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Seafood Safety and Quality: An Analysis of the Supply Chain in the Sultanate of Oman

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3 **1 Introduction**

4

5 Seafood products are essential part of basic food basket in many developing countries with
6 their quality and safety issues inherently linked to the concept of food security (Bose, 2010).
7 Fish and seafood products are considered an important part of a balanced diet and
8 contribute to a good nutritional status. They contain high levels of many important nutrients
9 not commonly found in other foods. Seafood is known to be an excellent source of proteins,
10 very long-unsaturated chains of omega-3 fatty acids (EPA and DHA), vitamin D, vitamin B12,
11 and many useful trace elements such as selenium and iodine. However they also pose
12 significant safety risks and the rapid increase in globalization of fish production and trade
13 has led to concerns and international incidents of contaminated fish (James, Ababouch, &
14 Washington, 2013).

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

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

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

37 **2 Overview of the fisheries sector in the Sultanate of Oman**

38

39 Historically, the fisheries sector in Oman has been dominated by small-scale fishermen and
40 retailers with some commercial fishermen. Recently, aquaculture farms and fisheries

41 establishment become important. The changes have been part of the government's
42 strategic plan to diversify the country's economy and promote private investment (MNE,
43 2007a, 2007b). The fish harvesting practices in most of the coastal communities have
44 remained the same over the years and the government's goal is to shift the sector from the
45 traditional practices to more modern systems(Bose, 2010).

46 **2.1 Economic status of the fisheries sector**

47 The fisheries sector is considered one of the most important non-oil sources of income for
48 Oman although its contribution to the GDP is only 0.5 percent and, combined with
49 agriculture, the figure is still only 1.2 percent (NCSI, 2013; WTO, 2013). However, the social
50 impact of this sector is immense particularly in rural development, employment and food
51 security. Most Omani people live in the coastal areas and fisheries provide livelihoods to
52 around 40,000 Omanis directly with about 280,000 individuals depending indirectly on
53 fisheries income (FSB., 2013; Worldfolio, 2012). The continuous growth in production of the
54 agricultural and fisheries sectors has led to their contribution to the provision of food to
55 nearly 39.5% of the Omani total food consumption during the period from 2009 to
56 2012(MAF, 2012).

57 The continuous growth in production of agricultural and fisheries sectors have led to an
58 increase in the contribution in the provision of food, hence both sectors contribute to
59 around 39.5% of the total consumption food in Oman during the period from 2009 until the
60 year 2012

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

72 In 1995, the country introduced a long-term national economic strategic plan known as
73 "Oman Vision 2020" which specifically aimed to reduce the economic dependency on
74 hydrocarbons sources including an increase the share of the non-oil sector to 15 percent of
75 GDP by 2020 (WTO, 2013). The diversification of the economy has been a vital pillar in the
76 economic policy of the Vision, with objectives of creating an economy that is founded on
77 renewable resources and a highly integrated part of the world economy (WTO, 2013). This
78 strategic decision has diverted attention to the socio-economic potential (i.e., contribution
79 to the Gross Domestic Product (GDP), foreign exchange earnings, employment creation and
80 food security) of the fisheries sector. In order to fulfil this vision, industrial estates, free
81 zones, fish harbours and well-structured landing sites were identified as necessary to
82 support the sector's growth.

83 **2.2 Fisheries sector**

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

86 ***Artisanal fisheries***

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

94 ***Commercial fisheries***

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

104 ***Aquaculture Production***

105 In the Sultanate of Oman, aquaculture is in its infancy stage of development with the
106 aquaculture production small in comparison to the contribution from capture fisheries
107 (FAO, 2006). Early attempts took place in 1986 with a production trial of the giant tiger
108 prawn (*Penaeus monodon*) but it was halted due to technical difficulties. In 2003 and
109 2004, commercial cultured fish commenced and the production increased from 352
110 tonnes in 2003 to 517 tonnes in 2004, with the production of gilthead seabream (*Sparus*
111 *aurata*) representing 89 percent of the total production (Table 3). In the same year, tuna
112 farming was launched producing 14 tons of yellowfin tuna (*Thunnus albacarus*), thus,
113 becoming the first country in the Middle East to have a project of this kind (ESCWA,
114 2007). In 2007, the Omani government with FAO collaboration developed a national
115 strategy for aquaculture development in the country (FAO, 2006). Describing this in 2012,
116 the Minister of Agriculture and Fisheries stated “*As worldwide demand for fish and*
117 *shellfish is on the rise amidst stagnating yields from traditional capture fisheries due to*
118 *depleted wild ocean stock, aquaculture holds the key to meeting global seafood supply*
119 *needs over the coming years*” (Worldfolio, 2012). With cultured species, priority has been
120 given to species found locally in Omani waters, and to exotic species with high
121 commercial values which are required to be screened prior to approval. Aquaculture has
122 been gaining momentum in the last ten years (2003 to 2013) with the introduction of
123 new species. *Penaeus indicus* has shown a steady growth reaching 350 Tonnes in 2013
124 and destined for domestic and regional markets. However efforts are also being made to
125 target the more lucrative markets such as the EU. Sustainability in this sector is the

126 primary aim for aquaculture governance in order to prosper over an extended period,
127 thus viable economically.

128 **2.3 Production, consumption and trade**

129 The annual production of the caught and cultured fisheries has increased in recent years
130 mounting from 95,000 Tonnes in 1985 to 206,000 Tonnes in 2013 (FSB., 2013) with total
131 values rising from just R.O 25million (US \$ 65million) to R.O 166million (US \$ 431million)
132 within the same period. In 2013 the revenues from export were R.O 97 million (US \$ 252
133 million) which represents 0.5% of the total GDP (NCSI, 2013). The increase has largely been
134 achieved by government support to the coastal fishermen (ESCWA, 2007). Despite the low
135 contribution of the sector to the GDP, its socio-economic effect is considered significant and
136 thus receives attention in the country's economic development campaign (Qatan, 2010).
137 The annual per capita consumption of fish in Oman is estimated to be 20.2 kg (FSB., 2013),
138 higher than the world figure of 17kg in 2007 (FAO, 2010).

