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Seafood Traceability in the United States: Current Trends, System Design, and Potential Applications

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ABTRACT: Increasing globalization of our food supply combined with recent outbreaks of foodborne disease has heightened concerns over food safety issues around the globe. In response to these growing concerns, both by government and consumers, many nations are looking at food traceability as a means to restore confidence in the food supply and limit damages incurred by the sale and distribution of unsafe products. Traceability, which allows for the tracking of food products through all steps of production, distribution, and sales, can provide information on the nature, origin, and quality of a product; allowing consumers to make more informed purchasing decisions while providing the mechanisms for quick and thorough product recall procedures. Implementing traceability systems will require improved vertical integration between entities and the development of standards for the collection and dissemination of traceability data. Fortunately, rapid advances in information technology have made it possible to implement traceability systems within the food industry. This review will explore the current trends toward traceability in the U.S. seafood industry. Current legislation, both here and abroad, and its effects on the seafood industry will be explored, and the design of a traceability system will be discussed.

Introduction

"Traceability" is defined as the ability to trace the history, application, or location of that which is under consideration (ISO 9000 2000 clause 3.5.4). The concept of tracing products from their origin to the consumer is not a contemporary idea. Many industries have incorporated product tracing into their internal operations for decades. Most of us have purchased items, from cars to electronics, that are labeled with unique serial numbers, allowing manufacturers and government authorities to identify and locate individual products. However, the introduction of traceability into the food supply sector is a relatively new concept that continues to gain momentum, particularly in the European community.

The seafood industry is a commercial food sector in which traceability is becoming a legal and commercial necessity (Borresen 2003). Globalization of trade and the lack of international standards have made identifying the origin and history of seafood products difficult, raising concerns from retail, food service, and consumers about the safety of their seafood supplies. These concerns have recently been heightened by the food safety problems experienced in Europe that have made traceability a prominent topic in the food industry. Driven largely by growing food safety issues, including bio-terrorism (Bledsoe and Rasco 2002), and demands by the consumer for detailed information on the nature, origin, and quality of the food they are purchasing, traceability will make an impact on the seafood industry. Whether this impact is perceived as positive or negative within the seafood industry will depend on the potential market benefits and the design, management, and marketing of traceability concepts (Thompson and others 2003).

Within the food industry, traceability implies the ability to trace and follow feed, food, and food-producing animals through all stages of production, processing, and distribution (FSA 2002). The fundamental basis for a traceability system is its ability to trace both products and activities (Moe 1998). This requires a system capable of (1) tracing products through the distribution chain, (2) providing information on product ingredients, and (3) understanding and communicating the effects of production practices and distribution on product quality and safety. While traceability by itself does not provide quality assurance, it has important aspects that relate to food safety, quality, and product labeling (Kim and others 1995). An effective traceability system also provides for an efficient flow of information through the entire market channel.

Limited traceability is not new to the U.S. food industry, particu-

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larly with respect to food safety. Mandatory procedures have been established to reject or recall products that present a food safety issue. Good manufacturing practices (GMP), ISO 9000 quality management, and hazard analysis and critical control point (HACCP) procedures are growing in use and broadening the scope of traceability in accommodating this information (Moe 1998). Inspection and data systems such as HACCP, which is mandatory for all seafood, are designed to control biological, chemical, and physical hazards during processing. HACCP, however, does not require a traceability system because most of the collected data are not communicated to other market channel members in the supply chain (Hernandez 2001).

Currently, product recall procedures and mandated documentation are the only form of product traceability in the United States. Despite the apparent success of this system in preventing foodborne illness, it still cost the U.S. food industry approximately 7 billion dollars in 2000 for foodborne disease (ERS 2003). The costs of product recalls associated with contamination are also increasing in the U.S. Class I product recalls, which are considered high health risk cases, have grown from 24 cases per year and 1.5 million pounds of affected food during 1993 to 1996, to 41 cases per year and 24 million pounds between 1997 and 2000 (Ollinger and Ballenger 2003). These trends may indicate that current regulations concerning food safety may be inadequate and that traceability could be an important strategy for reducing costs of foodborne disease and product recalls, while also addressing consumer concerns over quality, the environment, and resource sustainability. Some firms have voluntarily begun to offer traceable products to their customers. Although largely limited to niche markets, these actions highlight the growing demand, by food service, retailers, and consumers, for more information on food products.

