Lake Vättern Fish: From the Water to the Consumers

– Ecosystem-Based Fisheries Management Assessment, Fish & Fish Products Distribution Channels of Lake Vättern

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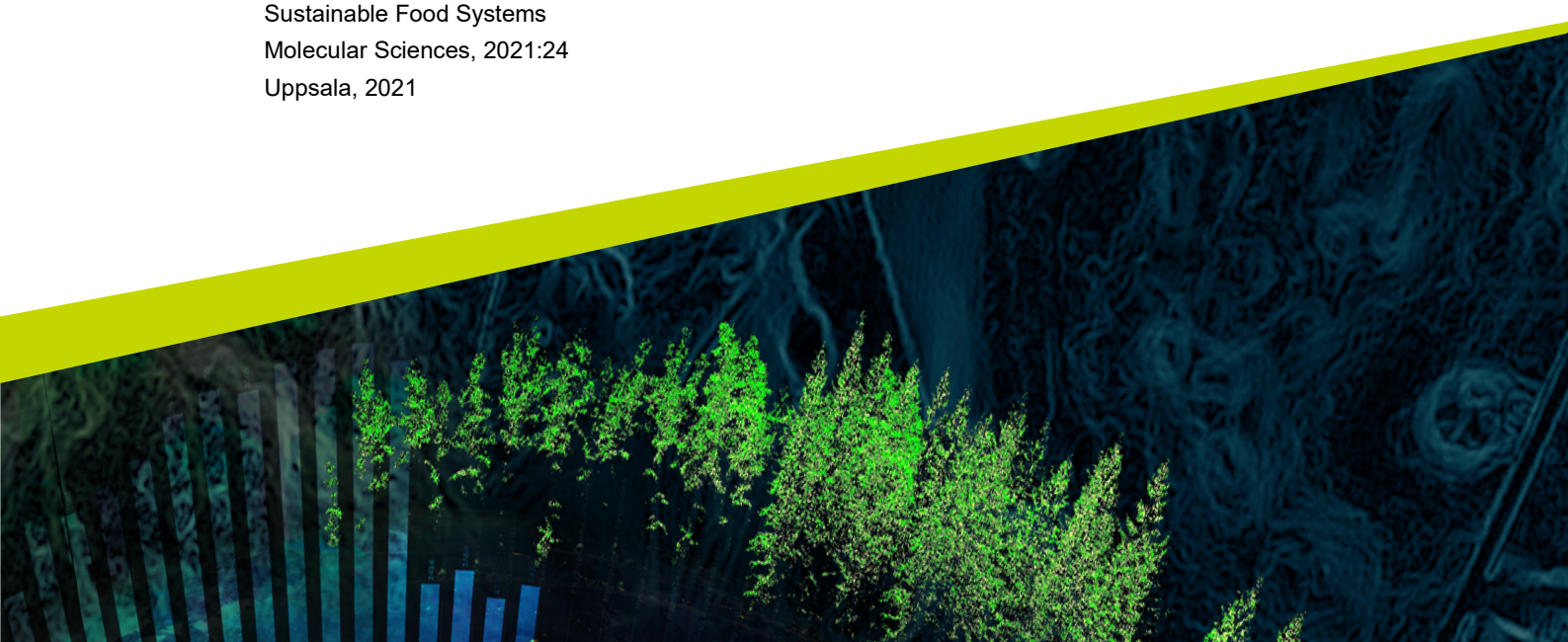

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Abstract

This study assessed the Ecosystem-Based Fisheries Management (EBFM) of Lake Vättern by using the EBFM objectives as spelt out by Engler et al. (2015) and Long et al. (2015). In order to fully understand the fish and fish products distribution channels, it was necessary to understand the lake's fisheries and their management. This is because a perturbation at any stage of the lake's fish supply chain could have resultant effects on other stages. On the other hand, this study traced the processing and distribution channels of commercial fish and fish products from Lake Vättern. Also, it examined the level of consumer-involvement (as stakeholders) in the 'co-creation' or co-management of the lake's fisheries. The certification status of the lake's fisheries, the impact of environmental toxins on fish products and consumers' reactions were also studied.

The assessment of the EBFM objectives shows that the lake's fisheries co-management team is on the right path in sustainably managing the fisheries (fish production level), but ignores the processing, distribution and consumption stages of the lake's fish supply chain. The co-management team engages relevant stakeholders in the lake's management except the fish consumers who are not represented at all. The lake's fisheries are not MSC-certified due to the issues of environmental toxins and invasive species.

The lake's signal crayfish, Arctic char and trout fisheries are the largest in terms of catch size and value. Fresh, filleted and smoked fish are the main fish and fish products commonly demanded for by consumers at the Lake Vättern region. These products are distributed through food restaurants, wholesalers, fish markets, fish shops and direct delivery by fishers to consumers. Many of the nineteen registered fishers of the lake process and retail their catches by themselves. The fish from the lake are not enough to meet local consumer demand, so fish are 'imported' to augment local supplies.

Keywords: Ecosystem-Based Fisheries Management (EBFM), Adaptive Co-Management, Lake Vättern, Supply/Value Chain.

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Abbreviations

EBFM	Ecosystem-Based Fisheries Management
EMFF	European Maritime and Fisheries Fund
EU	European Union
FAO	Food and Agricultural Organization
LVSWC	Lake Vättern Society of Water Conservation
PCB	Poly-chlorinated biphenyl
SLU	Swedish University of Agricultural Sciences
SwAM	Swedish Agency for Marine and Water Management
WWF	World Wildlife Foundation

1. Introduction

The goal of any natural resource management is to have the targeted resource well managed, and sustainably so. This is important for the natural resource in question to provide the desired benefits to the end users or consumers. To this end, it is imperative that the freshwater fishery in Lake Vättern, the second largest lake in Sweden, is well managed to reap its full benefits. Globally, fishes in freshwater ecosystems (rivers and lakes) are among the most endangered or threatened vertebrates (Freyhof and Brooks, 2011). This is because freshwater ecosystems have been greatly affected by anthropogenic activities such as dam constructions, agriculture, habitat modification for effective navigation, eutrophication, acidification, water extraction, as well as the release of farmed or non-native species into the freshwater ecosystems (Dudgeon et al., 2006). Just like what occurs in commercial marine fisheries, exploitation and/or over-exploitation of fish stocks in freshwater ecosystems leads to declines in fish populations, altered functional and structural characteristics of the freshwater ecosystem, as well as a consequent reduction in ecosystem services (Lewin et al., 2006). Attempts to mitigate these declines have led to several concerted fisheries management intervention and restoration efforts.

As defined by Arlinghaus et al. (2016), fisheries management is a process, which involves the utilization of reliable and scientific information to achieve set management and operational goals and objectives spelt out for fisheries resources. For inland fisheries (such as fisheries in Lake Vättern), management goals include; the sustainable harvest of fish stocks, aquatic biodiversity conservation, and the equitable or fair sharing of the derived benefits among all stakeholders concerned (Arlinghaus et al., 2016).

These goals come with the challenge of the need for a trade-off among myriads of stakeholder values and expectations, while translating these values and expectations into strong management objectives (Fenichel et al., 2013). However, Post et al. (2002) pointed out that many small inland fisheries are not viable economically enough to attract costly management and monitoring systems, and thus only require data-poor or data-scarce management systems (Arlinghaus and Krause, 2013). According to Arlinghaus et al. (2016), inland fisheries are prone to several complexities, and uncertainties surround how specific policies function, and so,

they recommend that managers should follow a transparent and an all-inclusive and an adaptive approach in order to achieve management goals and objectives. This need has, therefore, given rise to the increasing consciousness by fishery managers to embrace ecosystem-based fisheries management.

Ecosystem-based fisheries management (EBFM), according to Pikitch et al. (2004), refers to the use of an ecosystem approach in managing fisheries resources. It's a management system that recognizes the multiple interactions among the biotic and abiotic elements in an ecosystem rather than just focusing on a single target species or an isolated issue (Hornborg et al., 2019). Its management goal is to ensure the health, productivity and resilience of the ecosystem in order to provide the needed ecosystem services (Hornborg et al., 2019), or to ensure the economic, social and ecological sustainability of the fishery, as Long et al. (2015) put it.

From the myriads of EBFM definitions, Engler (2015) and Long et al. (2015) summarized the core principles of EBFM that are in consonance with the Food and Agriculture Organization (FAO) guidelines (as spelt out in the Code of Conduct for Responsible Fisheries (FAO, 1995; Garcia, 2003)) as follows;

- That EBFM should be based on science.
- It should make use of appropriate connections and scales.
- It should proactively manage uncertainty through the precautionary and adaptive management approaches.
- It should take into consideration the long-term social and ecological wellbeing of the ecosystem.
- It should ensure stakeholder participation and interdisciplinary involvement in decision making.
- That there should be effectiveness in achieving set objectives.

In Sweden, according to the Swedish Board of Fisheries (2009), the 2007-2013 National Fisheries Strategic Plan had the following objectives, amongst others;

- The use of ecosystem-based management approach to achieve set environmental management objectives.
- The development of rural communities and the creation of more jobs.
- Making fisheries-related enterprises more profitable.
- To have customers (consumers) of fish and fish products well-informed.

These EBFM objectives are reiterated in the current operational strategy for year 2020-2023 by the Swedish Agency for Marine and Water Management (SwAM; 2020), which is the current name for the national fisheries management body in Sweden.

EBFM was initially designed for the management of marine fisheries but is now being used in inland fisheries. As such, documented examples of the successful application of EBFM in the sustainable management of lakes are scarce. So, what are the performance indicators to measure the success (or failure) of EBFM against the set objectives as regards Lake Vättern? Has the Lake Vättern fishery been meeting the fish needs of the consumers in the rural communities around the lake and in Sweden in general? Moreover, have the fish consumers been involved in the 'co-creation' or co-management of the lake's fisheries as spelt out by the objectives? This study is an attempt at finding the answers to these questions.

1.1. Research Aim and Questions

The aim of this study is to assess the sustainable EBFM of Lake Vättern based on EBFM objectives, trace the distribution channels of the commercial fishes to the Swedish consumers, and assess the level of consumer involvement (as stakeholders) in the 'co-creation' or co-management of the fishery. Furthermore, this study examines the certification status of the lake's fisheries, the impact of environmental toxins on fish products and consumers' purchase behaviour, and the influence of the lake's fisheries on the local economy. The following are the research questions;

- Is Lake Vättern fisheries sustainably managed?
- Can its fisheries meet the fish needs of the consumers in the region?
- What channels do the fish and fish products take to get to the consumers?
- Are the fish consumers involved in the 'co-creation' or co-management of the lake's fisheries?

