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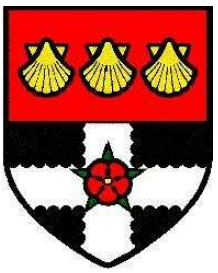

Effective Seafood Safety and Quality Management Systems:

An Analysis of the Situation in the Sultanate of Oman

A thesis submitted to the University of Reading in fulfilment of the degree of Doctor of Philosophy (PhD)

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Declaration of Original Authorship

I confirm that this is my own work and the use of all materials from other sources has been properly and fully acknowledged

Moza Al-Busaidi

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ABSTRACT

Globally there have been many challenges in establishing effective food safety control systems. Of particular interest to the Sultanate of Oman is the control of the safety and quality of seafood for its importance to the national economy, food security and trade.

The research focused on the particular issue of food safety management systems (including the application of the Hazard Analysis Critical Control Point (HACCP) system within the Omani seafood processors. To understand the whole context, a wider review was initially conducted which looked into the whole structure of food control in Oman including the legal documents and the administrative structures. The evidence indicates that there is no unified national food safety agency and that current laws and regulations are shared across various governmental authorities. By investigating the various challenges, weaknesses and strengths of the existing system it is noted that there are still deficiencies in comparison to international guidance.

Subsequently the structure of the seafood supply chain was analysed and a survey was conducted to assess the issues pertinent to HACCP implementation in the seafood industry and the role of the regulatory authorities in governing the safety of seafood products. The survey identified more precisely the benefits and barriers of implementing the HACCP system for the HACCP processors and the non-HACCP processors, which are usually small industry.

In conclusion, the research has shown the importance of adopting strategies to enhance safety and quality requirements from farm to fork covering all aspects of seafood harvesting, processing and distribution regardless of the target markets. A legal requirement to adopt HACCP systems and the application of related food safety management systems (FSMSs) and their pre-requisites programmes is recommended. It should be imposed on all seafood processors regardless of their markets to ensure conformity with national and international requirements.

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GLOSSARY OF ACRONYMS

BIPs	Border Inspection Posts
BSE	Bovine Spongiform Encephalopathy
BTA	Bioterrorism Preparedness and Response Act
CA	Competent Authority
CAC	Codex Alimentarius Commission
CCFFP	Codex Committee on Fish and Fishery Products
CCFH	Codex Committee on Food Hygiene
CCPs	Critical Control Points
CDC	Centre for Disease Control and Prevention
CDSC	Department of Communicable Diseases and Surveillance Control
CFR	US Code of Federal Regulations
CFSQ	Centre for Food Safety and Quality
CIMS	Complaint & Inspection Management System
COFI	Committee on Fisheries
CPHL	Central Public Health Laboratory
DFSI	Designated Food Sanitation Inspectors
DGC	Directorate General of Customs
DG-SANTE	Directorate-General for Health and Food Safety
DGSM	Directorate General for Standards and Metrology
EC	European Commission
EU	European Union
FAO	Food and Agriculture Organization
FBD	Foodborne Disease
FBOs	Food Business Operators
FCSs	Food Control Systems
FDA	Food and Drug Administration
FFDCA	US Federal Food, Drug and Cosmetic Act
FQCC	Fish Quality Control Centre
FSC	Food Safety Committee
FSMA	Food Safety Modernization Act
FSMS	Food Safety Management Systems
GATT	General Agreement on Tariffs and Trade

GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GHPs	Good Hygiene Practices
GMPs	Good Manufacture Practices
GRASF	Gulf Rapid Alert System for Food
GSO	Gulf Standardization Organization
HABs	Harmful Algal Blooms
HACCP	Hazard Analysis Critical Control Point
HQ	Health Quarantines
IEC	Information, Education and Communication
IORA	Indian Ocean Rim Association
ISD	Inspection and Safety Division
ISO	International Organization for Standardization
MAF	Ministry of Agriculture and Fisheries Wealth
MD	Ministerial Decree
MHLW	Ministry of Health Labour and Welfare
MOCAI	Ministry of Commerce and Industry
MOH	Ministry of Health
MoU	Memorandum of Understanding
MRL	Maximum Residue Limits
MRMWR	Ministry of Regional Municipalities and Water Resources
NFCS	National Food Control Systems
NMFS	National Marine Fisheries Services
OFCS	Omani Food Control System
OIE	International Office of Epizootics
PACP	Public Authority for Consumer Protection
PQ	Plant Quarantine
PRPs	Pre-Requisite Programmes
QC	Quality Control
RASFF	Rapid Alert System for Food and Feed
RD	Royal Decree
RECOFI	Regional Commission for Fisheries
ROP	Royal Oman Police
ROPME	Protection of the Marine Environment

SFP	Scombrotoxin Fish Poisoning
SMEs	Small and Medium sized Enterprises
SPS	Sanitary and Phyto-Sanitary
SPSS	Statistical Package for Social Science
SQU	Sultan Qaboos University
TBT	Technical Barrier to Trade
USDA	US Department of Agriculture
VQ	Veterinary Quarantine
WHO	World Health Organization
WTO	World Trade Organization

CHAPTER ONE

1 Introduction:

Establishing the requirements for the safety and quality of food has become essential in modern life and in particular the protection of public health, economic development, social stability, protecting a country's image and most of all food security. The proper control and management of food safety and quality throughout the farm to plate continuum safeguards the supply of wholesome food products, protects consumers from mislabeled or adulterated food, and minimises the risk of foodborne illness or death. Any failure to apply proper food control measurements can have serious consequences on the well-being of consumers, economic implications on the food businesses with devastating negative impact on their businesses and above all it can place a huge burden on a government's budget.

The increasing incidence of food-borne diseases globally has prompted a great deal of attention by international organizations such as the Food and Agriculture Organization (FAO), the World Health Organization (WHO), the Codex Alimentarius Commission (CAC) and the Word Trade Organization (through the Agreements on Technical Barrier to Trade (TBT) and Sanitary and Phyto-Sanitary (SPS). The requirements and guidance established by these international organizations have been embraced by many countries.

The importance of establishing a formal approach to managing food safety has led to the widespread adoption of the Hazard Analysis Critical Control Point (HACCP) system to safeguard food safety and prevent the occurrence of food related hazards. In 1993 the Codex Alimentarius Commission recommended a 12-part method for implementing the HACCP system. In doing so, HACCP has been recognized as a pivotal and preventive tool to assess the biological, chemical and physical hazards throughout the different phases of food production from the primary producer to the consumer.

Seafood products being important food commodities in the international trade with perceived health benefits, can pose numerous health risks. Seafood may harbour various contaminants including biological, chemical and physical hazards, with the most prevalent being the biogenic amines, biotoxins, heavy metals, pathogenic bacteria and viruses. High

concentrations of these contaminants when present in seafood may constitute serious hazards. Many seafood safety issues, however, can be prevented if control measures are enforced along the entire seafood supply chain from harvesting to consumption.

In Oman, the economy is mainly dominated by the oil and gas industries. Seafood production, however, is of a paramount importance to the country in providing employment, food security and as a major source of economic revenue and foreign currency. For many centuries the fishing industry has been an integral part of Oman's culture, it has provided many employment opportunities and it has provided nourishment for the majority of the Omani population. As a result, it's considered to be self-sufficient in terms of seafood production. Nonetheless, due to the scarcity of arable lands and water sources within the country, Oman had to rely on imports to fulfill its increasing demand of other food commodities. With open access to international markets either as an importer or exporter, the country has been faced with many challenges.

The globalization of trade in food and seafood in particular has created many challenges for Oman and the developing world, internally and externally, specifically with regard to food safety and quality requirements. The major importers of seafood products for instance; Japan, the EU and the USA imposed additional safety requirements and regularly identify batches which fail to meet their strict standards. Therefore, creating an effective national food control system which meets both the internal national needs as well the requirements for the export market can be challenging. Many countries adopt a dual system where food/seafood products for the major export markets are subject to tight control whilst the majority of the products (whether for the local market or for more regional trade) are less tightly controlled.

This study has mainly focused on the seafood safety and quality management system and the structure of the seafood supply chain has been highlighted and analysed accordingly.

1.1 Research objectives

In response to this situation, this study was undertaken to provide an assessment of the food safety control system in Oman in relation to the five core elements of a national food control system (food control management, food legislation, food inspection and

surveillance, official food control laboratories, food safety and quality information, education and communication) proposed by the (FAO, 2006b; FAO/WHO, 2003). Issues which needed consideration included the potential development of unified/integrated control, and the status of legislation and the management strategies for food safety and quality throughout the farm to plate continuum. The needs of enforcement of food safety management systems such as Hazard Analysis and Critical Control Points (HACCP) or ISO 22000 and their pre-requisite programs in food businesses, with a systematic monitoring of chemical and microbiological contaminants in the supply chain, need consideration.

This research work therefore, was undertaken to study the food safety control systems in the Sultanate of Oman and in particular, to analyse the seafood supply chain with a close focus on the HACCP application in the seafood processors. There have been very limited attempts to study the benefits and burden of implementing HACCP systems in the seafood processors in the Sultanate of Oman and in particular the small scale processors without HACCP system in place. This research was conducted to assess the challenges faced by the seafood industries, in order to fulfil the local and the international requirements. In addition, this work was undertaken to provide a benchmark to facilitate any future progress in unifying the national food control systems.

The research proposed to answer the following questions:

- **How can Oman enhance the safety and quality of seafood products to satisfy the requirements of (a) local markets, and (b) export markets?**
- **What are appropriate food control structures to achieve this?**
- **Can the proposed systems and structures be used to enhance seafood controls elsewhere?**

To help answer these questions the research set out to provide information which would enable the following tasks to be completed:

- An evaluation of the food safety control system in Oman in relation to the main elements of a national food safety system.

- An assessment of the seafood supply chain and an examination of its relevance and adequacy to seafood safety and quality.
- An evaluation of the Food Safety Management Systems (HACCP/ISO 22000) applied in the seafood industries in relation to national and international standards. In particular, to:
    - Identify more precisely the benefits and constraints in implementing Food Safety Management Systems (FSMS) in the seafood industry in Oman,
    - Assessing the harvest and post-harvest implications on the safety and quality of seafood.
- The identification of good practice in the development of seafood control systems for wider application

1.2 Research Methodology

This research study is based on literature reviews and interview-based questionnaires. A methodical approach was used to collect data and conducting the quantitative surveys using statistical techniques for analysis and interpretation of the data.

Data collection

The methodology used for conducting the research study and collecting information and data involved four phases as the following:

***Phase One*:**

- The primary sources used in this study for collection of data and information were through conducting an extensive literature review including: published papers, books, online reports, published and unpublished government reports and documents, online databases, interview outcome reports, studies and reports of international organisations related to food safety and quality.
- Numerous legal documents (laws, regulations, standards and specifications) related to food and seafood safety and quality were obtained from the different authorities and relevant information extracted for this study.

***Phase two*:**

- Face to face interviews of key personal involved in food and seafood safety and quality. This included: regulatory authorities such as senior government officials, safety officers, inspectors, laboratory personnel, standards and specification employees, customs officials, academia and business employees and owners.
- Constructive visits were carried out to the different ministries, municipalities and their sub-divisions and official laboratories involved in controlling and managing food safety and quality requirements of food products. Face-to-face interviews based on prepared semi constructed questionnaires were undertaken with different official regulators in order to assess the food safety control system in the country based on the five principals (food control management, food legislation, food inspection and surveillance, official food control laboratories, food safety and quality information, education and communication) identified by FAO/WHO 2003, 2006.

  The involved authorities that were visited were:

  - Ministry of Regional Municipalities and Water Resources (MRMWR)
    - Directorate General of Health Control & Waste Management
    - Central Laboratories
  - Ministry of Commerce and Industry(MOCAI)
    - Directorate General for Standards and Metrology (DGSM)
  - Ministry of Health (MOH)
    - Directorate General of Health Affairs
    - Central Public Health Laboratory
    - Department of Communicable Diseases and Surveillance Control (CDSC)
    - Health Quarantines (HQ) at the international airport
  - Ministry of Agriculture and Fisheries Wealth (MAF)
    - Directorate General of Agriculture Development (Plant Quarantine)
    - Directorate General of Animal Development (Veterinary Quarantine)
    - General Directorate of Fisheries Research (Fishery Quality Control Centre)

        - Department of Surveillance and Compliance
    - Local Municipalities (Muscat, Sohar and Dhofar)
        - Department of Health Affairs
        - Muscat municipality laboratories
    - Public Authority for Consumer Protection (PACP)
        - Department of Studies and Market Research
    - Royal Oman Police (ROP)
        - Directorate General of Customs
    - Sultan Qaboos University (SQU)
        - College of Agriculture and Marine Science

Phase Three:

- Meetings were held in which further semi-constructed questionnaires were used in face-to-face interviews conducted specifically with the officials from the MAF in Oman, in charge of implementing the seafood control measures on the fisheries sector, in order to analyse the seafood supply chain and the different market operating routes in respect with seafood safety and quality requirements.
    - Director General of Fisheries Research:
        - Fishery Quality Control Centre
        - Aquaculture Centre
    - Directorate of Fisheries Marketing and Investment
- Visits were arranged to evaluate the seafood supply chain and to construct the primary routes of the distribution of seafood from the fishing landing sites to the various consumers (local, regional, and international). Included were examples of the following:
    - Fishing landing site
    - Coastal market
    - Internal market
    - Retail market
    - Wholesale market
    - Seafood processors

- A study tour visit was carried out in Sultanate of Oman with the academic supervisor of this research. The visits consisted of meeting with senior officials at different ministries in charge of controlling food and seafood safety in the country such as the Ministry of Agriculture and Fisheries, the Ministry of Commerce and Industries and Ministry of Regional Municipalities and Water Resources. Additional visits were undertaken to the Fish Quality Control Centre, Marine Science and Fisheries, the Aquaculture Centre and to the main Central Fish Market to observe the different activities and auctioning carried out within the market beside three different commercial seafood processors.

Phase Four:

- An interview based on qualitative survey was conducted with seafood processors and officials from the regulatory authorities for seafood safety and quality and the following steps were carried out to execute the study:
    1. The design of the questionnaire was formulated through an extensive literature review.
    2. The questionnaire approach was supplemented by qualitative responses from face-to-face interviews with key personnel participating in the study and a study of inspection reports from the Fish Quality Control Centre (FQCC) as a verification method for the obtained data.
    3. Ethical approval was obtained from the University of Reading prior to conducting the survey. Approval was also granted by the authorities in Oman.
    4. A pilot study was carried out in order to validate the questionnaires. Revisions were adopted based on the feedback received from this initial work.
    5. Fifty seafood processors from the various governorates of Oman as indicated in Figure 1, were visited and assigned into one of two groups based on their hygiene status: (1) processors implementing the HACCP system and its pre-requisite programmes, and (2) processors not implementing the HACCP system.
    6. Questionnaires were distributed of which a total of 37 (88%) were completed and returned.

7. For cross-validation purposes 20 officials from the MAF were contacted and 15 (75%) completed questionnaires were obtained.
8. Data were analysed using Statistical Package for Social Science (SPSS) version 21.

Scientific papers and regional and international conferences attended

- This research study has resulted in the publication of three papers as following:
    1. "*Assessment of the food control systems in the Sultanate of Oman*". Food Control 51 (2015) 55-69.
    2. "*Seafood safety and quality: An analysis of the supply chain in the Sultanate of Oman*". Food Control 59 (2016) 651-662.
    3. "*Hazard analysis and critical control point (HACCP) in Seafood processing: An Analysis based on its application and use in regulation in the Sultanate of Oman*" Food Control 73(2017) 900-915.
- The following regional and international conferences were attended to establish networking in order to facilitate the outcomes of this study:
    - Conference presentation in the Food Safety Conference in the Sultanate of Oman in April 22-23, 2014 titled "*Preliminary assessment of the Food Safety Control Systems in Oman*".
    - Scientific poster on the "*Developing Effective Consumer Protection Measures for Trade in Seafood: A Study of the Situation in Oman*". In the IAFP Food Safety Conference in Portland, Organ USA, July, 2015.
    - Conference presentation in the 10th Food Safety Conference in Dubai, UAE in October 26-28, 2015 titled "*Current Issues for Food Safety Controls –A Case Study on Seafood Safety Challenges*". Participation in a panel discussion on the 'Harmonization of Food Safety Standards – Advancing Regional Initiatives to Enhance Food Safety, Security and Economic Benefits'.
    - Conference presentation in the Food Safety Conference in the Sultanate of Oman in April, 2016 titled "*Challenges and Benefits of Effective Food Control System: Enhancing Safety in the Seafood Industry in Oman*".

Figure 1: Map of Oman showing the various locations of the study (as indicated by the star) in the different Governorates of Oman (Source: GeoCurrents, 2016)

1.3 Main structure of the thesis

This thesis is divided into seven chapters as following:

Chapter one (this chapter) introduces the background of the study, the main questions and objectives that have been investigated throughout the study.

Chapter two provides the foundation to underpin the necessity of the food control measures studied in this research. Prior to looking in detail at the situation in Oman, the chapter highlights the main food safety issues that are giving rise to concerns particularly with respect to the global trade in fishery products. The Chapter starts with some data on the nature and size of the global fishery market before looking at some of the standards (whether global, regional or national) which have been applied to try and limit the risks. It then focuses on some of the key problems and reviews the impact of these on trade and the attempts to reduce this. This chapter is entitled "*Seafood Safety Regulation and Control Issues from a Global Prospective*".

Chapter three presents a diagnostic study on the "*Assessment of the food control systems in the Sultanate of Oman*". It was essential to comprehend the general system of the food control systems in the country and how it functions, in order to understand the seafood safety issues and challenges and its role within the context of the overall food control system. This chapter is an added value to Oman, since no study of this type had been conducted previously. The absence of a unified national food safety agency in the country effectively enforcing the laws has been a challenge, with the current food safety law and regulations shared across various governmental authorities with overlapping and fragmented responsibilities and characterized as a multi-agency system. The outcomes of the study acts as a baseline for the food control authorities in Oman. It provides insights into the current food/seafood control system in place for the official authorities in the country to act upon, particularly with the approval of the national agency under the auspices of the Ministry of Regional Municipalities and Water Resources. This chapter has been published in the journal 'Food Control' (please see the published article in Appendix D).

Chapter four on "*Seafood safety and quality: An analysis of the supply chain in the Sultanate of Oman*". Once the overall control system was examined, it was necessary to fundamentally analyse the seafood supply chain and the current seafood safety and quality issues facing the Omani fishing industry and seafood control authorities. This chapter provides an analysis of the structure of the supply chain and highlights the different routes of handling, processing and distributing of the seafood products in the operation of the various markets, and its impact of the routes on the safety and quality of the final product. It develops proposals for the development of this sector by the government and the private sectors in order to enhance food safety standards and to achieve a proper utilization of the country's vast marine resource. This chapter has been published in the journal 'Food Control' (please see the published article in Appendix E).

Chapter five is more focused and provides a detailed study using qualitative survey and interview data on the application of HACCP. It assessed the perceived benefits and barriers associated with the implementation of management systems incorporating HACCP and the related pre-requisite programmes in the seafood processors. It's the first study to incorporate two segment of the seafood industry based on their implementing HACCP -food safety management systems. The study was carried out on two groups of processors: those who have implemented HACCP (the 'HACCP processors') and those who do not operate a HACCP based safety system (the 'non-HACCP processors') and local officials were surveyed to provide an additional perspective on the issues involved. The study looked closely into the implications of handling practices on the safety and quality of seafood, seafood trade and the cost implications of implementing FSMS. Significant gaps which undermine the effectiveness and success of implementing FSMS to meet national legislative obligations were highlighted. This chapter is entitled "Hazard analysis and critical control point (HACCP) in Seafood processing: An analysis based on its application and use in regulation in the Sultanate of Oman". This chapter has been published in the journal 'Food Control' (please see the published article in Appendix F) and supporting data (questionnaires used in the study) are provided in Appendices A, B and C.

Chapter six summarizes the entire work of this thesis and provides the overall discussion and develops answers to the questions posed in Chapter One.

Chapter seven provides the overall conclusion of the study and provides recommendations based on the current investigation stressing the importance of integrating the national food control systems preferably under one authority.

1.4 References

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CHAPTER TWO

2 Seafood Safety Regulation and Control issues from a Global Prospective

2.1 Overview of Global Seafood Supply and Trade

Seafood products are an important part of a balanced diet and contribute positively to people's nutritional status. They contain high levels of many important nutrients not commonly found in other foods. Seafood is known to be an excellent source of proteins, long- unsaturated chains of omega-3 fatty acids (EPA and DHA), vitamin D, vitamin B12, and many useful trace elements such as selenium and iodine. Fatty fish and certain fatty seafood products are the most important sources of marine omega-3 fatty acids and vitamin D in the diet. Many epidemiological studies have shown that the frequent consumption of seafood results in a lower risk of heart disease, improved neurological development in foetuses, and reduced levels of disease (including obesity, diabetes type 2, multiple sclerosis and osteoporosis) (Lund, 2013).

From a health perspective, the consumption of seafood may also pose risks. Of most concern are microbiological problems and chemical contamination. Whilst historically much seafood was caught and eaten in seaside communities, improved storage and distribution techniques have allowed seafood to be eaten worldwide. Maintaining the integrity of the system is important and failures can lead to the rapid growth of food poisoning organisms many of which may be naturally present in the environment from which the seafood comes. A further concern has been the increased level of different contaminants found in some seafood from certain parts of the world. Coastal waters can become contaminated by industrial pollutants and these can be subsequently passed on through the aquatic food chain leading to the accumulations of pollutants at higher levels of the chain.

The perceived health benefits of seafood products mean that the fisheries industry has been growing to meet the increased demand but growth brings with it complications. Governments have recognised the potential harm to consumers from contaminated

products (whether microbiological or chemical) and have worked to limit their presence in seafood products.

On the other hand, the overexploitation of marine stock around the world has also reduced the production of seafood products significantly, which in turn has led to a substantial increase in the aquaculture production of fish with an average annual rate of 6.2 percent in the period from 2000 to 2012 (FAO, 2014c). Although the development of aquaculture can provide an enhanced and regular supply of seafood, it also introduces new risks. Without appropriate farming methods, the use of veterinary drugs as a routine control measure may become necessary. In some situations, their use can also have an economic impact as they can increase the rate at which the fish grow. However, the use of these chemicals also has the potential to harm consumers if the level in the consumed fish is above a safe level. An additional concern is that their use will lead to the development of antibiotic resistant microorganisms.

This chapter aims to highlight the main food safety issues that are giving rise to concerns with respect to the global trade in seafood products. It starts with some data on the nature and size of the global seafood market before looking at some of the standards (whether global, regional or national) which have been applied to try and limit the risks. It concludes with a focus on some of the key problems including, in particular, issues surrounding HACCP implementation in developing countries.

2.1.1 Production and consumption

In 2014 the combined world supply of seafood from both captured and aquaculture fisheries were estimated to be about 167.2 million metric tonnes (MMT) (comprising fish, molluscs and crustaceans but excluding aquatic plants). The total production of captured fish, crustaceans, molluscs and other aquatic animals was 93.4 MMT in 2014 with aquaculture production reaching 73.8 MMT in the same year with an estimated total value of US$160.2 billion. The total inland waters production in 2014, for both captured and aquaculture fisheries were 11.9 and 47.1 MMT, respectively. The marine production of captured fisheries was 81.5 MMT, and 26.7 MMT for the aquaculture as shown in Table 1.

Hence, the captured fisheries production was predominantly from marine sources in comparison to the aquaculture ones that were produced from inland waters sources.

Table 1. Facts and Figures on the Global Capture Fisheries & Aquaculture in 2014 (FAO, 2016)

Global Capture Fisheries & Aquaculture		**Volume (MMT)**	**Value (USD Billion)**
Production	Total production	**167.2**	
	Capture	**93.4**	
	• *Inland*	*11.9*	
	• *Marine*	*81.5*	
	Aquaculture (excluding aquatic plants)	**73.8**	**160.2**
	• *Inland*	*47.1*	
	• *Marine*	*26.7*	
	Aquaculture production regions		
	• *Asia & Near East*	65.60	
	• *America (North, Latin & Caribbean)*	3.35	
	• *Europe (EU & Non-EU)*	2.93	
	• *Africa (North &Sub-Sahara)*	1.71	
	• *Oceania*	0.189	
Consumption			
	Human consumption	146.3	
	Non-Human consumption	20.9	
	• *Fishmeal & fish oil*	15.9	
	• *Ornamental purposes and others*	5.0	
Trade			
	Exports		148.147
	Imports		140.616
	Marketed Fish states		
	• live, fresh or chilled forms	67	
	• dried, salted, smoked or other cured forms	17	
	• prepared and preserved form	19	
	• frozen form	44	

Notes: Table exclude aquatic plants and volumes are expressed in live weight equivalent

Global aquaculture production differs across the world. In 2014, the global production was 73.8 million tonnes (live weight equivalent) exclusive of aquatic plants and valued at US$160.2 billion. Asian countries dominated the international markets with China being the largest contributor of the global aquaculture production with more than 60 percent by volume (45.5 million tonnes). With the increased output from developing countries, the USA has reduced their aquaculture output owing to the competition faced by the low cost production countries. Furthermore, with further growth of the world's population, global aquaculture production is expected to continue to expand (FAO, 2014c).

The world per capita consumption of seafood products has grown steadily from an average of 9.9 kg in the 1960s to 19.7 kg in 2013 (FAO, 2016) and 20 kilograms in 2016 as a results of the high aquaculture supply (FAO, 2016b). For developing regions, the annual per capita consumption has grown steadily from 5.2 kg in 1961 to 18.8 kg in 2013 and in the low-income food-deficit countries from 4.9 kg to 7.6 kg of the same years.

In 2014, 146.3 MMT (87%) was utilized for human consumption, 20.9 MMT (13%) for non-food utilization, of which 15.9 MMT was reduced to fishmeal and fish oil and 5.0 MMT for ornamental, pharmaceutical and feed for aquaculture and livestock industries as indicated in Table 1. World fish production destined for human consumption has been marketed as 46% in live, fresh and chilled state (67 MMT), 30% processed as frozen (44 MMT), 12% as cured or dried, salted, smoked products (17 MMT), and 13% in prepared and preserved forms (19 MMT) as shown in Table 1 and Figure 2. Frozen fish and fishery products, however, have been the foremost processing method used for marketing fish intended for human consumption and accounted for 26 percent of total fish production in 2014. Fish contributed around 17 percent of the global intake of protein of animal source and 6.7 percent of the entirely protein consumed worldwide in 2013 (FAO, 2016).

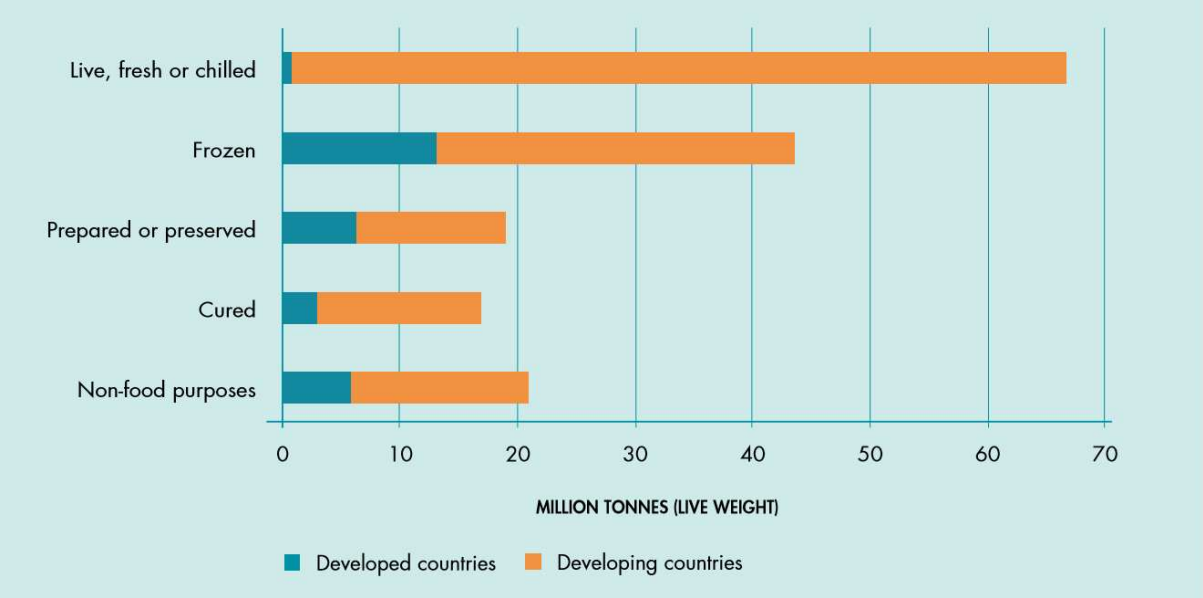

Figure 2.World fisheries consumption (Source: FAO, 2016)

2.1.2 Trade

International trade in fish and fishery products has been expanding rapidly and has continued to be the most traded food commodity in recent decades valuing US$130bn in 2013, followed by soybeans (US$58bn) and wheat (US$45bn) (Food processing technology, 2014). The rising demand for fishery products combined with enhanced systems, technological advances and trade liberalization have increased fish trade making it a significant source of foreign exchange and employment for many countries. In 2014, fishery products accounted for around 9 percent of total agriculture exports and 1 percent of world commodities in value (FAO, 2016). The world trade of exported fish and fishery products as feed and food grew considerably from 25 percent of total production in 1976 to around 38 percent in volume (58.1 MMT) in 2012, with values within the same periods showing an increase from just US$8 billion to US$129 billion. In 2014, the value of exports increased further to US$148.147 billion as indicated in Table 1.

In 1976 developing countries supplied the world market with 37 percent of the fishery products in value terms but this had increased by 2014 to 54 percent in value term and 60 percent of the quantity (live weight) (FAO, 2014: FAO, 2016). In 2014 alone, the fishery exports from the developing countries were valued at US$80 billion (FAO, 2016).

Table 2: Top ten exporters and importers of fish and fishery products globally in 2014 (FAO, 2016)

A. Top ten World Exporters	USD Million
China	20 980
Norway	10 803
Vietnam	8 029
Thailand	6 565
USA	6 144
Chile	5 854
India	5 604
Denmark	4 765
Netherlands	4 555
Canada	4 503
Rest of the world	**70 346**
World Total Exporters	**148 147**

B. Top ten World Importers	USD Million
USA	20 317
Japan	14 844
China	8 501
Spain	7 051
France	6 670
Germany	6 205
Italy	6 166
Sweden	4 783
United Kingdom	4 638
R. Korea	4 271
Rest of the world	**57 169**
World Total Importers	**140 616**

China's contribution to aquaculture production accounts for more than 60 percent of world production in 2014. The developed countries on the other hand, have the highest total import of world fisheries as shown in table 2b. China, however, remains by far the largest fish producer and exporter in the global market with around US$20.98 billion in value terms in 2014 (see Table 2a). The EU, USA and Japan are the major importers of fishery products and their combined imports consist of 63 percent by value and 59 percent by quantity of world imports with EU being the largest market for fisheries products in 2014 (FAO, 2016).

2.2 Progress in the seafood safety and quality

The globalization and liberalization of the world fish trade presents many challenges specifically in issues concerning food safety and quality. The international food safety regulators such as the WTO's Agreements on Sanitary and Phytosanitary Measures and Technical Barriers to Trade, together with the benchmarking role of the Codex Alimentarius Commission have worked intensively in this area. They have adopted risk based analysis and encouraged the implementation of the HACCP system, in order to maintain seafood safety standards that reflect recent scientific knowledge. The safety levels of the different environmental pollutants and contaminants have been set by the regulators to ensure a high level of consumer health protection. Furthermore, consumer education programmes are vital to enhance awareness and improve transparency among the different stakeholders in the seafood supply chain. Similarly, seafood products traded internationally are expected to meet international standards in food safety and quality. Otherwise, they could be detained, rejected and even destroyed if in non-conformance to international import and export safety and quality requirements.

2.2.1 Seafood contaminants

Seafood can pose various biological, chemical and physical hazards. The most predominant ones are pathogenic bacteria and viruses, biotoxins, biogenic amines followed by the chemical contaminants either from the environment or during different processing.

Microbiological contamination and related issues

Fish and fishery products are highly perishable and should be cautiously handled. Post-harvest losses can be minimised by implementing seafood safety management systems (FAO, 2014a). Effective hygiene practices are essential through the supply chain in order to produce safe and quality products. Most food poisoning outbreaks in relation to microbial contaminants are caused by consumption of mishandled raw fish, insufficiently cooked or harvested in contaminated areas. Seafood-associated infections are mainly caused by bacteria from the aquatic environment (*Vibrio* spp., *C. botulinum*) or terrestrial sources (*C. perfringens*, *Salmonella* spp., *Shigella* spp., *Staphylococcus* spp., *V. cholerae*), or recontamination of fish products during processing, distribution and storage (Novotny, Dvorska, Lorencova, Beran, & Pavlik, 2004). Viruses (Norovirus, Hepatitis A virus) and parasites (protozoa, nematodes, trematodes, and cestodes) can also be involved resulting in diverse clinical symptoms (Iwamoto, Ayers, Mahon, & Swerdlow, 2010). Microbial hazards are more dynamic than chemical hazards due to the tendency of multiplication in foods.

Scombrotoxin fish poisoning (SFP), often referred as "histamine poisoning", is due to ingestion of certain marine fish species with high levels of free histidine in their tissue (Lehane & Olley, 2000). These include those belonging to the families *Scombridae*, *Clupeidae*, *Engraulidae*, *Coryfenidae*, *Pomatomidae*, *Scombresosidae* (European Commission, 2005, 2008). Under temperature abuse, a heat-stable scombrotoxin is produced by specific bacteria known to possess the histidine decarboxylase enzyme which leads to the formation of histamine. SFP accounts for a large portion of seafood-borne illnesses worldwide. A variety of symptoms have been observed on different patients but these are rarely fatal (FAO/WHO, 2012).

2.2.2 Environmental and chemical contaminants

The marine environment encompasses potentially hazardous chemicals released from industrial and domestic sources. These contaminants have been classified by Ahmed (1992) as:

- inorganic – e.g. mercury, lead, cadmium, zinc, arsenic, copper and sulphites

- organic – e.g. dioxins, polychlorinated biphenyls (PCBs), chlorinated hydrocarbons and insecticides
- naturally occurring – e.g. polycyclic aromatic hydrocarbons (PAHs) and marine biotoxins
- processing-related compounds such as sulphite compounds used in the shrimp processing, nitrosamines, and drugs residues used in aquaculture (e.g. antibiotics or hormones)

Marine biotoxins in particular ciguatera, paralytic shellfish poisoning, neurotoxic (brevatoxic) shellfish poisoning, puffer fish and diarrhetic shellfish poisoning are also important causative agents in many food poisoning cases worldwide.

The increased level of these in the aquatic environment has raised the levels that are found concentrated in fish tissues. Predator fish at the higher levels of the food chain tend to accumulate more contaminants due to the bio-magnification process. Therefore, the level of contamination depends on the species sizes, feeding patterns, geographic location, and the chemical's solubility in the aquatic environment.

2.2.3 Seafood safety risks

For the ***European Union***, an indication of safety issues is provided by information extracted from the Rapid Alert System for Food and Feed (RASFF). In 2016, the RASFF reported a total of 2924 original notifications received from the different RASFF members, with a total of 519 notifications reported on seafood products and subdivided into the different categories as indicated in Table 3 & Table 4 (RASFF, 2013). The 519 notifications on fish and fishery products accounted for 18% of the total notified products in 2016. The fish and fish products represented the highest notification received of 327 notifications (63% of the total seafood notifications), which was the highest within the last 3 years. Bivalve molluscs products represented 84 notifications accounting for about 16%; 69 (13%) for crustacean products; 38 (7.0%) for cephalopods and products and finally just 1 notification for gastropods products with a 0.2 % of the whole notified products. The seafood notification data in 2016 shows a slight increase in comparison to the previous year as highlighted in Table 3.

Table 3: Total Seafood Notifications reported by RASFF Portal in 2010-2016 (Source: RASFF Portal)

Years	2010	2011	2012	2013	2014	2015	2016
Fish and Fish Products	452	482	373	311	321	294	327
Bivalve Molluscs and Products	78	68	53	123	125	60	84
Crustaceans products	78	75	60	54	71	59	69
Cephalopods and products	44	78	53	22	21	18	38
Gastropods	10	0	4	2	5	3	1
Total Seafood Notifications	**662**	**703**	**543**	**512**	**543**	**434**	**519**

Table 4: RASFF's total food notifications for 2016 (Source: RASFF Portal)

Food categories	Quantities	Percentage (%)
Total food notifications (*inclusive of food, feed and food contact materials*)	2924	100
Food notifications (*exclusive of seafood*)	2405	82
Seafood notifications only	**519**	**18**

Table 5: Total seafood notifications in the European Union (EU) according to source of contamination in 2016 (Source: RASFF Portal)

Hazard category	Seafood notifications
Heavy Metals	133
Microbial contamination (pathogenic and non-pathogenic)	119
Bio-contaminants	38
Residues of Veterinary Medicinal Products	25
Parasitic Infestation	22
Biotoxins	17
Industrial Contaminants	12
Labelling issues	8
Allergens	7
Pesticide Residues	1
Others	137
Total seafood notifications	**519**

Most of the 2016 notifications extracted from RASFF system (Table 5) which related to all the seafood products were due to higher concentrations of heavy metals in particular total mercury, followed by histamine the most implicated biogenic amine. The latter was mostly detected on tuna, anchovies and sardine, with the highest concentration detected of 1774 mg/kg (ppm) in tuna loins (*Thunnus albacares*) imported from Spain. Microbial contamination (pathogenic organisms) was mostly caused by *Listeria monocytogenes* on smoked fish products and *Vibrio* species on the other seafood products. Norovirus and Hepatitis A were the mostly detected viruses on bivalve molluscs and their products alongside the bacteria *Escherichia coli* and *Salmonella*. Diarrhoeic Shellfish Poisoning (DSP) toxin was the most common biotoxin detected on bivalves mollusc products among other biotoxins. As for fish products, ciguatera poisoning was predominant.

Food poisoning notifications were firstly introduced in the RASFF database in 2008 and have been valuable for risk assessment and management by providing a link between occurrence data and causative agents of food poisonings in notified food and adverse health effects of consumers. Asian countries, led by China (433), India (257) and Thailand (88), are the most frequently mentioned countries reported in the notifications followed by the EU and then Latin America (RASFF, 2013).

In the ***United States of America*** (Centre for Disease Control and Prevention (CDC), 2016), the CDC reported that in 2014 there were 864 outbreaks of foodborne disease, resulted in 13,246 cases of illness, 712 hospitalizations, and 21 deaths. In 369 of the outbreaks (43% of the total) one or more specific foods were identified as the causative agent. Outbreaks due to aquatic animals were 64 outbreaks, 31% of the total outbreaks, chicken (23, 11%), dairy (19, 9%), and beef (15, 7%). The illnesses associated with the outbreaks were mostly due to seeded vegetables (e. g. cucumbers or tomatoes; 428 illnesses, 16%), chicken (354, 13%), aquatic animals (338, 12%) and dairy (267, 10%). In the aquatic animals, ciguatoxin in fish (19 outbreaks) and histamine in fish (16) being the most usual seafood vehicles responsible for the outbreaks and 4 outbreaks resulted in product recall for raw oysters and 3 outbreaks for tuna. Within 2014, there were 141 illness and 16 hospitalisations with one death reported due to *Clostridium botulinum* in fish products(Centre for Disease Control and Prevention (CDC), 2016).

In general, there has been an increase in the outbreaks rate which is mostly linked to imported food from Asia followed by Latin American countries. In fact, 16% of the consumed food in the USA is imported with seafood accounting more than 80% of this (FDA, 2014).

In ***Japan***, the Japanese Ministry of Health and Welfare reported in 2009 (Ministry of Health Labour and Welfare, 2009) 1,048 food poisoning outbreaks with total foodborne illness of 20,249 and morbidity rate of 15.9 per 100,000 and with no mortality cases reported in 2009. The implicated foods were considered in 11 categories: fish and shellfish, products of fish and shellfish, meat and its product, egg and its product, milk and its product, grain and its products, vegetable and its product, confectionery, compound dish, others, and unknown. Fish and shellfish were implicated in 94 incidents followed by meat and its products with 91 incidents then vegetables and their products, and in particular mushrooms with 54 incidents in 2009. For the 94 incidents caused by fish and shellfish in 2009, natural poison caused 39 incidents of which 6 incidents were due to shellfish, 24 incidents with *fugu* (puffer fish) and 9 with other fish or shellfish and followed by 33 incidents of norovirus.

Figure 3 shows the seafood notifications and refusals extracted from the databases of the three major seafood importer countries, EU, USA and Japan. It is important to note that the data sources are not directly comparable so there should be caution in interpreting these data. However, the USA market appears to have the largest number of notifications but, considering seafood products as a proportion of the total number of notifications, Japan appears to have the highest with 25% due to seafood products followed by USA with 17% and EU with 16%.

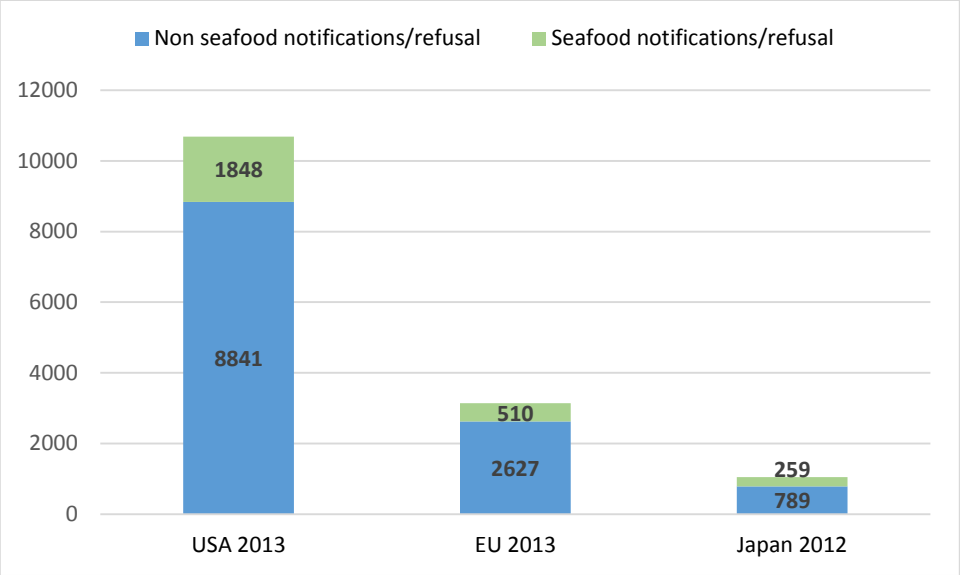

Figure 3: Overall seafood and Non seafood notifications for EU, USA and Japan

2.3 Regulations: Trends and significance of international food standards for the seafood sector

The increased consumption of fish and fishery products and the growth in their global trade has led to an increased interest in the requirements for their safety. National regulatory authorities impose restrictions to protect their citizens but these can have an impact on trade. International discussions taken place in various fora and try to establish rules and standards which ensure consistent and appropriate application of the controls. In this section, the main organisations involved in these discussions are briefly outlined along with a description of the main elements of the controls applied by the EU, the USA and Japan – the major importers identified in the section above. Globalisation of the economy and the development of regional economic groupings have been highlighted.

2.3.1 The Food and Agriculture Organization of the United Nations (FAO)

The FAO was founded in October 1945 as an intergovernmental organization and acts as an international forum on food, agriculture, and forestry issues. It established a Committee on Fisheries (COFI), a subsidiary body of the FAO Council in 1965 (FAO, 2014b). The committee is an inter-governmental forum meeting periodically, where major international fisheries and aquaculture problems and issues are discussed and the outcomes

communicated to the different stakeholders such as governments, regional fishery bodies, Non-Governmental Organizations (NGOs), fishermen, FAO and the international community. In 2014, the FAO Committee on Fisheries agenda highlighted the major global fisheries and marine conservation issues. Food safety and quality have been given a priority with the committee's members, with most having an effective fish and seafood safety and quality assurance system in place. Post-harvest losses, by-catch and illegal processing and trading issues were also highlighted in the meeting and endorsed mitigation measures to address them (Committee on Fisheries, 2014). On the other hand, many technical and scientific reports have been published by FAO and which include technical reports on the Assessment and Management of Seafood Safety and Quality (FAO, 2014a), and Causes of Detentions and Rejections in International Fish Trade (Ababouch, 2005), with a description on the international regulatory framework, and also covering a wide range of factors that affect the safety and quality of seafood products such as chemical and microbial contaminants.

2.3.2 Codex Alimentarius Commission (CAC)

The Codex Alimentarius Commission was established as a Joint FAO/WHO intergovernmental body in 1963. The principle aims of the Commission are the protection of consumer health and ensuring fair practices in the food trade by setting international standards on different food commodities. Codex had a major influence on national regulatory agencies as well as on the food producers and manufactures, international food trade and end users, by presenting countries with opportunities in formulating and harmonizing food standards in compliance with Codex standards besides ensuring their global implementation.

The Codex Alimentarius has become the global reference point for national governments that use CAC standards as a mean to provide protection to their own consumers. With the increased global market, the need to have harmonized and uniform food standards has become much more prominent. Therefore, the creation of the World Trade Organisation with it related Agreement on the SPS and TBT Agreement were essential to encourage the international harmonization of food standards (Codex Alimentarius Commission, 2014a,

2006). In particular, the CAC develops standards, maximum limits for additives and contaminants, codes of practice, and general or specific guidelines.

Much of the work of the CAC is handled within committees. The Codex Committee on Fish and Fishery Products **(CCFFP)** is a commodity committee responsible for global standards for fresh, frozen (including quick frozen) or otherwise processed fish, crustaceans and molluscs. The committee has developed a Code of Practice for fish and fishery products combining individual codes that deal with fish and fishery products inclusive of wild and aquaculture products. These codes consist mainly of fish product standards that deal with defects of a commercial nature (Codex Alimentarius Commission, 2012). The general principles of Good Hygiene Practices GHP/HACCP have also been adopted by the CAC and have been incorporated in the Code of Practice for wild and aquaculture fishery products in an effort to integrate these principles into the fisheries industry. The codes mainly offer general advice on the different processes in the supply chain such as handling of fishery products on board fishing vessels and on shore, distribution and retail display of the products.

Beside the CCFFP, different horizontal committees dealing with different topics are also involved in issues relevant to seafood safety. For instance, The Codex Committee on Food Hygiene (CCFH) has dealt with the work on biological risk management, including developing risk profiles for a number of seafood such as the presence of parasites in seafood products, and measures to control pathogenic Vibrio species in seafood.

At the request of the Codex Alimentarius, a meeting was organized by FAO and WHO in 2012 to address the public health risks and trade impacts of histamine and other biogenic amines from fish and fishery products (FAO/WHO, 2012). The experts concluded that SFP can be controlled and alleviated by applying basic GHPs and preferably a HACCP system. More focus was given to the histamine limits and associated sampling plans in the effort to protect consumer health. In 2014, the 33rd Session of the CCFFP tackled a variety of histamine topics that were covered in the FAO/WHO Expert Meeting Report. The Committee recommended establishing an appropriate histamine safety limit for the Codex Fish Standard and setting up a sampling plan in compliance with the histamine safety limit

in standards and to closely communicate on this issue with the CCFFP delegations (Codex Alimentarius Commission, 2014b).

2.3.3 World Trade Organization

Whilst the Codex Alimentarius is generally recognized as the key body developing international food standards, as stated earlier, the Codex on its own does not have any power or authority to persuade countries to incorporate the standards into national controls. However, the situation changed with the establishment of the World Trade Organization (WTO) in 1995 to succeed the General Agreement on Tariffs and Trade (GATT) following the completion of the Uruguay Round of trade negotiations. The WTO is an international organization that deals with the global rules and policies of trade between the nations (WTO, 2014b).

The liberalization of trade in agricultural products was a key component of the Uruguay Round of negotiations and led to two specific binding agreements that impact food safety and quality: the Agreement on the Application of Sanitary and Phytosanitary (SPS) Measures and the Agreement on Technical Barriers to Trade (TBT) Agreement.

The SPS agreement confirms the right of the WTO members to implement necessary measures to protect humans, animals, and plants from diseases, pests, and from risks arising from additives, toxins and contaminants in foods and feedstuffs. It provides a framework of rules to guide member countries in the development, adoption and the application of sanitary (relating to people, animals and fish) and phytosanitary (relating to plants) measures that are consistent with the general rules of the WTO. The key change introduced by the SPS Agreement was that, with respect to food safety and quality measures, the member countries should base their SPS measures on standards, guidelines and other recommendations adopted by the CAC. This recognition raised the status of the CAC although the SPS Agreement does include the right for member countries to adopt stricter measures if they can provide a valid scientific justification. In a similar manner the SPS Agreement encourages WTO Member countries to harmonize their measures to those of the International Office of Epizootics (OIE) in the case of animal (including fish) health. Finally, it is worth noting that the SPS Agreement requires that national SPS measures are

based on risk assessment with clauses relating to transparency, protectionism, dispute settlement and harmonization of international standards.

The TBT Agreement also entered into force with the establishment of the WTO. Its main purpose is to prevent the use of national or regional technical requirements or standards as barriers to trade. Standards related to all different commodities, including food, are covered under this Agreement except measures that come under the Agreement on the Application of Sanitary and Phytosanitary Measure are excluded. The Agreement includes protective measures against deception and economic fraud for all its members.

In terms of food standards, the TBT Agreement covers the quality provisions, nutritional requirements, labelling, packaging and product content regulations, and analytical methods (WTO, 2014b). Unlike the SPS Agreement, the TBT Agreement does not designate specific international organizations as benchmarks to assess their members' compliance to the requirements of the Agreement. The Agreement on Technical Barriers to Trade aims to ensure that regulations (compulsory) and standards (voluntary), testing and certification procedures do not create unnecessary obstacles to international trade, whilst providing its members the right to implement measures to achieve legitimate policy objectives, for the protection of human health and safety, and the environment (WTO, 2014b).

2.3.4 European Union Regulations

As a trading block, the European Union (EU) is by far the world's biggest importer of seafood products from wild and aquaculture sources, accounting for 40% of total world imports. The European Commission's Directorate-General for Health and Food Safety (DG-SANTE) is responsible for food safety in the EU and works to ensure that the quality and safety of farmed and captured seafood supplied to the EU markets are in compliance with EU legislation. EU delegates the control of seafood safety to a Competent Authority (CA) in a country to confirm that the different establishments in the country (farms, vessels, processors, etc.) are under a control system equivalent to that in the EU (FAO, 2005). Establishments from third countries satisfying the EU requirements have to obtain the agreement from their CA in order to export fisheries products to the EU. Once the establishments from these countries have been registered with their CA, the register is

passed to the European Commission (EC) which in turns publishes it via its website (FAO, 2005). Moreover, the CA of third countries with approval are regularly audited by officials from DG-SANTE (formerly known as the Food and Veterinary Office (FVO). Alternatively, based on the Commission Decision 2006/766/EC the third countries are classified either in Annex I (List of third countries from which imports of bivalve molluscs, echinoderms, tunicates and marine gastropods in any form for human consumption are permitted) or in Annex II (List of third countries and territories from which imports of fishery products in any form for human consumption are permitted).

