

Study No. 3

**Market Outlook in the
International Fish & Seafood Sector**

**Alternative Products/Uses and Food
Safety Issues**

by
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FOREWORD

This study is one of seven background studies commissioned or prepared by the federal Office of the Commissioner for Aquaculture Development (OCAD) as part of its review of the federal role in aquaculture.

In order to provide a report on the federal role for the Minister of Fisheries and Oceans, the Office of the Commissioner has undertaken a series of background studies pertaining to aquaculture. The studies are:

- Study 1 :** Current Status and Potential of the Canadian Aquaculture Industry: a review of the context in which the Canadian aquaculture industry is evolving today, and an assessment of its potential for future growth;
- Study 2 :** International Fish and Seafood Markets: a Canadian perspective: a review of general trends in international fisheries products markets (commercial fisheries and aquaculture) in light of major markets targeted by Canadian aquaculture products;
- Study 3 :** Market Outlook in the International Fish and Seafood Sector: Alternative Products/Uses and Food Safety Issues: a review of general trends affecting the value-added of fisheries products, new uses for products derived from aquaculture and commercial fisheries (pharmaceutical products, nutraceuticals, etc.), and issues affecting food safety, especially in terms of consumer behaviour and regulatory changes affecting international trade;
- Study 4 :** Review of Provincial and Territorial Program and Services in the Aquaculture Sector: a review and analysis of all programs and services provided to the Canadian aquaculture sector by provincial government ministries/departments and agencies;
- Study 5 :** Review of Federal Programs/Initiatives in support of Aquaculture: a review and analysis of all programs and services provided to the Canadian aquaculture sector by various federal government departments and agencies;
- Study 6 :** Federal Programs and Services for Five Resource-Based Industries: a comparative analysis of how the aquaculture sector is treated by the Canadian government, in comparison with four other primary sectors : agriculture, forestry, commercial fisheries and biotechnology;
- Study 7 :** The International Context for Aquaculture Development: Growth in Production and Demand and Long-Term Outlook: a review and comparative analysis of the international context and resulting major trends that will affect the development of aquaculture at the global, national and regional levels; includes an overview of policies, governance structures, programs and services in place in various countries to provide a framework and support for industry, and to foster smooth development of aquaculture; and, the lessons for Canada.

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1. Alternative Fish & Seafood Products and Uses

With many fish species yielding edible weight of 40 percent or less the maximization of profit from both the edible and inedible portions can often mean the difference between profit and loss. Optimization of market value through further processing (value addition) and the identification of by-products from fish and shellfish “waste” are critical to the economics of efficient seafood operations. In addition, disposal of processing waste has become a high cost of business and, in some cases, a source of pollution and health risk.

1.1 Value Added Seafoods

Adding value to seafood products has been the “holy grail” for seafood producers over the past decade. However, a review of successes and failures in value added would indicate that most attempts at added value wind up being added cost and ultimately fail in the marketplace.

True value added is usually some combination of product and packaging that reduces labor at the end user level through easier handling and greater convenience in preparation. The best example in recent years of true value added in perishables has occurred not in seafood but produce where pre-packaged cut salads have grown into a \$1.3 billion category within a decade. This product is branded, saves labor (no cutting and shredding) and utilizes new packaging technology (breathable bags). The cost per pound for packaged salads is easily two or three times that of uncut, unpackaged lettuce but the consumer has demonstrated a willingness to pay for convenience.

1.1.1 Fish Fillets

Historically, fish has moved through the U.S. value chain in whole eviscerated or headed and eviscerated (often referred to as headed and gutted or “H&G”) form. This product form was most practical when fish was shipped frozen or on ice via truck or rail. In addition, labor costs at point of sale, either foodservice or retail, were such that the fish could be cut into portions (steaks and fillets) cost effectively.

Advances in seafood shipping and packaging, as well as changing labor costs and end use operations have now made it imperative that much of the processing be done at point of origin and not point of sale. This “value added” is in effect labor reduction which in turn lowers the overall product cost. For example, hand filleting of salmon in

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Chile costs approximately U.S. \$1.50 per hour versus union scale rates in supermarkets of \$15.00 and up. Additional savings are made when shipping long distances either fresh via air or frozen via refrigerated container. By shipping fillets only the per pound product cost is reduced versus shipping headed and gutted product which must be converted to fillets at some point in the value chain.

Market Overview

The U.S. seafood market has moved rapidly toward a preference for filleted fish. The best example may be the rapid shift in Chilean salmon product form from H&G to fillet form. In 1995 the United States imported approximately 154 million pounds (70,000 metric tons) of salmon (round weight equivalent). Of this total, fillets accounted for 27 percent of the total. By 2001 salmon fillet imports had soared to 621 million pounds (282,000 metric tons) and fillets accounted for 69 percent of the total.

Other examples of the strong market penetration of filleted fish, particularly in the aquaculture sector, include farmed U.S. catfish and imported tilapia. In the case of catfish, for 2001 of the 296 million pounds (134,000 tons) of product sold, 13 percent was marketed fresh whole, 22 percent as fresh fillets and 39 percent as frozen fillets.

For 2001, the U.S. imported 22.6 million pounds (10,000 tons) of fresh tilapia fillets and 16.3 million pounds (7,400 tons) of frozen fillets.

Market Outlook

Market demand as well as technology will further the fillet trend in the U.S. seafood market. Consolidation within the beef packing industry is accelerating the move toward “case ready” beef that has been centrally processed and packaged. As supermarkets eliminate high labor butchers in their meat departments it is likely that fully-staffed service seafood departments will be phased out as well. In addition, advances in perishables packaging and preservation, including modified atmosphere packaging, irradiation and other innovations will dictate the need for filleted product.

1.1.2 Other Value Added Seafood Trends

There have been a variety of attempts at other forms of “value added” within the U.S. seafood industry, often these efforts wind up as “cost added.” The only other major trend in value added that is market driven is in cooked shrimp. In addition to shifting the labor component from end use markets to primary or secondary processors, cooked shrimp benefits from the U.S. consumer trend toward easier and faster food preparation.

Of interest to Canadian producers are some innovations in shellfish packaging and processing including high-pressure processing and pasteurization of oysters, frozen “half-shell” mussels and oysters and retort pouched mussels are other value added innovations finding market acceptance. HPP oyster processing reduces shucking costs and appears to provide some extension of shelf-life.¹

¹ Journal of Food Science, vol. 67, No 2, 2002.

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Supermarket sales of branded seafood products now exceed \$1.2 billion² and is growing faster than the market as a whole. Among the most popular new items are frozen seafood “bowls” containing shrimp and pasta, frozen fish and crab cakes and seafood-based soups.

Reasons Value Added Seafoods Fail

Most value added seafood products fail for reasons associated with marketing. The producer fails to understand the size of the market, the appropriate market segment or consumer preferences.

With millions of pounds of salmon now being produced, both from capture fisheries and aquaculture, there has been a strong imperative to develop new products. Still, with millions of dollars invested in the attempt few products with marketing “legs” have been developed. A number of salmon-based products were attempted using a “low fat” niche, including salmon sausage, salmon hot dogs, salmon burgers, salmon ham, etc. However, most of these products failed because the low fat niche had been successful filled by turkey-based products which cost less to produce than salmon-based products.

Frozen value added seafoods have been difficult to launch for a number of reasons. Producers who have developed one or two products strictly for the club stores (i.e. Costco) have found the margins to be extremely slim and the club store requirements for exclusive packaging designs an expensive cost of entry. In addition, companies that rely solely on a single market (such as club stores) are at the mercy of that market. Successful producers find that club store business provides high volume sales with minimal contribution to profit but can be part of a diverse marketing strategy where other business provides less volume but greater margins.

Most seafood producers have found it difficult to compete in the frozen seafood category at retail. Most major supermarkets require costly slotting fees before they will accept a frozen product and in most cases these new products are placed in the frozen foods section along-side the frozen fish sticks and breaded shrimp. Consumers looking for upscale frozen value added products generally do not go to the frozen foods section but rather the seafood department.

1.2 Alternative Fish & Seafood Products Market

As world fishery resources become even more finite and population continues to increase, it will become an imperative to recover all potential nutrient constituents

² Source: Information Resources Inc.

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from fishing and aquaculture operations. This recovery will include fishery by-catch as well as processing waste.

The wastes generated by commercial fish and shellfish production and processing represent both a problem and an opportunity. In the past disposal of this waste has been costly and, in many cases, detrimental to the environment. Commercial fisheries have also contributed to the problem through by-catch that in the past was simply tossed overboard but now must be utilized in some fashion.

Technical advances and market developments now make it possible to not only process this waste stream into useful and marketable products, but also make contribution to the bottom line. These alternative markets are as diverse as cosmetics and fertilizer but all result from the efficient recovery of proteins and biological constituents from fish and shellfish waste.

There are a number of processing technologies in use for converting fish and shellfish waste into marketable products. Some of these processes involve grinding and cooking of raw fish and offal, drying of raw material or the hydrolysis of fish protein through some form of enzymatic action. Output from these processes fall into a number of market categories including pharmaceuticals and nutraceuticals, industrial compounds, food products (oils, gelatins, flavors and extracts), feeds and fertilizers.

The market for many of these products is well known while other markets are not clearly defined in terms of size and value. In some cases the economics of these processes and markets are not documented. Currently a number of companies in the United States, Canada, Europe and Asia are involved in converting fish and shellfish waste into marketable products.

1.2.1 Alternative Products Processing Technologies³

Silage/Composting

Composting⁴

There's nothing worse than a pile of dead fish. Except maybe a pile of the leftover parts of dead fish – heads, tails, internal organs and all that. Disposing of this waste is a problem for anyone who cleans and processes fish, from big commercial food processors to small sport-fishing operations.

A promising solution, according to a Cornell professor, is composting, just like the process home gardeners use to make their own soil enhancer. "Large-scale industrial composting is more difficult, but it still may be the simplest and cheapest waste-stabilizing technology available to the processor," says Joe Regenstein, a Cornell

³ Much of the information on alternative processing technologies and products is highly technical in nature. The information provided in this report has been compiled from public sources and is meant to provide a general discussion of these processes and products.

⁴ Source: National Fisheries Institute web site for members only.

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professor of food science who teaches courses in food waste management and food law.

Fish-waste composting is a little trickier than the backyard variety, Regenstein admits. So he and Susan Goldhor, director of the Center for Applied Regional Studies, a New England environmental organization, are producing an instructional videotape explaining the technique, based in large part on their research in developing and demonstrating simple small systems. The project is sponsored by the National Fisheries Institute, which will distribute the tape to fish processors nationwide.

