Aquaculture in Sweden

Sustainability of land-based recirculation aquaculture as a future alternative for Swedish fish farmers

Daan W. van der Blom

Master’s programme
Science for Sustainable Development

Master’s Thesis, 30 ECTS credits
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Abstract

With the world’s population expanding rapidly and estimated to reach nine billion in 2050, the demand for food will increase. Therefore the need for more sustainable ways of food production, in particular meat, poultry and fish are needed. Aquaculture can significantly contribute to this. This thesis focuses on Swedish aquaculture and in particular the increasingly used method of food fish farming in Recirculation Aquaculture Systems (RAS). The aim of the thesis is to analyze and discern the possibilities and challenges of RAS in Sweden, with particular focus on Östergötland. Furthermore it examines if and how aquaculture can contribute to an economical, social and ecological more sustainable Swedish aquaculture sector. The methods used are semi-structured interviews with stakeholders and actors at different governmental levels and fish farmers, participation in stakeholder meetings and literature research. The results show that Swedish aquaculture has overtime developed a negative image among consumers, politicians, government officials and investors. Today Swedish aquaculture faces threats that need to be addressed and opportunities that should be taken. In order to succeed with RAS in Sweden solid business plans, conservative production/profit estimates and marketing are essential. Feed sources remain a concern from an environmental and economical point of view. Lack of financing from banks, investors and insurance companies, threatens Swedish aquaculture sector at the moment. Furthermore a lack of knowledge and capacity among lower government levels negatively influences aquaculture developments and this needs attention. The Östergötland region should concentrate on RAS and mussel farming and has the potential to become an example for the rest of Sweden. Aquaculture positively contributes to regional and rural development of the Swedish-country side by job creation and stimulation of local economies which is important for Östergötland and applicable to other regions of Sweden.

Keywords: Aquaculture, Food, Regional development, RAS, Sustainability
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<th>Acronym</th>
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<tr>
<td>ASC</td>
<td>Aquaculture Stewardship Council</td>
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<td>BEM</td>
<td>Baltic Eco Mussel</td>
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<td>CFP</td>
<td>Common Fisheries Policy</td>
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<td>EC</td>
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<td>European Regional Development Fund</td>
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<td>EU</td>
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<td>FAO</td>
<td>Food and Agriculture Organization of the United Nations</td>
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<td>LNRA</td>
<td>Land-based Nutrient Recirculation Aquaculture</td>
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<td>RAS</td>
<td>Recirculation Aquaculture Systems</td>
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<td>R&amp;D</td>
<td>Research and Development</td>
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<td>SCA</td>
<td>Swedish Center for Aquaculture</td>
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<td>SEPA</td>
<td>Swedish Environmental Protection Agency</td>
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<td>UA</td>
<td>Urban Agriculture</td>
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<td>UN</td>
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<td>WHO</td>
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1. Introduction

Seafood has been a staple source of protein in human diets for ten thousands of years (Diamond, 1997). With the world’s population expanding rapidly and estimated to reach nine billion in 2050, the demand for seafood products will increase. Moreover, it is estimated that the world population living in the coastal zone will increase from 2.3 to 3.9 billion in 2030 (Kay and Alder, 2005). The Food and Agricultural Organization of the United Nations (FAO) estimates that two thirds of the world’s major fish stocks are over exploited and that one billion people in the world today are solely dependent on seafood for their livelihood (FAO, 2009; Ziegler et al., 2003). Rivers, lakes, seas and oceans have long been seen as an unlimited source of abundance, a place from which we could take without consideration of the environmental, social and economic consequences and impacts. Today many fish stocks worldwide are under great pressure of overfishing due to intensified fishing efforts, growing food demand and technological developments. Research shows that fish stocks are depleting rapidly and environmental groups demand action (Costello et al., 2012; FAO, 2013b).

The situation in Europe is also pressing. In February 2013, a green party member in the European parliament Isabella Lövin stated that: “If the EU does not reform its common fisheries policy [CFP] now, only eight out of all the commercially exploited fish stocks [within European territories] will be at sustainable levels in 2022” (Lövin, 2013). She further warned that if we continue fishing, as it is done today in Europe, we will need to import more fish from overseas, or/and fish more elsewhere, and we will further destroy our marine ecosystems. Declining fish stocks and environmental degradation are also urgent in Sweden. Eutrophication of the Baltic Sea has caused multiple environmental problems including the rapid decline of Baltic cod stocks (Lindgren et al., 2009). The inland waters of Sweden have also been under increasing pressure during the last centuries. Human activities have caused degradation of many lakes and rivers affecting water quality and fish stocks. Physical changes such as damming of rivers for hydro electric power and water level regulation are some of the human induced changes to Sweden’s aquatic ecosystems (Lehtonen et al., 2008).

It is unlikely that widely adopted vegetarianism will be a voluntary choice for the majority of the world’s population so the need for more sustainable ways of food production, in particular meat, poultry and fish is needed. Research has shown that the need of more sustainable seafood has grown in trend with the need for other forms of sustainable food production (Roy et al., 2007). The farming of species in aquaculture systems, a method of cultivating marine or freshwater organisms such as food fish, shellfish, crustaceans and plants under controlled conditions, can possibly answer this demand. According to the FAO and WHO nearly 50% of the seafood consumed worldwide is produced in aquaculture systems. It is expected that this fast growing sector will further expand in the near future, where 80 million tonnes of fish and shellfish is necessary to meet the demand in 2030 (FAO 2011a; WHO 2006). Aquaculture is also a major economic activity. In 2008, world exports of fish and fisheries products were valued at US$102.0 billion, which doubled in respect to 1998 (FAO, 2011a). Asia is the biggest producer of aquaculture products with 88.8 percent of the global total followed by the United States with 4.6 percent and Europe with 4.5 percent. In Europe aquaculture accounts for 20% of the fish production, where hundreds different species are cultivated ranging from salmon to eel and oyster to shrimp. The aquaculture sector employs 65,000 people, in Europe, and Norway is the biggest producer. (FAO, 2011a).
1.1 Problem formulation

Although aquaculture is booming, the European aquaculture sector has seen only limited growth in recent years due to among others things tightened environmental laws and the world wide economic crisis. In the Baltic Sea region the aquaculture sector has even slightly declined (Aquabest, 2012b). This has affected the Swedish aquaculture sector which is relatively small compared to other Nordic countries (Ackefors, 2000; FAO, 2011a/b; Jordbruksverket, 2012). Many types of Swedish aquaculture are currently not completely ecologically, socially and economically sustainable; therefore the Swedish aquaculture sector faces a number of challenges. The limited magnitude of the Swedish aquaculture sector can also be seen as opportunity to redevelop itself and to strengthen its economic position while simultaneously becoming more sustainable (Berggren, 2007). In 2009 and investigation led by parliamentarian Håkan Larsson investigating the future of aquaculture in Sweden led to a report with a series of government recommendations aiming to improve the sustainability of Swedish aquaculture sector. The focus in this report lies on environmental, economical and social sustainability. Furthermore the Swedish government has stated that the aquaculture industry is a sector with great future potential. In 2012 and 2013 the Swedish Board of Agriculture (Jordbruksverket) has developed a national aquaculture strategy including a future vision and strategy designed to modernize and further develop Swedish aquaculture. In the end of 2013 a more detailed action plan will also be presented by Jordbruksverket. One of the 18 goals in the strategy is that the government should treat aquaculture in the same way as agriculture, since aquaculture is a way of food production. Besides, farmed fish is the most effective livestock for meat production based on biological resource efficiency (Lindahl et al., 2005). Furthermore development of the aquaculture sector can provide better control over food fish, more local produced food and improvement by job creation in the rural areas of Sweden (Jordbruksverket, 2012).

Increasingly used methods of fish farming are Recirculation Aquaculture Systems or RAS. In these systems aquatic species are farmed on land within closed water recirculation systems. Although still small in Sweden, this method is commonly used in the aquaculture industries of Sweden’s neighboring countries (Dalsgaard et al., 2013). RAS have proven to be a reliable, safe and economically viable way of fish production for a wide variety of valuable species (Badiola, 2012). At the same time, RAS can achieve higher yields than traditional open or semi closed aquaculture systems (FAO, 2011a; Bergheim et al., 2009). Also the environmental impact of RAS is lower and less natural resources are used e.g. water. Therefore RAS can be considered a more sustainable way of food fish production.

Most Swedish fish farms are situated in the rural areas of the country close to some source of water. The fish farms are often small scale family run businesses and have a production as little as halve a ton of food fish/year (SCB, 2012). The overcapacity of the Swedish fishing fleet has affected coastal communities, the slump in Sweden’s for export important wood and paper industry and that the price drop in agricultural products have caused unemployment in the rural areas of Sweden (Naturvårdsverket, 2008; Morf, 2006). The production of the Swedish aquaculture market is dominated by several big fish productions situated on the island of Åland (autonomous region of Finland) and in the province of Jämtland in northern Sweden. In these regions the aquaculture industry forms an important part of the local economy, providing jobs and thus compliments to the further development of these regions (Aquabest, 2012). This possibly affects the development of the aquaculture industry in other parts of Sweden. Knowing that aquaculture can contribute to regional development in rural
part of Sweden there might be opportunities to transfer this success to the rest of Sweden in order to develop the Swedish countries side.

1.2 Aim

With the problem formulation in mind the overarching aim of the thesis is to analyze the possibilities and challenges of achieving sustainable aquaculture in Sweden, with particular focus on Östergötland. The potential of Recirculation Aquaculture Systems realizing more socially, economically and environmentally sustainable aquaculture will be discerned.

1.3 Research questions

What would it mean to introduce land-based recirculation aquaculture systems to small scale fish farms in Sweden?

- Which economic, social and ecological threats, if any, to fish farms in Sweden can be identified?
- What opportunities exist to transform those businesses into land–based Recirculation Aquaculture Systems?
- Can this contribute to rural regional development in Sweden?
- Can this contribute to more economic, social and ecological sustainable aquaculture?


2 Background

2.1 A short history of aquaculture

Aquaculture has its origin in Asia and has been practiced for thousands of years. Different varieties of carp were among the first species to be farmed (Gerstmeier and Romig, 1998). In Europe, the farming of fish originated in the Middle-Ages. This started out as a non-intensified form of fish farming, where farmers would grow carp in heavily vegetated ponds which were drained just before harvesting. This was soon replaced by an intensified form of farming resulting in an increased production (Gerstmeier and Romig, 1998).

In Sweden, archeological excavations indicate that in the Middle-Ages fish were farmed at several monasteries throughout Sweden. However, the modern farming of fish started at the end of the 19th century when rainbow trout was introduced in Sweden (Gerstmeier and Romig, 1998). At the same time other species such as brown trout, salmon, whitefish and pike where also attempted to be cultivated. A first impulse to the Swedish aquaculture industry came around the mid 1950’s. The normalization of rivers and the building of dams to generate electricity caused a loss of diadromous wild salmon and trout. Companies responsible for this decline were imposed to restock the affected lakes and rivers. The knowledge gained in this process, became useful when in the 60’s the first food fish production facilities were established (NKFV, 2013; Ackefors, 1982).

In the 80’s the expansion of the Swedish aquaculture industry took flight. Many family-owned farms got into the aquaculture business to make extra money, often with no or little knowledge about fish and fish farming (Ackefors, 1982). In addition to fish, blue mussels and crayfish where starting to be cultivated on a large scale in Sweden. However, rainbow trout has dominated the Swedish market in food fish production. In the 1980’s the number of food fish producing farms rose from 135 to 250 with a peak in 1988 (SCB, 2012). The number of other types of fish rearing farms (e.g. production facilities for fish stocking and mussel farms) increased from 125 to 210 active farms. Throughout the 1990’s until the mid 2000’s, the food fish production industry faced a steady decline (except mussels) while the other types of aquaculture steadily grew. This was mainly due to stricter environmental laws, local eutrophication problems, environmental degradation of lakes resulting in a negative view from the government and the general public. Combined with a lack of knowledge and technology among farmers to address these issues adequately this resulted in financing and insurance problems ultimately bankrupting 95% of the sector. Although the number food fish farms throughout Sweden declined, their production increased from roughly 1600 tonnes in 1980 to 5800 tonnes annually in 2005 (SCB, 2012).

2.2 Modern methods of fish cultivation

The cultivation of species is conducted in a variety of aquaculture systems adapted to optimize production and local conditions. In general four different types of aquaculture systems can be distinguished: open (active feeding), open (passive feeding), semi-closed and closed (land-based) systems (Goodfishbadfish, 2012), where the last type is focused upon in this thesis. An open aquaculture system refers to the farming of species in enclosures in natural waterways. Usually, floating cages are used and food is automatically distributed (active feeding) to the fish (FAO, 2010a). The third and most criticized method of
aquaculture are semi-closed aquaculture systems. This system is often characterized by land-based ponds pumping in fresh or saline water and discarding the wastewater untreated back into river or coastal waters (Bush et al., 2010; Kay and Alder, 2005). A large number of species is cultivated in this way, for example tiger-shrimp and Tilapia. In these systems active feeding is applied and often antibiotics are used to insure the species health in high population density production systems. This type of aquaculture is criticized because of the negative effect on coastal ecosystems and the potential threats of chemicals and pharmaceutical compounds spilling in surrounding waterways (AKVA, 2013; Goodfishbadfish, 2012; Das and Khan, 2004). The most sustainable way of fish production at the moment is done in Recirculation Aquaculture Systems (RAS). Although RAS also have negative aspects, RAS systems reuse water, heat and in some cases nutrients as much as possible. In general there are three types of recirculation aquaculture distinguishable, RAS, Nutrient Recirculation Aquaculture Systems (NRAS) and aquaponic systems. The most common form are the RAS’s whereas NRAS and aquaponic systems are mostly practised on small scale or on trial farms and in university research facilities (Grabber and Junge, 2008). However the RAS technology develops extremely fast. New ways of improving feed and (bio) filtration for example have made enormous advance in the last 5 years (Badiola, Mendiola and Bostock, 2012).