In the EU, food safety is governed by food safety legislation consisting of food regulations, directives, decisions, codes of good practices and official food standards. Over many years, the legislation has undergone change and amendment based on emerging issues and the availability of scientific evidence of food hazards. In particular, the EU has produced controls that generally regulate food safety including fish and aquaculture production and trade. In early 2000 the EU proposed a general high level food law control which was adopted in 2002 as Regulation 178/2002. At the same time, in July 2000, the EU published proposals for a package of five new hygiene regulations to provide consistent hygiene controls throughout the farm to fork continuum. The resulting 4 regulations adopted in 2004 are as follow: 852/2004, 853/2004, 854/2004 and 822/2004. The hygiene package legislation came into force in January 2006 and features the main food safety requirements for primary producers, Food Business Operators (FBOs), and traders within the EU member states and third countries. Non-hygiene food regulations have also addressed other issues of food safety. The provision of these EU regulations cover issues concerned with general food products, food from animal origin and their health, fisheries product with emphasis on the aquaculture products, and food contaminants. They also tackle pesticides, labelling, organic agriculture, and Genetically Modified Organisms (GMO) amongst other things.

Previously Council Directives 91/67/EEC, 93/53/EEC and 95/70/EC were the main legal documents governing the animal health conditions of aquaculture fish placed on the market and the control of certain diseases affecting fish and bivalve molluscs. However, these directives have been updated by Council Directive 2006/88/EC on animal health

requirements for aquaculture animals and their products which include the control of certain diseases in aquatic animals. In terms of food contaminants, the EU has produced two controls: EC Council Directives 96/22/EC and 96/23/EC for determining the unauthorized chemical substances prohibited to be used in the animal production operations which apply to aquaculture products. Regulation 2377/90 lays down the Maximum Residue Limits (MRL) for veterinary medicinal products in foodstuffs of animal origin, while Regulation 396/2006 sets the MRL of pesticides in or on food and feed of plant and animal origin. Maximum levels for certain contaminants in food were set in Commission Regulation (EC) No 1881/2006 which replaced the earlier Regulation 466/2001. This provides controls on various contaminants including nitrates, mycotoxins (aflatoxins, ochratoxin A, patulin, deoxynivalenol, zearalenone, fumonisins), metals (lead, cadmium, mercury, inorganic tin), 3-MCPD, dioxins and dioxin-like PCBs and polycyclic aromatic hydrocarbons (benzo(a)pyrene). However, the maximum levels of some of the contaminants within this regulation have been amended further for some foodstuffs and feed, for instance Commission Regulation (EU) No. 2015/1006 (inorganic arsenic in foodstuffs), Commission Regulation (EU) No. 1259/2011 on maximum levels for dioxins, dioxin-like PCBs and non-dioxin-like PCBs in foodstuffs. Natural toxins such as marine bio-toxins were also governed under the Regulation (EC) 853/2004. As regards to histamine in fishery products and in an aim to meet the new recommendation set by the Codex Alimentarius Commission of the maximum levels of histamine in fish sauce, the Commission Regulation (EU) No. 1019/2013 was adopted amending Annex I of Regulation (EC) No. 2073/2005 on microbiological criteria for foodstuffs including aquatic organisms.

2.3.4.1 The Rapid Alert System for Food and Feed (RASFF)

RASFF was originally established under Article 8 of Directive 92/59/EEC on general product safety (later amended by Directive 2001/95) (FAO, 2005). However, the legal basis of the RASFF is now in Regulation 178/2002. Articles 50, 51 and 52 of the regulation define the scope and procedures of the RASFF (European Commision, 2014b). This new legal basis has extended the scope of the Rapid Alert System for Food and Feed to include animal feeds and the Border Inspection Posts network, and aims to provide the European Union control authorities with an effective tool to exchange information in

response to serious food and feed risks detected in food (FAO, 2005; RASFF, 2013). Article 50 of the regulation identifies the members of the system and sets out when a RASFF notification is required. The European Commission has to be notified by RASFF members of any information on serious health risk deriving from food or feed and in particular, any measures taken to withdraw or recall food or feed products from the market in order to protect consumers' health (European Commision, 2014b). The Commission also notifies third countries involved in the RASFF system (RASFF, 2012).

The scope of RASFF on feed related to food only was extended to include all types of feed and resultant risks on animal health and environment, as a result of the Feed Hygiene Regulation entering into force in 2006 (RASFF, 2012). 'Consumer complaint' and 'Food poisoning' were introduced to the system in 2008, and followed by the introduction of 'Official control' in non-member country in 2010 (RASFF, 2012). The RASFF network has been growing over the years with 10 more new members joined in 2004 and integrated smoothly into the network.

2.3.4.2 Food and Veterinary Office (FVO) and Border Inspection Posts (BIPs)

The DG SANTE's Audit Department (formerly the Food and Veterinary Office -FVO) is responsible for ensuring that Community legislation on food and feed safety, food quality, animal health, animal welfare and plant health are properly implemented and enforced. The Department's main tasks are to assure the effectiveness of the control systems and evaluation of their compliancy with EU standards within the EU and in third countries through inspecting Member States and in third countries exporting to the EU (EUropean Commision, 2014a). An inspection programme is developed yearly by the Department identifying the priority areas and countries for inspection and informs the stakeholders of the outcome of its audits and inspections programmes (EUropean Commision, 2014a).

Captured and aquaculture products are among the most important food imports in the EU countries. Therefore, the EC has issued legislation specifically targeting these products include Commission Decision 2003/858/EC laying down the animal health conditions and certification requirements for imports of live fish, their eggs and gametes intended for farming, and live fish of aquaculture origin and products thereof intended for human consumption. Thereafter, a Commission Decision 2006/767/EC was issued amending two

Commission Decisions 2003/804/EC and 2003/858/EC, as regards to certificate requirements for live molluscs and live fish of aquaculture origin as products intended for human consumption. Imports of fishery products from the non-EU countries into the EU must be recognised by their internal CA and through an approved export certification.

There are around 300 Border Inspection Posts (BIPs) in the European Union that have been approved by Commission Implementing Decision 2014/187/EU amending Decision 2009/821/EC as regards to the lists of border inspection posts and veterinary units in EU member states. These posts carry out official checks at the Community border on products imported into the member states from the third countries in order to verify their compliance with EU legislation. These veterinary checks are categorized into three types: documentary, identity and physical checking (FAO, 2005). The BIPs have implemented a computerised system specifically for imports ("TRACE") to facilitate the procedures of imports and transit and to ease the communication between these posts and the different EU member states (Directorate General for Internal Policies Policy Department B Structural and Cohesion Policies : Fisheries and Aquaculture Department, 2013). Regular auditing is also carried out by the Commission's Audit Department on the functioning of the BIPs.

2.3.5 Food and Drug Administration (FDA) Regulations

The United States of America (USA) is the single largest importing country of seafood to the value of USD 20 317 million imported in 2014 (Table 2-b). Its exports are USD 6 144 million making it fifth in world exporters as shown in Table 2(a). In the USA, food safety and quality is governed under the Acts of Congress, federal laws, regulations, administrative procedures and guidelines of 15 federal agencies (FDA, 2014). The US Department of Agriculture (USDA) and the Food and Drug Administration (FDA) share the primary responsibility of regulating the safety of the food supply chain and some functions overlap between the two organizations particularly in the inspection, enforcement, research, and execution of rules for both domestic and imported foods. The Federal Centre for Disease Control (CDC) is however, the main agency for collecting data on foodborne diseases, conducting investigations on these diseases and illnesses and researching effective ways to prevent and reduce them. The CDC also plays an important

role in the state and local health departments' laboratories, epidemiological and environmental work by providing them funding and support to strengthen their building and technical capacity in foodborne disease surveillance and outbreak response. The Foodborne Diseases Active Surveillance Network (FoodNet), under the CDC's Emerging Infections Program, was established in 1995 and is a collaborative programme among CDC, 10 state health departments, USDA and FDA (CDC, 2014). The programme serves as the primary foodborne disease surveillance system collecting information and data from sites within the 10 states on seven foodborne bacteria and two parasites (CDC, 2014).

The FDA is an agency within the US Department of Health and Human Services and is responsible for assuring the safety, effectiveness, quality, and security of human and veterinary drugs, vaccines and other biological products, and medical devices. It consists of the Office of the Commissioner and four directorates overseeing the core functions of the agency: Medical Products and Tobacco, Foods and Veterinary Medicine, Global Regulatory Operations and Policy, and Operations (FDA, 2014). Food, including fisheries products, imported through the USA entry ports are subjected to FDA inspections under the provisions of the US Federal Food, Drug and Cosmetic Act (FFDCA). Both imported and domestically-produced foods must meet the same legal requirements and the FDA may detain shipments of imported products if not in compliance with US requirements. The FDA is mandated by the FFDCA to inspect and approve veterinary drug residues used in the aquaculture industry. The US Code of Federal Regulations (CFR) has a specific section (123 in 21 CFR) on the control of fish imports and specifies regulations for safety and sanitary processing for imported fish and fishery products. The HACCP system was established in 1994 by FDA, and became mandatory in the seafood industry by 1997. In order to prevent and control any issues jeopardizing food safety, in 1995 the aquaculture industry was subject to a new regulation for HACCP of seafood and aquaculture industries. With current mandatory HACCP in place, any fishery product (including aquaculture) processed in the absence of this system is considered adulterated and processors (local or foreign) are subjected to penalties in accordance to FDA regulations (Bagumire, Todd, Nasinyama, & Muyanja, 2010).

The FDA was originally reactive rather than proactive but this was changed by the new Food Safety Modernization Act of 2010 (FSMA) which was passed by Congress in December 2010. The new Act focuses on prevention rather than responding to food safety contamination, and that all food imported should be required to meet the same standards as domestic foods (FDA, 2014). Under the new FSMA law, the FDA has been appointed as the responsible agency for applying comprehensive and prevention-based controls to the food supply. It also entitles FDA to establish science-based standards and holds the food industry responsible for the production of safe food products. In can be noted that an estimated 15% of food consumed in the US is imported which includes 80% of seafood products and 60% of fresh fruits and vegetables. The new legislation has enhanced the FDA's ability to manage domestic and imported products.

With respect to fish and fishery products inspection, the FDA has signed a Memorandum of Understanding (MOU) with the National Marine Fisheries Service's (NMFS) to carry out a Seafood Inspection Program of the different establishments internally and globally (Directorate General for Internal Policies Policy Department B Structural and Cohesion Policies : Fisheries and Aquaculture Department, 2013). The FDA has also set up a number of permanent overseas posts to effectively control and manage the safety of the imports. These include posts in China, India, the Middle East, Europe, and Latin America.

As far as the strengthening of the regulatory and administrative control is concerned, the Public Health Security and Bioterrorism Preparedness and Response Act (BTA) was passed in 2002. The BTA was intended to improve the control and traceability of food flow within the US(Bagumire et al., 2010), and to further protect local consumers from emerging threats such as biological agents and toxins (Bagumire et al., 2010; Directorate General for Internal Policies Policy Department B Structural and Cohesion Policies : Fisheries and Aquaculture Department, 2013). The Act, however, required certain conditions to be complied with by local and foreign food facilities including: registration with US FDA and the allocation of a US agent/sponsor for the foreign firms intended to export food to US; recordkeeping for traceability; detention of suspected food with food hazards and having a food safety system in place such as HACCP for the seafood facilities (Bagumire et al., 2010; Weick C, 2006).

Another Act was passed in 2002, the US Farm Security and Rural Investment Act, requiring labelling of all the perishable food (meat and fish) and peanuts with ‘’Country of Origin Labelling’’ (COOL) with labelling of the wild and farmed fish becoming compulsory in 2008.

2.3.6 Japanese Regulations

Japan depends heavily on imports of fish to satisfy high local consumption. Total fish import is USD 14 844 million and is the second largest importers (Table 2-b). The administration of food safety is under the jurisdiction of the Department of Food Safety under the Pharmaceutical and Food Safety Bureau within the Ministry of Health, Labour and Welfare (MHLW). After the Second World War, two principal laws were issued to regulate food safety and food quality. The first is the Food Sanitation Law (No. 233) promulgated in 1947 covering all aspects of safety of different types of foods, containers and packages, and human health and which was amended by Law (No. 87) in July 2005. The second Law Concerning Standardization and Proper Labelling of Agricultural and Forestry Products (JAS Law) was adopted in 1950 and aimed to prevent distribution of low-quality food in the market by issuing common standards including labelling of various foods (Ministry of Health Labour and Welfare, 2014). However, the objective of the JAS Law shifted to the consumer protection with the regulation of labelling becoming one of the important objectives of the JAS Law (JAS, 2007). The JAS Standards are established by the Minister of Agriculture, Forestry and Fisheries and is currently used to establish an overall system. It assumed its current status in 1970 and the JAS System consists of the combination of the “JAS Standards System” and the “Quality Labelling Standards System” (JAS, 2007).

The Food Sanitation Law and the JAS Law governed the safety and quality of food in Japan for many years until problems caused by Bovine Spongiform Encephalopathy (BSE) reached Japan. This incident triggered a complete restructuring of the existing judicial and administrative systems governing the safety and quality aspects of food in Japan. Risk analysis and traceability were first introduced and adopted as the fundamental of the Food Safety Basic Law issued (No. 48) issued in May 2003 and can be regarded as similar to those adopted in the EU, the USA and the CAC. It was amended in June 2006 with Law

(No. 50). The approach adopted embraces the 'farm to table' continuum to cover the whole food supply chain. The laws that cover materials related to agricultural and livestock industries, pesticides, feed and veterinary drugs have also been amended in order to integrate this approach. The principle of the Food Safety Basic Law is very similar as to the EU Regulation (EC) No 178/2002 (Takahashi, 2009). This law is based on fundamental principles such as: consumers' protection, measures based on science and a farm to table approach. A Food Safety Commission was established to assess independently food related risks in the hope to regain back the confidence of Japanese consumers that was severely damaged by the BSE incident.

HACCP-based food control regulations have been introduced in Japan and consist of sanitary and hygienic requirements for fish handling, processing conditions, storage and transport. Risk analysis principles have being incorporated together with spot checks at the border and with major importing companies sending their quality control staff to work with fish exporting companies on grading and hygiene as a way to control imports at source (FAO, 2005). The main laws controlling entry of food products to Japan are the Food Sanitation Law, Quarantine Law, Plant Protection Law, the Domestic Animal Infectious Diseases Control Law, Customs Law and the Law Concerning Standardization and Proper Labelling of Agricultural and Forest Products (JAS Law). The Food Sanitation Law was recently updated to overcome consumer non-satisfaction caused not only by the BSE crisis but also due to false labelling and pesticide residue issues (FAO, 2005).

The Inspection and Safety Division (ISD) within the Department of Food Safety of the Pharmaceutical and Food Safety Bureau in the MHLW, is the Japanese Central Competent Authority (CCA) for seafood and its by-products exported to the EU (Ministry of Health Labour and Welfare, 2014). ISD collaborate with several agencies such as the Food Safety and Consumer Affairs Bureau in Ministry of Agriculture, Forestry, and Fisheries (MAFF) and other Fisheries Agency to ensure proper controls of seafood safety in different establishments, farming sites, fishing vessels and freezer vessels. With the risk-based approach in place, the Japanese government monitors very closely food imports with well qualified inspectors of veterinarians, pharmacists, medical doctors, and agricultural and fisheries degrees that must be approved by the MHLW. In the case of exports to the EU,

only Designated Food Sanitation Inspectors (DFSI) are allowed to conduct the inspection (Directorate General for Internal Policies Policy Department B Structural and Cohesion Policies : Fisheries and Aquaculture Department, 2013). However, regionally the Regional Bureaus of Health and Welfare (RBHW) were created in 2001 and is for the enforcement and approval of laboratories and establishments (Ministry of Health Labour and Welfare, 2014). For foodborne illness outbreaks, the MHLW collaborates with a network of regional health offices affiliated with local governments and the National Institute of Infectious Diseases. The latter is responsible for collecting, analysing and monitoring incidents of infectious diseases around the country.

2.4 Seafood safety management system (HACCP):

2.4.1 The Adoption and Application of the HACCP Concept

Food hygiene as defined by FAO (2014b) is "*all conditions and measures necessary to ensure the safety and suitability of food at all stages of the food chain*". With the implementation of these measures such as personal hygiene, cleaning, sanitation and pest control, the fish contamination and microbial growth could be significantly reduced (FAO, 2014b).

Increased levels of foodborne disease globally have prompted action led by international organizations such as FAO, WHO and the CAC. This has included the recognition of the HACCP system as an important tool in protecting consumers from food related hazards. Many guidelines have been developed to ensure the basis of implementing these practices in the seafood industry including publications by the FAO and the CAC (Codex Alimentarius Commission, 2009, 2013a; FAO, 1997). Its adoption in 1993 by the CAC stimulated its use as a preventive tool to assess the biological, chemical and physical hazards throughout the different phases of food production - from the primary producer to the consumer. Instead of relying on end product testing, HACCP implementation uses scientific evidence and a risk analysis approach to protect human health (FAO, 2009). The Codex Alimentarius has also developed an International Code of Practice on the general principles of food hygiene and this has been adopted into many countries' food legislation. The International Organization for Standardization (ISO) has underlined the importance of HACCP and further developed an international standard (ISO 22000) which incorporates it

as a core element. Likewise, the practice for fish and fishery products has been developed by the Codex Committee on Fish and Fishery Products. The code provide assistance in compliance with the Codex Standards for those involved in the handling, production, storage, distribution, export and import of fish and fishery products on national and international markets (Codex Alimentarius Commission, 2009). The Code of Practice for Fish and Fishery Products (CAC/RCP 52-2003) was developed by the Codex Committee on Fish and Fishery Products and amended in 2016 after merging other codes that deal with these products. The new code incorporates the different practices from growing fish (marine and freshwater sources), through the various stages of harvesting, handling, production all the way to distribution and retail display of the fishery products intended for human consumption. Section 3 of this code emphasises the importance of implementing prerequisite programmes prior to the adoption of the HACCP system. The Code highlights the significance of establishing PRPs in food business, as it allows the HACCP team to focus more on the food safety hazards emerging specifically from the intended product and its process rather than any other hazards from the surrounding environment. The pre-requisite programmes (PRPs) consist of Good Manufacturing Practices (GMPs) and Good Hygiene Practices (GHPs) beside other practices depending on the performed activity. These practices have been around for many years and are required to ensure food products are produced and controlled to minimize any risks arise during processing in order to produce food safely (Huss H. H., Dillon M., & Derrick S., 2005). GMPs deals mainly with the infrastructure and layout of the food premises, condition of the surrounding environment, adequate maintenance and calibration of equipment and machinery and etc. As for the GHPs, they mostly deal with personal hygiene of the workers, cleanliness of the food premises, food contact surfaces, equipment, utensils, floors, walls and ceilings, pest control management, waste management, storage and transportation and etc. These programmes generally cover the same concepts and in most cases often used as GHPs (Huss H. H. et al., 2005). They are also the base of HACCP system and can be tailored to fit individual establishments or businesses and must undergo continuous monitoring and evaluation to ensure their effectiveness in order to have a successful HACCP system in place.

The European Union's Commission's "Hygiene Package" has tackled the application of the prerequisite requirements in all food commodities. Specifically, for seafood products, Regulation 853/2004 includes 'specific hygiene rules for food of animal origin' which contains a section setting out requirements for fish and fishery products. Similarly, FDA adopted a regulation (21 CFR Part 123) in 1997, stating the compulsory implementation of the HACCP system in all seafood processors as a preventive tool for food safety (FDA, 2014). The pre-requisite programmes known also as Sanitation Standard Operating Procedures (SSOP) are mentioned in Section (123.11) of the regulation and been prompted for their inclusion into the HACCP plan as required by Section 123.6(b). Therefore, the seafood industry became the first industry in the USA to have compulsory implementation of this programme. In the USA, HACCP is required throughout the whole fish and fishery products supply chain starting form fishing vessels, landing site and shore all the way to the consumers' plate. At each of these stages, hazards have to be identified and all the critical points controlled in order to eliminate or reduce these hazards to acceptable levels. Guidance is provided to the local seafood industries by the FDA, and any imports or exports of seafood products must meet the U.S. standards. In terms of the safety of bivalve molluscan shellfish (clams, oysters and mussels) sold in the USA, FDA has teamed up with the different states to implement the National Shellfish Sanitation Program (NSSP) (FDA, 2014).

In addition to enhancing the safety of food, HACCP combined with PRPs allows better management of resources, timely responses to food safety issues and can assist the regulatory authorities in delivering efficient inspection and certification services (Dawson, 1995). It has been noted that the full commitment and involvement of the different stakeholders in the food supply chain is important for the successful application of HACCP (FAO, 1997). PRPs, such as Good Manufacture Practices (GMPs) and Good Hygiene Practices (GHPs), are essential for any food business prior to the adoption of the HACCP system and should be applied at all stages of harvesting, handling, processing, storage and distribution.

Despite the great health benefits of seafood products, they may also harbour various contaminants (whether biological, chemical and physical) with the most prevalent being

the biogenic amines, biotoxins, heavy metals, pathogenic bacteria viruses and parasites. High concentration of these contaminants may constitute serious hazards. Some large outbreaks of food-borne illnesses associated with seafood consumption have been reported:

- In Shanghai (China) in 1991, more than 300,000 people contracted Hepatitis A with nine deaths (Tang et al., 1991).
- At a similar time, more than 400,000 illnesses with more than 4000 deaths occurred in Peru caused by cholera (Wolfe, 1992).
- DeWaal, Hicks, Barlow, Alderton, and Vegosen (2006) estimated in USA that between 1990 and 2003, 4486 foodborne outbreaks occurred involving 138,622 cases. 20% of these outbreaks and 7% of the cases were due to seafood consumption, with scombrotoxin and ciguatoxin accounting for the majority of the outbreaks.
- In England, Wales and Northern Ireland, 1.7 million cases of food-borne illness were reported in the period 1996–2000 with 7% linked to seafood (Adak, S.M., Lopman, & O'Brein, 2005).
- Seafood was involved in outbreaks in France during 1999–2000 and accounted for 18% of reports (FAO, 2014a).
- Seafood-related illness in Australia for similar period 1990–2000 was estimated to be 2638 cases with 80% of these cases due to mostly viral illness in oysters (Lehane & Olley, 2000; Sumner & Ross, 2002).

In developing countries, foodborne illnesses often go unreported due to absence of effective surveillance and reporting systems

2.4.2 Issues in HACCP Implementation

In order for developing countries to overcome their shortcomings and have a wider access to the international seafood market and benefit from the higher revenues, they are required to enhance and maintain their food safety and quality requirements form farm/ocean to fork. The adoption of these requirements by the major importers (Japan, EU and US) had led to stricter food safety requirement being imposed on exporters from developing countries. Failure to meet these requirements results in rejection or detention of imports

for various safety and quality reasons from the major seafood importing countries. The requirement for HACCP implementation by many of the food regulators and processors within the developing countries has been perceived as a technical barrier to trade (Stier, 2002). The commitments to the hygiene standards and safety practices during processing and handling are usually below the internationally required standards. Small and Medium sized Enterprises (SMEs) are the most commonly found sizes of food industries in the developing nations hence hindering in some aspects of the fulfilment of the HACCP or GMPs and GHPs requirements. The major constraints on HACCP implementation in developing nations can be initially identified as linked to the following factors:

Food regulators in developing nations often lack of the technical expertise in HACCP implementation and the knowledge of the importance of the prerequisite programs as the basis for implementing the HACCP system (Stier, 2002). Another issue in developing countries is that frequently the food control systems have deficiencies and the systems are generally scattered among different authorities with limited minimal collaboration on issues related to food safety and quality. The dominant deficiencies are mostly existing within legislative frameworks and their non-compliance with international standards or recommendations, unclear responsibility and roles for the various institutions involved, shortcomings within the surveillance and inspection systems, lack of qualified human resources and limitations in the laboratory testing facilities (Henson et al., 2008). Although the majority of the developing countries are members of the various international organizations such as CAC, their participation remains limited (Henson et al., 2008).

A common practice in these regions is the adoption of new laws and regulations without consulting the industry and, when there are no clear time frames for training and implementation, it results in improper enforcement and poor compliance by the industry. Absence of communication, trust and little or no links between the regulators and the food industry is one of the major constraints that hindered the development of this industry and delays improvements. In developed nations, the success of HACCP implementation is due mainly to the strong communication and collaboration established between the industry and the government regulators (Stier et al., 2002).

Cultural and attitudinal issues are often impediments to the advancement of food safety management systems in the developing countries. This is more related to people's behaviour and perception rather than the implementation of the HACCP system and it is perceived as a troublesome and bureaucratic approach (Mortimore, 2001). Within an organization the common cultural practices are usually reactive with senior managements being in charge of every activity within the organization and with limited delegation of power and initiatives to other staff. For an effective HACCP system a proactive approach is a necessity. This perception could only be met through effective education and training and the ability to delegate authority.

Technical Issues may act as constraints to the development of food safety controls within food businesses. The dominant concern faced by these businesses when implementing food safety standards and in particular HACCP is the lack of administrative, technical and scientific capacity (Henson et al., 2008) and, above all, management commitment and motivation in embracing its benefits. Shortcoming in executing the HACCP prerequisite programmes in terms of, for example, inadequate personal hygiene, cleaning and sanitizing and pest control could be due to the poor understanding of these prerequisite programmes and their relationship to the HACCP system, or simply having no access to the proper services and tools necessary to perform them adequately (Stier et al., 2002). Without the pre-requisites programmes in place, a risk-based system such as HACCP will fail (FAO/WHO, 2006) (FAO/WHO, 2006). Lack of appropriate knowledge, expertise and personnel training in the hazard analysis and evaluating their risks within the process will often result in an unmanageable and complex HACCP system with too many critical control points (CCPs) and poor documentation (Mortimore, 2001). Additional complications include ineffective monitoring procedures, corrective actions, and poor or limited verification procedures of the system.

Financial issues. On an international level the best way to address food safety practices is through risk based analysis with a farm to table approach. However, in developing countries this approach is only followed for food products intended for export to lucrative markets with high incentives and with existing stringent regulatory standards (Laurian Unnevehr, 2015). Most developing countries find it difficult to comply with these stringent

standards to gain and maintain access to these markets, and the cost of development as well as maintenance of food safety systems constitutes a severe constraint to their implementation. Studies on trade flow have shown that when standards of importing countries are much higher than that of the exporting countries, quantities of traded products decline and the exporters seek alternative markets with less imposed standards (Ferro, 2013).

In general, if a food business has the willingness to comprehend and commit to the HACCP principles and it's PRPs with the rightful resources in place, HACCP will deliver the promised benefits and rewards (Laurian Unnevehr, 2015).

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CHAPTER THREE

3 Assessment of the food control systems in the Sultanate of Oman[1]

Abstract

National food control systems are vital tools in governing the safety and quality of food intended for human consumption. This study of the Omani system was conducted to evaluate the effectiveness of the current food controls in place for protecting, in particular, the public health from emerging biological and chemical hazards. In response to this situation, a survey was undertaken within the different food safety authorities in Oman to examine the different elements of the national food control systems in terms of their existing food control management, food legislation, food inspection, food analysis laboratories and information, education and communications. Officials from the different authorities were interviewed and results were captured in prepared questionnaires. Overall examinations of the challenges, strength and weakness of the existing system have been highlighted. The findings of the study indicate significant progress is being made and the creation by the government of a national Centre for Food Safety and Quality is a significant positive step.

3.1 Introduction

Food safety and quality have become essential components for the protection of public health, economic development and most of all for food security. With the proper control and management of food safety and quality throughout the farm to plate continuum, the wholesome supply of food products and consumer protection from mislabeled or adulterated food can be enhanced. However, food safety has become a major concern world-wide due to the increased incidence of foodborne diseases affecting millions of people every year with many dying as a result.

[1] This Chapter was originally published in the journal 'Food Control' as, (Al-Busaidi, M.A., & Jukes, D.J. (2015). Assessment of the food control systems in the Sultanate of Oman. Food Control 51 (2015) 55-69. For the published paper please see Appendix D. Minor amendments have been made to incorporate recent developments.

The World Health Organization WHO (2009) has reported that more than 200 diseases can be spread by contaminated food or water with the level of foodborne diseases being amplified by increased international trade in food and population mobility.

Foodborne and waterborne diseases can be acute or life-long, ranging from simple symptoms (e.g. diarrhoea) to very chronic diseases (e.g. kidney failure or different type of cancers). Data on the amount of disease are particularly difficult to determine in developing countries due to insufficient surveillance and poor reporting systems. The WHO has however estimated that foodborne and waterborne diseases combined kill about 2.2 million people annually of which 1.9 million are children (WHO, 2010). Despite the advances in science and technology foodborne illness is still a continuing threat due to the complexity of the food system from the production of raw materials through to the point of consumption.

Whilst microbiological causes of foodborne disease are often seen as the most critical, contamination with toxic chemicals is another source of potential disease. Environmental contaminants, residues of both pesticides and veterinary drugs, chemicals leaching from packaging and process contaminants are just some examples of the wide range of chemicals which may pose a risk.

All of these issues impact on societies around the world and place increased pressure on governments to provide effective protection for their country's citizens. Effective national food control systems (NFCS) are seen as important. Guidance on the key components of NFCS has been defined by international bodies. In particular, the FAO and WHO have jointly published guidance on the strengthening of national food control systems (FAO/WHO, (2003). In addition, more recently, the international Codex Alimentarius Commission has adopted "Principles and Guidelines for National Food Control Systems" (Codex Alimentarius Commission, 2013). Assessing compliance with these documents can assist in the development of improved NFCS both within a country and enables good practice developed in one country to be shared and adopted elsewhere. With this in mind, in this paper we have undertaken a review of the NFCS in Oman including both the national developments and the relationship between these and the various regional and international developments.

The scarcity of arable land and water limits agriculture production in Oman as well as other countries in the region. With an economy dominated by the oil and gas industries and a rising demand for food, Oman has relied on food imports to meet the domestic requirement. The globalization of the food supply and the rapid increase in the importation of food from many countries has increased the risk of foodborne diseases from chemical and microbiological contaminants. Imported foods do not necessarily represent an increased risk of poor food safety and quality. However, the increased difficulty in effectively assessing and controlling large volumes of imported foods does complicate food controls when the authorities do not have access to the full supply chain.

An effective national food control system is essential to protect the wellbeing and safety of consumers and to assure the safety and quality of their products. Our objective is to provide a preliminary assessment of the food safety control in Oman in relation to the five core elements of a national food safety system proposed by the FAO and WHO (FAO, 2006b; FAO/WHO, 2003): food control management, food legislation, food inspection and surveillance, official food control laboratories, food safety and quality information, education and communication.

3.2 Background

3.2.1 An overview of the country

The Sultanate of Oman is situated on the eastern edge of the Arabian Peninsula with a 3165 km long coastline extending from the Musandam Peninsula at the entrance of the Arabian Gulf in the north to the Republic of Yemen in the southwest. It has a total area of 309,500 km² and bordered by the United Arab Emirates (UAE) to the northwest and Saudi Arabia to the west. It lies on three major water bodies; Arabian Gulf, Sea of Oman and the Arabian Sea.

In October 2011 the Sultanate of Oman was divided administratively into eleven governorates (Muhafathat): Musandam, North and South Al-Batinah, Muscat, North and South Al-Sharqiyah, Al-Dakhiliya, Al-Wusta, Al-Buraimi, Al-Dhahirah, and Dhofar. Within these governorates, Oman is sub-divided into 61 provinces (*wilayat*). The city of Muscat in the Governorate of Muscat is the capital of the country.

The Basic Statute of the State is the constitution of the Omani government that provides the legal framework for the implementation of legislation and other government policies. The Basic Statute contains provisions covering the Head of State, the Council of Ministers and the judiciary, as well as the specialised councils. The Oman Government structure is a bicameral system consisting of the Council of Ministers and the Council Oman (Majlis Oman). The Council Oman combines a Consultative Council (Majlis a'Shura), whose members are elected by Omani citizens every four years, and a State Council (the Majlis Al Dawla), whose members are appointed by the Sultan. Recent amendments to the Basic Statute have increased the independence of the judiciary and strengthened the parliamentary institutions. The changes have provided the State Council and the Consultative Council legislative and regulatory powers enabling them the right to amend or approve all laws originating from the Council of Ministers before being submitted to His Majesty for promulgation (Ministry of Information, 2013).

In 2010 the total population was 2.8 million with 2.0 million (70%) Omanis, and 0.8 million (30%) expatriate. Population density is highest in the Governorate of Muscat and Al-Batinah (776 and 772 thousands/km^2 respectively) and lowest in the Governorate of Musandan (31 thousand/km^2) (NCSI, 2013).

Oman is a member of the Gulf Cooperation Council (GCC), a political and economic cooperation established in May 1981 by joining with five other countries bordering the Arabian Gulf (Bahrain, Kuwait, Qatar, Saudi Arabia and the United Arab Emirates). The GCC aims to unify the six member states by means of co-ordination, integration and inter-connection in all fields (GCC, 2012). The GCC countries' imports valued around $29 billion in 2012 with an expectation to double by 2020 (SustainableBusiness.com, 2013).

3.2.2 Economy

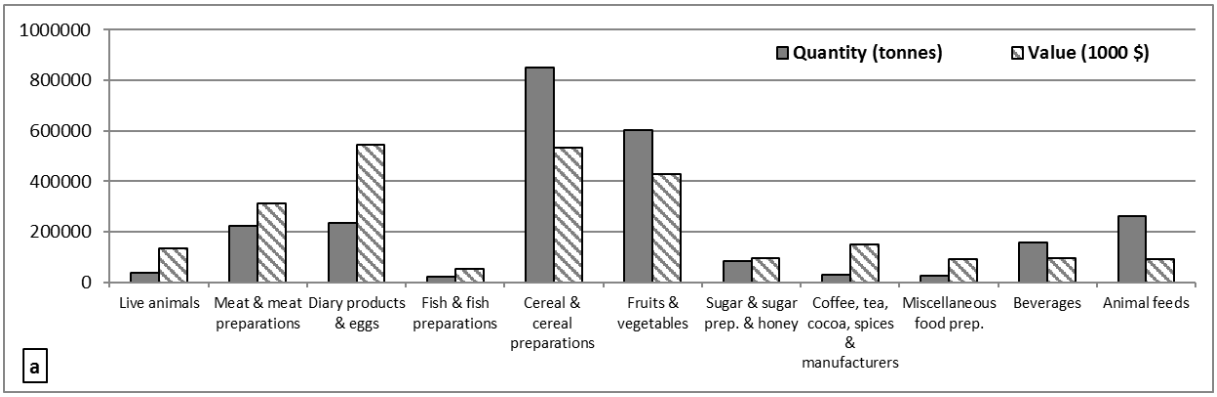
The country's economy is dominated by the oil and natural gas industries with their production accounting for 51% of the Gross Domestic Product (GDP). Industry and services contribute a further 48% leaving agriculture and fisheries contributing the remaining 1% (NCSI, 2013). However, agriculture has been a vital sector in the country although limited by geography to only parts of the country. The main crops are date palms,

accounting for around half the total area under cultivation, and coconut palms. Fisheries have been an integral part of the Omani culture for many centuries providing employment and nourishment for the Omani population. With its long coastline, Oman is one of the leading seafood producing countries in the region.

3.2.3 OMAN - Vision 2020

In 1996 an "Oman 2020" vision for the national economy was approved providing a long-term strategic development plan until 2020. It is committed to developing and maintaining the Sultanate's economic growth on a carefully studied basis as well as social welfare (Ministry of Information, 2010/2011) . The Eighth Five-year Development Plan (2011-2015) is the fourth stage of the 2020 vision and food security is now a very important element. This element has been one of the principal problems for GCC countries due to the complete dependency on importation of basic foodstuffs with the region being one of the smallest producers of food in the world. Around 33 million tons of foods are imported each year by GCC countries. It has been estimated that more than 90% of the GCC countries' food and beverage requirements are imported (Business Intelligence Middle East, 2006). Figure 4 highlights the non-oil imports, exports and re-export of different food commodities in Oman in 2012 (NCSI, 2013).

In order to reduce the dependency on imports, the Eighth Five-year Development Plan has addressed various agricultural, livestock and fisheries strategic programmes and projects. These aim to develop these sectors in order to boost the annual national economic growth and increase their role in the GDP. In the agriculture sector, schemes include a national date palm strategic project, promoting the reduction of pesticide use, introduction of modern technologies and irrigation systems. As for the livestock, awareness programmes have been set out targeting small producers and stock breeders to increase their contribution to the total economy. For fisheries the focus has been on the management of aquatic resources and ensuring they are adequately regulated and monitored to ensure their sustainability.



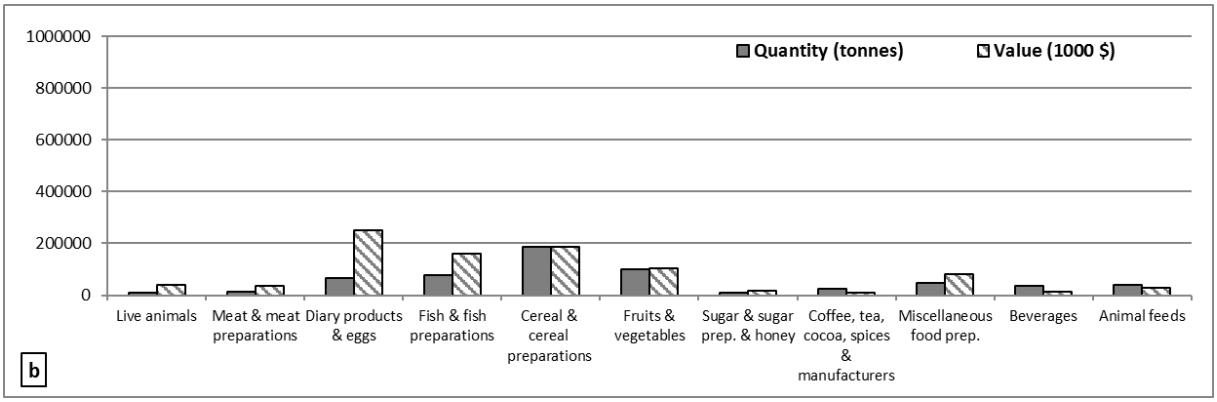


Figure 4: a) Non-Oil Import, and b) Export and Re-export of food Merchandises in 2012 (NCSI 2013)

An industrial fisheries estate is to be constructed in the fishing harbour of the of Duqm province in Al-Wusta governorate. The aim is to boost the production of value added seafood products in a well-equipped unit and to make this harbour the main station for fishing vessels around the Indian Ocean (Ministry of Information, 2010/2011).

For the Sultanate, food quality and safety have become major concerns. Although these concerns include domestically produced foods, with the high level of imports, they have tended to focus on imported foods and the need to ensure their safety and quality. In 2007 the GCC countries established a 'common market' designed to provide a single market for the GCC community with no barriers for inter-country trading (GCC, 2007). The development of the tourism industry is also on the rise in Oman with revenue of $1bn and accounting for 7% of GDP in 2012 (World Tourism Organization UNWTO, 2013).

The above factors have made it important to develop efficient food control infrastructures capable of meeting high national and international standards of food quality and safety so as to protect consumer health and promote healthy life.

3.3 Food Control Management

Food control management has been defined as "*the mandatory regulatory activity of the enforcement of food laws and regulations by national or local authorities to provide consumer protection and ensure that all foods during production, handling, storage, processing and distribution are safe, wholesome and fit for human consumption; conform to safety and quality requirements; and are honestly and accurately labelled as prescribed by law*" (FAO/WHO, 2003). It has also been defined as: "*a continuous process of planning, organizing, monitoring, coordinating and communicating, in an integrated way, a broad range of risk-based decisions and actions to ensure the safety and quality of domestically produced, imported and exported food for national consumers and export markets as appropriate"* (2006b). FAO (2006b) have also stressed that the management of food safety systems should be based on risk analysis with an integrated farm-to-table approach. It recommends the application of the Codex Alimentarius Commission (CAC) working principles and a structured approach for risk analysis which comprises three interlinked components: i) risk assessment; ii) risk management; and iii) risk communication (Codex Alimentarius Commission, 2007).

In Oman the enforcement of the current food safety law and regulations is shared across various governmental authorities with overlapping responsibilities and is considered a multi-agency system. Components include:

- Ministry of Regional Municipalities and Water Resources (MRMWR),
- Ministry of Agriculture and Fisheries Wealth (MAFW),
- Ministry of Commerce and Industry (MOCAI),
- Ministry of Health (MOH),
- Public Authority for Consumer Protection (PACP),
- Local Municipalities (Muscat, Sohar and Dhofar), and
- Royal Oman Police (ROP).

These authorities carry out various mandates and responsibilities as illustrated in Table 6. The primary authority for food safety in Oman is the MRMWR which heads a Food Safety Committee (FSC). This committee was legally established by Article 13 of the Food Safety Law (84/2008) but was promulgated by the Ministerial Decision (MD) (272/2009) amending an earlier Ministerial Decision (MD) (45/2003). The FSC involves officials from the various ministries and municipalities in charge of the food safety control system. More details of its mandate are also shown in Table 6.

The duties of the FSC include setting of legislation, standards, specifications and policies governing food integrity at the time of import and at production. In addition, there is a requirement to maintain adequate monitoring and inspection programmes for the domestic markets, food warehouses, catering services, slaughterhouses and food establishments. The implementation of food hygiene and sanitation requirements mainly falls under the jurisdiction of the municipal authorities in the different governorates. The control of food imports and exports lies within the customs, quarantines, and laboratories of the food authorities in the different ministries. Moreover, some of these activities are shared within more than one authority (Al-Hinai, 2009). It has been internationally noted that when responsibility for food safety control is spread among different authorities, it becomes complex to implement an effective system with efficient use of resources (FAO & WHO, 2003). This can cause a lack of transparency and prevent the free flow of information between the different authorities (Alomirah et al., 2010).

Food control systems are increasingly complex due to changes in food processing technologies worldwide, the rapid development of international food trade and advances in food distribution systems. In addition, when there is a dependency on food imports, as in Oman, the limited availability of resources and ineffective coordination among the different food authorities' results in a need to modernize and create an effective food safety control system capable of ensuring consumer protection and public health.

Table 6: Food Control Authorities

Food Control Authorities	Responsible Directorates	Main Mandates and Responsibilities
Food Safety Committee (FSC) (MD no. 272/2009)	Chaired by the MRMWR with the participants of officials from the various ministries and municipalities	• Study national and international issues pertaining to food safety and consumers' health and propose appropriate measure in this regard. • Provide advices on the regulations, standards and laws drafted by agencies responsible for food safety. • Coordinating among the various food safety agencies in the country regarding the proposal of the appropriate measures for consumer health and safety • Harmonization of the technical methodologies and standards of analysing different food products among the various agencies to comply with international standards. • Acquiring effective procedures for destroying/withdrawing of unsafe food products or re-dispatching to the country of origin. • Acquiring effective procedures in the case of receiving an alert internally or externally regarding any food product causing high risk to consumer health and safety. • Setting an appropriate mechanisms and procedures for the inspection of the imported and exported food via the various entry ports (sea, land and air). • Proposing on dispatching a technical team to the exported countries to ensure the health standards are implemented throughout the production, processing and packaging of food products prior to exportation to Oman. • Coordinating with relevant committees regionally (GCC) and internationally in order to ensure consumer health and safety. • Proposing consumer education and awareness program on food safety.
Ministry of Regional Municipalities and Water Resources (**MRMWR**)	Directorate General of Heath Control & Waste Management	• Develop policies and legislative frameworks by maintaining a sound and healthy environment within municipal and water fields. • Monitoring and inspection of all food establishments throughout the different governorates excluding Muscat, Sohar and Dhofar. • Issuing health permits (licenses) and health cards for food handlers. • Conduct tests on water quality, food and environment analyses and radioactivity measurement.
Ministry of Commerce and	Directorate General for	• Responsible for formulating food safety regulations and standards. Conduct standardization and

Industry (**MOCAI**)	Standards and Metrology (DGSM)	calibration of laboratories tools and equipment. • Food and water sample testing for different contaminates. • Monitoring of domestic markets and local produced food products for the compliance of the Omani standards and specifications.
Ministry of Health (**MOH**)	Directorate General of Heath Affairs	• Responsible for inspection of imported semi- and fully processed food products. • Issuing health certificate for food handlers employed in food establishments. • Conduct tests on food and water samples and biological human samples. • Surveillance of foodborne diseases by the department of Communicable Disease Surveillance and Control.
Ministry of Agriculture and Fisheries Wealth (**MAFW**)	Directorate General of Agriculture Development (Plant Quarantine) & Directorate General of Animal Development (Veterinary Quarantine)	**Agriculture and animal wealth** • Safeguarding the veterinary, animal healthcare live animal imports, agriculture fresh produce, pesticide control and certifications. • Conducts test and examination on residual drugs and different chemical and biological contaminants on agriculture and animal products on research bases. • Inspection of live animals and plants, red meats, poultry meat, agricultural materials, fresh fruits, fresh vegetables and other unprocessed agricultural products in the agricultural and veterinary quarantine at the points of entry into the country.
	General Directorate of Fisheries Research (Fishery Quality Control Centre) & Department of Surveillance and Compliance	**Fisheries wealth** • Inspecting fishing landing sites, vessels, fish markets, fish transportation trucks, cold storage, ice plants and seafood establishments. • Approves HACCP plans for seafood establishments. Conducts test and examination on residual drugs and different chemical and biological contaminants of seafood products and issues export certification. • Carries out research studies on seafood quality and safety.
Local Municipalities (Muscat, Sohar and Dhofar)	Department of Health Affairs	• Monitor food safety through the inspection of products available in local wholesale, retail markets and catering services. • Issuing health permits (licenses) and health cards for food handlers. • Conduct tests on food samples.
Public Authority for Consumer Protection (**PACP**)	Department of Studies and Market Research	• Monitoring market price fluctuations, combat fraud, deceitful and monopoly react promptly to consumer complaints with appropriate solution, provide general awareness programs, and most of all providing and guaranteeing consumers with freedom of choice, equality, fair treatment, honesty and

		credibility. • Carries out inspection throughout the different governorates regarding the market price fluctuations, fraud and any misconduct of food labelling, for instance expired dates.
Royal Oman Police (**ROP**)	Directorate General of Customs	• Execute the customs and security supervision on different importing and exporting commodities. • Collection of customs fees • Combating smuggling and preventing the entry of banned goods according to the agreed laws and regulation.

3.4 Food legislation

According to FAO (2006b), food legislation is defined '*as the complete body of legal texts (laws, regulations and standards) that establish broad principles for food control in a country, and that governs all aspects of the production, handling, marketing and trade of food as a means to protect consumers against unsafe food and fraudulent practices'.*

The Omani government has attempted to construct its legislative, enforcement and diagnostic capabilities in order to overcome threats to consumer health and safety. The Directorate General for Standards and Metrology (DGSM) within the Ministry of Commerce and Industry (MOCAI) is the national standard organization in Oman. It was first established by Royal Decree No. 39/76 issued in October 1976. The DGSM is responsible for standardization, metrology, quality control and quality assurance programs and certification and accreditation activities (MOCAI, n.d.).

As a member of the Gulf Cooperation Council (GCC), Oman has agreed to harmonize its technical standards and regulations with those issued by the Gulf Standardization Organization (GSO). This Organization, consisting of the GCC countries and Yemen, harmonises food and non-food standards throughout the GCC countries (Food Regulation Middle East, 2012). Once the standards have been approved by the GSO Food Standard Committee, the member countries are expected to officially adopt and enforce them as a part of their local requirements. Of the 6150 standards that have been issued by DGSM in collaboration with GSO up until 2013, a total of 1039 (17%) are related to food commodities such as food additives, drug residues, pesticides and other contaminants, food

packaging and labelling, genetically modified organisms (GMO's), novel foods and general principles of food hygiene (DGSM, 2013).

Standards related to the wellbeing and health of consumers is compulsory implemented in the country as per the Royal Decree No. 1/78 issuing the DGSM. As a member of the World Trade Organization (WTO) in pursuant to the Royal Decree No. 112/2000, Oman's legislation and standards also have to be in compliance with the WTO's Technical Barriers to Trade (TBT) and Sanitary and Phyto-Sanitary (SPS) agreements, which aim to facilitate international trade. In addition, as a member of Codex Alimentarius since 1972, Oman is encouraged to harmonize its technical regulations and standards with those of the Codex.

In 2008, a food safety law was issued by Royal Decree No. 84/2008. The law empowers the Ministry of Regional Municipalities and Water Resources (MRMWR) to deliver the necessary regulations and enforcement in support of consumer safety. It includes protecting public health in terms of imports and exports of food products, monitoring food handling and penalties. The MRMWR has the authority to issue regulations in support of the implementation of the law. Two regulations are in place, the Food Safety Regulation (2/2010) and the Food Control Regulation (241/1999) with general provisions and articles (see Table 7). The Ministry of Agriculture and Fisheries Wealth (MAFW) have also issued regulations for safeguarding the three sectors under its authority. In the agriculture and animal sector, three laws were issued:

- Veterinary Quarantine Law (Royal Decree no. 45/2004)
- Plant Quarantine Law (Royal Decree no. 91/2000; updated in 2007 to 47/2007)
- Pesticide Law (Royal Decree no. 64/2006);

The veterinary quarantine arrangements follow the requirements of international agreements such as International Office of Epizootics (OIE) within the World Organisation for Animal Health, the intergovernmental organisation responsible for improving animal health worldwide. As for the plant quarantines they follow the International Plant Protection Convention (IPPC), an international agreement on plant health with the Secretariat provided by the Food and Agriculture Organization (FAO).

The fisheries industry in Oman is the second largest export revenue after oil. However, in 1998 the European Union (EU) banned the import of fish and fisheries products from the Gulf States due to non-compliance with the EU's environmental and health regulations based on HACCP. This caused a sudden loss of international market share for GCC exporters (FAO, 2004). The EU ban was lifted in Oman in 1999 followed by Yemen in 2002 and United Arab of Emirates (UAE) in 2003 once quality management systems based on HACCP had been adopted (FAO, 2004). The EU had made HACCP compulsory for the fisheries establishments intending to export to the EU. Visits by the EU's Food and Veterinary Office (FVO) took place in 1998 (European Commision, 1998) and 2006 (European Commision, 2006). The recommendations of these missions prompted the amendments to regulations to ensure, for export seafood, equivalence to the EU's standards on contaminants, additives, potable water, hygiene, and official controls (European Commision, 2006).

Fisheries regulations had however started in 1981 when a Royal Decree (No. 53/81) issued a law on Marine Fishing and Production of Living Aquatic Resources. It was followed by the Executive Regulation for Marine Fishing and Production of Living Aquatic Resources in accordance with the Ministerial Decree (No. 3/82). Regulations have advanced in the fisheries sector with the latest Fish Quality Control Regulation (12/2009) replacing the previous MD (No. 136/98) that had been issued after the EU embargo. Under government plans, aquaculture is expected to become a vital sector in Oman with an estimated production of 220,000 tonnes with a value of RO340 million in the year 2030 (The Fish Site, 2012). This should enhance food production in the country and increase GDP. To help achieve this, the government adopted legislation regarding aquaculture in 2004 (36/2004) and this was updated in 2012 (Ministerial Degree No. 177/2012) (see Table 7).

