CHOICE OF A TRACEABILITY STRATEGY FOR U.S. SEAFOOD MARKET ENHANCEMENT: TRACEABILITY AS A SIGNAL OF QUALITY

by

Vugar Ahmadov

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To the Faculty of Washington State University:

The members of the committee appointed to examine the thesis of VUGAR AHMADOV find it satisfactory and recommend that it be accepted.

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Chair

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CHOICE OF A TRACEABILITY STRATEGY FOR U.S. SEAFOOD MARKET ENHANCEMENT: TRACEABILITY AS A SIGNAL OF QUALITY

Abstract

by Vugar Ahmadov, M.A.
Washington State University
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Chair: Thomas Wahl

The paper develops a comprehensive review of the literature on the fishery traceability systems and analyzes its economic benefits to the industry players. It involves a review of various qualitative and quantitative studies on the traceability systems, functions and models outlining a detailed overview on the application of traceability systems. The work identifies that traceability is an efficient market enhancement tool enabling firms to successfully enter and sustain their place in the market.

This study uses Alaskan pollock (*Theragra chalcogramma*) as a model product and depicts the details of a certification process for the U.S. Pollock fishery along with the application of traceability systems by an individual fish producers or processors. Further, it develops an economic analysis of value chain for this fishery in the United States and throws lights on future market trends for it, which may be transferable to other fisheries.

Furthermore, this research proposes a theory for a traceability system and shows

how it is a strategically important tool for U.S. Pollock producers to successfully promote their product forward in the value chain and finished products from pollock to consumers. This proposed theory involves the development of two game theory approaches to analyze and interpret the commercial interaction of producer and consumer in an asymmetric market versus a symmetric market environment. In the first approach the producer of a fish product knows the actual quality of the product but the actual of the product is unknown to the consumer. Therefore, this puts the producer in the position to make falsely high quality product claims and at the same time permit the use of low quality production practices[1]. In the asymmetric market situation, analytical strategies of the players depend upon the payoffs in one stage, infinite and infinite periods. However, the second symmetric market model incorporates traceability as a tool to help the purchaser or consumer to evaluate the actual quality of the product and transform the experience and credence attributes of product into search attributes. In addition, the second model affords different strategies for players depending upon their payoffs in the symmetric market.

Finally, the thesis supports the theory that if a traceability system is strategically chosen, it will enable the firm to maintain a good long run relationship with consumers and remain successful in the market place.

[1] This practice also can be observed in some situations in which pollock has been sent from U.S. producers to foreign secondary processors who then fail to process according to market specifications and ship low quality, adulterated or misbranded products to the U.S, European Union or elsewhere.

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To my wife and lovely daughter:

Shahla Ahmadova and Leyla Ahmadova

CHAPTER 1

Introduction

Food traceability systems have become more prominent in the seafood industry as a result of a desire of producers to differentiate their products from others, for example wild harvest from aquacultured product. Traceability systems can provide quality signals to consumers. In a regulatory context, traceability has been mandated by country of origin labeling requirements for aquatic foods sold in the United States starting in 2005. Also, the record keeping requirements under the Bioterrorism Act (The Public Health Security and Bioterrorism Preparedness and Response Act of 2002, PL: 107-188) have increased the requirement that seafood be traceable as a means of providing sufficient protection of the food supply from intentional contamination and in case of a recall if either intentional or unintentional contamination of a product is suspected (Rasco and Bledsoe, 2005, Bledsoe and Rasco, 2002). Traceability is built into HACCP (Hazard Analysis Critical Control Point Programs (HACCP)) through requirements for monitoring and verification; seafood products were the first foods to be covered by a mandatory HACCP plan, beginning in 1995 (21 Code of Federal Regulations Part 123 *et seq*.) Hopefully, all of these factors will lead to improvements in the overall safety of the food supply.

There is a perceived conflict in the objectives for traceability systems and whether these should be driven by the market or by food safety regulation, therefore, the following question should be asked: *"what is a food traceability system and how is this to be integrated with existing food safety systems such as ISO and HACCP?* To correctly answer those questions we need to define traceability and describe the contexts in which it is used.

Most commonly, traceability helps participants in the food industry or regulators to verify compliance with food quality and market standards and safety regulations. The design of a traceability system can provide both *ex-ante*[2] and *ex-post*[3] information on a food product and its ingredients (Hobbs 2004) at any point within a vertically integrated value chain. It should be also emphasized that traceability is just simply a system, reflecting the application of food safety procedures, and food quality and market standards to a particular situation. For a traceability system to be effective, several factors must be in place. First, food safety standards and regulations must be properly implemented, as these are the basis for ensuring safe food production; no quality food product can be made which is unsafe. Taking improved food safety procedures are also a means by which the private sector strives to increase its goodwill (Hobbs, 2004) and to reach higher net sales by setting production practices to meet voluntary market driven standards that exceed mandatory governmental requirements. In other words, implementation of a traceability system, in sense of product promotion, could be used as a tool to increase the marketability of products and improve the level of customer satisfaction with a product. Traceability also provides a mechanism to meet the increasing expectations of consumers 'right to know' the origin, source, content, composition and other features about their food.

In addition to providing an assurance of food safety, traceability enables a producer to eliminate, to a certain extent, some of the direct costs of a product recall costs in the unfortunate situation when a food must be removed from the marketplace when it is suspected of posing a risk of food ill borne illness, or when it is in the best interest of a producer to conduct a market withdrawal by removing a product from the marketplace

[2] *Ex post* – is Latin meaning "after the fact" but, here, it is one of traceability functions that enable the producer or any interested party in supply chain to trace the finished or product in process and ingredients back to their source of origin (derived in part from Hobbs 2004).

[3] *Ex ante* – is Latin meaning "before event" or "beforehand" but it represents one of traceability functions that enable producers in the supply chain to provide quality verification signals to consumers (Hobbs 2004).

due to a lack of conformity to quality standards. As an example of the impact of these market withdrawals, the cost of product recalls as well as the cost of proactive measures taken by the industry to reduce the likelihood of a recall is increasing. The recent nation wide recall of fresh spinach and spinach containing product to a small number of producers and one packaging facility in California in September 2006 is projected to reach direct cost of over 100 million dollars. The U.S. food industry spent 7 billion dollars in 2000 for measures to control food borne disease (ERS, 2003) these were primarily for preventive measures taken to improve food safety. Due in part to improved detection methods, along with greater precautions taken by the U.S. food industry to ensure that products in the market are safe and of suitable quality, the volume of product recalled[4] increased from 1.5 million during 1993 to 1996, to 24 million pounds between 1997 and 2000 (Ollinger and Ballenger, 2003).

Improving traceability strategies can improve cost control within a company. Food safety concerns and a recent large scale recalls involving pathogenic *Escherichia coli.* .Non-pathogenic forms of *Escherichia coli* colonize the intestinal tract of all warm-blooded animals including humans. However, cattle and other ruminants can harbor the pathogenic 0157:H7 variant[5] but still do not exhibit illness symptoms. One of the most famous outbreaks involving beef occurred in Washington State and other Western states in 1992 with undercooked ground beef served in the *Jack in the Box* chain of fast food restaurants. A large number of children in the Pacific Northwest contracted serious illnesses from the consumption of undercooked hamburgers ground meat. There were a small number of fatalities, but the most famous case was that of a young Seattle girl, Brianna Kiner, who spent months in the hospital and miraculously survived. Her case was followed closely in the local media and her case became a rallying cry for improvements to food safety in the meat industry.

[4] Annex 3 lists product recalls.
[5] There are a number of pathogenic *E. coli* strains, but 0157:H7 is the most notorious to date.

As a result of this outbreak, the parent company implemented an improved traceability system from carcass supplier to point of sale at restaurants and found that this cut both the probability and level of pathogen contamination without a significant increase in cost (Lyons at 749 citing Buzby and Roberts, 1996). *Jack in the Box* to this day remains a leader in food safety management for this segment of the restaurant industry.

Other incidents involving meat followed shortly thereafter. An incident in Australia in 1995 resulted in the death of a child from *E.coli* O157:H7 contamination from sausage product (Hobbs, 2003). In 1996 another bad outbreak by *E.coli* O157:H7, in central Scotland, was linked to cold and cooked meat products sold by a butcher, John Barr and Son, in the Lanarkshire town of Wishaw that also resulted in five deaths and left 280 people ill[6]. This year was also marked by another Pacific Northwest outbreak of *E. coli* 0157:H7, this time in contaminated unpasteurized fruit juice sold by the Odwalla company, which resulted in the death of at least two children and numerous illnesses. Some of other foodborne outbreaks and countries are outlined in the following table.

[6] Source: http://bmj.bmjjournals.com/cgi/content/full/313/7070/1424/a "E coli 0157 kills five people in Scotland".

TABLE 1.1. Foodborne Disease and Contamination in the Asia-Pacific Economic Cooperation Region

Disease/ Containment	Countries Reporting Outbreaks	Source or Vector
Listeria monocytogenes	Australia, Canada, US	Fruit salad, smoked salmon cream cheese, hot dogs, deli meats
Salmonella	Australia, Chile, Korea, New Zealand, U.S.	Pork rolls, unpasteurized orange juice, mayonnasia, meat raw eggs, fruit
E.coli bacteria O157:H7	Chile, Japan, Korea, U.S.	Fast food, radish sprouts, meat, unpasteurized juice, lettuce
Staphylococcus aureus	Japan	Unhygienic production-line valve at dairy company
Cyclospora cayetanensis	U.S.	Imported raspberries
Norwalk-like virus	Australia, New Zealand	Sick food handler, oysters
BSE (Creutzfeldt-Jakob disease)	Canada (Saskatchewan)	Meat likely consumed in UK from cattle infected with BSE
BSE	Japan	Five cases confirmed since Sept. 2001
Chloramphenicol	Canada	Imported honey and honey products
Cyanide	Chile	Several grapes shipped to U.S. thought to be contaminated
Antibiotics	China	Exports of prawns, shrimp, poultry and rabbit meat
Unreported	China	Soybean drink consumed by students
Rat poison	China	Deliberate poisoning of food in food shop
Cadmium or mercury	Chinese Taipei (Central region)	Rice
Bacteria or enteric viruses or	Chinese Taipei (Taipei city)	Prepared box lunches contamined with polluted storm water
High levels of pesticides	Japan	Imported green soybeans
Vibrio sp.	Korea	Seafood (claims)
Dioxin	Malaysia	Imported dairy and meat products
3-MCPD	Malaysia	Imported savory foods; soups; gravies; prepared meals, snacks, and mixes contamined with this genetoxic carcinogen
Hepatitis A	U.S. (Michigan)	Imported strawberries; point of contamination unknown

Source: http://www.ers.usda.gov/publications/agoutlook /Dec2002/ao297i.pdf

Another major source of food borne illness is *Campylobacter jejuni*. Campylobacteriosis is the acute infection and is the most commonly reported cause of foodborne illness in the United States. Each year it causes around 2 million cases of food borne illness, 10,000 hospitalizations, and 100 deaths. The Economic Review Service (ERS) estimates that each year the cost of acute illness in the United States from foodborne *Campylobacter* (all serotypes), accounts for $471.7 million. Treating the acute and chronic illness resulting from this microbe causes an estimated $1.2 billion in costs to the United States each year (ERS 2002).

These series of high profile food safety scares has heightened public awareness and concerns over food safety, and provide case studies for how traceability systems could be improved and implemented. For example, the Bovine Spongiform Encephalopathy (BSE) crisis in the UK beef industry in the 1990's has led to an improved individual animal identification system so that retail cuts currently sold in the UK can be traced back to a specific animal. From a producer's perspective, improved traceability will provide a mechanism for moving towards a more rational and integrated market driven food safety and quality system. Market realities require an expansion of negotiated vertical coordination in food production and less fragmentation, meaning that traceability will be an increasingly important tool for monitoring both the strict societal and market accountability required of food providers (Lyon, 1998 *et al.* 729).

Definitions of Traceability

"Traceability" is a system or method that enables interested parties to trace a food, its components, or features, backward and forward through all stages of production, processing, distribution and sales. The International Organization for Standardization (ISO) defines traceability as the "*ability to trace the history, application or location of an entity by means or location of an entity by means of recorded identifications*". Within ISO and HACCP food safety systems there is an implicit requirement for traceability since both programs require monitoring of ingredient sources, coding and tracking lots, and compilation and possible filing of data related to the production processes at least one step forward and one step back while the product is being manufactured at a facility and during its distribution. Traceability as it is currently understood should provide the ability of a party in the supply chain to trace the product from its origin up through consumer sale. In this sense, traceability is considered to be a system from "farm to fork" – providing a mechanism for tracing product all the way back and forward.

The Codex Alimentarius Committee on Food Imports and Export Inspection and Certification Systems (CACFICS) describes traceability as "*the ability to identify a food (product identification), how it was changed (if appropriate), where it came from and where it was sent (one step backward and one step forward) (product information) and the linkages between product identification and product information, while also noting that the applicability of these elements will depend on the objectives being pursued by the individual text*"[7].

The EU Commission defines traceability as: "*the possibility to find and follow the trace, throughout all the stages of production, processing and distribution of a foodstuff, feedstuff, an animal destined for food production or a substance destined to be incorporated in foodstuff or feedstuff or with a probability of being used as such*"[8]. The focus that these international organization place on traceability provides an indication of how important this issue is for food safety, compliance with internationally recognized sanitary and phytosanitary good practices and to promoting international trade[9].

Research Objectives

The overall objective of this research is to study economic benefits of traceability for U.S. pollock (*Theragra chalcogramma*) industry by identifying a "traceability system" as a strategic market enhancement tool. The study will develop a comprehensive analysis of industry wide practices and improvements to current practices that could lead to obtaining an industry wide certification. In this regard, the functions and working principles of the certification bodies, such as the Marine Stewardship Council for environmental fisheries management issues, and agencies, including governmental food safety and marketing entities, will be discussed throughout. In addition, the research will

[7] CCFICS, 11th Session, Adelaide, Australia, 2-6 December 2002, Agenda Item 7, CX/FICS/02/11/7 paragraph
[8] Art.3. Regulation (EU) No 178/2002 of the European Parliament and the Council of 28 January 2002.
[9] Discussion with Thomas I. Wahl, IMPACT Director

also analyze various traceability systems and product tracking techniques that are currently applied by different food industries or industry players.

To provide a better understanding of the U.S. pollock fishery and market structure an overview of pollock value chain will be depicted with strong focus on analyzing the market trends. In addition, the study also captures interesting information and data set for leading U.S. fisheries and species in terms of production and consumption that signal current and future market developments.

In order to illustrate the strategic and economic benefit of traceability systems for the pollock industry this research will develop two game theory models:

1. The first model describes a game between producer and consumer in an asymmetric market through one stage, finite and infinite period games. The objective of introducing the first model is to highlight the fact that the producer as a monopolist has enough knowledge about the actual quality of the product but the consumer does not have any information on the actual quality. This condition enables the producer to falsely claim that a low quality product is a high quality product and, for example, charge the same price for both products to avoid misleading the consumer.
2. The objective of the second model is to illustrate the condition where the consumer obtains the ability of successfully evaluating the actual quality of the product through the traceability system. Therefore, the producer will offer products that meet customer specifications (in this case high quality product) to satisfy the demand of the consumer otherwise, the consumer will not make the purchase.

The overall objective is to determine how a traceability system can transform the asymmetric model into symmetric model by empowering the ability of the consumer to evaluate the actual quality of the fish product.

Summary of Findings

The thesis suggests that a traceability system has different purposes and applications in different industries; for example, the U.S. beef industry has implemented a traceability system to differentiate products in the market place to gain some “market power” or to inform the consumer about the origin of the product. However, the fishery industry applies the traceability system to signal the consumer that the product is derived from sustainable and well-managed fishery, and to determine product country of origin, the location of the run of the fish, or the source of the fish (*e.g.* wild harvest or culture).

This research identifies through two game theory approaches that the traceability system is unique market enhancement strategy empowering the firm to signal the actual the quality of the product to the consumer. Therefore, the application of a traceability system is in the best interest of a rational consumer that is interested in obtaining a safe and quality product. In addition, traceability enables the firm to track down the product to the origin in the case of quality or safety disputes. The study also identifies that a one-stage game with asymmetric information where the producer has all knowledge on the actual quality of the product lead to the market failures, which can be eliminated if the producer does not cheat the consumer at the first stage. The first model of the research proves that the producer still may cheat the consumer at the last period of finite games. But the producer receives different payoffs from an infinite game: if the producer claims and offers high quality produce, then, the producer will receive a high payoff. In the case of deviation from the claim and the offering a low quality product, the producer will receive a one time lower level payoff. The consumer will receive either o payoff if the producer deviates or positive amount of payoff if the producer does not deviate but offer high quality product.

The second model develops a symmetric situation in which the consumer obtains an ability to evaluate the actual quality of the product and makes his or her purchasing decisions accordingly. In other words, traceability signals to the consumer whether the fish product belongs to high or low quality category.

Finally, the study derives very important and crucial findings that a symmetric market with a traceability system that empowers the producer's ability to maintain a long run relation with consumer. Therefore, the thesis concludes that the application of the traceability system is in the best interest and strategy of the producer.

Current Trends

Growing global trade in food products requires the ability to monitor food safety and quality across great distances quickly and reliably. The quality of our foods is of major concern to food processors and public health authorities. It is estimated that there are more than 80 million cases per annum of food-borne illnesses in the USA (Miller and Kvenberg 1986) and that the cost of these illnesses is in the order of many billions of dollars per year (Todd 1989b). More specifically, between 1973 and 1987 a total of 7,458 foodborne disease outbreaks (10% of which were attributed to aquatic food products, mostly involving raw molluscan shellfish) involving 237,545 cases reported in the United States (Bean and Griffin 1990). The economic losses due to spoilage are rarely quantified, but a report by the US National Research Council Committee (FNB/NRC 1985) estimates that one–fourth of the world's food supply is lost through microbial degradation alone, let alone damage from vermin, insects and endogenous biochemical or chemical changes that cause quality loss and make food either unsafe or inedible.

Thus, the need to control food quality is well documented. The reliability of food born illness reporting is improving in both developed and developing countries, and this presents an urgent need to improve both the traditional or conventional means of assuring

the quality of food[10] as well the development of new technologies for traceability and food quality monitoring. In an attempt to maintain product safety, most governments impose mandatory food safety measures and restrictions on the private sector to ensure a certain level of product safety. Traceability was initially implemented as part of hazard analysis critical control point programs (HACCP), as part of good manufacturing practices (in the United States, 21 CFR Part 110 *et seq* and Part 123 *et seq* for aquatic food HACCP) and mandatory recall programs (under 21 CFR Part 7). This has now expanded in scope, to a system recognized internationally to satisfy mandatory requirements in vertically integrated commercial values chains. HACCP strategies can function more reliably in vertically coordinated food systems (Lyon, 1998 at 775) and expansion of HACCP programs to include improved traceability.