139 Oman is regarded as a net exporter of fish products with around 61% of its production in
140 2013 exported mainly to neighbouring Gulf countries (FSB., 2013) as shown in Table 1. In
141 2013, Oman exported 125,000 Tonnes to 49 countries around the globe. Most of the
142 exports by volume were to the Gulf Cooperation Council (GCC) (70%) followed by Asian
143 countries (18%) with only 2.2% exported to EU. Although not showing in Table 1, the
144 proportion of exports to the highly valued national markets of the USA and Japan were tiny
145 representing 0.03% and 0.05% of all exports respectively, and less than 1 % in quantity. This
146 clearly demonstrates the opportunities available for market expansion and product
147 diversification.

148 In comparison, imports are small (less than 10% of the quantity of exports) and primarily
149 restricted to fish species which are either unavailable locally or subject to seasonal
150 shortages. The majority of the imports are derived from the GCC, and other countries,
151 followed by the Asian countries as shown in Table 1.

152 **3 The seafood supply chain**

153 The marketing of seafood in Oman is complex linking fishermen, transporters, traders,
154 processors, exporters, retailers and consumers. Based on our knowledge of the Omani fish
155 supply chain and discussions locally, we have developed the overview diagram shown in
156 figure 2. The main elements of this will now be considered.

157 **3.1 Fisheries Producers**

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

165 The overall marketing system in Oman consists mainly of the coastal fish markets
166 ('primary'), fish markets in the interior parts of the country ('secondary'), retail markets and
167 recently a central market in Wilaya Barka. Primary markets are typically basic structures
168 lacking services and are mostly located at the landing centres with fish offloaded directly

169 from the boats of the local fishermen. Sales from these markets can be both retail and
170 wholesale and depend on the fish species, the quantity involved and the clients (household
171 or commercial). Until recently all markets with the exception of the retail outlets were
172 under the jurisdiction of the local municipalities but a government decision in 2011
173 reallocated control of them to the MAF. This is part of moves to bring the entire seafood
174 supply chain under one authority and improve procedures throughout the chain. The
175 municipalities still control the retail markets and the super- and hypermarkets and supply
176 fisheries products to the different regions and interior governorates. They can vary in
177 capacity and infrastructure and are still under the jurisdiction of the different municipalities.
178 Currently 60 primary and secondary fish markets exist in the country and the Ministry is
179 developing minimum requirements covering structure hygiene and procedures which are
180 progressively being implemented throughout the country.

181 As recommended by various studies (Al-Jufaili M. Saud and Opara Linus U. , 2006; Al-Jufaili,
182 2006; A. Omezzine, 1998; A. Omezzine, Al-Oufi, & Al-Akhzami, 2004), in order to improve
183 the supply, safety and quality of fish for the internal and external supply chain, a large scale
184 wholesale fish market has been constructed by the MAF and the Muscat Municipality with
185 full modern services such as electronic auctioning, fish quality checking, ice machines,
186 potable water, hygienic containers, display areas, facilities for monitoring temperature,
187 sanitary inspections and etc... Further small wholesale markets have been established and it
188 is planned to connect all three electronically to assist buyers and sellers. As well as
189 facilitating trade of local fish, these central markets will in future be used for imported and
190 aquaculture fish. This will ensure that these products are properly labelled and checked
191 before entering the local market. Controls on transportation to the central market have
192 been weak and it is planned to extend controls to this in the near future. Enhanced
193 legislation for the organisation of fish markets has been recently issued by the MAF (MD No.
194 312/2014).

195 Most of imported fish products are sold at the retail markets with some going via the
196 primary and secondary fish markets and some being directly imported by processors as raw
197 materials for their added-value production and for re-export particularly in the low
198 production seasons.

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

214 The seafood processors serve domestic, regional and international customers. The majority
215 of these processors produce mainly fresh and frozen products of different species caught
216 locally. Only a few processors deal with added value products, such as canned tuna and
217 sardine or breaded products, with raw materials obtained from both local and external
218 markets. Currently 47 seafood processors are operational with 21 having national
219 certification for export (requiring the adoption of Hazard Analysis and Critical Control Point
220 (HACCP) procedure and its pre-requisite programmes) with the rest at different stages of
221 certification (figure 3). The Quality Control (QC) certificate and related QC number is
222 granted by the FQCC to the establishments, fishing vessels and fishery transporters when
223 they meet the provisions for export to major international markets set out in MD No. 12/09
224 (Ministerial Decision, 2009). Processors lacking the quality and safety systems required for
225 certification and a QC number may target other less demanding markets. Aquaculture
226 products are still a small element but usually find their way to the primary and retail
227 markets. Some are produced specifically for export to regional markets and international
228 markets.

229 **3.2 Domestic, Regional and International Consumers**

230 As shown in figure 2, the supply chain delivers products to consumers in three types of
231 markets: local, regional and international. The first two of these are similar with limited
232 levels of health and safety control; however, these controls intensify as approaching the
233 international market with the EU and USA market considered the most stringent.

