailable (38% of the time); but the importance of this information was ranked slightly lower than product data.

Table 5–Categorization of risks faced by businesses by "inside risks" (those within the control of the market chain), and "outside risks" (those not within the control of the market chain).

	Type of risk	
Source	Market risks	Operational risks
INSIDE	Supply variability New technology Environmental concerns Nonverification of source LOCATION Nonverification of source METHOD Nonverification of source DATE Nonverification of species IUU sourcing	Ability to verify harvest date Proper delivery specification Non/partial delivery Incorrect supply forecasting Incorrect demand forecasting Food safety recalls Poor handling Safety of fish Availability of fish supply Inconsistent quality Freshness/shelf-life Inappropriate labor practices
OUTSIDE	Changing regulations Inconsistent regulations Competitors' behavior Industry consolidation Inconsistent global traceability standards Inconsistent global food safety standards Subjective 3rd party verifications Inconsistent global tech. standards	Fluctuating input costs Fluctuating input supply Fluctuating consumer demand Fluctuating Prices

General summary. Of the heterogeneous sample of businesses that participated in this study, the overarching message was that traceability is of high importance in helping businesses to make

[14]Response rate of a total of 48 possible respondents shown in parentheses. Among those who did not respond, some indicated "no knowledge" or "not applicable." ** indicates the difference in opinion between upstream and downstream firms significant at the $P < 0.05$ level, * indicates significance at the $P < 0.1$ level (two-sample t-test used).

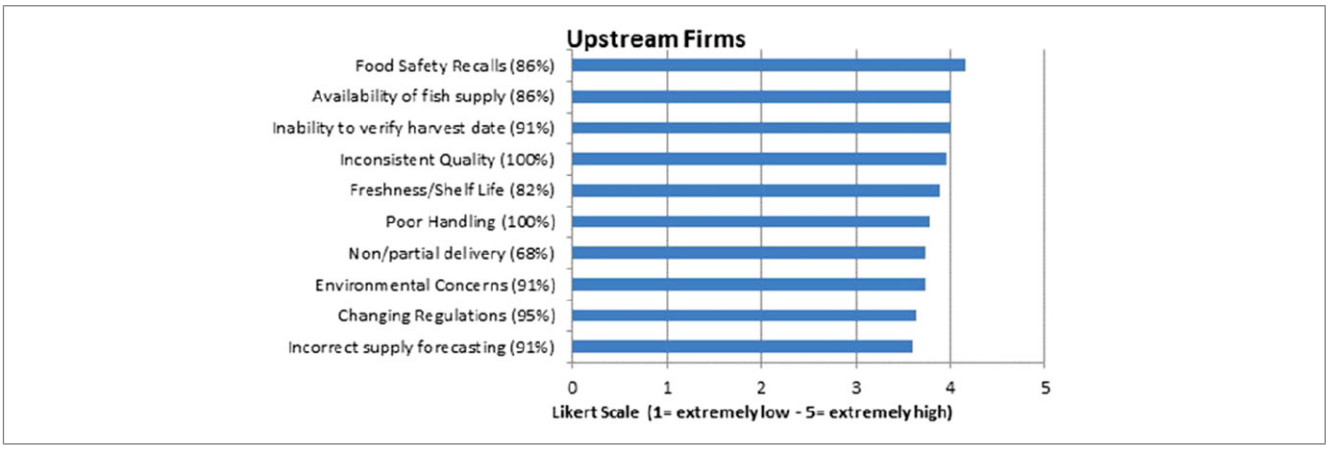


Figure 9–Top 10 risks that influence the ability of upstream businesses to make business decisions. Mean of the Likert scale responses shown.[15]

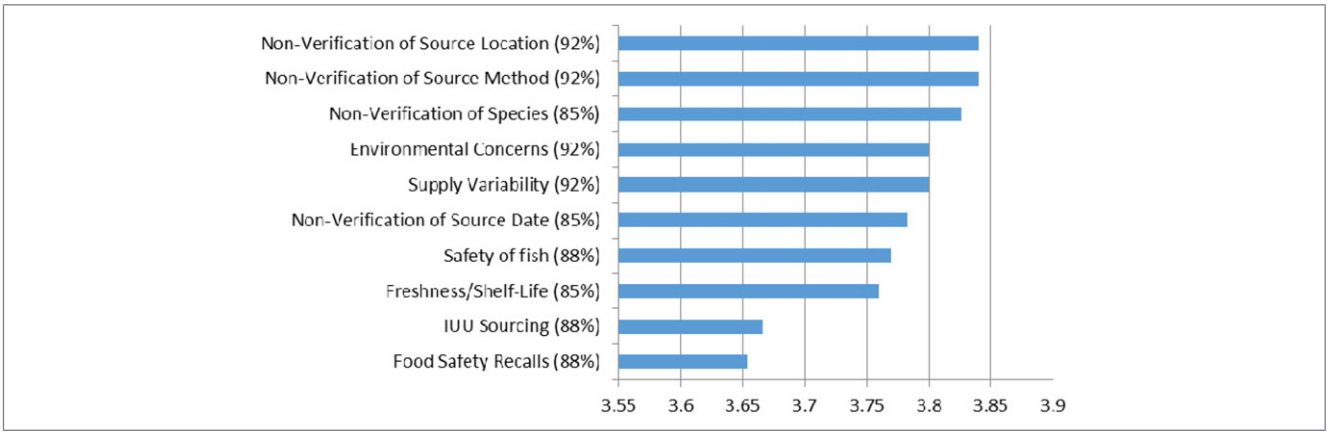


Figure 10–Top 10 risks that influenced downstream businesses' abilities to make business decisions. Mean of the Likert scale responses shown.[16]

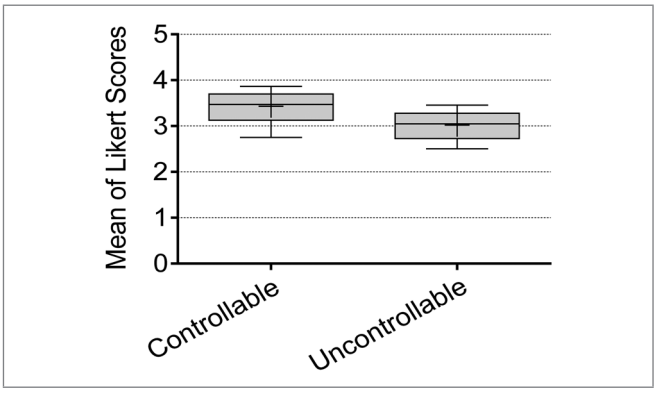


Figure 11–Box and whisker plot of the relative importance of controllable compared with uncontrollable risks.[17]

sound business decisions. Most businesses implemented their traceability system voluntarily, as opposed to it being mandated by regulation, and in most cases, businesses stated that the effectiveness of the system exceeded their expectations.

While one would expect that businesses expected significant challenges when implementing their traceability system, more than 33% of respondents indicated that they experienced no major challenges. In addition, the most common source of challenge was the behavior of other companies in the value chain. One would expect that highly fragmented value chains that do not share a set of common business practices would be less able to benefit from traceability than more coordinated and collaborative chains.

Responses indicate that businesses' traceability practices allow them to effectively generate a broad range of benefits. While many benefits of traceability practices and systems are measurable, in general the highest ranked benefits are those that are not easily measured. As a result, justifying investments in traceability systems can be difficult, especially when most traditional investments are scored on the basis of accounting metrics. Of the groups of benefits discussed, traceability systems were relatively effective at increasing benefits in all 3 of the benefit categories, including operational efficiencies, comparative market advantage, and business risk mitigation.

Of the risks that businesses face, those related to food safety recalls were regularly among the most significant. In addition, the need to verify product characteristics such as catch date, location, and identification were significant issues that create markets risks

[15]Response rate out of a total of 22 upstream firms shown in parentheses. Those not responding either did not respond, or indicated "no knowledge," or "not applicable."
[16]Response rates, out of a total of 26 upstream firms, are shown in parentheses. Among those who did not respond, some indicated "no knowledge" or "not applicable."
[17]Response rates, out of a total of 26 upstream firms, are shown in parentheses. Among those who did not respond, some indicated "no knowledge" or "not applicable."

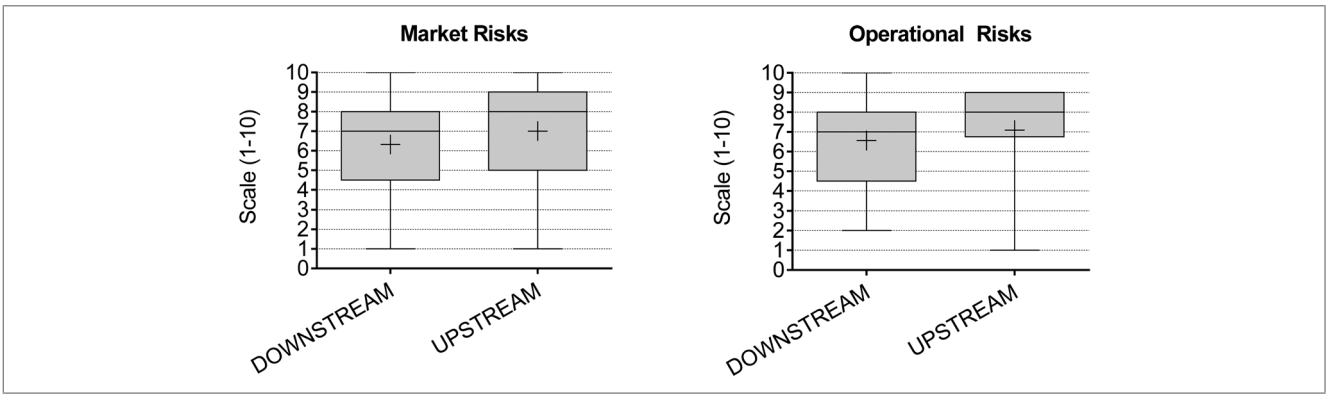


Figure 12–Box and whisker plots showing the distribution of the mean responses by upstream and downstream businesses about the effectiveness of their traceability system to address market and operational risks (1 = "not at all" 10 = "completely"). A total of 47 of 48 respondents indicated a score for these questions.

for businesses. Furthermore, these areas are considered as being effectively addressed by businesses' traceability practices and systems.

In general, upstream businesses were found to be more concerned than downstream businesses about both operational and market risks. Perhaps this is because they lie closer to the source of product, but they also had a higher opinion of the utility of their traceability practices and systems in mitigating these risks compared to downstream businesses. In general, upstream businesses rated the ability of their traceability practices and systems to generate a wide range of benefits as higher compared with downstream businesses.

These results, and the fact that there was no statistically significant difference between upstream and downstream businesses on the importance of their traceability practices and systems, may imply that while traceability is essential to the chain as a whole, it is more important for upstream segments of the value chain to implement effective traceability in order for the entire chain to benefit. Therefore, value chains that share information, implement similar business practices and standards, and which are overall more aligned, are likely to benefit from their traceability system to a greater degree than chains that do not.

Comparisons of cooperative, coordinated, and collaborative chains

Quantitative and qualitative analysis was conducted on the data received from the respondents in the 9 product-value chains, using the value-chain classifications described in Table 4.

The objective of this section is not to justify the classification of each chain we investigated, but to use the analysis to illustrate for each value chain the characteristics within each category. This exemplifies the relationship between the general state of interaction between the various business units in the value chains, and the extent of benefits achieved from introducing traceability systems.

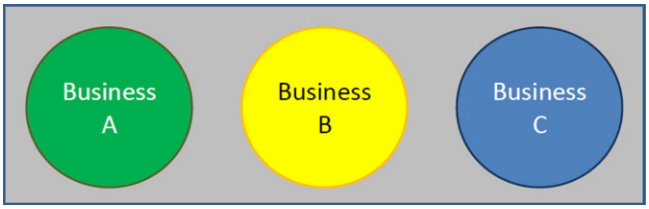
The practical implications are that businesses in the value chains should recognize the classification of interaction that they have reached to ensure that their strategy for developing traceability, and the outcomes they can expect to achieve is based on realistic expectations. Businesses in value chains that are fragmented may struggle to introduce any kind of substantial system, while businesses in value chains that are cooperative or coordinated may not achieve as much benefits as those in a chain that is collaborative, regardless of the sophistication of the system they may introduce.

Three analytical approaches were used to integrate and summarize the quantitative results comparing cooperative, coordinating, and collaborative classifications. The 1st approach compares the mean scores and variability (standard deviation) among the 3 clusters for traceability benefits, market risks, and operational risks (Table 6). The 2nd approach compared the scoring among the classes of benefits that were categorized as "driving efficiency," "competitive advantage," and "mitigating risks." The 3rd quantitative approach used the results from the first 2 analytical approaches to create 3 Venn diagrams illustrating the relationships of the benefits of "competitive advantage," "driving efficiency," and "mitigating risks" for the 3 clusters.

Findings from the analysis are presented in the following order: each chain is classified into a value-chain structure, as described in the literature review; then market benefits and risks are assessed, scored, and compared by chain structure. The section concludes with a summary of observations made in the interviews about how the imperative for traceability varies between species, sources, and customers.

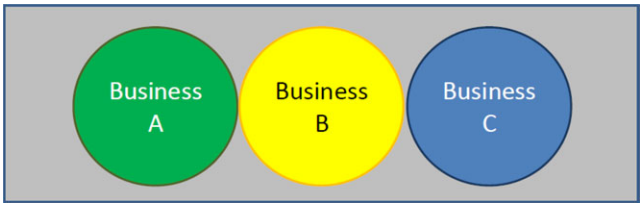
Summary of case study classifications

Level 1—Fragmented chains



Based on the selection process outlined in the methodology, fragmented chains were not included in this study.

Level 2—Cooperative chains



Case studies: E, H[18]

Two product-value chains (E and H) were classified as cooperative, generally displaying largely transactional relationships, and with some operational alignment. There was little evidence of value-chain members developing strategic competitive advantage, with innovations largely operational and tactical, and occurring in isolation along the chain.

Respondents perceived traceability to have little scope, with limited benefits. One distributor defined it simply as, "More paperwork." A processor in the other chain said that, "At present, traceability is more about satisfying customers than providing the ability to create stronger relationships with suppliers." Similarly, one of the retailers said that while they used the system for supplier evaluation, primarily it was for risk reduction on species substitution. In the same way, one of the processors recognized that traceability added to the reputation of the retailer and supplier, but saw the main benefit "at this point" as the ability to conduct a limited recall if a problem occurred. Another said traceability allowed "sniper rather than shotgun recalls" suggesting a lowering of risk and cost. One of the distributors felt that the introduction of the system was initially driven by buyer/retailer requirements, although some additional benefits were emerging.

Information flow was a problem in the cooperative chains. One distributor described the ongoing operational problem of suppliers not sending all the information required: "Folks just forget to send it. Those businesses who have an attitude of 'we move fish' are the least likely to embrace traceability beyond entering information into a system that cannot differentiate whether the information provided has integrity or not."

Distrust between chain members was reflected in a retailer's comment that some suppliers were more concerned about confidentiality of information they supplied into the system. Even within a company, colleagues sometimes showed little interest in traceability. Overall, "It's an ongoing battle to secure people's buy-in, whether external or internal to the business." However, for some businesses, the lack of internal commitment may reflect the inconsistent emphasis placed on traceability by their customers, with one distributor reporting that, "Just two of our fifteen regular retail customers have bought into the concept of traceability."

Perhaps in cooperative chains, the lack of traceability is both a cause and effect of poor relationships and lack of demand from the markets they serve. Indeed, neatly summarizing the challenge for cooperative chains, and even more so for fragmented chains, one interviewee observed that: "The importance of traceability comes into effect when the desired level of trust, ethics, and accountability does not exist between businesses. Ironically, that is the very time when the reliability and integrity of information provided by traceability systems comes into question." While this reflects a mentality where risk management is the only main objective of traceability, it highlights the conflict between that objective, and the effective operation of the system.

Key Findings for Cooperative Chains:
Characteristics, Attitudes, Behavior

- Lower sales and larger number of species
- Fewer employees trained in use of traceability
- Less use of GS1 Standards
- Significantly lower challenges in implementing traceability.

Benefits

- Only moderate benefits were expected from adopting traceability
- Benefits achieved from adopting traceability did not exceed expectations
- Significant benefits from adopting traceability are limited to only a few categories (4 of 27, Table 2) and 10 benefit categories scored "not effective" or "only slightly effective."

Risks

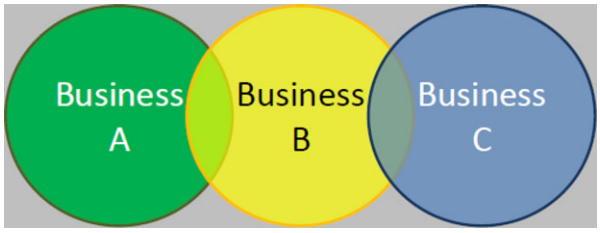
- Slightly higher concern for overall risks (Figure 1)
- Greater concern about risks that are endogenous (inside) to the chain (Figure C-24A and C-24B)
- Lower concern for risks exogenous (outside) to the chain (Figure C-24A and C-24B)
- Traceability only moderately successful in alleviating market and operational risk (Figure 3).

Key insights

- Expectations focused on legal compliance, improving customer service, improving quality, and risk mitigation around food safety
- Whole traceability is more critical where there is less business-to-business trust, as in cooperative chains; and because there is less trust, there are doubts about data integrity from upstream partners.

In cooperative chains, traceability can help to establish responsibilities for ensuring the integrity of information provided.

Level 3—Coordinated chains



Case studies: A, B, D, F, I

The 5 coordinated product-value chains (A, B, D, F, and I) showed some evidence of leveraging their stronger relationships into strategic competitive advantage related to traceability. This was reflected in chain members more consistently defining traceability with an entire chain perspective, and as well as referring to food safety, contributing to continual improvement, "driving down to identify causes of problems," full chain of custody management, and fishery sustainability.

For coordinated chains, risk mitigation remains a key driver of traceability, with interviewees mentioning verification of where/how/when seafood was raised or harvested, and avoiding species substitution and IUU sources. However, these chains have also started to exploit traceability systems beyond risk management. The Chain D distributor illustrated this by explaining that, "Our traceability system enabled us to reduce inventory—and associated working capital—waste, and distressed sales. It also improved our forecasting." Others used traceability for improving quality, for example by monitoring storage temperatures along the entire chain. Others cited linking their traceability system to financial systems, even using the data to calculate commissions

[18]Case studies in the research have been anonymized. The 9 value chains studied have been labeled A through I.

for vessel captains. Another chain used traceability practices and systems for investigating consumer complaints.

The Chain B processor explained the major investment in their ERP and traceability systems had easily paid for themselves by improving management of their production, marketing, procurement, inventory, marketing, and public relations. Acting effectively as one, the ERP and traceability systems connected to a database that allowed them to conduct analyses into improving quality, solving supply problems, and managing production and inventory. The system allowed them to discover patterns that they might have otherwise not been able to discover. In the future, the company hoped that all the vessels from which they source would have electronic logbooks which could be merged into their system.

Similarly, a member of Chain I reported that without traceability, "We would have to hedge decisions, because traceability gives greater confidence in the decisions we make. Without it, we would be back to making 80% of decisions with just 20% of the information we have now."

A member of Chain A had also found that, "[Traceability] takes the gut feel out of business decisions." The company finds it provides a greater box of insights and data on which to base decisions, for example by enabling comparison across products and suppliers more effectively than otherwise possible. "Without it we would be facing considerably greater risks – and risks cost money."

Generally, coordinated chain members did not feel pressured to introduce traceability, although sometimes those farther from retailers and consumers saw advantages less clearly. One retailer commented that, "Some suppliers and customers are on the same page as us. An observable trend is occurring among customers and suppliers, although the extent to which they buy into our views on traceability differs by function." There was also emerging recognition that value-chain stability is critical to effective systems, especially to meet stringent needs of the most demanding markets.

One distinction between coordinated and collaborative chains is that not all members fully embrace traceability, or else they retain limited objectives, and it is clear that not all members are yet aligned in the value they place on traceability. Typically, upstream members are more reluctant adopters. The distributor in one chain said that traceability investments were not tied to an ROI because they were "about safety, about avoiding problems." In another chain, the retailer said similarly that ROI was irrelevant because traceability was essential. In a 3rd chain, government regulation was seen by 2 retailer respondents as the critical driver, rather than management or commercial opportunities. One distributor said that while traceability is currently a differentiator, this did not mean better returns. In another chain, the processor commented that traceability "Was not something on which you can make money; it opens doors and opportunities;" another stated that "Traceability is about letting us sleep at night." Indeed, one interviewee commented that, even though the value chain was stable, the system was essential because of a lack of trust toward some foreign suppliers. Such attitudes may limit scope for collaborating to exploit additional opportunities.

Individuals in coordinated chains may have to use persistence and imagination to create corporate buy-in within their own businesses. An interviewee within one business said he had argued for introducing a traceability system "On the back of country-of-origin labeling" telling us, "When you say it's a legal requirement that creates an entry way." In another chain, the distributor cited a key barrier as being—"Colleagues who are old-fashioned and not forward-thinking."

As stated, upstream members appear slower to respond to traceability requirements and objectives may differ. For example, in Chain D, there are inconsistencies in perceptions. The processor considers traceability to be "fail safe system that enables us to trace back if every other system fails, to recover information that enables us to identify what went wrong." The distributor described traceability as "enabling recalls." The retailer describes traceability as "two-way flow of information." Nonetheless, the processor stated that any problems they experienced with their traceability practices and system were not significant, and more about training and time/efficiencies associated with the learning curve.

Ultimately, this variability all highlights the interdependence that is critical to successful traceability investments. As one company representative said, "It's not the systems that fail, it's the people using them."

Key Findings for Coordinated Chains: Characteristics, Attitudes, Behavior

- Greater sales and smaller number of species
- Larger number of employees trained in use of traceability
- Greater use of GS1 Standards
- Higher number of challenges in implementing traceability.

Benefits

- Larger benefits were expected from adopting traceability benefits
- Benefits from adopting traceability exceeded expectations
- Traceability strongly successful in alleviating market and operational risks (Figure 3)
- Significant benefits from adopting traceability were moderate in number (13 of 27, Table 2) and only one category scored not effective or only slightly effective.

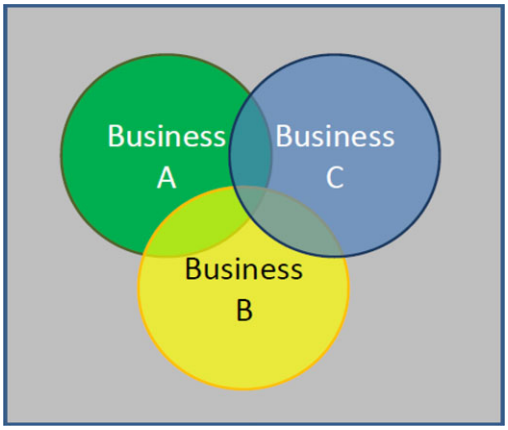
Risks

- Slightly lower concern for overall risks (Figure 1)
- Moderate concern about risks that are endogenous (inside) to the chain (Figure C-24A and C-24B)
- Slightly higher concern for risks exogenous (outside) to the chain Figure C-24A and C-24B).

Key Insights

- Coordinated chain members see traceability as two-way flow of information
- Traceability recognized as delivering some gains in efficiency and competitive advantage as well as risk mitigation.

Collaborative chains



Case Studies: C, G

Business in both collaborative chains (C and G) consistently defined traceability from an entire chain perspective. They reported that it helped inform activities upstream by improving individuals' and businesses' understanding of market requirements. The retailer in Chain G referred to a need for "Close, trusting relationships with suppliers." Both chains showed the most comprehensive attitude to outcomes from traceability, extending beyond risk management, into both allowing cost reduction and development of market opportunities.

Overall, a common refrain in collaborative chains was that the benefits of introducing traceability systems had exceeded expectations.

In these chains, costs were lowered not only for improving inventory management, resulting in reduced working capital and waste, but also for giving retailers greater upstream visibility. This allowed the retailer to efficiently resolve quality problems or concerns without needing to visit overseas suppliers. The Chain C retailer concluded that traceability had become essential across its operations, "From how we pay fishermen, to how we manage shelf-life." Similarly, the retailer in Chain G uses traceability for supplier evaluation and transparency to drive improvement in operational standards and capabilities. "Without traceability, we would have less visibility along the value chain leading to less effective management decisions, greater exposure to risk, and higher levels of waste." Again, this avoided greater personal interventions and travel to visit suppliers.

Upstream, the attitudes were similar. The processor in Chain G commented that, "Traceability is woven throughout our operations." The aquaculture farm in Chain G explained how traceability gave them greater control over costs of production and quality of product. They used their system to track fry and shrimp performance ("Everything depends on selection of fry"). This includes monitoring, and then comparing growth rate and survival rate by shipment from different hatcheries. "For [our] continual improvement, we need to know suppliers' processes and what they are doing." In terms of market opportunities, another upstream member appreciated that value-chain transparency is increasingly becoming a common requirement of many retailers.

Traceability also provided significant public relations benefits. Traceability allowed collaborative chains to refute critical media stories and NGO campaigns with robust evidence of their higher standards compared to those in the chains being exposed. Indeed, one retailer who emphasizes sustainability as core corporate value said that supplier selection and collaboration on sustainable sourcing would be impossible without their traceability system.

However, despite classifying these chains as collaborative, there are still areas of misalignment. One interview revealed that the internal business case for investment into traceability could be a challenge. For example, investing in new product development was more positively received compared to traceability investments because:

- New product costs and subsequent profit are very transparent
- New product ROI is readily quantifiable, and
- There is a single executive responsible for new product development budget and implementation.

Reflecting on this, another respondent said that while the benefits from traceability were significant, they were also complex and diffuse, touching many aspects of operation. One processor confirmed that it was considerably easier to calculate the necessary payback on a piece of equipment, as you can identify exactly what is required in terms of capacity to make money. "An information and communications technology is not like that. It is a more elusive decision."

Yet another processor commented about a continuing need to educate suppliers in organizing their data input, as well as the persistence of a view among suppliers that traceability was a necessary cost for accessing customers rather than a source of value. The retailers also emphasized the need for ongoing monitoring of data integrity, as well as problems in data communication and technology, managing expectations, as well as cultural/language barriers. In Chain G, the farm reported that while it would like electronic systems at the hatchery to help monitor quality and productivity, every hatchery had a different system. Indeed, the farm admitted that it struggled even to get its own employees to adhere to its program. Finally, one distributor added that some feed mills were unwilling to be transparent, which was detrimental for those European markets with requirements for GMO-free fish feed.

Key Findings for Collaborative Chains:
Characteristics, Attitudes, Behavior

- Greater sales and smaller numbers of species
- Larger number of employees trained in the use of traceability
- Greater use of GS1 Standards
- Higher number of challenges in implementing traceability.

Benefits

- Largest benefits were expected from adopting traceability benefits
- Benefits achieved from adopting traceability exceeded expectations
- Significant benefits from adopting traceability were highest in number (16 out of 27, Table 2); 6 benefit categories were rated high by 90% of businesses; and only one category scored "not effective" or "only slightly effective."

Risks

- Slightly lower overall concern for risks (Figure 1)
- Lowest concern about risks that are endogenous (inside) to the chain (Figure C-24A and C-24B)
- Highest concern for risks exogenous (outside) to the chain (Figure C-24A and C-24B)
- Traceability perceived as strongly successful in alleviating market and operational risks (Figure 3)

Key Insights

- Strong relationships enable the widest range of value from traceability to be captured by businesses, including improving company performance across functions and business lines, and enhanced risk mitigation

Even in collaborative chains, barriers still exist, as a result of corporate culture, management structure, and misaligned objectives/perceptions of departments.

Assessing market benefit and risks by chain structure. The 1st approach compares the mean scores and variability (standard deviation) among the 3 clusters for traceability benefits, market risks, and operational risks. Figure 13 summarizes the results and shows that cooperative chains received the fewest benefits compared to coordinated and collaborative businesses, and that they had the greatest variability in scores among their businesses (see also Figures 14 and 15). With respect to market risk assessment there

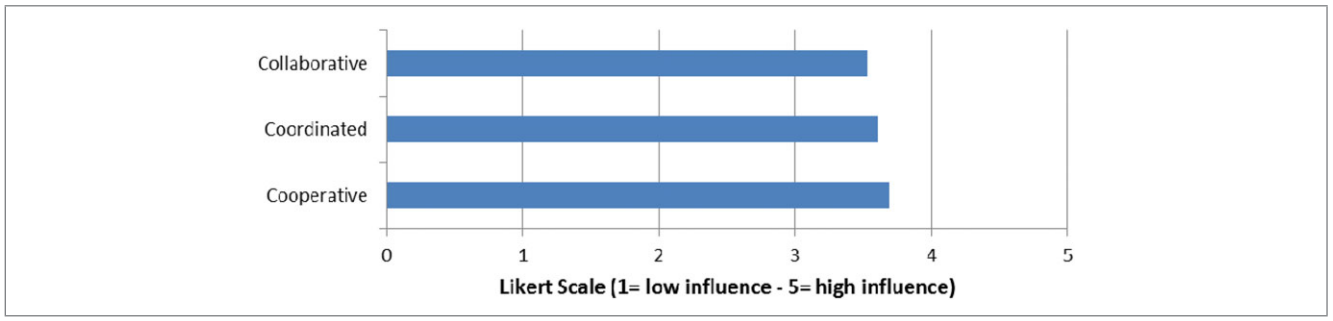


Figure 13–Likert mean scores for combined market and operational risks for the 3 market chain clusters.

