Strategic Approaches for Aquaculture Industry Development: Flat Oyster Cultivation in Scandinavia

Interreg IV A project NORD-OSTRON

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INTRODUCTION: Scope and objectives

The Scandinavian countries face a number of challenges related to the use of marine resources. First of all, the demand for seafood is increasing globally and nationally. The annual global demand in 2030 is estimated at 160 million tonnes of fish and shellfish. Wild fisheries can only supply 80-100 million tonnes annually (FAO Fishstat). This does not take into account the fact that most wild fish stocks are already over-exploited. A similar situation applies in Scandinavian countries where fish catches have been decreasing for decades (SCB). Subsequently, the demand for marine aquaculture products is increasing in order to meet both regional and global markets for fish and shellfish products.

Secondly, national and EU environmental protection policies set limits for the exploitation of marine resources through e.g. the Species and Habitats Directive, the Water Framework Directive and the Marine Strategy Directive. This is specifically a problem in the Kattegat-Skagerack (KASK) region where the marine areas are threatened by eutrophication. There is also the requirement that production of food or biomass from the sea must be carried out on a sustainable basis. Shellfish aquaculture can provide a partial solution to this challenge. Shellfish aquaculture does not require feeding or use of additives nor medication or other kinds of treatment involving use of hazardous or non-natural compounds. On the contrary, shellfish aquaculture provides goods and services to the ecosystem by removing nutrients through harvest and by providing increased water transparency via mussels' ability to filter out phytoplankton and other microscopic particles from the water. In addition, shellfish aquaculture provides either on-bottom or off-bottom substrates that can act as habitats and thus increase local biodiversity.

Production of seafood is also important for economic development in the Scandinavian countries. Problems with employment in rural coastal communities persist and the recent economic crisis has contributed to job losses in these communities. Lack of employment opportunities is influencing population demographics and poses a serious threat to the viability of coastal communities. In order for these remote areas to remain attractive not only to the inhabitants but also to tourists, they have to develop economic sectors independent of the tourist sector. Shellfish aquaculture represents an opportunity for income earning in rural coastal areas. High cost of labour is another challenge in Scandinavia, which requires both high-end products and efficient production in order to compete with aquaculture in other parts of the globe. Production of flat oysters represents a "window of opportunity" for sustaining livelihoods and work opportunities in coastal areas in Scandinavia. Oysters are a high-end product that can be produced in a sustainable way in rural coastal communities.

This report provides an assessment and suggestions for how aquaculture of the native European flat oyster *Ostrea edulis* in Scandinavia can develop into a viable, self-sustaining industry. As such, the report and proposed actions are intended to assist regulators, decision-makers and investors in developing relevant goals for industry development. There are some key factors for this to take place:

- **Technical and scientific expertise must be available to stakeholders in the region**
- **Markets and good marketing strategies need to be developed**
- **Clearly expressed government support to the industry and development of appropriate regulatory frameworks and policies to guide development must be in place.**

These issues are discussed in four sections: (1). Biological and environmental factors (2) Technical research and development (3) Market and production factors, and (4) Regulatory frameworks and institutional

factors. A SWOT (Strengths – Weaknesses – Opportunities – Threats) analysis has been conducted for each of these areas, both for Scandinavia as a whole and for each of the three participating countries separately. Some recommendations are based on the results from the case studies presented at the end of the report (Appendix A), where the most important factors underlying successful industry development in countries with similar environmental and socio-economic conditions as Scandinavia have been analysed. By considering a range of biological, technical, institutional and socio-economic factors, the report provides an overview of the potential for oyster aquaculture in Scandinavia and relevant next steps towards achieving this goal.

Summary of recommendations and proposed actions

The following section provides a brief summary of recommendations from this report in order to develop a competitive oyster industry within Scandinavia and with existing foreign producers.

(1). Biological and environmental factors

Many parts of the Scandinavian coast are ideal for bivalve shellfish aquaculture, as these regions possess excellent physical, geographical and ecological characteristics suitable for near-shore extensive aquaculture of mussels and oysters. Apart from populated areas around the large city centres, where the human impact on coastal water quality may impair food safety aspects, there is a large potential to establish oyster farming as a new industry in most rural areas of Scandinavia.

Parasite-free growing areas*:* The most important biological as well as marketing argument for Scandinavian oyster farming is the absence of the parasitic diseases Bonamiosis and Marteiliosis, which have caused the collapse of much of the flat oyster industry in more southerly European waters. Scandinavia is currently free of this disease, thus putting Scandinavian countries in a unique position to develop flat oyster production for European markets. ***S*trong regulations and control of transport of live oysters from other countries needs to be pursued by the responsible authorities in each of the Scandinavian countries to avoid the spread of these diseases**.

Spatial planning for oyster production*:* Rate of survival and growth vary depending on the specific environmental conditions at the on-growth site, with factors such as temperature, salinity and food supply being critical factors for growth. Site selection is thus a crucial issue for oyster farming, and biophysical site characteristics need to be assessed **and biological and environmental criteria for optimal growth and survival defined** in order to maximize productivity. This can be done for example through publicly funded research-industry project collaborations.

Seafood safety*:* Coastal water quality (i.e. low levels of anthropogenic contaminants and microbial pollution) is excellent in most of Scandinavia, which allows for production of a premium product and good branding opportunities. However, the on-going permanent classification of shellfish waters (A, B or C areas), which is currently undertaken by the Swedish Food Safety Agency, may result in restrictions to harvest and market oysters without a depuration step. **It might thus be of strategic importance to include depuration according to EU regulations as a regular part of production in order to provide quality assurance to consumers and to minimize the possibility for contaminated oysters to reach the market.**

Quality control: There is large seasonal variability in oyster meat quality. Oysters breed in the summer, reducing their quality for eating. However, summer is also the time of the year when the local demand from tourists and restaurants is highest. **Live-storage and relaying to maintain product quality during these periods should therefore be developed by the industry in order to be able to supply the market with high quality oysters year-round.**

(2). Technical research and development

Scandinavian production of flat oysters cannot rely on fisheries and natural spat collection from wild stocks if the production is to remain stable over time. Unpredictable recruitment among wild stocks currently limits increased volume production. A stable oyster production is thus dependent on controlled seed production through aquaculture.

Hatcheries: Seed production requires hatcheries. In most countries, hatcheries are sustained by public-private partnerships. In Sweden, the existing hatchery is currently funded entirely by the private sector, which may be detrimental to overall industry growth if it is subject to failure. In many other countries, especially during initial development stages, many hatcheries are affiliated with research organizations, and are funded in part through public investments. **Successful operation of hatcheries is crucial for the development of an oyster industry, thus public engagement and financial support for continued development of larvae and spat production are of utmost importance.**

Grow-out technology: The grow-out stage of oyster production generally includes all processes from deployment of seed oysters in sea-based nurseries to grow-out and final harvest. Methodology and equipment for grow-out varies depending on environmental conditions, but overall concepts are similar. **Technology transfer and basic research is needed to adapt foreign technology and equipment for local conditions in Scandinavia.** Adaptations include modifications to improve performance, durability or functionality of equipment under specific biophysical conditions (e.g. sea ice, seasonal water quality).

Processing technology and logistics: As the oyster aquaculture industry in Scandinavia is currently still small, post-harvest facilities for processing, storage and depuration have not been extensively developed. Likewise, transportation and logistics have not been systematically organised and implemented. Technologies have been developed in other countries with similar growing conditions such as Canada, Japan and New Zealand that enable year-round storage, processing and safe transportation of live shellfish products. **Scandinavia should benefit from the development in these countries by technology transfer of post-harvesting technologies, including minor adaptations for Scandinavian conditions.**

Genetic resources: There is a clear need for research to improve broodstock conditions and production yield through breeding programs, similar to what has been done in the finfish farming industry. Each country in Scandinavia faces unique environmental conditions and may have distinct genetic resources, thus requiring a different emphasis on broodstock management in each country. **In order to develop breeding programs, it is essential to provide public funding to research institutions for this purpose, as there are very few places in the world where the private sector is expected to bear the full cost for breeding programs, especially in early stages of industry development.**

Knowledge transfer and research partnerships: Funding is essential for researchers and industry representatives who can provide technology transfer from other countries that have successfully developed their oyster farming industries. **Specific support for technology training abroad for**

Scandinavian producers, and workshops providing information for the industry on recent international developments will increase the pace of innovation and development of the Scandinavian oyster industry.

(3). Market and production factors

Scandinavian oyster farming is still in its early stages of development, and thus local niche marketing directly to restaurants and consumers is one of the most accessible and viable ways for the current farming industry to move forward. Scandinavian demand for oysters is high, and demand will continue to increase if efficient aquaculture production can supply the market with a year-round, consistent and reasonably priced product. Prices will naturally fall with more entrants to the industry and more competition, at which point, it will be important to begin capitalizing on economies of scale. Commensurate with larger production volumes, it will then be possible to start looking outwards to European or Asian markets, where there is equally high demand for these products. Flat oysters fetch good prices due to scarcity, but there are still a lot of hurdles, which need to be overcome for the development of oyster aquaculture in Scandinavia.

Competition with the Danish oyster fishery: One of the strongest influences on flat oyster prices is the seasonal opening of the Danish oyster fishery that for the last decade has provided a substantial proportion of the total European flat oyster production, mainly as export to Spain and France. Production volumes from the oyster fishery in Denmark are predicted to decrease in the future. Nevertheless, **flat oyster farmers in Scandinavia will need to be able to carefully control aquaculture supply during the Danish fishing season when the market is saturated. They must also be able to demonstrate to consumers through marketing that the product quality of oysters grown on farms is higher and that the year-round availability of aquaculture produced oysters is worthy of a price premium.**

Shellfish sanitary testing programs: According to EU and national laws, government, through the respective National Food Agencies, is responsible for monitoring shellfish safety. In Sweden and Norway, there are currently no fees incurred by the farmer for safety testing, as shellfish monitoring programs are fully subsidised by the government. In contrast, shellfish farmers in Denmark are responsible for sampling, transport of samples to testing labs, and for the full cost of the testing, which currently amounts to approx. 6,000-8,000 DKK per week of harvest. This cost is a severe impediment to the build-up of an economically viable small-scale industry in Denmark, where the aquaculture industry is very small, and is focused primarily on local restaurants and direct sales to consumers. **It is therefore of utmost importance for the Danish government to subsidise the cost of shellfish sanitary testing programs in Denmark.**

Tourism development and marketing boards: In many countries with successful shellfish industries, tourism boards and government-funded tourism initiatives have assisted with branding and promotion of local seafood products. In many cases, this has involved large-scale regional initiatives, through creation of special shellfish marketing boards and food-tourism organizations. Such agencies can be involved in gathering information to define new market opportunities, developing informational/promotional initiatives based on product safety, nutritional value, and environmentally sustainable production methods. **Existing marketing boards and organisations could begin with branding and promotion of Scandinavian oysters, as there is already enormous potential to develop local tourism, and these brands could later be used for export purposes.**

Public education and industry profile: In general, it is not adequate to have testing programs for product safety without also providing public education about these programs and the positive benefits of shellfish consumption. Shellfish are high in omega-3 fatty acids, have trace minerals that are not found in many

other foods, and are also high in protein. Furthermore, they are sustainably produced, and are almost always ecologically certifiable. Shellfish therefore have a number of distinct health and environmental benefits and, in some countries, also have strong cultural significance. **Dedicated government initiatives that inform the public about food safety and health benefits are important, and the National Food Authorities in each of the Scandinavian countries should take the lead in public information campaigns.**

Value-adding and branding: Value-added products that are processed, packaged and labelled at point of origin have significantly greater market potential than untargeted mass-production, especially in mature European markets. Specific branding of Scandinavian seafood products will not only ensure loyalty in local markets, but also ensure market recognition abroad. **Scandinavia could benefit from cooperation towards generic marketing, as production volumes in each country are limited, and thus could potentially benefit from pooling of resources towards marketing of a "Scandinavian" brand***,* much as individual growers in New Zealand all pack, label and sell their products independently, but under the "New Zealand Greenshell" trademark.

(4) Regulatory frameworks and institutional factors

Policies, regulations and institutional factors play an important role in supporting development of the oyster farming industry, and a better understanding of these factors is needed to ensure successful growth. Historical development of shellfish aquaculture in countries such as Canada and New Zealand has clearly shown that industry success is often, at least in part, due to factors relating to the active role of policy makers and regulatory bodies, for example in facilitating the access to lease areas, planning for strategic economic development, subsidising mandatory monitoring programs while the industry is developing (e.g. seafood testing) and facilitating industry and government-funded research programs. **Government and regulatory agencies play an important role in creating a positive public perception toward aquaculture and its products, and for reducing conflicts between growers and the public. Governments need to be responsible for leading this focus with clear strategies and vision.**

Public funding of research and research-industry collaborations: Public funding for academic research and research-industry collaborations is essential to develop all stages of aquaculture production, from hatcheries to farming techniques and processing, as experience from other countries with successful industries has shown that without financial support from public funds, and coordinated government initiatives, industry development will be slow and hampered by lack of strategy. The ways in which public funding is allocated will make a difference in ensuring successful outcomes. Grants that are aimed at industry-wide development, such as through creation of hatcheries, processing facilities and technology development are generally more productive than subsidies to small-scale growers. **Thus national research and development programs specifically aimed at shellfish aquaculture should be adopted in the Scandinavian countries in order to facilitate industry development.**

Access to sea space and coastal zone planning processes: Access to lease sites is the first, and perhaps most fundamental, need of the aquaculture industry. Without clear access to sea space for cultivating shellfish, there is no possibility for industry growth. Shellfish aquaculture in other countries has benefited from coastal zone planning processes which explicitly, through legislation or government mandates, dictate that a certain percentage of coastal areas will be developed as shellfish farms. Local governmental authorities are then charged with public consultation processes to determine appropriate locations for these farms before permits are allocated. Permitting is thus simplified for the industrial partners. In Sweden, the long and complicated application process for lease permits, conflicting laws and the limited length of tenure creates unnecessary bureaucratic complications and a lack of financial security for lease-

holders **To facilitate and increase the pace for oyster farming industry development, it is strongly recommended that responsible governmental authorities in the Scandinavian countries take the lead in facilitating the lease application procedures and planning processes such as described above.**

1. BACKGROUND

1.1. The global perspective

Since 2001, global aquaculture production, including aquatic plants, has grown at an annual rate of 6.3% to reach 59.9 million tonnes (valued at US$ 119.4 billion) in 2010 (FAO FISH STAT). Over the past 10 years, worldwide shellfish aquaculture production has grown in value by more than 40%, with the highest rates of growth in East Asia, as well as a number of countries within Europe (Ireland, Greece, UK), Chile, New Zealand, the United States, and Canada. These growth rates are greater than any other food producing system. Yet aquaculture production must expand at an even greater rate to meet the growing demand for fish. Aquaculture now represents 36% of the volume and 50% of the value of global fish landings, including non-food sources; in terms of food production, aquaculture accounted for 47% of the aquatic food produced from our oceans and lakes in 2006 and likely exceeds 50% in the present day. By 2030, it can be expected that more than 50% of all fish and seafood products will originate from aquaculture.

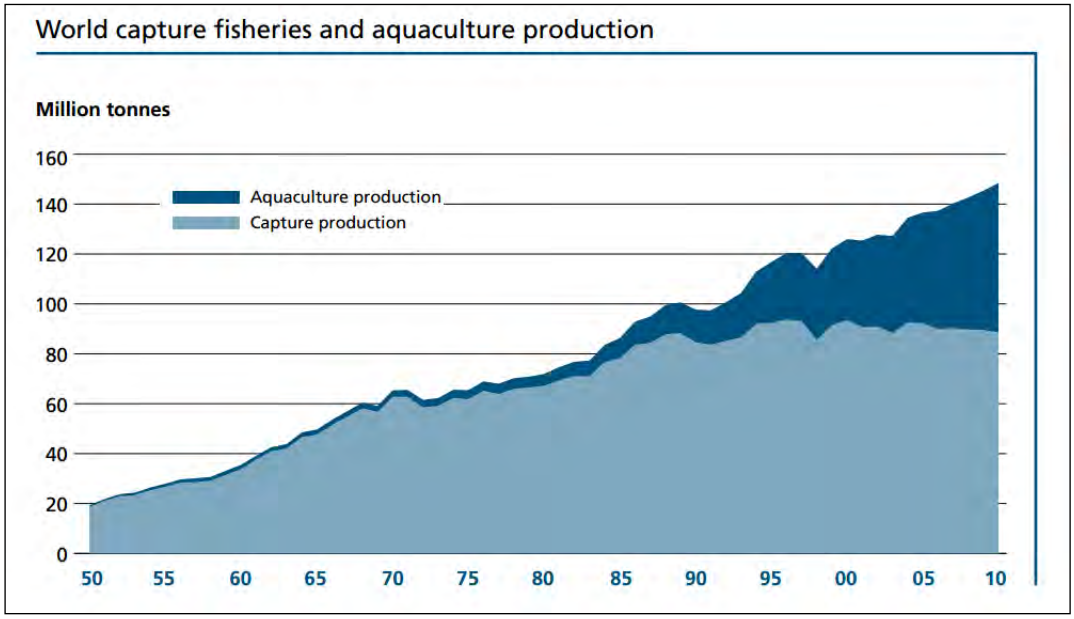

Figure 1. World aquaculture production exceeds fisheries production. While fisheries production is declining, aquaculture is growing at more than 10% per year. Source: UNFAO, 2012