2.2.1 Recirculation Aquaculture Systems

In RAS systems aquatic species are farmed on land in tanks where feed is added and water is reused after several treatment processes (fig.2). RAS systems were first developed to farm fresh water species that could tolerate a fairly poor water quality (Martins et al., 2005). RAS have been improved in response to environmental and health regulations. The EU water management directive (2000) is one of the drivers behind these improvements (Martins et al., 2010). There are several environmental advantages of RAS systems in comparison with conventional aquaculture. Water consumption can be reduced by as much as 95% which is one of the main advantages of these systems. Besides that, biological pollution can be controlled (no escaping animals), better hygiene and disease management are additional benefits. In addition RAS systems are also ideal for urban areas and can be situated close to markets and consumers, which reduces transport and CO2 emissions (Badiola et al., 2012; Martins et al., 2010). There are also a number of negative aspects to RAS that still have to be
solved to further improve the sustainability of these types of systems. Feed froms according to Badialo (2012) the biggest challenge to the sector because RAS still depends on wild caught fish for feed. Besides that there are questions raised about the health of the animals in RAS systems since fish are farmed in very high stocking densities in order to maximize profitability (Martins., 2010). For the moment the European aquaculture sector consists only for a small percentage of RAS. However, there are a number of trends within the sector that suggests a transformation of the sector towards RAS. For example available data from Bergeheim et al. (2009) show that on the Faeroe Islands and Norway the hatchery production of Atlantic salmon smolt has shifted from semi-closed systems to RAS because of large seasonal changes in water temperature, and water quality issues. In other European countries including the Netherlands, Denmark the majority of fish production today takes place in recirculation systems (Wageningen UR, 2013). Despite the growing number of RAS in Europe the main reasons behind this low adaptation seem to be the initial high investment costs and the high production densities needed, besides that poor management and lack of knowledge and training regarding these very complex and technological advanced systems play a significant role (Bush et al., 2010; Martins et al., 2010; Bandiola et al., 2012). Life cycle analysis (LCA) studies show the RAS have proven to be the most sustainable option to grow fish (Bainbridge, 2008). The main constraint to further improve RAS is the feed. All RAS rely on an external source or wild catch for their feed (nutrient input) e.g. fishmeal pellets. Feed is therefore where the biggest improvements can be made in modern RAS to increase the sustainability of the systems (Bainbridge, 2008).

*Recirculation aquaculture system (RAS) concept*

![Simplified Recirculation Aquaculture System](image)

*Figure 2. Simplified Recirculation Aquaculture System, Blue= water flow, Black= wastewater flow, Green= oxygen input, Yellow= heating, Red= processing*
2.2.2 Nutrient Recirculation Aquaculture Systems

A more environmental responsible form of RAS is NRAS, where nutrients are recycled (fig.3). Nevertheless, NRAS is still in an experimental stage and only small scale pilot projects exist. In the Netherlands a research farm is setup where sole is cultivated together with ragworm, shellfish and sea crops. Together they form a system that has multiple harvestable crops, shellfish and food fish (Wageningen UR, 2013). This facility is unique in Europe and aims to show that NRAS is feasible. The only nutrients added to the cycle, is when feeding the ragworms. The rest of the nutrients are brought in by the filtered seawater pumped into the system. Thereafter the ragworms bring nutrients into the water, where a part of the ragworms is fed to the sole. The water from the ragworm and sole basins is pumped into another basin to cultivated algae that are subsequently fed to juvenile ragworm and shellfish (mussels, oysters and clams). The remaining wastewater and sediment from the fish basins is used to fertilize the cultivated edible sea crops for example Sea aster and Marsh samphire. Finally the wastewater is filter by a saltwater marsh before pumped back into the sea. Additional to producing edible crops and food fish, biogas is also produced onsite from fish basins sludge. The energy produced is used to power the pump installations and to heat the juvenile Sole basins in wintertime (Wageningen, 2013). One major achievement is that the sole have naturally reproduced at the farm (Omroep Zeeland, 2012). This means that the farm could be less dependent on wild catch juvenile sole which increases its sustainability.

Recirculation aquaculture system (NRAS with aquaponics concept)

![Diagram of Recirculation Aquaculture System](image)

Figure 3. Recirculation Aquaculture System with aquaponics, example of the experimental farm from Wageningen University the Netherlands. Blue= water flow, Black= wastewater flow, Green= oxygen input, Yellow= heating, Red= processing
2.2.3 Aquaponic Systems

Aquaponic systems combine traditional aquaculture with the cultivation of plants in the wastewater (hydroponics), filtering the water by using up the available nutrients and reusing the water in the fish tanks (fig. 4). In essence, this is a type of recirculation aquaculture, with the significant difference that crop plants have taken over the mechanical/chemical filtration process. The benefit of aquaponic systems is that the additional fruits and vegetables produced can also be harvested and then marketed. In Europe aquaponic systems have only recently appeared in the aquaculture sector, although this method has ancient roots. The desire to increase the sustainability of RAS systems, increase economic gains and the European program for sustainable fisheries subsidies, has led to an increased number of aquaponic systems in Europe (Sustainaqua, 2012; FAO, 2010b; Graber and Junge, 2008). Studies have shown that aquaponic systems can provide both fish and vegetables grown in the same system and are suitable for human consumption. At the moment European aquaponic systems are still under development. Existing systems are often small scale and experimental. However, in Australia and Asia aquaponics have been applied on a commercial scale and proven profitable. Like RAS systems, Aquaponics still depend on a nutrient source from outside the system. The farmed fish need a balanced diet in order to maintain health and growth. This can for most species not be provided by the grown crop in the hydroponic part of a aquaponic system. Studies have shown additives of e.g. potassium to the systems are needed (Graber and Junge, 2008). Besides this, the ranges of species that can be farmed economically are mainly fresh and brackish water species. (FAO, 2010b).

Aquaponic system concept

Figure 4. Simplified Aquaponic system. Blue = water flow, Black = wastewater flow, Green = oxygen input, Yellow = heating, Red = processing
2.4 The present day situation of aquaculture in Sweden

Sweden has currently a small aquaculture industry where only a few species are farmed at a larger scale. The industry focuses almost entirely on the production of salmonid species namely: rainbow trout, Arctic char and salmon smolt. These species are either farmed for consumption or for fish stocking purposes. Besides those, another few species are farmed on and offshore in fresh and in salt water, including eel, perch, pike-perch mussels and crayfish. Apart from mussels which are farmed in coastal waters, most of the fish in Sweden is farmed in semi-closed cage systems in inland waters (Jordbruksverket, 2012; Ackefors, 2000). In the last two decades the Swedish aquaculture industry went through some significant changes. Many Swedish owned fish farms have been bought up or were merged with Norwegian, Icelandic and Finnish companies. According to the FAO (2013) this has been a way for Norway and Iceland to get access to the European market and its trade benefits. In return the Swedish aquaculture industry got better access to raw materials as fish fodder but also technology (FAO, 2011a).

For many years the Swedish production of food fish has been around 5000 tonnes/year (fig. 6). Despite the fact that the number of farms has declined with about 25%, the production has more than doubled over the past five years (fig. 6) (Berggren, 2007; SCA, 2013). Aquaculture is a growing industry in Sweden in particular in rural areas up north in Jämtland and Värmland, (see figure 5) where the already existing aquaculture industry is an important source for income. In 2011, it was estimated that 392 persons were directly employed by the Swedish aquaculture Sector (Jordbruksverket, 2013b; SCB, 2012; Berggren, 2007). Salmon and sea trout are no longer farmed for consumption in Sweden due competition from Norway. On the other hand the production of arctic char has increased (Jordbruksverket, 2006). In 2011 the Swedish aquaculture industry produced about 12,000 tonnes of food fish. The production of rainbow trout took up 90% of the annual production, followed by the production of Arctic char and European eel. Furthermore 1 470 tonnes of blue mussels were cultivated. Besides food fish many fish are reared for sport fishing or grown for fish (re)-stocking purposes. In 2011 1 065 tons of stock fish was produced and was made mainly by rainbow trout and crayfish. The same year the Swedish aquaculture industry had a turnover of SEK 405 million (SCB, 2012). Of all the food fish produced in 2011, almost 90% was exported (Jordbruksverket, 2013c). A large part of the Swedish production is exported to Finland but also to other counties; about 10% of the domestic production is consumed in Sweden. (SCB, 2012; Jordbruksverket, 2006).
Besides fish, mussel farming forms an important part of the Swedish aquaculture sector. Mussels are mainly farmed on the Swedish west coast where conditions are optimal. Mussels are filter feeders and take-up nutrients from the water. Therefore mussels help to improve water quality and in effect decrease eutrophication by taking up nutrients. Swedish research has shown that there is a potential to increase the mussels production along the Swedish coast. Since the domestic market for mussels is small and most of the production is already exported to other European counties, alternatives for an increased production have been suggested. One alternative suggested, is to produce mussels as a base for chicken feed or fish fodder. Boiled and dried mussel meat is high in protein and the shells are calcareous (Lindahl et al., 2005). Using mussels as a fodder in fish farming can be a way to be less dependent on traditional fodder made from wild caught fish. In Sweden there is also an increasing demand for fish fodder and agricultural fertilizer from organic sources (Dumitrescu, 2012). In recent years Swedish aquaculture has received more attention and projects are set up with the help of EU funding to give the aquaculture sector an impulse. EFF (European Fisheries Fund) is the main driver behind these developments.

**Figure 5. Modern large scale open cage fish farming in lake Ströms Vattudal, Jämtland Northern Sweden. (Photo: Erik Olofsson with permission)**

**Figure 6. Production of food fish year 1983-2011, mussels and hatchery fish (SCB, 2012).**
2.4.1 Recirculation aquaculture and aquaponics in Sweden

The aquaculture industry in the Nordic countries, except Norway, has been stagnant and has even declined in recent years (FAO, 2011b). RAS has increased in the Nordic countries compared to other aquaculture systems. In Sweden has RAS so far only played a very limited role with less than five operating food fish productions and slightly more RAS hatcheries, which produce juvenile fish for sports fishing and re-stocking purposes (SCB, 2011). One of the biggest RAS productions in Sweden today can be found in Helsingborg at Scandinavian Silver Eel AB. This company produces about 150 tonnes/year of European eel yearly using excess heat from nearby industries to heat their rearing tanks (Silvereel, 2013). Also a number of aquaponic systems have been set up in Sweden and are even fewer in number and seem not yet mature enough in order to speak of commercial productions which obtain a considerable market share. More or less successful productions seem feasible when exotic species are farmed for selected customers (Dalsgaard et al., 2013).

2.4.2 Aquaculture in Östergötland

As in many other parts of Sweden the aquaculture sector has declined where Östergötland is no exception. Östergötland is a relative densely populated province with three major Swedish cities: Linköping, Norrköping and Motala. These count for roughly half of the 450.000 inhabitants in the county (SCB, 2009). Despite its location on the Baltic Sea and its numerous lakes including lake Vättern the aquaculture sector in Östergötland is, compared to the rest of Sweden, extremely small. In 2011 only 15 tonnes of hatchery fish was produced by three farms and none of the two food fish farms in the county produced fish. This clearly indicates the insignificance of aquaculture industry in Östergötland (SCB, 2012). The five farms in Östergötland all use open cage systems and/or small dams in where the fish are kept mainly situated in the archipelago. At the moment no RAS exist in the county although this might change in the near future. Eutrophication of Östergötland’s lakes and in the Baltic Sea plays a major role in the decline of the local aquaculture industry (Hamilton, 2013).

2.5 Authority, policy and legislation regarding aquaculture in Sweden

Environmental protection, wastewater management and spatial planning are all responsibilities of the Swedish government. At a National level the government ministries most relevant to aquaculture and fisheries are the Ministry of the Environment (Miljödepartementet) and the Ministry for Rural Affairs (Landsbygdsdepartementet) where issues concerning fisheries are handled. The National Boards of Sweden also have responsibilities regarding environmental issues and spatial planning since they advice the national government and produce guidelines. At provincial level the County Administrative Board (Länstyrelsen) is responsible for aquaculture and give out permits to large productions where an Environmental Impact Assessment (EIA) is required. Finally municipalities handle permits for small scale productions that do not require an EIA. Besides that they are responsible for periodic assessments of aquaculture farms regarding environmental and animal health (see fig. 7).
In general the most influential government agencies regarding the Swedish aquaculture sector are the Swedish Environmental Protection Agency (SEPA), the Swedish Agency for Marine and Water Management, The Swedish Board of Agriculture and the Swedish Board of Housing, Building and Planning. The overall goal of these agencies is to achieve a sustainable community, together with the regional organizations have a responsibility to inform, consult and co-operate with the municipalities in different matters regarding aquaculture.

