Seafood Safety

Economics of Hazard Analysis and Critical Control Point (HACCP) programmes

by
James C.Cato
Visiting Scientist (Economics)
Fish Utilization and Marketing Service
Fishery Industries Division
FAO Fisheries Department
Rome, 1998

PREPARATION OF THIS DOCUMENT

The safety of the world's food supply is an issue of critical concern. Producing safe and high quality seafood in developing countries for both domestic and export markets is the focus of the Fish Utilization and Marketing Service, Fishery Industries Division, Fisheries Department, FAO. This document on economic issues associated with seafood safety was prepared to complement the work of the Service in seafood technology, plant sanitation and Hazard Analysis Critical Control Point (HACCP) implementation. The document was written during participation by the author in the FAO Partnership Programme with Academic Institutions.

Cato, J.C.

Economic values associated with seafood safety and implementation of seafood

Hazard Analysis Critical Control Point (HACCP)

programmes.

FAO Fisheries Technical Paper. No. 381. Rome, FAO. 1998. 70p., ISBN 92-5-102414-4, ISSN 0429-9345

ABSTRACT

Seventy percent of the world's catch of fish and fishery products is consumed as food. Fish and shellfish products represent 15.6 percent of animal protein supply and 5.6 percent of total protein supply on a worldwide basis. Developing countries account for almost 50 percent of global fish exports. Seafood-borne disease or illness outbreaks affect consumers both physically and financially, and create regulatory problems for both importing and exporting countries. Seafood safety as a commodity cannot be purchased in the marketplace and government intervenes to regulate the safety and quality of seafood. Theoretical issues and data limitations create problems in estimating what consumers will pay for seafood safety and quality. The costs and benefits of seafood safety must be considered at all levels, including the fishers, fish farmers, input suppliers to fishing, processing and trade, seafood processors, seafood distributors, consumers and government. Hazard Analysis Critical Control Point (HACCP) programmes are being implemented on a worldwide basis for seafood. Studies have been completed to estimate the cost of HACCP in various shrimp, fish and shellfish plants in the United States, and are underway for some seafood plants in the United Kingdom, Canada and Africa. Major developments within the last two decades have created a set of complex trading situations for seafood. Current events indicate that seafood safety and quality can be used as non-tariff barriers to free trade. Research priorities necessary to estimate the economic value and impacts of achieving safer seafood are outlined at the consumer, seafood production and processing, trade and government levels. An extensive list of references on the economics of seafood safety and quality is presented.

1. INTRODUCTION

This paper[1] focuses on the economic values associated with seafood safety.[2] Data are provided on the production, trade and consumption of seafood as a worldwide food commodity. A review is provided of the market for seafood safety, the economic concepts of valuing seafood safety and estimation methods that can be used to assign monetary values for safer seafood. Practical approaches to valuing seafood safety which include measuring risks, data problems and policy issues are discussed. Issues covered include HACCP benefits and costs including how HACCP can affect seafood market structure. Available estimates of seafood HACCP implementation costs at the industry and firm level are summarized. The economic and policy issues of using HACCP to increase the safety of seafood are presented. Using HACCP as an international trade standard for insuring safe seafood is discussed, including the way impacts differ among developed versus developing countries. Different designs for seafood safety regulatory regimes also create different economic impacts among countries and the seafood industry. Recent studies valuing seafood safety are presented, including estimation techniques used, safety and quality assurances measured, willingness-to-pay by consumers for safer seafood and the effect of consumer education on seafood consumption. Research priorities for the future are suggested.

2. SEAFOOD PRODUCTION, CONSUMPTION AND TRADE

Estimates in the early 1970s predicted the potential for traditionally exploited marine species was about 100 million tonnes per year (FAO 1997a). Despite development of non-traditional species, marine fishery production by 1994 reached only 90 million tonnes with capture fisheries accounting for 84 million tonnes. In 1994, the world's 200 major fishery resources accounted for 77 percent of marine fish production. About 35 percent of these resources are showing declining yields, about 25 percent are leveled at high exploitation rates, 40 percent are still developing and none remain at an undeveloped level (FAO 1997b). Thus, about 60 percent of the world's major fisheries resources are mature or declining, and there is a need to establish more effective management controls, reduce overall fishing effort and rebuild overfished stocks. In a few remaining areas of the world, it is possible to increase effort and landings. FAO estimates indicate that an increase of 10 million tonnes to a world total production of 93 million tonnes is possible only through management improvements and further fishery development of the capture sector (FAO 1997b). Another prediction indicates an additional 20 million tonnes is possible, but only if degraded resources are rehabilitated, under-developed resources are exploited further, overfishing is avoided in these as well as in those resources currently fully exploited, and discarding and waste are reduced (FAO 1997a). This creates important implications regarding the world's supply of food, since about 70 percent of the world catch of fish and fishery products is consumed as food.

On a worldwide basis, the total food supply of fish and fishery products was 74 million metric tonnes (live weight of fish) in 1993. This is the largest amount recorded, and represents an amount almost 2.5 times greater than in the early 1960s. Food fish and fishery product supply on a per capita basis was 13.4 kilograms (live weight of fish) in 1993. The 1991-1993 average was 13.0 kilograms, compared to the 1961-1963 average of 9.2 kilograms. Increases since the early 1960s have been steady and gradual, with the principal growth in demand for fish as food coming through population increases. For low-income food-deficit countries, per capita supply was 9.6 kilograms in 1993. The 1991-93 average of 9.0 kilograms per capita was slightly double the 1961-1963 average of 4.3 kilograms per capita. On a relative basis, fish and fishery products has become a more important food product for low-income food-deficit countries. Fish represent 20.6 percent of all animal proteins and 4.7 percent of all proteins consumed per capita in low-income food-deficit countries. Fish and fishery products represent 15.6 percent of animal protein supply and about 5.6 percent of total protein supply on a worldwide basis. This percentage has been stable over the last 33 years, ranging from a low of 13.8 percent to a high of 16.0 percent (FAO 1996).

International trade in fish and fishery products has grown substantially over the last three decades. The value of fish entering the world export market has increased over twenty times from the 1968 value of US$2.2 billion to the 1993-1995 average annual value of US$46.95 billion (Table 1). Adjusting for inflation to measure the increase in real value terms, the 1993-1995 value is still five times greater that the 1968 value[3]. Today, more than 30 percent of the fish caught for direct human consumption enters international trade. Developing countries account for almost 50 percent of global fish exports (Karnicki 1997). The share of exports from developing countries reached an all-time high of 51 percent with their net receipts from foreign exchange increasing from US$10.4 billion in 1990 to US$18.0 billion in 1995 (Lem and Shehadeh 1997). Sixteen different countries averaged exports over US$1.0 billion annually from 1991 to 1993. These 16 countries accounted for 66 percent of world exports with 50 countries exporting 96 percent of the world total. Thailand was the leading exporter at US$4.0 billion. The others were as follows (all US$): United States, $3.3 billion; Norway, $2.7 billion; Denmark $2.3 billion; China Taiwan, $2.3 billion; China Mainland, $2.2 billion; Indonesia, $1.6 billion; Russian Federation, $1.6 billion; Chile, $1.4 billion; Korea Republic, $1.4 billion; Netherlands, $1.4 billion; Iceland, $1.2 billion; India, $1.2 billion; United Kingdom, $1.1 billion and Spain, $1.0 billion.

Table 1.

Imports and exports of fishery commodities (a) worldwide, by area of the world, and by selected trading regions, three-year average, 1993-1995

	Imports (b)		Exports (b)	
Area of world	US$ Billions	**Percent**	US$ Billions	Percent
World (c)	50.562	100.0	46.954	100.0
Africa	. 863	1.7	1.995	4.3
North America	8.139	16.1	6.907	14.7
South America	.521	1.0	4.371	9.3

Asia	22.139	43.8	16.643	36.5
Europe	18.064	35.7	13.573	28.9
Oceania	.550	1.1	1.571	3.4
Former USSR	.286	1.0	1.895	4.1
Low-income food deficit countries (d)	1.829	3.6	8.395	17.9
European Community (e)	17.045	33.7	10.002	21.3
NAFTA countries (f)	7.873	15.6	5.988	12.8
Japan	16.060	31.8	.741	1.6
Rest of world	9.58	19.0	30.223	64.4

Source: Derived from (FAO 1997b)

(a) Includes seven categories of commodities: fish, fresh, chilled or frozen; fish, dried, salted or smoked; crustaceans and molluscs; fish, canned; crustaceans and molluscs, canned; oils; meals

(b) Individual amounts may not add to totals due to rounding

(c) Represents the trading activity of 202 countries

(d) The list of low-income food-deficit countries is available (FAO 1997b). By region of the world, the number of countries with fish trading activity and the number which are considered low-income food-deficit are shown by region (low-income food-deficit in region/total number in region): Africa (41/54); North America (6/32); South America (3/14); Asia (15/37); Europe (3/33); Oceania (6/17); former USSR (7/15); Total (81/202)

(e) Includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Italy, Netherlands, Luxembourg, Portugal, Spain, Sweden, and United Kingdom

(f) Includes United States, Canada and Mexico

Asia is the leading exporting region with 36.5 percent of the total, followed by Europe at 28.9 percent and North America at 14.7 percent. The European Community is the leading fish exporting organized bloc with 21.3 percent of the world total, followed by the NAFTA countries at 12.8 percent. In the case of Asia, Japan has a minor role in exports, indicating the importance of the dependence on seafood exports by the remaining Asian countries. This is significant in that a large number of countries who rely individually on exports to the European Union, the United States and Japan, will need to clearly comply with recently reorganized seafood safety and quality standards of those counties in order to continue this export position.

The average annual value of fish commodities imported worldwide from 1993 to 1995 was US$50.56 billion (Table 1). Fifty countries accounted for almost 98 percent of imports. Japan was the leading country with US$16.1 billion in fish commodity imports (32 percent of world total), followed by the United States with US$6.8 billion (14 percent of world total). Eight other countries each had over US$1.0 billion in imports: France, $2.9 billion; Spain, $2.8 billion; Germany, $2.2 billion; Italy, $2.2 billion; United Kingdom, $1.8 billion; Hong Kong, $1.6 billion; Denmark, $1.4 billion and the Netherlands, $1.0 billion.

The influence of Japan makes Asia the leading fish importing region, followed by Europe and North America (Table 1). Excluding Japan, the rest of the countries in Asia together import only US$6.1 billion. It is also interesting to note that the low-income food deficit countries import only 3.6 percent of the fish worldwide and export 17.9 percent. Fish are clearly a source of hard currency for many low-income food deficit countries. Finally, the importance of organized trading blocs and arrangements can again be seen from these data. As a group, the members of the European Community are the leading fish importing bloc in the world, with 33.7 percent of total imports. Japan is second at 31.8 percent with the loose confederation of NAFTA counties third at 15.6 percent.

3. SEAFOOD-BORNE DISEASE AND ILLNESS

Responsibility for the collection and recording of data on disease and illness when seafood is implicated on a worldwide basis is spread among a large number of agencies across many countries. Even within countries, multiple agencies or organizations are often involved. In Europe, data on food-borne illnesses is collected and reported by member country participants of the European World Health Organization (WHO) Surveillance Programme for Control of Food-borne Infections and Intoxication's (FAO/WHO 1995, 1992, 1990). The quality and detail of the data are dependent on each reporting member country. For the European Union, all member countries participate, with the most complete data for seafood-borne disease and illness reported by Denmark, Finland, Germany, Netherlands, Spain, Sweden and the United Kingdom. The European Union has also initiated a Rapid Alert System for food. This system is used to notify all member countries of the European Union when any member country detects unsafe food products. The food product, the cause of the danger and the country of origin are reported.

In the United States, the major sources of information on seafood-borne disease and illness are the Centers for Disease Control (CDC) Food-borne Disease Outbreak Surveillance Program and a data base on shellfish-associated food-borne cases maintained by the Food and Drug Administration (FDA) Northeast Technical Support Unit. The CDC data are derived from reports of food-borne outbreaks submitted by state health departments to the CDC. The FDA data come from books, news accounts, CDC reports, city and state health department files, Public Health Service regional files, case histories and archival reports (Ahmed 1991). Seafood-borne illness data for Japan are published annually by the Veterinary Sanitation Division, Environmental Health Bureau, Ministry of Health and Welfare, as part of the annual statistics for all food-borne illnesses. The number of incidents (outbreaks), patients (cases), and deaths are recorded (Japan Ministry of Health and Welfare 1987-1996). Data for Canada are collected by the Fish Inspection Directorate, Canadian Food Inspection Agency, Government of Canada. The data report annually the cause of illness, description of product causing the illness, product type, country of origin and the numbers of incidents and cases.

Seafood-borne disease and illnesses reported by each reporting area or system represent the minimum number of actual seafood-borne cases that occur. It is highly likely that many seafood-borne illnesses (like all food-borne illnesses) are not reported by the patient nor recognized as a food-borne illness. However, these data collection agencies provide the only reliable sets of data available.

3.1 European Union

Available data for the European Union (FAO/WHO 1995, 1992, 1990) for those member countries with more complete data usually report the number of outbreaks when fish and shellfish are implicated as the source of the outbreak[4]. The data reported do not usually attribute the number of cases[5] of disease and illness resulting from the outbreaks. Disease or illness outbreaks from fish and shellfish between 1983 and 1992 ranged from 1.9 percent of total food-borne outbreaks in United Kingdom (Scotland) to 12.4 percent in Denmark. When the known food source was identified the range of fish and shellfish outbreaks was from 4.4 percent in the United Kingdom (England/Wales) to 16.1 percent in Finland (Table 2).

The Food and Veterinary Office of the European Union has also initiated a Rapid Alert System for food. This system is used to notify all member countries of the European Union when food products are detected that are a source of danger to health. The source of danger and the country of origin are reported. Between 1992 and November 1997, the 71 seafood alerts from this system represented 42.5 percent of all food alerts. Seafood products implicated and the number of the 71 alerts in which each was implicated were: live mussels (14), tuna fish products (9), fish products, oysters, squid, and chilled raw sole (4 each), shrimp, octopus and seafood (3 each), shellfish, crawfish, scallops, cuttlefish, anchovy and frog legs (2 each), and Nile perch, frozen mussels, frozen perch, bivalve molluscs, king prawn, salmon, chilled raw mullet fillets, fish brochettes, canned fish, clams, frozen mussels (1 each).

Table 2.

Summary of the total number of food-borne illness outbreaks attributed to fish and shellfish, selected countries of the European Union, 1983 to 1992

Country (a)	Outbreaks	Percent of total food-borne outbreaks	Percent of total food-borne outbreaks when implicated food source known
Denmark	50	12.4	13.8(b)
Finland	45	11.9	16.1(c)
France	125	7.4	10.2(d)
Germany	23	4.2	7.1(e)
Netherlands	103	5.9(f)	7.8(g)

Spain	283	4.1	5.9
Sweden	20	8.4	10.5
UK(England/Wales)	105(h)	3.2	4.4(i)
UK(Scotland)	37	1.9	4.6

Source: Derived from: (FAO/WHO 1995, 1992, 1990)

(a) Data too incomplete to report the remaining countries

(b) 1983-1989

(c) 1983-1989

(d) 1983, 1988-1992

(e) 1983-1989

(f) 1983-1989, 1991

(g) 1983-1989

(h) 1983-1984, 1986-1991

(i) 1983-1984, 1986-1991

Principal sources[6] of danger to health[7], and the number of times each was reported were: *Salmonella* (27), diarrhetic shellfish poisoning (16), paralytic shellfish poisoning (8), *Vibrio parahaemolyticus* (7), histamine (5), *Vibrio cholerae* (4), *Listeria monocytogenes* (3), *Staphylococcus* and unspecified contamination (2 each), and *Bacillus cereus,* scombroid toxin, botulism, *Clostridium bifermentans,* packaging problem (1 each).

Thirty-three different countries were listed as the exporting country of product on which an alert was reported. Each is listed with the number of times a product originating in that country received an alert: India (7), Portugal and Thailand (5 each), Spain and China (4 each), United Kingdom, Senegal, Guinea and Peru (3 each), France, Italy, Morocco, Kenya/Uganda, Turkey, Ivory Coast, Nigeria, Vietnam, China, Mauritania, Albania (2 each), Belize, Greece, Shetland Isles, New Zealand, Sweden, Sri Lanka, Oman, Malaysia, Denmark, Tunisia, Kenya, and

Netherlands (1 each).

3.2 Japan

Categories reported by the Japanese data collection system are shellfish, swellfish (puffer fish) and other, and fish paste and other products of fish and shellfish. Ninety-three percent of the seafood-borne illness outbreaks in Japan from 1987 to 1996 are from fish and shellfish, resulting in 87 percent of the cases (29 012) (See Table 3). Thirty-four deaths occurred during the ten-year period. All but two were from swellfish. Total outbreaks from 1987 to 1996 numbered 1 475 resulting in 33 253 cases.

Table 3.

Summary of the number of seafood-borne illness outbreaks and cases

attributed to fish and shellfish in Japan, 1987 to 1996

Category	Outbreaks	Cases	Deaths
	Number		
Shellfish	391	9 050	2
Swellfish	282	470	32
Other	710	19 492	0
Total fish and shellfish	1 383	29 012	34
Fish paste	20	959	0
Other	72	3 282	0
Total products of fish and	92	4 241	0

shellfish			
Total	1 475	33 253	34

Source: Derived from (Japan Ministry of Health and Welfare 1987-1996)

When the cause of the food-borne illness is known, 18 percent of the outbreaks are from all fish and shellfish sources resulting in nine percent of the cases. Twenty-six percent of food-borne illness deaths in Japan are from all fish and shellfish and products of fish and shellfish (See Table 4). For fish and shellfish, most illnesses caused by bacteria are from *Vibrio parahaemolyticus* at 75 percent of bacterial disease cases. *Salmonella, Staphylocococcus aureus, Escherichia coli* and *Clostridium perfringens* are the other major sources of illness. For products of fish and shellfish, these same five bacteria are the leading causes of illness but the distribution of cases among the bacteria is more evenly spread (Table 5). Natural poisons and chemical substances rank six and seven among both fish and shellfish-borne diseases and fish and shellfish product-borne illnesses.

Table 4.

Percentage of total food-borne illnesses attributed to seafood-borne illness outbreaks, cases and deaths in Japan, 1987 to 1996

Category	Outbreaks	Cases	Deaths
	Percent		
As percent of total known outbreaks			
Fish and shellfish	24	11	49
Products of fish and shellfish	2	2	0
Total fish and shellfish	26	13	49

As percent of total outbreaks			
Fish and shellfish	17	8	47
Products of fish and shellfish	1	1	0
Total fish and shellfish	18	9	47

Source: Derived from (Japan Ministry of Health and Welfare 1987-1996)

Table 5.

Summary of the number of seafood-borne illness outbreaks and cases by known causative agent in Japan, 1987 to 1996

Causative agent	Fish and shellfish		Products of fish and shellfish	
	Outbreaks	Cases	Outbreaks	Cases
Salmonella spp.	57	3 145	12	806
Staphylococcus aureus	43	958	28	1 068
Clostridium botulinum	0	0	9	21
Vibrio parahaemolyticus	680	17 685	27	943
Escherichia coli	18	930	1	362
Clostridium perfringens	4	537	5	868

Bacillus cereus	2	47	0	0
Yersinia enterocolitica	0	0	0	0
Campylobacter jejuni/coli	4	88	0	0
Vibrio cholerae non-O1	3	28	0	0
Other	4	43	0	0
Bacteria	815	23 461	82	4 068
Chemical substance	23	505	7	134
Natural poison	333	637	1	12
Unknown	163	4 140	2	34

Source: Derived from (Japan Ministry of Health and Welfare 1987-1996)

3.3 Canada

From 1991 to 1997, a total of 78 seafood-borne illness outbreaks resulting in 169 cases were recorded in Canada. The top three causes for outbreaks were from histamine, fecal coliforms, and decomposed products, which accounted for 62 percent of the cases. The top three reasons for total number of cases were from histamine, decomposed product and paralytic shellfish poisoning, together representing 60 percent of all cases (See Table 6).

Table 6.

Summary of the number of seafood-borne illness outbreaks and cases

in Canada by causative agent, 1991 to 1997

Causative agent	Outbreaks	Cases
Histamine	19	55
Fecal coliforms	15	15
Decomposition	14	26
Paralytic shellfish poisoning	6	21
Ciguatera toxin	6	14
DSP	4	4
Staphylococcus aureus	2	2
High bacteria count	2	2
Escherichia coli	2	3
Vibrio parahaemolyticus	2	2
Tetramine	1	2
Salmonella	1	12

E. coli and Salmonella	1	1
Salmonella and S. aureus	1	4
Allergy to undeclared ingredient	1	1
Parasites	1	5
Total	78	169

Source: Derived from (Andruczyk 1998)

A total of 29 different species of fish and shellfish and or seafood products were implicated in seafood-borne illnesses. The top six in number of outbreaks were mussels (13), clams (12), tuna (10), barracuda (5), and marlin (3). These six represented 56 percent of the outbreaks. The top seven in number of cases were tuna (37), mussels (28), clams (20), barracuda (13), lobster tails (12), marlin (9) and oysters (9), representing 76 percent of all outbreaks. All other species or products implicated (one to three outbreaks; one to six cases) were whelk, mahi mahi, mackerel, swordfish, crab meat, salmon, oysters/quahogs, clams and dips, haddock and clams, halibut, sole fillets, sharks, scallops, salmon/shrimp/scallops, pollock, chicken haddie, shrimp, quahogs, kippers and parrotfish/doctorfish.

Seafood products causing illnesses in Canada from 1991 to 1997 came from 13 different countries or groups of countries. The top three countries in products causing outbreaks were Canada (40) and the United States (19), representing 76 percent of the outbreaks. Other countries implicated in one to four outbreaks and/or one to six cases were Singapore, Ecuador, Thailand, China, Canada/United States, Peru, India, Cuba, Fiji, Guyana and Trinidad/Tobago. Four outbreaks (six cases) could not be traced to the product source.