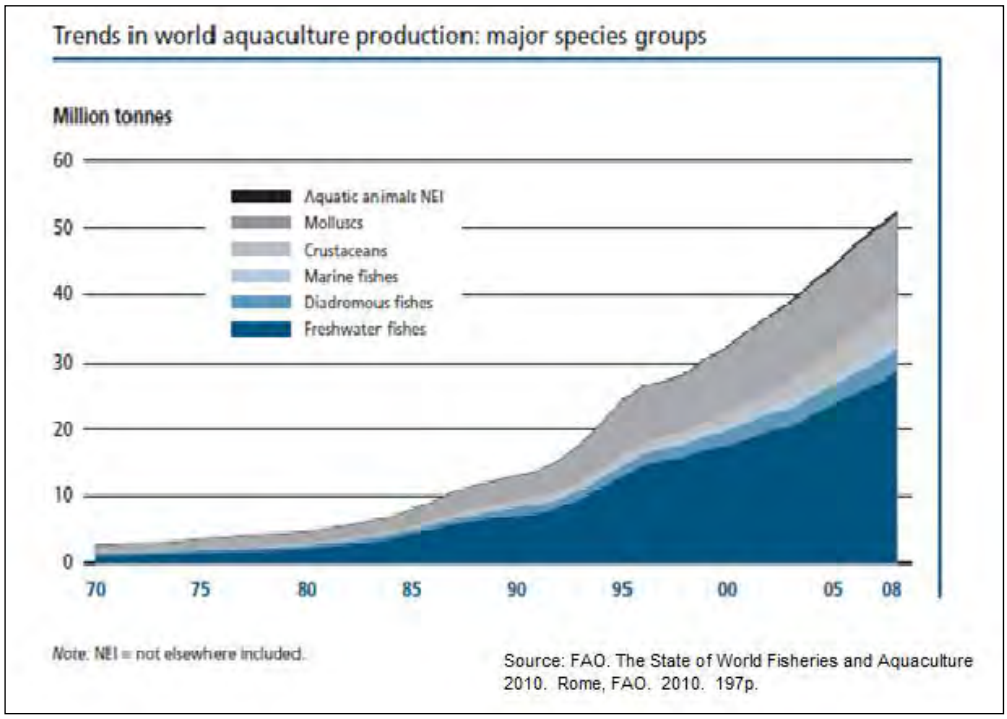

Figure 2. In Scandinavia, the aquaculture industry is still primarily focused on finfish, but worldwide, mollusc farming is the fastest growing and largest sector of the aquaculture industry. Source: UNFAO. For more discussion, see: http://sustainablefishfarming.blogspot.se/2011/01/aquaculture-overtakes-fishing-for.html

For world shellfish production, the estimated prediction for aquaculture to be the prevailing mode of production has already been fulfilled. Where aquaculture of shellfish in 1980 constituted approx. 50% of total world shellfish production, it was the reverse relation in 2005, where fisheries on wild shellfish stocks was approx. 50% of shellfish aquaculture (Fig. 1). Most of the increase in shellfish production has taken place outside Europe and especially in the new millennium European shellfish production has been decreasing.

Shellfish aquaculture is different from both terrestrial and aquatic husbandry. In shellfish aquaculture more than 60 different species are produced, whereas only few species are produced in agriculture and finfish aquaculture. Even though some of the species cultured in shellfish aquaculture are closely related and the high number to some extent is due to the specific mode of production in shellfish aquaculture, being partly dependent on seed collection from wild populations, it can be anticipated that further development and increase in production volumes will be at the expense of the present high diversity of produced species. Tolerant species that can be produced in hatcheries will become dominant.

1.2. Oyster production in Scandinavia

Flat oysters constituted in Scandinavia in prehistoric times an important part of the diet for people in coastal communities. In Denmark findings of oysters date back to the Stone Age (4-6,000 years B.C.). Large amounts of oyster shells have for instance been found in kitchen remnants in stone-age dwellings.

1.2.1. DENMARK

Historically, flat oyster production was most predominant in the Wadden Sea but with the saltwater intrusion from the North Sea into the Limfjorden in 1825, the Limfjorden became an important production area in the mid 19th century. Production was originally based on both natural recruitment and relay of seed oysters imported from e.g. Norway. The oyster fishery boomed in this period with yearly landings of up to 7 000 000 oysters per annum. The large out-take caused a major crash in the oyster stock and fishery was banned for 4 years towards the end of the 19th century. In recent times, i.e. since the beginning of the 20th century, the Danish oyster fishery has been characterized by two main features: a high variation in production volumes (Fig. 3) caused by variation in recruitment and fishery efforts and attempts to reduce these fluctuations by various methods, mostly relaying of imported or undersized natural oysters. After a period with very low levels of landings in the 1980s and most of the 1990s, the natural population of flat oysters increased in response to a number of warm summers. The continuous recruitment during the last decade has sustained an unprecedented high level of landings. Landings reached previous high levels at the beginning of this century and continued to increase and peaked at landings of up to 1 500 tonnes, which roughly corresponds to 14-21 000 000 oysters annually. The most recent burst in the oyster fishery in Denmark has been entirely based on recruitment of wild oysters and only takes place in the Limfjorden. Since 2009, natural recruitment to the oyster population in Limfjorden has almost ceased, and the average size of individual oysters has increased, leading to fewer oysters in the attractive size classes. Landings can be expected to decrease in the coming years. With the present downward trend in stock and landings, there is now an opportunity for oyster aquaculture as there have been established markets for the *Bonamia*- and *Martelia*-free Limfjorden oysters. Most Danish mussel farmers have license to produce oysters, so with access to spat they will be able to provide aquaculture oysters.

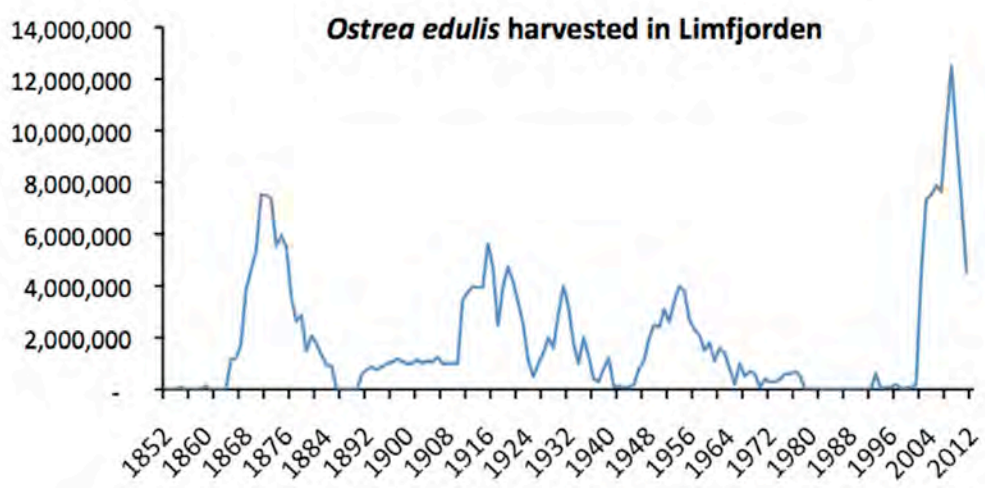

Figure 3. Oyster landings (number of oysters) 1850-2011 from Limfjorden.

1.2.2. Norway

From the 16th century and up to the mid-18th century, flat oysters were produced in considerable quantities and exported to e.g. Denmark, the Netherlands and the Baltic states. A dramatic decrease in production volumes occurred from 1850 and onwards and wild stocks almost vanished by 1870. Overexploitation has been suggested as the reason for the collapse, but many believe that the most likely explanation is climate change and low seawater temperatures causing massive extinctions. Collection of oysters for food has occurred for thousands of years. Commercial production of oysters started during the latter 18th century, primarily using so-called "pollers" along the southern and western seaboard. Pollers, or oyster ponds, are small embayments or a cove usually in the innermost reaches of a fjord, where temperatures may reach 20-22°C, sufficient for growing oysters. The commercial poller industry coincided with the loss of wild oyster populations. Many oyster companies were started, but most were dismantled or went into bankruptcy. Around 1900 there were 25-30 pollers left in use. Several efforts to revive production from early to the mid- 19th century did not succeed due to lack of predictability in the supply of juveniles for commercial production. In general, poller production conditions suffer from many climatic and biological factors of which oyster producers have little control. This, among other factors, represents a major reason why oyster production has not taken off on a grander scale earlier in Norway. From 1970-1985, a number of new initiatives were taken in order to establish oyster production in southern Norway. In 1985 there were 75 registered oyster producers who grew between 12 – 16 millions of oysters. A peak was reached in 1999 with 300 tonnes of flat oysters produced (fig. 13). Many oyster producers were found in the west of Norway, which represents the northernmost sea temperature limit for growing oysters (16 – 20°C). The gross sale of oysters has since then decreased dramatically to a level of 24 tons in 2009.

1.2.3. Sweden

Flat oysters occur along the Swedish West Coast from the northern parts of Halland to the Norwegian border. Similar to the coastal communities in Norway and Denmark, small-scale oyster fisheries have been carried out since at least the Bronze Age. The southward distribution is restricted mainly due to salinity, which hampers reproduction and larval survival. The sustainability of fisheries from natural populations is limited due to low and irregular natural recruitment. The landing of oysters in Sweden is thus characterized by large annual variation as reflected from historical catch records, where annual landings from a few tonnes up to 100 tonnes have been registered back to the 1950s. In 2010, Swedish landings of oysters were only 10 tonnes. There have been some initiatives along the western seaboard, during the last decades, to establish small-scale oyster farming based on oyster spat imported from Norway and Denmark. Harvest and trading of oysters are carried out by a handful of diving companies, with restaurants and wholesalers as the markets. In Sweden, law regulates the ownership of natural oyster stocks, and the oysters belong to the owner of the land/water up to 200 meters from the shore and around islands, which are larger than 100 meters. Recreational and commercial harvest of oysters thus requires an agreement with the owner, which is often problematic for various reasons. In view of the recent rise in demand by Swedish consumers, which have led to a huge rise in imports (fig. 12), a hatchery for spat production and cultivation of oysters began in August 2008 on South Koster in northern Bohuslän (Ostrea Sverige AB). The company's initial production target is set at 3 million adult oysters (300 tonnes) with an estimated value of 30 million SEK.

1.3. Oyster aquaculture – how is it done?

Oyster aquaculture is production of consumable oysters under controlled conditions, involving all steps from spat production to a ready-to-eat oyster (Fig. 4). The core issue is to produce viable juvenile oysters, called spat, which can be grown in the sea to desired size and quality. There are several ways to produce

oyster spat for seeding, either in intensive (hatcheries) or semi-intensive systems, where spat collectors (fig. 5 A) can be used in open bays, ponds or pollers (see 1.2.2.) to collect natural spat. Hatchery production is considered the only method with the potential to provide adequate volumes of spat on a regular and predictable basis.

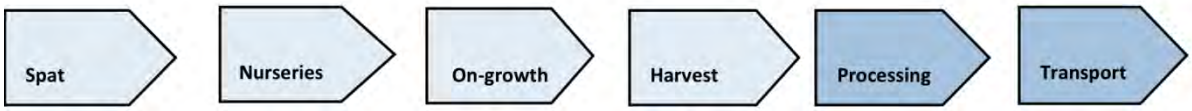

Figure 4. Flow-chart of the different steps in oyster production.

The European flat oyster (*O. edulis*) has a complex life cycle, which makes it a more complicated species to domesticate and breed in hatcheries compared to the Pacific, or cupped oyster (*Crassostrea gigas*), which is the most commonly farmed oyster species in the world. A sexually mature flat oyster is a hermaphrodite and can change sex, sometimes during the spawning season. Oysters breed naturally in early summer when the water temperature is about 15°C. The actual fertilization takes place inside the female's mantle cavity after the male sperms have been released into the open water. The larvae (fig. 5 B) develop inside the female on the gills for 1-2 weeks before they are released into the water. The larvae remain dispersed in the water column for about 2-3 weeks until settling on suitable surfaces, when they change (metamorphosis) into juvenile oysters, or spat.

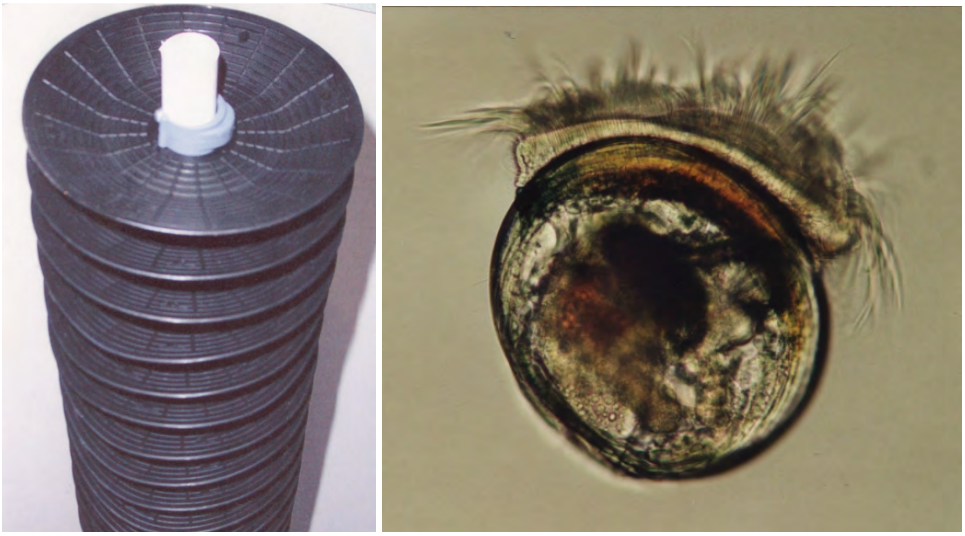

Figure 5 A. A system for spat collection, “chinese hats”, frequently used for collection of Pacific oyster spat in Europe. B. Flat oyster larvae.

In a hatchery, broodstock oysters are conditioned to breed and produce larvae by increasing the temperature to 16-18°C and feeding the oysters with adequate quantities of high-quality food (micro-algae). An essential part of hatchery production consists of growing microalgae as feed for adults, larvae and spat. There are several methods for algal production adopted by shellfish hatcheries, and some are more technically advanced such as the Biofence system (fig. 6 B). The larvae that are produced are collected and cultured in tanks until it is time for settling and metamorphosis.

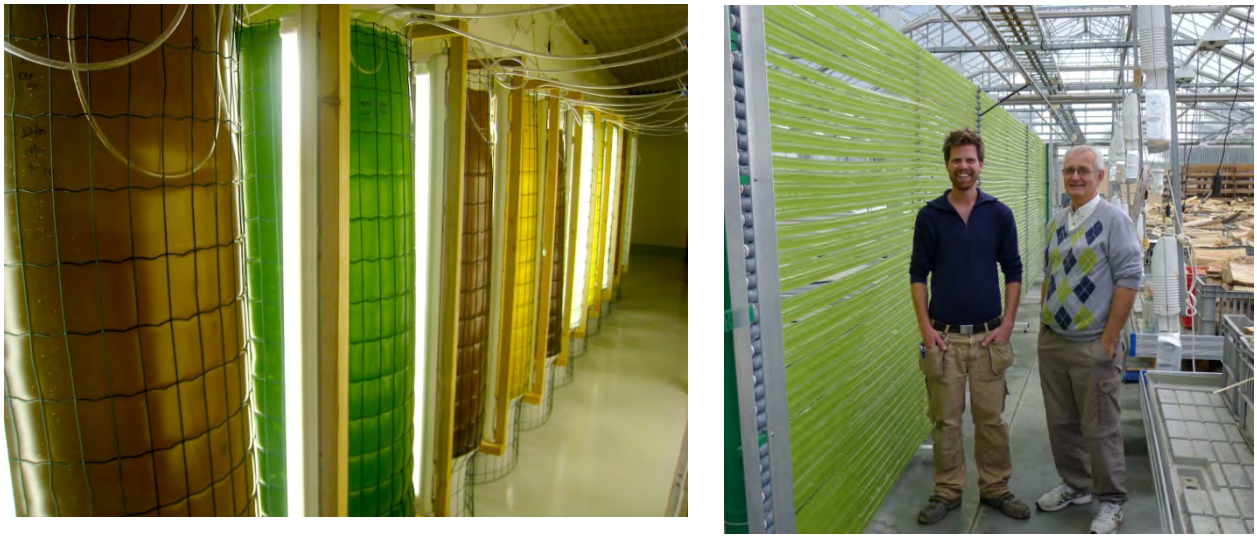

Figure 6. Methods for large-scale microalgae production in hatcheries. A. 300 L plastic bags B. Biofence system.

Spat grow to about 2-5 mm in the hatchery before placing them in nurseries, which can be either land-based or sea-based using various raceway systems, until they reach approx. 15-20 mm which is achieved within a year. The oyster spat are now moved into the sea, usually in suspended bags or cages (fig. 7) hanging from long-line systems or rafts. The rate of survival and growth can be highly variable depending on environmental conditions at the growth site, where temperature, salinity, availability of plankton (feed), biofouling and currents are the most critical factors for growth. Site-selection is thus a crucial issue for oyster farming and knowledge about the environmental factors is essential when choosing locations for oyster farming. In the sea, the oysters need to be regularly sorted and size-graded in order to achieve optimal growth and high survival. An annual mortality rate of about 10% is to be expected. A high labour input is also required to clean both the oysters and the farming equipment of predators such as starfish and fouling organisms. Some species of o sea squirts and barnacles can be a major problem. In optimal conditions, oysters reach consumer size in three to four years and are ready to harvest for further processing, packaging and transport to the market.

Figure 7. A raft system with oyster cages (Dark Sea Ltd) for on-growth.