2. Background

2.1. Fisheries in Sweden's Economy

According to FAO (2019), the fisheries sector plays a very small role in the economy of Sweden with a marginal contribution to the country's gross domestic product (1% in 2017) but has a significant impact on local or coastal economies where fisheries operate. Commercial fisheries take place both in the marine (onshore and offshore) and inland environments. Cod and herring are the most valuable species harvested for human consumption, but there are also fish landed for industrial purposes; these include sand eel, blue whiting, sprat, and herring (FAO, 2019). Fish for industrial use are those not consumed by humans but processed into other fish products such as fishmeal. Fishing for fishmeal and other industrial purposes constitutes more than 50% of all fish landings in Sweden by volume, because there is a poor consumption market for the landed pelagic species in the face of a sharp decline in the valuable cod stocks and its fishery being strictly regulated or closed (FAO, 2019).

In 2017, inland fisheries' total landings were 10,800 tons, from both commercial and recreational fishing (Fig. 1), while aquaculture produced 14,800 tons (Fig. 2) which constituted 6% of total fish production of (247,400 tons) for the same year (FAO, 2019). It is also reported by FAO (2019) that Sweden's per capita fish supply (live weight equivalent) for more than 40 years (1980-2015) was relatively stable at 25-33kg (Fig. 3), while also having a negative fish trade balance for several years (though there was incomplete data for 2019 when the report was published) (Fig. 4). For instance, fish imports for 2017 had a total value of USD 4.9 billion, while fish exports were valued at USD 4.1 billion (FAO, 2019).

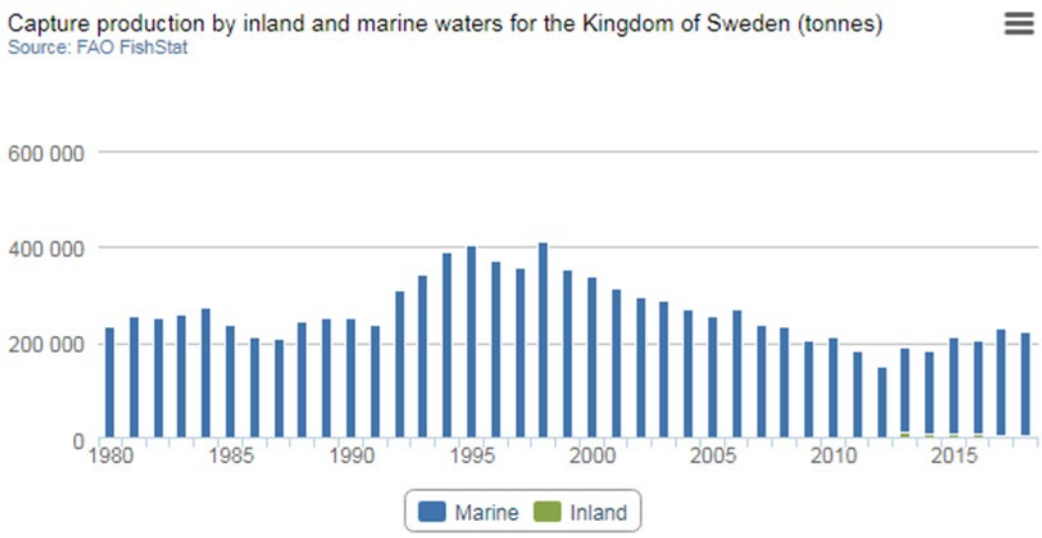

Figure 1. Total capture production by marine and inland waters in Sweden (tonnes). Source: FAO 2019.

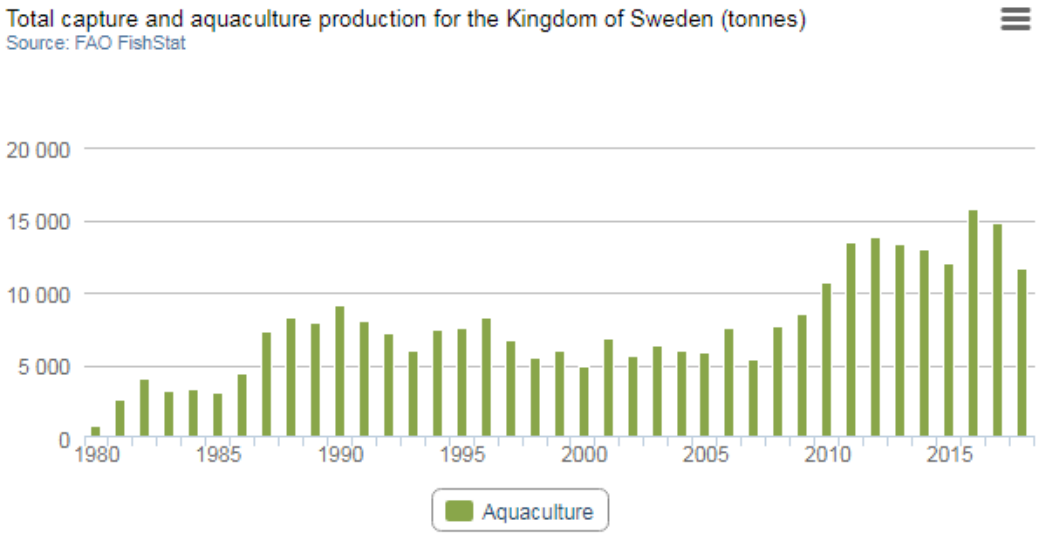

Figure 2. Capture and aquaculture productions for Sweden (tonnes). Source: FAO, 2019.

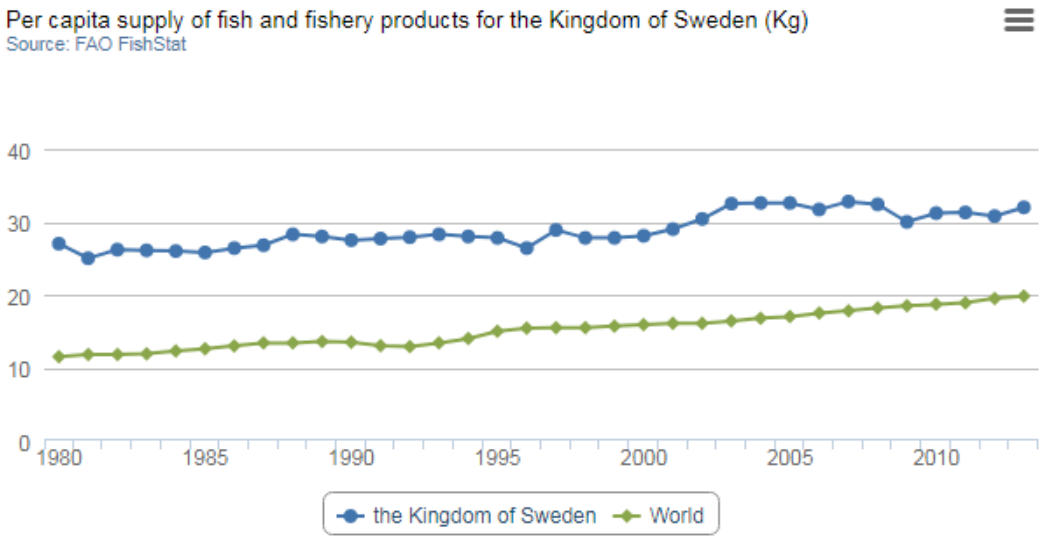

Figure 3. Per capita supply of fish and fish products for Sweden (kg). Source: FAO, 2019.

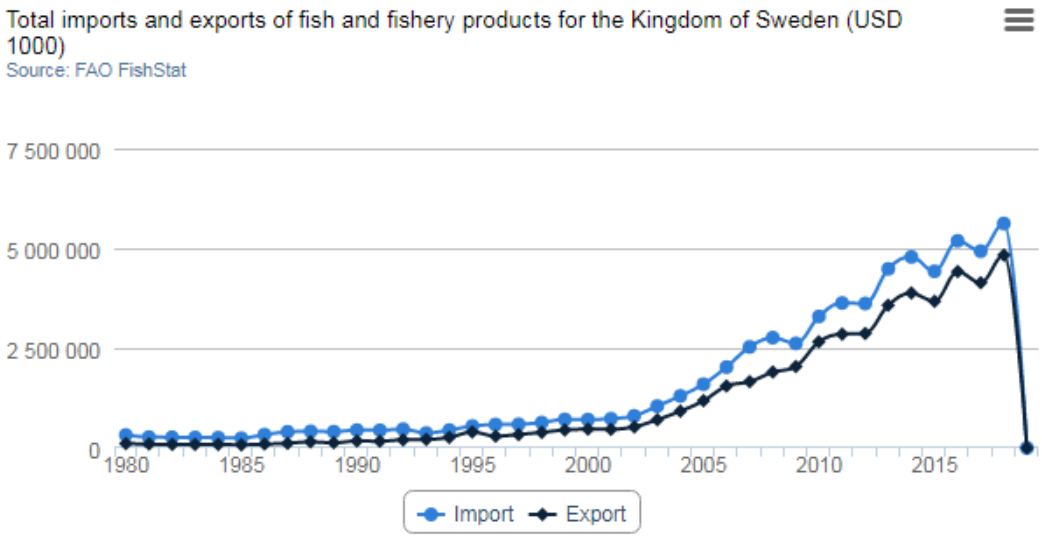

Figure 4. Total exports and imports of fish and fishery products (thousand USD) for Sweden. Source: FAO, 2019. Data for 2019 are incomplete.

2.2. Sweden's Fisheries Management

SwAM is responsible for the national regulation of fishing in seas, the five largest lakes, and in the water courses that flow into these lakes (SwAM, 2021). The aim is to protect and conserve fish species, ensure optimum populations, and maintain ecosystem services. Also, SwAM implements European Union (EU) fisheries control measures by "controlling the fish caught, landed, imported, exported, transported and sold in Sweden" (SwAM, 2021).

EU member states are required to draw up a national fisheries strategic and operational plan in order to receive financial support from the apex organization (FAO, 2010). For instance, the 2007-2013 National Fisheries strategic plan had the following objectives, amongst others;

- The use of an ecosystem-based management approach to achieve set environmental management objectives.
- The development of rural communities and the creation of more jobs.
- Making fisheries-related enterprises more profitable.
- To have consumers of fish and fish products well-informed.

To achieve these objectives, targets were set for information/data gathering, fisheries control, biology and environment, fish and fish products trade, fish processing industry, aquaculture, recreational fishing, and fish tourism enterprises (FAO, 2010).

2.3. Inland Fisheries in Sweden

According to FAO (2004), Sweden has inland waters, which include more than 90,000 lakes of more than 1 hectare in size, approximately 300,000 km watercourses, and with great inland fisheries potential. Fish catches from Sweden's lakes were 1,615 tonnes in 2008 (Swedish Board of Fisheries, 2009) and 1,671 in 2019 (SwAM, 2020), and with a total value of 77.9 million SEK in 2008 (Swedish Board of Fisheries, 2009) and 110,624 million SEK in 2019 (SwAM, 2020). These mean an increase in commercial fish volume and value over the 11-year period. See tables (Tables 1, 2, 3 & 4).

Table 1. Catches in inland Swedish waters by commercial fishers, 2008. (Source: Swedish Board of Fisheries, 2009).