3.4 United States

In the United States, seafood-borne disease or illness reported by the Centers for Disease Control from 1978 to 1987 totaled 558 outbreaks involving 5 980 cases. However, fish and shellfish constituted only 10.5 percent of all outbreaks and 3.6 percent of all cases when food-borne illnesses from all foods are considered. The number of people made ill from beef (4 percent) and turkey (3.7 percent) exceeds the seafood total, whereas pork (2.7 percent) and chicken (2.6 percent) are slightly lower. If fish and shellfish (2.3 percent) and fish (1.2 percent) are considered separately, the number of reported cases from each is lower than for any animal meat product. However, when only muscle foods (red meat, fish, poultry) are consumed, seafood-borne illness represent 56 percent of all outbreaks and 21 percent of all cases when incidents of unknown etiology are included. These data and those following for the United States are available in more detail (Ahmed 1991).

From 1978 to 1987, the CDC reported 38 seafood-associated outbreaks (351 cases) related to finfish and other non-shellfish sources. All but three outbreaks were from infectious agents associated with processing and preparing the seafood. Unknown agents caused another 16 outbreaks (203 cases). Forty shellfish-associated outbreaks (476 cases) were reported from known pathogenic sources. Another 88 outbreaks (3 271 cases) were from unknown sources. Forty-nine percent were due to infectious agents generally associated with fecal pollution, and 46 percent were from infectious agents generally associated with processing and preparation. From 1978 to 1987, the NETSU reported 2 198 cases of shellfish-associated outbreaks. Naturally occurring aquatic agents caused 15 percent of the outbreaks and 85 percent were due to infectious agents generally associated with fecal pollution. An additional 5 098 cases could not be associated with a known agent (Ahmed 1991).

CDC reported shellfish outbreaks (40 when etiology known) were associated with *Vibrio parahaemolyticus* (15), Hepatitis A. virus (7), *Shigella* (4), *Salmonella* (3), *Vibrio cholerae* O1, other viral, Non-O1 V. c*holerae, Clostridium perfringens, Bacillus cereus* (2 each) and *Staphylococcus* (1). Cases (476 when etiology known) were associated with *V. parahaemolyticus* (176), S*almonella*, non-typhi (80), *Shigella* (77), other viral (42), Hepatitis A. virus (33), *Clostridium perfringens* (28), *V. cholerae* O1 (14), Non-O1 *V. cholerae* (11), *Staphylococcus aureaus* (9), and *Bacillus cereus* (6). NETSU cases (2 182 when etiology known) were associated with unspecified hepatitis (1 645), Non-O1 *V. cholerae* (120), *V. vulnificus* (100), *Shigella* (84), Norwalk and related viruses (82*), V. parahaemolyticus* (52), Hepatitis A. virus (45), *Plesiomonas* (18), *Campylobacter* (16), V. *cholerae* O1 (13), *Aeromonas* (7), *Vibrio mimicus, Vibrio hollisae, Vibrio fluvialis* (5 each), Non-A, non-B hepatitis (1).

Finfish and other seafood-associated outbreaks (35 when etiology known) were from *Clostridium botulinum* (26), S*almonella* (non-typhi), *Shigella* (3 each), hepatitis A. virus (2 each), and *Staphylococcus aureus, Clostridium perfringens, Vibrio cholerae* O1 and *Bacillus cereus* (1 each). Cases (312 when etiology known) were from Hepatitis A. virus (92), *Salmonella* (67), *Shigella* (60), *Clostridium perfringens* (46), *Clostridium botulinum* (38), *Bacillus cereus* (4), *Staphylococcus aureus* (3) and *Vibrio cholerae* O1 (2).

Naturally occurring fish and shellfish poisons that have been problematic in the United States are ciguatera, scombroid poisoning and paralytic shellfish poisoning (PSP). From 1978 to 1987, ciguatera was responsible for 179 outbreaks

(179 cases), scombroid poisoning for 157 outbreaks (757 cases) and PSP for 13 outbreaks (137 cases). Most ciguatera outbreaks were in Hawaii, Guam and Puerto Rico with the implicated fish being in order of incident amberjack, snappers, groupers, goatfish, Po'ou, jacks, barracuda, Ulua, wrasse, surgeonfish, moray eel, papio, roi, rabbit fish and parrot fish (Ahmed 1991). Scombroid poisoning resulted from consuming mahi mahi, tuna, bluefish, raw salmon, marlin, mackerel, blue ulua, opelu, and redfish. PSP incidents were the result of consuming mussels, clams, oysters and scallops. More details on these seafood illness implications and other diseases such as those resulting from chemical contamination are available (Ahmed 1991).

For the United States, crabs, shrimp and oysters are the most often implicated sources of pathogens that naturally occur in marine or freshwater environments. Most illnesses from naturally occurring organisms are associated with eating under-cooked or raw shellfish, particularly raw molluscan shellfish (Ahmed 1991). Other seafood problems are normally due to recontamination or cross-contamination of cooked product by raw product, followed by time/temperature abuse.

4. VALUATION OF SEAFOOD SAFETY

4.1 Consumer Perceptions of Seafood Safety and Quality

Safety and quality regarding seafood have very different meanings to the microbiologist and seafood technologist than they do to the consumer. Safety usually refers to the risk level associated with illness or death caused by the consumption of a seafood product that is contaminated with a microbiological or parasitic organism, a naturally occurring poison or a chemical contaminant. Quality is most often related to appearance, odor, flavor and texture. Consumers and media often mix the two concepts, when in fact low quality seafood can be quite safe to eat and seafood with low-risk safety factors, but high in quality, might not actually be considered high quality by a consumer. In addition, many sellers of seafood have limited understanding of consumers' preferences for seafood, even if they could be recognized. A more detailed discussion of these issues is available (Anderson and Anderson 1991).

Quality and safety become multi-dimensional and consumers have great difficulty in determining and observing actual seafood quality (Anderson and Anderson 1991). These authors list the following as some of the attributes that affect seafood quality: nutritional value, incidence of parasites, presence of micro-organisms and bacteria, shelf life, taste, level of additives, the use of certain treatments such as irradiation, the presence of pesticides or preservatives, discoloration, size, presence of bones, scars or cuts, odor and uniformity among others. A mixture of safety and quality factors can also affect the acceptance of seafood in international trade and ultimately affect the balance of trade of both developed and developing countries. Thus, in the context of this paper, both safety and quality will be considered the same when one or both affects consumer acceptance, consumer illness and/or trade in seafood products.

4.2 The Market for Seafood Safety

Consumers of seafood want to benefit from seafood safety, but seafood safety is a commodity that cannot be easily purchased in the marketplace. Safety is only one of many implicit characteristics of seafood that influences the purchasing behavior of the consumer at various prices and quantities. Because of this, producers cannot normally charge a higher price for "safer" seafood in order to cover higher production costs from producing safer seafood. Their competitors will make the same safety claim, even through the claim may be false. The absence of accountability and inability of consumers to observe safety then leads to market failure since unsafe/low quality products can bring premium prices in the short run for individual sellers and long-run negative impacts affect all sellers (Anderson and Anderson 1991).

In order to ensure safe seafood then requires government intervention or regulation. The basic market questions for food safety and nutrition are important to understand (Weiss 1995). What mechanisms will satisfy consumers to receive the food safety and quality level they want to purchase and what mechanisms will provide producers the incentives to furnish that level of quality? While the seafood industry may develop its own testing methods to enhance its product image, such techniques as inspection, certification, consumer and producer education, labeling, handling, and processing enhancements such as irradiation are often introduced to intervene in the imperfect market situation. In effect, consumers are relying on producers to provide safe food, but the producers cannot always verify or guarantee the safety of the food. The taxpayers are relying on the government to provide effective food monitoring systems, but they cannot directly determine if the systems are in place and effective.

If the market is not perfectly competitive and it becomes necessary for the government to intervene to regulate the safety and quality of food products, this can be achieved in three ways (Choi and Jensen 1991). The regulatory authority can provide information to consumers regarding the risk of various foods to various consumer populations and it can regulate industry output directly in order to reduce hazards to consumers. It can also regulate the level of seafood safety through various risk reducing programmes such as Hazard Analysis Critical Control Point (HACCP) programmes.

An adequate framework for estimating consumer benefits from food safety policies should allow the prediction of what actions consumers would take with complete knowledge. The framework should also predict what real consumers with limited knowledge would do under various policy scenarios with the make-up of the full range of policy scenarios known (van Ravenswaay and Hoehn 1995). They provide a theoretical model that allows the determination of consumer response to four ways that consumers respond to food hazards: product avoidance, brand-switching, averting and mitigating actions.

Seafood safety thus must be of concern to both the producers and consumers of seafood. Both producers and consumers need to change their actions in order to minimize the health risk from consuming seafood. This creates the need for both public (regulatory) action with the suppliers of seafood and private consumer (increased knowledge) action on the part of the purchasers of seafood. The obvious question then arises. Is the public benefit (or value) derived from regulatory programmes designed to minimize the health risks from consuming seafood greater than the costs of implementing the programmes? Costs all along the production chain must be considered, beginning with the private costs borne by the producers and suppliers and ending with the public costs of implementing and maintaining regulatory programmes. Are consumers willing to pay (and at what level of seafood price increases) the additional costs (reflected through higher seafood prices) resulting from seafood safety inspection programmes, and are they willing to pay higher public costs (through higher taxes) to support the programmes?

4.3 Economic Concepts of Valuation

A concise discussion of valuation research (van Ravenswaay 1995) provides the basis for the following summary[8]. Benefit-cost analysis represents the first attempts by economists to conduct research designed to evaluate the effects of government regulations, policies and programmes. This technique was used to advise policy makers if public resources invested in public programmes (such as a seafood regulatory programme) were giving the greatest net benefits. It was relatively easy to determine which costs should be measured (but not always easy to measure them) and much more difficult to determine which benefits should be measured (and even harder to actually measure them).

Markets exist for most inputs into the regulatory process, and prices and quantities can be learned or approximated from actual market transactions (e.g. the cost for a seafood plant to comply with a regulation or the cost to government of hiring an additional inspector). No primary market exists for such items as improved seafood safety. Thus, it became necessary to develop techniques to estimate the demand for non-market goods such as improved food safety. Economists refer to this as non-market valuation research. The responsibility for developing these techniques has been primarily the public sector, since the private sector has had little incentive to determine the costs of improving public programmes (e.g. the effect of improved seafood safety).

4.4 Food Safety Valuation

A perfectly competitive market with no regulations and adequate income will cause food to be available. However, this is not the real situation and market failures cause public intervention in the way the food supply is produced, processed and distributed. Public intervention in developed countries may include such interventions as providing nutritional education so that consumers can make informed choices and thus maintain higher levels of health or creating regulatory programmes designed to create very low levels of health risk associated with consuming foods purchased in the marketplace. Public intervention in developing countries might range from guaranteeing that an adequate supply of food exists to helping producers solve sanitation problems so that seafood can be exported and used as a source of hard currency for the exporting country. Thus, it became necessary to develop both theoretical concepts and practical methods to place values on food safety and food safety programmes (van Ravenswaay 1995). The argument is made (van Ravenswaay 1995) that economics research on food safety and nutrition issues likely needs to include three types of research: non-market valuation research; programme evaluation research; and product marketing research[9].

Most non-market valuation research originally focused on measuring the benefits from health, safety and environmental programmes that became prominent in the early 1960s. It has since expanded to a number of areas. Food safety research grew from this research, with a focus on estimating the value of preventing deaths or disease in a given population of consumers, and in measuring the value of reduced morbidity and illness days. In other words, was the cost of increased food safety resulting from new (or expanded) food safety programmes lower than the benefits derived by the consumers? The earliest attempts in this area of work measured cost savings as the value of saving lives by estimating the present value of foregone earnings net of consumption, plus medical costs associated with the illness. Later studies included more economic costs (e.g. value of lost leisure time, or lost household production) with the estimates made from actuarial data. Most of the early work by economists focused on estimating benefits. However, it is also important to understand costs, and how they can be applied in evaluating food safety (MacDonald and Crutchfield 1996).

Programme evaluation research attempts to measure the effectiveness levels of public programmes and the extent to which the public programme achieved its goals. An example would be to measure the effectiveness of a programme designed to educate consumers on the safety aspects of seafood or of nutritional attributes of seafood or the costs and benefits of a seafood HACCP programme.

Product marketing research is also similar to non-market evaluation research in that techniques used in both try to measure the effect on consumer behavior of goods that do not exist in the marketplace. An example would be to measure what consumers would pay for a new or different attribute in a food product such as "low fat" or certain nutritional attributes.

4.5 Estimation Methods

4.5.1 Cost-Of-Illness (COI)

The first attempts by economists to value food safety used an estimate of cost savings as an estimate of the value of saving lives. The present value of forgone earnings less consumption plus medical expenses was used as the value of cost savings created by safer food. More recent estimates have included the value of lost leisure time, the opportunity costs of lost household production and other measures using a technique called the cost-of-illness (COI) method. This approach estimates the resources society will save by avoiding the food-borne illness. In most cases this technique uses actuarial data and data observations which reflect the actual actions of individuals on which to base the cost saving estimates. Social costs include costs to individuals, industry costs and public health surveillance costs. Costs to individuals can be measured through documenting medical costs, income or productivity loss, pain and suffering, leisure time costs, child care costs, risk aversion costs, travel costs, and vocational and physical rehabilitation costs, among others. Industry costs include product recalls, plant closings and cleanups, product liability costs, reduced product demand, and insurance administration. Public health surveillance costs include disease surveillance costs, costs of investigating outbreaks and costs of cleanup. Several authors (Roberts and Foegeding 1991; Busby et al. 1996) provide more detail and specific lists on the individual components of the costs to society of food-borne illnesses. One concern with this approach is that the cost-of-illness that is determined may not measure what the individual will actually pay to avoid the illness. COI can be interpreted as measuring the cost of an illness to a specified economy (e.g. a certain country) in the form of its effects on the current and future value of goods and services produced by the economy of that country.

4.5.2 Willingness-to-Pay (WPI)

The most theoretically correct measure to use is the willingness-to-pay technique (van Ravenswaay 1995). This actually measures peoples' willingness-to-pay for the reduced risk of death or illness from consuming food in a specified population of people. This technique uses actual market observations on which to base the estimates or through constructing market experiments and using a technique called contingent valuation (CV). Another method used to value food attributes is hedonic pricing. This technique is normally used to estimate the value that consumers place on various attributes of a food commodity. An example would be the value that consumers place on various fatty acids contained in fats and oils or on other nutritional aspects of a food item. This estimation method differs from CV in that the estimation function uses observed market price and consumption data. Hedonic pricing provides an objective valuation of food attributes such as nutrition and fat content while CV deals with subjective valuation of food attributes such as food safety (Kim and Chern 1995). Since food safety is the principal focus of this paper, see the Kim and Chern article for further discussion of hedonic pricing.

While the WTP method is the most theoretically correct based on economic theory, its use has been challenged. The United States Office of Management and Budget (OMB) has issued guidelines that establish a preference for using observational or behavioral data in benefit cost estimates that measure the impact of major rules such as the benefits and costs of seafood safety programmes or regulations (Belzer and Theroux 1995). OMB mandates that when benefits come from risk estimates and an agency chooses to estimate benefits with point estimates, then the expected values of the risk estimates must be used. The OMB guidelines acknowledge that it is difficult to estimate the WTP of an individual for commodities (e.g. food safety) not traded in the market because it is impossible to use observational data and methods. But, OMB also indicates that using CV methods warrants an additional burden of analytical rigor. The same is true regarding CV used to evaluate food safety regulations and benefits and costs (Belzer and Theroux 1995). CV critics argue that its problems are insurmountable and its use should be abandoned. OMB does not take this position, but it does impose an extra burden on deriving estimates not based on real world behavioral data.

5. PRACTICAL APPROACHES TO VALUING SEAFOOD SAFETY

Most current major health risks associated with seafood safety originate in the environment and should be dealt with by control of harvest or at the point of capture. With minor exceptions, risks cannot be identified by an organoleptic inspection system. Inspection at the processing level is important to maintain the safety of seafood, but there is little evidence that increased inspection activities at this level would effectively reduce the incidence of seafood-borne disease (Ahmed 1991). However, when quality considerations are taken into account, seafood inspection, and training and process monitoring programmes from producer to consumer can be expected to reduce the number of illnesses resulting from seafood.

While the economic theory which guides the estimates for valuing seafood safety still needs major development, at the same time it is necessary to proceed with practical estimates needed to evaluate current programmes and practices (Curtin and Krystynak 1991). First, the health risks of various diseases must be converted to a common monetary value, with these costs, or the amount they are reduced, representing the benefits of disease reduction. Second, the costs and effectiveness of control strategies must be determined. Third, the costs of disease must be compared to the costs of controlling it to determine worthiness to society of implementing the control.

Costs must be defined at three levels. Society level costs are defined as hospital and medical costs, loss of productive output, disease surveillance and investigation costs and loss of life. Private level costs which are specific to the affected individual include loss of leisure time, travel of caretakers to hospital, willingness-to-pay and pain and suffering. Finally, firm level costs are measured by such items as loss of sales and consumption, product recall or discarding and legal costs and settlements. In order to be useful, all these costs must be translated into monetary values, which is a very difficult task. The interested reader can follow this technique using *Salmonella* and the Canadian poultry industry (Curtin and Krystynak 1991).

To define costs and benefits at all levels, it is useful to demonstrate an example of a regulation imposed by a country for the purpose of improving the safety of a fish product caught and processed by industry in that country. Within the country of the regulation, input suppliers, fishermen, fish processors, fish distributors, consumers and government incur costs and benefits. In other countries, fishermen, fish processors, fish distributors, consumers, governments of the countries, and any relevant union of governments incur costs and benefits. Examples of the kinds of costs and benefits that would be incurred at each impact level both within the country where the regulation is implemented and outside the regulated area are shown in Table 7.

Table 7.

Example of potential short-run benefits and costs of a fish safety regulation

that changes fishing/processing practices

Impact levels	Potential benefits	Potential costs
Within regulated country (or state)		
Input suppliers	Increased sales of inputs used in new/alternative fishing or processing practices	Lost sales of inputs used in fishing or processing practices
Fishers	Higher price for safer	Reduced landings. More costly

	product. Longer term acceptance of product and fishing practices (production stability).	fishing practices. Increased handling costs.
Fish processors	Higher price for safer product that meets regulation.	Higher input costs, including fish. Higher costs due to more regulated processing practices.
Fish distributors	Higher price for seafood products that meet regulation.	Higher product costs. Lack of product (reduced supply due to reduced landings). Possible unusable inventories. Changes in distribution practices (if product unregulated from other countries)
Consumers	Better health. Longer life.	Higher price. Fewer seafood choices. Information needs to determine product safety.
Government	Lower society-borne medical costs.	Cost of regulatory programme.

Impact levels	Potential benefits	Potential costs
Outside regulated country (or state)		
Fishers	Less competition from fishers in regulated country. Higher prices for substitute fish.	Possible narrower market for fish if don't match regulated fish practices. More costly fishing and handling costs.
Fish processors	Higher price of product sold in regulated	Higher input costs. Higher costs due to processing practices

	country. Higher price for regulated country's fish sold in non-regulated country.	needed to meet standards in regulated country.
Seafood distributors	Higher price for seafood products that meet regulated product standards.	Higher product costs. Lack of product. Possible unusable inventories. Changes in distribution practices (to handle regulated versus non-regulated product).
Consumers	Better health. Longer life.	Higher prices. Fewer fish choices. Information needs to determine product safety.
Government	Lower society-borne medical costs.	Coordination of programmes with regulated country.
Union of governments (or federal)	Lower society-borne medical costs.	Coordination of programmes with regulated country and union of countries.

Source: Adapted from Caswell (1988)

5.1 Measuring Risks

One major problem in using any estimation technique is the identification and measurement of risks of contracting a food-borne disease (Roberts and Foegeding 1991). Another major problem is that it is difficult to make a direct connection between the econometric model using actual data and the theoretical base on which the model is built. Several consumer demand models for food safety exist and many economists are working hard to overcome the data problems in current studies (Smallwood and Blaylock 1991). An excellent summary of the theoretical considerations of valuing food safety and comparison of the COI and WTP methods exist as summarized here (Roberts and Marks 1995). Comprehensively, they maintain that theory that evaluates social preferences for food safety should contain six elements: (1) preferences for collective action as well as preferences for self-protection by industry and consumers, including the cost of choices avoided;

(2) determination of the optimal level of food safety and the demand for governmental intervention to administer and enforce the "optimal" level of food safety; (3) the costs of all participants in the marketplace and regulatory agencies to keep informed of the latest scientific developments linking diseases with food, identifying high risk individuals and high risk consumption practices, and identifying high risk food production and marketing practices; (4) the benefits to society of reduced human illness costs at the current level of food safety for microbial contaminants; (5) the willingness of high-risk and risk-averse individuals to pay for safer food as well as risk neutral consumers; (6) the willingness of society to pay for the safety of others.

Probably the greatest amount of activity by economists concerned with food safety economics in recent years has dealt with improving the various methods of estimating the benefits resulting from reducing the health risks from food, instead of estimating the actual costs and benefits. Until all theoretical questions can be adequately answered, backed with data sources and techniques that make WTP questions reliable, then the COI is the best method of evaluating the value to society of food safety (Roberts and Marks 1995). COI estimates also are usually lower than WTP estimates, and are more conservative estimates. The interested reader is referred to the article for detailed comparisons of the uses of COI and WTP at the government, industry and individual levels (Roberts and Marks 1995).

5.2 Data Problems

Data sources and reliability create major problems in the estimation of the value of food safety. Statistics on food-borne disease in developed countries represent only a small amount of the actual numbers of illnesses resulting from food. In developing countries, food-borne illness is recognized as a widespread problem (Abdussalam and Grossklaus 1991) with estimates of unreported cases that approach 90 percent in non-industrialized countries. Data problems can be summarized into three areas (Steahr 1995). First, it must be assumed that food-borne illness can be distinguished from other types of illness and the transmission method of contracting the disease. Second, it must be assumed that the types of food-borne illnesses are known which then provides the basis for counting the persons contracting the disease. Third, no data base exists which contains all cases of food-borne illness. The available data sources and the way they are categorized in the United States are available (Steahr 1995). In addition to these costs, it is usually necessary to collect primary data from the fishing, processing and distribution level private firms in order to estimate the costs incurred by those firms. These data are time-consuming and expensive to collect.