The Swedish parliament decided in 1999 on 15 national environmental quality objectives which are important to obtain sustainable development (SNG, 1999). A number of the objectives are relevant to water management issues and one of them especially mentions aquaculture:

“Land and water areas that are important for, commercial fishing or aquaculture shall, to the extent possible, be protected against measures that may significantly interfere with the operation of these industries” (SNG, 1999 p. 17).

Furthermore, the Act on the management of Natural Recourses (NRA) which came into force in 1987 states that land and water areas should be used for their purpose best suited, taking into account their nature and location as well as existing needs. It further states that priority should be given to uses that entail sound management. Although the act does not mention aquaculture directly, it does indicate special national interest areas including outdoor recreation, nature conservation and also areas for industrial development (NORCOAST, 1999). A second important act that is strongly linked to the NRA is the Planning and Building...
Act. The Act contains the regulations about the planning and building of land and water areas. One of the principles of the Act is that planning should promote the development of a balanced society with long-term sustainable living conditions for today’s and future generations. In Sweden the municipalities are responsible for the planning and use of both land and water areas. Every municipality should also have an up-to-date comprehensive plan that covers it entire jurisdiction including coastal areas where aquaculture activities might take place. The municipal plans also contain the intended purpose of land and water areas and economic activities such as fish farming. Although the comprehensive plans are advisory and not juridical binding, they have to be referred to in the making of plans or decisions in other laws connected to the NRA such as the Water Act (Jordbruksverket, 2012; Morf, 2006; NORCOAST, 1999).

An integrated approach to the management of fisheries is to a large extent demanded in Swedish legislation The Ministry of the Environment is the responsible body. Taking this into consideration, an integrated approach is already practiced in many plans and projects in all levels of government. Aquaculture has until 2011 been the responsibility of the Ministry of the Environment this is now chaired with the Ministry of Rural Affairs. Over the last few years, several projects have been started up by the Swedish government, local or international NGO’s or other interest groups (van der Blom and van der Werff, 2008). Furthermore, table 1 shows a series of application of acts that are important for Swedish coastal management and therefore influence the aquaculture sector. The economic zone and other zones (e.g. fishing zones) outside the territorial boundary (public water & economic zone) are regulated entirely at the central level – for fishing in the Fisheries Act. The national agencies, their regional offices, and the sector-specific agencies of the County Administrative Boards issue the permits for different types of use of coastal and inland waters (Morf, 2006; Svensktvattenbruk, 2013).

Table 1. National legislation regarding aquaculture in Sweden, Arrows indicate where the legislative Act has influence. (Based on, NORCOAST, 1999 p.9).

<table>
<thead>
<tr>
<th>Legislation</th>
<th>Land</th>
<th>Private Water</th>
<th>Public Water (3 mile Zone)</th>
<th>Economic Zone (12 mile zone)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NRA</td>
<td></td>
<td>(300 m offshore)</td>
<td></td>
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<tr>
<td>PBA</td>
<td></td>
<td></td>
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<tr>
<td>Nature Con. A</td>
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<td>Shore line reg.</td>
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<td>Cultural H. Act</td>
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<tr>
<td>Environ. Prot. A</td>
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<tr>
<td>Water Act</td>
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<tr>
<td>Mineral Act</td>
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<tr>
<td>Fisheries Act</td>
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</tr>
</tbody>
</table>
2.6 The Common Fisheries Policy

In 1995 Sweden joined the EU. Since then its resource management policies have been adapted to the Common Fisheries Policy (CFP). The CFP aims to achieve a thriving and sustainable European fishing industry. Co-financing of the fisheries sector is one of the tools of the CFP to achieve this. The European Fisheries Fund (EFF) 2007-2013 and future European Maritime and Fisheries Fund (EMFF) 2014-2020 co-finance palpable projects who work towards this aim (EC, 2013).

2.6.1 The European Fisheries Fund 2007-2013

The present EFF is set up by the European Union (EU) and part of the CFP. The EFF provides funding to the fishing industry and coastal communities to help them adapt to changing conditions within the sector and to become more economically resilient and ecologically sustainable (EC, 2013). For the period 2007-2013, 54.7 million euro out of the 4.3 billion euro in the EFF was allocated for Swedish projects (EFF, 2013). The funding is available for all sectors including aquaculture. Projects are funded on the basis of strategic plans and operational programmes drawn up by national governments. Each national authority should make a strategic plan in which they describe the long term view for their aquaculture and fisheries policy and explain how this will meet the CPF’s objectives. The plans must further explain priorities, objectives, public spending estimates and deadlines.

The EFF has five priority areas for funding (EC, 2013):

- Adjustment of the fleet
- Aquaculture, processing and marketing, and inland fishing (e.g. to support more environmentally friendly production methods)
- Measures of common interest (e.g. to improve product traceability)
- Sustainable development of fisheries areas
- Technical assistance to finance the administration of the fund

The second priority area for funding deals with aquaculture in particular. Funding for this sector is available for the diversification of the sector aiming to support the development of new aquaculture species and species with good market prospects. Besides that it funds environmentally-friendly aquaculture production, public and animal health measures, processing and marketing of aquaculture products and aquaculture education (EFF, 2009). In the last 5 years Swedish aquaculture has received more attention and projects are set up to give the aquaculture sector an impulse and are funded by the EFF. The Vegafish project is an example of an EFF funded project. Their mission is to develop cost efficient, safe, and environmentally sustainable processes for fish farming and selling of the resulting produce. The project is cooperation between Vegafish and the Swedish University of Agricultural Sciences (SLU). Recently Vegafish received a 500 thousand euro funding from the EFF (Vegafish, 2013).
2.6.2 The European Maritime and Fisheries Fund 2014-2020

Currently the EU and its member states are in the process of allocating their funding for a new fund stretching from 2014-2020. This new fund will replace the existing EFF and is named the EMFF. The EMFF will have the same intentions as the EFF namely transition to a sustainable European fisheries sector in addition special focus is given to RAS. The total budget for the fund is for the moment set on 6.5 billion euro. The new fund will be used to co-finance projects with member states and is based on the importance of the fisheries sector in each country. As in the EFF the EMFF funding is also depending on the willingness of each individual member state to allocate money for the sector. This means in practice that the EU finances 50% of the funding of approved project, the remaining 50% is paid by the national governments. Furthermore each member receives a share of the total budget based on the size of its fishing industry. Once each member state has drawn up an operational programme which specifies the intent of how the money will be spent, the EU commission approves each individual program after which decisions will be made by the national governments on actual funded projects (EC Europe 2013).

2.7 The European Regional Development Fund

In short the European Regional Development Fund (ERDF) aims to strengthen economic and social cohesion within the European Union by correcting imbalances between its regions. The ERDF gives direct financial support to companies to create employment. Besides that the fund supports infrastructures such as research and innovation, environment, energy and transport, has financial instruments to support local and regional development in order to support regional and local development and to promote cooperation between towns and regions (EC, 2013c). The ERDF can intervene in three objectives of regional policy:

- Convergence
- Regional competitiveness and employment
- European territorial cooperation

These three objectives all have a different focus. Convergence focuses on modernizing and diversifying economic structures while at the same time aims to safeguard and create sustainable jobs in different work fields including innovation and entrepreneurship, environment and research and technical development. The second objective, regional competitiveness and employment focuses on three priority areas namely innovation and knowledge based economies, environment and risk prevention and transportation and infrastructure. The third objective, European territorial cooperation focuses on cooperation and economy activities across borders, networking and exchange of experiences of local and regional authorities (EC, 2013c).

In Sweden the Agency for Economic and Regional Growth (Tillväxtverket) has the primary responsibility to strengthen regional development and to facilitate entrepreneurship nationwide. They are also responsible for the implementation of the two EU structural funds the ERDF and the European Social Fund (ESF). In the period 2007-2013 Sweden has received 15 billion SEK from the EU for the two funds combined. The Swedish government has identified four priority areas for funding; innovation and renewal, skill supply and improved workforce supply, accessibility, and cross border cooperation (Tillväxtverket,
The Swedish Board of Agriculture is also closely linked to the ERDF. The national Rural Development Program (RDP) led by the Swedish Board of Agriculture has roughly the same objectives as the ERDF and divides the funding it receives through the ERDF. However they focus on the development of the Swedish countryside promoting growth, competitiveness, entrepreneurship and employment. Since aquaculture productions are often found in remote rural areas and suffer multiple social, economical and environmental problems as described earlier the different programs and funds can play an important role in for Swedish aquaculture sector.

2.8 The Swedish aquaculture strategy 2012-2020

The Swedish board of Agriculture (Jordbruksverket), is the Government’s expert authority regarding agri-food policy, and is responsible for the agricultural and horticultural sectors. In 2012 Jordbruksverket presented an eight year strategy for the Swedish aquaculture sector, and will be followed in the end of 2013 by a more detailed action plan. The strategy has been developed in cooperation with the aquaculture industry, research institutes and NGO’s, and discuss how economic development, regional development, sustainable development and quality improvement can be achieved within the Swedish aquaculture sector. The strategy envisions a growing and sustainable aquaculture sector in 2020. According to the strategy, the challenge is to combine economic, ecological and social issues, which can be achieved though collaboration of industry, research institutes, government agencies, trade unions and policy makers. The strategy should be seen as a tool to achieve this and is therefore divided into three focus areas (Jordbruksverket, 2012):

- The economic future of aquaculture in Sweden
- Environmental and climate friendly products from Swedish lakes and seas
- Aquaculture as a driving force behind regional development.

The general aim of the strategy is to: “facilitate the realization of the vision of a growing and sustainable aquaculture industry which produces good and environmental friendly food with minimal ecological and climate impacts” (Jordbruksverket, 2012). According to Jordbruksverket the Swedish aquaculture sector can further develop into a green industry that will help to create jobs and growth in rural areas in Sweden. In order to realize the aim or vision of the strategy a number of specific targets are set (Jordbruksverket, 2012):

- “Increase production through improved competitiveness.
- Swedish aquaculture should produce good and healthy food, demanded by consumers both in Sweden and in rest of the world.
- Swedish aquaculture should produce stockfish for the sport fishing industry needs and conservation purposes.
- Swedish aquaculture should be characterized by the interaction between industry, researchers, NGOs and government
- Reduce bureaucracy and set clear rules and guidelines for the sector which in turn promotes the sectors development.
- Swedish aquaculture should be characterized by having as low as possible environmental impact.
- Swedish aquaculture should contribute to an ecologically, economically and socially sustainable food.
• New cultivation techniques should be developed together with cultivation of more species trail tested through cooperation between industry and research.
• Swedish aquaculture is characterized by prevention health promotion and healthy animals.
• Swedish aquaculture should have access to breeding material of high quality.
• Politicians at all levels and other stakeholders should perceive Swedish aquaculture as a safe, long-term and successful industry.
• Local politicians and other local stakeholders should promote and invest in Swedish aquaculture.
• A majority of the municipalities should identify and include suitable sites for aquaculture in its long term plans” (Jordbruksverket, 2012).
3 Theoretical framework

3.1 Sustainability

The terms sustainability and sustainable development are used in many different ways and connected to an array of issues. The flexibility of the terms is both positive and negative. Adams (2009) refers to sustainability as a buzzword that can be connected to everything. Universal use of a buzzword is unavoidable and causes a term to be free floating, without concrete referents. Furthermore, sustainability has been used by many interest groups in a broad context, which has resulted in different meanings of sustainability depending on the discussion and involved actors (Adams, 2009). According to Scoones (2007) sustainability has been used as a basis to establish networks, projects and in the construction of institutions and organizations. Moreover, sustainability is used in the debate over the human impact of climate change, whereas sustainable development is connected to a wide range of issues such as biodiversity. Sustainable development is defined in different ways. The definition for sustainable development from the Brundtland commission’s report Our Common Future (1987) is most commonly used and defined as: “A development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Brundtland Commission, 1987). Although the above motioned critiques on the concept of sustainability need to be addressed aiming for sustainable development of an industry can help to make it more resilient to stresses, disturbances and unexpected changes (Berggren, 2007). Berggren (2007) further explains that sustainability in the aquaculture sector in general is needed in order to regain a positive image of the sector, to address environmental problems such as eutrophication.

Summarizing it can be stated that the concept of sustainability is used in many different ways and is embraced by many organizations and institutions. The broad applicability of the concept can also lead to confusion which weakens it. According to Berggren (2007) there is no clear definition of sustainable aquaculture and therefore it is subjected to many different interpretations. Different aquaculture projects that are more or less sustainable today (production of fish for environmental restocking projects) might not be in the future (Due to genetic degradation of wild species). From an international perspective aquaculture is sometimes regarded as a more sustainable way of food production. At the same time there are issues regarding unsustainable feed sources used to produce food fish (Badiola et al., 2012). The ASC therefore does not use the term sustainable aquaculture but instead responsible aquaculture. The ASC also believes that consumers understand the term responsible better than sustainable (ASC, 2013). However the term sustainability is a well know term and useful to give direction in this thesis.