234 Domestic consumption of seafood products depends on their availability, income levels,
235 traditions and food perceptions. Fish exports are the most important source of foreign
236 currency rated second after non-oil exports. Policies therefore encourage the trade and a
237 high percentage of the local catch is exported to the neighbouring countries (regional
238 consumers) with the highest quality going to the international consumers. As a
239 consequence, local consumers suffer from occasional fish shortages, despite higher prices
240 being offered for certain commercial fish (Mbagha, Al-Jufaily, & Al Belushi, 2012). Therefore,
241 the ministry have employed appropriate measures with the local producers in order to
242 regulate the distribution of the seafood products in terms of the pricing and accessibility by
243 domestic markets and reduce inflation due to the elevated fish prices (Bose, 2010).

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

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

260 **4 Seafood Safety challenges**

261

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

268 **4.1 Microbial Contaminants**

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

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

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

294 **4.2 Environmental pollution**

295 In respect to environmental pollution, Oman has long coastline of 3165 km involving two
296 water bodies with different characteristics. To the southeast is the Arabian Sea, a part of the
297 Indian Ocean and an open body of water which is exposed to seasonal monsoons activities
298 and has high marine production. To the northeast is the Sea of Oman (or Gulf of Oman)
299 which is a strait that links the Indian Ocean via the Arabian Sea to the Strait of Hormuz and

300 the Arabian Gulf. Around one third of the world's oil production passes through the Strait of
301 Hormuz (Essa, Harahsheh, Shiobara, & Nishidai, 2005) and related oil exploration and
302 industry in this coastal area are sources of seawater contamination. Agrochemical residues
303 discharge into both areas and also pose an environmental threat with potential toxicological
304 effects on the marine biota and subsequent risk to public health. Although an upwelling
305 phenomenon triggered by the monsoon climate enriches the water with nutritional
306 components and increases the production of marine organisms, high levels of natural
307 cadmium are also brought into the surface waters by this process. Marine organisms,
308 including fish, can accumulate different contaminants including inorganic and organic
309 pollutants from the marine ecosystems leading to potential food safety issues (M. Al-Busaidi
310 et al., 2011; Al-Raesi H, Ababneh F, & Lean D, 2007; de Mora, Fowler, Tolosa, Villeneuve, &
311 Cattini, 2005; de Mora, Fowler, Wyse, & Azemard, 2004; Fowler SW, Villeneuve J-P, Wyse E,
312 & S., 2007; Tolosa et al., 2005).

313 A study of fish and shellfish collected from coastal areas of Oman (Moza Abdallah Al-Busaidi,
314 Yesudhason, Al-Mazrooei, & Al-Habsi, 2012) showed the mean concentration of heavy
315 metals (mercury, lead and cadmium) in the edible muscle of pelagic and benthic species
316 were mostly within the standards set by the EU, FAO and Oman. Elevated concentrations of
317 cadmium above the limits were however reported in fish liver which is due to the
318 physiological role of this organ and in oysters and clams (Poulose Yesudhason et al., 2013).
319 High levels of cadmium in fish livers have been found in elsewhere including Mauretania
320 (Rome et al., 1999), India (Rejimon., 2005; Rejimon et al., 2010; Profula et al., 2001), USA
321 (Monosson % Lincoln , 2006; Alexander, 1996), Malaysia (Agura et al., 2005), France
322 (Bustamante et al., 1998), Croatia (Kljakovic et al., 2002), Brazil (Paulo et al., 2007),
323 Argentina (Marcovechi et al., 1991,) and Antarctica (Bargagli et al., 1996). This is considered
324 to be due to upwelling phenomena rather than anthropogenic sources.

325 The country depends on the desalination of the sea water as a source of fresh water supply
326 and therefore control the quality of the marine environment is vital for the country. An
327 emerging threat to desalination and to public health is the formation of Harmful Algal
328 Blooms (HABs) commonly known as red tides. HABs occurrence in the Sea of Oman and the
329 Arabian Sea were reported as early as 1988 following a massive fish kill due to other types
330 of algae blooms (Thangaraja, Al-Aisry, & Al-Kharusi, 2007). An outbreak in the Arabian Gulf
331 and Sea of Oman in 2008/2009 was due to the dinoflagellate *Cochlodinium polykrikoides*
332 and lasted nearly eight months. The impact was great with massive loss of fish, damage to
333 coral reefs, restricted fishing and problems in the operation of the desalination plants in
334 Oman and the United Arab Emirates (UAE) (Richlen, Morton, Jamali, Rajan, & Anderson,
335 2010). Oman is planning to enlarge its mariculture activities and investing in aquaculture as
336 an alternative to seafood. These activities may increase the frequency of HABs (Al Gheilani,
337 Kazumi, AlKindi, Amer, & Waring, 2011) and therefore, bloom mitigation scheme are crucial.
338 Bivalve molluscs and other marine filter feeders have the tendency to accumulate biotoxins
339 and can retain them for a long time. Marine predators in turn feed on the bivalves and thus
340 become toxic themselves, posing a major threat to public health.

341 **4.3 Postharvest issues**

342 As soon as fish and fishery products have been caught, several biological and biochemical
343 changes take place. The changes that take place in fish muscle immediately after death are
344 crucial in determining the quality and safety of the harvested fish products. At the point of
345 death, fish muscle are fully relaxed with an elastic texture that persists for some time before

346 the onset rigor mortis (Alasalvar, Shahidi, Miyashita, & Wanasundara, 2011; Huss H. H.,
347 1995). The timing is affected by several factors such as temperature at the time of
348 harvesting and handling and the size and type of fish species (Huss H. H., 1995; Huss,
349 Ababouch, & Gram, 2003). Mishandling at the different stages of the supply chain can lead
350 to early rejection due to the onset of spoilage. Additionally, post-harvest losses of
351 perishable products such as fish are very significant, especially in developing countries,
352 owing to quality, safety and physical losses. FAO (FAO, 2014b) has estimated that in
353 developing countries these can amount to 10-12 million tonnes and account for around 10
354 percent of the global production of wild and cultured fish products.