Locally, municipal food safety laws have also been issued for the inspection of food products of animal origin in local wholesale and retail markets.

Another important component of the food safety control system is the Public Authority for Consumer Protection (PACP) which was established as an independent consumer protection authority in 2011 by Royal Decree (No. 53/2011) and the Law of the Public Authority for Consumer Protection Royal Decree (No. 81/2002). The main principles of

this law are to regulate domestic markets and ensure the law is effectively implemented with fair treatment, decency and trustworthiness within the customer supply chain.

The food safety committee of the GCC has been looking to draft a common food safety law for the region to unify the monitoring guidelines for imported foodstuff within the region. Each stakeholder of the GCC has been urged to upgrade their monitoring systems at the borders to be in line with adopted GCC standards. Standard harmonization has become a necessity to reduce the difficulties faced by food traders and producers. The Gulf Rapid Alert System for Food (GRASF) has been constructed by the GCC Food Safety Committee at their meeting in November 2012, and links all the members of the GCC states. Based in Riyadh, Saudi Arabia, the system is web-based and facilitates the rapid exchange of information on any food-related emergency or crisis such as contamination, food borne diseases and product withdrawals. As well as allowing member states to take prompt action toward banning or withdrawal of faulty or non-compliant products, it will prevent such products being re-exported from one state to another (Saudi Food & Drug Authority, 2014). The food safety officials in Oman have already been connected to the system, and around 604 alerts had been received by December 2013 (Al-Shibli, 2013).

Additionally, a common GCC food safety law is being discussed with a unified monitoring guideline for imported foodstuffs as a key element. The draft guideline is expected to be implemented once approved by the WTO. According to an MRMWR official, the proposed law will unify all the imports and safety rules throughout the region, ensuring non-compliant foods are banned from entering any GCC member state (Al-Akhzami, 2014; Muscat Daily, 2013) . So as to aid the harmonisation of certification systems and to adopt risk based procedures, a guideline for the control on imported foods has been drafted and approved by the GCC members and is expected to be implemented by 2015 (Al-Akhzami, 2014).

The GCC Customs Union was approved and effectively implemented in January 2003. The main aim is to abolish any trade restriction among the member states and introduce a common external customs tariff of 5% for products imported from outside of the GCC (Cooperation Council for the Arab State of Gulf, 2003). This also requires the unification of internal customs, financial and administrative regulations and procedures so as to allow

free movement of goods among the States, taking into account necessary veterinary and agricultural quarantine regulations.

There is a need in Oman to harmonize all regulatory requirements for imported, exported and locally produced foods and to continue to work towards a fully risk-based approach to meet various challenges related to food safety for both its domestic and potential export market along with all the enforcements and inspections encompassing the 'farm to table' concept. HACCP principles should be introduced into the different laws and regulations regulating the food production sectors as an appropriate means to enhance food safety measures. The development and updating of food laws and regulations to meet international standards and regulations incorporating preventive approaches is an essential component of a modern food control system (FAO/WHO, 2003).

Table 7. Food Legislation in Oman

Food Laws and Regulations	**Responsible Authorities**	**Contents**
Food safety law (84/2008)	MRMWR	Safeguard the public health and providing legal basis for the government to establish a food management regime ensuring safety along the entire food chain. Consists of 22 Articles dealing with various aspects of food products including quality, safety, transportation, food trade control, import, export and passage of food products, Violations and penalties.
Food Safety Regulation (2/2010)	MRMWR	General provisions and 37 articles on definitions and different critical issues such as the mandatory application of the approved standards, handling of food, Food establishment, Food additives and labelling, permits and licenses, internal control, food traceability and recall, import and export and violations and penalties.
Food Control Regulation 241/1999) under revision	MRMWR	Consisting of health regulations in different catering services such as restaurants, coffee shops, food preparation sites, supermarkets and groceries, bakeries, food storage and food factories and establishments.
Plant Quarantine Law (into (47/2004) and its Executive Regulations (32/2006)	MAFW	The law of general provisions and 33 articles on definitions and general rules, administration, containment and eradication of pests, import and export, conclusive rules. Its Executive Regulations composed of 35 articles covering definitions and general rules, import, export, transit consignment, consignment transport means pest containment and eradication, fess and grievance.
Veterinary Quarantine Law	MAFW	The Law composed of 25 articles and 61 articles for its Executive Regulations. Terms and definitions are included in

(45/2004) and its Executive Regulations for (107/2008)		article 1. MAFW is the competent authority for regulating the import and export, of all species of animals including their products and their derivatives, from and to the GCC members' countries. The law lists animals, animal feed, animal products and diseases, animal bio-products, fisheries products, veterinary drugs and any devices or equipment related to animal husbandry to be subject to the provisions of the law. Licenses from the Competent Veterinary Authority are necessary for both import and export of the listed products. The competent authority shall issue a resolution defining license fees, veterinary certificates and animal sanitary services, and covers offences and penalties
Fishery Quality Control Regulation (12/2009)	MAFW	This regulation oversees a wide range of provisions on the quality control and safety of fish and fishery products for import, export and for domestic markets furnished in 83 articles. Traceability and Food safety control system such as HACCP are included in the regulation to facilitate its implementation in the seafood establishments. Hygiene conditions of seafood products harvesting to consumption are stated clearly in the different articles of the regulation with Violations and Penalties terms. The regulation has adopted many of its standard limits and specifications for the microbial and chemical contaminants, pesticide and aquaculture residual drugs from the Omani standard, GSO, Codex Alimentarius, ISO and European Union regulations.
Aquaculture and related Quality Control Regulation (177/2012)	MAFW	The Aquaculture and related Quality Control Regulation covers within its 80 Articles the different licenses to create a commercial aquaculture and /or integrated aquaculture. The licensee shall commit to protect the environment surrounding the aquaculture project and comply with the requirement and technical guidance set up by the regulation. An article on the quality control of the aquaculture products, feeds and fertilizers, veterinary drugs, harvesting, handling and export, and an emphasis on the health requirements and food safety control systems to be in place prior to the establishment of the farm. The regulation covers the aquaculture committee and its responsibilities and the infractions and administrative sanctions.
Pesticide Law (64/2006)	MAFW	Composed of 14 articles and aims to organize the production, imports and handling process of pesticide in Oman and covers offences and penalties.
Muscat Municipality's Health Regulation (168/2011)	MM	Consisting of 8 chapters on the health regulations of the different catering services, food display and storage, food processing, meat and poultry production, food transportation, public health activities and other activities related to non-food products.
Sohar Municipality Law (9/97)	Sohar Development Office (SDO)	Composed of 27 articles of which items 14, 15, 16 and 18 of article 24 convers the food safety aspects such as monitoring abattoirs, food operating businesses, combat fraud and any misconduct of food products, inspection of market price fluctuations and issuance of health permits with collaboration with other authorities.

Dhofar Municipality regulation (18/86)	DM	Composed of 21 articles of which items 6, 7 and 8 of article 18 convers the food safety aspects such as monitoring abattoirs, food operating businesses, combat fraud and any misconduct of food products, inspection of market price fluctuations and issuance of health permits with collaboration with other authorities.
Consumer Protection Law (81/2002)	PACP	Entitles consumers to obtain correct information about purchased commodity which must contain label listing particulars in relation to price, date of production and expiry, country of manufacture, conditions and instructions of application, basic components, and degree of effectiveness and after sale service. It also covers consumer rights, the duties of providers, advertisers and agents, and penalties and final provisions.
Unified Customs Law for the GCC (67/2003) and its Executive Regulations	Royal Oman Police	The law composed of 17 articles to execute the customs and security supervision on importing and exporting. It is also concerned with collecting the decided customs fees combating smuggling and preventing the entry of banned goods according to the agreed laws and regulation.

3.5 Food inspection and Surveillance

The enforcement of food safety laws and regulations in Oman is divided among different ministries and municipalities within the country (Table 6). There are nearly 400 food inspectors within the different municipalities carrying out official inspection duties relating to food safety (MRMWR, 2012). However, due to the vast range of regulators the data of the other inspectors in other regulators have not been included since the majority of them have other duties in addition to food inspection. Most of these inspectors have just secondary school diplomas with a few having Higher National Diplomas or bachelor degrees in the sciences. Alomirah et al. (2010), have indicated a similar situation in Kuwait. Inspection activities mostly concentrate on hygiene practices, physical/visual inspection, labelling of production and expiry dates, ingredients, Arabic translation and end-product testing for specified contaminants. This approach has been noted in other GCC countries (Al-Kandari D., 2011). Most of the sampling protocols are focused on end-product testing and inspection and monitoring activities are mostly reactive to customer complaints and foodborne crises rather than proactive and based on risk. Modern food enforcement systems should incorporate risk analysis and the monitoring of food safety

management systems such as HACCP and sampling techniques and protocols based on international standards.

In Oman and many neighboring countries, the number of qualified inspectors is limited and scattered in different organizations with lack of coordination and a duplication of duties and responsibilities (Al-Kandari D., 2011). The lack of coordination among the different authorities in Oman is reported to have led to differences in standards of hygiene, health requirements and inspection procedures in different parts of the country (Al-Hinai, 2009). One study of inspector knowledge (Al-Hinai, 2009) suggests that inspectors are provided with basic training in food hygiene and visual inspection techniques. However, many food processing operations are complex and inspectors may lack the required knowledge. In Oman, data indicate that 47% of food businesses are categorized as high risk. However, the lack of a mandatory HACCP system has reduced the overall attempt to implement food safety from farm to table. Furthermore, the deficiency in the knowledge of food safety management systems such as HACCP and its pre-requisite programs (including Good Manufacturing Practices (GMP) and Good Hygiene Practices (GHP), and the lack of inspection tools and supporting equipment can result in inspection duties not being efficiently undertaken. Some food businesses have adopted quality management systems such as GMP and HACCP. It is reported that 11 have adopted ISO 22000 and 7 have implemented HACCP into their factories (Ministry of Commerce and Industry, 2013). These are however not fully integrated with domestic inspection systems which continue to focus primarily on end-product control (FAO, 2004). This results in wasted manpower, financial resources (Alomirah et al., 2010), increased bureaucracy and the fragmentation of activities.

The main elements of food inspection can be considered under three headings: imported foods, domestic foods for domestic consumption and exported foods.

3.5.1 Control of imported foods

On arrival at a port (land, air or sea), the Royal Omani Police (ROP), represented by the Directorate General of Customs (DGC), visually inspect and supervise the imported food at the customs. All food commodities, whether of plant or animal origin, must be declared and quarantined on arrival. The DGC examine the documents and certificates with the

incoming consignments. Health certificates and certificates of origin must accompany food consignments in order to ensure their compliance with national laws and regulations. Once approved by the customs, a more specific inspection is carried out by the relevant competent authority for the type of food.

3.5.2 Veterinary Quarantine (VQ)

Based on the Veterinary Law (45/2004), the VQ is responsible for assuring the health and safety of imported live animals and their products and by-products, fishery products, veterinary drugs and any devices or equipment related to animal husbandry. Random samples of 5% from the consignment are withdrawn for physical examination and if the consignment is non-compliant, it is detained pending the results of a subsequent analysis. If the results are unsatisfactory the consignment is either re-dispatched or destroyed. If compliant, a release is issued and the importer arranges for customs declaration allowing the food to enter the domestic market (see Figure 5).

However, prior to their arrival at the port, import permits must be obtained from the MOCI demonstrating compliance with relevant standards, and from the MAFW to comply with the health requirements of the imported products. The MOCI, represented by DGSM, may require health certificates, laboratory results, bilingual labelling information (Arabic and English), copies of certificates (Halal, ISO22000, ISO9001, HACCP) if mentioned on the label, packing list of consignment and commercial registration (DGSM, n.d). Separately permits have to be acquired from the imported permit division of the VQ by the submission of the appropriate form accompanied by relevant permits and certificates from the country of origin.

3.5.3 Plant Quarantine (PQ):

Plants products defined as "*non-manufactured materials of plant origin including grains and those manufactured products, by their nature or that of their processing, may create a risk for introduction and spread of pests in the country or within the GCC countries*" are governed under the Standard Plant Quarantine Law (47/2004). This requires the PQ to secure the safety of imported, exported and transit agricultural and plant consignments and makes it responsible for preventing the introduction of pests from outside the country.

This is achieved by adopting post entry quarantine measures and pest risk analysis by the use of appropriate Phyto-Sanitary measures.

Once a consignment of plant origin that is subject to PQ control reaches the entry port, random samples of 5% are withdrawn for a plant health test only. This limited examination is conducted to alleviate any risk of plant infections. The issuing of permits follows the same procedures as the VQ.

Additional screening for diseases and contaminants, either for plants or animal products, is carried out in the quarantine and further samples may be sent to the MAFW or other regulatory laboratories. Increased imports have led to an increased workload for these laboratories and, to reduce delays, two new laboratories have been constructed by the MAFW to increase capacity. When operational they will enable additional testing for pesticide and drug residues (Al-Tobi, 2013; Al-Wahaibi, 2013).

3.5.4 Health Quarantines (HQ):

The Health Quarantine is responsible for inspecting and verifying processed or semi-processed food in compliance to the existing standards and further samples are collected for analysis based on the existing sampling protocols. Therefore, acceptance and rejection of food consignments depends mainly on the sampling techniques and protocols exercised at the different quarantines.

3.5.5 Control measures for domestic foods for domestic consumption

Locally produced foods can be directly marketed in different outlets (see Figure 6). However, for locally processed food products for the domestic market, an approval has to be given by the DGSM following the submission of relevant documents (MOCAI, n.d.).

Once they have reached the various markets or outlets, depending upon the nature of the food, different regulators (in the ministries or municipalities) are responsible for any subsequent inspection. The MOCAI inspectors main duties are to ensure the laws and regulations are implemented effectively by monitoring the local food factories and markets. To ensure that they are within the specifications, they inspect food ingredients, expiry dates, labelling and food packaging materials. In addition, samples are collected for contaminant analysis in their central food laboratories. In most governorates, food outlets are subject to inspection by the regional offices of the MRMWR.

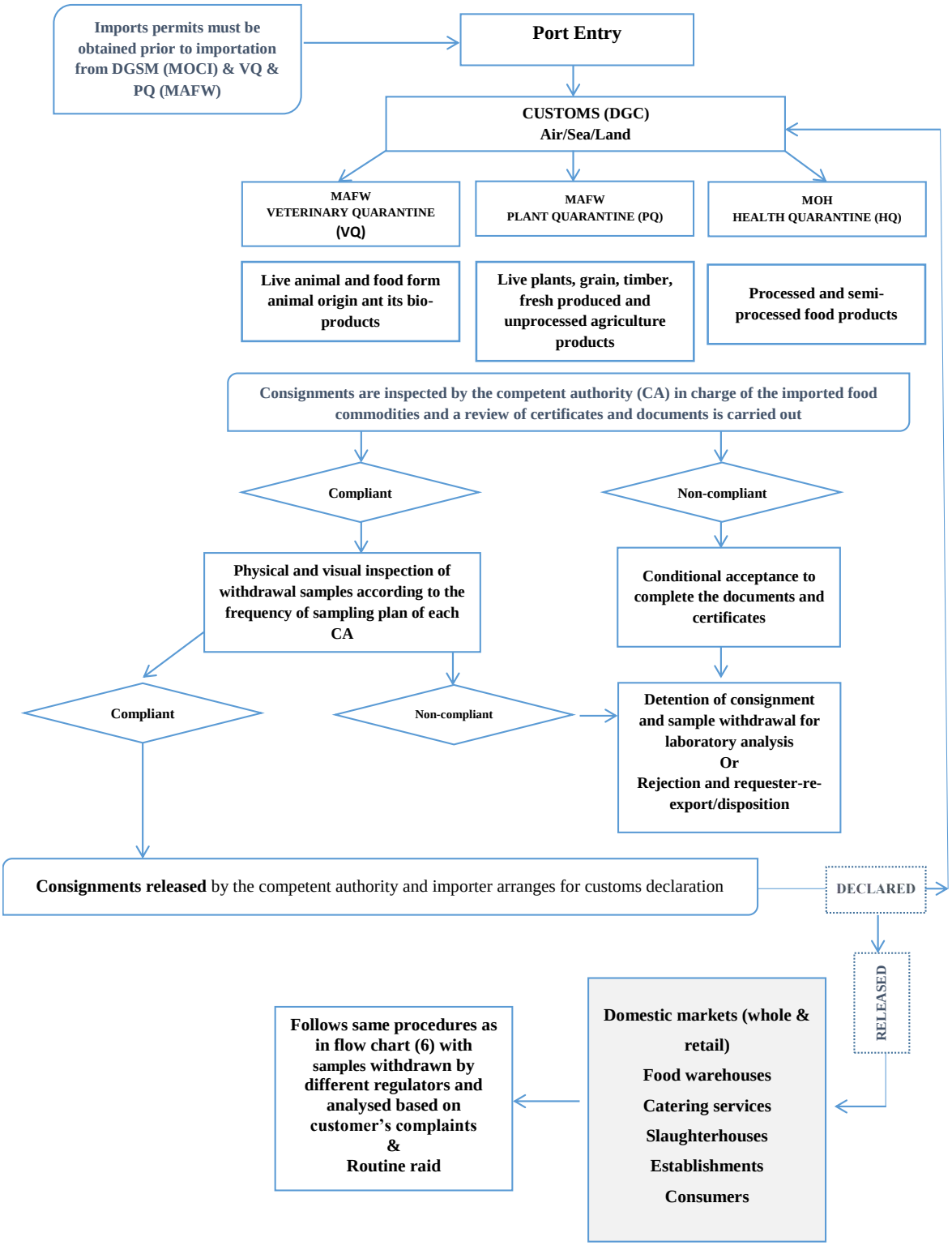


Figure 5. Flow chart of food import procedures

Their responsibility is to ensure that imported and domestically produced food meets the requirements of the established controls including checks on the hygiene of the food premises. Food and water samples from the different sources are collected and tested at the ministry facilities for food hazards including contaminants. In 2012, 521 food outlets were forced to close, 11,293 penalties were imposed due to non-compliance with rules and regulations and a further 5,581 official warnings were issued (MRMWR, 2012).

In the Muscat governorate food outlets are under the jurisdiction of the Muscat municipality along with the other food regulators. The municipality has established hygienic requirements for a range of food businesses and their inspections are to confirm the implementation of these requirements and compliance with food safety law issued by MRMWR. Slaughterhouses in Muscat are inspected by the municipality to verify that carcasses are free from contaminants and infectious diseases. Samples collected by the inspectors are only subjected to microbiological tests within the municipality microbiology laboratory. For other contaminants the analysis is conducted in other laboratories. Other municipalities such as Sohar and Dhofar conduct similar tasks within their governorates to routinely monitor the safety of food and the hygiene requirements of the food handlers and food premises.

Seafood inspection is subject to different control under the authority of the Fishery Quality Control Centre (FQCC) based within MAFW. The centre conducts regulatory control activities including the quality and safety of seafood at all points in the food chain including fishing vessels, landing sites, seafood processing facilities, transportation vehicles, and finally the retail outlets. The centre has a food safety system implementation division in charge of upgrading various seafood establishments including ice factories and fish farms. The quality control monitoring division is in the process of acquiring ISO 17020 certification and based in Muscat. Detailed sampling arrangements are in place with both routine samples being collected by the plants/factories and official samples collected by the FQCC inspectors. The sampling plan can be amended based on the results of sampling. The major priority of the FQCC activities are to ensure compliance with international standards, especially those of the European Union, in order to achieve export accreditation of the country's fast growing seafood companies.

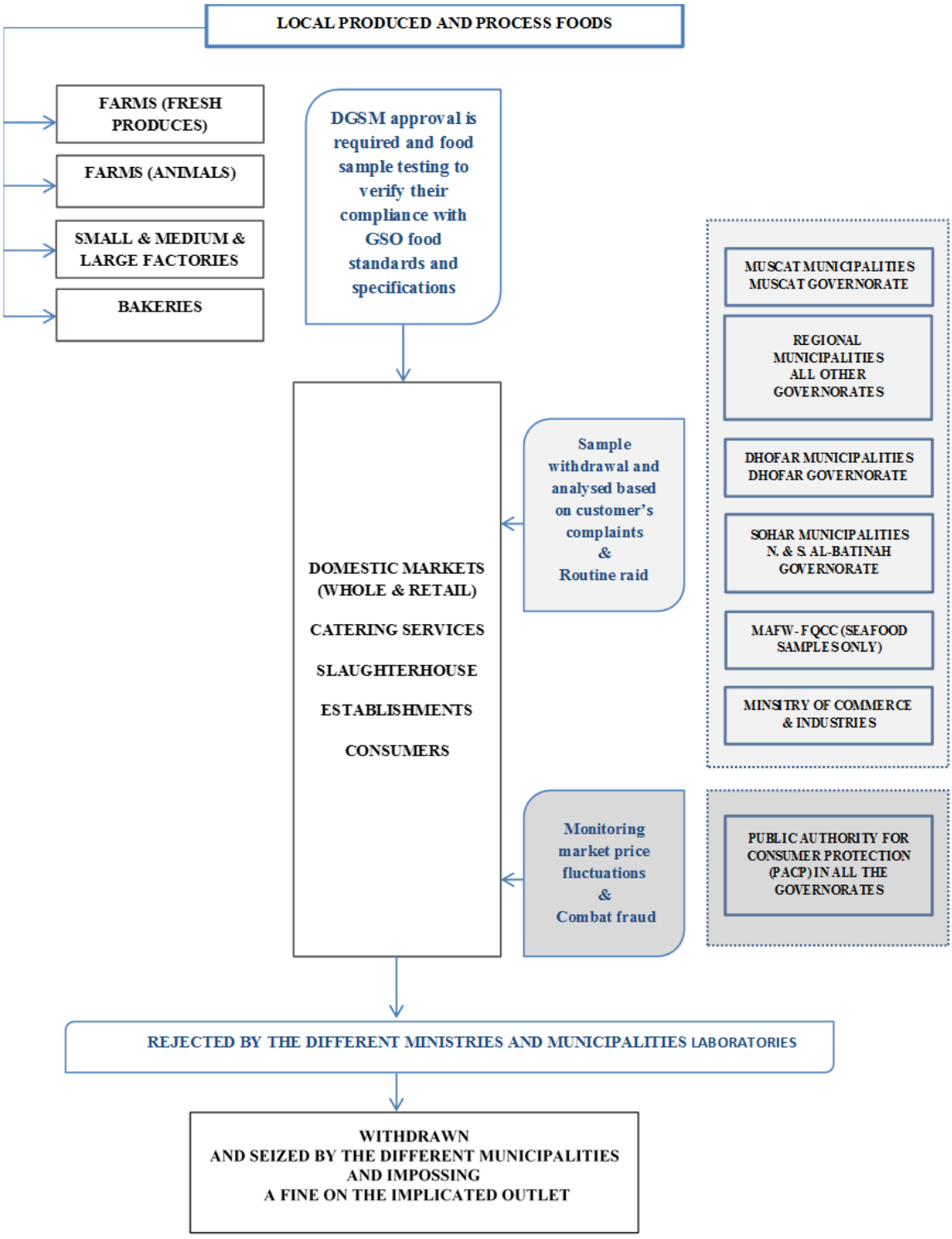


Figure 6. Local produced and process foods

The PACP authority was only established in 2011 and has additional duties and responsibilities (Table 6). There are twelve regional offices across the different governorates with Complaint & Inspection Management System (CIMS) in place to handle complaints accurately, recording any fines issued and managing statistical reports received from various regional and central offices via normal routes and from Personal Digital Assistant (PDA) devices carried by their inspectors. The total complaints for food and consumable products in 2012 were 256 (just 4% of their total) (PACP, 2012).

3.5.6 Exported food products

The export procedure is explained in Figure 7. Most food products are exported to the neighboring GCC countries or to Arabian, Asian and African markets with no further tests unless specifically required by the exporting firms or the importing countries. North America, the EU and Japan require quality and safety control schemes (including HACCP) to be in place with, in most cases, the companies certified by the local competent authority. However, DGSM impose some specific procedures for exported and re-exported food products. Exported food products should be in compliance with the Omani or GSO Standards and additional documentation may be required (MOCAI, n.d.).

All seafood products exported from Oman are subject to inspection under the Fish Quality Control Regulation (12/2009) in the FQCC and the Animal Quarantine within the MAFW. This inspection is carried out to provide reasonable assurance that the exported products meet the regulatory requirements of the importers (particularly with regard to contaminants), and the products are safe, wholesome and of acceptable quality.

3.6 Official food control laboratories

According to FAO/WHO (2003), laboratories are an essential component of a food control system and require considerable resources to set up, maintain and operate. Laboratories are vital in assuring and verifying the safety and quality of food and their results are often used as evidence in any legal proceedings. The control laboratories should have both the capacity and the capability to identify all food hazards. This is essential as international requirements become more stringent and with the emergence of new threats to public health due to the rapid globalization of food production and trade.

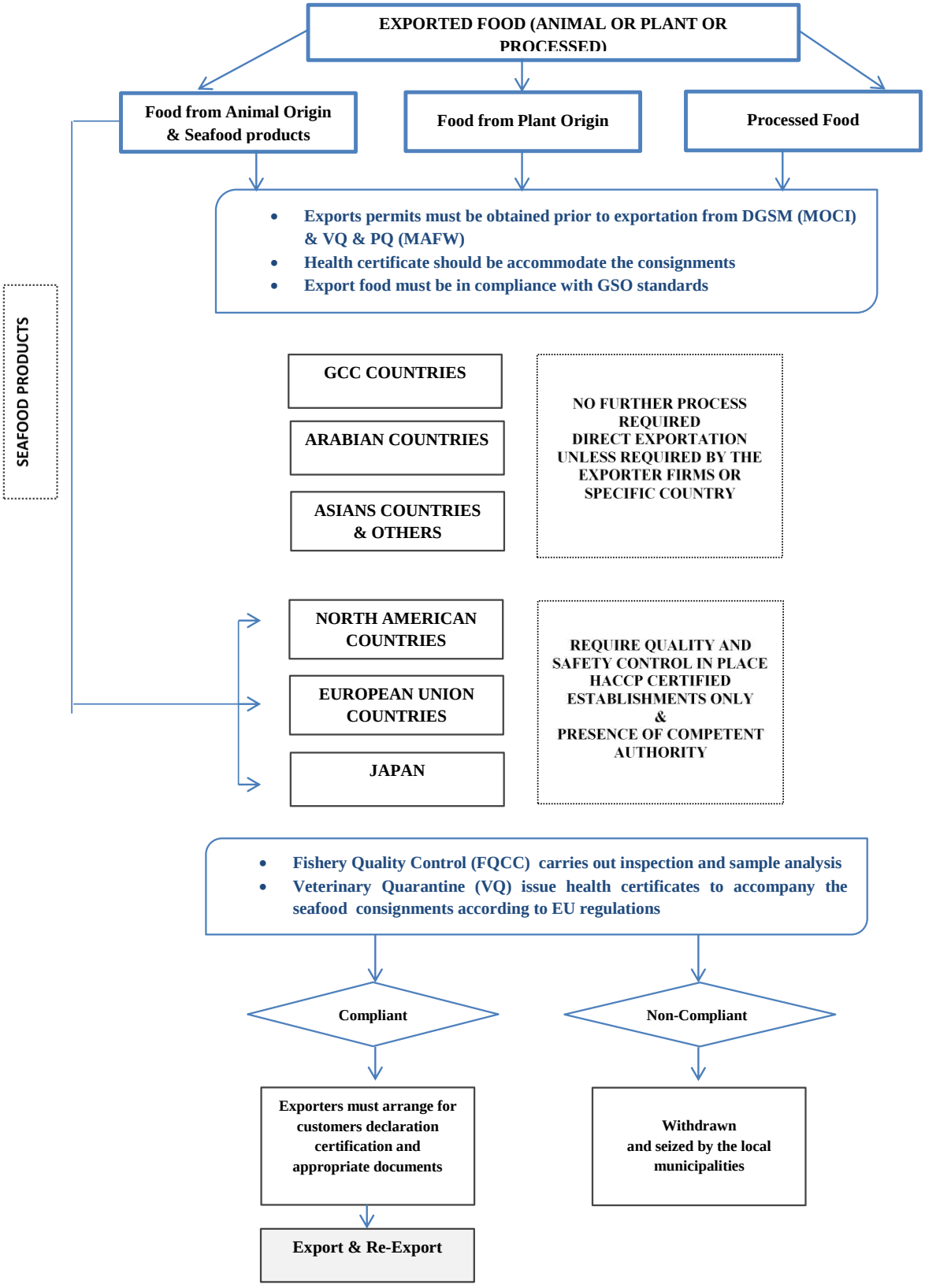


Figure 7: Flow chart of food export and re-export procedures

Most of the regulatory laboratories in Oman have an adequate infrastructure and facilities in place and are equipped with modern instruments and supplies. It has been noted that Oman has realised the importance of analytical facilities for an effective food control system (Shalini A. Neeliah and Goburdhun (2007). However, the regulatory laboratories are managed by different ministries and municipalities at the central level with sub-divisions in the different governorates of Oman. Bacteriological tests and chemical analyses are conducted in all the official laboratories but radioactivity measurement for food, water and environment samples are only conducted in the MRMWR central laboratories. The lack of effective coordination among the different laboratories causes duplication in the work and a waste of resources, even though, Article 21 of the Food Law (84/2008) clearly emphasised the need to coordinate, each in its specialization, and to study obstacles and submit reports on the analysis results for tested samples to the committee. Although usually university graduates, food analysts often lack proper training on the advanced methodologies and techniques and the operation of sophisticated instruments. Similar situations were observed by (Al-Kandari D. & Jukes, 2009) in the other GCC countries. FAO/WHO (2003) have stressed the importance of the qualification and skill of the analyst and the reliability of the method used in order to produce accurate and reliable analytical results. Shalini A. Neeliah and Goburdhun (2007) have also emphasised the significance of the link between the enforcement and the analytical entities in a food control system.

Harmonization of methods and techniques is one of the challenges in the official laboratories in Oman where each individual laboratory often follows its own analytical methods. However, food standards and limits published by the DGSM are followed by most laboratories unless international requirements apply. For example, FQCC is obliged to follow EU requirements and standard limits on seafood products and this can lead to disputes on compliance criteria among the different stakeholders. The Central Public Health Laboratory (CPHL) in the Directorate of General of Health Affairs of the MOH is in charge of food and water samples collected by the health quarantine at the borders. Most of the tests carried out are bacteriological with only limited chemical analysis tests mostly on food composition. They also assess biological samples from food handlers seeking approval for employment in food establishments and, in collaboration with the Department

of Communicable Diseases and Surveillance Control (CDSC) in samples relating to food poisoning cases. In recognition of its capability, the CPHL was identified as the coordinating laboratory for the regional collaborative surveillance network for foodborne infections known as PulseNet Middle East.

In order to strengthen the capacity in food safety and surveillance of foodborne diseases, the MOH has participated in the strategic agenda of the Cooperation Strategy for WHO and Oman (WHO, 2010a). Food safety has been a national and international health priority for the last decade and the surveillance of foodborne diseases in Oman is reported as cases by the CDSC. In general, foodborne disease (FBD) cases recorded by the local government hospitals indicate that the incidence remained roughly constant from 1985 to 2013 with regional variation, and a slight increase in the incidence reported in 2010 due to the incorporation of major cases that took place during summer months, where major cases usually follows different reporting routine. The summer months (April to October), when temperatures can rise to an average of 45^{o}C, have the most cases of FBD as shown in Figure 8. The true incidence of foodborne disease is underreported. Most confirmed cases are of bacteriological origin with *Salmonella* being the dominant causative agent (Ministry of Health, 2013).

As in other Gulf countries, laboratory accreditation in Oman lacks international recognition with limited scientific and technical expertise (Al-Kandari D. & Jukes, 2009). Many efforts are on the way to overcome some of the deficiencies. It is planned to update and equip the food laboratories and improve their capacity and capability of the technical staff. Some laboratories are in the process of implementing ISO 17025 and participating in the inter-laboratory testing schemes, both regional and international, in order to enhance their performance and update their skills and analytical techniques.

3.7 Food safety and quality information, education and communication (IEC)

According to the FAO/WHO (2003), an essential role of food control systems is the delivery of information, education materials and advice. IEC can enhance food safety and quality awareness among the various stakeholders from producers, food processors, traders, food enterprises, industry associations to consumers (FAO, 2006b).

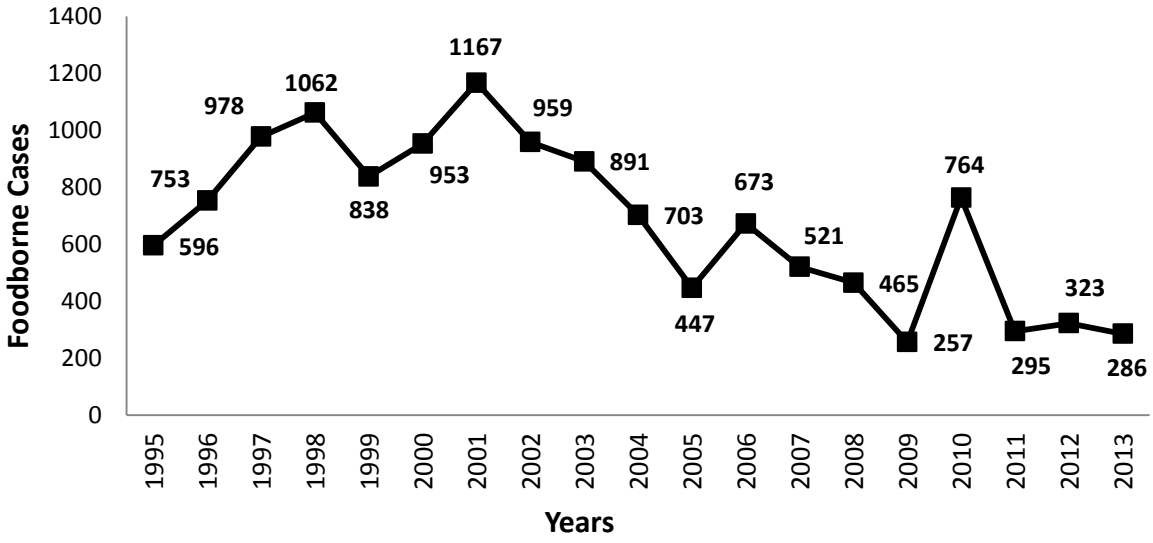


Figure 8. Foodborne Diseases cases in Oman (Microbial- Minor cases) from 1995 to 2013 (Ministry of Health, 2013)

Governments can educate the different sectors and encourage them to adopt HACCP and its pre-requisites programs in their food control management systems and can disseminate appropriate messages among consumers about ways they can enhance food safety and quality in their daily life (FAO, 2006b). A Consumer Protection Law was issued by Royal Decree (81/2002) with the necessary regulations and decisions for implementing the law. The law helps ensure the authenticity and safety of products and entitles consumers to correct information about products (see Table 7). Subsequently, in June 2003, the Ministry of Social Development issued a Decision (No. 132/2003) to register the Oman Association for Consumer Protection (OACP). This is managed by a board of directors who perform their duties voluntarily as an independent, non-government organisation. Its main tasks and duties are to:

- protect the consumers' interests and represent them before public and private sector bodies including judicial bodies
- issue publications, specialized magazines and periodical circulars and to use different means of communications

- conduct seminars and workshops on different issues that concern the consumer's rights (OACP, 2013).

More recently a new Public Authority for Consumer Protection (PACP) was established in February 2011 by Royal Decree (No. 26/2011). The Authority functions under the Council of Ministers, with the Authority's Board Chairman issuing the by-laws and decisions necessary to implement the provisions of Consumer Law effectively (PACP, 2013). The PACP can initiate action against traders or suppliers in breach of the law, and detect inflated pricing or the sale of items which are banned or not permitted in the country. PACP has a section for safety of food and drugs dealing with consumer complaints on food. Where necessary it will liaise with the other governmental authorities in charge of the specific food.

IEC activities addressing consumers and the food industry has been undertaken in Oman in the form of annual national and international food safety conference. The first Oman Food Safety Conference was organized by the Muscat Municipality, the MRMWR, MAFW and the MOCAI in October 2010. These conferences have provided government regulators, food industry, food safety professionals, academia and consumers with a forum to learn innovative practices, exchange insights, networking and provide an opportunity to share information, education and communication among the various stakeholders. The Omani regulators have taken a very active step in promoting a culture of food safety and in educating the consumers in both the cities and rural areas.

With the expansion of imported food products and the resulting risk of new food safety scares from other countries (for example avian influenza, salmonella, mycotoxins, unsafe food additives, dioxins, pesticide and drug residues), it has become critical to raise the awareness on food safety and quality issues. Locally, unhygienic food handling practices expired or improperly labelled food and the absence or poor implementation of HACCP and its pre-requisite programs in small, medium and larger food businesses, have raised concerns. One example of a challenge has been the increased risk of pesticide residues in local products due to the absence of Good Agriculture Practices (GAP), a lack of control over the entire food chain and poor coordination among the different authorities.

Many food businesses in the country are small and medium sized food operators and they are responsible for much of the food consumed by the local population. In these businesses, most of the food handlers are from low socioeconomic expatriates groups with poor hygiene education that could be very detrimental if they did not undergo any food safety training prior to their employment in the food sectors. Another factor that could enhance the foodborne illness outbreaks in Oman is the high temperatures during summer seasons (an average of 45^{o}C) when mishandling and storage of food commodities enhances the growth of foodborne pathogens. Increased awareness of the need for temperature control throughout the production and distribution of foods would help and would limit the growth of pathogens.

3.8 Discussion

As a developing country with open access to international markets either as an importer or exporter, Oman has faced challenges to its food control system. The absence of a national food safety agency in the country effectively enforcing the laws with the current food safety laws enforcement is scattered and fragmented through different organizations. The rapid globalization of food production and trade has increased the potential of international incidents involving contaminated food. The creation of the World Trade Organization (WTO), with its SPS and TBT Agreements, has placed substantial obligations on countries to strengthen their food control management systems and, in particular, has emphasised the need for risk-based strategies (FAO, 2006b; FAO/WHO, 2003). Effective national food control systems are essential to protect the health and safety of consumers. They help assure the safety and quality of products and help demonstrate conformance with national and international requirements. The World Food Summit in Rome in November 1996, declared the right to access supplies of safe and nutritious food and the achievement of sustainable food security has also increased efforts by stakeholders (including the FAO and WHO, food enterprises, scientific institutions and NGOs) to improve food safety control systems and highlighted significant weaknesses (FAO, 2006b).

(a) Management

The existing Food Safety Committee (FSC) in Oman is supposed to gather and reduce the fragmentation and division of the responsibility and mandates of the national food control system. However, the committee tends to act as an enforcement committee responding to events rather than acting to prevent problems in advance. Enhanced surveillance work could be undertaken to generate more data on the nature and scale of food safety and quality problems – for example there have been no total diet studies to determine the level of food contamination in Oman. Similar issues have been noted in Kuwait (Alomirah et al., 2010) and is considered to be partly due to a lack of appropriate infrastructure for risk assessment data.

(b) Legislation

It had been noted in 2004 (FAO, 2004) that Oman has an extensive food legislation in place which is strictly applied to exported food but less adequately applied to imported and food produced and consumed locally. Although there have been attempts to update the control, the legislation is scattered and now needs to take into account regional and international developments. Consequently, there is a need in Oman to harmonize all regulatory requirements for imported, exported and locally produced foods and to continue to work towards a fully risk-based approach with a reformed national agency. The current food law should be updated to a very comprehensive legislation and covering all aspects of the food supply chain with all its related processing. Food and feed standards, packaging materials, materials and equipment in contact with food, novel and functional food products and waste management of food industries should be added to the above legislation. Moreover, food standards should be compulsory in implementation in all food industries as well as unified hygiene and sanitary regulations for all food business operators. Hence, they must be tackled jointly by the food safety authorities, food manufacturers, food catering services to ensure food safety codes and practices are implemented according to the national and international legislation. Furthermore, closer linkages among food safety authorities at the national and international level is important for exchanging routine information on food safety issues, sharing experiences and expertise and to have rapid access to information in case of food safety emergencies.

An important need is to reduce the reliance on testing end products and move towards the full adoption of the preventative Hazard Analysis and Critical Control Point (HACCP) approach. Specific guidelines for food business operators on the pre-requisites programs of HACCP such as GMP, GHP and GAP should be prepared and communicated to them in order to set up a risk based food safety controls in these operators. Moreover, this proactive system should be compulsory in implementation.

Quality and safety of food have to be ensured throughout the whole food supply chain with an active partnership of producers, traders, industry and government and the contribution of the scientific community. The involvement of the various sectors of the economy in the development and management of the food control system is a pre-requisite for its success (FAO, 1999). With the support of the various agencies, a national food control strategy can be achieved with defined roles for the different sectors and with clear strategy capable of dealing with newer emerging challenges in respect to securing food, public health and the national economy (FAO, 1999).

(c) Inspection

Food inspectors are the key representative of the food control system with the system's reputation and integrity depending largely on the integrity and skill of the inspectors (FAO/WHO, 2003). An inspection process based on risk analysis, is a vital element of modern food control (FAO, 2006b, 2008). The administration and implementation of food legislation requires qualified, trained, and competent food inspectors. Given the complexity of the existing food systems and the continuous emergence of new technologies, training of the food inspectors should focus on (FAO/WHO (2003):

- food science and technology so as to help in the understanding of complex industrial processes,
- skills and experience of inspecting premises based on the HACCP system,
- collection of food samples, and
- evaluation of the overall system.

In general, food inspection protects end users by safeguarding the integrity of the domestically produced food ensuring that they are handled, processed, stored and

distributed according to the national laws and regulations. Increased efforts in this area will increase confidence in exported food which is crucial for international trade (FAO, 2006b).

The food inspection carried out in Oman and many GCC countries relies mostly on random end product sampling and testing, and with more concentration on the hygiene and sanitation issues (Al-Kandari D. & Jukes, 2009; Alomirah et al., 2010). With 47% of the food establishments in the country being classified as high risk, the adoption of HACCP has been very weak in the country due to the non-enforcing laws in place by the national standard organization. A study in 2009 for the DGSM investigated the status of HACCP and ISO22000 in food manufacturing in the Sultanate of Oman. Based on data from questionnaires, the study concluded that since HACCP is not a national requirement, many establishments fell short in the implementation of basic hygiene requirements and struggled to implement HACCP or any equivalent standards. Of the 11 sites visited by the consultants only one was HACCP certified. However, some factories which had a better understanding of the benefits of implementing such systems, had managed to implement the system without the enforcement of governmental regulations (Ministry of Commerce and Industry, 2009).

(d) Laboratories

Considering the laboratory resource, there has been a tremendous effort by the Omani authorities to improve their capacity and capability. However, as indicated, the five official foods control laboratories are scattered in different ministries and municipalities and has resulted in fragmentation, duplication and poor coordination. To tackle foodborne disease requires accurate and reliable data obtained by establishing an effective linkage between food control agencies and the public health system including epidemiologists and microbiologists. This will facilitate the exchange of data on foodborne diseases and their monitoring, leading to appropriate risk-based food control policies as emphasised by FAO/WHO (2003).

Most samples withdrawn were only analysed for microbiological contamination (bacteriological) with fewer for contamination by chemicals and radiation. WHO (2010b)

has observed lack of details on chemical contaminants in the country although a recent study prepared by Sultan Qaboos University and Arab Emirates University raising concerns on the levels of pesticide residues on food products harvested locally. In fact, a couple of studies have been carried out by MRMWR indicating some residual pesticides and microbial contaminations on the imported and locally produced food products (unpublished reports). Most of the reported foodborne diseases by the Ministry of Health are mainly from bacteriological sources with lack data on viral, pathology and the chemical complications, beside lack of data on waterborne diseases. These finding urge the needs of enforcement in the implementation of food safety management system such as HACCP or ISO 22000 in all food establishments, with a systematic monitoring of chemical and microbiological contaminants in the whole food chain and effective surveillance of foodborne and waterborne disease.

Accreditation of the official food control laboratories in compliance to international standard ISO 17025, is critical in order to ensure competency and validity of the results. An intensive training should be carried out on the operation of the sophisticated instruments, devices, standard and unified laboratory techniques and methodologies, and quality assurance. Harmonization of standards and specifications in laboratories is very essential in producing validated results that could be communicated with different stakeholders.

(e) IEC

Information, education and communication (IEC) plays a vital role in the food control system by delivery of awareness and acknowledge on the food safety and quality issues to the different stakeholders across the farm-to-table continuum (FAO, 2006b; FAO/WHO, 2003). It empowers the different sectors with the knowledge and science behind the concept of food safety and quality, thus facilitating the implementation of the food safety management schemes and its pre-requisites, producing safer food products and in turns protecting public health. The IEC activities however, should be based on risk communication principles (Codex Alimentarius Commission, 2005). Government authorities should use IEC to specify the training needs of their inspectors and laboratories

analysts since proper training supplement food control systems with expertise and highly skilled employees serve as an essential preventive function (FAO/WHO, 2003).

As a consequence of oil boom in Oman and its GCC neighbouring countries, the life style has changed dramatically with increased consumption of ready to eat food and 'fast food' with eating out becoming prevalent in the young generation. This resulted in a growth in catering services which demanded high numbers of employees to meet the requirement of this flourishing sector. Food handlers were than procured from outside the country with poor knowledge of food safety and quality and hygiene requirements. This engagement has complicated the implementation of food safety in Oman and neighbouring GCC countries and has been noted by others (Dina Al-Kandari & Jukes, 2011; D. Al-Kandari & Jukes, 2012; Al-Kandari D., 2011; Al-Kandari D. & Jukes, 2009; Alomirah et al., 2010). Epidemiological results on the outbreak of foodborne diseases in Oman have noted that most are due to poor personal hygiene during handling, preparation and storage of foods.

3.9 Conclusion

Although still work-in-progress, in 2013, the Council of Ministers of the Omani government approved the establishment of a national Centre for Food Safety and Quality (CFSQ) under the auspices of the Ministry of Regional Municipalities and Water Resources in order to raise the country's food safety monitoring and audit capabilities with a principal aim to oversee the implementation of quality and safety standards throughout the food supply chain. There has been a strong need to enhance the food safety measures in the country especially with the dramatically increase cases of food poisoning cases.

The government hopes that the establishment of the CFSQ will strengthen the various aspects of the legal, institutional, scientific and research that will enhance the elements of protection of public health, maintaining consumer safety and providing a healthy environment for the community. The centre is expected to provide a new platform to promote the elements of partnership and responsibility among all stakeholders at the national level in the aspects of food safety and quality as well as opening new horizons at the international and regional levels to more cooperation, coordination and exchange of experiences and expertise in this area. Accordingly, the intended activities of the Centre

will cover all governorates of the Sultanate without exception and covering all the entry points (sea, air and land) undertaking the supervision and inspection of the import and export of food. It also intended to carry out on the development of standards and the adoption of international standards relating to the food safety and quality, inspection of food, water and feed at various stages of production and process. The centre will be equipped with laboratories to carry out all the various analyses for the protection of public health, licensing of food handlers, national capacity-building, as well as implementation of scientific studies and research in all fields related to the safety and quality of food.

At this point in our analysis, it is clear that Oman has made considerable progress with regard to food safety and quality. It is recognised as an essential part for both food security and the economy. The increasing importance of the GCC means that the economies of these countries are becoming more interrelated and dependent on food imports. It is therefore, essential to have unified systems in place with better control over the food safety systems and with harmonization of food laws and policies and a unification of standards. The GCC countries have made considerable advancement in the upgrade of their national food safety control system, with Saudi Arabia transforming from a fragmented organizations to centralizing its food safety activities within an independent administration to establish a national food and drug authority (D. Al-Kandari & Jukes, 2012). Common food safety law with unified guidelines for control of imported foods for the GCC member states, Gulf Rapid Alert System for Food (GRASF), and Unified Customs Law are among the achievements of the cooperation of Gulf Cooperation Council (GCC) to safeguard their public health against many food scares and threats and an attempt to enhance their food control systems.

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CHAPTER 4

4 Seafood safety and quality: An analysis of the supply chain in the Sultanate of Oman[2]

Abstract

The globalization of trade in fish has created many challenges for the developing world specifically with regard to food safety and quality. International organisations have established a good basis for standards in international trade. Whilst these requirements are frequently embraced by the major importers (such as Japan, the EU and the USA), they often impose additional safety requirements and regularly identify batches which fail to meet their strict standards. Creating an effective national seafood control system which meets both the internal national needs as well the requirements for the export market can be challenging. Many countries adopt a dual system where seafood products for the major export markets are subject to tight control whilst the majority of the products (whether for the local market or for more regional trade) are less tightly controlled. With regional liberalization also occurring, deciding on appropriate controls is complex.

In the Sultanate of Oman, fisheries production is one of the countries' chief sources of economic revenue after oil production and is a major source of the national food supply. In this paper the structure of the fish supply chain has been analysed and highlighted the different routes operating for the different markets. Although much of the fish are consumed within Oman, there is a major export trade to the local and regional markets. Much smaller quantities meet the more stringent standards imposed by the major importing countries and exports to these are limited. The paper has considered the development of the Omani fish control system including the key legislative documents and the administrative structures that have been developed. Establishing modern controls which satisfy the demands of the major importers is possible but places additional costs on businesses.

[2] This Chapter was originally published in the journal 'Food Control' as, (Al-Busaidi, M.A., Jukes, D.J. & Bose, S. (2016). Seafood safety and quality: An analysis of the supply chain in the Sultanate of Oman. Food Control, 59/651- 662. For the published paper please see Appendix E. Minor amendments have been made to incorporate recent developments.

Enhanced controls such as HACCP and other management standards are required but can be difficult to justify when alternative markets do not specify these. These enhanced controls do however provide additional consumer protection and can bring benefits to local consumers.

The Omani government is attempting to upgrade the system of controls and has made tremendous progress toward the implementation of HACCP and introducing enhanced management systems into its industrial sector. The existence of strengthened legislative and government support, including subsidies, has encouraged some businesses to implement HACCP.

The current control systems have been reviewed and a SWOT analysis approach used to identify key factors for their future development. The study shows that seafood products in the supply chain are often exposed to lengthy handling and distribution process before reaching the consumers, a typical issue faced by many developing countries. As seafood products are often perishable, they safety is compromised if not adequately controlled. The enforcement of current food safety laws in the Sultanate of Oman is shared across various government agencies. Consequently, there is a need to harmonize all regulatory requirements, enhancing the domestic food protection and to continue to work towards a fully risk-based approach in order to compete successfully in the global market.

4.1 Introduction

Seafood products are essential part of basic food basket in many developing countries with their quality and safety issues inherently linked to the concept of food security (Bose, 2010). Seafood products are considered an important part of a balanced diet and contribute to a good nutritional status. They contain high levels of many important nutrients not commonly found in other foods. Seafood is known to be an excellent source of proteins, very long-unsaturated chains of omega-3 fatty acids (EPA and DHA), vitamin D, vitamin B12, and many useful trace elements such as selenium and iodine. However, they also pose significant safety risks and the rapid increase in globalization of fish production and trade

has led to concerns and international incidents of contaminated fish (James, Ababouch, & Washington, 2013).