3.2 Three pillars of sustainability

Sustainable development has been a term used since the 1980s where the Bruntland report gave direction to include the whole global solutions. It was completed in 2002 by the World Summit on Sustainable Development, where the three pillars of sustainability (social, economical and environmental) were addressed. Afterwards the term, followed by the pillars, has been widely used and a common quoted definition. Moldan et al. (2012) mean that since it is so well-known, it might be taken just as common sense. Hansmann et al. (2012) explains that the three pillars reflect a responsible development, where natural, human and economical aspects need to be considered. It is also mentioned that it is impossible to give advantage to
one pillar because they are not adequate on their own. On the other hand this has been criticized because they include different types of values which are not comparable to each other (Hansmann et al., 2012). In addition the interest of stakeholders mentioned as creating conflicts with one pillar, can lead to a focus on just one pillar instead of three. In aquaculture the three pillars of sustainability are relevant because aquaculture affects environmental, economical and social issues (FAO, 2011a). Aquaculture and sustainability can go hand in hand when approached in the right way but only when the focus lies on gaining both environmental, social and economical sustainability and not just on one of its pillars. In this thesis the tree pillars are all addressed in order to get a holistic view of the Swedish aquaculture sector.
4 Methods

In this section of the thesis the focus lies on the research methods that were used in order to gather the empirical data for the study. This chapter will describe the used methods and how they contribute to answering the research questions.

4.1 Scientific approach

For my research a qualitative approach is most useful since qualitative research focuses on qualities, perspectives, experiences and the meaning of things. This type of approach is often used when for example the opinion of people about a certain product, service or an experience is of importance (Bryman, 2012). Furthermore Darlington and Scott (2002) argue that qualitative methods are suitable and preferable when investigating questions in human services, and also when the complexities of human actions need to be interpreted and analyzed. The core of the qualitative research method is by Darlington and Scott (2002) referred to as three different research methods: “In-depth interviewing of individuals and small groups, systematic observation of behavior and analysis of documentary data” (p.2). The focus is on collecting information and analysis resulting in in-depth data, which is the aim in this study (Baarda and de Goede, 2006; Murray and Hughes, 2008). The main weakness is that the data produced can be hard to generalize and reproduce. The opinion of one person does not necessarily represent a larger group. Furthermore data collection and analysis are time consuming and can be influenced by the researchers own biases and tendencies (Berg, 2004; Bryman 2012).

4.2 Data gathering

In order to get the necessary data four types of data gathering were used. I conducted at literature research, a document analysis, interviews and to some extend participation and observation. These will be described in this section.

4.2.1 Literature review

In order to be well informed and to fully understand the background of the problem a literature study was done. A literature review also has as purpose to show how a study contributes to existing research and fills knowledge gaps (Bryman, 2012). I reviewed literature on aquaculture and fisheries from renowned organizations and institutes, as well as from scientific articles to get state-of-the-art knowledge about aquaculture such as Martins (2005, 2010), Badiola et al. (2012), Dalsgaard (2013).

4.2.2 Document analysis

Document analyses are often used to support and complement evidence from other sources, to verify made statements, places and names of key person mentioned in interviews (Yin, 2009). Furthermore companies often produce documentation and information to inform, influence or direct the general public. Therefore it is important to understand and to keep in mind that documents made public might not tell the whole story. By being aware of this the researcher is less likely to be deceived (Yin, 2009). I looked at documents from national and
international organizations including the FAO and WHO. Furthermore, I used policy documents from the Swedish national government and boards. I also reviewed international and national aquaculture and fisheries policy documents including the CFP, EFF, EMFF, ERDF, the Swedish environmental code and documents from the Swedish Environmental Protection Agency.

4.2.3 Participation and observation

I participated in and observed three different stakeholder meetings (details are given in section 4.5). All the meetings I attended had different aims but were held in the light of aquaculture and regional development, further described in 4.7. Another way of getting to know the “field” was by making telephone calls to seven different municipalities in Östergötland. I did this to get a quick overview of potential informants and to gain knowledge on how many people are actually working with aquaculture at municipal level in Östergötland.

4.2.4 Interviews

I used semi-standardized in-depth interviewing which is the most common method for data collection in qualitative research (Darlington and Scott, 2002). The advantages are that the both the interviewer and interviewee are able to clarify what the other means, and above all it is useful when the phenomena under investigation cannot be directly observed. Therefore it is argued to be a good way to find out how people think and feel in relation to a specific topic, which was the aim of this study. Moreover, is the opportunity to observe expressions, body language and (dis)satisfaction towards specific sensitive issues of the informants given (Berg, 2004). Additionally the flexibility in the interviews gave me the possibility to find out more about possible conflicts and the root of them. An important constraining factor argued by Kvale (1996) is that the results of an interview might be influenced by the pre-knowledge and vision of the study from the interviewee. Additionally the interviewer can unintentionally influence the informant by leading and supplementary questions.

4.3 Interview implementation

I started out with an internet search for fish farms in Östergötland and south-eastern Sweden. I contacted the ones which had a website, since it in my opinion shows a certain level of professionalism and I felt more comfortable contacting them. I selected and contacted six farms, from whom I did not receive any response to my requests for an interview.

By coincidence I came across a news item about an EU financed aquaculture project, Baltic Eco Mussel (BEM), on the local news channel. A two-day meeting was organized in Linköping by the East Sweden Energy Office (ESEO), through where I made contacts and was invited to the meeting. The meeting was held in early March and several key persons representing the Swedish government, research institutes and fish farmers involved in Baltic region aquaculture attended. At the meeting I made appointments with three informants whom I subsequently interviewed that same month (see appendix 1). After these first contacts a snowball sampling was used, which is described by Berg (2004) as a good way to locate subjects with certain attitudes and necessary characteristics in a study. This strategy is also often used when interviewing different groups of actors and stakeholders on different topics,
which is necessary for my study (Berg 2004; Kay and Alder 2005). During my interviews I asked if the informant could mention any specific person(s) suitable for interviewing regarding aquaculture. If I on multiple occasions heard the same name of key persons, I later contacted them for interviews.

I developed an interview script with thematically divided questions as described by Kvale and Brinkmann (2009). In the interview process was an introduction held to each topic. In the end of the interviews was a debriefing held and a short evaluation of the interview, for my own reflection. The interviews were held in English and preformed face-to-face, except for one which was done through telephone. Before the interview I send an explanatory email about my research to the informants. The interviews where held between the 18 of March and 10 of April 2013 and the time stretched between 45 and 75 minutes. In agreement with the informants were the interviews recorded, in order to be able to quote the interviews, and afterwards transcribed word-by-word. The transcriptions include indications of long and short pauses in spoken answers, laughing and conversational expressions such as haha and uhm. Questions that where repeated by myself or the interviewee were not transcribed. After the transcription, I conducted a thematic analysis of the material which can be read in the discussion in Chapter 6. It is also important to take into consideration that the informant’s answers to interview questions not necessarily reflect the opinion of the broader company or organization. This can sometimes be unclear for the interviewer.

4.3.1 Informants

I relied as mentioned on snowball sampling and my access to the BEM meeting for my informants. I wanted to gain as many different perspectives from different informants as possible and therefore my only criterion was that all informants had to have a professional relation to aquaculture. Because it is important to get real experiences from people who work with aquaculture on a daily basis (Bryman 2012), I included fish farmers as my informants. For practical reasons I decided to refer to my informants with an individual number assigned to each informant as is show in the list below.

<table>
<thead>
<tr>
<th>Table 2, List of informants</th>
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</thead>
<tbody>
<tr>
<td><strong>Name in thesis</strong></td>
</tr>
<tr>
<td>Informant 1</td>
</tr>
<tr>
<td>Informant 2</td>
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<tr>
<td>Informant 3</td>
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<td>Informant 4</td>
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<td>Informant 5</td>
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<tr>
<td>Informant 6</td>
</tr>
<tr>
<td>Informant 7</td>
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</tbody>
</table>
4.3.2 Ethical considerations

Ethical considerations must be made in the process of interviewing and transcribing interviews (Kvale, 1996). I followed the guidelines as stated in the ethical code of the Swedish Research Council for humanities and social sciences (Codex, 2013). The ethical considerations made primarily relate to the interview situations. This practically means that at the start of my interviews I informed the informants about their rights as an interviewee to stop the interview at any time, the possibility to be an anonymous informant or company in the thesis report and if I could record the interview for transcribing purposes.

4.4 Analysis of results implementation

I choose to do a thematic analysis of my results according to Berg (2006) and Oppenheim (1992). Berg (2006) explains that it is a good way to be able to analyze data in multiple transcriptions. Further on it is also needed to be able to relate them to particular themes and observed patterns. After analyzing each of the interviews, I compared and contrasted thematic finding of the interviews. I interviewed seven persons, five of my informants work mainly within different governmental levels with aquaculture fulltime or as a part of their job. Their work includes policy making, environmental law /regulations and enforcement, promoting aquaculture, governmental support, regional/ rural development. Three of my informants are (fish) farmers.

4.5 Participant observation implementation

I participated in three aquaculture related meetings, they gave me the opportunity to make contacts and to analyses the field and the important plays in the Swedish aquaculture sector. It also gave the chance to gain information through informal conversation with participants. The three meetings are here shortly described below.

4.5.1 Baltic Eco Mussel stakeholder meeting

I attended the BEM stakeholder meeting which was part of the Central Baltic Interreg IV A Programme 2007-2013. The meeting was held at the 12th and 13th of March 2013 in Linköping organized by the East Sweden Energy Office (ESEO). The first day had as purpose to inform different stakeholders involved in the BEM project on the current state of different aquaculture and regional development projects. Different projects were presented and discussed. This included different Baltic Sea mussel farming projects and the Swedish aquaculture Strategy 2012-2020. Besides this several speakers ranging from authority representatives to researchers gave their view on the current status of the Swedish aquaculture sector. On the Second day the participants were invited to join workshops were the future aquaculture and the BEM were discussed.
4.5.2 Swedish Aquaculture Association annual meeting

I attended the annual meeting of the Swedish Aquaculture Association. The association brings together fish producers from Sweden and shares information regarding aquaculture with its members (Vattenbrukarna, 2013). I found out about this meeting through their website. I was welcome to their two day meeting where normally only members are allowed. The meeting was held on the 26th and 27th of March 2013 in Örebro. The meeting involved a number of presentations and discussion regarding the future possibilities and threat to and for the Swedish aquaculture sector. The meeting and most of the presentations were held in Swedish, which meant that I probably missed some information. However during the breaks and lunch I did get the opportunity to talk with some fish farmers and a board member of the association. Those opportunities gave me valuable insight information to my research.

4.5.3 Future of fish farming in Östergötland seminar

The seminar was held in Linköping on the 18th of April 2013. I was invited to this meeting by the county administrative board of Östergötland. Here the consultancy firm AquaBioTech Group presented a report commissioned by the Kustlandet partnership. AquaBioTech investigated the economical possibilities for small-scale RAS farms in Southern Sweden. Their research was a very interesting complement to my own research. At this meeting I also met other fish farmers from which I gained information.

4.6 Limitations

One limitation is that my aim only focuses on Östergötland and south-eastern Sweden, while more farms can be found in the northern parts. Additional is the Swedish aquaculture sector small where everybody seems to know each other and only few people working with it. For me was this positive, since it was easy to get to know the field and establish a network. My informants had mostly a positive attitude towards aquaculture but did however mention also negative sides of the industry. It would have been interesting to interview people who are known to be skeptic about aquaculture in order to prevent an over positive view of Swedish
aquaculture. Furthermore I would have interviewed Anders Kiesling professor at SLU who is an aquaculture expert and researches new possibilities in making fish feed more sustainable, however due to time constrains this was not possible. One methodological limitation can be that I performed mostly face-to-face interviews. The informants can feel uncomfortable when confronted with certain questions and therefore talk less freely (Kvale, 1996). Also the setting and intonation of questioning can be a limiting factor as well as that it can be hard for informants to communicate their answers, informants understand questions in different ways. This should be taken into account in the analysis (Kvale 1996). The snowball sampling method can also have limited my results since my initial informants where found through the BEM stakeholder meeting.
5 Results

In this chapter the results of my interviews will be described. For readability I will refer to my informants by their number assigned as in table 2 for example #2 is informant 2. Stated questions will be refer to as Q1 = question one. First of all I will present my results according to the three main themes used in the interviews. In 5.4 specific threats and opportunities for Östergötland are described. It should be noticed that not all threats and opportunities brought forward necessarily belong to only one specific theme. Therefore certain subjects are presented in more than one theme from another perspective. In 5.5 is the future vision of the informants for the Swedish aquaculture sector given.

5.1 Introduction to the results

In Q3 and follow up Q4 I asked my informants about their views on the aquaculture sector in Sweden at present. Although not everyone could answer the questions, four informants agreed that the sector is in an undesirable state at the moment and that improvements should and could be made. They did not agree on how and where improvements should be made. #4 mentioned that it is important to strengthen and further develop the recently established regional aquaculture centres and further mentioned that Östsam (Östergötland’s regional council) should lead this development. The individual aquaculture centres, in Sweden, North, West and East should also work more together to get more influential power. #6 mentioned that the first thing we need to tackle is the challenge in finding suitable locations for aquaculture throughout Sweden with the help of spatial planning tools. #3 brought up the importance of governments tacking aquaculture and farmers seriously and recognizing it as a sustainable way of food production. #3 also referred to the importance of the new aquaculture strategy and the upcoming aquaculture action plan as a major step in bringing back aquaculture to the spotlight.

