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Review of marine fishery status along the supply chain in Sri Lanka

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Abstract
This paper provides a broad review of marine fishery including, coastal, offshore fisheries, and status of fish freshness quality along with the supply chain and fisheries management issues and opportunities. Past two decades of the marine fishery industry is compared from harvest to the consumer, reviewed parameters which related to fish freshness and shelf life throughout the marketing network and find out drawbacks or obstacles or problems of quality of the fish. Poor hygienic practices of deck handling, storing, fish landing sites, handling of fish, fish stalls, cleaning, gutting, cutting and use of other related equipment were emphasized on previous researches. Those factors were affected to freshness quality, shelf life, heavy losses and finally economic value. The relationship between fish quality and freshness correlate with six factors, but some factors not yet implemented for quality assurance in Sri Lankan fishery industry. Using modern technology, the rapid quality indicators can be used other than the sensory evaluation to determine the freshness of the fish.

Keywords: fish freshness, supply chain, rapid quality indicators, and sensory evaluation

1. Introduction

Sri Lanka is an island that is located between latitudes 50 30' and 100 00' North and longitudes 700 30' and 820 00' East in the Indian Ocean, bounded on the west by the Arabian Sea and the Gulf of Mannar and on the East by the Bay of Bengal. Fishing has been a major economic activity in Sri Lanka from time immemorial and has been the major livelihood of the coastal communities. The fisheries sector in Sri Lanka has been considered as one of the major potential areas for expansion of the economy. The sector plays a vital role with respect to provision of direct and indirect employment opportunities for 560,000 and livelihood for 2.6 million people, generation of income (MFARD 2011, MFRAD 2012, MFRAD 2015; Ceylon Chamber of Commerce; Blindheim & Foyn (1980) [38, 39, 40, 21, 16]. foreign exchange earnings and provision of reasonably priced protein for the rural and urban masses in the country. The fisheries sector constitutes three major sub sectors viz. Coastal Fisheries, Offshore/Deep Sea Fisheries and Inland Fisheries and Aquaculture. Mostly, in Sri Lanka, the term 'small scale fisheries' is almost the same with coastal fisheries and 'offshore/deep-sea fishery' is considered as large scale fishery (NARA) 1997) [81].

The coastal belt is about 1,760Km and a land area of 65,610 Km2. As per the declaration of an Exclusive Economic Zone (EEZ), extending up to 200 miles, Which equal to 517,000Km2 of with rich in fish species, thus giving Sri Lanka a high water to land ratio. The present study reviews the trends in the marine fishery in Sri Lanka with some concern on the status of the resources and supply chain.

As per the finding of environmental assessment by Dassanayake, 1994 [24] of bay of Bengal region is rich diversified fish ground was found and suggested to maintain sustainable level for fishery and further described by Charles, 2001 [20].

2. Sources of Information

Past records and information that has been published by MFRAD, NARA, IOTC, BOBP, FAO and reports of reviewed journals were analyzed for this study.

The marine fisheries industry in Sri Lanka has a long history. During the early stages of development, traditional methods of fishing using canoes and gear, such as beach-seines, hand-line, and nets made out of coir and stake nets, were used in coastal areas. Fish production in the 1940s was in the region of 40 000 t (Delgado *et al*, 2003) [28]. A high percentage of this production came principally from beach seines.

A stage of rapid development in fisheries began in the late 1950s after introducing motorized modern craft and methods (Joseph, 1983, Joseph *et al*,. 1985, ADB 2005, ACDI-VOCA, 2006) [60, 61, 02, 03]. With these technological developments and the open-access nature of operations, fishing effort has accelerated over the years, both by increasing fishing power and fishing units. In addition, the government provided motivations in the form of subsidies on capital goods and institutional credit (De Silva *et al*., 1996) [29]. As a results of introducing technological inputs coastal fish production was increased from 84 400 t in 1962 to 152 750 t in 1999.

Marine fisheries in Sri Lanka can be divided into two major categories such as coastal and offshore fisheries. The coastal fisheries can be further divided into pelagic and demersal fisheries. Wijayaratne, (2001), Barut, N.C *et al*., (2003), Ginigaddarage, (1992) [114, 14, 45] pointed out that the coastal fisheries still account for about 67% of the marine fish caught; the peak production of the fish from the coastal fishery was recorded in 1983 as 184,049 Mt, shared about 84% of the total fish production. But after then, it was droppedup to 121,350 in 2006, which was the lowest contribution for the total fish production. This situation was expressed by Maldeniya in 1998 [72], there were some uncertainties regarding further expansion of coastal fishing activities due to coastal sector had limited capacity for further expansion; many efforts were made to expand the fishing more towards the offshore areas. After 1980s the government promoted to develop the offshore fisheries by introducing 8.0 X 9.8 m boats to conduct multi-day fishing operations in offshore waters. Since then multi-day offshore fishing has developed rapidly and this had caused a substantial increase in marine fish production in Sri Lanka (Maldeniya & Amarasooriya, 1998; Samaraweera and Amarasiri, 2004) [72, 95].

Anon. 1997 [07] pointed out that the level of coastal fisheries production particularly the pelagic species caught with gillnets have either reached or are fast approaching their potential yields. But, marine fisheries in Sri Lanka still depend on coastal fisheries, which, according to available information, have reached optimum exploitation levels (Dayaratne. & Amarasir, 1991; Dayaratne and Sivakumaran.1994; Dayaratneand M De Silva. 1995) [25, 26, 27].