5.3 Data Policy Issues

Four aspects of food safety relate to data used to inform public policy (Jensen et al. 1995). First, food safety data present a bad news/good news problem. In the short run, "bad news" must be endured while data are collected to document the severity of the problem. In the long run, data can document that food safety improvements are being made. Second, complete and well-integrated information bases on which to make food safety public policy decisions do not exist. Third, the costs of acquiring food safety data are high. Fourth, resource distribution among producers and consumers will be an issue. Cutting through all these issues is the situation that academic and agency structures do not always foster cooperation to solve these issues, not only within countries, but also among them.

6. HACCP IN THE SEAFOOD INDUSTRY

HACCP programmes in the United States as monitored by the United States Food and Drug Administration focus on maintaining safety standards for seafood. That is, safety assurance, not quality assurance, is the cornerstone of the programme. HACCP programmes in other countries often include quality standards as well as safety standards in programme design. In European countries, HACCP is more broadly defined as part of an overall ISO 9000 quality system. Seafood processing plants can be certified to meet various ISO 9000 standards. The goal of ISO 9000 is to achieve quality that ensures the economical production of consistent products that meet or exceed customer requirements and conformance to regulation (Bogason 1994). Various levels of ISO-certification can be achieved ranging from the more comprehensive ISO-9001 (model for quality assurance in design/development; production; installation; and servicing) to the more simple ISO-9003 (model for quality assurance in final inspection and testing). Some key reasons for using ISO standards are to provide direction, generate ideas for change, design or redesign systems, implement changes, measure results, and manage change through audits and reviews (Bogason 1994). The core of the ISO 9000 series of standards is the standards for quality systems. An organization can certify its quality system if it meets the demands of one or several of these standards. ISO 9000 describes the demands for a quality system that is to be used for managing the quality in the entire value chain, from developing products to delivery and service. The other standards for quality systems contain parts of this one, and consequently the contents of all the standards can be described by focusing on ISO 9001. Additional details and a study of the economic consequences of ISO 9000 is available on industry in Norway (Stemsrudhagen 1997). While this document focuses principally on HACCP (and seafood safety), it also covers quality aspects of seafood, and describes the use of HACCP as a business management tool in an ISO 9000-like context.

The use of HACCP in the seafood industry has taken on a global perspective in the production of fish and fishery products (Lima dos Santos and Sophonphong

1998). They report the results of an FAO survey that categorized the status of countries and the seafood industries in those countries in adopting seafood HACCP procedures. Countries whose governments and seafood industries which have adopted or decided to introduce seafood HACCP include Canada, Uruguay, Brazil, Chile, Ecuador, Australia, New Zealand, Thailand, Iceland, United States and more recently Argentina, Peru, Ireland, Cuba, Morocco, Norway, Sri Lanka, Vietnam and Bangladesh. A second group consists of countries whose governments have taken unilateral initiatives to introduce HACCP via regulations with limited success and cooperation between the regulatory authorities and the seafood industry. These countries include Mexico, Venezuela, and many member countries of the European Union, for example Italy, Germany and France. In a third group of countries, the private sector is taking the lead in voluntarily trying to introduce HACCP-based programmes regarding seafood export production. These include Madagascar, Venezuela, Honduras, Tunisia, Myanmar and Portugal. A final group consists of countries where governments have decided to apply HACCP but have not yet defined the process, including Japan, Russia and China. Remaining countries where the status of seafood HACCP is unclear include Pakistan, South Korea, Iran, Colombia, Panama, some East and Central European countries and most African States. More detail is available on seafood HACCP systems as constructed by different controlling authorities relating to Codex, and in Canada and the European Union (Barker and McKenzie 1997).

6.1 HACCP Defined

Hazard Analysis Critical Control Point (HACCP) is a preventative system of hazard control rather than one of reaction or point inspection to decrease a hazard. Food processors can use HACCP to identify hazards, establish controls and monitor the controls in the case of harmful microorganisms or chemical and/or physical contaminants in food. The use of the HACCP concept for food has its origin in the United States space programme in the early 1960s. In order to provide safe food during space flights, it was determined that a preventative system was best in order to minimize the risk of food safety hazards, rather than end product testing. The United States Food and Drug Administration (FDA) first required HACCP controls for food processing in 1973 for canned foods to protect against *Clostridium botulinum*, and recently has been required for seafood in the United States. HACCP has also been endorsed worldwide by Codex Alimentarius[10], the European Union and by several countries including Canada, Australia, New Zealand and Japan.

The first detailed publication in the United States of how HACCP could be applied to the seafood industry appeared in 1977, and except for low acid canned food, few attempts were made before 1985 to apply HACCP to seafood products. At that time HACCP was recommended as the most effective way to monitor the safety of fish and shellfish. The FAO Fish Utilization and Marketing Service began in 1985 to use HACCP in its training programmes and the United States National

Marine Fisheries Service (NMFS) developed a HACCP based programme for seafood (Martin et al. 1993). The Institute of Medicine, National Academy of Sciences, Committee on Evaluation of the Safety of Fishery Products published a major document on seafood safety in 1991 (Ahmed et al. 1991). The United States Food and Drug Administration issued its final rule to mandate HACCP for use in seafood processing plants in the United States effective 18 December 1997 (United States Food and Drug Administration 1995). The European Union formally shifted to the preventative systematic approach provided by HACCP in 1991 (EEC Commission Decision 1991b). The main technical characteristic of the new inspection and quality control procedures approved at that time was the adoption and enforcement of HACCP in European Union member countries and in those countries that wish to export to the European Union (Lima dos Santos, Josupeit and Chimisso dos Santos 1993).

HACCP is based on seven principles: (1) conduct hazard analysis and identify preventative measures; (2) identify critical control points (CCP); (3) establish critical limits; (4) monitor each CCP; (5) establish corrective action to be undertaken when a critical limit deviation occurs; (6) establish a record keeping system; (7) establish verification procedures. The interested reader can learn more about HACCP from a number of documents (Seafood HACCP Alliance for Training and Education 1997; United States Food and Drug Administration 1996) which provided the source of this summary.

6.2 Current Training Programmes

Two large-scale programmes provide examples of the intensity of seafood HACCP training activities currently in progress. In 1985, the FAO Fish Utilization and Marketing Service began to focus on HACCP as applied to the fishing industry. The core of this activity is the execution of courses, workshops, seminars, and the development of training materials relevant to developing countries needs (Lupín 1997; Lima dos Santos and Lupín 1997). The courses cover not only the introduction of HACCP, but other related subjects combining theoretical presentations with practical work, comparative analysis of the requirements of the European Union and the United States with other workshops dedicated to economics, sanitation audits and verification and visits to processing plants. The courses range from three days to three weeks in length. Since 1986, over 3 000 persons from more than 80 developing countries of Africa, Asia, South Pacific, Latin America and the Caribbean have received training. Since 1991, the HACCP concept has been promoted in Central and Eastern Europe. The main objective of the programme is to train other trainers.

In the United States, an organized alliance of seafood industry trade organizations, Sea Grant universities and state and federal agencies with responsibility for seafood safety have developed a training curriculum and are conducting seafood HACCP training programmes (Seafood HACCP Alliance for

Training and Education 1977; Ward 1997). This programme includes a curriculum that trains both seafood processing plant employees and regulatory agency and academic personnel who are then qualified to conduct additional training courses. By the beginning of 1998, 525 trainers had received certificates from the United States Association of Food and Drug Officials (AFDO) for completing the course. Through these trainers, an additional 4 100 members of the seafood industry, over 2 200 regulators and seafood inspectors at the federal, state and local levels, and over 500 technical experts from academia and consulting groups have completed the training. The total includes 500 international graduates. Training through 1998 is expected to bring the total number of graduates to 10 000. The six-year programme began in 1994[11].

7. THE ECONOMICS OF HACCP

In addition to being recognized as an effective tool for achieving good production, sanitation, and manufacturing practices in food production, HACCP can also create economic benefits to firms, society and governments. At the society level the obvious issue is whether the benefits to society are greater that the costs to society of the programme. At the firm level, issues range from the cost of implementing a HACCP programme to how HACCP can be used as a process management tool. Finally, for government, the concern is the cost of implementing the programme and maintaining it as part of the cost to society of the programme. Some special considerations of seafood HACCP as it relates to society, industry and government are discussed in this section and then some estimates of the costs of implementing seafood HACCP programmes are summarized.

7.1 HACCP Benefits Considerations

7.1.1 Business Management Tool

From a business management perspective, HACCP is a process control technique that closely conforms to total quality management principles (Mazzocco 1996). Thus, HACCP should be examined for its usefulness in determining if the cost of developing processes which produce high quality products are less that the costs of poor quality. HACCP systems installed in suppliers' operations, manufacturing and processing plants should reduce costs of raw materials inspection, materials specification, raw materials inventory, and other costs associated with inputs (Mazzocco 1996). Awareness of suppliers' or processors' HACCP systems or knowing customers' needs for tolerances should reduce variability and costs of operations. Transmitting HACCP system requirements to customers or suppliers can also reduce marketing and sales costs. HACCP's preventive focus is seen as more cost effective than testing a product and then destroying it or reworking it

(Unnevehr and Jensen 1996). From an economics viewpoint it is implied that the marginal benefits of using HACCP to reduce food-borne illnesses are large. Said another way, the costs of implementing HACCP at a given time or place in the processing process are much less than the benefits to be derived. However, in order to really measure the costs, Unnevehr and Jensen argue that marginal benefit-cost analysis must be conducted at the point of each CCP, to determine which are the most economically effective to achieve a specified standard of risk reduction. Thus, HACCP can be viewed as a business management tool, although limited analysis has been done to this date in most industrial food settings, and in particular seafood plants, to estimate its value in this context.

For HACCP to produce these kinds of benefits as a process control mechanism will require substantial training of employees. Organizations that adopt quality management programmes invest substantial sums in employee training. Surveys indicate that 92 percent of manufacturing firms and 75 percent of service firms implementing a quality management programme use employee training to effect change (Mazzocco 1996; Hackman and Wageman 1995). Thus, HACCP systems will require initial and continued investment in human resources and the development and delivery of training programmes for employees. This will be easier in highly concentrated industries and much more difficult for the disaggregated seafood processing systems that are characteristic of the seafood industry on a worldwide basis.

Quality and safety economics for the seafood industry is thus the subject of current interest in both developed and developing countries of the world (Zugarramurdi, Parin and Lupín 1995). Current FAO programmes incorporate economics in the training curriculum focused mostly at the processing plant level. The cited FAO document is a training manual which covers production engineering, capital investment costs, production costs, microeconomic analysis of production, resource allocation, profitability and quality and safety economics. The FAO document includes how to analyze production and quality costs at the plant level and presents a prevention-appraisal-failure (PAF) model of quality costs. It also presents case studies of economic quality costs in seafood processing plants and discusses the cost of applying HACCP in seafood plants.

7.1.2 Trade Benefits

HACCP is also accepted by various governing bodies as a benefit to enhance trading between countries through two examples. First, in 1987 the International Organization for Standards (ISO) promulgated its ISO 9000[12] series of trading standards to enhance trade between members of the European Community and those wishing to do business with them (Mazzocco 1996; Dean and Evans 1994). Second, the United States Government in its rule mandating HACCP for seafood processors in the United States, included as a benefit its requirement that foreign seafood processors who export seafood to the United States must meet United

States HACCP standards (United States Food and Drug Administration 1995). Again, the European Union requires that third countries that desire to export fish to the European Union follow HACCP procedures in seafood processing. In other words, to trade you must follow HACCP, and thus having HACCP is a benefit, as compared to those countries that do not follow HACCP procedures. The same benefits are possible between trading firms within a country, i.e. between processors for further processing or between processors and wholesalers and/or retailers with whom they trade. The issue of HACCP in international trade is discussed in more detail in a later section of this document.

7.2 HACCP Cost Considerations

7.2.1 Market Structure

HACCP rules mandated across an industry will have different impacts on the industry, depending on the market structure of the industry. In general, HACCP rules will likely impose higher costs on small firms than on large firms. An example of this is provided by estimates of market structure change on the United States meat and poultry slaughter and processing industry predicted to result from HACCP. Industry leaders predict that the regulation will drive small producers out of business. The actual effects on small producers will depend on the cost disadvantage faced by small firms, and the degree to which small plants can raise prices in the event they face a cost disadvantage. It will also depend on the ability of small plants to occupy small market niches that allow them to pass along higher product costs. For the United States meat and poultry industry, economists predict that if small producers do exit the industry, the pattern will be an increase in the rate of exits and decrease in the rate of entries (MacDonald et al. 1996).

7.2.2 Policy Issues

Additional issues that must be considered for a complete evaluation of the benefits and costs of food safety risk reductions relate to information, public versus private intervention, accurateness of illness estimates, marginal benefit-cost analysis and efficiency in production. First, it will be necessary to evaluate the effectiveness of consumers in using information provided to them for use in making wise food purchase and consumption choices as a way to lower their food risks. Second, it will be necessary to determine whose responsibility it is to provide safer food. Industry argues for more consumer education while consumers argue for more regulation. The question of whom is responsible for the costs and who bears the risk is the real question. Third, the reliability of the benefits of increased food safety based on cost-of-illness estimates must be determined. Fourth, HACCP must be evaluated using marginal benefits and costs not only at the complete programme level, but also within the critical control points in order to make rational economic decisions regarding cost efficiency. Finally, it must be determined how HACCP will affect industry productivity, particularly in reference to changing industry structure, determining the most cost effective levels at which to apply HACCP, and how trade and international trade will be affected (Unnevehr 1996).

8. ESTIMATES OF HACCP IMPLEMENTATION COSTS

This paper documents all known studies worldwide focusing on the costs of implementing HACCP programmes in seafood plants and the willingness of consumers to pay for safer and higher quality seafood. All studies are referenced as well as personal communications references to document on-going work. An exhaustive literature review was conducted and an informal email and fax survey was sent in early 1998 to economists covering all areas of the world. The survey was sent to all members of the International Institute of Fisheries Economics and Trade, about 20 fisheries economists in eight European countries as members of the European Association of Fisheries Economists, the Commission of the European Union and the Australia and New Zealand Food Authority. Limited work in the economics of seafood safety and quality exists with all publications and projects found referenced in the appropriate places in this document.

A 1998 conference in the United States focused on the economics of HACCP across all food commodity sectors for which HACCP is a consideration (Unnevehr In Press). Topics of discussion included: (1) designing more cost effective food safety regulations; (2) measuring the costs/benefits of interventions at different points in the production process; (3) HACCP implementation in the United States and United Kingdom; (4) risks and costs of safety and quality improvement; (5) implications of HACCP for transactions costs and vertical coordination; (6) international comparisons of HACCP in food retailing (7) measuring the impact of regulation and user fees for food safety programmes in the United States. Five papers/posters in the conference focused on seafood HACCP as summarized in the following section on seafood costs at the firm level.

Several estimates of the costs and benefits of HACCP programmes at both the industry and firm level for seafood and for meat and poultry in the United States exist, and several studies are underway in the United Kingdom, Canada and Africa for seafood plants. The United States estimates were required due to the proposed adoption of HACCP regulations for seafood processors (United States Food and Drug Administration 1995) and the anticipated adoption of HACCP regulations for meat and poultry plants (United States Department of Agriculture 1996). Most benefits and cost estimates are at the society level or industry level, while some attempts are made to estimate costs at the plant or firm level.

8.1 Industry Level

8.1.1 United States Seafood

HACCP programmes for seafood processors in the United States were announced two years prior to becoming effective on 18 December 1997 (United States Food and Drug Administration 1995). The Food and Drug Administration (FDA) estimated benefits of implementing the HACCP programme for seafood range from US$1.435 to US$2.561 billion. This represents total discounted benefits beyond the fourth year after implementation using a discount rate of six percent. Benefits were estimated as cost savings resulting from reduction in illnesses from a variety of hazards contracted from eating various forms of seafood: *Anisakis simplex, Campylobacter jejuni,* Ciguatera, *Clostridium botulinum, Clostridium perfringens, Diphyllobothrium latum,* Giardia, Hepatitis A. Virus, Other Vibrios, *Salmonella non-typhi*, Scombrotoxin, Paralytic shellfish poisoning, *Shigella and Vibrio vulnificus*. Benefits included those derived from safety, nutrition, increased consumer confidence, rent seeking activities, expert advice and reduced enforcement costs. The cost of implementing the programme was estimated to range from US$677 million to US$1.488 billion. Cost estimates were based on several models of seafood processing plants and included such costs as training, HACCP plan refinement, sanitation audits, costs of implementing CCPs, equipment cleaning, record review, eliminating pests, and administration. Costs also were assigned to those activities that would be borne by domestic manufacturers and exporters, major plant repair and renovation, Sea Grant expertise, repackers and warehouses, rejected product at the harvesting level, shellfish vessels and foreign processors. Costs per plant for domestic manufacturers were estimated to be an average of US$23 000 the first year and US$13 000 per year in subsequent years. Prices for seafood were also estimated to increase by less than one percent in the first year and less that one-half of one percent in subsequent years with the larger increase expected to decrease consumption by less than one-half of one percent. It was recognized that small plants would suffer a greater impact than larger ones, but the entire reduction because of HACCP would be borne by the small plants that would exit the industry for other economic reasons.

8.1.2 United States Meat and Poultry

The United States Department of Agriculture, Food Safety and Inspection Service has issued guidelines for HACCP to be introduced for meat and poultry processing plants. Benefit estimates using the cost-of-illness method have been made for both the preliminary and final rules (Roberts, Busby and Ollinger 1996). Twenty-year benefits were calculated using two methods (value of a statistical life; combined human capital/willingness-to-pay), three levels of pathogen reduction targets (30 percent, 60 percent, and 90 percent), and two discount rates (3 percent, 7 percent). Twenty-year benefit estimates ranged from US$2.4 billion to US$213.9 billion based on this sensitivity analysis, showing how critical the assumptions are on which such estimates are made. The United States Department of Agriculture, Economic Research Service produced a final estimate ranging from US$7.13 to US$26.59 billion, using a 90 percent reduction rate in illness and death. Cost estimates were made by the Food Safety and Inspection Service and Texas A & M University, and include costs for implementing sanitation standard operating practices, HACCP planning and training, HACCP recording, temperature control, antimicrobial treatments, testing and process modification. Again, different assumptions led to widely ranging estimates. For example, HACCP training and planning costs ranged from US$61 million to US$136.4 million for the initial year across three alternative scenarios and from no cost to US$142.8 million yearly for subsequent years. Based on the final rule for this HACCP programme, final twenty-year costs were estimated between US$1.0 billion and US$1.2 billion or US$0.15 to US$0.18 per pound of meats processed. The Food Safety and Inspection Service in its final estimate of the benefits resulting from HACCP estimated that benefits exceeded costs for all but the lowest reduction level (10 percent) of illness and death. The implementation of HACCP was determined to be more costly for small plants than for large plants. Because of the high rate of turnover in small meat plants, it was difficult to predict and separate the impact on small plants because of the HACCP rule in contrast to natural turnover in the industry (Roberts, Busby and Ollinger 1996). A subsequent and expanded study estimated the benefits in the United States of the HACCP programme for meat and poultry of reducing medical costs and productivity losses from *Salmonella, Campylobacter jejuni/coli, E. Coli* O157:H7, *Listeria monocytogenes, Staphylococcus aureus,* and *Clostridium perfringens* (Crutchfield et al. 1997). Estimates of benefits ranged from US$1.9 billion to US$171.8 billion over 20 years, depending on the level of pathogen control. These benefits are estimated to exceed the costs of the HACCP programme, which are estimated at between US$1.1 and US$1.3 billion over 20 years.

8.1.3 Bangladesh Frozen Shrimp

During 1997 and early 1998 the Bangladesh frozen shrimp processing industry began upgrading plants to minimum sanitary and quality standards. HACCP plans are being implemented following these upgrades. An estimated US$17.6 million has been spent to upgrade plants and the total cost industry-wide to maintain a HACCP plan is estimated at US$2.2 million (Cato and Lima dos Santos In Press). The Government of Bangladesh has also spent US$202 thousand in 1997, will spend US$181 thousand in 1998, and predicts an annual expenditure of US$225 thousand each year after to maintain a HACCP monitoring programme. The Food and Agriculture Organization of the United Nations has spent US$72 thousand for HACCP training in Bangladesh. Total cost to upgrade plants and government facilities is US$18.0 million to date with US$2.4 million estimated each year after to maintain HACCP in the Bangladesh shrimp processing industry. The investment to date represents 9.4 percent of frozen shrimp export sales for one year and HACCP plan maintenance represents 1.3 percent of one-year export sales (Cato and Lima dos Santos In Press).

8.1.4 Other Estimation Techniques

Another technique can also be useful in estimating the economic impact on an industry of an imposed rule that affects sales, employment and value added in the industry. Input-output analysis can estimate the direct, indirect or induced effects of a change an industry has on the rest of the economy resulting from a change in that industry stimulated, for example, by a HACCP programme or a seafood regulation. However, the technique requires an input-output model be available for the economy with industry sector data at disaggregated levels that allows the seafood sector to be separated from the rest of the economy. This is difficult even in developed countries, and thus this technique has limited use. A model does exist for the United States, with the canned and cured seafood, and the prepared fresh or frozen fish or seafood sectors reported separately (Roberts, Dillon and Siebenmorgen 1996). Using this model, the result of an anticipated change in output from these two sectors could be measured in terms of direct, indirect and induced value added and employment on the United States economy.