I then asked my informants about why and how the sector is in the state as it is and why aquaculture has not developed earlier in Sweden (Q5). #5 and #7 did not answer this question. However, the other informants all gave an historic explanation to this. #3, #6 and #4 indicated that they feel that aquaculture got a negative reputation among consumers and politicians starting somewhere in the mid 80’s and early 90’s. #3 mentioned that aquaculture was seen as a novelty in the early 1980’s and early 90’s. #3 mentioned that aquaculture was seen as a novelty in the early 1980’s and early 90’s. #3 brought up the importance of governments tacking aquaculture and farmers seriously and recognizing it as a new opportunity to make money which drew many farmers to the scene who had no or little knowledge about aquaculture and its environmental consequences on the local natural environment. Over feeding (because of low grade feed) of fish in open cage systems resulted in nutrient leakage and local eutrophication problems. The negative environmental impacts of aquaculture resulted in critical governments, consumers and investors towards aquaculture. This made it harder to get environmental permits, market their products and get financing. This negative view of the sector is still something Swedish framers struggle with today. During that same time, according to #6, Swedish framers were faced with fierce unexpected competition from the Norwegian aquaculture sector. The Swedish farmers were outcompeted by the Norwegians for several reasons. The main reasons are that the Swedish farms were small scale, family owned and had very weak business plans. Market prices below production costs and mutual competition combined with the other problems “killed Swedish fish farming” (#6).
The role and approach to aquaculture of the government at that time was also pointed out by several informants. The Swedish Board for Fisheries (Fiskerieverket, today Havs- och Vattenmyndigheten) was the responsible government body for aquaculture. The Fisheries Board did not pay much interest to aquaculture which affected the other levels of government as well. “The Swedish government never thought aquaculture /.../ would be an important sector” (#4).

5.1 Social threats and opportunities

5.1.1 Regional and rural development

When asked about if and how aquaculture can contribute to regional development (Q9) all informants agreed that aquaculture can play an important social role. Several opportunities and threats are mentioned. The loss of jobs, closing of schools and other community services in rural areas is of concern to most of the informants. Young people are moving away from the rural areas and fish farming might not been seen as a good future career because of the negative image it has locally according to #5. However, “Aquaculture would contribute to employment in rural communities that is the most important of all” (#6). The many side effects of creating businesses in rural areas are that you not only create jobs on the farm itself, but throughout the whole supply chain, such as construction and maintenance, transportation and slaughter. The development of fish farming could thus have positive effects on an entire rural community. Although none of the informants can give any specific numbers or set targets of people that should benefit from this development or companies that should be set up there are already efforts made in Sweden to develop its countryside more. Swedish land use development plans and municipal comprehensive plans aim to make people want to live in rural areas (#3). However #7 warned that we should not rush the aquaculture sector development as a solution for rural development problems. “Developing aquaculture in rural areas will take time and structured steps should be taken to achieve this, in the long term [2020] it [aquaculture] could be an exciting industry” (#7).

5.1.2 Spatial planning and municipal comprehensive plans

The Swedish national aquaculture strategy will be followed up by the end this year by a more concrete aquaculture action plan (#3). The strategy aims to make municipalities take up aquaculture as part of their municipal comprehensive plans. The action plan is more detailed and can therefore possibly encounter some negative opposition from actors and stakeholders. One way mentioned, by #3, to avoid this is to inform municipalities at an early stage and show them that they can benefit from aquaculture.

“We [Jordbruksverket] advised to the national government that municipalities should include aquaculture in their spatial planning, rural development plans and comprehensive plans. Of course we can’t force the municipalities to do that but we want to make them aware of this opportunity for regional development” (#3).

People living in areas where aquaculture could be developed should also be informed by the municipalities. On the west coast expansion of mussel farm operations in the coastal zone has already lead to conflicts of interests with the tourism and recreation sector according to #3 and #6. #3 continued and mentioned that many people are generally positive about aquaculture developments, but NIMBY (Not In My Back Yard) often applies when actual
developments are made. “People living in those areas have to be aware that there are going to be fish farms” and “Sometimes you can’t have both in a certain area so you have to make a plan!” (#3). #4 explained that municipalities should have included aquaculture in their plans earlier, however this was not done because of lack of interest at municipal level in aquaculture. “They never wanted those types of aquaculture [open cage farming] therefore they haven’t made plans, I think it is important to that they are forced to do this “(#4). #5 said a municipal official did not think that the municipality (Norrköping) was working to put aquaculture in their comprehensive plans. The informant continued and explained that suitable locations for farms have to comply with the Swedish environmental code. Furthermore it is evaluated if aquaculture activities could disturb local inhabitants. According to #7 the first steps were taken to inform local politicians about the importance of including aquaculture in their comprehensive plans. Subsequently those politicians should take that message to their subordinates, #7 explained.

5.1.3 Knowledge and education

The importance of having adequate knowledge when it comes to aquaculture was brought up by all informants and was specifically asked about in interviews with fish farmers. Several areas were identified by the informants, where there is a lack of knowledge or education in the aquaculture sector. Efforts were made at a national level by the Ministry of Agriculture to give the Swedish aquaculture sector a quality impulse. Extra money (about 12 million SEK) was made available to the Swedish Board of Agriculture to promote aquaculture according to #6. The Swedish board of agriculture also recruited extra personal to work with aquaculture questions (#3). At a provincial level, the county administrative board is responsible for environmental impact assessments and permits for productions that use more than 40 tonnes of fish feed annually. #4 works at the County Administrative board of Östergötland and admitted that there is the only employee working full time with aquaculture questions and that it is just part of the job. This is because aquaculture became a very small industry in the county of Östergötland. At municipal level the knowledge at hand strongly depends on the presence of aquaculture activities within the municipal boundaries. #5 said “since we only have one farm, it is not a big part of my work and I follow it as much as I do with other industries”. The informant further explained that specific knowledge regarding aquaculture therefore can be lost, but the legal environmental framework for aquaculture industries is the same as for other industries that impact the environment.

From a practical point of view there is also a need for more knowledge and education, where #1 and #2 pointed out that in order to be a successful fish farmer you need at least basic farming skills. They felt that being a farmer themselves gives them an advantage over new comers to the business. This is also mentioned by #4 who explained that there is an interest from persons who want to start an aquaculture business. They often have no experience farming fish.

“it is sad that I can’t tell them ‘go to this place and learn about it’. It would be nice to say to those people you can go and take a course at the university but we don’t have that. We need to develop some type of education for all these people to answer their questions” (#4).

Besides university education another way of transferring knowledge to potential new fish farms is by experimental farms. Several informants mentioned that it is important to start up example farms with government support in order to show the benefits of (RAS) aquaculture
to other fish farmers, farmers who want to change business (for instance from pig to fish), potential new farmers, investors and banks, consumers and the general public. It is mentioned that by doing this aquaculture will receive positive attention and give the sector an opportunity to get rid of negative prejudices regarding aquaculture (#3,#4,#6,#7). Having adequate knowledge is seen as most important. #1 and #2 advice to learn as much as possible before starting a fish farm, and to “get some practical experience first for a few years by working at another fish farm” (#2).

5.2 Economical threats and opportunities

5.2.1 Financing, investments and insurance

Financing aquaculture developments, investments by banks and getting aquaculture business insured pose a significant threat to the sector. This is related to the negative image aquaculture in Sweden has today. Starting a fully operating fish farm costs millions of SEK, and it takes several years to get the initial investments back (#2,#6). #2 mentioned that the cost of their hatchery alone is 1 million SEK. Other farmers talked about a 60 million SEK investment for a 600 tonnes production farm yet to be built (Björk, 2013). All informants acknowledge that RAS aquaculture is by far the most expensive form of aquaculture regarded by initial investment. However, other types of aquaculture are also mentioned as costly. Financing proves very difficult for farmers, the main reason for this is that the banks are afraid to invest because of a lack of knowledge “they don’t know anything about it” (#2) and

“I have spoken with Nordea and Swedbank and asked them why they give investment and insurance to a lot of Norwegian [fish] farming but not in Sweden how come? And they just had not really thought of it! And it seems that they don’t really communicate with each other” (#3).

Banks do also not want to be associated with the negative image that aquaculture still has according to several informants. Besides money insurance companies are reluctant to work with these companies because of the risks involved. Furthermore insurance companies refuse to insure livestock. A solution to the above mentioned problems is not directly brought up by any informant. However, they do mention having a good business plan, multiple sources of financing, have some sort of security for the bank and having buyers for your fish before you start farming can help to raise the money needed. “We want investors to see aquaculture as a profitable sector and that they invest” (#3).

5.2.2 European Maritime Fisheries Fund 2014-2020

Many of the informants hope and think that the new EMFF 2014-2020, that will replace the current EFF 2007-2013, makes more money available for aquaculture funding. The EMFF is part of the CFP of the European Union. Aquaculture projects can apply for financing from the EMFF and up to 40% of the initial investment cost can be paid for by the fund. The amount of money available in the fund for Swedish projects depends on the Swedish national government. Half of the money in a counties fund has to be paid for by the national government. This is both a threat and an opportunity informants said. The more the Swedish government acknowledges the importance of aquaculture for Sweden the more money most likely will be made available and vice versa. For the moment the national government has not given any concrete numbers on the amount of money for the EMFF. This worries some of the
informants. Several informants are working hard to get the government to see the potential in aquaculture (#6, #3, #7). Farmers see the upcoming EMFF as an opportunity “You can have up to 40% paid for the equipment. It’s a sign you know! Governments want more aquaculture in Sweden and in Europe” (#1). Another farmer commented that “Getting 40% for your investment from the EU only, that shows how important it is. It’s incredible. If we don’t start farming now we will regret it” (#2).

5.2.3 Markets and price fluctuations

In the past price fluctuations have caused many fish farmers to go bankrupt (#6). This is still a problem although the few fish farms left in Sweden are mostly no longer individually owned farms. They are either owned by foreign companies or part of some kind of cooperation (#3, #6). This has given some economical security for these farms (#3, #6). In Sweden there is a market for fresh Swedish farmed or wild caught fish. There is also a European market for Swedish farm and wild caught fish (#2, #6). According to some of the informants it can be a challenge to access the right market for farmed fish “Somebody must eat the fish and mussels produced, so market knowledge is important” (#7). The bigger Swedish farms found up north mainly export their fish (#6). As a farmer is it important to establish a solid network of buyers for your fish. It is also mentioned that selling fish filets instead of whole fish can give a higher price. The interviewed fish farmers all said the reason they had chosen the fish they farm, which are Percidae (family of perch like fish) is because they get a higher market price. Prices used in calculations for their business models lay around 60 SEK/kilo for whole fish (#2). Moreover, farmers were of opinion that their farmed species could serve a niche market. One of the farmers already sold fish to high end Stockholm restaurants. Other species were considered to be farmed as well such as Rainbow trout and tilapia. However, price fluctuations, low market prices and foreign competition are seen as a potential threat (#1, #2). There are also potential threats to farm fish species which are relatively new to the aquaculture. From a market perspective farmers have to deal with uncertain markets and consumers and wholesalers, who are not familiar with the species. #6 summarized that

“Today it’s not economically viable to farm perch or pike-perch, I mean it’s impossible! The farming cost and the feed cost will eat you up, and I haven’t seen any figures about perch and pike-perch farms and if they make any money at all, I don’t think so.”

5.2.4 Feed

The cost of feed is one of the major running costs in a modern fish farm. It is also regarded, by the informants, as the biggest challenge to establish a sustainable fish farm from an environmental and economic perspective. From an economic point of view there are some threats mentioned that applies to any fish farm. First of all, developing the right food for the species farmed can be difficult. This since every species has its own nutritional needs. Creating a species specific feed can take decades, where for salmon this has taken almost 40 years (#1). Because of this farmers often depend on a limited number of feed suppliers. (#1) also mentioned that feeds are used developed for other species A possible opportunity is the use of fish meal made from mussel meat. Mussels are easy to farm and abundant in Sweden. Although research in this field is making steps forward, feed companies cannot produce mussel meal cheaper than fish meal. It was also stated that lately many feed companies have
been bought up by Chinese investors (#3, #6). Besides this, feed prices have risen steadily and are also closely linked to the oil prices.

5.2.5 Global competition and Nordic investments

On a global scale Swedish farmers have to compete with foreign markets and import of cheap alternatives such as tilapia (#2). However, the Swedish sector should focus more on niche market with high end sustainably produced fish, according to some informants. Others said that Sweden should focus more on conventional species such as Rainbow trout, Arctic char and mussels (#3, #4, #6). Those species are easier to market and known to the consumer. Sweden is at present reinventing and restructuring its aquaculture sector and should be careful not to be overambitious.

Sweden has seen increasing investments from foreign companies generally from the Nordic region, however none of the informants had any data about this. Norwegian and Finnish companies have invested in Swedish owned business because of two main reasons (#6). The Norwegians mainly invest in Sweden to get a better connection to the European market, since Sweden is an EU member. Besides this Norwegian environmental laws make it impossible to farm certain profitable aquaculture species (such as Arctic char) in their own waters (#3, #6). For the Finnish companies is the main reason that they have small possibilities to expand their industries, since they face Baltic eutrophication problems. Investments from Finland and Norway mainly concentrate to the North and North east coast of Sweden (#3).

5.2.6 Swedish national and regional aquaculture centers

The establishment of the Swedish Centre for Aquaculture, initiated by Gothenburg University and the Swedish university of agricultural sciences, is seen as a positive development by the informants. In addition three region specific aquaculture centers were set up: aquaculture center north, west and east. According to the informants the centers can help to promote aquaculture in a positive way among the general public. They also serve as a platform for innovation and knowledge exchange, and help to further develop aquaculture on a regional level (#3, #4, #6, #7). They are therefore, an opportunity for the Swedish aquaculture sector.