SPECIES	VÄNERN	VÄTTERN	MÄLAREN	HJALMÄREN	OTHER LAKES	TOTAL (t)
Salmon	24	4	1.1	-	-	**29**
Trout	6	3	0	-	1	**9**
Char	-	5	-	-	3	**8**
Whitefish	97	4	0	0	3	**104**
Vendace	247	1	14	0	0	**262**
of which Vendace roe	13	-	1	-	-	**13**
Pike	40	0	30	34	15	**119**
Pikeperch	136	0.01	175	162	59	**532**
Perch	49	3	6	73	9	**142**
Eel	22	-	47	23	20	**113**
Crayfish	0	146	-	27	2	**175**
Other	40	6	4	6	64	**121**
Total	**662**	**172**	**278**	**325**	**177**	**1615**

Table 1 above, the catches in Swedish lakes for the year 2008 show that vendace fishery was the most predominant in Lake Vänern, while crayfish fishery had the highest catches in Lake Vättern. Pikeperch fishery had the largest catches in Lakes Mälaren and Hjälmaren.

Table 2. Catches in Sweden's inland waters by commercial fishers, 2019. (Source: SwAM, 2020)

Fish species	Vänern	Vättern	Mälaren	Hjälmaren	Other Lakes	**Total 2019**
Salmon	5	1	0.1	0	73	**79**
Trout	3	5	0.0	0	0	**8**
Arctic char	0	8	0.0	0	2	**10**
Whitefish	5	8	0.0	0.0	1	**14**
Vendace	280	2.9	10	0	1.3	**294**
-Vendace roe	14	0	0.5	0	0	**15**
Pike	35	2	22	31	10	**100**
Pikeperch	130	0	182	198	74	**584**
Perch	28	5	6	29	8	**75**
Eel	20	0	36	8	24	**88**
Crayfish	31	118	0	56	2	**208**
Others	78	21	5	46	60	**210**
Total 2019	**616**	**170**	**261**	**369**	**255**	**1 671**

Table 2 shows figures of catches in Swedish lakes in 2019 with vendace still the leading fishery in Lake Vänern, and crayfish fishery still the most valuable in Lake

Vättern. Pikeperch fisheries still hold the most value in Lakes Mälaren and Hjälmaren

Table 3. Value of the catches in inland Swedish waters by fishers, 2008. (Source: Swedish Board of Fisheries,2009).

SPECIES	VÄNERN	VÄTTERN	MÄLAREN	HJALMÄREN	OTHER LAKES	TOTAL (thousand SEK)
Salmon	1160	272	62	-	-	**1494**
Trout	285	144	0	-	56	**485**
Char	-	298	-	-	280	**578**
Whitefish	3264	125	1	0	98	**3489**
Vendace	5901	7	456	0	5	**6368**
of which Vendace roe	5900	-	378	-	-	**6278**
Pike	678	9	680	559	293	**2218**
Pikeperch	8221	0	11646	10360	4157	**34383**
Perch	903	76	179	1047	305	**2511**
Eel	1213	-	2702	1276	1229	**6421**
Crayfish	0	15451	-	3405	316	**19172**
Other	428	72	74	25	219	**817**
Total	**22054**	**16454**	**15800**	**16671**	**6958**	**77936**

In terms of monetary value (Thousand SEK) of the fisheries, 2008 figures show that the pikeperch fishery in Lake Vänern had greater monetary value that the Vendace fishery with higher catches. In Lake Vättern, the crayfish fishery had the highest value with 15,451m SEK. The pikeperch fisheries in Lakes Mälaren and Hjälmaren were of highest value, just like their catches

.

Table 4. Value of fisheries in Sweden's inland waters, 2019 (Source: SwAM, 2020)

Fish species	Vänern	Vättern	Mälaren	Hjälmaren	Other Lakes	**Total 2019**
Salmon	250	38	10	0	2 892	**3 191**
Trout	280	382	0.0	26	16	**704**
Arctic char	0	897	0.0	0	216	**1 113**
Whitefish	91	273	0.0	0.2	46	**410**
Vendace	14 547	52	329	0	1	**14 929**
-Vendace roe	14 547	52	329	0	1	**14 929**
Pike	784	61	942	880	278	**2 945**
Pikeperch	9 278	5	14 089	14 976	5 034	**43 382**
Perch	1 196	469	313	443	317	**2 738**
Eel	1 759	0	3 178	703	2 085	**7 726**
Crayfish	5 602	16 789	0	6 666	332	**29 389**
Others	1 035	189	97	593	2 185	**4 098**
Total 2019	**34 822**	**19 958**	**18 958**	**24 287**	**13 402**	**110 624**

A similar pattern is seen in Table 4 above which shows that the most valuable lake fisheries in 2019 were those of vendace in Lake Vänern, crayfish in Lake Vättern, and pikeperch in Lakes Mälaen and Hjälmaren.

The four largest lakes in Sweden are located at the southern parts of the country and they are Lakes Vänern, Vättern, Hjälmaren and Mälaren, (Fig 5), with Vänern being the largest and accounted for 41% of 2008 total fish catches and 28% in total value (FAO, 2010). The catches in these lakes are mainly pike (*Esox lucius*), perch (*Perca fluviatilis*), pikeperch (*Sander lucioperca*), vendace (*Corregonus albula*), eel (*Anguilla anguilla*), whitefish (*Coregonus lavaraetus*), and signal crayfish (*Pacifastacus leniusculus*). As stated earlier, this study is centered on Lake Vättern.

2.4. Lake Vättern

Figure 5. Map of Lake Vättern and the other three largest lakes in Sweden. Source: County Administrative Board, Jönköping.

Lake Vättern (Fig. 6) is a cold-water lake and ranks second among the four largest lakes in Sweden, occupying a surface area of 1,912 km sq.; length – 135 km, width - 31 km, maximum depth – 128m, and mean depth – 39.5m (Vätternvårdsförbundet, 2017). Its water is very clear because it receives water from hillside streams and springs purified by running over gravel before flowing into the lake (Vätternvårdsförbundet, 2017). It also has a long water retention time (60 years), allowing plenty of time for particulate matter to sink to the bottom. The lake's large water volume stores enormous amount of heat which does not allow the lake to freeze until toward the end of the year, and sometimes doesn't even freeze for several years in a row. During summer, the lake is slow to warm up (Vätternvårdsförbundet, 2017). Using the classification of the EU Water Framework Directive, lake Vättern has high water nutrient status, good fish status, but poor rating in relation to environmental pollutants (Viss, 2021).

Figure 6. Fishing boat on Lake Vättern. Source: County Administrative Board, Jönköping.

The lake is a source of water for more than 280,000 inhabitants living in the four counties that border the lake (i.e. Östergötland, Västra Götland, Örebro and Jönköping). Lake Vättern is home to many fish species, and these include brown trout (*Salmo trutta*), Arctic char (*Salvelinus alpinus*), grayling (*Thymallus thymallus*), European whitefish (*Coregonus lavaretus*), and Atlantic salmon (*Salmo salar*) that was introduced into the lake (Vätternvårdsförbundet, 2017). The signal crayfish (*Pacifastacus leniusculus*) is a shellfish species that was also introduced into the lake. It is considered as invasive and it attracts extensive fishing (Vätternvårdsförbundet, 2017).

Taking a brief look into the lake's food web, these major fish species in the lake are either zoo-planktivorous or piscivorous, depending on their stage of development. For instance, Setzer and Jonsson (2012) reported that vendace (*Coregonus albula*) feeds on cyclopoids and Cladocera (zooplanktons), while smelt and small-sized whitefish prey on both zooplanktons and crustaceans. They also reported that Brown trout, Arctic char and Atlantic salmon are mainly piscivores (fish-eaters), but prey on crustaceans during their early stages of development when they are small-sized. See figure 7.

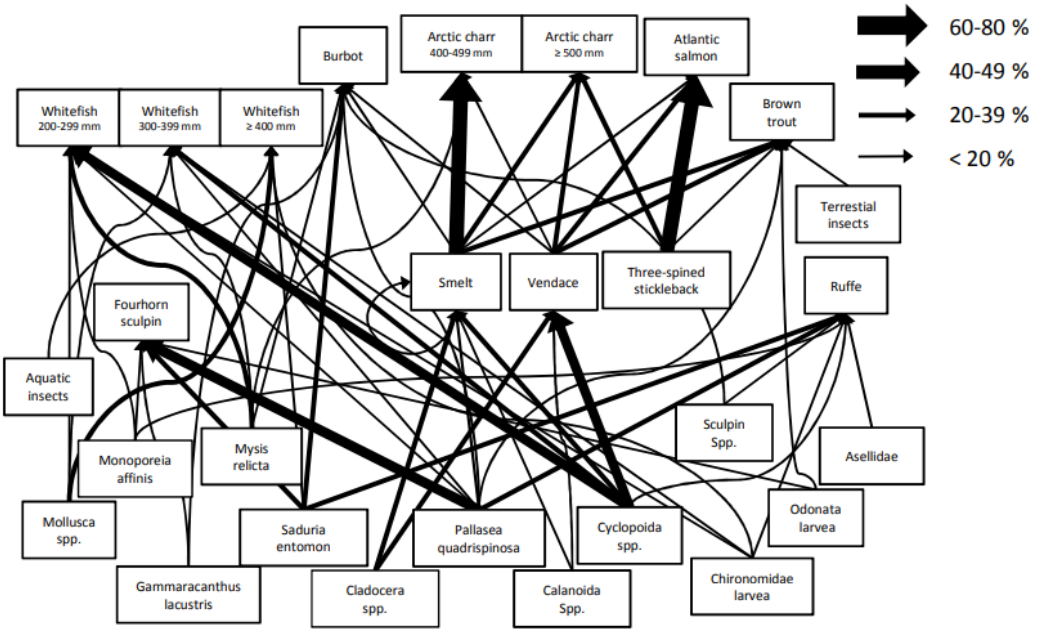

Figure 7. Lake Vättern Food Web. Source: Setzer and Jonsson (2012).

The whitefish is a high-fat species whose fishery in Lake Vättern is hampered by the bioaccumulation of pollutants such as poly-chlorinated biphenyls (PCBs) and lipophilic dioxins which reduces the sales value of the fish (Vätternvårdsförbundet, 2017). Though the concentrations of these organic environmental pollutants are also present in high-fat salmon, arctic char and trout, their product sales are not limited because Sweden obtained a sales exemption for these species (Vätternvårdsförbundet, 2017). According to Wu et al, (2018), all Swedish lakes (including Vättern) have mercury pollution which also bioaccumulates in fish.

Dioxins and PCBs are toxic fat-soluble compounds and are transferred to humans through fatty foods like meat, dairy products and wild-caught fatty fish such as Salmon from Lakes Vättern and Vänern, the Baltic proper and the Gulf of Bothnia (Swedish Food Agency, 2013). These pollutants have the characteristic of long-term accumulation in the body and affect the health of foetuses, infants, pregnant and nursing mothers, adolescents and all women of reproductive age (Swedish Food Agency, 2013). The negative health implications of these toxins are poor thyroid hormone levels, poor sperm quality at adulthood, poor brain development, weak immune system, and even cancer (Swedish Food Agency, 2013).