The use of informational labeling on food products is becoming a regulatory tool used to inform customers and influence markets for food quality (Caswell 1998). Currently, consumers are limited in the information about the origin and history of the food they purchase. The Commission of the European Communities believes that consumers have the right to receive information on the quality and constituents of their food so they can make informed decisions (FSA 2002). Surveys have shown that a large majority of consumers both in the European Union (E.U.) and the United States were willing to pay a premium price for products, which include Country-of-Origin-Labeling (COOL) and geographical labeling and certifications (Wessels and others 1999; Loureiro and McCluskey 2000; Clemens and Babcock 2002; Roosen and others 2003; Umberger and others 2003). Informational labeling requirements are likely to have a significant impact on the food market, helping to prevent fraud by providing more information to the consumer. Labeling, by itself, does not provide traceability; however, it is an important aspect of traceability that allows the physical tracking of the product and can be used as an effective means of differentiating products and creating brand recognition.

Growing Food Safety Problems

Recent food safety concerns in Europe including Bovine Spongiform Encephalopathy (BSE), hoof-and-mouth disease, dioxin poisoning in chicken feed, and the growing anxiety over the proliferation of Genetically Modified Organism (GMO) foods, have increased attention in Europe, Japan, the United States, and their trade partners on food traceability (Borresen 2003). In addition, the events of September 11, 2001, in the United States have highlighted the need to protect the national food supply from bioterrorism. Simply claiming that a product has been tampered with is sufficient enough to precipitate a full product recall, which may cost a firm, not only monetarily, but also its reputation (Bledsoe and Rasco 2002).

Despite more stringent controls on food safety, confidence in the global food supply has continued to decline. Consumer confidence of food safety in the United States fell from 83% in 1996 to its current level of 74% (ERS 2002). This has resulted in increasing attention on traceability by policymakers in the United States and other nations as a means to reduce uncertainty about food safety and to regain consumer confidence. Policy makers in the United Kingdom responded rapidly to the recent outbreak of BSE by enacting the Compulsory Beef Labeling Scheme (CBLS) in September 2000. This law required that all producers of beef and beef products conform to a strict set of traceability and labeling guidelines. In January 2003, Japan passed legislation developed by the Ministry for Agriculture, Forestry and Fishery requiring domestic producers of beef to register all cattle into a centralized database. Other countries including Australia, New Zealand, and Canada are considering or have implemented new traceability requirements for their meat products.

Emerging mandatory requirements have made traceability an international trade issue, which may strain relations and result in establishment of trade barriers. Traceability is also being debated within international forums. For example, during the most recent Codex Alimentarius committee meeting in December 2002, the United States strongly opposed the implementation of mandatory traceability. The United States argued that the government should not be involved in the day-to-day operations of private industry and should confine their role to issues of food safety. This debate is likely to continue as governments (1) attempt to increase consumer confidence in food safety, (2) counteract a heightened threat of bio-terrorism, and (3) confront a global economy increasingly influenced by consumer demands for more information on the origin and history of their food. The seafood industry, already confronted by inherent safety liabilities including scrombroid poisoning, ciguatera, shellfish poisoning, and mercury contamination, must address existing and emerging legislation and its effect on trade. In addition to food safety, concerns over declining fish populations and growing pressure from consumers to produce sustainable food will impact the role of food traceability in domestic and international markets.

Legislation

Although the specifics of a universal traceability system are yet to be defined, some nations have already passed legislation requiring comprehensive labeling and, in some instances, complete traceability of all food products. These regulations are not only directed toward domestic products, but will be required on all imported products as well. Food safety is already a major priority in the United States and although there is currently no general legal requirement for the establishment of traceability in our food chain, existing law obliges any entity that chooses to sell or market food products to provide assurance that only safe food is sold. The following list includes new labeling and traceability standards that will affect the way that U.S. companies do business both here and abroad.

European Union (E.U.), Article 4, regulation 104/2000

In effect since January 1, 2002, this regulation requires that all fishery products be labeled with commercial designation of the species, the production method (caught at sea, inland waters, or farmed), and if farm raised, the catch area or production location.

European Community Commission Regulation 2065/2001, Article 8

This regulation pertains to detailed provisions for the application of E.U. regulation 104/2000 and requires that all chilled, frozen, and smoked fish or fillets and shellfish, when offered for retail sale, be labeled in accordance with E.U. 104/2000. In addition to these requirements, this information must be provided at each stage of the marketing chain, either by direct labeling or acceptable commercial documentation.