The scare over mad cow disease in the mid-1990's precipitated major changes in traceability in the international food trade. Specifically, Japan, Canada, and European countries, particularly Denmark and England imposed traceability requirements on the private sector to provide adequate information to the consumer level regarding bovine spongiform encephalopathy (BSE, commonly known as mad cow disease) (Baines and Davies 1998). The EU demands accountability and proof that certain food safety standards have been met at all stages throughout the value chain for other products including meat and require that retail cuts be traceable back to the animal from which they came. This increased focus on traceability has led to advances in other areas, some driven by the market and others by regulatory requirements. Some restaurants and grocery stores now require their suppliers to establish safety and quality traceability systems and to verify the application and compliance of the system through the third-party certification. And some safety and quality certifiers such as the Swiss-based Société Générale de Surveillance (SGS) and the American Institute of Baking (AIB) recognize

[10] http://www.fao.org

traceability as tool for firms to control safety and quality issues (ERS 2004). Besides food safety considerations, traceability is required to meet organic and fair trade standards, whether mandated by the government or driven by market considerations.

Specific reasons for improving food traceability systems include:

a) Current consumer trends in the USA and across the world, which call for a special focus on knowing more about the purchased food products and their safety.
b) Regulatory requirements under the Bioterrorism Act (Public Health Security and Bioterrorism Preparedness and Response Act of 2002 (Bioterrorism Act: PL 107-188)) and regulations in effect as of 2005 requiring product traceability in case of an intentional tampering incident.
c) Requirements under the 2002 Farm Bill, seafood and other foods must be labeled with their country or origin at the point of retail sale in US markets.
d) To improve the ability of US food industry players to competitively position their products in domestic and international markets specifically Japan and the European Union.
e) To successfully market against sophisticated competitors in countries such as New Zealand, Uruguay and Canada, which have instituted well publicized traceability programs for muscle food markets (Dickinson and Bailey, 2002).
f) To reduce the amount of spending by state and private entities on control food borne disease transmission (ERS, 2003).
g) Market requirements to protect intellectual property, manage risk, and target market development (Lyon 1998 at 729).

The traceability is also in the interest of government, especially those agencies that are heavily involved in ensuring the welfare of consumers, avoiding any possible food related outbreaks and increasing the supply of quality food products.

Types of Traceability Programs

There are two types of traceability programs: internal and external, and their use is dependent upon the application, purpose, and point in the value chain where they are employed. *Internal traceability* is conducted within a company to maintain information on the origins of raw materials, the processing procedures, and product distribution. *External traceability* transfers sufficient product information from one player in the chain to the next one. Sometimes, external traceability is also considered to be the chain traceability that exists between companies or between countries. External traceability exists due to the availability of information by the internal traceability systems. There are some challenges (*e.g.* lack of an acceptable terminology for an entire value chain and co-operation among players or even countries) in the application of external traceability. Internationally, some projects (*e.g.* Tracefish) were launched to standardize chain traceability, this system was initiated by European Union. The objective of Tracefish is to develop a consensus among players of industries on: the type of data to be recorded for traceability and transmitted for seafood products, and how the recorded data needs to be coded electronically (Halldór, 2004)[11].

[11] http://www.microsoft.com/dynamics/industry/foodbev_traceability2.mspx

Different Traceability Functions

Recent developments and applications of traceability in different formats (Hobbs, 2004) help to identify three functions of tracing or tracking the products back and forward:

1. *Ex post* trace-back system. Tracing back to the food source, for example, livestock products or animals if there is a suspected food safety problem. In the livestock sector, effective trace-back efforts can control the possible outbreaks of food borne illness and reduces significantly costs related to a recall, mitigate damages and mitigate liability, and maintain company goodwill and maintain the reputation of the firm and industry segment. Traceability systems can also provide the firm with the ability to reduce *ex post* costs in the event a problem occurs. Many firms and quality services or product suppliers strive to reduce their liability by conducting timely due diligence measures (*e.g.* HACCP monitoring and verification) that speed the identification and segregation of affected protects, allows a company to cover, and protects their reputation as a supplier in the industry. The additional costs of due diligence for compliance with voluntary standards, protects quality product suppliers from ‘free riders’ who do not allocate either sufficient efforts or resources to good production practices. Within this context, a traceability system acts as a reactive function. For example; Washington Beef LLC that is active in the Yakima Valley supplies quality meat products to the major markets of Western North America (Seattle, WA, Portland, Vancouver and Victoria, BC) and internationally to Japan and other Pacific Countries. As a later part of this paper, specific scenarios will be proposed for the development of an industry-wide traceability system that will also facilitate the

adoption of certain measures aimed at strengthening safe production on industry wide scale.

2. Another *ex post* information system is applied by firms in an industry segment to establish and set safe production practices, as an incentive to avoid possible legal penalties imposed by government or monetary damages to a business from civil actions of buyers or consumers in case a food safety problem is identified. The direct costs of a recall are estimated to be roughly 10% of overall costs considering lost sales, loss of market share, cost to cover and reputation costs (Rasco and Bledsoe, 1999). At this point, the costs of a recall become a serious commercial interest of an industry that is willing to maintain its reputation. In the USA, legal liability is a significant deterrent to poor business practices, but it is not considered to be a strong incentive to implement improved food safety measures based upon the outcome of actual food borne illness cases since the number of the cases in which compensation is paid to affected plaintiffs is low and monetary compensation is also low (Hobbs 2004; Buzby, Frenzen and Rasco, 2002, 2001). However, products liability is becoming a crucial market factor in the EU and other markets which are moving rapidly towards a strict liability standard for the sale of food (*See* Reimann, 2003; Vera, .2005; Stapelton, 2002; Liu, 2004; Rasco, 1997).
3. The third type of traceability function is *ex ante*; one that provides sufficient information on the quality verification of food products. In this case, the food product label highlights information to satisfy the client's expectations related to the safety issues. However, livestock identification and trace-back systems should not be confused with *ex ante* quality verification programs. It should be noted that *ex ante* information systems provides enough information to clients for product verification, and generally avoids the need to pass extra information to

consumers. Often, a neutral third party agency would verify that the provided information on quality assurance statements is accurate and that a firm is in compliance with safety procedures. In addition, government inspectors, such as those involve in the mandatory USDA federal meat inspection program have a reputation among consumers for providing transparent oversight and an objective evaluation of meat product safety despite deficiencies in monitoring and enforcement (Lassiter, 1997), although this system of mandatory in-plant has its detractors. However, due to a lack of resources, training, and unfortunately governmental corruption, competent, reliable, cost-effective, and transparent government inspections cannot be are often not available in many developed and most developing countries.

The *exes post and ex ante systems both have* advantages and disadvantages. As we know, both functions of an *ex post* information system of traceability has the primary advantage of being able to trace food products back to the origin. Unfortunately, these systems lack the ability of providing pre-purchase quality verification to the customer, which is considered to be a primary advantage of *ex ante* information system. And *ex ante* information system, however, does not provide a trace back opportunity for players within food industry, which may cause high external costs.

Regardless, all these characteristics of the traceability systems they still do not create any credence attributes[12] and simply verify their existence. The traceability parameters, if set properly, provide various types of benefits for consumers and all of the other players involved in getting the final product to the consumers hands. Because of

[12] Credence attributes are based on two different attributes: content attributes that affect the physical properties of a product, although it is difficult for consumers to understand it (*e.g.* GMO attributes) and process attributes; those attributes that do not affect final product content but relate to characteristics of the production process which do not discernibly affect the chemical, microbiological, physical, functional or sensory characteristics of the food. Examples include country-of-origin, organic and free range, etc., neither testing equipment nor consumers can detect process attributes.

these benefits from the above stated functions, different industries individually or jointly have adopted either *ex post* or *ex ante* information systems to satisfy their clients' expectations. For example, EU and Canadian livestock sectors extensively implement *ex post* information systems, *e.g*. the traceability applied by Canadian meat industry enables an interested party to successfully trace back products all the way to the origin. Canada launched a national cattle identification program as mandatory system to trace animals from the retail to the farm of origin, which was in place for beef and dairy industry on January 1, 2001. The requirement has urged processing plants to read tags and maintain trace back of the carcass since July 1, 2001. The system also established monetary penalties for non-compliance with the cattle identification that was imposed on July 1, 2002.

Traceability Information Flow

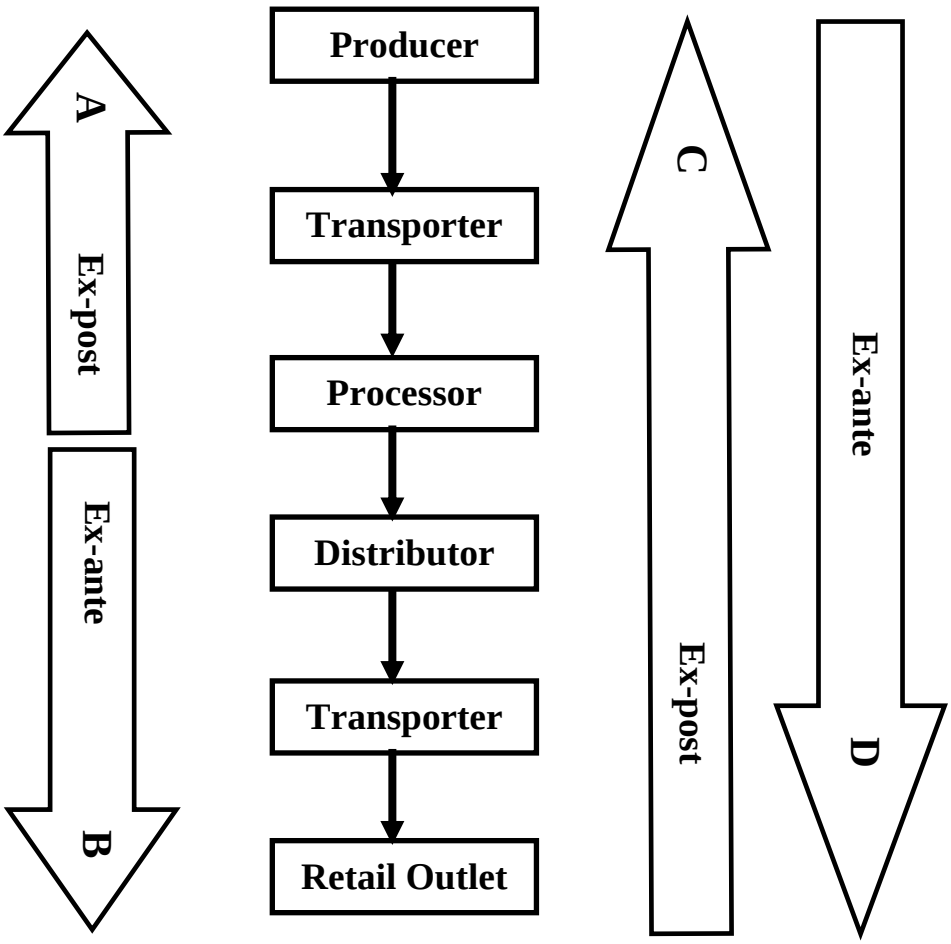
In previous paragraphs this paper touched upon the three functions of the traceability and provided a short overview of their application and benefits to the various food value chains. However, it is hard to visualize the flow of the information through supply chains by different methods and systems. Therefore, the following chart (*chart 1*) depicting traceability information flow system through all stages of value chain introduces four different scenarios:

A. EX-POST (information flow back) from processor to producer *e.g.* a livestock identification program enables interested parties to track animal from slaughter house or processing facility to the farm of origin,

B. EX-ANTE (forwarding information flow) from processor to retail out to verify the quality of food product or provide quality signals to consumers *e.g.* nicely packed and accurately labeled fish products satisfies consumers' expectations for quality assurance information such as the place and date of

processing and packaging. A and B is applicable separately or together *e.g.* in livestock sector and it very much depends on the type of value chain. And it is definitely useful for the vertically integrated value chain players to have ability to manage both functions as they have certain separate unique advantages and benefits.

Figure 2.1. Information Flow in *Ex Post* Traceability and *Ex Ante* Quality Verification



Traceability and Labeling

In certain food value chains, there is a direct relationship between a traceability system and food product labeling. Sometimes, the traceability could be applied to identify the product (*e.g.* fish origin of the product), which is information that appears on the

label. Proving information or signaling about the traceability to the consumers to build their trust or avoid concerns over the safety of the food products is successfully achievable through the labeling (detailed information label is provided on the next chapter). Proper labeling provides a valid and direct message or signal about the attributes of the product to the consumers. Therefore, with more adequate and accurate information, more trust and confidence of the consumer could be achieved. In addition fish products from the same harvest location or production lot may be sold under different brands, or in different product forms (*e.g*. round vs. headed or filleted etc.), and these factor would strongly favor the development of an accurate the traceability system. In most situations, the final product label signals the consumer information that affects their purchasing decisions.

CHAPTER 2

Seafood Traceability and Certification Programs

Mostly seafood producers follow a rational strategy of producing quality and healthy food products to maintain their reputation and strengthen their position in the market place and to increase production to meet consumer demand. Consumers have increased their consumption of fishery products and prefer to purchase and consume safe and healthy food items that will help them to maintain a healthy life style and avoid future health problems by limiting the intake of certain components, such limit saturated fat which is present in substantially lower levels in fish compared to meat product, avoid high medical expenses.

To meet these demands, firms in the fishing industry have taken steps to enlarge and automated their operations to meet the fast growing demand of consumers. Over the past decade, the fishery industry integrated more efficient production practices, HACCP systems and total quality control programs to ensure quality product. These actions taken towards rationalization and efficiency of the production practices have lead to competitive placement in the market and has maximized the profit in parallel reducing costs for input demands. In addition, these strategic improvements also enabled firms to successfully reach targeted groups of consumers with quality products. But neither of these efficient production strategies has the capability to provide a proof of the quality to the consumers besides what was visibly detectable or ascertainable by a simple chemical or microbiological test. For example, if any food safety related incident was experienced, huge costs to businesses would result because of the difficulty of tracking affected product. BSE in meat in the US in 2003 and the discovery of chloramphenicol in shrimp that same year coupled with other food scares encouraged the seafood industry to develop

better traceability systems. In addition, there has been continuing market pressure placed on the industry to maintain and promote sustainable fish resources and this has urged fishery industry players to seek a new way of providing evidence on the quality of the product (credence attributes), which in turn can only be verified by a reliable traceability system. One idea was simply to have a system that will enable the interested party to avoid any possible suspicion over the quality of the product by using some sort of coded tag for the product or lot that can be tracked through a computer tracking system that could verify the identity of the product any where in the value chain. A traceability system such as this has an enormous power of revealing a full path of a product throughout the value chain. In addition it can provide the consumer with full confidence of the quality and safety of the product that they purchase down to the retail level. Some fishery players use the traceability as dispute resolution tool when the buyers have certain doubts over the quality or they are trying to force a reduction in purchase price of a highly perishable product by alleging that the product is of lower quality that it was at the time of delivery. This is an issue that commonly arises with the pricing of seafood products destined for Japan, where a cartel of buyers sets the purchase price for specific products daily, regardless of prior agreements with fishers, and will claim that product is of a lower quality in order to force a reduction in price. Traceability also plays a crucial role for buyers who have the legitimate objective of wanting specific product traits to be the validated such as information on the origin, catching method, the kind of vessel used and production practices used and will only purchase product if the specified criteria can be met.

Almost all commercial value chains of seafood industry in the USA have to be certified for COOL (Country of Origin Labeling) with objective to meet the requirements. These requirements mesh with those under new Homeland Security measures for traceability under the Bioterrorism Act as well as with major customers e.g.

McDonalds and Kraft Foods who have strict requirements for traceback protocols for vendors in case of a market withdrawal and who also have established marketing programs based upon use of certain species and who require product from sustainable fisheries.

Marine Stewardship Council

The Marine Stewardship Council (MSC) is London, UK based independent, global, non-profit organization that promotes sustainable fisheries. In response to the continued decline in the world's wild capture fisheries, the MSC is trying to harness consumer purchasing power to generate change and promote environmentally responsible stewardship of this, the world's most important renewable food source[13].

The MSC has been quite successful in developing an environmental standard for sustainable and well-managed fisheries across the world. The council has been using a product label (eco-label) to recognize environmentally responsible fishery businesses and management practices. The MSC standard and label provides confidence based on an independent assessment to consumers who are concerned with over-fishing and its environmental and social consequences.

Globally, more than 40 fisheries are engaged in the MSC process, together representing over 3.5 million tons of the annual seafood harvest. It is an exciting fact that more than 320 MSC labeled seafood products are now available in 26 countries. Some leading American fisheries (*e.g.* Alaska Pollock – Bering Sea and Aleutian Islands, Alaska Pollock – Gulf of Alaska, Alaska Salmon, BSAI Pacific Cod Freezer Longline, US North Pacific Halibut and US North Pacific Sablefish) have obtained MSC five-year certification after the full assessment of fishing practices. The certificate can be renewed after a full reassessment when the initial period is completed.

[13] http://www.msc.org/html/content_462.htm

The MSC provides an equal access to its certification program irrespective of the size, scale, type location or intensity of the fishery. The review process for the MSC Standard is constantly conducted by an independent group of fisheries experts. Technical advisory board composed of experts from around the world monitors this review process. The technical advisory board operates under the terms of reference. Different world fisheries can apply to be independently assessed against this standard under its voluntary scheme. Independent certification bodies (not the MSC itself), can conduct these assessments. These certification bodies must be accredited by the MSC to conduct assessments against the established MSC standards. A certifier must consider all players in the value chain (from the fishing grounds to the retail consumer) and evaluate the supply chain against the MSC Chain of Custody standard. Usually, the value chain includes a number of different players. Therefore, the certifier will closely observe all steps in the value chain specifically place, where the products from a certified fishery could be commingled with products from a non-certified fishery. This forces a relatively rigid traceability system upon certified companies if they are to meet the MSC Standard, Chain of Custody certification must guarantee the traceability of MSC-labeled seafood. The MSC-label ensures that seafood product has been successfully segregated from non-certified and non-traceable product all the way through from the boat to the plate. Every business in the certified fishery must make sure that certified fish is kept separate from non-certified fish at every stage of production and that certified and non-certified product is not commingled during any type of production and processing operation whether this is the shipment of whole fish or production of highly processed foods containing minced fish such as fish pies. These businesses, to receive MSC certification, must also keep detailed records of where the MSC fish came from, who supplied the fish to them and who the next player is in the supply chain (unless this is the retail consumer).

It should be emphasized that Chain of Custody is the primary traceability element of the MSC certification program. An assessed and certified fishery receiving the MSC Standard for Sustainable Fishing is allowed to use the MSC eco-label on seafood products, which independently verifies that the product originated from a certified fishery. Only the Chain of Custody (CofC) Certificate provides this verification. Each certified business in the chain of custody will have a certificate showing these businesses understand the MSC program and integrated appropriate systems and procedures for ensuring that MSC fish are kept separate from other fish in their business. This certificate is a perquisite to using the MSC eco-label that signals the added value of sustainable seafood product to consumers.