“The tape is for everybody who handles fish, “ Regenstein says. “It will show how to actually construct a composting pile on different scales, for the medium-sized producer or small producer.” That means all the way down to a “garbage-can-sized” operation that could be used by a small fish farmer, he explains. Regenstein, who is vice-chairman of the Cornell Aquaculture Program, has been researching small-scale composting methods with funding from the National Sea Grant Institute.

In composting, garbage such as fish parts is mixed with plant waste such as sawdust, peat, wood chips, leaves, branches or bark. Microorganisms in the pile feed on the waste and over a period of several months convert it into a rich humus. In the process, the microorganisms generate a great deal of heat which pasteurizes the product, eliminating odor and destroying weed seeds and disease organisms.

The resultant product usually is sold as soil amendment or soil enhancer, Goldhor says. “Composting is no more difficult than brewing beer or baking bread, two other processes that take advantage of a different kind of microorganism,” she adds. “Anyone can do it, but as with brewing or baking, no one should expect a perfect process or a saleable product the first time around.”

Until recently it was common practice to dump fish waste back into the lake or ocean. The trouble was, dumping it all in one place could overload the ecosystem, so such dumping has been banned. That left New England fish processing plants, for example, with a quarter million pounds of waste a week on their hands. Some have found other markets, grinding up the waste to make cat food or converting it to liquid fertilizer by a process called hydrolysis, but much of it is still going into landfills. There are, so far, only two or three large-scale fish composting operations, Regenstein says.

Many small processors have started to use composting, however. For example, some small sport-fishing operations on Lake Ontario are using technology demonstrated by Regenstein and Goldhor in conjunction with the New York Sea Grant Institute Marine Advisory Service to compost the waste from fish cleaned by their customers in lakeside piles. When the customers come back a year later they can take the composted product home to fertilize their gardens.

Silage⁵

Fish silage is produced by acidification of fish waste using organic acids such as formic acid which is added at a rate of about 3.5% (w/w) or mineral acids such as sulfuric which is added at slightly lower levels. A third method sometimes used in tropical climates involves the addition of simple sugars such as molasses and a lactic acid bacterial culture which generates lactic acid through the natural breakdown of the sugar. The use of acid is necessary to inhibit spoilage bacteria, which could produce off odours, flavours such as trimethylamine or ammonia and/or toxins such as histamine if left to ferment at neutral pH. An excellent review of the technology of silage manufacture was presented by Raa and Gildberg (1982).

Fish and shrimp silage is highly nutritious and is traditionally fed as a protein supplement to swine, mink and poultry. It consists of autolyzed fish offal and is normally manufactured by the addition of fresh fish viscera which contain the necessary enzymes for autolytic breakdown. The liquefied product has a pleasant “malty” odour and is often blended with dry feed ingredients to form a semi-moist diet.

Silage has also been used successfully as a low cost ingredient in aquaculture diets (Lall, 1991; Espe *et al.*, 1992). In fact, shrimp silage has been used as a source of pigment as well as nutrition for farmed salmon (Guillou *et al.*, 1995). Fermented fish silage produced by the addition of lactic acid bacteria and a carbohydrate source has been produced from offal from tilapia (Fagbenro and Jauncey, 1993; Fagbenro *et al.*, 1994; and Fagbenro and Jauncey, 1995), shrimp (Sachindra *et al.*, 1994) and salmon (Dong *et al.*, 1993) and subsequently used in aquaculture diets. One advantage of this process over the traditional organic acid processes is that there is a substantial saving in operating costs provided an inexpensive source of carbohydrate such as molasses. Another potential advantage of using silage rather than meal in aquaculture diets is the fact that most of the silage processes used to date (with a few notable exceptions) do not involve heat denaturation of the proteins. One exception is a Norwegian process in which silage is produced in the traditional manner and subsequently transported to a thermal processing facility where the silage is heated in a two-stage process to eliminate pathogen transfer.

Another exception is the mixing of silage with other dry feed ingredients and then processing by thermoplastic extrusion to produce feed pellets which are heated under pressure and then expand when exiting the extruder producing air voids and thus a lower density. This latter process also results in the evaporation of water which is a requirement for product stability since silage normally contains 65-80% moisture before mixing with dry ingredients (Jangaard, 1991).

⁵ Waste from processing aquatic animals and animal products: implications on aquatic animal pathogen transfer. FAO Fisheries Circular. No. 956. Rome, FAO. 2000. 26p.

Reduction

Reduction is the process used to convert raw material, such as fish, into fish meal, fish oil and fish solubles. The process generally involves high temperature steam injection and is used in large volume fisheries such as menhaden and anchovies.

The bulk of the world's fish meal and oil is today manufactured by the wet pressing method. The main steps of the process are cooking for coagulation of the protein thereby liberating bound water and oil, separation by pressing of the coagulate yielding a solid phase (presscake) containing 60-80% of the oil-free dry matter (protein, bones) and oil, and a liquid phase (press liquor) containing water and the rest of the solids (oil, dissolved and suspended protein, vitamins and minerals). The main part of the sludge in the press liquor is removed by centrifugation in a decanter and the oil is subsequently removed by centrifuge. The stickwater is concentrated in multi-effect evaporators and the concentrate is thoroughly mixed with the presscake, which is then dehydrated usually by two-stage drying. The dried material is milled and stored in bags or in bulk. The oil is stored in tanks.

Hydrolysis

The process of hydrolysis, which produces fish hydrolysates, is relatively new and appears to be more effective in producing marketable end products.

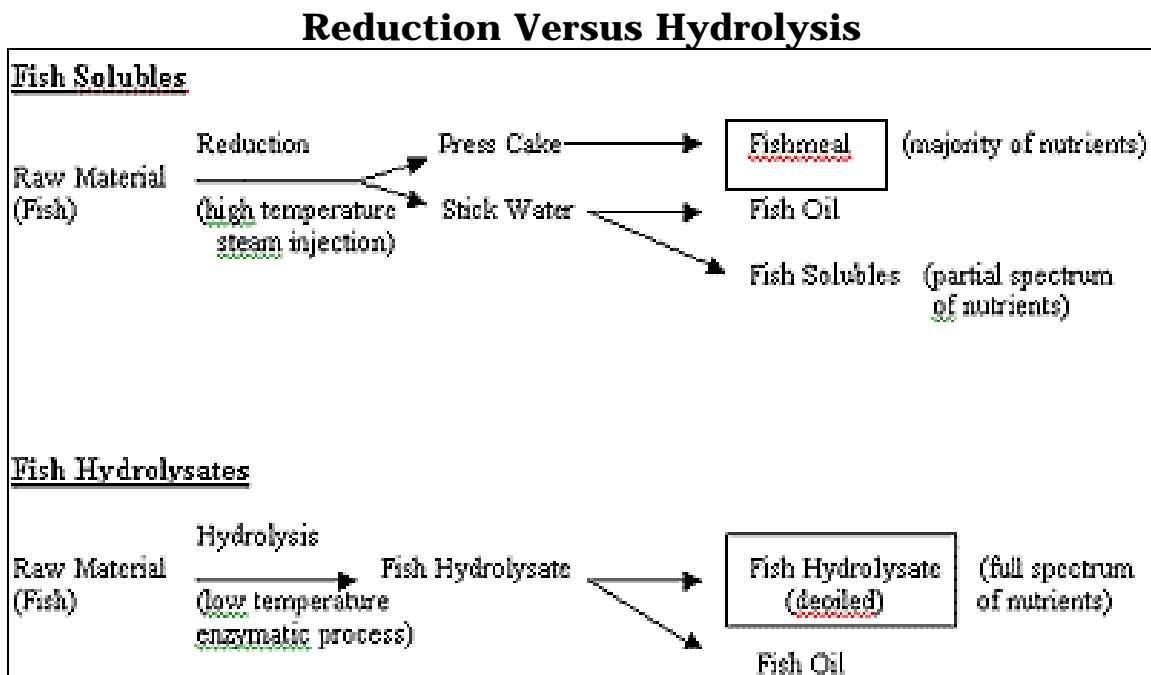


Figure 1. Source: Ocean Biosource

The process of converting fish-based raw material into liquified fish products through hydrolysis has been well understood for years. Fish hydrolysates are partial digests of fish protein resulting from proteolytic hydrolysis of whole fish or seafood processing

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by-products. Asian fish sauces are a fish hydrolysate produced by fermentation of highly salted fish. The purpose of the salt is to prevent spoilage.

Fish hydrolysates are made from fresh whole fish and/or fish processing by-products that are ground and permitted to partially hydrolyze. The resulting liquid is then de-oiled by centrifugation and concentrated by evaporation. The hydrolysate is then stabilized using antioxidants and acids.

What makes the fish protein hydrolysate opportunity timely is the coming need for new fish feed sources as, according to FAO, current anchovy and sardine stocks are diverted to human consumption. In addition, fishery management regulations, particularly in large fisheries such as the North Pacific, now mandate full retention of by-catch.

There are several companies and organizations pushing hydrolysate technology. One, Ocean Biosource, Inc., a privately held company in Vancouver, B.C. was established in 1999. The company states that they “utilize proprietary bioprocessing methods (i.e., natural biological processes) to convert global seafood-processing wastes and fishing by-catch into aquafeed ingredients primarily for the global shrimp markets, fish fertilizers for the organic fertilizer markets and animal feed ingredients targeting the North American hog markets.” The company also states they intend to develop value added products for the nutraceutical and pharmaceutical markets. Ocean Biosource sees a range of products and markets coming from their process. The products and markets include the following:

Table 1. By-Product Products and Applications

Industry	Product	Application
Aquafeed	Fish Hydrolysates	Feed Additives
Animal Feed	Co-dried Products	Flavorants and Attractants
Pet Food	Fish Hydrolysates Fish Oils Natural Pigments	Protein Supplements and Flavorants Fish Oils Antioxidants and Pigment Enhancement
Organic Food Industry	Fish Fertilizers	Plant Nutrition
Nutraceuticals	Fish Oils Peptides Chitin Chondroitin Sulphate	Health Promotion
Industrial Compounds	Chitin Gelatin Enzymes	Paper Making Cheese Processing Water Purification
Human Food	Fish Oils Gelatin Seafood Derivatives	Health Foods Kosher and Halal Gelatin Flavorants and Thickeners
Pharmaceuticals	Specialty Products	Drug Delivery Anticoagulants Arthritis, Cancer and Other Treatments Photoelectric Applications Biotechnology

Source: Ocean Biosource

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Other operations using similar enzymatic processes include the Oregon State University Seafood Laboratory at Astoria, Oregon working with a company called Protein Recovery, Inc. (Warrenton, Oregon) and Bio-Oregon Fish Feeds. A French company, Cooperative de Traitement des Produits de la Peche (CTPP) was founded in 1960 by an alliance of fishing industry businesses in Cedex, France to add value to industry by-products. CTPP, which was initially a fish meal producer, now specializes in “marine molecule extraction.” To produce:

- Proteins in the form of meal with an excellent amino acid profile that promotes animal growth.
- Highly digestible enzymatic protein hydrolysates promoting assimilation and nutritional efficiency.
- Peptides, polysaccharids for cosmetics, diet foods and flavorings.