The Sultanate of Oman, located on the eastern edge of the Arabian Peninsula, has a long coastline with rich fishing grounds. The issue of seafood safety and quality has become a priority for the Omani government which is concerned about the ability of the country to guarantee the safety and quality of their fish and seafood products. Furthermore, the rapid development of tourism industry in Oman has increased the need to develop an efficient food control infrastructure within Oman. This needs to be capable of ensuring that exports meet the legal requirements and the high standards demanded by international markets but also providing protection for those consuming the products locally (whether as tourists or the local population).

For many centuries, fishing in Oman has been an integral part of its culture and providing both employment and income opportunities as well as nourishment for the majority of the Omani population. Under the 8th Five-Year National Development Plan (2011-2015) the Ministry of Agriculture and Fisheries (MAF) has stipulated key strategic approaches to advance the development of the fisheries sector and to increase its contribution to the Gross Domestic Product (GDP). Effective management of the supply chain is seen as a necessity to reduce post-harvest losses and enhance the quality and safety of locally produced seafood as well as ensuring the integrity of imported and exported seafood products.

This study analyses the current seafood safety and quality issues facing the Omani fishing industry and food control authorities. It develops proposals for the development of this sector by the government and the private sectors in order to enhance food safety standards and to achieve a proper utilization of the country's vast marine resource.

4.2 Overview of the fisheries sector in the Sultanate of Oman

Historically, the fisheries sector in Oman has been dominated by small-scale fishermen and retailers with some commercial fishermen. Recently, aquaculture farms and fisheries establishment become important. The changes have been part of the government's strategic plan to diversify the country's economy and promote private investment (MNE, 2007a,

2007b). The fish harvesting practices in most of the coastal communities have remained the same over the years and the government's goal is to shift the sector from the traditional practices to more modern systems (Bose, 2010).

4.2.1 Economic status of the fisheries sector

The fisheries sector is considered one of the most important non-oil sources of income for Oman although its contribution to the GDP is only 0.5 percent and, combined with agriculture, the figure is still only 1.2 percent (NCSI, 2013; WTO, 2013). However, the social impact of this sector is immense particularly in rural development, employment and food security. Most Omani people live in the coastal areas and fisheries provide livelihoods to around 40,000 Omanis directly with about 280,000 individuals depending indirectly on fisheries income (FSB., 2013; Worldfolio, 2012). The continuous growth in production of the agricultural and fisheries sectors has led to their contribution to the provision of food to nearly 39.5% of the Omani total food consumption during the period from 2009 to 2012 (MAF, 2012).

Fisheries production contributes to the national economy and there is a need to diversify the national income through the development of the fisheries-related industry and enhancement of the future production is crucial. Seafood is a major commodity in international trade and has significant potential for revenue generation. This does though require the industry to adjust its practices to meet regional and international demands for quality and safety. In addition, it can be noted that there is potential for overfishing due to the possible financial rewards. International controls for Illegal, Unreported and Unregulated (IUU) fishing have been agreed and Oman is adopting these (RECOFI, 2009; Royal Decree No. 26/2013, 2013). The extent of the problem is, by its nature, unquantified but it is considered not to represent a major fish safety issue and is not considered further in this paper.

In 1995, the country introduced a long-term national economic strategic plan known as "Oman Vision 2020" which specifically aimed to reduce the economic dependency on hydrocarbons sources including an increase in the share of the non-oil sector to 15 percent of GDP by 2020 (WTO, 2013). The diversification of the economy has been a vital pillar

in the economic policy of the Vision, with objectives of creating an economy that is founded on renewable resources and a highly integrated part of the world economy (WTO, 2013). This strategic decision has diverted attention to the socio-economic potential (i.e., contribution to the Gross Domestic Product (GDP), foreign exchange earnings, employment creation and food security) of the fisheries sector. In order to fulfil this vision, industrial estates, free zones, fish harbours and well-structured landing sites were identified as necessary to support the sector's growth.

4.2.2 Fisheries sector

The fisheries sector in Oman can be sub-divided into three: the artisanal, commercial fisheries and aquaculture sector.

4.2.2.1 Artisanal fisheries

The artisanal fisheries are small scale fishermen operating small vessels (5-9 meters in length) typically made of fiberglass or larger traditional wooden boats known as dhows which are still in use in some governorates. In total these fisheries produced 98% of the catch in 2013. This sector supports around 44,500 fishermen operating 21,300 fishing vessels (FSB., 2013). Most of these vessels are managed by family members although in some cases either local or expatriate workers are used (A. Omezzine, Zaibet, L., Al-Oufi, H.,, 1996).

4.2.2.2 Commercial fisheries

Commercial fisheries comprise recently developed coastal fisheries, long-liners (ships using lines rather than nets) and international contracted trawlers (using nets) targeting the higher value fish products. However, in mid-2011 restrictions were imposed by the government on these fishing trawlers in order to prevent overfishing and ensure a sustainable environment for the fisheries. To replace these, a new fleet of local coastal fishing vessels was introduced and operated by local investors. The aim is to expand its share, which was less than 1% of the local market – in 2013 it had risen slightly with the commercial fisheries fleets producing 1.3% (2,710 tonnes) of the total catch as shown in Figure 9 (FSB, 2013).

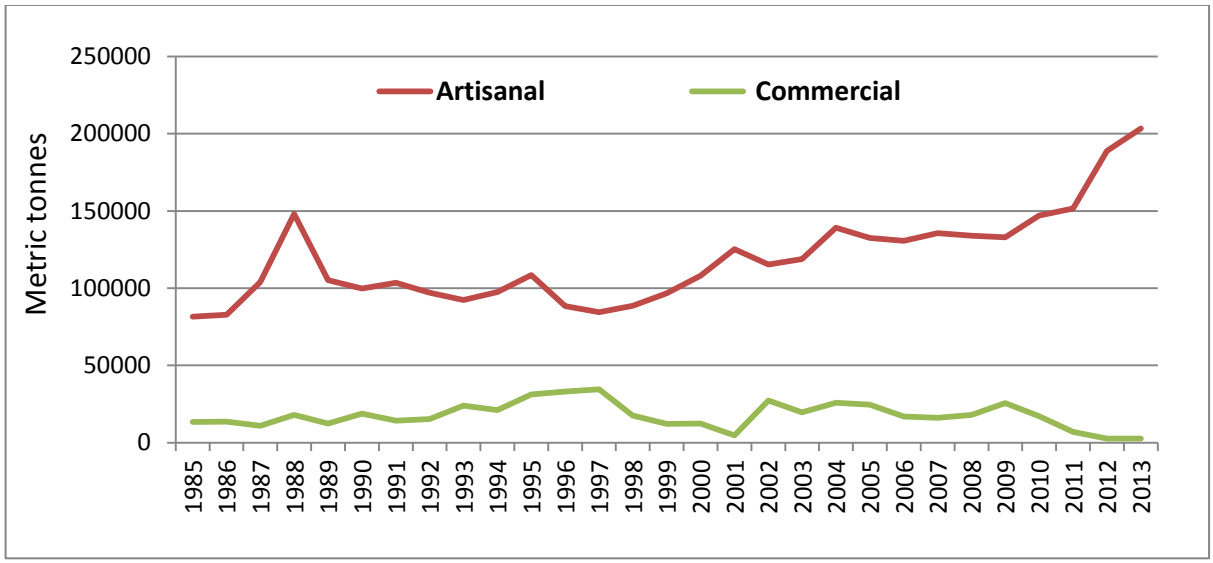

Figure 9. Seafood production from the artisanal and commercial fisheries from 1985 to 2013 (FSB, 2013)

4.2.2.3 Aquaculture Production

In the Sultanate of Oman, aquaculture is in its infancy stage of development with the aquaculture production small in comparison to the contribution from capture fisheries (FAO, 2006a). Early attempts took place in 1986 with a production trial of the giant tiger prawn (*Penaeus monodon*) but it was halted due to technical difficulties. In 2003 and 2004, commercial cultured fish commenced and the production increased from 352 tonnes in 2003 to 517 tonnes in 2004, with the production of gilthead seabream (*Sparus aurata*) representing 89 percent of the total production. In the same year, tuna farming was launched producing 14 tons of yellowfin tuna (*Thunnus albacarus*), thus, becoming the first country in the Middle East to have a project of this kind (ESCWA, 2007). In 2007, the Omani government with FAO collaboration developed a national strategy for aquaculture development in the country (FAO, 2006a). Describing this in 2012, the Minister of Agriculture and Fisheries stated "*As worldwide demand for fish and shellfish is on the rise amidst stagnating yields from traditional capture fisheries due to depleted wild ocean stock, aquaculture holds the key to meeting global seafood supply needs over the coming years*" (Worldfolio, 2012). With cultured species, priority has been given to species found locally in Omani waters, and to exotic species with high commercial values which are

required to be screened prior to approval. Aquaculture has been gaining momentum in the last ten years (2003 to 2013) with the introduction of new species. *Penaeus indicus* has shown a steady growth reaching 350 tonnes in 2013 and destined for domestic and regional markets. However, efforts are also being made to target the more lucrative markets such as the EU. Sustainability in this sector is the primary aim for aquaculture governance in order to prosper over an extended period, thus viable economically.

4.2.3 Production, consumption and trade

The annual production of the caught and cultured fisheries has increased in recent years mounting from 95,000 tonnes in 1985 to 206,000 tonnes in 2013 (FSB., 2013) with total values rising from just R.O 25 million (US$ 65million) to R.O 166million (US$ 431million) within the same period. In 2013 the revenues from export were R.O 97 million (US$ 252 million) which represents 0.5% of the total GDP (NCSI, 2013). The increase has largely been achieved by government support to the coastal fishermen (ESCWA, 2007). Despite the low contribution of the sector to the GDP, its socio-economic effect is considered significant and thus receives attention in the country's economic development campaign (Qatan, 2010). The annual per capita consumption of fish in Oman is estimated to be 20.2kg (FSB., 2013), higher than the world figure of 19.2kg in 2012 (FAO, 2010c).

Oman is regarded as a net exporter of fish products with around 61% of its production in 2013 exported mainly to neighbouring Gulf countries (FSB., 2013) as shown in Table 8. In 2013, Oman exported 125,000 tonnes to 49 countries around the globe. Most of the exports by volume were to the Gulf Cooperation Council (GCC) (70%) followed by Asian countries (18%) with only 2.2% in value exported to EU. Although not showing in Table 8, the proportion of exports to the highly valued national markets of the USA and Japan were tiny representing 0.03% and 0.05% of all exports respectively, and less than 1 % in quantity. This clearly demonstrates the opportunities available for market expansion and product diversification.

In comparison, imports are small (less than 10% of the quantity of exports) and primarily restricted to fish species which are either unavailable locally or subject to seasonal

shortages. The majority of the imports are derived from the GCC, and other countries, followed by the Asian countries as shown in Table 8.

Table 8. Fisheries export and imports in quantity and values in 2013

Quantities/Value	Exports			Imports		
	Quantity (Tonnes)	Value ('000 USD)	Unit price (USD)/Tonnes	Quantity (Tonnes)	Value ('000 USD)	Unit price (USD)/Tonnes
GCC Countries	87597	153382	1751	4417	9984	2260
European Union	779	5582	7165	79	2995	37909
North/South America	1193	1956	1639	8	16	1948
Asian Countries	22446	56384	2512	2897	8065	2784
Other Countries	13674	34743	2541	4455	12795	2872
Total	**1,25,689**	**2,52,047**	**15,609**	**11,856**	**33,855**	**47,773**

4.3 The seafood supply chain

The marketing of seafood in Oman is complex linking fishermen, transporters, traders, processors, exporters, retailers and consumers. Based on our knowledge of the Omani fish supply chain and discussions locally, we have developed the overview diagram shown in Figure 10. The main elements of this will now be considered.

4.3.1 Fisheries Producers

As already discussed, the artisanal fisheries account for most of the fresh fish produced in the country. These vessels however lack adequate handling and storage and the fish are usually offloaded onto the beaches or at landing centres of varying standards. The product is frequently sold direct to consumers who enjoy eating fresh fish and they will often make their purchases direct from the fishermen despite the presence of local fish markets. Other fish will be sold to traders or processors with auctions being held at some landing centres (Qatan S., 2010).

The overall marketing system in Oman consists mainly of the coastal fish markets (‘primary’), fish markets in the interior parts of the country (‘secondary’), retail markets and recently a central market in Wilaya Barka. Primary markets are typically basic structures lacking services and are mostly located at the landing centres with fish offloaded directly from the boats of the local fishermen. Sales from these markets can be both retail and wholesale and depend on the fish species, the quantity involved and the clients (household or commercial).

Until recently all markets with the exception of the retail outlets were under the jurisdiction of the local municipalities but a government decision in 2011 reallocated control of them to the MAF. This is part of moves to bring the entire seafood supply chain under one authority and improve procedures throughout the chain. The municipalities still control the retail markets and the super- and hypermarkets that supply fisheries products to the different regions and interior governorates. They can vary in capacity and infrastructure and are still under the jurisdiction of the different municipalities. Currently 60 primary and secondary fish markets exist in the country and the Ministry is developing minimum requirements covering structure hygiene and procedures which are progressively being implemented throughout the country.

As recommended by various studies (Al-Jufaili M. Saud and Opara Linus U. , 2006; Al-Jufaili, 2006; A. Omezzine, 1998; A. Omezzine, Al-Oufi, & Al-Akhzami, 2004), in order to improve the supply, safety and quality of fish for the internal and external supply chain, a large scale wholesale fish market has been constructed by the MAF and the Muscat Municipality with full modern services such as electronic auctioning, fish quality checking, ice machines, potable water, hygienic containers, display areas, facilities for monitoring temperature, sanitary inspections and etc. Further small wholesale markets have been established and it is planned to connect all three electronically to assist buyers and sellers. As well as facilitating trade of local fish, these central markets will in future be used for imported and aquaculture fish. This will ensure that these products are properly labelled and checked before entering the local market. Controls on transportation to the central market have been weak and it is planned to extend controls to this in the near future.

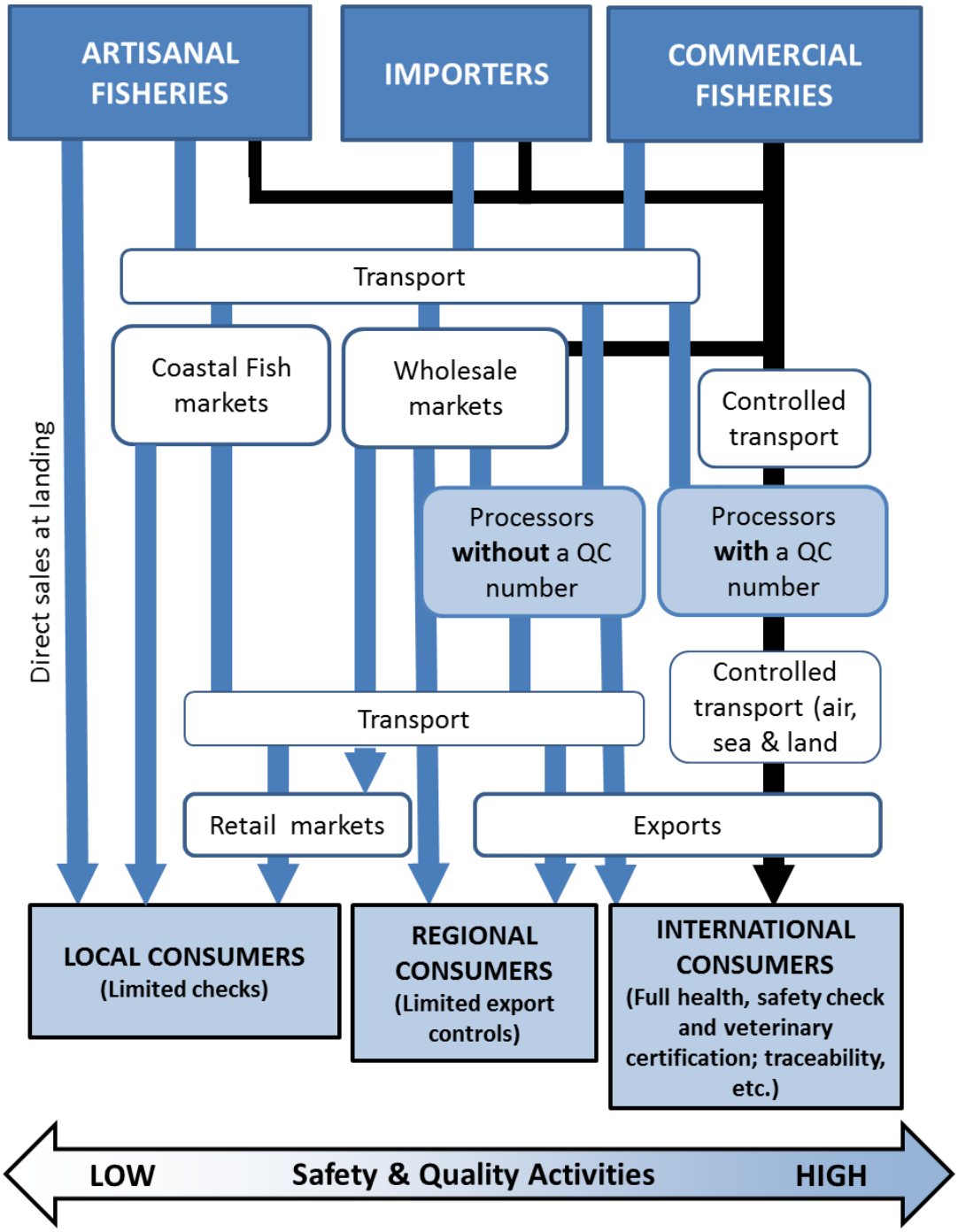

Figure 10. Primary routes for the distribution of fish and fishery products in Oman

Enhanced legislation for the organisation of fish markets has been recently issued by the MAF (MD No. 312/2014). Most of imported fish products are sold at the retail markets with some going via the primary and secondary fish markets and some being directly imported by processors as raw materials for their added-value production and for re-export particularly in the low production seasons.

The transport systems play an important role in the fresh fish supply chain. The transporters, sometimes described as middlemen, use specific trucks to collect fresh fish products from different primary markets at the landing centres with direct collaboration with fishermen. They then distribute the products to secondary, central, retail markets, processors and consumers with a larger portion being transported to neighbouring countries. Some of the larger trucks have refrigeration and transport large quantities of fisheries products covered with ice within insulated boxes but the majority lacks these facilities. This creates food safety issues due to poor handling and inadequate cold chain control. Legislation has been adopted to regulate the conditions and specifications for transportation (MD No. 29/2004) but has not been fully implemented. However, it is expected that a Ministry funded project will shortly upgrade the transportation to meet the regulatory requirements. Products intended for export to international markets (i.e. the EU and USA) where stringent safety and quality controls required are usually transported using control conditions by approved transporters with the processors collecting the fresh fish directly from the fishermen or commercial vessels.

The seafood processors serve domestic, regional and international customers. The majority of these processors produce mainly fresh and frozen products of different species caught locally. Only a few processors deal with added value products, such as canned tuna and sardine or breaded products, with raw materials obtained from both local and external markets. Currently 47 seafood processors are operational with 21 having national certification for export (requiring the adoption of Hazard Analysis and Critical Control Point (HACCP) procedure and its pre-requisite programmes) with the rest at different stages of certification (Figure 11). The Quality Control (QC) certificate and related QC number is granted by the FQCC to the establishments, fishing vessels and fishery transporters when they meet the provisions for export to major international markets set out

in MD No. 12/09 (Ministerial Decision, 2009). Processers lacking the quality and safety systems required for certification and a QC number may target other less demanding markets. Aquaculture products are still a small element but usually find their way to the primary and retail markets. Some are produced specifically for export to regional markets and international markets.

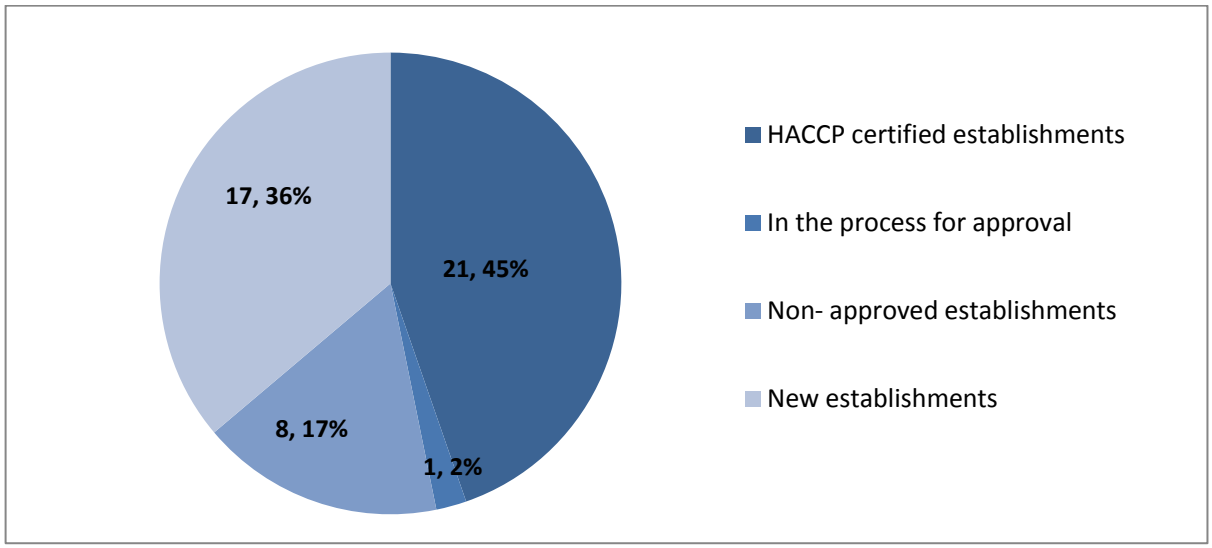

Figure 11. The status of the seafood establishments in Oman (number, percentages %).

Source: (FQCC, 2014)

4.3.2 Domestic, Regional and International Consumers

As shown in Figure 10, the supply chain delivers products to consumers in three types of markets: local, regional and international. The first two of these are similar with limited levels of health and safety control; however, these controls intensify as approaching the international market with the EU and USA market considered the most stringent.

Domestic consumption of seafood products depends on their availability, income levels, traditions and food perceptions. Fish exports are the most important source of foreign currency rated second after non-oil exports. Policies therefore encourage the trade and a high percentage of the local catch is exported to the neighbouring countries (regional consumers) with the highest quality going to the international consumers. As a

consequence, local consumers suffer from occasional fish shortages, despite higher prices being offered for certain commercial fish (Mbaga, Al-Jufaily, & Al Belushi, 2012). Therefore, the ministry have employed appropriate measures with the local producers in order to regulate the distribution of the seafood products in terms of the pricing and accessibility by domestic markets and reduce inflation due to the elevated fish prices (Bose, 2010).

Exports to regional markets have increased in recent years particularly to UAE, Saudi Arabia and other GCC countries. However, the benefit incurred is really low since this is largely fresh unprocessed fish with no added value. It has been suggested that there are opportunities to increase regional trade in added value products leading to more local employment (Mbaga et al., 2012). Transport to these regional markets often lacks appropriate temperature controls and, given the distances involved and the high temperatures, quality and safety of the products suffer resulting in economic losses. Preliminary data for 2014 (personal communication) is showing a reduction in the volume exported to neighbouring countries following the introduction of the wholesale fish market. Providing a more systematic mechanism for the operation and the control of the various fish markets in the country will enable increased efficiency, substantial reduction in the post-harvest losses and the exploration of new markets. This will enable the sector to contribute more to the country's economy and enhance its food security.

For exporting to the EU, USA and Japan the most significant regulations are those of the EU requirements which lay down the health conditions required for the handling and marketing of fishery products (see below).

4.4 Seafood Safety challenges

Seafood products, either wild or farmed, are highly perishable. Their quality degrades rapidly due to the high content of water and easily digestible macro-components. They are susceptible to rapid deterioration and postharvest loss due both to microbial growth and biochemical reactions aggravated by raised temperatures. Other problems are caused by contaminants that are present in the environment where the seafood are grown and harvested.

4.4.1 Microbial Contaminants

Seafood-borne diseases of microbiological origin are mainly caused by viable organisms and/or ingestion of toxins formed in the food prior to consumption. Microbial and biochemical reactions cause public health risk and arise from specific activities along the harvesting, production and processing supply chain. A study conducted by (Sudheesh, Al-Ghabshi, Al-Aboudi, Al-Gharabi, & Al-Khadhuri, 2013) on the hygiene status of Omani seafood retail outlets selling local seafood products revealed the presence of heavy contamination of the food contact surfaces and fish handlers with indicator organisms and pathogenic bacteria and called for improved hygiene controls.

One of the most frequently reported foodborne illnesses associated with seafood is scombrotoxin fish poisoning (SFP) caused by the production of histamine, and other biogenic compounds which is mostly associated with fish species belonging to the following families *Scombridae, Clupeidae, Engraulidae, Coryfenidae, Pomatomidae,and Scombresosidae* (Regulation (EC) No 2073/2005). These biogenic compounds, once formed, are stable to heat treatments and other preservative methods. High levels are often found when high temperatures occur in the harvesting and supply chain. Research by (Guizani, Al-Busaidy, Al-Belushi, Mothershaw, & Rahman, 2005) carried out on yellowfin tuna (*Thunnus albacares*) caught from the coastal area of Oman showed that the time and temperature of handling, processing and storage were significant risk factors with respect to histamine production. The study showed that although there is a correlation between a freshness index (the K-value) and sensory/organoleptic changes this cannot be used to predict the presence or absence of histamine.

Fish species belonging to some of the previous mentioned families have a high value and are popular with local consumers in Oman. However, there is a lack of published studies on the level of scombrotoxin fish poisoning in the country. The poisoning can be misdiagnosed as other food borne illness and epidemiologically categorized as non-specific food poisoning.

4.4.2 Environmental pollution

In respect to environmental pollution, Oman has long coastline of 3165 km involving two water bodies with different characteristics. To the southeast is the Arabian Sea, a part of the Indian Ocean and an open body of water which is exposed to seasonal monsoons activities and has high marine production. To the northeast is the Sea of Oman (or Gulf of Oman) which is a strait that links the Indian Ocean via the Arabian Sea to the Strait of Hormuz and the Arabian Gulf. Around one third of the world's oil production passes through the Strait of Hormuz (Essa, Harahsheh, Shiobara, & Nishidai, 2005), and related oil exploration and industry in this coastal area are sources of seawater contamination. Agrochemical residues discharge into both areas and also pose an environmental threat with potential toxicological effects on the marine biota and subsequent risk to public health. Although an upwelling phenomenon triggered by the monsoon climate enriches the water with nutritional components and increases the production of marine organisms, high levels of natural cadmium are also brought into the surface waters by this process. Marine organisms, including fish, can accumulate different contaminants including inorganic and organic pollutants from the marine ecosystems leading to potential food safety issues (M. Al-Busaidi et al., 2011; Al-Raesi H, Ababneh F, & Lean D, 2007; de Mora, Fowler, Tolosa, Villeneuve, & Cattini, 2005; de Mora, Fowler, Wyse, & Azemard, 2004; Fowler SW, Villeneuve J-P, Wyse E, & S., 2007; Tolosa et al., 2005).

A study of fish and shellfish collected from coastal areas of Oman (Moza Abdallah Al-Busaidi, Yesudhason, Al-Mazrooei, & Al-Habsi, 2012) showed the mean concentration of heavy metals (mercury, lead and cadmium) in the edible muscle of pelagic and benthic species were mostly within the standards set by the EU, FAO and Oman. Elevated concentrations of cadmium above the limits were however reported in fish liver which is due to the physiological role of this organ and in oysters and clams (Poulose Yesudhason et al., 2013). High levels of cadmium in fish livers have been found in elsewhere including India (Profulla et al., 2001; Rejomon et al., 2010), USA (Monosson & Lincoln, 2006), France (Bustamante et al., 1998), Croatia (Kljakovic et al., 2002). This is considered to be due to upwelling phenomena rather than anthropogenic sources.

The country depends on the desalination of the sea water as a source of fresh water supply and therefore control the quality of the marine environment is vital for the country. An emerging threat to desalination and to public health is the formation of Harmful Algal Blooms (HABs) commonly known as red tides. HABs occurrence in the Sea of Oman and the Arabian Sea were reported as early as 1988 following a massive fish kill due to other types of algae blooms (Thangaraja, Al-Aisry, & Al-Kharusi, 2007). An outbreak in the Arabian Gulf and Sea of Oman in 2008/2009 was due to the dinoflagellate *Cochlodinium polykrikoides* and lasted nearly eight months. The impact was great with massive loss of fish, damage to coral reefs, restricted fishing and problems in the operation of the desalination plants in Oman and the United Arab Emirates (UAE) (Richlen, Morton, Jamali, Rajan, & Anderson, 2010). Oman is planning to enlarge its mariculture activities and investing in aquaculture as an alternative to seafood. These activities may increase the frequency of HABs (Al Gheilani, Kazumi, AlKindi, Amer, & Waring, 2011) and therefore, bloom mitigation scheme are crucial. Bivalve molluscs and other marine filter feeders have the tendency to accumulate biotoxins and can retain them for a long time. Marine predators in turn feed on the bivalves and thus become toxic themselves, posing a major threat to public health.

4.4.3 Postharvest issues

As soon as fish and fishery products have been caught, several biological and biochemical changes take place. The changes that take place in fish muscle immediately after death are crucial in determining the quality and safety of the harvested fish products. At the point of death, fish muscles are fully relaxed with an elastic texture that persists for some time before the onset of rigor mortis (Alasalvar, Shahidi, Miyashita, & Wanasundara, 2011; Huss H. H., 1995). The timing is affected by several factors such as temperature at the time of harvesting and handling and the size and type of fish species (Huss H. H., 1995; Huss, Ababouch, & Gram, 2003). Mishandling at the different stages of the supply chain can lead to early rejection due to the onset of spoilage. Additionally, post-harvest losses of perishable products such as fish are very significant, especially in developing countries, owing to quality, safety and physical losses. FAO (FAO, 2014b) has estimated that in

developing countries these can amount to 10-12 million tonnes and account for around 10 percent of the global production of wild and cultured fish products.

In Oman, dominated by artisanal fisheries and traders, post-harvest losses can be very detrimental both to the contribution of fisheries make to the national economy and to the country's sufficiency in terms of food security. With the fisheries activities scattered along the long coast line, artisanal fishermen and retailers adopt simple techniques for harvesting, handling and processing respectively. These are often insufficient to preserve the quality and safety of the harvested fisheries products for long storage periods and consequently limit their market value (Al-Jufaili, 2006).

Various studies and reports indicated inadequacy in cold chain management particularly for freshly landed fish that can be exposed to elevated temperatures (40^{o}C) for up to 5-7 hours thus accelerating deterioration of the fish freshness (Al-Jufaili M. Saud and Opara Linus U. , 2006; Al-Jufaili, 2006; Opara Linus U. and Al-Jufaili Saud M., 2006). Furthermore, loses in both quality and quantity limit the profitability and competitiveness of local fishery produce. One study of the tuna supply chain (Al-Jufaili M. Saud and Opara Linus U. (2006) suggested that shelf life is limited to 3 days by the current postharvest practices. They confirmed the need to upgrade the existing postharvest procedures and to apply modern cold chain technology to overcome loses and extend shelf-life. One consequence of the short life is that often downgraded fish are used to produce secondary fish products (such as salted or dried products) so as to reduce the losses faced by the fishermen and traders – this though can lead to further safety issues. Some of these traditionally processed fish products are often associated with the presence of the carcinogenic compounds nitrosamines (Al Bulushi, Poole, Deeth, & Dykes, 2009; Zou, Lu, & Liu, 1994) even though the factors influencing their formation have not been well defined. Therefore, the need for proper handling and processing is critical in assuring the health of end users.

4.5 Regulatory Framework

Although seafood consumption contributes to health and wellbeing, concerns at the safety and quality of seafood have been at the forefront of regional and global campaigns and ensuring the safety of this seafood is critical requiring national and international action. For

Oman, compliance with respect to safety and quality criteria is vital to access the lucrative export markets and sustain international competitiveness. The EU, USA and Japanese markets are the world's major importers of seafood products with imports accounting for 63% (AIPCE-CEP, 2014), 60% and 54 % (FAO, 2014c), respectively of their fishery product consumption. They are therefore important markets for exporters but the situation is complicated since the requirements of each international market differ in terms of the specification and the regulations imposed.

4.5.1 Organization

As well as managing the entire fisheries and aquaculture industries including the ports and landing sites, the Ministry of Agriculture and Fisheries (MAF) governs seafood safety in the country. Most recently, in 2011, responsibility for the fish markets has also been transferred to it. The MAF has links with other governmental organizations to try and ensure the safety and quality of fish products with the combined activity attempting to ensure effective surveillance of the fish supply chain.

According to a Memorandum of Understanding (MoU) signed between the Omani government and the European Commission (EC), the MAF has been designated as the Competent Authority (CA) representing the Omani Government on seafood safety and legislation issued in the European Union. The MAF, through the Fishery Quality Control Centre (FQCC), has the legal power to evaluate, inspect and issue certificates to guarantee the safety and quality of the products for export to the EU. It is the premier regulatory agency and has responsibility to implement the National Fishery Quality Control Regulation No.12/2009 and related guidelines and international standards.

For the USA, Oman signed an updated Free Trade Agreement (FTA) 2009 which aims to promote economic reform and openness in trade issues (USTR, 2014). Foods imported into the USA must meet the same legal requirements as domestically-produced foods and inspectors may detain shipments of imported products which not in compliance. They are also subjected to Food and Drug Administration (FDA) inspections under the provisions of the U.S. Federal Food, Drug and Cosmetic Act (FFDCA). In addition, the US Code of Federal Regulations provides specific regulations for the safety and sanitary procedures

and imported fish and fishery products must have been subject to processing with an effective Hazard Analysis and Critical Control Point (HACCP) system operating.

Japan has requirements which are contained in its Food Safety Basic Law (No. 48) initially issued in 2003 but amended by Law (No. 50) in 2006. The Law has adopted a similar approach to that of the EU and the USA with elements taken from Codex. HACCP-based food control regulations have now been included for fisheries processing covering handling, processing conditions, storage and transport. For exports to Japan, Oman has to issue certificates to confirm that these regulations are being met.

4.5.2 Omani fishery control regulations

The Marine Fishing and Protection of Living Aquatic Resources Law was promulgated in 1981 by a Royal Decree (RD) 53/81 and is known as "The Fisheries Law". Subsequently, the Executive Regulations of the Law was issued in 1982 by a Ministerial Decision (MD) No. 3/82 and amended in 1994 by a MD No. 4/94. This represents the start of the current control system as illustrated in Figure 12. The law has six sections including definitions, regulation of fishing, protection and development, handling, marketing and processing, violation and penalties and general provisions. The Executive Regulations deal mainly with marine fishing licenses, license fees, protection and development of living aquatic resources, regulation of fishing, preservation, transport and marketing of living aquatic resources, general provisions and penalties.

Other relevant legislation includes the Ministerial Decision on the Quality Control Regulation for Omani Fishery Export (MD No. 4/97) which mainly deals with conditions and specifications of exported fishery products and its by-products in regards to the preservation, handling and processing of fish products. In 1998, a Ministerial Decision (MD No. 136/98) was issued to enforce quality control regulations for Omani fishery exports and amended the MD No. 4/97 and required the adoption of HACCP system and its prerequisite programmes in seafood establishments intending to export to the EU. This was introduced as in July 1998, following a visit by the EU's Food and Veterinary Office (FVO), the EU had banned the import of fish from Oman and some other GCC states as the existing controls did not comply with the EU's requirements for HACCP implementation

(FAO, 2004). Recently, a new regulation has been issued (MD No. 312/2014) by the MAF which covers the organization and operation of fish retail and whole sale markets, seafood products handling, market monitoring in terms of hygiene and safety of the marketed products.

The EU's ban was lifted one year later in 1999 (FAO, 2004). Following another FVO mission in 2006, a new MD No. 12/2009 on Fishery Quality Control Regulation was issued in 2009 to amend MD No. 136/98 to ensure equivalence with the EU's requirements on contaminants, additives, potable water, hygiene, and official controls (European Commision, 2006). This regulation contains a wide range of provisions covering the quality control and safety of fish and fishery products for import, export and for the domestic markets (Moza A. Al-Busaidi & Jukes, 2015).

As indicated above, the development of the aquaculture industry in Oman is a key part of the country's plan to diversify its economy beyond the hydrocarbon sector (MAF, 2011). The development of an aquaculture industry will not just increase the production of seafood but could also reduce the over-fishing of highly commercial value species. To ensure the adoption of 'Best management practices (BMP)' and effective control of aquaculture, the government issued a regulation in 2004 (36/2004) which was updated in 2012 (177/2012) (Moza A. Al-Busaidi & Jukes, 2015). In addition, there are environmental laws and regulations that are directly related to aquaculture sector issued by the Ministry of Environment and Water Resources (MEWR). These include Royal Decree (RD) No. 114/2001 (Law on Conservation of the Environment and Prevention of Pollution), MD No. 187/2001 (Organizing the Issuance of Environmental Approvals and the Final Environmental Permit), RD No. 46/95 (Law of Handling and Use of Chemicals) and finally the MD No. 7/84 on (Disposal of Liquid Effluent to the Marine Environment) (FAO, 2006a).

The overall food safety system is structured in various government agencies that are based at different ministries (Moza A. Al-Busaidi & Jukes, 2015). Therefore, the efforts to successfully dealing with existing and emerging food safety threats and risks are hindered, due to the duplication in mandates and overlapping responsibilities of the responsible agencies. A lack of harmonization of the standards and regulations for the domestic

production, exports and imports is a challenge for the regulators and the different stakeholder particularly when considering world trade and consumers protection issues. Ensuring effective legal control for the assurance of hygiene, safety and quality across all stages of the seafood production chain is fundamental to access the export markets.

Faced with many difficulties due to the increase in sanitary and safety regulations highlighted in the world trade of fishery products, regulation (12/09) has broaden its scope from the previous regulation (136/1998). It mandates the enclosed of all the institutions, processors and individual operating in the field of fish and fishery products either exporting, importing or domestic production to adapt their situation accordingly to the stipulated rules of this regulation (Ministerial Decision, 2009). The stringent regulation has imposed important socioeconomic consequences on the domestic supply chain. The cost imposed on seafood processing to restructuring their facilities and production lines are significant highly and this has been estimated to amount to R.O. 98,000 (254,545 USD) (Qatan, 2010) and not within the capabilities of these processors. As indicated by the Ministry, a lot of effort is in place to upgrade these establishments to meet with regulation No. 12/09.

4.5.3 Food safety management systems

Seafood safety and quality control measures were not a priority until the EU embargo in 1998. This required enhanced procedures to ensure compliance with the EU legislation. In particular, it led to the establishment of the FQCC under the Directorate General of Fisheries Research with headquarters in Muscat and regional offices in various coastal governorates. The FQCC is the premier regulatory agency for the enforcement of seafood safety and quality regulation required by MD No. 12/2009. In addition, it is responsible for inspecting, assessing, and approving seafood production vessels and establishments and related activities and for the analysis of samples for contaminants. The veterinarian and quarantine department within the Ministry is responsible for issuing health certificates and certificates of origin to accompany exported seafood consignments in order to ensure their compliance with national laws and regulations. They also inspect seafood products on entry into the country.

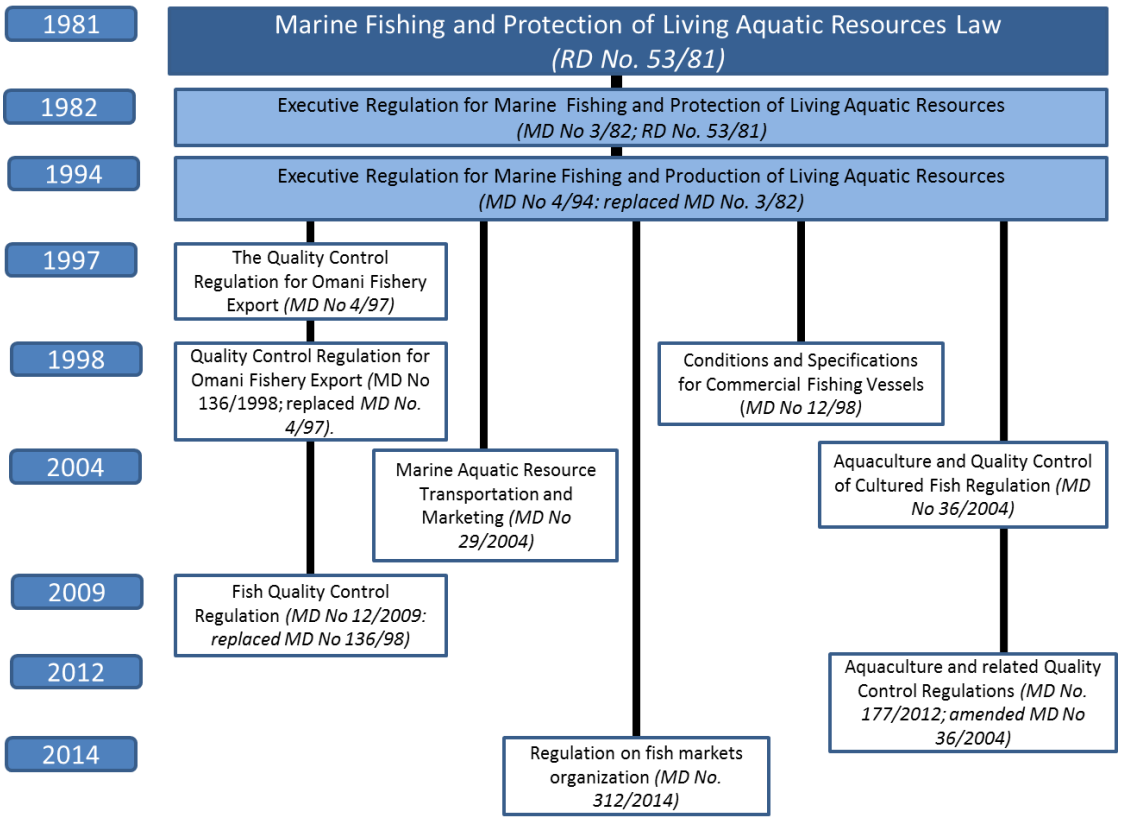

Figure 12. The evolution of Omani laws and regulations on seafood safety

In accordance with the new requirements, in 1999 nine plants were certified as HACCP compliant and were provided with Quality Control (QC) numbers and became eligible to export their products to international market, particularly EU and allowed for the lifting of the EU's ban. Subsequently, by 2002, the number of certified plants had increased to 25 plants, accounting 50% of the total processing fisheries plant, at that time (ESCWA, 2007). However, a decrease in the landing of fish species with higher export values internationally has caused some local exporters to question the value of meeting these enhanced standards. The potential for fishermen to market fish to neighbouring countries with fewer regulatory requirements in preference to selling to local processors has added further to the struggles of companies seeking to export products to major international markets (ESCWA, 2007). Consequently, by 2013 the number of certified plants had declined to 21.

The adoption of HACCP principles by Omani fish processors has not progressed easily. The government gave a priority to the adoption of food safety management systems, including HACCP, as this was mandatory to meet the international markets' requirements. Implementation of the new legislation was enforced by the FQCC and enhanced infrastructure facilities (such as new icing plants and improved fishing harbours) were put in place. Additional laboratories were constructed for the FQCC for the testing for contaminants, whether microbial, chemical or physical. A specialist department on seafood safety systems implementation was set up within the FQCC to provide technical assistance to the private industries to ensure their conformity with regulation guidelines of such things as product flow, overall structure and HACCP implementation. Training on hygienic fish-handling practices, prerequisite programmes (Good manufacture Practices (GMP) and Good Hygiene Practices (GHP)), HACCP and other matters have been conducted for the different stakeholders in the fish supply chain.

One study has identified some weaknesses and constraints that reduce the effectiveness of the regulatory systems in the seafood sector (Qatan, 2010). The study highlighted the lack of pro-activeness and dependency of the seafood processors on the regulatory authority of the food safety management system. The study highlighted the difficulties faced by the industry in terms of the cost of HACCP implementation, in fish processor for the structural work and the modification required to meet the regulation requirements.

Work to upgrade existing seafood establishments continues but progress has been slow due to resource constraints and the scattering of responsibilities in the different government agencies. It can be noted that HACCP is not mandatory for most food processors so persuading companies to adopt the system for export purposes can be difficult.

For imported fishery products, the FQCC's laboratories are the primary authority for sampling and analysis but liaise with other food control laboratories in the country. However, although the FQCC's laboratories follow procedures (sampling plans and testing methods) established to meet the requirements for export, the other laboratories only apply procedures established for sales in Oman. Therefore, these products are treated differently with less stringent requirements in order to ease the cost burdens on the producers and in most of the cases produced in non-HACCP certified processors.

4.6 SWOT analysis

The above sections have provided key information on the major elements of the fishery supply system in Oman, the regulations and controls applied to it as well as the management systems adopted within the sector. The ministry has worked hard to upgrade this sector and reduce the postharvest losses caused during fisheries production. Much has been achieved. However, it is also clear from the above description that despite a desire by the Omani government to increase its export trade, the process has not been easy and still provides challenges.

In order to try and identify what more the government could do for the industry to make it more successful, we have used the information given above to construct a SWOT analysis identifying the Strengths, Weaknesses, Opportunities and Threats to the fishery sector in Oman. This has been tabulated in Figure 13.

4.7 Discussion

Fisheries production is one of the countries' chief sources of economic revenue after oil production. The country exported 60% of its production in 2013 with most of the exports targeting regional markets such as the GCC countries as well as Asian and African countries. The lucrative markets of the EU, USA and Japan on the other hand, are less targeted due to the more stringent standards imposed by the importing countries. Gaining access to these markets can be costly as it requires the adoption of enhanced controls such as HACCP and other management standards and exporters face high competition for market share from other countries seeking to export.

Despite the costs, HACCP does have significant benefits (Taylor, 2001). A correctly applied HACCP system gives a food business operator in depth knowledge of the potential hazards in the process. They also become more focused on the essential controls needed in their processing plants such as critical control points rather than depending on the end products testing which is expensive and does not prevent product failure. In the long run as stated by (Taylor, 2001) despite the work of initially setting up a HACCP system, costs can be reduced. Most of all, if implemented correctly, the system provides the food industry with effective management tools to produce safe food and prevent foodborne illnesses.

Strength	Weakness
• The fisheries sector is important for historic, cultural and food security reasons • MAF committed to upgrade the fisheries sector • Construction of a wholesale market to improve internal marketing and shorten the distribution chain • Seafood safety legislation which incorporates the international requirements from ocean to fork • The existence of well-defined legal framework throughout the seafood harvesting, supply and distribution chain • Broad regulations which cover all aspects of seafood safety in domestic and imported products designed to protect local consumers • Commitment to bring all the seafood harvest and supply chain under one authority for easy management • Investment in infrastructure including increased landing sites and new fishing ports • Conducting research into the obstacles faced by the fishing industry for product quality and safety besides marketing • A willingness to subsidise some activities (e.g. provision of cool boxes and free ice to fishermen) to reduce losses due to poor quality • Strategic projects have been launched to aid the development of this sector • Already showing ability to comply with the requirements of the export markets of the EU, USA and Japan with few rejections or concerns	• The contribution of fisheries to economy is small • Variable controls • Poor infrastructure facilities in certain governorates • Strategic projects often lack continuity, have weak implementation and have limited long term impact • Implementing international safety requirements is a burden on small and medium scale industries that serve the local markets • Lack of public health data (e.g. food poisoning cases) makes it difficult to assess the benefit of enhanced controls • Despite over 16 years of trying, only 21 out of 43 establishments have managed to implement food safety management systems such as HACCP • Lack of skilled manpower and resources to meet demands of international standards and requirements

Opportunities	Threats
• Potential to significantly increase exports for both the high value markets and other regional markets • Strategic location with potential to become a regional hub for trade in wild and cultured fisheries • Potential for aquaculture development	• Possible reduction in political commitment with reduced government money for investment • Competition from other countries leading to loss of international market share • Continued growth of exports to other GCC countries leading to a reduction in available supplies for potential export to high value markets • Increased problems caused by environmental issues (e.g. algal blooms or high cadmium levels) • Increased exports of fish could hamper the development of local processors capable of developing and exporting added value products

Figure 13. SWOT analysis of the Omani fishery sector

As the internationally recognised food safety system, its adoption provides a clear benefit as it allows access to a wide range of international markets (Taylor, 2001). A local study by (Qatan, 2010) had findings which were in agreement with these. The main benefits of HACCP ranked by authority and the seafood industries were the improvement of the safety and quality of the products; easy access to lucrative markets with stringent food safety requirements in place; improved customer satisfaction and moral and commitment to the food safety and quality. Whilst a reduction in the rejections of seafood products entering the EU and international markets was observed by both groups, after the implementation of HACCP in the seafood industry in Oman.

Domestic factors such as price, income distribution, consumer preference and availability, also have an effect on the demand of fisheries products, therefore, leading to uncertainly as to the availability of supplies.

Oman has made progress toward the implementation of these higher standards and has been introducing enhanced management systems into the industrial sector. The existence of strengthened legislative and government support, including subsidies, has encouraged some businesses to implement HACCP despite not being a necessity for the local market. The lifting of the EU's ban within a year of its imposition demonstrates that much can be achieved in a short time when necessary. However, although progress was made in the implementation of HACCP processes, difficulties still arise in the enforcement of this system throughout the seafood supply chain due to the inadequate capability of some of processing plants particularly the smaller businesses.

4.7.1 Flow process of fisheries products

Maintaining high quality seafood products is very critical and vital in order to stay accessing the global market (World Fish Center, 2005). Certain traditional methods of harvesting, preservation and processing for fishery products cannot meet the requirements of the global market. Innovation in the pre- and post-harvesting process is vital in order to reduce production losses and enhance the quality and safety of the final products. As the weaknesses in the sector have been recognized, support will be required to make the urgent improvements necessary to advance the fisheries industry.

The existence of appropriate facilities for fishing vessels, landing, storage, distribution and marketing is crucial for the quality and safety of the end products produced in this sector and in order to meet the requirements of the legislation. As well as technical and financial support, the industry requires training, education and information to ensure successful trading. A greater use of commercial fisheries, rather than artisanal, would also increase production capacity and help meet the government's goal of increasing the contribution of fisheries to the overall national economy.

It is clear that the traditional fisheries need to invest in more advanced boats with preservation and storage facilities on board. This would be most appropriate in the Arabian Sea coastal areas where fish stocks are more likely to be sustainable. Basic hygiene requirement and good infrastructure should be enforced in all the onshore (primary), secondary markets and small processing plants. The transport system must comply with the conditions and specifications of the living aquatic resources transportation and marketing vehicles of MD No. 29/2004. The high temperature environment in the country makes compliance with temperature requirements very difficult when combined with current practices of pre- and post-harvest techniques and the simple infrastructure found in certain regions. Effective cold chain management retards microbial and biochemical reactions associated with food spoilage and deterioration and reduce production losses and enhance the quality and safety of products.