5.2.7 Research and development

With the informants was it discussed how research and development (R&D) can contribute to the development of the aquaculture sector and the opportunities of technological R&D. Especially RAS is constantly developing, it leans heavily on technological advances made that improve the technologies. Some informants recognized this and opted for more technological cooperation with Denmark, Finland and Norway where RAS has developed much more. It was mentioned that RAS is new to the Swedish sector and has not reached its full potential in Sweden (#3, #6). #4 mentioned that there is just no interest in RAS in Sweden yet, but that it will come.

The informants also thought that Denmark can play an important role in helping Sweden to develop their RAS sector. “I mean the Danish have the technique, I don’t know why we can’t just import that together with their knowledge?” (#3) and “I have heard that in Denmark the knowledge about RAS is very good, why reinvent the wheel!” (#7). # 6 said:
“It would be good if some Danish would move up to Östergötland and start a RAS, because they have the skills and knowhow. Like in Northern Sweden there are a lot of Norwegians who own aquaculture companies there”

The farmers explained that they went abroad to gain knowledge, to buy farming equipment and to see large scale RAS farms in operation, something not yet possible in Sweden. Besides importing knowledge and technology from abroad the informants thought that Swedish Universities in cooperation with the government should play a leading role in developing new aquaculture techniques.

5.2.8 Government and aquaculture

Since 2009 the Swedish government has made a number of important changes regarding aquaculture. One of these was to give the Swedish board of agriculture the responsibility over aquaculture, since it before was part of the fisheries board. All informants find that this change has been a good decision. They thought that aquaculture is part of food production and therefore belongs under the responsibily of the board of agriculture (#3, #4, #6). It also makes it easier for farmers since they only have to deal with one national authority. Furthermore, all informants felt that aquaculture is a hot topic at the moment and that the government, especially the board of agriculture, is very engaged in promoting the sector and develops it further. The presentation of the new aquaculture strategy (2012) by the agricultural board has also been seen as positive. However, some informants also mentioned that the board of agriculture still has to prove itself. Another interesting development is the aquaculture action plan that will be published this year. Especially the farmers are very curious to what this will mean for them and their businesses.

5.2.9 Permits

Fish farms need several permits for their operations. They depend on the County Administrative Board and local municipalities to grant them the permits. According to several informants lack of knowledge, bureaucracy and negative view on aquaculture contribute to long waiting times for a permit or an environmental impact assessment. This causes uncertainties for farmers. Farmers often rely on contact person in charge of aquaculture at municipal and provincial level. When such a key person is lost, knowledge and experience on specific cases is also lost. An important threat pointed out is that many municipalities and county boards have no longer specific persons working with aquaculture, this because of the diminishing sector.

5.3 Environmental threats and opportunities

5.3.1 Eutrophication

Eutrophication of the Baltic Sea and its negative consequences on the environment is thought to be the main reason for the negative image of open-cage fish farming in Sweden. This has also contributed to the decline of the sector. Even today this affects fish farmers in several ways. According to #4, #7 and #3 politicians and government official at regional and municipal level are still very negative about aquaculture practices, because of the eutrophication problems in the past. This result in a negative local environment, to start up a
new farm, and little attention is given to the different possible opportunities of fish farming for local municipalities. The eutrophication of the Baltic Sea also causes unrest among local residents, where #5 mentioned that they fear that fish farms cause extra eutrophication and other disturbances e.g. noise and birds. This is seen as a threat to their property value and residential area. This is reinforced by the fact that many coastal properties are often summer houses where people come to relax. #6 pointed out that recent application of permits, for large scale in land farming operation in northern Sweden, has caused controversy among local residents. They are afraid that these new farms will cause environmental degradation, including eutrophication of their lakes. RAS operations, which are known to be highly controllable, also suffer from this. #7 exemplified from a plan for a RAS farm in the south east of Sweden. Strict environmental regulations, complaints by local residents and negative local politicians, slowed down the permit and EIA process. It took 5 years before the entrepreneur finally gave up “They ‘killed’ the entrepreneurship” (#7). The informant added that this is the reason why it is important to send out the right information about the different social, economical and environmental impacts of a fish farm.

5.3.2 Local food

One of the advantages of RAS is that you can start it anywhere as long as you have some kind of water source. In Sweden this is not a problem and therefore a RAS system can even be build in the city “With RAS we can produce fish just outside the town” (#4). The benefits of local food production were brought up by #4, #5 and #6. According to the informants it makes RAS a preferred way of fish farming over other types of fish farming. They mentioned fresher products, less transportation and better control, besides that the idea of farming fish in the city is appealing. #4 mentioned that it could also be a good way to teach people about sustainable fish farming and local food.

5.3.3 Organic fish and eco-labeling

With the informants it was discussed if they thought organic fish production and eco labeling the produces is an opportunity for the Swedish aquaculture sector. The informants identified several factors that this depends on. First of all, several informants thought that the Swedish sector should mature before the additional challenges of organic fish production are taken on. It was recognized that RAS is the best way to eventually start with organic fish farming. Organic fish farming depends on an organic feed source which is expensive and hard to obtain. Besides it is only available for certain species (#1 #2, #6). The farmers indicated that they would prefer to use an organic feed alternative if available (#1, #2). #3 added that it is important that the general public accepts that fish already is the most environmental friendly way of terrestrial food production. The eco-labeling is said to be not a viable option, but mentioned that it will eventually (#2). The newly formed ASC (2013) could be a good option for Swedish farmers (#6). #2 said that this it still too expensive to carry on their products and they have therefore decided not to do this now. However, the farm equipment chosen for their production already meets the ASC requirements.

5.3.4 Breeding programs

The development of breeding programs, which aim to domesticate certain economic interesting species, deserves more attention. #1 and #6 explained that domestication of fish to
be able to farm it successfully can take up to 15 years. Carnivorous behavior, growth differences between males and females, pre mature spawning and death of fish are some of the challenges that need to be solved before a species can be farmed. # 6 said that the state should fund new breeding programs since they already fund Rainbow trout and White fish breeding programs.

5.4 Threats and opportunities for Östergötland

5.4.1 Aquaculture and rural development in Östergötland

Aquaculture can be a driver for regional development as explained in 5.1.1. According to #1, #2, #4 and #7 aquaculture can in this perspective especially be applicable to the coastal region of Östergötland The informants mentioned that the archipelago of Östergötland has seen many social, economical and environmental problems. They also said that aquaculture, as a form of fisheries farming, fits to the character of the Östergötland coastal zone and its long tradition of fishing. The informants felt that other regions within Östergötland would benefit less from aquaculture. #2 and #4 mentioned that the economic triangle Linköping, Norrköping and Motala, within Östergötland, is economically strong and that unemployment does not play such a big role as it does in the archipelago. They also thought that the population density within the triangle would pose a threat to new aquaculture developments. They said that this could slow the process of aquaculture development due to the fact that people might complain or that other developments such as housing are given priority.

5.4.2 Capacity and expert knowledge at provincial and municipal level

Several informants mentioned problems surrounding knowledge about the aquaculture sector and the capacity available to deal with aquaculture issues, as touched upon in 5.1.2 and 5.1.3. They also mentioned that there are substantial differences in knowledge between the different county administrative boards in Sweden (#3, #4, #5, #6). At a municipal level the differences are even bigger, which has to do with the small size of certain municipalities (#4). This is also supported by the matrix in appendix 3, which shows a lack of knowledge among certain informants. Within Östergötland many municipalities do not have anybody working specifically with aquaculture (#5). Some municipalities have chosen to share expertise and have one person responsible for multiple municipalities (#2).

5.4.3 Effects of eutrophication on the tourist sector

Eutrophication of the Baltic Sea plays an important role in the decline of the tourist sector on the Swedish east coast (#3). Östergötland has seen negative developments due to eutrophication (#3, #6, #7). This includes devaluation of coastal property, decline in number of tourists and loss of jobs (#5, #7). Therefore, the informants thought that this is a key issue which deserves the full attention of the government of Östergötland.

5.4.4 Linköping university research and education

Several informants mentioned that education and university research is the base for future development of a strong Swedish aquaculture sector driven by domestic technological
development. According to #3 and #7 Sweden is strong in developing technology. They also said that this could/should benefit the Swedish aquaculture sector. According to #4 it within Östergötland no university that focuses on aquaculture, nor is education provided regarding aquaculture. This is seen as a threat and a possibility for Linköping University to get involved in aquaculture as other universities in Sweden already do.

5.5 Informants view on the future of Swedish aquaculture

The informants mentioned RAS as having the most future potential for the Swedish aquaculture sector. At the moment they said that Östergötland could lead the way in this development. The northern regions of Sweden have highly developed open cage systems and the west coast has a well-developed mussel and oyster farming industry. Therefore, there is an opportunity for Östergötland to endeavor this into Sweden for new way of fish farming. Besides that they valued RAS as the most environmental way of fish farming, because it can be controlled (#4). Another informant mentioned that RAS is also a good alternative because it is easy to show the general public the benefits of RAS since it is land based (#7).

On the question to explain what RAS could mean for the Swedish aquaculture sector, #3 would like to see more RAS developing in Sweden and said that we should import RAS technology from Denmark. The informant also thought that RAS could play an important role in farming algae and micro-organisms as food for fish farms. Informant 4 and 7 referred that the Aquaculture Center Östergötland should focus on RAS. #7 said that efforts should be made to do research into the best RAS for Östergötland. This informant is also in favor of some kind of trade mission to gain knowledge. The interviewed farmers agreed that RAS has a future in Östergötland. #1 mentioned that in Linköping RAS could make use of excess heat from industries and that it might be an idea to work together with the local energy and heat supplier Techniska Verken to explore the opportunities.

As an ideal future vision for the Swedish aquaculture sector, #7 said that it would be ideal if there would be 5 to 10 RAS farms in Östergötland in 2020. Additionally it is said that there is a market for their produce. #6 mentioned that it would be nice if Sweden would produce 75 to 100 thousand tonnes of aquaculture products annually, and that there are thousands of hectares of mussel farms on the west coast. This informant also hopes that the development of an eco-label for the products will be developed for instance the ASC logo. #5 further hoped that fish will be produced in a sustainable way with a closed nutrient loop and that aquaculture does not contribute to the eutrophication of the Baltic Sea. #5 mentioned that more efforts are made to find a sustainable feed source and that we eat more locally produced fish in the future. #4 would like to see new aquaculture species and breeding programs developed in Sweden. Besides that #4 hoped that we will eat more fish instead of meat in Sweden and that we will create large RAS farms in Sweden to supply the market with Swedish products. #3 would like to see aquaculture as acknowledged as agriculture by the national government. #3 also said that in the future more investors will see the benefits of investing in aquaculture, that there will be more farmers and more people employed by the aquaculture sector. Besides this #3 hopes that trial farms will show the general public the benefits of RAS and that the negative image of fish farming will disappear. #2 would like to see more farms and bigger, as well as some sort of certification for Swedish produced fish. #1 would like to see 30 thousand tonnes of fish produced in Sweden annually. #1 also hopes that the general public will see that the oceans are getting empty and that aquaculture is the solution to answer to our sea food demand.
6 Discussion

This chapter interprets the results which were presented in the previous chapter. It relates and discussed them in connection to the presented literature, with the three pillars of sustainability as a thematically ground.

6.1 Social

Social and economical deterioration of rural areas is not something unique to Sweden, which could be seen from the literature review. Throughout the European country-side many sparsely populated counties face demographic problems such as aging rural communities, high unemployment and exodus of young people moving towards economic hotspots. The prospect of better social and economic opportunities is what drives many people to leave their rural homes. The possibility of better access to (university) education is also a reason to leave. At the same time the current economic climate in Europe induces this (Boverket, 2006; Niedomysl and Amcoff, 2011). The European Regional Development Fund (ERDF) aims to strengthen economic and social cohesion within the European Union. The Swedish Agency for economic and regional growth (Tillväxtverket) aims to strengthen regional development; therefore both the EU and Sweden have important tools to achieve their goals. These include structural funds, social and economic (EU) programs and cross border partnerships.

Swedish aquaculture is an economic sector historically found in the rural areas of the country and has faced multiple social and economical issues since the mid 90’s (SCA, 2012) The European structural funds such as the ERDF can therefore potentially benefit Swedish aquaculture sector substantially (Jordbruksverket, 2012). This opinion is shared by the informants who believe that aquaculture can play an important social and economic role in rural Sweden. The recent developments in the province of Jämtland, in Northern Sweden’s aquaculture sector, can be seen as a good example of how aquaculture can stimulate rural development when EU programs, in this case the Aquabest project, and regional and local governments have a common vision (Aquabest, 2012). The positive development of increased aquaculture production has been the driving force and has locally created more jobs and social/economical opportunities.

In my opinion there are possibilities to learn from and possibly copy the approach taken by the regional and municipal authorities of Jämtland and apply them to other parts of Sweden facing rural development problems such as Östergötland. It does however need a common vision and efforts to achieve this, sometimes only from a few driven individuals. On the other hand the social economical and environmental conditions in other part of Sweden are not the same. Therefore it is important to identify and analyze all the specific local conditions first before aquaculture is seen as the solution to rural development problems. Therefore, I agree with a comment made by one of my informants that developing aquaculture in rural areas of Sweden will take time and should be undertaken in structured steps.