Chitosan Manufacturing

Chitosan has been receiving considerable attention as a natural diet additive. It absorbs fat and oil, so it is deemed to be good at reducing cholesterol levels and helping a person to control weight. It is also used commercially in such products as swimming pool cleaners.

Chitosan is found in the exoskeleton of insects and crustaceans. The commercial product is made from shrimp and crab shells.

Chitosan is produced from shrimp waste by a multistage process. First the salt is washed out and the material is shredded. Then the protein, which makes up 30% of the waste, is removed in a hot bath. The calcium, 50%, is removed with acid. After caustic neutralizing the remaining material, chitin, is first pressed and then dried in a rotary drum dryer. Another process is used to convert the chitin into chitosan. This process, too, involves pressing water from the material and then drying it.

1.2.2 Alternative Products/Markets

Products derived from by-product recovery cover a broad range of industrial and consumer applications. In some cases the markets for these products are well-established and defined, in other cases market applications are just now being identified.

According to the U.S. National Marine Fisheries Service the wholesale market for oyster shell products, together with agar-agar, animal feeds (but not meal and oil), crab and clam shells processed for food serving, fish pellets, Irish moss extracts, kelp products, dry and liquid fertilizers, pearl essence and mussel shell buttons was valued at U.S. \$82.3 million in 2000.

1.2.2.1 Pharmaceuticals and Nutraceuticals

Marine Oils

In the United States nutraceuticals are marketed under the Dietary Supplement and Health Education Act of 1994. Consequently, scientific data supporting claimed benefits is not always available as they are for traditional pharmaceuticals.

Fish oils are an important component of both pharmaceuticals and nutraceuticals. Other fish and shellfish-derived ingredients are also being utilized as new benefits are identified.

Pharmaceutical applications for marine products generally focus on the use of fish oils in capsule form for the reduction of serum cholesterol or other cardiovascular benefits. This use differs from nutraceutical applications in that the oil is not considered a food ingredient.



A nutraceutical is any substance that may be considered a food or part of a food and provides medical or health benefits, including the prevention and treatment of disease.⁶ Products include isolated nutrients, dietary supplements, genetically engineered “designer” foods, herbal products and processed foods such as cereals, soups and beverages. According to the Foundation for Innovation in Medicine, the nutraceutical market includes potential nutraceuticals and established nutraceuticals. A potential nutraceutical is one that holds a promise of health or medical benefit but lacks sufficient clinical data which demonstrates such a benefit. An established nutraceutical is one that has been demonstrated through clinical research to provide the benefits described.

Fish oils are an important component in nutraceuticals. Omega-3 fatty acids, found in fish and fish oils have been demonstrated to be beneficial in cholesterol reduction, cardiovascular health and potentially beneficial in such areas as attention deficit disorder (ADD). Research is ongoing regarding nutraceutical oils for high-risk candidates for cancer or cardiovascular or hypertensive problems and other disorders such as dyslexia, arteriosclerosis, childhood asthma and brain and retinal development. These oils may be encapsulated so that they disperse readily in the aqueous component of a variety of foods. A program at the University of Wisconsin Sea Grant is investigating the combination of omega-3 fatty acids into value added food products.

Considerable research is being conducted on the beneficial effects of marine oils. In Australia the Fisheries Research and Development Corporation is assisting industry develop new marine oil based value-added products from existing or new fisheries including the by-catch and waste generated by fishing and related industries. Activities include:

⁶ The definition is from the Foundation for Innovation in Medicine (FIM) which also claims to have coined the term nutraceutical.

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- Evaluation of new deep-sea and other shark species for squalene content and oil composition.
- Determination of the composition of marine oils from underexploited pelagic and other species with particular reference to identifying optimum sources of omega-3 polyunsaturated fatty acids and other specialty oils (e.g. diacylglycerol ethers from deep-sea and other sharks)

The Australian researchers have found that marine oils had application as lubricants, in degreaser and hand cleaner products and in cosmetics and nutraceuticals. Orange roughy oil was found to contain wax esters which, when refined, produced high purity products with application as degreasing and hand cleaning products.

In the case of shark livers (which can make up 20 percent of the total shark weight), researchers identified the commercial applications for squalene in nutraceuticals. For omega-3 oils, the Australian research group has been working on techniques to add value. Future market opportunities include enhanced feedstocks, and food additives (in Scandinavia oils are added to bread).

Chitin and Chitosan

Chitin and chitosan are primarily acetylated polymers of glucosamine that have basic (high pH) characteristics. Chitosan is a collective term applied to deacetylated chitins in various stages of deacetylation and depolymerization. Chitan is found in the exoskeletons of a wide variety of animal species including krill and shellfish. On a dry weight basis shellfish, on average, consists of 25 percent chitin with crab and shrimp averaging three to six percent.

In the case of whole clams, 65 percent of the weight consists of shells and in oysters the figure rises to 85 percent.

The applications of chitin and chitosan are extensive and range from food wrapping film to wound healing applications. Glucosamine, a “food supplement” derived from shellfish shells, has been found to be affective in reducing cartilage deterioration and for the relief of osteoarthritis.

In 2001, two licenses were issued in Canada for the processing of shellfish waste into products such as chitin or chitosan. According to the press release prices for chitin and chitosan range from \$10 to \$1,000 per kilogram (depending upon product quality). Some end-use products may sell for as much as \$2,000 to \$3,000 per kilogram.

Market Overview

Market growth in pharmaceuticals and nutraceuticals with marine by-products is strong but difficult to quantify. In Canada consumption of pharmaceuticals amount to CAN\$ 8 billion in 1999 and nutraceuticals an estimated \$ 3.3 billion. One study, by the U.S.-based Fredonia Group estimated the world demand for nutraceutical chemicals would increase ten percent per year to \$11.2 billion in 2004. Of this figure, minerals and nutrients accounted for \$2.99 billion.

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The broader nutraceutical market, including fortified foods, fortified beverages and dietary supplements was forecast to total \$28 billion in the U.S. alone by 2003.⁷ The nutraceutical market is expected to reap benefits from the aging of the baby boomer population. An extensive analysis of world markets for chitin and chitosan is being conducted by Global Industry Analysts, Inc. and will be available for U.S. \$3,850. A table of contents is available at www.the-infoshop.com.

Market Outlook

While marine by-products are not widely used as supplemental ingredients in food products, the opportunity exists to promote the benefits of marine oils incorporated into food and beverages. However, any label claims will require approval of the U. S. Food and Drug Administration. Currently the FDA allows the following claim: "Consumption of omega-3 fatty acids may reduce the risk of coronary heart disease. FDA evaluated the data and determined that, although there is scientific evidence supporting the claim, the evidence is not conclusive." Some marketers, recognizing that many consumers are aware of the benefits of omega-3 fatty acids, simply add, "contains omega-3" on their label. Since no direct benefit is claimed, this appears to be acceptable to FDA.

1.2.2.2. Fish Meal and Oil

Historically most of the world's fish meal has come from the reduction of high volume, low value species such as sardines, anchovies and menhaden. However, as these raw materials shift in availability (due to natural phenomena or demand as human food) companies are looking to other sources of raw material including fisheries by-catch and seafood production waste. In addition, new pollution regulations require companies to deal with their waste streams rather than dumping this material into the marine environment or landfill. The cost of handling this waste stream can be high and converting this material into marketable products is a major trend.

Market Overview

According to the United Nation's Food and Agricultural Organization (FAO), the international trade in fish meal was 4,326,400 metric tons worth U.S.\$1.8 billion. Fish oil (not including fish liver oil) totaled 867,000 tons worth U.S. \$246 million. U.S. production of meal and oil was valued at U.S. \$135.8 million in 2000.

The total volume and value of fish meal and oil is highly dependent upon Peruvian anchovy production which accounts for the bulk of "industrial" fish production. In 1998, as a result of el niño, Peruvian anchovy production fell to 1,729,000 tons before rebounding to 11,276,000 tons in 2000. Other key species used in the production of fish meal and oil include: Atlantic herring and gulf menhaden.

Market Outlook

With aquaculture production expected to increase substantially over the next decade demand for fish meal and fish oil is expected to be strong. According to the International Fish Meal and Oil Manufacturer's Association (IFOMA), fish meal and

⁷ Source: Datamonitor

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fish oil production is likely to remain at current levels but that of raw materials may change as current products such as sardines and anchovies are diverted to human consumption and other sources, such as by-catch and processing waste.

Table 2. Forecast Global Aquaculture Production 2000 and 2010

Species	% on Feed		Feed Conversion		Feed Required '000 Tons	
	2000	2010	2000	2010	2000	2010
Carp	25%	50%	2:1	1.5:1	6,991	27,000
Tilapia	40%	60%	2:1	1.5:1	779	2,106
Shrimp	80%	90%	1.8:1	1.6:1	1,489	2,425
Salmon	100%	100%	1.2:1	0.8:1	1,051	1,255
Marine Fish	60%	80%	1.8:1	1.5:1	923	1,670
Trout	100%	100%	1.3:1	0.8:1	585	586
Catfish	85%	90%	1.6:1	1.4:1	505	761
Milkfish	40%	75%	2:1	1.6:1	303	554
Flatfish	100%	100%	1.2:1	0.9:1	126	585
Eel	80%	90%	2:1	1.2:1	346	284
Total					13,098	37,226

Source: International Fishmeal and Oil Manufacturers Association (IFOMA)

China is currently the largest consumer of fish feed primarily due to the massive amount of carp grown in that country. Tilapia production is also increasing in China. However, the actual percentage of fish meal and fish oil in aquaculture diets varies greatly. For carp the fish meal and oil content is very small while for salmon and trout the content is much higher.