The Fridtjot Nansen Survey in 1978 – 80 [106] estimated the potential yield from coastal fish resources within the continental shelf to be 250,000 tons per year of pelagic and demersal species; pelagic fish were estimated to have a maximum sustainable yield of 170 000 t per year and demersal species 80 000 t. “Preliminary estimates of Sri Lanka’s offshore resources indicate that 50 000 - 90 000 t per year could be taken without the risk of overexploitation. Deep sea fisheries mainly targeted medium and large tunas with skipjack (Katsuwonuspelamis) and yellow fin (Thunusalbacares) dominating the catches while sailfish (Istiophorusplaytypterus), swordfish (Xiphias gladius) and marlin are also common in the catch. Many species of sharks are also a part of the deep sea catches. Many international governmental and non-governmental organizations have pointed out that country’s catch estimates were subjected to a high degree of uncertainty (Hasarangi *et al*-IOTC, 2009; Amaralal, 2010) [51, 05]. Atapattu, 1996 [10] predicted that the total marine fisheries resources, including Sri Lanka’s offshore area, could yield up to 350,000 t per year.

The fishing effort has increased with the catch remaining static. The fishing sector has reacted to this declining catch rate by investing in new fishing gear such as purse seine, ring net in pelagic fisheries and bottom long-line and trammel nets in demersal fisheries. This type of gear is be¬yond the capital resources of the majority of small scale fishers. There is therefore inequitable distri¬bution of income from fishing, leading to increased conflicts among fishers in traditional fisheries and in modern fisheries (Fernando, 1984) [36]. However, improvement in technology has led to marginal increases in Catch per Unit Effort (CPUE), but also to the over-exploitation of coastal resources. The involvement of around 120, 000 fishers in mostly small scale fishing in the Coastal waters has forced the government to consider small scale fisheries in Sri Lanka as a priority target for poverty relief (Dissanayake *et al*., 2008; Dissanayake, 2009) [31, 32].

3. Status of the Fishing fleet (operational) of fishery sector

As per the Table 01 and Table 02 show that the total fishing fleets were increased 48 % within fifteen years (from 1999-2015). Non-motorized boats were increased 31% and motorized boats were up to 60% level on the above period of time. As per fishery statistics the fishing pressure of the coastal region is reached up to maximum level because the fish production from the coastal fishery estimated that Maximum Sustainable Yield (MSY) 250,000 Mt. The yield of coastal fishery was reported 269,020 Mt in 2015. Therefore it would seem to be reached to overexploited level. The fleets that engaging the offshore fishery also were increased 68%.

3.1 Status of fish trade and processing

Table 2: Trends in fish trade and processing year 2105 statistics

	2015
Active Fish Sales Outlets of Ceylon Fisheries Corporation (CFC)	128
Fish processing plants (EU approved)	28
Fish processing plants (other)	09
Annual export earnings (SLRs. Mn)	18,456
Annual import expenditure (SLRs.Mn)	20,964

Table 03 shows that the active fish sale outlets were established covering up suburban areas under Ceylon Fisheries Corporation it was a semi-governmental body.

Comparing the previous decade this type of involvement is tend to encourage the maintenance of standard sales outlets those who are engaging trade market in private owners.

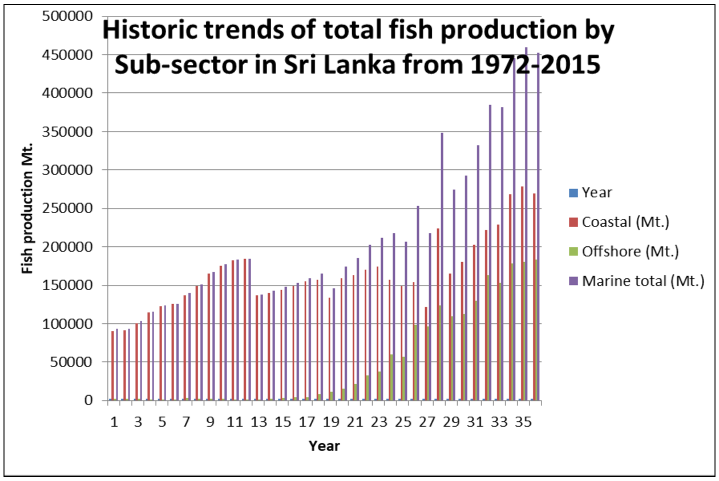
Recently the fish outlets are established as a part of super markets and those outlets are maintained least standards. It is a greenlight for consumers because they have more opportunities to purchase freshness fish than the retail outlets established in the outside. EU approved fish processing plants are seem to be increased comparing with previous decade in the field of fishery industry.

3.2 Status of infrastructure facilities

Table 03 indicates that the infrastructure facilities of the fishing industry in 2015. Comparing the previous decade considerable development has been shown that ice production plants and new anchorage centers were established. It would be contributed to easy maintain of supply chain of the fishery.

Table 3: Trends in infrastructure facilities in 2015

	2015
Fisheries harbor in operation	20
Anchorage	58
Minor fish landing centers	890
Active ice plants	90
Ice production capacity Mt/day	2788
Cool rooms	43
Cool room capacity Mt/day	2112



Source: Censuses of Statistics and Ministry of Fisheries Sri Lanka

Fig 1: Historic trends of total fish production by sub-sector in Sri Lanka from 1972-2015 Year 1= 1972…Year 35= 2015

In Sri Lanka commonly use two types of ice such as blocking ice and flakeice plants. The block ices that contain 50 kg block are mostly used for the fisheries sector. The water for block ice processing is originated from wells close to the plants or from municipal tap water. Water source is usually stored in sumps and overhead tank before it is used.

The quality of ice used for cooling of fish is not up to the required hygiene standards (personnel communication). Mainly two types of freezing methods are used in fish processing plants in Sri Lanka (plate freezing and blast freezing). Considerable amount of fish is being exported in fresh form with the use of gel ice packs (Wijesekara, 2016) [117].