1.4. Scandinavian perspectives for oyster farming

Production of flat oysters in aquaculture is a promising new enterprise in Scandinavia. First and most importantly, the harmful diseases Bonamiosis and Marteiliosis are not present in Scandinavian waters thus making it very advantageous to culture flat oysters in the region. In other parts of Europe where these diseases exist, high mortality rates make farming difficult. This puts Scandinavia in a unique position to develop flat oyster cultivation for export to lucrative European markets. Secondly, oysters are a native food product that can be produced in an ecologically sustainable manner. As such, oyster farming is not a controversial industry from an environmental perspective. Further, there is a high level of technology involved in the cultivation of oysters, thus making it a highly skilled industry, less dependent on labour and more on technical knowledge. Shellfish farming therefore fits within the existing economic framework for Scandinavian food production. Finally, prices for flat oysters are very high, and demand is growing on European markets for high-quality shellfish products. Flat oysters are a premium product subject to intense scarcity, thus opening the potential for rapid business expansion. A 2009 European Commission Fisheries study on the marketing and consumption of fishery and aquaculture products for instance, indicated that EU demand for oysters is growing rapidly and the price is increasing (http://ec.europa.eu/fisheries/documentation/studies/study_market/fap_exec_summary_en.pdf).

An important feature of the Scandinavian flat oyster production is the story telling associated with the product. There is a long history of oyster consumption dating back to the Stone Age, with royal privileges associated with access to oysters. Early attempts with historic aquaculture production forms, i.e. the poller systems, constitute an enormous strength in terms of branding of a unique product. The present low production volumes and the predominant production mode – fishing and collecting – are however major challenges for the development of a Scandinavian production of flat oysters.

2. BIOLOGICAL AND ENVIRONMENTAL FACTORS

Many parts of the Scandinavian coast are ideal for bivalve shellfish aquaculture, as these regions possess excellent physical, geographical and ecological characteristics suitable for near-shore extensive aquaculture of mussels and oysters. Apart from the most populated areas around the large city centres (Gothenburg, Oslo and Copenhagen), where human impacts on coastal water quality may impair food safety aspects, there is a large potential to establish oyster farming as a new industry in rural areas. Three crucial factors make oyster farming in Scandinavia particularly desirable

2.1. Disease and parasite-free growing areas

The most important biological (as well as marketing) argument for Scandinavian oyster farming is the absence of the parasitic diseases Bonamiosis and Marteiliosis The protozoan parasite *Bonamia ostreae* causing Bonamiosis spread rapidly throughout Europe in the late 20th century, and caused the collapse of much of the *O. edulis* industry in more southerly European waters. Scandinavian waters are currently free of this disease, thus putting Scandinavian counties in a unique position to develop flat oyster production for European markets. Scandinavian oyster populations exist at the very edge of the natural temperature range for this species, and it is speculated that the cold waters provide protection against spread of this parasite. However, the colder waters of Scandinavia also impede natural recruitment by causing fluctuations in reproduction within wild oyster populations, thus limiting natural supply of juveniles for a large-scale industry. Hence, spat production in hatcheries is likely a prerequisite for the development of a farming industry in Scandinavia.

As the reasons for the absence of Bonamiosis in Scandinavia is not conclusive, it is still essential for authorities and the farming industry to implement strong regulations and control of live oysters imported from areas where the parasite may exist, in order to protect the Scandinavian oyster populations from future possible infection.

2.2. Good water quality for shellfish aquaculture

Outside the large city centres, coastal water quality is excellent in the shellfish-producing water bodies, in terms of low levels of anthropogenic contaminants and microbial pollution, which allows for production of a premium product of a high safety standard and unique branding opportunities. In the rural areas, where the majority of oyster farming is likely to take place, shellfish production areas are predominantly classified as A (highest grade), and harvests can be conducted without including depuration which greatly reduces the cost of production. However, the on-going permanent classification of shellfish waters into A, B or C areas currently undertaken by the Swedish Food Safety Agency may result in some areas being classified as B and thus there may be restrictions to harvest and market oysters without a depuration step. To date, there is one geographically restricted small area outside the town of Grebbestad in Sweden which has been designated a B area, where oysters can not be harvested and sold without either a relaying period in A waters or depurated in approved facilities. Nevertheless, when the production volume increases, it might be of strategic importance for the industry to include depuration as a regular part of the production chain in order to minimize the possibilities that contaminated oysters reach the market, and to provide quality assurance to consumers. Perceptions of contamination, or poisoning events can lead to entrenched negative public attitudes regarding fresh oysters, and are one of the most serious marketing concerns.

2.3. Nutrient uptake: shellfish farming as a tool to improve coastal water quality

The coastal waters along the Swedish west coast, in the Danish Limfjorden and around the Oslofjord in Norway are characterized by high levels of nutrients, primarily due to nutrient runoff from agriculture. Eutrophication is considered a serious environmental problem for marine biodiversity in these areas. Shellfish aquaculture however, can benefit from this nutrient-rich environment, while also improving water quality. The high primary productivity of nutrient-enriched waters promotes fast growth of shellfish. Indeed, experimental works on oyster grown along the Swedish coast suggest that in some areas, oysters may reach a size of 50-60 mm ("cocktail oysters") within 18 months. Rate of survival and growth vary depending on the specific environmental conditions at the on-growth site, with factors such as temperature, salinity and food (plankton) supply being the most critical factors for growth. Site-selection is thus a crucial issue for oyster farming, and knowledge about biophysical factors is essential when choosing ideal locations for oyster farming. Also, there is seasonal variability in both growth rates and meat quality. Summer is not a good time for harvesting oysters, as at this time of year when the oysters breed and lose condition (e.g. decreased meat content, milky flesh). In Sweden, this is also the time of the year when the local demand from tourists and restaurants is highest. Live-storage and relaying to maintain product quality during these periods can be a solution for the industry to be able to supply the market with high quality oysters.

The nutrient-rich environment also promotes settling and fast growth of unwanted predators and fouling organisms. This problem is not unique to Scandinavia, although it may present a additional cost for Scandinavian producers as significant labour input is required to handle and clean fouled farm equipment and oysters, and labour costs are typically higher in Scandinavia than in other parts of Europe.

Shellfish farms can play an important role in environmental remediation by helping regulate nutrient flows between terrestrial and marine environments, by sequestering excess nitrogen and phosphorous and

delivering these organic products back as human consumables. In Sweden, for instance, the Environmental Protection Agency has recognized shellfish farming as a means to improve water quality and to address environmental objectives for balanced coastal ecosystems. Indeed, nutrient credit trading systems have been proposed in Sweden using shellfish farms as nutrient sinks to meet European Water Quality Directives. The recognition by authorities of shellfish aquaculture as ecological tools to improve coastal water quality is a major advantage for the establishment and governmental support to oyster and mussel farms compared to finfish aquaculture, which is restricted due to the environmental problems associated to fish farms.

2.4. Summary of SWOT regarding biological and environmental factors

Strengths

- Free from Bonamiosis and Marteiliosis is both a production and market asset
- High nutrient levels yields high productivity and fast growth of the oysters
- Clean waters- good marketing and seafood safety characteristics
- Recognition of shellfish farming as a tool to improve coastal water quality by authorities facilitates industry development

Weaknesses

- Variability in product quality due to seasonal factors
- Biofouling on farming equipment (not unique to Scandinavia)

Threats

- Spreading of diseases such as Bonamiosis and Marteiliosis
- Outbreak of seafood poisonings

3. TECHNICAL RESEARCH AND DEVELOPMENT

Scandinavian production of flat oysters cannot rely on fisheries of wild stocks if the production is to be stable for longer periods. Unpredictable recruitment among wild stocks currently limits increased volume production. A stable oyster production is thus dependent on controlled seed production with aquaculture as the solution.

3.1. Larvae production in hatcheries

One of the most pressing issues in oyster production is the development of land-based hatcheries that can supply the industry with sufficient amounts of seed on a regular basis. The principles of hatcheries have been described in a previous section of this report, but it is important to recognize that hatchery production of oyster seed is a specialised process requiring a high level of technological and scientific competence. European countries, which already have significant oyster production, such as France and Spain, have invested substantial resources towards developing flat oyster production in hatcheries. The specialised requirements for hatchery production in terms of equipment and knowledge makes it impossible for individual oyster farmers or small companies to meet the challenges for a continuous supply

of seed and specialized hatcheries, and thus expertise backed by a research environment, with strong government and university commitment, is required to build the oyster farming industry in Scandinavia.

Hatchery facilities and infrastructure for production of flat oyster spat exists in all Scandinavian countries. In Sweden, a new hatchery (Ostrea Sverige AB) began operation in 2008 on the island of Koster near the marine field station at Tjärnö, owned by the University of Gothenburg. In Norway, Scalpro A/S has produced flat oyster spat for several years, and has recently been involved in a European FP7 project (SETTLE) towards improving hatchery techniques for this species. In Denmark, the Danish Shellfish Centre (DSC) has over the last decade tried to establish a reliable seed production under a variety of R&D projects. All hatcheries are privately owned but DSC will in the near future become a part of the Danish Technical University. Key infrastructure for development of the oyster industry is thus present in each of the countries, yet considerable benefit could still be achieved through implementation of common Scandinavian R&D programmes for shellfish aquaculture development.

The Scandinavian hatcheries have, as other hatcheries worldwide, had problems with survival of larvae and continuity in the production. But in contrast to many other countries, there is limited academic competence and government or university support for this type of development in Scandinavia. In each of the Scandinavian countries, only a few researchers are engaged in shellfish research, and even fewer have specialized expertise with oysters. There is therefore still a need to benefit from technology and expertise from other parts of the world where oyster industries are well established. A regional collaboration across national boundaries would also help meet the challenges associated with the creation of sustainable seed production. Through the current project NORD-OSTRON, the basis for these necessary collaborations has been established, it has been demonstrated that regional collaboration can lead to very positive outcomes. To-date, NORD-OSTRON has involved hatcheries by providing access to international knowledge, and by increasing information among Scandinavian industry partners. The involvement of academic staff from relevant universities has further increased the level of experience and knowledge in this area. In parallel, the European funded SETTLE project has developed new and improved hatchery methods for flat oysters, thus providing knowledge that through academic networking has been made accessible to Scandinavian hatcheries.

3.2. Natural spat collection

Historically, spat in Scandinavia was collected naturally in pond-based nurseries (pollers) or in estuaries on special spat collectors. Although not reliable because of really variable recruitment, as well as being labour intensive, such alternatives are still potentially viable for small-scale growers, and are much simpler and less costly than the large investments required for a land-based hatchery. Traditional pollers are still in use in parts of Norway. A poller is an enclosed, shallow water basin where seawater is naturally heated by the sun to the required spawning temperatures (20-22°C). The poller system uses adult oysters collected from the sea, which are transferred to a poller, where larvae are released and settle on spat collectors deployed in the poller. Unlike hatcheries, the poller process is subjected to a wide variety of unpredictable environmental conditions. Thus the low-tech poller system is cost-efficient but does not produce seed in a predictable and large-scale manner. Also, it is only used during the natural spawning season and cannot be used year-round.

In the Limfjorden, Denmark, where summer seawater temperatures are much higher than in Norway, one producer has tried to establish a business based on specially devised seed collectors, which can be subsequently used to grow oysters almost to marketable size, thus reducing handling and labour costs. The system has to-date been proved efficient in collection of seed, but so far has not resulted in production of

either seed or adult oysters in sufficient quantities to sustain commercial production. In mainland Europe, many traditional oyster industries still use a variety of spat collectors, and new types of collectors are sometimes implemented, but so far innovation has not resulted in the development of a predictable and economically attractive method, particularly as most of these systems are highly labour intensive and thus not viable in Scandinavia.

3.3. Aquaculture grow-out

The grow-out stage of oyster production generally includes all processes from deployment of small oysters (seed) in sea-based nurseries to final harvest. Methodology and equipment for grow-out varies depending on local environmental conditions, and thus differs between Scandinavian countries, and even between sites within countries. Overall concepts however, are similar. In the Kattegat-Skagerrak region, highly nutrient-enriched coastal waters result in high biofouling loading of grow-out structures. Biofouling can become a problem for water exchange rates in trays, nets or cages where grow-out takes place, thus reducing growth rate and survival of the oysters. Oyster growers therefore need to develop skills and equipment to reduce handling costs for managing biofouling. In general, such management does not require expensive technological solutions, and is not unique to Scandinavian waters, but high labour costs in Scandinavia do require that the problems can be overcome without labour intensive solutions. R&D in this area is therefore still important.

3.4. Post-harvest challenges

As the oyster aquaculture in Scandinavia is currently still small, post-harvest facilities for processing, storage and depuration have not been extensively developed. Likewise, transportation and logistics have not systematically been organised and implemented. For the industry to develop beyond the level of direct sales, the supply chain needs to be developed. Logistics, transport and storage are currently only a matter of implementing available technology, as the industry can to some extent rely on experiences and network of the already well-established seafood sector. Product development focused on post-harvest value adding provides many opportunities for implementation of new technology, some of which has already been invented here in Scandinavia. Post-harvest challenges do not need to be solved in the short term, but are important in the long run (e.g. 5-8 years).

3.5. Summary of SWOT regarding technical factors

Strengths:

- Infrastructure and technical facilities for spat production are available.
- A regional scientific collaboration has been established allowing for technological development and transfer of knowledge.
- Scandinavia has existing infrastructure and competence in fisheries and aquaculture for transport and distribution.

Weaknesses:

- Still unstable seed production in hatcheries and pollers with need of technological improvements.
- Research and development is highly dependent on external (public) funding and further development of the scientific knowledge and technology is required.

- No systematic interaction between industry and scientific institutions.
- Dependence on logistical solutions that are not tailor-made to oysters

Opportunities:

- Common Scandinavian R&D programmes for aquaculture development.
- Further technology transfer from other parts of the world.
- Logistical solutions due to market demand and/or increased production volumes.

4. MARKET AND PRODUCTION FACTORS

4.1. Market situation

Global trends

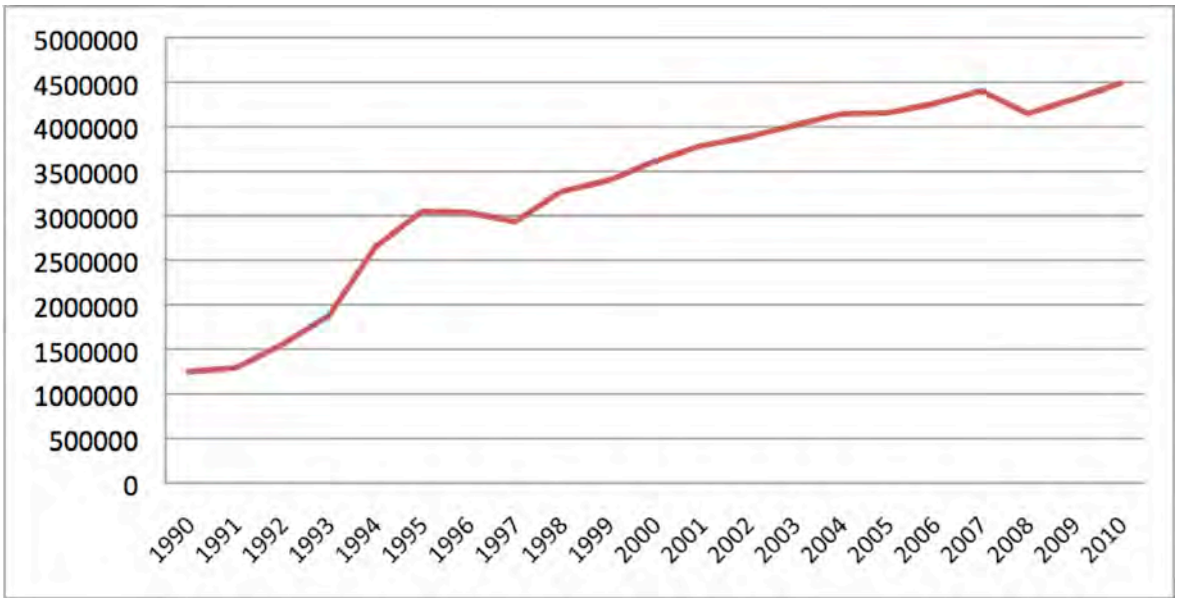

Figure 8. Global production of oysters in tons, 1990 - 2010. Source: FAO statistics

The global demand for oysters has increased in recent years. This is expressed both through a steady increase in production from 1997 onwards (Fig. 8) and increased imports into major markets. In general, there has been a massive increase in global production from around 3 million tons in 1997 to 4.5 million tons in 2010, which is an increase of 50% over only a 13-year period. The increased import of oysters to Japan is the most striking feature of international trade in oysters.

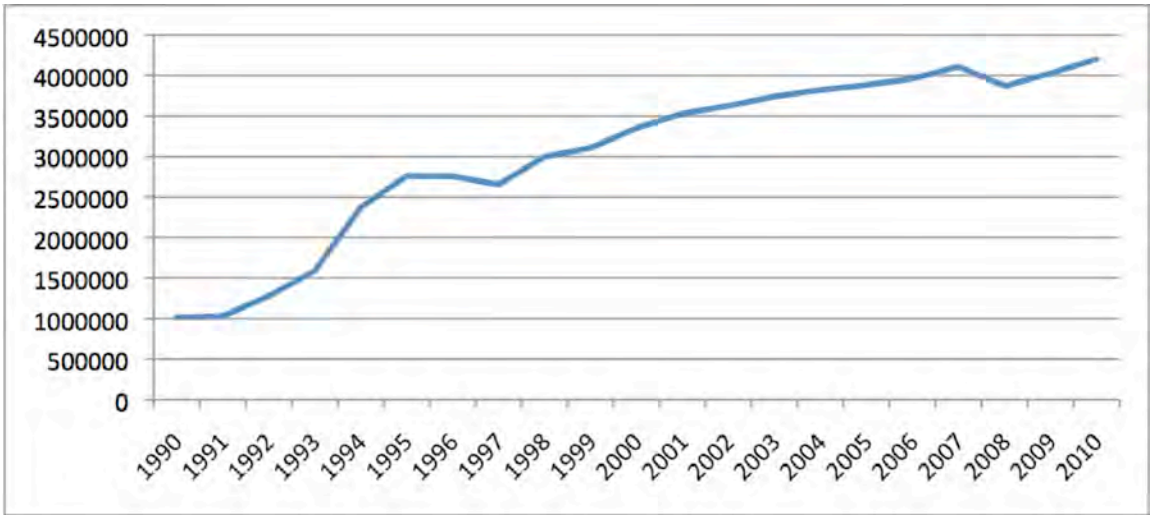

Figure 9. Asian production of oysters in tons, 1990 - 2010. Source: FAO statistics

The most dramatic increase in production has occurred in Asia, which in 2010 produced 93% of all oysters (by volume) in the world (Fig. 9).