To prevent these negative health consequences, the Swedish Food Agency gave out diet recommendations about the fish from these lakes. The recommendations are that women of child-bearing age, pregnant and breastfeeding women, children and adolescents should not eat fish from these sources more than three times in a year, while other consumers outside these groups should each such fish not more than once in a week. These recommendations are in line with the EU set maximum limits

(MLs) for the levels of dioxin and PCB in foods (Swedish Food Agency, 2013). Overall, the presence of pollutants, increasing water temperatures due to climate change, and invasive species constitute the main present threats to Lake Vättern ecosystem (Vätternvårdsförbundet, 2017).

As a part of efforts to curtail the challenge of environmental toxins, aquaculture is not allowed in and around Lake Vättern (Vätternvårdförbundet, 2017). This is clearly stated in one of the lake's steering documents, *Fish and Fisheries Plan,* for 2017-2022. The guideline stresses that there should not be any aquaculture in and around the lake in order to avoid pollution and risks to the lake's fisheries and aquatic health (Vätternvårdsförbundet, 2017).

SwAM regulates all fisheries in Sweden, including that of Lake Vättern. The fishing right in Lake Vättern is shared by both the private and public water owners. 300 m from the lake's shoreline constitutes the private water, while the other parts beyond the 300 m limit is public water. Private water owners have the right to set their own fishing restrictions and can even charge a fishing fee within the private waters.

There is a local organization involved in the co-management of Lake Vättern called the Lake Vättern Society of Water Conservation (LVSWC), or Vätternvårdsförbundet in Swedish. LVSWC is co-organized by the four County Administrative Boards that border the lake, and the body is made up of different interest groups with stakes in the lakes. These stakeholders are, e.g. recreational and commercial fishers, tourism representatives, private water owners, SwAM, and researchers from Swedish University of Agricultural Sciences (SLU), approved by SwAM.

LVSWC has the responsibilities of managing all anthropogenic pressures on the lake ecosystem, dealing with invasive species, managing the water quality, and handling the ecolabelling of fish products from the lake (van Mastrigt, 2013; Lundholm and Stöhr, 2014). Also, LVSWC promotes dialogue among stakeholders, initiates restoration efforts on the lake (where necessary) and organizes three fisheries co-management stakeholders' meetings every year. The first of such meetings for year 2021 took place on the fourth of March, and I was privileged to attend the meeting as a research student.

2.5. Fish Processing

Sweden's fish processing industry is dominated by a few, but large processing companies mainly situated at the west coast. FAO (2010) reported that many of these companies were once Swedish-owned companies bought over by or merged with Icelandic or Norwegian companies, and that 80% of the raw materials for these

companies are imported, with just 20% sourced from Sweden. This has increased the raw material availability in the processing industry, while the Icelandic and Norwegian companies have better inroad into the EU fish markets (FAO, 2010).

The main fish products from these companies are cod, herring, shrimp, mackerel, haddock and salmon products (FAO, 2010). The year 2008 research figures revealed that fish and fish products from Sweden constituted 2% of the West European market with a value of €1,482m, and of this amount, frozen fish represented 31%, canned fish 25%, fresh fish 21%, dried/smoked/salted 23% (Food For Thought, 2009).

In Lake Vättern, the fishers do a lot of processing their own catches themselves (Leader Vättern, 2017). For example, they smoke some of the fish and boil the crayfish. Leader Vättern (2017) also reported that a relatively small amount of the fish harvested from the lake are locally consumed but gave no reason for this. This study attempts to find the reason. There are more discussions on this at the result and discussion sessions.

2.6. Demand for Eco-labelled Fish Products

In Sweden, there is a growing consciousness for sustainable diets and consumers are increasingly making demands for eco-labelled food products (FAO, 2010). Fish eco-labelling is a tool that gives consumers the opportunity to choose fish and fish products from sustainably managed fisheries (FAO, 2010). Krav is the main eco-labelling organization in Sweden, but its credibility, just like that of any other eco-label, is enhanced by certification from a third-party organization such as the Marine Stewardship Council (MSC), a notable certification scheme for fisheries.

According to the Marine Stewardship Council (2017), pikeperch from Lakes Mälaren and Vänern were certified in 2017, joining the pikeperch fishery of Lake Hjälmaren (certified in year 2006) that have met the high standards of a sustainably managed fishery. A clear advantage of certification of an inland fishery is that it gives such fishery the opportunity to serve local and foreign markets with sustainably managed and traceable fish products (Marine Stewardship Council, 2017).

Of the four big Swedish lakes, Lake Vättern is the only one whose fisheries are yet to be certified by MSC. Why is this so? Is Lake Vättern not yet sustainably managed? Is it about the problem of environmental toxins? We hope for answers at the end of this study. However, it is interesting to know from the World Wildlife Foundation (WWF) during the last co-management meeting about Lake Vättern, that the WWF has recently changed its listing of burbot in Lake Vättern from RED

(Purchase is not recommended) to GREEN (Purchase is recommended). Burbot is a threatened species in southern Sweden in general, with Lake Vättern currently being an exception.

3. Theoretical Frameworks

To sustainably manage a complex socio-ecological system such as Lake Vättern will require multi-disciplinary skills and the application of a plethora of relevant theoretical frameworks for the resource management to be successful. Three theoretical frameworks are currently being applied in the management of Lake Vättern; these are the ecosystem approach, adaptive co-management approach and the precautionary approach. These theoretical frameworks are described below alongside some other frameworks suggested by the author of this study.

3.1. Adaptive Co-Management

The desires of inland fishers are improvements in the rate of catch, catch size or harvest opportunities, while the desires of the inland fishery management is to identify strategies directed at three key things; the habitat (the aquatic-terrestrial interface), the biota (target fish and other plant and animal species in the ecosystem), and the humans (all stakeholders) (Arlinghaus et al., 2016).

According to Stöhr et al. (2014), the overexploitation of natural resources is a critical challenge facing humans. In order to tackle this challenge and extract (harvest) natural resources at sustainable levels, fisheries managers have called for the setting up of centralized, top-down command and control structures. Armitage et al. (2008) point out that this strategy has failed to solve the problem of overexploitation and is somewhat limited in solving complex and dynamic ecological systems. More issues confronting the top-down control to solve the exploitation problem are higher uncertainties characterizing ecological and social systems, high costs of monitoring and enforcing regulations in an environment where non-compliance is high and the lack of flexible and resilient attributes required to adapt to changes in the socioecological environment (Stöhr et al., 2014).

What about allowing communities to manage resources in a bottom-up approach? Plummer (2005) stated that community management alone cannot fully address the multiple issues of policy formulation, property rights and other issues that cannot be handled at the community level. Thus, Carlson and Berkes (2005) opined that a combination of top-down and localized community management efforts will be the

best way to solve environmental, social and economic sustainability concerns. This combination of stakeholders in resource management is referred to as adaptive co-management (Plummer and Fitzgibbon 2004).

Fisheries management in Europe has been experiencing an increased interest in co-management (Österblom et al., 2011), however, documented studies about co-management of fisheries in Europe are rare (Symes et al 2003). This is due to the command and control structure of European fisheries governance system, and because co-management initiatives are found in few member states, often very restricted to localities.

Adaptive co-management, as a theory, emphasizes resource management in which all stakeholders share authority and decision making, and allowing room for continuous learning and adaptability to changing conditions (Plummer and Fitzgibbon, 2004). One feature of adapting co-management is that it involves some steps or phases in application; these include identifying and involving stakeholders and building networks, taking advantage of opportunities to make a change, and carrying out actions that help to build the strength and resilience of the system through continuous learning, experimentation, negotiations and trade-offs (Plummer, 2009).

In the Lake Vättern region, a local fisheries co-management initiative launched by LVSWC was established in 2005. It was set up to proffer sustainable solutions in solving and managing the complex socio-ecological challenges facing lake Vättern in other to reap its ecosystem services. It is co-organized by the four counties that surround Lake Vättern and is made up of different stakeholders from the bottom to the top. These include the local commercial and recreational fishers, fishing guards, the private water owners, the county administrative boards, the municipalities, researchers, and SwAM (the regulating body). All these stakeholders with different skills brainstorm together to co-manage the lake ecosystem and its fishery. With the co-management approach in Lake Vättern, the stakeholders generally agreed (at their meeting held in March 2021) that the co-management approach helps to clarify roles, processes and responsibilities, and enables learning from one another.

The weakness of this concept is that it focuses on the strategies of key stakeholders but doesn't capture important contextual factors critical for the underlying conditions responsible for the emergence of the collective action (Brummel et al., 2012). This simply means that this approach focuses on dealing with the symptoms and stakeholder interests, and not the root causes of each problem. As regards Lake Vättern, the stakeholders believe that co-management approach takes time for all stakeholders to agree on any issue, and things don't get done speedily. This is expected.

3.2. The Precautionary Approach

The precautionary approach, as a concept, is aimed at improving environmental and resource conservation by minimizing the risk of damage to them (Garcia, 1996). It safeguards decision makers and regulators in their decisions when there is an inconclusive scientific work and management actions must be taken. It acts as a balance between short-term considerations (e.g. causes of overfishing and damage to the environment) and long-term considerations (e.g. the need to conserve resources for future generations). The precautionary approach promotes intergenerational equity by minimizing the impacts of the present-day high economic discount rates, which strongly encourage overfishing and places more emphasis on present consumption without considerations for future consumption (Garcia, 1996).

In a nutshell, the precautionary approach is defined as;

> "a set of agreed cost-effective measures and actions, including future courses of action, which ensures prudent foresight, reduces or avoids risk to the resources, the environment, and the people, to the extent possible, taking explicitly into account existing uncertainties and the potential consequences of being wrong" (Garcia, 1996).

To this end, the fisheries co-management group in Lake Vättern (Samförvaltning Fiske, in Swedish) include researchers from the Swedish University of Agricultural Sciences (SLU) who are saddled with the responsibilities of data collection, evaluation and description for stock assessments and to determine sustainable yields of the different fish and shellfish species in the lake. The researchers, also, are currently developing models for the different species in the lake and considering developing ecosystem models which will all help to assess uncertainties in the ecosystem, for better management. The weakness of this theoretical framework is that in practice (as applied in Lake Vättern), its focus or emphasis is more on minimizing risk or damage to the natural resource and the ecosystem, and less on the socio-economic factors.

3.3. Ecosystem Approach

The Ecosystem Approach is a strategy used for the combined management of water, land and living resources (FAO, 2003). This approach promotes the conservation and sustainable use of resources in an equitable manner, and it has three key components it addresses; conservation of the natural resource, sustainable use of the resource, and fair and balanced sharing of benefits that accrue from utilizing genetic resources (FAO, 2003). The ecosystem approach employs the use of scientific methodologies which deal with levels of biological organization

involving the "structures, processes, functions and interactions among organisms and their environment" (FAO, 2003). Importantly, it recognizes that humans are an integral part of many ecosystems. EBFM is a way to implement the Ecosystem Approach for fisheries (Long et al., 2015).