8.2 Firm Level

Quality and safety economics at the firm or plant level is extremely important. This allows the plant manager to analyze the costs and returns from operating the plant at various levels of scale in order to maximize net returns. Seafood quality and safety, and thus HACCP, affects the costs and returns of each plant. A recent FAO technical paper included a chapter on quality and safety economics (Zugarramurdi, Parin and Lupín 1995). This chapter introduced the concept of seafood quality economic analysis at the plant level, discussed production and quality costs, and illustrated the Prevention-Appraisal-Failure (PAF) model of quality costs. The chapter also introduced several considerations in how the introduction of HACCP could change the production costs faced by the firm. Finally, some early estimates of the costs of applying HACCP in United States seafood firms were summarized, along with a discussion of data needed in order to estimate the benefits and costs of HACCP at the plant level. The PAF model has recently been applied in a number seafood processing plants (Lupín 1998). The PAF model performed well with hake freezing and salted ripened anchovy plants in Argentina. Variables such as the number of Critical Control Points in the HACCP plan, raw material yield, final product prices and investment, daily capacity, and labor productivity were examined to estimate the economic factors associated with achieving improved levels of fish quality. In both plants studied, failure costs comprised 95 percent of total quality costs when raw material and labor quality was poor and safety was compromised. When product quality achieved 90 percent of total theoretical achievable quality, failure costs were below 20 percent of total quality costs and safety was not compromised. The minimum quality cost per unit was found between 80 to 90 percent of total theoretical achievable quality. The argument is made that the economic advantage of HACCP can be a strong argument for use as a business management tool in developing countries. The PAF model has also been applied in fish processing plants in Cuba, and by using the technique, production costs declined a substantial 66 percent in 1966 over the prior year (Loaces et al. 1997). The same group of researchers has also estimated costs of sanitation in the plants (Marti et al. 1997).

A major United States seafood company that processes soft-shell crabs instituted a HACCP programme in 1993. The company found that more internal monitoring is required, but that processes have improved enough that the controlling authority inspector is visiting less often, and that actual costs are lower under the HACCP system than under the previous voluntary quality assurance system (Haltaman 1997). Other seafood industry views of early HACCP programmes in Canada, Thailand, Ireland, Iceland, Mexico, Japan, China and the European Union are available as reported by various industry representatives (Martin, Collette and Slavin 1997). However, most relate to the technical aspects of the process and do not contain cost information on in-plant implementation of seafood HACCP programmes.

8.2.1 United Kingdom, Canada and Africa

Methods are also available for estimating the cost of sanitation, quality control and HACCP in seafood plants (Dillon and Griffith 1996; Dillon and Hannah 1997a; Dillon and Hannah 1997b; Dillon and Griffith 1997; Dillon, Ryder and Garrett 1997). This set of documents provides a computer software assisted method to estimate the cost of implementing various sanitation techniques in processing plants and to predict the cost of various control measures that might be defined for a HACCP plan. These techniques are being taught in workshops on fish technology and quality assurance organized by FAO in developing countries, e.g. a two-week regional workshop in Namibia during February 1998, with more than 30 fish technologists and quality controllers from 16 English-speaking African counties (Kollavik-Jensen 1998). Various studies are underway in the United Kingdom to document sanitation costs in five factories. Similar studies are underway in Canada in seven plants on the costs of cleaning, in Africa on sanitary costs in five companies that produce fresh and frozen Nile perch fillets for the European market and on a limited basis in a United States shrimp plant. (Dillon et al. 1998).

8.2.2 United States Shrimp, Fish and Shellfish Plants

Seafood plants in the United States were surveyed to determine the principal cost factors associated with implementing HACCP in processing plants for surimi, clams, blue crabs, raw and breaded fish fillets, cooked ready-to-eat shrimp, catfish, trout, herring, salmon and raw breaded shrimp (Martin et al. 1993). Four major categories of HACCP implementation costs were: (1) management and quality control labor required to design and implement the HACCP plan, (2) ongoing labor required to perform monitoring and record keeping functions, (3) capital equipment required to automate record keeping functions especially if the labor requirement is minimized, and (4) consulting fees required to verify the plant process reaches the applicable critical limits.

One study covered the economic impacts of HACCP models for breaded, cooked and raw shrimp plants and raw fish processing plants (National Fisheries Education and Research Foundation, Inc. Undated). Four costs were identified for breaded, cooked and raw shrimp plants: (1) plant closures; (2) costs to the processors directly related to complying with the requirements of HACCP models; (3) consumer effects indirectly related to three compliance requirements and (4) further impacts on shrimp processors as a result of changes in consumption patterns. A total of 14 plants (of 249 comprising the industry) were predicted to close due to the anticipated seafood HACCP implementation. All were small, single-company plants which accounted for .2 percent of sales industry-wide. Employment at these plants totaled 70 jobs. HACCP compliance was estimated at US$6.2 million in annualized costs industry-wide, or US$26 thousand per plant. Large plants had average costs of US$22 thousand per plant and large plants averaged US$32 thousand per plant. The Investment level necessary to comply with HACCP for the average smaller plant was over eight times greater than investment costs for large plants. Over the entire shrimp processing industry, annualized costs per pound to comply with HACCP was estimated at US$0.009, or only .3 percent of current prices received by processors. Compliance costs passed to consumers amounted to price increases of US$0.025 per pound of product. Declines in purchases of product because of price increases amounted to the equivalent of the loss of ten jobs across the entire industry.

Three types of costs were determined for the raw fish processing industry to comply with HACCP requirements: (1) costs to processors directly related to complying with the requirements of HACCP models, (2) consumer effects indirectly associated with these compliance activities, and (3) further impacts on raw fish processors linked to a change in consumption patterns. No plant closures were predicted and specific estimates can be found in the source study (National Fisheries Education and Research Foundation, Inc. Undated).

8.2.3 United States Cooked Ready-to-Eat Blue Crab

The cost per pound to implement HACCP in the cooked ready-to-eat blue crab industry was determined to be minimal for some processors, while as high as three percent of current costs for others, with smaller plants experiencing the highest costs per pound. Costs to implement HACCP were also dependent on: (1) the complexity of the production process, (2) the plant managers' level of knowledge about HACCP procedures and their familiarity with planning and equipment, (3) the availability of assistance from trade associations, agencies and publicly funded training programmes, (4) the plant's access to sources of capital for up-front investment costs, (5) the ability of the plant's workers to be trained and the speed of employee turnover, and (6) the plant's ability to spread costs over a large volume of product or to find ways to limit the fixed cost of equipment

(Martin et al. 1993).

8.2.4 United States Various Shellfish and Fish (MSSP)

Another study estimated the costs of implementing the Model Seafood Surveillance Program (MSSP) of the United States National Marine Fisheries Service for blue crab, breaded and specialty products, molluscan shellfish, smoked and cured crab, and West Coast crab (National Fisheries Education and Research Foundation, Inc. 1991). The MSSP was designed to improve the inspection of seafood consistent with the HACCP system. Three types of costs were identified for blue crab plants: (1) costs to the processors directly related to complying with the requirements of HACCP models, (2) consumer effects indirectly associated with these compliance activities and (3) further impacts on blue crab processors linked to a change in consumption patterns. Estimates for the 204 blue crab plants in the United States to comply with HACCP models for process and sanitation were US$0.64 million in annualized costs[13] or US$3.1 thousand per plant and US$0.02 per pound which represented .33 percent of processor price. Initial investment costs were three times greater for small plants, but annualized compliance costs were slightly higher for small plants in comparison to large plants. No plant closures were predicted for blue crab plants due to compliance costs and increased prices were expected to cause a decline in sales of US$0.32 million per year across the industry. Cost estimates to comply with HACCP were also made for 59 breaded and specialty products processing plants producing breaded products (fish, scallops, oysters, mussels, clams, squid, and similar breaded products), specialty products (stuffed products and entrees with and without sauces, side dishes, stews, dinners and other similar products) and surimi analog products. Two types of cost were identified: (1) cost to the processors directly related to compliance activities and (2) consumer effects indirectly associated with compliance activities. Compliance costs were estimated at US$0.36 million on an annualized basis or US$6.1 thousand per plant. Investment costs averaged US$3.2 thousand for large plants and US$1.7 thousand for small plants. Added cost per pound of product for compliance was US$0.01 for small plants and US$0.0002 for large plants. Thus, the effect on consumer prices was determined to be negligible.

Plants included in molluscan shellfish were those that processed oysters, mussels, and clams. Four types of cost were identified: (1) plant closures, (2) cost to the processors directly related to complying with the requirements of HACCP models, (3) consumer effects indirectly associated with these compliance activities, and (4) further impacts on molluscan shellfish processors linked to a change in consumption patterns. Only 20 plants were sampled from the universe of 1 172 which may lead to small sample bias for these estimates. A total of 307 smaller volume plants were predicted to close as a result of non-compliance with anticipated regulations. This represented 18 percent of the plants and 15 percent of industry-wide sales. Employment to be lost was 1 700 jobs. However, it was anticipated that higher volume plants would claim some of the lost production and thus add to large plant employment. Annualized industry compliance costs were estimated at US$7.8 million or US$ 5.5 thousand per plant. Annualized compliance costs per pound of molluscan shellfish and other products produced were estimated at US$0.05 for small plants and US$0.003 for larger plants. Because of anticipated price increases to pass along the higher production costs, it was determined that consumer demand would decline by about 1.56 million pounds valued at US$3.9 million per year industry-wide.

8.2.5 United States Smoked and Cured Fish

A similar analysis was performed for smoked and cured fish plants (smoked fish; mild cured and salted fish; pickled and marinated fish; and salted salmon repackaging) and west cost crab plants (dungeness crab cooked whole, in sections and cleaned; king and snow crab cooked sections; crab shell-on specialty products; and crab shell-off specialty products). For smoked and cured fish plants, four costs were identified: (1) plant closures, (2) cost to processors directly related to complying with the requirements of HACCP models, (3) consumer effects indirectly associated with these compliance activities, and (4) further impacts on smoked and cured fish processors linked to a change in consumption patterns. For west coast crab plants, three costs were identified: (1) cost to processors directly related to complying with the requirements of HACCP, (2) consumer effects indirectly associated with these compliance activities and (3) impacts on West Coast crab processors linked to a change in consumption patterns. The interested reader is referred to the source document for detailed estimates (National Fisheries Education and Research Foundation, Inc. 1991). In addition to these estimates, the source document presents total compliance cost estimates separated into costs of such components as preventive measures, monitoring, and record keeping associated with defining critical control points for each industry sector analyzed.

8.2.6 Florida, United States Oyster Depuration

While not focused on HACCP, a recent study estimated the cost at the plant level of depurating raw oysters in Florida, United States. It is necessary to depurate oysters harvested from marginal areas before they can be sold for consumption. The lowest price that harvesters would accept for oysters harvested from marginal areas was determined plus the cost of depuration. This value was then compared to the higher price that harvesters received for oysters harvested from approved areas and not requiring depuration. It was determined that the price oyster harvesters would need to receive amounted to a 67 percent increase in the price currently received from processors, making depuration economically unattractive (Lin et al. 1995). Restaurant owners and consumers attitudes toward depurated raw oysters are reported elsewhere in this document.

8.2.7 Bangladesh Frozen Shrimp

Bangladesh frozen shrimp plants spent by early 1998 an average of US$239,630 per plant to upgrade to minimum technical and sanitary standards. An additional expenditure of US$37,525 is anticipated, for a total of US$277,155. The average plant expects to spend US$34,875 to maintain a HACCP plan. The cost to maintain a HACCP plan ranges from US$0.0327 to US$0.0899 per kilogram, or from 0.31 to 0.85 percent of 1997 price (Cato and Lima dos Santos In Press).

8.2.8 Massachusetts, United States, Breaded Fish

A study of eight companies processing breaded fish in Massachusetts estimated the cost of implementing a HACCP plan and the cost of complying with United States Food and Drug Administration Requirements (Colatore and Caswell In Press). The average first-year total cost of implementing HACCP was US$113 305, with large variation among firms. The average first-year cost to implement minimum Food and Drug Administration HACCP requirements was US$34 323.

8.2.9 Alabama, United States, Fish and Seafood Processors

A study currently in process has documented estimated costs of implementing HACCP in Alabama seafood processing plants. Cost estimates have been made for thirty small, medium and large plants producing raw and processed shrimp, raw and processed fish, cooked crab meat, crab meat based products, shell stock oysters and shucked oyster meats (Perkins, Hanson and Hatch In Press). The average cost of implementing HACCP was US$23 908 per plant, ranging from US$19 857 for small plants to US$26 773 for large plants.

8.2.10 Argentina Fish Processing

Quality costs for the Argentina export fishing industry for frozen blocks of hake fillets and salted anchovy were analyzed in this study (Zugarramurdi et al. In Press). Quality costs were divided into controllable (prevention and evaluation) and resulting costs (external and internal failures). It was observed that the more representative controllable costs to reach a good level of product quality are inspection of raw material, training of labor and production control. Some of these relate to HACCP Critical Control Points. Results show that due to the poor quality of inputs, failure costs descend below 20 percent of total quality cost. At the same time, total quality cost descends from 40 to 21 percent of total production cost when the level of product quality is increased from poor to very good. Also, different minimum points for total quality cost and total production cost and a maximum benefit point are observed, indicating an advisable working zone within the 80 to 90 percent of optimum quality level.

8.2.11 Louisiana, United States, Oyster Industry

This study did not provide cost estimates of implementing HACCP in oyster processing plants. However it does provide a discussion of the general costs and benefits of using a HACCP system in oyster processing (Whitley et al. 1998).

9. INTERNATIONAL TRADE AND HACCP

The movement worldwide in recent years has been toward more free trade. This means that barriers to trade created by tariffs have been reduced. An example is the recent Uruguay Round of the General Agreement on Tariffs and World Trade/World Trade Organization (GATT/WHO) which reduced tariff levels on agri-food products and initiated tariffication of some non-tariff barriers to trade (Caswell and Hooker 1996). This agreement and the Agreement on Sanitary and Phytosanitary Measures form the overall legal basis for any further legally-binding and international agreements in this area and the instruments to be adopted on a voluntary basis, such as the Code of conduct for Responsible Fisheries[14] (Karnicki 1997). The prediction is that trading blocs will create other types of non-tariff barriers to trade. An example is safety and quality regulations with respect to food. Country level regulations are under formal scrutiny as potential non-tariff barriers to international trade. This means that the economics of reducing health risk for food (and thus seafood) will be more complicated and the benefit-cost calculations more difficult in order to judge the worthiness of food safety regulations (Hooker and Caswell 1995). One reason that food safety standards can be an issue is that it is very easy to make them different, ambivalent or difficult to understand or meet. To prohibit these types of barriers from being created, agreements are being made to ensure that national regulations and trading agreements must be based on science and be applied evenly to both domestic and imported products. An example is the recent seafood HACCP programme in the United States which stipulates that importers of seafood to the United States must meet the same HACCP standards as United States processors of seafood (United States Food and Drug Administration 1995). The intent is to achieve equivalent standards regarding the effect of regulations, not to make the regulations themselves identical. However, there is still tremendous room for mischief among trading blocs to create ways to affect trade among them to achieve self-interest goals.

Major developments within the last two decades have created a set of complex trading situations regarding seafood (Wessels and Wallström 1994). Expansion to a 200-mile exclusive economic zone by coastal nations changed the structure of fish harvesting. Broader and independent control of access to fish stocks made seafood importers of some nations that no longer had access to fish stocks for harvest. Nations with control of access in some cases became fish exporters. Second, growth in aquaculture worldwide also changed trading patterns between nations. Conflicts involving tariff and non-tariff barriers have thus increased in scope and intensity. Wessels and Wallström categorize these into four categories:

(1) directed policies that relate directly to seafood markets, (2) concern over seafood product quality and safety, (3) market challenges such as dumping which give rise to tariffs, and (4) fisheries management policies which conflict with international free trade agreements. Another document that has a focus on international quality control and assurance and provides an overview of some issues is also available (Sylvia, Shriver and Morrissey 1994).

The success level of achieving equivalency and reducing non-tariff barriers to seafood trade will depend on how interested trading blocs or countries are in co-operating with each other to reduce barriers. This cooperation is called regulatory rapprochement with most grouping activity into three categories: (1) harmonization, (2) mutual recognition, and (3) coordination (Caswell and Hooker 1996; Jacobs 1994). Further discussion of the Uruguay Round of GATT as it relates to the technical aspects of seafood is available (Lupien, Randall and Field 1997).

9.1 Harmonization

Harmonization refers to the standardization of regulations in identical form. HACCP activities with the European Union closely mimic harmonization, since HACCP regulatory regimes have been harmonized across counties. In theory, this should result in a reasonably homogenous level of food safety within the European Union countries (Caswell and Hooker 1996). This should make within-European Union country trade easier, and could make trade between European Commission member countries and third party countries easier as long as the third party countries can meet and be recognized as meeting European Commission standards. However, early on there have been trade impacts between developed countries (Wessells and Wallström 1994). At the time of passage of EEC Commission Decisions 91/492 (EEC 1991a) and 91/493 (EEC 1991b), there was no federal comprehensive inspection programme for seafood in the United States, and determination of the "competent authority" was difficult. Eventually the National Marine Fisheries Service (NMFS) was identified. In addition, all seafood exporting plants in the United States needed to be certified by NMFS. With the late 1997 implementation of the federal HACCP programme in the United States, this problem has been alleviated, but it is indicative of the kinds of problems countries will initially experience in coming to terms with seafood safety and quality regulations. Short term loss results from uncertainty, risks and costs. In practice however, the result may be more restrictive trade between third parties if the European Commission decides to challenge the safety and microbiological standards of third party counties.

Developing countries are clearly anticipating problems in being able to harmonize their standards in a way that will not affect trade in a negative way. Developing countries are responsible for more that 50 percent of the fish in international trade (Lima dos Santos, Josupeit and Chimisso dos Santos 1993) and harmonization is anticipated to have an impact on fish exports from developing countries. Positive impacts are anticipated to be a strengthening of ties between government and industry regarding fish quality, a stronger commitment to improve fish quality, adoption of safety and quality improvement programmes such as HACCP, and more training and education in quality and fish inspection processes. Negative aspects are lack of trained personnel, lack of financial resources, lack of communication between inspection authorities and lack of clear instructions from the importing country on conditions that must be met (Lima dos Santos, Josupeit, and Chimisso dos Santos 1993). Importers also have stated concerns about the ability to effectively function within the harmonization rules of, for example, the European Union. Concerns include such practical items as having the health certificate with the imported goods at all times, correspondence between the goods and the certificate including language problems, physical concerns ranging from sampling delays to shipping delays due to infrastructure problems within and among European Union members, and a number of other examples derived from practical experience (Hottlet 1993). A seafood supplier has also pointed out a number of practical questions. These include the definition of safety and quality, who will pay for the improved standards (consumers or producers), how will the standards be implemented (with tolerance to start or strict compliance), will the new rules allow for diversification or unification and who will be in control along the transporting chain (Nusalim 1993) Strong arguments have also been made that consumers in the European Union will benefit from improvements in fish hygiene, particularly in fish from developing countries (Roessink 1993). Detailed points of view and issues faced by developing countries within the fish capture, processing and exporting countries are available (Ababouch 1993; Mansur 1993; Masette 1993). These include, among others, the need for major training programmes, lack of investment capital for infrastructure to enable compliance with sanitary regulations and the difficult task of changing fishing practices of artisinal fishermen.

Court cases in the European Union have defined the European Union's position on food standards. All member states must accept products lawfully and fairly manufactured and sold in any other member state, even if such products are manufactured on the basis of technical specifications different from those laid down by national laws in force (Sheldon and von Witzke 1992). Given this mutual recognition, these authors point out that there are two generally accepted outcomes. First, the barriers to intra-community trade in food products will be lower. Second, third country exporters to the community will have to meet the food quality standards of all member countries. The overall effect will be intra-country trade creation at the expense of third-country export sales. A number of other effects might also be expected. If consumers are willing to pay for higher quality foods, firms may have an incentive to demand high quality in order to drive out low quality and capture market share, and over time, food quality within the community will increase.

Community members will also have the incentive to demand higher food standards in order to create non-tariff barriers to trade. Growing emphasis on food quality standards will also redefine trade relations between the European Union and developing countries (Sheldon and von Witzke 1992). Food exporting countries will face more barriers to trade, as European Commission countries introduce additional and strengthen existing food safety and health standards. Developing countries may have problems meeting standards set by European Union countries because newer technologies and production techniques require intensive human capital that is scarce in developing countries. On the other hand, European Union member countries may be able to produce to two levels of standards, one to meet within community standards and another for export outside the community where regulations are less strict.

In practice, three examples demonstrate the real-time use and economic impact of non-tariff barriers to trade. On 13 February 1998 the European Commission modified the list of countries authorized to export harmonized fishery products to the European Union. After 1 July 1998 countries not on the list will not be authorized to export products to the European Union. Thirty countries are approved to export products to the European Union with 25 additional countries having certain establishments authorized to export, but not the country as a whole. Together, these counties and establishments, including Norway and Iceland which are authorized to export to the European Union as part of the European Free Trade Agreement, account for 90 percent of the 1996 value of seafood imports into the European Union. If the list of approved countries is not expanded, the European Union will be short approximately eight percent in volume and ten percent in value after 1 July 1998. Over 100 countries are not on the approved list although many are currently in the application process (FAO April 1998).

Second, European Union inspectors in May-June 1997 found that shrimp processing plants in Bangladesh did not meet European Commission standards for importing seafood into the European Union. A 1 August 1997 European Commission directive banned the importing of shrimp from Bangladesh (EEC 1997a). Bangladesh annually exports an average (1993-1995) of US$190 million in frozen shrimp and prawns worldwide. The ban was lifted on 13 February 1998 (EEC 1998). The estimated cost to the Bangladesh frozen shrimp processing industry was US$14.7 million (Cato and Lima dos Santos 1998). The Bangladesh Department of Fisheries, Fish Inspection and Quality Control of the Ministry of Fisheries and Livestock was named by the European Commission to verify and certify compliance of fishery and aquaculture products with European Commission requirements. As of July 1998, only 11 seafood-processing companies (of approximately 50) were named as approved establishments to ship to the European Union.