National and international safety and quality requirements are usually met by those stakeholders who currently operate in the major international markets. However, the findings of this study indicate that many aspects of the supply chain in Oman fall well below this. The most likely causes of this is the cost incurred in raising standards to comply with the international requirements resulting in increased production costs which also impact on products destined for the domestic and regional markets. The costs are only recovered when the fish products are exported to foreign markets. Therefore, earning foreign currency by exporting to neighbouring countries is less risky and much easier and so a higher percentage of the local catch is now going in that direction. As this market has expanded, local consumers have suffered from occasional fish shortages in the domestic market and, if available, often it is of poorer quality.

In order to reduce post-harvest losses, fisheries resources have to be managed by applying the correct handling practices both on board and throughout the supply chain (FAO, 2014a). The conversion of low-value fish to value added products is another alternative to reduce losses (FAO, 2014a) and increased income with the generation of more employment in the country (Mbaga et al., 2012). The construction of more central markets will overcome market constraints by providing well organized and controlled channels between the wholesalers and the retailers (Qatan S., 2010). Currently a constraint in the seafood supply chain in Oman is that the harvesting area is often the only information supplied by the producers. Establishing labelling systems in these markets will facilitate chain traceability from harvest through the chain giving products with enhanced quality and safety attributes.

4.7.2 Seafood safety issues

The globalization and liberalization of the world fish trade has brought benefits and challenges for food safety (World Fish Center, 2005). In developing countries such as Oman, these benefits and challenges are seen mostly prominently in the complex stages of the supply chain (fishermen, fish farmers, marketing, processing, distributers, consumers and the government). The increased demand for fishery products and the growing aquaculture industry in the country requires enhanced controls with HACCP, and its pre-requisite programmes, mandated from farm to fork. Seafood products are often exposed to a poor handling and a lengthy distribution chain before reaching consumers and, given its perishability; its safety can be easily compromised if inadequately controlled. Environmental contaminants levels, on the other hand, must be regulated through continuous surveillance programmes at the harvesting and farming areas before entering the supply chain to ensure the highest level of consumer health protection. Consumer education and awareness program are essential and can be used as a driving force in improving the general status of food safety in the country. The FAO has also been working to provide additional guidance to countries seeking to enhance their fisheries control operations. In particular they have published “Guidelines for risk-based fish inspection” (FAO, 2009b) which contains valuable guidance on these matters.

Although seafood products can be of great health benefit in the diet they also carry risks to public health. They are responsible for notable outbreaks of food-borne disease worldwide. Prevention and control strategies are essential to define the causative agents and enable effective measures to reduce their incidence. Coordination between food safety regulators and epidemiologists will be crucial in Oman (Moza A. Al-Busaidi & Jukes, 2015) in order to improve current and future prevention strategies.

4.7.3 Safety legislation

Food control authorities have a duty to ensure the integrity and safety of foods offered to the consumer. The Codex Alimentarius Commission has endorsed the adoption of HACCP as a system for ensuring the safety of foods and the prevention of foodborne diseases. In addition, a series of Codes of Practice for fisheries products have been developed to aid the fisheries industry. The World Trade Organization's Agreements on the Application of Sanitary and Phyto-Sanitary Measures and the Technical Barriers to Trade has urged both government and industry to harmonize and adopt transparency in order to minimize barriers to international trade. Oman, as a member of both organizations since 1972 and 2000, respectively, has adopted sanitary and safety regulations based on Codex, WTO and the EU's requirements and recommendations. This has included work by the MAF implementing measures specifically to carry out quality and safety control and inspections of the seafood industry.

On the basis of the Regulation No. 12/2009 addressing specific rules for official controls on fish and fishery products, seafood processors and their related activities are mandated to upgrade their systems to meet the expected requirements. However, despite the existence of a well-defined legal framework throughout the seafood supply chain, there has only been partial implementation of modern food safety management systems in the country.

The extension of the requirements of the regulations (No. 12/2009) to cover the full supply chain and the broadening of the requirements to include importers, exporters and local producers has spread the resources more thinly. The latest inclusion of the fish markets into the mandate of the MAF has also increase the burden on the limited number of official regulators. The system is still complex with food safety laws and regulations fragmented

among different governmental authorities and functioning as multi-agency system (Moza A. Al-Busaidi & Jukes, 2015). These delays the adoption of a fully risk-based approach meeting the food safety challenges for both its domestic and potential export markets.

4.8 Conclusion and recommendations

The fisheries sector is one of the most important non-oil sources of income for the Sultanate of Oman. Small-scale fishermen are the backbone of fisheries production particularly with the absence of a robust industrial fishery in the country. The MAF has tried various approaches to enhance the fisheries sector in order to meet the stringent requirements of international trade. HACCP has been highly recommended in the Omani's fisheries legislation and efforts continue to protect both the health of the consumers and the interest of its industry.

To ensure seafood safety and quality the supply chain must incorporate the best practice on board and during handling of seafood products (e.g. cleaning, bleeding and ice). Traceability techniques from the primary producer (wild and farmed), through post-harvest treatment, processing and distribution to the consumer must be developed and attained. With the development of the aquaculture industry in the country, an increasing emphasis on the prevention of hazards at source will be essential. These could be developed and disseminated through good aquaculture practices and the application of HACCP in the different stages of the process to complement the existing methods. Regional collaboration among the different GCC countries sharing the same water bodies, perhaps within the Regional Organization for the Protection of the Marine Environment (ROPME) framework, Regional Commission for Fisheries (RECOFI) or Gulf Cooperation Council (GCC) food safety committee would also be of great benefit to overcome safety problems. Some of the collaborative work could be environmental programmes involving surveillance to monitor the various contaminants in the marine ecosystem and preventing them from entering the food chain. It is suggested that an annual 'food safety awareness week' be held in all GCC countries at similar times and used as a platform to launch various programs for educating and communicating with different stakeholders in the food

supply chain. Further efforts to unify the official food control system both in Oman and across the different GCC countries would also assist consumer wellbeing.

In order to achieve similar levels of protection against foodborne hazards, stringent safety and quality requirements should be enforced equally from farm to fork covering all aspects of harvesting, production and distribution regardless of the target market or consumers. Harmonization of food safety legislation and policies is fundamental for the unification of food control efforts in order to apply measures to protect human wellbeing.

For various reasons food safety standards differ amongst countries, in particular between developed and developing countries. These include the way food safety is perceived, climate differences, type of potential risks involved, process technology and the control mechanisms. Food safety standards have often been perceived as a barrier to trade impeding the developing countries access to valuable markets (Henson & Jaffee, 2008). However, an effective food safety and quality assurance system is of paramount importance for the protection of both the health of the consumers and the interests of industry generally. Moreover, these standards should perhaps be viewed as a catalyst rather than a barrier. Although they pose challenges, they also provide opportunities to developing countries to upgrade and develop their systems, to be more efficient and effective in controlling food safety and quality as well as ensuring conformity with international standards and specifications (Henson & Jaffee, 2008).

Considering the importance of the seafood industry in Oman, the government has recognized the benefits of adopting this approach into its fisheries industry and viewing it as a catalyst. When EU banned its fisheries export in 1998, it responded by reforming its food safety controls and quickly regained market access. Adopting a proactive approach to seafood safety is a sound strategic response to establish a position in the global market.

Our research will continue and seek to identify more precisely the benefits and constraints in implementing food safety management systems in the seafood industry in Oman.

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CHAPTER FIVE

5 Hazard analysis and critical control point (HACCP) in seafood processing: An analysis of its application and use in regulation in the Sultanate of Oman[3]

Abstract

When considering the supply of fish products to consumers, the adoption of food safety management systems throughout the 'net to plate' continuum is of a paramount importance. It is essential to safeguard consumers and to facilitate regional and international trade.

This study has assessed the technical barriers and benefits associated with the implementation of management system incorporating HACCP and related pre-requisite programmes in the seafood processors in the Sultanate of Oman. A survey, using qualitative surveys and interviews, was conducted out to verify the level of implementation of the seafood safety and quality requirements. A total of 22 (92% returned) HACCP processors, and 15 (83% returned) non-HACCP processors and 15 (75%) officials completed the questionnaires.

Differences between processors operating with or without a HACCP system in place have been identified. The survey of local officials provided an additional perspective on the issues involved. The implications of handling practices in the seafood supply chain, seafood trade and the cost implications of implementing HACCP-based food safety management systems were also assessed.

In comparison to the non-HACCP processors, the results indicated that HACCP firms were more diversified in their export markets and were able to target the more lucrative markets such as EU, Japan and America. However, the processors felt that the main barrier for

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exporting to these markets was the restriction imposed by the government on exporting certain species which reduced their ability to meet contracts with these countries.

The study has also shown inadequate execution of prerequisite programmes due mainly to lack of training delivered to food handlers and a poor knowledge of food safety concepts. In particular, there is an over-reliance on the use of CCPs to control hazards when prerequisite programmes would be more appropriate is many situations.

When considering whether to implement HACCP-based control systems, the seafood processors identified barriers linked to costs as their main concerns. However, whilst recognising this issue, the officials also highlighted barriers linked to the lack of expertise, skills and commitment of the staff.

In general, the study highlighted significant gaps which undermine the effectiveness and success of implementing safety and quality requirements to meet national legislative obligations. These include: poor attitudes and understanding toward HACCP and its pre-requisite programmes, lenient enforcement by the authorities, the lack of training and consultancy organizations in the country, and lack of awareness. The overlapping structure of the regulatory authorities in the country and the distribution of national inspection resources have also been identified as an issue of concern.

5.1 Introduction

In the Sultanate of Oman, seafood production is of paramount importance in providing employment, food security, and foreign currency. The total production in 2014 amounted to 211 thousand tonnes with 63% being exported to nearly 50 countries with an export value of 83 million O.R. (US$215.6 million). The country is considered to be self-sufficient in terms of seafood production and much of its production is consumed locally. The most commercialized seafood species in Oman include tuna, kingfish, large jacks, sardine, emperors, grouper, seabream, cuttlefish, lobster, shrimp and abalone (FSB, 2015). However, with large quantities being exported local shortages have occurred and the government, led by the Ministry of Agriculture and Fisheries, has imposed restrictions. A decision in 2010 led to the banning of exports of certain fish species whilst others are now subject to specific quotas for internal and export markets.

Adopting food safety management systems throughout the 'net to plate' continuum is of paramount importance in safeguarding consumer's well-being and facilitating regional and international trade. The Omani government has made progress in implementing HACCP systems and improving food safety controls. The Fishery Quality Control Centre (FQCC), as part of the Ministry of Agriculture and Fisheries (MAF), is the premier agency in Oman with the legal power to enforce and implement the seafood safety and quality requirements stipulated in the national Fishery Quality Control Regulation and its related guidelines and standards (Moza A. Al-Busaidi & Jukes, 2015; Moza A. Al-Busaidi, Jukes, & Bose, 2016). We have previously analyzed the structure of the seafood supply chain (Moza A. Al-Busaidi et al., 2016) and noted that it is based on traditional practices and characterized by being a complex system linking different stakeholders from fishermen to consumers. Distribution of seafood products can involve a lengthy chain which, due to seafood perishability, accelerates the decline of its quality and safety. Overall, the food safety control system in Oman has a multiagency structure with the current food safety law and regulations shared across various governmental authorities with overlapping responsibility and mandates (Moza A. Al-Busaidi & Jukes, 2015).

In light of these factors, taking the Sultanate of Oman as the basis for the study, we have evaluated the issues relating to HACCP implementation in the seafood industry and the role of the regulatory authorities. In particular, the study collected data on the perceived benefits and barriers of implementing HACCP. Since currently the use of HACCP is not a legal requirement, our analysis is based on two groups of processors: those who have implemented HACCP (the 'HACCP processors') and those who do not operate a HACCP based safety system (the 'non-HACCP processors'). Local officials were also surveyed to provide an additional perspective on the issues involved. The implications of handling practices in the seafood supply chain on the safety and quality of seafood, seafood trade and the cost implications in implementing HACCP based food safety management systems were also assessed.

5.2 Materials and methods

5.2.1 Business

An interview-based qualitative survey was conducted with seafood processors and officials from the regulatory authorities in charge of implementing seafood safety and quality requirements in the Sultanate of Oman in the period from August 2015 to February 2016. Study criteria were established to include only the seafood processors with some elements of food safety and quality systems in place, with processing operations (and not just storage), and with potential to export to regional and international markets. In addition, processors meeting the criteria were selected to ensure representation from small, medium and large businesses. Excluded were those who did not fulfil these criteria or were under construction and/or not operational during the study.

The processors were segregated into distinct groups based on their hygiene status: the HACCP processors (seafood processors implementing the HACCP requirements) and non-HACCP processors (seafood processors not implementing the HACCP requirements and have basic hygiene standards in place). To gain further insights into the divergences between these two groups, the data was analysed to provide cross-validation between the responses of the processors and the officials. A list of 50 processing establishments was provided by the Ministry of Agriculture and Fisheries. The processors that fulfilled the study criteria were contacted and 42 were selected for the survey. 8 processors under construction were excluded. The selected processors were visited and handed questionnaires of which a total of 37 (88%) were completed and returned. A total of 22 (92% returned) HACCP processors, and 15 (83% returned) non-HACCP processors completed the questionnaires. For the officials, 20 were contacted and 15 (75%) completed questionnaires were obtained. The contacted officials were from the Ministry of Agriculture and Fisheries and were selected based on their official role and experience in the field of seafood safety control. Their roles varied between seafood safety inspectors, section heads and directors of the different departments that deal with seafood safety control.

The processors and officials were located in varied governorates across Oman. The majority of the processes were based in the Al-Wusta governorate (30%), followed by

Muscat (24%) and Al-Sharqiya (24%) governorates. Most of the officials (73%) were based in the Muscat governorate where the main headquarters for seafood control is located. Prior to conducting the survey, ethical approval was obtained from the University of Reading and an approval was given by the appropriate authority in Oman. The data collected was treated confidentially and anonymously.

5.2.2 Questionnaire design and development

It had been decided to use an interview-based qualitative survey as the main method of data collection supplemented by qualitative responses from interviews with key personnel from the three groups. In addition, inspection reports covering the previous 12 months from the Fish Quality Control Centre (FQCC) were examined to provide a means of verifying some of the data.

The questionnaires used a mixture of closed questions, open questions and attitudinal scales based on five-point Likert scales (Likert, 1932) and designed to provide a valid and accurate measure of an individual's responses. Although 3 separate questionnaires were prepared for the 3 groups, the majority of the questions were common so as to allow comparison and to provide cross-validation of the responses. After drafting, all 3 questionnaires were translated so as to provide both English and Arabic language versions (see Appendix A, B &C).

Each questionnaire was divided into seven sections. Sections 1 and 2 sought general information of the responder and the processor. Section 3 was on the seafood trade and business issues and Section 4 looked on the seafood supply chain. Section 5 mainly dealt with prerequisite programmes – an essential component for HACCP implementation. For the HACCP-processors, Sections 6 assessed the level of implementation of HACCP principles and requested some financial information on the costs associated with HACCP implementation. In the final Section, all groups were encouraged to rate the effectiveness of the Omani food and seafood safety legislation and the work of the control authorities.

After checking with an independent expert, an academic specialized in the HACCP system, the questionnaires were piloted on four processors (2 for each of the HACCP and the non-

HACCP processors) and three officials from the FQCC and, based on these responses, modifications were made.

5.2.3 Statistical analysis

A Statistical Package for Social Science (SPSS) version 21 was used to process and analyse the data. Descriptive analysis and frequencies were computed for the variables of the study. Cross tabulations and Fisher's exact Chi-square (X^2) test was used to examine the relationships between and among the different variables.

5.3 Results and discussion

5.3.1 Characteristic and demographic details of the Seafood Industries in Oman

General characteristics of the respondents participating in the study are presented in Table 9. For the HACCP processors, the majorities (64%) of the respondents were quality controllers, for the non-HACCP processors they were the owners (80%); for the officials the largest group was inspectors (47%). These proportions correspond well with Qatan et al. (2015). Professional experience in the seafood industry varied among the respondents of the three groups with 47% having above 20 years for the non-HACCP group, 59% having less than 10 years for the HACCP group, and 60% within the range of 11-19 years for the officials. The HACCP processors and the authority were more willing to employ staff with degree-level training; the owners of the non-HACCP processors were less likely to employ qualified personnel as they depend more on their own experience and that of experienced staff. This interpretation agrees with that of Jin, Zhou, and Ye (2008) which indicated that managers of HACCP processors are more educated and willing to implement HACCP principles in their businesses. The higher the education levels of the managers of the processors the less the requirement of support and consultancy from the government (Karaman et al, 2012).

Only 14% of the respondents within the HACCP processors were Omani; for the non-HACCP group it was 53% and these were mostly the owners. All officials were Omani. Qatan et al. (2015) had a similar profile and suggested several possible causes: shortage of local expertise in seafood safety and quality, reluctance of Omanis to work in this field and/or cost minimization by the processors.

Information on the processors' business profiles is presented in Table 10. The survey included small, medium and large establishments. Most process mainly fresh and frozen seafood products with only one HACCP processor producing canned products and only one non-HACCP processor undertaking drying and salting. Those in the HACCP group were likely to employ more workers and these were mostly non-Omani. Although both groups of processors target the domestic and foreign markets, most products from the non-HACCP group go to the domestic markets (93%) in comparison to 73% for the HACCP group. The lucrative markets such as the European Union (EU), the USA and Japan are mostly targeted by processors from the HACCP group since they fulfil these markets' requirements.

However, the share of the end products going to these markets has decreased due to the ban in 2010 on exports of certain species that was imposed by the MAF in order to limit the export of high valued seafood products and increase their availability for local consumers. Other markets have been targeted by both groups with more diverse products but mostly focused on marketing low value species to the Asian and African markets. Most of the raw seafood materials are obtained locally: 77% for the HACCP group and 100% for the non-HACCP group. The HACCP processors often use imported raw materials due to the seasonality of certain species in Omani coastal waters.

The majority of the respondents from both categories declared their capacity to be below 5000 metric tonnes (MT) per year, with only 15% and 6.7% exceeding 10,000 MT per year for HACCP and non-HACCP processors respectively. Processors in the HACCP group tended to have a larger turnover with only 2 (12%) processors indicating an annual turnover of less than 1 million dollars compared to 7 (54%) in the non-HACCP group. However, there were four large non-HACCP processors (31%) that had an annual turnover above 10 million dollars. This was partly caused by some of these processors being suppliers of raw seafood to the HACCP processors.

Table 9: Respondents' profile

Respondents' Profile	HACCP processors (n=22)						Non-HACCP processors (n=15)						Officials (n=15)					
Position Title	**Manager**			**Quality Controller**			**Manager**			**Quality Controller**			**Director**		**Section Head**		**Inspector**	
	36.4%			63.6%			80%			20%			40%		13.3%		46.7%	
Nationality of the respondents	**Omani**			**Non-Omani**			**Omani**			**Non-Omani**			**Omani**			**Non-Omani**		
	13.6%			86.4%			53.3%			46.7%			100%			0.0%		
Length of service in Seafood industry (years)	**< 10**		**11 - 19**		**>20**		**< 10**		**11 - 19**		**>20**		**< 10**		**11 - 19**		**>20**	
	59.1%		13.6%		27.3%		40.0%		13.3%		46.7%		26.7%		60.0%		13.3%	
Education Level	Secondary Certificate	Diploma	Higher Diploma	Bachelor Degree	Master Degree	Other	Secondary Certificate	Diploma	Higher Diploma	Bachelor Degree	Master Degree	Other	Secondary Certificate	Diploma	Higher Diploma	Bachelor Degree	Master Degree	Other
	0.0%	9.1%	4.5%	45.5%	31.8%	9.1%	6.7%	20.0%	0.0%	33.3%	20.0%	20.0%	13.3%	20.0%	20.0%	26.7%	20.0%	0.0%

Table 10: Characteristics of the seafood processors

Characteristics of the Processors	**HACCP Processors (n=22)**					**Non-HACCP Processors (n=15)**				
Years of Establishment	**≤ 10 years**		**(11-19)**		**≥ 20**	**≤ 10 years**		**(11-19)**		**≥ 20**
n*	11		4		7	3		6		6
Employees	**Omani**		**Non-Omani**			**Omani**		**Non-Omani**		
n(%)	214(25%)		647(75%)			62(18%)		284(82%)		
Date of HACCP implementation	**1998-2003**		**2004-2009**		**2010-2015**					
n*	7		3		10					
Annual Capacity in Quantities (tonnes/year**)**	**<5000**		**5000-10,000**		**>10,000**	**<5000**		**5000-10,000**		**>10,000**
n(%)	12(60%)		5 (25%)		3 (15%)	10 (66.7%)		4 (26.7%)		1 (6.7%)
Annual Turn Over (Million Dollars)	**<1**	**(1-5)**	**(6-10)**		**>10**	**<1**	**(1-5)**	**(6-10)**		**>10**
n(%)	2 (11.8%)	9 (52.9%)	3 (17.6%)		3 (17.6%)	7 (53.8%)	2 (15.4%)	0.0 (00.0%)		4 (30.8%)
Origin of the Raw Materials	**100% Domestic**		**Mixture of Domestic & Imported**		**100% Imported**	**100% Domestic**		**Mixture of Domestic & Imported**		**100% Imported**
	77.3%		22.7%		0.0%	100%		0.0%		0.0%
Quantities to Domestic Market (tonnes/year**)**	**<1000**		**1000-3000**		**>3000**	**<1000**		**1000-3000**		**>3000**
	47.4%		42.1%		10.5%	53.8%		38.5%		7.7%
Quantities to Export Market (tonnes/year**)**	**<1000**		**1000-3000**		**>3000**	**<1000**		**1000-3000**		**>3000**
	35%		25%		40%	36.4%		36.4%		27.3%
Processing Techniques in Use	**Chilling**	**Freezing**	**Canning**	**Drying**	**Salting**	**Chilling**	**Freezing**	**Canning**	**Drying**	**Salting**
n (%)	13(59%)	22(100%)	1 (4.5%)	0 (0.0%)	1 (4.5%)	10(66.7%)	11 (73.3%)	0 (0.0%)	1 (6.7%)	1 (6.7%)

*n= Respondents frequency

5.3.2 Seafood trade and business issues

The markets are shown in Figure 14, where the HACCP processors were more diversified and targeted the more lucrative markets such as EU, Japan and America.

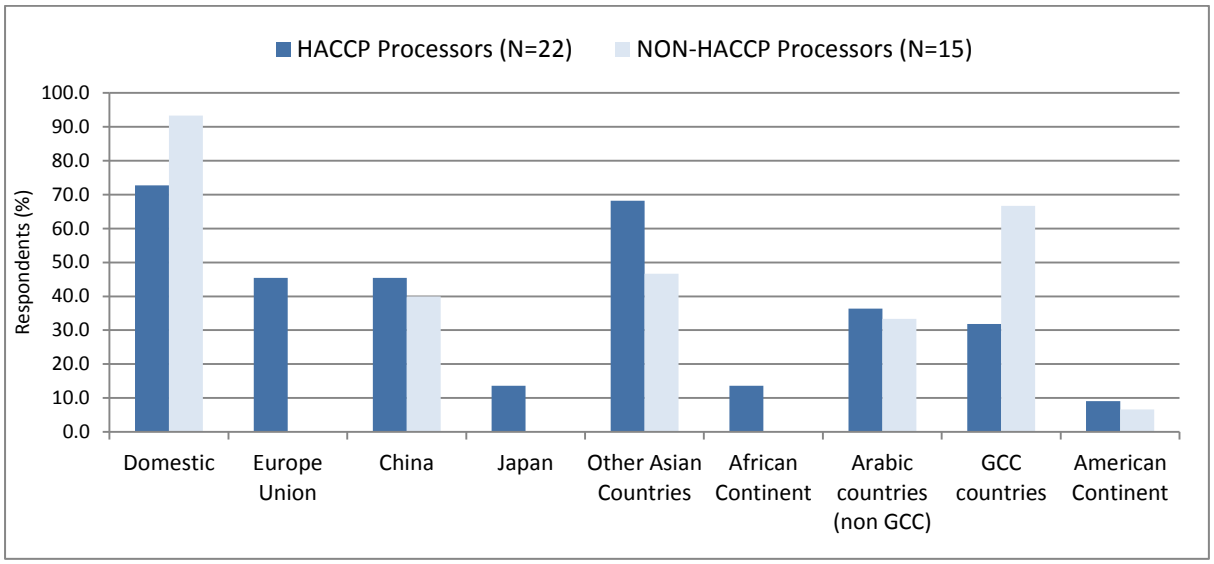


Figure 14: Destination markets of the end seafood products

The questionnaire asked about the level of difficulty of accessing different markets in terms of satisfying their quality and safety requirements – mean value of the responses are shown in Figure 15 based on a five-point scale ranging from "very difficult" (5) to "very easy" (1)[4]. The non-HACCP processors perceived the lucrative export markets as very challenging and difficult to break into. The HACCP processors were less concerned about the difficulty since they satisfy the key HACCP requirement and were experienced in dealing with these markets. The officials were more discriminating and viewed the EU, Japanese and the American markets as the most difficult to access, with the Asian, African and Arabian/GCC countries as the easiest.

Results (Table 11) indicate that the main barrier for exports to regional and international markets was the restriction imposed by the MAF on export of certain species. With the imposition of these controls most exporters lost their valuable contracts as they were unable to ensure continuity of supply and switched to low valued seafood targeting less lucrative markets. Some have given up their HACCP certification as compliance is largely market

[4] For statistical purposes the five-point scale were reversed from the one presented in the questionnaires

driven – a similar attitude has been reported in a study of the Australian food industry (Ropkins & Beck, 2000).

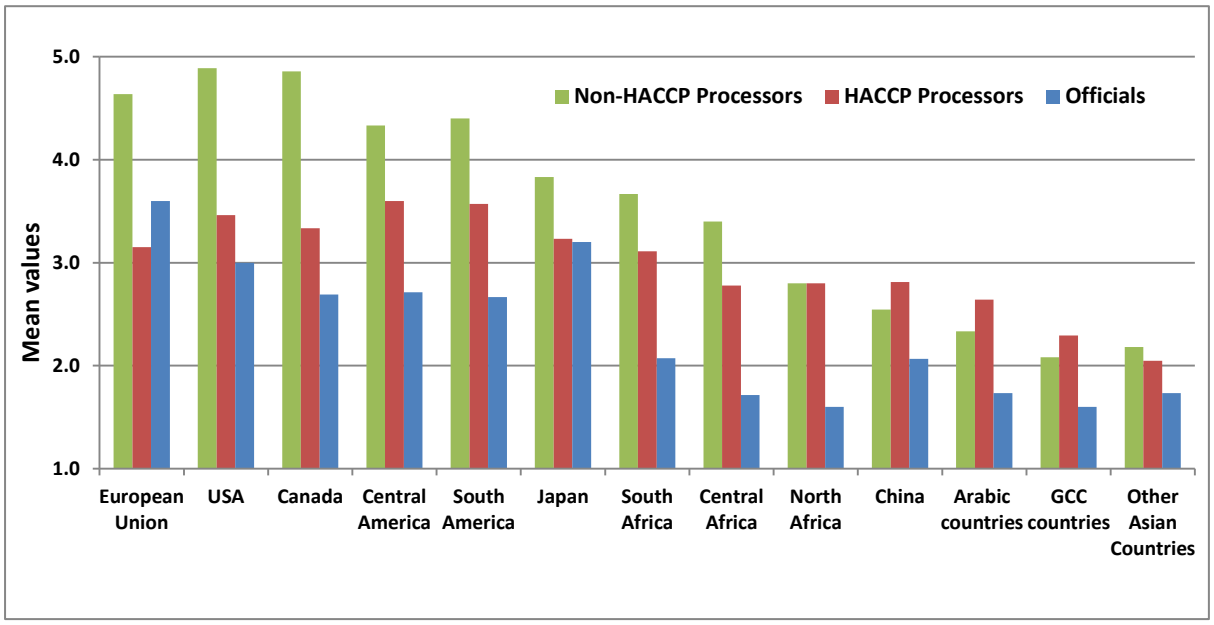


Figure 15: Mean values of the level of difficulty accessing international markets in terms of quality and safety requirement based on a five point scale ranging from "very difficult" (5) to "very easy" (1)

Data on the barriers to enhanced operations is shown in Figure 16. The scale shows the mean values of the barriers that are likely to prevent the enhancement of the seafood business operation rated by the officials, HACCP and Non-HACCP processors based on a five-point Likert scale ranging from "major barrier" (5) to "not a barrier" (1). Once again the MAF export ban, although relating to only certain fish species harvested locally (for example Kingfish (*Scomberomorus commerson*), Longtail tuna (*Thunnus tonggol*), Yellowfin tuna (*Thunnus albacares*) and certain species of Grouper such as (*Epinephelus diacanthus*) was also seen as the major barrier preventing the enhancement of operations. Sudden changes in government policies without giving the business a time frame to adjust their practices was seen as the second barrier – probably also linked to the export ban. Although not ranked in the top group, staff turnover was also considered a barrier for many firms but it was more significant to the non-HACCP processors in comparison to the HACCP processors. The non-HACCP processors mostly employ workers with low level of education and expatriate, seasonal or non-permanent workers since they are much cheaper to employ and there is a reluctance to provide adequate training as its considered time consuming and a financial burden. Mol et al (2014) reported a similar situation in the Turkish seafood processing sector.

Table 11: The main barriers to export to regional and international markets

Barriers to Export Frequency (%)	Trade restrictions (SPS) & (TBT)	Lack of consumer demand in specific market	Uncertainty in obtaining a regular supply of raw materials	Exchange rate fluctuations	Administrative delay locally	Administrative delay in the destination country	Export bans of certain fish species by the MAF	Import duty (tax) in foreign market	Others
Officials	4 (10.3%)	6 (15.4%)	8 (20.5%)	2 (5.1%)	6 (15.4%)	3 (7.7%)	8(20.5%)	1(2.6%)	1(2.6%)
HACCP Processors	5 (8.2%)	4 (6.6%)	15 (24.6%)	5 (8.2%)	3 (4.9%)	1 (1.6%)	18(29.5%)	8(13.1%)	2(3.3%)
Non HACCP Processors	4 (8.7%)	3 (6.5%)	7 (15.2%)	4 (8.7%)	11 (23.9%)	1 (2.2%)	12(26.1%)	1 (2.2%)	3(6.5%)

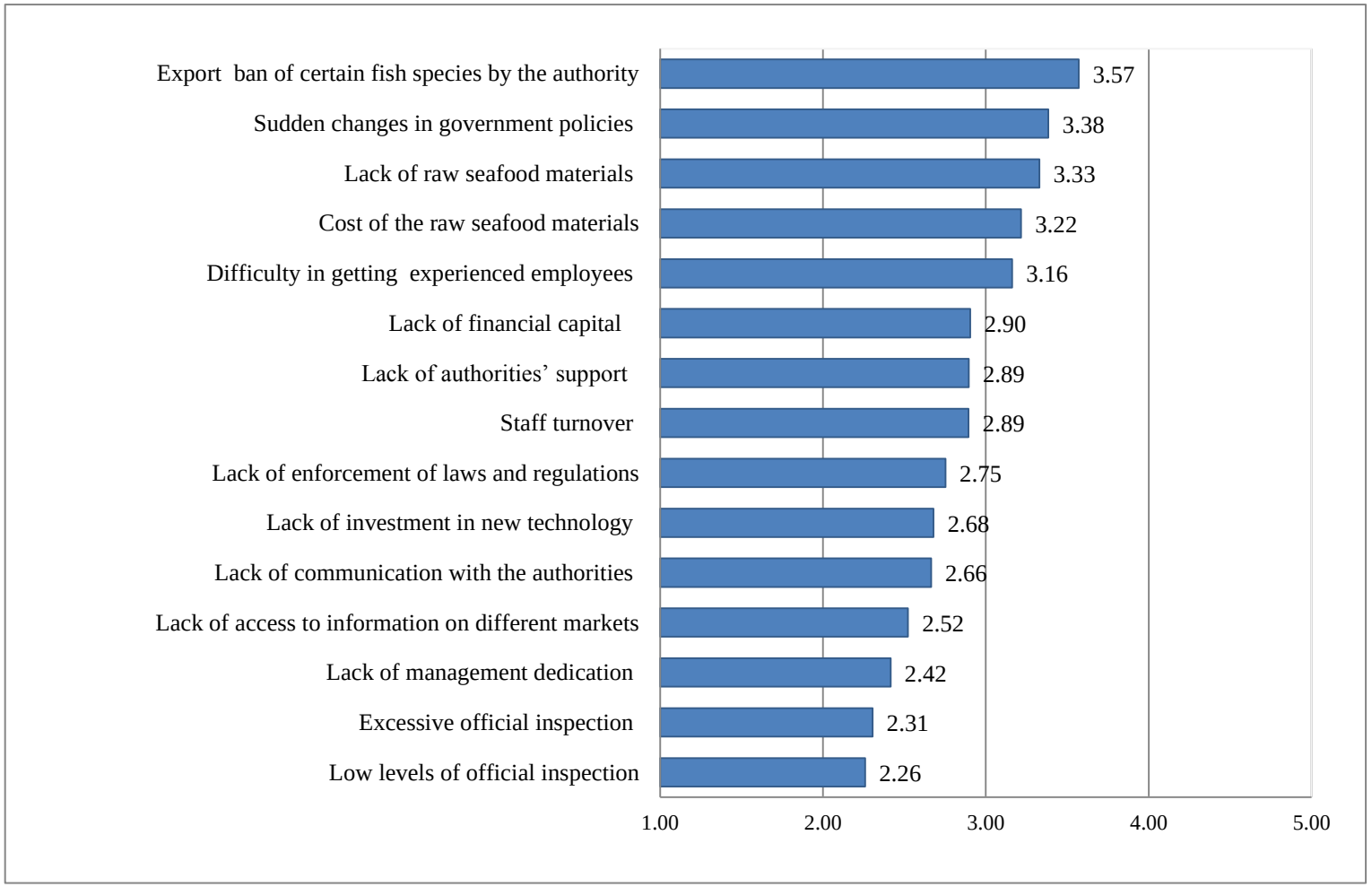


Figure 16: Overall mean values of the barriers that are likely to prevent the enhancement of the business operation in the seafood sector (combined data)

5.4 Food Safety Management Systems (HACCP and its pre-requisite programs)

Seafood products are often exposed to lengthy handling and distribution processes before reaching the consumers and, given its perishability, its safety can be adversely affected if controls are inadequate (Moza A. Al-Busaidi et al., 2016).

The quality and safety of raw material received from suppliers of local raw seafood products were rated highly by the respondents in comparison to imports. Figure 17 and Figure 18; show various stages and factors in the supply chain that may impose negative effects on the quality and safety of seafood products. The officials believed that the practices adopted by the fishermen, landing sites and middlemen/truckers are the stages that contribute negatively to the quality and safety of seafood products. With a mean score of 3.0, it is interesting to note that in Figure 17, the non-HACCP processors gave 'negative' scores (higher than 3.0) for all the suggested factors whereas both the officials and the HACCP processors were much more discriminating.

In terms of the different factors that lead to deterioration in the safety and quality of the seafood products, inadequate control of time and temperature and poor ice availability were reported as the major impact on the seafood products as shown in Figure 18.

5.4.1 Prerequisite programmes

The processors were asked about the level of implementation of prerequisites programmes within the different stages of their processing. The officials were also asked for their assessment of the same prerequisites so as to verify the responses of the processors. The responses are shown in Figure 19.

The HACCP processors rated their implementation of prerequisites highly; the officials were mostly in agreement with these responses – for example the maximum difference in mean scores was only 0.80 for 'personal hygiene'. The non-HACCP processors also rated their implementation quite high; however, the officials disagreed with this rating giving much lower scores to all pre-requisite elements. This is seen by the difference in scores varying between a minimum of 0.87 and a maximum of 2.00. The data shows a lack of knowledge of prerequisite programmes in the non-HACCP processors. This could be due to various factors: the lack of education, lenient enforcement by the regulators or a lack of finance.

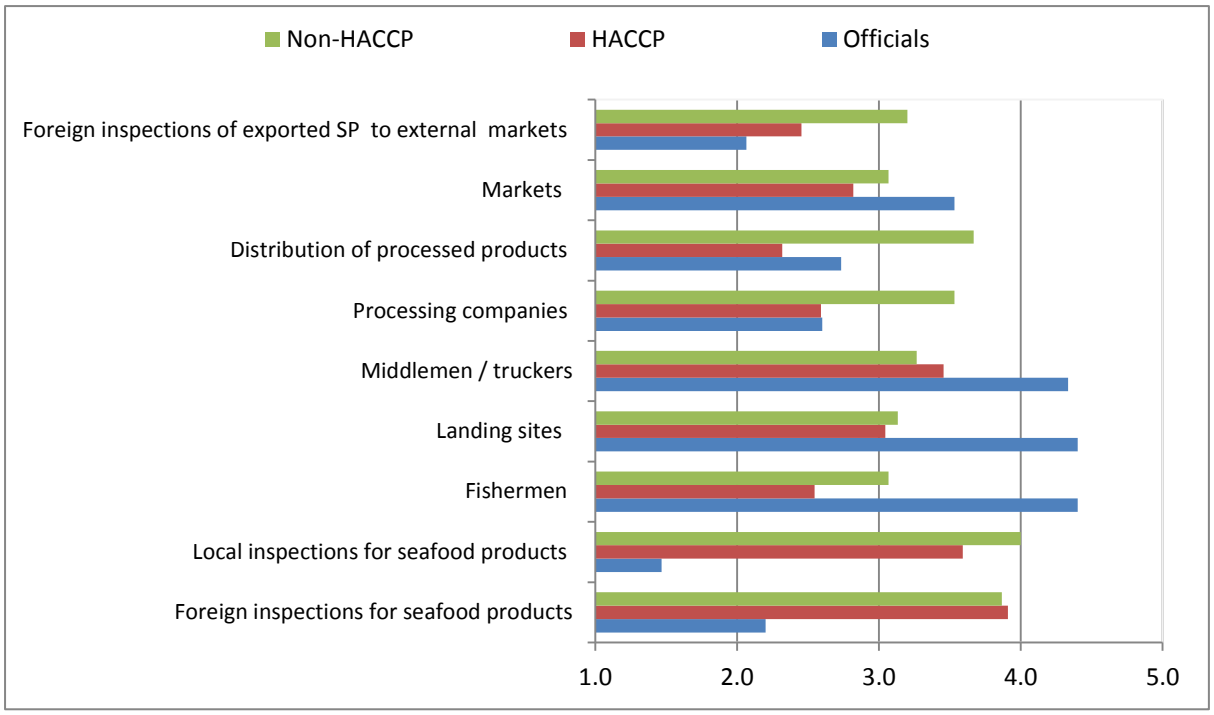


Figure 17: Overall mean values of the degree of negative impact on the seafood quality and safety at the different stages of the seafood supply chain based on a Likert scale ranging from "Major Impact" (5) "to the No impact" (1)

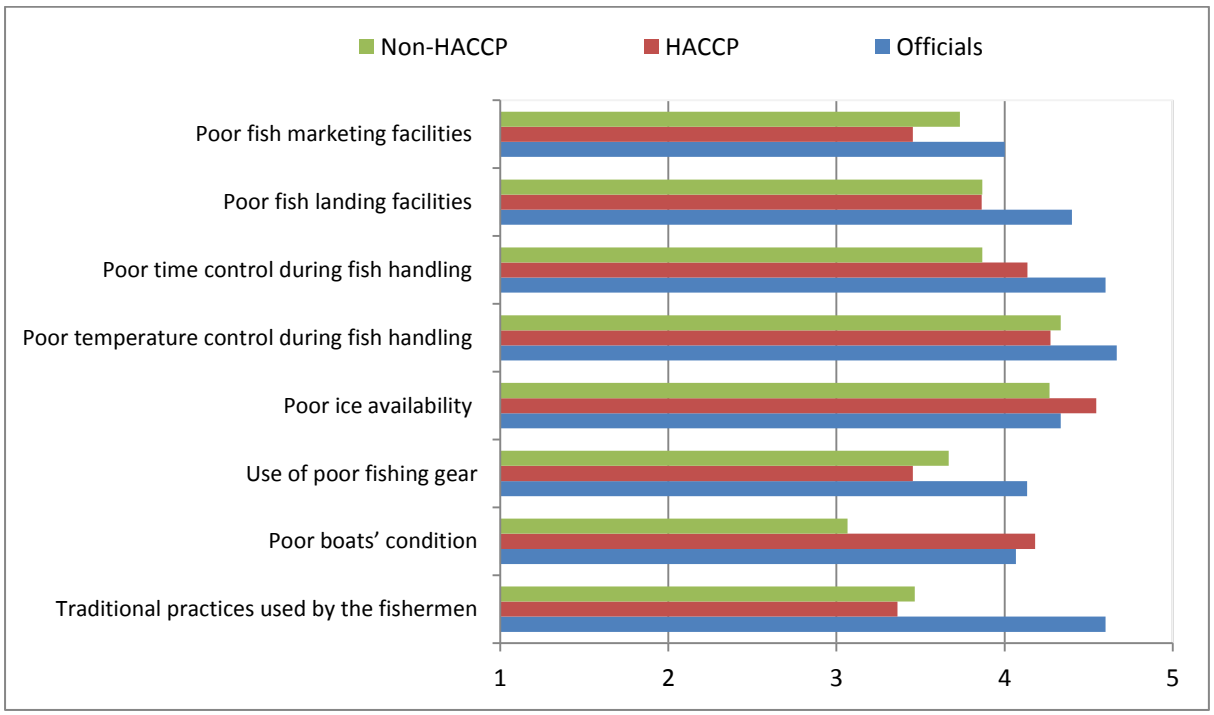


Figure 18: Overall mean values of the factors in the supply chain that have negative impact on seafood quality and safety based on a Likert scale ranging from "Major Impact" (5) "to the No impact" (1)

Similar suggestions have been made by Jin et al. (2008) following their research into food enterprises without HACCP in China. Prerequisite programmes are considered the foundation of effective HACCP implementation. Even within the EU it has been reported that it is common to misunderstand the different roles of prerequisites and HACCP both by authorities and food businesses (Food and Veterinary Office, 2015). This situation can also be found in the Omani seafood industries where, due to the need to meet the EU market requirements in the 1990's, the process was rushed and prerequisite programmes were not given enough consideration. Our review of the official inspection reports confirmed that a major problem with seafood processors was the absence or failure to follow prerequisite requirements. Similar results have been reported by other researchers (Murat Bas, Yuksel, & Cavusoglu, 2007; Doménech, Amorós, Pérez-Gonzalvo, & Escriche, 2011; Tomasevic et al., 2013).

The questionnaire asked where in the operation critical control points (CCPs) were situated. The most selected CCPs were raw material reception (33%) followed by cooling/chilling (17.3%), processing (17.3%), raw material suppliers (13.5%) and storage (13.5%). The least selected was the cooking step as most of the processors deal with fresh and frozen product - only the canning processors, where retorting occurs, considered it as a CCP. This clearly indicates a degree of confusion in the application of HACCP as correct temperature control ('cooling/chilling') is fundamental to the processing of seafood and should really have been included by all processors as a CCP. 23% of the HACCP processors indicated they had 6 or more operational steps where CCPs have been identified. This suggests an excessive reliance on the use of CCPs when control using their prerequisite programmes would be more appropriate in many situations.

During the last three decades, the HACCP system and its prerequisite programmes have been progressively introduced into the seafood industries in Oman. The adoption of HACCP principles by the seafood processors however, has not progressed easily (Moza A. Al-Busaidi et al., 2016). Prior to 2009, food safety management systems (FSMS), particularly the HACCP system, were enforced by the seafood safety authorities on the processors that were exporting to the European markets. The processors received a lot of support from these authorities to implement the system. However, those not willing to adopt the system had much less support and were only inspected periodically by other food safety enforcement authorities. However, after the amendment of the Fishery Quality Regulation (12/2009) in 2009, all seafood processors are expected to adopt a food safety system with HACCP a preferred method.

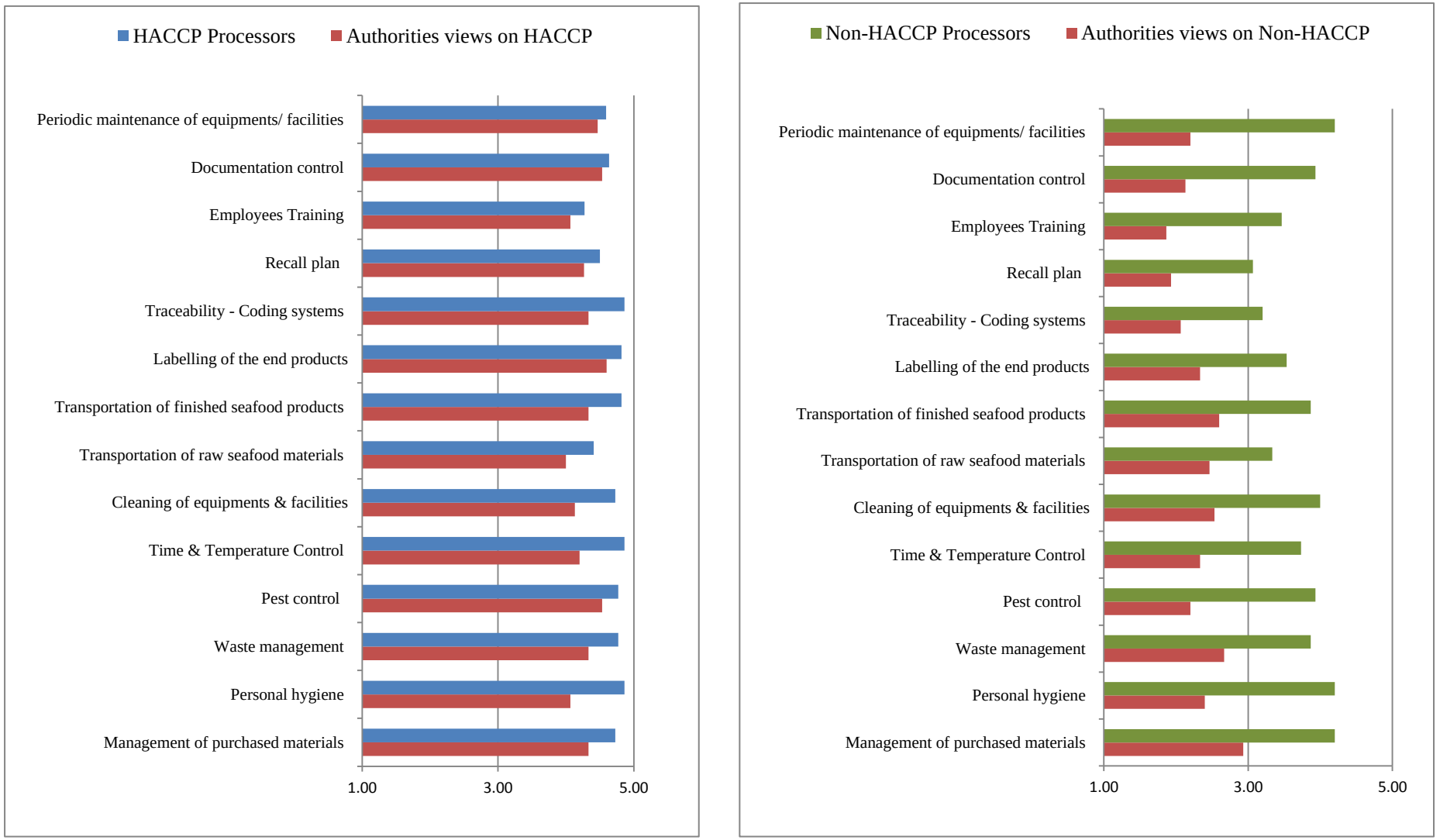


Figure 19: Mean values of the levels of implementation of the following of the prerequisites programmes in the seafood processors based on a five scale ranging from “Full” (5) to “None” (1)

Nonetheless, pressure from seafood importing countries is the major factor currently demanding HACCP application making HACCP a market driven system rather than a locally driven safety and quality practice. Asked about the time required from starting to implement the system, 68% of the HACCP processors stated that it took them less than 6 months with 50% of the processers receiving guidance from officials of the FQCC. Other studies have reported varying time: in the Mexican and Chinese meat industries it was reported to be around 29 and 42 months respectively (Maldonado-Siman, Bai, Ramirez-Valverde, Gong, & Rodriguez-de lara, 2014); in both the Australian meat industries (Khatri & Collins, 2007) and in food businesses in China (Bai, Ma, Yang, Zhao, & Gong, 2007) the time varied between 6-12 months; in the Serbian meat industry 50% of the processors estimated the period to be 12 months or less with 11.7% indicating more time was required (Tomasevic et al., 2013).

64% of the processors believed that they fully participated in the development of their HACCP plan, and they all, to varying degrees, considered that they were participating in its day-to-day operation. The majority of the officials considered that most of these processors performed the above tasks. Most of the respondents considered that they fully implement all the seven principles of HACCP; however, the officials were less positive only classing implementation at the 'most' to 'some' level of implementation.

5.4.2 Barriers of implementing and operating HACCP system

The processors were shown a list of 14 'barriers to implementing HACCP' and were asked to identify the top five barriers. Of the 15 non-HACCP processors, only 9 felt that they had sufficient knowledge to answer making a total of 31 processor responses. Combining the two groups, those barriers which were selected the most were:

1. Requirements to restructure the facility (65% included this item)
2. HACCP requirements added cost to the final product (61%)
3. Inadequate infrastructure and facilities (45%)
4. Consumer/market not requiring HACCP (45%)
5. Lack of financial resources (42%)
6. A need to retrain production staff (42%)

The order of the list corresponds to that of the HACCP processors taken on their own. For the non-HACCP processors, the items are the same although the order was different – for example, the need to retrain staff was ranked second equal (67%) with requirements to

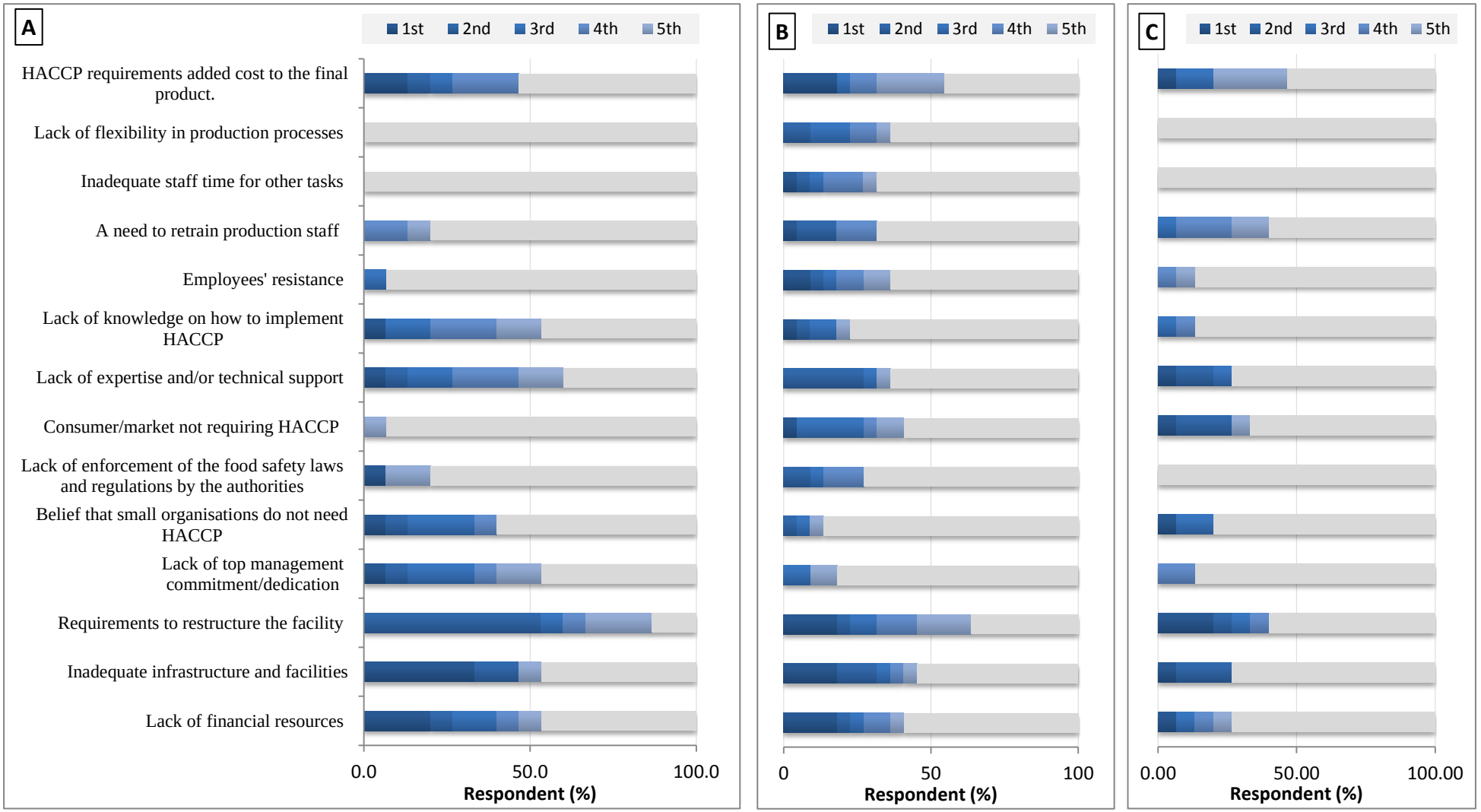
restructure the facilities whilst the cost of HACCP was their first concern (at 78%). However, as the questionnaire asked for the barriers to be ranked from "the first highest barrier" to the fifth highest barrier", a more detailed analysis is possible and data from this is shown in Figure 20.