Table 3. Forecast Global Use of Fish Meal and Oil in Aquaculture in 2010

Species	% Fish Meal in Feed		Fish Meal Required '000 T		% Fish Oil in Feed		Fish Oil Required '000 T	
	2000	2010	2000	2010	2000	2010	2000	2010
Carp	5%	2.5%	350	675	1%	0.5%	70	135
Tilapia	7%	3.5%	55	74	1%	0.5%	8	11
Shrimp	25%	20%	372	485	2%	3%	27	73
Salmon	40%	30%	454	377	25%	20%	283	251
Marine Fish	45%	40%	415	668	20%	15%	185	251
Trout	30%	25%	176	147	15%	20%	88	117
Catfish	3%	-	15	-	1%	1%	5	8
Milkfish	12%	5%	36	28	3%	2%	10	11
Flatfish	55%	45%	69	263	10%	12%	13	70
Eel	50%	40%	173	114	5%	10%	17	28
Total			2,115	2,831			708	955

Source: IFOMA

The IFOMA forecasts increases in both fish meal and fish oil demand by 2010 but raises the question of whether there will be sufficient raw material to produce the required feeds. Alternative feeds utilizing fishery by-catch and processing by-products, as well as grain-based feeds, could make up some of this shortfall.

1.2.2.3 Extracts/Flavorings

In 2001, total world food additive sales were estimated to be about U.S.\$20 billion.⁸ The additive market includes flavors, hydrocolloids, flavor enhancers, acidulants, sweeteners, colors, fat replacers, enzymes, preservatives, emulsifiers, vitamins and minerals and antioxidants.

Extracts and flavorings derived from fish products are popular items, particularly in Asian markets. Products include powders extracted from: anchovies, clams, crab, squid, scallops, salmon, cod, shrimp, krill, bonito, oyster, tuna and lobster. Sauce powders and juices are also made from fish products. The process for extracts and flavors involves biotechnical treatments to extract the aromatic components. Extraction and concentration also results in high quality standardized flavors.

Market Overview

Extract and flavor products include seafood powders, seafood extract powders, seafood pastes, seafood flakes, freeze-dried seafoods and seafood oils. Markets for these products are primarily in Europe and Asia.

Market Outlook

Leatherhead Food RA, a U.K. food research company, notes growing demand for natural and organic ingredients and healthful ingredients for functional foods.

In New Zealand a powder has been marketed from Greenshell mussels. The powder is sold as a nutritional supplement beneficial to support joint and connective tissue functions and physical performance for both humans and animals.

It is estimated that the market for seafood-based extracts and flavorings is significant and growing. However, without further research it is impossible to quantify the opportunity for raw material suppliers.

1.2.2.4 Fish Scales and Leathers

Pearl essence are crystals produced from fish scales through a process that removes, collects and purifies the crystals for use in paint pigments, cosmetics and a host of other products where unique luster is important. Soft, cloudy lotions and shampoos often contain pearl essence. Pearl essence pigments are also found in some high-end automotive paints.



Fish skins have been used as a leather substitute for many years and have been made into wallets, shoes and belts. A number of fish species can be utilized as skins including shark, wolffish, salmon, halibut and carp.

⁸ Source: Leatherhead Food RA

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It is difficult to quantify the market for fish scales and/or fish leathers. The leading U.S. buyer of fish scales, Mearl Corporation, is now a part of Engelhard Corporation, a Fortune 500 company that develops, manufactures and markets technology-based performance products and engineered materials for a wide spectrum of industrial customers. Mearl purchases fish scales from the North Atlantic herring fishery and produces pearl essence for paint pigmentation and consumer products. While the markets for these end products are huge (the pearlescent pigment market for automobiles is growing at a rate of 12 percent per year) it is difficult to pin down the value of the raw material (fish scales). A 1999 study by SRI Consulting found that organic pigments had sales of U.S.\$4.3 billion but this included printing ink, paints and coatings.

The market for fish skins is even more elusive. Over the years various companies have gotten into and out of the fish skin end product market including companies in Alaska, Nova Scotia and British Columbia. Many leather manufacturers have moved away from fish skins to more readily available, and cheap, skins from cattle and pigs. Artificial leathers have also taken market share. One company contacted, Pacific Leather in Vancouver, B.C. reports that ten years ago they produced a range of products from salmon skins but due to declining demand now only use salmon skins for custom orders. There are fish hide tanneries in Iceland and a line of products, to include fish skin wallets available through Icelandic craft and goods shops. One company, Iceland Fish Tannery, reportedly uses 50 to 70,000 skins per year supplying tanned skins to upscale fashion houses in Europe.

Market Outlook

New entrants may find it difficult to break into the fish scale market. The only major company known to purchase fish scales in the Eastern United States is closely tied to the sardine industry in Maine. It is likely (although not confirmed) that this business is viable only when it is a part of a high volume secondary processing operation (in this case the production of sardines). In effect the fish scales are produced as a by-product that is sold to a plant that converts the scales into a marketable material (pearl essence). The barriers to entry in this business would seem insurmountable for new players.

1.3 By-Products Market Summary

Realization of by-products market opportunities will require large-scale plants operating near major fishing ports and/or processing centres to capitalize on economies of scale in raw material availability. Before most of the end product markets can be exploited, upstream processes need to be put in place to convert waste products into end products.

Given the current regulatory environment for by-catch retention and waste management, there appears to be significant opportunity for a “win-win” situation that takes one industry’s “problems” and converts them into marketable “solutions.” Lemons into lemonade so to speak.

By-product utilization and seafood technology advances are of paramount interest to industry. The National Fisheries Institute will sponsor the 2003 Technical Seafood Innovations Conference in Orlando, Florida February 4-7. The 2nd International Seafood Byproduct Conference will be held November 10-13 in Anchorage, Alaska. Program details can be found at:

www.uaf.edu/seagrant/Conferences/byproduct.html

The marine hydrolysate technology appears to be best suited for exploitation of the waste and by-product disposal and market opportunities. However, it is beyond the scope of this report to provide an economic analysis of the opportunity. Further evaluation of opportunities presented by the fish hydrolysate technology would require:

1. Understanding of the raw material volumes necessary for economic operation.
2. Analysis of current industry waste streams (by-product and processing) on a regional and/or port-by-port basis.
3. Determination of the best business form (private company, industry cooperative, etc.) for implementation.
4. Capital requirements.
5. Realistic definition of end use markets.
6. Identify the government role (if any) in facilitating development.

2. Food Safety Issues

2.1 Overview

Food safety is an overriding concern for all companies in the seafood value chain. Over the past decade there have been numerous initiatives, some regulatory, some technical, to improve food safety and communicate with consumers that the products they purchase are safe.

In the United States the U.S. Center for Disease Control (CDC) reports that an estimated 76 million people contract a foodborne illness each year and over 325,000 are hospitalized. According to the CDC, between 1990 and 2002 there were a reported 2,472 outbreaks of foodborne illness including 539 seafood-related outbreaks which accounted for 6,781 reported cases of illness. For the period seafood ranked highest among foodborne outbreaks although a number of other sources (produce, eggs, beef, poultry, etc.) had higher incidences of illness but fewer outbreaks.

A new concern in the United States is the threat posed by bioterrorism to the food supply. Measures to combat this threat may well affect international seafood trade.

Issues related to seafood safety include various product labeling schemes to assure consumers of the content and/or origin of products, traceability programs to track seafood through the value chain, technical advances in processing and packaging and international standards in seafood quality and safety.

2.2 Key Issues

2.2.1 Product Labeling (identification of product source)

There are a number of product labeling initiatives within the seafood industry. In Europe a series of labeling programs have been developed by various national organizations, private companies or cooperatives. In addition, Europe's ISO 14001 International Standard has a labeling component.

In the United States seafood origin labeling has long been required on frozen packaged products (when packaged in country of origin) but more recently origin labeling is being used as a trade weapon. The recently adopted U.S. farm bill requires retailers to label the country of origin on seafood, meat and produce. This measure, scheduled to take effect in 2004, resulted from the perceived impact on U.S.-grown catfish by imported product from Vietnam.

2.2.1.1 European Seafood Labeling Programs

The complexity of food labeling programs can be seen by the number and diversity of labels in use in France. Some of these labels address traceability, while others deal with seafood quality and or environmental friendliness.

Table 4. French Labeling Programs					
	Label	Full Traceability	Flavorsome, Tasty, Superior Quality, Freshness	Environment Friendly	Economic Acceptable Ethic
National Official Label	Label Rouge				
	AB Agriculture Biologique				
	Atout Certifie Qualite				
Private Collective Labels	Qualite Aquaculture de France				
	Charte Qualite Truite				
	Line caught sea bass				
Private Label	Gulf Stream, Intermarche				
	Filiere qualite Auchan				
	Filiere Qualite Carrefour				
International Standards	ISO 14001				

Source: Seafood International magazine, July 2002

2.2.1.2 United States Labeling Requirements

The 2002 U.S. Farm Bill, signed into law on May 13, 2002, included a provision for country of origin labeling. This provision applies to certain commodities including farm-raised fish and wild fish. The section requires retailers in the United States to inform consumers at the point of purchase as to the country of origin of the product. A retailer may designate a commodity as have a United States origin if, in the case of farm-raised fish, the fish is hatched, raised, harvested, and processed in the U.S. In the case of wild fish the product must be harvested in the waters of the United States, a territory of the United States, or a state. The notice of country of origin for wild and farm-raised fish must distinguish between wild and farm-raised fish. The information may be provided to consumers by means of a label, stamp, mark, placard, or other clear and visible sign on the commodity or on the package, display, holding unit, or bin containing the commodity at the point of sale. This provision targets retailers but exempts foodservice establishments such as restaurants. The country of origin labeling program will be implemented through the U.S. Department of Agriculture's Agricultural Marketing Service (AMS). Voluntary guidelines are to be established this year with final regulations in place by September 30, 2004.

For the purpose of this provision, the term farm-raised fish includes shellfish, fillets, nuggets, and any other flesh from a farm-raised fish or shellfish. The term wild fish means naturally-born or hatchery-raised fish and shellfish harvested from the wild. The term wild fish includes fillet, steak, nugget and any other flesh from wild fish or shellfish. The term wild excludes netpen aquaculture or other farm-raised fish.

