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Does Market Failure Exist in the Swedish Oyster Industry?

A Cost-Benefit Analysis

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Abstract

This paper studies the socio-economic and private economic costs and benefits from farming *Ostrea edulis* in Sweden and aims at providing a foundation for policy-makers making decisions regarding the development of aquaculture in Sweden. Using Ostrea AB, Sweden’s only oyster company close to industrialisation, as a model, a cost-benefit analysis is conducted, in order to examine whether market failure exists within the Swedish oyster industry due to socio-economic net benefits resulting from the production process being greater than private economic net benefits. Our findings show that market failure does exist; between 2006 and 2018, the discounted socio-economic net benefits exceed the discounted private economic net benefits. However, the sensitivity analysis performed, reveals that the results are sensitive to changes in the volumes produced and sold.

Key words: Aquaculture, cost-benefit analysis, environmental economics, market failure, oysters.

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1. Introduction

Swedes are eating more oysters than ever before. During 2001, 29 tons of oysters were consumed in Sweden and by 2009 this figure had increased to 350 tons (SCB, 2012). During the same year, the Swedish government appointed an official report to examine the opportunities of industrial aquaculture in Sweden (SOU 2009:26).

Oysters are filter feeders that live off plankton. Through consuming excess nutrients, such as nitrogen and phosphorus, they help to prevent eutrophication in the sea. These bivalve molluscs also contain an abundance of vitamins and minerals, making them not only environmentally friendly, but healthy too (Styregård, 2011). Experts call them the “food of the future” (Lindegarth, 2012a) and nothing indicates that the increased demand will diminish.

With an increasing demand for oysters in Sweden (SCB, 2012), there is an interest in expanding the Swedish oyster industry. Moreover, natural oyster banks across the world have disappeared and it has been estimated that, in total, 85 per cent of oyster banks have been lost globally, due to overfishing or climate change (Beck et al., 2011). The banks on the West Coast of Sweden are not an exception; during long periods of time, the Swedish indigenous oyster has been almost extinct (Swedish Agency for Marine and Water Management, 2012a) and currently, the natural banks are not large enough so as to be able to provide a stable supply of oyster spawn if the demand for oysters is to continue to increase in Sweden (Lindegarth, 2012a). However, currently, the industry in Sweden does not appear to be economically viable as it requires licenses, specialised knowledge, advanced technology and large investments. Despite the increasing demand, willingness to farm oysters (Lindegarth, 2012a) and an interest in the environmental benefits of the industry, it faces extremely slow growth; currently there is only one oyster company in the country even close to being industrialised.

If the industry is to grow and for consumption to be able to increase at the same speed, the demand for a stable supply of spawn must be satisfied through spawn production in oyster hatcheries. According to the Food and Agricultural Organisation of the United Nations (FAO, 2008), farming is the only way to sustain consumption of fish and shellfish.

If the private economic net benefits do not arrive at the same level as the socio-economic net benefits, it is not economically viable to enter the industry, thereby preventing industry growth - to the detriment of the potential socio-economic benefits that could be achieved, including environmental benefits. In other words, the result is an industry that fails to deliver an efficient allocation of resources, also known as market failure.

2. Background

2.1 Market Failure, Externalities and Ecosystem Services

A concept within economic theory, market failure occurs in situations in which the free market does not provide an efficient allocation of goods and services in society meaning that the outcome is not sustainably pareto efficient (Bator, 1958). If, on the other hand, a market is free from inefficiencies, the willingness to pay (hereafter referred to as WTP) of consumers should be roughly the same as the marginal cost of production (Zerbe & Bellas, 2006, p. 131). A market where perfect competition prevails is characterised by "no (or negligible) taxes, no externalities and no firms with significant market power and in which both suppliers and consumers have good information" (Zerbe & Bellas, 2006, p. 98). Classical examples of market failures include monopolistic enterprises that produce a lower quantity of goods and charge excessive prices (market failure due to monopoly), free markets that do not produce enough education or public transportation (market failure within public goods) and overproduction of harmful emissions (market failure due to negative externalities). Traditionally, market failure is solved through governmental intervention, using policies such as subsidies, taxes, minimum wages and regulations (Boardman, et al., 2011, pp. 85-97).

The definition of an externality is the impact that consumption or production has on a third party's utility, which occurs outside the price mechanism as a result of the impact not being included in the market price for the good. If the outcome is an increase in utility, the externality is classified as positive, whereas negative externalities cause a decrease in utility. Environmental impacts resulting from an individual's or a company's actions are considered externalities as they are by-products, of production or consumption (Boardman, et al., 2011, p. 91).

When production of an output or input generates external damage to society, every additional production of the input ought to be valued including the cost of the negative social impact it has in order to find the real marginal cost of production, which would otherwise be undervalued (Zerbe & Bellas, 2006, pp. 108-109). Consider a company producing chemicals, which emits harmful waste product into the environment and significantly lowers the quality of life for those living in the area and ultimately imposes costs on the whole society due to negative effects on health. This negative externality is not taken into consideration during production, nor is it captured in the price of the goods produced by the company and therefore, a competitive market will lead to overproduction of pollution (Boardman, et al., 2011, p. 91).

External benefits, on the other hand, will be under produced since producers do not take the benefits to third parties into account, an example being benefits from ecosystem services. Ribaudo, et al. (2010) write that market prices for well-functioning commodity markets are used to indicate to farmers what to cultivate on their land and how to attain an efficient allocation of resources. In general, markets for ecosystems, however, have not developed, leading to a under provision of ecosystem services from a socio-economic point of view (Ribaudo, et al., 2010).

The ecosystem service provided by oysters lies within the water cleaning and nutrient removal they provide. Oysters filtrate the water and consume plankton containing excess nutrients such as nitrogen and phosphorous. When harvested, they contain these eutrophication-causing substances, which are thus removed from the sea (Coen, et al., 2007). Since this eco-service is not accounted for in the market price of the oyster, it is classified as a positive externality.

2.2 About the Oyster

Before the early 20th century, there was a great abundance of oysters in the world, something which the many, large piles of oyster shells, so called middens, some of which date back to 40 000 years ago, indicate (Stott, 2004, p. 34). Oysters were mainly food for poor people during the 19th century (Stott, 2004, p. 54) and in many coastal areas of the U.S., for example in Texas, roads were even produced using oyster shells (Beck et al., 2011, p. 107).

In the course of time, extensive water pollution became widespread and increasing demand lead to overfishing which severely exhausted the oyster supply and the bivalve mollusc became a rare delicacy in the early 20th century (Neild, 1995, p. 104) and is still considered one today.

The oysters we eat are the so called *true oysters* (hereafter referred to as oysters) and are members of the family *Ostreidae*. The European flat oyster (*Ostrea*), the Japanese Oyster (*Crassostrea*) and the Olympia (*Ostreola*) are just a few of the many different types offered on the market (Gosling, 2003, p. 46).

Oysters are protandric hermaphrodites, meaning that one same individual can change sex but cannot be both sexes at the same time. Oysters are born male and after a few annual cycles, they can transform themselves to females and then back and forth, to the betterment of their species (Gosling, 2003, p. 131). Normally, oysters reach maturity within a year. They usually spawn during the summer, when the water reaches a certain temperature, however, the spawning can go on for as long a period as from May to October, in waters with warmer temperatures (Gosling, 2003, p. 137).

A female oyster releases around 500 million eggs during one season (Smith, 2010, p. 32). Whereas a female of the *Ostrea* genus filters water including oyster sperm and incubates fertilised eggs inside her shell for about 10 days before expelling them into the open sea (internal fertilisation), the male and female members of the *Crassostrea* genus spawn directly into the open water column (external fertilisation), possibly because they tend to inhabit warmer seas (Gosling, 2003, p. 151). The eggs develop into larvae, which swim along with the currents in the water. After a time period of two to four weeks, the larva starts to develop an extensible, ciliated foot, used by the larva to fixate itself onto something in the sea - a rock or another oyster's shell, for example - which becomes their home for the rest of their lives, a phase known as "settling" or "spatting" since the settled larva is referred to as a spat (Gosling, 2003, pp. 156-160). The oyster's reproduction cycle is highly sensitive; larvae mortality can be as high as 99 per cent and thus very few make it to the settling phase and reach maturity (Gosling, 2003, p. 156).

2.3 The Swedish Indigenous Oyster

The Swedish indigenous oyster, *Ostrea edulis*, also called the *European flat oyster*, exists naturally in Skagerrak on the West Coast of Sweden, from its border with Norway down just past Gothenburg to Varberg, where it has lived for centuries, if not millennia (Ostronakademien, n.d.). The Swedish oyster population is the densest in the northern and middle part of Bohuslän (Swedish Agency for Marine and Water Management, 2012b).