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

362 Various studies and reports indicated inadequacy in cold chain management particularly for
363 freshly landed fish that can be exposed to elevated temperatures (40°C) for up to 5-7 hours
364 thus accelerating deterioration of the fish freshness (Al-Jufaili M. Saud and Opara Linus U. ,
365 2006; Al-Jufaili, 2006; Opara Linus U. and Al-Jufaili Saud M., 2006). Furthermore, loses in
366 both quality and quantity limit the profitability and competitiveness of local fishery produce.
367 One study of the tuna supply chain (Al-Jufaili M. Saud and Opara Linus U. (2006) suggested
368 that shelf life is limited to 3 days by the current postharvest practises. They confirmed the
369 need to upgrade the existing postharvest procedures and to apply modern cold chain
370 technology to overcome loses and extend shelf-life. One consequence of the short life is
371 that often downgraded fish are used to produce secondary fish products (such as salted or
372 dried products) so as reduce the losses faced by the fishermen and traders – this though can
373 lead to further safety issues. Some of these traditionally processed fish products are often
374 associated with the presence of the carcinogenic compounds nitrosamines (Al Bulushi,
375 Poole, Deeth, & Dykes, 2009; Zou, Lu, & Liu, 1994) even though the factors influencing their
376 formation have not been well defined. Therefore, the need for proper handling and
377 processing is critical in assuring the health of end users.

378 **5 Regulatory Framework**

379

380 Although seafood consumption contributes to health and wellbeing, concerns at the safety
381 and quality of seafood have been at the forefront of regional and global campaigns and
382 ensuring the safety of this seafood is critical requiring national and international action. For
383 Oman, compliance with respect to safety and quality criteria is vital to access the lucrative
384 export markets and sustain international competitiveness. The EU, USA and Japanese
385 markets are the world's major importers of seafood products with imports accounting for
386 63% (AIPCE-CEP, 2014), 60% and 54 % (FAO, 2014c), respectively of their fishery product
387 consumption. They are therefore important markets for exporters but the situation is
388 complicated since the requirements of each international market differ in terms of the
389 specification and the regulations imposed.

390 **5.1 Organization**

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

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

405 For the USA, Oman signed an updated Free Trade Agreement (FTA) 2009 which aims to
406 promote economic reform and openness in trade issues (USTR, 2014). Foods imported into
407 the USA must meet the same legal requirements as domestically-produced foods and
408 inspectors may detain shipments of imported products which not in compliance. They are
409 also subjected to Food and Drug Administration (FDA) inspections under the provisions of
410 the U.S. Federal Food, Drug and Cosmetic Act (FFDCA). In addition the US Code of Federal
411 Regulations provides specific regulations for the safety and sanitary procedures and
412 imported fish and fishery products must have been subject to processing with an effective
413 Hazard Analysis and Critical Control Point (HACCP) system operating.

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

420 **5.2 Omani fishery control regulations**

421 The Marine Fishing and Protection of Living Aquatic Resources Law was promulgated in
422 1981 by a Royal Decree (RD) 53/81 and is known as "The Fisheries Law". Subsequently, the
423 Executive Regulations of the Law was issued in 1982 by a Ministerial Decision (MD) No. 3/82
424 and amended in 1994 by a MD No. 4/94. This represents the start of the current control
425 system as illustrated in figure 4. The law has six sections including definitions, regulation of
426 fishing, protection and development, handling, marketing and processing, violation and
427 penalties and general provisions. The Executive Regulations deal mainly with marine fishing
428 licences, licence fees, protection and development of living aquatic resources, regulation of
429 fishing, preservation, transport and marketing of living aquatic resources, general provisions
430 and penalties.

431 Other relevant legislation includes the Ministerial Decision on the Quality Control Regulation
432 for Omani Fishery Export (MD No. 4/97) which mainly deals with conditions and
433 specifications of exported fishery products and its by-products in regards to the

434 preservation, handling and processing of fish products. In 1998, a Ministerial Decision (MD
435 No. 136/98) was issued to enforce quality control regulations for Omani fishery exports and
436 amended the MD No. 4/97 and required the adoption of HACCP system and its prerequisite
437 programmes in seafood establishments intending to export to the EU. This was introduced
438 as in July 1998, following a visit by the EU's Food and Veterinary Office (FVO), the EU had
439 banned the import of fish from Oman and some other GCC states as the existing controls did
440 not comply with the EU's requirements for HACCP implementation (FAO, 2004). Recently, a
441 new regulation has been issued (MD No. 312/2014) by the MAF which covers the
442 organization and operation of fish retail and whole sale markets, seafood products handling,
443 market monitoring in terms of hygiene and safety of the marketed products (Qatan, 2010).

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

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

464 The overall food safety system is structured in various government agencies that are based
465 at different ministries (Moza A. Al-Busaidi & Jukes, 2015). Therefore, the efforts to
466 successfully dealing with existing and emerging food safety threats and risks are hindered,
467 due to the duplication in mandates and overlapping responsibilities of the responsible
468 agencies. A lack of harmonization of the standards and regulations for the domestic
469 production, exports and imports is a challenge for the regulators and the different
470 stakeholder particularly when considering world trade and consumers protection issues.
471 Ensuring effective legal control for the assurance of hygiene, safety and quality across the all
472 stages of the seafood production chain is fundamental to access the export markets.