Table 6–Mean scores and variation (standard deviation) among the 3 clusters for traceability benefits and market and operational risks.

	Traceability benefits		
	Cooperative	Coordinated	Collaborative
Mean score	2.93	3.58	3.85
Variability	1.57	1.16	1.07
	Market risks		
	Cooperative	Coordinated	Collaborative
Mean score	3.57	3.53	3.49
Variability	1.04	1.23	1.76
	Operational risks		
	Cooperative	Coordinated	Collaborative
Mean score	3.80	3.67	3.58
Variability	1.52	1.30	2.06

was only a slight difference in mean scores among the 3 clusters (although there were differences in perceptions about "outside" compared with "inside" risks). Cooperative businesses scored concerns about operational risks the highest among the 3 clusters, but collaborative businesses showed the greatest degree of variance. See Figure 16.

Scoring benefits associated with traceability by chain structure. The 2nd approach compared the scoring among the classes of benefits that were categorized as "driving efficiency," "competitive advantage," and "mitigating" risks (Figure 17, 18, 19). The scores for each class of benefits were then aggregated and graphed, as shown in Table 7. The results show that benefits classified as "driving efficiency" scored the lowest (2.1 to 2.7) compared with "competitive advantage" benefits (3.2 to 3.7) and "mitigating risks" benefits (3.3 to 4.0). Cooperative chains scored the lowest in each class, with coordinating chains in the middle, and collaborative the highest.

Table 7 provides an overview illustration of the benefits associated with traceability, comparing the 3 different value-chain structures. The proportion of businesses responding is indicated by:

- gray shading (the darker shade indicates more than 75%, and lighter shading 50 to 75% of businesses provided a response)
- Green indicates that businesses had a mean score greater than 3.5
- Yellow indicates a mean score between 2.5 and 3.5
- Red indicates a mean score below 2.5
- Dark red indicates that more than 90% of businesses scored only 1 or 2
- Dark green indicates that more than 90% of businesses scored a 4 or 5.

Table 7–Effectiveness of implementing traceability on benefit categories based on a 5-point Likert scale (1 indicates "not at all effective" and 5 indicates "extremely effective") for "Cooperative," "Coordinated," and "Collaborative" market chains.

Benefit categories	Proportion of respondents	Overall score	Scores value chain cluster		
			Cooperative	Coordinated	Collaborative
Ensure environmental sustainability					
Improve product recalls					
Reduce pilfering					
Increase distribution accuracy					
Verify harvest date/Location					
Improve inventory tracking					
Avoid short weighting					
Avoid species substitution					
Increase sustainability					
Stabilize supply					
Reduce waste					
Improve food safety					
Increase quality					
Mitigate risks					
Influence business structure					
Develop pricing models					
Improve customer service					
Respond to consumer demand					
Respond to customer demand					
Access new markets					
Reduce quality variation					
Increase revenue					
Increase market share					
Increase productivity					
Reduce input costs					
Increase margins					
Reduce administrative costs					

Table 7 clearly reveals that as businesses become more aligned within their respective value chains, they perceive greater benefits from implementing traceability. This occurs both within and across the categories of benefits described above. The greatest benefits relate to ensuring improved product recalls, verifying harvest date and location, increasing quality as well as responding to demands from both consumers and customers. Benefits related to improved sustainability and waste reduction were also reported among more aligned chains.

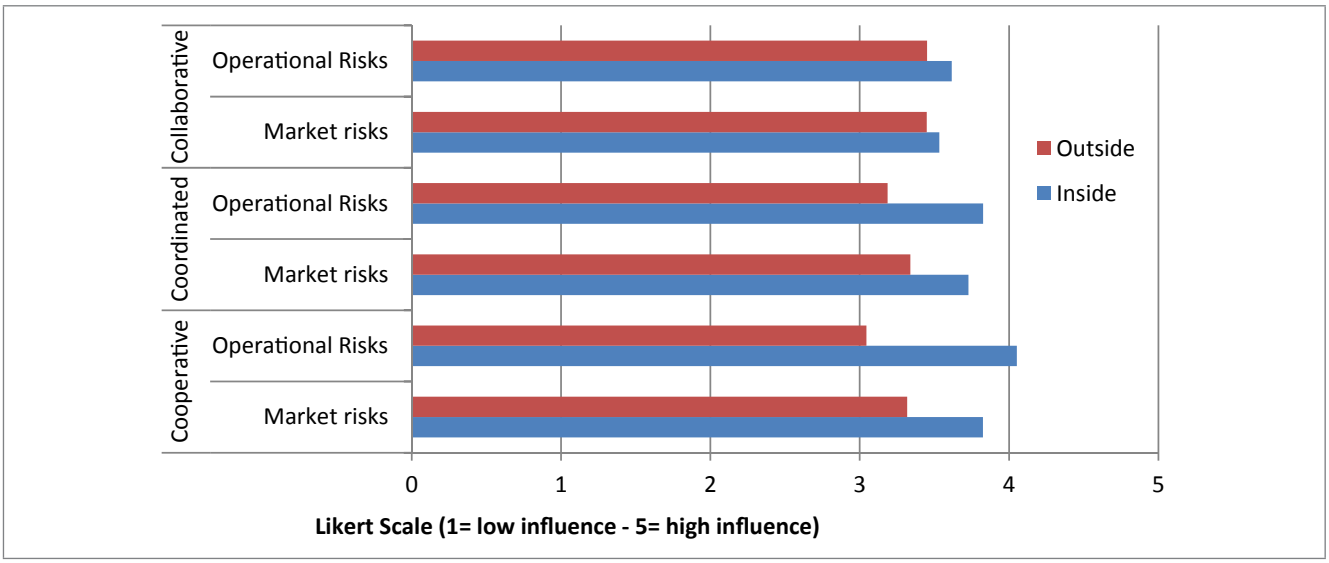


Figure 14–Likert scores for market and operational risks for "outside" and "inside" risks for the 3 market chain clusters.

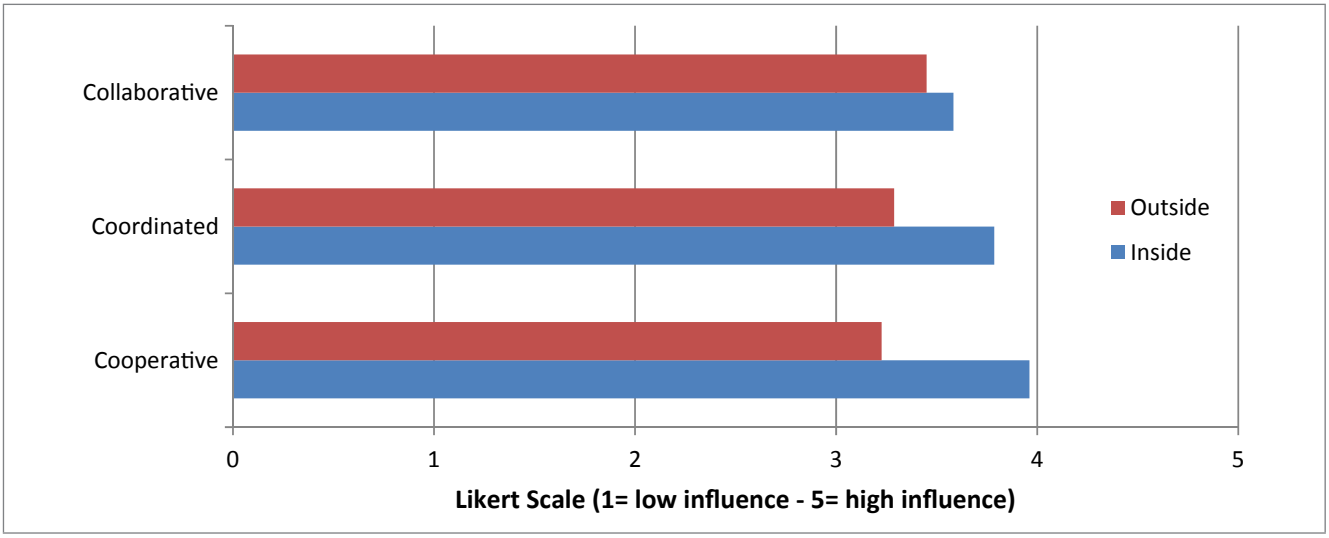


Figure 15–Likert scores for aggregate scores for "outside" and "inside" risks for the 3 market chain clusters.

Comparing perceived benefits by chain structure. The 3rd approach used the results from the first 2 analytical approaches to create 3 Venn diagrams illustrating the relationships among the benefits of "competitive advantage," "driving efficiency," and "mitigating risks" for the 3 clusters (Figure 6A to C). The diagrams should be considered a 1st attempt to use quantitative information to illustrate the degree to which there were differences and synergies in the types of traceability benefits derived between the 3 types of value chains.

By adding up the means for each benefit class we can evaluate the overall importance of each class of benefits for each chain cluster (Figure 20). "Driving efficiency" benefits generate lower scores than "competitive advantage" and "mitigating risks" benefits. Collaborative chains scored the highest in each benefit class, Cooperative chains scored the lowest.

The following Venn diagrams (Figure 21 to 23) illustrate the degree to which there were differences and synergies in the types of traceability benefits derived between the 3 types of chain. They are for directional purposes only.

The size of each circle corresponds to the aggregate mean of the Likert responses for benefits in each category. The transparency of the colors reflects how strongly respondents in each type of chain thought that their traceability system was effective in capturing benefits in each class (the stronger the color, the higher proportion of "high" Likert responses). The degree of overlap between the circles correlates with the consistency in ranking benefits as "high" between the 3 benefit classes (the higher the degree of overlap, the greater the similarity in percentage of "high" scores out of all scores).

The Venn diagrams presented in Figure 21 and 23 illustrate the benefits generated for each chain classification for each major class of benefits and any alignment, for maximum effect.

The results show that Cooperative chains had the weakest intensity and breadth of benefits as well as the lowest consistency in scoring compared to the other 2 classifications of value chains.

For all 3 classifications, "driving efficiency" is the weakest benefit class in size and intensity, with the smallest degree of overlap.

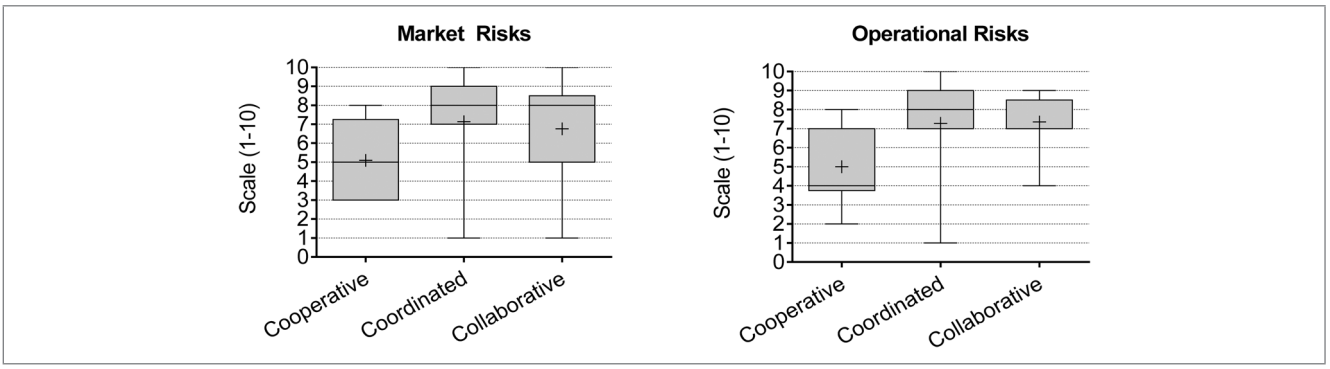


Figure 16–Box and whisker plots of Likert scores on a scale of "1" (not at all) to "10" (completely) indicating the extent to which traceability systems alleviated market and operational risks.

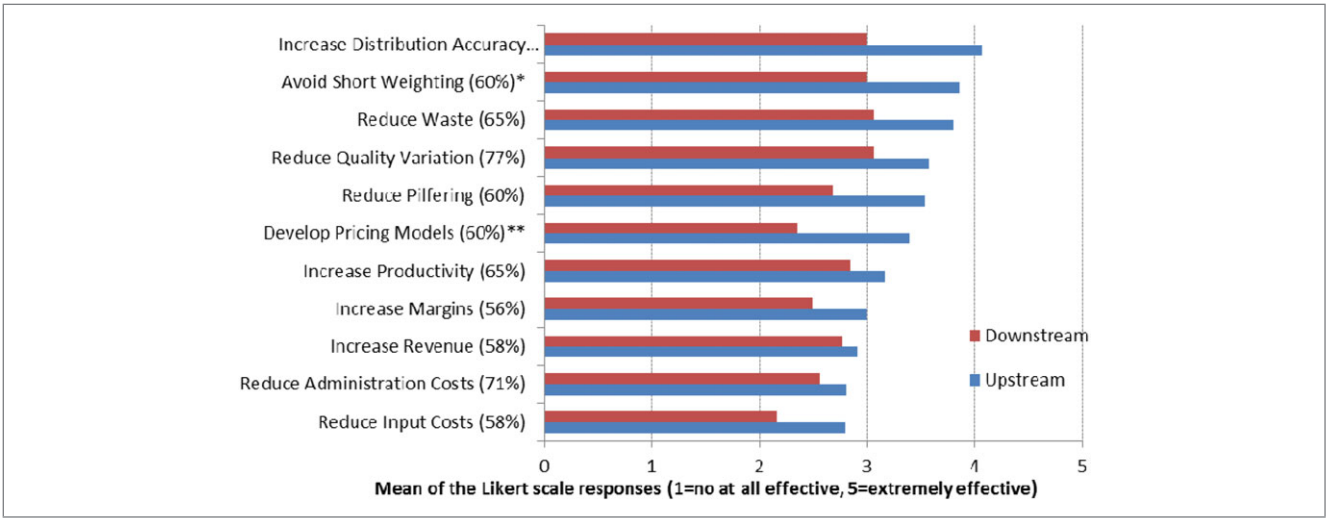


Figure 17–Mean scores among the 3 clusters for benefits classified as "driving efficiency."[19]

"Mitigating risks" is the largest circle, but competitive advantage has a greater intensity of color, indicating a higher proportion of high responses. The degree of overlap and therefore potential for synergy and reinforcement of benefits within chains is highest for the Collaborative value chains and weakest for the Cooperative group.

Additional insights from product-value chain case studies

The interviews revealed traceability investment considerations that extend beyond the collaborative capacity of the chain and the characteristics of the value chains in which a business operates. These can be summarized as variations in opportunities and practical challenges between species, product, sources, and customers.

Variations between product species. Some argued that species integrity was impossible without traceability, and that this was especially important for tuna because of the higher risk of species substitution, and hence the need for validated segregation of yellowfin, bluefin, and bigeye. Others argued that the case was strong for species at risk from overfishing, or for those at risk of scombrotoxin (histamine) formation and hazard (mainly from tuna, swordfish, and mahi mahi).

Some respondents who look at using traceability for business improvement rather than risk management argued that farmed shrimp had considerable potential in using traceability to drive improvement because the choice of fry is critical to success, and traceability systems, including the segregation that is required, allows for closer monitoring of different suppliers' performance.

In terms of products, one interviewee highlighted that the challenges and benefits varied between frozen products distributed through regional distribution centers to fresh products with direct store delivery.

Variations between sources. Several case studies highlighted how downstream demand for systems reflects source origin of products, for example, depending on the perceived risk of fraud and safety. European customers were considered more demanding of traceability from Asian sources, especially China, Vietnam, and Indonesia, than from suppliers operating within the European Union. Retailers did not trust those sources where they believed governments did not have much control over the industry, and so importers needed to assert control. North American suppliers were considered lower risk.

Traceability could also create additional value when a product's provenance was valued by consumers.

[19]The mean of responses for both upstream and downstream businesses on "effectiveness" of a firm's traceability system in generating benefits that drive efficiency. Response rates reflecting a total of 48 possible respondents, are shown in parentheses. Among those who did not respond, some indicated "no knowledge" or "not applicable." ** indicates the difference in opinion between upstream and downstream firms significant at the $P < 0.05$ level, * indicates significance at the $P < 0.1$ level (two-sample t-test used).

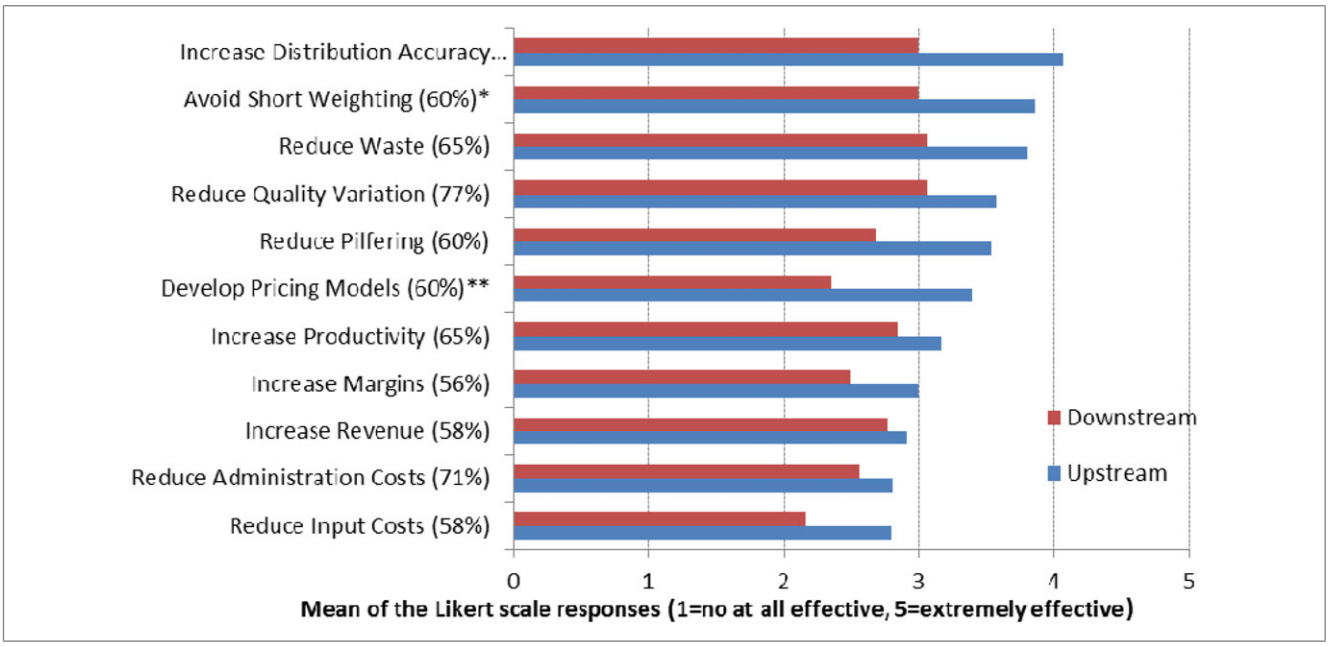


Figure 18–Mean scores among the 3 clusters for benefits classified as "competitive advantage."[20]

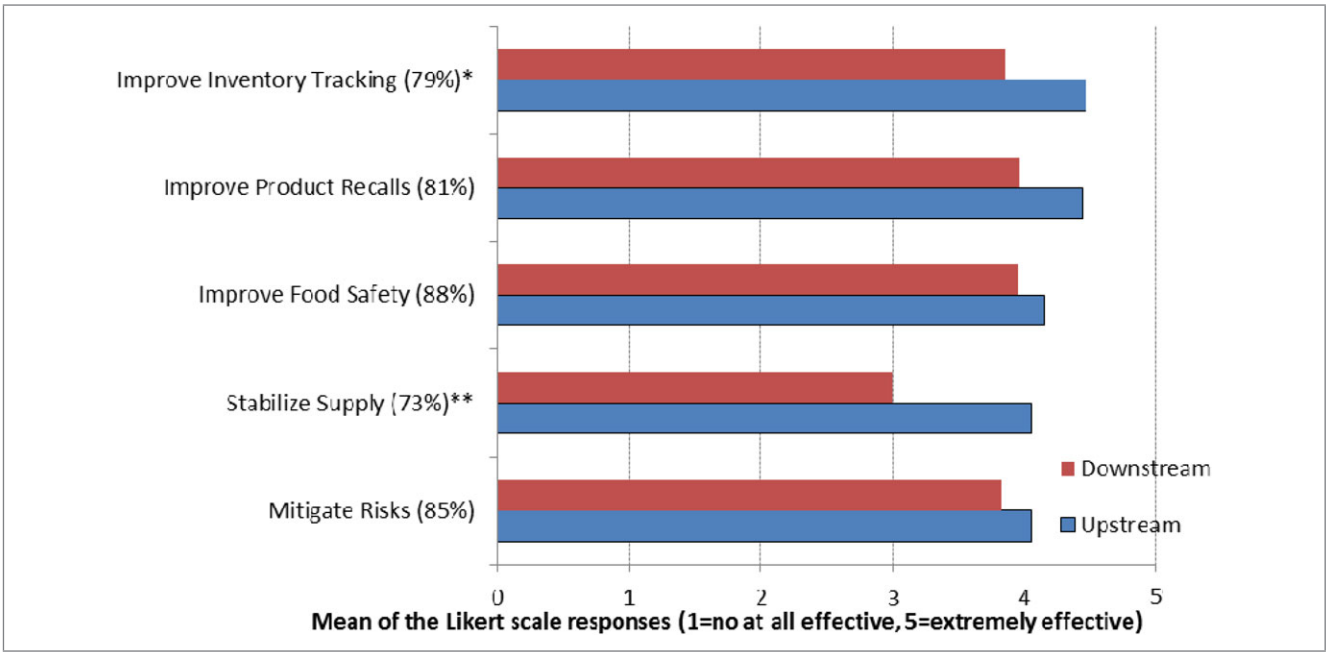


Figure 19–Mean scores among the 3 clusters for benefits classified as "mitigating risks."[21]

Variations between customers. There was a widespread view by participants that North American retailers were largely responding to pressure from NGOs, while consumers were driving traceability requirements in the European market, albeit influenced by NGOs. Another distinction was that the main concern of U.S. retailers was food safety assurances; and another concern specifically for aquaculture was they sought traceability back to the farm. European markets additionally sought assurances about non-GMO feed being used in aquaculture, requiring traceability back to hatcheries and feed suppliers, although it was perceived that these retailer requirements were ahead of consumer expectations. In particular, North Western European customers (such as

[20]The mean of responses for both upstream and downstream businesses on effectiveness of a firm's traceability system in generating "competitive advantage" benefits. Response rate, reflecting a total of 48 possible respondents, is shown in parentheses. Among those who did not respond, some indicated "no knowledge" or "not applicable." ** indicates the difference in opinion between upstream and downstream firms is significant at the $P < 0.05$ level, * indicates significance at the $P < 0.1$ level (two-sample t-test used).

[21]The mean of responses for both upstream and downstream businesses on effectiveness of a firm's traceability system in "mitigating risks." Response rates reflecting a total of 48 possible respondents are shown in parentheses. Among those who did not respond, some indicated "no knowledge" or "not applicable." ** indicates the difference in opinion between upstream and downstream firms significant at the $P < 0.05$ level, * indicates significance at the $P < 0.1$ level (two-sample t-test used).

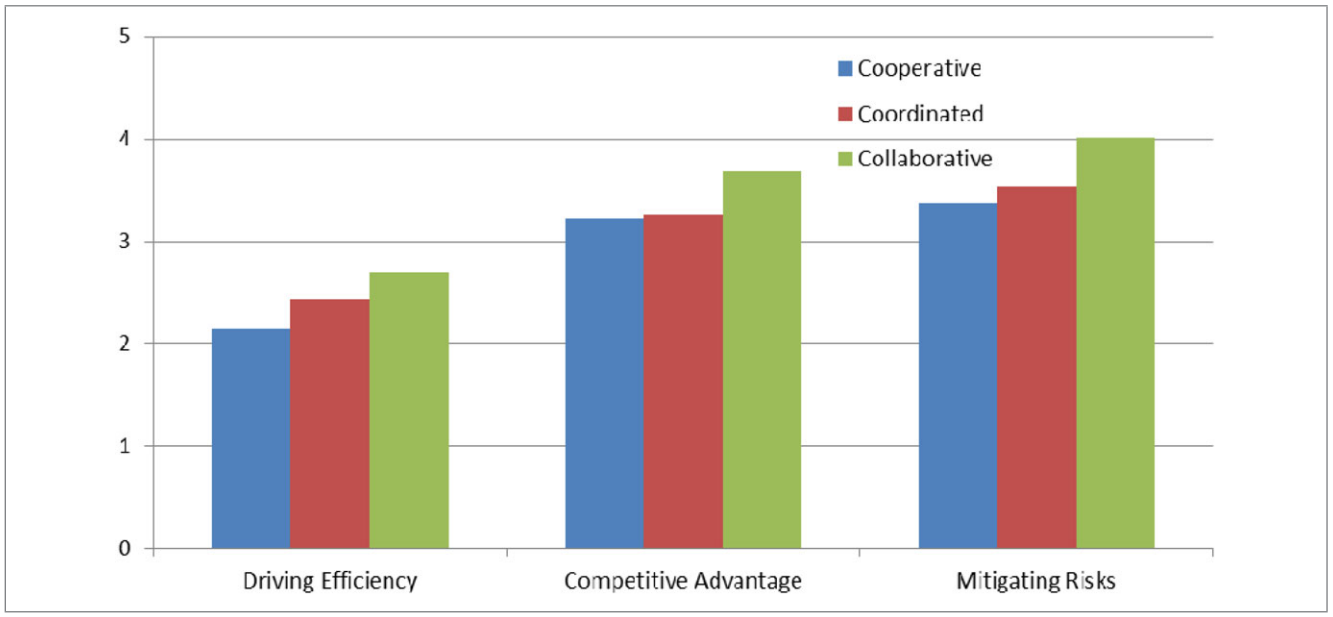


Figure 20–Mean aggregated scores among the clusters for the 3 classes of benefits.

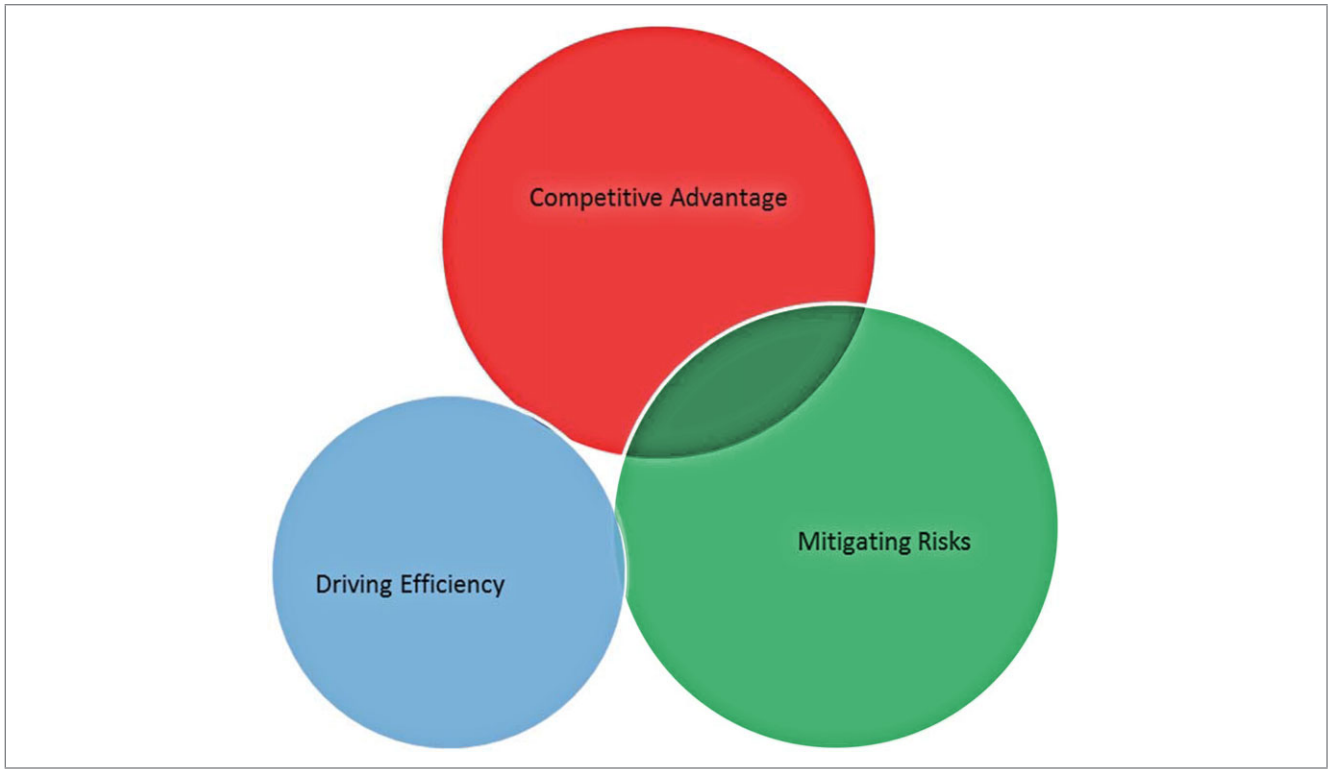


Figure 21–Venn diagram of the cooperative cluster for the 3 classes of benefits.

Germany and the Netherlands) were seen as early adopters, and retailers often preferred specific traceability systems to be used. In Southern and Eastern European markets, consumers were less demanding. Asian customers were considered to focus on price, rather than quality and traceability.