Figure 10. European production of oysters in tons, 1990 - 2010. Source: FAO statistics

In contrast to the strong growth in oyster production worldwide, mainland European countries such as Spain and France, which formerly had large industries, have shown a steady decrease in production, particularly in recent years (2008-2012) due to a series of disease outbreaks (Fig. 10). Demand for oysters in these markets remains strong, and increased imports to replace domestic production have come from Chile, Greece, Ireland and Scotland among others. European flat oysters in particular, have shown a major decline from a peak output of over 16 thousand tons in 1961 to around 6 thousand tons in 2009. In the 1980s and 1990s there was a strong shift to rearing of Pacific cupped oysters (*C. gigas*), primarily due to disease outbreaks of Bonamiosis and Marteiliosis, affecting the flat oyster production. But as disease such as Marteiliosis and Herpes infections have become more prevalent, cupped oyster stocks have also been affected.

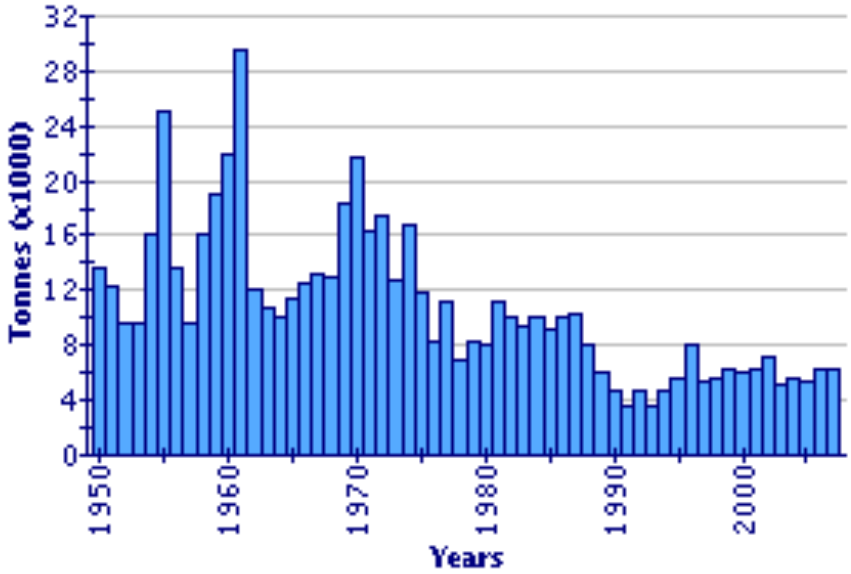

Figure 11. Global aquaculture production of flat oysters (*Ostrea edulis*) (FAO Fishery Statistics)

The European flat oyster production has remained low throughout the decade 1993-2008 from around 4000 to 7000 tonnes with a peak in 1996 (7 996 tonnes, fig. 11). The main producer countries are Spain with around two thirds of the production volume, followed by France with one fourth of the production. Ireland and UK have had minor production. In 2002 the European flat oyster industry constituted less than 0.2% of the total global production of all farmed oyster species. The value was estimated USD 24.3 million. Although a relatively small amount, it remained important to the domestic sector in the few areas where it was farmed.

Flat oysters are just one of the many oyster species, and consequently face substitution in the market unless cultural preferences or strong niche marketing efforts differentiate them from other species. For instance, flat oysters have historically fetched higher prices in the European market place, with an average wholesale price 3 to 5 times greater than that of the more common Japanese oyster. The product therefore occupies a unique economic niche, and is considered as a luxury seafood item - an expensive delicacy for specialized consumers. The experience within the mussel industry shows that European consumers have a curiosity for shellfish grown in Scandinavian waters. Scandinavia already has strong market power because of public perceptions about its “clean” waters for seafood production.

4.2. Market opportunity in Europe

In Europe the production of oysters has decreased by approximately 18% since 2004, while the value per unit sold has increased by 23%. The largest drop has occurred in France due to disease of the variant of the Ostreid herpes virus 1 (or OsHV-1). In 2010, the oyster harvest in France plunged 38% to 80,000 metric tons from about 130,000 tons a year earlier, according to the national shellfish-growers committee. Recent years have seen extremely low production volumes and hence scarcity, driving price upwards. Between 2009 and 2011, farm-gate prices in France increased by 65%. Prices continue to fluctuate depending on size and local availability, but are currently at an all-time high. Retail prices in some parts of Paris climbed to between 14 and 17 euros per dozen in 2011. The total annual sales price of oysters in France for 2009 was estimated at 630 million euros, and this is only a partial fraction of the total European market. There is no

reason to believe that the French oyster industry will solve the problems with the herpes virus in the near future, and Spanish and UK oyster growers are also reporting problems. Therefore the Scandinavian oyster industry is ideally situated in the market provided they can increase production levels.

Lack of trade barriers and easy access through the trade agreements in the European Economic Area also makes Europe a more natural market for Scandinavian producers than more distant locations such as the US or Asia. However, a clear understanding of consumer preferences and seasonal patterns in the European market need to be understood in order to make marketing within Europe effective. Currently, Scandinavian producers are unable to produce flat oysters in sufficient volume to export. There are currently only a small number of producers, and inability to produce a consistent volume of high-quality oysters on a regular basis implies that export markets may not be the way forward at this stage, but focus should instead be on local and national markets as most relevant for producers. Expansion of domestic markets through concerted generic advertising campaigns focused on health benefits and luxury characteristics of shellfish might be extremely beneficial as Scandinavian per capita consumption of shellfish is currently very small relative to many other developed countries in Europe and North America.

4.3. Market opportunity Scandinavia

In Scandinavia, the majority of oysters consumed are imported rather than produced domestically in spite of excellent natural conditions for developing an oyster aquaculture industry. In Sweden, for instance, the average volume of landed oyster production is around 10 tons, while imports amounted to over 300 tons in 2010 (fig. 12). In Norway, the situation is somewhat similar, with domestically produced oysters only accounting for a small percentage of the national consumption. Domestic consumption is also growing. In Sweden, in the seven years between 2002 and 2009 oyster imports increased 10 fold, from 30 tonnes in 2002 to 350 tonnes in 2010. Domestic landing of oysters in Sweden however has at the same time remained small, less than 10 tonnes per annum. As such, oyster landings in Sweden represent only around 3% of the volume of imported oysters. Domestic consumption is growing within Scandinavia, and local production as well as more competition in the market –with inherent price reductions – would likely increase this level of consumption even further.

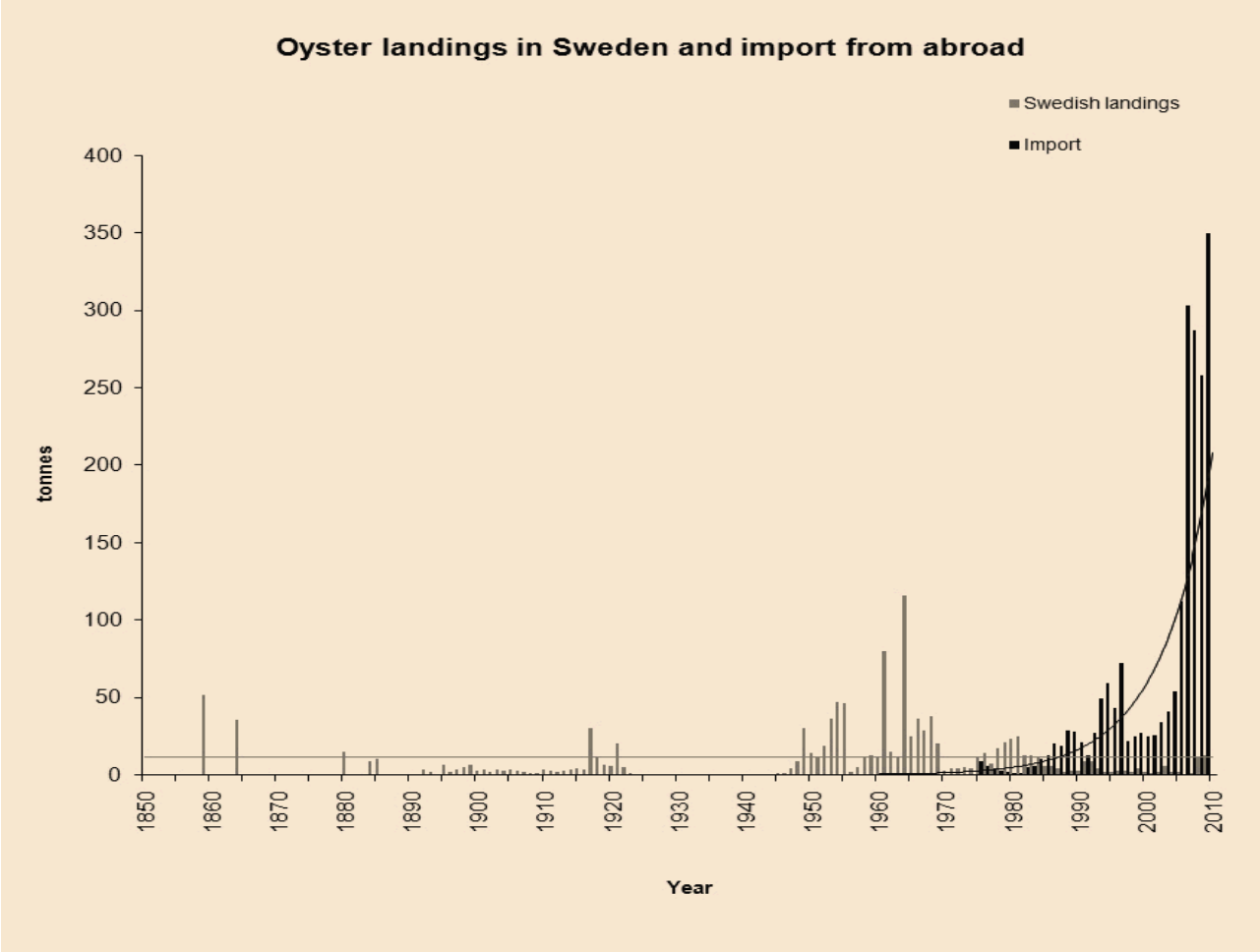

Figure 12. Import and landing of oyster in Sweden 1850 – 2010 (after M. Ulmestrand)

In Norway, similar statistics are observed, where the import of fresh oysters has increased from a low of 30 tonnes in 2008, to over 60 tonnes in 2011 (fig. 13). This doubling of demand in only a few years indicates the same changing consumer preferences as in Sweden. Like in Sweden, import of oysters exceeds by far the national production. For example, from 2001 to 2010 production of oysters in Norway represented on average only 10% or less of the volume of imported oysters.

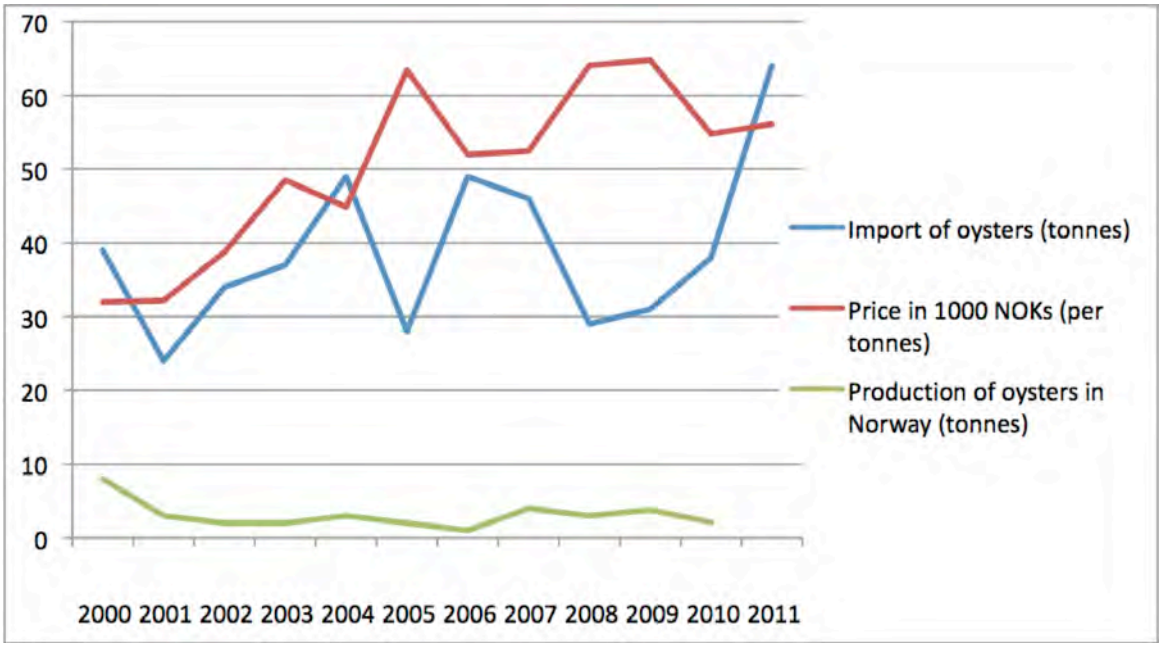

Figure 13. Production and import of oysters to Norway (in tonnes) and price (*1000 NOK per tonnes), during 2000 – 2011.

The market price of oysters is also increasing. The wholesale price of oysters today is almost double the price what it was only a decade ago. This major increase in both demand and price demonstrates that a national oyster industry could easily replace, at least in part, the import of oysters without having any major effect on price (Source: Norwegian Seafood council).

In Norway the overall export value of shellfish in 2011 was 900 mill NOKs, which is not insignificant. There has, however, been a decrease of 50% in the volume of production over the last ten years, with exports falling by 35%. The current trend however, has been slightly more positive, where since 2010, there has been a slight increase in production levels (~12%).

One of the strongest influences on price within the Scandinavian market has been the seasonal opening of the Danish oyster fishery that for the last decade has influenced the market by providing a substantial proportion of the total European flat oyster production mainly as export to Spain and France where the oysters to some extent have been relayed. Flat oysters growers in Scandinavia will need to be able to carefully control aquaculture supply during the annual Danish 'flooding' of the oyster market to maintain a price premium for year-round availability. Such quality differences are already well established in the European market, thus making this a lesser consideration in export markets. Recent development in the Limfjorden standing stock of flat oysters will enhance the need for an aquaculture production as TAC has been decreased over the last two seasons due to lack of recruitment to the natural population. From TACs above 1,000 t annually for the last 5 years, TAC for the 2012/13 season is 200 t and even smaller TACs can be expected in the future. This will not only benefit prizing of cultured Scandinavian oysters but can also be the necessary stimulus to kick-start a Scandinavian aquaculture production of flat oysters.

4.4. Market strategies Europe

Oysters are currently sold in several product forms, including canned, frozen, dried, salted, smoked as well as obviously fresh or chilled. Flat oysters are sold mainly live (fresh, chilled). In Europe, relevant markets are very quality conscious, and there are significant price differences relative to species growth, quality/grade, size, origin and production season. There are a number of companies that are already well established in this market, and in order to penetrate the European market, it may be important for Nordic manufactures to link up with, or establish partnerships with existing distributors. One of the essential prerequisites to succeeding with exports to European markets is the ability to deliver oysters in large enough volumes, with consistent quality characteristics at affordable prices. Producers currently struggle to meet distributor's requirements, both with regard to reliability and quality. In part, this is due to a lack of good processing and packaging facilities, but also a limited ability to deliver the required volumes.

Scandinavian oyster producers will need to acquire a better understanding of demand-characteristics of export markets. As an example, one of the most discouraging aspects of mussel production in Norway has been the lack of targeted marketing, with clear understanding of consumer trends and seasonal demand in receiving markets. In France, which is one of the largest shellfish markets in Europe, only 5% of domestic production is exported, and primarily to near-neighbours such as Belgium, Germany, Italy and Switzerland. Only 7,000 metric tons are exported to Asia. At the moment, France also imports about 3,300 metric tons of flat oysters from other European countries. Such figures indicate clear demand within the French market, as well as potential for export to other countries. Oysters and mussels have distinct market characteristics, and are not similarly marketed. A third of oysters in France for instance, are sold live in retail (city fishmongers), a third are sold to restaurants, and the remainder is sold directly as local production. In contrast, almost 75 % of mussels are sold at the retail level. The buying pattern also differs. Oysters are generally considered to be a spontaneous purchase, reserved for special events and holidays (e.g. the largest volume of sales in France occurs at Christmas/New Years). Mussels, on the other hand, are often bought specifically as part of a meal, so the purchase is generally planned, and thus prepared products (e.g. cleaned, on the half shell or frozen with sauce) are more desirable for ready-made dinners.