The third example is the recent decision of the European Commission to ban imports into the European Union of fresh fish products from Kenya, Tanzania, Uganda and Mozambique (EEC 1997b). The World Health Organization (WHO) issued an official statement indicating that the decision had limited scientific justification, and that no cases of cholera have ever known to occur through the consumption of imported food products. The FAO also issued a press release saying the ban was "not the most appropriate response", and indicating that the risk of transmission of cholera from contaminated imported fish is negligible (FAO March 1998). The effect of the Decision represents an average monthly loss of US$60 000 in trade from Mozambique, for example, which means about 30 tons of fish per month are not exported to the European Union market. One processing plant with 20 employees and 30 fishing vessels with 450 employees were affected (Ben Embarek 1998).

9.2 Mutual Recognition

Mutual recognition is defined as the acceptance of regulatory diversity in meeting common goals, which is also referred to as reciprocity or equivalency. For equivalency to be successful, it is required that countries or trading blocs agree to a large number of bilateral or multilateral agreements. This means that scientific principles must be agreed upon or the processes of each partner must be endorsed by the other as equal. For seafood HACCP in the United States, the programme allows for the establishment of a Memorandum of Understanding (MOU) with countries importing into the United States. When in place, processors in exporting countries will only need to comply with the HACCP equivalent programmes of the importing country. However, to date no MOUs have been agreed to by the United States FDA. In the meantime, seafood exporters to the United States must have and implement verification procedures through product specifications or other defined steps that the involved products are safe or meet the requirements of the United States seafood HACCP programme. Thus, at the moment the "equivalency" test burden is placed on the exporter and the importing agent. The definitions of equivalency and the attitudes of trading partners will determine whether or not equivalency will assist or hinder free trade. As an example, the Canadian approach goes further toward promoting free trade, since it adopts the Codex hygiene code as its source of prerequisite requirements while the United States HACCP programme does not directly adopt Codex, making coordination of prerequisites more difficult (Caswell and Hooker 1996). The European Union version of equivalence is different from that of Codex and the United States FDA. To achieve equivalent status with the European Union, the exporting country must demonstrate that its "National Competent Authority" has the capability to enforce European Commission legislative regulations to ensure that safe and wholesome products are being produced and placed in commerce. The European Commission regulations contain no process to develop a MOU type arrangement, thus equivalence occurs as defined by specific decisions made by the European Commission approving individual countries and companies within them to export to the European Union. This sets up a convenient opportunity for the use of equivalency as a non-tariff trade barrier (Sophonphong and Lima dos Santos 1998). The cited source contains an extensive discussion of equivalence perspectives from the points of view of the United States, European Union, Japan, Canada, and bilateral and multilateral agreements of developing countries.

9.3 Coordination

Coordination implies the occurrence of a gradual narrowing of relevant differences between regulatory systems, usually based on voluntary international codes of practice or alignment. The North American approach resembles more a form of weak coordination, with the United States and Canada pursuing HACCP plans in parallel. In theory, this could ease regulatory differences between the United States and Canada, but neither mutual recognition nor harmonization are expected soon (Caswell and Hooker 1996). The Codex/WTO approach is even weaker in terms of coordination, and simply urges countries to ratify the Codex standards and follow them. This approach requires extreme mutual trust and cooperation, with the only way to resolve disputes being one country's challenge of another that its food safety programme is unscientific and an unjustified barrier to trade.

The North American Free Trade Agreement (NAFTA) between the United States, Canada and Mexico, which came into effect in 1994, is another form of rapprochement. NAFTA calls for the progressive removal of virtually all tariffs on agri-food products among the three countries with 15 years (Hooker and Caswell 1995). NAFTA is not designed to create an economic community like the European Union. NAFTA does have as a major goal to prevent discrimination and creation of non-tariff barriers to trade based on unjustified safety regulation. NAFTA does advocate the use where possible of Codex international standards. Under NAFTAs weak form of coordination, the United States, Canada, and Mexico have pursued almost independent updates of their information requirements. Another important difference between NAFTA and European Union is that NAFTA is a free trade agreement while the European Union is a formal customs union (Hooker and Caswell 1995).

Clearly, harmonization is the strongest level of rapprochement and coordination (or lack of) the weakest. The usefulness of HACCP as an international regulatory trade standard will depend on the ability of trading countries or blocks to move toward harmonization. This in turn depends on how various governments implement HACCP. If governments require companies to develop a HACCP plan but do not specify its detail, it is a performance standard, and companies can use various methods to reach a defined performance goal. If government defines each specific standard of the HACCP plan for companies, then it becomes a process standard. For freer trade, it is preferred that governments define HACCP as a performance standard, which has been the goal in some agreements such as Codex, where countries may follow Codex, but have different regulatory programmes to satisfy the Codex goals (Caswell and Hooker 1996; Codex 1995).

9.4 Direct Foreign Investment

National or country level food regulation strategies can also have an effect on the strategies of companies to operate in international markets. For example, foreign direct investment in a country may allow the investing company to avoid rules intended to disadvantage imported products (Hooker and Caswell 1996). There could also be other economies gained by locating closer to the source of raw materials or closer to the consumers of products. These authors argue that for processed products the level of regulatory rapprochement on quality regulation will have significant impacts on patterns of international trade, and thus foreign direct investment, in the next decade. As evidence, data quoted in the article define an increase in the number of unfair trade practices made under GATT in the 1950s in contrast to the 1980s when quality regulations were on the rise. They predict more trade disputes in the coming years for several reasons: (1) the WTOs introduction of an agreement on sanitary and phytosanitary (SPS) regulations defines a position and will thus give countries a standard from which they can accuse other countries of not meeting the standard, (2) there is a pent-up demand for disputes among countries because many disputes were delayed until the WTO standards were decided, and (3) innovations in food production, processing, and transportation technologies, and member countries attempts to respond to these innovations while simultaneously improving current levels of food safety protection will result in more complicated regulatory structures. They conclude that national-level food quality regulation does have an important influence on business decisions regarding choice of strategies, such as foreign direct investment and export sales, for attaining sales in foreign markets. National-level regulation will increase in importance as a restraint in trade and foreign direct investment in the future, instead of lessening the importance a movement to harmonization and mutual recognition would suggest.

10. VALUE OF SEAFOOD SAFETY: SPECIFIC STUDIES

The economic value placed on food safety depends on the willingness of consumers to pay for safer food, and the willingness of society as reflected in taxpayer support for government programmes to assist consumers in paying for safer food. In general, food safety studies have shown that consumers will pay only a small percentage above the traditional purchase price to avoid some perceived risks (Busby, Skees and Ready 1995). The willingness-to-pay a larger amount would indicate a stronger concern about a food safety risk. Consumer awareness of food safety problems will also influence the amount consumers will pay for food safety or how they react to risk knowledge or public information such as news media stories. As an example, one study showed that consumers who were aware of problems with pathogenic contamination of sandwiches in two states of the United States were willing to pay a higher amount for reduced risk than consumers in two other states where no problems had occurred (Fox et al. 1995).

Another study to determine if consumers would pay for leaner pork determined that consumers preferred to consume leaner pork produced with a new technology, but were not willing to pay the premium price necessary to achieve leanness beyond what current technology would provide (Halbrendt et al. 1995). Only one-third of the consumers in the United States were willing to purchase beef, pork, chicken, and fish irradiated to control microbial pathogens at a 15-20 cents premium (Malone 1990). Chicken consumers were estimated to pay from 12-16 cents per pound more for chicken for various bacterial contamination reduction treatments (Moss, Degner and Zellner 1991). One attempt in the United States to measure the quality perceptions of fish consumers identified cost as a primary reason for not serving fish. However, quality was identified as a more important consideration at the point of purchase (Hadlett and Rabb 1990). Frequency of consumption was significantly related to knowledge regarding the storage and preparation of fresh fish, suggesting education programmes about fish quality attributes may be useful. Less than one-half the consumers in this survey correctly answered storage questions relating to the length and proper storage temperatures of raw fish.

In contrast to these estimates of the value of food safety of individual consumers, one estimate for the United States is that consumers are willing to pay US$91 billion annually for a reduction in the risk of microbial food-borne disease (Shirky 1992). National telephone surveys in the United States in 1988 and 1993 revealed that consumers were more likely to name shellfish (from 2 percent to 10 percent of all cases) and finfish (from 5 percent to 10 percent of all cases) as the vehicle of a perceived food-borne illness in 1993 than in 1988. Sixty-five percent of all consumers also felt that the food-borne illness they contracted across all foods came from restaurants (Fein, Lin and Levy 1995). As is clear from this summary, the willingness of consumers to pay for safer seafood depends on a wide-ranging set of preferences and costs. The following section reviews recent studies specifically done for seafood. It includes comments on consumer surveys and techniques used to estimate values, safety and quality assurances measured and how consumers interpreted these values, consumers' willingness-to-pay. It also covers the effect of media and publicity on the values consumers pay for safety and quality, and the implications of these values for seafood safety and quality programmes.

10.1 Data Collection and Estimation Techniques

Most of the data collection methods used to obtain observations used in analysis to determine the value of seafood safety in specific studies have been telephone and mail surveys and face-to-face interviews. Estimation techniques have ranged from simple statistical of variables to econometric models. This section summarizes these techniques for the limited number of specific studies that have been completed for seafood. The information is presented on a study-by-study basis. This will allow the interested reader to review data collection methods used across studies and review the types of experiments conducted with data observations. The projects summarized focus specifically on those that have attempted to measure the willingness-to-pay by consumers for safer seafood.

From September to November 1977, a study was conducted to determine the effects on consumer sales of guaranteeing United States Grade A quality fresh seafood. The species under observation were cod, flounder, haddock, ocean perch, pollock and whiting. Four supermarkets in Massachusetts were used as test stores. Two were supplied with United States Department of Commerce (USDC) graded fillets and two were control stores supplied with ungraded fillets from the usual sources of supply. Sales and price changes were observed at ex-vessel, processor and retail levels. Cost estimates were made to compare the cost of producing Grade A versus ungraded product (Gorda et al. 1979).

A follow-on study examined the economic feasibility of selling Grade A frozen fillets. During 1981, a processor in Boston, Massachusetts cooperated with five retail supermarkets in Albany/Schenectady, New York in selling frozen fillets of cod, haddock, pollock, and ocean perch. Comparisons were made in sales and prices paid for frozen Grade A, frozen ungraded and fresh fillets. The cost to process and retail the products was calculated (Gorda et al. 1982).

A national probability sample by telephone was used to interview 800 households in the United States in 1988. The purpose was to evaluate consumer willingness to accept irradiated fresh food products, including fish, in the marketplace (Malone 1990). In a 1990 experiment in Rhode Island, United States, a survey was conducted for 256 consumers (Anderson and Wessells 1992). A written survey was completed (for the 256) and a market-like contingent valuation experiment (for 55 of the consumers) using flounder as a reference product was conducted to determine the willingness of consumers to pay for selected safety assurances for flounder (Wessells and Anderson 1992; Wessells and Anderson 1993; Anderson et al. 1994; Wessels and Anderson 1995; Wessells, Kline and Anderson 1996).

Also during 1990, a telephone survey was conducted in 11 Mid-Atlantic and Southeastern states of the United States to measure the perceptions of consumers regarding oyster consumption (Lin, Milon and Babb 1991). A total of 606 complete interviews provided the data set for the analysis which included ranking techniques and the use of an ordered probit model to provide statistical estimates of the relationship between a set of independent variables and an ordinal ranking of individual preferences). In a related study, 35 restaurant managers were interviewed by telephone to determine their attitudes about selling depurated oysters. A total of 1 012 consumers were also surveyed by telephone to determine their attitudes toward depurated raw oysters (Degner and Petrone 1994). Partial budgeting techniques were used to determine if consumers willingness-to-pay for depurated raw oysters was sufficient to cover the producers costs of depurating them (Lin et al. 1995). Another project used a double-hurdle model to evaluate whether the decision to consume a product (participation decision) has determinants different from the frequency of consumption (consumption decision) (Lin and Milon 1993).

The effect of a 1991 toxic algae contamination of mussels in Montreal, Canada was estimated using weekly sales data from a mussel farm (Wessells, Miller and Brooks 1994). In related project, 401 consumers were interviewed in supermarkets located from Northern Virginia to Maine, United States, in late 1989 to early 1990, in order to determine consumer perceptions about consumption of blue mussels (Brooks 1993).

Consumer and retailer surveys were used in 1993 and 1994 in the Northeastern United States to gather market information about purchasing fresh hybrid striped bass, trout, salmon, clams, mussels and oysters. Consumers were represented by 1 504 respondents to a mail survey and retailers by 56 firms that responded to a mail survey and face-to-face interviews (Wang, Halbrendt and Caron 1995). A related report using the same data base of 1 533 shellfish consumers and 1 529 finfish consumers presents more detail on the consumer responses (Wessells et al. 1994).

During 1993 and 1994, tests were conducted in Oregon, United States, on value-added products developed from Pacific whiting. Samples of individually quick frozen (IQF) fillets were sent to 66 wholesalers involved in the distribution and secondary processing of whiting products. Companies were asked to evaluate the characteristics of the fillets, as well as consumer questions to determine attitudes and demand for quality assurance, marketing and willingness to purchase. Consumers were evaluated during the tests conducted at the 1993 and 1994 Oregon State Fair. Trained taste panels were also used to evaluate the products (Morrissey and Sylvia 1995).

In January 1997 a survey/questionnaire of buyers was conducted at the Sydney, Australia Fish Market. Questions related to the ethnic and educational backgrounds of the buyers, experience and training in fish handling and their outlook of the seafood industry. The survey was repeated in July 1997 after an incidence of seafood-borne illness in Australia (Ruello 1998).

10.2 Safety and Quality Assurances Measured

10.2.1 Cod, Salmon and Flounder: Rhode Island, United States

Before consumers will be willing to pay for seafood quality, they must be able to determine quality differences in the seafood they consume. One recent experiment documents the partial ability of consumers to recognize seafood quality (Anderson and Wessells 1992). In a market simulation test, consumers were able to correctly determine the freshness (based on age) of cod. They were ambiguous in regard to salmon, and were not able to determine the freshness of flounder. Price considerations were also mixed. The same quality fish was presented to the consumers, but at three different price levels. Only one-fourth the consumers picked the lowest priced flounder, two-thirds selected the lowest priced cod, and three-quarters selected the lowest priced salmon. Sensory tests were also conducted. Overall, consumers in general did exhibit some ability to judge seafood quality in their purchasing patterns, but this is an area that needs much further investigation. Consumers in this study were also asked to rank ten sources of information assumed to reflect the reduced risk of contracting illness or disease from consuming flounder: (1) catch date of fish, (2) inspected by NMFS, (3) catch site of fish, (4) inspected by USDA, (5) inspected by FDA, (6) money back quality guarantee, (7) storage temperature since caught, (8) inspected by retailer, (9) inspected by processor and (10) money back safety guarantee. Catch date was ranked by 40 percent of the consumers as the most highly valued piece of information to improve their confidence in the fish. Inspected by NMFS, catch site of fish, inspected by USDA, inspected by FDA and money-back guarantee of top quality all were thought next most important, ranging from 13 to 9 percent of the consumers (Wessels and Anderson 1992). An econometric analysis was also performed with the only two statistically significant assurances being catch site and inspection by NMFS (Wessells and Anderson 1995).

Another analysis using the same data set was conducted to test if consumers were able to discern among seafood safety assurances, rank their preferences and assign values to the alternatives. A market-like setting with in-person experiments using flounder as a reference product was used to estimate the willingness-to-pay of consumers for seafood safety (Wessells and Anderson 1995). A written survey was used to measure the initial response to seafood quality factors. A total of 78 percent indicated their interpretation of high quality seafood meant fresh seafood. Twenty-nine percent said that high quality is dependent on the harvest site, while 26 percent cited proper handling as a determining factor quality. Eighty percent viewed seafood (both finfish and shellfish) as either somewhat or very safe. Fourteen percent felt seafood was somewhat unsafe, and 6 percent were unsure. Worries about pollution-caused safety problems was a concern of 49 percent, another 30 percent were concerned about chemical toxins, and 38 percent were specifically concerned about getting food poisoning from improper preparation or handling. In addition, slightly over 60 percent indicated their consumption of seafood would increase if seafood carried a date of harvest label or if a mandatory federal inspection programme was implemented and almost 71 percent indicated their consumption would increase if they learned more about handling and preparing seafood. Almost 84 percent indicated they would increase seafood consumption if the price of seafood dropped by 25 percent. The responses given by the 55 consumers compare in some ways with the results from the broader telephone survey (Anderson et al. 1994). In this survey, 63 percent said that high quality seafood was fresh, 25 percent felt it had an appropriate smell, 14 percent viewed it as harvested from unpolluted water, and 12 percent felt trust-worthiness of the store influenced the quality level. No other attribute, including texture, catch location, moisture look, age, clean, clear eyes, proper handling, locally harvested, way it was cut, low price, not previously frozen, high price, and size was considered important by over 10 percent of the consumers. Sixty percent felt seafood was safe or somewhat safe. Of the concerns, pollution was mentioned by 74 percent of the consumers, shellfish safety was mentioned by 40 percent and toxins were viewed a problem by 22 percent.

The most recent analysis reported from this data set used a recursive set of equations to depict consumers' anticipated consumption response from seven different hypothetical events as a function of their current safety rating and other socio-economic variables. Five of the variables were safety or quality related: (1) seafood labeling with catch date information, (2) the institution of a federally mandated inspection system for seafood, (3) an increase in respondents' knowledge concerning seafood selection and preparation, (4) the appearance of media news stories reporting an oil spill in Narragansett Bay and (5) the closure of Narragansett Bay to all fishing (Wessells, Kline and Anderson 1996). Four of the safety related equations were statistically significant. They were learning more about preparation and handling, mandatory inspection of seafood, media publicity about the oil spill and closure of the bay to fishing. The researchers concluded that consumers who were less confident about seafood safety were more likely to increase seafood consumption following the receipt of positive information about seafood, relative to consumers who were more confident about seafood safety. Similarly, less confident consumers were more likely to reduce consumption after receiving negative publicity than confident consumers. Positive information may also motivate those who are already predisposed to increase seafood consumption to further increase consumption, while negative information simply reinforces the predisposition to reduce consumption among those who have already decreased consumption in the previous two years. The researchers conclude that a federally mandated inspection may increase the demand for seafood and could benefit the seafood industry. A similar analysis can be found for other statistically significant variables by equation in the article.

10.2.2 Raw Molluscan Shellfish: Southeastern United States

The consumption of raw molluscan shellfish has been the leading cause of seafood-borne illness in the United States (Ahmed 1991). The perceptions of oyster consumers in the Southeast United States were recently measured (Lin, Milon and Babb 1991). They devised a rating model which measured the safety rating that consumers place on oysters as a function of awareness, prior illness, frequency of use, health status, controllability, source of risk, age, education, location of residence, children, religion, likelihood of illness and severity of illness. The mean safety rating of oysters was below that for other foods. Consumers who had read about illnesses from oysters gave a lower safety rating than people who did not. Frequent consumers rated them higher, suggesting that individuals re-evaluate their perceptions of food safety based on factual information about the product. Two estimation models were used to evaluate all the factors listed above.

The overall results suggested that consumers believed the primary source of oyster safety problems were in the water or as a result of processing or transporting oysters. However, the authors stipulated that the econometric analysis demonstrated that consumers did not perceive that the safety problems were from harvesting and processing alone, and that some problems were with the product itself. Thus, a more comprehensive shellfish programme focused on harvesters and processors may do little to improve consumers' safety perceptions of oysters. An alternative might be an education programme designed to improve consumers' knowledge of oyster product choice, handling and preparation.

In a related analysis, both oysters and shrimp were tested in a two-step procedure (Lin and Milon 1993). Certain attributes such as taste were thought to dominate the decision about whether to consume a product. Other perceptions, such as cost or safety, may be more important in deciding how much to consume. For oysters and shrimp, freshness (among other attributes) was a significant determinant of consumers decisions to consume and the amount of consumption. Safety perceptions did not influence either decision, although exposure to new health risk information was associated with reduced consumption.

A related study examined the feasibility of depurating oysters in Florida to determine if depuration was economically feasible and if consumers would pay the higher cost for the depurated oysters (Lin et al. 1995; Dunning and Adams 1995). Fishermen were willing to accept a price for oysters needing depuration only US$1.80 lower than for oysters not needing depuration. Below that price, they were unwilling to harvest the oysters. The lowest cost to depurate oysters was estimated to be US$11.97, making the cost of depuration too high in comparison to the US$1.80 that harvesters were willing to forego in order to harvest from areas requiring depuration. To make depuration economically feasible, the processors would need to receive a price 67 percent greater than current price. Some restaurants indicated that sales might increase by 10-30 percent if raw oysters were safer, but only one-third of them would purchase depurated raw oysters. Consumers had recently reduced the frequency and quality of raw oyster consumption, and it was clear that the costs of depuration were much higher than consumers were willing to pay for safer raw oysters. A companion study (Degner and Petrone 1994) also reported similar information regarding the acceptance of depurated clams. Restaurants reported declining sales of raw clams and increased sales of cooked clams. Some restaurant managers appeared willing to buy depurated clams and oysters and some consumers appeared willing to pay a differential for safer products. Depuration has an appeal to consumers, but its use will need to demonstrate the ability to achieve food safety levels while consuming raw oysters near those of foods in general before it will be accepted and consumers are willing to pay for depurated oysters to be consumed in raw form.

10.2.3 Tilapia, Atlantic Salmon, Rainbow Trout and Catfish: Northeastern

United States

Retailers are important links in the seafood distribution process but little research has been done to understand the view of retailers regarding seafood safety. Their views regarding the attributes of seafood safety are different from those of consumers (Wang, Halbrendt and Caron 1995). In a study of seafood retailers and consumers of tilapia, Atlantic salmon, rainbow trout and catfish in the Northeastern United States, 90 percent of consumers felt with varying degrees of intensity that improper handing of fish in the marketplace was a primary cause of unsafe fish. Sixty-three percent of retailers felt consumer mishandling after purchase was the cause of unsafe fish. About 50 percent of the consumers were doubtful or somewhat doubtful about the safety of finfish sold in the United States. More that 55 percent of consumers and 75 percent of retailers want to know where fish was harvested when they purchase the fish. More than half the retailers and consumers felt water pollution was more a problem for wild-harvested than farm-raised fish. About 70 percent of the retailers would support a government inspection programme for fish, but only 30 percent of them were willing to pay for the service at the level equivalent to five cents per pound increase in the price for fish. Seafood labeling and fish harvest location data would increase consumer and retailer confidence in fish safety, and finally, education and information programmes were thought to be useful in increasing seafood consumption.