473 Faced with many difficulties due to the increase in sanitary and safety regulations
474 highlighted in the world trade of fishery products, regulation (12/09) has broaden its scope
475 from the previous regulation (136/1998). It mandates the enclosed of all the institutions,
476 processors and individual operating in the field of fish and fishery products either exporting,
477 importing or domestic production to adapt their situation accordingly to the stipulated rules
478 of this regulation (Ministerial Decision, 2009). The stringent regulation has imposed

479 important socioeconomic consequences on the domestic supply chain. The cost imposed on
480 seafood processing to restructuring their facilities and production lines are significant highly
481 and this has been estimated to amount to R.O. 98,000 (254,545 USD) (Qatan, 2010) and not
482 within the capabilities of these processors. As indicated by the Ministry, a lot of effort is in
483 place to upgrade these establishments to meet with regulation No. 12/09.

484 **5.3 Food safety management systems**

485 Seafood safety and quality control measures were not a priority until the EU embargo in
486 1998. This required enhanced procedures to ensure compliance with the EU legislation. In
487 particular it led to the establishment of the FQCC under the Directorate General of Fisheries
488 Research with headquarters in Muscat and regional offices in various coastal governorates.
489 The FQCC is the premier regulatory agency for the enforcement of seafood safety and
490 quality regulation required by MD No. 12/2009. In addition it is responsible for inspecting,
491 assessing, and approving seafood production vessels and establishments and related
492 activities and for the analysis of samples for contaminants. The veterinarian and quarantine
493 department with the Ministry is responsible for issuing health certificates and certificates of
494 origin to accompany exported seafood consignments in order to ensure their compliance
495 with national laws and regulations. They also inspect seafood products on entry into the
496 country.

497 In accordance with the new requirements, in 1999 nine plants were certified as HACCP
498 compliant and were provided with Quality Control (QC) numbers and became eligible to
499 export their products to international market, particularly EU and allowed for the lifting of
500 the EU's ban. Subsequently, by 2002, the number of certified plants had increased to 25
501 plants, accounting 50% of the total processing fisheries plant, at that time (ESCWA, 2007).
502 However, a decrease in the landing of fish species with higher export values internationally
503 has caused some local exporters to question the value of meeting these enhanced
504 standards. The potential for fishermen to market fish to neighbouring countries with fewer
505 regulatory requirements in preference to selling to local processors has added further to the
506 struggles of companies seeking to export products to major international markets (ESCWA,
507 2007). Consequently, by 2013 the number of certified plants had declined to 21.

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

521 One study has identified some weaknesses and constraints that reduce the effectiveness of
522 the regulatory systems in the seafood sector (Qatan, 2010). The study highlighted the lack of
523 pro-activeness and dependency of the seafood processors on the regulatory authority of the

524 food safety management system. The study highlighted the difficulties faced by the industry
525 in terms of the cost of HACCP implementation, in fish processor for the structural work and
526 the modification required to meet the regulation requirements.

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

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

538 **6 SWOT analysis**

539

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

547 In order to try and identify what more the government could do for the industry to make it
548 more successful, we have used the information given above to construct a SWOT analysis
549 identifying the Strengths, Weaknesses, Opportunities and Threats to the fishery sector in
550 Oman. This has been tabulated in Figure 5.

551 **7 Discussion**

552

553 Fisheries production is one of the countries' chief sources of economic revenue after oil
554 production. The country exported 60% of its production in 2013 with most of the exports
555 targeting regional markets such as the GCC countries as well as Asian and African countries.
556 The lucrative markets of the EU, USA and Japan on the other hand, are less targeted due to
557 the more stringent standards imposed by the importing countries. Gaining access to these
558 markets can be costly as it requires the adoption of enhanced controls such as HACCP and
559 other management standards and exporters face high competition for market share from
560 other countries seeking to export. Despite the costs, HACCP does have significant benefits
561 (Taylor, 2001). A correctly applied HACCP system gives a food business operator in depth
562 knowledge of the potential hazards in the process. They also become more focused on the
563 essential controls needed in their processing plants such as critical control points rather
564 than depending on the end products testing which is expensive and does not prevent
565 product failure. In the long run as stated by (Taylor, 2001) despite the work of initially

566 setting up a HACCP system, costs can be reduced. Most of all, if implemented correctly, the
567 system provides the food industry with effective management tools to produce safe food
568 and prevent foodborne illnesses. As the internationally recognised food safety system, its
569 adoption provides a clear benefit as it allows access to a wide range of international markets
570 (Taylor, 2001). A local study by (Qatan, 2010) had findings which were in agreement with
571 these. The main benefits of HACCP ranked by authority and the seafood industries were the
572 improvement of the safety and quality of the products; easy access to lucrative markets
573 with stringent food safety requirements in place; improved customer satisfaction and moral
574 and commitment to the food safety and quality. Whilst a reduction in the rejections of
575 seafood products entering the EU and international markets was observed by both groups
576 after the implementation of HACCP in the seafood industry in Oman.

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

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

589 **7.1 Flow process of fisheries products**

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

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

604 It is clear that the traditional fisheries need to invest in more advanced boats with
605 preservation and storage facilities on board. This would be most appropriate in the Arabian
606 Sea coastal areas where fish stocks are more likely to be sustainable. Basic hygiene
607 requirement and good infrastructure should be enforced in all the onshore (primary),
608 secondary markets and small processing plants. The transport system must comply with the
609 conditions and specifications of the living aquatic resources transportation and marketing

610 vehicles of MD No. 29/2004. The high temperature environment in the country makes
611 compliance with temperature requirements very difficult when combined with current
612 practices of pre- and post-harvest techniques and the simple infrastructure found in certain
613 regions. Effective cold chain management retards microbial and biochemical reactions
614 associated with food spoilage and deterioration and reduce production losses and enhance
615 the quality and safety of products.