In the oyster market, the relationship between customers and suppliers is well established, and the lack of labelling on fresh seafood often means that consumer preferences display strong loyalty to particular trusted shops or retailers. As most of French consumption is also produced domestically, French buyers have developed local preferences for oysters, and are at the same time potentially sceptical of new products, even if they might be curious, for instance about Scandinavian flat oysters. A strong relationship with buyers is therefore necessary. In order to reach the European market it may also be necessary to establish a generic marketing strategy, in order to establish Nordic oysters as high-quality product. A major drawback for Scandinavian producers is that the average price of flat oysters among retailers in France is currently on par with the export prices of Norwegian oyster farmers. Even with the currently high prices in European markets due to difficulties experienced by French oyster producers, Scandinavian producers will need to increase efficiency and reduce their production cost in order to provide oysters at competitive prices to European retailers.

There are currently only a few shellfish producers in Scandinavia, and to-date there have been no concerted efforts to build professional producers organizations or marketing boards. The existence of such entities are necessary for a strong generic Nordic marketing strategy to emerge, thereby facilitating export to the EU and ensuring high returns on investment for Nordic producers. A clear marketing strategy is needed not only for exports, but also to secure and increase the value of Nordic domestic markets. Given current trends, it is very probable that there will be continued sharp increases in domestic shellfish

consumption within Scandinavia. Current scarcity in European markets however, is liable to drive import prices upward, thus increasingly limiting an existing niche market. If competitiveness can be maintained, and a clear marketing strategy established, a much larger domestic market segment is likely.

One of the most critical limitations is currently not only a lack of processing facilities, but also a clear distribution and marketing capability. With the development of shared Nordic processing facilities and trade organizations, economies of scale become possible. Collaboration can also facilitate uniform packaging for brand recognition, management of supply and demand, as well as and better handling of distribution networks. Standard methods need to be developed to store the oysters (on crushed ice, nitrogen freezing or use of gel-ice). In Norway, there has until recently been a lack of cooperation among mussel growers to develop branded, distinctive products. As such, competition among growers selling undifferentiated products undercuts margins. Growers or trade organizations can instigate marketing campaigns abroad to control prices. Ultimately, with an increase in the volume of production, and clear market strategies, Nordic growers may be able to eventually engage in price-setting behaviours.

The premium value of Scandinavian oysters can be established in a number of ways. This includes quality assurance and clear branding based on place of origin. A local seafood tourism industry is also important, in order to develop the profile of individual growers. Development of a local profile for the industry is perhaps one of the easiest initial steps towards establishing a reputation for Nordic growers. It will be important to study the many examples from other parts of the world in regards to developing local tourist interest in shellfish, as well as advertising material towards clear brand recognition for wholesale. Many examples are presented in Appendix A of other countries or regions, which have organized marketing strategies for generic brand recognition.

4.5. Market strategies Scandinavia

Scandinavian oyster farming is still in early stages of development, and thus local niche marketing directly to restaurants and consumers is one of the most accessible and viable ways for the current farming industry to move forward. Scandinavian demand for oysters is high, and demand will continue to increase if efficient aquaculture production can supply the market with a year-round, consistent and reasonably priced product. The Danish oyster fishery seasonally has a strong influence on the market (see 4.3.), and even though the production volumes from the oyster fishery in Denmark are predicted to decrease in the future, oysters farmers in Scandinavia will need to be able to carefully control aquaculture supply during the Danish fishing season, and demonstrate to consumers through marketing of the higher product quality of oysters grown on farms, and their year-round availability, is worthy of a price premium.

Prices will naturally fall with more entrants to the industry and more competition, at which point, it will be important to begin capitalizing on economies of scale. Commensurate with larger production volumes, it will then be possible to start looking outwards to European or Asian markets, where there is equally high demand for these products. Flat oysters fetch good prices due to scarcity, but there are still a lot of hurdles, which need to be overcome for the development of oyster aquaculture in Scandinavia.

Initial short-term goals to develop the domestic market may include arranging local or national oyster festivals with the purpose of introducing new consumers to oysters as a high-quality, luxury product. Farmers could also be more pro-active towards local tourism, but having public signage or interpretive events to show how oysters are grown. It is also possible to have direct retail opportunities by arranging tours, gastronomic events and oyster tasting on-site at farms. There are also many opportunities for selling oysters to local fish shops, restaurants and seafood bars. In many parts of Scandinavia, the demand from

restaurants for oyster products far exceeds what local producers can deliver. At the moment, this has not provided incentives for broader marketing strategies, though some producers in Norway have entered into sales agreements with chains of restaurants in order to facilitate wider distribution and visibility for their products. Good relationship and co-arranging events with regional tourists board is clearly important for local visibility. Public perceptions about oysters may differ slightly between the Scandinavian countries. Sweden and Denmark have traditionally been consumers of oysters, more so than Norwegians, but this has been changing as a result of the higher purchasing power of Norwegian consumers, and increased interest in foreign gastronomy, especially involving high quality seafood products.

Retail markets are much harder to penetrate than the hotel, restaurant and institution (HRI) trade, and require an ability to produce in predictably large volumes with excellent professional packaging facilities. The nature of the retail industry requires consistent delivery and product consistency. This implies greater attention to quality control in production, as well as careful timing of harvest to meet market demand. At current levels of production, it would also require careful cooperation between farmers in order to meet both consistency and volume of supply.

4.6. Summary of SWOT regarding market and production factors

Strengths

- Good production localities (Sweden and Denmark), fairly good in Norway
- Disease free areas
- Relatively good knowledge and competence on fish farming – some of which is transferable to farming of oysters
- Success achieved in other countries with somewhat similar production opportunities – also achievable in Scandinavia (see Appendix A)

Weaknesses

- Relatively high capital investment
- Price sensitivity
- Slow return on initial investments (4/5 year production cycle)
- Unstable production
- Limited access to capital (pre-seed, seed etc.)
- High cost of labour

Solutions/opportunities

- Improve the value chain (handling, packaging on land, transport etc.)
- Raise awareness of shellfish industry as a basis for rural employment and economic development
- Link oyster production with other income earning opportunities (tourism)
- Create producer/trade organizations
- Market initiatives for raising domestic demand

Threats

- Competition from Danish oyster fishery, with low production costs and seasonally high production volumes

5. REGULATORY FRAMEWORKS AND INSTITUTIONAL FACTORS

Policies, regulations and institutional factors play an important role in supporting development of an oyster farming industry, and a better understanding of these factors are of outmost importance to ensure successful growth. Examination of the historical development of shellfish aquaculture industries outside of Scandinavia may provide insight into factors, which have promoted successful development elsewhere (see Appendix A). In fact, the very rapid industry expansion, which has occurred in countries such as Canada and New Zealand shows that industry success is often, at least in part, due to factors relating to the active role of policy makers and regulatory bodies, for example in facilitating the access to lease areas, planning for strategic economic development, and facilitating industry and government-funded research programs. Government and regulatory agencies also play an important role in creating a positive public perception toward aquaculture and its products. Government needs to be responsible for leading this focus with clear strategies and vision.

In this section, the regulatory frameworks and existing support and mandates for the shellfish aquaculture sector are described and a comparison between the three Scandinavian countries are summarized in a SWOT analysis.

5.1 Lease application processes and access to sea space

Access to lease sites is the first, and perhaps most fundamental, need of the aquaculture industry. Without clear access to sea space for cultivating shellfish, there is no possibility for industry growth. However, in many examples from abroad, it has been shown that simply developing permitting systems to allow access to lease sites is not adequate to stimulate economic development of the industry. In some countries, high levels of speculation about the potential inflationary value of leases leads to significant numbers of aquaculture permit applications, while actual aquaculture operations remain underdeveloped or inactive. As such, the availability of permits does not necessarily translate to productivity, and some form of clause is potentially useful in making permits redundant if there is no production for a significant period of time (3-4 years). At the same time, tenure for active operations must be long enough to guarantee returns from investment in infrastructure (10-20 years).

There are different national acts and laws as well as responsible authorities regulating the access and permits to sea space in Scandinavia. In Sweden, legal statutes governing aquaculture leases are contained under the Fisheries Act and the Environment Act. The County Administrative Boards (Länsstyrelserna) are responsible for directly handling lease applications, but several other institutions are also involved, such as the local municipality where the lease is situated, as well as the Swedish Transport Agency and Swedish Maritime Administration. In Denmark, access to mussel and oyster leases is specified in Ministry Regulation 267 under the Danish Ministry of Food, Agriculture and Fishery. The Danish AgriFish Agency is the responsible authority, which submit the lease application for review by other national (e.g. Danish Maritime Authority) and local (municipalities) agencies and stakeholder organisations. In Norway, three different Acts are relevant to the leasing process: relating to aquaculture, the Act relating to the management of wild living marine resources, and the Act relating to food production and food safety.

In Norway, the county council (Fylkeskommunen) handles permit applications, but with the involvement of several other institutions at the national and regional level with responsibility for environmental protection, food and food safety, pollution and spatial planning. Also, local authorities for wildlife, environment and outdoor interests have the right to comment on the plan prior to the granting of sites for shellfish production.

In addition to the regulations and official bodies, public and/or private parties are also involved in the process. In Sweden, a prospective shellfish farmer needs permission from local landowners if the lease is situated within a privately owned marine area, as access to sea space can be limited by the interest of upland owners who also control access to historic oyster beds. In Sweden, private individuals such as cottage owners may also raise objections to leasing, and can cause significant delays in permit issuances, and in some cases obstruct issuance of permits indefinitely. In Norway, plans for a shellfish farm will be put out for public comment, wherein local landowners and the business community have the right to raise objections. Typically such objections and obstructions do not occur in Denmark, where private parties are not consulted during the permitting process. Because many levels of government are involved in the process, it can sometimes take several years (18-36 months) in Sweden to get a permit, especially in cases where private or public parties appeal against the farm installations. In Denmark it generally takes 4-12 months for the application to be processed, while in Norway, the average time is 6-12 months. Norwegian regulations prescribe that applications should take no longer than 22 weeks, but this is seldom achieved.

Regarding fees for lease applications, there are no specific fees to get an aquaculture permit in Sweden, but licensure is costly in relation to the time and labour required. There is no support for the establishment of leases and it is up to the farmer to do all the planning and paperwork. Similarly, there are no fees in Denmark, but a bank guarantee (approx. 200.000 DKK) is required in order to secure clean- up of the lease area (should the farm fail). In Norway, a fee of 12.000 NOK is required for all applications under the Aquaculture Act and regulations. Also, an additional fee of 3000 NOK has to be paid for applications of other species than salmon, trout and rainbow trout, thus rendering the overall cost for an oyster-farming lease at 15.000 NOK. A bank guarantee of 2500 NOK per acre to secure clean up of the leased area is also required.

Providing appropriate security of tenure for lease contracts to investors is important for aquaculture development. In Sweden today, permits are sometimes only given for 3-5 years, after which time the permit has to be renewed through a new application process. This is not an adequate time-scale for security of tenure, and such a short leasing period limits investor interest in Swedish shellfish farming. In Denmark, permits are generally given for 10 years with options for extension, thus giving investors incentive to develop infrastructure and for new growers to achieve business stability before the end of the leasing period. Permits are dependent of use and if an area is not used, the permit will be withdrawn. Licences for aquaculture in Norway are not time-limited once approved, provided that management of the shellfish farm meets environmental and safety standards. After receiving a permit, the leaseholder has two years to start the shellfish farm, or the permit is cancelled.

Governments that engage in proactive spatial planning can eliminate much of the bureaucracy and controversy associated with shellfish leaseholds. In other countries, government and regulatory bodies for instance, have set aside significant tracts exclusively for shellfish leaseholds as part of comprehensive marine coastal planning. It is not clear why in Sweden similar pre-designated areas have not been made available for shellfish aquaculture, even though local municipalities are required to take aquaculture into consideration when engaging in marine planning. Currently it would appear that there is a lack of knowledge in municipalities about how to plan for aquaculture installations, a situation that is also true in

Denmark. In Norway, there are no national pre-designated areas for shellfish aquaculture but at the local level, many municipalities have designated areas for shellfish farming in their land-use plans. The Norwegian government is also currently developing tools to improve planning of aquaculture installations at the local and regional level.

5.2. Regulatory responsibilities with regard to seafood safety, trading and disease control

Reputation and image are very important for growth of a new industry, and ensuring that there are relevant regulations in place for health and environmental compliance is not enough to support strong development. For instance, many governments test shellfish for food safety, but do not provide active public education programs to inform the public about the reasons for safety testing programs, as well as the many health benefits of consuming shellfish. As a result, consumers hear only about safety risks rather than a balanced view including the rarity of illness, and the relative benefits of shellfish consumption. Such an approach will not inspire the type of public confidence necessary develop a strong industry.

In order to protect the industry, it is also critical to implement shellfish disease monitoring programs, as well as implementing careful restrictions when it comes to import/export of live oysters, as the spread of shellfish diseases, while not of human health concern, can be devastating for the industry. A recent discouraging example of a disease outbreak is the Oyster Herpes Virus (OsHV-1), which has devastated the French and New Zealand oyster farming industries, and is easily spread between populations causing mass mortalities and economic losses. Careful management in the movement of oyster stocks could reduce or eliminate the spread of this disease. Currently, Scandinavian stocks appear to be uninfected and thus it is imperative to implement strict prohibitions on stock movement.

Shellfish sanitary testing programs in Scandinavia are subject to EU and national regulation, with various National governmental bodies responsible for monitoring and execution of sampling programs. In Sweden, it is the National Food Agency that is responsible for shellfish safety in regards to human consumption. There are no fees incurred by the farmer for safety testing, but farmers must be actively involved in collecting samples and transporting those samples to the testing lab. The monitoring program currently has an annual cost of approximately 2.5M SEK, which is fully subsidised by the Swedish government. The corresponding authority in Denmark is the Danish Veterinary and Food Administration. Danish farmers are responsible for sampling, transporting samples to testing labs and for the full cost of the monitoring program, which currently amounts to approx. 6000-8000 DKK per week of harvest. In Norway, it is the Norwegian Food Safety Authority together with the Norwegian Veterinary Institute who conducts seafood safety testing. Farmers are responsible for taking samples and the cost of transport of samples to the testing labs. Previously, farmers paid 7000 NOK per year in addition to costs of tests during harvest time, but authorities have been reviewing the fee system lately, and the fees paid during 2010 were repaid to the shellfish farmers. From 2011, there will be no fees for the shellfish sanitary program in Norway.

At the moment, new EU regulation requires that each country institute a classification of shellfish waters into production areas of class A, B and C. This task is currently underway along the Swedish west coast by the Swedish National Food Agency but it is both a timely and costly process. This shellfish waters classification will have a major impact on the future expansion of the industry depending on how many areas that fall into classifications A, B and C respectively. Already, one important Swedish oyster fisheries area has been designated as class B, which will severely restrict further harvesting of oysters at this location. In Denmark, each lease is currently being considered as an individual area that will earn status as a class A area after such time as 18 out of 20 water quality samples have been negative. But future leases will only be granted in areas already designated as safe "mussel" producing-areas (A-areas) as defined in the EU

Shellfish Water Directives (2006/113/EC). In Norway, there is no general permanent classification of the coasts into A, B or C areas. When a new application for a lease is processed, authorities plan to conduct necessary analyses and designate the area as either A, B or C. Only A areas are suited for shellfish farming. If the area is designated as B, the leaseholder must obtain a special permit to uphold the lease.

To conclude, lease permitting for new oyster farms may be very difficult in areas permanently classified with a B designation. It is recommended that oysters leases are located in A-classified areas, both for sanitary and economic reasons.

When it comes to export/import and trading of live oysters, there are both EU and national regulations in place in all Scandinavian countries. In Sweden, the Swedish Board of Agriculture is responsible for handling applications and permits for international trading of live animals. Both the exporting and importing party need to be registered as importers or exporters with the Board 30 days prior to the import/export occasion. There is a small registration fee (500 SEK) for the importer only. A health declaration (transport documents) is needed for import of living shellfish, which are to be transferred to marine holdings (e.g. introduced into the marine environment). The required tests needed are slightly unclear at the moment, but the shellfish must come from an approved area and show no signs of disease. Costs for obtaining such health declarations are paid by the industry. In Denmark the Danish Veterinary and Food Administration are the responsible authority for managing import/export of shellfish. Registration with the Danish Veterinary and Food Administration is required and there is a small registration fee for the importer. For import from outside EU, a fee for the health certificate is required. Similar to Sweden, a health declaration (transport document) is needed for import of live shellfish, which are to be transferred into marine areas in order to prevent spread of disease. This is especially the case for the Limfjorden, which is certified to be free from Martelia and Bonamia parasites. Import to the Limfjorden is only allowed from other certified parasite-free areas. Costs for obtaining a health declaration are paid by the industry. Similar protocols are in place in Norway.

Disease control programs, regulated both by EU and national legislations, exist in all countries. The Swedish Board of Agriculture together with the National Veterinary Institute are responsible for animal health and there is a control program in place for known diseases requiring control programmes, but only for wild populations and with limited temporal and spatial replication and sampling sizes, or in the case of unusually high mortalities. The Danish Veterinary performs similar functions and Food Administration performs for wild shellfish populations. In Norway, it is the Norwegian Food Safety Authority and Norwegian Veterinary Institute who are in charge of a national disease control program for both wild and farmed stocks. Currently, 22 sites are included in the program, which also includes two oyster farms. No fees are paid by the industry at the moment in any Scandinavian country, as disease control programs are fully subsidised by the government in all countries.

5.3. Existing support and mandates for aquaculture development

One of the key success factors to the development of new industries is governmental support, and the specific formulation of strategies where challenges are identified. In Sweden, an official report on Aquaculture development "Det växande vattenbrukslandet" was published in 2009. This was followed by the preparation of a National Strategy for Swedish Aquaculture by the Swedish Board of Agriculture (completed in June 2012"Svenskt vattenbruk- en grön näring på blå åkrar. Strategi 2012-2020"). The strategy has been developed in collaboration with official bodies, industry, research and non-governmental organisations, and will be followed by an action plan during autumn 2012.