Ostrea edulis is by many, considered to be the most exquisite of all oysters, since it is mainly wild, lives close to the bottom of the sea, in colder water and therefore has a much more varied taste range. One of the advantages for it is the surrounding water's high density of plankton. The disadvantages, on the other hand, are low water temperatures causing fewer reproduction possibilities, since the Swedish oyster requires a water temperature of approximately 14° C in order to spawn (Walne, 1964) as well as slower growth and a lower survival rate for the oyster larvae. In addition to the minimum water temperature, the spawning process requires relatively high levels of salinity - around 33-35‰ - and a rich supply of plankton (Berntsson, 2012a). Due to these harsh conditions, natural stock varies in size, making the supply of oysters unstable at times (Lindegarth, 2012a).

Although the cold temperature of the water in Bohuslän cripples the development of *Ostrea edulis*, it is also believed to provide protection from parasites such as *Marteilia refringens* and *Bonamia ostreae* (Berntsson, 2012b). A typical Swedish oyster weighs between 75 and 100 grams when it is ready to be harvested, of which 80 per cent is made up by the weight of its shell and 20 per cent by the weight of its meat. Regarding the eutrophication-causing nutrients, the oyster meat contains, for example, 1 per cent of nitrogen, translating into that each 100 gram oyster carries 0.2 grams of nitrogen, resulting in that each harvested 100 gram oyster removes 0.2 grams of nitrogen from the water. *Ostrea edulis* does not pose a significant threat to or disturb the natural habitats of other aquatic species (Berntsson, 2012b; University of Gothenburg, n.d.). The only potential negative impact from the oysters is the faeces they expel into the sea. This is a potential threat to the marine environment since the faeces contain excess nutrients such as nitrogen. If they become concentrated in one area, they can cause changes in the sediment to occur and areas close to the ocean bed can be affected by lack of oxygen and a decrease in species that live at those depths (Marine Research Centers at Stockholm University and Umeå University). However, this negative impact is negligible since the oysters don't thrive when placed too close to each other (Berntsson, 2012b).

2.4 The Swedish Oyster Industry

Organised natural farming has been conducted along the West Coast of Sweden for hundreds of years, albeit on a small scale (Ostronakademien). Carried out by divers who hand-pick oysters from the natural oyster banks, this practice requires permission from the land-owners along the coast who own the waterways up to 200 metres off their river bank, according to Swedish law (SFS 1993:787). Swedish law also states that an oyster needs a minimum diameter of 6 centimetres in order to be harvested (The National Board of Fisheries, 1993). In 2010, natural oyster farming in Sweden amounted to a meek 10 tons (The National Board of Fisheries, 2011). Imports, on the other hand, amounted to 350 tons in 2009, 240 tons in 2010 and 164 tons in 2011, (SCB, 2012).

Ostrea AB

Large-scale oyster farming (hereafter referred to as *the industry*) in Sweden is currently far from developed. Sweden's very first oyster company, Ostrea AB, was established in 2006 and its production facilities, including a hatchery, finalised in 2008 in Ekenäs on the south Koster Island, situated a 45 minute boat ride from Strömstad on the West Coast of Sweden (Ostrea AB, 2012).

After spending many years in Bassin d'Arcachon in France, where most of the oyster spawn supply in France originates from (Smith, 2010, p. 122), Karl Johan Smedman, CEO and Founder of Ostrea AB, identified a business opportunity in farming *Ostrea edulis* in Sweden. During the 1970s, the production of *Ostrea edulis* in Europe was wiped out by the parasites *Marteilia refringens* and *Bonamia ostreae* that rapidly gained foothold due to widespread trading between oyster farmers all over the world. Only about 5 per cent of the native flat oyster deposits remain (Smith, 2010, pp. 236-237). Farmers in the affected countries were forced to proceed into the business of farming the cupped oyster *Crassostrea gigas,* which is resistant to the above-mentioned parasites (Gosling, 2003, p. 306). Moreover, oyster farming during that decade led to inbreeding depression among *Ostrea edulis* and less genetic diversity (Launey, et al., 2001). However, comparative studies show that the natural stock of *Ostrea edulis* in Norway has a higher degree of genetic variability than the natural stock in other parts of Europe (Launey, et al., 2002), which could imply that the Swedish supply also displays more genetic variability, since it did not take part in the European oyster trading (Berntsson, 2012b).

The rarity of *Ostrea edulis* in combination with its high regard means it yields a higher market price than other types of oysters; three to five times more than *Crassostrea gigas*. Together with marine biologist Kent Berntsson, Karl Johan Smedman founded Ostrea AB, with the aim of farming the Swedish indigenous oyster on a large scale. Today, the company is owned by various Swedish, mainly private, investors. (Berntsson, 2012b).

Ostrea AB's Business Model

Ostrea AB's business model is based on managing each stage in the production of *Ostrea edulis*, from hatching to packaging and distribution to wholesale dealers in Europe, the vast majority of oysters going to France (Ostrea AB, 2012), a mature market and the largest in Europe. The company's secondary target markets are Sweden, Germany, Spain, Holland and Great Britain. The French are responsible for 90 per cent of Europe's oyster consumption (Ostrea AB, 2012) and eat 40 oysters per person annually (Nilsson, 2011).

During 2002 to 2009, oyster production in France (95 per cent *Crassostrea gigas)* was approximately 130 000 tons annually and the industry valued at EUR 630 million. However, due to widespread mortality among the larvae during recent years, production of *Crassostrea gigas* has merely reached approximately 80 000 tons a year in the past couple of years, leading to increased oyster prices. France's annual import amounts to 3500-4000 tons annually, Ireland being the dominating international supplier (Ostrea AB, 2012; Partos, 2010).

Within the European market for oysters, there are numerous demands for product information, such as origin, cultivation process, quality and environmental impact. Ostrea AB aims at establishing its own trading organisation in France, in order to concentrate sales work in one geographical area, with approximately 40 wholesale dealers. The oysters will be shipped on a weekly basis, directly to the wholesale dealers in France, transported from Bohuslän to France by lorries. If packaged in the right way, the oysters keep 10 days from when they leave Ostrea AB until they need to be consumed (Ostrea AB, 2012).

In recent years, the demand for smaller oysters, so called cocktail oysters, has grown. With a size ranging from 50 to 70 grams, cocktail oysters reach maturity a year earlier than the standard 100 gram oysters, thus involving lower production costs, but they still fetch practically the same price on the wholesale market, namely €1.5 a piece, or 150 SEK per kilogram (Ostrea AB, 2012).

Production Process

Ostrea AB's production process is divided into breeding and spawn production, sea-based growth and, finally, harvest, refinement and packaging. In addition, the company grows its own microalgae to feed the breeding-stock, larvae and spawn. The development process from larva to maturity in terms of commercial size takes two to three years - a knowledge and capital-intensive business involving large fixed costs with the possibility to attain economies of scale (Smedman, 2012a).

Due to the sensitive nature of the oyster, Ostrea AB performs the initial stage of production, breeding, in their land-based hatchery. The breeding oysters are brought in from the natural supply, placed in tanks, subjected to heated water and fed with highly nutritious algae for around two months in order to get them to start spawning. 10 days after fertilisation takes place, the female oyster releases the larvae into the tanks (Jönsson, 2012).

In order to secure larval survival, the water used in the cultivation needs to be very clean. The facilities on the Koster Islands include a large pump, which draws in water from a depth of 40 metres, where salinity is at the desirable level. The water that is pumped in passes several cleansing mechanisms, for instance filtration stations, protein skimmers to physically remove organic compounds from the seawater and UV burners that kill bacteria. The entire facilities, including the tanks where the oysters are bred, are cleaned on a daily basis so as to ensure the quality and hygiene of the production and increase the survival rate of the larvae. Until recently, the basic detergent *Ultra* and the acidic detergent *Cidmax*, both which pose a negative impact on environment, were used to clean the equipment but the company is currently in the midst of changing to *Oxy-San*, an eco-friendly and biodegradable detergent based on hydrogen peroxide which does not have any negative impact on the environment. After cleaning, the wastewater is treated by the local sewage treatment works (Berntsson, 2012a). Ostrea AB aims at conducting its business as a whole in a sustainable way and does not believe in the use of antibiotics (Berntsson, 2012b). The relatively cold temperature of the Koster Fjord also indicates that it is not necessary to use antibiotics to prevent parasites from spreading (Valero & Loo, 2008).

Once the larvae are hatched, their development needs to be closely observed so as to make sure that they do not accidentally settle onto the wall of the breeding tank. Instead, they are placed in another sieve-clad tub containing small stones, onto which the larvae may settle. After another month the oysters are ready to leave the hatchery and placed in baskets on rafts in the sea, where they are grown until they are ready to be harvested. The entire process from hatching to harvesting takes approximately two to three years (Berntsson, 2012b).