Traceability was considered more important in supplying retail than foodservice customers; the priorities and opportunities of retailer reflected not only the prevailing market in the country, but also the market segment served by each retailer, which is addressed in the next section, which reviews the results of the consumer research.

Lack of standardization. There is a widespread view among respondents that a lack of standardized technology and regulations between countries hampers traceability investments. Businesses typically view this lack of uniform requirements as a barrier to effective traceability. The differences were considered as usually stemming from differences in government policy goals and regulations, along with an unwillingness and/or inability

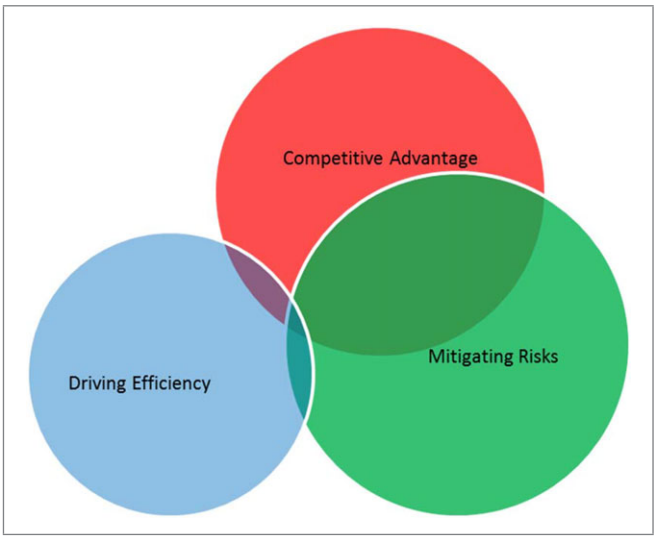


Figure 22–Venn diagram of the coordinating cluster for the 3 classes of benefits.

to collaborate with other nations. Close, strategically orientated business relationships appear to encourage environments in which businesses rely less on industry and national-level traceability practices or systems. This could help explain why the international Collaborative and Coordinated chains that participated in this study said that they had gained the greatest benefits from implementing traceability throughout the entire product-value chain.

A question that we were not able to answer in the research is the extent to which a lack of global standards negatively impacts traceability capabilities and the benefits accrued from the use of traceability among businesses operating in Fragmented value chains.

Consumer Research

As explained in Subsection "Consumer research," Ipsos Agriculture and Animal Health undertook the consumer research in 5 markets (Canada, China, Germany, the Netherlands, and the United States). The research was achieved through surveys of consumption patterns and included a choice-based conjoint exercise. In the choice-based conjoint study, respondents were presented with a series of choices between 2 products with different configurations of:

- Production method (none, wild, or farmed) verification;
- Species verification (with or without);
- Sustainability certification (none, by manufacturer or retailer, by independent 3rd party, or by government);
- Critical dates verification (none, best-before date, or best-before plus packaging date);
- Price relative to the current market price (−25%; current price; +10%; +25%).

Key findings

Generally, in most markets and product categories, being able to verify critical dates had the most impact on product choices by consumers. In fact, not identifying critical dates has a negative impact on product choice to the extent where most consumers will not buy. Therefore, having best-before dates on seafood packages did not necessarily yield a premium (especially in the canned category, where perishability is not as significant a consideration). In short, having best-before dates represents a fundamental requirement. The small incremental increase in consumer preference between best-before dates and best-before dates plus packaging dates indicated that consumers did not necessarily differentiate between

Figure 23–Venn diagram of the collaborative cluster for the 3 classes of benefits.

the 2 attributes; they simply value at least one of those attributes on the package.

The 2nd most impactful attribute for consumers was sustainability verification; and this finding was consistent across seafood types in Western markets. However, while verification of sustainability claims was found to be important to consumers, the type of certifying body (manufacturer or retailer, independent 3rd party, or government) was less important. Nonetheless, in most markets government agency verification was preferred to a 3rd-party certifier or certification by the manufacturer or retailer.

Production method verification was the 3rd most impactful attribute on consumer choice. In most categories, across all markets, verifying wild-caught seafood production had more impact on demand than verifying farmed production. In some instances, the identification of the production method was more important than the difference between farmed and wild; whereas in other cases, verification of aquaculture products had little impact on product choice compared to no verification, whereas wild had a significant impact.

In most of the 5 countries studied, species verification was not a strong driver of consumer choice. This finding runs counter to claims often heard by media and other sources. Understanding the impact of price on product choice is more complex, potentially because premium species were already linked to premium market prices, and respondents were unwilling to pay a further premium for the reassurance of species by verification.

Examples of the more detailed insights are presented in Table 8, which compares a small selection of different products and markets from the survey data. Notably, these examples reenforce the insights from the case studies reported above in terms of consumer choice regarding species and sources by market. The data from the consumer surveys emphasize the importance of businesses basing decisions on factual analyses, rather than incorporating assumptions made within the seafood sector.

Details of the Ipsos report are provided in Section "Consumer Research." A PowerPoint presentation of the findings is also available at www.globalfoodtraceability.org and covers:

- Purpose and Methodology (visuals 3 to 4)
- Using the Discrete Choice Simulator (visual 5) based on the choice-based conjoint study
- Summary of key findings, addressing consumption patterns by species, and the influence of product attributes (visuals 6 to 10)
- Seafood purchasing and consumption, addressing for each product and market:
  - consumption pattern of whether eaten at home or in restaurants
  - frequency of purchase as fresh, frozen, canned, or other
  - where purchased, such as supermarket, grocery store, seafood store/market, direct from fisherman, and so on (slides 11 to 26)
- Importance of product attributes in each market, presented in the order of production method verification; critical dates verification; sustainability verification; species verification (visuals 27 to 54)
- Importance of different sustainable fishing practices, for example not overfished; not impacting other marine animals; not damaging reefs/habitats; audited (visuals 55 to 59)
- Relative importance of source of verification (that is, by government, independent association, manufacturer, or retailer (visuals 60 to 63)
- Perceptions of whether fishing in different sources is sustainable (visuals 64 to 68)
- Demographic analysis of respondents (visuals 69 and 70)
- Product isotherms by country, derived from the simulator (visuals 71 to 104)
- Product prices used in the Discrete Choice Model by country (visuals 105 to 109)

Research limitations

The research had certain limitations, which are addressed in recommendations for future research. The limitations were:

1. The research examined primary shoppers' self-reported attitudes, rather than exploring their actual behavior. Increasingly, loyalty card data can be used to triangulate findings, as well as testing shoppers' reaction to different product attributes, for example by piloting new products, or new information, through point of sale or other marketing media.
2. Consumer attitudes are dynamic, and research of this kind can only take a snapshot. For example, several case study participants mentioned some shoppers' choices are influenced by NGO campaigns and media stories, at least in the short term.
3. While consumer preferences and shopper behavior are significant factors in making investments in new product attributes, including those derived from traceability, they need to be considered alongside the decision-making process of retailers as gatekeepers to the market. Retailers' priorities from products and especially for suppliers' service may be quite different from those of consumers/shoppers. As part of this, retailers will consider the specific market segment they serve, and several retailers involved in the case studies commented that more affluent and higher educated shoppers took much greater interest in issues around sustainability.
4. In responding to a survey, shoppers may report that particular factors have greater influence on their decisions, but in reality they may trust their chosen retailers to have already considered these issues in selecting which products to sell. Similarly, some retailers may be looking to build their "green credentials," knowing that this may drive traffic, even if it does not affect the individual purchasing decisions that shoppers make. Indeed, a couple of interviewees during the case studies mentioned that the requirements of some retailers are considered to be ahead of their shoppers' expectations.

Discrete choice simulator

The responses from the choice-based conjoint study were used to populate a Discrete Choice Simulator, which is available free-of-charge at www.globalfoodtraceability.org. The choices that respondents made are consolidated by the simulator to predict the market share split between any 2 products with 2 hypothetical sets of attributes. There are 3 steps to using the simulator:

1. Choose a product: shrimp/prawns, salmon, or tuna, and then select either fresh/frozen or canned format.
2. Choose the target market, either the United States, the Netherlands, Germany, China, or Canada, or a combination of these 5 countries. As you will see each is given a different weighting based on market size. The choice of countries determines the weightings applied to each attribute, based on the consumer research findings.
3. Test 2 contrasting sets of attributes, selected from among:

Table 8–Overview of consumer research findings.

	Fresh/frozen salmon: Germany and United States		Fresh/frozen tuna: United States and the Netherlands		Canned tuna: United States and Canada		Fresh/frozen shrimp: United States
	Germany	United States:	United States:	Netherlands:	United States:	Canada:	
Overall rankings	Price 29% Critical dates 26% Sustainability 21% Production 15% Species 8%	Price 27% Critical dates 22% Sustainability 21% Production 21% Species 9%	Critical dates 29% Price 23% Sustainability 20% Production 20% Species 8%	Critical dates 32% Price 27% Sustainability 23% Production 14% Species 4%	Price 30% Critical dates 28% Sustainability 23% Production 14% Species 4%	Price 28% Critical dates 24% Sustainability 21% Species 15% Production 12%	Price 32% Critical dates 32% Sustainability 23% Production 12% Species n/a
Production: Wild or farmed	Both these markets valued wild-caught above farmed salmon, but this difference in consumer value was much greater in the United States, where it was a very significant driver of choice.		While farmed tuna is very rare in both countries, Americans placed greater overall weighting on having production method on the label: 20% influence compared to 14%.		While farmed tuna is rare in both countries, production method matters less to Americans when choosing canned tuna than when choosing fresh/frozen tuna (just 14% weighting, compared to 20%).		Wild shrimp is valued 19% higher than when not identifying a production method; farmed shrimp is valued 10% higher
Species verification	In both countries, for pink salmon species verification added value (15% in the United States and 12% in Germany), whereas verification of sockeye had very little effect on consumers' willingness to pay in either country.		Americans placed twice as much emphasis on species verification for fresh/frozen tuna than for canned tuna, but this factor still only accounted for 8% and 4% of decision making.		Canadians valued verification of species much more highly than Americans (15% influence on decisions, compared to just 4%) and they especially valued skipjack, even giving albacore a negative value—worse than no verification.		n/a
Sustainability verification	In all these cases, sustainability verification by government agency is valued more than by an independent 3rd party, and verification by manufacturer or retailer was valued only marginally more than no verification. In all cases, sustainability verification was associated with notably less perceived consumer value.						This was the only product for which certification by a manufacturer or retailer was valued higher than by an independent 3rd party.
	The response to sustainability verification was very similar in both countries. Compared to other products, the lack of verification had a very negative response.		Dutch consumers applied slightly greater weighting to sustainability.		Little distinction was seen between U.S. and Canadian consumers. The preference for verification by government agency was stronger for canned tuna than fresh/frozen.		
Critical date verification	German consumers had a slightly stronger preference than U.S. consumers. The lack of any verification caused a stronger negative reaction for fresh/frozen salmon than it did for fresh/frozen tuna.		Uniquely among the products tested, critical date verification ranked more higher in perceived value than price. The verification using best-before and packaging date together was preferred to just best-before date.		Both markets rated this as the 2nd most significant driver after price.		Critical date information was as influential as price for fresh/frozen shrimp in the United States.

Table 9–Discrete choice simulator results: illustration 1.

Product: Canned tuna			
Market: United States			
	Weighting	Product A	Product B
Production verification	14%	Yes: wild	Yes: wild
Species verification	4%	Yes: albacore	Yes: albacore
Critical date verification	28%	Yes: best-before date	Yes: best-before date
Sustainability verification	23%	None	Yes: by government
Price	30%	Current market price*	10% above market price*
Relative market	29%	71%	

*When completing the survey, respondents were given the price that this represented. Product A = US$1.39/5 oz.; Product B = US$1.53/5 oz.

Table 10–Discrete choice simulator results: illustration 2.

Product: Fresh/frozen salmon			
Market: Canada			
	Weighting	Product A	Product B
Production verification	18%	Yes: wild	Yes: wild
Species verification	8%	Yes: pink	Yes: sockeye
Critical date verification	22%	Yes: best-before date and packaging dates	Yes: best-before date
Sustainability verification	20%	Yes: 3rd party	None
Price	32%	10% above market price*	Current market price*
Relative market	88%	12%	

*When completing the survey, respondents were given the price that this represented: Product A = CA$13.18/lb; Product B = CA$16.49/lb.

- Production Method Verification: none/farmed/wild-caught
- Species Verification: none, then sockeye/pink for salmon, or albacore/skipjack for tuna
- Critical Dates Verification: none/best-before date/best-before plus packaged-on date
- Sustainability Verification: none, or certified by government, or a 3rd party, or a manufacturer/retailer
- Price relative to current market price: −25%/ current price/+10%/+25%

Following these 3 steps, the simulator then shows a bar chart illustrating the relative consumer preference (discrete choice) between the 2 products.

As a simple illustration, Table 9 sets out the results for 2 canned tuna products sold to only the American market. In this case, the only difference is that Product B provides consumers with verification by government that the product is sustainably sourced; but this product is 10% more expensive. Despite the higher price, the simulator predicts that Product B would achieve consumer presence by predicting 71% market share.

The simulator can explore any number of combinations of countries, species, package formats, and verification preferences. The study was limited but the simulator can handle expanded consumer buying influences.

Using the same survey data, more complex comparisons can be easily tested. In Table 10, farmed pink fresh/frozen salmon (Product A) and wild fresh/frozen pink salmon (Product B) are compared for sales in the United States and Canada, with the markets given equal weighting. In addition to a different production method, the farmed salmon had 3rd-party sustainability verification, with a 10% price premium. The simulator predicts nearly twice the preference.

Implications

The primary implications of all project research is that it describes the commercial benefits and competitive advantages that businesses operating in the seafood industry can derive from implementing traceability practices and systems. The research also identified specific differences in the extent to which businesses and market chains are using traceability to capture commercial benefits.

The benefits identified included using traceability to enhance the physical qualities of a product (for example, monitoring temperature history to manage freshness) and to reduce company-level costs (for example, shrinking inventory to reduce working capital). Traceability was also identified as an effective tool for managing or diminishing risk factors associated with the individual company (for example, maintaining tighter control of processes that impact food safety) and the wider industry (for example, mitigating the risk of sourcing illegal seafood).

These results revealed an notable dichotomy that impacts the ability of businesses to justify financial investments in traceability systems: the greater the benefits, the more ubiquitous traceability is within the company and along the value chain(s) in which they operate; however, the more ubiquitous that traceability is, the more difficult it is to precisely quantify the benefits. Many of the respondents who participated in this research voiced this very challenge. The research findings led us to identify implications that impact:

a. the extent to which businesses can capture value from implementing traceability practices and systems; and
b. the factors required to implement traceability practices and systems that are effective in allowing businesses to capture value.

The impact of each of the implications below will differ depending on individual businesses and their specific situation. Therefore, we have not prioritized them according to their expected impact on the global seafood industry.

This section of the report elaborates on the following implications:

1. The characteristics of the value chain in which a business operates influences the value that it can derive from implementing traceability practices and systems;
2. Traditional perceptions about the purpose and role of traceability are rapidly changing;

3. Attitude, equally as much as knowledge, determines which businesses derived the most value from traceability systems;
4. For the participating companies, the primary drivers and value of traceability were reducing company-level costs, improving competitive advantage, and managing business risks;
5. Profiting from traceability relies on exchange of reliable, relevant, readily accessible information;
6. For consumers, the ability to verify the authenticity of a product and critical dates (such as use-by date) are perceived as more important than production methods in making their purchasing decisions;
7. The size of a business does not determine its ability to capture value through traceability;
8. Justifying financial investment in traceability is particularly challenging for businesses supplying into the foodservice sector;
9. Upstream businesses (closer to the catch) perceive they have gained greater benefits from implementing traceability than downstream businesses;
10. NGOs can play an important role in encouraging purposeful change among businesses and consumers.

Value-chain characteristics

The sharing of information and the ability to act on the resulting knowledge is strongly influenced by the extent to which robust constructive relationships exist between businesses. This is a common finding when studying food value chains. Value formation also depends on the businesses in a chain possessing complimentary capabilities that are aligned to delivering value to target consumers. The literature review identified that these are characteristics of value chains whose members possess a shared vision and purpose in serving the market, a culture of transparency and trust, and an attitude of partnering for profit.

The current research found that businesses operating within Coordinated[22] and Collaborative value chains are able to benefit more from their traceability systems than businesses operating in Cooperative (and likely Fragmented) value chains. They use traceability to continually improve their operations in line with, sometimes even ahead of, market demands. This results in more innovative practices and focus on alignment of efforts to a common outcome. It also results in an increased ability to develop sustainable competitive advantage. Respondents noted that retailers and foodservice operators are seeking to source from businesses exhibiting these characteristics. This suggests that the competitive advantage which Coordinated and Collaborative value chains extract from traceability is likely to further increase compared to that which is possible for those businesses operating in Fragmented and Cooperative value chains.

Changing perceptions about the purpose and role of traceability

The seafood industry has traditionally viewed traceability as a means of more effectively and efficiently managing a recall or food safety emergency. The current research identified that some businesses now view traceability from a more strategic perspective.

As has occurred in industries such as aerospace, automotive, and pharmaceutical, traceability is increasingly being viewed as an outcome of a rigorous, professionally managed approach to the gathering, retention, and analysis of KDEs at critical traceability events along the value chain. Much like the "quality is free" notion that drove improvements in automotive and aerospace industries, this is leading businesses to embed traceability into the design and application of their business practices, information systems, and management processes.

The research showed that adopting this more strategic approach allows businesses to benefit from levels of transparency throughout the entire chain that were previously difficult or unattainable. With commercial transparency, businesses are able to make more rapid and assured management decisions, and then monitor their effectiveness in relation to measurable targets. In having enhanced ability to identify and then manage the root causes impacting business performance, firms are able to more effectively manage 2 of the most important influences on financial performance and competitiveness: predictability and consistency.[23] This encourages businesses to design and implement additional innovative traceability practices and systems from an entire chain perspective.

Attitude influences the value derived from traceability

The 1st implications of the research showed evidence of the influence of attitude, particularly among senior management and executives, in determining the value derived from traceability. If leaders view food traceability as an imposition that occurs "outside" of their commercial operations (for example, in response only to regulatory requirements), then the benefits are likely to be perceived as more limited. As with any other practice or system, if use of traceability is viewed unfavorably, its impact is lessened. The current research identified examples of this perception and the potential impacts on business performance.

Conversely, businesses that view traceability as an opportunity to innovate and continually improve performance derive measureable commercial benefits. This is partly due to being more likely to invest in staff training and properly implement systems that are suited to the specific business requirements. Such businesses integrate traceability into routine business practices and their wider information and communication technology (ITC) and overall operations. The implications are that the good manufacturing practices (GMP) flow from the discipline required for traceability and are characteristic of top businesses in all industries and sectors.

Primary benefits: improving efficiency, reducing risks, increasing competitive advantage

The research found that traceability improved efficiency and customer service, reduced certain risks, and increased competitive market advantage, and this resulted in significant financial benefits to participating businesses. For example, one firm stated they achieved a 50% reduction in food waste directly attributable to their traceability practices and system. Other benefits included reduced inventory (lower working capital costs), more efficient and effective recall management, and more effective utilization of labor and other resources.

The research found that some businesses operating within Coordinated and Collaborative value chains did in fact increase revenue through the implementation of traceability. Access to new markets and customers was of particular note, followed by larger market

[22]The terms Fragmented, Cooperative, Coordinated, and Collaborative are used to reflect the extent of strategic and operational alignment that exists between the businesses who together comprise a value chain.

[23]Adapted from Value Chain Management Centre (2012) *Characterizing the Determinants of Successful Value Chains*: http://vcm-international.com/wp-content/uploads/2013/04/Characterizing-the-Determinants-of-Sus-VC-031912.pdf.

share, increased security and quality of supply, and more confident development of new products. In addition, these businesses believed their operations were more market-aligned with customers and suppliers.

Traceability relies on the exchange of reliable, relevant, readily accessible information

Traceability is both a tool and outcome of businesses exchanging information that they trust. This trust is built upon practices and systems that are reliable, relevant to needs, and quickly accessible for use in decision making. Verification that the information recorded and stored is reliable and accurate is an area of increasing interest to leading seafood businesses. They foresee verification as a means to lower costs (less inventory and more confident order processing) and to allow management to trust the information.

A fundamental finding that explains why respondents indicated traceability "for its own sake" is an invalid concept is that information produced by some traceability systems and suppliers is perceived as less rigorous, verifiable, or relevant. Respondents provided specific examples and explanations of traceability systems and suppliers that they believe are relatively weak and of lower value. These research results suggest that suppliers of traceability systems had better increase their efforts in developing functionality so that from a commercial perspective their systems reinforce the reliability and relevance of the information provided by their tools to decision makers.

Consumers value authenticity and critical dates more than production methods

As described in the Ipsos consumer research, quantifying the impact of species verification on price and consumer choice is complex. The importance of species verification differs across species, the price charged, the national market, and the format in which the product is sold (such as fresh/frozen and canned). There is not a consistent strong relationship between verification of the specific species and consumer preference. This may imply that a level of consumer trust still exists, and/or that this characteristic is relatively less important than other product and label attributes.

Assurance of critical dates is strongly linked to product quality and safety. For fresh products, in the absence of catch dates and other quality information and sensory indicators, consumers tend to use the best-before date as an indicator of freshness (the more distant the best-before date, the fresher the product is perceived to be). Although seafood companies would argue that freshness is the result of a complex set of production- and product-handling decisions within the supply chain, consumers are not interested. They are looking for clear and unambiguous indicators on which they can base a buying decision.

A recommendation for further research is to investigate different metrics for freshness/quality and product labeling/communication and their impact on consumer behavior. Different metrics and product labeling/communication may present a potent opportunity for some companies and chains to generate additional value from traceability practices and systems.

Scale does not determine ability to benefit from traceability

The research encompassed businesses of many sizes, with the total annual revenues of participating businesses ranging from US$190000 to over US$60B). Overall, the research did not identify a strong correlation between business size and the extent to which businesses benefit from traceability practices and systems. Because the largest businesses were downstream retail companies, it was difficult to quantitatively isolate the impact of company size from a financial perspective. Upstream benefits are discussed below.

Qualitatively, the preliminary cost data, which were available for only one-third of respondent firms, indicate that the costs to implement and manage traceability-linked information systems were much higher on a per unit of revenue for smaller firms than larger firms. This suggests that size and the availability of resources are not the primary drivers of business traceability benefits. As described earlier, the explanation for this appears to stem from the characteristics of the value chain in which businesses operate and the influence of attitude on a company's ability to capture value from traceability.

Smaller size, in fact, may be an advantage, since smaller firms can react more quickly in dynamic markets and capture maximum advantages from traceability. However, if they do not take advantage of their nimbleness and act more decisively than larger businesses, smaller companies can quickly find themselves at a distinct economic disadvantage that is hard to redress. They may experience higher per unit costs while simultaneously attempting to capture competitive advantage on factors other than price. Larger competitors that are vertically integrated and have resources to implement traceability across multiple links along the value chain have the advantage of leveraging resources to overcome barriers to entry into new markets.

It is therefore critical that small and medium-sized enterprises understand the most effective means for them to proactively apply traceability to secure competitive advantage ahead of more resource-rich competitors. Closer strategic and operational relationships are beneficial for companies seeking cost-effective innovation. Operating within Coordinated and Collaborative value chains will likely become increasingly essential for smaller companies to benefit from traceability.

Justifying financial investment in traceability

A challenge commonly cited among respondents, regardless of their size, location, products, and packaging formats sold to consumers, is the difficulty they have had (or are having) in justifying investment in traceability. Respondents told us that the business case can be more easily established for new products or increasing production capacity (such as new equipment) of existing products than for investing in new or upgraded stand-alone traceability systems.

The primary reason for this challenge is that investment in physical products, capacity, or capabilities produces more readily quantifiable financial returns. The outcomes and benefits of traceability, however, are more diffuse: they can broadly impact a business or multiple processes of a business, and management often does not perceive a direct connection back to traceability. Even in the event of a food safety incident and recall, respondents told us that it can be difficult to show the investment on return of an upgraded traceability system. Equally, a number of respondents said that their traceability systems resulted in benefits which had not been foreseen, and so could not have been included in the original business case.

The project research shows that 3 factors typically exist before a significant investment is made in traceability. The 1st is the explicit support of owners or senior management and executives who have direct accountability for the company's success. These individuals may have experienced an incident in which investment did or did not produce distinct commercial return or benefit. The 2nd factor

is investing in an operating platform or management information system, an outcome of which is traceability, rather than investment in traceability. The return on this kind of "indirect" investment is more difficult to quantify through general accounting methods.

The challenge of justifying investments in traceability was the rationale for part of this project to be devoted to designing and developing an online seafood traceability financial (ROI) tool—to provide a simple-to-use instrument that has a disciplined process to guide a discovery of the business case for investment. The software tool examines the impact of traceability on multiple facets of a business, some of which may not have been previously considered by decision makers.[24] For example, the tool leads the user through the cost savings calculations for items like liability insurance, recall procedures, and inventory shrinkage. These savings, and others, offset the investment costs and the tool provides a net present value (NPV) chart that be used to support an investment decision.

A 3rd factor is the influence of market pressures on a business decision to invest in traceability. Participants in the research indicated that grocery retailers typically exert more pressure on their suppliers to implement traceability systems than do foodservice operators. This largely stems from differences in the drivers of consumer choice. At retail, a clearer link can often be established between traceability and the factors influencing consumer choice. The result is a growing number of global seafood retailers are differentiating themselves based on traceability credentials. In foodservice, the consumer purchasing decision is influenced more by factors that are related less to the product itself than a balance of socioeconomic considerations. These considerations may include restaurant ambiance, perceived credence value, price, the story behind the food, and overall eating experience.

Upstream businesses perceive benefits from traceability

The research showed that respondents in upstream businesses (fishing fleets, brokers, and primary processors in wild-caught fisheries; and farms, brokers, and primary processors in aquaculture) expressed relatively more consistent satisfaction with the return on the traceability practices and systems they implemented than those in downstream businesses (secondary processors, distributors, retailers, and foodservice operators). The reasons for this difference relate to the perceived improvement across a wide range of benefits that are associated with improving efficiency, driving competitive advantage, or mitigating risks.

Participants also cited that traceability enables them to mitigate the negative impact of risks over which they have no control, allowing, for example, demonstration and verification that the sourced seafood had not been impacted by a crisis or a food contamination event (for example, an oil spill). For some companies, more effective traceability helped to counter claims made against them by 3rd parties, and to distinguish themselves from another seafood company that may be implicated in unethical or illegal practices.

Some suppliers felt that traceability improves business performance, including access to and retaining of markets and customer. Traceability allowed these companies to demonstrate accountability for a reliable supply of safe, good quality seafood that meets or exceeds market expectations.

The role of NGOs

The research revealed that seafood companies commonly feel that the campaigns of some NGOs to motivate industry changes are counterproductive. Respondents indicated that NGOs could adopt a more effective and influential role by collaborating with companies on traceability issues and to translating consumer attitudes about the environment and sustainability practices into changed consumer behavior.

Changing consumer behavior is a difficult task. It is an area that has not been researched extensively in the seafood industry. Companies in the research project suggested that rather than campaigning to seek to blame the food industry, more NGOs could partner with companies to change consumer and industry behavior through more positive methods, such as public messaging and collaboration on pilots of innovative promotional, packaging, and merchandizing practices.

Recommendations

The definition of traceability, which served as a guide for the research reviewed in this report, is: "the ability to access any or all information relating to that which is under consideration, throughout its entire life cycle, by means of recorded identifications" (Olsen and Borit 2013).

The research project's objectives were to clarify how businesses are using "interparty" traceability systems to strengthen their competitive advantage from an entire product value-chain perspective, along with how and why they expected their use of "interparty" traceability to change in the next 5 y. This required the researchers to determine how traceability was being used by businesses operating at different points along the value chain and the nature of the benefits accrued. The researchers also needed to identify the relative impact of enterprise, industry, and socioeconomic drivers that are impacting the use of interparty traceability, along with the perceived and realizable value of traceability, from an entire value-chain perspective.

The research found that distinct differences exist in the extent to which businesses experience commercial benefit from traceability. Identified benefits include enhancing the physical qualities of a product (for example, by monitoring temperature history to manage freshness), reducing costs (for example, by shrinking inventory to reduce working capital), and managing or mitigating risks associated with the individual business enterprise (that is, maintaining tighter control of processes that impact food safety) and with the wider industry (that is, eliminating the risk of sourcing illegal seafood).

The study found an interesting dichotomy that impacts ability to justify financial investment in traceability practices and systems. The greater the benefits, the more ubiquitous traceability is across a business and along the value chain(s) in which it operates. The more ubiquitous traceability is across a chain of businesses, the more difficult it is to precisely pinpoint and quantify the benefits. Many of the respondents who participated in this research voiced this challenge.

The benefits of traceability were found to be allowed by or resulted from a series of common factors. This finding allowed identification of recommendations for how companies can achieve competitive advantage. By taking the company-level findings and extrapolating them to an industry-level, we established a series of recommendations for businesses, governments, and NGOs that relate to how they can balance the needs of individual businesses with the creation of a more sustainable seafood industry.

Businesses

View traceability from a strategic perspective. The research found that the benefits of traceability are greater when businesses

[24]The ROI calculation tool, instructions on its application, along with a webinar on how to use the tool are accessible at: https://seafoodtraceability.org/.

more tightly integrate traceability systems into their respective value chains. Highly collaborative chains are characterized by businesses working in concert to deliver value more efficiently to the consumer. These businesses see traceability as a catalyst for improving collaboration. As collaboration increases, the traceability system also evolves, resulting in business benefits and commercial opportunities that would otherwise not have been attained.