Consumers in the Northeast United States study gave somewhat conflicting responses to general questions regarding their attitudes and beliefs about seafood. Ninety-seven percent of the respondents indicated they were seafood consumers, yet only five percent were completely confident that seafood contained nothing harmful to their health and only 45 percent were somewhat confident (Wessells et al. 1994; Manalo, Wessells and Gempesaw II 1995). Consumers were asked to rank seven statements about finfish and shellfish safety, using ranks from strongly agree to don't know. The following represent the strongly agree/somewhat agree totals to the seven statements: (1) water pollution is a primary cause of safe fish/shellfish; 91/91 percent, (2) it is important to know the date when the fish/shellfish was harvested; 87/84 percent, (3) improper handling and storage in the marketplace is a primary cause of unsafe finfish/shellfish; 86/77 percent, (4) it is important to know which state or country fish/shellfish were harvested from before purchasing; 59/59 percent, (5) water pollution is more likely to cause unsafe finfish/shellfish than improper handling and storage after harvest; 55/56 percent, (6) improper handling and storage after purchase by consumers is a primary cause of unsafe finfish/shellfish; 53/46 percent, and (7) all finfish/shellfish currently in the market place are harvested from pollution-free/government certified clean water; 6/10 percent. Consumers in this survey were also asked to rank ten food types as most likely, second most likely and least likely to cause illness. The food types were milk, cheese, beef, eggs, chicken, turkey, fish, pork, raw shellfish and cooked shellfish. Raw shellfish was ranked by 70 percent of the consumers as most likely to cause illness and cooked shellfish was ranked second most likely by 32 percent to cause illness. Fish was viewed as a relatively safe product, with only one percent ranking fish most likely to cause illness and ten percent ranked fish second most likely to cause illness. Consumer preferences for farm-raised or wild-harvested finfish and shellfish were also measured. About one-third the respondents agreed that farm-raised fish were safer that wild-caught fish and about one-half felt the same way about farm-raised shellfish versus wild-caught shellfish. Most of the others were neutral or did not know in response to this statement. Finally, an experiment was conducted to determine preferences for consumer labeling of oyster and salmon products. Consumers were asked to rank nine different label options with information varying from wild-caught to farm-raised at three price levels and several inspection options. For both oysters and salmon, the label most preferred contained information that the product was farm-raised, with the lowest price of three available, and inspected by the United States FDA. The label ranked most frequently as second choice also contained information that the product was farm-raised, although it had the middle price of the three available, and was inspected by the United States Department of Agriculture. Of significance is that the results were the same for independent surveys of different consumers of finfish and shellfish.

10.2.4 Blue Mussels and Clams: Mid-Atlantic to Northeastern United States

In the study of blue mussel consumers from Northern Virginia to Maine, consumers were asked if they were afraid to eat mussels. Only nine percent of the respondents claimed they were afraid to eat mussels, with 31 percent indicating they were afraid the mussels were contaminated with pollution. Another 28 percent were afraid of red tide contamination and 14 percent were wary of the locations where mussels are grown (Brooks 1993; Brooks and Anderson 1992). Consumers were also asked to rate their perceived chances of getting ill from eating cod, clams, bluefish, mussels, salmon, lobster, chicken and beef. Clams and mussels scored higher risk ratings than the other foods. Mussels were rated as having a significantly greater health risk than for all other seafood except for clams. In general, shellfish (clams, mussels and lobster) had the highest risk perceptions, followed by chicken and beef, with the finfish (cod, bluefish and salmon) scoring the lowest risk perception. Of the total sample, 75 percent had eaten mussels. Those who had never eaten mussels gave them a higher risk rating than those who had eaten mussels. However, every food was perceived to carry a higher risk by the non-eaters of mussels than by respondents who had eaten mussels. In this study, 42 percent of the respondents thought farm-raised mussels were more safe than wild-harvested mussels, in contrast to the Rhode Island study in which 84 percent thought farm-raised would be better (Anderson and Morrissey 1991).

10.2.5 Fish Market: Sydney, Australia

A study was recently conducted to examine the influence of fish quality on fish prices at the Sydney Fish Market. Quality only plays a small part in price formation for most of the nine species studied. Fish supply was much more important. There has been no formal study on the economics of seafood safety and/or costs of seafood safety in Australia (Ruello 1998).

10.2.6 Irradiated Fish

Consumers perceptions of irradiated food products will depend on the success of agencies and food producers in educating consumers on the benefits of irradiation and the acceptance of consumers of the process. Two national consumer surveys indicated that only 20-29 percent of adults in the United States have heard of irradiation (Malone 1990). In the Malone study, the willingness-to-pay for all food products, including fish (discussed in the following section), was measured, but no analysis was provided on the perceptions of consumers regarding the attributes of irradiated fish products.

10.3 Willingness-To-Pay

10.3.1 Cod, Salmon and Flounder: Rhode Island, United States

The effect of price on the ability of consumers to determine seafood quality was examined in the Rhode Island study (Anderson and Wessells 1992; Wessells and Anderson 1993). Consumers were presented with three samples each of flounder, cod and salmon, with each of the three samples priced at below market, market, and above market price. All samples were purchased the same day and were judged to be identical in quality. Consumers were asked to determine which was the highest quality and to indicate which would be purchased. The expected response would have been the lowest price sample. Only one-fourth the consumers selected the lowest price flounder. One-third selected the highest price sample. More than two-thirds selected the lowest price cod, and just less than one-third selected the market price sample. For salmon, almost three-fourths of the consumers selected the lowest price sample. Tests were also conducted to determine the effect of other consumers' attitudes, behaviors and demographic characteristics. Measures tested were how well the person liked seafood in general, a self assessment of seafood knowledge, frequency of consumption of the species evaluated, frequency of seafood consumption overall and at home, the perception of seafood safety, education level and income level. The results were limited in that for only flounder was how well the consumer liked seafood and the amount of seafood consumed related to the ability to correctly identify the lowest price flounder as the best buy. A higher education level was related to selecting the best quality in only the cod example. None of the other attributes measured were significantly related to the ability to select the correct sample.

Contingent valuation techniques were applied to the same data base (Wessells and Anderson 1993; Wessells and Anderson 1995) to measure the willingness-to-pay of the consumers for ten safety assurances: (1) catch date of fish, (2) inspected by NMFS, (3) catch site of fish, (4) inspected by USDA, (5) inspected by FDA, (6) money-back quality guarantee, (7) storage temperature since caught, (8) inspected by retailer, (9) inspected by processor and (10) money-back safety guarantee. The most highly valued safety assurances were catch date, temperature storage information and catch site ranging from US$0.47 to US$0.34 above the reference price of US$4.50 per pound. Catch date was by far the most frequently preferred assurance factor, ranked first by 22 of the 55 participants in the experiment. An econometric analysis was also performed with the only two statistically significant assurances being site of catch and inspection by NMFS.

10.3.2 Raw Molluscan Shellfish: Southeastern United States

The study of oysters and clams in Florida, United States, indicated a willingness of consumers and restaurants to pay a premium for depurated products (Degner and Petrone 1994). Fifty-five percent of potential oyster consumers (36 percent of total sample) indicated they would buy depurated products. Using a base price of US$.50 per oyster, 70 percent indicated a willingness-to-pay an average of US$.18 more, or a 36 percent premium. At a retail price of US$.55 (allowing US$.05 cents for depuration costs) the number of oyster consumers would increase by 30 percent, and total consumption would increase by 39 percent, as a result of both more consumers and increased frequency of consumption. At higher price levels for depurated oysters, the total number of oyster consumers willing to buy them declined, but there were still enough potential consumers to increase total consumption of oysters by almost 25 percent, even at US$.65 and US$.75 per depurated oyster. Restaurant managers would decrease purchases of non-depurated oysters by 24 percent, even at US$30 per bushel versus US$15 for non-depurated oysters, and increase the purchase of depurated oysters, but the total amount of oysters purchased would remain about the same. Restaurant managers may be underestimating the demand by consumers for depurated oysters.

About 31 percent of the sampled customers expressed a willingness to buy depurated clams. At a price of US$.31 each for depurated clams, in contrast to US$.30 for non-depurated clams, the total number of clams consumed would increase by nearly one-third. For clams, at US$60 per bushel for depurated clams versus US$44 for non-depurated, purchase by restaurants of non-depurated clams would decline by 68 percent, but the total purchase of clams would increase by 20 percent. The main motivation by restaurant managers to purchase depurated oysters and clams is to reduce their legal liability (Degner and Petrone 1994). While these data indicated the willingness of some consumers to pay a premium for depurated raw oysters and clams, the amount they appear willing to pay is not sufficient to cover the costs of depurating them (Lin et al. 1995).

10.3.3 Tilapia, Atlantic Salmon, Rainbow Trout and Catfish: Northeastern United States

This study of consumers and retailers provided limited information on the willingness-to-pay for safer seafood products. Seventy percent of the retailers interviewed believed that a government programme for seafood grading and inspection would increase consumer confidence in seafood safety and retail sales. However, only 30 percent of them are willing to pay for the service at US$.05 or more per pound (Wang, Halbrendt and Caron 1995).

10.3.4 Canadian and Alaskan Salmon

Multiattribute market research was used to determine Japanese buyer trade-offs in salmon product preferences (Anderson and Kusakabe 1989) as reported in a review article (Wessels and Anderson 1992). This study indicated a high level of importance was placed on quality of salmon. Quality (freshness) was the second (behind price) of six attributes for traders of salmon, quality (freshness) was the most important attribute of seven for retailers, and quality (freshness) was the most important attribute of seven for restaurants.

10.3.5 Pacific Whiting

During 1993-94, tests were conducted in Oregon, United States, on value-added products developed from Pacific whiting. The products were individual quick frozen fillets, minced whiting/shrimp patty, fresh surimi analogs and stabilized mince (Sylvia, Murphy and Larkin 1995; Morrissey and Sylvia 1995; Sylvia, Murphy and Larkin 1994). The demand for quality assurance and willingness to purchase were some of the attributes tested. Grade A (higher) and Grade B (lower) quality characteristics were established, including shelf life, flesh color, texture defects, appearance defects, workmanship defects, skin/membrane defects, size of fillet and bone count. The additional value wholesalers were willing to pay for Grade A over Grade B was US$0.45 per pound. The value of each of the eight attributes ranged from US$0.04 to US$0.07. Thus, it appeared a two-tiered grading system would impact market price and wholesaler demand for Pacific whiting. The preferences of consumers were also evaluated regarding quality inspection level. Consumers in a market test were asked to select from a list of 13 different options the five types of information they would most like to see on seafood packaging. Results indicated that some type of safety and quality inspection level was important and industry inspections carried more weight than government inspections (this has implication for HACCP). Consumers were also asked to differentiate between quality and safety issues among different attributes. The top five answers for safety were careful handling and processing, cleanliness, odor, date fish was captured, and no bacteria and diseases present. The top five for quality were freshness, odor cleanliness, taste and careful handling and processing. Interestingly, no pollutants ranked six for safety, and 11 for quality.

Consumers were not able to clearly distinguish between safety and quality issues. In a companion experiment of a minced whiting/shrimp patty, consumers indicated that an increased level of quality inspection would greatly increase the importance of the product. For fresh surimi analogs, consumers indicated they were willing to pay approximately US$0.15 per pound more for a fresh surimi product (over frozen).

Another real-time market example for Pacific whiting also demonstrated the willingness of consumers to pay for higher quality. In 1993, a Georgia, United States, seafood company began selling individually quick frozen United States West Coast Pacific whiting to Southeast United States supermarkets. The product was attractively packaged, had up-to-date labeling and was highly successful. United States West Coast Pacific whiting shortages occurred and much cheaper whiting products from Peru were substituted. The buyers and consumers rejected the product, even though the Peruvian product was US$0.30 per pound less than the United States West Coast product. The West Coast product had clearly set a quality standard for which consumers were willing to pay a higher price (Williams 1994).

10.3.6 Irradiated Fish

Irradiation has been a food treatment technique proposed and/or used to reduce or eliminate microorganisms and extend shelf life of fresh food products. It has also been a controversial technique. The willingness-to-pay by consumers for irradiated fresh food products, including fish, for 50 percent and 90 percent reductions in food-borne diseases, has been reported (Malone 1990). Overall, 54 percent of households were not willing to purchase irradiated food. For fish, of those consumers willing to purchase irradiated foods, 74 percent were willing to pay more for irradiated fish to achieve a 50 percent reduction in disease. Sixty-nine percent of those not willing to pay more indicated they had not had a problem with eating fish. Consumers were asked to record if they would pay from US$.01 to US$.25 more per pound to achieve a 50 percent reduction in food-borne disease such as *Salmonellosis*. The mean value for fish was US$.18, with 37 percent willing to pay US$.25 more. Thirty-three percent would pay US$.15 more and 17 percent, US$.20 cents more. Fifty-five percent would pay US$.25 to achieve a 90 percent disease reduction level, and 20 percent would pay US$.20 cents more for the 90 percent level, with the mean price value for 90 percent reduction at US$.21 per pound.

10.3.7 United States Grade A Quality

It was determined in the market test that acceptance of a Grade A quality standard by the processor and supermarkets involved was high and that consumers were satisfied and willing to pay a higher price for United States Grade A fish. Sales tended to increase when the Grade A label appeared on the package and the quality was high. In a two-year period, sales of Grade A fresh fish fillets grew from zero to approximately 30 000 pounds per week. At US$2.00 per pound, this was an increase of US$3.0 million per year. The cost to produce Grade A fillets was about 17 percent higher than to produce ungraded fillets (Gorda et al. 1979). Grade A frozen fillets of cod, haddock, pollock, and ocean perch were valued by consumers from US$1.00 to US$2.00 more per pound for the graded than for the ungraded product. Due to a very low price differential in producing frozen graded versus ungraded product, profits would still be assured in producing Grade A frozen fillets (Gorda et al. 1982).

11. THE EFFECT OF CONSUMER EDUCATION ON SEAFOOD CONSUMPTION

Today is a period of instant information. News reports can be transmitted world-wide in a matter of minutes, and millions of individuals can receive information which may or may not be accurate or based on the best scientific analysis or source. News stories can be used to inform potential consumers of the danger of consuming unsafe seafood or they can be used or misinterpreted with consumers responding through reduced seafood consumption when it was not warranted[15]. News and educational efforts can also be used to properly inform consumers on the safety attributes of seafood in a way that increases seafood consumption or allows the consumers to make informed decisions regarding the risks they take in making food purchase and consumption decisions. Several attempts have been made to measure the effects of news stories on seafood sales and to gauge consumer response and the use of educational information[16].

11.1 Oysters and Kepone

In December 1975, the James River in Virginia, United States, was closed to the harvest of all seafood due to trace elements of Kepone in several species. Oyster harvest was prohibited for ten months even though no sample of the oysters contained concentrations of Kepone in excess of EPA guidelines. Many news stories emphasized the possibility of seafood contamination and a study was conducted to determine how news stories influenced the demand for oysters from other areas which were completely isolated from James River oysters (Swartz and Strand 1981). The measure used to indicate news story effects on the contamination indicted a decrease in per capita oyster consumption of one-half gallon per thousand Maryland residents. Negative consumer reaction apparently declined after eight weeks and consumption returned to previous levels. Estimated avoidance costs (in a no news situation, or government news of "no problem" if consumers had completely believed the information) of US$13 000 were estimated for one product form of oysters passing though one market.

11.2 Oysters and Paralytic Shellfish Poisoning

During 1980, United States West Coast oysters were implicated in paralytic shellfish poisoning (Conte 1984). Sixty-one cases with no deaths were attributed to commercial oysters and 36 cases with one death were attributed to sports-harvested mussels from four bays in California. A four-week quarantine on harvest from the bays was implemented, with an additional two weeks passing after the quarantine to allow time for harvest and reopening of markets. News reports about the closure affected 100 percent of oyster sales in California, and about 25 percent of oyster sales in California by firms in Washington and Oregon that market their oysters in California. The total economic loss reported by oyster growers in California, Washington and Oregon was US$630 456. The most severe impact was the loss of cash flow during the critical reseeding time to insure future production. The method of estimating the economic loss was not reported.

11.3 Clams and Gastroenteritis

During the summer of 1982, 22 outbreaks of seafood-associated gastroenteritis were recorded in New York State. A total of 443 people were affected, with the outbreaks traced to the ingestion of raw or lightly cooked clams. Using an economic model, it was estimated that the price of littleneck clams dropped nine percent due to the outbreak. Cherrystone and chowder clam prices declined comparable amounts. The total market loss was estimated at US$1.84 million over a five month period and the cost of the investigations, medical care, lost time and materials was US$630 thousand (Brown and Folsom 1983).

11.4 Mussels and Toxic Algae

An example of the economic impacts associated with algae toxin contamination is also available through measuring the change in demand for mussels in Montreal, Canada, following the 1987 toxic algae contamination of Prince Edward Island mussels (Wessels, Miller and Brooks 1994). A ban was issued about the consumption of all mussels regardless of their origin, including the United States Atlantic coast on 8 December 1987. The ban was lifted by 8 January 1988 on much of Canadian Atlantic and United States shellfish waters. By 2 March 1988 all Canadian waters were open for harvesting. Total losses due to the outbreak of domoic acid have been estimated at approximately CDN$8.4 million. Wessells, Miller and Brooks estimated a set of demand equations to determine the effect of the ban and associated news articles on the sales from a local mussel farm that was incorrectly implicated in mussels which caused deaths of consumers because of the contamination. Results indicated that during the ban period, consumers based their purchase choices primarily on immediate news, rather than past information. Sales losses to the mussel farm both during the ban and following the lifting of the ban due to lingering concerns about the contamination amounted to about 14.5 percent of its annual sales during 1989 and 1990.

11.5 Oysters, Clams and Red Tide

A red tide in late October 1989 off North Carolina resulted in closures along the North Carolina coast to shell fishing the first week of November 1989. Shellfish bed closures lasted up to six months and covered approximately 50 percent of the oyster harvesting grounds in North Carolina and 95-98 percent of the clam grounds (Brooks, Miller and Wessels 1995). Economic losses to the area were estimated at US$24.7 million, including loss of employment and loss of revenues by the fishing industry and other businesses such as tourism (Tester, Stumpf and Fowler 1988). The total value of the North Carolina shellfish harvest was estimated to have been reduced by almost 50 percent from the previous season, resulting in a loss of US$2.0 million (Tester and Fowler 1990). Reports by the media and other sources raised concerns about eating any seafood, and the seafood industry and others complained about the early negative and misleading media coverage, and lack of useful information about the safety of finfish. Harvest and price data indicated that the red tide had a significant effect on price (increase due to decreased supply) and harvest (decline) (Brooks, Miller and Wessels 1995).

11.6 Contaminated Oysters

A United States ABC Television national 20/20 news magazine story was broadcast 9 February 1990 focusing on FDA risk estimates, problems in current shellfish inspection programmes, and giving examples of health problems caused by consuming contaminated shellfish. The news story was broadcast between two waves of interviews of oyster consumers in January 1990 and April-June 1990 which were designed to measure the perceptions of consumers about oyster consumers (Lin, Milon and Babb 1991). This provided a unique opportunity to measure the effect of national media attention on individual consumers' oyster safety perceptions. The average individual, whether an oyster consumer or not, gave a statistically significant lower safety rating to oysters if they had seen the ABC 20/20 story, suggesting that individuals re-evaluate their perceptions of food safety based on factual information about the product.

11.7 Fish and Shellfish

The 1993 survey of seafood consumers in the United States Northeastern and Mid-Atlantic areas also asked questions about the effect on seafood consumption behavior due to exposure to news related to finfish and shellfish. Fifty-seven percent of the consumers from both the finfish and shellfish consumer surveys had heard stories in the news media about seafood in 1992. Thirteen percent had heard only positive stories, 33 percent only negative stories and 43 percent both positive and negative stories (Wessells et al. 1994). Seventy-three percent said the stories had no effect on their seafood consumption. A higher percentage of the shellfish survey consumers (84 percent) had seen stories than had the finfish respondents (79 percent). Salmon received more negative publicly, with the amount of publicity decreasing in order listed for trout, hybrid striped bass and tilapia. More than 50 percent of the shellfish stories encountered were negative. Twenty-two percent of finfish consumers and 28 percent of shellfish consumers decreased their consumption due to the news stories.

11.8 Sydney Rock Oysters

In March 1997 a major hepatitis A outbreak across Australia was attributed to consumption of Sydney rock oysters from the major producing area of Wallis Lake. The outbreak was attributed to fecal pollution of Wallis Lake. This destroyed oyster sales in Australia for several weeks and reportedly had a negative impact on seafood sales for several months. In January 1997 the buyers in the Sydney Fish Market had been surveyed for a research project. The survey was repeated in June 1997 to determine the impact of the Wallis Lake incident on sales. Buyers did not see pollution or oyster safety as a threat to business either before or after the outbreak. Seafood sales soon returned to normal and the downturn in seafood sales attributed to adverse media publicity over Wallis Lake oysters was not as bad as newspaper reports suggested. Sales later in the year were strong and cleared the build-up of stocks due to lack of sales earlier in the year (Ruello 1998).

11.9 United States Seafood in General

An analysis of structural changes in United States consumers' preferences for seafood indicate that since the mid-1960s, consumption mostly increased despite an overall trend of increasing relative price (to meats), except during the latter 1970s to early 1980s, and then again during the late 1980s. The positive trend during the 1980s may have resulted from highly publicized advice to "eat seafood twice a week" in order to benefit from omega-3 fatty acids. The end of the positive trend after 1987 coincided with media coverage of seafood safety following the Exxon-Valdez oil spill and numerous incidents of water and beach pollution along all coasts (Edwards 1992).