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The impetus for this provision in the Farm Bill was most likely the catfish farmers in the Southern United States who have seen their market eroded by imported Vietnamese catfish. When implemented, this labeling requirement will likely create new marketing initiatives by farmed and wild producers seeking to favorably position their products. For Canada, which most likely has high favorable consumer perceptions, labeling of wild and/or farmed products may prove to be an advantage if consumers relate Canada with clean waters and high quality.

2.2.2 Eco Labeling

A number of initiatives have been launched to promote environmentalism and sustainability to seafood consumers through an eco label design to communicate to consumers that the seafood labeled has been caught in a manner consistent with the principals and criteria of the certification organization. The most widely known eco label is the one issued by the Marine Stewardship Council.

Marine Stewardship Council

Established in 1997, the Marine Stewardship Council (MSC) is a non-profit, non-government, international organization established to promote “sustainable” fisheries and responsible fishing practices worldwide. The MSC accomplishes their mission through the certification of individual fisheries which meet three key principles:



1. A fishery must conduct itself in a manner that does not lead to overfishing or depletion of the exploited fish population. For those that are depleted, the fishery must be managed in a manner that leads to recovery.
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 is dependent.
3. A 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.

Fishery certification, which is voluntary, allows those that meet the principles to utilize the MSC logo on packaging and advertising. Major seafood buyers in Europe such as Unilever (an MSC founder) have indicated a preference for seafood from certified fisheries. In the United States there is little evidence to date that the MSC logo results in either expanded markets or higher prices.

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Currently New Zealand hoki, Alaska salmon and West Australian rock lobster have been certified with applications pending for Alaska pollock and British Columbia salmon. MSC guidelines do not allow the certification of aquaculture products.

Label Rouge

France has a consumer labeling program titled “Label Rouge” (red label) that can be used by certified growers of fish and poultry that meet certain quality requirements. For farmed salmon these requirements include:

- Fish feed is based exclusively on ingredients of marine origin and vegetable meal, with no growth antibiotics.
- Defined lipid content to guarantee more flavor.
- Independent panel taste tests.
- Stocking density, to allow fish space to swim freely.
- Inspection of specifications by certified bodies approved by the state.

Thus far Scottish salmon farmers have received the Label Rouge accreditation, the only non-French food to meet the quality standard. Still, the quantity of Label Rouge salmon sold in France is relatively small, approximately 4,800 tons in 2001, when compared to overall sales. Label Rouge poultry, on the other hand, has a 30 percent share of the French market.

2.2.2.1 Consumer Reactions to Eco Labels

Consumer acceptance of eco labels is much farther advanced in Europe than the United States. This may be because the eco label movement began in Europe and/or because there are more products in the market with eco labels.

In the United States a consumer survey by the National Fisheries Institute found that only one in three respondents were aware of eco labels. However, of those familiar with eco labels there was some indication of support.



Figure 2. Source: National Fisheries Institute

2.2.3 Product Traceability (producer/harvester to consumer)

Traceability, the documentation of product movement throughout the value chain, is a fact of life in Europe and most likely will become a necessary part of business in North America in the near future. Traceability is important from a regulatory standpoint to track product origin in the case of catch documentation (such as is the case with Chilean sea bass entering the U.S.) and for food safety if there are issues involving contamination of product or feed used in culture products. Traceability also becomes an issue in eco-labeling where certification bodies need to document product origin.

Numerous programs are being developed to allow full traceability of seafood products from point of harvest to point of consumption. Some of these programs are Internet-based while others involve proprietary software. Traceability provides another level of quality assurance along the entire value chain and, in the case of certification programs, documents the product is what it says it is and originates where it says it originates.

1. The European Union is moving to make the traceability of food marketed in the EU mandatory by 2005. The EU regulation includes the following provisions:
2. The traceability of food, feed, food-producing animals, and any other substance intended to be, or expected to be, incorporated in a food or feed shall be established at all stages of production, processing and distribution.
3. Food and feed business operators shall be able to identify any person from whom they have been supplied with a food, a feed, a food-producing animal, or any substance intended to be, or expected to be, incorporated into a food or feed. To this end, such operators shall have in place systems and procedures that allow for this information to be made available to the competent authorities on demand.
4. Food or feed which is placed on the market or is likely to be placed on the market in the Community shall be adequately labeled or identified to facilitate its traceability, through relevant documentation or information in accordance with the relevant requirements of more specific provisions.
5. Provisions for the purpose of applying the requirements of this Article in respect of specific sectors may be adopted in accordance with the procedure laid down in Article 58(2).

The EU-wide concerted action project "Traceability of Fish Products" (TRACEFISH) is a voluntary program funded by the EU's 5th Framework Program and coordinated by the Norwegian Institute of Fisheries and Aquaculture, with fish industry research institutes, industry retailers and others in the value chain.

The objective of TRACEFISH is to "facilitate full-chain traceability of fish products" by developing a set of workable traceability standards, which any operator anywhere in the world can apply. The project is seeking a consensus among industry and research establishments, which will be used as the basis for a European standard on how to

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operate and maintain voluntary traceability schemes for both capture and farmed fish products. These standards are likely to provide the foundation for commercial database packages and will specify the type of information to be stored in a traceability system, and will also define the technical data structure. More information on TRACEFISH is available at www.tracefish.org.

2.2.4 Processing/Packaging

Modified Atmosphere Packaging

Modified atmosphere packaging (MAP) involves special barrier packaging containing gas mixtures, which slow oxidation and product spoilage. MAP requires a well-managed temperature control system throughout the distribution chain. MAP has been reported to extend seafood shelf-life threefold.

MAP seafood packaging is more prevalent in Europe where retailing is more concentrated and distribution lines shorter. In the United States some supermarket chains have introduced MAP seafood products and the trend will likely increase particularly with more retail consolidation. Other factors likely to spur U.S. development of MAP seafood products is increased aquaculture production and the move by some retail chains to phase out full service seafood departments and replace them with self service. In a self-service seafood department there will be greater reliance on pre-packaged seafoods.

Irradiation

Irradiation is a proven process for treating foods to decrease or eliminate harmful bacteria. Food irradiation is allowed in nearly 40 countries and is endorsed by the World Health Organization and the American Medical Association. The U.S. Food and Drug Administration (FDA) has approved irradiation of meat and poultry but not seafood. Public opinion appears to be moving toward irradiation in the United States after a series of deaths from E. coli which could have been prevented had the food (hamburger) been irradiated. Irradiation technology has shown to be an extremely powerful weapon against disease-provoking bacteria such as listeria and salmonella.

The National Fisheries Institute (NFI) petitioned the FDA to allow irradiation of shellfish to provide shrimp, crab, lobster, and crawfish producers with “the best technological means to ensure effective seafood safety.”

Carbon Monoxide Treatment

Often referred to as “tasteless smoke” CO processing of fresh fish results in a “redder” flesh color. This process is being used extensively to treat yellowfin tuna and tilapia.

2.2.5 ISO/HACCP/EU Standards

HACCP stands for Hazard Analysis and Critical Control Point, a process-oriented food safety management system based on the identification of potential hazards and critical

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points during seafood processing and handling. HACCP was first developed in the United States, but since the Sanitary and Phytosanitary Agreement concluded during the Uruguay Round of the World Trade Organization (WTO), it has been endorsed by national governments and international bodies as the basis for ensuring food safety. HACCP certification is now mandatory for all U.S. seafood producers and foreign producers exporting to the United States. In 1997, the HACCP system was incorporated in the World Health Organization (WHO)/FAO Codex Alimentarius in the form a general guideline. This makes the HACCP system the basic reference for international trade disputes under the World Trade Organization (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures. However, the inclusion of the HACCP system as a general guideline for the Codex Alimentarius does not make all HACCP systems identical. For instance, the United States' HACCP regulations apply to processors, while the EU regulations apply to the whole production chain, from handling fish on board fishing vessels to retailing of fish.

The ISO initiative, the International Standard's Organization 9000 series of standards, also follows a process-oriented approach, but one which is entirely voluntary. The standards stipulate the elements that a quality management should have in place to ensure the consistent quality of the end products.

ISO 14000, released in 1996, is a global series of environmental management systems (EMS) and standards providing a framework for organizations to demonstrate their commitment to environmental responsibility. An EMS enables an organization to control the environmental aspects and impacts of its activities, products and services by establishing targets and objectives related to identified environmental management goals. Once implemented, an EMS will improve compliance with legislative and regulatory requirements, reduce exposure to liability, prevent pollution, reduce waste and create a more positive public image.

Norwegian-based salmon farmer Fjord Seafood is in the process of gaining ISO 14000 certification.

2.2.6 Farm-based HACCP

United States

In the United States there is a special section of the FDA HACCP guidelines that applies to aquaculture products. The focus of this section is on uses and abuses of aquaculture drugs which may pose a food safety threat.

According to FDA preventive measures for the control of aquaculture drugs used in aquaculture operations can include:

- On-farm visits to review drug usage (other than investigational new animal drugs - INADs) before receipt of the product, coupled with a supplier's lot-by-lot certificate that any INADs used were used in conformance with the application requirements;

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- Receipt of supplier's lot-by-lot certification of proper drug usage, coupled with appropriate verification (See Step #18 - Verification);
- Review of drug usage records (other than INADs) at receipt of the product, coupled with a supplier's lot-by-lot certificate that any INADs used were used in conformance with the application requirements;
- Drug residue testing;
- Receipt of evidence (e.g. third party certificate) that the producer operates under a third party- audited Quality Assurance Program for aquaculture drug use.

Currently the following drugs are FDA approved for aquaculture in the U.S.:

Chorionic Gonadotropin Supplied by Intervet, Inc., Millsboro, DE, may be used as an aid in improving spawning function in male and female brood finfish, (21 CFR 522.1081);

Formalin solution Supplied by Natchez Animal Supply Co., Natchez, MS or Argent Laboratories, Redmond, WA, may only be used in salmon, trout, catfish, largemouth bass, and bluegill for the control of protozoa and monogenetic tremetodes, and on the eggs of salmon, trout and pike (esocids) for control of fungi of the family *Saprolegniaceae*, (21 CFR 529.1030);

Formalin solution Supplied by Western Chemical, Inc., Ferndale, WA, may be used to control: external protozoa and monogenetic tremetodes on all fin fish species; external protozoan parasites on shrimp; and fungi of the family *Saprolegniaceae* on the eggs of all fin fish species, (21 CFR 529.1030);

Tricaine methanesulfonate (MS-222) Supplied by Argent Laboratories, Redmond, WA, and Western Chemical, Inc., Ferndale, WA, may only be used in the families *Ictaluridae* (catfish), *Salmonidae* (salmon and trout), *Esocidae* (pike), and *Percidae* (perch) when the fish is intended to be used for food. It may not be used within 21 days of harvesting fish for food. In other fish and in cold-blooded animals, the drug should be limited to hatchery or laboratory use, (21 CFR 529.2503);

Oxytetracycline For feed use, supplied by Pfizer, Inc., may only be used in salmonids, catfish, and lobster. Withdrawal times are: marking in Pacific salmon, 7 days; disease control in salmonids, 21 days; catfish, 21 days; lobster, 30 days (21 CFR 558.450). Oxytetracycline tolerance in the flesh is 2.0 ppm, (21 CFR 556.500).