E.U. General Food Law Regulation 178/2002, Article 18

This article, which does not come into effect until January 2005, will require that traceability of food or food-producing animals or any other substance intended, or expected, to be incorporated into food or feed shall be established at all stages of production, processing, and distribution. It also requires the identification of supplier and customer for each market channel transaction, and provisions of all relevant documentation.

U.S. Farm Security and Rural Investment Act of 2002

This act requires "country-of-origin" labeling on all beef, lamb, pork, fish, perishable commodities, and peanuts. Voluntary guidelines were established in October 2002, and will become mandatory after new interim rules were established on September 30, 2006, for all items except fish and shellfish, which will be implemented on April 4, 2005.

U.S. Bio-terrorism and Response Act of 2002

Effective as of June 12, 2002, this law requires the registration of all food facilities, domestic and foreign, supplying food to the United States. It addition, it mandates records to identify the suppliers and recipients of all food products.

The events that triggered this recent round of regulations will continue to have a dramatic effect on the U.S. food industry (Sporleder and Moss 2002). The E.U. has made the 1st move in requiring complete traceability on all fish and fish products by the year 2005, including imports. Although recent U.S. regulations do not mandate traceability, they contain some of the key concepts of traceability systems. Mandatory implementation of COOL will require all suppliers of food to the United States to clearly label the origin of all seafood products. Many sectors of the U.S. food industry support COOL legislation; however, there is also strong opposition to mandatory labeling. On January 27, 2004, President Bush signed public law 108-199, which effectively delays the implementation of mandatory COOL requirements for all covered commodities except wild and farmed-raised fish and shellfish until September 30, 2006. Implementation and enforcement of COOL for fish and shellfish suppliers has also been delayed by an interim final rule (IFR). Enforcement of COOL for fish and shellfish will not take place until April 4, 2005. In addition to delaying implementation, the IFR institutes a grandfather clause that exempts any frozen fish or shellfish caught or harvested by December 6, 2004, from labeling requirements. Many processed foods will also be exempt from the new labeling requiremetns including processed foods which change thr physical or chemical properties of the fish or shellfish component (COOL legislation can be found at http://www.ams.usda.gov/cool/ls0304ifr.pdf). Lobbying by both sides continues and debates are ongoing at this time regarding whether or not mandatory labeling should be required and how it will be funded. A cost-benefit analysis of COOL, completed by the Agricultural Marketing Service, estimates the costs for the 1st year of implementation to be 3.9 billion dollars to create and maintain COOL information systems (Krissoff and others 2004). A final ruling on COOL by the United States Dept. of Agriculture is expected soon, once all comments received are reviewed, the majority of which were related to the designation of wild or farm-raised fish and shellfish. In addition to COOL, the Bio-Terrorism Act clearly requires certain traceability-related information, including the registration of all food-related businesses with the U.S. government. However, this legislation does not specify, beyond the identity of the entity, what and how much information should be collected. There is increasing pressure to develop standardized traceability systems worldwide. During the 11th session of the Codex Committee on Food Import and Export Inspection and Certification Systems (CCFICS) held in December 2002 in Adelaide, Australia, a discussion paper highlighted standardized elements to be included within a definition of traceability and presented a framework for the future analysis of CCFICS texts with respect to product tracing (CCFICS 2003). The United States, however, argues that this issue should only be addressed in Codex, as the global science-based international standards-setting body for food safety, and not other international forums. These developments make it clear that traceability has become an international issue and is being discussed as a means to provide increased food safety and quality assurance to consumers.

Traceability

Traceability can essentially be described as a record-keeping system designed to identify and track products from origin to consumption while providing the ability to quickly trace back products at any point in the food chain. The terms "product tracking" and "product tracing" have different meanings in the context of traceability. "Product tracking" refers to the recording of information as the product makes it way through the food chain, and the ability to identify in real time where the product is and what processes it has undergone. "Product tracing" refers to the ability to follow a product back through these processes from the consumer to their origin. Traceability appears to be a relatively simple concept; however, the actual process of creating an informational link between the origin of materials and their processing and distribution can be extremely complicated, especially given the quantity of food that makes its way into the global marketplace.