Complete and up to date spatial and municipal comprehensive plans are an important condition to develop and assign suitable areas for aquaculture in Sweden. The Swedish Board for Agriculture underlines this in their aquaculture strategy 2012-2014. The Agriculture board also emphasize that it is important that municipalities understand the benefits of including aquaculture in their comprehensive plans. According to the literature aquaculture
has to compete for suitable space with other land users and stakeholders in the Swedish coastal zone. Moreover tourism and holiday homes form a significant threat to new aquaculture developments (Ackefors 2000; Morf 2006).

Informants claim that municipalities have no direct interest in aquaculture, are negative towards the idea of more aquaculture development and are unaware of the opportunities of aquaculture. This can have several reasons, where first of all aquaculture is a relative new competitor for space and attention. Coastal tourism and going to the summerhouse (“åka till stugan”) has a much longer history and is seen as a common Swedish good. Secondly, the economical benefits of seasonal tourism and holiday homes are seen as more beneficial than fish farming. Moreover, the Baltic Sea region has already seen a decline in the tourism sector due to eutrophication problems which has caused a loss of income for municipalities. Another reason, for the lack of action among municipalities and to put aquaculture on their agenda, is the fact that they fear public complains that aquaculture possibly entails #5 explains. In order to put aquaculture forward some informants think municipalities should be made more aware about the benefits of aquaculture for them, for instance via tax incomes and job creation. Other informants aim for a top down approach; they think that the Swedish national government should force municipalities to include aquaculture in their plans. However, the current laws and legislations cannot force municipalities to undertake this.

From the interviews and calls made to several municipalities it can be concluded that aquaculture receives little attention at municipal level in Östergötland. This has partly to do with a lack of knowledge among officials. On the other hand there seems to be too little man power to handle emerging issues. Furthermore due to the decline of the aquaculture sector many municipalities have no active farms within their jurisdiction which means that there is no need keep knowledge up to date. It is uncertain if these issues also apply to other parts of Sweden. Although municipalities might have other interest than aquaculture such as tourism and property development, suitable areas for aquaculture are protected under the Swedish environmental code, which governments have to abide. This was also reflected in interviews and conversations with several municipalities and confirmed by informants from different Swedish government authorities. Although steps are undertaken to make municipalities aware of the benefits of aquaculture they cannot/should be forced.

Beside awareness there is an additional condition to successful development of the Swedish aquaculture sector. Sufficient knowledge about aquaculture practices should be available to government employees. Fish farmers complained that there is a lack of knowledge among municipal and the County administrative Board officials. According to the farmers this causes unnecessary delays in environmental impact assessments, in the issuing of permits and granting subsidies. Also potential new fish farmers face these problems. Informants, from both municipalities and the County administrative Board, acknowledge these problems and claim that aquaculture has become relative a small part of their daily job due to the shrinkage of the aquaculture sector. Therefore, knowledge is lost. Another reason is that when knowledgeable and experienced employees leave due to e.g. retirement, they are often not replaced. However, the Swedish national government has made efforts to invest in knowledge and capacity building among its employs regarding aquaculture. Yet these funds are only made available for the national boards. It is difficult to say if the situation portrayed above applies to all municipalities and Country Administrative Boards throughout Sweden since only the situation in Östergötland is reviewed. Several municipalities and County Administrative Boards focus more on aquaculture, as is the case in Jämtland.
In the case of Östergötland it will take time to get experience back; on the other hand knowledge can be relatively easily reinstalled by for example training and education. Currently efforts are made by the East Sweden Regional Council (Östsam) to inform and educate the Östergötland municipalities about possibilities and benefits of aquaculture. However, the present situation forms a threat to successfully further development of the aquaculture sector in Östergötland. RAS might in this case be the best option since it does not have to take place in the coastal zone and disturbances are minimal. Furthermore, once awareness is created municipalities might embrace RAS aquaculture as a viable and valuable addition to their local economy. However the uncertainty of the markets and price fluctuations described in 5.2.3 are of concern. Markets for fish products are often internationally orientated and therefore depend on the world economy. Judging al social aspects mentioned in chapter five, RAS has as a form of aquaculture possibly the best potential to create social sustainability in rural areas as long as its limitations are carefully considered.

6.2 Economical

From both the literature and the interviews could it be seen that financing, investment and insurance form a significant threat to fish farmers. Starting up a fish farm is expensive. Fish farms require high investments before and several years before any profit can be made, which is especially true for RAS. Many farmers depend on banks or investment companies to finance their operations. At the moment aquaculture in Sweden is not seen as a safe and profitable investment, having several reasons. First of all, aquaculture in general is not a failsafe easy money making investment. This is reflected in the literature where Badiola et al. (2012) points out that high investment cost, expensive equipment, technology and running cost challenge fish farms to become financial healthy. Dalsgaard et al. (2013) also mention the financial issues surrounding aquaculture, and claims that high capital cost form the biggest challenge to (RAS) aquaculture in the Nordic countries.

In the results this is also brought up by the informants and mentioned at the annual meeting of the Swedish Aquaculture Association. Beside that the results show that the historic negative image is what makes banks unwilling to invest in Swedish aquaculture. In order to make a better chance of securing investments, a fish farmer has to put a lot of time and effort into this. Having a solid business plan is important as well as making conservative calculations on cost and potential profits, knowing your market and secure contracts with buyers. When these areas have been covered a farmer has a bigger chance of getting the investments needed. Like the results show it will remain difficult to secure funding in the near future. The aquaculture sectors must first all get rid of its negative image. This can possibly be done by focusing on promotion of Swedish aquaculture as an environmental responsible way of food production. Secondly, the Swedish financial sector has to be made more aware of the benefits of investing in aquaculture. Most Swedish banks are international oriented companies and do already invest in aquaculture in other Nordic countries. Even though worldwide financial crisis has not affected Sweden so much, banks are internationally oriented and markets globally linked.
RAS is, and will remain in the near future, the most expensive way of growing fish. However, the financial benefits and low environmental impacts might eventually outcompete other less sustainable types of aquaculture. This especially among environmental aware Swedish consumers, where RAS might be preferred which in turn could stimulate banks and investors to invest. Besides funding from banks there is EU funding available for aquaculture. Currently the EFF pays up to 40% of the initial investments needed to Swedish aquaculture related projects and fish farms. The amount of funding available is directly linked to decisions made on a national level. This means that the amount and percentage of available EU funds can differ in each EU member state, depending on its national agenda. This can result in unfair competition among European fish farmers and is an argument to make more money available for the EFF. The results show that Swedish farmers and aquaculture projects depend on subsidies from the EFF for economic viability, and are also seen as a great opportunity. Furthermore, in 2013-2014 the budgets for the new EMFF 2014-2020 will be established. There are high expectations that the Swedish government will make more money available for aquaculture and in particular RAS. Everything indicates that there is a growing political desire to make more funding available for aquaculture development in Sweden. The money invested in the Swedish Board for Agriculture to promote aquaculture is a first step. Secondly, in order to show that the government further supports and takes the aquaculture sector seriously the national budget for the new EMFF should increase. Especially RAS should receive extra attention in the form of funding, since it is particularly mentioned by the EU as a high potential industry. If the national government supports aquaculture others might follow, which in turn can give the whole sector a boost.

As mentioned before feed costs are the biggest single cost to fish farmers and form a huge economical challenge. The reviewed literature supports this (Badiola et al., 2012; Martins et al., 2005, 2010) and also the WHO and FAO have identified feed/ fodder as a major economical and environmental threat to (sustainable) aquaculture. In the interviews this was also brought up and the farmers acknowledged this. Feed prices depend on several economic factors on the world markets e.g. oil prices. Recent development of Asian influences on the European feed market put a further pressure on farmers. The nutritional values of feeds have improved; technology has made feeding equipment more efficient and up scaling of Swedish farms has resulted in lower in-buy prices. There is no direct solution to the high and probably rising cost of feed. Advancements made in laboratories to utilize algae and microorganisms as a fish feed source sound promising but are still experimental. Therefore, feed cost will remain a major threat to aquaculture in the near future.

Besides feed costs, farms need to sell their produce. The prices they can get depend on various economic conditions. The small-scale Swedish farms have to compete with other countries that can produce larger volumes at lower prices. Therefore, I conclude and sharing the opinion of the several informants that the Swedish market should focus on high quality environmental responsible products. This is also a target described in the aquaculture strategy 2012-2020 from the Swedish Board of Agriculture and mentioned in reports (AquaBioTech, 2013). Furthermore, there is a market for high value species. Also farmers should consider selling fish filets and processed products instead of whole fish to get a better price. Moreover Swedish farmers should work together to market their fish as a more environmental responsible or sustainable in order differentiate their product in supermarkets. Additional is the marketing, and promotion, of Swedish fish is important. The establishment of the three Swedish regional Aquaculture Centers can help to do this. The results show that there are opportunities to improve the image of the sector. Furthermore they can form a platform for innovation and a place for knowledge exchange.
Research and development is an important factor that can drive the aquaculture sector. It can also increase the efficiency and sustainability of the sector (AquaBioTech, 2013; Badiola et al., 2012). The results show that there is a need for more technological cooperation between Sweden and the other Nordic countries. Sharing technology and information could benefit the Swedish sector. Swedish farmers depend on aquaculture technology from abroad since little R&D is done in Sweden. Norway, Denmark and Finland are leading in the field of aquaculture technology. In Sweden few companies specialize in aquaculture because of the small domestic market and foreign competition. Sweden does not have to reinvent the wheel however, Sweden is known to be a strong technological advanced country and has the capability to do more aquaculture R&D. Universities and companies could work together and develop technologies and systems suitable to Swedish conditions. Government-university-industry working together is beneficial to all involved (Etzkowitz, 2000, 2012). The focus should lie on developing more sustainable production methods such as RAS, developing breeding programs for new profitable species (Vegafish, 2013) and alternatives for fish feeds. By doing so, the sector can be more resilient to changes and set itself apart from its competitors.

The Swedish government has changed policy regarding aquaculture since 2009. This has led to more money and attention presented for the sector. The attended stakeholder meetings and the interviews show that the current political direction is seen as a positive development. The Swedish Board of Agriculture gets a lot of positive feedback. It however remains to be seen what the upcoming Action plan from the Board will include and how much funding will be put aside for the EMFF. This concern was also expressed by several farmers. In my opinion the Board and national government are indeed working in the right direction. And especially the action plan will be an important document that will give more direction to the future of Swedish aquaculture. If done right, the action plan will be great opportunity for the entire Swedish aquaculture sector.

To conclude, from an economical suitability point of view RAS might not be the best choice as, high system costs, lack of investments in aquaculture in general and competitive global fish markets will make it hard for RAS to establish themselves in Sweden. However a positive governmental view on RAS, government investments and EU funds can possibly help to overcome these problems. Moreover other countries such as Denmark have managed to establish an economically sustainable RAS sector (Dalsgaard et al., 2013). Sweden could take the opportunity to learn from other countries.

6.3 Environmental

Eutrophication has far reaching consequences on the Baltic Sea’s tourism sector, local economy, coastal communities and its natural environment according to Lindgren et al. (2009) and Lethonen et al. (2008). The issues surrounding eutrophication have also received attention from the Swedish government. The Swedish Board of Agriculture and Swedish Environmental Protection Agency have devoted several reports addressing the issues. Eutrophication also affects the aquaculture sector significantly and forms the biggest single ecological threat to traditional Swedish open-cage aquaculture. It is believed to have led to strict environmental regulation which makes it virtually impossible to obtain permits for new
lake/sea based developments. Statistic from SCB (2012) and the results show that there are almost no fish farmers left on the Swedish Baltic coast.

Eutrophication problems have also added to the negative view that consumers and local authorities have regarding aquaculture. It seems unlikely that the eutrophication problems in the Baltic Sea will be solved in the near future. Therefore aquaculture in the Baltic Sea according to the results has no sustainable future. The research done by the EU Baltic Eco Mussel project and research from Lindahl et al. (2005) shows that mussel farming however does have a sustainable future. I agree with this and think that the Swedish government should support further research into the possibilities and make funding through the EMFF available. Mussel farming in the Baltic can provide an eco-service by nutrient uptake or possibly used for human consumption or as fish feed in aquaculture. RAS is the best environmental sustainable option to farm fish on the Baltic coast because no nutrients are released in the sea. Existing farmers can with help from the EMFF make the switch to RAS. This depends on the willingness of regional and local authorities. From an environmental perspective RAS and Baltic mussel farming are two valuable opportunities for the Swedish aquaculture sector.

An important benefit of RAS farms is that they can be and are set up anywhere (Badiola et al., 2012; Martins et al., 2010). From a local food perspective this means that food fish can be produced near places of consumption. The flexibility of RAS systems also give the advantage of utilizing industrial excess heat often produced in cities. The results show that these possibilities are seen an important benefit of RAS. Furthermore, projects like the Vegafish project show that there is an interest in setting up new RAS systems. Swedish Universities are also involved in such projects (Abborös, 2012). Local food in general plays an increasing important role to many consumers and politicians (Oken et al., 2012). Therefore it would be positive and an opportunity if RAS projects/farmers would highlight the benefits RAS in relation to local food production. This can in my opinion contribute to general acceptance and a positive attribute to RAS in Sweden.

There has been a discussion going on among fish framers about the benefits of an eco-label for their produce. In general eco-labeling is seen as opportunity because it could set their products apart from the bulk and possibly give higher market prices. However, at the moment the Swedish aquaculture sector is not yet at the point that this is an option. There is no national strategy from the Swedish Aquaculture Association to achieve this. Besides that farmers and the ASC have stated that the feed used in fish farming is a limiting factor. Therefore it seems that an eco-label is still far away. On the contrary could an investigation be made to see if a local food label would be feasible and brings benefits to Swedish fish farmers.