Sulfamerazine Supplied by Roche Vitamins, Inc., may only be used in trout. It may not be used within 21 days of harvest (21 CFR 558.582). Sulfamerazine tolerance in the flesh is zero, (21 CFR 556.660). Note: this product is currently not marketed.

Sulfadimethoxine/ormetoprim combination Supplied by Roche Vitamins, Inc., may only be used in salmonids and catfish. Withdrawal times are: salmonids, 42 days; catfish, 3 days (21 CFR 558.575). Sulfadimethoxine/ormetoprim combination tolerance in the flesh is 0.1 ppm for both drugs, (21 CFR 556.640).

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In Canada the list of Health Canada–approved therapeutic products, parasiticides, fungicides, disinfectants and anesthetics is similar and includes:

Sulfadimethozine/ormetropim Sold in Canada under the Romet 30® brand by Alpharma and used as an antibiotic against bacterial infection.

Sulfadiazine/trimethoprim An antibiotic sold under the Tribriksen 40® brand by Schering-Plough.

Oxytetracycline an antibiotic used to combat broad spectrum bacterial infections and sold under the brand Terramycin Aqua® by Philbro.

Florfenicol Sold under the brand name Aquaflor® and manufactured by Schering-Plough for the treatment of gram negative bacterial infection.

Tricaine methanesulfonate An anesthetic sold under the TMS® brand by Aqua Life.

Formaldehyde/Formalin Used in salmonid culture as an antifungal treatment. Sold under the Parasite-S brand by Western Chemicals.

Hydrogen peroxide Used as an antifungal treatment for salmon eggs and marketed under the Perox-Aid brand by EKA Chemicals.

Tricaine methanesulfonate A salmonid anesthetic sold by Syndel Labs under the Aqua Life TMS brand.

Azamethiphos A parasiticide for sea lice sold under the brand name Salmosan® and manufactured by Aqua Health.

Emamectin benzoate A parasiticide for sea lice sold under the brand name Slice® and manufactured by Schering-Plough.

Canada

Canada's food safety system is rigorous. Protection of public health is of paramount importance in this country. Canada's fish inspection system has evolved from the traditional approach of product testing to a modern food safety system based on preventive measures. Health Canada is responsible for policy formulation and setting standards related to the safety and nutritional quality of all food commodities sold domestically. Furthermore, they have the mandate to monitor food-borne illness. Health Canada's Pest Management Regulatory Agency regulates pesticides use in Canada while their Veterinary Drugs Directorate approves new therapeutants for use. The Canadian Food Inspection Agency (CFIA) registers licensed vaccines and antibiotics. CFIA, under the authority of the Feeds Act and Regulations also oversees the sale, import and manufacture of livestock feeds in Canada. Health Canada is the national body regulating the use of therapeutic compounds in this country. Canada enjoys a solid international reputation in fish and seafood quality and safety. In foreign markets, Canada is known to produce safe and wholesome fish and seafood products (CFIA, HC, AAFC, SHC, 2002).

2.2.7 Organic Certification

The organic Foods Production Act (OFPA) of 1990 authorizes the National Organic Standards Board (NOSB) to advise the Secretary of Agriculture on production and handling standards for organically produced agricultural commodities. In May of 2001 the Aquatic Animal Task Force of the NOSB presented recommendations regarding organic certification of farmed seafood. The certification process, which will be in place in October of 2002, does not apply to wild-caught fish or molluscan shellfish (except those grown in recirculating systems). It also appears that carnivorous species, such as trout and salmon, may not be allowed unless they have been fed a vegetarian (grain-based) diet. A copy of the Task Force recommendations can be found at the USDA web site:

<http://www.ams.usda.gov/nop/nop2000/nosb%20recommedations/Livestock%20recommend/aquacult0501.htm>

Market Overview

The market for organically grown and certified foods is growing rapidly in the United States and totaled an estimated \$9.5 billion in 2001. According to the Organic Consumer Trends 2001, published by the Natural Marketing Institute in cooperation with the Organic Trade Association (OTA), retail sales are forecast to reach \$20 billion by 2005. One of the main factors behind the positive growth in organics is the increasing consumer awareness of health and environmental issues and concerns regarding food safety and contamination.

Market Outlook

It is likely a number of companies and the aquaculture industry will jump on the organic bandwagon, particularly tilapia and catfish producers. The key issue for these producers is the use of antibiotics and, in the case of tilapia, methyltestosterone which is used to "sex reverse" the fish so that only females are grown to market size.

The U.S. market for organically grown fish and shellfish (if in recirculating systems) will initially be in supermarkets and restaurants that already offer organic products. The U.S. supermarket chain Whole Foods has indicated they would purchase organic fish and a number of food coops around the country would likely do so as well.

2.2.8 GMO products

Although genetically modified organisms (GMOs) are a fact of life in the U.S. food chain, they are not yet acceptable for seafood products. While selective breeding and hybridization to improve food quality and productivity have been conducted in the United States for decades, genetic engineering using modern-day DNA technology to transfer specific genes with specific traits from one species to another is relatively new. In agriculture this technique has resulted in grain crops with greater disease and/or insect resistance. GMO crops have also been used to extend the shelf-life of some fruits and vegetables.

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Genetic engineering (GE) has allowed the development of an aquaculture-raised Atlantic salmon that grows 400 to 600 percent faster than non-engineered fish through the addition of a gene from Arctic char. This increased growth allows these salmon to grow from egg to market-size in approximately 14 months. Critics have labeled this salmon “Frankenfish” and the resulting negative publicity has stalled attempts to gain approval by the United States Food and Drug Administration (FDA). One of the concerns expressed by critics is that if engineered salmon escape they could out-compete native stocks of Atlantic salmon. GMO work is also underway on tilapia, carp, Pacific salmon, trout and other species.

Table 5: Some Aquatic Genetically Modified Organisms (Transgenic Species) Currently Being Tested			
Species	Foreign Gene	Desired Effect	Country
Atlantic Salmon	Anti-freeze protein (AFP) AFP salmon growth hormone (GH)	Cold tolerance Increased growth and feed efficiency	United States Canada
Coho Salmon	Chinook salmon GH + AFP	After 1 year, 10-30 fold growth increase	Canada
Chinook Salmon	AFP salmon GH	Increased growth and feed efficiency	New Zealand
Rainbow Trout	AFP salmon GH	Increased growth and feed efficiency	United States Canada
Cutthroat Trout	AFP salmon GH	Increased growth	Canada
Tilapia	Modified tilapia insulin-producing gene	Production of human insulin for diabetics	Canada
Salmon	Rainbow trout lysosome gene and flounder pleurocidin gene	Disease resistance, still in development	United States Canada
Striped Bass	Insect genes	Disease resistance, still in early stages of research	United States
Channel Catfish	GH	33% growth improvement in culture conditions	United States
Common Carp	Salmon and human GH	150% growth improvement in culture conditions; improved disease resistance; tolerance of low oxygen level	United States China
Indian Major Carps	Human GH	Increased growth	India
Goldfish	GH, AFP	Increased growth	China
Abalone	Coho salmon GH + various promoters	Increased growth	United States
Oysters	Coho salmon GH + various promoters	Increased growth	United States

Source: FAO

A report from a specially formed committee put together by the U.S. National Research Council puts the possibility that certain genetically-engineered fish and other creatures might escape and introduce engineered genes into wild populations at the top of its list of concerns regarding animal biotechnology.

Market Overview

The introduction of GMO fish, such as salmon, would put the producer at a decided economic advantage and could, in the case of Canada, offset much of the production cost advantage enjoyed by Chilean salmon farmers.

Market Outlook

The National Fisheries Institute has established the position that GMOs are a valuable tool in the production of seafood that may enhance productivity and efficiency and thereby contribute to global food security. The NFI recommends however that additional research be conducted on the impacts of GMOs on natives species and ecosystems before final regulatory decisions are made.

However, it is likely that any U.S. market opportunities for GMO fish are years if not decades away. Environmental NGOs in the United States have waged an aggressive pre-emptive campaign to ban GMO seafood and have successfully signed up a number of retail and foodservice operators that have vowed not to purchase GMO seafoods.

2.2.9 Shellfish Purification

According to the United States Center for Disease Control (CDC), between 1990 and 2002 there were 539 outbreaks⁹ of seafood-related illnesses in the U.S. affecting 6,781 individuals. Molluscan shellfish, including oysters, clams and mussels accounted for 82 outbreaks and 2,681 cases. In the case of illnesses associated with *Vibrio vulnificus*-contaminated raw oysters, the illness can be fatal. According to a report¹⁰ by the consumer group Center for Science in the Public Interest (CSPI), between 1989 and 2000 there were 263 known *V. vulnificus* cases in the United States resulting in 138 deaths. *V. vulnificus* infections typically are caused by consumption of contaminated shellfish that are raw or undercooked (e.g. lightly steamed). The bacterium may be present in all types of shellfish including oysters, clams and crabs and cannot be detected by sight, smell or taste.

Food safety fears have inhibited shellfish consumption in the United States with consumption falling from approximately .25 pounds (edible weight) in 1998 to .16 pounds in 2001. Much of the problem with oysters is related to Gulf of Mexico wild harvests. The *Vibrio* virus is common in Gulf waters during warmer months. According to a report from Louisiana State University oysters are a U.S.\$52 million industry in that state.

Efforts to reduce or eliminate shellfish-related illnesses have focused on area closures, documentation of product source through the value chain, depuration (flushing of toxins in clean water) and several new technologies to kill the *Vibrio* organism. A European Commission-funded project begun in February 2000 is designed to investigate virus safe seafood. The three-year project will also help develop “innovative technology” for shellfish purification.