Achieving traceability throughout the food supply chain requires the building of strong relationships in both directions along the food chain and a level of vertical integration surpassing what is currently found within the industry. Integrating information flow between seafood companies in the United States and internationally will be complicated by the diversity within the industry and the requirement of greater transparency. Although challenging, vertically integrating can result in more cooperative relationships, greater efficiency, and longer-term market success by increasing consumer knowledge and satisfying their need for safe and quality products (DAFFA 2000). Information and knowledge management, which is enhanced by traceability, can help firms respond rapidly to internal challenges and external market opportunities (Peterson 2002).

Two important motives for the formation and coordination of information in vertical supply chains is to manage liability associated with adulteration or contamination, and to identify and preserve quality traits (Westgren 1999). Traceability systems can be defined by these motives. Segregation systems attempt to separate batches of food and ingredients from each other during processing, whereas identity preservation systems identify the source and nature of each batch, requiring considerable information to guarantee that the traits and qualities of the product are maintained throughout the supply chain (Golan and others 2002). The type of system to be used will depend on what the producers want to accomplish and how much information they want to make available to other firms in the supply chain. Information on products and production practices must remain in the control of the entity responsible for these processes. Arrangements will need to be made between individual companies on how and what information will be shared to protect confidentiality and limit access to only legally entitled entities. Knowledge is a vital asset of all companies and the dissemination of proprietary knowledge will always remain an issue in traceability; thus knowledge-based integration will always, by the nature of the free market, be restricted.

Traceability Concepts

The Food Standards Agency of the European Community recognizes 2 levels of traceability within the food industry. The 1st level, called "internal traceability," takes place within 1 link of the chain (Moe 1998; FSA 2002). Considerable internal traceability already exists within the food industry providing individual firms the ability to track product through their internal operations; however, only very limited information actually follows the product to the next step (Golan and others 2003). The real difficulty in designing and implementing a traceability system lies within the complexity of the next level, called chain traceability (Moe 1998; FSA 2002). Chain traceability, which provides traceability between individual entities throughout the entire food chain, cannot be achieved without considerable knowledge-based vertical integration and may entail any number of entities in the seafood industry including fishers, buyers, processor, wholesalers, transporters, and retailers. Achieving chain traceability requires comprehensive planning during the initial stages of development, particularly when addressing the 3 issues most crucial to the success of any traceability system: (1) compatibility, (2) data standardization, and (3) the definition of a traceable resource unit (TRU) (Kim and others 1995). Defining a TRU may be one of the most difficult steps involved in the design of a traceability system. A TRU is simply defined as a unit of trade, such as a whole fish or a batch of fish at the initial stage. However, this will invariably change during processing as new TRUs are being assigned at each step within the food chain. The initial TRU must follow each fish or lot, through all steps of processing, distribution, and retail. This process can become very complicated, especially during processing, and it may be difficult to keep from mixing fish from several batches, especially when processing may include portioning, additional ingredients, processes, storage, and transportation. Mixing of batches can occur between resource units, which may cause problems in identifying individual batches. Each firm must develop a system of assigning new TRUs during processing, distribution, and retail.

Compatibility is the 1st component in a successful tracing system; it must be possible to trace products from 1 entity to another. This requires that all entities within the chain are able to communicate and transmit data efficiently. Having the ability to transmit and receive data does not, in itself, ensure traceability, it only provides a means. Rapid advances in information technology (IT) and increased compatibility between available operating systems have provided the necessary tools to improve knowledge-based vertical integration. Standardized data transmission protocols and new computer applications are available with the ability to upload and download data between different operating systems and databases. Once compatibility has been established, data requirements must be identified and standards implemented. For traceability to work on a national or international level, standard data transmission protocols must be established. Without industry standards, close-knit supply chains may be able to integrate knowledge-based operations, but more diverse and extensive food chains may find it difficult to implement traceability without carefully selected set of cost-effective minimum standards (Wagner and Glassheim 2002). Standardization of data requires identifying which parameters during handling, processing, and storage are important in preserving the identity of the product and its quality attributes. Once these parameters have been determined, standardized data formats are established at each step within the chain. Standardizing the content and quantity of information to be transmitted alleviates problems that may arise due to inconsistencies in data-transmission protocols. The desired degree of detailed information will invariably change according to the purpose and entity (Moe 1998). Some firms may require more information than others. If an entity is conducting business with several firms, each with different data requirements, this can ultimately lead to considerable confusion and inefficiencies. In addition to data requirements within a sector, requirements will differ between sectors of the industry; processors will require information that may differ in content and quantity from that required by retailers. Another complex factor is the addition of new product information that occurs as the product moves through the food chain. Products may undergo additional handling and processes, including transformation, value addition, packaging, transport, and storage. Hernandez (2001) conducted a study of quality management and traceability in a fish-processing facility and concluded that the key to complete traceability lies in the ability to follow products accurately through both mixing and transformation. The amount of information that becomes available for a given product may be significant. When one multiplies this information by the quantity of products produced daily, it becomes easy to understand how traceability systems may become too expansive, complex, and inefficient. For this reason, it is vital that any chain traceability system set minimum data requirements to constrain the number of variables that must be recorded for transmission to the next entity to only those critically necessary for identification, quality, and safety purposes. Supplementary information may also be collected at any step within the food chain to provide data for analysis and optimization of production practices. In addition, it is necessary to establish limits on the length of time this information must be available to the food chain, government, or consumers.