Anyone that wishes to apply MSC logo to a fish product must first obtain a CofC certificate. Each member of the value chain including processors, retailers and restaurants must be certified up to the point of applying the label to the product. Only, those products with a certified value chain will be eligible to use the MSC logo. It can be also considered that MSC label provides the consumer with confidence that eco-label product is originated from the certified sustainable fishery and Chain of Custody standards ensures whether the firm may trace independently the certified products from other fish products in the business. In addition the MSC encourages improvements in the management of fishery industry and also provides independent verification of the traceability of sustainable products. It also controls the use of the MSC eco-label with proof that all labeled products is definitely from the certified sources. The firm (*e.g*. processor, retailer, and restaurant) that deals with the final stage of packaging or wrapping up of the seafood product for the consumer needs to be certified for Chain of Custody. Once the requirements of the MSC Chain of Custody Standard are met, the certification body will issue a certificate following the audit. After obtaining the MSC Chain of Custody (that is

presented in details in the following diagram), the firm can apply for the use of the MSC eco-label.

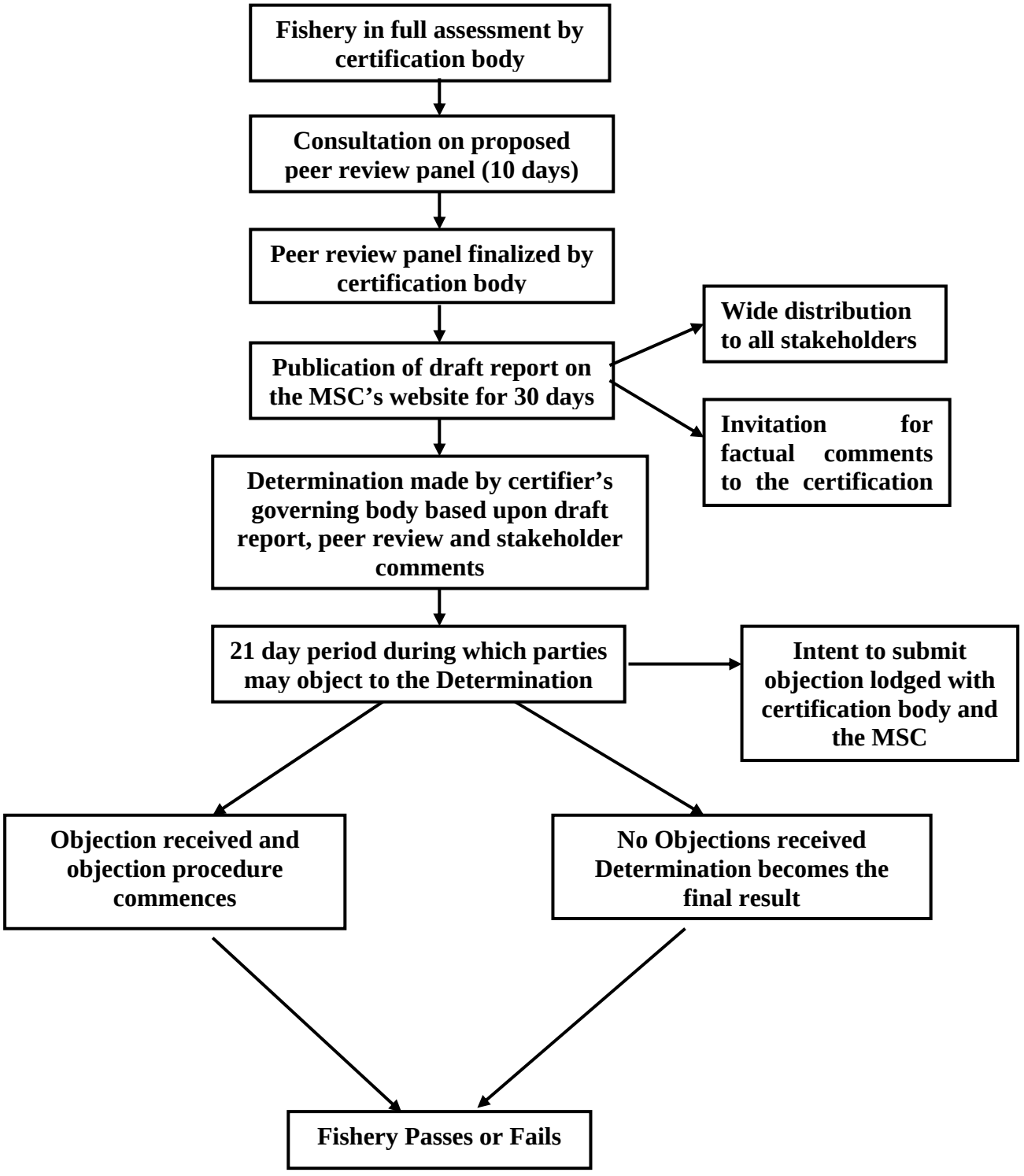
So far experiences suggest that fishery clients have included the governmental agencies, fishing industry associations, local management authorities and co-clients involving fishing industry associations and NGOs.

The MSC does not receive any payment for fishery or chain of custody certification; any funds paid are paid directly to the independent third party certification body. When the MSC logo is used by the organization, only then, MSC receives payment. However, use of the logo requires a payment of a license fee to the MSC's trading company, MSC International (MSCI) and MSCI remits additional funds back to the MSC after recovering its administrative costs. This process enables the MSC to retain its non-profit status as the majority (currently about 95%) of its operating funds comes from donation and grants[14].

The following diagram, sourced from website of MSC represents details of main steps in fishery assessment process:

[14] http://www.msc.org/assets/docs/fishery_certification/InfoSheet4_Costs.pdf

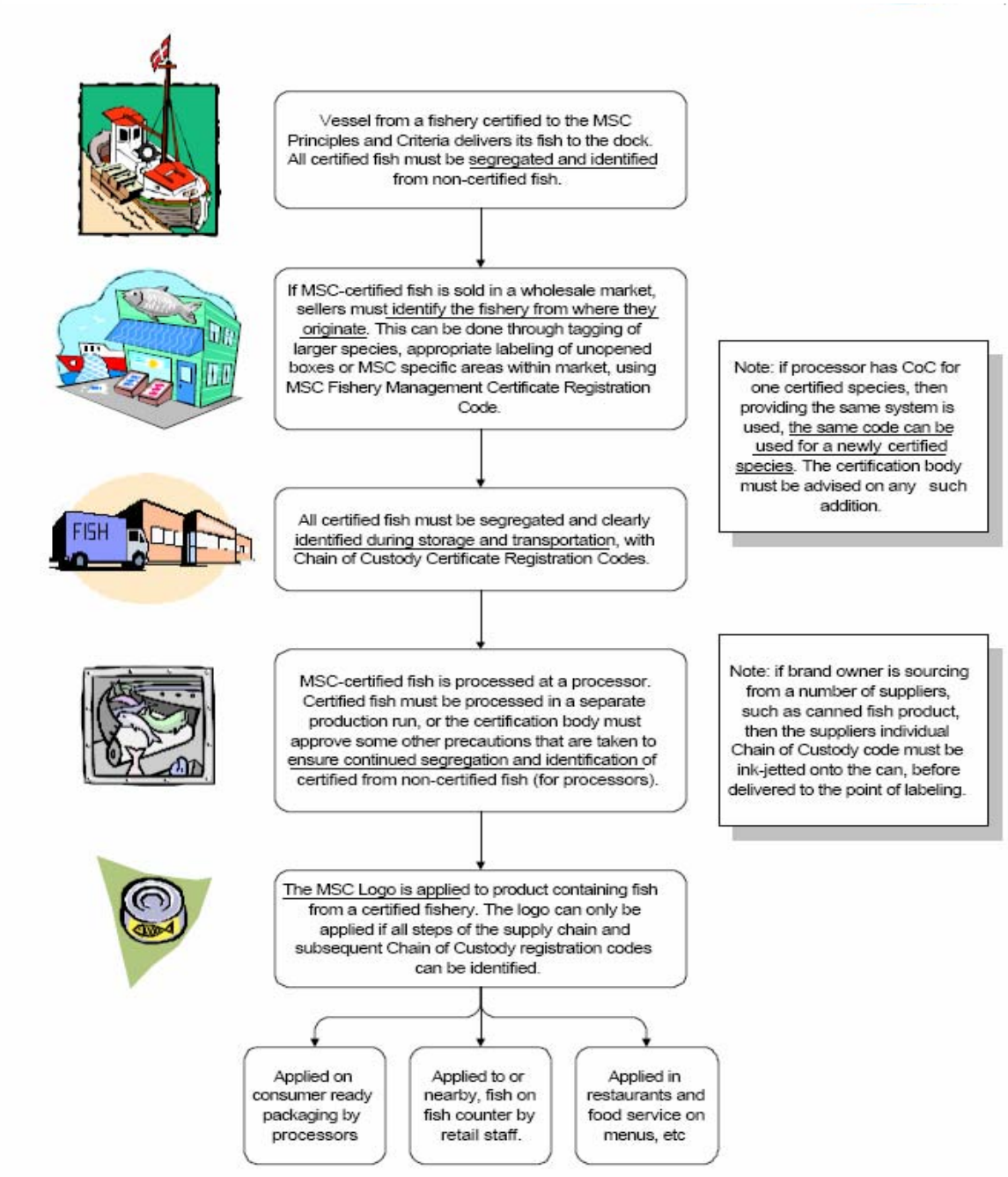
Figure 2.2. Details of the last stages of MSC Assessment



Source: www.msc.org

Now, the next step is to obtain a Chain of Custody for every fishery or point in the value chain for a specific business through qualifying the following certification process.

Figure 2.3. Chain of Custody Certification Process



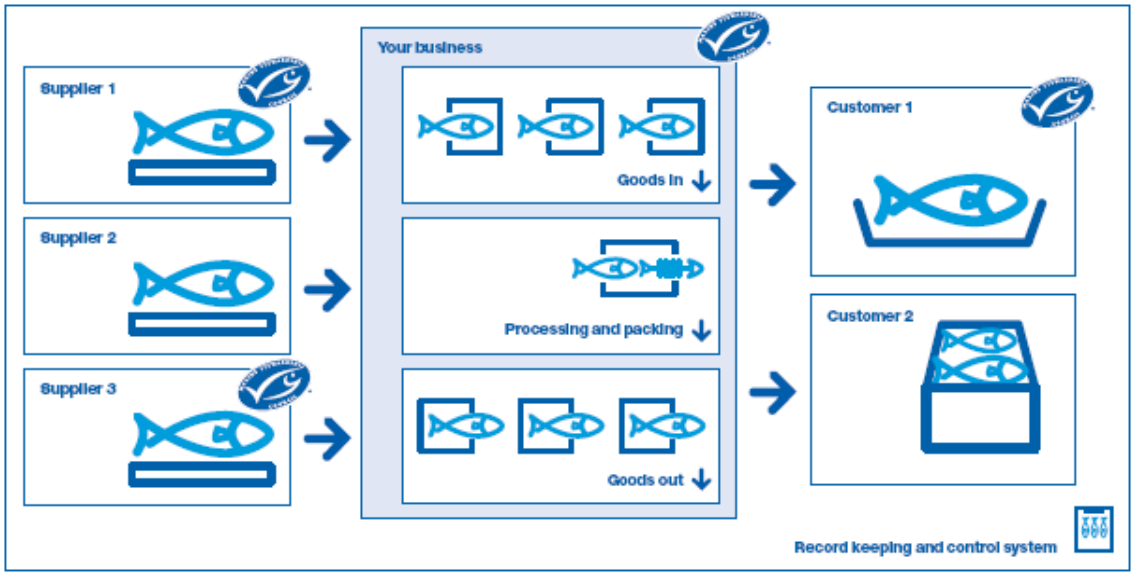
Source: www.msc.org

The process suggests that a company willing to apply the MSC logo to a seafood product(s), contacts and then, contracts a MSC accredited certifier to assess the supply chain(s) for product(s). Then, the contracted certifier will request documentation on that value chain from the company and will usually visit one or more points in the value chain to verify the product to which the logo will be applied originated from a certified fishery.

Mostly, the conducted verification of a value chain is very straightforward as the all companies have already integrated the product identification and tracking systems for other purposes *e.g*. ISO9000 Certification for HACCP. Generally, it is easier for a company to prove the certifier that it meets the requirements of MSC CofC Standard, if it documents its operations is in compliance with the HACCP, FDA or USDC. It should be noted that the compliance with other systems and programs does not necessarily replace meeting the requirement for MSC CofC Certification. If no case related to the mixture of the products from the certified fishery with non-certified fishery, the company will receive a CofC Certificate. The certification for Chain of Custody lasts for 3 years with an annual review that is conducted by the certifier. The certification body also may carry out a random audit at any time between annual reviews to ensure the value chain is operating in an appropriate manner. It is very crucial for a company to have an adequate control system on keeping the records of information for supplier, production practices and shipment from the firm. The firm is one of players in the value chain and e.g. certifier audits the supplier's goods out records and processor's goods in by matching the records form. Only the correctly kept records will provide accurate information to the auditor. The Information recording is important for each of the following three steps:

- Goods-in
- Processing
- Goods-out

Figure 2.4. Product Record Keeping Chart



Source: www.msc.org

These records of information on the deliveries of MSC products should include species, weight and supplier. And every batch of MSC product should have a batch code within your business. The firm is expected to keep records of batch number, weight and processing details every time you use MSC product. All records should be kept for at least three years.

Use of the MSC logo firstly requires that the company must be certified for Chain of Custody before packing and supplying the product in its “consumer ready” form. This process must be followed by any party e.g. processor, retailer and restaurants in the value chain that present the product in its “consumer ready” form. As it is mentioned earlier on, once Chain of Custody certification is obtained, the firm will apply for a logo license agreement from the MSC’s trading company, Marine Stewardship Council International (MSCI). The MSC logo is a registered trademark, and use of the trademark requires that the firm agree to only use the logo on certified products. The firm must also agree to submit packaging for certified product for approval before printing showing the compliance with logo use guidelines. In addition the firm will also provide the details of sales to MSCI for the calculation of the volume royalties and will pay licensing fees for

the logo. The use of logo sets two types of charging systems, a) for consumer facing products, b) for non-consumer facing products (*e.g*. product sold in bulk packaging). For both types of products, payment of a minimum royalty as shown in the following table is required. For consumer facing products (retail packaging, presuming that the consumer would prefer to purchase a product because of the logo), and additional royalty based upon volume and sales is charged. The minimum royalty is based on total sales of facing and non-consumer facing products but the volume royalty is only based on the sales of non-consumer facing products. The following table explicitly illustrates how the minimum royalty and a volume royalty are paid by business:

Table 2.1 Payment Scheme for MSC logo use.

Sales of MSC-labeled products	**Consumer facing**	**Non-consumer facing**
0 USD – 200 000 USD[15]	250 USD + 0.1% of sales[16]	250 USD
200 001 – 500 000 USD	1000 USD + 0.1% of sales	1000 USD
> 500 000 USD	2000 USD + 0.1 % of sales	2000 USD

Source: www.msc.org

Country of Origin Labeling

For many years, various agricultural and consumer advocacy groups have argued for legislation that would require food suppliers to provide consumers with country-of-origin information about food products. The U.S. fruits, vegetables and cattle producers that were favoring mandatory country of origin labeling (COOL) claimed that consumers would be able to alleviate some of their food safety concerns if they knew where their food came from. Advocates also predicted that the labeling would increase U.S. consumers' preference for purchasing domestic products that is perceived to be safer and that this would contribute to the development of local food industries. The recent

[15] United States Dollar
[16] Sales means sales of consumer-ready MS-labeled products only

instances of bovine spongiform encephalopathy (mad-cow disease) in the United States and in Canada undermine this position somewhat. However these BSE incidents increased public pressure upon government agencies to institute COOL and also upon the private sector to improve traceability of products and to consider a voluntary COOL program disclosing country of origin as a means of improving consumer perception of their products.

In 2002, Congress amended the Agricultural Marketing Act of 1946 by incorporating COOL in the Farm Security and Rural Investment Act of 2002 (Public Law 107-171, henceforth denoted the Farm Act or Law) and Supplemental Appropriations Act of 2002 (Public Law 107-206). USDA issues specific guidelines for voluntary labeling in 2002 that are currently in effect. USDA proposed mandatory labeling rules in October 2003. The Farm Act states that mandatory COOL is to be promulgated no later than September 30, 2004. However, Congress recently agreed to delay COOL for 2 years to revisit some of the legislative requirements and perhaps make COOL voluntary. Unfortunately, this delay did not apply to farm-raised and wild fish. Seafood was held to the mandate and, following rule making, began implementation in April 2005. Currently, The U.S. Department of Agriculture's Agriculture Marketing Service (AMS) is responsible for regulating and enforcing the mandatory country-of-origin labeling regime.

Under the Farm Act and the proposed rule the retailers would be required to identify legibly the country of origin on fish and shellfish. In addition, fish and shellfish must be identified as either wild or farm-raised. Retailers may use a label, stamp, mark, placard on the package and covered commodity at the final point of sale. Retailers need to indicate the specific country of origin for imported covered commodities including U.S. country-of-origin products. COOL is not required if these foods are ingredients in processed food items *e.g*. seafood medley. It should be also pointed that food service players are exempt from COOL requirements. Under the proposed rule, restaurants, food

stands and similar facilities together with retail stores (salad bars and delicatessens) are exempt from COOL. Under the Law and proposed rules, retailers can designate the United States as the country of origin only if the food is exclusively a U.S. product. For wild fish, the product must be harvested in U.S. waters or by U.S flagged vessel and processed in the United States or abroad a U.S. flagged vessel. Farm-raised fish must be hatched, raised, harvested, and processed in the United States. Under the proposed rule, if a product is not exclusively of U.S. food origin, labels for fish are required to reveal the mixed origins. A product is of mixed origin when the final production step occurs in the United States but one or more prior production steps occur outside the United States.

The Farm Bill provisions include detailed country of origin labeling requirements for seafood, which is defined in the statute to include both fish and shellfish. Whole fish and shellfish are covered, as well as "fillets, steaks, nuggets, and any other flesh" from a fish and shellfish. In addition to country of origin marking the Farm Bill requires that labeling inform the consumer whether the product is "wild" or "farm-raised".