Successful farming of fish for human consumption is depending on breeding programs (Dalsgaard et al., 2013) The Swedish government funds breeding programs for Rainbow trout and Arctic charr. In order to set Swedish aquaculture products apart from its competition research into new species are already made (Abborös, 2012). From breeding program to suitable new species for aquaculture takes time. Aquaculture Centre West, AquaBioTech and the Aborrös project have identified species that are suitable for farming in Sweden. Therefore, the Swedish government should put emphasis on the support of breeding programs for new species together with funding from the EMFF. Possible breeding programs can provide an opportunity for the Swedish aquaculture sector. It furthermore gives an
opportunity for Universities, the state and industries to work together in the field of aquaculture.

To conclude, from an environmental suitability point of view RAS is possibly the best form of aquaculture for the Swedish sector. Because its land based and uses high technologilical filtering systems RAS does not contribute to the eutrophication of lakes and seas in contrast to other forms of aquaculture. It also can be set up anywhere which is a great advantage. Breeding programs are still a concern since only a limited number of species have successful breeding programs in Sweden. Other species farmed in Sweden still rely on the import of fry and smolt from other countries which decreases its environmental sustainability. Addressing this problem by setting up breeding programs for new economic interesting species supported by the government might help to improve environmental and at the same time economic sustainability of RAS.

6.4 Östergötland

Several threats and opportunities discussed above apply especially to Östergötland. Problems exist concerning tourism, unemployment, eutrophication and several other social, economical and environmental related issues in Östergötland’s rural areas. Despite this national, regional and local governments are aware of the EU funding from the ERDF, ESF and EFF and are used to finance projects such as the Aborrös project. Furthermore, municipalities along the Baltic in Östergötland benefit from these funds. The results show that several informants share this opinion. A precondition in order to gain the most from the existing funds in regards to aquaculture is that the local and regional authorities in Östergötland acknowledge aquaculture are a opportunity to develop their communities, socially, economically and environmentally. At the moment the results suggest that municipalities do not yet have the knowledge, capacity and willingness to embrace aquaculture as part of their strategy to counter the social, economical and environmental threats they are facing.

The results further show that here is a need for education at university level, since this is not yet available in Östergötland. Linköping University could start with this. In addition the University technical social and environmental departments could maybe focus on aquaculture in co-operation with Östergötland’s County Administrative Board and the aquaculture sector. Cooperation’s between universities, the government and industry have proven to be beneficial for all parties involved (Etzkowitz, 2012).

If aquaculture is to be revitalized in Östergötland, RAS seems to be the most promising option for the future. This opinion is also shared by several of my informants. Eutrophication of the Baltic Sea and rural unemployment play a big role in the county. At the same time there seems to be more support from the national government to tackle these problems. RAS could form a part of the solution to created jobs and produce food without adding to the eutrophication problems.
7 Conclusions

Farming fish in aquaculture systems will be more common in the future to answer the food demand of the growing world population. Sweden is lagging behind in the field of aquaculture compared to other European and Nordic Counties. Swedish aquaculture has overtime developed a negative image among consumers, politicians, government officials and investors. Today Swedish aquaculture faces threats that need to be addressed and opportunities that should be taken.

Open cage fish farming is not a sustainable and environmental responsible form of aquaculture and not suitable any longer for southern Sweden. Land-based RAS have however the potential to be the most sustainable way of fish farming for southern Sweden and specially Östergötland where the eutrophication of the Baltic Sea is the main limiting factor to open-cage aquaculture.

RAS has proven to be economic and environmental viable form of aquaculture in other Nordic countries and has therefore also potential in Sweden. In order to succeed with RAS in Sweden solid business plans, conservative production, profit estimates and marketing are essential. Also feed sources remain an issue from an environmental point of view and due to rising feed cost also from a economic point of view. Furthermore, there seems to be a lack of knowledge and capacity among lower government levels which negatively influences aquaculture developments. Municipalities should be made more aware of the possibilities that aquaculture can have for them. Municipalities should also be encouraged to include aquaculture in their municipal comprehensive plans and spatial planning in order to create a balance between other actors and stakeholders and to avoid (future) conflicts of interest. Lack of financing from banks, investment and insurance companies, forms a significant threat to the Swedish aquaculture sector and should be addressed by aquaculture organizations, the government and the Swedish Aquaculture Centers. RAS in Sweden are not viable without government funding. The Swedish national government has show increased interest in the development of the Swedish aquaculture sector. Making funding available in the upcoming EMFF is important and can further stimulate Swedish aquaculture development.

Efforts should also be made to positively promote Swedish aquaculture products as an environmental responsible way of food production. The political will and investments made to promote the sector, the EMFF and other EU funds and the entrepreneurship and ingenuity among Swedish farmers will help Swedish aquaculture forward. Östergötland should concentrate on RAS and mussel farming and the province has the potential to become an example for the rest of Sweden. Aquaculture can also positively contribute to regional and rural development of the Swedish country-side by job creation and stimulation of local economies which are important for Östergötland.
7.3 Suggestions for further research

- It would be interesting to make a comparison of the Swedish RAS sector with successful RAS counties, like the Netherlands and Denmark, in order to find out how they tackled problems, developed their RAS sector in the early stages of development, how they have solved investments issues and what the role of the governments was.

- It would be good to make an investigation into the possibilities of some type of university education, course or program at Linköping University that would include aquaculture, since there might be an increasing demand for this type of education among (future) fish farmers and government officials that need to be retrained.
Acknowledgements

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Daan van der Blom
References


Aquabest project report (2012b), *Environmental regulation of aquaculture in the Baltic Sea Region- A broad view of the legal framework*. Finnish Game and Fisheries Institute, Helsinki


Codex, Ethical Code of the Swedish Research Council for the Humanities and Social Sciences website, Available at; http://www.codex.vr.se/en/index.shtml, last accessed at 12-04-2013


EC 2013 European commission website, Available at:


Jordbruksverket (2013b) website article, Available at: [http://www.jordbruksverket.se/amnesomraden/landsbygdsutveckling/vattenbruk.4.e01569712f24e2ca0980008260.html](http://www.jordbruksverket.se/amnesomraden/landsbygdsutveckling/vattenbruk.4.e01569712f24e2ca0980008260.html), last accessed at 26-02-2013

Jordbruksverket (2013c) website article, Available at: [http://www.jordbruksverket.se/amnesomraden/landsbygdsutveckling/vattenbruk/nationalvattenbrukskonferens2012.4.59e3f5e513566bddd04d8000342.html](http://www.jordbruksverket.se/amnesomraden/landsbygdsutveckling/vattenbruk/nationalvattenbrukskonferens2012.4.59e3f5e513566bddd04d8000342.html), last accessed at 27-02-2013


SCA, Swedish Centre for Aquaculture website, Available at: [http://nkfv.se](http://nkfv.se), last accessed at 01-03-2013

SCB, Statiskiska Centralbyrån (2009), website, Available at: [http://www.scb.se/Pages/TableAndChart293162.aspx](http://www.scb.se/Pages/TableAndChart293162.aspx) last accessed at 08-04-2013


Silvereel AB company website, Available at: [http://www.silvereel.se/EelFarm.html](http://www.silvereel.se/EelFarm.html) last accessed at 09-04-2013


Svenskt vattenbruk website, Available at: [http://www.svensktvattenbruk.se](http://www.svensktvattenbruk.se) last accessed at 28-02-2013.

Tillväxtverket, Swedish Agency for Economic and Regional Growth website, Available at [http://www.tillvaxtverket.se/ovrigt/englishpages/structuralfunds.4.3c4088c81204cca906180008263.html](http://www.tillvaxtverket.se/ovrigt/englishpages/structuralfunds.4.3c4088c81204cca906180008263.html), last accessed at 08-04-2013


Vegafish company website, Available at: [http://www.vegafish.com](http://www.vegafish.com), last accessed at 05-03-2013

Wageningen UR aquaculture website, Available at: [http://www.aquaculture.wur.nl](http://www.aquaculture.wur.nl), last accessed at 14-02-2013


Appendix 1 – List of informants

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<tr>
<th>Name</th>
<th>Organization</th>
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<tr>
<td>Mats Emilsson</td>
<td>Fish farmer in Östergötland, Sankt Anna Fisk AB</td>
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<tr>
<td>Anonymous</td>
<td>Two fish farmers in Östergötland</td>
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<td>Ulrika Bergman</td>
<td>Swedish Board of Agriculture, Fisheries Division</td>
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<td>Per-Erik Larsson</td>
<td>County Administrative Board of Östergötland</td>
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<td>Karin Dalhström</td>
<td>Norrköping municipality, inspector at environmental Health dept.</td>
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<td>Erik Olofsson</td>
<td>Aquaculture centre North (VCN) and Aquabest EU project</td>
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<td>Harry Leiman</td>
<td>Centre for Regional Development in Östergotland (Östsam) and Aquaculture Centre East (VCÖ)</td>
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Appendix 2 – Main interview questions

Introduction, history and today
1. What is your professional relation to aquaculture? And how did you get involved?
2. Do you think that the Swedish sector aquaculture resilient to changes, stresses and disturbances?
3. Do you think that the Swedish aquaculture sector is in a desirable state at the moment (economically, socially, and environmentally?)
4. If not what is needed to change this and how?
5. Why has aquaculture not developed earlier in Sweden compared to the other Nordic countries? And especially in southern Sweden?
6. Is the sector underdeveloped because there is no demand (governmental, economical) in Sweden for aquaculture, would it be more developed if there was more demand from society for aquaculture?

Social
7. In which way can we give farmers who want to change, to aquaculture or a different kind of aquaculture the capacity to change, to a more sustainable aquaculture practice?
8. How are the social, economical and ecological interests judged to find suitable aquaculture locations?
9. Do you think that aquaculture can contribute to regional development in this of Sweden? And in particular Östergötland. How could, does aquaculture contribute?

Environmental
10. Do you think sustainable development within aquaculture is necessary /useful? And in what way?
11. In what sense can the Swedish government (your organization) help to promote more sustainable aquaculture?
12. How does aquaculture contribute to a sustainable economical development in Sweden?
13. The three pillars of SD how does it help them.
14. Who has or should have the responsibility to develop more sustainable aquaculture in Sweden?
15. Certification (ASC, Krav) how important do you value that for the Swedish aquaculture sector?

Political/policy
16. Aquaculture is in policy documents and visions often part of general fisheries policies. How is aquaculture specifically targeted by the Swedish government (your organization)?

Economical
17. It seems that many aquaculture companies in Sweden quickly go bankrupt. Do you agree, why is this? How can this be prevented? And what is the role of (your organization) in this?
18. Many Aquaculture projects seem to stop after a few years, why? 
   When the money from the government is up, this seems not economically sustainable, 
   how can this be made sustainable? 
19. Is it necessary to develop the Swedish aquaculture sector more? And how can this be 
   done? 
20. What is needed to move to a more sustainable Swedish aquaculture sector? 
   Especially in Östergötland? 

**Future** 
21. What are according to you the most interesting and promising developments in the 
   aquaculture sector? 
22. What is your opinion of recirculation aquaculture? Is this type of aquaculture the best 
   option for Sweden? 
23. What is you ideal near future (5 /10 years) vision for the Swedish aquaculture sector? 
24. What would you advice to persons who want to start with aquaculture? 
25. How do you see aquaculture in the near future develop in different regions in Sweden? 

**Extra questions asked specifically to fish farmers** 

1. Can you describe your farm? 
2. Which species do you farm and why? 
3. Which life stage of the species will you produce? 
4. What feed do you fish get? 
5. What will your end product produced be? 
6. What is your water source? 
7. Do you receive any subsidies? 
8. Could you manage without governmental financial support? 
9. How is your farm funded? (Bank loan, own money)? 
10. How long did it take to get your initial investment back? 
11. Which part of your farm is most difficult to manage? 
12. Do you miss certain knowledge and would like to have additional training? 
13. Have you considered changing to another type of aquaculture? 
14. Would you have done certain think different if your farm that you do know? 
15. What is your opinion about the Swedish aquaculture strategy? 
16. How difficult is it to get the environmental permits needed for you farm? 
17. Did you do market research before choosing your species farmed? 
18. Are other companies willing to share information (technical, economical)?
Appendix 3 – Interview analysis matrix

**Index**
- **Green:** Strong similarities in answers with other interviewees
- **White:** No similarities in answers to other interviewees
- **Red:** Question not asked to interviewee
- **Yellow:** Has no answered the question/does not know
- **Blue:** Informant farms (fish)

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Question not used in analysis
Many different opportunities mentioned
# Appendix 4 – Names list of some aquaculture species

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<tr>
<th>English name</th>
<th>Latin name</th>
<th>Swedish name</th>
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<tbody>
<tr>
<td>American Brook trout</td>
<td>Salvelinus fontinalis</td>
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<td>Arctic char</td>
<td>Salvelinus alpines</td>
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<td>Atlantic salmon</td>
<td>Salmo solar</td>
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<td>Blue mussel</td>
<td>Mytilus edulis</td>
<td>Blåmusslor</td>
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<td>Brown trout/Sea trout</td>
<td>Salmo trutta, morpha trutta</td>
<td>Havs öring</td>
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<td>Cod</td>
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<td>Perca fluviatilis</td>
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