Respondents told us that traceability systems are not equivalent in relation to the needs and resources of individual businesses. How a traceability system is operated and applied can have more of an influence on the benefits of competitive advantage than the system's sophistication or size.

To help to decide which traceability system best suits current and foreseeable needs, we recommend that businesses 1st honestly examine which of the descriptions (Fragmented, Cooperative, Coordinated, and Collaborative) contained in the literature review and research best reflects their desired business model. Then they should consider whether to implement traceability as an element to develop closer, aligned relationships with business partners.[25] If the decision is made to implement traceability, then the system and supporting practices should be designed to motivate partners in their respective value chains to share critical data in a disciplined fashion. This requires that the data used for traceability are readily accessible, reliable, and relevant to the operations and processes fundamental to the success of each partner business. This, in turn, requires that traceability be imbedded into the design and application of each business' overall information systems.

When implementing traceability throughout the value chain, a chain captain[26] is a key factor to drive implementation and the realization of benefits. Without an influential and respected captain who motivates less willing businesses to embrace traceability by sharing their experience and knowledge, the effort required to operationalize systems will invariably lapse. This will result in suboptimized implementation and limited benefits being realized.

If trusting and aligned relationships with suppliers and/or buyers are not of strategic importance to a business, then the internal traceability system may be designed simply to perform transactional, gatekeeping functions. In this scenario, it is recommended that businesses focus on verifying that their employees follow agreed upon practices that support at least basic regulatory traceability requirements, otherwise the business may be incurring substantial risks. Internal traceability systems help to ensure that the information about the path that products follow within a business' control can be documented and verified for regulatory purposes. Training and education will still be required to help employees to adhere to the required processes.

Establish purpose and objectives before selecting technology. A traceability system does not need to be overly comprehensive or costly to be effective. Businesses operating in chains B, E, G, and H were among those stating that determining why traceability is desired is the most important factor in making a sound investment decision. Businesses should seek answers to a few probing questions about their purpose for traceability. Is traceability being implemented as a reaction to government policy and regulations? Will the traceability be used for proactive purposes, such as mitigating risks (for example, by preventing the sourcing of IUU seafood), increasing efficiencies (such as by reducing waste and associated costs), reducing capital investments (such as by lowering inventory levels), or capturing consumer value (for example, creating verifiable freshness)? Or will traceability be used for other purposes?

Once a company has identified the purpose and objectives of the intended traceability practices, then it will be in a stronger position to decide which business practices need to be supported by a system, and in turn solidify the criteria that will help it select a system that is best suited to reinforcing strategic value.

We found that the participating businesses in this research already collect the data required for most traceability requirements. Although several readily admit they are not doing so as effectively as they would prefer, generally seafood companies in this project gather the necessary data.

Transitioning from the current state to an "improved future state" can depend as much on changing practices as it does on investing in new technology. Company owners and managers should bear in mind that traceability system changes almost inevitably drive changes in business traceability practices.

Approach traceability with big vision, small steps. Traceability hinges on the ability to maintain the integrity, relevance, and accessibility of data throughout their collection, storage, analysis, and reporting. Technology will not improve processes that are performed incorrectly or which are not suited to achieving strategic business outcomes.

Most companies participating in the research had meaningful visions of where they want to take their businesses, and they advised a stepwise approach to implementation of traceability.[27] They have learned that technology can produce desired outcomes but rarely without also changing the practices among management and employees. Attempting to make overly ambitious changes can be costly and leave businesses in a weaker position than prior to attempting change (Kotter 1996).

Once a business has decided which traceability solution is appropriate, then the implementation of the technology becomes a matter of well-known stepwise project management processes: establish a project scope and charter for implementing a pilot, rigorously manage the deliverables, and regularly communicate progress to key stakeholders in the value chain. If the pilot is successful, then steadily expand the initiative across the business and (if appropriate) engage with other partners in the value chain. This approach will help ensure that the implemented traceability system provides strategic value.

Respondents uniformly believe that governments and NGOs can play an important role to play in creating an environment that encourages companies to "do the right thing" when it comes to traceability. The businesses we researched realize that they can use traceability to create economic value for themselves and the wider industry, as well as support environmental outcomes (such as sustainable fisheries). Based on the study, the following recommendations are offered.

Government

Enforce the legislation that exists. A common theme that emerged among the responses is that businesses are concerned about the tendency of governments to develop new legislation and regulations when they address an issue. While admitting this

[25]An example is Chain G, which implemented a specific system as part of strategy to establish competitive advantage via forming close progressive relationships along the entire value chain.

[26]Chain captain is a term often used to describe an individual who plays a leading role encouraging and facilitating individuals from across the involved businesses to think and act with an entire-chain perspective.

[27]Businesses operating in Cooperative, Coordinated, and Collaborative value chains described the evolution of their current system, along with how and why it would evolve in the foreseeable future.

may be required in some situations, most participants were frank in stating that a more effective approach would be one involving more consistent enforcement of existing legislation and regulations. Although to differing degrees, all of the respondents indicated that concerns such as IUU fishing is a legal, ethical, and environmental issue that governments can address by enforcing current requirements more consistently.

Enforce legislation by means that produce the intended outcomes. Enforcement includes ensuring that laws and regulations perform as intended. Participants in the research gave examples in which the intent of legislators appears ideal for creating a climate that fosters positive economic and environmental outcomes; but in practice, their opinion is that enforcement falls short. Examples included government departments that are more concerned about following a process than determining if and why the process does not produce the intended outcomes. This undermines the effectiveness of public policies, enacted laws, and regulations designed to enable and motivate the creation of an economically and environmentally sustainable seafood industry.[28]

Participating firms suggested that governments could more effectively drive the adoption of traceability by encouraging companies to use traceability for business purposes and employ existing regulatory mechanisms to broaden adoption. These incentives do not necessarily need to be financial. For example, communicating and speaking knowledgably about the benefits of traceability to businesses through various government programs and communications would help encourage positive behavior more than the industry could achieve alone.

Pursue international consistency and harmonization. The lack of international harmonization on traceability policies and regulations creates weakness and limitations that are difficult for individual businesses to address. It also increases the costs of traceability. Differences in traceability requirements, technology-related policies, and regulations around the world also negatively impact the effectiveness of traceability systems (Thompson and others 2005). Lack of harmonization also creates regulatory gaps which create opportunity for exploitation. Among the 48 participants, the impact of lack of consistency and global standard requirements rated very high as 4 or 5 (on a Likert 1 to 5 scale):

- 25 respondents, in relation to the impact of inconsistency in global traceability standards
- 22 respondents, in relation to the impact of inconsistency in global food safety standards.

Harmonization of policies, regulations, and legislation are viewed by the participating businesses as precompetitive factors over which individual businesses have little if any control. Governments should play a role in partnering with leading businesses in establishing a constructive international dialog regarding regulatory harmonization to encourage the use of traceability systems that produce public good: environmental, economic, and sustainability benefits.

NGOs

Engage in constructive dialog. Traceability is critical to enabling the commercial transparency used to verify to consumers the mechanisms, practices, and journey that seafood has followed in reaching the retail store or restaurant in which it was purchased. This generally positive impact of traceability upon consumer perceptions can provide real incentive for companies seeking to differentiate themselves in the marketplace.

It is worth noting that many of the participating businesses said that an important reason for them to implement traceability is to help defend themselves against NGOs that may want to drive change by maligning their business practices.

The attitudes expressed by consumers in this research may differ from their shopping behavior. The research did not delve into behavior, so the attitudes expressed may not be actualized in buying choices. Conflicting messages from NGOs about seafood industry practices can confuse consumers and undermine the efforts of NGOs and seafood businesses that are working to ensure creation of an economically and environmentally sustainable industry.

The recommendation from this research is that NGOs find other ways of motivating changes in business behavior. Based on the consumer research we conducted, we suggest one approach would be to better understand what influences consumer behavior to purchase seafood harvested and produced in an environmentally sensitive manner.

It is recommended that NGOs focus on collaboration with industry and government on issues of importance to their stakeholders. In particular, the research in this report demonstrates there are opportunities to find other means to motivate and enable more purposeful consumer behavior. Chain captains[29] in the industry can play an important leadership role in establishing this collaborative dialog and demonstrating the necessary changes. We conclude by suggesting that the question of how to influence consumer behavior to in turn encourage seafood businesses to "do the right thing" needs further investigation.

Future Research

The seafood industry and stakeholder businesses currently face an array of challenges. The literature review and subsequent research described in this report found that there are still gaps in the information and knowledge required that would allow the seafood industry and commercial businesses to adapt to these challenges in a collaborative and effective manner.

The project we undertook investigated the level of strategic alignment and commercial relationships that exist between businesses along 9 specific value chains operating in the global seafood industry. The project examined the characteristics of the representative value chains, to understand the impacts of traceability on business performance, food waste, and consumer perceptions. The project also identified the relative impact of factors found to influence development and maintenance of traceability practices. The consumer research conducted as part of this project at a national level in 5 countries provided further insight into the factors that influence purchasing decisions about seafood, and the opportunities for businesses to create and capture value through traceability.

This project produced knowledge and foundational information for conducting further research and also insights into what additional knowledge and capabilities would allow the development of a more collaborative global seafood industry that is economically and environmentally sustainable. With this in mind, the following are recommendations for future research.

[28]The primary research identified this as being predominantly associated with developing countries.

[29]Chain captains are individuals (generally from one or more businesses) in a value chain that encourage the use of traceability for mutual benefits.

Investigate the challenges of operationalizing best practices

Building on the trust established between the research team and the businesses who participated in the study, we recommend that research be conducted in greater depth to allow development of additional recommendations on leveraging the value of traceability. Specifically:

- Investigate the challenges that executives and business managers face in using traceability at a functional level, and the implications of how this impacts businesses' use of traceability to improve operations and information flow between business partners;
- Research how traceability allows businesses to respond to market opportunities more nimbly than competitors, and identify case studies on the achievement of financial benefits that specifically lead to waste reduction;
- Examine how traceability is used to create and capture value through improved marine ecology management and other aspects of environmental and social sustainability;
- Assess training and education requirements for seafood traceability systems, and create a program of recommended methods and means that work best at increasing the effectiveness of training for various stakeholders (small, midsize, and large firms).

The goal of such research projects would be to increase the seafood industry's capability to collaborate and use traceability to improve the quality of seafood in relation to customer expectations, to mitigate environmental impact of operations, and to more effectively adapt to changing consumer attitudes and behavior.

Conduct further research into consumer behavior

The current project studied consumer attitudes and perceptions about seafood and how purchasing decisions are made. Yet it is consumer behavior that ultimately determines the success of seafood companies and the sustainability of a commercial seafood industry.

Research that quantifies the impact of traceability on motivating positive changes in consumer buying behavior is lacking. There is little empirical knowledge on how to change the behavior of consumers purchasing seafood so that they will behave as they claim they want to behave. This perhaps is not unique to seafood buying preferences, but testing the effectiveness of different interventions specifically related to traceability would help to illuminate ways of encouraging economic and environmental decisions that, in turn, will create a more sustainable seafood industry.

The discrete choice model developed during this research project could be applied to establish which marketing and merchandising arrangements should be tested and how they should be tested. The attitudinal insights from the study described here can guide the design of future behavioral research.

Motivating changes in behavior is a more complex and challenging undertaking than attitudinal change, which is itself a time-oriented process impacted by many variables. Thus, behavioral research should be time-oriented and designed to assess the relative impact of a set of chosen variables on consumer behavior. The scope for such research could include investigation of the influence of child education, of the children themselves and of the family unit in which they reside.

In this project, we discovered that there is an opportunity to evaluate loyalty card data to track the relative impact of different interventions on the purchase decisions of consumers across multiple demographics. These interventions could include aspects of traceability that influence consumer propensity to buy.

The results from the consumer survey conducted in this project suggest that consumers do not understand differences in seafood species and subspecies to the extent that industry believes they do. As an example, for sockeye salmon, consumers appear comparatively less concerned about species authentication than other attributes, such as verification of critical dates and sustainability practices. This information raises the question: To what extent do these insights hold true in relation to consumers' actual purchasing behavior and their willingness to pay? In what situations do differences in subspecies and species or species authentication matter to consumers, and among which consumer demographics and why? How much would verification of species (for example, with certified testing) cause a change in buying behavior?

We recommend that behavioral research be conducted to address these questions.

Quantify the financial impact of traceability on business performance

The current project showed that traceability can positively impact business profitability, and why it has a positive impact. Few respondents, however, shared detailed financial information associated with their traceability systems. This limited the ability to quantify the extent of the positive impact of traceability on profitability, the ROI of investing in traceability, and how to maximize the financial benefits of implementing traceability within a business or from a whole chain perspective.

Future research could build on the insights and foundation established through this project and explores the financial impact of traceability from multiple perspectives. The research could include distinguishing between the ROI and commercial benefits of traceability designed to produce business-wide or chain-length improvements in performance, compared with the ROI and commercial benefits of traceability required to access premium markets, in situations where traceability is a prerequisite.

The seafood traceability financial (ROI) tool that was developed as part of this project can help to remove this roadblock. The tool can be accessed at https://seafoodtraceability.org/. By using this readily and freely accessible calculation tool, future researchers could conduct comparative business cases in a disciplined, efficient manner.

Individual companies are encouraged to conduct before and after analyses using this tool to understand their own specific ROI.

Quantify the commercial and environmental sustainability relationship

The results of this project found that businesses can implement traceability practices and systems to improve their financial performance; at the same time, these businesses are creating outcomes that advance their operations in ways that strengthens economic and environmental sustainability. However, the project did not quantify the impact of best practices used by businesses to simultaneously produce positive commercial gains and environmental benefits along the value chain.

Future research could include investigation of how traceability can be used to implement operational improvements that directly enhance sustainability and reduce food waste. Additional research could assess the comparative financial returns that would encourage businesses to use traceability to sustain environmentally friendly processes and systems of communicating effectively with consumers (use of QR codes on packaging, for example).

Conduct scenario analysis

Initiating a study based on scenario analysis, the extent to which factors identified in this project may impact traceability ROI and evolve during the next 5 to 10 y could be understood. Such research could investigate these factors, along with their relative importance and impact, and determine recommendations for which optimal factors businesses should consider when designing and/or selecting traceability systems. By revealing the potential consequences of uncertainties surrounding the factors, the research could provide guidance and criteria for business executives to use in selecting a system that is more adaptable to changes in the global seafood industry.

The research activity might involve determining the key attributes necessary to design and implement traceability systems that can be adjusted as government regulations, retailers' policies, market demand, or technological innovation make them more attractive investments. Furthermore, recommendations might arise for how food business owners and executives should assess the capacity of alternative systems to optimize ROI in different business contexts.

Conduct comparative analysis of NGO activities

The research in this project showed that businesses believe some NGOs behave in a way that may degrade the ability of the seafood industry to improve economic and environmental sustainability. There is a need for both businesses and NGOs to better understand and consider the realities facing businesses and the mutual stakeholders that NGOs and businesses share. Further research would inform both industry and NGOs about the extent to which NGO campaigns understand and can leverage the complex market interplays that shape consumer attitudes, drive consumer propensity to purchase, and influence consumer behavior.

Research into this area would establish clarity about which industry and NGO activities are likely to be most effective in motivating purposeful changes in consumer behavior.

There would also be merit in determining what collaborative activities by businesses, NGOs, and governments could best encourage the use of traceability as an instrument to capture the economic and financial value of seafood products and encourage ecologically friendly practices.

Examine the role and value of traceability in fragmented value chains

We found that the characteristics of the value chain in which a business operates directly impacts the value that it can derive from traceability. We found that the levels and nature of the interaction of the characteristics along a value chains impacts on profitability and competitive advantage. When we approached businesses to invite them to participate in this research project, many of them used 2 important criteria in deciding to participate. First, they already believed in the business value of traceability and, 2nd, they had strong relationships with a business or individual that championed their involvement.

This approach precluded businesses that operate in the 1st level of interaction, which we consider and refer to as Fragmented value chains. The companies in these types of chains (small, midsized, and large) did not see value in food traceability. This type of chain is typical of a significant portion of the seafood industry and needs to be addressed.

We suggest that research be conducted to examine the role traceability can play in helping businesses in Fragmented chains to better understand how traceability helps manage risk, reduce costs, and increase relative competitive position. Such research would help illuminate the potential value of traceability in addressing structural questions about the seafood industry. How does operating in a Fragmented value chain impact the desire to use traceability systems compared with businesses in more strategically and operationally aligned value chains?

Further research could also investigate:

1. Best practices used by businesses that proactively adopt traceability;
2. The role of traceability in influencing business practices within Fragmented chains and influence on economically and environmentally beneficial outcomes; and
3. The role of traceability in motivating businesses to strengthen business relationships and resulting in more strategically and operationally aligned chains.

Conduct an international policy assessment

The literature review and research reported here highlighted the challenges associated with compliance and traceability in a global marketplace, which includes the complexities that stem from a lack of harmonized regulations and policies existing between nations.

For example, Canada and the United States are important seafood trading partners. The Canadian Food Inspection Agency (CFIA) lists nearly 800 species of seafood, while the U.S. Food and Drug Administration list more than 1800 species. The similarity in species listed between these 2 lists is approximately 500 species. The extent of misalignment in listed species creates substantial transactional challenges on businesses as they seek to comply with traceability requirements, whether voluntary or those subject to regulation.

Addressing issues such as these begins by understanding the scale of the problems that impact trade, compliance, traceability, and associated costs. An international policy assessment would help quantify the extent to which such misalignments exist between jurisdictions, and the scale of their potential impact on commercial businesses and the seafood industry.

Role of traceability in information flow up the value chain

A two-way flow of information is central to prosperous value chains and individual businesses. The researchers investigated the role and value of traceability in aiding information flow downstream toward the consumer. The study did not investigate the role and value of traceability in helping information to flow upstream, from the consumer and market back to the businesses that can then convert that information into new product ideas.

Questions that an "upstream study" could answer include: How can traceability be used to capture information on consumer attitudes and behaviors and feed it back up the chain? What value would this capability create? How would it give businesses more ability to adapt to changing market and consumer demands and more effectively and efficiently fulfill those demands?

Determine which combination of drivers most impacts traceability adoption

The research identified a combination of internal and external factors that drive the participating businesses to adopt traceability. To differing degrees, internal and external drivers (such as government regulations, mandated customer requirements, and changing consumer attitudes) lead businesses to imbed traceability into their management information system.

The study did not investigate which combination of internal and external drivers have the greatest effect on motivating businesses and entire value chains to adopt specific types of traceability systems. Such research would inform the seafood businesses and

industry about which combination of drivers are likely to result in deployment of a traceability system, in which situation, and why.

As more governments institute regulations that will encourage businesses to implement traceability, knowing which combination of drivers work most effectively is worthy of further investigation.

Conduct comparative research in other food sectors

The research in this report focuses on seafood, and it is believed to be one of the 1st of its nature and scope. The project sets a benchmark for better understanding the business case for seafood traceability, and led to development of a method of investigation through which the results we report were documented. This outcome presents an opportunity to apply the approach we used and lessons we learned to further assess the business case for traceability in other sectors of the broader food industry.

For example, additional research could address these questions:

- How does the role and value of traceability in the beef industry (or any other sector) compare to that for seafood, and why?
- What factors influence the adoption and evolution of traceability in other key sectors of the food industry? What lessons can be learned?
- What do our findings show about the factors influencing the implementation traceability practices and systems, and the extent to which helpful factors and barriers transcend sectors or may differ between countries?
- What does this other research imply about advice concerning government policies, programs, laws, and regulations?

Research across multiple sectors from a global and whole chain perspective would provide substantive beneficial insights that would strengthen the ability to motivate the development of more effective food traceability.

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Appendix A: Checklist for Determining Potential Participants' Suitability

Potential Participants of Seafood Traceability Research: Evaluation Checklist

Name of lead business *(point of entry into chain)*
Countries proposed to be involved
Country into which the chain sells *(market location)*
Proposed market type: retail or foodservice
Source stock, geographic location, ecological sustainability
Proposed species
Estimated annual turnover of lead business

Topic or Factor	Level of confidence, relevance to study 1	2	3	4	5
General criteria (rechain or business that will act as entry into the chain)					
Considered an exemplar user of traceability					
We are confident that it can produce a business case on traceability					
Confident that findings will be generalizable to other parts of industry					
Confident that it will address gaps in current knowledge					
Business/chain is involved a sector that is experiencing significant change					
Business/chain faces distinct challenges that research could help address					
Business/chain likely to view project an as important opportunity for them					
Subtotal	**0**	**0**	**0**	**0**	**0**
Geography					
Chain encompasses more than one country					
Chain located where interviews/visits are practical					
Chain supplies market that can provide valuable consumer insights					
Chain sources from a market that can provide valuable research insights					
Subtotal	**0**	**0**	**0**	**0**	**0**
Chain-related factors					
Belong to a definable chain, that can be mapped and analyzed as a unit					
An influential business exists that will ensure others' participation					
Is an identifiable senior person that will champion others' participation					
The champion acknowledges the importance of traceability					
A strong sense of collaboration exists among the involved businesses					
Subtotal	**0**	**0**	**0**	**0**	**0**
Relationships/Culture					
Entry point to chain is a learning organization which champions learning					
Lead influencer within chain is not a defensive business					
Lead influencer has a close trusting relationship with the researchers					
Likely willing to confidentially share information of a sensitive nature					
The involved business share close trusting relationships					
Chain or lead business has previously participated in research					
Subtotal	**0**	**0**	**0**	**0**	**0**
Total	**0**	**0**	**0**	**0**	**0**

Appendix B: Implications of Findings Identified in the Literature Review

Definition of traceability: the ability to access any or all information relating to that which is under consideration, throughout its entire life cycle, by means of recorded identifications" (Olsen and Borit 2013).

Findings and implications	Value of traceability	Consumer	Value-chain analysis	Regulations
Knowledge gaps	Few business case analyses of traceability, especially from a practical perspective of implementation.	Influence of traceability in shaping consumer behavior in specific markets, by species.	Cultural, structural, and management determinants of creating value from traceability.	Extent to which regulations may impact business costs and opportunities.
Why gaps exist	Typically, analysis has focused on technology and equipment aspects of traceability; direct costs; and food safety impacts.	Focus has been seafood *per se* and on consumer attitudes, many from only a regional perspective.	Scant objective chain length analysis of the seafood industry *per se*, not just on traceability.	Little objective analysis of why existing regulatory and legal systems are not driving traceability.
Research needs	Quantitative and qualitative analysis of costs, benefits, ROI/NPV, by value-chain member; focus on key determining factors.	What is the influence of traceability and its outcomes on consumer behavior, by species across demographics?	To what extent do business decisions reflect consumer value; does implementation and benefits reflect degree of collaboration?	Why is the broader voluntary adoption of chain length traceability lacking globally?
Findings and implications	**Standards**	**Wild compared with Aquaculture**	**Industry power**	**Species**
Knowledge gaps	Extent to which a lack of technical standards is impacting value proposition of traceability systems.	Comparative use and benefits of traceability to each process and why.	Extent that power has shifted in favor of aquaculture and to developing nations.	Comparative shifts of supply and demand in species and products in existing compared with emerging markets.
Why gaps exist	No multilateral agreement on technical standards for traceability. No analysis of resulting impact this is having on the food industry.	Little quantitative comparative analysis from structural, process, market perspectives.	Lack of comparative analysis conducted into the global seafood industry and its subsectors.	Assumption that existing and traditional markets will remain the dominant players.
Research needs	What changes in uniform technical requirements are needed, and what is the potential impact on industry?	What are the cultural, structural, scale, and production factors in each sector on value of traceability?	What is the future interplay between production and supply? Where, why; what will be outcomes?	What is the value of traceability for minimizing risks as shifts occur in species demand, production, and markets?

Appendix C: Quantitative Results from the Seafood Traceability Survey for 9 Market Chains

Introduction

A comprehensive interview was conducted with each of the 48 firms representing 9 seafood value chains.[30] A survey questionnaire included both closed and open-ended questions designed to provide detailed information on the characteristics of each firm and their opinions about traceability and its costs, benefits, and value for mitigating risks. This report summarizes the quantitative results from the survey. The results are organized in 2 parts: *Part I. Overall Analysis,* and *Part II. Comparisons of the Cooperative, Coordinating, and Collaborative Market Chains*. Most of the results are presented in tables and bar graphs. For some data, statistical analyses (means tests) are used to determine statistical confidence of the results. Means tests were not valid for analyses in Part II given lack of independence between chain clusters (when same firm was found in multiple clusters).

Part I: Overall analysis

General perspectives. Forty-eight firms representing 9 value chains were surveyed. Of the 48 firms, 24 had a base of operations in North America, 11 in Europe, 11 in Asia, and 2 in South America. Most of the individual firms surveyed participated in more than one activity (such as processing and distribution). Of the 48 firms surveyed, 11 of them participated in fish farming and/or wild capture, 26 indicated they participated in primary and/or secondary processing, 19 participated in distribution, and 17 participated in either retail, restaurants, or foodservice. Twenty firms surveyed were classified as "small" (having annual sales of $100 million or less), and 28 were classified as "large" (with annual sales greater than $100 million).

In order to preserve the anonymity of the firms that participated in this research, market chains are coded with a letter from A to I (consistently throughout the report). It is important to note that some firms were included as a part of more than one chain—for example, when the market location for 2 separate species was the same. There were a minimum of 4 firms, a median number of 6 firms, and a maximum of 10 firms surveyed per chain.

Firm characteristics. Among the surveyed firms, downstream[31] firms were generally much larger in terms of annual sales and number of employees (Figure C1).[32] There was also significant variation in these metrics between chains due to the fact that some chains contained large retail corporations in the downstream end, while other chains' retail outlets were much smaller.

[30]The term value chain describes the businesses who perform the activities required to catch (wild) or produce (aquaculture) seafood, then process and distribute for sale to consumers in retail or foodservice.

[31]Throughout this section, *upstream* refers to those firms that engaged in any of wild capture, aquaculture or primary processing. *Downstream* refers to those firms that engaged in distribution, secondary processing, and retail activities. There were 22 firms classified as "upstream" and 26 firms classified as "downstream" in this study.

[32]When reading a box and whisker plot, the box represents the middle 50% of the data, from the 25th to the 75th percentile. The median is represented by the line that separates the box into 2. The mean is represented as a "+". The minimum and maximum values are represented by the ends of the whiskers.

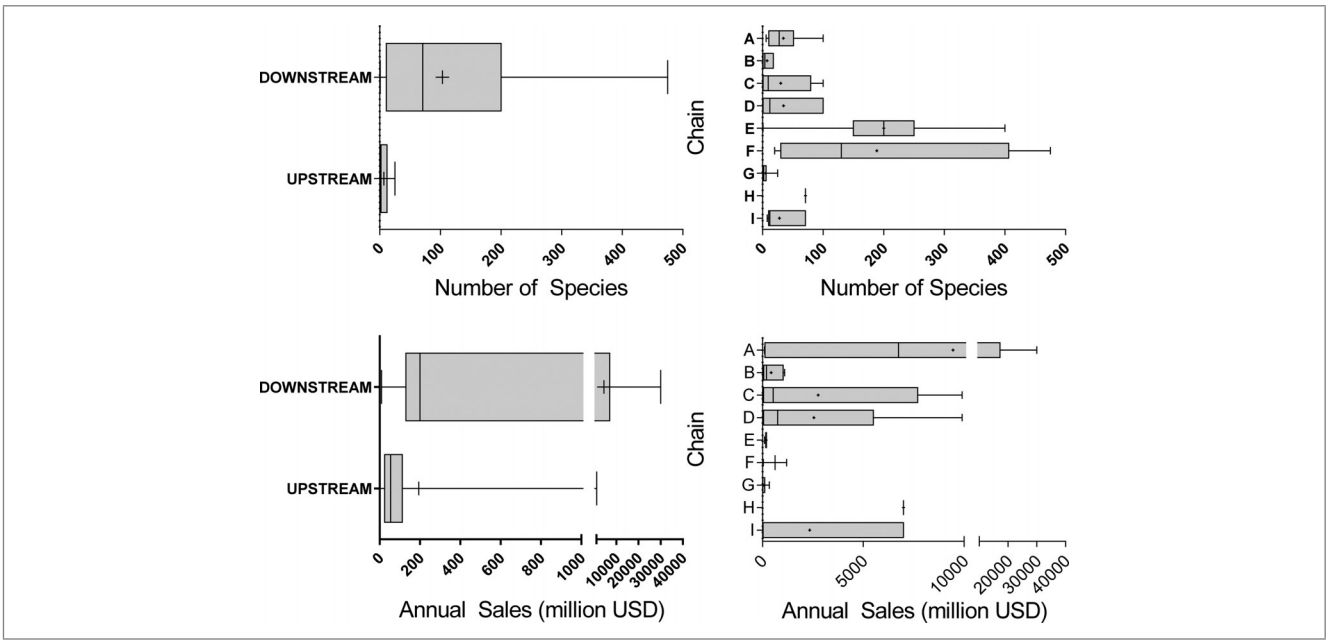

Figure C1–Box and whisker plots of the annual sales and number of species which individual firms handled. Of the 48 firms in the study, all are represented in the "number of species" graphs while 44 offered annual sales information.