There are over 250 types of illnesses that have been described all over the world as being transmitted through food (United States Department of Health and Human Services, Centers for Disease Control, 2001). The food supply in Canada is one of the safest in the world. Despite this high level of safety, Health Canada estimates that there are each year more than one million cases of food-borne illness reported. These

⁹ An outbreak is a foodborne illness that affects more than one person.

¹⁰ Death on the Half Shell, Center for Science in the Public Interest, www.cspinet.org/reports

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cases represents a price tag of close to one billion dollars to Canadian taxpayers (Canadian Partnership for Consumer Food Safety Education, 2001).

Fish and seafood like any other food commodities can cause illness in humans. However, to put things in perspective, the occurrence of seafood-borne illnesses is substantially lower than the number of illnesses from other food commodities. There were only 169 cases from 78 outbreaks recorded in Canada between 1991 and 1997. These cases involved 29 different species of fish and shellfish and or seafood products. Mussel and clams represented respectively more than one third of the outbreaks and close to forty percent of the reported cases. Raw or undercooked molluscan shellfish from contaminated waters is one of the main sources of seafood-borne illness. A total of 13 countries were involved in the outbreaks. However, close to 75% of the cases were from domestic or United States origin.¹¹

Depuration

Depuration is the process of placing live shellfish into a clean water environment (tanks) where the natural filter-feeding mechanism of the shellfish purges the product of toxins. Depuration has been practiced in various fashions around the world for almost a century and has been demonstrated to successfully reduce to low levels the number of bacterial and some viral agents in moderately polluted shellfish. However, studies indicate that successful depuration may well depend upon a number of variables including the health status of the shellfish, the type of pathogen and level of contamination and the environmental parameters of the depuration facility (salinity, temperature, turbidity).

Research by the Australian Fisheries Research and Development Corporation (www.frdc.com.au) has concluded that, although depuration is mandatory in Australia, there continue to be food poisoning outbreaks associated with shellfish. The current research is attempting to identify optimum environmental factors such as salinity, temperature and turbidity and also the size of individual depuration facilities. A similar course of research is being conducted in France testing various depuration conditions such as temperature, oxygenation, salinity and oyster loads. The tanks are equipped with recycling pumps, flint filters and UV lights.

Radiation Pasteurization

Irradiation has been demonstrated to control a variety of pathogens including *V. vulnificus* and hepatitis A. Recent data have shown that ionizing radiation doses of only 1kGy are adequate to eliminate *V. vulnificus* in oysters. When combined with a traditional depuration, or controlled purification, radiation doses of 2 kGy were demonstrated to decrease significantly the number of hepatitis A virus in clams and oysters.¹² To date the United States Food and Drug Administration (FDA) has not approved irradiation treatment of seafood but an application is pending.

¹¹ Cato, J. C., 1998. Seafood-Borne Disease and Illness. In: Seafood Safety - Economics of Hazard Analysis and Critical Control Point (HACCP) programmes. FAO Fisheries Technical Paper. No. 381, Rome, FAO. 1998. 70 pp.

¹² Radiation Pasteurization of Food, Issue Paper No. 7, Council of Advisors on Science and Technology, April 1996

Heat Pasteurization

Louisiana State University in cooperation with AmeriPure Oyster Processing Company has developed a process utilizing mild heat to pasteurize oysters. The process, similar to the pasteurization of raw milk, subjects the oyster, still in the shell, to a mild heating process that kills the *Vibrio* bacteria. While the oyster dies during the process, it looks like a live oyster and a rubber band is placed around each oyster. The oysters are treated with in a 126°F water bath for 10 minutes. The oysters are then submerged in a 40°F bath. The patented pasteurization process is owned by AmeriPure Oyster Company of Empire, Louisiana. The treated oysters are the only Gulf Coast oyster product sold in California which is not required to have signs warning of the dangers of eating “raw” oysters.

Ultra High Pressure Pasteurization

This method of pasteurization uses high pressure to break up the bacterial microorganisms. The pressure treating doesn't affect the taste, color and nutritional value of the product and, in the case of oysters, pressure treatment forces open the shell, saving time in shucking the oyster meat. A U.S. company, Motivatiit Seafood, holds a patent on High Pressure Process (HPP) and has branded their oysters “Gold Band Oyster®”. According to Motivatiit, HPP treated oysters have a 14-21 day shelf. The process does not involve heat and are still considered a raw oyster.

2.3 Present and proposed structures for ensuring the production and distribution of safe and wholesome seafood

The issue of seafood safety is being addressed internationally, regionally and locally by a wide variety of government and non-government agencies including the World Health Organization (WHO), colleges and universities, seafood trade groups and national regulatory bodies. In the United States food safety is the responsibility of a number of agencies including the U.S. Department of Agriculture (meat and poultry) and the Food and Drug Administration (seafood). In Canada the Canadian Food Inspection Agency is responsible for seafood safety.

2.3.1 Regulatory measures

United States

As indicated in section 2.2.5, HACCP has become the international standard for seafood safety. A recent FDA report found that 85 percent of U.S. seafood processors (4,100 facilities) were in compliance with government HACCP requirements. The report concluded that the seafood HACCP program has “increased the margin of safety for American consumers.”

There are very few “standards” regarding seafood quality in the United States. Many standards are set by commodity organizations. These standards may deal with quality grades and product sizes. In recent years many commodity groups have used

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branding as a way to promote quality standards. In Canada The Quality Management Program is a regulatory-based system that incorporates HACCP and non-safety issues including fish quality and labeling.

In the United States shellfish safety is regulated by the Interstate Shellfish Sanitation Conference (ISSC), a coalition of shellfish-producing states and industry representatives that set state standards for the shellfish industry. The Conference, which was designed to facilitate the interstate sale of raw shellfish, such as oysters, clams and mussels, sets standards governing hazards such as *Vibrio vulnificus* and Norwalk virus.

The consumer group Center for Science in the Public Interest (CSPI) strongly opposes ISSC and the failure of FDA to more closely monitor shellfish safety. To protect consumers from the hazards of *Vibrio*-contaminated raw molluscan shellfish, the CSPI recommends:

1. Restaurants, retailers, and shellfish brokers should not buy Gulf Coast shellfish harvested during the months of April to October for raw consumption unless the shellfish are treated to kill *Vibrio vulnificus*.
2. The FDA should add safety standards for molluscan shellfish to its food safety regulations.
3. The ISSC should be limited to setting water-quality standards for the shellfish industry.
4. Consumers who want to eat raw bivalve shellfish should ask where the shellfish were harvested. Consumers should not eat raw Gulf Coast oysters, clams, or mussels unless they have been processed to kill the *Vibrio vulnificus* bacterium.

Canada

The safety of shellfish harvesting in Canada is controlled under the Canadian Shellfish Sanitation Program (CSSP). The objectives of the CSSP are firstly, to ensure that all bivalve molluscan shellfish consumed in this country, originating from the commercial fishery or cultivated, comes from approved shellfish growing areas. Secondly, those pollution sources are identified, and finally, that shellfish are harvested, transported and processed in an approved manner. In Canada, the legal authority for the CSSP is provided by the Management of Contaminated Fisheries Regulations under the Fisheries Act and the Fish Inspection Regulations (FIR) under the Fish Inspection Act. The responsibility for monitoring of marine biotoxins in shellfish was also transferred from the federal Department of Fisheries and Oceans to the Canadian Food Inspection Agency (CFIA) in 1997. CFIA conducts sentinel sampling of the harvest areas and processing plants to monitor biotoxin levels. Since the domoic acid mortalities

implicating blue mussels from PEI in 1988, there has been no reported case of marine biotoxin poisoning in commercial bivalve molluscan shellfish in Canada.¹³

2.3.2 Best management practices

A “best practice” is a method which has been judged to be superior to other methods with respect to a process or environmental consequence. A number of states in the United States (Florida, Arizona, Hawaii) for example have developed best management practices for aquaculture operations. However, most of these practices are in relation to environmental consequences such as discharge water quality. In the United States there does not appear to be a central document or organization tracking best management practices in a seafood quality context.

2.3.3 Government and non-government “standards” and Codes of Conduct

FAO

The Food and Agriculture Organization (FAO) of the United Nations has adopted a Code of Conduct for Responsible Fisheries. This code, which includes aquaculture operations as well, was adopted in 1995.

(see <http://www.fao.org/fi/agreem/codecond/codecon.asp>).

This Code sets out principles and international standards of behaviour for responsible practices with a view to ensuring the effective conservation, management and development of living aquatic resources, with due respect for the ecosystem and biodiversity. The Code recognizes the nutritional, economic, social, environmental and cultural importance of fisheries and the interests of all those concerned with the fishery sector. The Code takes into account the biological characteristics of the resources and their environment and the interests of consumers and other users.

The FAO code introduction states: *Fisheries, including aquaculture, provide a vital source of food, employment, recreation, trade and economic well being for people throughout the world, both for present and future generations and should therefore be conducted in a responsible manner. This Code sets out principles and international standards of behaviour for responsible practices with a view to ensuring the effective conservation, management and development of living aquatic resources, with due respect for the ecosystem and biodiversity. The Code recognizes the nutritional, economic, social, environmental and cultural importance of fisheries, and the interests of all those concerned with the fishery sector. The Code takes into account the biological characteristics of the resources and their environment and the interests of consumers and other users. States and all those involved in fisheries are encouraged to apply the Code and give effect to it.*

¹³ Lanteigne, Stephen (2002). Current Status and Potential Of The Canadian Aquaculture Industry. Office of the Commissioner for Aquaculture Development. Ottawa. 56 p.

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Key provisions of the code include:

1. This Code is voluntary. However, certain parts of it are based on relevant rules of international law, including those reflected in the United Nations Convention on the Law of the Sea of December 10, 1982. The Code also contains provisions that may be or have already been given binding effect by means of other obligatory legal instruments amongst the Parties, such as the Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas, 1993, which, according to FAO Conference resolution 15/93, paragraph 3, forms an integral part of the Code.

The Code is global in scope, and is directed toward members and non-members of FAO, fishing entities, sub regional, regional and global organizations, whether governmental or non-governmental, and all persons concerned with the conservation of fishery resources and management and development of fisheries, such as fishers, those engaged in processing and marketing of fish and fishery products and other users of the aquatic environment in relation to fisheries.