Offshore fishing fleets are presently practiced with limited post-harvest technology, equipment and information. Usually practicing gills and gutting before ice the longlines fishing and no practicing gills and gutting before ice the gill nets fishing.

As per figure 01 and table 06 can see that historical changes about the marine fishery in past forty three (43) years, comparing with other sub sectors.

Considering the fishing boats for catching tuna and tuna like species, the table 04 summarized that classification of multiday fishing vessels in Sri Lanka.

Table 1: Historic trends of the fishing fleet (operational) of fishery sector

Fleet	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2014**	**2015**
Off-shore multi-day boat- (IMUL)- Offshore fishery	1419	1430	1572	1614	1530	1581	1328	2900	4,447
Day boat with inboard engine- (IDAY)- Coastal & Lagoon fishery	1475	1470	993	1029	1486	1493	1164	950	876
FRP boat with outboard engine- (OFRP)-Coastal & Lagoon fishery	8623	8690	8744	9033	11020	11559	11010	17,100	23,962
Traditional boat with outboard engine- (MTRB)-Coastal & Lagoon fishery	1274	1404	839	776	6018	674	1660	2,100	2,720
Total motorized boat	12791	12994	12148	12452	20054	15307	15162	23050	32005
Beach seine boat (non-motorized)- (NBSB)-Coastal	900	900	900	900	953	1096	589	1095	1,174
Traditional boat (non-motorized)- (NTRB)-Coastal & Lagoon fishery	14944	15109	15000	15600	15040	15260	15162	18,200	21,963
Total Non-motorized	15844	16009	15900	16500	15993	16356	15751	19295	23137
Grand total	26635	29003	28048	28952	36047	31663	30913	39345	55142
Fleet	1999	2000	2001	2002	2003	2004	2005	2014	2015
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Source: http://www.unuftp.is/static/fellows/document/susara09prf.pdf
Source: http://www.fao.org/fi/oldsite/FCP/en/LKA/profile.htm
http://www.statistics.gov.lk/agriculture/fishery/table6.pdf

Table 4: Classification of multiday fishing vessels in Sri Lanka operates for tuna and tuna like species.

Boat category	Boat description
UN2B	8.8 - 9.8 m (28' - 34'). FRP or wooden, Inboard engine (single) - 40 HP Insulated fish hold - no gear hauler, may have GSP/sounder/fish finder
UN3A	9.8 - 12.2 m (34' - 40'). FRP or wooden. Inboard engine (single) - 60 HP Insulated fish hold and may have gear- hauler/ GSP/sounder/fish finder
UN3B	12.2 m – 15.2 m (40' - 50'). FRP or wooden. Inboard engine (single) - 60 + HP. Insulated fish hold and may have freezer facilities. Gear Hauler/GSP/sounder/fish finder
UN4	15.2 - 18.3 m (50' - 60') Inboard engine, fish storage facility, may have RSW or CSW or freezing facility, gear hauler, GPS, echo-sounder/fish finder, radio communication

Source**:** IOTC–2011–WPB09–28

3.3 Fisheries production, demand and supply in Sri Lanka

Sivasubramaniam,1997;1985;1971;1970 and Sugunan, (1997)[100,101,102,103,104], pointed out over 96% of Sri Lankans consume fresh or processed fish, which provides an estimated 65- 70% of the mean annual animal protein intake in Sri Lanka in the period of 1972 to 1997, as well as 85% of animal protein intake in rural areas fulfilled by the fish. The total annual fish production of Sri Lanka was 25,000 t in 1952 as per, 269,850 t in 1998 and 520,190 in 2015 (Fishery industry outlook 2011, 2015), When studying the period of 1958 to 1988 Per capita consumption rose steadily during the 1980’s to a peak of 18.6kg and has been stabilized around 15-16kg per capita (Table: 05). Early 1980’s the required fish production was not fulfilled the demand for the country then, it was increased the importing fish. The remaining coastal fisheries on the East, West and Southwest coasts are reportedly close to their maximum sustainable yields, whilst demand continues to increase (NARA 1997) [87]. The deficit is being filled by increased exploitation of offshore fisheries whilst deep-sea fisheries are being more slowly developed. Considering current status of the fish production, net fish production in Sri Lanka (local fish production – export production) is sufficient to meet approximately 78% of current demand. Much of the balance is imported in dried form of marine origin in addition to a smaller amount of canned produce (Jinadasa, 1997) [58].

Marine fish production was 452,890 Mt while the rest 67,300 Mt from inland and aquaculture out of the total production of 520.190 Mt. in 2015. The share of fisheries to the Gross Domestic Production (GDP) of the country was 1.3 with a stable contribution of inland (0.1) and marine fisheries (1.2) (Fisheries Industry Outlook 2015) [40].

Considering the scale of fishing in marine fishery can be grouped into two small scale fisheries, which is carried out within a day & limited to coastal waters (40 km) and large-scale operation, which is operated 10 to 45 days beyond 40 km from shore. Drift-net is the popular and important gear for small scale. The important fishing gear in use is primarily drift-net, long line and troll line.

Table 5: Historic trends in Per capita fish Consumption in Sri Lanka (kg) Per capita Consumption: 1958-1979 period avg.=13.0 Kg, 1980-1988 period avg. =15.8Kg, 1990-2010 period avg.=15.5 kg

Year	Kg/year	Year	Kg/year
1958	15.6	1988	18.6
1965	14.9	1990	15.1
1972	14.5	1993	15.4
1973	11.2	1996	15.6
1974	11.0	2006	13.5
1975	11.8	2007	14.3
1976	10.8	2008	15.4
1977	10.4	2010	19.1
1978	11.3	2011	
1979	13.0	2012	
1980	14.2	2013	
1981	14.2	2014	
1985	16.4	2015	

Source**:** NARA year book, Murray 2000 [78]

Although marketing systems are complex and regional variations exist, internal trading in the Sri Lankan fisheries sector can be classified into three broad categories that occupy progressively smaller market spaces.