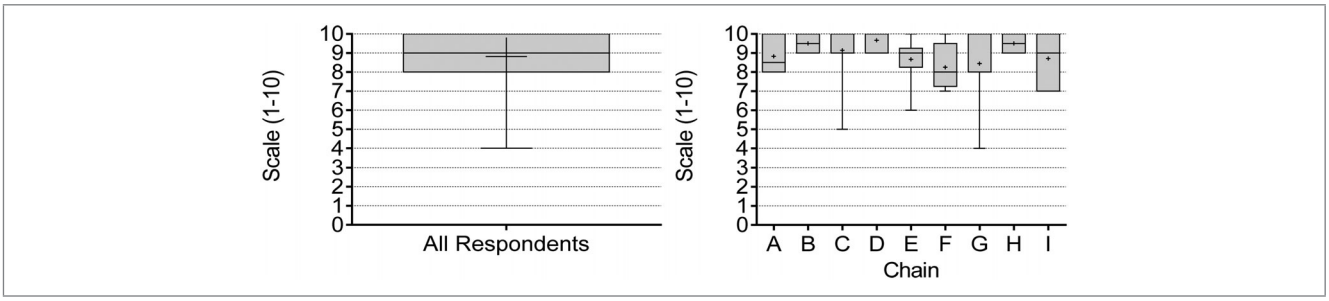

Figure C2–The importance of traceability to the success of a firm's business for all respondents and individual chains (1 = completely unimportant, 10 = extremely important). A total of 47 of 48 respondents offered an opinion regarding traceability importance.

Of the firms surveyed, there was an extremely high correlation (more than 0.90) between those firms in the downstream section of the supply chain and those firms that had annual sales greater than $100 million per year. It was, therefore, not possible to disentangle the effect of firm size from effects stemming from the position of the company in the supply chain. Throughout this report, therefore, the analysis for upstream firms is roughly synonymous for "small" firms (those with sales less than $100 million per year), and the analysis for downstream firms is roughly synonymous for "large" firms (those with sales greater than $100 million per year).

Importance of traceability. A consistently strong message that transcends the size of firm, and its location in the value chain, was a firm's belief that traceability systems are important to the success of their business (Figure C2).

While traceability was of similar importance to both downstream and upstream firms, its importance to downstream firms increased markedly when considering certain species and their source. These distributors and retailers were particularly concerned about the ability to trace seafood sourced far from the final market (such as tuna and shrimp from Southeast Asia), as well as products carrying ecolabels such as "dolphin safe" tuna.

KDEs and GS1 standards. The KDEs that were the most important to firms from a traceability perspective were *when* the product was harvested or processed, and from *where* it originated (Figure C3).

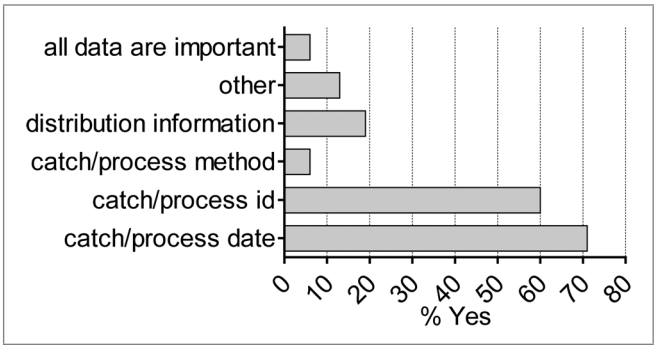

Figure C3–The percentage of firms indicating that a particular KDE (Key Data Element) is important.

GS1 standards regarding the identification of products, information captured in a bar code or other electronic-based mechanism, and the sharing of such information are widely used in the seafood industry. Approximately 50% of the firms surveyed used GS1 information standards. This indicates that many firms find benefits

in adhering to universal standards which are perhaps more flexible in an international business environment than nonstandard approaches. Of the firms that used GS1 standards, most were at either the item level, batch/lot level, or both.

The majority of firms surveyed had implemented their current traceability system within the last 8 y. The majority of firms (92%) used an all-electronic system or combination of paper and electronic means. Many traceability systems were integrated with a business resource enterprise program (ERP) such as SAP.

Attitudes. Most firms adopt traceability systems voluntarily. When asked for a statement that most closely reflects their opinion, approximately 80% of firms said that "*traceability is a necessary cost of business in order to reduce exposure to business risks*." Approximately 65% of firms indicated that "*traceability enables us to manage our business more successfully than otherwise possible*." Over half of respondents indicated that traceability is essential for fostering relationships with their downstream clients, such as consumers and retailers. Less than 30% of firms indicated that traceability was forced on them by 3rd parties such as ecolabelers, and less than 40% indicated that traceability was mandated by regulation.

Traceability training. Of the firms surveyed, 94% trained at least some of their employees in the use of traceability, although only 33% trained all of their employees. Upstream firms were more likely to train all of their employees but were also more likely to have a fewer employees, indicating that the proportion of a firm's activities that affect, or are affected by, their traceability system is higher the closer to the source a firm is. Firms that trained their employees in traceability did so for an average of 7.5 h per year (Figure C4). Interestingly, while upstream firms trained a higher percentage of their employees than downstream firms, they spent fewer hours training them—a mean of 4 h per year per employee compared with 14 h for downstream firms. This may be due to greater reliance on direct supervision and mentoring by upstream firms.

The 1st and 2nd most cited method of training was internal company workshops (50%) and mock recalls (40%).

Implementation challenges. Most firms implemented the most recent version of their traceability system within the last 8 y. Approximately 35% of respondents reported that no significant challenges were faced during implementation. While a similar percentage reported challenges arising from their immediate environment (budgetary, technical), the most common implementation challenges were caused by difficulties arising from the behavior of other firms in the supply chain (44% of respondents indicated this problem). This suggests that benefits of traceability are likely to be higher when members of a supply chain are closely aligned, rather than fragmented.

Costs of traceability

Monetary costs. More than half of the respondents did not have financial understanding of their firm's traceability system knowledge and were unable to share costs on implementation and maintenance. Of those firms that did respond, most provided costs for the larger information system (such as ICT (Information Communication Technology) and ERP (Enterprise Resource Planning)) since traceability systems were embedded within the ICT system.

Results revealed that implementation costs were larger than maintenance costs. However, as a percentage of annual sales, large firms (those with annual revenues of over $100 million) incurred implementation costs that were on average lower than maintenance costs, and proportionately small at 0.01% and 0.03%, respectively. Small firms (those with annual revenues of less than $100 million) spent on average 1% of annual sales to implement a traceability system, but an average of 3% to maintain it. Smaller firms, therefore, spent a significantly higher proportion of earnings (10 times higher) than large firms on implementing and maintaining their traceability system. See Figure C5.

Payback and ROI. Taking a low response rate into account, nearly 30% (about 65% of those that provided information on this topic) of firms indicated that they calculate payback time on the order of 3 to 5 y, and 17% (about 50% of firms that provided information) indicated that they expect a modest ROI of between 2% and 5%. While there is no information to suggest that payback actually occurred, this indicates that some firms were expecting payback within this time period, and were expecting a positive ROI.

Expectations. Before implementing their current traceability system, the median firm[33] expected that the system would enable them to make better and more informed business decisions at 7 on a scale of 1 to 10. After the system was implemented, the median score had risen to approximately 8 of 10. Seventy-five percent of firms showed a positive change in opinion from before implementation to after implementation of their traceability system, indicating that the benefits of implementing a traceability system surpassed their expectations. A Wilcoxon-signed rank test was conducted to evaluate the differences between firms in their expectations and their postimplementation opinions. The positive change in opinion was statistically significant at the $P < 0.05$ level. See Figure C6.

Benefits of traceability. The types of benefits that firms derive from the use of a traceability system are widespread. Based on a Likert scale (1 = not effective, 5 = extremely effective) respondents were asked to evaluate the effectiveness of their traceability system for generating benefits in 27 categories. Figure C7 shows the mean score for all respondents, as well as the breakdown of high, medium, and low scores overall. The 7 highest scoring benefits in order of rank were "increase quality," "improve product recalls," "improve inventory tracking," "improve food safety," "improve customer service," "respond to consumer demand," and "verify harvest date and location." Fourteen of the benefits were scored between 3 and 4, and 6 benefits were scored below 3. The 6 lowest scoring benefits, by ranking from the bottom, were "reduce input cost," "reduce administration costs," "increase margins," "increase revenue," "develop pricing models," and "increase productivity." Note that low scores were also associated with a lower number of individual responses.

To more strategically evaluate the responses, benefits were grouped according to whether they tend to: (1) drive company-level efficiency, (2) provide firm-level competitive advantage in an industry, or (3) mitigate market and operational risks faced by the firm.

Benefits: driving efficiency. Traceability systems can be used to drive firm-level efficiency such as reducing input and administration costs, reducing waste and pilferage, and increasing revenue. Figure C8 shows how upstream and downstream firms ranked the ability of their traceability system to capture efficiency benefits. The overall average score for this category of potential benefits was 3.0, indicating that traceability systems were only moderately effective at increasing company-level efficiency. The highest ranked benefits in this category were related to reducing waste and pilferage, while the lowest ranked benefits of a traceability system were related to reducing company-level input and administration costs. More than 60% and 47% of respondents indicated that their

[33]The "median firm" or "midpoint" firm implies that half of the firms scored higher and half scored lower with respect to expected benefits from the traceability system prior to its implementation.

Figure C4–Box and whisker plots showing the percentage of employees trained and the number of traceability training hours per year per employee undertaken by upstream compared with downstream firms. A total of 45 of 48 firms trained their employees in traceability. Of these, 28 offered information regarding the percentage of employees trained, and 16 offered information regarding the number of training hours per employee. A Mann-Whitney U test was performed to test for differences. While the differences in the percentage of employees trained between upstream and downstream firms were not significant, the differences in the number of training hours per employee were significant at the $P < 0.1$ level.

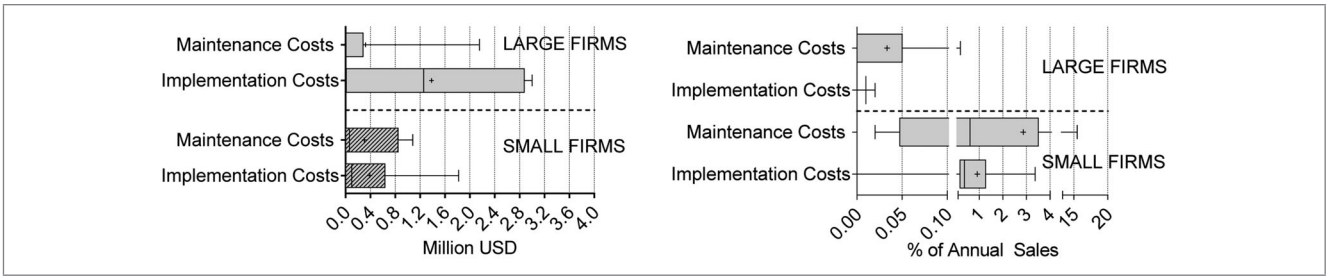

Figure C5–Costs of implementing and maintaining firms' traceability systems. Only 30% of firms were able to provide cost information.

traceability system was "not at all effective" at reducing input costs and administration costs, respectively. On average, downstream firms ranked the ability of their traceability system to effectively increase firm-level efficiency a half a point lower than upstream firms.

Benefits: competitive advantage. Figure C9 shows potential benefits related to increasing a firm's "competitive advantage." The highest scoring benefit categories included increasing product quality, responding to consumer and customer demand, and the ability to verify product characteristics, such as catch date and location. The overall average score was 3.8, implying that firms believe that their traceability system is highly effective at increasing their competitive advantage. Similar to the "driving efficiency" category, upstream firms ranked the ability of their traceability system to increase their competitive advantage higher than did the downstream firms. The most common highly ranked benefits of traceability were increasing the quality of products and responding to customer and consumer demand. More than 80% of respondents ranked these benefits as high (4 or 5 on the Likert scale); 95% and 78% of upstream firms and downstream firms, respectively, stated that their traceability system generated high benefits for improving product quality.

Benefits: mitigating risks. Among the 3 categories of benefits, the mitigating risks category generated the highest mean benefits scores (4.0). Firms indicated the belief that their traceability system is highly effective at improving food safety, reducing product recalls, and improving inventory tracking. This group of benefits was also ranked as high by a significant proportion of respondents (more than 75%). Again, upstream firms scored the benefits higher than downstream firms. See Figure C10.

Risk management and mitigation. Firms in this study faced 2 broad categories of risk. Market risks are those that potentially impact a firm's input costs and/or output prices and revenue, while operational risks are those that could potentially impact how a firm conducts its business. In addition, risks can be categorized by whether they are controllable (that is, the source of the risk is "inside" the supply chain), or uncontrollable (their source is "outside" the supply chain). Table C1 shows the broad categories of market and operational risks and their most likely source.

Table C1–Categorization of risks faced by firms as "inside risks" (those within the control of the market chain), and "outside risks" (those not within the control of the market chain).

	Type of risk	
Source	Market risks	Operational risks
INSIDE	Supply variability	Ability to verify harvest date
	New technology	Proper delivery specification
	Environmental concerns	Non/partial delivery
	Nonverification of source LOCATION	Incorrect supply forecasting
	Nonverification of source METHOD	Incorrect demand forecasting
	Nonverification of source DATE	Food safety recalls
	Nonverification of species	Poor handling
	IUU sourcing	Safety of fish
		Availability of fish supply
		Inconsistent quality
		Freshness/shelf-life
		Inappropriate labor practices
OUTSIDE	Changing regulations	Fluctuating input costs
	Inconsistent regulations	Fluctuating input supply
	Competitors' behavior	Fluctuating consumer demand
	Industry consolidation	Fluctuating prices
	Inconsistent global traceability standards	
	Inconsistent global food safety standards	
	Subjective 3rd-party verifications	
	Inconsistent global technology standards	

Respondents were asked to score each type of risk according to its influence on shaping their business decision. Figure C11 and C12, respectively, shows the 10 highest ranked risks that, on average, impacted upstream and downstream firms' abilities to conduct business. Upstream firms were most concerned about

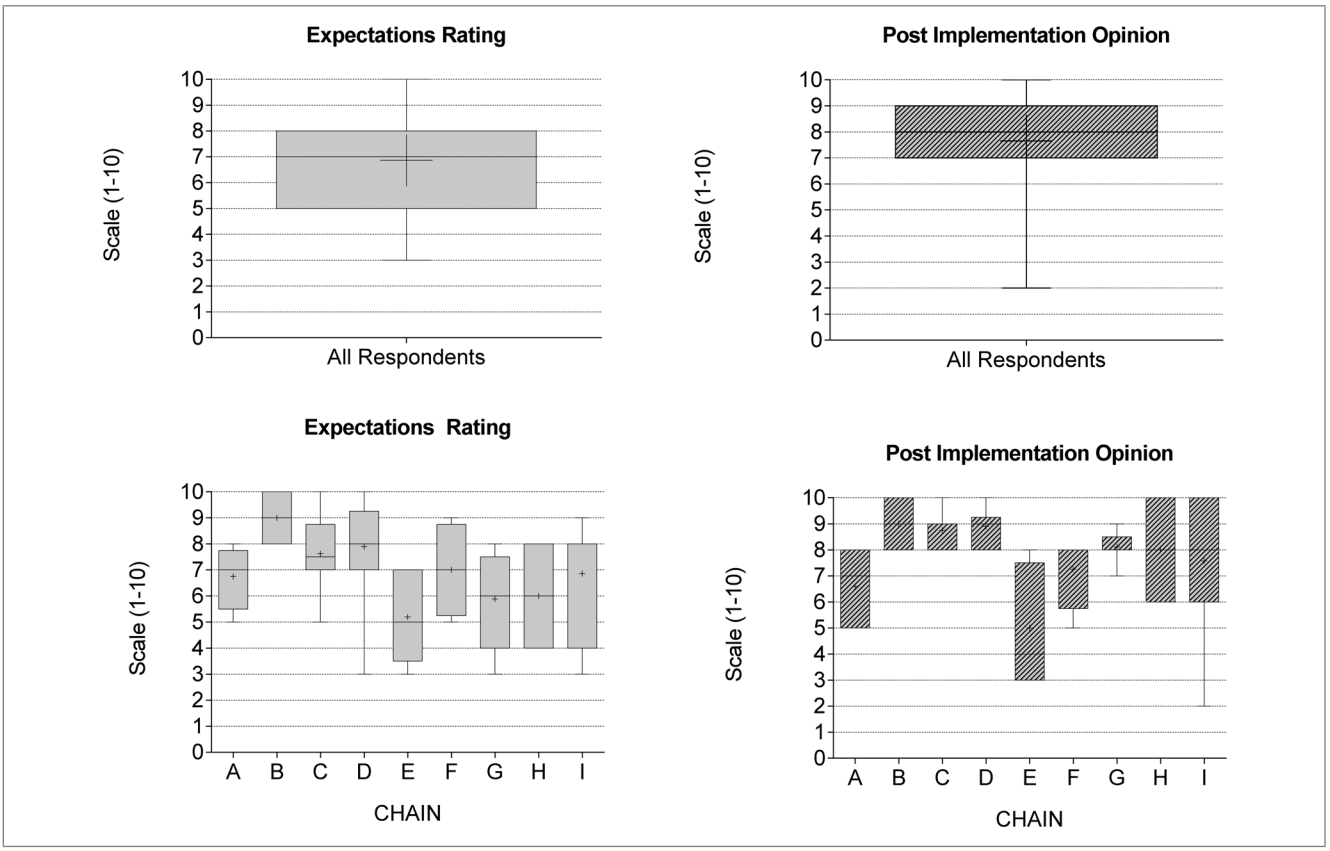

Figure C6–Expectations of the effectiveness of a firm's traceability system to help make business decisions compared with the postimplementation opinion of those firms. Responses are on a scale of 1 to 10 (1 = not effective, 10 = extremely effective).

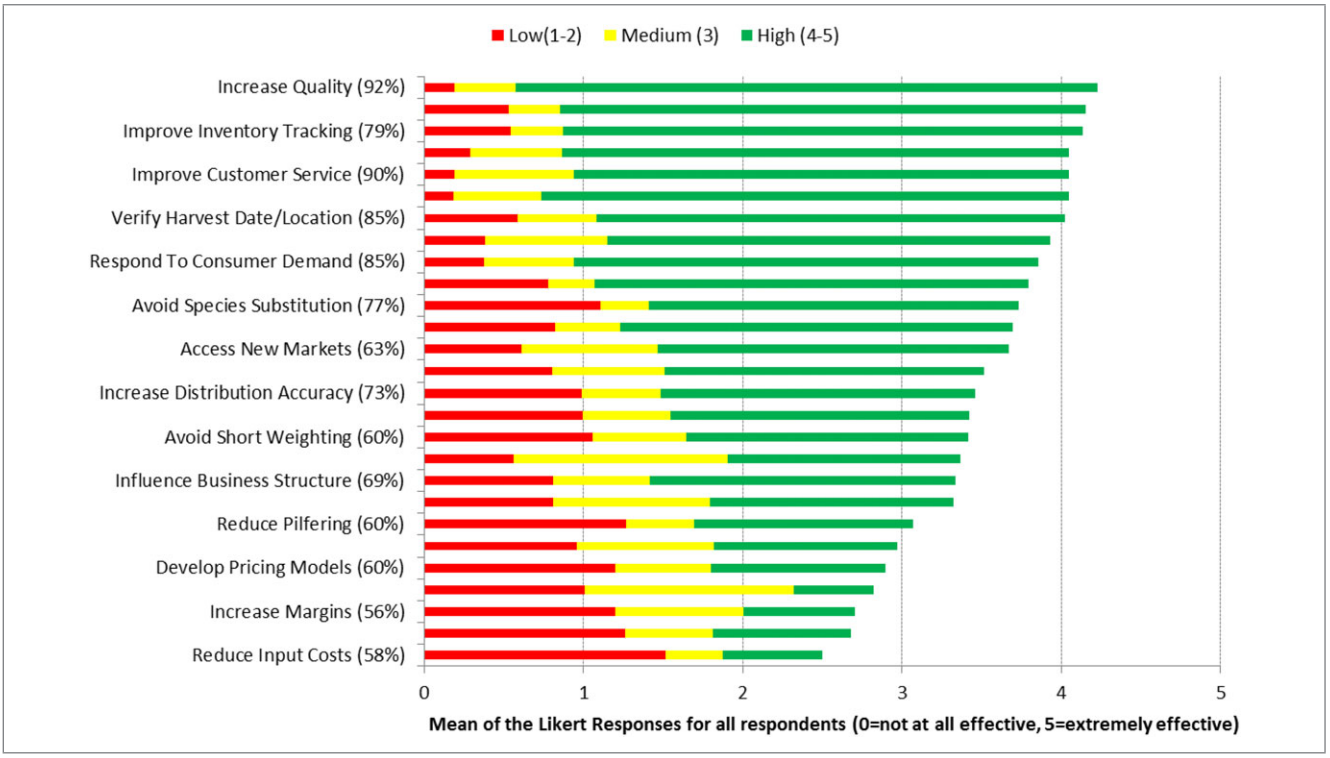

Figure C7–Benefits of traceability and the mean response of firms when asked how effective their traceability system has been at addressing each possible benefit. The proportion of high, medium, and low scores for each benefit are shown. The probabilities to the left of each benefit category indicate the proportion of firms responding out of a possible total of 48. Those not responding either did not respond, or indicated "no knowledge" or "not applicable."

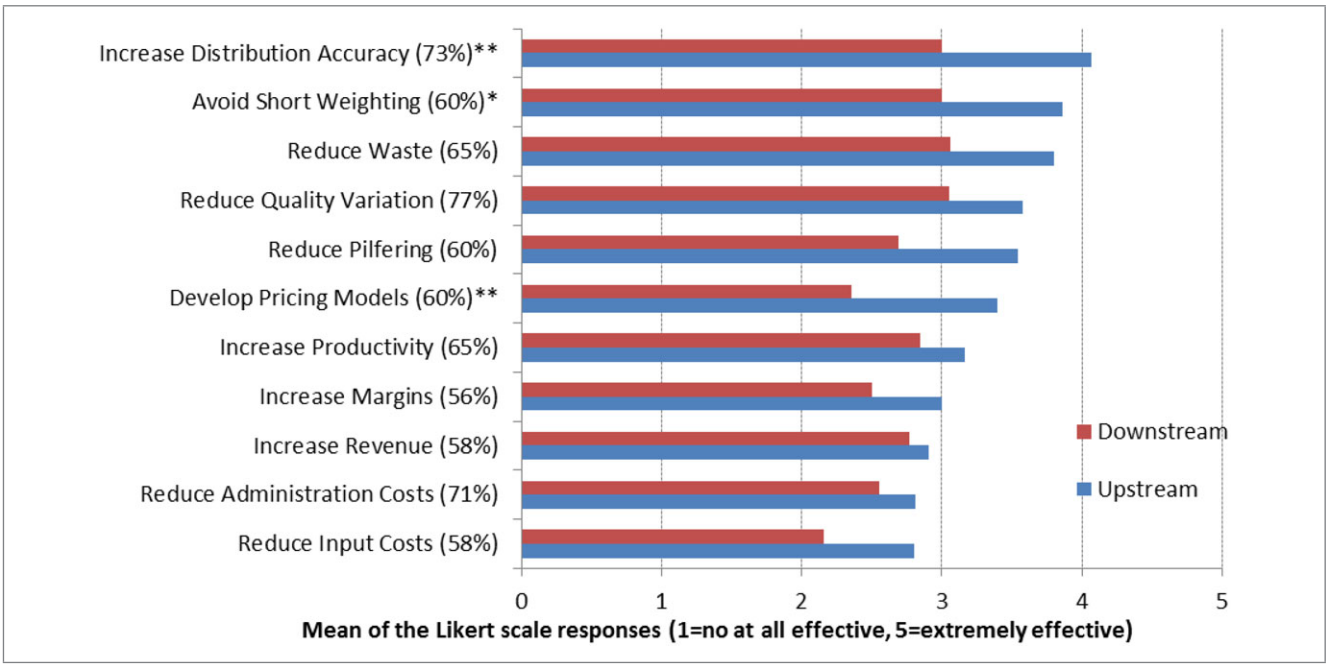

Figure C8–The mean of responses for both upstream and downstream businesses on "effectiveness" of a firm's traceability system in generating benefits that "drive efficiency." Response rate of a total of 48 possible respondents shown in parentheses. Those not responding either did not respond, or indicated "no knowledge" or "not applicable." [34]

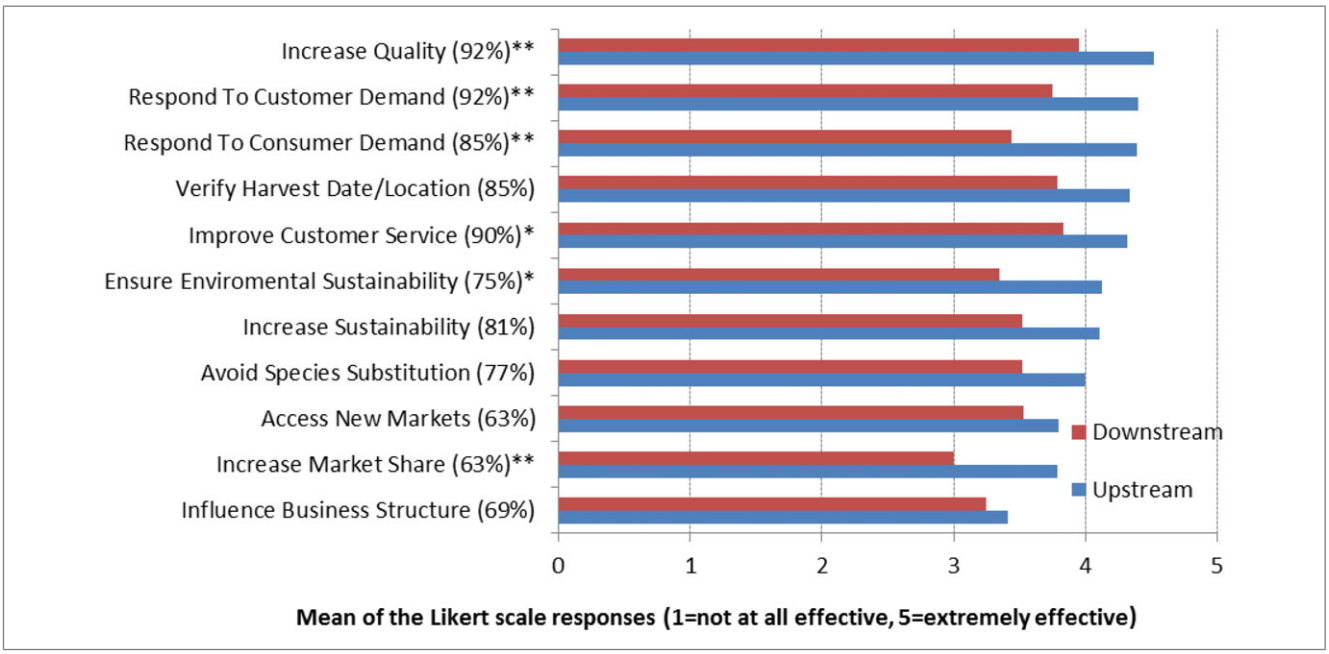

Figure C9–The mean of responses for both upstream and downstream businesses on effectiveness of a firm's traceability system in generating "competitive advantage" benefits. Response rate of a total of 48 possible respondents shown in parentheses. Those not responding either did not respond, or indicated "no knowledge" or "not applicable." [35]

risks that would impact their ability to provide a consistent and high-quality supply of fish to downstream firms, such as the availability of fish at the source and quality-related risks. Downstream firms were most highly concerned about the ability to identify a product's origin, date of harvest, and exact species. Food safety recalls and product shelf-life risks were of high concern to both downstream and upstream firms.

Figure C13 shows the distribution of the mean rankings of all firms for "inside" (controllable risks) and "outside" (uncontrollable risks) in influencing their business decisions. Although the difference in mean rankings for controllable and uncontrollable

[34]** indicates the difference in opinion between upstream and downstream firms significant at the $P < 0.05$ level, * indicates significance at the $P < 0.1$ level (two-sample t-test).

[35]** indicates the difference in opinion between upstream and downstream firms significant at the $P < 0.05$ level, * indicates significance at the $P < 0.1$ level (two-sample t-test used).