Interestingly, researchers are involved in the co-management team of Lake Vättern, and they are saddled with the responsibility of using scientific methods and models to understand the complex ecosystem interactions of the lake and its environment. The aim is to better manage the natural resource and measure levels of uncertainties in the system.

FAO (2003) posits that *Ecosystem Approach* needs *Adaptive Management* in dealing with the dynamic and very complex nature of ecosystems characterized by the absence of accurate knowledge or insight into their proper functioning. As ecosystem processes are often non-linear, surprises and uncertainties are the outcomes, and so, it is imperative that managers must be responsive and adaptive in order to deal with such uncertainties (FAO, 2003). The managers of Lake Vättern employs this framework in its management of the lake, as I discovered during the lake's co-management and all-stakeholders' meeting.

3.4. Systems Thinking

Richmond (1994) defines *Systems Thinking* concept as the art, science and ability to develop deep understanding of an underlying structure of a system in order to make accurate judgements and predictions about the behavior of that system. He stressed that 'System Thinkers' should position themselves at a vantage point where they "can see both the forest and the trees; one eye on each" (Richmond, 1994). Arnold and Wade (2015) in their definition, pointed out the connectivity among the 'trees' in the 'forest' by defining *Systems Thinking* as a set of analytic skills that are in synergy, and used to enhance the identification and understanding of systems in order to correctly predict their behaviors and make necessary adjustments to them to achieve desired results.

This study seeks to buttress why the sustainable management of Lake Vättern requires the use of the *Systems Thinking* concept. Its use in the lake's management will help to fully understand the underlying mechanisms in the system for better prediction of future outcomes and better management. It is not one of the theoretical frameworks applied in the management of the lake presently. For instance, with systems thinking approach in place, Lake Vättern's managers will be able to understand how and why any perturbations in the lake's socio-ecological systems can affect fish availability on the dining tables in Sweden. Also, the managers will

be able to recognize how and why fish consumer behavior can affect the fish stocks in the lake.

Although the *Adaptive Co-management*, *Precautionary* and *Ecosystem Management* approaches have been useful tools in the management of Lake Vättern, they are not designed to 'look broadly' or 'see both the forest and the individual trees' at the same time. They do not have the capacity to 'notice' consumers' need nor can they tell the distribution channels that the fish and fish products from the lake follow. Their major focus is on fisheries and ecosystem management. This study will employ the *Systems Thinking* approach.

3.5. Stakeholders Analysis

According to Smith (2000), a stakeholder is an individual, a group or an organization that has a form of interest in a project and can directly or indirectly influence the outcome of such projects. Also, Project Management Institute (1996) defines a stakeholder as an individual or an organization that is either directly involved in a project or who's interests are positively or negatively impacted by the outcome of such project execution.

Stakeholder analysis, therefore, refers to the set of actions and tools used to identify and appreciate the needs, expectations and influences of principal interest groups within and without the project environment (Smith, 2000). A good understanding of all stakeholders and the unique characteristics and interrelationships they share assists managers in strategic planning and execution of projects (Smith, 2000). Fig 8 is an analysis of all stakeholders involved in the co-management of Lake Vättern;

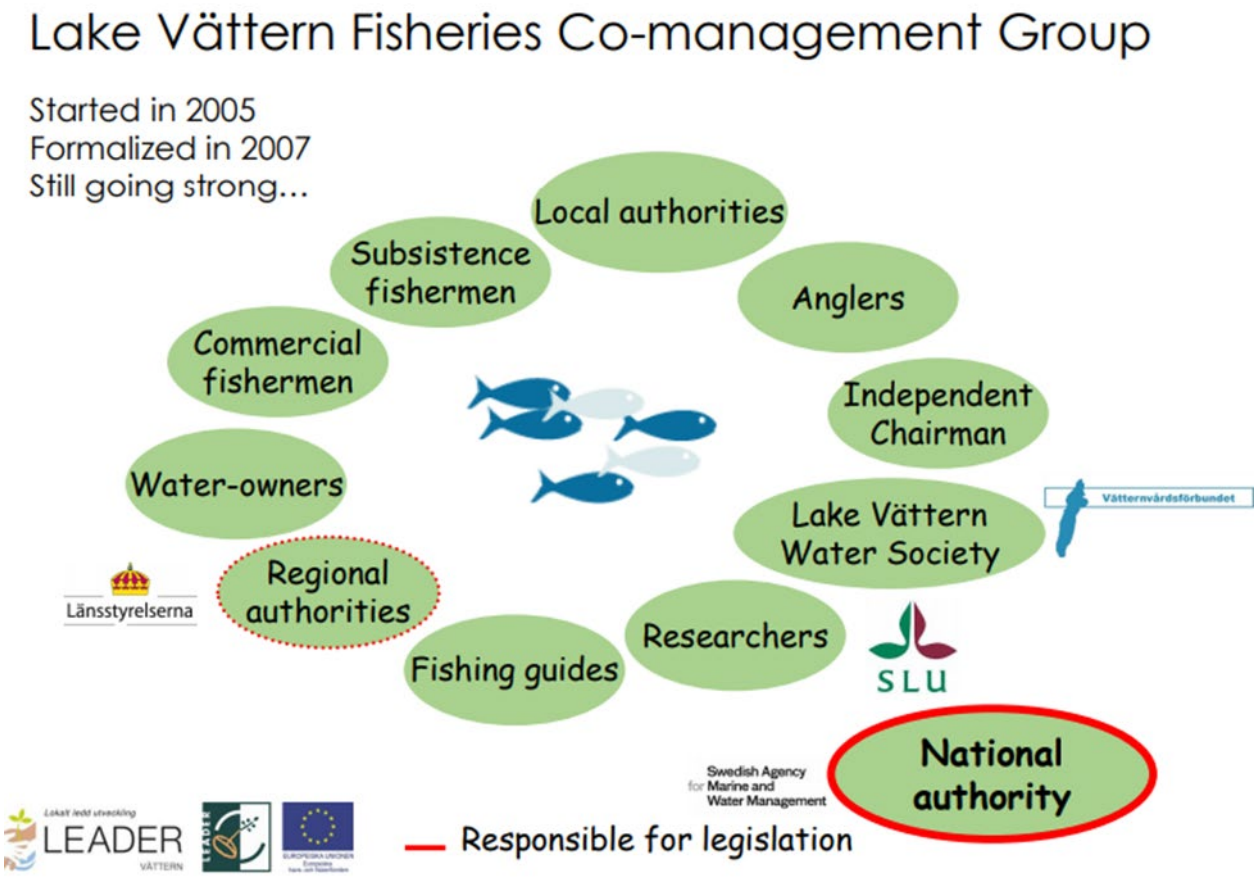

Figure 8. Stakeholder Analysis of Lake Vättern Fisheries Co-Management . Source: County Administrative Board, Jönköping.

Water owners: These are landowners whose lands border the lakes shoreline. By law, they own the portion that is within about 300m into the lake.

Commercial Fishers: These are stakeholders who depend on the lake fishery for commercial purposes. They own fishing boats with which they fish. They either sell their fish to open markets, food restaurants or process their catches themselves before sales.

Subsistence Fishers: These stakeholders depend on the fish from the lake as their means of livelihood.

Recreational Fishers (Anglers): These are people who fish in Lake Vättern mainly as a means of recreation or engagement in sports.

Lake Vättern Society of Water Conservation (LVSWC; Vättenvårdsförbundet): This is the co-management group involving all Lake Vättern stakeholders. It is primarily funded by membership fees. The group is co-organized by the four counties within the Lake Vättern region. They act as an advisory body to the national fisheries regulation authority. This co-management

group has five working groups to facilitate its smooth operation. These groups are; the fishing surveillance group, investigation and monitoring group, rules group, salmon group, crayfish group and grayling group.

Local Authorities: These are the eight municipalities around the lake. They are members of LVSWC.

The Regional Authorities or the County Administrative Boards (länsstyrelserna): These are the four counties within the Lake Vättern region; they are Östergötland, Västra Götland, Örebro County and Jönköping County. These counties contribute with parts of the funds and resources needed in the co-management of the lake.

The National Authority or The Swedish Agency for Marine and Water Conservation (SwAM): This the national body saddled with the responsibility of regulating both the marine and freshwater fisheries in Sweden. Their regulations are passed down to and enforced at the local levels. SwAM also contributes with funds for developing management of the lake.

Researchers: These comprise of researchers from Swedish universities commissioned by SwAM. Researchers from the Swedish University of Agricultural Sciences are part of the lake's co-management group and are responsible for data collection, analysis, interpretation and giving of scientific advice about the lake's fishery to the co-management group.

4.0. Materials and Methods

This study has two main parts. The first part is assessing the EBFM of Lake Vättern by juxtaposing the current lake's management strategies with the core EBFM objectives as enumerated earlier. These objectives, as summarized by Engler (2015) and Long et al (2015) are;

- That EBFM should be based on science
- It should make use of appropriate connections and scales
- It should proactively manage uncertainty through the precautionary and adaptive management approaches
- It should take into consideration the long-term social and ecological wellbeing of the ecosystem
- It should ensure stakeholder participation and interdisciplinary involvement in decision making
- That there should be effectiveness in achieving set objectives

The assessment was done by studying and gathering relevant information from available documented records about the sustainable management of Lake Vättern. Also, first-hand information was gathered from the stakeholders during my participation at the lake's fisheries co-management meeting. In a question-and answer email message, Malin Setzer, staff of the County Administrative Board Jönköping, also provided very useful information about the labeling and certification status of the lake's fisheries.

The second part of this study traced the distribution paths the lake's commercial fish and fish products take from harvest to the dining tables in Sweden. There are no documented records on Lake Vättern's fish distribution channels. So, this task was carried out using an online survey application (Netigate). Questions having English and Swedish versions were sent through text messages and emails to the nineteen (19) licensed fishers in the lake's fishery. Many of these fishers are also processors and retailers since they process their own catches and then sell through

their own fish shops. This ‘fisher-processor-retailer’ group was, therefore, the right target group to provide the answers the survey sought for.

The response to the survey was low. The reasons for this low response could be due to people’s apathy towards surveys in general, or the surveys may have been delivered into their spam folder. This shortfall was made up for, however, by gathering more information from the chairperson of the fishers’ association through email, coordinated by staff of the County Administrative Board, Malin Setzer, who did the translations. More information was also gathered in a question-and-answer session with Malin Setzer (as a staff of the County Administrative Board, Jönköping). The information gathered from the chairman of the fishers’ association and from the County Administrative Board corroborated those from the respondents to the survey.