The new guidelines include within their scope "all fresh and frozen fish and shell-fish items" but exclude "cooked and canned fish products" and "restructured fish products, such as fish sticks and surimi". The guidelines further provide that "processed products where the fish or shellfish is an ingredient, such as sushi, crab salad and clam chowder are excluded."[17]

The Farm Act and the proposed COOL rule have stringent requirements on the depth of record keeping. Firms along the supply chain must maintain records to preserve country-of-origin information from the immediate previous source and to pass along COOL information to the subsequent recipient of the transaction. For an imported product, the traceability system must extend back to at least the port of entry into the

[17] Bill of Unintended Consequences: How a New Country of Origin Marking Regulation Would Harm American Food and Agriculture, American Frozen Food Institute, 2003

United States. There is flexibility in the types of records that need to be maintained and in the systems that transfer information[18]. Records need to be kept for at least 2 years[19].

The mandatory COOL has its benefits and costs for every food industry. The main benefits of COOL for the firm will be:

- To increase confidence of the consumers over local products;
- To establish a full traceability system that will enable players easily and possibly lead to less costly food recalls or outbreaks

In 2002 Congress amended the 2002 farm bill required USDA to issue voluntary guideline for country of origin labeling by September 30, 2002, and mandatory rules by September 30, 2004. The Mandatory COOL for seafood was finalized on September 30, 2004 (Geoffrey S. Becker, 2005).

Table 2.2. Seafood COOL Cost Summary

	Cents/lb.	**Segment Cost (Million USD)**	**Calculation Process**
Producer: Wild Catch and Aquaculture		1.0 USD	Minimal Cost for Wild Catch: Book Keeping Cost for 2100 Aquaculture Farms
Processor/Wholesaler	0.5	15.0 USD	2.9 billion pounds
Retail Distribution	2-3	20 – 30 USD	1.0 billion pounds
Retail Store	3-4	30 – 40 USD	1.0 billion pounds
Total Cost		**66-86 USD**	**6.6 – 8.6 cents per pound sold**

Source: www.ams.usda.gov/cool/records.htm

The above stated table illustrates a summary of expected COOL compliance costs for the fish and seafood industry that was calculated on 2003 values. Because of a large percentage of fish and seafood consumption in the US is of foreign origin, there are some challenges to be overcome to meet the compliance procedures. Commingling of US and imported product does occur for some processors and products but the degree to which new handling and storage systems for product segregation is not clear, however there are

[18] www.ams.usda.gov/cool/records.htm
[19] Country-of-origin Labeling: Theory and Observation, Barry Krissoff, Fred Kuchler, Kenneth Nelson, Janet Perry, and Agapi Somwaru (www.ers.usda.gov)

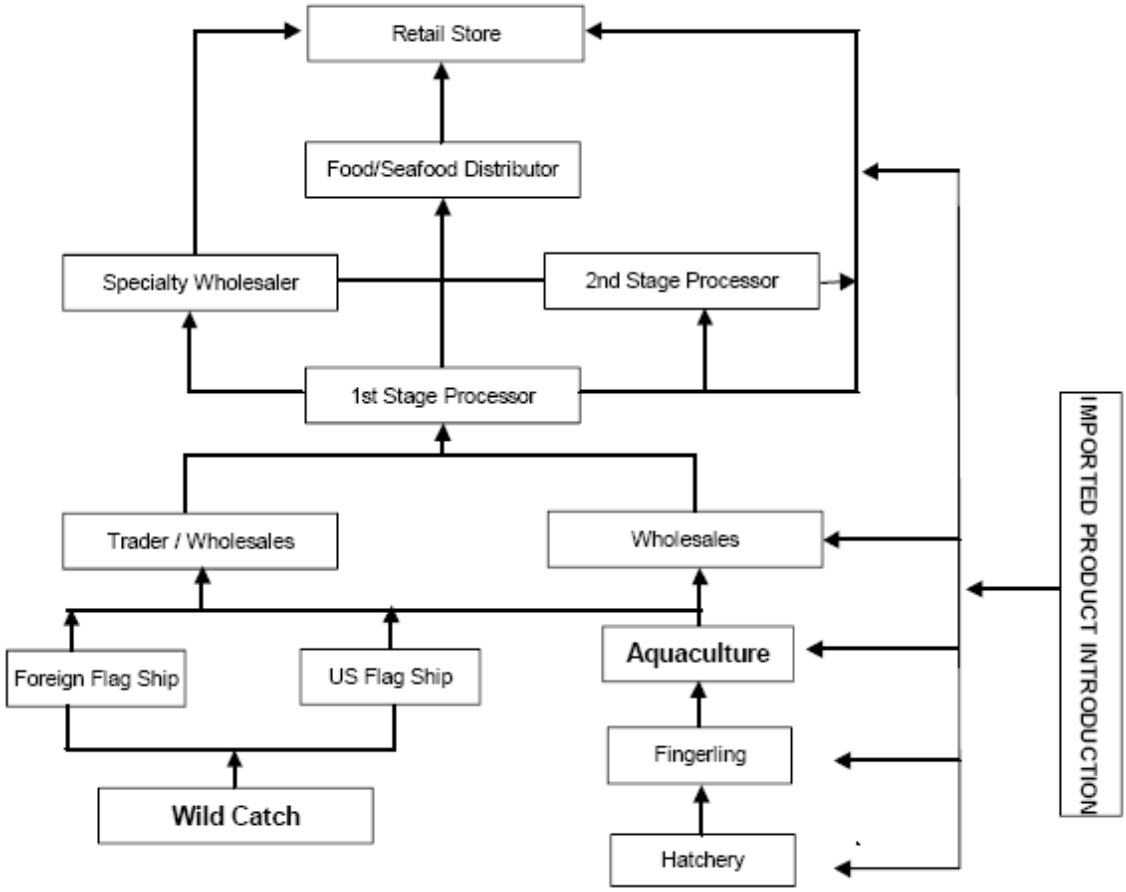
predictions that compliance with this requirement for seafood processors will not be nearly as burdensome as is the case in the beef sector.

- A review of the supply chain and an assessment of current operating and product identification systems suggest that compliance costs at the product level for wild catch and fish farms will be relatively small; estimated at $1 million/year.
- At the processor and fish wholesaler level, formalized tracking of invoices will need to occur and limited additional segregation of product will be required. Estimates suggest that at this segment of the chain, costs will be one-half cent per pound. However the records keeping and retention costs are not factored into the government estimate so the estimated cost of compliance is underestimated.
- Based on an estimated 2.9 billion pounds of fish and seafood being handled through the processing/wholesale segment of the chain, the cost will be $15 million per year.
- Government estimates of this cost fail to include that COOL will result in a permanent increase in operating expenses for the seafood industry and that this puts the US in an uncompetitive situation vise a vise foreign suppliers. Because US produced product is subject to this expense from the farm or harvest area forward, the cost of the program at earlier stages of production will be passed along, wherever possible up the supply chain.
- Costs of records maintenance and retrieval are not factored in as expenses that will face not only the retailer but other players as well
- Capital expenses for segregating products of different origin may lead to can involve greater needs for increased refrigerated and frozen holding capacity as shipments will no longer be commingled and will have to be handled and

stored separately. Rental and costs for refrigerated and frozen storage are likely to increase as a result of COOL.

- Greater costs for product handling will result simply from the increased record keeping requirements.
- Managing product inventory of product will become more complicated as origin will have to be specified at the level of each retail lot.
- Packaging expenses will increase, as numerous different types of packaging will be required based on the country of origin of the product. This will involve an increased cost in the production of packaging and label stock as well as the expenses associated with inventory and storage of these materials. Packaging is a significant expense in the food industry..

Figure 2.5 Seafood Cool Process Chart



Source: http://www.countryoforiginlabel.org/PDF/cool1118.pdf

Retail Distribution and Store

The seafood retailer will have to institute labeling, segmentation and record-keeping costs at both the retail distribution center as well as at the retail store level. Currently, retailers receive boxes of whole fish or fillets into their distribution facility that may already have country of origin information. However, often this information is not specifically captured and tacked as to country of origin so it is likely that a system of scanning fish and seafood products into and out of the distribution facility will be required in order to put in place a verifiable audit trail for compliance purposes and this may require a significant capital investment as well as a restructuring of recordkeeping functions, the development of new forms and additional costs for records maintenance as

well as costs for worker training. In order to comply, the retailer will need to add COOL information to the product label in the store, and in some cases segment the display counter to distinguish between domestic and imported fish. It is uncertain at this time as to whether additional cold storage and expanded slotting requirements would also be needed in the distribution facility.

Compliance Costs

The portion of edible seafood supply that would require labeling at the retail store is estimated at approximately 1.0 billion pounds, which is equivalent to about 33% of the total US consumption of fresh/frozen fish and seafood. In arriving at this volume estimate, adjustments were made to discount consumption volumes for processed seafood (*e.g.* canned tuna) and products destined for foodservice (mainly restaurant) demand, which accounts for nearly two-thirds of total US fish/seafood consumption. Estimates for retail distribution costs are at 2-3 cents per pound to cover all activities that will need to occur at the distribution prove to be conservative depending upon the range of product offerings in the store. At the retail distribution/retail store level of the supply chain, compliance costs for fish and seafood are estimated at 5-7 cents per pound of product sold and assuming 1 billion pounds of product sold in this covered product category, the total industry cost for this segment of the supply chain would be $50-70 million. This estimate includes a combination of batch labeling, individual product labeling, store display labeling and all the activities and their associated costs for product segregation and tracking in the distribution facility and on out to the retail store case. It also assumes that seafood wholesaler/distributors provide adequate and verifiable country of origin information to the retailers.

Processor/Wholesaler

There are about one thousand processors and three thousand wholesalers in the seafood/fish segment of the US supply chain. The largest processors are typically forward

integrated from processing to distribution and tend to supply most of the retail market. Small processors typically deliver to food service institutions or small/local retailers.

Compliance of COOL legislation will not be overly difficult for this segment of the supply chain although some additional costs are certain to occur. Large processors already have origin documentation of imported fish (US Customs invoice and label on the shipping box). Domestic fish typically is delivered to the processor in large containers (about 1,000 pounds each) and then processed and boxed into smaller containers. The processors will need to collect documentation from the producer, reconfigure its labels or boxes to note that fish is a US product, and store the necessary documentation so that other parties in the supply chain can verify the origin information and pass it up the supply chain. Overall, processors will need to connect mostly existing pieces of information into a reporting system (paper or electronic).

It is important to note that large processors already have some type of scanning or tracking technology in place, thus implementation of COOL will not be an excessively high new cost.

Compliance Costs

At the process or/wholesaler level, labeling will be required for approximately 2.9 billion pounds of fresh and frozen fish and seafood. Once again, adjustments were made to discount for processed seafood (*e.g*. canned tuna) but not for foodservice demand because end point destination of the covered products (retail or food service) will likely be unknown at this point in time so full accounting of all volumes will be needed, therefore all product will be labeled, although it is likely that only 1/3 of the total volume would be covered by COOL. Seafood wholesalers that supply both the food service and retail sectors are not likely to segregate retail products for COOL compliance; thus, origin compliance will apply to the larger volume for wholesalers than retailers (2.9 vs. 1.0 billion pounds).

The overall cost of implementing a COOL reporting system and maintaining/storing country of origin information for this segment of the supply chain is estimated to be $15 million or about 0.5 cents per pound.

Producer (Wild Catch and Aquaculture)

For wild-catch fish, the documentation required is relatively small; the flag of the fishing vessel indicates the origin of the fish. Processors and wholesalers will only need to verify the countries that issue the vessel's fishing license. So, there is no apparent hurdle with compliance. If a foreign flagged vessel harvest fish in US waters, then it will need to show to the processor/wholesaler documentation (i.e. a fishing license), to qualify the fish for US origin.

Compliance Costs

Most fishing vessels and fish farms will need to comply with COOL. At the production stage, it is difficult to segregate foodservice from retail. Currently, the documentation that is passed on from the fishing vessel to the processor/wholesaler already has country-of-origin information, thus there will not be an apparent added cost to fisherman/fishing vessels. The cost for aquaculture producers (2,100 food fish farms in 1997) is estimated to be $1.1 million. This cost is mostly for record-keeping purposes, however aquaculture faces a novel glitch. Fish eggs and fry are often imported for grow out in the United States. If the egg 'hatches' in the US then the product can be labeled product of the USA, however, if the product is grown from fry produced in another country, then it is possible that the product will have to be labeled as to the country of origin of the fry.

The Agricultural Marketing Service (AMS) will enforce mandatory country-of-origin labeling in retail stores. If COOL extends beyond seafood, then AMS would have jurisdiction to enter meatpacking and processing operations, on boats and in seafood

operations, on produce and peanut farms and in produce and peanut processing operations. In addition, AMS is expected to enter into agreements with state agencies to provide additional enforcement assistance. Penalties for non-compliance with COOL are strict at $10,000 per violation per day.

Different Traceability Technologies

A growing demand for the traceability applications force the industry players to improve the efficiency of the system by introducing new technologies and methods of tracking records. Radio Frequency Identification and DNA based tagging systems are among the most effective and most popular. These methods as a cost element of traceability vary according to the efficiency and type of industry that is expected for application. Based on benefits and costs of each method firms apply either of these systems in their production, processing and marketing. This area or aspect of traceability (the most efficient method) is still under an extensive study of current food and economic sciences. This paper identified three major methods of the traceability that are still being applied by different industries or countries. Those methods are the follows:

Radio Frequency Identification (RFID) is an automatic identification method based on storing and remotely retrieving data from the RFID tags by transponders. More specifically, the RFID tag is a small item that can be attached to or incorporated into seafood product packaging. RFID tag that are designed to be passive, semi-passive and active. Some RFID tags are passive devices that must be activated for reading, others contain batteries and can both transmit as well as retrieve and store information.

Passive RFID tags because they have no internal power supply and do not require batteries, can be much smaller and have an unlimited life span compared to other tags. These tags can practically read distance ranging from about 2 mm up to a few meters. Semi-passive RFID tags are very similar to passive tags except for the addition of a small

battery. This battery allows the tag integrated circuit (IC) to be constantly powered, which removes the need for the aerial to be designed to collect power from the incoming signal (as it is the case with passive tag). Active RFID tags contain their own internal power source that is used to supply power to any ICs to generate the outgoing signal. Active RFIDs are mostly used to typing and tracking cattle, fish, companion animals and humans because they can behave very effective in "RF challenged" environments like water.

Recently, there has been successful an integration of RFID system into U.S. seafood industry, enabling suppliers to meet the traceability requirements of leading U.S. seafood retailers. Consequently, food retailers' benefit from the products being RFID tagged to reduce their costs related with inventory management and to reduce inventory loss including theft and fraud by their employees. Wal-Mart mandated that its top 100 suppliers to use RFID tagging by Jan 1, 2005. Under this requirement passive RFID tags will be required on pallets and cases, identified with an EPC global symbol. Target, Albertsons, Best Buy Co., Circuit City and Kroger's have officially announced plans for the integration of RFID tagging, following the announcement of Wal-Mart. Recently, Wal-Mart renounced that its top 300 suppliers must be compliant with RFID tagging by January 2007[20].

An RFID system may consist of several components: tags, tag readers, edge servers, middleware, and application software[21].

Globally, low-frequency (LF: 125 – 134.2 kHz and 140 – 148.5 kHz) and high-frequency (HF: 13.56 MHz) RFID tags can be used without a license. However, ultra-

[20] http://www.foodproductiondaily-usa.com/news **(**Ahmed El-Amin, Start small, start early on RFID report advises Wal-Mart suppliers, 27/04/2006)
[21] http://www.rfid-101.com and www.aquacultureassociation.ca/ac05

high-frequency (UHF: 868 MHz-928 MHz) cannot be used globally as due to non-existence of global standard[22].

RFID systems operate at 4 major frequency ranges. The costs of these systems are affected by the frequency which affects effective reding length and reading speed for the devices.

Table 2.3 Different types of RFID systems

Frequency	Range	Tag cost	Applications
Low-frequency 125 – 148 KHz	3 feet	$1+	Pet and ranch animal identification; car key-locks
High-frequency 13.56 MHz	3 feet	$0.50	library book identification; clothing identification; smart cards
Ultra-high freq 915 MHz	25 feet	$0.50	Supply chain tracking: Box, pallet, container, trailer tracking
Microwave 2.45GHz	100 feet	$25+	Highway toll collection; vehicle fleet identification

Source: http://www.rfid-101.com

Cost of the RFIDs varies across the seafood industry based upon the size of the company and the type of tags and other RFID elements used in the process. For example; Beaver Street Fisheries, one of Wal-Mart Seafood suppliers, has spent roughly 70 cents and $1-plus each tag[23]. Biomark – Fish Tagging Service, based on Idaho, reports that the per-fish price to RFID tag juvenile fish ranges on averages between $0.90 and $1.50 (This price does not include RFID tag cost). The per-fish cost is dependent upon the number of fish that are being tagged with the price going down when larger numbers of fish are tagged[24]. Also these two particular systems can be used on product containers down to individual retail containers if the product is valuable enough. Both of these product can tolerate water and salt and under cool (but not frozen) temperatures.

The barcode is a machine-readable symbols used to store bits of data that is intensively used for identification, tracking in food value chain, most specifically retail

[22] http://www.rfid-101.com
[23] http://www.rfidjournal.com/article/articleprint/1546/-1/162/
[24] http://www.biomark.com/RFID-tags.htm

point of sale and has been in widespread commercial use for two decades. Barcode information is coded using different systems known as barcode symbologies. Different vertical markets use different symbologies. Some symbologies are fixed length, others variable; some are numeric-only and others are alphanumeric (letter and numbers). Three main types of bar coding are relevant to the food and food product industries:

One-dimensional bar code, the most widely used form of bar coding, is also referred to as a one-dimensional bar code. Usually, these bar codes include the identification number, and sometimes other information such as sell-by dates and prices.

Two-dimensional bar code, allows information to be coded as either a matrix (image), or stacked (multi-line). Two-dimensional bar codes are more robust than one-dimensional barcodes for readability, recording and addition of more information.

Molecular Bar Code, allowing the use of DNA information to develop the bar code identifier. It can also be incorporated into a conventional one or two dimensional barcode.

Universal Standard of Barcode ID system, under regulations of EAN International and the Uniform Code Council, apply to the trade in goods of all types is already in operation throughout the world.

The EAN.UCC system defines a trade unit as any item (product or service) upon which there is a need to retrieve pre-defined information and that may be priced or ordered or invoiced at any point in the supply chain, and adds this definition covers raw materials through to the end-user products and also includes services, all of them having pre-defined characteristics[25].

A Global Trade Identification Number (GTIN) marks trade units, incorporating a code allocated by EAN.UCC to uniquely identify the company and another code given by the company to denote the item (usually indicating product

[25] http://www.aquatt.ie/files/TRACEABILITY/website/Section4.pdf

type). The production batch and item serial numbers or simply the date and time of production, are often used to identify each trade unit. This information is important for a company to identify particular locations can allocate a further EAN code, the Global Location Number (GLN).

UPC bar codes are mostly used in the U.S. and Canada on retail items. EAN and JAN symbols are used in Europe and Japan respectively.