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

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

637 **7.2 Seafood safety issues**

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

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

661 **7.3 Safety legislation**

662 Food control authorities have a duty to ensure the integrity and safety of foods offered to
663 the consumer. The Codex Alimentarius Commission has endorsed the adoption of HACCP as
664 a system for ensuring the safety of foods and the prevention of foodborne diseases. In
665 addition, a series of Codes of Practice for fisheries products have been developed to aid the
666 fisheries industry. The World Trade Organization's Agreements on the Application of
667 Sanitary and Phyto-sanitary Measures and the Technical Barriers to Trade has urged both
668 government and industry to harmonize and adopt transparency in order to minimize
669 barriers to international trade. Oman, as a member of both organizations since 1972 and
670 2000, respectively, has adopted sanitary and safety regulations based on Codex, WTO and
671 the EU's requirements and recommendations. This has included work by the MAF
672 implementing measures specifically to carry out quality and safety control and inspections
673 of the seafood industry.

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

679 The extension of the requirements of the regulations (No. 12/2009) to cover the full supply
680 chain and the broadening of the requirements to include importers, exporters and local
681 producers has spread the resources more thinly. The latest inclusion of the fish markets
682 into the mandate of the MAF has also increase the burden on the limited number of official
683 regulators. The system is still complex with food safety laws and regulations fragmented
684 among different governmental authorities and functioning as multi-agency system (Moza A.
685 Al-Busaidi & Jukes, 2015). These delays the adoption of a fully risk-based approach meeting
686 the food safety challenges for both its domestic and potential export markets.

687 **8 Conclusion and recommendations**

688
689 The fisheries sector is one of the most important non-oil sources of income for the Sultanate
690 of Oman. Small-scale fishermen are the backbone of fisheries production particularly with
691 the absence of a robust industrial fishery in the country. The MAF has tried various
692 approaches to enhance the fisheries sector in order to meet the stringent requirements of
693 international trade. HACCP has been highly recommended in the Omani's fisheries
694 legislation and efforts continue to protect both the health of the consumers and the interest
695 of its industry.

696 To ensure seafood safety and quality the supply chain must incorporate the best practice on
697 board and during handling of seafood products (e.g. cleaning, bleeding and ice). Traceability

698 techniques from the primary producer (wild and farmed), through post-harvest treatment,
699 processing and distribution to the consumer must be developed and attained. With the
700 development of the aquaculture industry in the country, an increasing emphasis on the
701 prevention of hazards at source will be essential. These could be developed and
702 disseminated through good aquaculture practices and the application of HACCP in the
703 different stages of the process to complement the existing methods. Regional collaboration
704 among the different GCC countries sharing the same water bodies, perhaps within the
705 Regional Organization for the Protection of the Marine Environment (ROPME) framework,
706 Regional Commission for Fisheries (RECOFI) or Gulf Cooperation Council (GCC) food safety
707 committee would also be of great benefit to overcome safety problems. Some of the
708 collaborative work could be environmental programmes involving surveillance to monitor
709 the various contaminants in the marine ecosystem and preventing them from entering the
710 food chain. It is suggested that an annual 'food safety awareness week' be held in all GCC
711 countries at similar times and used as a platform to launch various programs for educating
712 and communicating with different stakeholders in the food supply chain. Further efforts to
713 unify the official food control system both in Oman and across the different GCC countries
714 would also assist consumer wellbeing.

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

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

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

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

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740

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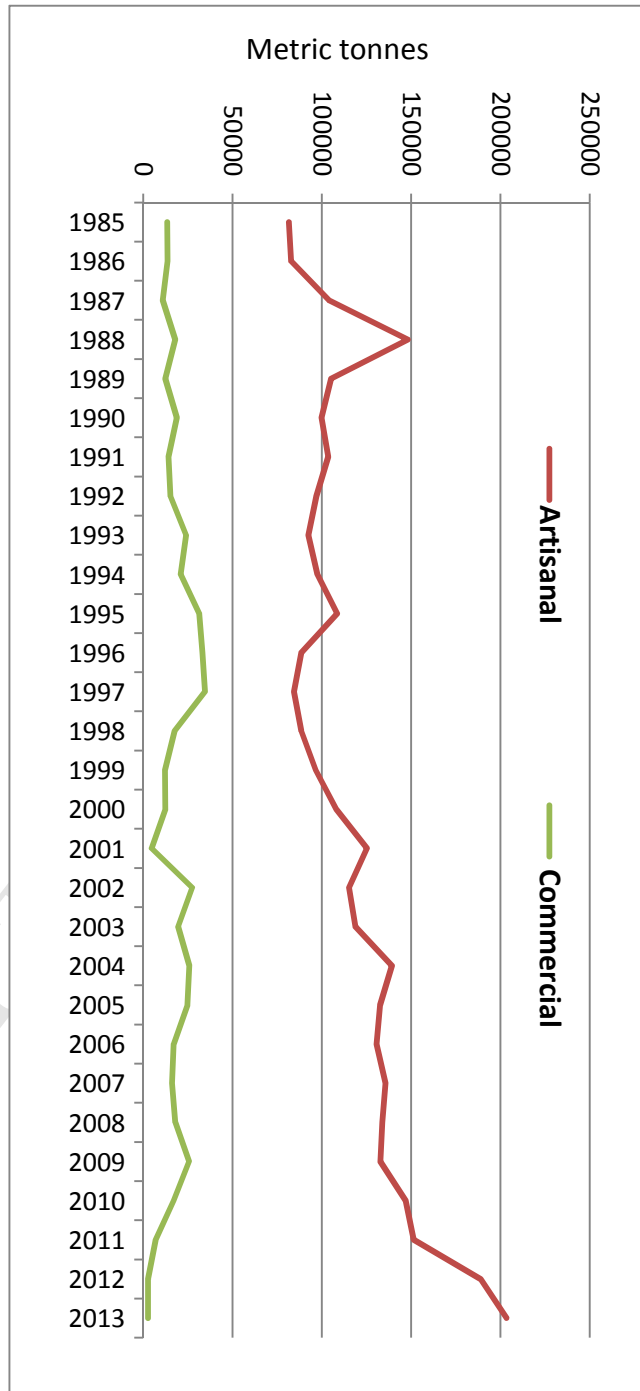
List of figures and tables**List of Figures:**