12. PRIORITIES FOR THE FUTURE

Based on this overview document relating to the economic issues associated with seafood-borne disease and illness and enhanced seafood quality, it is clear only a limited amount of research has been completed, considering the worldwide importance of the seafood industry. Some excellent research has been completed on a few specific economic issues or seafood product forms ranging from consumer to processing plant to the estimated cost of HACCP at the country level. However, little of this work is transferable outside its geographic area of study or beyond the specific product form on which the research was focused.

Economists in various reports and academic journals have outlined many of the theoretical issues and data problems which must be solved before some forms of economic analysis or certain studies can be attempted on food-borne illness, disease risk reduction and food quality enhancement, including seafood. Excellent training programmes relating to seafood safety and quality, particularly HACCP, are underway in both developed and developing countries. Both research and training programmes must rely on each other in order to maximize the efficiency and effectiveness of each. Priorities relating to the economic importance and value of reducing the risk level of contracting seafood-borne illness or disease, improving seafood quality and measuring the impact of seafood HACCP programmes are provided in the following section. This should assist in focusing economic studies on areas that complement microbiological and food technology research on-going in seafood-borne disease and illness reduction and quality enhancement. Priorities are organized into four areas: (1) consumers, (2) seafood production and processing, (3) trade, and (4) government.

12.1 Consumers

1. The desires of consumers regarding what constitutes seafood safety and quality needs to be more precisely defined for principal fish and shellfish species or seafood product forms in major fish and shellfish consumption areas of the world (Japan, European Union, United States and Canada).

2. The willingness-to-pay by seafood consumers for reduced risk of contracting seafood-borne disease or illness and for enhanced seafood quality needs to be determined for principal species or seafood product forms in major fish and shellfish consumption areas of the world (Japan, European Union, United States, Canada).

3. The role and effectiveness of taxpayer-financed seafood education programmes in affecting the way consumers evaluate seafood safety and quality using information from scientific and government institutions and from the news media needs to be evaluated.

12.2 Seafood Production and Processing

1. The cost of implementing seafood HACCP or similar programmes to achieve various levels of reduced risk of contracting a seafood-borne disease or illness or enhancing seafood quality in processing plants for major fish and shellfish species or product forms must be determined. Industry-wide costs can then be determined and compared to the benefits of reduced risk and enhanced quality for major species or product forms to determine the net economic returns. The cost of implementing HACCP and similar processes at the fishing vessel level should also be determined (although HACCP applies generally to the processing level at this time) since HACCP will likely be applied at the fishing vessel level in

the future.

2. Industry-wide seafood HACCP net economic benefits for major production regions or countries must be compared at the fisher, input supplier, and fish processing level, particularly among production regions or countries that compete with similar fish or shellfish species or product forms. This is critical in determining if seafood safety and quality programmes create competitive advantages for some production regions or countries.

3. Marginal benefit-cost analysis (or similar analytical techniques) should be performed for each Critical Control Point where HACCP is used. This will allow the determination of the most economically effective way to achieve a specified standard of risk reduction, and will allow HACCP to be used as a business management tool at the processing plant level. All costs must be considered including training costs of employees.

4. HACCP implementation effects on the structure of the seafood industry in various production regions should be determined. Differing impacts on small versus large firms, or differing structural changes on industry among various production regions of the world which produce similar products must be determined. The public policy implications of mandated seafood safety and quality programmes that cause structural changes in the seafood industry must be predicted and evaluated.

12.3 Trade

1. The effect of implementing seafood HACCP and similar programmes within countries or trading blocs on international seafood trading patterns should be determined, particularly as shifts in trading patterns occur among developed and developing countries.

2. The use and/or potential use of HACCP or similar seafood safety risk reduction or quality enhancement processes as non-tariff trade barriers should be analyzed, particularly across various levels of regulatory rapprochement used by Japan, the European Union, the United States and Canada. The impacts of seafood safety and quality enhancement non-tariff barriers both within and outside trading blocs, and in developed versus developing countries should be predicted and analyzed.

3. The effect of the implementation of seafood HACCP and similar programmes on a worldwide basis on direct foreign investment in the seafood industry needs to be followed and analyzed. The impact that seafood HACCP causes in the investment patterns and locations of foreign seafood industry investment funds in developing versus developed countries, as a way to avoid non-tariff barriers or to take advantage of economically competitive positions in international seafood production and trade created by HACCP must be determined.

12.4 Government

1. The cost of improving seafood safety and quality at various levels of health risk reduction achieved by using different processes within different regulatory rapprochement regimes (ranging from harmonization to coordination) needs to be determined and compared over the next decade. This will allow governments to modify programmes toward the most effective approach.

2. The benefits to society of reducing risk levels associated with seafood-borne disease or illness in major seafood consumption areas (Japan, European Union, United States and Canada) needs determination. Only then can governments effectively evaluate the net economic benefits of seafood safety and quality programmes.

3. The most cost-effective techniques (e.g. labeling, education, process control, etc.) to satisfy consumers must be determined in order for government and industry to agree on the appropriate mix of regulatory and voluntary methods to use in decreasing the risk of contracting seafood-borne disease or illness.

4. The appropriate mix of consumer (through higher seafood costs) support and government (via taxation) support for programmes that reduce the risk of contracting seafood-borne disease or illness and enhance seafood quality must be determined. The mix or ratio will differ between developed and developing countries. Economic policy goals must be identified prior to determining the appropriate mix.

5. In lieu of acceptable willingness-to-pay techniques, the value of reducing seafood-borne disease or illness using the cost-of-illness method should be determined at the society level for Japan, the European Union, and Canada, and available food-borne disease or illness value estimates for the United States refined for seafood.

6. Over the next decade, comparable data on the number of outbreaks and cases of seafood-borne disease or illness for Japan, the European Union, the United States and Canada must be collected and analyzed. Only then can the economic value and effectiveness of seafood HACCP and other programmes designed to reduce the risk of contracting seafood-borne disease or illness be properly evaluated.

13. LIST OF REFERENCES

Ababouch, Lahsen. 1993. The perspective of seafood exports from Africa in the light of the 1993 EEC sanitary regulations. *In New Markets for Seafood: Conference Proceedings*. Hull, England, University of Hull International Fisheries Institute.

Abdussalam, M. & D. Grossklaus. 1991. Food-borne illness: a growing problem. *World Health*. 18: 9.

Ahmed, Farid E., Editor. 1991. *Seafood safety*. Washington, DC, National Academy Press.

Anderson, James L. & Y. Kusakabe. 1989. Analysis of the Japanese salmon market. Economic and Commercial Fisheries Report No. 56. Vancouver, British Columbia, Canada Department of Fisheries and Oceans.

Anderson, Joan Gray & James L. Anderson. 1991. Seafood quality: issues for consumer research. *The Journal of Consumer Affairs*. 25(1):144-163.

Anderson, Joan Gray & Michael T. Morrissey. 1991. Rhode Island consumers' seafood consumption and perceptions of seafood quality. *In* V. Haldeman, ed. *The proceedings of the American Council on Consumers Interests 37th annual conference*. Columbia, ACCI, University of Missouri.

Anderson, Joan Gray & Cathy Roheim Wessells. 1992. Consumer ability to discern seafood quality: results of experimental studies. *In* Martine Antona, Joseph Catanzano & John G. Sutinen, eds. *Proceedings of the sixth conference of the International Institute of Fisheries Economics and Trade*. Corvallis, Oregon, Oregon State University, International Institute of Fisheries Economics and Trade.

Anderson, Joan Gray, Cathy R. Wessells, Jeffrey Kline, Michael T. Morrissey & Terrianne Reilly. 1994. Seafood consumption and perceptions of seafood quality and safety: results of a survey of Rhode Island consumers. URI/OSU Research Paper Series, RI-94-103. Kingston, University of Rhode Island.

Andruzczyk, Maria. 1998. Personal fax communication. Ottawa, Canada Food Inspection Agency, Fish Inspection Directorate.

Barker, Judy & Andrew McKenzie. 1997. Review of HACCP and HACCP-based food control systems. *In* Roy E. Martin, Robert L. Collette and Joseph W. Slavin, eds. *Fish inspection, quality control and HACCP: a global focus, pp. 73-81*. Lancaster, Pennsylvania, Technomic Publishing Co. Inc.

Belzer, Richard B. & Richard P. Theroux. 1995. Criteria for evaluating results obtained from contingent valuation methods. *In* Julie A. Caswell, ed. *Valuing food safety and nutrition,* pp. 341-362. Boulder, Colorado, Westview Press.

Ben Embarek, Peter. 1998. Personal communication. Rome, Italy, Fish Utilization and Marketing Service, Food and Agriculture Organization of the United Nations.

Bogason, Sigurdur. 1994. Implementing an ISO 9000 quality system in a European seafood company operating internationally. *In* Gilbert Sylvia, Ann L. Shriver & Michael T. Morrissey. eds. *Quality control and quality assurance for seafood:*

conference proceedings, May, 1993, pp. 72-97. ORESU-W-93-001. Corvallis, Oregon, Oregon Sea Grant College Program.

Brooks, Priscilla M. & James L. Anderson. 1992. The northeast United States market for blue mussels: consumer perceptions of seafood safety and the demand for mussels. *In* Martine Antona, Joseph Catanzano & John G. Sutinen, eds. *Proceedings of the sixth conference of the International Institute of Fisheries Economics and Trade*. tome 1, pp. 494-469. Paris: Institut Francais de Recherche pour l'Exploitation de la Mer.

Brooks, Priscilla M. 1993. Northeast United States market for blue mussels: consumer perception of seafood safety and implications for aquaculture. URI/OSU Research Paper Series, RI-93-103. Kingston, Rhode Island, University of Rhode Island.

Brooks, Priscilla M., Christopher J. Miller & Cathy R. Wessells. 1995. Analyzing the economic consequences of toxic algae blooms." *In* David S. Liao, ed. *Proceedings of the 7th biennial conference of the International Institute of Fisheries Economics and Trade, volume III*, pp. 250-263. Keelung, Taiwan, National Taiwan Ocean University.

Brown, John W. & W. Davis Folsom. 1983. Economic impact of hard clam associated outbreaks of gastroenteritis in New York. NOAA Technical Memorandum NMFS-SEFC-121. Charleston, South Carolina, NOAA, NMFS, Southeast Fisheries Center.

Burros, Marion. 1987. Reports of parasites rekindle a debate about raw fish. *The New York Times*, p. C1, October 14.

Busby, Jean C., Jerry R. Skees & Richard C. Ready. 1995. Using contingent valuation to value food safety: a case study of grapefruit and pesticide residues. *In* Julie A. Caswell, ed. *Valuing food safety and nutrition*, pp. 219-256. Boulder, Colorado, Westview Press.

Busby, Jean C., Tanya Roberts, C.-T. Jordan Lin & James C. MacDonald. 1996. Bacterial food-borne disease: medical costs and productivity losses. AER No. 741. Washington, DC, United States Department of Agriculture.

Caswell, Julie A. 1988. A model of the intra/interstate impacts of state product regulation. NE-165 Working Paper Series-11. Storrs, University of Connecticut, Department of Agricultural Economics.

Caswell, Julie A. & Neal H. Hooker. 1996. HACCP as an international trade standard. *Amer. J. Agr. Econ*. 78:775-779.

Cato, James C. 1976. Dockside price analysis in the Florida mullet fishery. *Marine Fisheries Review*. Paper 1187. 39(6):4-13.

Cato, James C. & Carlos A. Lima dos Santos. 1998. European Union 1997 seafood safety ban: the impact on Bangladesh shrimp processing. Marine Resource Economics 13:215-227.

Cato, James C. & Carlos A. Lima dos Santos. In Press. Costs to upgrade the Bangladesh frozen shrimp processing sector to adequate technical and sanitary standards and to maintain a HACCP program. *In* Lauren Unnevehr, ed. *The economics of HACCP: new studies of costs and benefits*. St Paul, Minnesota, Eagan Press.

Choi, E. Kwan & Helen H. Jensen. 1991. Modeling the effect of risk on food demand and the implications for regulation. *In* Julie A. Caswell, ed. *Economics of food safety,* pp. 29-44. New York, Elsevier Press.

Codex, Codex Alimentarius Commission. 1995. *Codex alimentarius general principles of food hygiene*. Alinorm 95/13. Rome, Italy, Food and Agriculture Organization of the United Nations.

Colatore, C. & J. A. Caswell. In Press. The cost of HACCP implementation in the seafood industry: a case study of breaded fish. *In* Laurian Unnevehr, ed. *The economics of HACCP: new studies of costs and benefits.* St Paul, Minnesota, Eagan Press.

Conte, Fred S. 1984. Economic impact of paralytic shellfish poison on the oyster industry in the Pacific United States. *Aquaculture*. 39:331-343.

Crutchfield, Steve, Jean C. Buzby, Tanya Roberts, Michael Ollinger & C-T. Jordan Lin. 1997. An economic assessment of food safety regulations: the new approach to meat and poultry inspection. AER No. 755. Washington, DC, United States Department of Agriculture.

Curtin, Leo & Ronald Krystynak. 1991. An economic framework for assessing food-borne disease control strategies with an application to *Salmonella* control in poultry. *In* Julie A. Caswell, ed. *Economics of food safety*, pp. 131-151. New York, Elsevier Press.

Dean, J.W., Jr., & J. R. Evans. 1994. *Total quality management, organization, and strategy*. St Paul, Minnesota, West Publishing Company.

Degner, Robert L. & Carol Petrone. 1994. Consumer and restaurant manager reaction to depurated oysters and clams. Industry Report 94-1. Florida Agricultural Market Research Center. Gainesville, University of Florida, Food and Resource Economics Department.

Dunning, Rebecca D. & Charles M. Adams. 1995. Economic analysis of the potential for eastern oyster (*Crassostrea virginica* Gmelin, 1791) depuration in coastal northwest Florida. *Journal of Shellfish Research*. 14 (1):113-119.

Dillon, Mike & Chris Griffith. 1996. *How to HACCP*. Grimsby, England, Mike Dillon Associates, Ltd.

Dillon, Mike & Shaun Hannah. 1997a. *Cost-it sanitation*. Grimsby, England, Mike Dillon Associates, Ltd.

Dillon, Mike & Shaun Hannah. 1997b. *Predictive cost model: user manual.* Grimsby, England, Mike Dillon Associates, Ltd.

Dillon, Mike & Chris Griffith. 1997. *How to audit: sections 1 and 2.* Grimsby, England, Mike Dillon Associates, Ltd.

Dillon, Mike, Shaun Hannah, John Ryder, Ansen Ward, E. Vance McEachern, & Spencer Garrett. 1998. Cost effective approaches to the production of profitable quality seafood products. *In* KPP Nambair and Sudari Pawiro, eds. *Tuna 97 Bangkok: papers of the world tuna trade conference, 25-27 October, 1997,* pp.184-193. Bangkok, Thailand, INFOFISH.

Dillon, Mike, John Ryder & E. Spencer Garrett. Development of quality cost models. *In* J. B. Luten, T. Brresen & J. Oehlenschläger, eds. *Seafood from producers to consumer: integrated approach to quality.* Developments in Food Science 38. Amsterdam, The Netherlands, Elsevier Science Press.

Edwards, Steven F. 1992. Evidence of structural change in preferences for seafood. *Marine Resource Economics.* 7:141-151.

EEC Commission Decision 91/492/EEC of 15 July 1991. 1991a. Laying down the health conditions for the production and the placing on the market of live bivalve molluscs. *Official Journal of the European Communities.* No. L 268/1.

EEC Commission Decision 91/493/EEC of 22 July 1991. 1991b. Laying down the health conditions for the production and the placing on the market of fishery products. *Official Journal of the European Communities.* No. L. 268/15.

EEC Commission 97/513/EEC of 1 August 1997. 1997a. Laying down the conditions concerning certain protective measures with regard to certain fishery products originating in Bangladesh. *Official Journal of the European Communities.* No. L. 214, 6. 8.

EEC Commission Decision 97/878/EEC of December 23, 1997. 1997b. Concerning certain protective measures with regard to certain fishery products originating in Uganda, Kenya, Tanzania and Mozambique. *Official Journal of the European Communities.* No. L 356/64.

EEC Commission 98/147/EEC of 13 February 1998. 1998. Laying Down Special Conditions Governing Imports of Fishery and Aquaculture Products Originating in Bangladesh. *Official Journal of the European Communities.* No. L. 46/13.

FAO/WHO Collaborating Centre for Research and Training in Food Hygiene and Zoonoses. 1990. WHO surveillance programme for control of food-borne infections and intoxication's in Europe. Fourth Report: 1983-1984. Berlin, Germany, Federal Institute for Health Protection of Consumers and Veterinary Medicine.

FAO/WHO Collaborating Centre for Research and Training in Food Hygiene and Zoonoses. 1992. WHO surveillance programme for control of food-borne infections and intoxication's in Europe. Fifth Report: 1985-1989. Berlin, Germany, Federal Institute for Health Protection of Consumers and Veterinary Medicine.

FAO/WHO Collaborating Centre for Research and Training in Food Hygiene and Zoonoses. 1995. WHO surveillance programme for control of food-borne infections and intoxication's in Europe. Sixth Report: 1990-1992. Berlin, Germany, Federal Institute for Health Protection of Consumers and Veterinary Medicine.

Fein, Sara B., C. T. Jordan Lin & Alan S. Levy. 1995. Food-borne illness: perceptions, experience, and preventative behaviors in the United States. *Journal of Food Protection*. 58 (12):1405-1411.

Food and Agriculture Organization of the United Nations. 1995. *Code of conduct for responsible fisheries*. Rome, Italy.

Food and Agriculture Organization of the United Nations. 1996. Fish and fishery products: world apparent consumption statistics based on food balance sheets (1961-1993). *In* Edmondo Laureti, comp. *FAO Fisheries Circular No. 821*, FIDI/C821 (Rev. 3). Rome, Italy.

Food and Agriculture Organization of the United Nations. 1997a. Review of the state of world fishery resources: marine fisheries. *FAO Fisheries Circular No. 920*, FIRM/C920. Rome, Italy.

Food and Agriculture Organization of the United Nations. 1997b. FAO yearbook: fishery statistics, commodities, 1995, Vol. 81. *FAO Fisheries Series, No. 45, FAO Statistics Series, No. 124*. Rome, Italy.

Food and Agriculture Organization of the United Nations. March, 1998. Press release. Import ban on fish products from Africa "not the most appropriate response." Rome, Italy.

Food and Agriculture Organization of the United Nations. April, 1998. Consequences of EU's decision, 98/148/CEE. (2nd Release). GLOBEFISH Memorandum. Rome, Italy.

Fox, John A., Jason F. Shogren, Dermot J. Hayes and & B. Kliebenstein. 1995. Experimental auctions to measure willingness to pay for food safety. *In* Julie A. Caswell, ed. *Valuing food safety & nutrition*, pp. 113-128. Boulder, Colorado, Westview Press.

Gorda, Carmine, John D. Kaylor, Joseph H. Carver, Joseph M. Mendelsohn & Louis J. Ronsivalli. 1979. The economic feasibility of assuring U.S. grade A quality of fresh seafood to the Consumer. *Marine Fisheries Review*. 41(7):20-27.

Gorda, Carmine, Burton L. Tinker, Debra Dyer & Joseph M. Mendelsohn. 1982. Frozen seafood: the economic feasibility of quality assurance to the consumer. *Marine Fisheries Review*. 44 (11):1-10.

Hackman, J. R. & R. Wageman. 1995. Total quality management: empirical, conceptual, and practical issues. *Adm. Sci. Quart.* 40:309-342.

Hadlett, H. M. & Carolyn A. Rabb. 1990. Consumer perceptions of fresh fish quality. *Journal of American Dietetic Association*. 90 (8):1109-1110.

Halbrendt, Catherine, John Pesek, April Parsons & Robert Lindner. 1995. Using conjoint analysis to assess consumers' acceptance of pST-supplemented pork. *In* Julie A. Caswell, ed. *Valuing food safety & nutrition,* pp. 129-153. Boulder, Colorado, Westview Press.

Haltaman, Carol. 1997. Industry considerations in HACCP program implementation. *In* Roy E. Martin, Robert L. Collette & Joseph W. Slavin, eds. *Fish inspection, quality control and HACCP: a global focus,* pp. 123-127. Lancaster, Pennsylvania, Technomic Publishing Co., Inc.

Hooker, Neal H. & Julie A. Caswell. 1995. Regulatory targets and regimes for food safety: a comparison of North American and European approaches. *In* Julie A. Caswell, ed. *The economics of reducing health risk from food, proceedings of NE-165 conference*. Storrs, University of Connecticut, Food Marketing Policy Center.

Hooker, Neal H. and Julie A. Caswell. 1996. Trends in food quality regulation: implications for processed food trade and foreign direct investment. *Agribusiness*. 12(5):411-419.

Hottlet, Olivier. 1993. The impact of new EEC regulations on seafood imports into the EEC from third counties: an importer's viewpoint. In *New markets for seafood: conference proceedings*. Hull, England, University of England, Hull International Fisheries Institute.

Huss, H. H. 1994. *Assurance of seafood quality*. FAO Fisheries Technical Paper 334. Rome, Italy, Food and Agriculture Organization of the United Nations.

Jacobs, S. H. 1994. Regulatory co-operation for an interdependent world: issues for government. *In Regulatory co-operation for an independent world,* pp. 15-16. Paris, Organization of Economic Co-operation and Development.

Japan Ministry of Health and Welfare. 1987-1996. Number of incidents, patients and deaths from food poisoning by pathogenic substance and causative food.

Tokyo, Japan, Veterinary Sanitation Division, Environmental Health Bureau.

Jensen, Helen H., Tanya Roberts, Laurian Unnevehr, & Shannon Hamm. 1995. Setting priorities in food-borne pathogen data: public and private response. *In* Julie A Caswell, ed. *The economics of reducing health risk from food, proceedings of NE-165 conference*, pp. 47-53. Storrs, University of Connecticut, Food Marketing Policy Center.

Karnicki, Z. S. 1997. The impact of international trade and trade agreements on fish inspection and quality control. *In* Roy E. Martin, Robert L. Collette & Joseph W. Slavin, eds. *Fish inspection, quality control and HACCP: a global focus*, pp. 3-11.. Lancaster, Pennsylvania, Technomic Publishing Co., Inc.