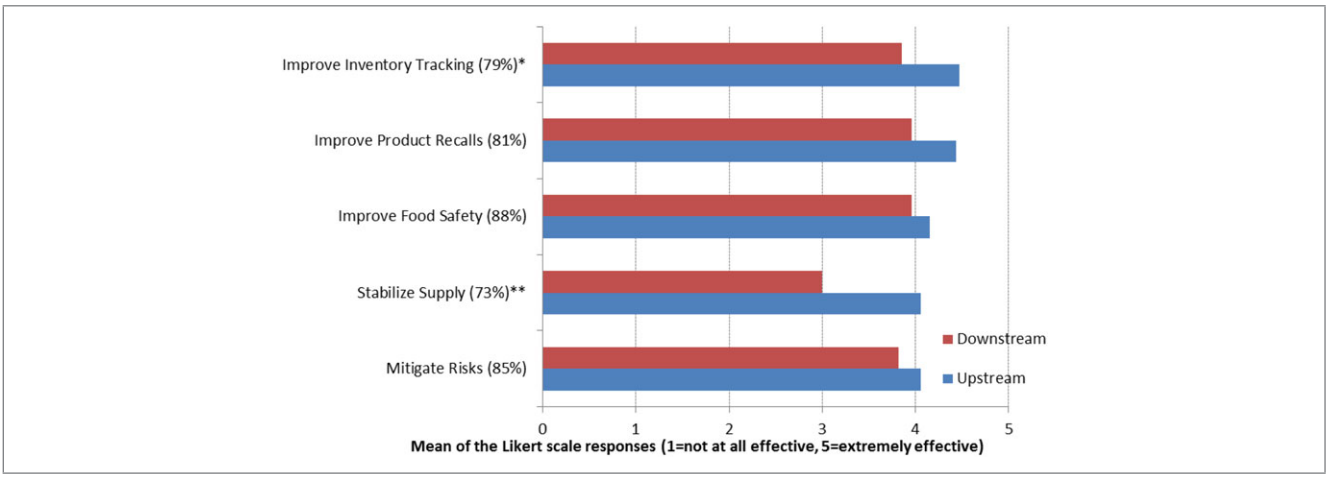

Figure C10–The mean of responses for both upstream and downstream businesses for effectiveness of a firm's traceability system in "mitigating risks." Response rate of a total of 48 possible respondents shown in parentheses. Those not responding either did not respond, or indicated "no knowledge" or "not applicable."[36]

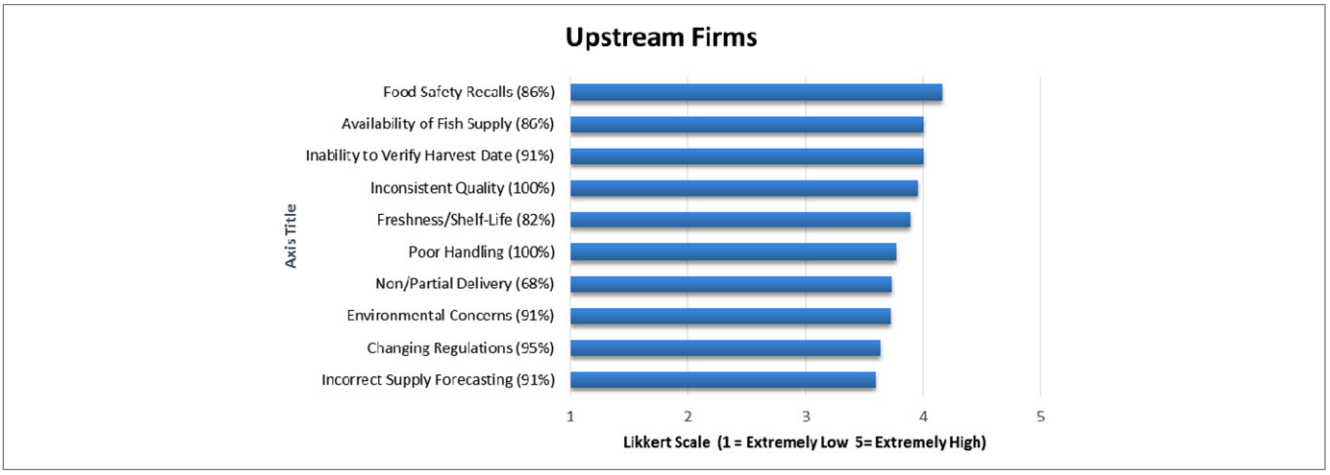

Figure C11–Top 10 risks that influence upstream businesses' abilities to make business decisions. Means of the Likert scale responses are shown. Response rate out of a total of 22 upstream firms in parentheses. Those not responding either did not respond, or indicated "no knowledge" or "not applicable."

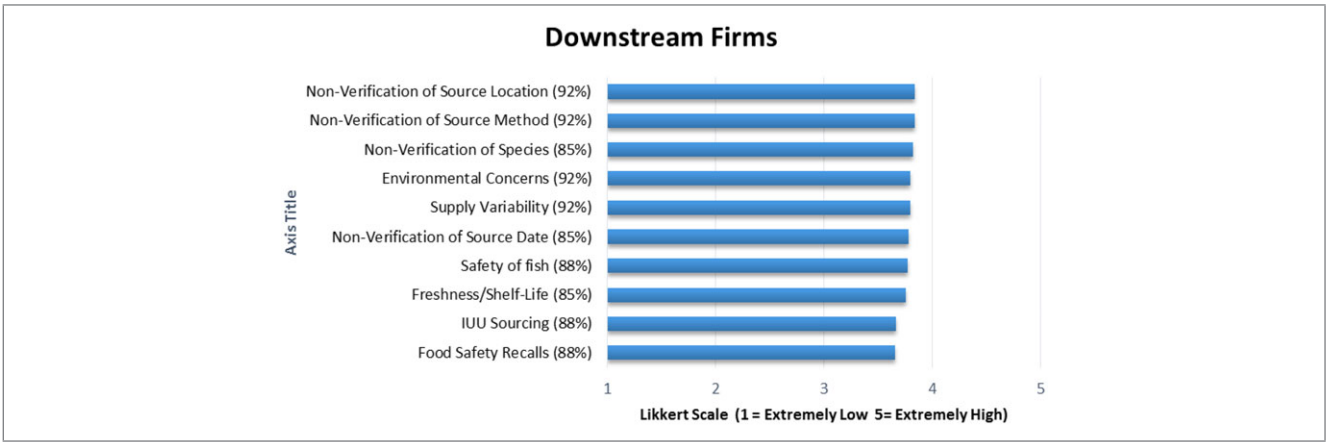

Figure C12–Top 10 risks that influenced downstream businesses' abilities to make business decisions. Means of the Likert scale responses are shown. Response rate out of a total of 26 upstream firms shown in parentheses. Those not responding either did not respond, or indicated "no knowledge" or "not applicable."

[36]** indicates the difference in opinion between upstream and downstream firms significant at the $P < 0.05$ level, * indicates significance at the $P < 0.1$ level (two-sample t-test used).

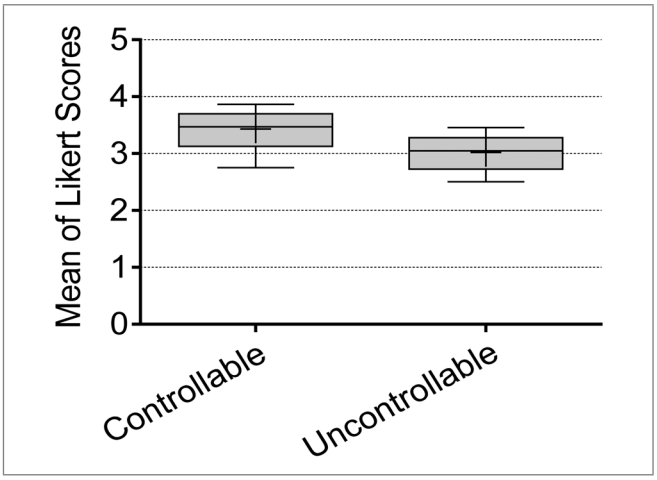

Figure C13–Box and whisker plot of the relative importance of controllable compared with uncontrollable risks. The distributions of the means of the Likert scale responses are shown (1 = "extremely low," 5 = "extremely high"). Response rate for each individual question varied from 67% to 96%, with an average of 85% (total possible responses = 48).

risks were not statistically significant, it appears that businesses may overall be more influenced by risks that are within the control of the value chain that the firm is a part of.

Mitigation. While firms were exposed to many different kinds of risks, and many that had a substantial influence on business decisions, traceability systems were generally effective in helping to mitigate these risks. Figure C14 shows how upstream and downstream firms ranked the ability of their traceability system to address both market and operational risks.

Although not statistically significant, it appears that upstream businesses expressed greater confidence in the ability of their traceability system to help mitigate both market and operational risks, with a median rating of 8 of 10 in both categories. Downstream businesses expressed moderately high confidence in the ability of their traceability system to address both types of risk, with a median score of 7.

Shortcomings. Figure C15 shows the various types of information that firms may or may not receive that would improve their traceability system, as well as their rankings of the importance of missing information. Overall, firms received most of the information they require to make effective business decisions. Temperature history, as well as the date and location of harvest are important pieces of information that are missing approximately 40% of the time. Information on labor practices was also commonly missing (38% of the time) but the importance of this information was ranked slightly lower.

Part II. Comparisons of cooperative, coordinating, and collaborative market chains

General perspectives. *Size and diversity of the firm—species and revenue.* The 3 traceability clusters demonstrated fundamental differences in baseline characteristics—those which influence chain relationships and the costs, benefits, and risks associated with developing and implementing traceability systems. The survey results demonstrate that 75% of collaborative and coordinating firms handle between 1 and 70 species (with means of 25 and 60, respectively), compared to 75% of firms in the cooperative chains that handle between (20 to 200 species with a mean of 130 species). However, although cooperative firms handle far more species, they generate on average only 60% of the revenues ($200 million) that firms participating in collaborative and coordinating chains generate ($300 and $400 million, respectively). This lower revenue (and ostensibly lower profitability) per species, including species produced within a traceability system, may have made it significantly more challenging to implement and manage traceability systems for one or a few selected species and products given the 100 plus species that the firms handle, and the lower margins. See Figures C16 and C17.

Key data elements (KDEs). All 3 chains demonstrated the same patterns in expressed importance of KDEs. Catch and processing dates and ID were the most important elements selected by all 3 market chain clusters (Figure C18).

Gs1 protocols and standards. Twice as many collaborative and coordinating firms (60%) use GS1 Protocols and Standards than cooperative chain firms (30%). This may indicate that firms in coordinating chains are less experienced with developing standards for managing and tracking product.

When was traceability implemented? Most firms implemented traceability fairly recently (mean year 2008), although some firms implemented some form of traceability as early as 1980. There was no difference between the 3 classes of chains for the year when traceability was implemented. See Figure C19.

Traceability system—paper or electronic. The majority of firms (60%) indicated that they use a combination of paper and electronic methods for recording and tracking traceability

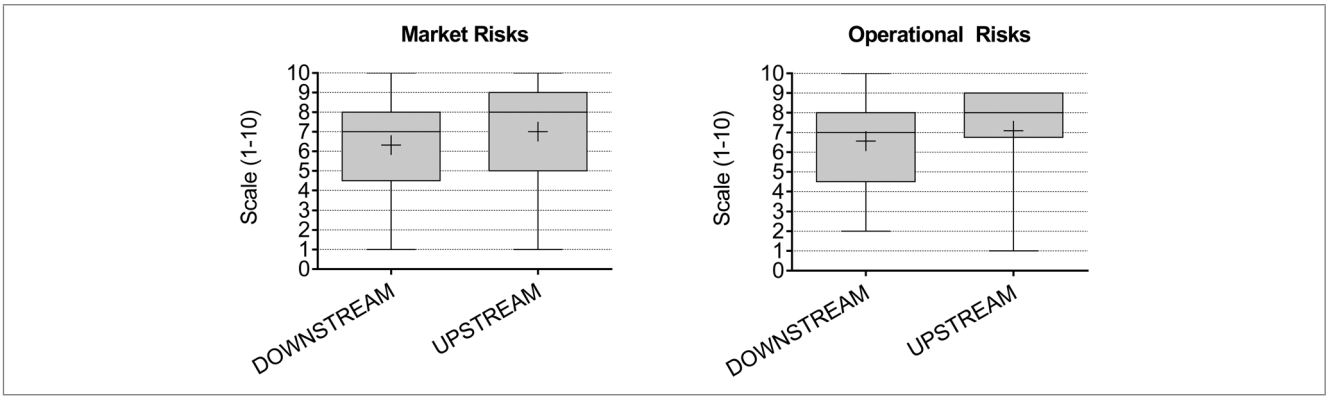

Figure C14–Box and whisker plots showing the distribution of the mean responses by upstream and downstream firms for the effectiveness of their traceability system to address market and operational risks (1 = "not at all," 10 = "completely"). A total of 47 out of 48 respondents indicated a score for these questions.

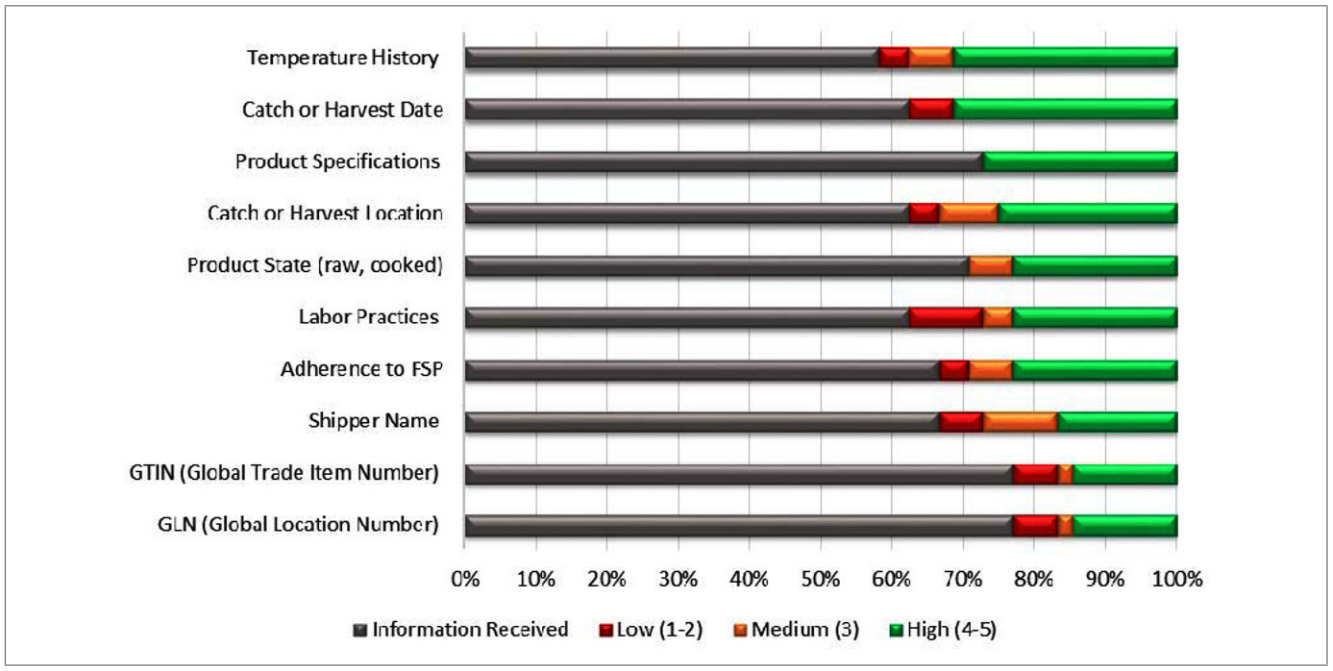

Figure C15–Categories of information that firms may or may not receive, and the potential importance of that information for improving a firm's traceability system. The "information received" category includes all responses that did not provide a positive Likert score. A total of 45 out of a total of 48 firms responded to this question.

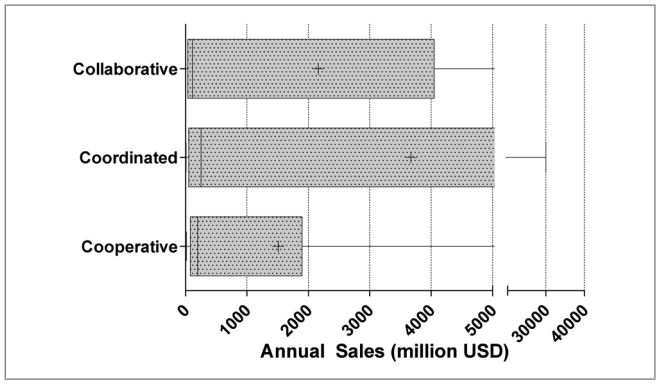

Figure C16–Annual sales for the 3 clusters of market chains.

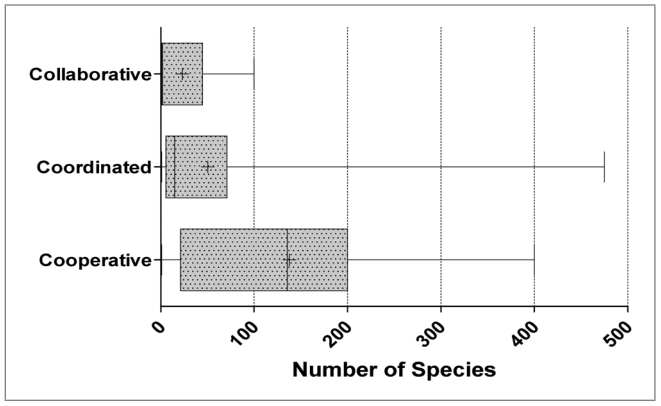

Figure C17–Number of species for the 3 clusters of market chains.

information. However, more collaborative and coordinating firms have primarily electronic traceability systems than cooperative firms. This could indicate a higher level of sophistication and commitment to Traceability Communication and Information (TCI) systems.

Attitudes. *Importance of traceability*. A fundamentally critical question was the relative importance of traceability to the success of a firm's business. Regardless of the cluster, almost all firms (more than 90%) indicated that traceability is very important to their business. Cooperative firms scored 1 point lower than coordinating and collaborative firms. However, as will be shown below, the underlying depth and diversity of the benefits associated with that importance varied considerably between the 3 clusters.

Opinions about traceability. More than twice as many collaborative and coordinating firms (55%) believe that "traceability is essential to fostering "good relationships" than cooperative firms (20%). This lower response rate for cooperative firms may indicate that codeveloping traceability systems has not led to better business relationships—or, conversely, that the system has not performed well enough to generate mutual benefits for all members of the chain.

Behavior. *Training in traceability*. While almost all firms indicated that they train employees in the use of traceability, more than twice as many collaborative firms (40%) train all of their employees compared to coordinating firms (23%) and cooperative firms (20%). Almost half of all companies continuously train employees in the use of traceability regardless of their chain classification. On average, collaborative firms train 55% of employees in traceability, compared to 45% for coordinating firms and 22% for cooperative firms, although there is significant variance among collaborative and coordinating firms. Surprisingly, collaborative firms average only 4 h of formal training a year compared to 7 h per year for coordinating firms and 20 h per year for cooperative firms.

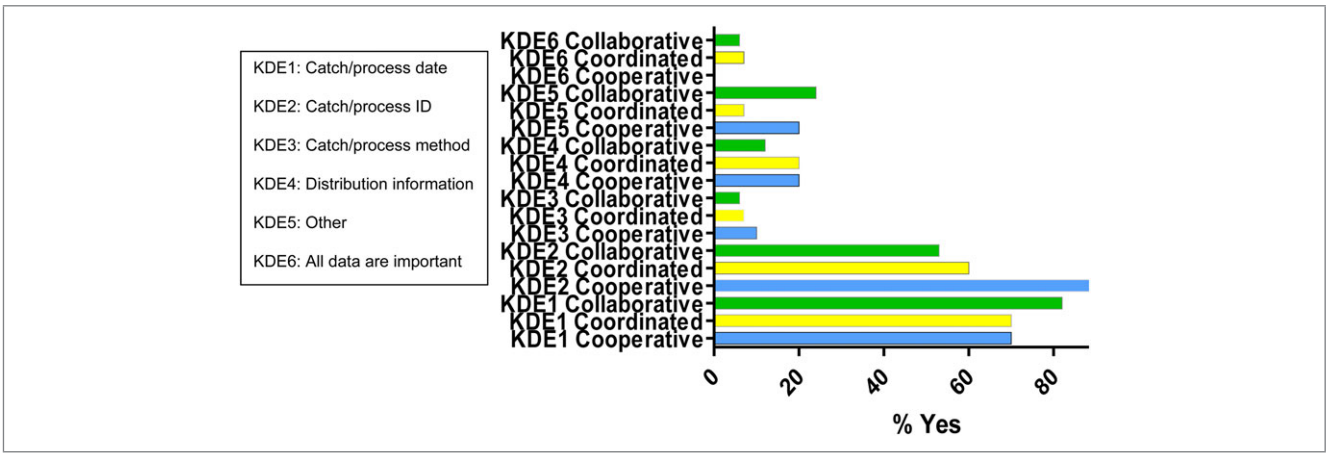

Figure C18–Proportion of firms indicating that selected "key data elements" (KDEs) were important.

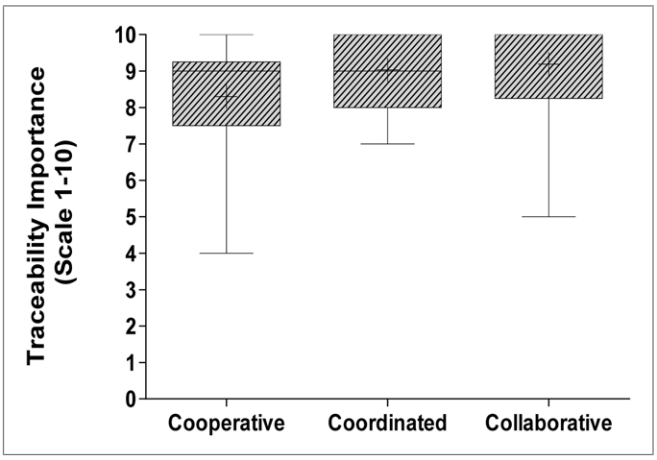

Figure C19–The importance of traceability, by chain structure.

However, this is primarily the result of a much greater dependence on continual supervisor oversight for informal training for collaborative and coordinating firms (49% and 52%, respectively) compared to coordinating firms (10%).

Traceability challenges. *Significance of challenges in implementing traceability*. About 33.3% of firms indicated that they faced significant challenges in implementing traceability. Fifty-four percent of collaborative and coordinating firms indicated that they faced significant challenges, compared to only 20% of cooperative firms. Approximately 40% of collaborative and coordinating forms indicated that they faced internal and/or external challenges. Cooperative firms reported facing fewer internal challenges. Based on other findings in this research, one explanation is that cooperative firms developed systems that were less complex and which were designed to address a more limited number of objectives.

Costs of traceability. Traceability costs differed primarily by firm size rather than cluster.[37] However, cooperative firms appear to have shorter payback periods (1 to 5 y) as compared to coordinating and collaborative firms, which reported having payback periods as long as 8 or more years. Coordinating companies also indicated having, on average, lower expectations on annual returns (6% to 10%) than coordinating and collaborative firms (11% to 15%). However, although the results are intriguing, the small response rate limits making inferences about the role and expectations of financial expectations of firm attitudes or implications with respect to the value-chain clusters.

Benefits and opportunities. There were major differences between cooperative and coordinating and collaborative firms with respect to the anticipated and actual effectiveness of traceability for helping firms make better business decisions (Figure C20). Cooperative firms scored, on average, their expected effectiveness 3 points lower than cooperative and collaborative firms. After implementation, their scores remained on average the same. In contrast, firms in cooperative and collaborative chains increased their scores by 1 point. These responses demonstrate that cooperative firms had lower expectations for traceability and that these expectations were generally met, but not exceeded. The fact that for cooperative and collaborative chain firms traceability exceeded expectations that it would help the firm make better business decisions suggests that these firms were more active in using traceability information to more broadly improve business practices rather than meet only a regulatory, supplier, or market requirement.

Table C2 demonstrates the wide range of benefits that respondents were able to address using traceability. Firms in cooperative value chains reported gaining significantly lower benefits from implementing traceability compared to coordinating and collaborative firms. Conversely, collaborative firms gained the largest benefits across the widest range of categories. Only 4 benefit categories were scored high by cooperative firms: improve food safety, increase quality, respond to consumer demand, and respond to customer demand.

In contrast, firms in cooperative chains scored 13 categories, and collaborative firms 16, as generating high benefits. In 6 categories, more than 90% of collaborative firms scored the category as generating high benefits. In 10 categories cooperative firms scored benefits as very low, and in 2 categories (developing pricing models, reducing administrative costs), more than 90% of cooperating firms scored the benefits as low or nonexistent.

Although firms in collaborative chains tend to score higher than coordinating chains in many categories, in only 4 benefit categories did collaborative firms score benefits as being significantly higher than cooperative firms: increasing distribution accuracy, stabilizing supply, reducing wastes, and reducing input costs. In only a single category did firms from collaborative chains score benefits as low as, or significantly lower than, coordinating chains

[37] A cluster is one of the 3 types of value chains in which the firms were found to operate: cooperative, coordinated, collaborative.

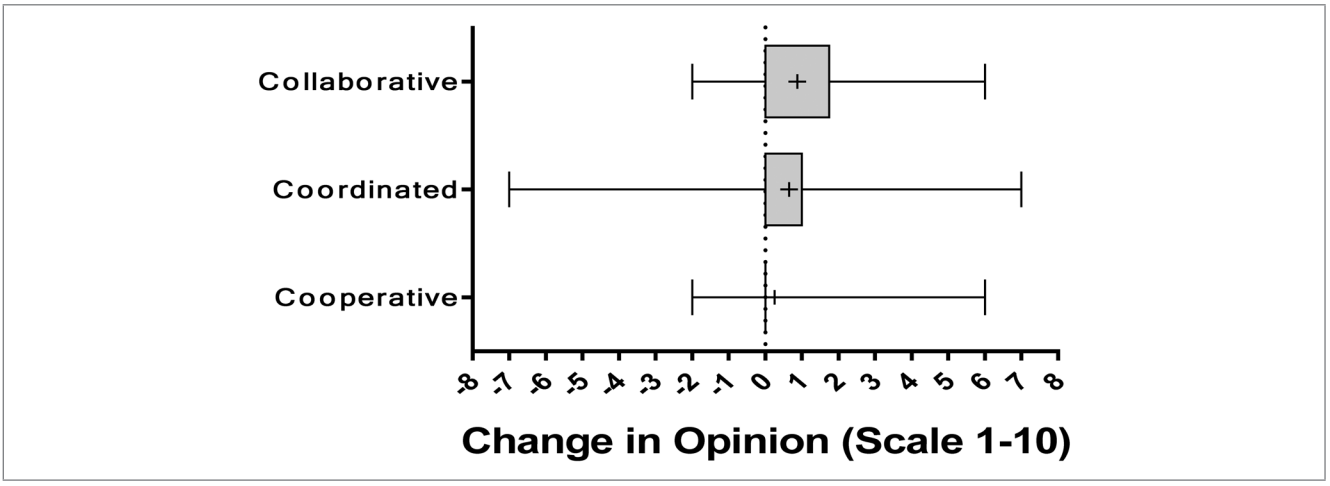

Figure C20–Difference in scores between anticipated and actual benefits from implementing traceability in the 3 market chain clusters.

Table C2–Effectiveness of implementing traceability on benefit categories based on a 5-point Likert scale (1 indicates "not at all effective" and 5 indicates "extremely effective") for "cooperative," "coordinated," and "collaborative" value-chain clusters. Proportion of firms responding is indicated by gray shading (the darker shade indicates more than 75%, and lighter shading 50% to 75%, of firms provided a response). Green indicates that firms had a mean score greater than 3.5, yellow between 2.5 and 3.5, and red below 2.5. Dark red indicates that more than 90% of firms scored only 1 or 2, and dark green indicates that more than 90% of firms scored a 4 or 5.

Benefit Categories	Proportion of Respondents	Overall Scores	Scores Value Chain Cluster		
			Cooperative	Coordinated	Collaborative
Ensure environmental Sustainability					
Improve product recalls					
Reduce pilfering					
Increase distribution Accuracy					
Verify harvest date/Location					
Improve inventory tracking					
Avoid short weighting					
Avoid species substitution					
Increase sustainability					
Stabilize supply					
Reduce waste					
Improve food safety					
Increase quality					
Mitigate risks					
Influence business structure					
Develop pricing models					
Improve customer service					
Respond to consumer Demand					
Respond to customer Demand					
Access new markets					
Reduce quality variation					
Increase revenue					
Increase market share					
Increase productivity					
Reduce input costs					
Increase margins					
Reduce administrative costs					

(reduce pilfering); and only in the benefit category of reducing input costs did coordinating firms score benefits as low.

To better illustrate the patterns revealed in Table C2, Figure C21(A) to (D) provide statistical detail on a subset of the benefit categories for the 3 value-chain clusters, including "increase productivity," "verify harvest date/location," "mitigate risks," and "stabilize supply." The 4 figures show in more detail that cooperative firms score significantly lower than firms in collaborative and coordinating clusters. Figure C21(A) shows that not a single coordinating firm found that traceability resulted in high increases in productivity. In contrast, about 50% of the coordinating and collaborative firms indicated that they found that traceability was effective at a high level in improving productivity. Ninety-three percent of all collaborative firms reported that traceability was highly effective in verifying harvest date and location (Figure C21B). In contrast, only 50% of firms in cooperative clusters reported that traceability was effective in verifying this information. This suggests that many of the traceability systems operated by firms in the cooperative cluster are inefficient or error-prone in providing key traceability information. Only 22% of cooperative firms reported that their traceability system was highly effective in mitigating risks (Figure C21C).

In contrast, more than 80% of firms in Coordinated and Collaborative clusters believe that traceability is highly effective in helping to mitigate risks. As is discussed below, risks are an important issue for cooperative firms, suggesting that these firms may not have developed effective risk management tools capable of using traceability information for mitigating and managing risks. Figure C21D) illustrates that only 17% of firms in cooperative chains believe that their traceability systems have proven highly effective in helping to stabilize supply, compared to 59% and 86% for coordinating and collaborative firms, respectively.

Risks—operational and market. Figure C21(C) shows the significant differences in perceived effectiveness of traceability for mitigating risks among cooperative, coordinating, and collaborative clusters. To understand broader concerns regarding risks, firms were asked to provide their opinion about risks that could impair how their firm conducts business. Two types of risks were considered: market risks and operational risks. Specific categories of risk are listed in Table C1.