In an attempt to address these complex issues, the European Commission funded a program from 2000 to 2002 entitled "Traceability of Fish Products," or TraceFish, a consortium made up of 24 companies and institutes including representatives from exporters, processors, importers, and research institutes (www.Tracefish.org). The goal of TraceFish was to identify informational requirements for chain traceability and formulate voluntary industry standards for the electronic collection and dissemination of traceability data. This program led to the development of standards for both captured fish and farmed fish chains as well as establishing standards for data transmission protocols. In their report they attempted to identify all variables that can be recorded at each step and divided these into 3 categories: information that "shall be recorded" (required), information that "should be recorded" (preferred), and information that "may be recorded" (optional). These voluntary standards may form the basis for Europe's 2005 mandatory traceability requirements and have recently been adopted by the European Committee for Standardization (CEN 2002), an organization designed to promote voluntary technical harmonization within Europe. Despite the development of these standards, a complete system for the collection and transmission of traceability data, including software to meet these standards, was not created by the TraceFish consortium. However, a traceability system has already been developed for the Danish fresh fish chain (Frederiksen and others 2002), which was in development before the TraceFish project. This research focused on all aspects of the fresh fish chain by using bar codes and serial shipping container codes to identify each resource unit and track each delivery. This research was successful in showing that traceability could be achieved and recognized the fact that system costs for vessels and small firms need to be addressed and more friendly user interfaces must be developed to promote efficiency. In addition, trials on traceability systems are currently being conducted in Japan (Hashimoto and others 2003) and the Shetland Islands in Scotland, which are moving toward chain traceability by installing systems on 10 vessels as part of Seafood Scotland project (MacDubhghaill 2000).

Once the required information is defined for each link of the chain, a decision must be made on how this information will be transmitted and archived. The system must be developed to ensure that each individual in the chain receives the data they require. If additional data are required by an entity further down the chain, it must be determined if the information is transferred through the previous entity or is acquired from the source. The amount of information can be enormous, especially as one travels further along the food chain, where companies may have hundreds of different vendors. For transparency, this information should be stored in databases that are easily accessible by entities within the food chain, including additional information desired by consumers and required by governmental organizations. These databases, owned by the producers of the information, must be designed to allow access, possibly by passwords, to those who have a right to the information. This method may be the most desirable for those firms that want to have more control over who has access to their information but may also become extremely difficult to manage.

Another option is the use of a centralized database in which all the traceability information is stored and disseminated. Access would need to be controlled if any propriety information is stored on the database; however, this would allow firms to query information that they desire without receiving unnecessary information. This would help to streamline the system; removing some of the responsibility firms would otherwise have if required to transmit data from a previous source forward. One serious concern is system cost. Individual databases would require each firm to design and maintain their own resources. In addition to suitable computer hardware and software, each firm would need to develop its own accessible Web sites for data dissemination. A centralized system would require that firms send relevant traceability documentation, when it becomes available, to the central database. This information would be available through a single Web site and would provide simplified access to information. The major problem facing the implementation of a central system is deciding who will pay for the design, development, and maintenance of the system. Each system will need to be designed to take into consideration the quantity and content of the information as well as the accessibility of the system. Access must be controlled yet provide for the needs of the consumers. The system itself must be easy to use and navigate, and computer or database problems cannot hamper the day-to-day operations of the industry.