Advantages of Barcode versus RFID Traceability Methods

In the process of an intensive application of barcodes and RFID certain advantages and disadvantages of both technologies were identified. These attributes of technologies show that RFID is more rigorous and efficient system than barcodes:

- Barcode readers need a direct line of sight to the printed barcode, but RFID readers do not need a direct line of sight to read or communicate with either active RFID tags or passive RFID tags (these types of RFID tags that we have already mentioned).
- RFID tags can be read at much greater distances, which means that a RFID reader can receive information from a tag at distances up to 300 feet. However, the barcode reading range is much less and it typically reads no more than fifteen feet.
- RFID readers can read RFID tags much faster; the reader can handle forty or more tags per second. Reading capacity of barcodes consume more time than RFID because it requires a direct line of sight, if the items are not properly oriented to the reader it may take seconds to read an individual tag. If the surface of the barcode is damaged or crinkled it will not be possible to read it. Barcode readers usually take a half-second or more to successfully complete a read.

- Barcodes have no read or write capability; so it is not possible to add to the information written on a printed barcode. However, RFID tags can be read and write devices; the RFID reader can communicate with the tag, and alter as much of the information as the tag design will allow.
- RFID tags are typically more expensive than barcodes, in some cases, much more so[26]. They can be reused and both single and multiple use RFID tags are expected to drop in cost as these devices become more popular.

DNA-Based Tracking Technology

DNA is a unique identifier, which is found in all living organisms. It is mostly used in traceability to match DNA sequences of two samples, taken from blood or tissue in fish. The system provides end-to-end traceability, from birth to finished or semi-finished product, but is not currently intended to be used within processing or production operations because of the time required analyzing material recovered from the tag. DNA based technologies for traceability is being demanded by some export markets so that individual animals can be tracked. DNA is not widely used in the fishery industry on the food production side, but it is important for stock assessment and management of threatened and endangered species. Therefore, the fishery community has a mindset on how these data can be used well, and when cost effective measures are available, will be less likely to fight adoption than other food product sectors. DNA based technologies are currently widely used internationally in some segments of the muscle foods industry: for cattle in EU, Canada, Australia and Japan and also for pork for Japanese markets. IDNA traceability for cattle will probably have broad application in future if the cost is controlled to allow for individual testing and records maintained on each animal.

DNA provides a number of advantages that other technologies lack, and can be a rigorous and efficient traceability system:

[26] http://www.technovelgy.com/ct/Technology-Article.asp

- DNA is a unique identifier for each animal and in this way it is secure and integral part of the product that cannot be altered so there is no way that any value chain player could modify the data.
- The technology is easily transferable from one product to other similar products, for example from cattle or hogs to sheep.
- It can allow for recovery, analysis and identification of materials from multiple sources in a product containing materials from multiple sources *(e.g.* ground meat made from the tissue of more than one cow).
- DNA is somewhat stable to heat, acid, chemical treatment and dehydration so it can be recovered after tissues have been processed. DNA can persist through partial or full cooking and other processing steps and be recovered.

Cost analysis of DNA based testing identifies that there are some key additional costs related to the application of DNA technology for traceability in food products throughout value chain that do not apply to either barcode or RFID based traceability systems[27]:

- Specific genotypes or other DNA-related data must be tied back to source data, this requires development of an appropriate data base.
- Methods have to be developed to identify genotypes and to match test samples with those in a database.
- DNA samples (including reference samples) have to be securely stored and cataloged so that animal tissue recovered at a later day (possibly years later) can be identified and correlated back to the originating animal through the database.
- Analysis of samples (including transport to a laboratory) must be properly done.
- A great deal of skill is required to analyze results from these tests.

[27] http://www.aquatt.ie/files/TRACEABILITY/website/Section4.pdf

- Records must be taken and maintained and it will be critical to have a system to provide access to records for analyzed samples, reference samples, and to the database.

CHAPTER 3

METHODS AND RESULTS

This paper studies various traceability systems and analyzes their economic benefits to the industry players by a game theory approach. Game theory identifies that the traceability is an efficient market enhancement tool that enables producer to build a long run relation with consumer and sustain successfully in the market place.

Two game theory approaches have been used to analyze and interpret the commercial interaction of producer and consumer in asymmetric market versus symmetric market environment. In the first approach, the producer of a fish product knows the actual quality of the product but the quality attributes are unknown to the consumer. Therefore, the producer is in the position to make falsely high quality product claims but while selling low quality product or using less acceptable production practices. In this paper, an asymmetric market situation is analyzed evaluating the strategies of players depending upon the payoffs at one stage, and during finite and infinite periods. The second symmetric market model incorporates traceability as a tool to help the consumer evaluate the actual quality of the product and transform both the experience and credence attributes of product into search attributes. In addition, the second model offers different strategies for players depending upon their new payoffs in the symmetric market.

By comparing the two different payoffs from asymmetric and symmetric market models, the producer identifies that it is much more profitable to supply a traceable fish product (in a symmetric market) because this increases the level of consumer confidence about the actual quality of the product and this factor encourages the consumer to purchase the product at a higher price.

The study also analyses examples from the U.S. seafood industry to identify the current consumption and production trends to successfully identify economic benefits from instituting traceability in certain market sectors.

U.S. Seafood Industry

The U.S. seafood industry is one of the leading and commercially sustainable food industries in the world and significantly contributes to the overall economy of USA. The industry has a minimum of almost four centuries of commercial capture fisheries and several centuries of fish farming experience by the Native peoples some technologies adopted and modified after settler arrived. Both types of fisheries have been successfully developed. Compared to other industries, the seafood industry is more vertically integrated than other aspects of food production in the United States and that makes it easier to identify and improve possible deficiencies in forwarding seafood product to the consumer and allows for efficiencies in the development of traceability systems.

Statistics for the industry suggest that current U.S. imports account for 88% of the edible seafood supply, after exports are subtracted, from the overall domestic market supply. In addition the U.S. exports more than 80% of its domestic catch (in round weight). The comparison of two years (2003 and 2004) shows that overall edible U.S. seafood supply has experienced a decrease of 291.000 tons or 5.4 % over this period, much of this decline tied to the value of the dollar in foreign markets and a continuing recession in Japan, a major seafood importer.

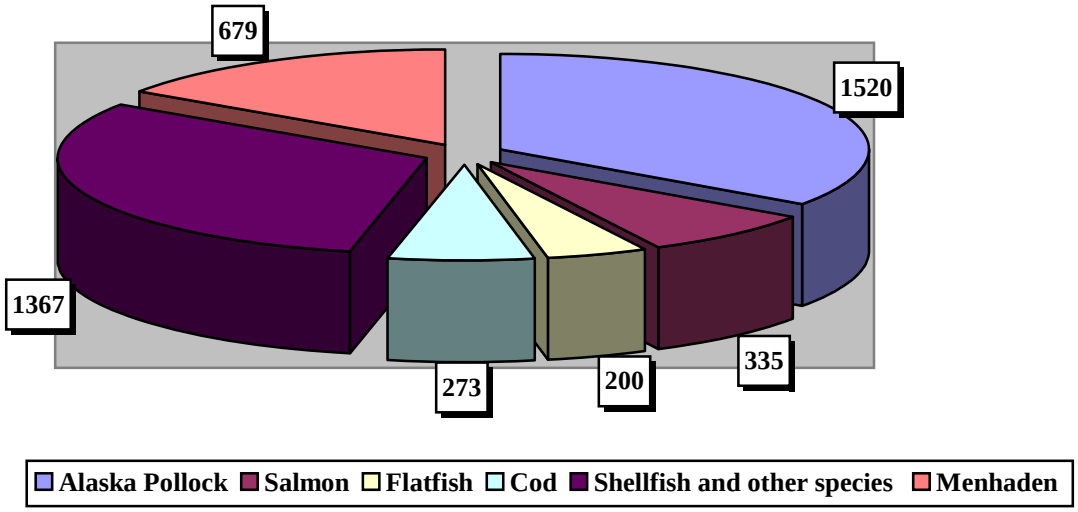
Table 3.1 U.S. Edible Seafood Supply 1995 – 2004 (round weight)

(In `000 tons)	1996	1997	1998	1999	2000	2001	2002	2003	2004
Domestic Catch	3.391	3.287	3.255	3.100	3.136	3.318	3.269	3.412	3.524
Imports	2.790	2.947	3.176	3.462	3.556	3.626	3.994	4.386	4.470
Exports	1.985	1.963	1.683	1.873	2.081	2.620	2.535	2.446	2.931
U.S. Seafood Supply	4.197	4.271	4.748	4.688	4.611	4.324	4.728	5.351	5.062

Source: NMFS and Glitnir Seafood Industry Report

Several species predominate in the U.S. capture fishery. These are: Alaska pollock, salmon, flatfish such as flounder and sole, cod, menhaden (for fish meal production), and shellfish of various kinds. (Figure 2.6)

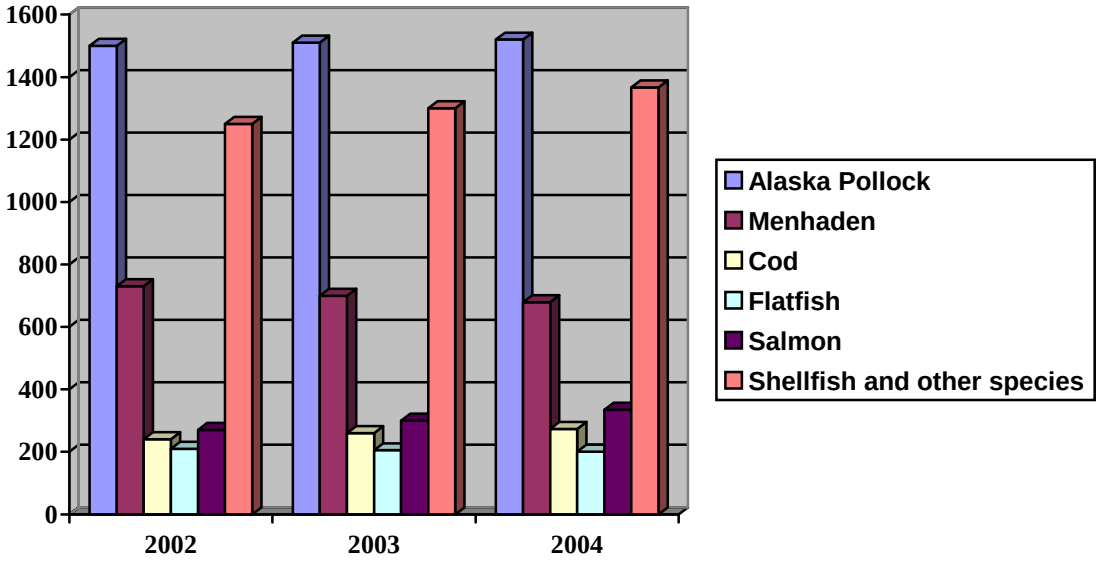
Figure 3.1 U.S. Domestic Landings 2004 (1000 tons) Top 5 species (Capture Fisheries only)



Source: NMFS and Glitnir Seafood Industry Report

Alaska Pollock is the largest volume fish specie with a harvest of 1,520,000 tons i above). The below stated diagram explicitly illustrating the growth levels for Alaska Pollock, cod and salmon over a recent two year period (2002-2004).

Figure 3.2 U.S. Commercial Landings 2002-2004 (1000 tons) Top 5 species



Source: NMFS and Glitnir Seafood Industry Report

The U.S. seafood industry has a very strong, historical reputation in the global seafood market, as it is one of the biggest suppliers of the seafood products in the world. The following tables represent a list of export trade partners/countries and value of the exports by the product.

Table 3.2 U.S. seafood export trade partners

Value in million USD	**2003**	**2004**	**2005**
Japan	999	1080	1100
Canada	710	752	708
China	187	269	409
South Korea	384	342	403
Germany	106	188	210
Netherlands	93	119	161
France	93	125	133
United Kingdom	77	104	118
Mexico	89	60	92

Source: NMFS and Glitnir Seafood Industry Report

Table 3.3 U.S. Fishery exports by product

Value in million USD	2003	2004	2005
Pollock Fillets	133	212	182
Pollock Roe	288	288	329
Surimi (from Pollock)	331	316	423
Fresh/Frozen salmon	268	327	406
American Lobster	306	307	335
Canned salmon	147	176	177
Flatfish	124	142	143
Crabs and Crab Meat	115	113	114
Salmon Roe	96	78	110
Fresh/Frozen Shrimp	86	77	64

Source: NMFS and Glitnir Seafood Industry Report

The consumers have been utilizing seafood products as another healthy source of food substitutes for chicken and red meat. In addition the fast growing population of Hispanics in the U.S. provides businesses opportunities for the seafood industry players. The Hispanic population is now the largest group in the USA with 38 million people and it is growing at a faster rate than the population in general. Traditionally, Hispanic families have relatively high seafood consumption. But not all species of seafood products are cheaper and considered to be economically alternative to the chicken product. Nevertheless, there is an increasing demand for seafood products and Table 2.8 shows comparative consumption per capita of two different periods (1998 and 2004) for top species.

Table 3.4. U.S. seafood consumption per capita

	1998		2004	
Rank	**Item**	**Kg**	**Item**	**kg**
1	Canned tuna	1.54	Canned tuna	1.50
2	Shrimp	1.27	Shrimp	1.90
3	Pollock	0.75	Pollock	0.58
4	Salmon	0.63	Salmon	0.98
5	Catfish	0.48	Catfish	0.50
6	Cod	0.44	Cod	0.27
7	Crab	0.26	Crab	0.29
8	Flatfish	0.18	Flatfish	0.15
9	Clams	0.18	Clams	0.21
10	Oysters	0.10	Tilapia	0.32
Total		**6.76**		**7.53**

Source: NMFS and Glitnir Seafood Industry Report

Consumer interest in fish and seafood has grown as Americans have become more health-conscious and have begun looking for new ways to add these items to their diets. A February study by the Economic Research Service of the United Department of Agriculture (USDA) reports that the growth of the population will create and additional demand for seafood over the next two decades in the United States. This will positively affect the development of U.S. seafood market and growth of the industry. Individual seafood companies will need to develop their supplies to meet the changing and growing consumer trends. Consumer (by NPD Group CREST) research shows that older adults in the U.S. eat more seafood than other age groups. And even USDA is forecasting an increase in per-capita consumption of seafood of 6.58 % by 2020, largely driven age factor. So, the combination of demographic effect on per-capita consumption and population increase predicts by the year 2020 will shift up the seafood demand to 0.5 billion edible weight. It is also estimated that the top four seafood products consumed by 2020 would be salmon, catfish, shrimp and tilapia.

Rich and middle-income buyers buy in small quantities but purchase high-end value added seafood products. This trend also encourages certain seafood producers to diversify their products by introducing different products into commodity and high value niche markets. The diversified production strategies will enable seafood companies to maximize the profit and develop new markets. Seafood companies that are competitively position in market place may introduce high value and high cost fish products under successful branding strategy. The product diversification requires certain improvements in the value chain, especially introducing innovations and technology for labeling and packaging. Even low-price giant Wal-Mart is expanding the use of self-service seafood departments, which will be supplied with prepackaged, case-ready product. Tyson and Perdue were able to successfully integrate this concept (case-ready) into beef and poultry

industry. Tyson has experience with commercial fishing ventures, being the previous owner of Artic Alaska Seafoods.

There is also very strong competition among the seafood supply chain players such as U.S. leading restaurants, which are highly specialized in seafood products. Their estimated and actual sales account for millions and in some cases billions of dollars and these players own hundreds and thousands outlets throughout the country including: Red Lobster (Darden Restaurant Group) with 673 outlets at USD 2,430 million sales annually and Landry's/Joe's Crab Shack/Chart House's sales which account for USD 1,106 million through its 286 outlets (Seafood Statistics[25] 2005). Other restaurant outlets carry substantial quantities of seafood (mostly pollock) such as McDonald's, Wendy's and Subway (pollock surimi, shrimp)

U.S. Seafood Retail Traceability Applications

Retailers have been pushing their food suppliers to apply RFID as a mean of tracking products more efficiently through the supply chain. Despite its benefits as a sufficient tracking system, RFID is costly technology to be integrated into production practices (outside of providing RFID labeling) and this technology is most likely to remain an important factor in distribution, retail and production.[26] Eventually, leading supermarket chains in USA and Europe will require that more of their suppliers to apply RFID technologies to food products. As mentioned earlier, Wal-Mart, the world's largest retailer, has taken a lead in this area by requiring RFID implementation. Other major chains have followed their lead. RFID has been assessed as an efficient tool for avoiding any fraud and theft and reducing certain costs related with inventory control of food items in storage or supermarkets. RFID has sped up checkout in Japanese test markets where

[25] Sea Food Statistics at http://www.aboutseafood.com/media/facts_statistics_detail provides statistical information on "Who are the top ten leading U.S. seafood restaurant chains?"
[26] http://nutraingredients-usa.com/news

systems are in place for consumers to scan all of their items themselves. This avoids having company employees handle a customer's food products, an important feature in this market because of societal norms along with high labor costs. An increasing demand for traceability applications will require more rigorous and sufficient systems of tracking food products throughout the value chain and this will require that standards be established so that there is uniform symbology and compatible software developed that can be used by all players in the value chain. Some companies such as, ID TechEx believes that about 900 billion food items could be RFID tagged by 2015, and 824 million livestock (requiring more sophisticated, and more expensive tags) by the same date. RFID has long been touted as the future of logistics for all companies by allowing retailers and suppliers to track goods throughout the supply chain.. Analysts believe RFID will become critical to most supply chains within the next ten to 20 years, with the market projected to be worth $1 billion by 2006. The main objective of the largest retailers is to maximize their capacities, improve efficiencies, and be able to meet the satisfaction of the consumers.

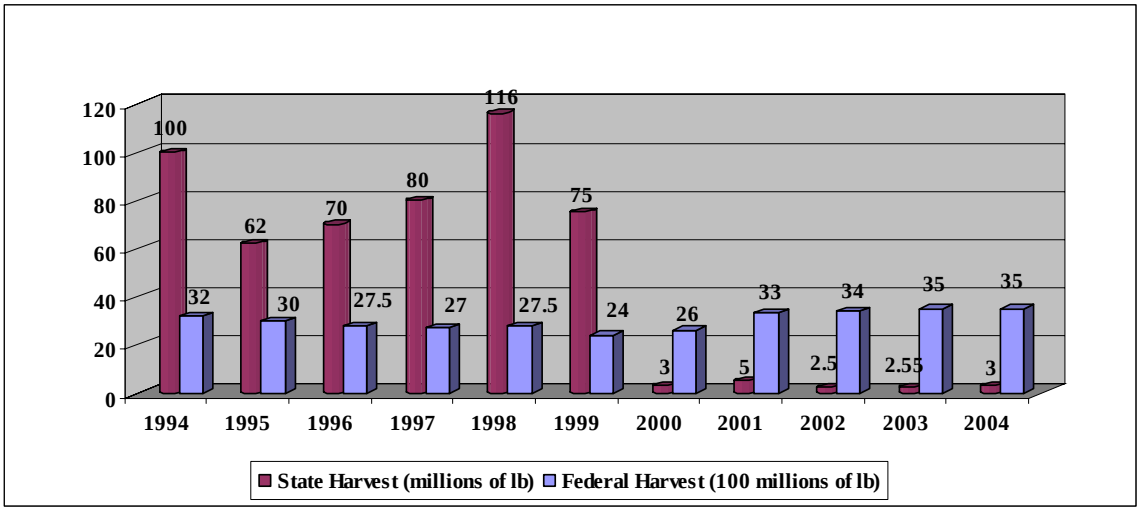
The Pollock Fishery

The study focuses on the application of and experiences with traceability in the pollock value chain to signal the actual quality and safety of the final product to the consumers. Traceability measures are in place for this fishery already since most of downstream players demand their upstream partners or suppliers to supply traceably fish products. This issue here is how effective these systems are and how they could be improved.