The rafts will be placed on the west side of the south Koster Island. Caution must be taken so as not to place the oysters too close to each other since they do not thrive when living under crowded conditions. Small motorboats will be used to travel to and fro the rafts in the fjord for maintenance. At a production level of 1200 tons of oysters in 2018, which is the maximum volume that the existing facilities can handle, Ostrea AB will have 35 rafts in the sea, each the size of 8x8x1.5 metres. Since the rafts will be placed next to each other, only a small amount of boat trips will need to be made for maintenance (Berntsson, 2012a).

Ostrea AB aims at producing 240 million larvae per year. The volume of oysters harvested in 2014 is based on the spawn placed in the Koster Fjord mainly during 2010 and 2011 but also during the beginning of 2012. The current survival rate of spawn, from a size of 1 millimetre up to a harvesting size of 80-100 grams, is approximately 20 per cent (Ostrea AB, 2012).

Today, Ostrea AB has nine employees corresponding to six and a half full-time posts. At the maximum production level of 1200 tons of oysters, the company predicts it will have 60 full-time employees, and during the intermediate years, the number of employees is assumed to increase in accordance with production volume. However, predictions are highly uncertain as they stretch far into the future (Smedman, 2012b). The work force is needed, first and foremost, for managing the oysters planted in the water for further growth; cleaning the baskets in the rafts, sorting and redistributing the oysters according to size, controlling water conditions and finally harvesting them when they are mature, but also for handling logistics, administration, quality assurance, and spawn production in the hatchery (Smedman, 2012c). The monthly wages are estimated to be between 20 000 SEK and 25 000 SEK. However, these estimates are also uncertain and may very well be revised in the future (Smedman, 2012b).

Risks and Limited Experience

The many risks associated with farming *Ostrea edulis* are: finding the right conditions in the water, i.e. temperature, salinity and acidity, gaining the right licenses, feeding breeding-stock and spawn with the right amounts of nourishment, microbiological risks, for example, bacteria and parasites, and market risks such as fluctuations in demand, currencies, quality demand and competition (Ostrea AB, 2012). Specialised expert knowledge is needed throughout the whole process in order to make sure that the oysters survive to make it to adulthood.

Since the oyster industries of other countries mainly focus on farming *Crassostrea gigas*, there is limited knowledge on large-scale production of *Ostrea edulis.* Besides the expensive technological equipment, there is also a need for continuous research on how to conduct the farming in order to overcome problems that occur. For example, in 2011, all of a sudden all the oysters planted out in the Koster Fjord died suddenly. It took several months and a visit to a Canadian oyster farm to realise that the mortality was caused by a dramatic increase in levels of acidity in the water. The solution is to lime the water (Berntsson, 2012b).

Swedish authorities have very little knowledge of oyster cultivation, which makes it difficult to enter the industry (Berntsson, 2012b; Lindegarth, 2012b). Furthermore, as previously mentioned, licenses from land-owners are required to farm oyster, both on a small and large-scale level. In Ostrea AB's case, the National Property Board in Sweden owns the Koster Islands and so licenses have been granted through them. For Karl Johan Smedman and Kent Berntsson who had been working on their business idea for years, the process of applying and being granted licenses was not all too complicated and only took a couple of months but for someone without any previous knowledge, the application process and obtaining the right information is likely to be complicated and time-consuming, especially if the land-owner is unknown (Berntsson, 2012b). For these reasons, many individuals lose interest in the idea of farming *Ostrea edulis* (Lindegarth, 2012a).

Recently, Mare Novum, a non-profit association established in 2004 by The University of Gothenburg and the municipalities in the Bohuslän region with the mission to work for the development of sustainable aquaculture in Sweden, released a handbook for oyster farmers (Mare Novum and the University of Gothenburg, 2012). However, since the industry is underdeveloped, there are very few guidelines, besides this handbook, to be found on how to start an oyster business.

As mentioned previously, the majority of Ostrea AB's capital is from the private sector, even though the company has been granted subsidies from EU (Berntsson, 2012b; Smedman, 2012c). During its first years, the company only had an income of around 20 000 SEK annually from subletting its facilities. Currently, Karl Johan Smedman and his colleagues are at a critical point where they need to show their investors and other industry participants that their business concept is viable. If Ostrea AB does not go according to plan in the next couple of years it will be very hard for the company to survive, given it is dependent on continued flow of capital from its investors. It is therefore necessary that Karl Johan Smedman and his colleagues manage to control the production process and that sales reach the predicted volumes in the following years. If not, there is a great risk that Ostrea AB will not survive as the company's supply of money will run out and new investments will not be considered as attractive (Smedman, 2012c).

Ostrea AB expresses an interest in conducting its activities in a sustainable way and believes that the knowledge about mistakes that have been made in cultivation in other parts of Europe creates good prerequisites for maintaining a sustainable development within the Swedish oyster industry. The company is aware of the risks of inbreeding when using limited breeding-stock and aims at breeding the oysters with consultation from experts, in order to preserve genetic variability (Berntsson, 2012b).

3. Current State of Knowledge

3.1 Purpose of the Study

When looking at the oyster industry today in Sweden, the possibilities of farming oysters in the country seem untapped. The demand for oysters is increasing, at the same time as the production of oysters in France has decreased. In addition, there are people willing to start farming on the Swedish West Coast (Lindegarth, 2012b). This, in combination with the socio-economic benefits of developing the production of oysters, makes the possibilities of developing the industry in Sweden seem profuse. Still, oyster production is highly underdeveloped in Sweden. With this misalignment, there is good reason to believe that we have a possible market failure at hand as the underlying cause.

The purpose of this paper is to examine whether market failure has occurred within the Swedish oyster industry, by studying the advantages and disadvantages to society of farming oysters on a large scale in Sweden, versus the advantages and disadvantages to Sweden's only large-scale oyster farmer, Ostrea AB. The starting point for this paper was the ecosystem service that oysters supply. We hope to provide a foundation for policy-makers and other industry participants in making decisions about whether to take measures to correct the possible market failure or not.

3.2 Previous Research in the Field

International Research

The positive environmental effects provided by oysters are well-documented. Many of these studies, however, focus on the ecosystem services provided by natural oyster reefs rather than the effects of farmed oysters. For example, Grabowski & Peterson (2007) list and evaluate a number of ecosystem services that natural oyster reefs provide, including improving water quality in eutrophicated water by filtering excess nutrients, provision of habitat for epibenthic inverts and carbon sequestration. Regarding the water-cleaning effect specifically, Dame, et al. (1989) provide calculations on the amount of carbon, nitrogen and phosphorus filtered and absorbed by the American oyster (*Crassostrea virginica*). These studies are written by marine biologists, with, in the case of Dame et al., assistance from statisticians or environmental economists. The studies mentioned above both apply a positive approach, meaning that they investigate the effects of oysters rather than making statements of how things should be. Grabowski & Peterson (2007) mention that “previous attempts to assess the monetary value of ecosystem services provided by oyster reefs are limited, which inhibits the ability of managers to evaluate alternative habitat restoration options and make informed choices about how to manage restored oyster reefs” (Grabowski & Peterson, 2007, p. 283). Their purpose is therefore to “discuss how to quantify the economic value of each of the ecosystem services provided by oyster reefs” (Grabowski & Peterson, 2007, p. 283), as is often done within the field of environmental economics.

As a consequence of the environmental benefits of oysters, there are several studies focusing on the preservation of natural oyster reefs. Beck, et al. (2011), for example, compile data on oyster reef conditions in 140 bays, and identify different actions that could be taken in order to preserve and revitalise oyster reefs. The quantitative data is primarily drawn from literature and statistics on oyster prevalence and fishery, and serve as a basis for normative recommendations regarding what actions ought be taken to increase oyster reef preservation and thereby benefit from the eco-services provided by the existence of oyster reefs and oysters (Beck, et al., 2011, p. 110). Another study focusing on the natural oyster reefs and their effects on eutrophicated water is conducted by Cerco & Noel (2007). The study concentrates on the hypothesis that restoring natural oyster reefs is a way to reverse eutrophication in the Chesapeake Bay, famous for its rich supply of fish and shellfish in previous years and currently subject to debates regarding overfishing and environmental problems. In order to investigate the issue, a predictive model is built and the outcome is compared with experimental results. Cerco & Noel conclude their study by stating that a tenfold increase of oysters in the bay have limited impact on the deep pelagic water, and that oyster restoration should be used as a complement to other abatement methods (Cerco & Noel, 2007, p. 341).

Swedish Research

In Sweden, oyster farming and research is nowhere near as developed as in other countries. However, aquaculture has gained a lot of attention lately. As mentioned previously, Mare Novum aims at examining the possibilities of developing the industry and promoting innovation within the field (Mare Novum, 2011). In 2009, the Swedish government initiated an official report (a so-called SOU) about the growth and potential of aquaculture in the country (SOU 2009:26). The report states that the conditions for developing aquaculture in Sweden are beneficial, and investigates different actions that could be taken in order to support sustainable industry growth.