5.0. Results

The results are presented in two parts: results from the assessment of EBFM of Lake Vättern using the EBFM objectives (Engler et al, 2015; Long et al, 2015) as a basis; and results from the survey and interviews conducted. These survey and interviews sought to determine the distribution channels of the commercial fish and fish products from Lake Vättern to the fish consumers in Sweden. They also sought to know the effects of environmental toxins on fish and consumer reactions, and the MSC-certification status of the lake's fisheries.

5.1. Assessment of Lake Vättern's Fisheries Management Using EBFM Objectives (Engler, 2015; Long et al., 2015).

Why was it necessary to assess the sustainable management of Lake Vättern while tracing the distribution channels of its fish and fish products? The system thinking concept requires that a holistic view be taken of a system in order to fully understand the different parts of that system. It was, therefore, imperative to assess the EBFM of Lake Vättern as perturbations in any one part of the system could offset the stability of other parts. The findings are as follows:

Objective 1. EBFM Should Be Based on Science: The Lake Vättern Society of Water Conservation (LVSWC, Vätternvårdsförbundet) has its work and management strategy established on the scientific or research knowledge from some universities in Sweden. The Swedish University of Agricultural Sciences (SLU) is part of the lake's fisheries co-management group and is actively involved with research on the lake and its fisheries. For instance, researchers from SLU, in collaboration with their counterparts from University of Skövde, conducted a research which looked at how a collaboration between researchers and fishers could affect and/improve selectivity in the whitefish fishery in Lake Vättern (Sandström et al., 2020). Also, Chalmers University of Technology and Stockholm University conducted a research on stakeholder interaction in the co-management of the lake's fishery (Lundholm and Stöhr, 2014). Furthermore, a consortium of American Universities, with their researchers, referred to Lake Vättern as a good example of

a system with reversed eutrophication and nutrient abatement (Schindler et al., 2016).

At the last co-management meeting of the lake (which I was a part of), researchers from SLU emphasized their roles of data collection, evaluation and description which they carry out regularly on the lake's fishery. After the data analysis, the researchers give scientific advice or recommendations to the lake's fisheries co-management group. The researchers also reported at the meeting that they have designed models for many fish species in the lake and are currently considering designing ecosystem models for the lake. With the involvement of researchers, it is obvious that the management of Lake Vättern employs scientific evidence in taking informed decisions.

Objective 2. The Use of Appropriate Connections and Scales in EBFM: As expected, there are strong connections among the aquatic species, the water and the land environments of Lake Vättern. The co-management group, Lake Vättern Society of Water Conservation (LVSWC), is very much aware of these connections, and has developed three steering documents to address these issues and the impacts of their connectivity. These steering documents are;

1. The Water Management Plan (Vattenvårdsplan) which seeks to ensure good water quality of the lake
2. The Management Plan for Fish and Fishery (Förvaltningsplan Fisk och Fiske)
3. The Conservation Plan (Bevarandeplan) ensuring that the lake environment is free of toxins and harmful chemicals and safe for the lake's water and species.

These steering documents help the co-management group to recognize species' interactions with their land and aquatic environments and manage the outcomes of such interactions. The documents also help the managers to recognize the roles and influence of species in the ecosystem. Furthermore, the documents help to pinpoint and mitigate the impact of industrial wastes and airborne pollutants on the lake's water quality.

At the last co-management meeting, the stakeholders from municipalities reported that Jönköping municipality is currently finding ways to address the loading of pollutants from urban runoffs into the lake. The municipality is also working on improving the conditions of Lake Munksjön which drains into Lake Vättern. Also, the municipality is currently cooperating with Linköping municipality in finding ways to decrease pharmaceuticals in sewage within their municipalities.

Responding to a question asked by a participant at the last fisheries co-management meeting about military shooting fields and their impacts on the lake's environment, the municipalities' representatives said the government has asked the military to decrease pollutants from their shooting fields. This will help to reduce negative impacts on the lake. They stated further that the municipalities are currently working on removing fish migration barriers from the five brooks which connect to the lake.

With regards to the appropriate spatial scales, the catchment areas of the lake are natural delineations from the lake proper. The lake proper has three delineated fishery protection areas. These are; Tängan, Fingals and Norrgrundet where crayfish pots are the only fishing gears allowed. In terms of temporal scales, the three steering documents by the co-management group have been designed for a five-year assessment cycle, a time period considered appropriate to roll out management measures and follow up on them. It is right to say here, too, that the lake's fisheries management are doing well in their use of appropriate connection and scales.

Objective 3. EBFM Should Proactively Manage Uncertainty Through Precautionary and Adaptive Management Approaches: As explained earlier, natural resource management often come with some degree of uncertainties. This is mostly due to spatial and temporal variabilities and errors in measurements. Lake Vättern fisheries co-management has one of its working groups that is responsible for addressing issues of uncertainties. This working group is called *Investigation and Monitoring* group. For instance, this working group intensively monitors the Arctic char population.

At the last co-management meeting, researchers from SLU reported that burbot and whitefish fishing could increase, but that of arctic char should not (because it is not sustainable to do so). Also, optimal size analysis is ongoing for burbot and Arctic char. This will be a means of establishing the maximum size in catch for these fish species. Models have also been developed to measure the degrees of uncertainties in the management of the commercial fish species in the lake. These are all part of the precautionary measures to ensure that populations of these species do not fall below sustainable levels.

As regards adaptive management measures being undertaken at the lake, the fisheries co-management group is sensitive and responsive to the constantly changing conditions in and around the lake and develops strategies to deal with such changes. For instance, LVSWC at the last fisheries co-management meeting reported that the lake has been experiencing warmer temperatures since 1950s. They stressed that the warm temperatures during the winter periods are not ideal

for cold-water species like arctic char in the lake. Rising temperatures is a global phenomenon due to climate change. The fisheries co-management group has no localized solution to solve the rising temperatures but is ensuring that the water is clear or less turbid to reduce heat retention. This they do by controlling the effluents that enter the lake.

Also, LCSWC reported that a new knowledge portal, "Life at Vättern" would be launched in May 2021. The new portal will seek input from all stakeholders in order to fashion out a more adaptive management direction with up-to-date knowledge. Furthermore, LVSWC stated that the program for the coordinated environmental monitoring of Lake Vättern is undergoing revision for the first time since 2001. This is to ensure that the management gets up to date with the current environmental, climatic and managerial realities. Likewise, the Water Conservation Plan and the Management Plan for Fish and Fisheries are being revised to cater for the coming years 2021-2023.

In like manner, the national regulatory body, the Swedish Agency for Marine and Water Conservation (SwAM) reported at the last fisheries co-management meeting that there were ongoing plans and meetings for the purpose of creating a new common co-management structure for fisheries in the four big lakes in Sweden, and that includes Lake Vättern. Again, the lake's management is on the right path on this EBFM objective.

Objective 4. EBFM Should Consider the Long-term Social and Ecological Wellbeing of the Ecosystem: At the heart of the management strategies of Lake Vättern's fisheries co-management group is the concern for the long-term social and ecological wellbeing of the lake's ecosystem. The three steering documents for water, fisheries and ecological conservation of the lake are attestations to this fact. Also, all the six working groups of the lake's fisheries co-management group have the mandate and objective of ensuring the socio-ecological stability of the lake's ecosystem.

For instance, the Grayling, Salmon and Crayfish working groups have the tasks of ensuring that their respective species are sustainably managed. Likewise, the Investigation & Monitoring working group ensures that degrees of uncertainties associated with species management, such as that of Arctic char, are determined and managed. Models have been developed (and more are still being developed) to understand and manage the lake's fishery and the entire ecosystem sustainably. Furthermore, the Rules and Surveillance working groups set relevant rules and ensure compliance to such rules in order to conserve the ecosystem on a long-term basis.

On the social wellbeing of the lake's fisheries, the lake's co-management supports commercial and recreational fisheries and tourism which will create jobs, economic gains and recreation. On this EBFM objective, the lake's fisheries co-management group is on the right path to achieving it.

Objective 5. EBFM Should Ensure Stakeholders participation and Interdisciplinary Involvement in Decision making: Lake Vättern fisheries have a robust involvement of stakeholders in its management. As discussed earlier, the stakeholders involved in the co-management of the lake and its fisheries include local, regional and national governmental authorities, researchers, commercial and recreational fishers, water owners, and the tourism board. As previously mentioned, these stakeholders form the LVSWC, including a fisheries co-management group in charge of the lake. This group meets three times a year to deliberate on issues regarding the sustainable management of the lake and its fisheries. The first meeting for this year was held on the 4th of March 2021, the second will take place on the 27th of May 2021, while the third meeting will be later in the year.

These stakeholders involved in the lake's management are brought together due to the complexity of the lake's ecosystem and the need for interdisciplinary decision making and proffering solutions. Experts from various backgrounds and disciplines are actively involved in the lake's management. Also, the fisheries co-management group relies strongly on local knowledge in its decision making. Information from the local communities around the lake helps in the early detection of new problems, leading to quick resolution of such problems in the lake's ecosystem.

The fisheries co-management group is doing relatively well on this EBFM objective but has left out an important stakeholder group. The major group of stakeholders left out in the lake's fisheries co-management is the fish consumer group. Fish and fish product consumers are not part of the stakeholder group, so there are no strategies in place to develop a complete fish value chain for Lake Vättern fisheries. This could be a reason why there are no documented records of the lake's fish and fish products distribution channels

Objective 6. EBFM Should Be Effective in Achieving Set Objectives: A group of North American researchers reported that Lake Vättern is an example of successful nutrient abatement and eutrophication reversal in a lake ecosystem, judging from the lake's improved water quality (Schindler et al., 2016). This testimony is an indication of some degree of effectiveness in meeting set environmental and ecological objectives for the lake's ecosystem. Also, management efforts from the fisheries co-management group is resulting in increased stakeholder participation, improving crayfish, arctic char and burbot fisheries, and in their current support to make the lake region a tourist destination.

However, there are a couple of bottlenecks in achieving set objectives for the lake. The first is lack of adequate funding. All the developmental projects require funding. As revealed during the last stakeholder meeting, limited funding come mainly from membership fees, but also from the municipal, county and national authorities. Also, Leader Vättern, a non-profit organization and an arm of the European Maritime and Fisheries program helps with funding for some specific projects of the lake's fishery.

Another obstacle is the time taken to make decisions and implement them. The stakeholders at the last fisheries co-management meeting raised this point. With the co-management approach in Lake Vättern, it takes time for all stakeholders to come together and take decisions on any issue. Also, major decisions taken are put in the form of suggestions that are then passed on to the national regulatory body, SwAM. Getting feedbacks and approvals from SwAM takes time, so starting and finishing major projects on time suffer setbacks, obviously. Issues about fish and fish product distribution and consumer satisfaction are not a part of these discussions.

During the last co-management meeting, stakeholders from the County Administrative Board mentioned a third obstacle; non-compliance to set rules and regulations over the years. The board explained that more was needed to be done to enforce compliance/abidance to rules and regulations by all stakeholders. They, however, reported that there was better or improved abidance to fishing and environmental rules in the past year 2020, because there was a decrease in the number of legal charges.