Alaska pollock is one of the largest volume fisheries in the U.S. The fish is also as the Walleye Pollock, and the scientific name is; *Theragra chalcogramma*. It is distributed from central California through the Bering Sea to St. Lawrence Island and on the Asian

coast to the Kamchatka Peninsula through Okhotsk Sea and to the Southern Sea of Japan (Alaska Department of Fish and Game). Usually, Pollock are schooling fish found on or near the sea bottom as well as at mid water and near-surface depths with most catches between 50 and 300 m (Rogers *et al.* 1980). The concentrations of adult pollock in the Bering Sea are usually found in water temperatures between 2 and 4^0 C (Serobaba 1970). Pollock population is widely concentrated in the western Gulf of Alaska with the Sanak area having routinely high catch volumes the Chirikof and Kodiak areas. Recent harvest data for Pollock are presented in Figure 3.3. The pollock begin spawning at age two, but age classes four and five contribute the most to potential reproduction of the population (Smith *et al.* 1981). Pollock are a commodity product at a relatively low per unit price. Pollock are harvested and processed into frozen fillets, fillet blocks or surimi at sea with the roe recovered during certain seasons of the year. The fish may also be harvested and then taken to shore based plants in Alaska for processing, although the quality of product made at these shore based facilities can be lower since the fish are processed in a less fresh condition. Pollock are also frozen whole and shipped to China for processing into fillets, fillet blocks and other products.

Figure 3.3 Alaska Commercial Harvests



Source: http://www.gov.state.ak.us/omb

Economic Benefits for Seafood Industry from Improved Production Practices

Increasing demands of consumers for high quality and safe seafood products drives U.S. seafood players to intensively improve the production practices and introduce a new market enhancement system to achieve success in the marketplace. The key factor ensuring the success for seafood value chains as well as any other food industry is to develop a set of "quick and sufficient"[28] responds to the changes of market trends. Intensive commercialization process across the value chains always urges chain players to rationalize economic behaviors and serve as a basis for the sophistication of the market trends that are significantly dependent on multi-exogenous variables, such as: age, sex, demographics etc. The unique and distinguishable qualities *e.g.* a strategic management and continuous improvements increase an immunity of firms to tolerate sudden changes in the marketplace and to remain successfully integrated as a part of value chain. Most of this success derives from the demand-driven ability that enables firms to understand and consumer needs and act accordingly. Previous discussions in the paper suggest that the U.S. as well as other countries' seafood industries have developed a traceability system to maximize their compliance with mandatory standards for the export and domestic trade of seafood products and addressing concerns of consumers about product standards and quality attributes. Under the 2002 Bill Farm, USDA's Agricultural Marketing Service is the responsible party for implementation of this program at least with regard to country of origin. However, other aspects of traceability are left completely under the control of market forces providing a great deal of flexibility for companies to develop programs which are most appropriate for them and for their market segment.

Rational consumers will respond positively to traceability even if the specific characteristics of the product are not promoted, and this assurance of knowing the chain of custody of a food product is known and this fact in itself adds value. Traceability

[28] This system constitutes a quick and sufficient response tools (*e.g.* branding, labeling and advertising etc.) to the changes of market.

provides evidence stating and assigning a certain level of "good" quality to seafood products. In addition, traceability allows the consumer to develop a sense of confidence about the quality of seafood products after experiencing it from the same or most importantly a reliable source or supplier. The knowledge of the source can be achieved in long run by multi-variable signals such as branding and labeling, which still does not fully ensure verification about the origin of a product. In this context, traceability is an excellent and uniquely powerfully method that enables any interested party to receive and transmit reliable information on seafood products.

The use of traceability in the commercial and intensively operated industries enables players to predict product attributes in advance and provide sufficient controls to reduce possible deficiencies in product quality and also to obtain consumer confidence in product quality. These unique characteristics of the traceability program create a number of "positive"[29] benefits, which are of different types, for example, economically valuable and safe food products[30]. The current paper mostly emphasizes the economic benefits of traceability, which has been addressed in limited number of studies. The economic benefits, generated from the application of traceability vary from one value chain to another chain or from one firm to another firm. This condition depends on various factors including product type and firm size etc. that are related to the specifics of industry chains[31] and governmental interventions[32], regulating the development and sustainability of industries.

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[29] These benefits contribute to profit maximization and, cost minimization for firms by improving product and quality, gaining reputation in the marketplace and confidence of the consumers.

[30] The producers and processors control possible contamination of food products for safety purposes.

[31] For example; U.S. fisheries and poultry value chains produce and distribute the final forms of these perishable products within a short period. This is due in part to intensive production practices and a sufficient vertical integration. More specifically, U.S. commercial fishery industry has a long historical evolution as well as being one of the leading suppliers of seafood in the world. Therefore, members of the U.S. seafood industry make their best efforts to satisfy the needs of buyers and establish production practices accordingly to emerging market trends.

[32] USDA has set mandatory standards for food industry (meat, poultry and fresh produce etc.) to apply Country of Origin Labeling (COOL, which has been thoroughly described in the paper) under Farm Bill that was signed by President Bush on May 13, 2002. On January 27, 2004, President Bush signed Public Law 108-199, which delayed the implementation of mandatory COOL for all covered commodities except

Basically, the traceability system contributes to the welfare of two groups of beneficiaries; a) consumers and b) sellers including producers, processors, retailers, restaurants and hotels etc. These benefits represent heterogeneous levels of positive contributions to the welfare of involved parties, which are characterized by the level of detail in application of a traceability program. There are three primary economic benefits, sourcing from the successful application of the traceability in the seafood value chain:

- Product Differentiation
- Supply-Side Management
- Food Safety and Quality Control

Product differentiation enables firms to strategically enter certain segments of the market with an objective to maximize profit margins. Under this strategy, firms mostly develop and introduce private brands or labels to their value added products to signal credence quality attributes of products to the consumers. The traceability program in this case significantly contributes to the increase of brand equity and reputation and expands the sales of value added products in long run. A product differentiation strategy is considered to be a market enhancement tool.

Supply-side management is a crucial factor for the successful survival of the firms in competitive markets. In these markets, a single extra cost element tracks off very successful businesses from being efficient and sustainable over the long-term. However, efficient tracking systems enable firms to control a majority of cost elements that are related with the production, warehousing and distribution of food products.

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wild and farm-raised fish and shellfish until September 30, 2006. This deadline has been further extended and on November 10, 2005, President Bush signed Public Law 109-97, which delays the implementation for all covered commodities except wild and farm-raised and shellfish until September 30, 2008. In addition EU Directive 2002/991EC and Directive 91/493/ECC also mandated the traceability for fisheries products.

Food Safety and Control produces economic and non-economic[33] benefits that constitute the follows:

- Rationalization and efficiency of production practices;
- Reduction of recall and liability expenses in the long run;

Traceability Costs

In parallel with benefits of the traceability there is a dynamic interplay of different levels of costs that set the variation of investment in traceability across food supply sectors. The USDA[34] identifies certain cost elements for the implementation of the traceability in the food supply sector; breadth, depth and precision, differ across different U.S. food supply chains:

Breadth describes the amount of information the traceability system records. The type of a value chain or a firm will determine the amount of information (attributes) is needed for recorded in addition to the mandatory minimum requirements.

Depths describe how far back or forward the system tracks. In most cases, its breadth largely determines the depth of a system and again the value chain or the firm decides which attributes are worth recording. For food safety, the depth of the traceability system depends on where hazards and preventive measures can be introduced into the food production chain.

Precision reflects the degree of assurance with which the tracking system may identify a product move and attributes of food products. The unit of analysis used in a traceability system and the acceptable error rate determines precision. In some cases, the objectives

[33] Food safety and quality control, in the context of non-economic benefits, relates to identification of deficiencies in the production technology that produce unsafe, adulterated or unwholesome food products in the context of food safety or fails to meet technical specifications in the case of poor quality food. A more rigorous example of such a situation is when the firm identifies an existing deficiency in the product line after reviewing tracked information. This case can be interpreted as a technological improvement from processing standpoint as well as a means for increasing efficiency of production with an average cost minimization. The latter one is considered to be provide more of an economic benefit while the first situation, greater technological benefit.

[34] http://www.ers.usda.gov/publications/aer830/aer830brochure.pdf

of the system will dictate that a very precise system with a smaller unit of analysis be employed, while for other objectives a less precise system will be required.

CHAPTER 4

A THEORETICAL MODEL, TRACEABILITY AS A SIGNAL

Quality and Safety Preferences

Recent market trends encourage industry players to identify and capitalize opportunities for differentiated and improved quality products (Frazão and Allshouse 1996). This strategy can enrich the quality of sale-associated services *e.g.* successfully branding and labeling (Roosen 2003) and position a firm's products competitively in the market place. The most critical attributes shaping the current market trends are quality[35] and safety[36]. Caswell *et al.* 2000 suggests that the quality attributes of food products can be effectively analyzed along three dimensions: a) intrinsic *e.g.* nutritional and extrinsic *e.g.* brand name, b) informational environment *e.g.* search, experience and credence, c) vertically and horizontally differentiated *e.g.* same quality ranking versus differentiated quality ranking.

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[35] Rasco *et al*. defines the quality of food products as the ability of the product to be in compliance with the technical specifications for it. It is also worthy mentioning that the technical specifications are primarily developed by the market and driven by consumer demands or market incentives. Grades of a product relate to specific product attributes, with lower grade products characterized as being poorer in a specific product attribute and higher grades of a product being characterized as having greater or superior features. Therefore, it is quite possible to have a 'high quality' but a 'low grade' product because the product meets the technical specification for low grade within tight tolerances. Likewise it is possible to have a 'high grade' product of low quality, because adherence to the technical specifications for the high grade is not reliably attained.
McCluskey defines quality as "customized products" with different quality levels to satisfy demand where the firm will set the quality level through technical specifications depending upon customer demand. There are also certain technical issues related with the elaboration and approval process of technical specifications and how this is done, moreover how the elaboration of technical specifications interface with compliance requirements.
These can, unfortunately, be complex matters, and outside the scope of this research to address.

[36] Rasco *et al* points out that the product may belong to a low quality category because of a limited ability to be consistently and fully complaint with the technical specifications that define its quality but still be safe. However, a high quality product, at least in the food and consumer products area, is by definition also safe. A high quality product would be down graded if it carries contaminants that make it unsafe. Unfortunately a recent example of this phenomenon is the September 2006 *E. coli* 0157:H7 contamination incident of washed, bagged, organic spinach produced in California. One role of third party monitoring is to ensure that both grade and safety criteria are met so that high quality products are produced.

Likewise, with regard to aquatic foods, which are the focus of this paper, quality and grade should not be considered to be the same (Rasco and Bledsoe, 2000 & 2005). A number of recent studies with aquatic foods have examined quality factors. Roheim *et al.* in 2004 conducted survey to measure the consumer preferences for eco-labeled seafood products. Consumers (65% of 366 respondents) noted quality, as their first choice of the product attribute, when price, quality and species attributes of a fish product were provided. When their survey increased the number of attributes to four (including eco-label) quality still ranked as the important attribute to consumers, but it decreased 65% to 48%, however, the rank of quality attribute remained unchanged in consumer preferences.

In another study, Loureiro *et al.* 2001 measured the marginal effects of several factors (including food safety and quality attributes) affecting consumer preferences and decisions in purchasing eco-labeled, organic and regular apples through a multinomial logit model. That study identified positive statistical significances of quality and safety attributes in consumer preferences.

McCluskey (2000) took a game theory approach to evaluate quality properties of organic foods, stressed the fact that the ability of the consumer or buyer to verify the quality of a food product is highly correlated with the information environment for a product (*e.g*. search, experience and credence as per Caswell *et al*. (2000)). In the case of experience for a product such as canned tuna, if the consumer wants to verify the quality of the product or whether the producer has made a true or false claim about the quality attributes of the product he or she needs to sample and consume the product to verify quality and grade. For a credence attribute, the consumer's task is more complicated than for experience attributes, since the attribute is not something that is easily discernible (or discernible at all) by the consumer using sensory analysis or their understanding of the market. To verify credence attributes, third party involvement is required to evaluate the

actual product quality. For example, the source of a fish could be an important quality feature to some consumers, however it is one that a consumer is technically incapable of determining. A fish from the same species would most likely not exhibit any differences in sensory properties regardless of whether it is from a wild harvest or from aquaculture.

Usually, the use of a third party auditor is costly and there must be enough value in the market to support their involvement. Certain market forces that have little to do with product quality or safety also come into play. For example, the introduction of a non-organic product into an organic supply chain could induce an activist to sue a downstream supplier for some alleged harm.

Food safety attributes fall primarily within the category of credence attributes. Roosen's (2003) paper on "Marketing of Safe Food through Labeling", states that the food safety attributes are credence attributes that cannot be assessed by the consumer directly. Highly trained laboratory personnel can only verify many food safety defects, such as pathogen or toxin contamination. Obvious features of the product such as dirt or an unusual color or aroma can signal the safety of a product to a certain extent but this is not a reliable indicator. These studies (McCluskey (2000); Jutta Roosen (2003) throw light on the fact that food quality and safety characteristics are very hard to observe or impossible to detect if there is asymmetric information in the market place.

Gibbons (1992) introduced several asymmetric information market models showing that these lead to market inefficiencies and failures in long run if one of players deviates. The buyer and seller only interact one time, an example being the prisoners' dilemma game. Under this scenario, neither the producer nor the seller has an incentive to cooperate. Usually, a single stage game will provoke a firm to produce food products with the lowest-cost methods and often of low quality and low grade. Good examples of those games are moral hazard, adverse selection or Akerlof's "lemons" problem in 1970 (Mas-Colell and Andreu *et al* 1995). Moving from Akerlof (1970) type of problem

formulation to Grossman (1981) type of a game setting will definitely improve an interaction between producer and consumer. Because Grossman (1981) suggests that the requirement for making the disclosure on the actual quality of the product will ensure disclosure of true information to the consumer.

Under incomplete information conditions market players have tendency to act heterogeneously by obtaining certain level of "market power". Hal R. Varian 1992 points out that "market power" enables firms to set a price that will only make firms better off and consumers worse off without obtaining socially optimal price. The monopolist tries to capitalize more revenue by increasing a producer surplus and decreasing a consumer surplus. By controlling a whole market or a segment of the market they set monopolistically price, which provides higher returns than homogenous agents receive under perfect competition. The strategic vision and plan of homogenous agents *e.g.* producers is to target at sustaining an ability to be able recover their marginal effort equal marginal benefit (price is equal to marginal cost or minimum average cost).

The U.S. pollock industry represents a market structure of an oligopoly with competitive fringe (McCluskey 2006)[37] that means there are four to five leading firms controlling the market by setting a price but the rest of the firms have small shares of the market by taking the price. There is very significant difference between the market structures of oligopoly with prefect competition that is more efficient (Hal R. Varian, 1992). Under perfect competition conditions, a different set up of equilibrium is established? for agents; producers keep entering the market until they find no more opportunities to exploit economic profits (or economic profit is equal to zero)., For example, consumers purchase a supplied food product if the marginal utility per dollar

[37] McCluskey class notes for Industrial Organization 594, School of Economic Sciences, Washington State University, Fall 2006

they drive from that product is at least equal to the opportunity cost or that parameter[38] of other purchases (McCluskey 2000).

In addition there have been several methods or techniques proposed by researchers to establish a symmetric information between agents to transform an inefficient market into an efficient one. The symmetric information condition provides a full disclosure on the quality and safety of the product to the consumer through market incentives with less policy and regulations. Caswell *et al.* 1996 pointed out that the quality signaling through labeling and information disclosure requirements encourages market incentives with the limited intervention of governmental institutions.

The primary objective of this study is to analyze the effects of a single factor, product traceability on U.S. Alaskan pollock (*Theragra chalcogramma*) industry in terms of generating economic benefits to the market agents, both producers and consumers. In order to highlight a strategic importance of traceability as a market enhancement tool, and to reduce concerns and doubts of the consumers will have over the quality and safety of a final product in the US polllock market we will analyze it effect by two models. Both of those models will be based on the game theory approach and will differ from each other by availability of the traceability as a signal.

In these models, fish are assumed to be an experience good in both models. In the first model there is asymmetric information between players (buyer and seller) but in the second model symmetric information is established. Traceability will be introduced into the second but not into the first one model. It is clear that buyer would not be able to observe the quality of either credence or experience attributers under imperfect information conditions. These models take some direction from game theory models used by McCluskey (2000), and Kihlstrom *et al*. (1984). McCluskey (2000) developed a game theory approach to analyze behaviors of agents in the markets with asymmetric

[38] The marginal utility per dollar that is driven from other purchases

information. Kihlstrom *et al*. (1984) also introduced a two-stage game to show that advertising is a signal of quality. The model in this paper is incorporates features from both of these models and introduces two game theory approaches where traceability transforms the U.S. pollock market with asymmetric information into the market with symmetric information.

Grolleau *et al.* at 2005 developed a diagram that illustrates the process of switching attributes across search, experience and credence categories. The process provides a unique insight on the diversity of factors that affect consumer decisions in evaluating search, experience, and credence. For example, proper labeling under the monitoring of the third party transforms a credence attribute into a search attribute, but lack of experience in assessing wine quality switches an experience attribute into a credence attribute and finally, product sampling transforms experience into a search[39]. In the theory of this study the traceability system "from sea to fork" is suggested to be a very powerful tool for consumer to transform the experience goods and into search goods.