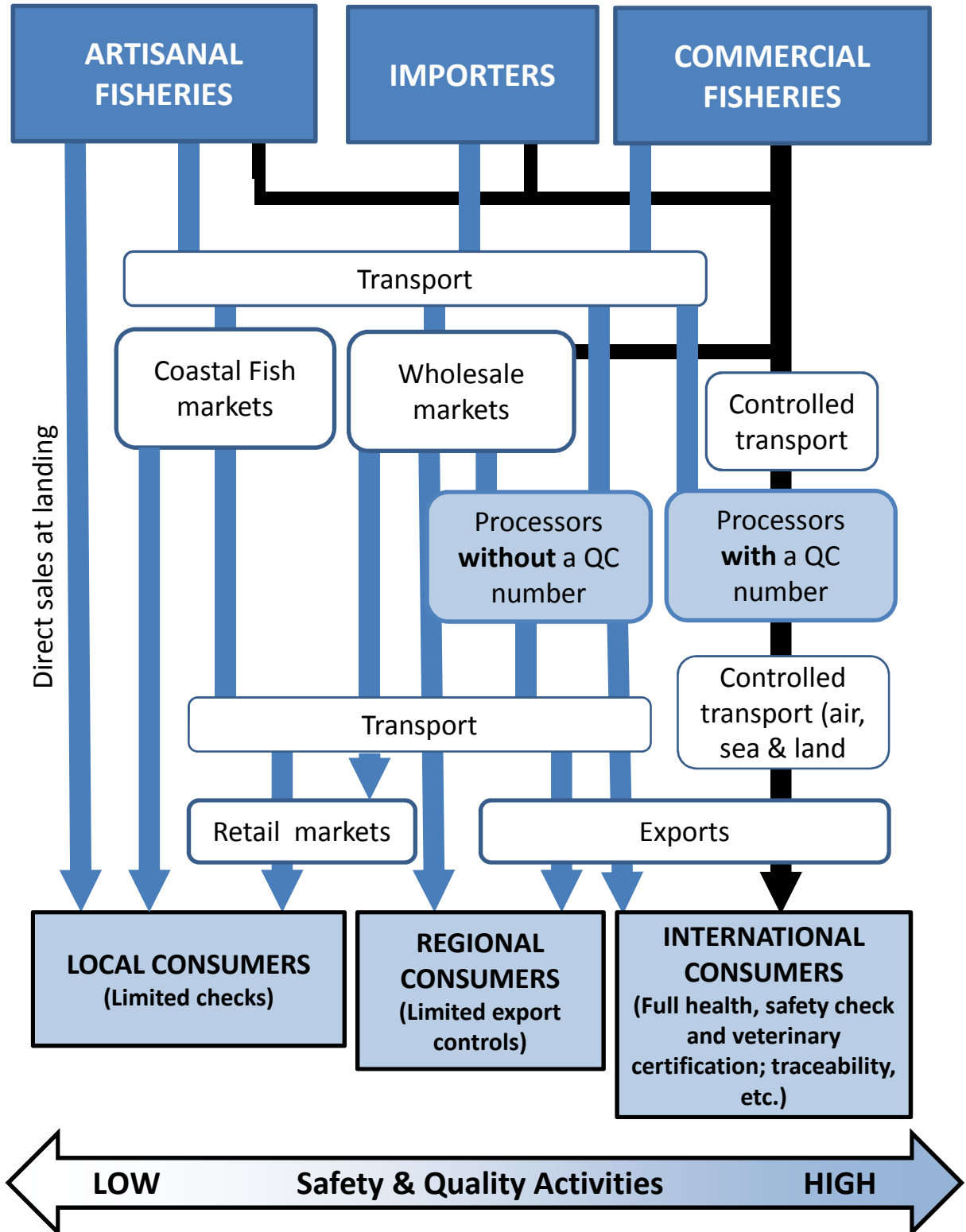
- Figure 1. Seafood production from the artisanal and commercial fisheries from 1985 to 2013 (FSB., 2013)
- Figure 2. Primary routes for the distribution of fish and fishery products in Oman
- Figure 3. The status of the seafood establishments in Oman (number, percentage %) Source: (FQCC, 2014)
- Figure 4. The evolution of Omani laws and regulations on seafood safety
- Figure 5. SWOT analysis of the Omani fishery sector