Table C3A(A) and C3B(B) list the highest and lowest ranking scores for each of the 3 traceability clusters. The tables show that

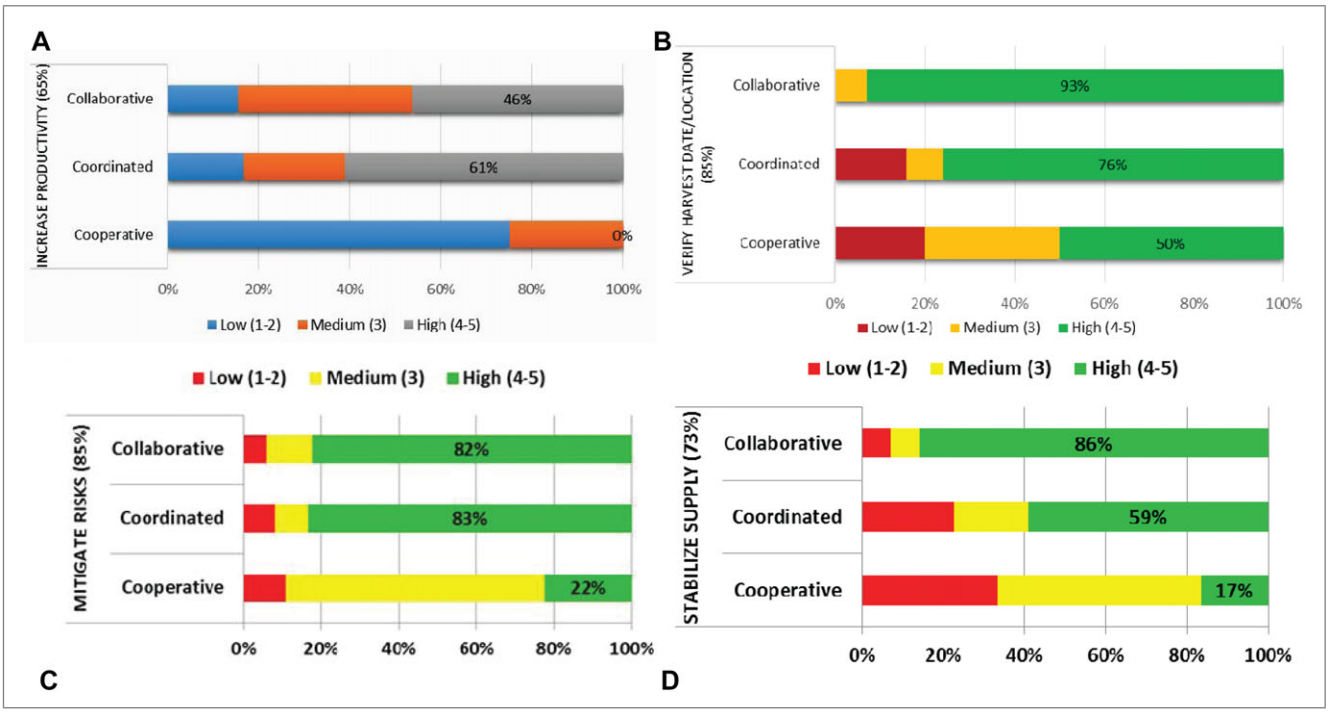

Figure C21–(A)–(D) The effectiveness of implementing traceability on increasing productivity based on a 5-point Likert scale (1 indicates "not at all effective" and 5 indicates "extremely effective") for the 3 market chain clusters.

Table C3A–Highest ranking scores for operational and market risks that could impair a firm's conduct of business, based on a 1 to 5 Likert scale ("1" = extremely low impairment, "5" = extremely high).

Cooperative	
Risk	**Mean score**
Food safety recalls	4.7
Proper delivery specification	4.5
Environmental concerns	4.3
Inappropriate labor practices	4.3
Ability to verify harvest date	4.3
Freshness/Shelf-life	4.3
Inconsistent regulations	4.2
Supply variability	4.2
Nonverification of source METHOD	4.1
Safety of fish	4.1
Coordinated	
Risk	**Mean score**
Freshness/Shelf-life	4.1
Ability to verify harvest date	4.0
Safety of fish	4.0
Nonverification of source LOCATION	4.0
Food safety recalls	4.0
Nonverification of source DATE	3.9
Availability of fish supply	3.9
Nonverification of source METHOD	3.9
IUU sourcing	3.9
Inconsistent regulations	3.9
Collaborative	
Risk	**Mean score**
Environmental concerns	4.4
Food safety recalls	4.2
Inconsistent quality	4.1
Supply variability	4.0
Inconsistent global tech. standards	3.8
Nonverification of source LOCATION	3.8
Nonverification of source DATE	3.8
Freshness/Shelf-life	3.8
Inconsistent global traceability standards	3.8
Poor handling	3.8

Table C3B–Lowest ranking scores for operational and market risks that could impair a firm's conduct of its business, based on a 1 to 5 scale ("1" = extremely low impairment, "5" = extremely high).

Cooperative	
Risk	**Mean score**
Subjective 3rd-party verifications	3.3
Incorrect demand forecasting	3.3
Industry consolidation	3.1
New technology	3.1
Inconsistent global food safety standards	3.0
Fluctuating input supply	3.0
Fluctuating consumer demand	3.0
Inconsistent global traceability standards	2.9
Inconsistent global technical standards	2.9
Fluctuating input costs	2.8
Coordinated	
Risk	**Mean score**
Inconsistent global traceability standards	3.4
Non/Partial delivery	3.4
Fluctuating prices	3.4
Fluctuating input supply	3.4
Inconsistent global food safety standards	3.2
Fluctuating consumer demand	3.1
Fluctuating input costs	3.0
Inconsistent global tech. standards	2.9
New technology	2.8
Industry consolidation	2.7
Collaborative	
Risk	**Mean score**
Inappropriate labor practices	3.4
Fluctuating consumer demand	3.3
Non/Partial delivery	3.3
Incorrect supply forecasting	3.2
IUU sourcing	3.1
Competitors' behavior	3.1
Incorrect demand forecasting	3.1
New technology	3.1
Industry consolidation	2.8
Nonverification of species	2.7

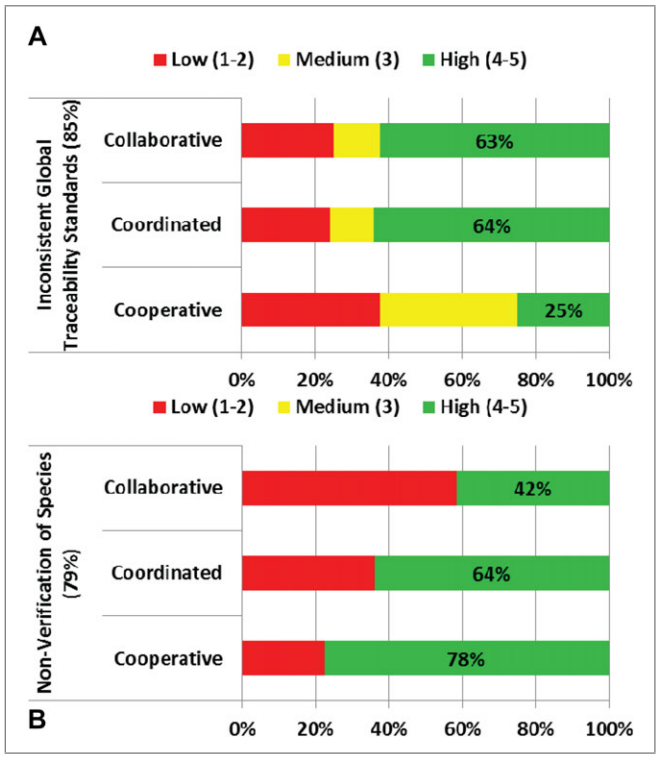

Figure C22–(A)– Percentage of scores for the 3 value-chain clusters in response to risk concerns regarding inconsistent global traceability standards. (B) – Percentage of scores for the 3 value-chain clusters in response to risk concerns regarding non-verification of species.

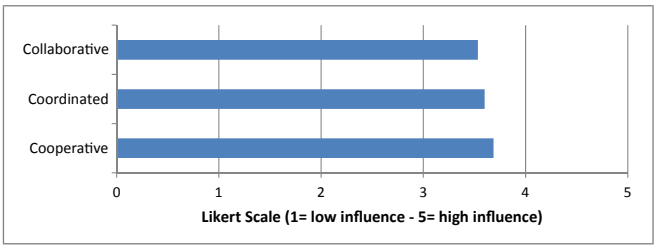

Figure C23–Likert mean scores for combined market and operational risks for the 3 market chain clusters.

Table C4–Mean scores and variation (standard deviation) among the 3 clusters for traceability benefits and market and operational risks.

	Traceability benefits		
	Cooperative	Coordinated	Collaborative
Mean score	2.93	3.58	3.85
Variability	1.57	1.16	1.07
	Market risks		
	Cooperative	Coordinated	Collaborative
Mean score	3.57	3.53	3.49
Variability	1.04	1.23	1.76
	Operational risks		
	Cooperative	Coordinated	Collaborative
Mean score	3.80	3.67	3.58
Variability	1.52	1.30	2.06

cooperative firms tended to score risk concerns higher than cooperative and collaborative firms. Food safety had the highest mean score of any risk concern (mean score of 4.7 for the cooperative cluster), and was listed in the top 10 list of all 3 market chain clusters. It was also the only safety concern consistently listed in the top 10 by all 3 clusters. There was more consistency of agreement in the listing of the risk concerns that ranked the lowest, but even so, there were only 3 items that made the list for all 3 clusters. The collaborative group had "inconsistent global technology" and "inconsistent traceability standards" on the top 10 list, while the other clusters had these risk concerns in the bottom 5. In general, there was significant difference in the relative rankings and category scores.

Figure C22(A) and (B) provide 2 examples of risk potential scores by the 3 cluster chains. Figure C22(A) shows that collaborative and cooperative firms are highly concerned (63% and 64%, respectively) regarding inconsistent global traceability standards. In contrast, cooperative firms are significantly less concerned. Figure C22(B) shows a different trend with respect to risk concerns associated with "nonverification of species." In this case, there is greater concern in the cooperative clusters than in the collaborative clusters, although this may have been influenced by the type of species being handled by the collaborative and cooperative chains.

The results of our analysis of concerns for the mean scores for operational and market risks are summarized in Figure C23. The figure illustrates that there is only a slight trend of greater concern for risk among the cooperative clusters as compared with the collaborative clusters. However, as shown in Table C2, C3, and C4, risk concerns for specific issues can significantly vary by cluster. To explore this variability, risk concerns were disaggregated according to the risk class (operational or market) and whether risks were "inside" risks (potentially controllable within the chain) or "outside" the chain (exogenous risks not directly controllable by the chain) (see Table C1).

Figure C24(A) and (B) demonstrate that the class of risk (operational or market) was less important than whether the risk was an inside or outside risk. This was especially true for cooperative chains which showed mean risk concerns of more than "4" for such "inside" issues as food safety recalls, proper delivery specifications, inappropriate labor practices, ability to verify harvest dates, freshness/shelf-life, and safety of fish. Figure C24(B) shows that inside risk concerns scored higher than outside risks for all 3 clusters. However, comparative concerns relating to outside compared with inside risk concerns move in opposite directions across the 3 clusters. Outside risks tend to score lower among firms operating in collaborative compared with coordinated and cooperative chains. In contrast, concerns relating to inside risks are lower in firms operating in collaborative chains than those operating in coordinated and cooperative chains. These findings suggest that, while inside risks are substantial, collaborative chains are somewhat less concerned about operational risks than coordinated chains, or especially cooperative chains.

Figure C25 shows the degree to which traceability systems alleviate market and operational risks for each market chain cluster. Firms located in cooperative clusters scored the ability of traceability systems to alleviate market and operational risks significantly lower than coordinating and collaborative firms, and generally showed more agreement and less variability in scores than did cooperative firms. This was especially true for operational risks. Given the scores for risk concerns, these results indicate that cooperative clusters have not developed the same degree of experience and skills in using systems such as traceability in addressing risk, especially inside risks, which, ostensibly, chains have more ability to influence.

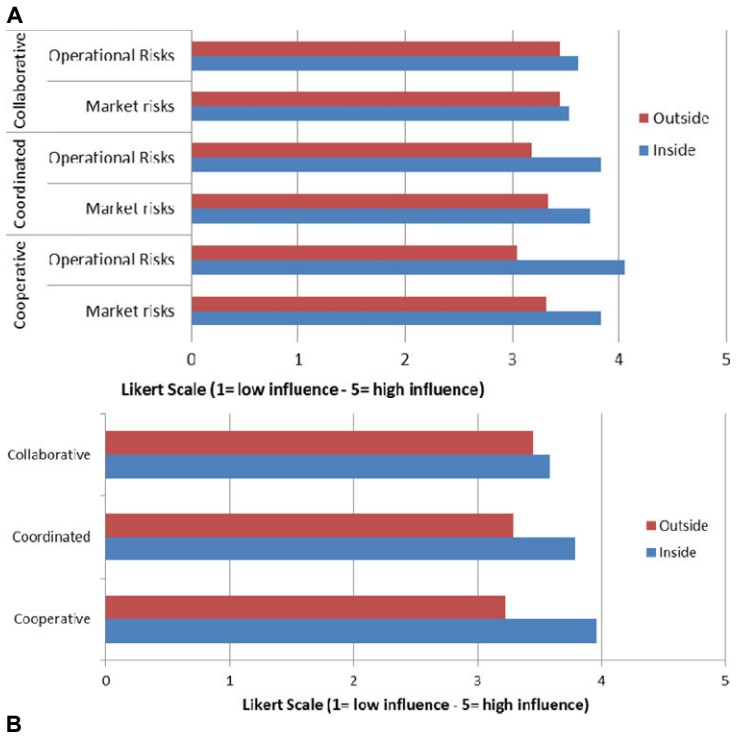

Figure C24–(A) – Likert scores for market and operational risks for "outside" and "inside" risks for the 3 market chain clusters. (B)– Likert scores for aggregate scores for "outside" and "inside" risks for the 3 market chain clusters.

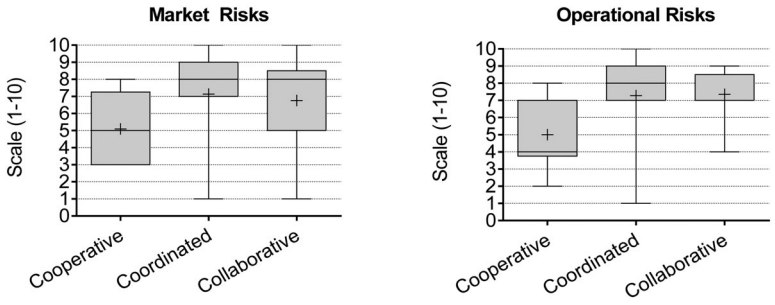

Figure C25–Box and whisker plots of Likert scores on a scale of "1" (not at all) to "10" (completely) indicating the extent to which traceability systems alleviated market and operational risks.

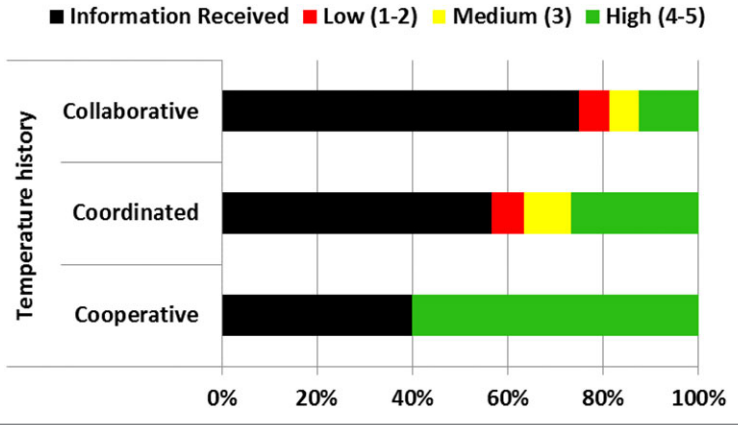

Figure C26–Proportion of firms in each cluster currently not receiving information on "temperature history" and importance of this information to the firm ("1" = not at all important and "5" extremely important).

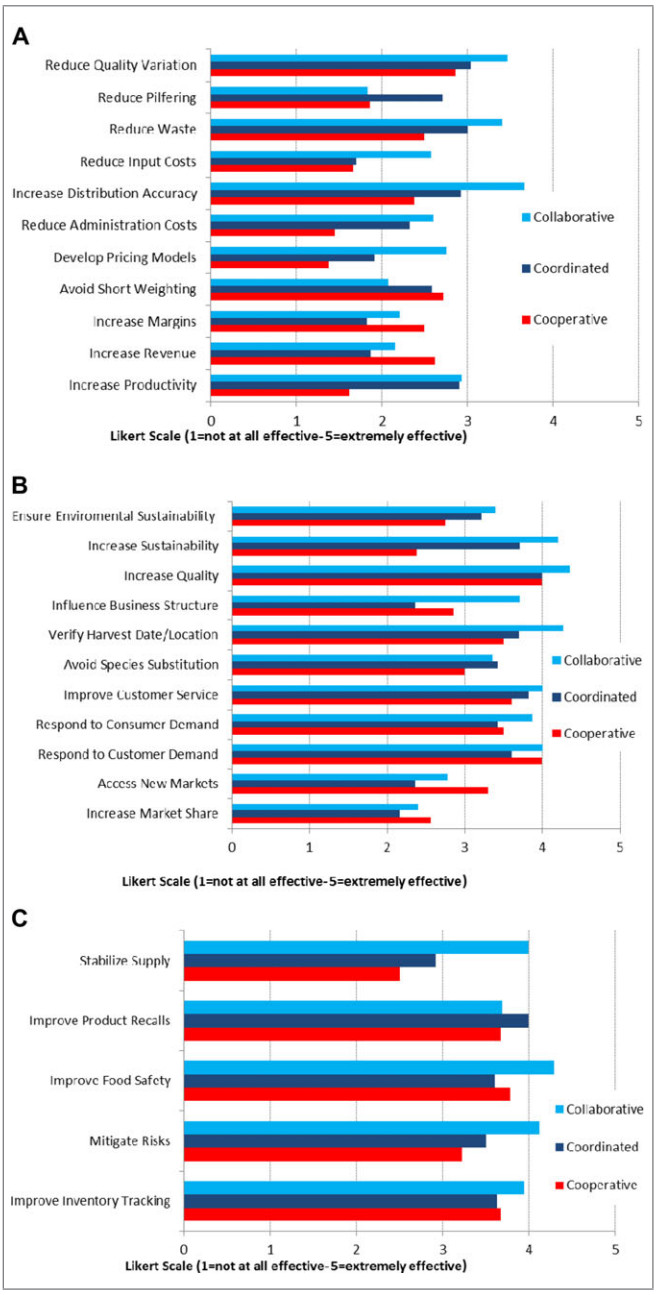

Figure C27–(A)– Mean scores among the 3 clusters for benefits classified as "driving efficiency." (B)– Mean scores among the 3 clusters for benefits classified as "competitive advantage." (C)– Mean scores among the 3 clusters for benefits classified as "mitigating risks."

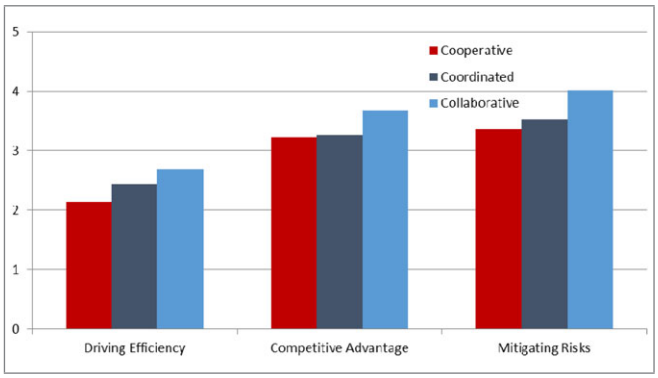

Figure C28–Mean aggregated scores among the clusters for the 3 classes of benefits.

Shortcomings. Overall, regardless of the cluster, a significant majority of firms indicated having received the information that they needed to improve their traceability systems. See Figure C18 for a listing of the information and a summary of the results across all firms. The one exception, however, as shown in Figure C26, was temperature history, which was not available to firms in 60% of cases, while being considered highly important by cooperating firms. In contrast, only 24% of collaborative companies did not have this information.

Integration. Three analytical approaches were used to integrate and summarize the quantitative results that compared integration for cooperative, coordinating, and collaborative clusters. The 1st approach compares the mean scores and variability (standard deviation) among the 3 clusters for traceability benefits, market risks, and operational risks. Table C4 summarizes the results and shows that cooperative chains indicated the fewest benefits compared with coordinated and collaborative firms, but they exhibited the greatest variability in scores among their firms. With respect to how the firms assess market risk, there was little difference in mean scores among the 3 clusters (although as shown above there were differences in perceptions about "outside" compared with "inside" risks). However, collaborative firms exhibited the greatest variance. Cooperative firms scored concerns about operational risks the highest among the 3 clusters, but collaborative firms showed the greatest degree of variance.

The 2nd approach compared the scoring among the classes of benefits that were categorized as "driving efficiency," "competitive advantage," and "mitigating" risks (Figure C27A to C). The scores for each class of benefits were then aggregated and graphed in Figure C28. The results show that benefits classified as "driving efficiency" scored the lowest (2.1 to 2.7) compared with "competitive advantage" benefits (3.2 to 3.7) and "mitigating risks" benefits (3.3 to 4.0). Firms operating in cooperative chains scored benefits the lowest in each class, followed by those operating in coordinated chains. Firms operating in collaborative chains gave the benefits received the highest score.

The 3rd approach used the results from the first 2 analytical approaches to create 3 Venn diagrams illustrating the relationships of "competitive advantage," "driving efficiency," and "mitigating risks" benefits for the 3 clusters (Figure C29A to C). The diagrams are a "1st attempt" to use the quantitative results to illustrate the degree to which there were differences and synergies in the types of traceability benefits derived between the 3 types of chains. The size of each circle corresponds to the aggregate mean of the Likert responses for benefits in each category. The transparency of the colors reflects how strongly respondents in each type of chain thought that their traceability system was effective in capturing benefits in each class (the stronger the color, the higher proportion of high Likert responses). The degree of overlap between the circles correlates with the consistency in ranking benefits as high between the 3 benefit classes (the higher the degree of overlap, the greater the similarity in percentage of high scores out of all scores).

The results show cooperative clusters had the weakest intensity and breadth of benefits as well as the lowest consistency in scoring compared to the other 2 clusters. For all 3 clusters, driving efficiency was found to be the least source of benefits, as shown by being the smallest circle in size and intensity of color, along with

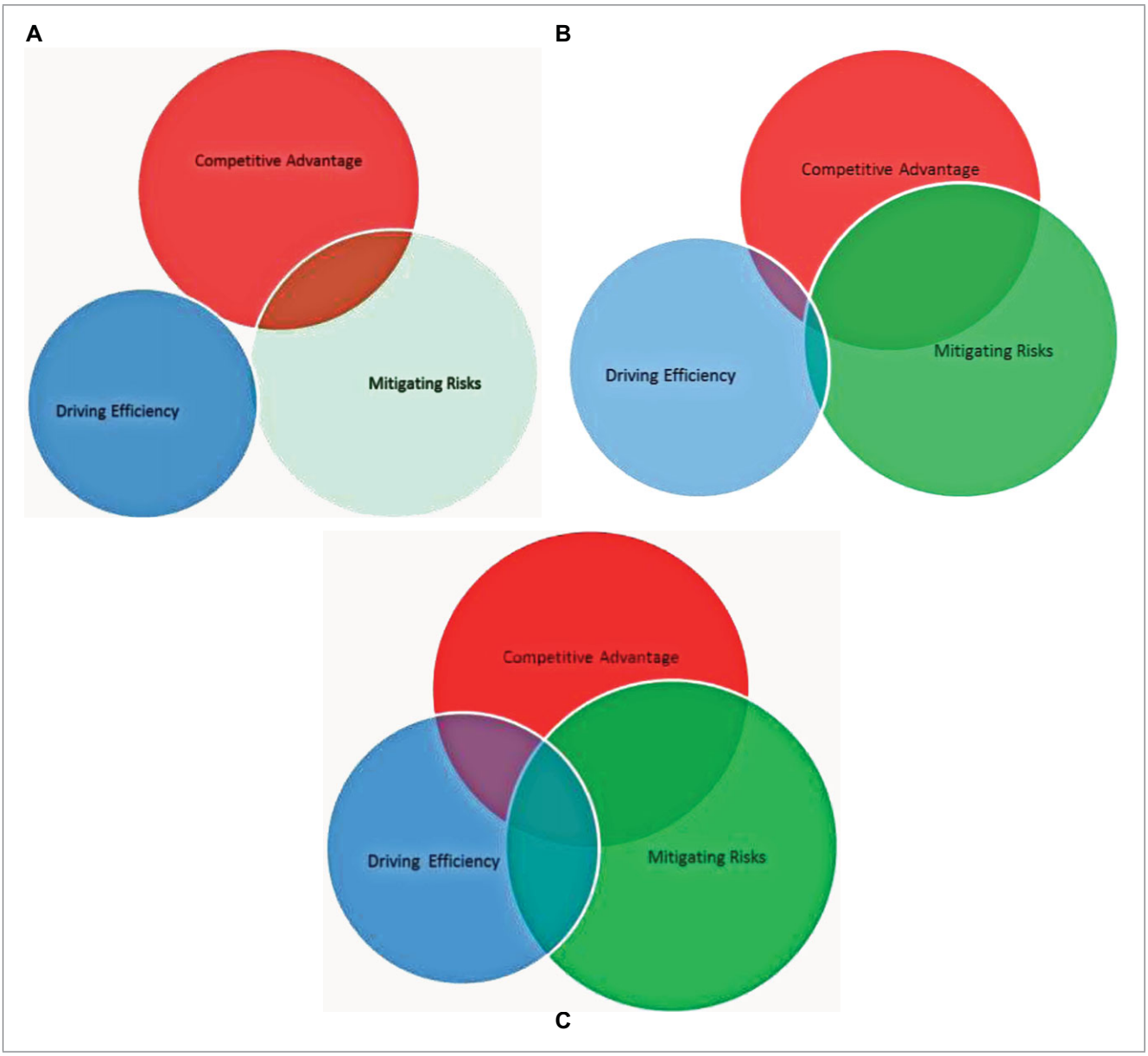

Figure C29–(A)– Venn diagram of the cooperative cluster for the 3 classes of benefits. (B)– Venn diagram of the coordinating cluster for the 3 classes of benefits. (C)– Venn diagram of the collaborative cluster for the 3 classes of benefits.

the smallest degree of overlap. Mitigating risks is the largest circle (size of aggregate means), but competitive advantage has a greater intensity of color indicating a higher proportion of high responses. The degree of overlap and potential for synergy and reinforcing benefits is highest for the collaborative cluster and weakest for the cooperative cluster.