It should be made very clear that traceability does not necessarily mean to be only a significant exogenous variable affecting the sales of Pollock products as there are many other key exogenous variables promoting the product or proving signals to the consumers. Wilson (1985) studied multiple-signals by extending the analysis to a continuum of qualities and any finite number of signaling variables. Wolinsky (1983), Milgrom *et al.* (1986), Gal-Or (1989), Wernerfelt (1990), Bagwell *et al.* (1991) and Mahenc (2003) emphasized the significance of many other variables; price, warranties and advertising as signals of quality to the consumers. In most of these literatures the significances of those signals to potentially increase the sales of two type-product markets (high and low) have been hypothesized. And we will also differentiate a quality

[39] The discussion with Thomas I. Wahl, IMPACT Director.

of the product by assigning high and low qualities to the products to identify effects of a traceability system. In real world the different management experiences and processing practices determine the quality of Pollock products and implement different levels of a traceability system.

The purpose of the study is to study and analyze a long-term profit maximization benefit of traceability system for U.S. Pollock market but not to analyze the structure of that market, which is an oligopoly with a competitive fringe. Because the paper hypothesizes that the traceability system is a strategic market enhancement tool. But more rigorous models based on the game theory approach *e.g.* Bertrand, Stackelberg and Cournot could explain the benefit of the traceability to the firm or industry with an oligopoly with a competitive fringe (Mas-Colell *et al.* 1995, Varian 1992).

Model I: Asymmetric Market

The first model has the following assumptions, some of which overlap with the assumptions of the second model:

1. There is one firm or producer in the market that behaves monopolistically. Therefore, the monopoly price is greater than the marginal cost, which is the socially optimal price.
2. The producer can claim two quality types of Pollock products: high and low quality.
3. The monopolistic producer knows the actual quality of the product, but it is unknown to the consumer.
4. The market lacks the third party monitoring or mandatory regulation that urge a monopolist to make the quality of the fish product observable to the consumer. This condition encourages the producer to falsely claim high quality when it is actually low (McCluskey 2000).
5. If the producer makes a high claim, the producer charges the same price (uniform price) on the both of the qualities. The price is denoted by p to avoid possible doubts

of the consumer over the quality of the product. However, both of those products are safe but a safer product is assumed to be high quality[40] not the other way around.

6. A demand function of the monopolist is denoted by $q = D(p)$ and is differentiable with decreasing property in p (where $D'(p) < 0$).

7. The firm's cost function is not the same across the qualities of a fish product and they are denoted by:

$$C_h(q) > C_l(q) \quad \textbf{(1)}$$

We will derive our marginal cost from (1) that is differentiable and increasing as an extra unit of product produced:

$$\frac{\partial C_h(q)}{\partial q} = C_h'(q) > \frac{\partial C_l(q)}{\partial q} = C_l'(q) \quad \textbf{(2)}$$

8. Based on (1) and (2) we will drive the profit maximization condition for the firm with high and low quality product demand functions but replacing quantities by demand functions:

$\pi_h = p(D(p)) - C_h(D(p))$ profit max problem with high quality cost **(3)**

$\pi_l = p(D(p)) - C_l(D(p))$ profit max problem with low quality cost **(4)**

9. The utility of the consumer depends on which product he or she buys:

$u(x_h, x_j)$ if the consumer happens to get high quality fish product **(5)**

$u(x_l, x_j)$ if the consumer happens to get low quality fish product **(6)**

Where there are two goods, i is either l or h for low and high quality fish products and x_j represents all other products and is equal to income less price paid for x_i.

The figure 1 shows the dotted line between the two decision nodes levels of the consumer, as the consumer does not know at which node he or she is located. The

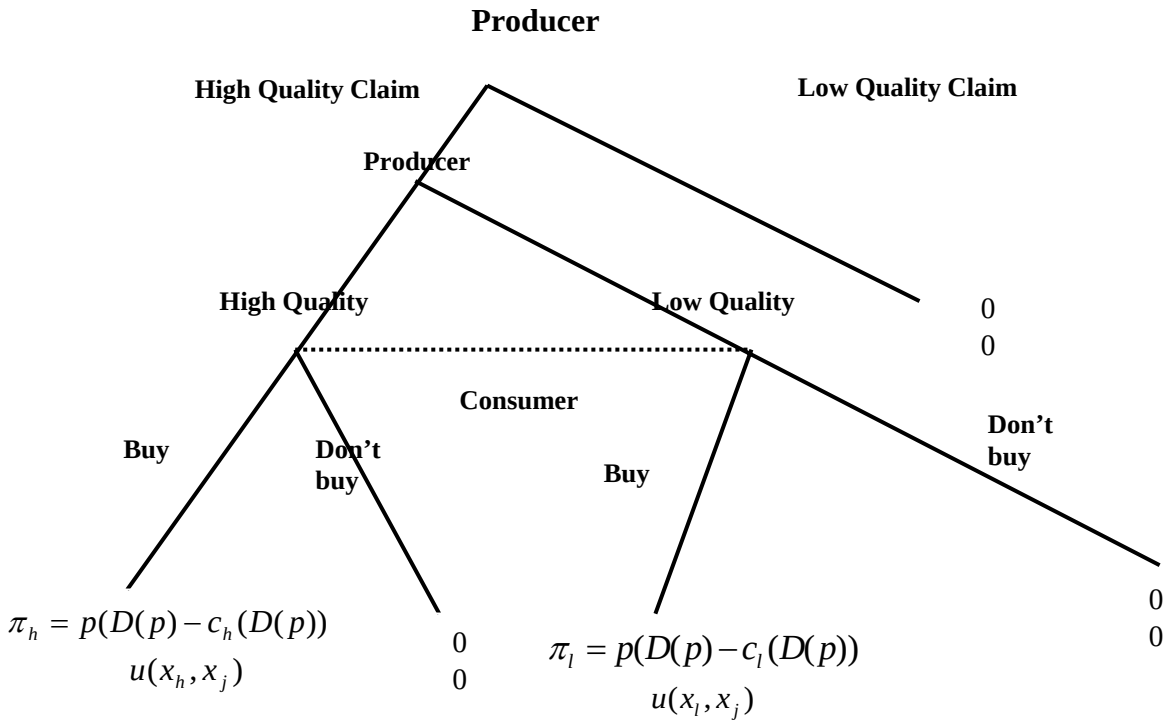
[40] Rasco *et al.* 2005 defines quality being high or low depending how well the food product complies with its technical specifications.

producer claims two different claims: high and low quality. McCluskey in 2000 suggests that, in the continuation of the game, equilibrium depends on the sign of the consumer's payoff given he or she buys low quality product, after the producer chooses high quality claim.

We also know that the producer will not choose to the strategy of (high quality in high quality claim) because $\pi_h \leq \pi_l$ (since $C_h(D(p)) > C_l(D(p))$ holds). It is true that possible difference between two total costs (high and low) conditions the payoff from low quality product to generate more profit than high quality product for the producer. The doted lines between two decisions nodes at the consumer's level is an information set which indicates that the consumer does not know at which node he or she is located. Since both high quality and low quality produce have the same quality claim.

The only Nash equilibrium of the continuation game is the strategy profile (low quality, don't buy), if the $u(x_l, x_j) < 0$ and if $u(x_l, x_j) > 0$, then the strategy profile (low quality, buy) (McCluskey 2000).

Figure 4.1 Asymmetric Market Game



It is true that this game can be played in a finite horizon of T periods to capture "unraveling effect" but still producer will have an incentive to sell low quality product to the consumer the period before the game over. Since the consumer has no way to penalize the producer for deviation. However, the finite games might be played in a series of T periods as well.

We can also develop this model in infinitely repeated game that will not produce any unraveling effects. The "folk theorems" for repeated games proves that feasible and rational payoffs can be reached through equilibrium if the players are sufficiently patient (Fudenberg and Tirole 1993). I propose the following strategies: the producer will offer high quality product in the first period and keep producing high quality product if the consumer buys in all preceding periods. If the consumer does not buy then, the producer will not make high quality product claim. The consumer will buy in the first period. He or she will keep buying if the producer offers high quality products in all preceding periods. In the case of producer deviation from offering high quality product the consumer will choose "do not buy" strategy.

We will assume an identical discount rate for payoffs of both players that is denoted by δ (where $\delta = \frac{1}{1+r}$) and the present-value payoffs are shown in the table 1. To capture post-effect of cheating the consumer we will calculate deviation payoffs on one-stage. The present value payoffs that are generated from offering high quality product must be greater than the one-time benefit from cheating the consumer with a false high quality claim (McCluskey 2000). Therefore, the following relation of payoffs must hold to have producer to offer high quality product:

$$\frac{\pi_h = p(D(p) - c_h(D(p))}{1-\delta} > \pi_l = p(D(p) - c_l(D(p)) \qquad (7)$$

If the both of the players are patient enough to play the game strategically, the equilibrium of high quality product will be possibly reached. The benefit from the

deviation is limited to one stage as consumer penalizes the producer by not buying his or her product.

Table 4.1 Payoffs for players in infinite game

	Equilibrium Payoffs	**Deviation Payoffs**
Producer	$\frac{\pi_h = p(D(p) - c_h(D(p))}{1-\delta}$	$\pi_l = p(D(p) - c_l(D(p))$
Consumer	$\frac{u_h(x_h, x_j)}{1-\delta}$	0

The findings of the first model strongly recommend that the producer should not cheat the consumer, if high quality product claim is made, to keep long run relations.

Model II: Symmetric Market

To develop the second model we will change some of above model assumptions to analyze and interpret an interaction between producer and consumer through incorporating the traceability system:

1. The same monopolistic producer sets price greater than the marginal cost.
2. The producer can make two quality type claims of Pollock products: high and low quality.
3. Both of agents: producer and consumer observe the actual quality of the product as the mandatory or market driven traceability system signals information on the quality attribute of a fish product to consumer. So, the traceability system converts credence attributes of Pollock product into search attributes.
4. The monopolistic producer charges two different prices, denoted by p_h and p_l on different quality quantities to purposely differentiate the product.
5. Two different demand functions of the monopolist are denoted by $q_h = D_h(p)$, $q_l = D_l(p)$ and are differentiable with decreasing property in p (where $D_h'(p) < 0$

and $D_l'(p)<0$). The producer receives two different total revenues that are denoted by $p_h(D_h(p_h))$ and $p_l(D_l(p_l))$.

6. The firm's cost function is not again the same across the qualities of a fish product and the traceability cost is also integrated into. Usually, any traceability system has a cost structure comprised of a fixed cost *e.g.* the salary of data base entry specialist and a variable cost *e.g.* tag if its cost is modeled as an endogenous variable. To make the interpretation of the second model easy to understand we will define the cost of traceability by t, as an independent variable. The model captures two different levels of traceability that are denoted by t_h for high quality production and t_l for low quality production. We will add the cost of a traceability system as an exogenous variable into the total production cost. Those cost functions are denoted by:

$$C_h(q_h,t_h)) > C_l(q_l,t_l)), \text{ where } t_h > t_l \geq 0 \qquad (8)$$

We will derive our marginal cost from (8) that is differentiable and increasing as an extra unit of product produced:

$$\frac{\partial C_h(q_h,t_h)}{\partial q_h} = C_h'(q_h,t_h) > \frac{\partial C_l(q_l,t_l)}{\partial q_l} = C_l'(q_l,t_l) \qquad (9)$$

7. Based on (8) and (9) we will drive the profit maximization condition for the firm with high and low quality product demand functions:

$\pi_h = p_h(D_h(p_h)) - C_h(D_h(p_h,t_h))$ profit max. problem for high quality (10)

$\pi_l = p(D_l(p_l)) - C_l(D_l(p_l,t_l))$ profit max. problem for low quality (11)

8. The utility of the consumer is formed in the same way as in previous model but x_j is different. Since consumer pays different prices due to high and low quality and x_j represents all other products and is equal to income less price paid for x_i:

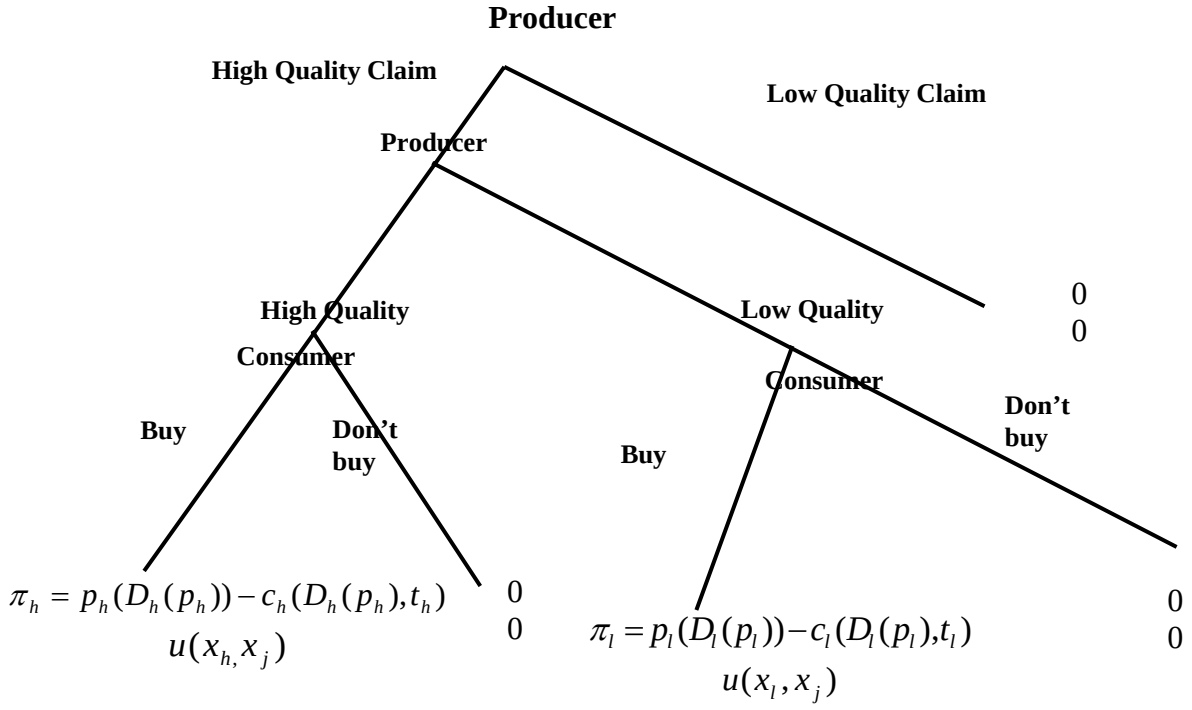
$u(x_h, x_j)$ if the consumer happens to get high quality fish product (12)

$u(x_l, x_j)$ if the consumer happens to get low quality fish product (13)

The product is promoted to be a traceable product that ensures high level of compliance to the technical specification and standards in food production. If the logo or some kind of traceability identifier is marked on the label of the fish product, then the consumer will have confidence that the product is driven from a reliable and safe source.

Our figure 2 models the game with perfect information as the quality of the product is being signaled through the traceability.

Figure 4.2 Symmetric Market Game



In the game shown on figure 2 the producer decides whether or not to make high quality product claim. Now, the information is symmetric and the consumer easily observes or evaluates the actual quality of the product through the traceability. We can divide the game into two subgames to find Nash Equilibrium for each subgame by the backward-induction method. In this case, the players will play with the following strategy profiles:

- Consumer: buy if the producer offers high quality product, and “do not buy” if the producer offers low quality product.
- Producer: produce high quality product. Therefore, the following conditions hold:

$$\pi_h \geq 0 \tag{14}$$

$$u(x_h, x_j) > 0 \tag{15}$$

$$u(x_l, x_j) < 0$$

In this game, there is a Nash equilibrium that Pareto efficient for both players of the game: high quality produce, buy. The strategies for this equilibrium are in the best interests of both players. If we set up the normal form of this game, we will reach the same result. The second model illustrates that the credence type product could be transformed into search good through the traceability system. In other words, the traceability provides an effective signal to consumer to sufficiently evaluate the actual quality of product. It is also possible that the consumer may end up not choosing “buy” strategy if the producer is still trying to cheat him or her. Since the cheating is identifiable and verifiable through an effective traceability system. Therefore, the rational players will stick to those strategies that will ensure long-term economic relations.

CHAPTER 5

SUMMARY AND RESULTS

The paper develops an interesting theory to support the hypothesis that traceability is an efficient signal to transform an asymmetric market condition into a symmetric market one. In addition, the theory shows that the asymmetric markets lead to market failures if the consumers prefer to purchase a high quality and safe fish products and the producer is trying to cheat him or her through claiming that a low quality product is a high quality product. The review of the previous studies on asymmetric markets revealed that asymmetric information condition did not serve to maintain the long-term relations among the players if one of them deviates or cheats. Therefore, the research successfully introduces that a traceability system can serve as a signal to increase the knowledge of the consumer and provide some tools to them to sufficiently evaluate the actual quality and safety a product. The study also analyzes the benefits of the different type traceability systems with focus some focus on the cost and technical aspects in a specific fishery. That aspect of the study identified that the type of traceability system for an entire value chain or a single firm is mostly driven by downstream players *e.g*. Wal-Mart requiring implementation of traceability systems on major suppliers based upon RFID technologies.

The application of traceability also depends on the type and structure of the industry *e.g.* fishery industry is more integrated than the beef, which enables the players or partners to sufficiently harmonize the traceability system. Since the system requires from personnel sufficient level of accurateness and consistency in a) data entry and storage and b) tag coding and tagging *etc*. The amount and level of the effort for the application of the traceability system varies across types. It is true that the most sufficient systems are costly and require high switching costs.

In addition, the research analyzes the process of certification for being sustainable and well-managed fishery with traceable products. In that regard the work and certification process of Marine Steward Council (MSC) has been extensively analyzed. An increasing demand of the consumers for quality and environmentally friendly fish products urged MSC to develop a logo for sales of fish products. This logo signals to the consumer that the fish is derived from a sustainable (meaning not over-fished) and well-managed fish stock. MSC certification is an internationally recognized system and is being applied by fisheries of world nations. In addition to this voluntary program, there are certain country specific requirements for traceability such as U.S. Country of Origin Labeling (COOL) program. U.S. COOL system requires the food retailers to identify the product's country of origin and this establishes a requirement for a verifiable chain of custody for all members in the supply chain. Recent application of traceability in fisheries has been limited and the scope of the research has reviewed practices and traceability systems for fisheries in other countries. However, industries in some countries *e.g.* Canada, Japan and EU countries have shown positive progress in implementing the traceability in beef products and other products.

The study was limited with the development and interpretation of a theoretical game theory model, as the time is not efficient to capture the effect of the traceability through the empirical research. In other words, the positive or negative effects of the traceability system cannot be captured until the system has been implemented for as 3 to 5 years. However, the thesis strongly recommends future work be conducted to analyze different benefits of traceability systems that may lead to the identification of the most system for the fishing industry or at least specific segments of it.

The research develops the theory through two different game theory approaches: one in which the consumer cannot evaluate the actual quality and safety of the product, as he or she does not know much about the product, and get no information through the

appearance or readily observable attributes of the product. He or she has to purchase or consume the product to increase his or her knowledge on the product. It is true that the producer will mostly cheat the consumer if there is no any mechanism that enables the consumer to observe the quality of the product before purchase and consumption. In that regard, the product type and attributes matter as consumer behaves differently in facing search, experience and credence good. Finally, the lack of knowledge on the actual quality attribute of the fish product and cheating by producer does not encourage the consumer to make another purchase with the producer of those fish products in the second stage of the game. This case leads to break up of a long-term relation between the producer and consumer.