5.2. Results of Lake Vättern's Commercial Fish and Fish Products Distribution Channels

5.2.1. Survey Result

There are nineteen licensed fishers in Lake Vättern, surveys were sent to them all through emails and SMS (in both Swedish and English versions) but only three of them responded to the survey using the Swedish version. Their responses showed that they have been fishing in the lake for eleven years and above. Results also reveal that the fish/shellfish commonly caught in lake Vättern include signal crayfish (the largest in volume and value), Arctic char, burbot, trout, grayling, vendace, (a species of whitefish), pike, salmon, and very rarely, perch (Fig. 9). Fishing duration for the fishers vary from 3-7 months in a year. Daily fish catch per fisher is between 50kg-200kg/day.

1 SignalKräfta	3 (100%)
2 Lake	2 (67%)
3 Röding	2 (67%)
4 Öring	2 (67%)
5 Harr	2 (67%)
6 Siklöja	2 (67%)
7 Gädda	2 (67%)
8 Lax	2 (67%)
9 Gös	0 (0%)
10 Annan art (vänligen specificera)	1 (33%)
Answers	3

*Figure 9. Fish and shellfish species commonly caught in Lake Vättern.**

**Translation of figure 9 from Swedish to English: Signalkräftor (Signal crayfish); Lake (Burbot); Röding (Arctic char); Öring (Trout); Harr (Grayling); Siklöja (Vendace (species of whitefish)); Gädda (Pike); Lax (Salmon); Gös (Pikeperch); Annan (Others (Perch)).*

The fishers process a part or all their catches before sale. They process between 76%-100% of fish caught into fish products. These processed fish products include fish fillets, smoked fish, and boiled crayfish. These 'fisher-processors' buy fish from other fishers to process when their own catches are not enough to meet consumer demands. Fish and fish products are sold mainly to restaurants and wholesalers. Other sales outlets are the fish open markets (in Stockholm), to other fish processors, as well as in fishers' own fish shops.

5.2.2. Results of Interviews.

A. Interview about fish processing and distribution channels: Email questions were sent directly to the chairman of Lake Vättern fishers' association, Jonny Ståhl, through Malin Setzer of the County Administrative Board, Jönköping. This approach replaced the earlier plan to have a one-on-one interview with the chairman. Below are the uncensored answers (as translated from Swedish by Malin Setzer):

> "All fishermen have access to cold rooms and freezer containers that hold about 5.000 kg on average for each fisherman. It is mainly to cope with the storage of crayfish bait that the freezing capacity is needed. The species that are commonly harvested, processed and sold are signal crayfish, trout, arctic char and whitefish. Trout, arctic char and salmon are sold whole, as fillet and as smoked (whole or in fillets). Boiling crayfish is done on a large scale. Fish drying and salting do not occur, and no canned fish are made" (JS: Pers. obs.).

> "A large part of the catch is sold directly to consumers in the fishermen's own stores. But restaurants are also usually big customers. The fish is sold locally at 90 %. The crayfish, which account for 90 % of commercial fishing income, have the greatest value and the largest volume. As a rule, very few complaints come from the customers as the fish is sold without having been transported and thus is of good quality. The caught fish are not enough to meet the demand. A lot of whitefish, char and salmon are brought in and sold locally around Lake Vättern" (JS: Pers. obs.).

In a nutshell, signal crayfish is the main shellfish species harvested, processed and marketed in the region as well as nationally, while trout, arctic char and whitefish are the most valuable fin-fish species harvested, processed and sold in the locality. The catches are either sold fresh, processed into fillets and frozen or smoked (whole fish or fillets). The signal crayfish is boiled on a large scale and its market accounts for about 90% of commercial fishing income in the lake region.

About 90% of the fish and fish products from the lake are sold to the consumers in the locality through fish shops owned by the fishers themselves and through local food restaurants. Also, wholesalers buy from the fishers and take the fish to open fish markets (fiskauktioner) in Stockholm or elsewhere. The results show that consumers are pleased to buy fish from the lake because they believe the fish are fresh since they have not been transported through long distances before purchase. However, the fish from Lake Vättern are not enough to meet local demands, and so, lots of whitefish, Arctic char and salmon are 'imported' into the locality to augment supplies.

B. Interview about MSC certification of Lake Vättern Fisheries: A staff of the County Administrative Board, Malin Setzer was interviewed about the MSC status of Lake Vättern fisheries. This is what she had to say;

> "In Lake Vättern there are no MSC-certified or other eco-labelled fisheries. They thought about trying to MSC-certify the signal crayfish but then the species were target of EU list of invasive, alien species. And the stock of whitefish has trouble with dioxin and PCB levels. Still there is an application for labeling whitefish as an origin labeling (Skyddad ursprungsbeteckning SUB). The stock of arctic char is still recovering from overfishing and there are no other species targeting for MSC. If burbot were a requested species by the consumers the burbot could perhaps be targeting for MSC. But now the species is fished to be used as a bait in fishing crayfish. There are no pikeperch stock in Lake Vättern, only a small planted stock in the northern part of the lake" (MS: Pers. obs.).

C. Interview about toxins in fish and fish products and consumer behavior: At the last co-management meeting of the lake, I put a question to the stakeholders about the effect of toxins in fish and fish products on consumer behavior. Jonny Ståhl, the chairman of the fishers' association, responded by saying that consumers were fully aware of pollutants in fatty fish from the lake, and they know of the diet recommendations regarding such fish and fish products. In his words;

"I got a reaction when I wanted to deliver burbot to a restaurant. The fish was on the WWF red list, and so, they didn't want to handle it. Consumers make informed choices and ask questions when they come to my fish shop. Many women know about limit consumption in fish, while some older consumers think that eating fish once in a week is enough. Many of my customers have gone from eating meat to eating fish and vegetables" (JS: Pers. obs.).

6.0. Discussions, Conclusions and Recommendations.

6.1. Ecosystem-Based Fisheries Management of Lake Vättern

The results of this study reveal that the co-management of Lake Vättern is on the path of achieving the set EBFM objectives. How well these objectives are achieved or pursued is not the scope of this study. Rather, this study was an attempt to describe how EBFM is practiced in Lake Vättern fisheries management, and the effect this has on the lake's fisheries and the commercial fish and fish product distribution in the lake's region.

The application of EBFM in and around the lake and its fisheries is quite impressive. It takes cognizance of many socio-ecological pressures and there are concerted attempts to tackle them headlong. To achieve these, the lake's fisheries co-management team set up working groups that manage different areas of the lake and its fisheries. This assertion is supported by van Mastrigt (2013) who, in a quantitative study, revealed that Lake Vättern's fisheries co-management had high social and ecological sustainability scores regarding its commercial fisheries.

Some of the gains recorded from the co-management of the lake include increased stakeholder participation. I attended the last co-management meeting and experienced the cooperation and enthusiasm the stakeholders shared. Sandström et al. (2020) also observed this 'spirit of participation and cooperation' among the stakeholders; they stated that the collaboration between the lake's fishers and researchers is a boost to the selectivity of the lake's whitefish fishery. Also, models designed by the researchers help the managers, the researchers, and indeed all stakeholders to understand tradeoffs and ecosystem processes. Other gains include improved nutrient status of the lake due to nutrient abatement, clearer water, less turbidity, decreasing levels of pollutants, and increasing recovery of Arctic char population which suffered heavy overfishing in the recent past (Vätternvårdsförbundet, 2021).

However, there are many challenges confronting the fisheries co-management group of Lake Vättern. One major problem is what I would refer to as 'oversight'. The body has six working groups; the *Fishing & Surveillance*, *Rules Group*, *Investigation & Monitoring*, *Crayfish Group*, *Salmon Group*, and *Grayling Group*. All these subgroups manage different aspects of the lake's fishery, but there are no working groups to take charge of issues regarding fish processing, ecolabelling, fish and fish products distribution, consumers' needs and complaints. In fact, the fisheries co-management group does not recognize or include 'non-fisher processors', 'non-fisher-distributors' or the consumers in their stakeholder group.

A proper stakeholder analysis must give due recognition to consumers and adequately involve them in co-creation or co-management of the product they consume. In the co-management group that manage Lake Vättern, the consumers are not adequately represented. Even though the subsistence, recreational and commercial fishers also consume fish and fish products, they are what one may refer to as 'consumers with an economic interest'; they depend on the lake for survival, recreational or economic interests other than just fish consumption. The fish consumers who purchase their fish from the markets or stores are clearly not represented in the Lake Vättern stakeholder group involved in the co-management of the lake.

The reason for this omission or oversight is because of the non-application of *Systems Thinking* in the lake's fisheries management approach. As discussed in previous sections above, the *Adaptive Management Approach*, the *Precautionary Approach* and the *Ecosystem Approach* being applied in the lake's management all deal with specific issues of water, environment, fisheries, and ecosystem health. None of these theories takes a holistic view of the lake's fish value chain – from the fishery down to the processors, distributors, consumers, and to even management of wastes from the lake. It is, therefore, imperative that the lake's fisheries co-management adopts the *Systems Thinking Approach*, alongside other approaches currently in use. This will help the management to 'see the forest and the individual trees' at the same time. This means that the management will be able to have a holistic management view of the entire value chain, and as well recognize the effect a fisheries management action has on the fish on our dining tables.

The value/supply chain of any natural resource production include the stages of production, processing, distribution (wholesale and retail), consumption and waste management. In the Lake Vättern value/supply chain, more emphasis is placed on the production of fish and the 'wellbeing' of the lake's ecosystem than on the other stages. For instance, there is no management sub-group to see to the proper processing and distribution of the fish and fish products from Lake Vättern just like there are sub-groups in charge of grayling or salmon fishery or the tourism group.

There is also no working group to attend to fish consumers' needs and expectations. If there was a working group in charge of fish distribution and consumer satisfaction, that group would have been of great support to this study and there would have been a higher number of responses to the research survey.

Another weakness stemming from the non-application of *Systems Thinking* by the lake's management is the one-sided research efforts. I gathered at the last management meeting that all research efforts on the lake tilt towards fisheries and ecology. The researchers from SLU only talked about their ongoing research efforts in the lake's fisheries, ecology, and ecosystem model design – no research on the value chain beyond the food production (fisheries) stage. Right now, there is no scientific document detailing the lake's commercial fish processing and distribution channels. I strongly recommend that food scientists should join Lake Vättern's team of researchers so that they can carry out research on fish processing methods, fish and fish product distribution channels and fish consumption patterns.

Also, there is the challenge of decision-making by the co-management of the lake. Core management decisions are made only by the national regulatory body, SwAM). The fisheries co-management group only acts as an advisory body to SwAM. Decisions taken at the co-management meetings are presented as suggestions to SwAM who then makes the final decision. Such was the case at the last management meeting I was a part of. At the meeting, twenty (20) suggestions were presented for submission to SwAM. Most of these suggestions aimed at improving the conditions for fish in the lake. According to Stöhr et al (2014), Lake Vättern stakeholders were displeased that the fisheries co-management group had no authority to make management decisions. To this end, I strongly recommend that in decision-making, a fusion of bottom-up and top-down management style should be adopted. This would result in consensus-based decision-making by all stakeholders. This will give the stakeholders more sense of 'ownership'.