3.4 Import and wholesale at national level

State sector organizations i.e. the CooperativeWholesale Executive (CWE) and private sector organizations including various multinationals undertake these functions. Private sector organizations enjoy the major share of the dried fish import and wholesale distribution market.

3.5 Wholesalers and retailers at regional (provincial and district) level

Wholesalers bid for catches at landing sites, which are dispatched primarily to Peliyagoda wholesale market in

Colombo (very close to the main commercial city) and ultimately sold to consumers through a chain of smaller retailers. Currently Peliyagoda is the largest wholesale market in the country; secondary regional wholesale markets exist in the towns of Galle, Kandy and Anuradhapura. These markets cater principally for marine fish production whilst very little inland production enters thesenetworks.

3.6 Sub-regional retailers and wholesalers

Middlemen supply capital or credit to fishermen, informally contracting their entire catch. Marine fish may be consigned to Colombo anddistributed directly or indirectly through small-scale retail networks including boutiques, daily markets in larger towns, weekly fairs (polas) in smaller market towns and extensivenetworks of mobile -wheeler vendors.

Table 6: Historic trends in marine fish landings 1972 – 2015

Year	Coastal		Offshore		Marine		Total
	mt.	% cos	mt.	% off	mt.	%	mt.
1972	90,717	47.1	2,557	1.3	93,274	48.5	192,429
1973	91,312	90.7	2,385	2.4	93,697	93.0	100,702
1974	100,805	91.1	2,230	2.0	103,035	93.1	110,695
1975	114,863	88.9	970	0.8	115,833	89.7	129,140
1976	122,783	90.4	548	0.4	123,331	90.8	135,871
1977	125,386	90.4	312	0.2	125,698	90.6	138,766
1978	136,900	87.4	2,949	1.9	139,849	89.3	156,587
1979	148,851	88.4	2,099	1.2	150,950	89.7	168,375
1980	165,246	88.1	2,148	1.1	167,394	89.2	187,660
1981	175,075	84.6	2,178	1.1	177,253	85.7	206,843
1982	182,532	84.1	1,078	0.5	183,610	84.6	216,933
1983	184,049	83.4	689	0.3	184,738	83.7	220,806
1984	136,642	80.7	823	0.5	137,465	81.2	169,347
1985	140,266	80.0	2,400	1.4	142,666	81.3	175,409
1986	144,266	78.8	3,400	1.9	147,666	80.7	183,056
1987	149,278	78.6	4,259	2.2	153,537	80.8	190,002
1988	155,099	78.5	4,425	2.2	159,524	80.8	197,536
1989	157,411	76.7	8,155	4.0	165,566	80.7	205,287
1990	134,132	82.0	11,666	7.1	145,798	89.1	163,664
1991	159,151	80.4	15,080	7.6	174,231	88.0	198,063
1992	163,168	79.1	22,000	10.7	185,168	89.8	206,168
1993	169,900	76.9	33,000	14.9	202,900	91.9	220,900
1994	174,500	77.9	37,500	16.7	212,000	94.6	224,000
1995	157,500	66.3	60,000	25.3	217,500	91.6	237,500
1996	149,300	65.3	57,000	24.9	206,300	90.3	228,550
2004	154,470	53.9	98,720	34.5	253,190	88.4	286,370
2006	121,350	47.8	95,999	37.8	217,349	85.6	253,879
2007	224,320	57.6	123,950	31.8	348,270	89.5	389,170
2008	165,320	51.8	109,310	34.3	274,630	86.1	319,120
2009	180,410	53.1	112,760	33.2	293,170	86.3	339,730
2010	202,420	52.6	129,840	33.8	332,260	86.4	384,670
2011	222,350	50.0	162,920	36.6	385,270	86.6	444,830
2012	228,482	52.3	153,000	35.0	381,482	87.3	437,182
2013	267,980	52.3	177,950	34.7	445,930	87.0	512,840
2014	278,850	52.1	180,450	33.7	459,300	85.8	535,050
2015	269,020	51.7	183,870	35.3	452,890	87.1	520,190

***Source*:** Ministry of Fisheries and Aquatic Resources Development & NARA year book

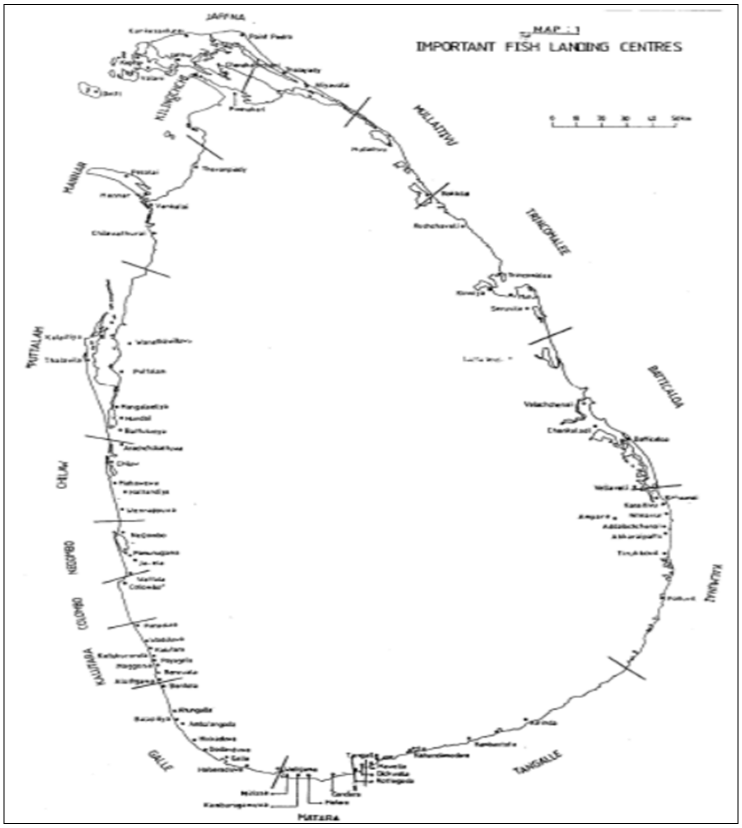

Fig 2: Principal marine fish landing sites in Sri Lanka. (Source: NARA 1997).