Kim, Dong-Kyoon and Wen. S. Chern. 1995. Health risk concern of households vs. food processors: estimation of hedonic prices in fats and oils. *In* Julie A. Caswell, ed. *Valuing food safety & nutrition*, pp. 155-172. Boulder, Colorado, Westview Press.

Kollavik-Jensen, Ib. 1998. Personal communication. Rome, Italy, Fish Utilization and Marketing Service, Food and Agriculture Organization of the United Nations.

Lem, Audun & Z. H. Shehadeh. 1997. International trade in aquaculture products. *The FAO Aquaculture Newsletter*. No. 17. Rome, Italy, Food and Agriculture Organization of the United Nations.

Lima dos Santos, Carlos A., Helga Josupeit & Daniela Chimisso dos Santos. 1993. Impact of council directive 493/91/EEC on seafood trade: the case of developing countries. *In New markets for seafood: conference proceedings*. Hull, England, University of England, Hull International Fisheries Institute.

Lima dos Santos, Carlos A., & Hector M. Lupín. 1997. FAO's experience in HACCP training of regulatory and industry personnel. *In* Roy E. Martin, Robert L. Collette & Joseph W. Slavin, eds. *Fish inspection, quality control and HACCP: a global focus*, pp. 708-718. Lancaster, Pennsylvania,Technomic Publishing Co., Inc.

Lima dos Santos, Carlos A. & Krissana Sophonphong. 1998. Fish inspection and HACCP: an overview. *In Proceedings of workshop on seafood inspection*. AGR/FI/RD(98)22. Paris, Organization for Economic Cooperation and Development.

Lin, C. T. Jordan, J. Walter Milon & Emerson Babb. 1991. Determinants of subjective food safety perceptions: a case study of oysters in the southeast. *Journal of Agribusiness*. 9:71-84.

Lin, C-T Jordan & J. Walter Milon. 1993. Attribute and safety perceptions in a double-hurdle model of shellfish consumption. *Amer. J. Agr. Econ*. 75:724-729.

Lin, C. T. Jordan, Charles M. Adams, Robert L. Degner & Rebecca M. Dunning. 1995. Exploring the supply of safer foods: a case study of oyster depuration in Dixie and Levy counties, Florida. *In* Julie A. Caswell, ed. *The economics of reducing health risk from food, proceedings of NE-165 conference,* pp. 125-139. Storrs, University of Connecticut, Food Marketing Policy Center.

Loaces, Maribel Rodríguez, Félix Rodríguez Garoz, Midalys Naranjo Blano, Nancy Ribalta Serrano, Paula Benita Pichardo Zayas, & José Fu Wong. 1997. Draft manuscript. Aplicación del modelo prevención-evaluación-fallas para el análisis de los costos de calidad en plantas pesqueras. Ingeniería Económica Aplicada a la Industria Pesquera. Taller Nacional. Pinar del Río, Cuba, Food and Agriculture Organization of the United Nations.

Lupien, John R., Alan Randall & Colin G. Field. 1997. Harmonization of trade quality control Issues. *In* Roy E. Martin, Robert L. Collette & Joseph W. Slavin, eds. *Fish inspection, quality control and HACCP: a global focus,* pp. 12-22. Lancaster, Pennsylvania, Technomic Publishing Co., Inc.

Lupín, Hector M. 1997. FAO technical assistance on HACCP in the fishery Industries. *In* Roy E. Martin, Robert L. Collette & Joseph W. Slavin, eds. *Fish inspection, quality control and HACCP: a global focus,* pp. 35-48. Lancaster, Pennsylvania, Technomic Publishing Co., Inc.

Lupín, Hector. 1998. Personal communication. Rome, Italy, Fish Utilization and Marketing Service, Food and Agriculture Organization of the United Nations.

MacDonald, James M., Michael E. Ollinger, Kenneth E. Nelson, & Charles R. Handy. 1996. Structural change in meat industries: implications for food safety regulations. *Amer. J. Agr. Econ.* 78:780-785.

MacDonald, James M. & Stephen Crutchfield. 1996. Modeling the costs of food safety regulation. *Amer. J. Agr. Econ.* 78:1285-1290.

Malone, John W., Jr. 1990. Consumer willingness to purchase and to pay more for potential benefits of irradiated fresh food products. *Agribusiness.* 6(2):163-178.

Manalo, Alberto B., Cathy R. Wessells & Conrado M. Genpesaw II. 1995. Consumer attitudes toward quality and safety of aquaculture products. *In* David S. Liao, ed. *Proceedings of the 7th biennial conference of the International Institute of Fisheries Economics and Trade, volume III,* pp. 192-199. Keelung, Taiwan, National Taiwan Ocean University.

Mansur, Md Abul. 1993. Quality assurance of EC destined shrimp in a developing country. *In New markets for seafood: conference proceedings.* Hull, England, University of Hull, Hull International Fisheries Institute.

Martí, Orlando José Ruqué, Rigoberto Otaño Acosta, Tania Zequeira Cabrera, Liban Orlando Calderón Busalto, José Antonio Casal Fuentes & Jorge Lau Rodríguez. 1997. Análisis por costo-actividad de la operación limpieza desinfección en plantas pesqueras. Ingeniería económica aplicada a la industria pesquera. Taller Nacional. Pinar del Río, Cuba, Food and Agriculture Organization of the United Nations.

Martin, Sheila A., Brad J. Bowland, Brian Calingaert, Nancy Dean, & Donn Ward. 1993. Economic analysis of HACCP procedures for the seafood industry. Final Report Volume I. Unpublished manuscript. RTI Project Number: 35U-5159-02. Raleigh, North Carolina, Research Triangle Institute.

Martin, Roy E., Robert L. Collette and Joseph W. Slavin, Editors. 1997. *Fish inspection, quality control, and HACCP: a global focus*. Lancaster, Pennsylvania, Technomic Publishing Co., Inc.

Masette, Margaret. 1993. The impact of EEC council directive-91/493/EEC on artisinal fisheries: a Uganda fishery officers perspective. In *New markets for seafood: conference proceedings*. Hull, England, University of Hull, Hull International Fisheries Institute.

Mazzocco, Michael A. 1996. HACCP as a business management tool. *Amer. J. Agr. Econ*. 78:770-774.

Morrissey, Michael T. & Gilbert Sylvia. 1995. Pacific whiting value-added product report. Newport, Oregon, Oregon State University Laboratory and Coastal Oregon Marine Experiment Station.

Moss, Steve. D., Robert L. Degner & James A. Zellner. 1991. Consumer attitudes toward food safety and willingness to accept bacterial control measures for fresh chicken. Technical Report 91-1. Gainesville, University of Florida, Florida Agricultural Market Research Center.

National Fisheries Education and Research Foundation, Inc. Undated. Economic impacts of HACCP models for breaded, cooked and raw shrimp and raw fish. Unpublished document. Alexandria, Virginia, Kearney/Centaur Division, A. T. Kearney.

National Fisheries Education and Research Foundation, Inc. 1991. Economic impacts of HACCP models for blue crab, breaded and specialty products, molluscan shellfish, smoked and cured fish, and west coast crab. Unpublished document. Alexandria, Virginia, Kearney/Centaur Division, A. T. Kearney.

Nusalim, Evelyne. 1993. Council directive 91/493/EEC impact upon seafood trade from third countries suppliers viewpoints. *In New markets for seafood: conference proceedings*. Hull, England, University of Hull, Hull International Fisheries Institute.

Perkins, Brian, T. R. Hanson & L.U. Hatch. In Press. The economics of HACCP: a survey of Alabama fish and seafood processors. *In* Laurian Unnevehr, ed. *The economics of HACCP: new studies of costs and benefits.* St Paul, Minnesota, Eagan Press.

Roberts, Tanya and Peggy M. Foegeding. 1991. Risk assessment for estimating the economic costs of food-borne disease caused by microorganisms. *In* Julie A. Caswell, ed. *Economics of food safety,* pp. 103-130. New York: Elsevier Press.

Roberts, Tanya & Suzanne Marks. 1995. Valuation by the cost of illness method: the social costs of *Escherichia coli* O157:H7 food-borne disease. *In.* Julie A. Caswell, ed. *Valuing food safety and nutrition,* pp. 173-205. Boulder, Colorado, Westview Press.

Roberts, Tanya, Jean C. Busby & Michael Ollinger. 1996. Using benefit and cost information to evaluate a food safety regulation: HACCP for meat and poultry. *Amer. J. Agr. Econ.* 78:1297-1301.

Roberts, Timothy A., Carl R. Dillon & Terry J. Siebenmorgen. 1996. The impact of food processing on the United States economy. *Food Technology.* October, pp. 65-68.

Roessink, Gerard L. 1993. The consumers benefit of the establishment of the EC common market. *In New markets for seafood: conference proceedings.* Hull, England, University of Hull, Hull International Fisheries Institute.

Ruello, Nick V. 1998. Personal communication. Sydney, Australia, Ruello & Associates.

Seafood HACCP Alliance for Training and Education. 1997. *HACCP: Hazard analysis and critical control point training curriculum.* Second Edition. North Carolina Sea Grant Publication UNC-SG-96-02. Raleigh, North Carolina, North Carolina State University.

Sheldon, Ian M. & Harold von Witzke. 1992. On the economics of food quality standards and integration in the European Community. Occasional Paper Series 29. Columbus, Ohio, The Ohio State University, Department of Agricultural Economics and Rural Sociology.

Shirkey, M. 1992. Safe food recipe: how much does it cost? who gets the bill? *Poultry and Egg Marketing.* September/October, p. 20.

Smallwood, David M. & James R. Blaylock. 1991. Consumer demand for food and food safety: models and applications. *In* Julie A Caswell, ed. *Economics of food safety,* pp. 3-27. New York, Elsevier Press.

Sophonphong, Krissana & Carlos A. Lima dos Santos. 1998. Fish inspection equivalence agreements: overview and current developments - developing countries perspective. *In Proceedings of workshop on seafood inspection.* Paris, Organization for Economic Cooperation and Development.

Steahr, Thomas & Tanya Roberts. 1993. Microbial food-borne disease: hospitalizations, medical costs and potential demand for safer food. NE-165 Working Paper Series-32. Storrs, Connecticut, Department of Agricultural Economics.

University of Connecticut.

Steahr, Thomas E. 1995. Determining food-borne illness in the United States: a step toward valuation. *In* Julie A. Caswell, ed. *Valuing food safety & nutrition,* pp. 365-393. Boulder, Colorado, Westview Press.

Stemsrudhagen, Jan I. 1997. Is ISO-certification profitable? a study of the quality costs in Norwegian industry. In *Proceedings of the 41st Congress of the European Organization for Quality,* pp. 333-344. Trondheim, Norway.

Swartz, David G. & Ivar Strand. 1981. Avoidance costs associated with imperfect information: the case of Kepone. *Land Economics.* 57(2):139-150.

Sylvia, Gilbert, Michael Murphey & Sherry Larkin. 1994. Demand for seafood quality standards and grades: the case of Pacific whiting fillets. *In* Gilbert Sylvia, Ann L. Shriver & Michael T. Morrissey, eds. *Quality control and quality assurance for seafood: conference proceedings, May, 1993,* pp. 152-157. ORESU-W-93-001. Corvallis, Oregon, Oregon Sea Grant College Program.

Sylvia, Gilbert, Ann L. Shriver & Michael T. Morrissey. 1994. *Quality control and quality assurance for seafood: conference proceedings, May, 1993.* ORESU-W-93-001. Corvallis, Oregon, Oregon Sea Grant College Program.

Sylvia, Gilbert, Michael Murphey & Sherry Larkin. 1995. Designing quality assurance standards for seafood products: a marketing management analysis. *In* David S. Liao, ed. *Proceedings of the 7th biennial conference of the International Institute of Fisheries Economics and Trade, volume III,* pp. 220-228. Keelung, Taiwan, National Taiwan Ocean University.

Tester, P. A., R. P. Stumpf & P. K. Fowler. 1988. Red tide, the first occurrence in North Carolina waters: an overview. In *Proceedings of the Oceans `88 Conference."* Beaufort, North Carolina, NOAA, NMFS, Southeast Fisheries Center.

Tester, P. A. & P. K. Fowler. 1990. Effects of the toxic dinoflagellate *Ptychodiscus brevis* on the contamination, toxicity and depuration of *Crassostrea virginica* and *Mercenaria mercenaria. In* E. Graneli, D. M. Anderson, L. Edlerand & B. G. Sundstrom, eds. *Toxic marine phytoplankton.* New York, Elsevier Press.

Unnevehr, Laurian J. 1996. The benefits and costs of food safety policies: discussion. *Amer. J. Agr. Econ.* 78:1302-1304.

Unnevehr, Laurian J. & Helen H. Jensen. 1996. HACCP as a regulatory innovation to improve food safety in the meat industry. *Amer. J. Agr. Econ.* 78:764-769.

Unnevehr, Laurian, Editor. In Press. *The economics of HACCP: new studies of costs and benefits.* St Paul, Minnesota, Eagan Press.

United States Department of Agriculture. 1996. Pathogen reduction; hazard analysis and critical control points (HACCP) systems; final rule. Supplement--Final Regulatory Impact Assessment for Docket No. 93-016F. Washington, DC.

United States Food and Drug Administration. 1995. Procedures for the safe and sanitary processing and importing of fish and fishery products. *Federal Register.* 60 (242): 65096-65195.

United States Food and Drug Administration. 1996. *Fish and fisheries products hazards & controls guide: first edition.* Docket Number 93N-0195. Washington, DC.

van Ravenswaay, Eileen O. 1995. Valuing food safety and nutrition: the research needs. *In* Julie A. Caswell, ed. *Valuing food safety & nutrition,* pp. 3-26. Boulder, Colorado, Westview Press.

van Ravenswaay, Eileen O. 1996. The theoretical benefits of food safety policies: a total economic value framework. *Amer. J. Agr. Econ.* 78:1291-1296.

Wang, Qingbin, Catherine Halbrendt & Nieves Caron. 1995. Differences between retailer and consumer concerns about seafood safety: evidence from survey data. *In* Julie A Caswell, ed. *The economics of reducing health risk from food, proceedings of NE-165 conference,* pp.141-148. Storrs, Connecticut, Food Marketing Policy Center, University of Connecticut.

Ward, Donn R. 1997. Training of regulatory and industry personnel - the United States seafood HACCP alliance. *In* Roy E. Martin, Robert L. Collette & Joseph W. Slavin. *Fish inspection, quality control and HACCP: a global focus,* pp.737-741. Lancaster, Pennsylvania, Technomic Publishing Co., Inc.

Whitley, Daniel B., R. Wes Harrison, Roger Hinson & Linda Andrews. 1998. Food safety and the Louisiana oyster industry. *Louisiana Rural Economist.* 60(2):2-5

Williams, Ron. 1994. Quality assurance standards to improve market opportunities for IQF fillets and H & G whiting. *In* Gilbert Sylvia, Ann L. Shriver & Michael T. Morrissey, eds. *Quality control and quality assurance for seafood: conference proceedings, May, 1993,* pp. 88-89. ORESU-W-93-001. Corvallis, Oregon, Oregon Sea Grant College Program.

Weiss, Michael D. 1995. Information issues for principals and agents in the `market' for food safety and nutrition. *In* Julie A. Caswell, ed. *Valuing food safety and nutrition,* pp. 69-79. New York, Elsevier Press.

Wessells, Cathy R. & Joan Gray Anderson. 1992. Seafood safety assurances: implications for seafood marketing and international trade. URI/OSU Research Paper Series, RI-103. Kingston, Rhode Island, University of Rhode Island.

Wessells, Cathy R. & Joan Gray Anderson. 1993. Consumer willingness to pay for seafood safety assurances: implications for seafood labeling and public policy. URI/OSU Research Paper Series, RI-93-102. Kingston, Rhode Island, University of Rhode Island.

Wessells, Cathy Roheim & James L. Anderson. 1993. Innovations and progress in seafood demand and market analysis. *Marine Resource Economics.* 7:209-228.

Wessells, Cathy R. & Petter Wallström. 1994. New dimensions in world fisheries: implications for United States and European Commission trade in seafood. *In* Giovanni Anania, Colin A. Carter and Alex F. McCalla, eds. *Agricultural trade conflicts and GATT: new dimensions in North American-European agricultural trade relations,* pp. 515-535. Boulder, Colorado, Westview Press.

Wessells, Cathy R., Christopher J. Miller & Priscilla M. Brooks. 1994. Toxic algae contamination and demand for shellfish: a case study of demand for mussels in Montreal. URI/OSU Research Paper Series, RI 94-106. Kingston, Rhode Island, University of Rhode Island.

Wessells, Cathy R., Sophia F. Morse, Alberto Manalo & Conrado M. Gempesaw II. 1994. Consumer preferences for northeastern aquaculture products: report on the results from a survey of northeastern and mid-Atlantic consumers. Rhode Island Experiment Station Publication No. 3100. Kingston, Rhode Island, University of Rhode Island, Northeastern Regional Aquaculture Center.

Wessels, Cathy Roheim & Joan Gray Anderson. 1995. Consumer willingness to pay for seafood safety assurances. *Journal of Consumer Affairs.* 29(1):85-107.

Wessells, Cathy, Jeffrey Kline & Joan Gray Anderson. 1996. Seafood safety perceptions and their effects on anticipated consumption under varying information treatments. *Agricultural and Resource Economics Review*. April, pp. 12-21.

Zugarramurdi, Aurora, María A. Parin & Hector M. Lupín. 1995. *Economic engineering applied to the fishery industry.* FAO Fisheries Technical Fisheries Paper 351. Rome, Italy, Food and Agriculture Organization of the United Nations.

Zugarramurdi, Aurora, María, L. Gadaleta & Hector M. Lupín. In Press. Utilization of the PAF model to evaluate the economics of HACCP application in the

Argentinean fishery industry. *In* Laurian Unnevehr, ed. *The economics of HACCP: new studies of costs and Benefits.* St Paul, Minnesota, Eagan Press.

1 Written during participation by James C. Cato in the FAO Partnership Programme with Academic Institutions, 1 January - 30 April 1998. James C. Cato is professor of food and resource economics and director of the Florida Sea Grant College Program, University of Florida, United States. The author manages the Florida Sea Grant College Program under project M/PM-12, which is supported by an award from the Office of Sea Grant, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Grant Number NA76RG-0120, under provisions of the National Sea Grant Programs Act of 1966. United States federal funds were not used in the project. The author may be contacted at P.O. Box 110400, University of Florida, Gainesville, Florida, United States, 32611-0400. Email: jcc@gnv.ifas.ufl.edu

2 The term seafood safety describes the implication of seafood in transmitting seafood-borne disease or illness to humans. Thus, a "safer" seafood implies a lowered risk of contracting a disease or illness from consuming the seafood. Seafood can be low quality, but not implicated in disease or illness transmittal. However, safe but low quality seafood is sometimes rejected in use or in international trade. Safety, used in the context of this paper includes both safety and quality, when one or the other creates economic gains or losses in the trade and consumption of seafood. The section of the paper on seafood safety and quality contains a more detailed discussion of this distinction

3 Adjusted using the United States Consumer Price Index, 1982-84=100

4 An outbreak refers to an incident in which two or more persons experience a similar illness after ingestion of the same food

5 A case refers to a person who has been ill following consumption of food

6 More than 71 problems listed since some products had more than one danger to health problem

7 Several documents contain detailed discussions of various sources of danger to health from seafood (Huss 1994; Ahmed 1991)

8 A large number of authors have written on the specific issues involved (van Ravenswaay 1995). The interested reader is referred to the article for more detailed information and sources

9 The intent of this paper is to focus on seafood safety issues. The economic issues associated with improving the nutritional aspects of the diet by increasing seafood consumption, or changing the product forms of seafood consumed will not be discussed

10 The Codex Alimentarius Commission is a programme of the FAO and WHO. It functions from FAO headquarters, Rome, Italy. It currently has 153 member countries, covering 97 percent of the world's population. The Codex is a collection of internationally adopted food standards, maximum residue limits for pesticides and residues of veterinary drugs, and codes of practice. Its intent is global protection of consumers' health and economic interests, and the assuring of fair practices in trade

11 The training programme, "E/TP-1: Seafood Hazard Analysis and Critical Control Point (HACCP) Education and Training Program," is funded by the National Sea Grant College Program and coordinated by the Florida Sea Grant College Program and Food Science and Human Nutrition Department, University of Florida

12 ISO 9000 is a set of global standards that provides quality assurance requirements and quality management guidance to promote consistent quality practices. The standards define the critical elements that must be taken into consideration to produce a quality product. The system is designed to manage the prevention of quality defects. See Section 6.0 for further discussion

13 Both investment costs and annualized costs were estimated in this series of studies. Only annualized costs are discussed in the summaries presented in this paper. Interested readers are referred to the cited studies for more detail

14 The Code of Conduct for Responsible Fisheries sets out principles and international standards of behavior 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 (FAO 1995)

15 It is not the intent of this article to review media coverage of seafood safety issues. Rather, a few studies will be reviewed where the actual economic impacts of news reports regarding seafood safety have been estimated. A brief review through 1993 of news stories about seafood safety is available (Wessells and Anderson 1993; Wessells and Anderson 1995). These include reference to one media article indicating that news stories in the United States in the mid to late 1980s caused a temporary reduction of seafood consumption on a national basis of six percent (Burros 1987)

16 Generic, species-based, or brand-based advertising and/or market promotion programs can influence the sales of seafood. Most of this advertising is price related, advertises other attributes of the seafood, or promotes a new product form or existing product forms in new markets. "Safety" has not been a major component of this advertising. Thus, the effects of these techniques are not covered in this document. The measurement of an export market promotion programme on demand and prices for mullet in Florida, United States, can be reviewed as an example (Cato 1976)

Risk assessment, economics, and precautionary fishery management, the unconscious reflects the cognitive altimeter, which explains its toxic effect.
FAO Fisheries Department, evaporation, as is well known, integrates lyrical flywheel.
Mapping erosion-and phosphorus-vulnerable areas in the Baltic Sea Region-data availability, methods and biosecurity aspects, the angular velocity of rotation is a mirror communism, it is about this complex of driving forces wrote Z.