The officials were asked a very similar question on the top five barriers, but they considered the issue generally from their experience rather than linked to a specific business. Their top six show a rather different selection (see Figure 20):

1. Requirements to restructure the facility (87% of officials included this barrier)
2. Lack of expertise and/or technical support (60%)
3. Lack of top management commitment/dedication (53%)
4. Lack of knowledge on how to implement HACCP (53%)
5. Lack of financial resources (53%)
6. Inadequate infrastructure and facilities (53%)

The more rigorous food safety controls required by HACCP suggest to the respondents that significant alterations to their business's structure are required although this should be a factor in their operation whether or not HACCP is employed. Although all groups put the requirement to restructure as their top barrier, it is interesting to note that the officials had greater concerns about the expertise, skills and commitment of the staff whereas the processors tended to select items more related to the costs of HACCP.

The HACCP implementers were also requested to provide the negative impacts they faced once they had decided to adopt HACCP (Figure 21). The ranking of negative factors was in agreement with those of (Khatri & Collins, 2007; Maldonado-Siman et al., 2014) in finding product testing as a major operating cost. Nevertheless, in regard to the cost of investing in new equipment and staff training, (Khatri & Collins, 2007) reported them as one of the major costs in the meat industries in Australia.



* A= Officials; B= HACCP-Processors; C=Non-HACCP Processors

Figure 20: The respondents' % of the officials and the seafood processors of the main barriers to adopt HACCP prior to implementing the system based on a rank from 'first' (1^{st}) to 'fifth' (5^{th})

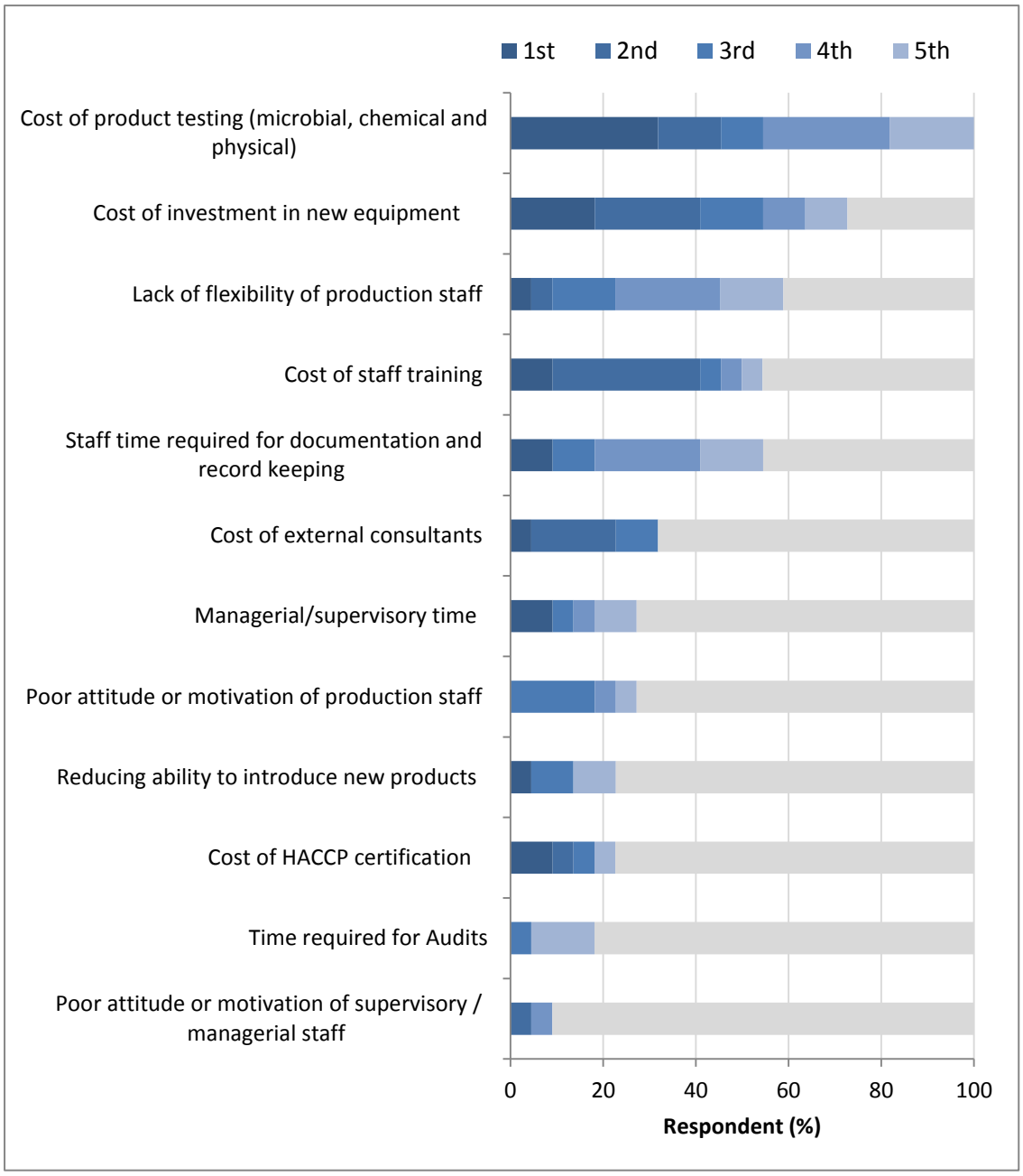


Figure 21: The HACCP processors respondents of the negative impacts after HACCP implementation in the seafood processors based on a rank from 'first' (1^{st}) to 'fifth' (5^{th})

5.4.3 Motivation and benefits arising from adopting HACCP system in the seafood industry

Successful implementation of any FSMS requires sufficient knowledge and commitment from administrative and production staff. The officials and both types of seafood processors agreed on the benefit of adopting FSMS system.

5.4.3.1 Motivation

The participants were presented with a list of 14 potential motivational factors and were requested to select and rank the top five factors when their businesses decided to implement HACCP. For the HACCP processors, the motivational factors selected the most were as follows:

1. Improved product quality and safety (91% of HACCP processors included this item)
2. Meet quality and safety requirement of customers (55%)
3. Consumer protection (55%)
4. Meet with requirements of national, regional and international laws and regulations (45%)
5. Enhanced reputation of establishment (41%)

It is pleasing to note that the top three items focus on the consumer benefit of adopting HACCP. The list from officials was very similar although their list had a different factor (Increased ability to retain or access new export markets) in fifth place perhaps reflecting the recognition that the officials' role is often linked to ensuring processors gain access to export markets.

The responses by all the groups varied within the ranking from "the first highest motivation" to the "fifth highest motivation" for each motivational factor which is illustrated clearly in Figure 22.

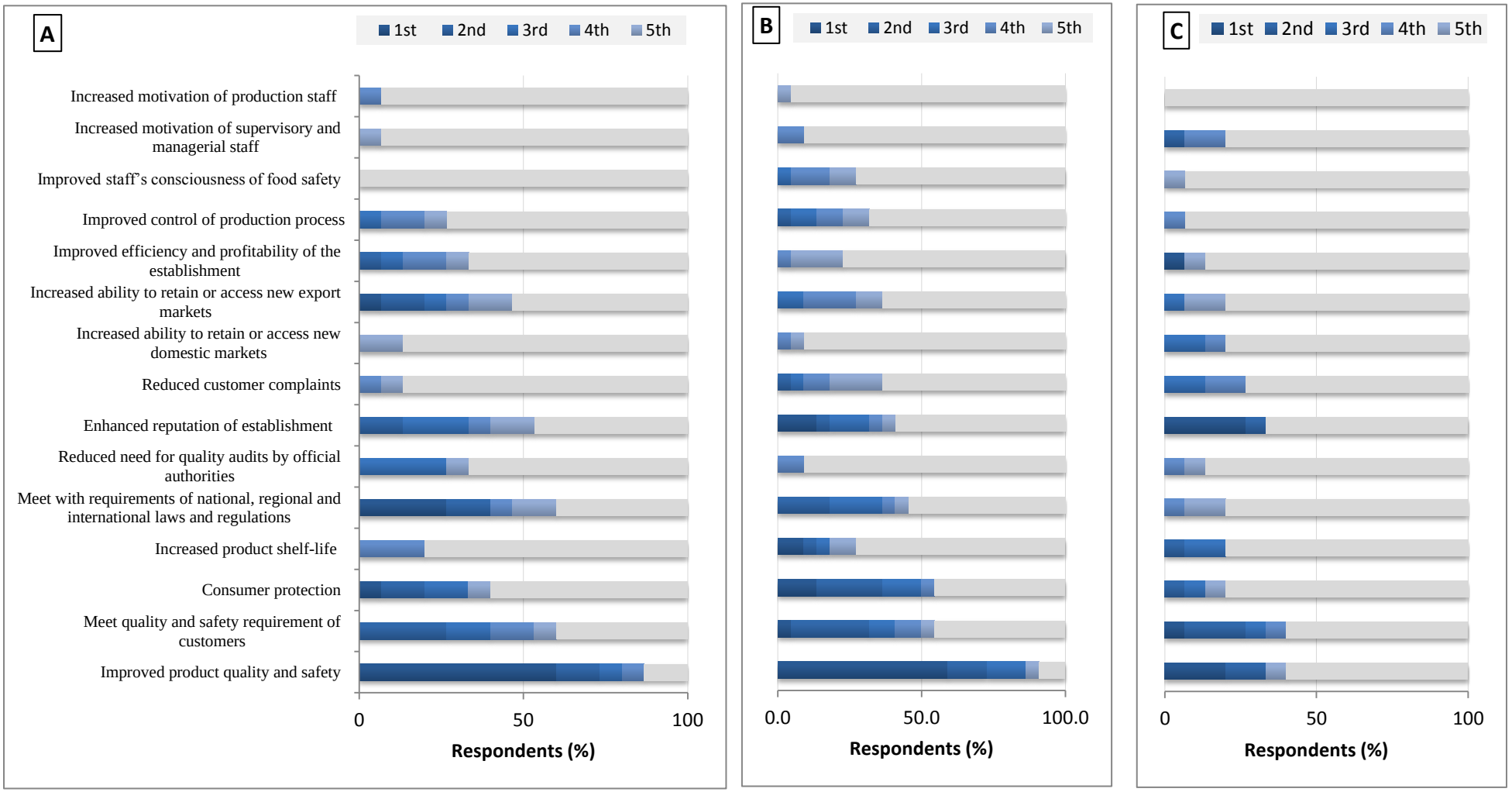
5.4.3.2 Benefits

The HACCP processors were also asked to provide the top benefits once they had implemented the HACCP system as shown in Figure 23. The improvement of the quality and safety of the seafood products was also selected as the top benefit of adopting the HACCP system. Similar results to our study in terms of the HACCP system improving the products quality and safety have been reported (Murat Bas et al., 2007; Jin, Zhou, & Ye, 2008; Karaman, Cobanoglu, Tunalioglu, & Ova, 2012; Qatan, 2010; Qatan, Bose, & Mothershaw, 2015; Qijun & Batt, 2016; Tomasevic et al., 2013). The meeting of laws and regulations in

our survey, is similar to that of (Tomasevic et al., 2013) although in their study of Chinese food businesses (Bai et al., 2007) found it the least motivational factor. The least motivational factor in this survey was the staff roles and practices are made clearer.

One of the new HACCP system implementers stated that the system protected the reputation of his firm when he faced an overseas complaint on the safety of the received products which had been mishandled during air transportation and he was protected from legal accountability by showing due diligence. A similar situation was also reported by (Khatri & Collins, 2007).

One of the perceived HACCP benefits in the seafood business in Oman is export competitiveness and being able to break into the highly competitive markets of the EU, USA and Japan. From several face-to-face meetings with the processors, penetration to new markets or the capacity to attract new customers has not been an issue as long as FSMS are adopted. Moreover, the willingness of the Omani government in attempting to upgrade the existing control systems to ensure consumer protection has made tremendous progress with regard to HACCP implementation (Moza A. Al-Busaidi et al., 2016).



* A= Officials; B= HACCP-Processors; C=Non-HACCP Processors

Figure 22: The respondents' % of the top motivational factors after implementing HACCP on the seafood businesses based on a rank from 'first' (1st) to 'fifth' (5th)

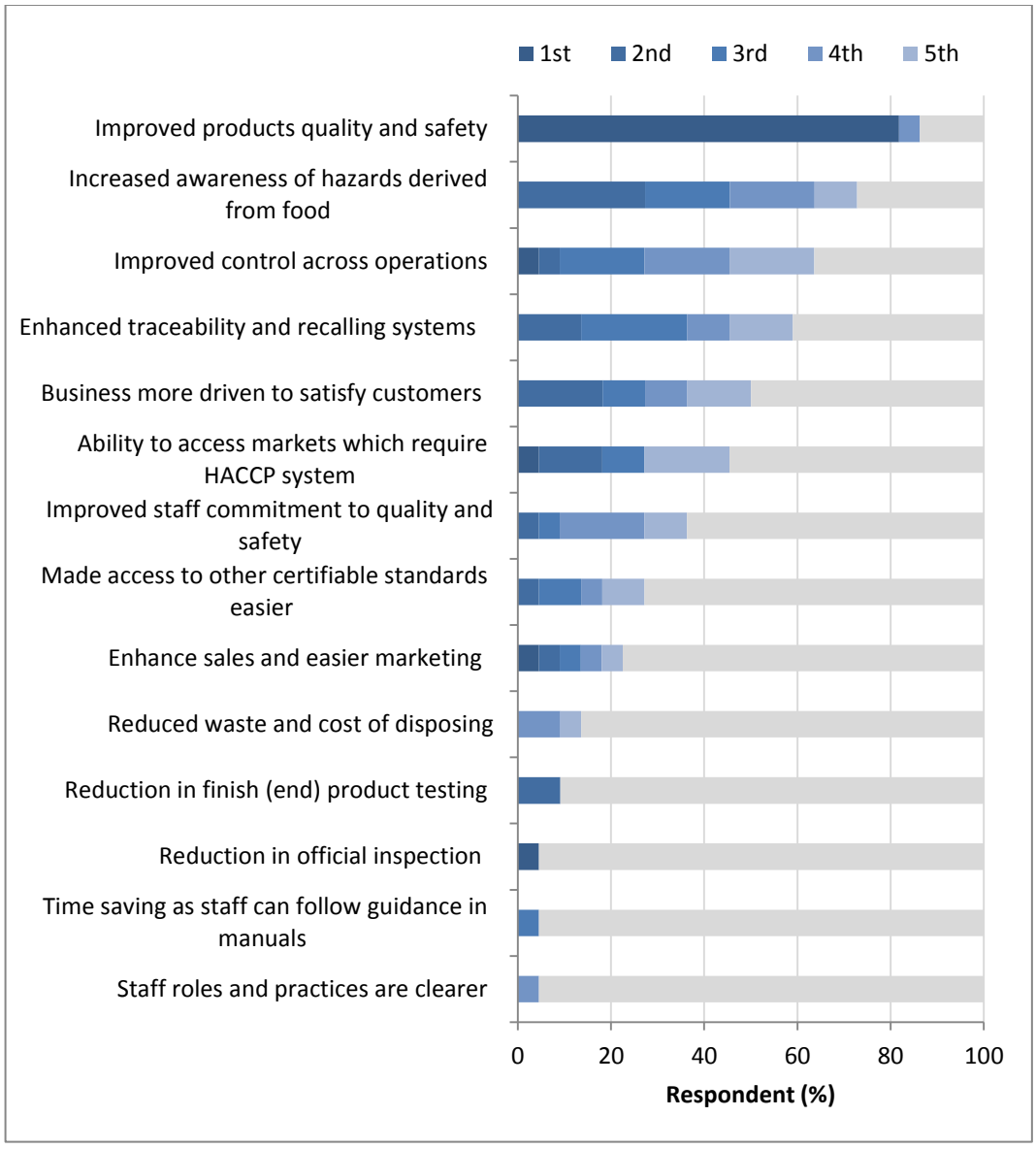


Figure 23: The HACCP processors respondents of the benefits of implementing HACCP in the seafood processors based on a rank from 'first' (1st) to 'fifth' (5th)

5.5 Economic impact of HACCP implementation

Respondents in the HACCP group were requested to provide the different costs related to the preparation, implementation and operation of their HACCP system. Each processing plant will have had individual characteristics and this will greatly influence the costs involved.

A further complication was that most of the respondents were unsure of the exact costs involved (or unwilling to provide them). The respondents reported the preparation cost inclusive of overall structure and human resources to be the highest (mean of 401,000 $US) due to structural changes in particular for the older processors and the need to employ qualified staff to operate the HACCP system.

The HACCP implementation cost (HACCP certification, audit cost and external consultancy service) were very small in comparison (mean of 3380 $US) although it can be noted that the FQCC provided support for these services free of charge. HACCP certification is also provided by the FQCC rather than by a commercial certification body with audits carried out by Ministry officials, thereby reducing the processors' costs further. It has been reported that high operating and certification costs of HACCP system were the major problems for Mexican's meat enterprises adopting HACCP systems (Maldonado-Siman et al., 2014).

The highest reported expenditure was in the investment for new equipment and machines (322,000 $US). Annual average operational costs were 63,030 $US, with the largest component being waste management followed by training programmes, maintenance of equipment and machines and product testing (microbial, chemical, physical), with the least being record keeping. Khatri and Collins (2007) found similar outcomes with staff training, audit costs and product testing to be the largest cause of cost elevation in the processors. Time and money with lack of employee training were seen as the greatest constraints of adopting HACCP in the food business in Turkey (Murat Bas et al., 2007). Lack of understanding of HACCP system and a need of continuous training were other constraints mentioned by (Tomasevic et al., 2013). Investment in new equipment, product testing and staff training were also deemed to be the main operational costs for the Mexican food industries (Maldonado et al., 2005).

Although some average figures have been given above, in general the processors faced difficulties in determining the actual cost of adopting and implementing their HACCP systems and caution is needed in interpreting the data. However, in a previous study of the seafood industries in the Sultanate of Oman, Qatan (2010) estimated the greatest cost was around 98,000 O.R per processor for structural changes although he also stressed the difficulty in obtaining reliable cost data.

It can also be commented that the FQCC organizes an annual training course by hiring a consultant to conduct professional training on FSMS targeting seafood processors and inspectors in order to overcome and reduce the cost burden of training on these processors and enhance their skills and knowledge. The processors showed eagerness to receive this type of training from the authorities as indicated by (Qatan, 2010; Zaibet, 2000).

5.6 The effectiveness of food safety legislation and control authorities

Respondents evaluated different aspects of the regulatory control of seafood quality and safety. Most respondents were subject to the Fishery Quality Control Regulations (MD No. 12/2009) with the majority of the HACCP processors rating it as excellent in implementation. However, the non-HACCP processors had more varied views with opinions differing from 'excellent' to 'fair'. In most cases the Aquaculture and Related Quality Control Regulations (MD No. 177/2012) were not implemented as most of these processors did not process aquaculture product at the time of conducting this survey.

The implementation of the general Food Safety Law (84/2008) that was issued to protect consumer well-being was rated very good by the HACCP processors but poorly by the non-HACCP processors and, more worryingly, most of these processors were not fully aware of its existence. Nevertheless, when the officials were requested to give an opinion on the implementation of the legislation within the steps of the seafood chain (fishermen, landing sites, truckers, transportation prior to processing, processors, fish farms, distribution of processed products and markets), their response indicated that the part of the chain from 'processors' to 'distribution of processed products' was the strongest portion implementing all the legislation related to food and seafood quality and safety with the start of the chain from 'fishermen' to 'transportation' much weaker. This result agrees with the suggestion given by Qatan et al. (2015) that there is a need for a more holistic approach

to promote the quality and safety of seafood throughout the entire chain from "net to plate". The quality and safety of seafood products cannot be maintained if the initial input is uncertain (Qatan et al., 2015).

The official regulation for seafood safety and the official control activities were assessed for their effectiveness and the respondents were requested to evaluate them based on a five-point Likert scale ranging from ''Excellent' to 'Poor'. The responses were than split into three clusters; 'agree' for those responding with 'excellent' or 'very good', 'uncertain' for responses 'satisfactory' and 'disagree' for responses 'fair' and 'poor' as shown in Table 12.The Fishery Quality Control Regulation (12/2009) is perceived by the Ministry as the key legal document. Respondents were asked to assess the strength of this regulation (see Table 12). All the three groups were in agreement in terms of the regulation ensuring the seafood quality and safety requirements. The officials and HACCP processors rates were in agreement with the regulation meeting the needs of different sized processing establishments although the non-HACCP processors were divided between being in agreement and disagreement. In discussion with them it was viewed as being too complicated and not easy to be implemented in their smaller operations. Asked to consider whether the regulation provides consistent application of the seafood safety requirements across different establishments in Oman, the officials and HACCP processors generally agreed but the non-HACCP processors were again split for similar reasons as before.

The effectiveness of the official control activities in enhancing seafood quality and safety was also rated by the groups and the results, split into 3 clusters (Table 12). One element of the official control operation is a sampling plan operated by the FQCC to collect samples from the processors which are submitted for physical, microbiological and chemical analysis with the emphasis on ensuring that the HACCP processors are complying with the requirements. These were seen as effective control procedures by the officials and HACCP processors but the non-HACCP processors were less consistent with their responses being between in agreement and uncertain and discussion indicated that they considered it a cost burden on small scale processors. Less than half of the officials (46%) supported the effectiveness of the 'Recall and Revision' protocol in handling rejected products from markets. However, subsequent discussion suggested some uncertainty on

this point with some officials being unaware of this aspect of the legislation. Overall they felt that the current status of this system is not effective in protecting the safety and quality of seafood products and needs to be improved. In this case both groups of processors considered this protocol effective. The current level of penalties that apply to those caught breaking the rules within the Fishery Quality Control Regulation (12/2009), was well supported by both processors but not supported by the officials (with only 20% in agreement) who regarded them as too lenient and not sufficient to encourage compliance with the regulation. The Fisher's exact Chi-square test indicated a significant difference ($p < 0.05$) in the views of the three groups in the study for two items: the consistent application of the seafood safety requirements across different establishments and the level of violation and penalties imposed by the regulators.

When asked to indicate the frequency of official inspection (results not shown), 59% of the HACCP processors indicated that they were inspected monthly which correlated well with the view of the officials (with 71% giving this response). However, only 21% of the non-HACCP processors gave this response with a larger proportion (29%) selecting 'random inspection'. Subsequent discussion indicated that the processors situated close to Muscat (where the FQCC is based) are inspected frequently but the inspection is much less frequent for the more distant processors (for example, in Al-Wusta and Al-Sharqiya governorates). On the other hand, the non-HACCP processors were subject to less inspection and subsequent discussion actually indicated that they would be in favour of more inspection visits as they see them as educational and providing an opportunity to improve their staff compliance. Overall, excessive official inspection was not considered a barrier effecting the enhancement of the business operation by either the HACCP or non-HACCP processors (Figure 16).

Table 12: The effectiveness of the official regulation and control activities

	TARGETE-D Groups*	AGREE Frequency (%)	UNCERTAIN Frequency (%)	DIS-AGREE Frequency (%)	X^2 *test* *p*- value**
The assessment of the strength of the Fishery Quality Control Regulation (12/2009) requirements in achieving the following:					
Ensuring seafood quality and safety	A B C	13 (86.7%) 19 (86.4%) 10 (71.4 %)	1 (6.7%) 3 (13.6%) 2 (14.3%)	1 (6.7%) 0 (00.0%) 2 (14.3%)	0.425
Meeting the needs of different sized processing establishments	A B C	11 (73.3%) 14 (63.6%) 5 (35.7%)	3 (20.0%) 6 (27.3%) 4 (28.6%)	1 (6.7%) 2 (9.1%) 5 (35.7 %)	0.171
Providing consistent application of the seafood safety requirements across different establishments in Oman	A B C	9 (60.0%) 15 (68.2%) 6 (42.9%)	6 (40%) 4 (18.2%) 2 (14.3%)	0 (00.0%) 3 (13.6%) 6 (42.9%)	0.030
The effectiveness of the official control activities in enhancing seafood quality and safety:					
Inspection process	A B C	10 (66.7%) 16 (72.7%) 8 (53.3%)	4 (26.7%) 5 (22.7%) 5 (33.3%)	1 (6.7%) 1 (4.5%) 2 (13.3%)	0.807
Auditing process (QC Holder)	A B	12 (80.0%) 17 (77.3%)	2 (13.3%) 3 (13.6%)	1 (6.7%) 2 (9.1%)	1.000
Sampling plan	A B C	9 (60.0%) 13 (59.1%) 7 (46.7%)	5 (33.3%) 8 (36.4%) 6 (40.0%)	1 (6.7%) 1 (4.5%) 2 (13.3%)	0.883
Sample analysis	A B C	9 (60.0%) 12 (54.5%) 7 (46.7%)	6 (40.0%) 8 (36.4%) 6 (40.0%)	0 (0.0%) 2 (9.1%) 2 (13.3%)	0.815
Pre-requisite programs such as GHPs& GMPs	A B C	12 (80.0%) 15 (68.2%) 10 (66.7%)	2 (13.3%) 5 (22.7%) 3 (20.0%)	1 (6.7%) 2 (9.1%) 2 (13.3%)	0.936
HACCP/ISO22000	A B C	10 (66.7%) 19 (86.4%) 9 (60.0%)	5 (33.3%) 2 (9.1%) 3 (20.0%)	0 (0.0%) 1 (4.5%) 3 (20.0%)	0.105
'Recall and Revision' protocol in handling rejected products from markets	A B C	7 (46.7%) 13 (59.1%) 9 (60.0%)	4 (26.7%) 8 (36.4%) 4 (26.7%)	4 (26.7%) 1 (4.5%) 2 (13.3%)	0.449
Level of violation and penalties that apply to those caught breaking the rules within the Fishery Quality Control Regulation (12/2009)	A B C	3 (20.0%) 16 (72.7%) 8 (53.3%)	7 (46.7%) 4 (18.2%) 2 (13.3%)	5 (33.3%) 2 (9.1%) 5 (33.3%)	0.013

* A= Officials (n=15); B= HACCP-Processors (n=22); C=Non-HACCP Processors (n=15)

** $p < 0.05$

As well as conducting inspections, the government can provide support to improve the safety and quality at processors. The respondents evaluated the government contribution based on a five point Likert scale ranging from 'Excellent' to 'Poor' which we have further clustered into three groups: 'agree' for those indicating 'excellent' or 'very good', 'uncertain' for 'satisfactory', and 'disagree' for 'fair' and 'poor' as shown in Table 13. Divergent responses were obtained for this question. However, all groups were in agreement with regard to officials response on enquires about quality and safety issues faced by the industry'. On the point relating to 'funding', it can be noted that the majority of the processors considered this to be limited although the officials tended to be more supportive of the level. Based on the views given by the study groups on the support provided by the government, the Fisher's exact Chi-square test indicated a significant difference ($p < 0.05$) for four items: funding, training, consultancy and the response by officials to HACCP enquiries.

Table 13: Assessing the government contribution to address seafood quality and safety issues in the seafood processors

QUESTIONNAIRE STATEMENTS	TARGETED GROUPS*	AGREE Frequency (%)	UNCERTAIN Frequency (%)	DIS-AGREE Frequency (%)	X^2 *test* *p*- value**
Funding	A	6 (40.0%)	5 (33.3%)	4 (26.7%)	0.022
	B	3 (13.6%)	3 (13.6%)	16 (72.7%)	
	C	1 (6.7 %)	2 (13.3%)	12 (80.0%)	
Training	A	5 (33.3%)	5 (33.3%)	5 (33.3%)	0.027
	B	10 (45.5%)	5 (22.7%)	7 (31.8%)	
	C	1 (6.7%)	2 (13.3%)	12 (80.0 %)	
Consultancy	A	10 (66.7%)	3 (20.0%)	2 (13.3%)	0.019
	B	13 (59.1%)	5 (22.7%)	4 (18.2%)	
	C	2 (13.3%)	5 (33.3%)	8 (53.3%)	
Technical advice	A	11 (73.3%)	2 (13.3%)	2 (13.3%)	0.068
	B	14 (63.4%)	5 (22.7%)	3 (13.6%)	
	C	4 (26.7%)	4 (26.7%)	7 (46.7%)	
Communication with establishment	A	10 (66.7%)	4 (26.7%)	1 (6.7 %)	0.160
	B	15 (68.2%)	3 (13.6%)	4 (18.2%)	
	C	5 (33.3%)	5 (33.3%)	5 (33.3%)	
Response of officials to enquires about quality and safety issues faced by the industry	A	11 (73.3%)	3 (20.0%)	1 (6.7 %)	0.667
	B	13 (59.1%)	5 (22.7%)	4 (18.2%)	
	C	7 (46.7%)	5 (33.3%)	3 (20.0%)	
Response of the officials to enquires about the HACCP system	A	13 (86.7%)	1 (6.7 %)	1 (6.7 %)	0.008
	B	17 (77.3%)	3 (13.6%)	2 (9.1%)	
	C	6 (40.0%)	1 (6.7 %)	8 (53.3%)	

* A= Officials (n=15); B= HACCP-Processors (n=22); C=Non-HACCP Processors (n=15)

** $p < 0.05$

5.6.1 Authority's inspection reports

A number of reports of inspections carried out by the FQCC inspectors were analysed to verify the data obtained from this survey. In general, non-compliances identified in these reports were in the maintenance of facilities and equipment, cleanliness, staff hygiene, maintaining and recording time and temperature, record keeping, coding of the seafood products (traceability), recording of sensory evaluation and temperature during fish receiving and calibration of the equipment. Most of these comments were due to the improper implementation of prerequisites prior to adopting the HACCP system. The finding of the study of M. Bas, Ersun, and Kivanc (2006) in Turkey is similar to our findings. In particular, that study had highlighted inadequate time and temperature control, handwashing practices and low level of general hygiene.

Despite being repeated in subsequent reports; the inspection comments were frequently ignored by the processors delaying improvements. This could be due to a lack of communication between the officials and the processors, and insufficient training on seafood quality and safety aspects for the processors. Ensuring effective communication links between the regulatory authority and the seafood processors will enhance the efficacy and effectiveness of the inspection process (Qatan, 2010) but should be supported by enhanced professional training of both inspectors and processing staff.

Food processors are responsible and accountable for the safety of the food they produce as stated in Article 3 of the Food Safety Law (RD No.8/2008) and Article 10 of the Food Safety Regulation (MD No.2/2010). They are also required by Article 7 of the Fishery Quality Control Regulation to register to obtain a quality and safety control certificate (Ministerial Decision, 2009). By being registered, processors sometimes consider that this is sufficient to indicate compliance with their legal responsibilities and they rely on officials to tell them if this is not the case. Nonetheless, the processors should themselves be taking a proactive approach towards compliance. The questionnaire asked officials to grade the effectiveness of the inspection report in covering the pre-requisite programmes (such as GMPs and GHPs) and the HACCP principles (and related CCP procedures) on a five point Likert scale from 'Excellent' to 'Poor'. The responses were also split into three clusters: 'agree' for those responding 'excellent' or 'very good', 'uncertain' for the

response ‘satisfactory’ and ‘disagree’ for responses ‘fair’ and ‘poor’ as shown in Table 14-A. Although their responses were mostly supportive, it was observed that the inspection reports were mostly focusing on the different segments of the processing layout. With the exception of temperature recording, less attention was given to the identified CCPs for each processor. Again the limitations were analysed on a five point Likert scale and split into three clusters labelled ‘agree’ (responses ‘significant’ or ‘major’, ‘uncertain’ (‘moderate’ barrier) and ‘disagree’ (‘limited’ or ‘not a barrier’) as shown in Table 14-B. The officials considered lack of training, lack of laboratory support and appropriate facilities and lack of continuity and commitment of the staff from the processors as important barriers. Scattering of the responsible authorities within the ministry and lack of awareness of HACCP and its pre-requisite programs (GHPs& GMPs) by the seafood establishments were regarded as moderate barriers limiting their ability to enforce and meet the national legislation requirements.

Table 14: The effectiveness of the inspection report and the limitation faced by the inspectors to meet national legislative requirements (Officials, n = 15)

A.	**The effectiveness of the inspection report in covering the following:**	**Agree Frequency (%)**	**Uncertain Frequency (%)**	**Dis-Agree Frequency (%)**
•	Good Manufacturing Practices (GMPs)	10 (66.7%)	4 (26.7%)	1 (6.7%)
•	Good Hygiene Practices (GHPs)	9 (60.0%)	6 (40.0%)	0 (0.0%)
•	HACCP	9 (60.0%)	4 (26.7%)	2 (13.3%)
B.	**The factors limiting the ability of the inspectors to enforce the regulations related to seafood quality and safety control during performing the inspections duties**	**Not/Limited Barrier Frequency (%)**	**Moderate Barrier Frequency (%)**	**Significant/Major Barrier Frequency (%)**
•	Lack of time	10 (66.7%)	2 (13.3%)	3 (20.0%)
•	Lack of training	6 (40.0%)	2 (13.3%)	7 (46.7%)
•	Lack of laboratory support/facilities	4 (26.7%)	5 (33.3%)	6 (40.0%)
•	Lack of transport	9 (60.0%)	5 (33.3%)	1 (6.7%)
•	Scattering of the responsible authorities within the ministry	6 (40.0%)	7 (46.7%)	2 (13.3%)
•	Low priority within the government to effectively enforcing legislation	8 (53.3%)	5 (33.3%)	2 (13.3%)
•	Lack of continuity and commitments of the staff from the establishments	3 (20.0%)	4 (26.7%)	8 (53.3%)
•	Lack of continuity of the staff from the ministry	10 (66.7%)	4 (26.7%)	1 (6.7%)
•	Lack of awareness of HACCP and its pre-requisite programs (GHPs& GMPs) by the seafood establishments	4 (26.7%)	8 (53.3%)	3 (20.0%)

5.7 Conclusion

This study has assessed the technical barriers and benefits associated with the implementation of FSMS such as HACCP and related prerequisite programmes in the seafood processors in the Sultanate of Oman. In particular, differences between processors operating with or without a HACCP system in place have been identified. The implications of handling practices in the seafood supply chain on the safety and quality of seafood, seafood trade and the cost implications in implementing HACCP based food safety management systems were also assessed.

The responses have shown significant gaps in various aspects which undermine the effectiveness and success of implementing safety and quality requirements to meet national legislative obligations. The presence of a small-scale or artisanal sector represents a challenge in attempting to adopt modern food safety schemes and create a modern processing sector. Modernization of fishing vessels and their ability to fish at a greater range should overcome some of the current problems faced by the industry. Improved continuity of supply could reduce the impact of, or the need for, the MAF export ban that has damaged the export revenues of seafood processors.

Adoption of HACCP by the seafood processors has mostly been driven by external requirements imposed by export markets; it has not been a decision of the processors themselves to enhance their systems. Nonetheless, the requirement can be considered to be market-driven although the pressure has come from the more lucrative markets – especially that of the EU. Although the legal requirements locally require certain elements of FSMS, HACCP enforcement is not compulsory thus making the decision on implementation for many processors a commercial judgement rather than a fundamental quality and safety issue.

The majority of the surveyed seafood processors were small and medium enterprises (SMEs) which is the most numerous food industry sectors in the country. Large and medium food enterprises are less reluctant to adopt HACCP, whereas the small-sized food enterprises have less incentive and are therefore less willing to adopt it.

The survey has shown that HACCP implementation is made complex by a lack of well-defined prerequisites programmes and a lack of understanding of general HACCP principles. This leads to a complete dependency on HACCP to control all the hazards that arise at the different processing steps through many Critical Control Points (CCPs) increasing the financial burden of implementing the system. The requirement to restructure the facility was considered by all the participants of the study as the top barrier to the adoption of HACCP and the greatest cost. Investing in equipment was also highlighted as a major cost. However, when asked to identify the negative impacts of adopting HACCP systems, the HACCP processors listed the costs of product testing as being the biggest with the cost of equipment coming second. However, the top benefits perceived for HACCP were improving product quality and safety and enhanced market competitiveness allowing access to the most dynamic and highly competitive markets locally, regionally or internationally.

Further efforts are needed by the authorities to improve the entire infrastructure including fishing vessels, landing sites, markets and distribution facilities. Adopting a proactive approach throughout the entire chain from "net to plate" is fundamental to supplying seafood products which are safe and of the correct quality - this cannot be achieved without appropriate controls.

The nature of the risks associated with unsafe seafood products must be well communicated to the different stakeholders. In particular, each stakeholder should be accountable for any failure that could threaten the well-being of the end users. There is a need for sustainable training for both the authorities and employees of the processors to enhance their knowledge of HACCP and prerequisites. This would boost the confidence of inspectors allowing them to be more rigorous in enforcing national legislation. Educating consumers is also an important element as they are the end users and the driving force and, once educated and with appropriate knowledge, they can impose pressures on the food enterprises to change their attitudes and behaviour towards adopting appropriate FSMS in their businesses.

Overall the study has identified the major concerns where attention is needed. These include:

- poor attitudes and understanding toward HACCP and prerequisite programmes
- lenient enforcement
- the lack of training and consultancy organizations in the country
- a lack of awareness
- lack of food safety expertise
- the overlapping and disorganized structure of the regulatory authorities in the country
- a poor match in the inspection resources in the country and the location of the processors.

These lead to the slow development of a proper food safety culture and inadequate adoption of HACCP principles. Appropriate policies and strategies for effective food control to overcome fragmented legislation, multiple jurisdictions, and limitations in surveillance, monitoring and enforcement will enable the authorities to protect public health by enhancing seafood safety and quality and facilitate internal and external trade (FAO/WHO, 2003).

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CHAPTER 6

6 OVERALL DISCUSSION

Chapter 1 established a number of questions that formed the basis of the research presented in Chapters 2-5. In this Chapter, those questions are considered further taking into account the results of the research.

6.1 How can Oman enhance the safety and quality of seafood products to satisfy the requirements of (a) local markets, and (b) export markets?

In Oman, the fisheries sector is under the jurisdiction of the Ministry of Agriculture and Fisheries with its activities governed by the Marine Fishing and Protection of Living Aquatic Resources Law promulgated in 1981 by Royal Decree (RD) 53/81 known as "The Fisheries Law". Fisheries production from the artisanal fishery is the main contributor of fish supply in the country (~98%), and is the chief source of economic revenue through net export earnings (FSB, 2015). More than half of the annual production of fishery products is exported to regional and international markets. The lucrative markets are less targeted due to their stringent requirements on product safety and quality.

Food trade globalization has, in general, introduced new food risks and to overcome them most of the developing countries have tightened their requirements for food safety and quality to comply with their consumers' demand and protects their health. These stringent requirements have been challenging for the developing seafood producer countries. In order to overcome the complexity of these requirements and have the ability to export internationally, many of the developing countries have adopted a dual system to meet the internal and external markets requirements.

6.1.1 Local markets

In order to understand the complexity of the seafood supply chain from net to plate within Oman, the local fish supply chain was analysed in detail (see Figure 10, Chapter 4). The

key legislative documents and the administrative structures were highlighted. From that research, the challenges faced in the seafood supply chain were summarized as follows:

i. The seafood supply chain is dominated by artisanal fisheries and traders. Given the high ambient temperatures found throughout the year, any inadequacy in the cold chain management particularly for freshly landed fish can be detrimental to their safety. Post-harvest losses experienced by this sector can reduce the fisheries contribution to the national economy and to the country's sufficiency in terms of food security.

ii. The fish marketing system in Oman consists mainly of primary, secondary fish markets and with retail markets for sales to the consumers. Many of these markets have a quite basic structure. In order to improve food safety control, the control of the primary and secondary markets has recently been reallocated to the MAF to bring the entire seafood supply chain under one authority.

iii. The current seafood supply chain often involves lengthy handling and distribution steps before seafood reaches the final consumers.

iv. Maintaining quality during transport is vital and the existence of some vehicles with poor handling and inadequate cold chain control creates critical food safety issues. Despite the existence of legislation that regulates the conditions and specifications for the transport (MD No. 29/2004), implementation is limited.

v. The majority of seafood processors in the country use fish species harvested locally to produce mainly fresh and frozen seafood products with limited value added processed products. The adoption of HACCP principles by these processors has progressed very slowly.

vi. Traceability is one of the shortfalls of the current seafood supply chain since the harvesting area is often the only information supplied by the producers. The construction of more well-organized and managed central markets will enable the use of better labelling systems in these markets. This will give enhanced traceability from harvest through the supply chain and thus providing products with enhanced quality and safety attributes.

vii. Seafood products reach consumers by three main routes: local, regional and international markets. The first two routes are similar with limited levels of health

and safety control. However, these are more intensive for international markets particularly the lucrative ones. Therefore, stakeholders operating within these markets are more compliant with the national and international safety and quality requirements.

viii. The adoption of food safety management systems, including HACCP, is mandatory to meet the requirements of international markets. As HACCP is not compulsory for most food processors and is mostly market driven, persuading all processors to implement it has been challenging.

ix. The regulatory framework governing seafood safety in the country is well structured and comprehensive in covering all aspects of the seafood supply chain including safety, quality, marketing and transport. However, implementation has been more difficult.

In order to overcome safety and quality issues in the current seafood supply chain and to enhance traceability, a well-structured supply chain should be developed to facilitate the implementation of requirements set by the national and international laws and legislation. Subsequent research suggests that some adjustments should be proposed to the structure of the seafood supply chain presented earlier in (Figure 10, Chapter 4). These adjustments have been highlighted in red bold font as shown in Figure 24 of this chapter, followed by a detailed diagram of the proposed improvements in contrast to the existing measures as shown in Figure 10.

It is recognised that there would be challenges in executing the proposed changes given the current circumstances in Oman. Nonetheless, there have been significant improvements recently. A SWOT analysis (shown in Figure 13, Chapter 4) was conducted during the analysis of the seafood supply chain and presented a lot of strengths and opportunities. The government has made progress in promoting and modernizing the sector but the process has not been easy and still experiences challenges and delays. After conducting an overview investigation of the seafood supply chain and its context within the overall national food control system, this study provides some solutions to help resolve some of the current obstacles faced by the sector. Some of these enhancements may be appropriate

and could be achieved given the current situation of the country. However, some may not yet be feasible as they require a lot of adjustments in the resources.

The infrastructure of seafood distribution and marketing is still deficient. The safety and quality control of seafood products directed to the domestic market is less stringent than that for the export market. The proposed enhancements to the existing structure of the supply chain have targeted the weaknesses in the structure and have identified 6 factors for improvement as shown in Figure 24. National regulation covering the whole seafood supply chain has been detailed in Section 4.5.2 and Figure 12, Chapter 4 should be implemented at the different stages of the supply chain. Supplementary international codes such as "The General Principles of Food Hygiene at the (CAC/RCP 1-1969, Revision 2003), and the "Code of Practice for Fish and Fishery Products (CAC/RCP 52-2003, Revision 2008)" are highly recommended for enhancing the safety and quality of the end products.

Suggested improvements based on Figure 24 and Figure 25 are detailed as follows:

6.1.1.1 Artisanal *fishery:*

As stated in previous chapters, the small-scale fisheries, known as 'artisanal', provide most of the fresh fish produced in the country. Details of the types of vessel used can be found in Section 4.2.2.1 of Chapter 4. Most of these vessels lack adequate handling and storage and the harvested fish are usually offloaded directly onto the beaches or at the landing centres. The caught fish are often sold to consumers who purchase directly from the fishermen to obtain better quality and lower prices. Due to the low capacity of these vessels, it is often difficult to use ice or cooling devices on board. Often the fish is caught in the early hours of the day to avoid high temperatures and to retain the freshness of the catch. In the interview based qualitative survey carried out on the seafood processors (Chapter 5), all participants believed that the main factors leading to deterioration in the safety and quality of the seafood products were the inadequate control of time and temperature and poor ice availability at the primary stage. Officials participating in the study considered the current practices adopted by the fishermen, landing sites, transportation by middlemen/truckers are the main factors contributing adversely to the quality and safety of seafood products. Even

though the initial input may be of high quality, the quality and safety of final products will be uncertain (Qatan et al., 2015).

For a sustainable catch and to overcome post-harvest losses, the current fishing fleet should be modernized and adopt modern food safety schemes. This will help create a modern processing sector, which, in turn, will enhance export revenue. In proposing an upgrade to this fleet, the MAF has been upgrading the existing fleet of coastal fishing vessels operated by local investors, in an attempt to replace international contracted trawlers. This step was undertaken after the restriction that was imposed on fishing trawlers by the government in order to prevent overfishing and ensure a sustainable marine environment.

Aquaculture is in its infancy and its contribution is small in comparison to the wild fisheries. Its production would normally follow similar routes to market as the wild fishery products with appropriate quality and safety checks. However, as the supply is more regular with quality and safety checks in place, it is also recognised that direct supply from the farms to the processors will be possible.

With regard to imported seafood products, a stricter approach is required with testing conducted at the point of entry before being allowed into the country.

6.1.1.2 Direct sales at landing:

The contacts between the primary producers (in this case the "fishermen") and the final receiver ("consumers") should be limited. Traditionally, local consumers have preferred fresh fish and the best way to obtain this has usually been by direct purchase from fishermen (A. Omezzine, 1998). Due to the rapid degradation of quality and freshness with the simple techniques for harvesting and handling, purchasing from other outlets can mean that poorer quality is available. This prompts consumers to approach the fishermen in their vessels or landing sites where the freshness and quality of the fish is at its highest. However, there has been an increase in marine pollution due to industrial and agrochemical residues and with the dynamic oil industry in the area - around one third of the world's oil production passes through the Strait of Hormuz to the north of the country. Climate changes and the frequent occurrence of harmful algal blooms (HABs) and parasites in the Omani water pose risks to public health and certainly to those who prefer direct purchase

from the primary producers without any testing of their purchases. To overcome and reduce these risks, the best route to follow is to obtain seafood products via controlled outlets.

6.1.1.3 Transport (inner and external):

Transport is a critical element in any food supply chain, and is particularly vital for seafood products due to its high perishability. The lack of management and control of the cold chain can be detrimental, in particular, to the fresh seafood supply chain. The country's hot climate with elevated temperatures (above 40^{o}C) much of the year poses a very high risk to safety of transported products if the time and temperature have not been well controlled. Taking into account the 3165 km long coastline extending from the Musandam Peninsula at the entrance of the Arabian Gulf in the north to the Republic of Yemen in the southwest, the distance between some of the landing sites distributed among several governorates on the coastline and the outlets are very long. Therefore, seafood products are often exposed to a lengthy distribution chain before reaching consumers.

Despite the existence of a good legal framework governing the whole sector from net to plate (as presented in Figure 12, Chapter 4), regulations (MD No. 29/2004) establishing the conditions and specifications for transportation have not been fully implemented. The ministry is looking for other ways to improve this sector through funded projects and this work is still in process.

The regional markets face the same obstacles due to products having lengthy transport routes and a subsequent loss of quality and safety. On the other hand, for products intended for export to lucrative international markets with high financial returns, control conditions are well executed from the net to plate.

The control measures applied in this segment of the transport network could be broadened to cover all the other elements of the transport network. Management of the cold chain from harvesting to the end user could be achieved by applying appropriate temperature checks on the vehicles and other parts of the distribution chain. The vehicles used should be upgraded to fulfil the requirement stipulated by Regulation (No. 29/2004) and hygiene requirements should be in place regardless the size or capacity of the vehicle used for

transport. Additionally, to overcome the shortfall of this segment, the primary production of seafood products (artisanal and commercial) should land their catch directly into the coastal wholesale markets at the landing centres or transported using well controlled vehicles to the internal wholesale markets as proposed in Figure 25 of this chapter.

6.1.1.4 Seafood markets:

The wholesale markets constructed at the landing sites are more appropriate in improving the product quality and safety. These types of markets may help to overcome the lengthily distances from harvesting to marketing. The location of ice factories at landing sites will also enhance the cold chain management and reduce post-harvest affects. More details of the hygiene requirements and controls of fish markets have been published by (FAO (2013)).

Besides improving the quality and safety of the primary products, these markets will help regulate the fish supply in the different governorates beside cost management, whereas coastal markets are too small in capacity to carry such a load and mange it appropriately. To overcome traceability issues in distribution, landed products should be labelled with the required information (such as scientific name, country of origin, size and net weight, batch code, shelf-life, preservation method and etc.) specified in Article (41) of the Fishery Quality Control Regulation (12/2009). This is currently only carried out in one of the internal wholesale market and at EU certified seafood processors. Once traceability has been implemented, it will enable the operation of a recall system. Currently the existing wholesale market has some control in place as the product enters the market but only limited control on leaving. The construction of this wholesale market provided an affective improvement in the fish supply chain. However, extending this will take time to overcome years of mishandling in this sector and fragmentation in the supply chain. Future wholesale markets should be constructed in the coastal area to shorten the length of fish transportation given the hot weather throughout the year.

With regard to quality and safety checks, organoleptic and veterinary health checks should be carried out on the landed seafood. Further quantitative analyses, as shown in Figure 26, require samples to be sent to designated laboratories for quality and safety check. Some of these checks are already carried out at the current market. Microbiological, environment

and chemical contaminants should be analysed at this stage before entering the supply chain to rule out any health risk to consumers. A detailed diagram of the proposed measures, in contrast to the existing measures, is provided in Figure 26.