Regarding bivalve molluscs in Sweden, research has mainly focused on the established blue mussel industry. Swedish studies have been conducted concerning the impact of mussel farming in culturally eutrophicated seawater containing high levels of nitrogen. Lindahl, et al. (2005) and Gren, et al. (2009) explain how farming mussels can help combat eutrophication on the Swedish West Coast and in the Baltic Sea respectively. Lindahl, et at. (2005) argue that mussel farming should be used as a method to reduce nitrogen levels in the sea of Skagerrak. They point out that "commercial mussel producers currently benefit society by the removal of nitrogen from coastal waters, for which they are unrewarded" (p. 133) and subsequently suggest that mussel farmers should be paid per unit of nitrogen removed. The value of nitrogen removal by farming mussels is estimated by comparing the costs of mussel farming to costs of other abatement methods, using the costs of a sewage treatment plant in Lysekil as a model. The study concludes that in order for large-scale mussel farming to grow in Sweden, decision-makers need to be shown that mussel farming is a cost-effective and environmentally friendly way to fight eutrophication. Similarly, results from the study by Gren, et al. (2009) show that mussel farming used to combat eutrophication problems should be used as a complement to other abatement methods such as those of sewage treatment plants and changing practices and regulations regarding fertilising and land use (Gren, et al., 2009, p. 936).

Regarding eutrophication in Sweden, the Swedish Environmental Research Institute has investigated the possibility of introducing an emission payment system for sewage plants exhausting excess nutrients in the sea (Olshammar, et al., 2012). The study focuses on nitrogen and phosphorus, which are the main nutrients filtered by mussels and oysters, and also mentions the possibility of rewarding sewage treatment plants cultivating mussels. This indicates that there exists opportunities to introduce new ways to use shellfish farming in Sweden.

When it comes to oysters specifically, the interest is rapidly increasing. At the University of Gothenburg, a project lead by Mats Lindegarth (Associate Professor in Marine Ecology) and Lena Mossberg (Professor in Marketing) focusing on sustainable development of the oyster industry and the possibilities of expanding the tourism industry around seafood activities is currently ongoing. The project, "Strategic research for the development of sustainable bivalve shellfish industry on the Swedish West Coast", is a collaboration between the Department for Biological and Environmental Sciences and the School of Business, Economics and Law (Centre for Tourism, the School of Business, Economics and Law, University of Gothenburg, 2012, p. 6).

Despite the increasing interest for oysters and the increasing popularity of environmental economics and sustainability, there are, to our knowledge, no studies that focus on evaluating the socio-economic benefits and costs, as well as the opportunities of conducting business, within large-scale oyster farming in Sweden. Our aim is to fill this gap.

3.3 Our Contribution

We aim to investigate whether there exists market failure in the Swedish oyster industry as a result of socio-economic net benefits outweighing the viability of the industry from a private economic viewpoint. In order to do so, we aim at studying and evaluating both the positive and negative externalities and the private economic revenue and cost of farming *Ostrea edulis* in Sweden.

We have chosen to limit the scope of our study to the direct effects of *farming* the Swedish oyster, i.e. the process from breeding to harvesting which is the core in the oyster industry, and will thus not include costs and benefits of the suppliers and distributors, but only the costs and benefits generated by the production of oysters. Some examples of effects that will not be taken into consideration are: pollution from factories producing the machines used in the farming process, pollution from lorries, boats and other means of transportation used for distributing oysters, new jobs created within the supplier or distributor sectors, and revenue and costs from the supplier and distributor sides. Also, since oysters grow naturally on the West Coast of Sweden where the water is saltwater and not fresh water, the water cleaning effect of oysters will be represented by nitrogen removal as this is a greater problem than phosphorus on the West Coast. The effect from phosphorus will thus be excluded in the analysis, in order to make the analysis manageable.

In addition, health-related effects from consuming oysters and spill-over effects to other industries such as the tourism industry cannot be viewed as direct results of the production from the Swedish oyster industry and have therefore not been included in the analysis below.

This delimitation enables a close examination of the farming process per se and is considered appropriate for the scope of this paper. However, it is necessary to be aware of the drawbacks of excluding the broader perspective as it means that no account will be taken to the fact that the development of the oyster industry might have effects on other industries in Sweden. In order to gain a comprehensive understanding of the impact of developing oyster farming in Sweden, the total effects resulting from the industry, i.e. also the effects from suppliers and distributors ought to be included. It would be even more optimal if the effects of several industries in Sweden, and the interactions between them, could be observed simultaneously, so as to determine the true effect of the oyster industry on society as a whole, since no one industry operates completely isolated.

Since our purpose is to provide a foundation for policy-makers and other industry participants in deciding whether measures need to be taken to correct market failure within the oyster industry or not, it is exceptionally important that the wider perspective is taken into account; in deciding whether to support an industry or not, one has to consider that investing in one industry constrains us from investing in other industries that might result in even better benefits. These arguments should, ideally, be considered to get a full understanding of the socio-economic impacts of the oyster industry.

Lastly, due to the limited scope of this thesis, we will not dig deeper into potential corrective measures that could be taken should we reach the conclusion that we have market failure at hand. This brings us to our research question:

Do the socio-economic net benefits of farming Ostrea edulis *in Sweden exceed the private economic net benefits - that is - does market failure exist in the Swedish oyster industry?*

4. Method

In order to answer the research question stated above, all socio-economic and private economic benefits and costs that the Swedish oyster production could entail, need to be quantified and weighted against each other. In order to do this, we choose to calculate the net impacts by performing a cost-benefit analysis (hereafter called CBA), which is the commonly used method for quantifying social benefits. Traditionally, CBA is used as a tool to predict the outcome from taking on one project instead of another, and often serves as a guide in decision-making and formulation of policies. In this case, however, CBA is not used in a conventional way. Instead, it is used as a model when calculating the socio-economic and private economic net benefits from farming oysters in Sweden, rather than serving as a basis for comparing different projects. By calculating the socio-economic net benefits of the production of oysters and thereafter comparing this value to the calculated private economic net benefits of the oyster farmers, we aim to answer the question of whether market failure exists within the Swedish oyster industry or not; if the socio-economic and private economic net benefits are equal we do not have market failure, if they however are not equal, we will arrive at the conclusion that market failure exists.

As a model for the calculations outlined in this paper, Ostrea AB serves as a model. This implies that all private economic impacts, as well as socio-economic impacts resulting from its farming processes, are calculated with respect to the conditions that are specific for Ostrea AB. Only the company's EBIT will be calculated and will thus represent the private economic net benefits. The time span is limited to the years from 2006 to 2018, with respect to, on the one hand, the year in which the model company was established (2006), and, on the other hand, the year in which it will reach its maximum production capacity with the existing facilities (2018). Making predictions regarding production volume, costs and market conditions beyond 2018 is considered too risky (Smedman, 2012b). Therefore, this time frame is considered to be a reasonable foundation for calculations.

The analysis is thus built on valuations of the expected benefits and costs arising from the predicted development of the industry in terms of the development of Ostrea AB and through painting a predicted future scenario rather than evaluating the impacts afterwards. This means that a so-called *ex ante* analysis, or standard CBA as it is sometimes called is conducted (Boardman, et al., 2011, p. 3). This kind of analysis is usually carried out when deciding whether the project under consideration should be undertaken or not. *Ex ante* CBA contrasts to *ex post* CBA, which is conducted as part of the evaluation of a project that has already been undertaken. The aim of an *ex post* CBA is to contribute to learning among politicians and other decision-makers regarding which project to undertake in the future, while *ex ante* CBA directly affects current decisions being made. In answering the research question stated in this paper, the latter CBA lacks relevance; since the industry examined is still under development, there is no point in evaluating the effects of the industry yet. Nevertheless, *ex post* CBA might be valuable in the future, looking back at decisions made today.

The Process of Conducting a Cost-Benefit Analysis

The CBA method can be broken down into different steps in order to make the process manageable. In this paper, we have chosen to use Boardman's nine major steps of CBA (Boardman, et al., 2011, p. 6) as a basis for structuring the analysis.

The first of the nine steps of CBA consists of specifying the set of alternative projects (Step 1). However, for reasons mentioned above, this paper does not compare different projects but compare the private economic net benefits of the industry with the socio-economic net benefits. Consequently, this step is not applicable in the conventional sense to our analysis.

Next, an overview of who has standing is provided, i.e. whose benefits and costs are to be taken into consideration throughout the paper (Step 2). Specifying this is essential in order to reach relevant conclusions since an event that is costly for one group of people could potentially benefit another group of people. A classic example of this issue is whether a project of cleaning the Danube river should give standing to the people of the nation whose government is conducting the project or whether standing should be given to the people of several nations through which the Danube passes through, who's people therefore may benefit from the cleaner water (Zerbe & Bellas, 2006). If going with the former alternative, the project might not seem worth while its costs since only one country's inhabitants are made better off. Going with the latter alternative however means that more people have standing and that more people benefit from cleaner water, resulting in a larger net present value (hereafter referred to as NPV) (Zerbe & Bellas, 2006). This step lays the foundation for the following steps of identifying the impact categories that affect the utility of those who have standing and how these impacts should be measured. It is worth noting that CBA is anthropocentric, i.e. only values to humans are included. This means that, for example, intrinsic values of the existence of an animal or plant, is measured in terms of WTP by humans for the preservation of the species.