In Denmark, "Muslingeudvalgets hovedrapport" from 2004 includes an overall national strategy for the development of the shellfish industry. In 2011, the Region of Nordjylland also created a regional strategy for the development of the aquaculture sector, including the highly productive Limfjorden region. Such strategies are being implemented through allocation of regional growth and innovation funding and the European Fisheries Fund.

In Norway, there are several strategies for the development of the marine sector: The government's strategy for Norway's marine sector; “Environmentally Sustainable Aquaculture Industry” (2009) by the Ministry of Fisheries and Coastal Affairs and “Sustainable Seafood - alfa and omega”. Implementation is being done by relevant ministerial action plans as follow-up of the national strategies.

5.4. Funding for research and development, subsidies to growers

There are no national research programs specifically for applied aquaculture research and industrial development in Sweden, but funding for research is allocated through VINNOVA, FORMAS, and Havsmiljöanslaget (Swedish Agency for Marine and Water Management). In Denmark, national funding bodies include GUDP, Danish Strategic Research Fund, European Fisheries Fund (EFF), and Local Action Groups for Fisheries (mostly industrial development and only 30-50% coverage). On the European and Nordic level, funding is available through the 7th European framework program, Interreg and the Nordic Innovation Centre.

In Norway, aquaculture research is prioritized and funding is available through the Norwegian Research Council and the Norwegian Seafood Federation, though in practice, such bodies primarily fund finfish research and not shellfish. Individual coastal municipalities have their own corporate fund for development of the private sector that includes aquaculture enterprises. There is also sometimes funding available for aquaculture pursuits at the regional level under the auspices of county councils. Innovation Norway has several different funding mechanisms that are relevant for aquaculture (low risk loans, seed capital, stipend, establishment stipend etc.).

When it comes to subsidies to farmers from public sources, farmers may obtain 30-40% subsidies for new investments in aquaculture from the European Fisheries Fund in Denmark and Sweden. In Norway, business enterprises engaged in research and development activities may apply for a tax deduction of up to 20% of R&D project costs for SME's under the SkatteFUNN scheme. To be eligible for a tax deduction, business enterprises must be subject to taxation in Norway, although they do not have to owe tax.

5.5. Summary of SWOT regarding regulatory frameworks and institutional factors

In summary, there are numerous strengths and weaknesses regarding the current regulatory frameworks in Scandinavia for governance of shellfish aquaculture. Some of the strengths include good coastlines in all countries for access to lease sites, and a reasonable length of tenure in Denmark and Norway. Although Sweden could benefit from a longer length of tenure, Sweden, like Denmark, does not have leasing fees for applications. Norway has led the Scandinavian countries in its local land-use planning for aquaculture, with designated areas set aside for aquaculture.

Basic strategies for development of the aquaculture sector exist in all countries, and Denmark and Sweden provide some subsidies for farmers to help with initial costs of investment. Tax deductions are available for farmers in Norway who are engaged in R&D projects. Aquaculture research is also prioritized in Norway, however, no specific funding is allocated towards shellfish aquaculture. Researchers currently report the

inability to get funding from the Norwegian Research Council for shellfish related projects, with finfish research receiving priority.

Several areas for improvement should be highlighted. In Sweden, the long and complicated application process for lease permits and the limited length of tenure creates unnecessary bureaucratic complications and a lack of financial security for holders of farm leases. In Sweden, there is also a need for proactive spatial planning for aquaculture. In Denmark, the costs for shellfish sanitary testing, which is passed along to the growers, is very high, and all costs for food safety are supported by the industry without subsidies from the government. In the case of start-up shellfish growers, this places an undue burden on small businesses, reducing the number of entrants to the industry and limiting their financial viability. In Norway, the higher cost of leases may place a similar burden on small businesses.

A lack of national research programs specifically targeted for shellfish aquaculture also continues to limit development of the industry. Without planning for, and research on, the viability of shellfish aquaculture, growth will continue to be limited. One strategy for planning is contained in the Alaskan model, where a government mandate decreed the creation of a specific number of new shellfish farms. A public planning process was then undertaken to appropriately site these farms based on social, economic and biological considerations. The resulting farms were then released through an application process, thus streamlining application procedures and creating new opportunities for small-scale entrants to the industry.

Strengths

- Relative ease of access to lease sites and reasonable length of tenure in Denmark and Norway
- No fees for lease applications in Sweden and Denmark
- Designated areas for aquaculture in many local land-use plans in Norway
- Strategies for development of the aquaculture sector exist in all countries
- EU subsidies for investments are available for farmers in Sweden and Denmark
- Tax deduction for farmers engaged in R&D projects in Norway
- Aquaculture research is prioritized in Norway although no specific funding is allocated towards shellfish aquaculture

Weaknesses

- Complicated and long procedures to get lease permits and limited length of tenures in Sweden
- Relatively high fees for lease applications in Norway
- Lack of proactive spatial planning for aquaculture in Sweden and Denmark
- High costs for farmers for the shellfish sanitary testing in Denmark. All costs for food safety are supported by the industry without subsidies from the government
- Lack of national research programs specifically for aquaculture in Sweden and Denmark

Opportunities

- Proactive spatial planning for aquaculture in local municipalities where public perceptions of visual impacts from farm installations are considered in planning

Threats

- Objections from public and private parties against establishment of aquaculture installations due to negative public perceptions of visual impacts
- Permanent classification of shellfish waters into B areas may severely restrict the development of oyster farming
- Inadequate disease monitoring may result in potential introduction of diseases to Scandinavia

Appendix A: case studies

Over the past ten years, worldwide shellfish aquaculture production has grown in value by more than 40%, with the highest rates of growth in East Asia, as well as a number of countries within Europe (Greece, Ireland), as well as Chile, New Zealand, the United Kingdom, the United States, and Canada. Despite limitations in wild shellfish stocks and sharp increases in demand for shellfish aquaculture products, not all countries with significant seafood sectors have shown increases in their shellfish production volumes.

Many countries possess the requisite biophysical features to develop successful shellfish aquaculture industries. However, not all countries with these basic biophysical characteristics have active shellfish industries, and rates of development vary significantly. For instance, countries such as Norway, which possess promising biophysical characteristics for shellfish industry growth, have been slow to develop, while other countries such a New Zealand and Canada have experienced extremely high rates of growth.

Comparisons among countries with fast-growing shellfish industries and those, which have not thrived reveal a specific combination of natural, social, and institutional factors which may have contributed to successful expansion in both volume and value of production. For instance, the rapid development, which has occurred in countries such as Canada and New Zealand, indicates significant potential for a similarly lucrative and diverse shellfish aquaculture industry in Scandinavian countries, where there are similarly clean marine waters, extensive coastlines, and extensive technological expertise in both aquaculture and agriculture. Examination of the historical development of shellfish aquaculture industries outside of Scandinavia may provide insight into factors, which have promoted successful development. Although it is difficult to identify exact characteristics, or combinations of characteristics which have led to industry growth, several key factors are discussed in this report including:

- A regulatory environment that actively facilitates access to lease areas
- Regulatory bodies that are proactive in planning for strategic economic development of the aquaculture sector
- Coordination between industry and government-funded research programs, as well as extension services to develop industry capacity
- Multi-species hatcheries and relevant technological expertise for on-growth
- Expertise in marketing of agriculture or seafood products
- Positive public perceptions toward aquaculture products
- Consolidated processing industry aimed at value-added production
- Development of producer and/or marketing boards to develop generic branding of shellfish products

Numerous examples exist of large-scale, very successful shellfish industries, such as those in China. However, in the context of this report, the most interesting and relevant case studies to guide development are of locations similar to Scandinavia that did not historically have local shellfish industries or markets, and have faced significant barriers to industry growth (e.g. high labour or transportation costs, limited domestic consumption). By examining locations with similar characteristics, which have succeeded in developing thriving industries, successful models can aid in identifying existing barriers to development in Scandinavia, and serve as possible examples of ways to increase competitiveness of the Scandinavian shellfish industry. In the following five case studies, the goal will be to examine four examples of rapidly growing shellfish

aquaculture industries (USA West Coast, Canadian West Coast, Atlantic Canada, and New Zealand). Each case study focuses on the type of supply and demand conditions, institutional and regulatory characteristics, business strategies, and general public policies that lead to good economic performance during development of a domestic shellfish aquaculture industry. Within each case study, the objectives are explored in relation to a possible combination of relevant 'success factors', as well synergies between particular combinations of factors. In the final sections, these factors are analysed for their applicability to industry development in the Scandinavian countries.

Case study 1: Alaska and Washington States, USA

The United States is a large consumer of shellfish, where demand is met primarily by imports. For example, in 2009, Americans consumed approximately 57 million pounds of blue mussels, of which domestic production was only 3.4 million pounds. Approximately 93% of these mussels (blue and green shell) were imported from Canada and New Zealand. New Zealand imports are largely frozen, pre-processed half shell mussels, while 85% of the US market for premium live farmed mussels (> 8,000 MT/yr) is served by imports from Canadian suppliers (USDA 2004), most of which come from Prince Edward Island.

The US also has a large market for fresh oysters, scallops, clams and other shellfish. On the West (Pacific) Coast of the US, there is a significant shellfish industry worth more than $117 million (of which Pacific oysters represent 75% of the total value).

	Oysters	Clams	Mussels	Geoduck	All Shellfish	Total
Washington					**Larvae and Seed**	**Current**
Pounds	61,000,000	9,520,000	2,750,000	1,650,000	$7,000,000	**74,920,000**
Sales	$57,750,000	$19,550,000	$3,162,500	$20,100,00		**107,562,500**
California						
Pounds	9,270,995	741,463	315,000		$2,300,000	**10,327,458**
Sales	$12,361,326	$830,000	$945,000			**16,436,326**
Oregon						
Pounds	2,379,988					**2,379,988**
Sales	$ 2,253,135				$750,000	**3,003,135**
Alaska						
Pounds	206,709	7,839	1,988		$126,000	**216,536**
Sales	$ 441,781	$24,841	$6,610			**599,232**
Total pounds	**72,857,692**	**10,269,302**	**3,066,988**	**1,650,000**		**87,843,982**
Total sales	**$ 72,806,242**	**$ 20,404,841**	**$ 4,114,110**	**$20,100,000**		**$117,425,193**

Pacific Shellfish Grower's Association 2009 Total Production Values

Oysters make up 89% of the shellfish production volume on the American West Coast. The total dollar value of oyster production in 2009 was $72.8 million, with more than $57 million (87% of total value) produced by the State of Washington. The Washington State industry employs approximately 3000 people with an industry that is distributed over 4500 hectares of lease area. The success of the oyster industry in Washington is similar to other locations such as Louisiana, and is largely attributable to **legislative acts allowing private leasing of seabed** that would otherwise be considered a public amenity. The Washington state shellfish industry began supplying oysters to California in the mid-1800s. In the late 1800s, an important legislative Act in Washington allowed for sale of tidelands into private ownership, which was crucial for industry development. Subsequent legislation, which was passed almost 100 years later in 1985, **declared aquaculture to be an agricultural endeavour**, thereby placing the shellfish industry under laws that apply to the advancement and protection of agriculture. The classification of aquaculture as an agriculture endeavour is important as it provides access to loans, as well as income support and stabilization programs (including crop insurance), that are available to land-based farmers. It also provides access to the same standards of food safety and quality, to environmental monitoring programs, as well as to science and innovation grants available to agriculture. Since 1985, the Washington Department of

Agriculture has been the lead agency in all aquaculture matters, thus providing **a supportive framework including general marketing and promotional assistance** for farm activities and products.

The State of Alaska provides an interesting contrast to Washington State, as success factors for shellfish aquaculture development were very different. Unlike Washington, Alaska **did not historically have an oyster industry,** nor did they have legislative acts supporting leaseholds within the marine environment. Neither did Alaska have a historic agriculture industry. Initially, there was very little government or public support for developing an aquaculture industry, and as a result, shellfish farming in Alaska was much slower to expand than in Washington State. There were very few shellfish farmers in business prior to promulgation of the Alaskan Aquatic Farm Act of 1988. This Legislative Act (modelled on the Washington State Act of 1985), clarified what type of aquaculture operations were legal within the state (e.g. allowing for shellfish and aquatic plants, while prohibiting finfish farming). The 1998 Alaskan Aquaculture Act also cleared the way for private investment to safely flow into the industry, as prior to that time there was no **guarantee of access to lease areas**.

When Alaskans first began investing in shellfish farms, they **imported a "ready-made" industry** from elsewhere in the US that required very little R&D or adaptation. As Alaskan oysters do not spawn, spat is shipped to growers in Alaska from hatcheries on the West Coast (e.g. Washington State). Much of the technology for oyster grow-out has also been directly imported from other locations in the US, at a time when the industry had matured sufficiently to be technically versatile. Yet Alaska faces a number of challenges that are not relevant in other states. These include, among others, harsher environmental conditions and difficult logistics, thereby creating both **high transportation and production costs**. Other significant barriers exist, most notably a series of **regulatory and public policy obstacles** that effectively contained industry expansion until the past decade.

A predominant constraint to shellfish aquaculture expansion in Alaska has been a s**trong public stance against aquaculture**. In a state where salmon fishing is the second primary source of income, salmon aquaculture has been heavily stigmatized due to perceived environmental problems associated with finfish farming of Atlantic salmon. Perceptions about salmon farming are often reflected in public attitudes towards shellfish farming, which have made it difficult to advocate for expansion of shellfish farm sites. Improved **public education about the positive benefits of shellfish culturing**, including its positive environmental and economic benefits, have attempted to clarify the distinction between shellfish and finfish in media and public opinion. However, for much of the 1980s and 1990s, resistance to finfish farming and suspicions about shellfish aquaculture resulted in a cumbersome permit process for aquaculture site leases, burdensome farm operation regulations, and confrontational public attitudes towards shellfish farmers. These problems have been largely resolved by proactive Alaskan state government **programs for shellfish aquaculture licensing, and comprehensive planning for shellfish aquaculture as an economic development strategy**.

A second key factor in Alaskan shellfish development is the result of creation of cooperative agreements to develop **strong cohesion among growers, processors and other support businesses**. In the fall of 2001, a working consortium composed of university personnel, relevant regulatory agencies, and industry stakeholders was assembled to develop a strategy for sustainable shellfish production in Alaska. As a result, a strategic approach to industry development was designed based on a model adopted from Cedar Keys, Florida for clam aquaculture. This model was selected, as the Florida clam aquaculture program had been very successful at transforming unemployed commercial fishermen into clam farmers through efforts of the State of Florida, University of Florida, and the local community (Philippakos et al. 2001). In the Florida case, **targeted government programs, in conjunction with establishment of grower's organizations and/or**

processing and marketing boards had stimulated rapid industry development, and Alaska wished to achieve the same results for rural development. The South-eastern Alaska economy had been in difficulty for many years due to reductions in timber harvest and low salmon prices (Knapp 2002). In this part of Alaska, communities had implemented a number of economic programs to attract businesses and provide local employment; however, many of these programs, largely based on tourism revenues, have failed to have significant economic impacts (ISER 2001). Even though tourism development had been prioritized for many years, detailed studies after implementation of the programs showed that tourism industry jobs were seasonal and often filled by out-of-state residents. Research has also demonstrated that only a third of tourism dollars remain in the local community (Colt and Huntington 2002). In contrast, a survey of early shellfish farm expenditures in Alaska showed that over 50% of the income generated remained in the local community, 72% in the region (e.g. S.E. Alaska) and 95% within the State of Alaska. Spinoff benefits were also significant with additional benefits for the shipping and freight industries.

The shellfish industry in Alaska has developed very recently and to-date remains small. In 2009, there were only 79 farm leases in Alaska, and most of the farms were less than 10 years old. Yet for the more successful of these growers, profits have been high as cold Alaskan waters are capable of producing quality Pacific oysters during summer months, when more southerly waters in the US are unable to supply marketable oysters due to poor meat condition. The **demand for Alaskan grown oysters far exceeds supply**, and it is not unusual for a single US buyer to request weekly oyster deliveries equal to the yearly production of the entire state of Alaska. Expansion of the industry is imminent, as approximately 37 acres of new farm sites were released in 2010.

The Alaskan case study is interesting to Scandinavian aquaculture development for several reasons: (1) there was no historical precedent for a shellfish industry and thus no prior legislative or regulatory frameworks to support the industry; (2) Alaska developed a comprehensive and successful program to lease aquaculture areas for shellfish production despite initial strong public controversy; (3) Alaska has high labour and transportation costs relative to its competitors; (4) Alaskan oysters occupy a unique niche market because they are of high quality during seasons when other oyster producers in the mainland US cannot compete; (4) Alaska developed a well-defined strategy for shellfish farming through direct cooperation between government, researchers and industry. Although total exports from Alaska remain small relative to other producing regions of the US, higher prices through careful marketing have allowed Alaskan shellfish farmers to remain profitable, despite the harsher climate and shorter growing season.

Case study 2: British Columbia, Canada

British Columbia (BC) is the Canadian province between Alaska and Washington USA. To date, BC remains a relatively small player in world shellfish production. Farmed salmon is currently BC's primary agricultural export. Even though per pound market prices for shellfish are low and fluctuating, they do not show the same downward trends as prices for aquaculture-produced salmon. Indeed, some specialty oysters have much higher market value than farmed salmon, with much lower production costs. Ironically, however, salmon production has grown much more quickly with significantly higher volumes of total production.

In BC, the primary shellfish species cultured are Pacific oysters and manila clams, with culture of geoduck clam, mussel, and scallops occurring at a much smaller scale. In 2008, BC's shellfish aquaculture industry produced a harvest volume of 7,200 tonnes with an estimated wholesale value of $27 million (322 companies, 506 sites, 3334 hectares). Salmon production, by contrast, produced $312 million farm gate value, with an additional $56 million in value from processing and wholesale sectors.