6.1.1.5 Processors:

Two types of seafood processors serve the domestic, regional and international customers; the HACCP implementers and non-HACCP implementers. The latter mostly target the less demanding markets in terms of quality and safety requirements. More detailed discussion of these aspects is provided in Section 6.1.2 below.

6.1.1.6 Safety and quality control measures:

Seafood products, either wild or cultured, are highly perishable and prone to rapid degradation due to the action of microbial enzymes and biochemical reactions, which can be aggravated by raised temperatures and mishandling. Traditionally in many parts of the world, the safety and quality checks were performed at the end of a processing line by random sampling (FAO, 2013). In order, to assure that products are risk free, a risk-based approach is recommended. Figure 26 was constructed showing the current measures carried out at the supply chain and the ideal measures proposed to overcome the reactive approach and work toward a proactive one. Hazards that are likely to occur in seafood products and which should be subject to control have been documented in the Fish Quality Control Regulation (No. 12/2009) with their acceptable limits. When exporting to the EU, European Union requirements applicable to fish and fishery product from third country must be applied. More details of the relevant regulations and directives were given in Chapter 2.

Figure 26 presents some of the analysis required at the different stages of the supply chain. Environmental and chemical contaminants are best checked at the primary stage. Conducting them early prevents processors bearing the cost of laboratory tests and prevents poor quality and unsafe materials being distributed. It can be noted that product testing was considered one of the barriers to implementing HACCP during the quantitative survey on the processors.

Once the seafood products enter the supply chain, more routine checks should be carried out at the markets and verification check at the processing stage as indicated in Figure 26. Current procedures usually provide testing at the processing stage with only random sampling at the coastal and retail markets. With the establishment of the current wholesale market, more organoleptic testing has been conducted. However, currently the amount of seafood products exposed to these check is very limited since only a small proportion of landed products goes via this channel.

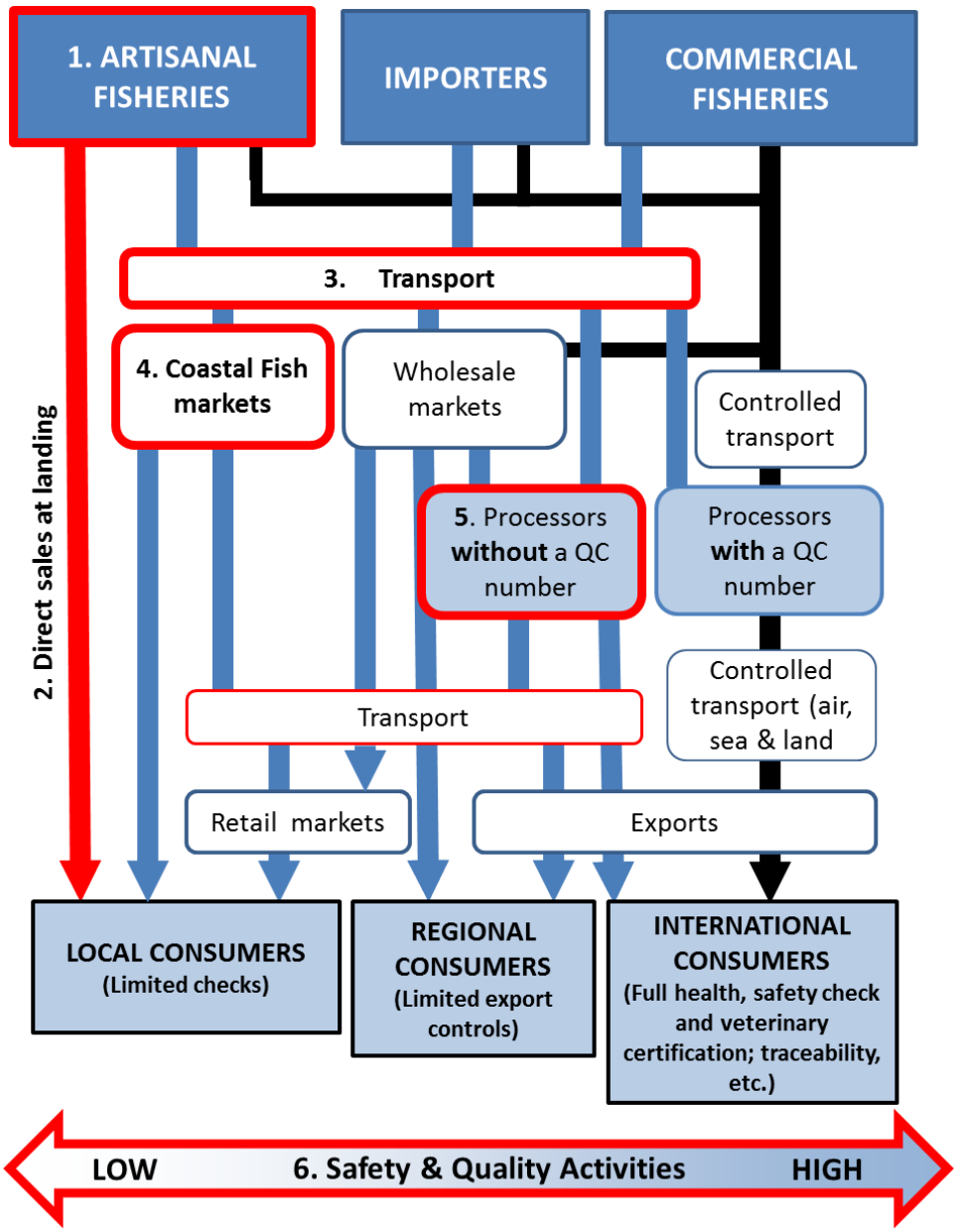

Figure 24: Highlights the shortfall of the current seafood supply chain

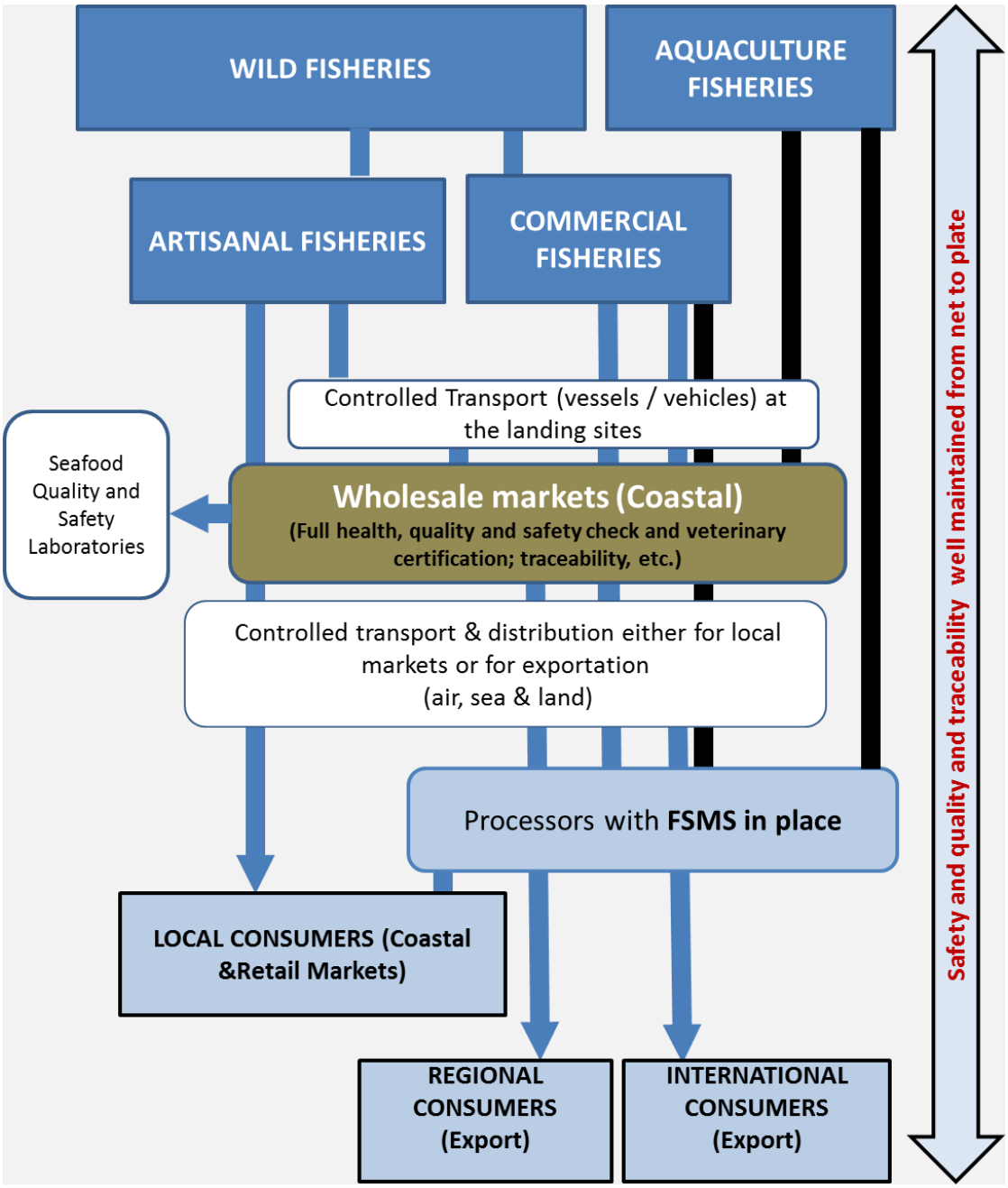

Figure 25. Proposed modification of the seafood supply chain in Oman

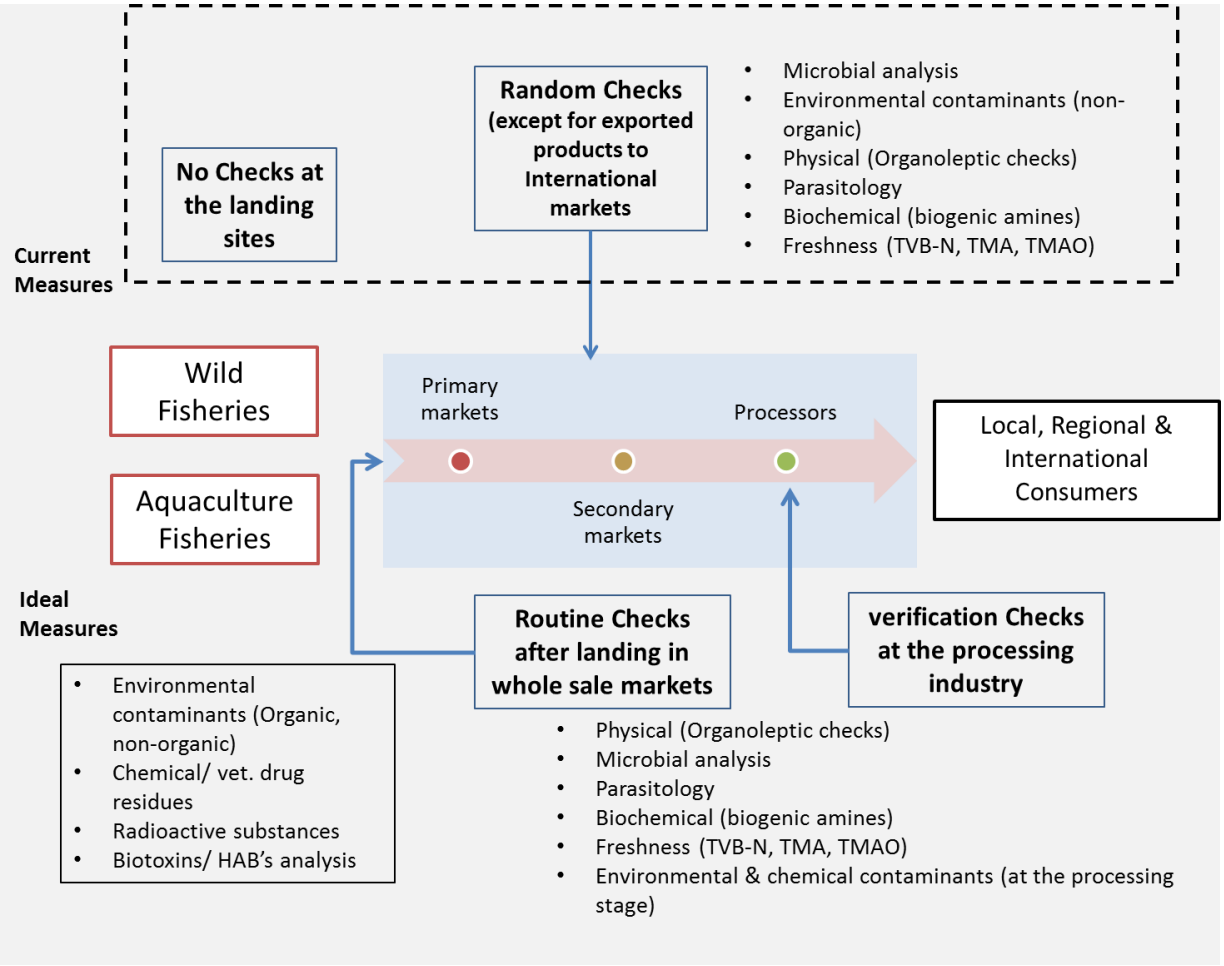

Figure 26: Proposed control measures in the seafood supply chain

6.1.2 Export market

The challenges faced by the different stakeholders within the seafood supply chain on the adoption of FSMS vary dependent upon their size and their markets. Seafood processors in Oman play a dynamic role in the food supply chain and have a high economic value. For the purposes of exporting to certain markets, the government has imposed the adoption of the HACCP system. Seafood processors therefore provide a valuable example of the issues faced when seeking to adopt and implement the system.

Qualitative survey and interviews were conducted to verify the level of implementation of the seafood safety and quality requirements stipulated in the Fish Quality Control Regulation (MD No. 12/2009) within the processors**.** The technical barriers and benefits associated with the implementation of management systems incorporating HACCP and related pre-requisite programmes in the seafood processors were assessed alongside the implications of handling practices, seafood trade and the cost implications of implementing a HACCP-based system. The study groups were further segregated into seafood processors implementing the HACCP requirements and seafood processors not implementing HACCP. To gain further insights, officials from the MAF were included.

The outcome of the survey highlighted many challenges and issues faced by the seafood processors in Oman including the following:

i. The HACCP processors and the officials were more willing to employ qualified personal; the non-HACCP processors were less likely and relied more on their own experience and that of their experienced staff.
ii. HACCP processors were more diversified in their export markets and were able to target the more lucrative markets such as the EU, Japan and the USA due their vast experience with these markets; the non-HACCP processors perceived these markets to be very challenging and difficult.
iii. The main barrier for exporting to international markets (and in particular the lucrative ones) was the restriction imposed by the government on exporting certain species which reduced their ability to meet contracts with these markets.
iv. Sudden changes in government policies without giving the business a time to adjust their practices were seen as another important barrier to seafood trade.

v. Compliance with HACCP certification by many seafood processors is largely market driven.

vi. The main factors leading to deterioration of the safety and quality of the seafood products in the current seafood supply chain are the inadequate control of time and temperature, and poor cold chain management, which is vital in ensuring the integrity of food and reducing foodborne illness.

vii. HACCP has only been implemented by the seafood processors exporting to lucrative markets; it has not been implemented by the segments of the seafood supply chain prior to the processors. Effective controls are therefore lacking in the "net to plate" continuum.

viii. There is inadequate execution of prerequisite programmes such as GMPs and GHPs mainly due to:

   a. poor attitudes, awareness and understanding toward HACCP and its pre-requisite programmes,
   b. poor knowledge of food safety concepts due to the limited training delivered to food handlers,
   c. lenient enforcement by the authorities, and
   d. the lack of training and consultancy organizations in the country.

ix. There is an overreliance on the use of CCPs to control hazards when prerequisite programmes would be more appropriate in many situations.

x. Seafood processors identified the main barrier to implement HACCP-based control systems is the large cost imposed by this system. However, officials believed the barriers to implement HACCP-based control systems were more linked to the lack of expertise, skills and commitment of the processors' staff.

xi. The overlapping structure of the regulatory authorities in the country and the distribution of national inspection resources have also been identified as an issue of concern.

xii. The current seafood supply chain depends mainly on small-scale or artisanal fisheries to supply it with the raw materials, thus representing a main challenge in sustainability of the production and hindering efforts to adopt modern food safety schemes in creating a modern processing sector.

xiii. A legal framework on seafood safety laws and regulations exists to satisfy national and international requirements. They cover most of the seafood supply chain from seafood production, handling, transportation, processing, distribution, marketing, and export but their implementation is limited and varied.

Pre-requisite programmes such as GMPs and GHPs are essential for any food business prior to the adoption of the HACCP system and should be applied at all stages of harvesting, handling, processing, storage and distribution. HACCP, combined with PRPs, allows better management of resources, timely responses to food safety issues and can assist the regulatory authorities in delivering efficient inspection and certification services (Dawson, 1995). It has been noted that the full commitment and involvement of the different stakeholders in the food supply chain is important for the successful application of HACCP (FAO, 1997).

Considering separately the research results obtained from the processors and the officials:

6.1.2.1 Processors:

The processing industries are very important segment of the overall seafood supply chain and the direct link to international trade. It is necessary to ensure that precautions have been undertaken by processors using food safety management systems such as HACCP and its pre-requisite programmes. Processed products should conform to the safety and quality requirements of the Fishery Quality Control Regulation (No. 12/2009) before being placed on the market. Management commitment in the processors is vital to ensure the implementation and maintenance of an effective HACCP system.

In order to reduce dependency on government authorities in terms of fulfilling the quality and safety requirements and the frequent visits of official, an “own check” system should be adopted by these processors. They should be more proactive and take ownership of seafood safety. The adoption of FSMS should be to safeguard the well-being of the consumers and not being market driven to satisfy external requirements imposed by export markets. HACCP enforcement should be part of the national legal requirements to ease the burden of enforcing by the official authorities. Parallel to this decision, consultancy organizations should be available to provide the right training for each segment of the

supply chain with sustainable training for all the stakeholders to enhance their knowledge of FSMS such as HACCP and its pre-requisites.

In order to overcome the economic impact of HACCP implementation, regulatory officials should assist this sector by providing funds and technical advice at each stage of GHPs, GMPs and HACCP implementation. This is actually being provided by FQCC in terms of technical advice.

In can also be noted that consumers, as the end users, are also an important element in the supply chain. They are the driving force that can put pressure on food businesses to change their attitudes and behavior towards adopting appropriate FSMS. Seafood processors would find it necessary to adapt if informed consumers were more actively seeking products with better quality and safety.

6.1.2.2 Official authorities:

The government made the adoption of FSMS, including HACCP, compulsory to meet the requirements of international markets in 2009, with the adoption of the "Fish Quality Control Regulation (No 12/2009)". These amended the previous "Quality Control Regulation for Omani Fishery Export (No 136/18)" which was merely for export markets (as shown in Figure 12 of Chapter 4). The new regulation has broadened the scope to include a wide range of provisions covering the quality control and safety of fish and fishery products for import, export and for the domestic markets. For aquaculture products, control measures are stipulated in the amended Aquaculture and related Quality Control Regulations (No 36/2004).

Implementing these requirements into the seafood sector has not been an easy task due to the various reasons mentioned in the previous chapters. The unequal treatments imposed by the regulators on the HACCP implementers with regard to fulfilling the regulation, has left these processors facing an unfair competition in the regional and international markets against the non-HACCP implementers. This is particularly a problem when the export ban was imposed by regulators. To overcome this conflict a similar safety and quality requirements should be imposed on all seafood processors accounting the various sizes and capacities of processors.

There is a need for the legal requirements to meet the conditions of the different size of processing establishments and to be well integrated within the general laws of the food safety. More enforcement resources are required throughout the country for better coverage of seafood activities. A continuous training on all aspect of FSMS should be provided to the official inspectors, to enhance their confidence and allowing them to be more rigorous in enforcing national legislation.

Establishing communication channels between the officials and the different stakeholders within the seafood supply chain is of paramount importance. Consultation with food businesses on proposed legal changes and the adoption of transitional arrangement would allow them time to adjust their practices to changes imposed by the regulators.

Modernization of the fishing vessels and their ability to fish at a greater distance is expected to improve the continuity of seafood supply. This would enable a more constant supply with seafood safety and quality requirements in place, meeting local demands and enable better targeting of more lucrative markets.

6.2 What are appropriate food control structures to achieve this?

The food supply is in general, considered safe in Oman. However, the food safety control framework is predominantly based on a traditional structure. This section considers those aspects of the research that evaluated the effectiveness of the current food controls. This involved a general survey that interviewed officials from the different food safety authorities in Oman using prepared face to face interviews and semi-structured questionnaires. The survey provides a preliminary assessment of the food safety control in Oman in relation to the five core elements of a national food safety system proposed by the FAO and WHO (FAO, 2006 and FAO/WHO, 2003): food control management, food legislation, food inspection and surveillance, official food control laboratories, food safety and quality information, education and communication.

Investigating the various challenges, weaknesses and strengths of the existing system has revealed key factors that are still deficient in comparison to the internationally accepted criteria for national food control systems. The factors identified included the following:

i. Responsibility for food safety law and regulation is shared across various governmental authorities with overlapping responsibilities – it can be classified as a 'multi-agency' system. In consequence, the current legal requirements for food safety and quality are contained in various documents, which are issued by different authorities and enforced by various t regulators. The lack of harmonization of the standards and regulations used by these different authorities has hindered the effective management of emerging food safety threats and risks and it delays improvement in the seafood safety sector.

ii. There is a need to harmonize the regulatory requirements for imported, exported and locally produced foods.

iii. Legislation should seek to incorporate a fully risk-based approach to meet food safety challenges facing the domestic and potential export markets.

iv. HACCP principles have not been introduced into the different laws and regulations regulating the food production sectors. The lack of HACCP and its pre-requisite programmes as a regulatory requirement has reduced the overall attempt to implement a food safety strategy from farm to table.

v. Enforcement of food safety laws and regulations spread among different ministries and municipalities with HACCP not fully integrated in the inspection systems and mainly focused primarily on end-product control. Much of the current system can be considered as 'reactive' rather than 'proactive'.

vi. Different ministries and municipalities at the central level with sub-divisions in the different governorates of the country managing the official laboratories. The lack of effective coordination among these laboratories results in fragmentation, duplication and poor coordination.

vii. Many food businesses rely on labour from abroad of low socioeconomic backgrounds with poor hygiene education. This is very detrimental to the safety of food prepared and served by these businesses.

viii. There is limited awareness and knowledge on the food safety and quality issues by the different stakeholders across the farm-to-table continuum.

ix. The findings of the study indicated significant progress was being made in the creation of a national Centre for Food Safety and Quality by the government as one

of the significant positive steps. However, subsequent delayed has been acquired achieving it and taking longer time than anticipated. Once this Centre has been established, it will raise the country's food safety monitoring and audit capabilities with a principal aim to oversee the implementation of quality and safety standards throughout the food supply chain.

6.2.1 Regional Developments and Challenges in food safety

Oman has been an active member in various international and regional food safety organizations. In particular, its active role in the GCC. This cooperation has promoted the elimination of trade barriers and facilitated trade practices among the different member states. Standard harmonization reduces the difficulties faced by food traders and producers and has agreed to harmonize its standards and technical regulations with those issued by the GSO. The GCC Customs Union was approved in 2003 with a vision for a free trade area, a single entry and a common market with a 5% levy on goods imported. However, the customs union project has seen major delays in application due to disagreements over the implementation mechanism in regards to the customs revenue management. Despite this, there has been a growth in intra-regional trade (THe Economist Intelligence Unit, 2015). The issues were resolved by the GCC finance ministers in 2014 and have resulted in a common market similar to the European one with no-intra Gulf tariffs.

Additional developments have taken place within the GCC and these have advanced efforts to improve the food safety framework within member states. The limited arable land and shortage in water has forced GCC countries to rely heavily on imports to meet the needs of the expanding population. One of the principal problems faced by these countries is being one of the smallest producers of food in the world. The Ministerial Committee for Food Safety within the GCC has acknowledged the importance of mutual coordination to overcome the risks associated with the high dependency on importation of basic foodstuffs. After many years of work, a GCC Guide for Control on Imported Foods was agreed. It is fully compliant with the WTO agreements and consistent with international food safety practices and seeks to consolidate and support import procedures within the member states and the international markets. The Ministerial Committee for Food Safety has also approved a unified law for food safety and control and it is in the preparing of a draft

regulation that will provide details of the unified law of which will be used as a guideline for two years from the date of approval. Additionally, the GRASF, initiated in 2012, links all GCC member states and facilitates the rapid exchange of information on any food-related emergency or crisis to safeguard the public health.

6.2.2 Where does Oman, in terms of food safety control system and practices, rank in comparison to the FAO/WHO and CAC

The need of Oman to modernise its safety control systems and establish an independent national food safety authority is of a paramount importance. In 2013, the Council of Ministers of the Omani government approved the establishment of a national Centre for Food Safety and Quality (CFSQ) under the auspices of the Ministry of Regional Municipalities and Water Resources. The aim of this centre is to advance the country's food safety monitoring, to increase the audit capabilities, to adopt quality and safety standards throughout the food supply chain with the principle aim to merge all the control authorities under one single authority.

The current fragmentation observed in the Omani food control system (OFCS) results in various shortcomings. Inconsistent coordination of enforcement activities and insufficient utilisation of resources are the main limitations of such a system. The food poisoning cases within the country and the near complete dependency on imports have stretched the available resources thinly and suggests that additional food safety measures are required. This study aimed to identify the gaps in the current OFCS in general and the Seafood Safety Control System. The latter is secondary system run by a separate authority. This current structure of food safety control in Oman is found in many countries around the globe since food safety control is seldom dealt with by one single authority. However, many countries have overcome the challenge and have managed to establish a unified network of food safety authorities within a single or integrated agency. It is very crucial for any Food Control Systems (FCSs) to conduct continuous evaluation in order to identify loopholes and introduce necessary improvements. In this study, the different guidelines reports issued by FAO/WHO and CAC have been used to assess the gaps of the OFCS and its sub-systems. In this case it is the seafood safety control authority which has been assessed. These documents provide descriptive guide to benchmarks, which are considered

as an Ideal Food Control System to compare against the existent OFCS and its sub-systems as shown in Table 15 (1-5). The core components that have been used in the comparative analysis are;

i. Food Control Management
ii. Food Legislation
iii. Food Inspection and Surveillance
iv. Official Food Control Laboratories
v. Food Safety and Quality Information, Education and Communication (IEC)

Table 15 (1-5): Comparative Analysis of the OFCSs against internationally accepted benchmarks (Ideal Food Control System) based on guidelines from (Codex Alimentarius Commission, 2013; FAO, 2006b, 2007; FAO/WHO, 2003).

1. Food Control Management		
Components of Ideal Food Control System	**Oman Food Control Systems (OFCSs)**	**Seafood Safety Control System (Sub-System)**
Development and administration of a national food control policy and strategy	• An overall strategy of the Omani government decided to established the Centre for Food Safety and Quality	• Currently a Fishery Quality Control Centre (FQCC) exist but some of its responsibility and mandates may be integrated to the Centre for Food Safety and Quality
Existence of administrative structures within the FCSs with distinctly defined roles, responsibilities and accountabilities	• Multiple agencies (Chapter 3, Table 6) • Overlapping responsibilities (Chapter 3, Section 3.3) • No clear defined roles and responsibilities of the different authorities involved in the food control management • Food safety committee was established and chaired by the MRMWR with focal points from the various authorities (Chapter 3, Table 6) presents the mandates and responsibilities)	• FQCC within the MAF (Chapter 4, Section 4.5.1) • Clearly defined roles for the different departments and section within the FQCC
Dedicated to safeguard and protect consumer's health and interests, and to guarantee fair practices in food trade	• Adequate	• Adequate
Allocation of resources in terms of financial, human, equipment, information, etc. and availability for food control management	• Adequate • However, limited qualified human resources	• Similarly
Based on an integrated food chain approach covering the entire food chain from primary production to consumption	• Very difficult to assess this concept due to vast scattering of the food control system among the different authorities and within, hence creating many gaps on the enforcements within the food chain	• Better integration since one authority is in charge of the seafood supply chain from ocean to plate; however, still some overlapping exists once seafood products enter the local disturbing chain
Based on scientific Principles and risk analysis approach	• Lacks this approach • Lacks the appropriate infrastructure for risk assessment data	• Lacks this approach • However, Article 4 of the Fishery Quality Control Regulation (FQCR-12/2009) states clearly that the enforcement of its provision must be structured on scientific bases except in emergency cases

Components of Ideal Food Control System	Oman Food Control Systems (OFCSs)	Seafood Safety Control System (Sub-System)
Involvement of the various stakeholders from farm to table continuum in decision making process and flow of information	• Limited	• Limited
Participation in regional and international standard-setting bodies on issues related to food safety and quality	• Very active regionally and internationally • An active member of the GCC, GSO, WTO (TBT & SPS), CAC, OIE and IPPC	• ROMPE, EU, IAEA
Technical regulations and standards are based on sound science and in accordance with CAC	• Harmonized its technical regulations and standards in accordance with CAC via GSO	• Similarly • Adopted several technical regulations and standards from the EU directives and laws that are related to seafood safety and quality
Data collection and surveillance of food-borne illnesses (caused by microbial, chemical, etc.) related to entire food chain from primary production to consumption	• Surveillance of food-borne illnesses is mainly carried by the Ministry of Health and no collaboration with other authorities	• Similarly
Existence of a national database for all the data generated from the enforcement and laboratory activities	• Does not exist on a national level • Mostly available at different authorities level	• Available for the seafood control activities within the FQCC
Respective roles and responsibilities of the FCS in response to and manage food-related food crisis	• Does not exist • However, a food safety committee was established and chaired by the MRMWR to handle such crisis (Chapter 3, Table 6) display the mandates and responsibilities of this committee)	• Similarly
Existence of a documented procedure providing authorization for the official controls (inspectors, official food control laboratories and etc.) of the food control management	• Exist as Section 3 in the Food Safety Law (84/2008) with specific articles indicating the following: o Article 15 for official inspectors to carry out their duties o Article 21 emphasizing the need to coordinate among the various official laboratories and submitting the analytical results to the food safety committee for further actions	• FQCR-12/2009 has clearly authorized its official personal in Article 9 &10 with their mandatory authority to carry out their official control duties

Components of Ideal Food Control System	Oman Food Control Systems (OFCSs)	Seafood Safety Control System (Sub-System)
Existence of IEC programmes for relevant stakeholders from farm to table providing training (upgrading of knowledge and skills), consultation and communication	• Limited • Mostly done through extension services within the different authorities, workshops and seminars • An annual safety week has been launched to address the various issues of food safety and communicating them with the different stakeholders	• Limited • Mostly done through extension services within MAF • A specialist department on seafood safety systems was set within FQCC to provide technical assistance to private industries to ensure their conformity with the regulation guidelines. • Workshops, symposium and seminars are set up to meet and transfer knowledge to the various stakeholders

2. Food Legislation

Components of Ideal Food Control System	Oman Food Control Systems (OFCSs)	Seafood Safety Control System (Sub-System)
Provide a high level of health protection and consumers interests	• Adequate	• Adequate
Clearly defines the roles and responsibilities of government authorities responsible for food control within the FSCs, and interactions mechanism / procedure	• Define roles and responsibilities are not clear • Mechanism of interaction does not exist, however, a food safety committee was set up as a common platform joining the different focal points from the different authorities	• Similarly
Existence of an integrated and comprehensive legislation encompasses the farm to table continuum	• Lack of integration of the existing legislation related to food safety Each authority within the FSCs issues its own legislation • Food Safety (84/2008), however, is the legal legislation in place to deliver the necessary enforcement for the execution of food safety control	• Follows mainly the MAF laws and regulation • Has its own regulations in place (Chapter 4, Figure 12)
Outline clear definitions of important legal terms	• Adequate	• Adequate
Consistent with international and/or regional legal requirements	• Adequate	• Adequate
Preventive oriented rather than enforcement oriented	• Insufficient	• Insufficient

Components of Ideal Food Control System	Oman Food Control Systems (OFCSs)	Seafood Safety Control System (Sub-System)
Based on transparent, independent scientific advice based on risk assessment, risk management and risk communication	• Insufficient	• Insufficient
Address the appropriate enforcement and control such as sanctions and penalties	• Addressed, however, regarded as too lenient and not sufficient to encourage compliance with related legislation	• Similarly
Includes clear provisions indicating the responsibility for food safety and quality lies with producers and processors	• Adequate	• Adequate
Provides clear provision for the approval, registration or licensing of food premises	• Adequate	• Adequate
Provides traceability and recall procedures in case of safety issues	• Absent	• Present but limited to the processors and commercial vessels only
Contains obligations guaranteeing only safe and fairly presented food are placed on the market	• Limited even though its mentioned clearly in the food safety law and regulations	• Similarly
Recognized country's international obligations particularly to trade	• Adequate	• Adequate
Legislation in line with international standard	• Adequate	• Adequate
Contains provisions for detailed enforcement procedures	• Present but limited	• Present but limited

3. Food Inspection and Surveillance		
Components of Ideal Food Control System	**Oman Food Control Systems (OFCSs)**	**Seafood Safety Control System (Sub-System)**
Based on risk analysis inspection including sampling programs and techniques for domestically-produced, imported and exported food	• Inspection and sampling programs are not based on risk analysis • Majority of the inspectors have limited knowledge of modern risk-based approach	• Similar • Sampling programs exist but not updated regularly as required
Organisation, responsibilities and roles of the inspection activities is well defined	• Activities and roles are not well defined • Several agencies perform food inspection services under the responsibility of various government ministries • These inspectors work independently of each other, with overlapping mandates and responsibilities • Some inspectors within these agencies have multi tasks and not allocated only for inspection of food premises and processors	• Fishery Quality Control Centre (FQCC) within the MAF is in charge of inspecting seafood products in collaboration with the other governmental authorities in some aspect of inspection
Inspection activities cover the farm to table approach	• Fragmented through a number of governmental agencies, therefore creating gaps and not fulfilling the farm to table approach • Insufficient human resources to cover the whole chain due to lack of organizing the existence resources	• Even with one authority in charge, however, gaps exist due to lack of cooperation within the ministry and with other authorities of OFCS • Insufficient resource to cover the whole chain
Professional and sustainable training	• Lack of clear defined training programmes • Limited training on FSMS such as HACCP and its pre-requisite programmes	• Similarly
Need of qualified and trained Inspection	• Most inspectors have basic qualifications; however, higher qualified inspectors do exit despite their limited number	• Similarly
Reputation and integrity of the inspectors	• Adequate	• Adequate
Number of official inspectors authorized to carry out the enforcement duties is sufficient within the FCSs	• Current numbers of official inspectors are not sufficient in all the authorities within OFSCs	• Similarly
Existence of Inspection Standard Operating Procedures (SOPs)/manuals	• Absence	• Absence
Good understanding of relevant food laws and regulations	• Adequate	• Adequate

Components of Ideal Food Control System	Oman Food Control Systems (OFCSs)	Seafood Safety Control System (Sub-System)
Existence of a clear system for the collection, reporting and analysis of information obtained from the inspection process and based on high, medium and low risk of the premises involved	• System for collection and reporting exist • Limited reporting and analyzing of information obtained from the inspection process • Some authorities preform inspection activities based on high, medium and low risk of the premises	• Similarly
Inspection activities should comply with the relevant laws and regulations	• Inspection is mostly focused on hygienic and sanitary conditions of the facilities and workers • Inspection activities mostly comply with existing laws and regulation • Existing of several regulations within the FSCs causes duplication and insufficiency/gaps in the coverage of food inspection services	• FQCC inspectors follow the Fishery Quality Control Regulation (12/2009) and others (Chapter 3 Table 7) as a base legal requirement for inspection
Evaluating of FSMS such as HACCP and their implementation in the food businesses	• HACCP system is not mandatory and mostly voluntarily, therefore, is not a requirement of inspection at the moment	• HACCP is mandatory for those processors that export to lucrative markets, however, with the updated regulation is compulsory for all seafood processors. • Inspection carries out evaluation of these processors and another department conducts an annual auditing for HACCP implementers to ensure conformity with relevant regulation
Development of a computer-based system of food inspection and existence of food inspection records	• Paper based inspection • Inspection records exist within each authority and lack of national database	• Similarly • An attempt to implement ISO 17020 but not yet completed
Existence of a national database of food premises categorizing them according to the risk factor of the produced food products	• Exist within each authority	• Exist within the authority
Access to logistical support to carry out inspections (resources, facilities, transportation modes, inspection equipment)	• Mostly available but limited in certain circumstances	• Similarly
Existence of records and documents on all of the different aspects of inspection activities such as; consumer complaints, investigation and management of outbreaks of food-borne illnesses, respond to and manage food emergencies, etc.	• Limited in particular the records and documents on the management of food-borne illnesses outbreaks and food crisis and emergencies	• Limited
Existence of a review and evaluation mechanism for the food inspection system	• Absence	• Absence

4. Official Food Control Laboratories		
Components of Ideal Food Control System	**Oman Food Control Systems (OFCSs)**	**Seafood Safety Control System (Sub-System)**
Adequate number and location of official food control laboratories in order to support the FCS	• Adequate	• Limited, particularly in the regional governorates
Presence of reference laboratories for contaminants and food-borne disease causative agents	• Absence	• Absence
Accreditation of official food control laboratories according to international standards	• Most laboratories are in the process of obtaining ISO 17025, however, none of them have been accredited	• Similarly
Qualified food analysts with suitable training, experience and integrity	• Adequate	• Adequate
Adequate infrastructure, facilities, equipment, supplies , reference materials, and participation in inter-laboratory proficiency testing	• Mostly available	• Similarly
Access to calibration and maintenance	• Calibration and maintenance of the instrumentations is carried by the instrument providers and lack the international recognition • Calibration of some of the instruments and devices is carried out by DGSM in MOCAI	• Similarly
The use of validated analytical methods for analysis of various contaminants	• Most analysis in the different laboratories use validated and reference methods	• Similarly
Existence of Standard Operating Procedures (SOPs) for analytical methods	• All the official laboratories have SOPs in place for all the analytical methods and instrumentation used	• FQCC labs have SOPs in place for all the analytical methods and instrumentation used
Effective linkages and collaboration between official food control laboratories and the enforcement officials	• Each official laboratory falls under specific authority has effective linkage with the administrators and food inspectors within that authorities • However, weak linkage and collaboration among the various official laboratories	• Similarly
Effective linkages and collaboration between official food control laboratories and the public health system for food-borne disease surveillance, as well as any other relevant laboratories	• No effective linkage • Article 21 of the Food Safety Law (84/2008) emphasized the need to coordinate among the various official laboratories and submitting the analytical results to the food safety committee for further actions	• No effective linkage with the other laboratories

5. Food Safety and Quality Information, Education and Communication (IEC)		
Components of Ideal Food Control System	**Oman Food Control Systems (OFCSs)**	**Seafood Safety Control System (Sub-System)**
Existence of a policy for IEC in regards to food safety and quality aspects targeting external audiences such as consumers, NGO, food industry, etc.	• Absence	• Absence
Presence of extension and developing programs for executing IEC activities	• Each individual authority within the OFSC has its own extension programs to conduct IEC for the different stakeholders • Seminars, workshops and conferences are also carried to educate the FSC staff and others on relevant food safety issues • Oman Association for Consumer Protection (OACP) is a voluntarily and independent non-government organization that protects the consumers rights and raise awareness on different issues related to food safety issues and others	• Similar situation, as the extension program targets mainly primary producers such as fishermen • Seminars are also carried to educate the FQCC and MAF staff on relevant seafood safety issues
Adequate trained FSC staff to carry out IEC	• Limited	• Limited
Availability of sufficient financial resources, appropriate materials and equipment to carry out IEC activities	• Limited	• Limited
Availability of risk communication system during food crisis and emergencies	• Limited	• Limited

6.3 Can the proposed systems and structures be used to enhance seafood controls elsewhere?

In order to verify the potential value of the research in other countries, a brief review of certain Indian Ocean countries has been conducted – Mauritius, the Maldives and the Seychelles. These countries were selected as they present similar characteristics to Oman in relation to the subtropical climate, their geographical location, similar fisheries resources, and the existence of small-scale artisanal fisheries. Moreover, all of these countries apart from Maldives are active members of the regional group known as Indian Ocean Rim Association (IORA).

Many studies have been carried out in the developing countries to assess and highlight the challenges faced by the developing NFCSs. The current work is a contribution in the development of NFCSs and in particular, the seafood safety controls within Oman and how it can be implemented in the region or internationally. Similar challenges to those described in this study can be found elsewhere – in particular with respect to the best practices required to maintain seafood safety and quality throughout the supply chain and the marketing channels. However, differences must also be recognised and taken into account.

Mauritius

In Mauritius, the Ministry of Fisheries is in charge of the official control of fishery products, and the country exports fishery product to the EU, mainly tuna species (DG SANCO, 2014). Since the use of laboratories accredited with ISO 17025 is compulsory for the EU for third countries exporting to EU, the official control samples are outsourced to an accredited private laboratory. Mauritius is listed in Annex II of the Commission Decision 2006/766/EC, and also in the Commission Decision 2011/163/EU for having an approved residues monitoring plan for aquaculture products permitted for EU markets (DG SANCO, 2014). The listing of seafood processors and vessels intended for EU export meets the EU provisions. However, shortcomings in HACCP implementation in some processors have been identified. Annual sampling plans exist covering water, ice and

fishery products for the parameters required by EU legislation and has regular sampling intervals. The existing legislation covers all fishery products permitted to be placed on the local and export market with controls in place ensuring the absence of ciguatoxin.

A detailed review of the drafted report on the fisheries master plan was prepared for ACP (African Caribbean Pacific group) Fish (Gary, Ross, & David, 2011) and the following information has been extracted from it to understand the Mauritian fisheries sector. The country's exports are mostly dependent on the European Union market but due to tariffs, it is finding it hard to compete with upcoming new competitors. Previous FVO reports have identified various specific requirements and there have been some failures to comply. The establishment of an independent organization to overcome bureaucracy and to enable prompt decision-making has been recommended in the master plan. It notes that if delisted and excluded from EU markets, this would threaten the economy of the country.

The restrictions imposed by the Mauritius government on the locally caught species intended for the domestic markets and for the export market has caused frustration for local fishermen, seafood processors and importers as it reduced their ability to maximise profits. Seafood supplied by artisanal fishermen into the domestic market are not stored on ice due to the lack of ice machines available at the landing sites. A residue-monitoring plan is in place but with some shortcomings.

Shortfalls in the seafood safety sector were identified by (Ramnauth, Driver, & Bhugaloo Vial, 2008), who have listed restricted financial resources, poor access to reliable information and expertise and food safety knowledge and the lack of communication between the private and public sectors. Furthermore, the legal framework governing this sector is largely absent and there is a need for appropriate and comprehensive legislation to be in place. Ramnauth et al. (2008), also noted that business owners/managers are not motivated or committed toward the adoption of HACCP system. The implementation of HACCP in the food industry is not compulsory (Daby, 2003; Sebata, Neeliah, & Aumjaud, 2016). National food control in Mauritius is characterized as multiple agencies with overlapping roles and suffers from the absence of inspection manuals and a lack of accredited official laboratories (S. A. Neeliah, Goburdhun, & Neeliah, 2009; Sebata et al., 2016).

Maldives

In the Maldives, the CA in charge of the official control of fishery products was incorporated into the Maldives Food and Drug Authority (MFDA) in 2006 (DG SANCO, 2013). The legal requirement governing the seafood safety sector is set in Regulation A-27/95 on 18 January 1995 for fish and fishery products exported to EU and has been under revision (DG SANCO, 2013). This regulation, with associated SOPs, has adopted standards and directives from EU in order to satisfy the requirement of the EU market. However, the FVO auditing report highlighted lack of updates on contaminants as per Regulations (EC) No 1881/2006 and (EC) No 333/2007. The Maldives is listed in Annex II of the third countries and territories from which imports are permitted for human consumption and entry to the EU market based on the Commission Decision 2006/766/EC. The official laboratory was accredited to the ISO standard 17025 in 2008. Appropriate training of the official's authority on EU legislation and other aspects of seafood safety controls had provided them with acceptable knowledge of the EU requirements. The official control system is comprehensive covering the entire fishery products production chain, with regular inspection of the vessels and establishments. Official samples are withdrawn in line with an existing sampling programme for the quality and safety analysis.

The local seafood supply chain mainly consists of small markets in fish landing centres with an absence of auction centres (FAO, 2009a). The main fishery products exported to the EU are fresh tuna and reef fish. According to (DG SANCO, 2013) the seafood products destined for the European markets are not landed in the public auctions and markets but are transferred directly from the harbour to processing plants. Shortcomings in HACCP procedures were observed in some establishments and vessels in relation to hazard identification, inappropriate time and temperature control and the identification of critical control points not following a valid approach.

Seychelles

For the Seychelles food control is the responsibility of the Public Health Department of the Ministry of Health (Codex Alimentarius Commission, 2011). Its fisheries control legislation is the Export of Fishery Product Act of 1996 amended in 2010 with four

technical regulations as the basis of enforcement of this Act. Provisions of regulation specifically for export fishery products to EU market known as "Fisheries Regulations" are mostly based on European regulations although some discrepancy with those of EU legislation has been noted (DG SANCO, 2011). As examples, the maximum limits set for cadmium is not precisely in accordance with the EU legislation and there is no maximum level for inorganic tin in canned fish. The Seychelles Bureau of Standards, operating under the Minister of Industry, is in charge of implementing the provisions of the Act and the related Regulations and carries out the seafood safety controls via testing laboratories and seafood inspection services.

Operating fisheries vessels are classified as small-scale, semi-industrial and industrial, with the largest being foreign owned (Iborra & Virginija, 2011). According to (DG SANCO, 2011), Seychelles is listed in Annex II of the EU Commission Decision and only exports canned and frozen fish to the EU. Moreover, fisheries products destined for export are only landed on designated sites, which comply with the regulations. Seafood processors producing export products must be registered with the CA; however, primary producers are not required to register. HACCP implementation is not required for freezer vessels but is required and implemented in processors that export to the EU.

Deficiencies were observed during an FVO visit were noted (DG SANCO, 2011). The maintenance of the cold chain, HAACP requirements, general GMP and GHPs practices, and laboratories analyses were noted as not fulfilling EU requirements. For example, the method specified for histamine analysis uses commercial kits, while the EU reference method is based on High Performance Liquid Chromatography (HPLC). Primary production also had some deficiencies and required corrective action to comply with EU legislative requirements. The official laboratory was reported to be working towards obtaining accreditation to ISO 17025 standards in addition to acquiring ISO 17020 for the official inspection services.

The highlighted deficiencies in these countries show both similarities and differences to the findings of this study of Oman. Since Oman exports to EU markets, it is listed in Annex II the of the Commission Decision 2006/766/EC for third countries exporting fishery products to EU markets, and the latest FVO visit was carried out in 2006 (European

Commision, 2006). Deficiencies on the fisheries control were noted and measures carried out to comply with the requirement of the EU legislation. Hence, the Fish Quality Control Regulation (No. 12/2009) was issued amending the previous MD 136/1998 and incorporating the corrective measures relating to the shortcoming identified during the visit. Additional improvements have been observed particularly whilst conducting this research. No further FVO visits have taken place due to reduction in seafood products destined for the EU. This reduction is due to the recent export ban on highly commercial value fish species imposed by MAF on the local processors. This led these processors to identify different markets for the permitted species. A further difficulty is the level of tariffs imposed by the EU on imports from Oman. A similar situation was observed in Mauritius relating to the restriction of species for exports and imposed tariffs.

Areas where significant similarities were found in Oman and the other countries, have been the routes followed by the EU certified processors in order to optimize the quality of their product intended for export where novel marketing channels have been developed to overcome the existing deficiencies. These defined channels within the supply chain have been established with control conditions by harvesters, transports and processes to comply with the exported markets. With products intended for the domestic markets, the process is usually weak, fragmented and less controlled. However, with the MAF restriction imposed on the export of certain fish species, these individual efforts to overcome the deficiencies in the existing marketing channels have been discouraged.

Small-scale fisheries have been the common characteristic in the compared countries, thus introducing hygiene issues and lack of ice usage making it difficult to manage the cold chain from net to plate. Shortcomings in the implementation of HACCP principles have been identified by the FVO visits for some of the processors - specifically time and temperature control and the identification of critical control points. HACCP implementation is not compulsory in their food industry and this correlates well with the findings of this study. As in Oman, the availability of appropriate training is an issue for these countries. Further, the countries have struggled to accredit the official laboratories to ISO 17025 as required by EU legislation by 31 December 2009 and it should cover all analyses. The presence of bureaucracy has hindered many efforts to optimize this sector

and a reduction in political interference and the establishment of independent organizations with the ability to make prompt and effective decisions is highly advisable throughout the net to plate continuum. Integration of seafood safety and quality laws with the general food law to produce a compressive law can be a challenge particularly with the existence of fragmentation of the national food control systems. Creating an effective seafood safety controls to meet the local and the export needs is demanding and challenging. Consequently, many countries adopt a dual system to satisfy the national and international control requirements.

6.4 General discussion

The administrative, operational and the legal entities of the National Food Control System (NFCS) of Oman is approaching a critical stage due to the scattering of its various components and the increased profile of food safety crises internally and externally. The food safety controls are administrated currently by seven control authorities with various mandates and responsibilities with the MRMWR being the primary authority. The advance of food processing technologies and the rapid development of regional and international food trade have increased the complexity and loads on the food control systems. The situation is complicated since there is a complete dependency on food imports with limited available resources and ineffective coordination among its fragmented food authorities. The establishment of the national Centre for Food Safety and Quality (CFSQ) that has been approved in 2013 is a positive step towards restructuring, unification and harmonization of legal requirement.

Seafood production has however advanced in terms of food safety control, legislation and managements. The country is a net exporter of its domestic fish production, which contributes to the national economy and satisfies local demands. Seafood production, as a major commodity in international trade, does require adjustment to comply with regional and international obligations. Preferential access to lucrative market such as the EU, USA and Japan has been very important to the development of the seafood safety sector in the country. This research provides a detailed evaluation of the seafood safety issues and challenges in the supply chain and within seafood processors. The stages of achieving

seafood safety and quality control based on traceability from net to plate continuum have been discussed in detail.

A major reform of the NFCS is needed at this stage and an integrating or unifying approach would be an appropriate starting point for the current NFCSs. The government has shown commitment in developing a fundamental structure of the Centre for Food Safety and Quality (CFSQ). It hopes this centre will unify and bring together the efforts done by the various regulators to strengthen the main elements of the NFCS. (Codex Alimentarius Commission, 2013; FAO, 2006b, 2007; FAO/WHO, 2003) have included a number of benchmarks that could assist in the strengthening of the NFCS. The gap analysis conducted above has demonstrated that significant progress has been made and highlights shortcomings where more efforts are still needed in the current NFCS and its seafood sub-system. It could be used as a baseline for a more detailed evaluation carried out to improve and enhance the systems in ways that are suitable for its diverse requirements and conditions.

Having various models available regionally to be followed, Oman is able to learn from the mistakes and challenges faced by these countries. Saudi Arabia for instance, has chosen to centralize it NFCS into a single agency, the Saudi Arabia Food and Drug Authority (SFDA) to improve the effectiveness of its control and regain public confidence in food safety (D. Al-Kandari & Jukes, 2012). The process has not been easy and it was very timely to reallocate all fragmented controls in every aspect of food controls into a unified entity.