After deciding who has standing, Boardman's steps of CBA include identification of the impact categories (Step 3), i.e. identifying all impacts resulting from a project (in this case: the process of farming *Ostrea edulis* in Sweden) and deciding whether the consequences are positive or negative, i.e. whether they are benefits or costs, respectively. Also, measurement indicators, i.e. in what terms the impacts are measured, are decided upon here. An example of a positive impact would be cleaner air, measured in tons of harmful particles removed. In this paper, only impacts that are found to be significant will be assigned measurement indicators. After cataloguing all possible impacts, quantification of the significant impacts (Step 4) in each time period follows. All impacts of significance are then to be monetised (Step 5). For structuring reasons, these three steps are in this paper presented integrally in the analysis below by identifying, quantifying and monetising one impact at a time.

In order to identify and quantify the socio-economic and private economic impacts, literature on oysters, farming and marine environments serve as a basis for analysis. Also, several interviews with experts in different fields have been conducted. As mentioned above, Ostrea AB serves as a model when predicted benefits and costs are calculated, regarding socio-economic impacts as well as private economic impacts resulting from the business. Several interviews with Karl-Johan Smedman (CEO, Ostrea AB) and Kent Berntsson (marine biologist, Ostrea AB) provide information about not only production volume, profits, costs and risks of the business, but also predictions about market conditions, price level and demand. In addition, Susanne Lindegarth (marine biologist, University of Gothenburg and chairman of Ostronakademien[1]), has given us valuable insights regarding the current state of the oyster industry in Sweden.

Regarding the monetisation of impacts, previous research in the field, interviews with the above mentioned experts and literature serve as a basis for our work. For the monetisation of the values of the water-filtering service provided by oysters, a similar study on blue mussels conducted by Lindahl, et al. (2005) is used as a guideline since the corresponding values for oysters are difficult to obtain. Values that cannot be measured in monetary terms are discussed in order to decide in what direction the impact could affect the results.

Next, all monetised values of impacts are discounted (Step 6) in order to get numbers in today's value. In this way, past, present and future values can be compared and added together. Thereafter, NPVs of the private economic net benefits of farming *Ostrea edulis* are calculated and compared with the NPV of the corresponding socio-economic net benefits (Step 7). Finally, the difference between the discounted socio-economic and the private economic net benefits will be calculated to see if market failure exists as a result of socio-economic net benefits exceeding the private economic net benefits.

We round off our CBA by performing a sensitivity analysis (Step 8) to handle uncertainties and give perspective to potential assumptions and limitations that may affect the results. In this way, the

[1] A non-profit association aiming at increasing the interest and knowledge about *Ostrea edulis* (for more information, please see www.ostronakademien.se).

robustness of our results is examined. Finally, our analysis results in a recommendation (Step 9), before a concluding discussion is given regarding the results and how they relate to our research question in a broader sense.

Criticism of CBA

As a method, CBA works well for the purpose of calculating straight-forward results in monetary terms. However, it is important to be aware of the drawbacks of the method, and the criticism that exists against it. The use of the method is based on the assumption that all impacts resulting from a project can, and should, be valued in terms of money. This fact has practical, as well as principal, drawbacks. Firstly, all impacts cannot be quantified nor monetised (Zerbe & Bellas, 2006). This is especially important to notice when dealing with environmental issues since nature is not a good traded in the market to a market price. Trying to set a price on an impact that we as humans do not know the value of, and then discount that impact, leads to significant uncertainties that one needs to be aware of since it can change the results drastically, according to Chichilinsky (2009). As she puts it: "A warning sign with flashing red lights should be placed on all cost-benefit analyses of projects involving some of the most important environmental resources known to humankind: we do not know how to price them." (Chichilinsky, 2009).

Also, since all impacts are valued from a human perspective, any intrinsic values of biological species are overlooked or, at best, valued in terms of what people are willing to pay (Boardman, et al., 2011, p. 224). Thus, human knowledge about the environment is determining for the value assigned to it. This implies that, in this specific case, the values assigned to the environmental effects of the oyster industry and the oysters themselves need to be critically evaluated.

In addition to the fact that many things cannot easily be translated into monetary terms, one can also ask what pricing a good actually tells us? A project with a positive value might be ethically inappropriate if the people whose costs and benefits count do not value morality in the same way that the rest of society does. Therefore, one could argue that, for moral reasons, monetising is not always appropriate and might potentially increase the risk of obtaining misleading results. Thus, a strict CBA does not necessarily provide full information about whether a project should be undertaken or not. Therefore, it is best viewed as one of several other complementing methods for evaluation of projects or impacts.

Alternative Methods

To deal with the drawbacks of using CBA, other possible methods could have been used to value the costs and benefits at hand. One of these methods, dealing with environmental impacts in particular, is Environmental Impact Assessment (European Commission, 2012). However, this method only evaluates a project's environmental effects and consequently, this method would not provide us with a complete answer to the market failure question in monetary terms.

Closely linked to CBA is Economic Impact Analysis. In Economic Impact Analysis, all economic effects a project will have on a specific region are estimated (Zerbe & Bellas, 2006, p. 46). Thus, the method is restricted to economic valuations in a specific area, in contrast to CBA, which is used to estimate all net benefits and costs resulting from a project. In our case, Economic Impact Analysis could be used to estimate e.g. the economic impact of expanding the oyster farming industry in Bohuslän. However, such an analysis would leave out the non-monetary environmental values of a project and would therefore be inappropriate for our study.

For policy-makers subsidising or taxing specific projects, cost-effectiveness analysis, also calle cost-utility analysis, could be helpful in evaluating the efficiency of money invested in a project, compared to investments in other projects (Boardman, et al., 2011, pp. 464-488). In this case, a cost-effectiveness analysis on investments in the oyster industry could be of interest for investors wanting to know the extent of social impact their money can give, in comparison to investing in mussel farming or other industries. For comparing purposes this method could serve as a complement to CBA when priorities have to be set regarding where investments should be made. However, it is not sufficient for answering the question whether the industry suffers from market failure and is therefore not considered a viable alternative to CBA.

5. Cost-Benefit Analysis

5.1 Specify the Set of Alternative Projects (Step 1)

As mentioned under *Method*, the first step of the CBA includes specifying the alternatives at hand. Since we are not conducting a classical CBA, we will not compare two or more different projects and therefore, this step is excluded. However, we will return to the reasoning behind this step and the importance of comparing alternatives to each other in the concluding discussion below.

5.2 Decide Whose Benefits and Costs Count - Who Has Standing? (Step 2)

When examining issues of environmental character in particular, a global perspective is usually preferred in order to avoid the risk that a project that benefits the environment in one area results in costs to the environment in another area. However, given the limited scope of this paper, the complexity of examining the Swedish oyster farming process from a global perspective and the clearly local effects on the environment within the Swedish borders, we choose not to take on the issue from a global perspective in this case. Moreover, as stated above, we have chosen to analyse the socio-economic net benefits, and compare them with the private economic net benefits, and thus focus on issues including but not limited to environmental aspects.

When estimating society's benefits and costs from farming *Ostrea edulis* on the Swedish West Coast, there are several potential solutions to the issue of standing, i.e., whose benefits and costs count in the CBA. Sweden's only oyster farm, Ostrea AB, which serves as a model for the calculations in this paper, operates on the south Koster Island and uses the water surrounding the Koster Islands in the farming process and therefore, estimating the benefits and costs to the people living in the municipality of Strömstad (in which the Koster Islands are included) may seem like a natural starting point for our CBA. The people and businesses in this area are directly affected by the water quality, the surrounding flora and fauna, the opportunities of outdoor life, the labour market and the economy in the region. However, this disregards the fact that the idea of "society" commonly includes the people of a nation under the notion that a nation's citizens share a common constitution and the norms and rules that come with it (Boardman, et al., 2011, p. 38). Moreover, Boardman et al. argue that assuming a local viewpoint provides a less valuable foundation for policy-makers (Boardman et al p. 38) since policy-makers need to take the whole country's interests into account and make sure that benefits to one sub-national area are not being offset by costs to another. In other words, the wider perspective reveals if the positive local effects of a project are being outweighed by costs in another area.