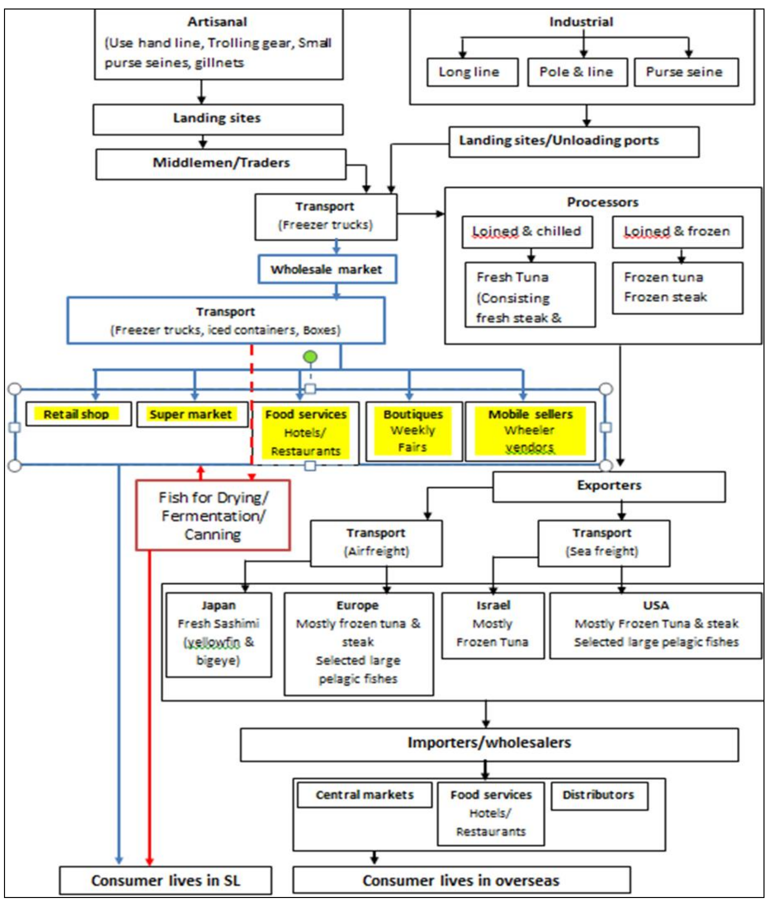

Fig 3: Supply chain of marine fishery in domestic and export market network in Sri Lanka

Figure 03 illustrates the conceptual supply chain of marine fishery in Sri Lanka and further transportation channel described by figure 04.

Considerable post- harvest value losses and harvest value losses were taken place due to poor marketing & transport throughout the supply chain. According to Murray *et al*., 2000 [78] reported their observation, based on the findings the potential for future development of market networks and entry points for target beneficiaries with making aware of respective participatory groups. It was added to the value of fisheries products.

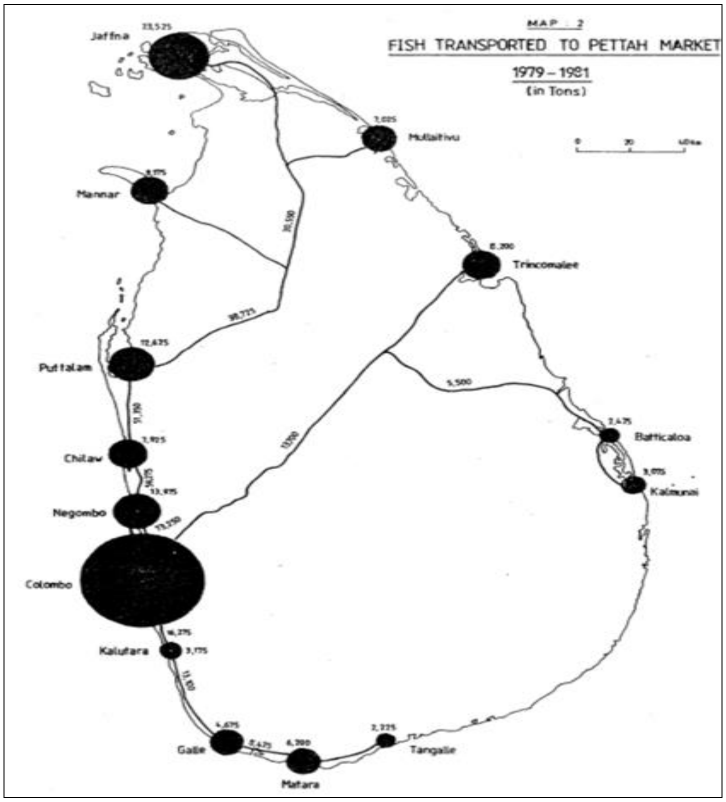

Fig 4: Main sources and volumes of marine fish transported to Pettah market in early 1980s. (source: NARA 1997).