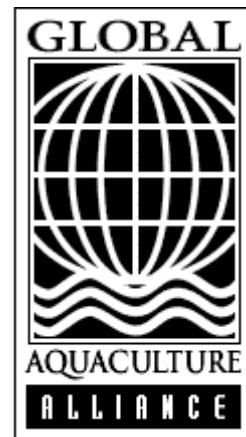
The Code provides principles and standards applicable to the conservation, management and development of all fisheries. It also covers the capture, processing and trade of fish and fishery products, fishing operations, aquaculture, fisheries research and the integration of fisheries into coastal area management.

In this Code, the reference to States includes the European Community in matters within its competence, and the term fisheries applies equally to capture fisheries and aquaculture.

Global Aquaculture Alliance

The Global Aquaculture Alliance (GAA) was formed to promote the aquaculture industry and to advance environmental and social responsibility throughout the process of raising, processing and distributing aquaculture products. The GAA is headquartered in the United States and has focused most of its efforts on shrimp farming. Although the GAA does not have a certification program, they have developed “Guiding Principles for Responsible Aquaculture” as follows:

1. Shall coordinate and collaborate with national, regional, and local governments in the development and implementation of policies, regulations, and procedures necessary and practicable to achieve environmental, economic, and social sustainability of aquaculture operations.
2. Shall utilize only those sites for aquaculture facilities whose characteristics are compatible with long-term sustainable



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operation with acceptable ecological effects, particularly avoiding unnecessary destruction of mangroves and other environmentally significant flora and fauna.

3. Shall design and operate aquaculture facilities in a manner that conserves water resources, including underground sources of fresh water.
4. Shall design and operate aquaculture facilities in a manner that minimizes effects of effluent on surface and ground water quality and sustains ecological diversity.
5. Shall strive for continuing improvements in feed use and shall use therapeutic agents judiciously in accordance with appropriate regulations and only when needed based on common sense and best scientific judgment.
6. Shall take all reasonable measures necessary to avoid disease outbreak among culture species, between local farm sites, and across geographic areas.
7. Shall take all reasonable steps to ascertain that permissible introductions of exotic species are done in a responsible and acceptable manner and in accordance with appropriate regulations.
8. Shall cooperate with others in the industry in research and technological and educational activities intended to improve the environmental compatibility of aquaculture.
9. Shall strive to benefit local economies and community life through diversification of the local economy, promotion of employment, contributions to the tax base and infrastructure, and respect for artisanal fisheries, forestry, and agriculture.

Among the activities of the GAA are publication of a monthly magazine **Global Aquaculture Advocate** and an annual shrimp conference called Global Shrimp Outlook. The GAA has considered certification programs for aquaculture but to date has not pursued this opportunity. Darden Restaurant Group, operators of Red Lobster Inns, is a founding member and strong supporter of GAA.

2.4 Consumer Trends and Perspectives

Food Safety

U.S. consumers are generally not concerned with the safety of the seafood they eat. In fact, a 2002 survey of 4,500 consumers by the U.S. Food and Drug Administration found that the percentage of those polled who said they were eating raw oysters increased from 8 percent in 1998 to 12 percent in 2001. In Europe concerns of “mad cow disease” has driven more consumers to seafood.

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In the past two decades there has been significant negative publicity in the United States regarding seafood safety including lengthy articles in **Consumer Reports** magazine in 1992 (“Is Our Fish Fit to Eat”) and again in 2001 (“America’s Fish: Fair or Foul?”). Following the 1992 article the Alaska Seafood Marketing Institute hired a research firm to advise them on how best to respond to the negative publicity. After surveying consumers the PR firm suggested they spend money to promote their products and not spend money to counter the negative publicity suggesting “consumers have short memories when it comes to negative publicity regarding seafood safety.”

At the present time there is considerable negative publicity in the United States with respect to farm-raised salmon. While some of this publicity is related to environmental issues, food safety is also at issue. Some organizations have charged that farmed salmon contains high levels of PCBs or other contaminants as a result of using tainted feed. In addition, so the charge goes, much of the farmed salmon has been over-medicated with disease-preventing drugs. Still, U.S. per capita consumption salmon set record levels in 2001.

Environmental issues

When U.S. consumers were asked about environmental issues related to aquaculture, they generally were not aware of specific issues or even differences between farm raised fish and wild caught.¹⁴

When consumers were asked if they preferred farmed or wild seafood 26 percent state they preferred wild or naturally caught fish while 25 percent said they preferred farm raised fish.

Nearly half of the respondents through aquaculture represented a “good” alternative to wild seafood and only 4 percent considered it a “bad” alternative.

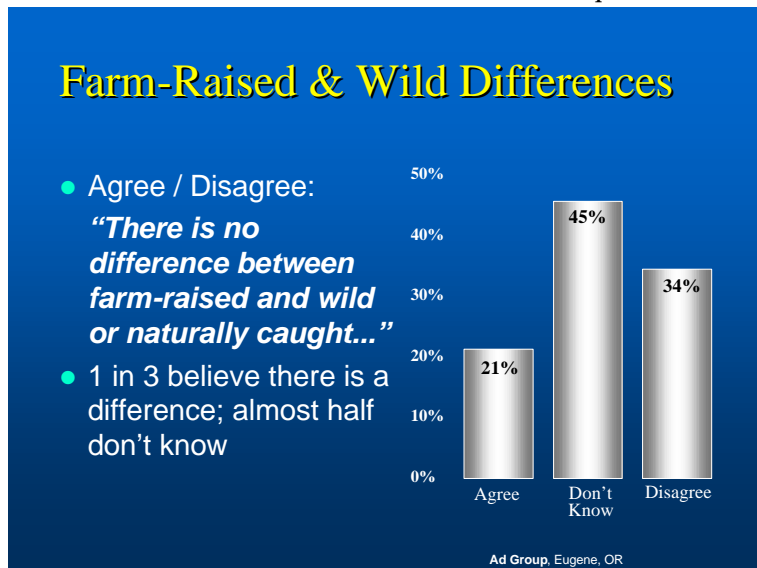


Figure 3. Source: National Fisheries Institute

¹⁴ Source: National Fisheries Institute

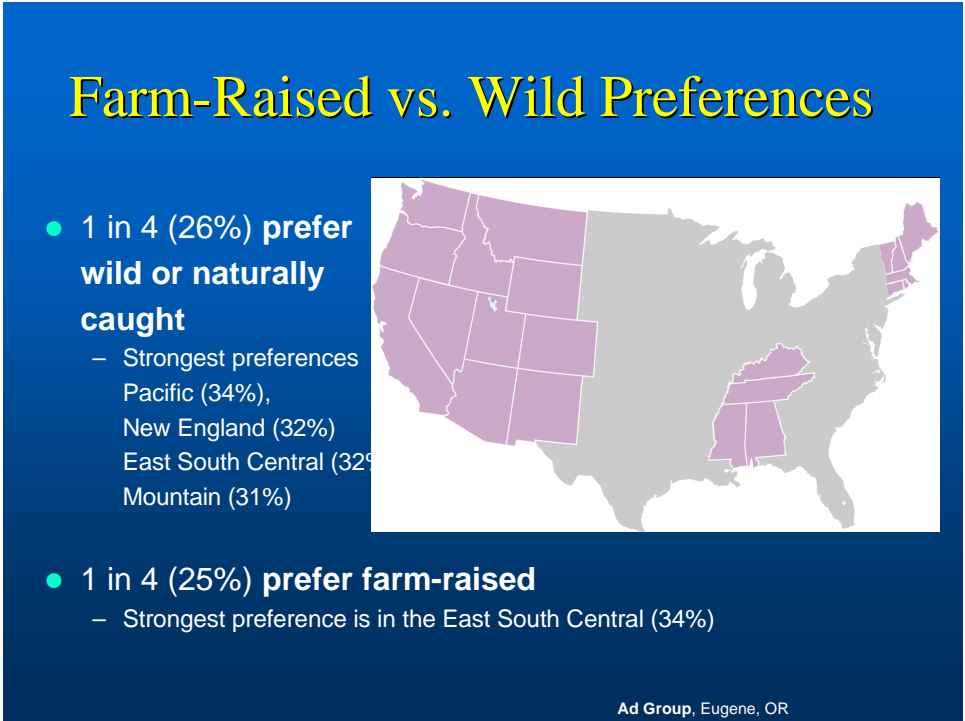


Figure 4. Source: National Fisheries Institute

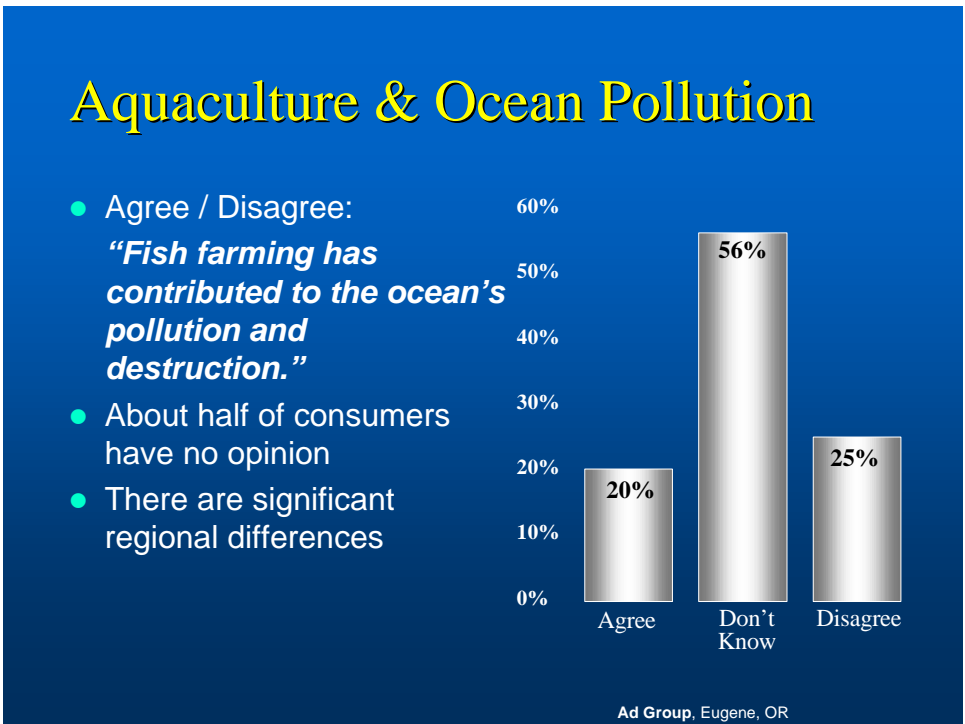


Figure 5. Source: National Fisheries Institute