In our case, employing a local perspective effectively disregards four important matters. Firstly, is disregards the fact that people residing in other parts of Sweden besides the nearby areas may at some point in time make use of the Koster Fjord, and therefore appreciate being able to use it (so called optional non-use value). Secondly, people living in other areas might take pleasure in knowing that the people in the area close to the fjord can enjoy clean water and that life in sparsely built-up areas can be lead. For example, a Swede living in the sparsely-populated county of Norrbotten may feel solidarity with people in other sparsely-populated areas in Sweden, and approve of an industry providing jobs in such areas, even if they are not likely to move there and take a job there themselves. The value to these people is called existential non-use value. Thirdly, the fact that clean environment and the creation of new jobs are national political concerns and not just each municipality's own affair is overlooked. The fourth problem is that laws and regulations regarding aquaculture and licensing are set by Swedish authorities and decisions regarding potential subventions and compensations of new industries and environmental projects are usually made by policy-makers working in the national public sector. As stated above, the aim of this paper is to provide a foundation for decision-makers and other industry participants to decide upon whether corrective measures need to be taken or not. We therefore conclude that a scope wider than the local perspective ought to be adopted.

It may also seem appropriate to include people living in the adjacent regions of Østland and Sørland in Norway or Skagen in Denmark, as they are situated on the other side of the Skagerrak and may, due to currents, be affected by the water quality from the Koster Fjord. However, the argument above regarding the idea of "society" as a nation (Boardman, et al., 2011, p. 38) is applicable to this issue as well. In order to follow the aim of this study – to provide a foundation for policy-makers in deciding whether to take corrective measures or not - standing in this CBA is given to the citizens of Sweden.

5.3 Catalogisation, Quantification and Monetisation of the Identified Impacts (Steps 3, 4 and 5)

As described under *Method*, steps 3 to 5 in the process of conducting CBA are to, firstly, identify the impacts resulting from the project under study, catalogue them, and select measurement indicators, secondly, quantify all impacts of significance and thirdly, monetise them. For simplicity, these three steps are integrated below. All impacts are listed and catalogued as either benefits or costs (please see Table 5.1). Only impacts that we, after discussing them, consider to be significant will be assigned measurements indicators. For a summary of the analysis regarding steps 3 to 5 (please see *Appendix C*).

	Socio-economic impacts	**Private economic impacts**
Benefits	▪ Eutrophication prevention ▪ Expansion of the Swedish labour market ▪ Biodiversity ▪ Private economic benefits (revenue)	▪ Revenue
Costs	▪ Pollution from hatchery ▪ Emission and noise from boats ▪ Negative impacts from electricity consumption ▪ Less space for outdoor life in the fjord area ▪ Private economic costs (total staff costs, other external expenses, depreciation of tangible fixed assets)	▪ Total staff costs ▪ Other external expenses ▪ Depreciation of tangible fixed assets

Table 5.1. *Catalogue of identified socio-economic and private economic benefits and costs resulting from Swedish oyster production.*

SOCIO-ECONOMIC BENEFITS

Eutrophication prevention by nitrogen removal, expressed in tons of nitrogen removed

As mentioned previously, the standard weight of an *Ostrea edulis* on the market is 100 grams, of which one fifth (20 grams) is meat. The oyster meat contains one per cent of nitrogen amounting to that each *Ostrea edulis* contains 0.2 grams of nitrogen. Hence, harvesting oysters means the amount of nitrogen in the water, which causes eutrophication, decreases. Thus, the process of harvesting oysters is a positive impact on environment, with positive implications for the people and other businesses using the water in the area and people and businesses that care about the environment. Ostrea AB will harvest its first batch of oysters in 2014 (25 tons), translating into that 0.05 tons of nitrogen will be removed from the water. During 2018, when production is predicted to be 1200 tons, 2.4 tons of nitrogen will be removed from the water (see Table 5.2 below).

When estimating the value to society of reducing the amount of nitrogen in the sea, previous studies on mussels (see *Previous Research*) use a replacement cost method, meaning that the cost of farming mussels is compared to the cost of other abatement methods. In the case of oyster farming, similar calculations could be used for the evaluation of nitrogen removal. Lindahl, et al. (2005) present a case study on mussel farming in the Gullmar Fjord surrounding Lysekil, situated 90 km south of Strömstad, with information about the effects and costs of the local sewage treatment plant. The Gullmar Fjord is different in the sense that it is a deep bay, whereas the Koster Fjord is an open ocean area. However, the two areas are similar in the sense that they are both part of Skagerrak and are the only two bodies of water in Sweden where hard-bottom communities can be found at depths greater than 100 metres. In addition, they are the only fjords in Sweden which provide a natural habitat for several uncommon species (Swedish Environmental Protection Agency, 2009, p. 35). Due to the two areas' proximity to each other and marine biological similarities, in combination with the lack of appropriate literature on costs of cleaning the Koster Fjord with its local sewage treatment plant, it is found reasonable to assume that the costs for handling nitrogen removal in the Gullmar Fjord are applicable to the Koster Fjord. Thus, the values from the study on mussels by Lindahl, et al. (2005) are concluded to be applicable to the case of farming *Ostrea edulis* on the south Koster Island. Under the above stated assumption, it is determined that the cost of removing nitrogen is 9.70 USD per (Lindahl, et al., 2005), equalling a price of 65.50 SEK per kilogram (calculated with current exchange rate 5th May, 2012).

The study by Gren, et al. (2009) regarding farming mussels for nutrient removal in the Baltic Sea focus on the effects of mussels farmed solely for environmental purposes. Therefore, their study also views the cost of farming mussels as a cost to society, since the mussels provide an eco-service for society. In this paper, however, it is to be noted that the costs of oyster farming are considered private economic costs as the oysters are farmed commercially and are predicted to yield revenue to Ostrea AB in the future - once sales commence. Thus, for society, the cost of nitrogen removal is assumed to be zero leading to that the socio-economic benefit equals the amount saved from replacing the nitrogen removal performed by a sewage treatment plant with nitrogen removal from oysters, i.e. 65.50 SEK per kilogram.

To get the final monetary values of the water cleaning provided by the oysters in the Koster Fjord, in this case represented by the amount of nitrogen removed, each kilogram of nitrogen removed is multiplied by the 65.50 SEK. The results are presented in Table 5.2 below. For further explanations on how values are calculated, please see *Appendix A*.

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Volume sold (tons)	0	0	0	0	0	0	0	0	25	160	400	700	1200
Nitrogen removal (tons)	0	0	0	0	0	0	0	0	0.05	0.32	0.8	1.4	2.4
Monetary value (thousands of SEK)	0	0	0	0	0	0	0	0	3.3	21.0	52.4	91.7	157.2

Table 5.2. *Quantification and monetisation of nitrogen removal provided by oysters. For calculations, please see Appendix A.*

Expansion of the Swedish labour market, expressed in the number of new jobs going to previously unemployed people

When observing the labour market effects resulting from the production of oysters in Sweden, the main area of interest involves opportunities of work for people who would otherwise be unemployed, i.e. workers in surplus (Boardman, et al., 2011, p. 105). This group of people includes those willing to take a job to the salary offered in the market, but who cannot get one since there are not enough jobs. It does not, however, include those who are in between jobs and therefore only temporarily unemployed, or those who are not willing or able to work as they are not considered to be outside the workforce rather than unemployed (Boardman, et al., 2011, p. 105). The reason that workers in surplus are of interest is that new jobs employing people that would otherwise be unemployed result in an increase in the employment rate and tax income, and less government spending on employment projects, which benefits society. A new job that does not lead to employment for a previously unemployed person is not a benefit to society since the job opportunity is simply transferred from one person to another (Zerbe & Bellas, 2006, p. 41). It is important to clarify that, in order for a new job to count as a benefit, it does not necessarily need to go directly to a previously unemployed person; as long as the final result (in a chain of episodes) is that someone in the group of surplus workers goes from being unemployed to employed. To illustrate this, consider the following example: if a new job is given to a person who is already employed and that person leaves his or her current job, thereby creating a vacancy, the new job is still a benefit to society if someone who is unemployed, i.e. a worker in surplus, fills the vacancy created, since the total employment rate will increase (Boardman, et al., 2011, p. 105).

In order to calculate the socio-economic benefits from new jobs created from farming *Ostrea edulis* in the Koster Fjord, information about the number of new jobs created, and the value of each of these jobs, is needed. The number of new jobs created each year is difficult to predict since predictions about the future are always complex and uncertain. However, as Ostrea AB has 6.5 full-time employees today (2012) and forecasts that it will need 60 employees at a production level of 1200 tons during 2018, these numbers are used for calculating the number of new jobs created in the years between 2006 and 2018 (see *Background*). The number of full-time positions at Ostrea AB between 2006 and 2018 can be viewed in Table 5.3. For simplicity, it is assumed that the new jobs generated by Ostrea AB will go to Swedish citizens, despite the Koster Islands proximity to the Norwegian border.