Once each entity defines its resource units, it must decide on an appropriate labeling scheme. Most food manufacturers and retailers around the world already use Universal Product Code (UPC) labels to identify their products. UPC labels are recognized internationally and are based on standards set by the Uniform Code Council (UCC) of the U.S. and European Article Numbering (EAN) system. EAN-UCC labels come in a variety of configurations, depending on the informational needs of the firm. One-dimensional UPC labels are limited in the amount of information that they can carry (up to 50 bytes), but are the most widely used UPC labels. They generally contain information that identifies only the entity and the product type; however, there are a variety of 1-dimensional labels that can be used to provide more information, including a unique product identification number. Two-dimensional UPC labels are also available and are able to hold significantly more information (up to 3000 bytes). Both 1-dimensional and 2-dimensional labels have the ability to pass on limited traceability information, but this information is only accessible by manually scanning the label with a bar code reader. Bar codes can present some difficulty when attempting to read UPC labels in cold and wet environments, which are common in the seafood industry.

New technology is becoming available that may eventually make paper bar code labels and manual scanning obsolete. Radio Frequency Identification (RFID) tags are becoming more widely accepted. RFID tags have the ability to hold much data, up to several megabytes, and can be custom tailored to suit individual needs including time and temperature readings and tracking of product movement. These tags come in 2 types: passive and active. Passive tags do not contain their own power source and are dependant on a signal from a RFID reader to start downloading their information. Active tags come equipped with their own supply of power and actively send out radio signals that are received by RFID readers as they move into range, automatically downloading their information without the need to wait for a signal. RFID tags are more expensive than UPC labels but have several additional features that make them appealing. They do not require manual scanning, and hundreds of RFID tags can downloaded into a computer at 1 time. One potential liability is that humans cannot read RFID tags without the use of machines, making the reliability of an RFID system of utmost importance. The ability to read numerous tags at once will save considerable time and manhours as well as decreasing the number of errors that can occur with manual systems. RFID tags are currently being used in the Natl. Livestock Identification Scheme of Australia to track cattle and other livestock and are also becoming more widely used in the E.U. meat industry. One factor complicating the use of RFID technology is compatibility since they are available in 4 different frequencies and there is no standardization. This discrepancy is currently being addressed by the UCC-EAN partnership, which is in the process of developing an international standard for RFID technology called the Electronic Product Code (EPC) (Information on EPC's can be found at epcglobalinc.com). RFID tags can be reused, which can reduce overall costs. They can be attached to a box of products, track those products until they are removed from the container, and once the container is returned, the tag can be reprogrammed and reused.

Software Solutions

As traceability gains momentum throughout the global food chain, it has created economic incentive for computer software designers to develop software capable of tracking seafood from "fish to dish." Advances in IT have made knowledge management and data transfer affordable, reliable, and efficient. Coupled with rapid advances in data capture devices and secure data transmission, traceability is attainable, not only for large firms, but also for small and mid-size enterprises. One major problem confronting traceability in the seafood industry is not technology related, but rather the heterogeneous nature of the fishing industry. Traceability within a major corporation that encompasses all aspects of the supply chain, from the fisher through processing and transportation, can achieve traceability by incorporating Enterprise Resource Planning (ERP). ERP involves the integration of all functions of each department of a company into a single computer system and program. It requires that the needs of each department, from finance to processing, be incorporated into a single database, making information sharing and communication seamless, which enhances the ability of the company to achieve internal and chain traceability. ERP solutions are available for both small and large companies but require that each system use the same software package. This may be impossible, however, for many small businesses operating with a myriad assortment of hardware and software systems, which complicates vertical integration and makes true ERP solutions more difficult.

The problem of data transmission between different operating systems and programs has led to the development of protocols and programs to facilitate communication. Electronic Data Interchange (EDI) allows computers to exchange information in a standardized format facilitating communication between entities. The exchange of data through EDI formats may require some manipulation for individual uses but has become a growing application for data transfer and e-commerce. Data exchange can also be accomplished by use of programs capable of Open DataBase Connectivity (ODBC). ODBC applications are designed to make it possible to access data from any application, regardless of which database management system (DBMS) is operating. OBDC is an open standard application programming interface (API) that is based on standard Structured Query Language (SQL) and can be used to access files in a number of different database formats including Access, Excel, dBase, Lotus, Oracle, FoxPro, SQL servers, and Text. ODBC is accomplished through the use of ODBC driver, which is capable of translating data queries received from a sending application into SQL requests that are converted by the receiving system into requests recognized by its DBMS. Both the sending and receiving systems must have programs that are ODBC compliant and are equipped with an ODBC driver. ODBC versions also exist for UNIX, OS/2, and Macintosh platforms.