In order to avoid the possibility of market failure and establish sustainable market relation between consumer and producer, the study develops a second game theory approach creating a symmetric market environment. Under this condition the producer wants to supply the consumer with easily traceable fish product that will strengthen a long-term economic relationship between the producer and the consumer. The consumer is fully satisfied with symmetric information condition, as it perfectly provides a signal to the consumer that the fish product is high quality versus low quality. This helps the consumer to make a right decision and does not generate “hidden agenda” for the producer to be able to cheat the consumer.

Finally, the theory proves that it is in the best interest of the producer strategically to supply a fish product to consumer in the symmetric market. There is almost no chance that the consumer will buy again from the same producer on the following stages if he or she is cheated in the preceding stage. But the consumer will continue to buy the fish product in symmetric market as he or she can receive a sufficient amount of information through the traceability on the actual quality of the product. Therefore, the latter suggests us that the producer’s best interest is to create and maintain the symmetric market for

long run relation with the consumer. The limitation of the theoretical approach does not encourage more accurate estimation of payoff or profit differences for producer in asymmetric versus symmetric market. However, it is possible to achieve more accurate estimation through successful empirical study.

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Annex 1

MSC Principles and Criteria for Sustainable Fishing

At the center of the MSC is a set of *Principles and Criteria for Sustainable Fishing* which are used as a standard in a third party, independent and voluntary certification program. These were developed by means of an extensive, international consultative process through which the views of stakeholders in fisheries were gathered.

These Principles reflect a recognition that a sustainable fishery should be based upon:

- The maintenance and re-establishment of healthy populations of targeted species;
- The maintenance of the integrity of ecosystems;
- The development and maintenance of effective fisheries management systems, taking into account all relevant biological, technological, economic, social, environmental and commercial aspects; and
- Compliance with relevant local and national local laws and standards and international understandings and agreements

The Principles and Criteria are further designed to recognize and emphasize that management efforts are most likely to be successful in accomplishing the goals of conservation and sustainable use of marine resources when there is full co-operation among the full range of fisheries stakeholders, including those who are dependent on fishing for their food and livelihood.

On a voluntary basis, fisheries, which conform to these Principles and Criteria, will be eligible for certification by independent MSC-accredited certifiers. Fish processors, traders and retailers will be encouraged to make public commitments to purchase fish products only from certified sources. This will allow consumers to select fish products with the confidence that they come from sustainable, well-managed sources. It will also benefit the fishers and the fishing industry that depend on the abundance of fish stocks, by providing market incentives to work towards sustainable practices. Fish processors, traders and retailers who buy from certified sustainable sources will in turn benefit from the assurance of continuity of future supply and hence sustainability of their own businesses.

The MSC promotes equal access to its certification programme irrespective of the scale of the fishing operation. The implications of the size, scale, type, location and intensity of the fishery, the uniqueness of the resources and the effects on other ecosystems will be considered in every certification.

The MSC further recognises the need to observe and respect the long-term interests of people dependent on fishing for food and livelihood to the extent that it is consistent with ecological sustainability, and also the importance of fisheries management and operations being conducted in a manner consistent with established local, national, and international rules and standards as well as in compliance with the MSC Principles and Criteria.

Preamble

The following Principles & Criteria are intended to guide the efforts of the Marine Stewardship Council towards the development of sustainable fisheries on a global basis. They were developed assuming that a sustainable fishery is defined, for the purposes of MSC certification, as one that is conducted in such a way that:

- it can be continued indefinitely at a reasonable level;
- it maintains and seeks to maximize, ecological health and abundance,
- it maintains the diversity, structure and function of the ecosystem on which it depends as well as the quality of its habitat, minimizing the adverse effects that it causes;
- it is managed and operated in a responsible manner, in conformity with local, national and international laws and regulations;
- it maintains present and future economic and social options and benefits;
- it is conducted in a socially and economically fair and responsible manner.

The Principles represent the overarching philosophical basis for this initiative in stewardship of marine resources: the use of market forces to promote behavior which helps achieve the goal of sustainable fisheries. They form the basis for detailed Criteria, which will be used to evaluate each fishery seeking certification under the MSC programme. Although the primary focus is the ecological integrity of world fisheries, the principles also embrace the human and social elements of fisheries. Their successful implementation depends upon a system, which is open, fair, based upon the best information available, and which incorporates all relevant legal obligations. The certification programme in which these principles will be applied is intended to give any fishery the opportunity to demonstrate its commitment to sustainable fishing and ultimately benefit from this commitment in the market place.

Scope

The scope of the MSC Principles and Criteria relates to marine fisheries activities up to but not beyond the point at which the fish are landed. However, MSC-accredited certifiers may be informed of serious concerns associated with post-landing practices. [41]

The MSC Principles and Criteria apply at this stage only to wild-capture fisheries (including, but not limited to shellfish, crustaceans and cephalopods). Aquaculture and the harvest of other species are not currently included.

Issues involving allocation of quotas and access to marine resources are considered to be beyond the scope of these Principles and Criteria.

[41] Other complementary certification programmes (e.g., ISO 14000) provide opportunities for documenting and evaluating impacts of post landing activities related to fisheries products certified to MSC standards. Constructive solutions to address these concerns through appropriate measures should be sought through dialogue with certification organisations and other relevant bodies.

PRINCIPLE 1

A fishery must be conducted in a manner that does not lead to over-fishing or depletion of the exploited populations and, for those populations that are depleted, the fishery must be conducted in a manner that demonstrably leads to their recovery [42]:

Intent:

The intent of this principle is to ensure that the productive capacities of resources are maintained at high levels and are not sacrificed in favor of short-term interests. Thus, exploited populations would be maintained at high levels of abundance designed to retain their productivity, provide margins of safety for error and uncertainty, and restore and retain their capacities for yields over the long term.

Criteria:

1. The fishery shall be conducted at catch levels that continually maintain the high productivity of the target population(s) and associated ecological community relative to its potential productivity.
2. Where the exploited populations are depleted, the fishery will be executed such that recovery and rebuilding is allowed to occur to a specified level consistent with the precautionary approach and the ability of the populations to produce long-term potential yields within a specified time frame.
3. Fishing is conducted in a manner that does not alter the age or genetic structure or sex composition to a degree that impairs reproductive capacity.

PRINCIPLE 2:

Fishing operations should allow for the maintenance of the structure, productivity, function and diversity of the ecosystem (including habitat and associated dependent and ecologically related species) on which the fishery depends.

Intent:

The intent of this principle is to encourage the management of fisheries from an ecosystem perspective under a system designed to assess and restrain the impacts of the fishery on the ecosystem.

Criteria:

1. The fishery is conducted in a way that maintains natural functional relationships among species and should not lead to tropic cascades or ecosystem state changes.

[42] The sequence in which the Principles and Criteria appear does not represent a ranking of their significance, but is rather intended to provide a logical guide to certifiers when assessing a fishery. The criteria by which the MSC Principles will be implemented will be reviewed and revised as appropriate in light of relevant new information, technologies and additional consultations

2. The fishery is conducted in a manner that does not threaten biological diversity at the genetic, species or population levels and avoids or minimizes the mortality of, or injuries to endangered, threatened or protected species.

3. Where exploited populations are depleted, the fishery will be executed such that recovery and rebuilding is allowed to occur to a specified level within specified time frames, consistent with the precautionary approach and considering the ability of the population to produce long-term potential yields.

PRINCIPLE 3:

The fishery is subject to an effective management system that respects local, national and international laws and standards and incorporates institutional and operational frameworks that require use of the resource to be responsible and sustainable.

Intent:

The intent of this principle is to ensure that there is an institutional and operational framework for implementing Principles 1 and 2, appropriate to the size and scale of the fishery.

9. Management System Criteria:

1. The fishery shall not be conducted under a controversial unilateral exemption to an international agreement.

The management system shall:

2. Demonstrate clear long-term objectives consistent with MSC Principles and Criteria and contain a consultative process that is transparent and involves all interested and affected parties so as to consider all relevant information, including local knowledge. The impact of fishery management decisions on all those who depend on the fishery for their livelihoods, including, but not confined to subsistence, artisanal, and fishing-dependent communities shall be addressed as part of this process;

3. Be appropriate to the cultural context, scale and intensity of the fishery – reflecting specific objectives, incorporating operational criteria, containing procedures for implementation and a process for monitoring and evaluating performance and acting on findings;

4. Observe the legal and customary rights and long term interests of people dependent on fishing for food and livelihood, in a manner consistent with ecological sustainability;

5. Incorporates an appropriate mechanism for the resolution of disputes arising within the system[43];

[43] Outstanding disputes of substantial magnitude involving a significant number of interests will normally disqualify a fishery from certification.

6. Provide economic and social incentives that contribute to sustainable fishing and shall not operate with subsidies that contribute to unsustainable fishing;

7. Act in a timely and adaptive fashion on the basis of the best available information using a precautionary approach particularly when dealing with scientific uncertainty;

8. Incorporate a research plan – appropriate to the scale and intensity of the fishery – that addresses the information needs of management and provides for the dissemination of research results to all interested parties in a timely fashion;

9. Require that assessments of the biological status of the resource and impacts of the fishery have been and are periodically conducted;

10. Specify measures and strategies that demonstrably control the degree of exploitation of the resource, including, but not limited to:

    a) Setting catch levels that will maintain the target population and ecological community's high productivity relative to its potential productivity, and account for the non-target species (or size, age, sex) captured and landed in association with, or as a consequence of, fishing for target species;
    b) Identifying appropriate fishing methods that minimize adverse impacts on habitat, especially in critical or sensitive zones such as spawning and nursery areas;
    c) Providing for the recovery and rebuilding of depleted fish populations to specified levels within specified time frames;
    d) Mechanisms in place to limit or close fisheries when designated catch limits are reached;
    e) Establishing no-take zones where appropriate;

11. Contains appropriate procedures for effective compliance, monitoring, control, surveillance and enforcement which ensure that established limits to exploitation are not exceeded and specifies corrective actions to be taken in the event that they are.

10. <u>Operational Criteria</u>

Fishing operation shall:

12. Make use of fishing gear and practices designed to avoid the capture of non-target species (and non-target size, age, and/or sex of the target species); inimize mortality of this catch where it cannot be avoided, and reduce discards of what cannot be released alive;

13. Implement appropriate fishing methods designed to minimize adverse impacts on habitat, especially in critical or sensitive zones such as spawning and nursery areas;

14. Not use destructive fishing practices such as fishing with poisons or explosives;

15. Minimize operational waste such as lost fishing gear, oil spills, on-board spoilage of catch, etc.;

16. Be conducted in compliance with the fishery management system and all legal and administrative requirements; and

17. Assist and co-operate with management authorities in the collection of catch, discard, and other information of importance to effective management of the resources and the fishery.

ANNEX 2

MARCH 2005

NOTICE TO THE TRADE

MANDATORY COUNTRY OF ORIGIN LABELING FOR FISH AND SHELLFISH

Purpose: Based upon a number of inquiries and comments from retailers and their suppliers, the Department of Agriculture (USDA) is issuing this Notice to the Trade to clarify the documentation and records that must be maintained to substantiate country of origin and method of production claims.

Background: On April 4, 2005, the provisions of the Interim Final Rule (IFR) for the mandatory country of origin labeling (COOL) of fish and shellfish covered commodities will become effective. The IFR was published in the Federal Register on October 5, 2004, and requires designated retailers to label fish and shellfish covered commodities for country of origin and method of production (i.e., wild or farm raised). The full text of the IFR can be found at: http://www.ams.usda.gov/cool/index.htm.

Recordkeeping Requirements: The statutory provisions authorizing the mandatory COOL program are clear that the supply chain must provide information on country of origin and method of production to retailers who merchandise fish and shellfish covered commodities. The statute is equally clear that USDA may require a verifiable recordkeeping audit trail to substantiate label claims. The recordkeeping requirements for both retailers and their suppliers are set forth in Section 60.400 of the IFR. The following clarifies specific recordkeeping and documentation requirements set forth in the IFR.

Question: For covered commodities, what records or documentation must be maintained for compliance purposes?

Response: For compliance purposes at both the retail and supply chain levels, the records used to substantiate claims consist of two separate, but equally important, parts. The first part of the record establishes the chain of custody of the product. Retailers and their suppliers must maintain Chain of custody information for all covered commodities. We anticipate that, in almost all cases, routine business documents will be sufficient record to document chain of custody information.

The second part of the record establishes country of origin and method of production for the covered commodity. For pre-labeled products, the label itself is sufficient record on which the intermediary supplier and retailer may rely while the product is in their possession. Once the pre-labeled covered commodity leaves the possession of an intermediary supplier or retailer, no further recordkeeping documenting country of origin and method of production is required. By contrast,

the documentation for covered commodities that are not pre-labeled for country of origin or method of production must be maintained at the retail site while the product is on hand and for a period of 1 year by both the retailer and their suppliers.

Question: What records or documentation must suppliers who initiate country of origin and method of production claims maintain?

In all cases, the supplier who is responsible for initiating a country of origin or method of production claim must possess or have legal access to records that are necessary to substantiate the claims for 1 year from the date the product is sold.

Question: Do "pre-labeled" products include those covered commodities repackaged by the retailer?

Response: No. Anytime the term "pre-labeled" is used in the IFR it is referring to covered commodity packaging (i.e., consumer packages or shipping containers), which is labeled for country of origin and/or method of production by the firm or entity responsible for making the initial claim for these attributes or by a further processor or repacker (i.e., firms that receive bulk products and package the products as covered commodities in a form suitable for the retailer).

Question: The IFR states that country of origin and method of production information may be provided to the retailer: 1) on the product itself; 2) on the master container; or, 3) in a document that accompanies the product through retail sale provided that it identifies the product unique to that transaction by means of a lot number or other unique identifier. Does this mean that all covered commodities must be assigned and tracked with a lot number or other unique identifier?

Response: The tracking (i.e., unique identifier) for covered commodities which are pre-labeled for country of origin and method of production on the product itself or on the master container will consist of documentation that specifies the immediate previous source, product name, amount, and when the product was received. We anticipate that, in almost all cases, this information will be a component of routine business documents.

For covered commodities that do not have information on country of origin or method of production on the package or container labels, such information must be provided to the retailer by some document or other verifiable record for each transaction between buyer and seller. In this case, the IFR recordkeeping provisions require this document or record to contain information that specifies: the product, country of origin and method of production, and some form of tracking (i.e., unique identifier) that links the documentation to the covered commodity.

Question: The IFR states that retailers must maintain certain records related to a covered commodity's supplier and country of origin and/or method of production claims for, "…a period of 1 year from the date the declaration is made at retail." What does USDA consider the "date of declaration"?

The date of declaration at retail is the date the covered commodity with appropriate labeling as to country of origin and method of production in accordance with the IFR is first made available for purchase by consumers.

Question: In the case of further processors or repackers, what documentation over and above that required for other suppliers must be maintained?

The same recordkeeping and documentation requirements apply to this group of suppliers with one exception. In addition to chain of custody and country of origin and method of production records or labels, further processors and repackers must maintain internal system records that document the processes used to further process or repackage covered commodities. That is, internal system records that document the transfer of product and country of origin and method of production information from bulk containers to the packaging provided to retailers must be maintained.

Annex 3

Table 4.2. Food Products Recalls in 2005 – 2006

Case Number and Recall Notification Report	Quantity Reported Recovered by Establishment	Case Number and Recall Notification Report, 2006	Quantity Reported Recovered by Establishment, 2006
053-2005, Pot Roast Dinners (undeclared allergen)	58 pounds	026-2006, Ground Beef Products (*E. coli* O 157:H7)	105 pounds
052-2005, Expanded Turkey, Ham and Bologna Lunch Maker Meals (*Listeria*)	1,911,519 pounds	026-2006, Ground Beef Products (*E. coli* O 157:H7)	545 pounds
051-2005, Goetz Ham and Beef Products (*Staphylococcus aureus*)	243 pounds	023-2006, Hot Dogs (*Listeria*)	4 pounds
050-2005, Chicken Products (contamination by pesticide)	31,624 pounds	022-2006, Frozen Meat Loaf Entrees (Pieces of metal)	3,397 pounds
049-2005, Isabelle's Kitchen, Inc. Chicken Salad Products (*Listeria*)	1,630 pounds	021-2006, Ground Beef (E. coli O157:H7)	205 pounds
048-2005, Ready-To-Eat Chicken Product (*Listeria*)	237 pounds	020-2006, Jumbo Franks (undeclared allergen)	2,088 pounds
046-2005, Philly-Gourmet Frozen Ground Beef Patties (*E. collie* O 157:H7)	12,096 pounds	019-2006, Beef Stick (Mislabeling)	375 pounds
045-2005, Chef's Delight Ready-to-Eat Beef Products (*Listeria*)	828 pounds	018-2006, Ham Products (Staphylococcus aureus)	253 pounds
044-2005, Ready-to-eat Meat and Poultry Products, Trader Joe's (*Listeria*)	4,177 pounds	014-2006, Chicken Fillets (underprocessed)	6,580 pounds
043-2005, Ham Products, Sunny Valley Smoked Meats, Inc. (undeclared allergens)	17,105 pounds	013-2006, Chicken Toddler Food (pieces of bone)	872 pounds
042-2005, Pure Farms	792 pounds	012-2006, Ham	48 pounds

Cooked Chicken Sausage Products and Beef Wieners (*Listeria*)		Salad (*Listeria*)	
040-2005, Flanders and Saver's Choice Beef Patties (*E. coli* O 157:H7)	4,634 pounds	011-2006, Dried Beef (Listeria)	100 pounds
038-2005, Chorizo, Blood Sausage, and Blood Pudding (*Listeria*)	210 pounds	010-2006, LIPTON Chicken Noodle Soup Product (undeclared allergen)	27,840 pounds
037-2005, Sausage and Bacon Products (unsanitary conditions)	1,008 pounds	009-2006, Frozen Stuffed Chicken Entrees (*Salmonella*)	10,496,25 pounds
		008-2006, Meatball Products (undeclared allergen)	158,808 pounds
		007-2006, "Griffin's, Pork BAR-B-Q, UNSKINNED PORK WITH SAUCE" (*Listeria*)	15 pounds
		006-2006, Beef Sausage (potential contamination)	7 pounds
		005-2006, Chicken Egg Rolls (undeclared allergen)	691 pounds
		004-2006, Sausages (undeclared allergen)	3,589 pounds
		002-2006, Asian Style Pot Stickers (foreign material)	2,491 pounds
		001-2006, Lancaster and Hatfield Brand Beef (undeclared allergen)	56,952 pounds