Now that the number of new jobs have been calculated, the next step is to determine how many of them will go to previously unemployed. In doing so, it could be reasonable to observe the unemployment rate in Sweden (since Swedish citizens have standing in this study) and compare it to the country's current Non-Accelerating Inflation Rate of Unemployment (NAIRU), which is the unemployment rate associated with a constant rate of inflation. For unemployment rates below the NAIRU, inflation will rise. Therefore monetary policy cannot temporarily push down unemployment any further without causing inflation to climb. This type of unemployment is recognised as structural. If, on the other hand, unemployment is at a level above the NAIRU, this means that the percentage of unemployment above the NAIRU has to do with the state of the market and can thus be lowered through monetary policy without affecting the inflation (Lundborg, et al., 2007).

In December 2011, unemployment in Sweden was at a level of 7.5 per cent (Ekonomifakta, 2012), while the NAIRU in December 2011 was estimated to be 6.5 per cent by The National Institute of Economic Research (2011, p. 107). Thus, the unemployment rate is higher than the NAIRU, implying that new jobs created by Ostrea AB will involve new jobs being assigned to previously unemployed, either directly or through the above-mentioned job chains. However, before drawing a complete conclusion, the concept of labour force mobility ought to be taken into consideration. Unless it is believed that Sweden's labour force is completely mobile, that is that people are willing to move to or commute to areas where there are jobs, comparing the country's unemployment rate to the NAIRU is of little relevance. Applied to this study, it is not considered plausible that unemployed people will move close to or commute to the Koster Islands where Ostrea AB is located, it is of less interest to examine the whole country's unemployment rate and more relevant to study the local unemployment rate. Since the islands are located roughly a 45 minute boat ride away from Strömstad, and due to the fact that Strömstad is a small town with no special cultural events or special attractions, it does not, in general, seem probable that workers in surplus located in other parts of Sweden will move there for a job. Therefore, it is assumed that the new jobs at Ostrea AB will go to locals. For this reason, it is concluded that it is more purposeful to compare the unemployment rate of the municipality of Strömstad, i.e. 7.4 per cent (Ekonomifakta, 2012) with the NAIRU. It can be concluded that the local unemployment rate is above the NAIRU and there is thus leeway to lower the unemployment rate.

Since population in the municipality is 12 010 people (Strömstad, 2012), and the difference between the NAIRU and the unemployment rate is 0.9 per cent, this means the number of people unemployed above the NAIRU is 108 people. Therefore, the new jobs created by Ostrea AB (predicted to amount to a total of 60 jobs by 2018) will lower the unemployment rate.

The value of each new job created is usually estimated as the opportunity cost (also called reservation wage) for the unemployed of taking the job rather than doing other activities (Boardman, et al., 2011, p. 105). This opportunity cost includes the value of other things that could have been produced or activities that could have been carried out if the unemployed person had not been given the new job, such as household activities, child care or non-market jobs, implying that the opportunity cost for an individual is some positive value. For certain individuals, the opportunity cost of working could therefore be a high positive value. Even if the unemployed person only spends his or her time doing nothing, this leisure time is likely to be of some value to him or her. Therefore, the opportunity cost of each unemployed is assumed to be above zero (Bartik, 2012).

Also, Bartik (2012) claims that the social gain of a new job is even higher than the opportunity cost of the individual, due to spill-over effects on, for example, other wages within the same areas of occupation, and the fact that other unemployed people benefit from decreased competition within the job searching process when someone previously unemployed gets a job. However, since it is not possible for us to quantify and monetise the additional effects from new jobs, they are excluded from this analysis. Thus, the individual gain, and, also, the socio-economic benefit of a new job created is assumed to be equal to the actual wage minus the opportunity cost for the unemployed to take the job.

Valuing the opportunity cost of working instead of doing other activities is difficult since there is no market price to the other possible activities that could be carried out. A common way to estimate the value of the opportunity cost of working, described by Boardman, et al. (2011) as well as by Bartik (2012), is to examine the labour supply curve. It is assumed that unemployed people are equally distributed along the labour supply curve, i.e. that they all attribute different values to a potential employment and are thus willing to accept different wages. As mentioned above, the opportunity cost of each unemployed is assumed to be above zero. However, as it is not probable that the lowest price at which any unemployed is willing to acquire a job is known, the price is assumed to be somewhere between zero and some positive value, and for simplicity, the supply curve is assumed to pass through the origin, implying that the lowest wage accepted by an unemployed person is equal to zero. In reality, minimum wage laws result in minimum wage rates higher than zero. Still, according to Boardman, et al. (2011), as risks of illness, suicide, divorce etc. increase with unemployment, the minimum price at which someone is willing to accept employment could be very close to zero, at least to some people.

Furthermore, it is assumed that the unemployed people who get the new jobs at Ostrea AB are more or less equally distributed along the labour supply curve, i.e. that they all value a potential employment somewhere between zero and the wage rate paid. If so, the average opportunity cost of working, can be calculated as ½*(0+wage rate), that is, half of the market wage.

One could argue that it is more likely that new jobs go to people with low opportunity costs as the individual benefit from working is higher for them which may lead them to be more engaged in job search activities and, hence, more likely to get hired (Bartik, 2012). If so, the total benefits might be slightly higher than in the case of assuming an average opportunity cost. However, as the method of using the average opportunity cost effectively provides a lower-bound estimate of the socio-economic benefits resulting from new jobs created, and thus reduces the risk of overestimating, this is concluded to be the most reasonable way of calculating social benefits from new jobs in this paper.

Moreover, it could be interesting to contemplate on the additional value of creating jobs in sparsely-populated regions. Giving people the possibility of living and working in these regions can be considered important for two main reasons. Firstly, it prevents urban areas from becoming over-crowded and hinders a negative impact on the urban areas' natural resources. Secondly, it facilitates economic activity and thus a higher quality of life in these areas, which could have positive spill-over effects onto various activities that safeguard the community and landscapes, for instance, preserving landscapes and making sure that natural resources are well-kept and keeping a check on real estate property of summer guests. The issue of supporting economic development in sparsely-populated areas is usually considered a political matter of national importance. However, as we cannot quantify the additional value of creating jobs in the municipality of Strömstad, this positive externality will not be included in our analysis.

Since the future employees at Ostrea AB will have a monthly wage between 20,000 and 25,000 SEK (see *Background*), an average wage of 22,500 SEK per month is used in the calculations of the socio-economic benefits resulting from new jobs (please see Table 5.4). For further explanations on how values are calculated, please see Appendix B.

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Volume sold (tons)	0	0	0	0	0	0	0	0	25	160	400	700	1200
Number of jobs at Ostrea AB	3	5	5	5	6	6.5	6.5	8	14	24	38	60	60
Number of new jobs created	3	2	0	0	1	0.5	0	1.5	6	10	14	22	0
Number of new jobs to unempl.	3	2	0	0	1	0.5	0	1.5	6	10	14	22	0
Value of new jobs (TSEK) (thousands of SEK)	405.0	270.0	0	0	135.0	67.5	0	202.5	810.0	1350.0	1890.0	2970.0	0

Table 5.3. *Quantification and monetisation of the socio-economic benefit from new jobs created by the oyster farming processes. For calculations, please see Appendix B.*

The value of biodiversity, measured in the preservation of the species Ostrea edulis

People's WTP to consume *Ostrea edulis* is already included in the market price of the good. However, in this section, the value of biodiversity, in this case, the additional value of preserving species, is discussed. Thus, the value of biodiversity in this study is acknowledged as the extra value beyond the market price of *Ostrea edulis*. From this perspective, biodiversity is considered a positive externality and is therefore listed as a socio-economic benefit.

The notion of biodiversity, and its significance, is often touched upon, especially in recent decades with increasing awareness of both the impact from humankind and climate change on flora and fauna. Sweden has signed the UN Convention on Biological Diversity (CBD), which was established in 1992 with the objectives of conserving biological diversity, using its components in a sustainable way and sharing the benefits of genetic resources in a fair manner (Convention on Biological Diversity, 2012). A decline in biodiversity can affect eco-systems and their stability, productivity and resilience (Sjöström, 2007, p. 5).

Biodiversity can be divided into three different levels: biodiversity at eco-system level, biodiversity of species, including interplay between species, and genetic variation within and between populations. Preserving biological diversity is about maintaining a large variety of species, different types of nature and genetic variation within species (Norling & Sköld, 2002, p. 20). It is widely recognised that eco-systems consist of an array of organisms mutually dependent on each other. Most people can comprehend the importance of having a great variety of plants and animals, each with different qualities and characteristics needed for various reasons. Therefore, it is not uncommon for people to, albeit on a conceptual level, be able to appreciate even an insect that may seem of little value to us; most people attribute some sort of intrinsic value to biodiversity.

According to Norling & Sköld (2002, p. 21), there are four main arguments for protecting biodiversity in the sea. The first is the utility argument, which states that biological diversity is needed because we use it or may use it in the future. Applied to the case of *Ostrea edulis*, this means that fishing and consumption are dependent on the resources and genetic variation in the marine environment. The second argument is the ecological value, which entails that the eco-systems of the sea provide services for society, many of which people take for granted. The third argument is the aesthetical value, meaning that the sea accommodates inspiration and aesthetical experiences, which are valuable for art, literature and creativity. The fourth and final argument is the ethical argument, stating that nature's biodiversity is the result of evolution and that humankind must ask the question whether it has the right to deplete resources at the expense of other species and future generations.