Rapid advances in IT and database connectivity has made it possible to vertically integrate the knowledge-based operations of various entities involved in the seafood industry. A large majority of small businesses use Microsoft Windows operating systems and many of the programs, which advertise complete traceability, have been designed to operate in a Windows environment. Many software packages designed for traceability offer companies, both small and large, management tools to integrate their business operations. Modular options and different levels of customization allow small businesses the ability to design systems for their specific management needs while offering larger firms the ability to design completely integrated ERP solutions. Incorporating purchasing, sales, accounts receivable, accounts payable, general ledger, and inventory control into a single accessible database offers businesses both flexibility and control. ERP solutions for the seafood industry also have the ability to integrate with electronic data capture devices (including handheld computers), various devices including bar-code scanners and printers, RFID devices, electronic scales, fish grading devices, and data loggers for time and temperature control. Scanvaegt International A/S, Aarhus, Denmark and and Marel, Gardabaer, Iceland, manufacturers of fish-processing machinery, have recently incorporated traceability software that seamlessly integrates their line of processing equipment offering turnkey solutions to seafood processors wanting to provide traceability.

ERP software is primarily designed to track products in lots or sub-lots through food processing including tracking of additional ingredients, portioning, and transformation. However, the recent push for traceability and subsequent legislation have made several software suppliers to the fishing industry including Wisefish and C-trace, incorporate traceability into vessel software, which either integrates with their land-based solutions or with ODBC compatible systems, allowing the exporting and importing of data between the various ODBC spreadsheet formats. Immediately after harvest, data can be transmitted from the vessel to shore-based processors and buyers. This integration allows for traceability requirements to be met from catch through processing. Using ODBC capabilities makes traceability possible without the advantage of using the same software. These features will help to simplify integration; however, additional steps may be needed to ensure seamless data transfer and incorporation of this data into inventory modules and customer accessible databases.

Summary

It is clear that traceability will have an impact on the U.S. seafood industry. Governments around the globe are preparing or enacting legislation requiring seafood traceability. The reason for this seems clear: traceability is a policy designed to increase consumer confidence in the food supply. This decline in consumer confidence can mainly be attributed to global food safety issues, including the BSE crisis and bio-terrorism and recent concerns about mercury in seafood. These safety and liability concerns will encourage the development of effective traceability systems with time and temperature monitoring to ensure that quality parameters are maintained (Merlmelstein 2002). The potential benefits of traceability on the seafood industry will depend on the design and development of cost-effective IT-based traceability systems, the willingness of consumers to pay for greater access to information about the origin and history of their seafood purchases, the capacity for traceability to improve efficiencies in supply-chain management, and the ability of these systems to provide brand recognition and protection.

A well-designed traceability system may benefit many in the seafood industry. Dickinson and Bailey (2002) suggest that traceability could become a valued public good, especially for food safety. Companies that have accredited and verifiable traceability systems may be able to command favorable premiums from their insurance providers by reducing liability in foodborne illness cases (Gledhill 2002). By preserving the identity of favorable attributes throughout the entire food chain, seafood producers can provide quality assurance securing the firm's reputation (Unnevehr and others 1999) and create value if the information is used to provide assurances to consumers for which they are willing to pay (Bailey and others 2002). Traceability may also provide information to the consumers about the sustainability of the resource and whether it is harvested in accordance with national and international management. These types of consumer concerns, which are not related to food safety, are becoming more important in domestic and global seafood markets.

American companies that export seafood to the European community will have to implement traceability systems that meet E.U. requirements by the y 2005. The U.S. government seems unlikely to implement mandatory traceability requirements for the U.S. seafood industry. It is apparent, however, that traceability is gaining ground internationally as a food safety issue. This makes it important that industry stays abreast of the current developments and takes a proactive stance in the design and development of traceability systems that can meet the requirements of importers. The costs associated with these systems have not yet been determined. In the absence of mandatory traceability and in the case of seafood producers that do not export, the implementation of traceability systems will depend on the needs of the individual firm and the benefits that may be gained relative to potentially significant costs.

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