Note: the transport road system was little bit changed (added to Southern highway) and the main center of the Pettah mark*et al*ready shifted to Peliyagoda.

comparing with past two decades, the infrastructure facilities of major fish landing sites (see figure 02) and main fish wholesale market, considerable improvements were implemented by the responsible organizations, But, Available facilities of the market has not been maintained by responsible sellers, mostly they have not considered to practice adequate level of icing to embed the fish, proper hygienic conditions, clearance, avoidance of contamination of the retail or workplace bench. Those factors would be affected to the quality and shelf life of the fish. Making attention about the infrastructure facility of marine fishery is essential. Central Bank report, 2003 mentioned as the expansion of trade in fish and fishery products, there is a need for good quality infrastructure if Sri Lanka is to become internationally competitive in the fish export trade. The process of globalization has definitely led to an improvement in the export quality of the Sri Lankan fish and fishery export products. To be a market leader in seafood exports in the South Asian region, Sri Lanka has decided to adhere strict quality assurance procedures under the European Union (EU) directives (Hemantha & Amarasinghe. 1983, Hewapathirana & Bandulage 2009, Holmgren 1994, Huss 1988, Huss 1994, Ilona *et al* 2006, Jayaweera *et al* 1988) [52, 53, 54, 55, 56, 57, 59].

Wijesekara, 2016 [116] explained for further details about current practices of the fish landing site as follows; cleaning fish at landings with harbor water is critical for fish contamination with virus and other harmful materials. Harbor water used by 77% while freshwater use by 23% for fish cleaning. Depending on the quality, fish grading into three categories and grade-I and grade-II goes export to Japan and Europe and grade –III goes to the local market. 50% of the production is directly purchase by the companies and about 25% is supplied by intermediate buyers. Total export is about 65% from those supplies depending on the quality.

4. Fish freshness, quality and shelf life:

Lakshmanan *et al*. 194; Raatikainen *et al*. 2005; Madushani *et al*, 2017; Niroshana1 *et al*. 2013; [67, 89, 71, 81] investigated that the relationship between fish freshness and quality of fish. They emphasized six major factors correlated with the fish freshness and it makes a major contribution to the quality of fish or fishery products. Just after harvesting of fish, the shelf life and freshness depend on the bacterial flora, storage temperature,handling and physiological condition of fish. The shelflife reflects the quality of the final fish product eitherfresh or processed. The quality of fish can be estimatedby sensory tests, microbiological methods, measuring volatilecompounds and lipid oxidation, determination ofchanges in muscle proteins, ATP breakdown productsand physical changes (including electrical properties of skin) in fish. They may include mathematical models toenvisage remaining shelf life for the fishing industry,trade and food inspection officials. However, that can be varied depending on sex, age habitat, food & feeding habits and season. Quality parameters may be physicalchanges including consistency, water content or colour, or they may be biochemical changes such as changes inlipids, proteins or enzymes.

The stateof freshness can be described by a variety of definiteproperties of the fish which can be assessed by various indicators (Olafsdottir *et al*. 2003) [83].

Table 5: Rate constant of freshness-lowering in the muscles of amberjack and big-eyed tuna during storage at different temperatures (source: Kaminishi *et al*. 2000) [64]

Species	Rate constant kf X 10^3 (h^{-1})							
	-4^0 C	-1^0 C	0^0 C	3^0 C	7^0 C	10^0C	15^0 C	20^0 C
Amberjack	0.23	-	0.92	-	1.61	3.22	5.07	9.90
Big-eyed tuna	0.46	1.15	-	2.30	-	3.46	5.07	8.52

These properties, freshness and quality of the end product are dependent on different biological and processing factors which influence the degree of various physical, chemical, biochemical and microbiological changes occurringpost mortem in fish flesh (Olafsdottir *et al*.,2004)[84]. Figure 05 shows that the relationship between freshness and quality of the fish.

4.1 ATP breakdown products

Saito *et al*., 1959 [93, and Uchiyama *et al*., 1970 [106], Connell 1995 [22], Dorian el al 1992 [33] pointed out that, the temperature variation of fish products for different times are taken place from capture to distribution to consumers. Then, the storage conditions cause changes in product quality. Fish freshness has been analyzed chemically & expressed as a K-value which is a useful index of “sashimi (raw fish)” grade. Hara & Uda, 1984 [50]; Miki, 1984 [77] pointed out that freshness- lowering of fish muscle depends upon temperature and time. Based on the gathered information on the kinetics of muscle deterioration enabled prediction and stimulation of quality changes from the storage temperature history.

K-values determined by Freshness Testing Paper (FTP) that have widely used for fishermen, distributors, and marketers in evaluating the freshness of fisheries products in Japanese fish industry.

Kaminishi *et al*., 2000 [64] investigated the relationship between K-values determined by FTP and column chromatography. In addition, the rates of freshness-lowering were obtained from K-values determined by FTP and the freshness of fish muscles with different history of storage temperature was predicted by applying kinetics parameters (i.e. activation energy (Ea) and frequency factor (A)). The kinetic parameters for the freshness-lowering, activation energy and frequency factor were obtained from Arrnhenius’ plots of K-values at the storage temperatures between –1 and +20°C, and then it was clarified that the quality two different tuna species with the different history of storage temperature should be predictable on the basis of these kinetic parameters (Kaminishi *et al*. 2000) [64]. As per the data given in table 05, the values related to rate constant of freshness-lowering (K-values), can be used as good indicator for detecting the freshness quality of fish. Indirectly it has been given about the fluctuation of temperature with time alone with the supply chain fish.

4.2 Microbiology and biochemical compounds

Contamination of fish with pathogenic bacteria reflects use of un-cleaned utensils, contaminated water and ice, inadequate amount of ice and unhygienic handling practices (Saritha, 2014 [96]; Ariyawansa *et al*, 2016 [8] investigated about the quality of fish with microbiological effects among the large pelagic and small marine fish varieties due to improper handling of fish at the landing site and storing.