Other challenges facing the lake's management are the issues concerning invasive species, environmental toxins, and MSC certification of the lake's fishery. There are no MSC-certified fisheries in Lake Vättern like in Lakes Vänern and Hjälmaren with MSC-certified pikeperch fishery. Lake Vättern has no pikeperch fishery but has a thriving signal crayfish fishery. Signal crayfish fishing accounts for 90 % of the lake's commercial fishing income and has the largest value and volume compared with other fisheries of the lake (JS: pers. obs.). The signal crayfish fishery is not certified because the species is on EU's list of invasive species.

The signal crayfish is creating jobs, providing income and improving the local economy in the Lake Vättern region, and as such, it should be well managed locally to optimize its benefits, downplay the odds and remove it from the 'invasive' list

within that locality. If the species is being fished actively and not disrupting the wellbeing of other species in the lake's ecosystem, I recommend it should be 'delisted' from the EU invasive species list and certified (just for the Lake Vättern region). On the other hand, the fatty whitefish still has issues with environmental toxins and cannot be certified yet, so I therefore recommend that the arctic char fishery be boosted and prepared for MSC certification. MSC-certified fishery could help in gaining consumers' confidence in the safety and sustainability of the fish and fish products from the lake.

6.2. Fish Distribution Channels

From the results of the survey and interviews conducted, Lake Vättern fish and fish products distribution channels are depicted in Fig. 10 below;

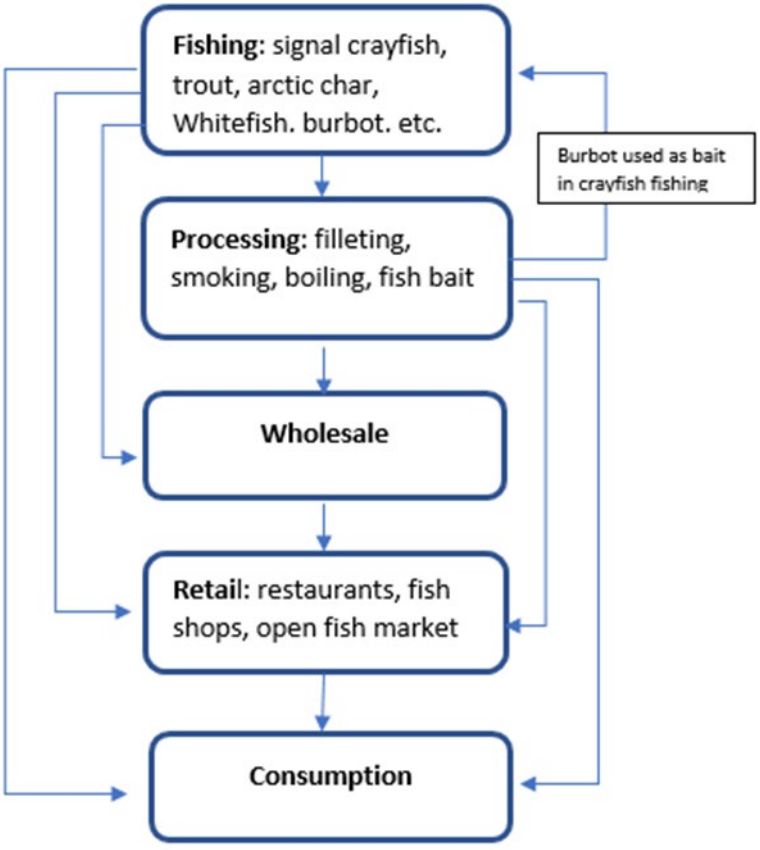

Figure 10. Fish and Fish Products Supply/Value Chain of Lake Vättern.

Figure 10 is a schematic expression of the results of this study. As shown in the figure, Lake Vättern fish supply chain starts from harvesting fish from the lake. The major fisheries of the lake are those of signal crayfish, trout, arctic char, and whitefish. Others include those of the burbot, salmon, grayling and pike. All the

fisheries have similar distribution channels. The nineteen licensed fishers harvest fish and shellfish species from the lake. They process their catches into fillets and smoked fish products, and as well boil the signal crayfish. They sell both fresh and processed fish products to wholesalers, food restaurants, fish shops and fish markets. The consumers either buy fish directly from the fishers or from restaurants, fish shops or open market. Burbot in the lake is caught and processed for use as bait in the crayfish fishery as it has little human use. The Lake Vättern region's short fish supply chain is expected to be of help to the local economy by creating more jobs and improving standards of living, if the fisheries are greatly improved. The small-sized fish processing ventures, food restaurants and fish shops are positive indicators of the fish supply chain's benefit to the development of the local economy.

The lake's fisheries create opportunity for the local consumers to 'buy local'. Buying local is expected to result in less carbon footprints because of shorter transports to the market. Also, consumers benefit from fresh fish products directly from fishers, while the fishers would benefit from the premium price fresh products command. Hammarlund et al (2021) stated that 'buying local' is fast becoming a trend in the marketing of food in the high-income nations of the world. This trend, I believe, is a consequence of the current consumer awareness to eat healthy. The EU policy on rural development encourages support for local markets and 'short supply circuits' as areas member states could focus on (ENRD, 2016). To this end, the European Maritime and Fisheries Fund (EMFF) encourages local partnership projects which fund and promote sales of fish harvested within the same locality (European Commission, 2014).

The present Covid-19 pandemic calls for the need for a short food supply chain by the production and sales of food products (such as fish and fish products) within the same locality, as much as possible. It is recommended here, therefore, that the Swedish government should further develop the fisheries of the numerous lakes in Sweden. This will help to make fish and fish products available to consumers in all the local communities where these lakes are. It will also help to reduce fish supply distances, reduce carbon emissions from long distance transports, and as well create more jobs and improve the local economies.

Finally, I see the need for further detailed research into the commercial fish and fish products distribution channels for all the big lakes in Sweden. I also recommend a research into the fish and fish products distribution channels of the entire fish industry in Sweden. This is necessary and of utmost urgency because there are presently no documented records of fish and fish products distribution channels in Sweden. Such research should not only trace the fish sales channels but should also

reveal who the brokers are (and their powerplay), the pricing strategy, as well as the uniqueness and challenges in the Swedish fish supply/value chain.

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Appendix 1: Popular Science Summary

Over 90,000 lakes of more than 1 hectare in size abound in Sweden. These numerous lakes have the potential to provide enough fish needs for Sweden if well managed. Marine fisheries in Sweden are dwindling leading to the closure of the Baltic cod fisheries, and Swedish aquaculture contributes very little to annual total fish production. There is therefore the need to explore the fisheries potentials of these numerous lakes in order to reap their benefits and meet the fish needs of the Swedish consumers.

The aim of this research was to examine how one of these lakes, Lake Vättern, is being sustainably managed, and to trace the distribution paths the fish and fish products from the lake take before getting to consumers around the lake's region and beyond. The research sought answers to the following questions; is Lake Vättern fisheries sustainably managed? Are the fish from the lake enough to meet the fish needs of consumers in the lake's region? Into what products are the fish processed and where are the fish sold? Are the consumers in any way involved in the co-management of the lake? To get answers to these different questions, four methods were used to gather information, these are: gathering of information from documented records/literature about the lake's management; first-hand information gathered by the researcher's participation in two of the lake's fisheries co-management meetings in March and May, 2021; interviews conducted on key stakeholders of the lake through emails; and survey administered to the nineteen (19) licensed fishers of the lake.

The study assessed how well the lake is being managed by simply comparing the current management approach with ecosystem-based fisheries management style spelt out in literatures and recommended by the FAO. The assessment revealed that the lake's fisheries management makes use of science-based information and data in making decisions. It recognizes that the lake's land, water, and organisms are strongly connected and manages them as a system but minding the peculiarities of the different parts. Also, results showed that risks and uncertainties are managed using the precautionary and adaptive co-management approaches, while taking note of the long-term socio-ecological wellbeing of the lake's ecosystem. The lake's management also engages stakeholders with multidisciplinary backgrounds. All these are attributes of a well-managed lake.

The second half of the study traced the fish and fish products sales channels from the harvest to the consumer. Signal crayfish, Arctic char, burbot, trout, grayling, whitefish, pike and salmon are the commonly caught species. The crayfish fishery is the biggest in terms of volume and value, giving the fisher more profits. The whitefish fishery is hampered by the presence of environmental toxins which accumulates into the fish. Burbot is not a commercial fish but is harvested and used as baits in signal crayfish fishing. The caught fish are processed into fillets and smoked fish, while the signal crayfish are boiled in large quantities. These products are then sold to restaurants, wholesalers, fish shops or fish open markets (in Stockholm) where consumers have access to them. The fish from the lake are not enough to meet local fish needs, so Arctic char, whitefish and salmon are brought in into the locality to augment local supplies.

None of the lake's fisheries is MSC-certified. The Signal crayfish fishery of the lake is the largest, but it is not certified because it is considered as an invasive species (i.e. introduced into the lake but now rapidly spreading and displacing native crayfish species). The whitefish is not certified because of environmental toxins that bioaccumulate in its flesh, and as such, not too healthy for regular human consumption. The Arctic char population is still recovering from overfishing, so it cannot be certified yet. The burbot fishery, though has good population, cannot be certified because the fish has low consumer demands and is used mainly as baits in crayfish fishing.

This study recommends the use of *Systems Thinking* approach to the lake's management alongside the current management approaches in use. The current approaches mainly focus on the fish and its lake environment. *System Thinking*, on the other hand, is one that allows a management to take a holistic view of the entire value chain; it will enable the lake's fisheries management to 'see' broadly and take actions that will cater for the entire fish value chain. It will not only focus on fish production but also see the fish processing, distribution and consumers' needs and preferences. *Systems Thinking* will also enable the management to see the need to involve consumers in the co-management of the lake. Furthermore, they will see the need to set up a working group to take care of issues regarding fish processing, distribution, consumer complaints, and even MSC-certification of some of the lake's fisheries. Consequently, research efforts in the lake's fisheries will not only be focused on the fish and its ecosystem but will also beam its searchlight on the other parts of the lake's value chain. This will expand the lake's fisheries and increase its fish products to meet consumers' fish demands, beyond what obtains in the lake presently.

It is also recommended that the decision-making style of the co-management should be consensus-based rather than the current top-down approach where the national

regulatory body takes suggestions from the lake's co-management group and then solely makes the decisions. This will give the stakeholders sense of 'ownership' of the lake and the lake's fisheries and the entire fish value chain will be the better for it. Lastly, this study recommends detailed research/studies of the sustainable management and fish distribution channels of the three other big lakes in Sweden (Lakes Vänern, Mälaren and Hjälmaren) as well as for the entire Swedish fish industry. Documented records in these areas are scarce.