Approximately 60% of Canadian oysters are produced in British Columbia (Pacific oysters or Crassostrea gigas); the remainder are produced in Atlantic Canada (New Brunswick, Prince Edward Island and Nova Scotia produce Eastern oysters or *Crassostrea virginica*). However, total BC oyster production accounted for only 5.0% of total North American production. In comparison to prices obtained by Alaskan growers, farm gate values of oysters in the neighbouring Canadian province of British Columbia have historically been significantly lower for a number of reasons, potentially due to a **lack of marketing expertise among producers**. Oysters, unlike mussels, tend to be a **niche product** where scarcity creates upward price pressure. For instance, the scarcity of good quality oysters during summer months in the mainland US creates a luxury demand for Alaskan oysters, which also have the benefit of other positive attributes associated with Alaskan brand equity (unpolluted waters, exotic etc.). Although the waters of British Columbia and Alaska are very similar in their attributes, shellfish producers who report the highest profits have been **proactive at developing specialty products** for high-end luxury markets, and have developed **strong marketing strategies to brand their products**. For instance, principles of scarcity, and the accompanying price premiums, have been employed to create demand for kumamoto oysters, European "flats" and other specialty oysters grown in Washington State. In general, BC has fallen behind its US counterparts in developing niche products and brand equity using targeted marketing strategies.

Farm-gate prices for BC oysters

		2004	2005	2006	2007	2008	2009
European Oyster	$/doz	5.36	5.47	4.99	3.13	4.93	5.00
Pacific Oyster	$/doz	2.75	2.42	2.64	2.67	2.76	2.74
Pacific Oyster	$/gal	17.49	15.15	16.19	16.26	18.43	19.31 (meat only, processed)
Pacific Oyster	$/lb.	3.50	---	1.96	---	---	3.51
Specialty oysters	$/doz	---			14.00 (Kumamoto and other oysters)		

BC Shellfish Grower's Association www.bcsga.ca

Numerous feasibility studies have been conducted on the potential for shellfish aquaculture in BC, and all of these studies highlight favourable cost-benefit analyses under a variety of economic conditions and management systems. The findings of these reports also consistently suggest that shellfish aquaculture, more so than salmon production, can create opportunity for coastal communities in ways that lead to new employment opportunities, skill development, and investment in infrastructure. Yet, assessments of economic costs and benefits, and investigations of capacity among existing fisheries stakeholders to adopt new practices, have not explained why the rate of expansion in the shellfish industry remains slow relative to the salmon aquaculture industry.

The 1997 report by the Western Economic Diversification (WED) Commission prompted the provincial government to launch a BC Shellfish Development Initiative in 1998, which was intended to facilitate industry growth by doubling the amount of Crown land in shellfish aquaculture leases within 10 years (Ministry of Agriculture and Lands, 2007). The Shellfish Aquaculture Working Capital Fund, which provides loans for shellfish aquaculture entrepreneurs, was also initiated at this time (BC Shellfish Growers Association, 2007). In 2004, an important WED report suggested that the BC shellfish aquaculture industry had the potential to grow from $12 million to $100 million, contributing 1000 additional jobs to the economy by 2010 (Gislason & Associates Ltd., 2004). The nature of shellfish aquaculture means that most of this economic development would be created in coastal rural areas that have high unemployment following decline of the fishery and forestry sectors. However, despite predictions, the total wholesale

value of shellfish aquaculture in BC in 2006 had only risen to $33.9 million, far below initial expectations for industry growth (Ministry of Environment, Oceans and Marine Fisheries Division, 2007).

This slow growth has been attributed to various factors including "**lack of intergovernmental coordination, premature tenure expansion announcements without adequate consultation of local communities, [and] uncertainty surrounding unresolved Aboriginal claims**" (Howlett & Rayner, 2004). Similar to the Alaskan case, **aquaculture development in BC has been very contentious.** British Columbia historically had strong wild fisheries (e.g. salmon, but also for shellfish such as clams). The seafood sector is currently undergoing a transition from a predominantly wild fishery to aquaculture production, and property rights associated with aquaculture development have been problematic as have environmental concerns about finfish farming. No further expansion of the finfish industry has occurred since 2003 due to caps on available lease sites. Shellfish site approvals continue, though further development of the shellfish aquaculture industry depends in part on:

- The ability of existing industry stakeholders engaged in the wild shellfish harvests to adopt new methods and technologies for aquaculture production;

- Availability of social or economic capital to either constrain or promote a mobilization of resources for aquaculture development.

The BC case study is relevant to Scandinavian aquaculture development for several reasons: (1) there was no historical precedent for a shellfish industry, but a highly developed and technologically advanced finfish aquaculture industry has emerged in the last two decades; (2) BC has coastal communities that have been economically affected by economic downturns in fishing, and can benefit from employment in a related sector where existing training and infrastructure can be put to use; (3) BC is a good example of a location that lacked intergovernmental coordination in development of the shellfish aquaculture industry, and has similar market characteristics to the Norwegian case study (case study 5). The opening up of new lease areas for shellfish farms, combined with a marginal amount of economic stimulus funding, has not been adequate to spur the originally anticipated industry growth. A lack of post-processing and value adding to British Columbia shellfish products, as well as lack of penetration in new markets (especially strong markets in Asia) has retarded growth. Nonetheless, some producers have been very successful, and future expansion continues to be projected, as considerable sea space is still available for shellfish aquaculture farms and markets remain strong. The industry has increasingly been able to market its products in a "green" or environmental niche, in sharp contrast to the salmon farming industry where increasing controversy is making farmed salmon products, and expansion of salmon aquaculture facilities, very problematic.

Case study 3: Atlantic Canada

Atlantic Canada is an interesting case study in shellfish production because of the relative successes of different provinces in developing their industries. All Eastern Canadian provinces have similar biophysical characteristics for aquaculture production, and all have had similar access to Federal government support for industry development. Shellfish aquaculture production in Eastern Canada was primarily a result of a carefully planned Federal **government strategic plan to promote aquaculture** as an alternative to dwindling wild fisheries, and to provide jobs in an otherwise economically depressed area of the country. Today, the province of Prince Edward Island is by far the most successful shellfish producing region in Canada, where the sector currently employs between 1500 and 2000 people on farms and in processing plants (Warris, 2007). Eastern Canada provides 99% of Canada's total mussel production, with Prince

Edward Island (despite its very small size) as the major producing province (80% of total volume). In 2006, total farmed mussel production in Canada was 23,822 tonnes, valued at over $33 million. Mussels constituted 33% of total aquaculture production and 13% of total value from Atlantic Canada (ACOA, 2006a). More than 97% of the Canadian shellfish harvest is marketed to domestic markets in Canada or to the northeastern US (total value of Canadian mussel exports to the United States was $23 million in 2006).

Similar to New Zealand, Alaska, and BC, there was no historical basis for a shellfish aquaculture industry the Canadian Atlantic provinces of Nova Scotia, New Brunswick, Prince Edward Island, and Newfoundland. In 1987, only 2,885 tonnes of mussels were produced in Canada. At the time, Canada imported significant amounts of bottom-cultivated mussels grown by Maine (US) companies, which dominated the North American mussel market until the late 1980s. Bottom-cultivating had been the prevalent growing method in the industry, even though these mussels were lower quality, were only seasonally available, and received lower prices than long-line cultured mussels.

Throughout the 1970s and 1980s, **seafood consumption patterns were changing rapidly** in North America, as health-conscious, primarily urban consumers, began moving away from traditional diets of red meat, and were increasingly willing to **pay a premium for new protein sources**. Mussels and oysters were high in protein, low in calories and cholesterol, and had an exotic appeal. Seafood demand was increasingly rapidly, and in keeping with these trends, the government of Canada initiated an aquaculture development strategy, including new education programs in aquaculture and **targeted government policies for economic development of rural regions. In Eastern Canada,** the strong period of growth in the Canadian aquaculture industry during the late 1980s emerged in part through efforts and funding of the Atlantic Economic Opportunities Agency (AEOA).

A combination of government strategy, positive market trends, strong industry coordination, as well as key **technological advances** led to rapid expansion of the industry in the Atlantic provinces. From 1985 to 1995, the Canadian aquaculture industry grew on average 10% per year, as compared for instance to 3% growth in livestock meat production, and 1.6% in capture fisheries over the same time period. Growth was extremely rapid in the late 1980s in the shellfish sector e.g. in 1987, mussel production grew by more than 75%, and in some areas, such as Prince Edward Island, by 112%. Currently, PEI provides 97% of total Canadian mussel production, 27% of total oyster production, and 64% of total Canadian shellfish production by volume. In contrast, nearby Nova Scotia, which has much longer coastlines and a larger population, produces only 9% of total Canadian mussel production and 8.6% of total Canadian shellfish production.

A number of factors may explain the relative success of Prince Edward Island, as opposed to Nova Scotia, in developing their shellfish industry. At early stages of industry development, Prince Edward Island received strategic planning support from the regional (provincial) government in the form of a **comprehensive aquaculture plan developed by the PEI Fisheries Department** (PEIAA, 2007). This 1986 document included a number of important decisions to develop the industry, including coordination of a **pro-active planning strategy to select water lease sites** administered by the Canadian Federal Department of Fisheries and Oceans (DFO). As the industry developed, **significant research grant money** was also made available through the Atlantic Canada Opportunities Agency, which allowed for **experimentation in determining the most efficient systems for new forms of production** (e.g. long-line production; Porter, 2005). The provincial government and regional development agencies also facilitated programs which provided **loans for new boats and gear** during the initial period of industry development, as well as **coordinating technical assistance** from various levels of government.

Similar research and development funding, as well as initial capital loans, were available to all Atlantic provinces. However, PEI experienced much higher growth rates of shellfish farming than other provinces such as Nova Scotia and New Brunswick, despite similar favourable environmental conditions and access to the same technology and government assistance. Similar to the Alaska case study, it can therefore be concluded that the PEI government's well-developed **strategy and lease-zoning policy** in the 1980s was extremely important in helping to promote early growth (PEIAA, 2007).

In contrast, development of the nearby Nova Scotia shellfish aquaculture industry was hindered by a **challenging regulatory climate** where it was difficult to secure lease sites as a result of multiple levels of bureaucracy with unclear jurisdictional boundaries between provincial and federal authorities. In an aquaculture development strategy released in 2005, the government of Nova Scotia identified a number of factors that had significantly hindered industry growth: 1. an onerous and expensive licensing system, 2. insufficient lease tenure period, and 3. the inability to access capital or support programs offered to other industries such as agriculture (Nova Scotia Agriculture and Fisheries, 2005). The report also stated that the Nova Scotia industry had suffered from **inadequate screening of applicants for funding programs**, as it appears to have fast-tracked subsidies for numerous large-scale aquaculture projects that lacked proven technical capability (Nova Scotia Agriculture and Fisheries, 2005). Failures of large projects such as these set a track record which made it difficult for subsequent more viable projects to obtain government support.

In recent years, the shellfish aquaculture industry in Nova Scotia has shown moderate growth, with the value of shellfish production increasing from 3000 tonnes in 1996 to 10,423 tons in 2009. Although these statistics seem promising, when compared with PEI or Newfoundland, Nova Scotia's production has lagged. For instance, Newfoundland had a much more rapid increase in production (from 50 metric tons in 1996 to 13,600 tonnes for a value of $92 million in 2009; StatCan, 2009). Newfoundland, as a late entrant to the shellfish industry, followed a development strategy modelled on Prince Edward Island. However, it encountered numerous unanticipated technical and environmental problems during early stages of development, thus dampening initial progress. However, the Newfoundland industry is now growing, assisted by increasing support from commercial fishermen, an increased number of leases available (some in relatively exposed "offshore" sites), and government-assisted marketing initiatives.

Market factors: One of the key factors in Prince Edward Island's success included a **strong focus on market competitiveness.** In the 1980s and 1990s, PEI's only competitors (Maine US producers) experienced very limited growth as they continued to focus on low to medium-quality market niches for bottom-cultured mussels. At the same time, PEI growers were proactive in assessing market trends and developing new technology consistent with market demand for long-line mussels, which were available fresh throughout the year and had consistent quality characteristics. During this time, Maine production volumes remained relatively constant, while Canadian production increased rapidly through rapid innovation in growing techniques and a move towards off bottom long-line culturing. By 2009, the small province of PEI had surpassed the entire state of Maine's production 3000 times: in 2009, the Maine mussel industry had 10 farms on 228 acres, which produced only 0.36 tonnes of mussels (worth ~ $1M), while PEI in contrast produced 18,500 tonnes (worth ~60M).

Rapid rate of growth of the PEI mussel industry in the 1980s increasingly posed a risk of oversupply relative to market demand. As a result of this oversupply, Prince Edward Island growers and provincial government officials spent a considerable amount of time and money deciding what to do with the mussels being produced. The industry, through cooperation and price-setting agreements, devoted considerable effort to marketing, in an attempt to **positioning their "Island Blue" mussels as the industry standard for high**

quality mussels. In the 1980s, shellfish sales were primarily targeted at the restaurant sector in large North American cities, where seafood was offered as a specialty, high mark-up item. Retail trade for fresh fish and shellfish (e.g. supermarkets and fish shops) was not growing, and market studies increasingly showed that growth of the aquaculture industry required **targeted marketing of high quality pre-packaged and pre-processed niche products for Hotel, Restaurant and Institutional (HRI) markets**.

Markets for exports of live PEI mussels were limited, not just because of transportation and storage characteristics, but also by a very narrowly defined market demand. Europe was a mature market with known suppliers and therefore had few prospects for new entrants, while Asia was capable of meeting much of their own demand from local sources. North American consumer preferences had not matured adequately to move beyond existing specialty markets. Primary Canadian shellfish markets were in restaurants (70%), with less than 30% of demand in the retail sector (e.g. supermarkets). Domestic retail sales within Canada were primarily targeted at Mediterranean wholesalers in large cities who were already familiar with shellfish products and had known markets among immigrant populations. There was therefore very little room for expansion in known regional markets.

In order to find new markets for mussels, the PEI **growers' organization** joined efforts to achieve what could not be accomplished without coordination: **targeted exports towards new and undeveloped markets**, primarily in the retail sector in the Eastern United States. Initially, transportation costs and the limited storage characteristics of live mussels restricted the potential for wider distribution, but as grower's organizations began developing more **targeted strategies for processing and handling of products**, as well as **marketing**, they were also able to open new export markets in the Western United States and Western Canadian cities.

The first stage of the strategy for Prince Edward Island growers, with assistance from the provincial government, was to **invest in developing a generic brand**, thereby positioning "Island Blue" mussels as the industry standard for high quality mussels. Marketing efforts were also focused in key new markets, rather than competing with lower-quality bottom-cultured mussels from Maine in known US East Coast restaurant markets. One of the key success factors was the **development of processing capacity and supply chain management** in conjunction with strong marketing efforts towards the retail sector, particularly in the American mid-west and West.

In 1982, three processors handled 80% of Prince Edward Island mussel landings. The advantage of such a small number of processors was the ability to cooperate in smoothing out demand and supply cycles. In 1985, the three existing Prince Edward Island processors had organised **a cooperative to process and market all grower's products**, which they incorporated under the name Atlantic Mussel Growers Corporation (AMG). Within the existing processing plants, a grower-owned corporation was able to centralized tracking such that all deliveries were tagged, stored in tanks for up to two weeks, graded, cleaned, polished, boxed, and labelled with the "Island Blue" brand name. All growers received the same price for the same quality product, and the responsibility for marketing was transferred to the processors and marketing board. Industry development became coordinated such that by the late 1980s, Prince Edward Island growers were realizing substantially higher margins than nearby Nova Scotia growers for the same product, largely because supply chains, marketing expertise and generic branding were coordinated as well as **ability to limit oversupply and undercutting**.

During early development of the mussel farming industry, there were still many difficulties due to inconsistent quality standards, seasonal supply fluctuations, as well as environmental hazards such as dinoflagellate blooms or "Red Tides" which made mussels periodically toxic. In 1987, toxic Prince Edward

Island mussels were implicated in the "Montreal Mussel Scare", where two deaths and 134 cases of illness were attributed to eating mussels from Prince Edward Island. Domestic mollusc sales, regardless of source (only PEI had been affected by the blooms), dropped completely, and it took several years before markets returned to pre December 1987 levels.

However, two positive developments occurred in the aftermath of this event. The first included much **tighter regulations, tracking and monitoring of the shellfish industry by federal government agencies, and better self-regulation among growers** to prevent harvesting in closed areas. The second benefit was **investment in public relations expertise**. In 1990, the federal government, Prince Edward Island growers, and their provincial government devoted more than $2 million to a promotional campaign aimed at increasing domestic mussel consumption. Although numerous factors, including already changing consumer preferences may have resulted in the subsequent increased domestic demand, it has been argued that the Montreal Mussel Scare may have in fact benefited the industry as a result of the elaborate publicity campaigns in the aftermath. This effort served as a foundation for the shellfish industry to develop more elaborate marketing campaigns, which have benefitted subsequent industry expansion.

In recent years, expansion of the mussel industry (the primary industry in PEI) has slowed. Since 2001, there has been no growth in mussel production in PEI. On-shore sites are now fully developed, and although offshore siting could allow for increased productivity, on-going conflict with the lobster fishery currently limits expansion potential. A move to continuous longline production, rather than single droppers, would also benefit the industry as it has in Nova Scotia and Newfoundland. In addition, while PEI was an early leader and innovator, there have been few recent developments in research or technological efficiencies.