That team revealed that 160 samples of fish were analyzed then reported large and small fish contained APC in the range of 2.0 x102 - 2.0 x 106 and 8.0×103 - 2.0×108cfu/g, respectively. 5% of large fish were contaminated with E.coli and ranged from ND to 15 MPN/g. E.coli was present in 70% of small fish samples and ranged from ND to >1100 MPN/g. Of the 160 fish samples, tested Salmonella spp were detected in nine occasions. Of the 160 fish samples, L. monocytogenes was found in eight Katsuwonuspelamis and one Sardinellaalbellafish.TVB-N of large fish was found at range of 1-67 mgN/100 g and 79% samples contained unacceptable levels. Small fish contained about 25.10-104.30 mgN/100 g.

Balasubramaniam, 2009, Kyrana & Lougovious 2002, Lakshmanan *et al* 1984, Oehlenschlanger 1998, Serasinghe *et al* 1999, Weerasekara *et al* 2015)[11, 66, 67, 84, 99, 113] also pointed out that proper post-harvest handling of catch is the most crucial step in the production of a high qualityfinished fishery product to meet the consumer demand. Contamination of fish with pathogenic bacteria reflects useof un-cleaned utensils, contaminated water and ice, inadequate amount of ice and unhygienic handling practices.

4.3 Low temperature

Considering the effect of temperature of the fish freshness, the control of spoilage by reducing the temperature is the most common and practical way of keeping fish fresh. The lower the temperature, the longer it will take for the fish to spoil. Remember, fish may already be several days old by the time it reaches consumer. “Use-by” dates placed on products by suppliers is only relevant if strict temperature control is adhered to at all stages from delivery, during storage and on display. At the endpoint of supply chain (consumer level) the freshness quality of the fish can be maintained for longer period time (more than week). It was proved fifteen days from date of catch if maintained in optimum conditions, the intrinsic quality of the fish at the time of catching may also affect the shelf-life. High temperatures increase the rate of bacterial growth, enzyme activity and oxidation leading to rapid spoilage, decreased shelf-life and possible food safety risks. Consequently, poor temperature control leads to increased waste and decreased profit for your business.

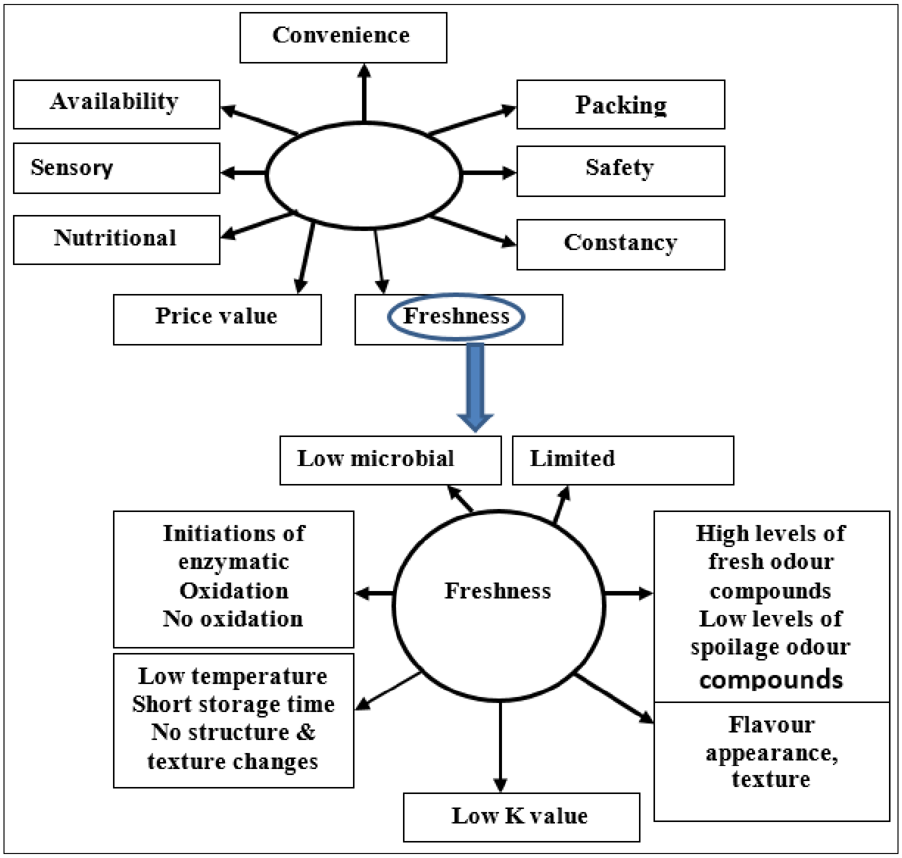

Fig 5: The relationship between quality and freshness of fish

The shelf-life is greatly increased if it is maintained at a temperature between 0°C and 2°C. The most effective way of maintaining product temperature between 0°C and 2°C is the liberal use of ice. This is an excellent way of chilling fish without freezing it. Correctly used, ice can rapidly reduce the temperature of fish. Ice should be made from potable water.

Kayim, 2010 [65] observed that pH level as a disadvantage for shelf life of product. The shorter shelf life negatively effects on salability of meat. The meat quality traits must include suitable pH that indicates eating quality and shelf life. Gregory *et al*., 1994 [48] revealed that lower pH value is related to greater losses during further meat processing and high pH value is related to shorter shelf life but also better eating quality.