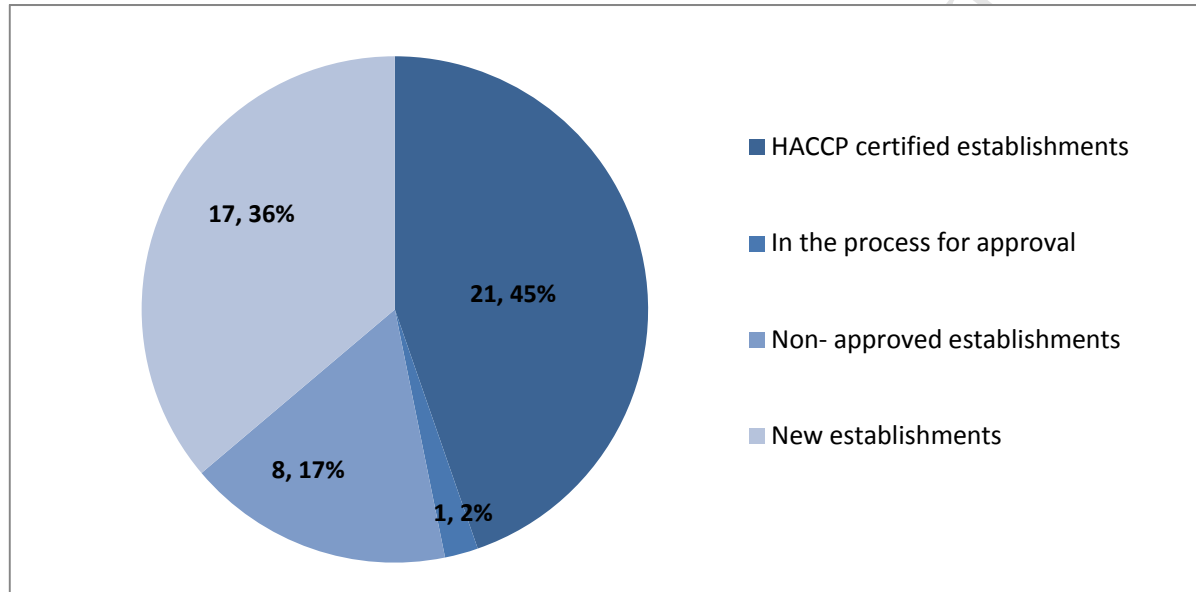
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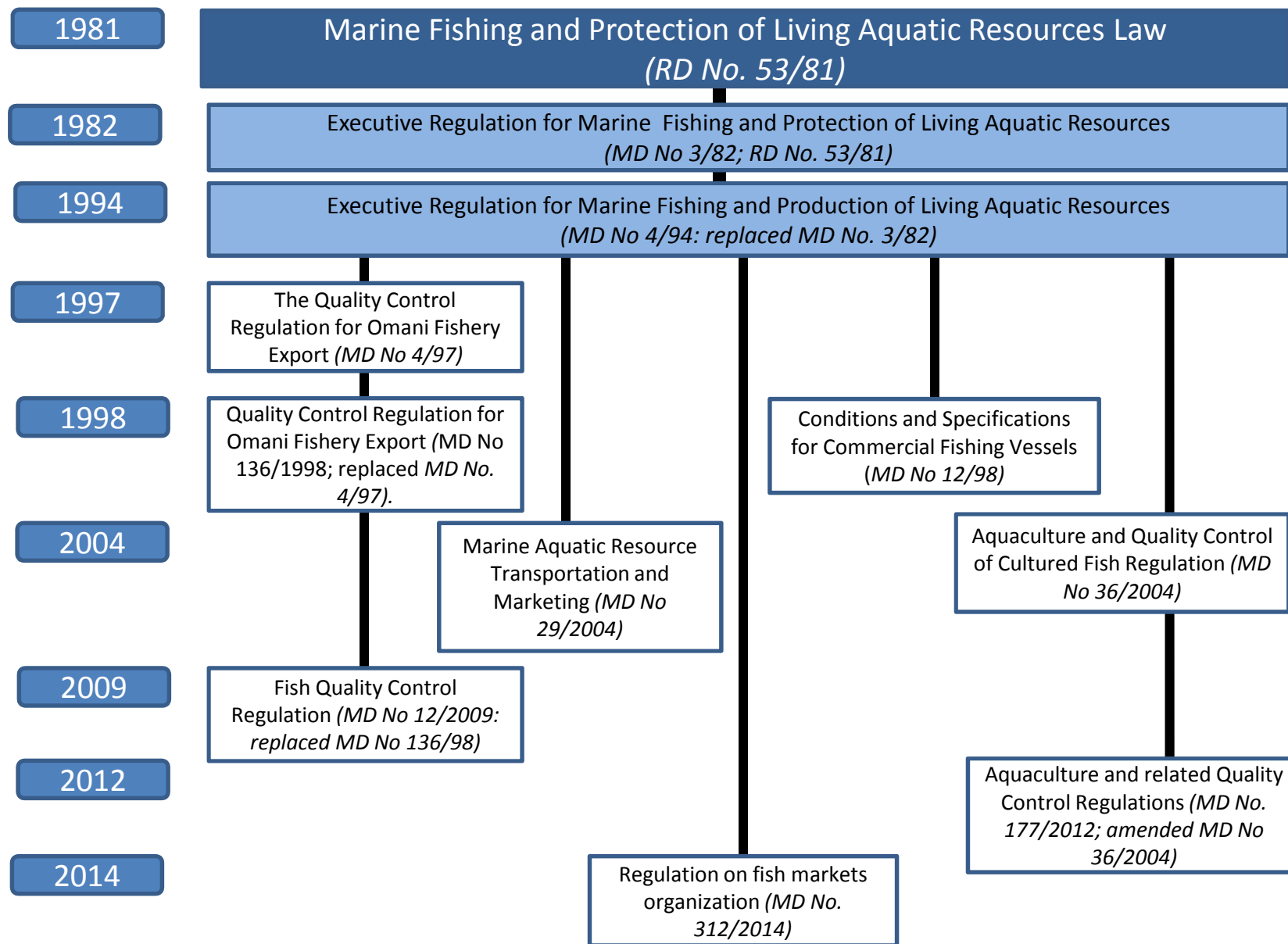
- Table 1. Fisheries exports and imports in quantity and values in 2013

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	125689	252047	15609	11856	33855	47773









Strength	Weakness
<ul style="list-style-type: none"> • 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 	<ul style="list-style-type: none"> • 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
<ul style="list-style-type: none"> • 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 	<ul style="list-style-type: none"> • 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

Highlights:

- Seafood safety and controls in Oman are reviewed
- The complex supply chain in Oman for seafood is described
- Control requirements are identified and vary according to the final market
- Improvements have occurred but the research indicates that further progress is needed