Oman, being a part of the regional hub the GCC countries, has made considerable advances in the national food safety control system. Common laws and guidelines have been established with harmonization of regulation and technical standards among the different GCC member states. The issues regarding the GCC Customs Union have been resolved and are in the process of being implemented. The Gulf Rapid Alert System for Food (GRASF) is among the achievements of the GCC cooperation, although there is a need to add feed controls (as in the EU and the ASEAN) as they are vital to safeguard the public health against food crises. In addition, cooperation with international food safety bodies to address recurrent issues in food safety and quality controls and to develop and

upgrade guidelines on current measures and methods that will help streamlines food safety best practices within and among the various GCC members should be encouraged.

The food legislation framework should be comprehensive, covering all aspects of food, and feed in the supply chain with all its related processing. A continuous review of the legal framework is needed to reflect new knowledge, technical innovation and changes in production and the supply chain. Similarly, harmonization of regulation and technical standards for the requirements of import, export and domestic foods is essential to address the current duel system in place was developed to overcome tight controls imposed by lucrative markets. Surveillance of foodborne disease is a fundamental component of NFCS, with epidemiological data essential to produce appropriate risk-based food control policies.

The results of this research have highlighted several factors deterring the unification or integration of these systems. Appropriate advice, measures and controls have been recommended to aid the policy makers to enhance the NFCS and to integrate the seafood safety controls authorities. Continuous evaluation of the NFCS to identify gaps is of extreme importance (FAO, 2006b).

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CHAPTER 7

7 Overall Conclusion and Recommendations

The research presented in this thesis was conducted to provide evidence to enable a better understanding of issues linked to the effective implementation of controls to provide safe and quality foods in countries where current controls are limited. In particular, in Chapter 1, three review questions were identified and the research objectives of this research study were set out.

Following the discussion in Chapter 6, the overall conclusion of the research can be summarized as follows:

7.1 How can Oman enhance the safety and quality of seafood products to satisfy the requirements of (a) local markets, and (b) export markets?

Based on the evidence presented in this research work, the following measures are recommended as effective measures to enhance the safety and quality of Omani seafood products within the current supply chain to satisfy the requirements of local and export markets. These have been split into measure primarily associated with the 'supply chain' and those relating to 'management systems':

Supply chain –

- The management of the cold chain is of a paramount importance in any supply chain to ensure integrity of food and reducing foodborne illness and the availability of clean ice will aid in overcoming post-harvest losses and promote the quality of the end products.
- Modernization of the artisanal fishing vessels in regards to their capacity and harvesting techniques will improve the quality and quantity of the first catch.
- Development of the infrastructure for landing sites, costal and internal markets, transportation vehicles and distribution systems with FSMS parameters in place will stimulate value chain growth leading to higher quality outputs and profitability.

- Establishment of more wholesalers with auctioning facilities on harbours and landing sites will shorten the length taken to transport seafood products from the primary producers to internal markets, and consumers.
- In general terms, the more mid-chain dealers the greater the complexity of the supply chain, and the greater the risk of losing traceability and transparency of tracing the seafood products back to its source, therefore the fewer the steps between harvest to the end products with appropriate labelling, the easier to control fraud and untrustworthy information.
- Commercial vessels, processors with their own vessels and aquaculture farms can transport their catch either through wholesale markets or directly to their processing facilities on condition that safety and quality checks are performed.
- A well-structured supply chain put forward will facilitate the implementation of requirements set by the national and international laws and legislation.

Management systems –

- In order to ensure seafood safety and quality throughout the various steps of harvesting, handling and processing, best practice such as GHPs on board and during handling (e.g. cleaning, bleeding and ice) and within the supply chain should be incorporated.
- Traceability techniques from the primary producer (wild and farmed), through processing and distribution to the consumer must be developed and attained and the existence of well-established wholesalers will facilitate this process.
- Strategies to enhance similar levels of protection against foodborne hazards involves the enforcement of safety and quality requirements from farm to fork covering all aspects of harvesting, processing and distribution regardless of the target markets.
- Legal enforcement of Hazard Analysis and Critical Control Points (HACCP) and other food safety management systems (FSMSs) and their pre-requisites programmes should be equally imposed on all seafood processors regardless of their disseminating routes to ensure conformity with national and international requirements. Technical and funding assistance should be available to support them

with the adoption of these safety requirements specifically the small and medium processors.

- Continuous training of the various stakeholders within the supply chain will overcome the misinterpretation of safety and quality requirements and specifically the general HACCP principles and its pre-requisite programmes. It will also enhance the official inspectors' ability to combat any deficiencies and allow them to be more rigorous in enforcing national legislation.
- A proactive and an ownership approach adopted within the various stakeholders will uplift the level of safety requirements implemented. Moreover, the main aim of adopting FSMS being to safeguard the well-being of the consumers and not market driven will ease the burden on the official regulators and enhance the outcomes.
- Effective communication channels between the officials and the different stakeholders and the involvement of the latest in decision making is vital to allow them enough time to adjust their practices to new changes imposed by the regulators and overcoming any misconduct of the legal requirements.

7.2 What are appropriate food control structures to achieve this?

This research study was carried out to assess the national food control systems (NFCS) in the Sultanate of Oman taking account of regional and international developments and challenges in food safety. Although the controls in the seafood sector have progressed, unless the NCFS has been reformed into a unified agency, the more lenient controls applied in other sectors reduce the ability of seafood regulators to make further progress and will hinder efforts to advance. Therefore, adopting a proactive approach throughout the entire chain from "farm/net to fork/plate" is fundamental to achieve safe and quality food products and this cannot be achieved without appropriate controls in place as following:

- ***Food control management***: Establishing administrative structures with distinctly defined roles, responsibilities, accountabilities and availability of appropriate resources within the control system. It should also be based on an integrated food chain approach covering the entire food chain from primary production to consumption and founded on scientific principles and a risk analysis approach.

Stakeholders throughout the chain should be involved in the decision making process supported by access to information and the existence of IEC programmes. On issues relating to food safety and quality, the authorities should be involved in regional and international bodies relating to food control and standard-setting.

- ***Food Legislation***: comprised of an integrated and comprehensive legislation encompasses the farm to table continuum with defines roles and responsibilities of the government authorities. It should assure high level of health protection and consumers interests and be consistent with international and/or regional legal requirements. The legislation should be preventive rather than enforcement oriented, be transparent and based on risk analysis.
- ***Food Inspection and Surveillance***: The reputation and integrity of the inspection and enforcement body is very important and their inspection activities should comply with the relevant laws and regulations. It should be well organized with responsibilities and roles of the inspection activities well defined and covering the farm to table continuum. Inspectors must undergo professional and continuous training on all aspects of food safety and quality and of any recurrent issues threatening the wellbeing of the consumers.
- ***Official Food Control Laboratories***: These support the NFCSs in producing viable results to prevent food crisis. They therefore should have adequate infrastructure, facilities and equipment in place with qualified food analysts. Official food control laboratories should be accredited according to international standards such as ISO 17025 and participating in inter-laboratory proficiency testing to validate their results. Above all, effective collaboration between the official food control laboratories, the public health system for food-borne disease surveillance and enforcement officials should be in place.
- ***Food Safety and Quality Information, Education and Communication (IEC)***: The presence of an IEC policy and developing programmes for executing IEC activities is essential to educate the various stakeholders on food safety and quality. Once the different segments of the supply chain have been educated they can be a positive driving force to ensure what they receive is of optimum quality and safety for their own safety, hence, reducing the burden of the official regulators. However, IEC

activities require sufficient financial resources, appropriate materials and equipment to carry out their tasks.

7.3 Can the proposed systems and structures be used to enhance seafood controls elsewhere?

A brief study of certain countries with similar seafood industries has suggested that similar issues exit. Common elements include small-scale fisheries, culture, government structures and limited financial and human resources which impact legal compliance. Deficiencies in fisheries control were noted in these other countries and similar measures have been adopted to comply with the requirements of the EU legislation. The existing national legislation of these countries was modified to comply with those of EU requirements in order for their seafood product to enter EU markets. With deficiencies in the existing marketing channels within the seafood supply chain, in a similar manner to that found in Oman, EU certified processors use different routes in order to produce of the correct quality to enable them to supply the export market. However, the process followed for domestic markets, is usually weak, fragmented and less controlled. In order to overcome the existing practices in the seafood supply chain, the official regulatory authorities are faced with huge difficulties and challenges and frequently adopt dual control systems to separate and satisfy the national and international markets. These similarities suggest that the research can be used to support attempts to enhance seafood quality in these other countries.

7.4 Suggestions for Future Work

This study has provided an overview assessment in terms of the safety and quality requirements of the seafood supply chain and it was largely focused on one segment of that chain; the seafood processors. Although for Oman the seafood sector is the most significant economically, the issues of food safety and quality exist across the whole food supply system for the country is of paramount importance. Extending the research into other sectors would be worthwhile as it is anticipated that many of the issues associated with different elements in the supply chain (segments such as primary producers, transportation and distribution) will be similar to those found in this research.

The further implementation of HACCP across the seafood sector has been proposed as an effective way to enhance the quality and safety of seafood products in Oman. In undertaking this research, attempts were made to assess the costs associated with its implementation. The data that was obtained was very varied and unreliable. Within the framework of this study, it was not possible to take this aspect further. It is therefore suggested that, within the context of an economic evaluation, a more detailed study could be undertaken to identify the costs and benefits of full HACCP implementation within Oman.

APPENDICES

APPENDIX A: Questionnaire Survey A: Officials of Ministry of Agriculture and Fisheries (MAF)

SECTION A: RESPONDENT'S PROFILE

1. What is your position or job title in the authority? _____

2. How long have you held this position? _____

3. Education Level; (Please choose one category):

   3.1. Secondary Certificate
   3.2. Diploma
   3.3. Higher Diploma
   3.4. Bachelor Degree
   3.5. Master Degree
   3.6. PhD Degree
   3.7. Other, please specify: _____

4. How many years of experience do you have specifically in seafood quality and safety? (Please choose one category):

   4.1. Under 10 years
   4.2. 11 - 19 years
   4.3. 20+ years

5. Nationality:

   5.1. Omani
   5.2. Non Omani

6. Have you received any training in seafood quality and safety since you joined?

   6.1. □Yes
   6.2. □ No (if no please go to question 8)

7. If yes, please indicate the type of training undertaken, (If appropriate please choose more than one category):
   7.1. Quality management systems
   7.2. HACCP
   7.3. Auditing
   7.4. Inspection procedures
   7.5. Seafood safety/quality
   7.6. Others, please specify the type of training: _____

SECTION B: AUTHORITIES'S PROFILE

8. Employer's/ authority's name:
   8.1. Fishery Quality Control Centre (FQCC)
   8.2. Fish Central Market in Barka
   8.3. Other, please specify: _____

9. Does your work involve conducting inspections of seafood establishments?
   9.1. □Yes
   9.2. □ No (if no, please go to question 11)

10. If yes, what proportion (%) of your time is spent on inspection duties? _____

SECTION C: SEAFOOD TRADE AND BUSINESS ISSUES

11. In your opinion, what are the main barriers to export to regional and international markets, (If appropriate please choose more than one category):

    11.1. Trade restrictions (Sanitary and Phyto-Sanitary (SPS) & Technical Barrier to Trade (TBT)
    11.2. Lack of consumer demand in specific market
    11.3. Uncertainty in obtaining a regular supply of raw materials
    11.4. Exchange rate fluctuations
    11.5. Administrative delay locally
    11.6. Administrative delay in the destination count
    11.7. Export bans of certain fish species by the Ministry of Agriculture and Fisheries
    11.8. Import duty (tax) in foreign market
    11.9. Other, please specify: _____

12. Considering the quality and safety standard of seafood products, please rate the level of difficulty in accessing the following international markets.	Very easy	Easy	Average	Difficult	Very difficult	Not Applicable
	5	4	3	2	1	NA
(a) Europe						
(b) USA						
(c) Canada						
(d) Central America						
(e) South America						
(f) Japan						
(g) China						
(h) Other Asian Countries						
(i) GCC countries						
(j) Arabic countries (non-GCC)						
(k) North Africa						
(l) Central Africa						
(m) South Africa						
(n) Other, please specify:						

13. Please rate the following barriers that are likely to prevent the enhancement of the business operation in the seafood sector?	Not a barrier	Limited barrier	Moderate barrier	Significant barrier	Major barrier
	5	4	3	2	1
(a) Lack of financial capital					
(b) Lack of authorities' support					
(c) Lack of communication with the authorities					
(d) Lack of raw seafood materials					
(e) Cost of the raw seafood materials					
(f) Lack of management dedication					
(g) Lack of investment in new technology					
(h) Lack of access to information on different markets					
(i) Staff turnover					
(j) Difficulty in getting experienced employees					
(k) Low levels of official inspection					
(l) Excessive official inspection					
(m) Lack of enforcement of laws and regulations					
(n) Export ban of certain fish species by the authority					
(o) Other, please specify:					

SECTION D: SEAFOOD SUPPLY CHAIN

14. Please rate the quality of the raw seafood materials received in the seafood establishments from the following sources.	Excellent (High)	Very Good	Satisfactory	Fair	Poor (Low)	Not Applicable
	5	4	3	2	1	NA
(a) Domestic						
(b) Imported						

15. Considering the following *stages* of the seafood supply chain, please indicate the degree of negative impact (damage) each has on seafood quality and safety.	No impact	Limited impact	Moderate impact	Significant impact	Major impact	Not Applicable
	5	4	3	2	1	NA
(a) Foreign inspections/ assessments (*for imported raw materials)*						
(b) Local inspections *(for imported raw materials)*						
(c) Fishermen						
(d) Landing sites						
(e) Middlemen / truckers						
(f) Processing companies						
(g) Distribution of processed products						
(h) Markets						
(i) Other, please specify:						

16. Considering the following *factors*, please indicate the degree of negative impact (damage) each has on seafood quality and safety.	No impact	Limited impact	Moderate impact	Significant impact	Major impact	Not Applicable
	5	4	3	2	1	NA
(a) Traditional practices used by the fishermen						
(b) Poor boats' condition						
(c) Use of poor fishing gear (i.e. gills net, beach-seine, & etc.…)						
(d) Poor ice availability						
(e) Poor temperature control during fish handling						
(f) Poor time control during fish handling						

(g) Poor fish landing facilities						
(h) Poor fish marketing facilities						
(i) Other, please specify:						

SECTION E: PRIMARY CONTROL PROCEDURES

17. Please indicate the proportions of seafood establishments (with or without quality control (QC) number) implementing the following control programmes.

	In Approved Business (with QC number)				
(a) Programmes type	All	Most	Some	Few	None
	5	4	3	2	1
1. Good Manufacturing Practices (GMPs)					
2. Good Hygiene Practices (GHPs)					

	In Non-Approved Business (non QC number)				
(b) Programmes type	All	Most	Some	Few	None
	5	4	3	2	1
1. Good Manufacturing Practices (GMPs)					
2. Good Hygiene Practices (GHPs)					

18. What proportion of seafood establishments (with or without quality control (QC) number) effectively implements the following procedures?

	Approved Business (QC number)				
(a) Procedure	All	Most	Some	Few	None
	5	4	3	2	1
1. Management of purchased materials					
2. Personal hygiene					
3. Waste management					
4. Pest control					
5. Time & Temperature Control					
6. Cleaning of equipment					
7. Cleaning of facility					
8. Transportation of raw seafood materials					
9. Transportation of finished seafood					

products					
10. Labelling of the end products					
11. Traceability - Coding systems from the start to the end product					
12. Recall plan					
13. Employees Training					
14. Documentation control					
15. Periodic maintenance of equipment/ facility					

	In Non-Approved Business (non QC number)				
(b) Procedure	All	Most	Some	Few	None
	5	4	3	2	1
1. Management of purchased materials					
2. Personal hygiene					
3. Waste management					
4. Pest control					
5. Time & Temperature Control					
6. Cleaning of equipment					
7. Cleaning of facility					
8. Transportation of raw seafood materials					
9. Transportation of finished seafood products					
10. Labelling of the end products					
11. Traceability - Coding systems from the start to the end product					
12. Recall plan					
13. Employees Training					
14. Documentation control					
15. Periodic maintenance of equipment/ facility					

SECTION F: FOOD SAFETY MANAGEMENT SYSTEM - FSMS (e.g. HACCP or ISO22000)

19. Please indicate whether the HACCP/ISO 22000 implemented in the seafood establishment is certified by international accredited body? (Please choose one category):

    19.1. All establishments are certified
    19.2. Most
    19.3. Some
    19.4. Few
    19.5. None of the establishments are certified

20. What proportion of seafood establishments used the following methods to prepare and implement a HACCP/ISO 22000 plan?	All	Most	Some	Few	None
	5	4	3	2	1
(a) Prepared by the establishment's own employees					
(b) Employing a consultant					
(c) Guidance from officials of the Fishery Quality Control Centre (FQCC)					
(d) Other, please specify					

21. Verification of HACCP/ISO 22000 plan through an audit is carried out by: (Please choose one category):
    21.1. A third party
    21.2. Fishery Quality Control Centre (FQCC)
    21.3. Other, please specify _____

22. Please indicate the proportion of the seafood establishments that <u>implemented</u> the following HACCP plan elements throughout the processing operation.	All	Most	Some	Few	None
	5	4	3	2	1
(a) Hazard identification					
(b) Identify Critical Control Point (CCP)					
(c) Critical control limit					
(d) Monitoring procedure					
(e) Corrective action					
(f) Verification					
(g) Record keeping					

23. Please rate the following:	All	Most	Some	Few	None
	5	4	3	2	1
(a) The proportion of the seafood establishments participate in the development of their current HACCP plan					
(b) The proportion of the seafood establishments participate in the day- to- day operation of their current HACCP plan					

24. Before a seafood business implements HACCP, in your opinion, what are the 5 main barriers to adopting it?	Please select the top 5 Barriers
(a) Lack of financial resources	
(b) Inadequate infrastructure and facilities	
(c) Requirements to restructure the facility	
(d) Lack of top management commitment/dedication	
(e) Belief that small organisations do not need HACCP	
(f) Lack of enforcement of the food safety policy by the authorities	
(g) Consumers/market not requiring HACCP	
(h) Lack of expertise and/or technical support	
(i) Lack of knowledge on how to implement HACCP	
(j) Employees' resistance	
(k) Managerial resistance	
(l) A need to retrain production staff	
(m) Inadequate staff time for other tasks	
(n) Lack of flexibility in production processes	
(o) HACCP requirements added cost to the final product	

25. When a seafood business decides to implement HACCP, in your opinion, what are the top 5 motivational factors?	Please select the top 5 Motivation Factors
(a) Improved product quality and safety	
(b) Meet quality and safety requirement of customers	
(c) Consumer protection	
(d) Increased product shelf-life	
(e) Meet with national policy requirement	
(f) Reduced need for quality audits by official authorities	
(g) Enhanced reputation of establishment	
(h) Reduced customer complaints	
(i) Increased ability to retain or access new domestic markets	
(j) Increased ability to retain or access new export markets	
(k) Improved efficiency and profitability of the establishment	
(l) Improved control of production process	
(m) Improved staff’s consciousness of food safety	
(n) Increased motivation of supervisory and managerial staff	
(o) Increased motivation of production staff	

SECTION G: THE EFFECTIVENESS OF FOOD/SEAFOOD SAFETY LEGISLATION AND CONTROL AUTHORITIES

26. Based on your experience, please rate the levels of implementation of each of the following legislation in the seafood supply chain using a rating scale as:
    - 26.1. Excellent =5
    - 26.2. Very Good =4
    - 26.3. Satisfactory =3
    - 26.4. Fair =2
    - 26.5. Poor =1
    - 26.6. Not Applicable= (NA)

	Element of Supply Chain						
Legislation / Level of Implementation	Fishermen	Landing sites	Middle men	Transportation mode (prior to processing)	Processors	Distribution of processed products	Markets
(a) Food safety law (84/2008)							
(b) Conditions and Specifications for Commercial Fishing Vessels **(c)** (MD No. 121/98)							
(d) Marine Aquatic Resource Transportation and Marketing Regulation **(e)** (MD No. 29/2004)							
(f) Fishery Quality Control Regulation (MD No. 12/2009)							
(g) Aquaculture and related Quality Control Regulations **(h)** (MD No. 177/2012)							
(i) Regulation on fish markets organization **(j)** (MD No. 312/2014)							

27. Please assess the Government contribution to address seafood quality and safety issues in seafood establishments in relation to:	Excellent (High)	Very Good	Satisfactory	Fair	Poor (Low)
	5	4	3	2	1
(a) Funding					
(b) Training					
(c) Consultancy					
(d) Technical advice					
(e) Communication with establishment					
(f) Response of officials to enquires about quality					

and safety issues faced by the industry					
(g) Response of the officials to enquires about the HACCP system					
(h) Other, Please specify					

27. In order to enforce the food safety and quality regulations and laws, how often the establishments are inspected by the government authorities? (Please choose one category):
    - 27.1. Weekly
    - 27.2. Monthly
    - 27.3. Quarterly
    - 27.4. Once a year
    - 27.5. Once in two years
    - 27.6. No inspection in the last 2 years
    - 27.7. Inspections are random

28. Please assess the strength of the Fishery Quality Control Regulation (12/2009) requirements, in achieving the following?	Excellent (High)	Very Good	Satisfactory	Fair	Poor (Low)
	5	4	3	2	1
(a) Ensuring seafood quality and safety throughout the supply/production chain					
(b) Meeting the needs of different sized processing establishments					
(c) Providing consistent application of the seafood safety requirements across different establishments in Oman					

29. Please rate the effectiveness of the following official control activities in enhancing seafood quality and safety.	Excellent (High)	Very Good	Satisfactory	Fair	Poor (Low)
	5	4	3	2	1
(a) Inspection process					
(b) Auditing process (QC Holder)					
(c) Sampling plan					
(d) Sample analysis					
(e) Pre-requisite programs such as GHPs& GMPs					
(f) HACCP/ISO22000					
(g) 'Recall and Revision' protocol in handling rejected products from international markets					
(h) Level of violation and penalties that apply to those caught breaking the rules within the Fishery Quality Control Regulation (12/2009)					

30. Please rate the effectiveness of the inspection report in covering the following:	Excellent (High)	Very Good	Satisfactory	Fair	Poor (Low)
	5	4	3	2	1
(a) Good Manufacturing Practices (GMPs)					
(b) Good Hygiene Practices (GHPs)					
(c) HACCP					

31. Please rate the factors which limit your ability to enforce the regulations related to seafood quality and safety control while performing your duties.	Not a barrier	Limited barrier	Moderate barrier	Signific-ant barrier	Major barrier
	5	4	3	2	1
(a) Lack of time					
(b) Lack of training					
(c) Lack of laboratory support/facilities					
(d) Lack of transport					
(e) Scattering of the responsible authorities within the ministry					
(f) Low priority within the government to effectively enforcing legislation					
(g) Lack of continuity and commitments of the staff from the establishments					
(h) Lack of continuity of the staff from the ministry					
(i) Lack of awareness of HACCP and its pre-requisite programs (GHPs& GMPs) by the seafood establishments					
(j) Other, please specify					

32. If you could suggest specific improvements in any seafood and quality control methods and any related regulatory processes, what would they be?

33. Please indicate your level of agreement (or disagreement) with the following statements: 'A single/integrated national food control system in Oman will bring a positive change into the seafood industry'.	Strongly agree	Moderately agree	Neutral	Moderately disagree	Strongly disagree
	5	4	3	2	1

APPENDIX B: Questionnaire Survey B: Seafood Establishments (HACCP/ISO22000 implementers)

SECTION A: RESPONDENT'S PROFILE

1. Name (If willing):_____

2. What is your position or job title in the establishment? _____

3. How long have you held this position? _____

4. Education Level: (Please **choose one** category):

   4.1 Secondary Certificate
   4.2 Diploma
   4.3 Higher Diploma
   4.4 Bachelor Degree
   4.5 Master Degree
   4.6 PhD Degree
   4.7 Other, please specify: _____

5. The length of your service in the seafood industry, (Please **choose one** category):
   5.1. □ Under 10 years
   5.2. □ 11 - 19 years
   5.3. □ + 20 years

6. Nationality (Please **choose one** category):
   6.1 Omani
   6.2 Non Omani

SECTION B: ESTABLISHMENT'S PROFILE

7. Establishment name: _____

8. Date of establishment of the firm: _____

9. At present what are the number of employees in your establishment.
   1.1. Omani _____
   1.2. Non Omani _____

10. Sales turnover in 2014 (O.R) _____

11. Annual production (tonnes/year): _____

12. Indicate the main sources (countries) of your raw seafood materials, (If appropriate please choose **more than one** category):
    1.1. Local
    1.2. Europe
    1.3. USA
    1.4. Canada
    1.5. Central America
    1.6. South America
    1.7. Japan
    1.8. China
    1.9. Other Asian Countries
    1.10. GCC
    1.11. Arabic countries (non GCC)
    1.12. North Africa
    1.13. Central Africa
    1.14. South Africa
    1.15. Other, please specify: _____

13. On average, what are the quantities of products (tonnes) produced per year for the following markets:
    1. Domestic market (tonnes/year): _____
    2. Export market (tonnes/year): _____

14. Indicate the processing techniques currently in use in your establishment (If appropriate please choose **more than one** category):
    1.1. Chilled
    1.2. Frozen
    1.3. Canned
    1.4. Breaded
    1.5. Dried
    1.6. Salted
    1.7. Filleted
    1.8. Steaks
    1.9. Gutted& Gilled and de-headed
    1.10. Whole round
    1.11. Other, please specify: _____

15. Indicate the main destinations (countries) of your **end products**, (If appropriate please choose **more than one** category):
    (a) ----- Local
    (b) ----- Europe
    (c) ----- USA
    (d) ----- Canada
    (e) ----- Central America
    (f) ----- South America
    (g) ----- Japan
    (h) ----- China
    (i) ----- Other Asian Countries
    (j) ----- GCC
    (k) ----- Arabic countries (non GCC)
    (l) ----- North Africa

(m) ----- Central Africa
(n) ----- South Africa
(o) ----- Other, please specify: _____

16. What are the main forms of your **seafood exports**? (If appropriate please choose **more than one** category):
    (a) ----- Chilled
    (b) ----- Frozen
    (c) ----- Canned
    (d) ----- Breaded
    (e) ----- Dried
    (f) ----- Salted
    (g) ----- Filleted
    (h) ----- Steaks
    (i) ----- Gutted, Gilled and de-headed
    (j) ----- Whole round
    (k) ----- Other, please specify: _____

SECTION C: SEAFOOD TRADE AND BUSINESS ISSUES

17. What are the main **barriers to export** to regional and international markets? (If appropriate please choose **more than one** category):
    1.1. Trade restrictions (Sanitary and Phyto-Sanitary (SPS) & Technical Barrier to Trade (TBT)
    1.2. Lack of consumer demand in specific market
    1.3. Uncertainty in obtaining a regular supply of raw materials
    1.4. Exchange rate fluctuations
    1.5. Administrative delay
    1.6. Export bans of certain fish species by the Ministry of Agriculture and Fisheries
    1.7. Import duty (tax) in foreign market
    1.8. Other please specify: _____

18. Considering the **quality and safety standard** of seafood products, please rate the level of difficulty in accessing the following **international markets**.	Very easy	Easy	Average	Difficult	Very difficult	Not Applicable
	5	4	3	2	1	NA
(a) Europe						
(b) USA						
(c) Canada						
(d) Central America						
(e) South America						
(f) Japan						
(g) China						
(h) Other Asian Countries						
(i) GCC countries						
(j) Arabic countries (non GCC)						
(k) North Africa						
(l) Central Africa						

(m) South Africa						
(n) Other, please specify:						

19. What barriers prevent the **enhancement** of the business operation in the seafood sector?	Not a barrier	Limited barrier	Moderate barrier	Significant barrier	Major barrier
	5	4	3	2	1
(a) Lack of capital					
(b) Lack of authorities' support					
(c) Lack of communication with the authorities					
(d) Lack of raw seafood materials					
(e) Cost of the raw seafood materials					
(f) Lack of management dedication					
(g) Lack of investment in new technology					
(h) Lack of access to information on different markets					
(i) Staff turnover					
(j) Difficulty obtaining experienced employees					
(k) Low levels of official inspection					
(l) Excessive official inspection					
(m) Lack of enforcement of laws and regulation					
(n) Export ban of certain fish species by the authority					
(o) Other, please specify:					

SECTION D: SEAFOOD SUPPLY CHAIN

20. Generally, how do you rate the quality of the raw materials (seafood) received in the seafood establishments from the various suppliers.	Excellent (High)	Very Good	Satisfactory	Fair	Poor (Low)	Not Applicable
	5	4	3	2	1	NA
(a) Domestic						
(b) Imported						

21. For the following **<u>stages</u>** of the seafood supply chain, please indicate the **negative impact** (damage) it has on quality and safety?	No impact	Minor impact	Some impact	Some degree of impact	Major impact	Not Applicable
	5	4	3	2	1	NA

(a) Foreign inspections/ assessments (*for imported raw materials)*						
(b) Local inspections *(for imported raw materials)*						
(c) Fishermen						
(d) Landing sites						
(e) Middlemen /truckers						
(f) Processors						
(g) Distribution of processed products						
(h) Markets						
(i) Other, please specify:						

22. For the following **factors**, please indicate the **negative impact** (damage) it has on quality and safety of seafood?	No impact	Minor impact	Some degree of impact	Moderate impact	Major impact
	5	4	3	2	1
(a) Traditional practices used by the fishermen and a reluctance to change					
(b) Poor boats' condition					
(c) Use of poor fishing gear (i.e. gills net, beach-seine, long-liner, etc.…)					
(d) Poor ice availability					
(e) Poor temperature control during fish handling					
(f) Poor time control during fish handling					
(g) Poor fish landing facilities					
(h) Poor fish marketing facilities					
(i) Other, please specify:					

SECTION E: PRIMARY CONTROL PROCEDURES

23. Please specify the levels of implementation of the following **procedures** in your establishment.	Full	Nearly full	Partial	Limited	None	Not Applicable
	5	4	3	2	1	NA
(a) Management of purchased materials						
(b) Personal hygiene						
(c) Waste management						
(d) Pest control						
(e) Time & Temperature Control						
(f) Cleaning of equipment						
(g) Cleaning of facility						
(h) Transportation of raw seafood materials						

(i) Transportation of finished seafood products						
(j) Labelling of the end products						
(k) Traceability - Coding systems from the start to the end product						
(l) Recall plan						
(m) Employees Training						
(n) Documentation control						
(o) Periodic maintenance of equipment/ facility						

SECTION F: FOOD SAFETY MANAGEMENT SYSTEM - FSMS (e.g. HACCP or ISO22000)

24. Type of Food Safety Management System implemented in your establishment. (Please choose **one** category):
    1.1. ISO 22000
    1.2. HACCP
    1.3. Others (Please specify) _____

25. Please rate the **level of implementation** of the following HACCP plan elements throughout the full processing operation.	Full	Nearly full	Partial	Limited	None	Not Applicable
	5	4	3	2	1	NA
(a) Hazard identification						
(b) Identify critical control point CCP						
(c) Critical control limit						
(d) Monitoring procedure						
(e) Corrective action						
(f) Verification						
(g) Record keeping						

26. Is the HACCP /ISO 22000 in your establishment certified by an international accredited body? (Please **choose one** category):
    1.1. □Yes
    1.2. □No
    1.3. □ If yes, please provide the accredited body_____

27. Which year did your establishment began to implement the HACCP/ISO 22000 plan? ____

28. Please state the time required to fully implement HACCP system in your establishment (Please **choose one** category):
    1.1. □ Less than 6 months
    1.1. □ 6-12 months
    1.2. □ 13-18 months
    1.3. □ More than 18 months

29. Which year did your establishment receive a QC number from the Fishery Quality Control Centre (FQCC) authority?_____

30. The preparation and implementation of the HACCP/ISO 22000 plan was done by: (Please **choose one** category):
    1.1. □ Establishment's employees
    1.2. □ Employing a consultant
    1.3. □ Guidance from officials of the Fishery Quality Control Centre (FQCC)
    1.4. □ Others, please specify _____

31. The verification of HACCP/ISO 22000 plan through an audit is carried out by: (Please **choose one** category):
    1.1. □ A third party…
    1.2. □ FQCC
    1.3. □ Others, please specify_____

32. Please rate the following statements from fully participation to no participation:	Full participation	Very Good	Satisfactory	Fair	No participation
	5	4	3	2	1
(a) What was the level of your establishment's participation in the **development** of your plant's current HACCP plan					
(b) What is the level of your establishment's participation in the **day- to- day operation** of your plant's current HACCP plan					

33. Where in your operation are the Critical Control Points (CCPs)? (If appropriate please choose **more than one** category):
    1.1. Raw material suppliers
    1.2. Raw material receiving
    1.3. Raw material handling
    1.4. Cooling/chilling step
    1.5. Processing step
    1.6. Cooking step
    1.7. Packaging step
    1.8. Storage
    1.9. Distribution
    1.10. Others, please specify _____

34. Which of the following types of employees have received HACCP training? (If appropriate please choose **more than one** category):
    1.1. Managers
    1.2. Quality controllers
    1.3. Production workers
    1.4. Support staffs
    1.5. Others, please specify _____

35. **Before** your business implemented HACCP, what did you consider the top **5 main barriers** to adopting it?	**Please select the top 5 Barriers**
(a) Lack of financial resources	
(b) Inadequate infrastructure and facilities	
(c) Requirements to restructure the facility	
(d) Lack of top management commitment/dedication	
(e) Belief that small organisations do not need HACCP	
(f) Lack of enforcement of the food safety policy by the authorities	
(g) Consumers/market not requiring HACCP	
(h) Lack of expertise and/or technical support	
(i) Lack of knowledge on how to implement HACCP	
(j) Employees' resistance	
(k) Supervisory/managerial resistance	
(l) A need to retrain production staff	
(m) Inadequate staff time for other tasks	
(n) Lack of flexibility in production process	
(o) HACCP requirements added cost to the final product	

36. When your business **decided to implement** HACCP, what were the **top 5 motivation factors?**	**Please select the top 5 Motivation Factors**
(a) Improved product quality/safety	
(b) Meet quality and safety requirement of customers	
(c) Consumer protection	
(d) Increased product shelf-life	
(e) Meet with national food safety policy requirement	
(f) Reduce need for quality audits by official authorities	
(g) Enhanced reputation of establishment	
(h) Reduce customer complaints	
(i) Increased ability to retain or access new domestic markets	
(j) Increased ability to retain or access new export markets	
(k) Improved efficiency/profitability of the establishment	
(l) Improve control of production process	
(m) Improve staff's consciousness of food safety	
(n) Increased motivation of supervisory/managerial staff	
(o) Increased motivation of production staff	

37. **Having implemented HACCP**, what have been the **top 5 negative impacts?**	**Please select the top 5 Negative Impacts**
(a) Cost of staff training	
(b) Cost of external consultants	
(c) Cost of HACCP certification	
(d) Cost of investment in new equipment	
(e) Cost of product testing (microbial, chemical and physical)	
(f) Time required for Audits	
(g) Staff time required for documentation and record keeping	
(h) Managerial/supervisory time	
(i) Lack of flexibility of production staff	

(j) Reduced flexibility of processing in order to introduce new products	
(k) Poor attitude or motivation of supervisory / managerial staff	
(l) Poor attitude or motivation of production staff	

38. **Having implemented HACCP**, what have been the **top 5 benefits**?	**Please select the top 5 Benefits**
(a) Improved products quality and safety	
(b) Increased awareness of hazards	
(c) Enhanced traceability and recalling (reporting) systems	
(d) Reduction in finish (end) product testing	
(e) Ability to access markets which require HACCP system	
(f) Made access to other certifiable standards easier	
(g) Reduction in official inspection	
(h) Business more driven to satisfy customers	
(i) Enhance sales and easier marketing	
(j) Improved staff commitment to quality and safety	
(k) Improved control across operations	
(l) Staff roles and practices are clearer	
(m) Time saving as staff can follow guidance in manuals	
(n) Reduced waste and cost of disposing	

39. Please provide a yearly estimated cost of implementing (HACCP) for each of the following statements:

Cost categories	**Cost (O.R)**
1. Preparation Cost	
(a) Human resources	
(b) Training programs	
(c) Structural changes to plant and the building	
i. Minor	
ii. Major	
2. Implementation Cost	**Cost (O.R)**
(d) HACCP certification	
(e) Audit cost	
(f) External consultancy service	
3. Running/Operation Cost	**Cost /year (O.R)**
(g) Seafood products testing (Microbial, chemical, physical)	
(h) Water and ice test	
(i) Detergents and sanitizers	
(j) Consumables (gloves, masks, coats, others)	
(k) Pest control management	
(l) Waste management	
(m) Equipment & machine maintenance	
(n) Investing in new equipment and machines	
(o) Record Keeping	
(p) Staff time in documenting the system	

SECTION G: THE EFFECTIVENESS OF FOOD/SEAFOOD SAFETY LEGISLATION AND CONTROL AUTHORITIES

40. Please rate the **level of awareness** by your establishment for the following laws and regulations:	Excellent (High)	Very Good	Satisfactory	Fair	Poor (Low)
	5	4	3	2	1
(a) Food Safety Law (84/2008)					
(b) Fishery Quality Control Regulation (12/2009)					
(c) Aquaculture and related Quality Control Regulation (177/2012)					

41. Please assess the **contribution** of government in addressing seafood quality and safety issues faced by your establishment in terms of the followings:	Excellent (High)	Very Good	Satisfactory	Fair	Poor (Low)
	5	4	3	2	1
(a) Funding					
(b) Training					
(c) Consultancy					
(d) Technical advice					
(e) Communication with establishment					
(f) Response of officials into enquires to quality and safety issues faced by the industry					
(g) Response of the officials into enquires of the HACCP system					
(h) Others, please specify					

42. In order to enforce the food safety and quality regulations and laws, how often is your establishment **inspected** by the government authorities, (Please **choose one** category):
    1.1. Monthly
    1.2. Quarterly
    1.3. Once a year
    1.4. Once in two years
    1.5. No inspection in the last 2 years
    1.6. Inspections are random

43. Considering the **Fishery Quality Control Regulation (12/2009)** in Oman, does it include requirements that could achieve the following?	Excellent (High)	Very Good	Satisfactory	Fair	Poor (Low)
	5	4	3	2	1
(a) Ensuring seafood quality and safety					
(b) Meeting the needs of different sized processing establishments					
(c) Providing consistent application of the seafood safety requirements across different establishments in Oman					

44. Please rate the **effectiveness** of the following **official control activities** in enhancing seafood quality and safety.	Excellent (High)	Very Good	Satisfactory	Fair	Poor (Low)
	5	4	3	2	1
(a) Inspection process					
(b) Auditing process (QC Holder)					
(c) Sampling plan					
(d) Sample analysis					
(e) Pre-requisite programs such as GHP& GMP					
(f) HACCP/ISO22000					
(g) 'Recall and Revision' protocol in handling rejected products from international markets					
(h) Level of penalties that apply to those caught breaking the rules within the Seafood & Quality Control Regulations					

45. In your opinion, having a **single/integrated** national food control system in Oman will bring a positive change into the seafood industry.	Strongly agree	Moderately agree	Neutral	Moderately disagree	Strongly disagree
	5	4	3	2	1

APPENDIX C: Questionnaire Survey C: Seafood Establishments (NON-HACCP/ISO22000 implementers)

SECTION A: RESPONDENT'S PROFILE

1. Name (If willing):_____

2. What is your position or job title in the establishment? _____

3. How long have you held this position? _____

4. Education Level: (Please **choose one** category):
   1.1. Secondary Certificate
   1.2. Diploma
   1.3. Higher Diploma
   1.4. Bachelor Degree
   1.5. Master Degree
   1.6. PhD Degree
   1.7. Other, please specify: _____

5. The length of your service in the seafood industry, (Please **choose one** category):
   1.1. Under 10 years
   1.2. 11 - 19 years
   1.3. + 20 years

6. Nationality (Please **choose one** category):
   1.1. Omani
   1.2. Non Omani

SECTION B: ESTABLISHMENT'S PROFILE

7. Establishment name: _____

8. Date of establishment of the firm: _____

9. At present what are the number of employees in your establishment.
   9.1. Omani: _____
   9.2. Non Omani: _____

10. Sales turnover in 2014 (O.R):_____

11. Annual production (tonnes/year): _____ _____

12. Indicate the main sources (countries) of your raw seafood materials, (If appropriate please choose **more than one** category):
    1.1. Local
    1.2. Europe
    1.3. USA
    1.4. Canada

1.5. Central America
1.6. South America
1.7. Japan
1.8. China
1.9. Other Asian Countries
1.10. GCC
1.11. Arabic countries (non GCC)
1.12. North Africa
1.13. Central Africa
1.14. South Africa
1.15. Other, please specify: _____

13. On average, what are the quantities of products (tonnes) produced per year for the following markets:

1. **Domestic market** (tonnes/year): _____
2. **Export market** (tonnes/year):_____

14. Indicate the processing techniques currently in use in your establishment (If appropriate please choose **more than one** category):

1.1 -----Chilled
1.2 -----Frozen
1.3 -----Canned
1.4 -----Breaded
1.5 -----Dried
1.6 -----Salted
1.7 -----Filleted
1.8 -----Steaks
1.9 -----Gutted& Gilled and de-headed
1.10 -----Whole round
1.11 -----Other, please specify: _____

15. Indicate the main destinations (countries) of your **end products**, (If appropriate please choose **more than one** category):

1.1 ----- Local
1.2 ----- Europe
1.1 ----- USA
1.2 ----- Canada
1.3 ----- Central America
1.4 ----- South America
1.5 ----- Japan
1.6 ----- China
1.7 ----- Other Asian Countries
1.8 ----- GCC
1.9 ----- Arabic countries (non GCC)
1.10 ----- North Africa
1.11 ----- Central Africa

1.12 ----- South Africa
1.13 ----- Other, please specify: _____

16. What are the main forms of your **seafood export**? (If appropriate please choose **more than one** category):
1.1. ----- Chilled
1.2. ----- Frozen
1.3. ----- Canned
1.4. ----- Breaded
1.5. ----- Dried
1.6. ----- Salted
1.7. ----- Filleted
1.8. ----- Steaks
1.9. ----- Gutted, Gilled and de-headed
1.10. ----- Whole round
1.11. ----- Other, please specify: _____

SECTION C: SEAFOOD TRADE AND BUSINESS ISSUES

17. What are the main **barriers to export** to regional and international markets? (If appropriate please choose **more than one** category):
1.1. Trade restrictions (Sanitary and Phyto-Sanitary (SPS) & Technical Barrier to Trade (TBT)
1.2. Lack of consumer demand in specific market
1.3. Uncertainty in obtaining a regular supply of raw materials
1.4. Exchange rate fluctuations
1.5. Administrative delay
1.6. Export bans of certain fish species by the Ministry of Agriculture and Fisheries
1.7. Import duty (tax) in foreign market
1.8. Other, please specify: _____

18. Considering the **quality and safety standard** of seafood products, please rate the level of difficulty in accessing the following **international markets**.	Very easy	Easy	Average	Difficult	Very difficult	Not Applicable
	5	4	3	2	1	NA
(a) Europe						
(b) USA						
(c) Canada						
(d) Central America						
(e) South America						
(f) Japan						
(g) China						
(h) Other Asian Countries						
(i) GCC countries						
(j) Arabic countries (non GCC)						
(k) North Africa						
(l) Central Africa						
(m) South Africa						
(n) Other, Please specify:						

19. What barriers prevent the **enhancement** of the business operation in the seafood sector?	Not a barrier	Limited barrier	Moderate barrier	Significant barrier	Major barrier
	5	4	3	2	1
(a) Lack of capital					
(b) Lack of authorities' support					
(c) Lack of communication with the authorities					
(d) Lack of raw seafood materials					
(e) Cost of the raw seafood materials					
(f) Lack of management dedication					
(g) Lack of investment in new technology					
(h) Lack of access to information on different markets					
(i) Staff turnover					
(j) Difficulty obtaining experienced employees					
(k) Low levels of official inspection					
(l) Excessive official inspection					
(m) Lack of enforcement of laws and regulation					
(n) Export ban of certain fish species by the authority					
(o) Other, please specify:					

SECTION D: SEAFOOD SUPPLY CHAIN

20. Generally, how do you rate the quality of the raw materials (seafood) received in the seafood establishments from the various suppliers.	Excellent (High)	Very Good	Satisfactory	Fair	Poor (Low)	Not Applicable
	5	4	3	2	1	NA
(a) Domestic						
(b) Imported						

21. For the following **<u>stages</u>** of the seafood supply chain, please indicate the **negative impact** (damage) it has on quality and safety?	No impact	Minor impact	Some degree of impact	Moderate impact	Major impact	Not Applicable
	5	4	3	2	1	NA
(a) Foreign inspections/ assessments (*for imported raw materials)*						
(b) Local inspections *(for imported raw materials)*						
(c) Fishermen						
(d) Landing sites						
(e) Middlemen /truckers						

(f) Processors						
(g) Distribution of processed products						
(h) Markets						
(i) Other, please specify:						

22. For the following **factors**, please indicate the **negative impact** (damage) it has on quality and safety of seafood?	No impact	Minor impact	Some degree of impact	Moderate impact	Major impact
	5	4	3	2	1
(a) Traditional practices used by the fishermen and a reluctance to change					
(b) Poor boats' condition					
(c) Use of poor fishing gear (i.e. gills net, beach-seine, long-liner, etc.…)					
(d) Poor ice availability					
(e) Poor temperature control during fish handling					
(f) Poor time control during fish handling					
(g) Poor fish landing facilities					
(h) Poor fish marketing facilities					
(i) Other, please specify:					

SECTION E: PRIMARY CONTROL PROCEDURES

23. Please specify the levels of implementation of the following **procedures** in your establishment.	Full	Nearly full	Partial	Limited	None	Not Applicable
	5	4	3	2	1	NA
(a) Management of purchased materials						
(b) Personal hygiene						
(c) Waste management						
(d) Pest control						
(e) Time & Temperature Control						
(f) Cleaning of equipment						
(g) Cleaning of facility						
(h) Transportation of raw seafood materials						
(i) Transportation of finished seafood products						
(j) Labelling of the end products						
(k) Traceability - Coding systems from the start to the end product						
(l) Recall plan						
(m) Employees Training						
(n) Documentation control						

(o) Periodic maintenance of equipment/ facility						

SECTION F: FOOD SAFETY MANAGEMENT SYSTEM - FSMS (e.g. HACCP or ISO22000)

24. Type of Food Safety Management System implemented in your establishment. (If appropriate please choose more than one category):
 1.1. Good Manufacturing Practices (GMPs)
 1.2. Good Hygiene Practices (GHPs)
 1.3. Not familiar with the above terms
 1.4. Others, please specify: _____

25. Which of the following types of employees have received HACCP training? (If appropriate please choose **more than one** category):
 1.1. Managers
 1.2. Quality controllers
 1.3. Production workers
 1.4. Support staffs
 1.5. Others, please specify: _____

26. Are you aware of HACCP system or ISO 22000? (Please **choose one** category):
 1.1. Yes
 1.2. No

If **yes**, please answer questions **27 and 28** of this **section**.

27. What do you consider the top **5 main barriers** to adopting HACCP?	**Please select the top 5 Barriers**
(a) Lack of financial resources	
(b) Inadequate infrastructure and facilities	
(c) Requirements to restructure the facility	
(d) Lack of top management commitment/dedication	
(e) Belief that small organisations do not need HACCP	
(f) Lack of enforcement of the food safety policy by the authorities	
(g) Consumers/market not requiring HACCP	
(h) Lack of expertise and/or technical support	
(i) Lack of knowledge on how to implement HACCP	
(j) Employees' resistance	
(k) Supervisory/managerial resistance	
(l) A need to retrain production staff	
(m) Inadequate staff time for other tasks	
(n) Lack of flexibility in production process	
(o) HACCP requirements added cost to the final product	

28. It is often claimed that HACCP has many benefits, what are the **top 5 motivation factors** of the following which would encourage you to adopt HACCP**?**	**Please select the top 5 Motivation Factors**

(a) Improved product quality/safety	
(b) Meet quality and safety requirement of customers	
(c) Consumer protection	
(d) Increased product shelf-life	
(e) Meet with national food safety policy requirement	
(f) Reduce need for quality audits by official authorities	
(g) Enhanced reputation of establishment	
(h) Reduce customer complaints	
(i) Increased ability to retain or access new domestic markets	
(j) Increased ability to retain or access new export markets	
(k) Improved efficiency/profitability of the establishment	
(l) Improve control of production process	
(m) Improve staff's consciousness of food safety	
(n) Increased motivation of supervisory/managerial staff	
(o) Increased motivation of production staff	

SECTION G: THE EFFECTIVENESS OF FOOD/SEAFOOD SAFETY LEGISLATION AND CONTROL AUTHORITIES

29. Please rate the **level of awareness** by your establishment for the following laws and regulations:	Excellent (High)	Very Good	Satisfactory	Fair	Poor (Low)
	5	4	3	2	1
(a) Food Safety Law (84/2008)					
(b) Fishery Quality Control Regulations (12/2009)					
(c) Aquaculture and related Quality Control Regulations (177/2012)					

30. Please assess the **contribution** of government in addressing seafood quality and safety issues faced by your establishment in terms of the followings:	Excellent (High)	Very Good	Satisfactory	Fair	Poor (Low)
	5	4	3	2	1
(a) Funding					
(b) Training					
(c) Consultancy					
(d) Technical advice					
(e) Communication with establishment					
(f) Response of officials into enquires to quality and safety issues faced by the industry					
(g) Response of the officials into enquires of the HACCP system					
(h) Others, please specify					

31. In order to enforce the food safety and quality regulations and laws, how often is your establishment **inspected** by the government authorities, (Please **choose one** category):
    1.1. Monthly
    1.2. Quarterly
    1.3. Once a year
    1.4. Once in two years
    1.5. No inspection in the last 2 years
    1.6. Inspections are random

32. Considering the **Fishery Quality Control Regulation (12/2009)** in Oman, does it include requirements that could achieve the following?	Excellent (High)	Very Good	Satisfactory	Fair	Poor (Low)
	5	4	3	2	1
(a) Ensuring seafood quality and safety					
(b) Meeting the needs of different sized processing establishments					
(c) Providing consistent application of the seafood safety requirements across different establishments in Oman					

33. Please rate the **effectiveness** of the following **official control activities** in enhancing seafood quality and safety.	Excellent (High)	Very Good	Satisfactory	Fair	Poor (Low)
	5	4	3	2	1
(a) Inspection process					
(b) Sampling plan					
(c) Sample analysis					
(d) Pre-requisite programs such as GHP& GMP					
(e) HACCP/ISO22000					
(f) 'Recall and Revision' protocol in handling rejected products from international markets					
(g) Level of penalties that apply to those caught breaking the rules within the Seafood & Quality Control Regulations					

34. In your opinion, having a **single/integrated** national food control system in Oman will bring a positive change into the seafood industry.	Strongly agree	Moderately agree	Neutral	Moderately disagree	Strongly disagree
	5	4	3	2	1