Abbas *et al*., 2006 [01] indicated the shelf life and freshness of stored at 00 -1000 C for 28 days and have found that from sensory and pH point of view various storage temperature, the higher the storage temperature the faster is the increase in both sensory and pH values which can be used as measurements for quality deterioration and shelf life production in the fish marketing sector.

Considering the different characteristics of freshness as approached by the different subgroups ofthe projects, that can be explained to some extent by some objective sensory, (bio) chemical, microbial and physical parameters and can therefore be defined as an objective attribute which must show normal odour, flavor, appearance and texture characteristics of the species to be used for samples. (Olafsdottir *et al*., 1997) [83].

5. Conclusion and recommendation

Analyzing the market (supply) chain required packaged icing and temperature maintenance is a problem, especially which was happened in domestic pathway of fish to consumer who lives in rural and suburban areas. In the coastal fishing, generally small boasts that do not carry ice. Normally, their catch is small, but some fish are landed by deep water trawlers (around two percent). Fish are distributed through a complex series of middlemen, particularly in large towns and then retails. Retail sales of fish are typically through small fish stalls or via mobile vendors. The marketing system for fresh fish has a number of intrinsic factors for reducing losses. If fish is spoiling and difficult to sell at the producer (fisherman) level, it may be converted into dried fish, which then sells at a lower price.

The losses at harvesting can be attributed to catching methods, the type of fishing gear used, and the lag time between the catch and marketing. Long period of entrapment in gill net fishery causes physical damage to the fish, which become tired and die and spoil faster. (Ganegama Arachchi *et al*, 1999; 2000a; 2000b) [41, 42, 43] alos proved that on the above matters. The typical boats used to haul fish do not have the adequate space to carry ice.The caught fish lie on the boat deck exposed to high temperature, which rise up to 300 Cand autolytic reactions commences. Most of the fish landing site appeared that, the lack of normal fish-handling equipment, such as chilled storage and auctioning facilities, inadequate water and ice supplies, cleaned environment and beaches, increase the losses. The initial sale of fish begins at the landing sites where the fish are improperly iced (if ice is even available) in dirty wooden fish boxes.

Although, ice should be used from the moment of catch to the final retail sale, even this simple, effective preservation technique is not used because of the high price and erratic supply of ice. At the landing site, the fish after unloading or auctioning or selling kept on the open environment without using ice because transportation is not available or sometimes, until a sufficient quantity of fish is available for transportation to markets. During this period, also, quality deterioration can be occurred.

Considering the wholesale fish market condition noticed that lack of chlorinated (potable) water facility, chilled storage facility, uncement (damaged) flooring, insufficient drainage facilities, poor handling and contaminated with fecal matters of the stall from birds can be deteriorated the quality of fish. Fish caught from different areas are transported to the main wholesale market place in Peliyagoda where additional losses may be taken place due based on the above mentioned reasons.

Clucas, 1982 [17]; Eyo, 2001 [35]; Barile *et al*. 1985 [13], revealed that fresh fish is susceptible to spoilage when exposed to ambient temperature, then deterioration during post-mortem period is as a result of series of biochemical and microbiological mechanisms. In the high ambient tropical temperature, fish will spoil within twelve to twenty hours depending on species, methods of capture and handling condition of fish.

Loss of freshness followed by spoilage is a complex combination of microbiological, chemical and physical processes (Alles *et al*. 1980; Ngwu, 2012; Pedrosa-Menabrito & Regentein, 1990) [4, 82, 87].

Most market places in Sri Lanka, fresh fish is simply displayed on metal, wooden, or cement tables and exposed to high temperature with more flies. The spoilage of fish at the retail shops could be happened very easily because of insufficient ice or sometimes no ice at all. Furthermore some issues for the consumer due to quality changes was emphasized by Anderson 1991 [6].

The improvement of the boat design considering the better fish holds and equipment for fish preservation would be needed at the relevant authority levels. Therefore some technological applications are seem to be adapted to the fishing fleet. Based on the reviewed research papers were suggested their recommendation about this improvement. Eventually it would be affected to the fish quality and shelf life.

Most of the crew members those who are engaging the fishing were not known best handling practices when catching fish and deck maintenance in particular fishing fleet. The hygienic practicesof the fleet, landing site or a place of unloading were not considered by personals those who are engaging the fishery. Most of researchers were assessed and reported the microbial contamination, spoilage and quality deteriorations in fish. Therefore the relevant short term training programs are needed to conduct for targeted groups. Although CFC personals are engaged in observation and recording fishing at the landing site, the quality assurance is questioned due to follow the procedures.

At the transport the required ice, quality of ice, stacking & packing, temperature maintenance are also questionable, because the instructions and guidelines are not followed the relevant personals.

Most of the fish landing site required storage facilities was not sufficient and some places were not functioned or maintained appropriate conditions. It was a failure of respective monitoring bodies. Promoting the use of hygienic stackable boxes for fish storage transport needed to establish with facilities for sorting or handling or packing off fish at landing centers.

The quality of ice and clean water availability is ensured in fish handling and transport.

Establish chill storage facilities at major port and markets and provide freezing and cold storage facilities in selected areas. This would enable rational marketing of fish and reduce spoilage Establish a commission to review practices in the industry, revise standards of fish identification, formulate codes of practice in simple form for use by all industry segments, and consider measures to improve quality. This could provide a basis for industry-wide improvement of existing handling practices. However, arbitrary quality standards that prohibit sale of low-quality fish should not be established before a mechanism to ensure adequate protein supply to low-income consumers is developed Explore application of alternative energy sources and appropriate technology in handling and processing of fish. The application of alternative energy sources such as energy from fish wastes and solar energy should be explored to improve the handling practices of fish. The derived energy would have applications in operating absorption refrigeration systems use of evaporative cooling, and drying and smoking of fish.

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