In 1986, Atlantic Canada's mollusc production (e.g., mussels, oysters, quahogs, dams, etc.) was valued at $16 million (2% of the landed value of all fisheries). Although the majority of export volume was in mussels, oysters also had high retail values, and by value, mussels therefore only constituted 20% of total exports, while 20% of the shellfish industry value was in oysters, with 5% in quahogs and the remaining 50% in a wild fished species of soft-shelled dams (*Mya arenaria*). The mussel industry was growing rapidly, though mussel shipments were usually included in mixed distribution channels for other seafood products. During this period in the 1980s, Prince Edward Island growers and government agents had been active in **developing value added products** such as mussels frozen in the shell, and mussels in wine sauce, which they perceived as a good outlet for undersized mussels. These products were in keeping with general seafood trends for pre-processed and packaged products in a market where fresh unpackaged seafood was experiencing sharply declining demand.

Oyster production was also in need of similar value adding, but oyster growers were much slower to develop cooperatives and marketing boards, possibly because in early stages, profits rested in the ability to niche market rather than in economies of scale. During early stages of industry development, there was less incentive to form processing and marketing boards as volume of production had not reached a critical supply threshold. Yet as the volume of other shellfish exports increased from both Nova Scotia and Prince Edward Island, growers in these provinces also began expanding their oyster production, and organized marketing efforts emerged to export oysters alongside other seafood products.

The majority of aquaculture-produced oysters in Nova Scotia and PEI are now exported (55-80%), primarily to US markets. In contrast, in New Brunswick, the shellfish industry remained disjointed, and the low production volumes and **lack of coordination among growers** led to consistently poor sales, with the majority of oysters going to nearby Quebec where they sold for much lower prices than were potentially

available in US markets. Even thought New Brunswick had technical capacity in their oyster industry, production volumes remained low and markets undeveloped.

The United States has historically produced large volumes of oysters for their domestic market, although domestic supply has been steadily decreasing since the early 2000s due to disease outbreaks and poor environmental conditions. Domestic supply will decrease even further post 2010 due to the Gulf Oil Spill and chronic problems in West Coast hatcheries. In addition to domestic consumption, the United States has also been a significant importer of oysters (in 2009, the $US imported 56 million dollars worth of oyster products from various countries, of which Canadian imports are approximately $US 26 million). Historically, the bulk of the imports have been shelf-stable value-added commodities such as canned smoked oyster originating from Asian countries. However, the imports of these types of products have declined considerably over the past two decades, while Canada's exports of fresh oysters have increased during the same period. Provided institutional factors continue to support the shellfish industry, further rapid expansion of the Canadian oyster production is expected in the next ten years to supply key domestic, American and potentially also Asian markets.

Case study 4: Norway

Much of the technology for fish farming was developed in Norway, and similar technological developments should, in theory, have been transferable to other species. The early era of salmon production in Norway was characterized by **entrepreneurial experimentation** and close **collaboration between the research sector and the aquaculture industry** (Aarset, 2004). When farmed salmon first entered the market, the product commanded a **price premium** as Norway was the only initial global supplier of adequate volumes of farmed salmon to create **a year-round commodity market**. Although wild salmon were available in North America, fish could be sold fresh only seasonally, while in Europe, and especially in Norway, salmon was a scarce, high-value commodity. Initial salmon farm development occurred in Norway throughout the 1970s and 80s, and included significant experimentation of small-scale entrepreneurs with a variety of farming techniques. A period of trial and error by small-scale growers was followed by increasing competition, and industry consolidation throughout the 1990s, thereby allowing for **economies of scale** and creating **production efficiency through vertical integratio**n. Supply chains became increasingly sophisticated, were **focused on new markets**, while the returns from high profit margins were reinvested for future industry growth. By the end of the 1990s, Norway was one of the world's top salmon aquaculture producers, even as other countries, many of which had lower costs of production, attempted to enter the market.

Throughout the 1980s and 1990s, a number of studies and reports predicted a similarly promising future for the Norwegian shellfish aquaculture industry. Norway was historically a world leader in the maritime industries, had extensive underutilized coastlines, and was in proximity to traditionally lucrative European seafood markets. Furthermore, Norway was in the process of developing technology for salmon farming and had historically been a key processor of wild-caught seafood. Yet despite this lengthy list of favourable factors, throughout the late 1990s and into this decade, sales figures for shellfish production in Norway have shown a downward trend, with only a small percentage of mussel and oyster companies reporting profits. Total productivity of the Norwegian shellfish industry has been minimal, and has in fact declined, while counterparts in other countries have experienced high growth rates in both volume and value.

Shellfish culturing in Norway is currently based on three main species of bivalve molluscs: blue mussels (*Mytilus edulis*), great scallops (*Pecten maximus*), and flat oysters (*Ostrea edulis*). In 2007, Norwegian exports of mussels amounted to only 304 tonnes, while scallop and oyster production were at minimal

levels, with only a few operational farms. Scallops are primarily sea ranched with virtually no suspended culturing. In the following sections, we ask why the Norwegian shellfish industry has not been more successful, particularly in light of the profitability of shellfish production elsewhere and the comparative success of the Norwegian salmon farming industry.

Biological constraints were initially cited as a limitation to shellfish industry expansion in Norway. Such factors included sea bird predation and toxic algal blooms, which rendered shellfish seasonally unharvestable. Diseases, particularly in hatcheries and/or in seed-stock production, have also presented obstacles to industry development. However, the effects of these biological factors remain largely resolvable through changes in farm-siting procedures, improved water testing protocols, or technological changes in production methods. Similar issues, including disease outbreaks, have beleaguered the salmon industry for the past 20 years, as well as shellfish industries in other countries, yet they have not been insurmountable. In light of the significant research addressing contaminants, disease, and predation, it is unlikely that such factors should be viewed as primary limitations to industry growth. Norway's biological conditions are similar to other countries such as Ireland, Canada and the United States where similar (or identical) species of shellfish are successfully grown.

High labour costs are also often cited as an inhibiting factor for developing food production and processing industries in Scandinavia. However, technology and mechanization are available for shellfish production that can decrease labour inputs significantly. Further, significant underutilized infrastructure (e.g. processing plants, port facilities in rural areas) already exists in Norway, as does considerable technical expertise in aquaculture. The regulatory environment is favourable to rural coastal development, and has been supportive of shellfish aquaculture as an environmentally sustainable industry. Factors that may have contributed to a lack of growth in the Norwegian shellfish industry appear to have been primarily **institutional rather than environmental or technological.**

One of the first factors which may have been counterproductive to growth were Norwegian government programs which provided considerable subsidies directly to shellfish growers under the guise of rural coastal development. However, subsidies to growers are rarely effective unless there is established infrastructure for processing and distribution of products, as these subsidies create inherent inefficiencies in production without ensuring viability of the subsequent supply chain. Subsidies to processing and marketing organizations are generally viewed as preferable to grower subsidies, wherein government can provide strategic assistance in early stages of industry development towards **supply chain management. In many countries where shellfish industries have been successful, government assistance to shellfish producer and marketing boards have been important during early stages of industry development.** However, unlike Norway, subsidies in these countries were aimed not at producers, but for post-production stages of the supply chain, such as processors or distributors. Norwegian producers did not suffer primarily from a biological inability to produce a high-quality product, but from a lack of coordination in subsequent stages of the supply chain. With critical missing links in the supply chain, such as post-processing and a clear marketing strategy, there was limited coordination between **supply and demand of product, and a lack of linkages between producers, processors, wholesalers and markets.**

Historically, there have been few shellfish producers in Norway, with **no shellfish processors' organizations or marketing boards**. Producers of seafood in Norway traditionally specialized in volume sales for fixed prices to National buyers' organizations, and thus did not understand the seasonal market demand of what were largely saturated European markets. There was no shellfish processing industry in Norway to support value adding, and only a limited domestic market for unprocessed Norwegian shellfish products, as Norwegians did not traditionally eat shellfish. Instead of focusing on development of new markets, such as

expanding the potentially lucrative domestic market, or taking marketing initiatives to target rapidly expanding Russian or Asian markets for seafood, Norwegian producers were focused primarily on volume sales within Europe, thus giving them no niche characteristics for their product.

It could be argued that live blue mussels from Norway were not a niche product, even with a good marketing and clear branding of product. However, with relatively few shellfish producers in Norway, shellfish supply volumes were not sufficient to support increased market share in existing European and other foreign markets. For price setting and export to new markets, Norway would require much higher volumes of production. The few Norwegian shellfish producers who currently report profits are primarily focused on low-volume production for the domestic market. Within Norway, domestic markets, unlike exports, are safer as they do not require the type of consistent production necessary to meet critical supply thresholds, nor do they require sophisticated marketing strategies, as domestic markets are often insular with known relationships between suppliers and buyers, and lacking competition due to protectionist trade restrictions.

In the absence of existing infrastructure for a shellfish processing industry, capital investment is needed in order to safely process and market safe, high quality products and provide marketing, distribution and value-adding functions. However, capital has not been the limiting factor in the Norwegian shellfish industry. Largely on the basis of the salmon farming experience, Norwegian investors speculatively placed significant capital into shellfish aquaculture companies such as Norshell in much the same way they had invested in the salmon industry, not realizing that they did not have command of the target market. In the early days of salmon farming, salmon was still a **newly emerging commodity**. Blue mussels did not have the same market characteristics as salmon. Markets for shellfish aquaculture products were growing, but consumer preferences were in many cases already well established based on historic wild shellfisheries or existing aquaculture production in Europe, Asia, and the Americas. Norwegian growers who were focused on volume sales to the European Union poorly understood the characteristics of mature markets. Norwegian shellfish producers therefore overwhelmingly reported that they were subject to wholesaler's prices, monopolies and consistent undercutting, as their low production volume and indistinct market characteristics give them little or no direct bargaining power. Even though oysters exhibit more distinct niche-market characteristics than blue mussels, Norwegian exports of oysters were also subject to similar considerations, including the fact that Europe was a mature market with well -established supply and distribution chains. There is also a continual threat from substitute products as Denmark has a thriving wild fishery, which regularly floods the market with seasonally available, inexpensive bottom-trawled mussels and oysters. Norwegian producers, without the benefits of marketing campaigns to distinguish their products from bottom trawled mussels, and without volume to outpace suppliers such as Denmark, have not been unable to control quality and price in the face of competition with these fisheries and other imports to the EU, such as from farms in Chile.

Norway does not currently even produce a sufficient consistent supply of shellfish to meet its domestic demand for scallops, mussels, and oysters. The country currently imports more than 80% of the shellfish consumed. Norwegian producers, with uncertain production levels, and a lack of processing and marketing investment, have been unable to supply adequate and consistent product year-round, thereby requiring even the Norwegian hotel, restaurant and institutional (HRI) industry to source their shellfish primarily from imports.

To be successful, the industry must develop processing and distribution networks, through shared processing facilities and trade organizations. In the Norwegian industry, there was a lack of cooperation among growers focused on consistently branded, distinctive products. Generic marketing campaigns

(country-based marketing such as Greenshell mussels™) can eliminate such competition among growers, while allowing for volume expansion into new markets. Generic branding, similar to New Zealand or Prince Edward Island, has proven extremely useful and could be similarly useful for the Norwegian industry in its marketing efforts. However, the failure of Norshell and other subsequently unsuccessful processing and marketing efforts in Norway has contributed to the overall perception that shellfish aquaculture is not economically viable.

Case study 5: New Zealand

New Zealand's shellfish aquaculture industry has grown dramatically over the past thirty years (over 700% growth in the past ten years) and serves a good example of successful industry expansion. The primary focus of the New Zealand aquaculture industry has been on Greenshell mussels 86% by volume ($204.3m), though also produces salmon (9% by volume; $43.9m) and oysters 5% by volume; $16.9m) http://www.aquaculture.org.nz/aquaculture-in-nz/industry-overview/overview/

New Zealand's shellfish fishery began with wild collection of native green-lipped mussels (*Perna canalicus*) and wild oysters. Attempts at farming mussels began in the 1960s. Experimentation by the Fishing Industry Board in the mid-1970s led to adoption of Japanese long line systems for culturing mussels across the industry, and the industry began to grow (Gibbs, 2006). New Zealand began exporting mussels in the late 1970s. A **1980 agreement on shellfish exports to the United States further boosted growth by providing a target market for farmed mussels**. To this day, the US accounts for approximately 35% of all New Zealand's mussel exports. The remainder go to Europe and Asia (NZ Seafood Industry Council, 2007b).

The volume and value of the mussel industry grew substantially in the 1980s and 1990s—between 1988 and 1996, mussel export volume increased by 473 % while export value grew by 413 % (Bess & Harte, 2000). **By 2009, mussels were one of New Zealand's most valuable seafood exports, with more than 80% of New Zealand mussels destined for export markets** (Aquaculture NZ, 2010). Domestic and international sales of cultured mussels in 2009 totalled over NZ$224 million, with an export value of approximately $126 million US. The industry currently employs 2500 people in New Zealand, and exports shellfish to more than 72 different countries. **The growth of New Zealand's shellfish aquaculture industry in the last 30 years, with over 700 % growth in the past decade, makes it an instructive example of rapid industry growth in a favourable regulatory framework.**

Development of the industry can be attributed to four main factors:

1. Vertical and horizontal consolidation across the industry;
2. Cooperation between producers, leading to important innovations;
3. On-going collaboration between government and industry; and
4. Government support through the regulatory framework and funding tailored to industry needs;

Both the mussel and oyster fisheries began as a series of small, owner-operated farms. Pressure from **global competition and a drive for marketing and production efficiencies led to consolidation**, both vertically and horizontally, across the industry. The larger companies were better able to take advantage of expanding export markets.

Much of the rapid growth can be attributed to **early and on-going cooperation among shellfish producers**. In the early stages of industry development, producers funded research into innovative production techniques (Jeffs & Liyanage, 2005; NZSIC, 2007b). **Innovations in harvesting, processing, packaging, and targeted marketing of frozen half-shell products allowed New Zealand to overcome significant distance and transportation barriers.** For example, despite the existence of North American mussel suppliers, over 90% of frozen mussels consumed in the United States come from New Zealand.

Through cooperative marketing, the industry established and developed quality controls and branding similar to the Island Blue marketing strategy used successfully in Prince Edward Island. New Zealand created a generic mussel product, marketing all New Zealand green-lipped mussels under the name Greenshell™. The industry has also **increased the proportion it exports as value added product**. New Zealand exports approximately 95% of its Greenshell™ mussels in frozen, half-shell form for the food service and catering markets. **The NZ industry also adopted organic certification, becoming one of the first producers in the world to be organically certified** (FAO, 2007c). The industry has also taken advantage of rising environmental concerns and recognized the potential for a **premium on environmentally friendly, sustainable products**.

Cooperation throughout the industry continues today. **The New Zealand Seafood Industry Council, owned by the seafood industry, funds on-going research, speaks for the industry on policy issues, and targets markets for and improves access international trade in shellfish.** Species-specific councils, such as the New Zealand Mussel Industry Council, are owned by producers and fund projects related to individual species. Both levels are funded by compulsory industry levies (NZ Seafood Industry Council, 2007a).

In 2006, the government issued the **New Zealand Aquaculture Strategy, a comprehensive national strategic development plan for aquaculture** (FAO, 2007c). The strategy itself was driven by industry, and aims for an aquaculture sector with sales of $1 billion by 2025.

Government has supported the industry through funding tailored to industry needs, and development of a **favourable regulatory environment**. The Resource Management Act, amended in 2004, provides most of the framework for aquaculture in New Zealand. Although three ministries, Conservation, Environment, and Fisheries, have related responsibilities, aquaculture is directly managed at the regional and territorial level using regional coastal plans (FAO, 2007b). These **plans define zones for aquaculture and set limits on the character, scale and intensity of aquaculture and related industry activities**. There are 17 regional local government agencies that control access to aquaculture sites via this mechanism. **By concentrating decision-making at the regional level, conflicts with other coastal stakeholders and users can be reduced. The regulatory burden on mussel and other farmers is also reduced as applications and permits for new and existing aquaculture sites are dealt with at the regional level by a single entity.**

Expansion of shellfish aquaculture has attracted opposition from environmentalists and residents concerned about farms' visual and environmental impacts (Bess & Harte, 2000). Land claims by Maori tribes claiming ownership of the seabed and foreshore led to disputes over access to coastal areas. Two pieces of legislation were introduced in 2005 to address these concerns. The Aquaculture Reform Act allowed regional councils to determine where new developments would be permitted and simplified the permitting process. The Maori Commercial Aquaculture Claims Settlement Act recognized Maori claims and allocated 20% of existing and new aquaculture tenures to the Maori (Tollefson & Scott, 2006).

While Greenshell™ mussels account for 86% of seafood production, New Zealand also produces salmon (9%) and oysters (5%). **Aquaculture of Pacific oysters (Crassostrea gigas), was introduced accidentally in**

the 1950s, and tripled in value between 1986 and 2010. New Zealand now produces 4000 tonnes per year, with a value of approximately $36 million. As of 2009, the development of large-scale hatchery production of spat has facilitated use of single-seed oysters, which should result in rapid increases in production volume and value.

New Zealand's **aquaculture sector has grown steadily at an average annual rate of 11.7% by volume over the 20 years up to 2005**. Despite this expansion, the sector retains considerable potential for profitable growth. In 2009, the mussel farming industry in New Zealand included 645 farms occupying almost 5000 ha of lease area and produced over 97 000 tonnes of shellfish (FAO, 2009c; MFA, 2010). However, total aquaculture farms now account for only about 0.2% of New Zealand's coastline out to 12 nautical miles. The total space allocated to aquaculture in the coastal marine area is more than 13,000 hectares, with much space yet to be approved or developed.

New Zealand's experience is instructive. Although it produces mainly mussels, New Zealand's oyster industry is growing and will continue to grow, particularly given the industry and government support for aquaculture. Like Scandinavia, New Zealand has a long coastline, cold water, and a clean environment well suited to aquaculture. It also has expensive labour, transportation, and distribution costs, a heavily regulated legal environment and developed infrastructure. New Zealand's experience demonstrates the importance of collaboration between members of the industry, and between industry and government, to overcome significant barriers.