Appendix D: Chain Maps—KDEs and Critical Tracking Events

Chain A: Icelandic Cod Sold in Netherlands (Chilled Retail Packs)

Trawler	Landed (Iceland)	Primary processing	Airfreight to Netherlands	Secondary processing	Distribution	Retail (Netherlands)
Critical Tracking Events as selected by individual businesses						
• Caught • Chilled	• Transferred to truck • Road transport	• Filleted • Chilled	• Transport • Inspection	• Retail-ready packaging • Packed into crates • Dispatched	• Road transport • Delivered to DC • Cross-docked • Shipped to retail stores	• Crates unpacked • Inventory • Displayed in store • Purchased by customer
Key Data Elements						
• Catch date • Catch location • Catch method • Trawler ID • Species	• Trawler • Location landed • Date landed • Time received • Species • Time in transit	• Receival date • Receival time • Source • Weight • Lot number • Inventory • Shipping date	• Lot number • Batch code • Species • Date shipped • Date received	• Lot number • Batch code • Catch date • Catch location • Age of fish • Date filleted • Date frozen • Where filleted • Inventory • Supplier • Customer	• Supplier • Species • Specification • Lot number • Batch number • Temperature • Specification	• Supplier • Species • Specification • MSC • Global Gap • BRC • Lot number • Batch number • Catch date • Catch method • Catch location • Temperature

Chain B: Fiji Tuna Sold in United States (Canned)

Fishing Vessel	Carrier	Landed (Fiji)	Processing	Seafreight to United States	Further processing	Distribution	Retail (United States)
Critical Tracking Events as selected by individual businesses							
• Caught	• Aggregated • Transferred to shore	• Trader receives order (volume) • Trader receives whole tuna • Prepared for shipment • Supplies to order • Road transport	• Thawed • Cleaned • Cooked • Graded • Vacuum packed • Frozen • Palletized	• Seafreight to US • Road transport in US	• Thawed • Canned • Retort cooked • Labelled • Cased • Palletized	• Road transport • Delivered to DC • Shipped to retail	• Receive • Inventory • Display • Sell
Key Data Elements							
• Catch tonnage • Catch date • Catch location • Catch method • Catch time • IMO number • Species • Dolphin safe ID	• Tonnage transshipment • Where offloaded • IMO number of catch vessel • IMO number of carrier • Species • Dolphin safe ID	• Tonnage • Catch date • Catch location • Catch method • Date received • Where received • IMO numbers • Laboratory tests: i.e. histamine • Lot number • Pallet identifier	• Species • Date received • Where received • IMO numbers • Where cut into loins • Date cut into loins • Laboratory tests: i.e. histamine • Lot number • Pallet identifier • Rack tags • Where cooked • Line on which cooked • Time cooked • Quality measures • Dispatch date	• Species • Lot number • Pallet identifier • Batch numbers • Date shipped • Date landed in US • Transport companies	• Species • Supplier • Date dispatched • Date received • Where received • Laboratory tests: i.e. histamine • Lot number • Batch identifier • Pallet identifier • Where canned • Date canned • Marinate supplier • Marinate method • Quality measures • Inventory • Dispatch date	• Product • Lot number • Pallet identifier • Batch number • Dispatch date • Receival date • Transport companies • Inventory	• Species • Product • Specifications • When processed • Where processed

Chain C: Canadian [and United States] Sardines Sold in Canada (Canned)

Purse seine or Weir	Landed (Canada)	Processing	Distribution	Retail store (Canada)
Critical Tracking Events as selected by individual businesses				
• Caught • Chilled	• Received fresh or frozen, depending on supplier	• Cleaned • Graded • Filleted • Canned • Marinated • Sealed • Cooked • Packed • Inventory • Dispatch	• Road transport • Receival at DC • Inventory • Dispatch to retail DC • Cross-dock • Shipped to retail stores	• Receive • Inventory • Display • Sell
Key Data Elements				
• Species • Catch date • Catch location • Catch method • Catch time • IMO number • Species	• Supplier • Species • Temperature • Catch date • Catch location • Catch method • Date received • Time received • IMO numbers • Shipment number	• Species • Catch location • Date received • Time received • Time from receival to processing • IMO numbers • Date cooked • Time cooked • Line on which cooked • Ingredients • Specifications • Quality tests • Lot number • Batch number • GTIN code • UPC code • Quality measures • Inventory • Date dispatched	• Product • Date received • Time received • Date cooked • Where cooked • GTIN code • UPC code • Lot number • Batch number • Inventory • Dispatch date	• Species • Specification • Date received • Shelf life • GTIN code • UPC code • Lot number • Batch number • Inventory • Catch method

Chain D: Thai Tuna Sold in Canada (Canned)

Albacore = Long line Skipjack = Purse Seine	Received in Thailand	Processing	Seafreight to Canada	Distribution	Retail (Canada)
Critical Tracking Events as selected by individual businesses					
• Caught • Frozen	• Trader receives whole tuna • Aggregates multiple boats' catch • QA tests • IDs individual fish • Grades • Dispatch	• Thawed • Cleaned • Cut • Cooked • Canned • Sealed • Retort cooked • Packed • Labelled • Cased • Palletized • Dispatched	• Road transport to port • Seafreight to Canada • Road transport in Canada	• Road transport • Receival at DC • Inventory • Dispatch to retail DC • Cross-dock • Shipped to retail stores	• Receive • Inventory • Display • Sell
Key Data Elements					
• Catch date • Catch location • Catch method • Catch time • Dolphin safe protocols • IMO number • Species • Fish identifier • Tonnage	• Species • Date received • Where received • Catch date • Catch location • Catch method • IMO of catch boat • Dolphin safe certification • Laboratory tests: i.e. histamine • Lot number • Dispatch date • Where shipped • Customer ID	• Species • Date received • Where received • Fish (individual) ID • Where caught • Date caught, trip dates • Catch method • IMO of catch boat • Dolphin safe certificate • Where cooked • Line on which cooked • Time cooked • Specifications • Ingredients • Ingredient suppliers • Specifications • QA tests: i.e. histamine • Batch code • Lot number • Pallet identifier • Dispatch date • Where dispatched	• Species • Lot number • Pallet identifier • Batch number • Date shipped • IMO of freight vessel • Date landed in Canada • Transport companies	• Product • Date received • Time received • GTIN code • UPC code • Lot number • Batch number • Inventory • Date dispatched	• Species • Specification • Date received • Shelf life • GTIN code • UPC code • Lot number • Batch number • Inventory

Chain E: Faroe Island Farmed Salmon Sold in US Retail (Fresh) and US Restaurants

Farm	Primary processing	Seafreight (to UK)	Airfreight (to USA)	Importer	Secondary processing	Distribution	Retail (United States)	Restaurant (United States)
Critical Tracking Events as selected by individual businesses								
• Eggs received • Eggs hatched • Fingerlings batched • Placed in pond • Fish grown (2 yrs) • Ponds managed • Caught	• Receive • Filleted • Graded • Packed • Chilled • Palletized • Dispatch	• Road transport to dock • Ferry to UK • Road transport to Heathrow	• Flown to USA • Inspected • Road transport to Importer	• Receive • Inspect • Disaggregate • Pack • Stage • Dispatch	• Receive • Clean • Pin bone • Cut / portion • Pack • Stage • Dispatch	• Retail: Road transport to retail DC • Restaurant: Road transport to restaurants	• Receive • Inventory • Display • Sell	• Receive • Inventory • Prepare • Sell
Key Data Elements								
• Species • Eggs source • Hatch rate • Stocking date • Pond ID • Feed source • Growth rate • Stocking density • Water quality • Fish size • Mortality • Health incidents • Health treatments • Harvest date • Batch ID • Dispatch date	• Species • Harvest date • Pond ID • Date received • Size • Weight • Grade • Date processed • Where processed • Batch number • Temp at dispatch • Dispatch date • Where dispatched	• Species • Dispatch date • Origin • Batch number • Lot number • Inspection • Export clearance • Destination • Vehicle ID • Route taken • Arrival time • Arrival date	• Species • Dispatch date • Origin • Batch number • Lot number • Flight number • Arrival time • Arrival date • Destination • Customer	• Date received • Time received • Species • Temp at receival • Origin • Batch number • Lot number • Re-package ID • Customer • Dispatch date	• Date received • Time received • Species • Origin • Specification • Batch number • Lot number • Re-package ID • Customer • Dispatch date • Dispatch temp	• Date received • Time received • Temp received • Species • Origin • Supplier • Re-packaged ID • Dispatch date • Temperature	• Species • Product type • Specifications • Temperature • How caught • When caught • When processed • Where processed • Batch code • Source • Shelf life	• Species • Product type • Specifications • Batch code • Source • Shelf life

Chain F: Icelandic Plaice sold in German Retail (Frozen)

Trawler	Landed (Iceland)	Processed	Airfreight to Netherlands	Importer	Distribution	Retail store (Germany)
Critical Tracking Events as selected by individual businesses						
• Caught • Chilled	• Inspected • Road transport	• Inspected • Graded • Cleaned • Filleted • Boxed • Packed • Frozen • Dispatches	• Airfreight • Road transport • Inspection	• Inspects • Disaggregates • Packed into crates • Palletized • Dispatches	• Road transport to Germany • Delivered direct to retail stores	• Crates unpacked • Inventory • Displayed in store • Purchased by customer
Key Data Elements						
• Catch date • Catch location • Catch method • Trawler name / ID • Species • MSC	• Trawler ID • Location landed • Date landed • Time received • Species • MSC/ASC certification • Time in transit • Destination	• Receival date • Receival time • Source • Trawler name / ID • MSC/ASC certification • Catch date • Catch location • Specification • Time processed • Where processed • Weight • Batch number • Lot number • Inventory • Dispatch date • Where	• Supplier • EU 224/2009 & EU 404/2011 declarations • Species • Catch location • Trawler name/ID • Lot number • Batch code • Species • Date dispatched • Date received	• Species • Lot number • Batch code • EU 224/2009 & EU 404/2011 • EIN • Weight • Specification • Temperature • Trawler name / ID • Catch date • Catch location • Catch method • Where processed • Date frozen • Inventory • Supplier • Customer	• Supplier • Species • Specification • Lot number • Batch number • Temperature • Specification	• Supplier • Species • Specification • MSC/ASC certification • EIN • Weight • Lot number • Batch number • Catch date • Catch method • Catch location • Temperature • Inventory • Shelf life

Chain G: Thai Shrimp sold in US Retail (Frozen)

Farm	Harvest and Transport	Processing	Seafreight to United States	Distribution	Retail (United States)
Critical Tracking Events as selected by individual businesses					
• Fry received • Feed delivered • Fry in nursery • Young shrimp in pond • Shrimp grown • Ponds managed • Caught	• Harvested • Cleaned • Ice slurry added • Loaded on truck • Road transport to processor	• Inspected • Cleaned • Graded • Shelled • Cooked • Further processed • Packaged • Frozen • Inventory • Dispatch	• Road transport to port • Seafreight USA • Road transport in USA	• Shipment received • Shipment disaggregated • Orders assembled • Orders cross docked • Excess in inventory • Shipped to retail DC • Cross docked • Shipped to stores	• Receive • Inventory • Display • Sell
Key Data Elements					
• Species • Fry source (hatchery) • Fry Movement Documentation (FMD) • Date fry delivered • Fry quality • Mortality rate • Feed source • Feed quality • Feed inputs • Feed batch ID • Feeding rate • Growth rate • Water quality • Farm ID • Pond ID • Stocking density • Water quality • Health incidents • Health treatments • Processor's yield • Shrimp quality • Specification • Grading feedback • Harvest date	• Species • Farm ID • Pond ID • Fry hatchery • Water quality • Harvest method • Harvest date • Size at harvest • Ice slurry quality • Ice slurry temp • Shrimp quality • Yield • Batch code • Fry Movement Documentation (FMD) • Movement Documentation (MD) • Truck ID • Shipment number • Dispatch date • Where dispatched • Destination	• Species • Date received • Time received • Temp received • Farm ID • Pond ID • Time from harvest to receival • Time from receival to processing • Temperature log • Management "short code" • Line of which shelled • Yield (quality, size, weight) • Date cooked • Time cooked • Line on which cooked • Ingredients • Specifications • Undersized "keep code" • Quality tests • Lot code • Batch code • Quality measures • Inventory • Date dispatched • Where dispatched • Truck ID • Order number	• Species • Specification • Temperature logs • Lot code • Batch code • Container number • Date dispatched • Where dispatched • Truck ID • Order number • Vessel IMO	• Species • Date received • Time received • Supplier/source • Species • Specification • Temperature logs • Lot code • Batch code • Date dispatched • To where dispatched • Truck ID • Order number	• Species • Supplier • Date received • Time received • Temp at receival • Specifications • Where processed • When processed • Timing at key points along chain • UPC • BRC cert • FSA cert • Lot code • Batch code • Inventory • Order number • Feed fed shrimp • Feed ingredients

Chain H: Ecuador Mahi Mahi sold in US Retail (Fresh)

Trawler	Landed (Ecuador)	Processing	Airfreight to United States	Distribution	Retail (United States)
Critical Tracking Events as selected by individual businesses					
• Caught • Chilled	• Aggregated • Road transport	• Inspected • Graded • Cleaned • Filleted • Boxed • Packed • Dispatched	• Airfreight • Road transport • Inspection	• Disaggregates • Inspects • Re-ices • Dispatches to stores	• Receives • Inventory • Displayed in store • Purchased by customer
Key Data Elements					
• Species • Catch date • Catch location • Trawler ID	• Species • Trawler ID • Location landed • Date caught • Catch location • Date landed • Temperature • Destination	• Species • Receival date • Receival time • Trawler name / ID • Catch date • Catch location • Specification • Time processed • Where processed • Weight • Batch number • Lot number • Inventory • Dispatch date • Where dispatched	• Species • Supplier • Lot number • Batch code • Species • Date dispatched • Date received	• Species • Supplier • Specification • Lot code • Batch code • Temperature • Specification	• Species • Specifications • Lot code • Batch code • Source • Shelf life • Temperature • How caught • When caught • Where caught • When processed • Where processed

Appendix E: Survey Questionnaire

Dear Respondent,

Thank you in advance for your participation. The data required to complete this study is being gathered through the following survey.

The seafood industry is experiencing massive change, including rising ecological concerns, evolving consumer attitudes and behavior, rising demand for seafood from developed and developing nations, shifting market power, incidences of fish fraud that heighten risks, retail and foodservice demands that are driving increased investment, and increasingly stringent regulations of the supply and marketing of seafood.

It is believed that traceability and information exchange play an important role in enabling the international seafood industry to transition through the myriad of challenges that it faces. The purpose of this project, led by the Institute of Food Technology's Global Food Traceability Center (GFTC),[38] is to undertake an extensive assessment of the value and role of traceability from a variety of perspectives. This includes the capture/production, distribution, and marketing of seafood.

Conducted by recognized international experts in economic and financial analysis, marine business management, and consumer research, the project deliverables include an assessment of:

- The role of traceability and information exchange in enabling businesses to transition through the significant changes affecting the global seafood industry; and
- The economic and financial value that businesses can derive from using traceability and information exchange to create customer and consumer value.

Businesses who participate in the study will receive a copy of the final report. They will also benefit from receiving a confidential report that will:

- Cite examples of the exemplary use of traceability, and suggested improvement opportunities;
- Provide recommendations on how to evaluate investment decisions relating to traceability; and
- Detail consumer insights in relation to the chosen seafood species and national markets.

Please note that all the information gathered during our research will be treated under strict confidentiality. Anonymity is assured. The data from your returned questionnaire will be given an identification number, thereby ensuring that all attributable information is kept anonymous. All quantifiable information will only be presented in aggregate. No information will be shared between businesses or made public without the respective participants' permission. Furthermore, all the individual responses will be destroyed at the end of the research.

If you have any questions or would like further information about this study, please contact:

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[38] www.globalfoodtraceability.org.

Location and capacity of operations
Annual sales
Number of employees
Number of distinct species harvested or purchased
Number of distinct products produced

General Perspectives

1) Which of the following options best describe your business? Please tick all that apply.
   ☐ Harvester
   ☐ Farm (aquaculture)
   ☐ Primary Processor
   ☐ Secondary Processor
   ☐ Distributor
   ☐ Retailer
   ☐ Quick service Restaurant
   ☐ Restaurant
   ☐ Institution Food Service
   ☐ Other_____

2) In one sentence, what does the term traceability mean to you?

   _____

   _____

3) On a scale of 1–10 *(1 = completely unimportant, 10 = extremely important)* how important do you consider traceability is to the success of your business? Please circle.

Low									High
1	2	3	4	5	6	7	8	9	10

4a) Does traceability become more important to you when you consider
   - Specific species Yes ☐ No ☐
   - Specific market type (i.e., retail) Yes ☐ No ☐
   - Specific market location (i.e., China, US) Yes ☐ No ☐
   - Specific supplier or source (i.e. Vietnam) Yes ☐ No ☐

4b) If you answered yes to any of the above, please elaborate

   _____

   _____

5a) For the bestselling product/species in your product mix, please describe the path that it follows from the point at which it is received by your business to the point at which it is sold to a customer, and any processing or packaging that occurs while in your firm's possession. *Modify question to suit the species/chain being researched.*

   _____

   _____

5b) At which stages along the pathway you described above do events occur that are critical from a traceability perspective (e.g., harvest/catch date, receival, aggregation, disaggregation, processing, packaging)?

   _____

   _____

6) What information (*often referred to as Key Data Elements, KDEs)* do you consider are the most critical from a traceability perspective in your business (e.g., supplier, premises ID, date/time of processing)?

_____

_____

7) Is your business' traceability system
   ☐ Primarily electronic
   ☐ Primarily paper-based
   ☐ A combination of electronic and paper based

Comments, *incl. extent to which your traceability system is linked to your ERP or other enterprise systems.*

_____

_____

8) Do you use GS1 protocols and standards in your business? Yes ☐ No ☐

If **yes**, at which level is it used?

☐ Batch / Lot
☐ Container
☐ Item
☐ Logistics unit

Traceability: attitudes

9a) Please indicate which of these statements most closely reflects your opinion (*circle all that apply*).
   (i) Traceability is a necessary cost of business that is forced upon us by regulations.
   (ii) Traceability is a necessary cost of business that is forced upon us by third parties, such as insurance companies, certification programs.
   (iii) Traceability is a necessary cost of business in order to reduce exposure to business risks.
   (iv) Traceability is a necessary cost of business that is required by our customers.
   (v) Traceability enables us to manage our business more successfully than otherwise possible.
   (vi) Traceability is essential in fostering good relationships with our customers.
   (vii) Traceability is essential in fostering good relationships with our suppliers.
   (viii) Traceability is valued by consumers.

Please explain

_____

_____

9b) Is the same opinion held by your business colleagues? Yes ☐ No ☐
9c) Is the same opinion held by your suppliers? Yes ☐ No ☐
9d) Is the same opinion held by your customers? Yes ☐ No ☐
9e) If you answered NO to questions 9b, 9c, or 9d, please elaborate on the differences and reasons why.

_____

_____

Traceability: behavior

10a) Do you train your employees in the use of traceability? Yes ☐ No ☐
10b) If YES, do you train
   ☐ All employees?
   ☐ Some employees (approximate number or percentage of employees_____)?

10c) If yes, do you train employees in the use of traceability at time of hiring? Yes ☐ No ☐
10d) If yes, do you continuously train employees in the use of traceability? Yes ☐ No ☐
10e) If yes, approximately how many hours per year does each employee receive in training? _____
10f) If yes, what means do you use to train your employees in the use of traceability?
   ☐ Company workshops (internal)
   ☐ Industry workshops (external)
   ☐ Continual supervisor oversight
   ☐ Mock recalls

Other_____

Challenges Associated With Traceability

11) What year was your current traceability system implemented? _____
12) Did you face significant challenges in developing and implementing your current traceability system?
   ☐ Yes, significant internal challenges (e.g., managers, operational staff, budgetary constraints or reporting procedures)[39]
   ☐ Yes, significant external challenges (e.g., suppliers, customers)

If you answered yes to either or both questions, please describe the challenges and methods used to overcome those challenges.

_____

_____

Cost of traceability

13) What level of costs were incurred when **implementing** your current traceability system?

If you do not wish to provide a definite dollar value, please provide a range or percentage of sales.

- Software costs: _____
- Hardware costs: _____
- Installation/implementation costs: _____
- Operationalizing costs, incl. training: _____
- Consulting costs: _____

14) What ongoing costs are incurred by the **operation and maintenance** of your traceability system?

If you do not wish to provide a definite dollar value, please provide a range or percentage of sales

- Software update costs: _____
- Hardware costs: _____
- Maintenance costs: _____

[39]For example, new product development is favored over traceability partly because its costs and subsequent profit are transparent, its ROI is readily quantifiable, and there is a single executive responsible for NPD budget and implementation.

- Annual operating costs, incl. training: _____
- Consulting costs: _____

15a) If your company was **twice** its present size, on per unit of output, would your traceability costs
☐ Remain the same
☐ Increase
☐ Decrease

15b) if you answered "increase" or "decrease," can you estimate by approximately how much? ($ or %)

_____

16) When making an investment in traceability and information systems, over what time horizon does your firm calculate payback time?
☐ 1–2 years
☐ 3–5 years
☐ 6–7 years
☐ 8–10 years
☐ Other _____

17) When making an investment in traceability and information systems, what is the necessary annual return on investment for your firm? *(This may also be referred to as the internal rate of return.)*
☐ 2–5%
☐ 6–10%
☐ 11–15%
☐ 16–20%
☐ Other _____

Traceability: benefits and opportunities

18a) On a scale of 1–10 *(1 = extremely low, 10 = extremely high),* before implementing your current system, how high were your expectations regarding the effectiveness of the traceability system to enable you to make better and more informed business decisions (circle one score)?

Low								High	
1	2	3	4	5	6	7	8	9	10

18b) Using the same 1–10 scale *(1 = extremely low, 10 = extremely high)*, after having implemented your current system, how effective is your traceability system for enabling you to make better and more informed business decisions? (Circle one score).

Low							High		
1	2	3	4	5	6	7	8	9	10

18c) If the score in 18a is higher than the score selected in 18b, how would you close the gap and positively improve the system's impacts on your business now and in the future?

_____

19) In comparison to before you implemented you current traceability system, how effective has your current traceability system been to enable you to address the following? Please answer on scale of 1–5 *(1 = not at all effective, 5 = extremely effective), circling one score for each factor. If a factor is Not Applicable please circle NA. If you have no opinion or knowledge on a specific factor please circle NK*:

Factor, issue, or opportunity	Effectiveness of Traceability System Not at all Extremely
Increase productivity with same or less labor	NA – 1 – 2 – 3 – 4 – 5 – NK
Increase market share relative to competitors	NA – 1 – 2 – 3 – 4 – 5 – NK
Increase revenue (realizable value)	NA – 1 – 2 – 3 – 4 – 5 – NK
Increase margins	NA – 1 – 2 – 3 – 4 – 5 – NK
Access new markets	NA – 1 – 2 – 3 – 4 – 5 – NK
Respond to customer demand	NA – 1 – 2 – 3 – 4 – 5 – NK
Respond to consumer demand	NA – 1 – 2 – 3 – 4 – 5 – NK
Provide greater value/service to your customers	NA – 1 – 2 – 3 – 4 – 5 – NK
Avoid species substitution (mislabeling)	NA – 1 – 2 – 3 – 4 – 5 – NK
Avoid short weighting (mislabeling)	NA – 1 – 2 – 3 – 4 – 5 – NK
Improve the tracking of inventory	NA – 1 – 2 – 3 – 4 – 5 – NK
Verify where caught or harvested	NA – 1 – 2 – 3 – 4 – 5 – NK
Develop/implement more accurate or informed pricing models or strategies	NA – 1 – 2 – 3 – 4 – 5 – NK
Proactively influence the nature or structure of business contracts	NA – 1 – 2 – 3 – 4 – 5 – NK
Better manage or mitigate business risks	NA – 1 – 2 – 3 – 4 – 5 – NK
Increase quality assurance	NA – 1 – 2 – 3 – 4 – 5 – NK
Reduce administration costs	NA – 1 – 2 – 3 – 4 – 5 – NK
Improve/increase food safety	NA – 1 – 2 – 3 – 4 – 5 – NK
Ensure more accurate ordering, delivery, forecasting	NA – 1 – 2 – 3 – 4 – 5 – NK
Reduce input costs (e.g., feed, labor)	NA – 1 – 2 – 3 – 4 – 5 – NK
Reduce shrink/waste (e.g., from extending shelf life)	NA – 1 – 2 – 3 – 4 – 5 – NK
Reduce pilfering/embezzlement	NA – 1 – 2 – 3 – 4 – 5 – NK
Improve product recall capabilities, reduce associated costs	NA – 1 – 2 – 3 – 4 – 5 – NK
Reduce variations in quality	NA – 1 – 2 – 3 – 4 – 5 – NK
Increase assurance of supply *(mitigated supply risk)*	NA – 1 – 2 – 3 – 4 – 5 – NK
Ensure sustainability of your business	NA – 1 – 2 – 3 – 4 – 5 – NK
Ensure environmental sustainability of species harvested/purchased/sold	NA – 1 – 2 – 3 – 4 – 5 – NK
Other #1	NA – 1 – 2 – 3 – 4 – 5 – NK
Other #2	NA – 1 – 2 – 3 – 4 – 5 – NK

20) In the absence of a traceability[40] system, how would you make the above business decisions differently?

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Risk management and mitigation

Questions 21 to 26 broadly ask about market and operational related risks. As many of the factors associated with the two types of risk are interrelated, the questions overlap somewhat.

Market risks

21) We define market-related risks as those which potentially impact your input costs and/or your output prices.

[40]Restate the project's definition of traceability

What broad market risks have the greatest influence on your business decisions?

Rank each risk on a scale of 1–5 (1 = extremely low, 5 = extremely high) according to its influence on shaping your business decisions (circle one score for each risk). *If a risk is Not Applicable please circle NA. If you have no opinion or knowledge on a specific risk please circle NK*:

Listed below are risks you may face. Please include other important risks that are not listed.

Market risks	Potential impact on business decisions
	Low High
Changing government regulations	NA – 1 – 2 – 3 – 4 – 5 – NK
Supply variability	NA – 1 – 2 – 3 – 4 – 5 – NK
Inconsistency in government regulations	NA – 1 – 2 – 3 – 4 – 5 – NK
Competitors' behavior	NA – 1 – 2 – 3 – 4 – 5 – NK
Industry consolidation	NA – 1 – 2 – 3 – 4 – 5 – NK
Availability of new technology	NA – 1 – 2 – 3 – 4 – 5 – NK
Environmental concerns related to fisheries or aquaculture	NA – 1 – 2 – 3 – 4 – 5 – NK
Inconsistency of global traceability standards	NA – 1 – 2 – 3 – 4 – 5 – NK
Inconsistency of global food safety standards	NA – 1 – 2 – 3 – 4 – 5 – NK
Subjective third party verifications/assertions	NA – 1 – 2 – 3 – 4 – 5 – NK
Inconsistency of global technology standards	NA – 1 – 2 – 3 – 4 – 5 – NK
Inability to verify where harvested or raised	NA – 1 – 2 – 3 – 4 – 5 – NK
Inability to verify how harvested or raised	NA – 1 – 2 – 3 – 4 – 5 – NK
Inability to verify species	NA – 1 – 2 – 3 – 4 – 5 – NK
Sourcing from Illegal, Unreported, Unregulated fishing (IUU)	NA – 1 – 2 – 3 – 4 – 5 – NK
Other (please state)	NA – 1 – 2 – 3 – 4 – 5 – NK
Other (please state)	NA – 1 – 2 – 3 – 4 – 5 – NK
Other (please state)	NA – 1 – 2 – 3 – 4 – 5 – NK

22) Ranked on a scale of 1–10 *(1 = not at all, 10 = completely)* to what extent does your traceability system enable you to address the above mentioned market risks?

Not at all									Completely
1	2	3	4	5	6	7	8	9	10

23) Which of the above market-related risks does your traceability system most effectively address, and how?

Operational risks

24) We define operational risks as those risks which could impair how your firm conducts its business.

What operational risks have the greatest influence on your business decisions?

Rank each risk on a scale of 1–5 (1 = extremely low, 5 = extremely high) according to its influence on shaping your business decisions (select one score per risk). *If a specific risk is Not Applicable please circle NA. If you have no opinion or knowledge on a specific risk please circle NK*:

Listed below are risks you may face. Please include other important risks that are not listed.

Operational risks	Potential impact on business decisions
	Low High
Inability to verify freshness/catch or harvest date	NA – 1 – 2 – 3 – 4 – 5 – NK
Deliveries not meeting required specifications	NA – 1 – 2 – 3 – 4 – 5 – NK
Non or partial delivery of goods	NA – 1 – 2 – 3 – 4 – 5 – NK
Incorrect forecasting of supply	NA – 1 – 2 – 3 – 4 – 5 – NK
Incorrect forecasting of demand	NA – 1 – 2 – 3 – 4 – 5 – NK
Food safety recalls	NA – 1 – 2 – 3 – 4 – 5 – NK
Poor handling/storage (e.g., lack of temperature history)	NA – 1 – 2 – 3 – 4 – 5 – NK
Fluctuating input costs	NA – 1 – 2 – 3 – 4 – 5 – NK
Fluctuating supply of inputs	NA – 1 – 2 – 3 – 4 – 5 – NK
Fluctuating consumer demand	NA – 1 – 2 – 3 – 4 – 5 – NK
Safety of fish (e.g. contaminants, handling)	NA – 1 – 2 – 3 – 4 – 5 – NK
Availability of supply of fish	NA – 1 – 2 – 3 – 4 – 5 – NK
Inconsistency of quality	NA – 1 – 2 – 3 – 4 – 5 – NK
Freshness/shelf life	NA – 1 – 2 – 3 – 4 – 5 – NK
Fluctuating prices paid by your customers	NA – 1 – 2 – 3 – 4 – 5 – NK
Inappropriate labor practices (e.g., no slave labor)	NA – 1 – 2 – 3 – 4 – 5 – NK
Other (please state)	NA – 1 – 2 – 3 – 4 – 5 – NK
Other (please state)	NA – 1 – 2 – 3 – 4 – 5 – NK
Other (please state)	NA – 1 – 2 – 3 – 4 – 5 – NK

25) *Ranked* on a scale of 1–10 *(1 = not at all, 10 = completely)* to what extent does your traceability system enable you to alleviate the above mentioned operational risks?

Not at all									Completely
1	2	3	4	5	6	7	8	9	10

26) Which of the operational risks listed above does your traceability system most effectively address, and how?

Impediments to your traceability system

27) What information do you NOT currently receive from your suppliers or customers that would improve your traceability system?

Please rank from 1 to 5 (1 = not at all important, 5 = extremely important) how important it is for you to obtain each of the following types of information from your suppliers or customers. If a specific type of information is Not Applicable please circle NA. If you have no opinion or knowledge on a specific type of information please circle NK:

Information type	Level of importance
	Not at all Very
Catch or harvest date	NA – 1 – 2 – 3 – 4 – 5 – NK
Catch or harvest location	NA – 1 – 2 – 3 – 4 – 5 – NK
Temperature history	NA – 1 – 2 – 3 – 4 – 5 – NK
Shipper name	NA – 1 – 2 – 3 – 4 – 5 – NK
Product specifications	NA – 1 – 2 – 3 – 4 – 5 – NK

Information type	Level of importance
	Not at all Very
Product state (e.g. raw, cooked, blended, unadulterated)	NA – 1 – 2 – 3 – 4 – 5 – NK
Adherence to stated food safety practices	NA – 1 – 2 – 3 – 4 – 5 – NK
GTIN (Global Trade Item Number)	NA – 1 – 2 – 3 – 4 – 5 – NK
GLN (Global Location Number)	NA – 1 – 2 – 3 – 4 – 5 – NK
Labor practices (e.g., verifying no slave labor)	NA – 1 – 2 – 3 – 4 – 5 – NK
Other (please state)	NA – 1 – 2 – 3 – 4 – 5 – NK
Other (please state)	NA – 1 – 2 – 3 – 4 – 5 – NK
Other (please state)	NA – 1 – 2 – 3 – 4 – 5 – NK
Other (please state)	NA – 1 – 2 – 3 – 4 – 5 – NK
Other (please state)	NA – 1 – 2 – 3 – 4 – 5 – NK

28) What are the barriers that prevent you from receiving the information that you identified as being most important to your business?

General

29) Are there other issues not covered by this survey that you consider important for assessment of the effectiveness of traceability systems and for enabling industry to adapt to a rapidly changing commercial and ecological environment?

Sincere thanks for your participation and interest