As previously mentioned (see *Background*), the natural supplies of oysters around the globe have been subjected to overfishing and climate change (Coen, et al., 2007). In many parts of Europe, the supply of *Ostrea edulis* has been exhausted as a result of inbreeding depression (Launey, et al., 2001) and the parasites *Bonamia ostreae* and *Marteilia refringens* (Gosling, 2003). Even though Swedish oysters are believed to be protected from the parasites by the cold water temperatures (Berntsson, 2012b), cultivating the species could potentially increase the chances of its survival, should the parasites manage to gain foothold in the Koster Fjord, if, for instance, water temperatures increase due to climate change. Furthermore, it is likely to be worth preserving the Swedish *Ostrea edulis* since it is one of the few natural supplies that has not been subjected to the widespread trading and the subsequent inbreeding depression (Launey, et al., 2001) and genetic invariability for certain populations (Launey, et al., 2002) and is unique in this way. In addition, growing consumption could potentially threaten the Swedish oyster population and the Food and Agriculture Organisation of the

United Nations state that in order to be able to sustain consumption of shellfish, farming must be conducted so as not to exhaust the natural supplies (FAO, 2008).

An extreme example of the threat to biodiversity is the case of the cod fishing industry in Newfoundland, Canada – the world's largest supply of cod for over 30 years. Fishing-fleet from all over the world trawled cod-fish, resulting in massive overfishing and, finally, the complete collapse of the fisheries in 1992, with enormous socio-economic repercussions following. Ten years later, the cod had still not returned (Hirsch, 2002). Even though the situation for the oyster supply in Sweden is not close to a complete collapse, it is still worth noting that it is difficult to predict the true impact of a species becoming extinct before extinction becomes a reality. Kent Berntsson says that during his lifetime, there has been a significant decline in the supply of fish on the Swedish West Coast (Berntsson, 2012a). There is good reason to believe that every species whose genetic variability is damaged and every species that becomes extinct poses a cost to society.

Moreover, since the Swedish indigenous oyster is treasured by connoisseurs for its wide range of taste and healthy contents, it is presumed likely to be in the interest of the Swedish people to work towards safeguarding its survival, especially since aquaculture, and the possibilities of cultivating fish and shellfish in a sustainable way, have been given attention by the Swedish government (SOU 2009:26).

When arguing for biodiversity in the case of preserving *Ostrea edulis*, it is necessary to examine whether the oyster poses any negative effects. A potential threat to biodiversity lies within the release of its faeces into the water. During the farming process, when the oysters are placed onto rafts and thus concentrated to one spot, the faeces, which are expelled into the water and sink to the sea-bed, can result in high concentrations of excess nutrients, such as nitrogen, in the water column beneath the oysters, which can lead to oxygen deficiency and ultimately a change in species composition, and mortality of sea-bed life. The harmful effect is mainly caused by the fact that the excess nutrients are concentrated to one spot. Chamberlain, et al. (2001), who have studied negative impacts from mussel farming write that "heavy sedimentation of faeces and pseudofaeces beneath mussel farms effectively lead to organic enrichment and thus alter macrofaunal communities." (Chamberlain, et al., 2001, p. 411). However, mussel farming and oyster farming differ in how close the individuals in the population are placed. Mussels are placed on large ropes and sit very close together, whereas *Ostrea edulis* do not thrive if located to close to each other. Therefore, the risk of creating oxygen deficiency in the water column under the oyster clusters is not very large (Lindahl, 2012).

From the analysis above, it is concluded that the net value of biodiversity, measured in the preservation of the species *Ostrea edulis*, is a positive value, implying positive socio-economic effects. However, the value of biodiversity cannot be quantified or monetised, simply because of a lack of knowledge in this field. The question of evaluating this impact will be left to experts and policy-makers. However, we will circle back to the effect biodiversity as a socio-economic benefit in our conclusion below and aim to discuss the implications of it for the result of this study.

Private economic benefits

Since the owners of Ostrea AB are Swedish citizens, and Swedish citizens have standing in this CBA, all private economic benefits deriving from production will be included in the calculation of total socio-economic benefits, since these benefits also impact society in a positive way. An extensive review of all private economic benefits will follow below, under the section *Private Economic Effects*.

SOCIO-ECONOMIC COSTS

Pollution from the hatchery

Due to the various detergents used for cleaning purposes in the production of *Ostrea edulis*, which are left in the wastewater cleaned by the local sewage treatment plant, it is assumed that the farming process results in some pollution. However, three reasons have been identified as to why this impact is insignificant. Firstly, detergent quantities used are small. Secondly, the company has recently started using the biodegradable detergent *Oxy-San* which thus poses no negative threat to the water. Thirdly, the majority of detergents are assumed to be removed in the sewage treatment plant. As a result, this impact will not be quantified and monetised in the CBA.

However, it is important to note that if production grows, cleaning routines at the facilities may need to be revised. As a result, the significance of this impact may need to be further studied.

Emissions and noise from boats

Emission and fuel leakage from the small motor boats used to reach the oyster rafts, affect the water and air by the release of chemicals, such as polycyclic aromatic hydrocarbons (Swedish Transport Agency, 2010a) which are carcinogenic and potentially cause fish populations to decline when released into the water (Institutet för miljömedicin, 2009). Another harmful effect caused by the use of boats is the antifouling paint, used to keep the boat clean from fouling organisms such as algae and barnacles, which peels off into the water (Swedish Chemicals Agency, 2011). The paint often contains chemicals and metals such as copper and zinc that are released into the water and can cause harm to algae, mussels and other species. In addition, water pollution from boats is potentially a cost to people who are hindered from swimming, fishing or doing other water-activities. This pollution also affects the natural benthic flora and fauna (Swedish Transport Agency, 2010b). Furthermore, the motors of the boats could potentially disturb the peace in the Koster Fjord, posing a cost for the people residing in the area.

However, due to the low frequency of boat trips and the fact that the rafts will be located in the same spot (Berntsson, 2012a), this impact is assumed to be negligible and will therefore not be quantified and monetised in the CBA.

Negative effects on the environment caused by electricity consumption

As the high-tech equipment used in the hatchery requires electricity for activities such as pumping water from the sea, adjusting temperatures in tanks and containers, measuring and controlling water quality, sterilising water and culturing plankton, potential harm to the environment from producing electricity needs to be taken into consideration. This impact is, however, assumed to be negligible and will therefore not be quantified and monetised in this CBA.

Less space for outdoor life in the fjord area

As mentioned, Ostrea AB estimates to have 35 rafts on the west side of the Koster Islands during 2018 (Berntsson, 2012b). The rafts make up a potential hinder to boat traffic and leisure activities (e.g. swimming, water skiing, kayaking and leisure boating) in the fjord. Also, a large number of rafts might cause unsightly views for people living in the area. However, due to the relatively small size of the rafts in comparison to the surface of 30 000 hectares of the Koster Fjord as a whole (Swedish Environmental Protection Agency, 2009), the negative effect is considered to be negligible will therefore not be quantified and monetised in this CBA.

Private economic costs

Just as in the case of the calculation of total socio-economic benefits (which include all private economic benefits), the private economic costs deriving from production will be included in the calculation of total socio-economic costs. An extensive review of all private economic costs will follow below, under the section *Private Economic Effects*.

PRIVATE ECONOMIC EFFECTS

Below, is a list of Ostrea AB's "benefits" – i.e. its revenue in SEK – as well as their costs. When categorising private economic effects, the company's annual report serves as a model, in which the company's costs are divided into *staff costs*, *other external expenses* and *depreciation of tangible fixed assets*. For the calculations presented below, Ostrea AB is assumed to sell everything it produces. This assumption is likely to be true since the demand for *Ostrea edulis* is considered relatively stable in France, which is Ostrea AB's target market.

Revenue - Market price times sold quantity of oysters, in SEK

Since Ostrea AB plans on selling its oysters to the current market price of *Ostrea edulis* at 150 SEK per kilogram (Ostrea AB, 2012), the private economic "benefits" (the revenues) are simply assumed to be the market price (150 SEK per kilogram) times the amount of oysters sold in each year. Please see Table C2, *Appendix C*). The small amount of income gained from letting production facilities between the years 2006 to 2012 is not included in the analysis, as it is not a direct income effect deriving from oyster production.

PRIVATE ECONOMIC COSTS

The private economic costs 2006-2011 are based on Ostrea AB's annual reports. Costs are thus divided into *total staff costs, other external expenses* and *depreciation of tangible fixed costs.* For the years 2012-2014, total costs are assumed to follow the progress of the total costs during 2006-2011. After consulting with Lena Hölscher, controller at Ostrea AB (Hölscher, 2012), it is assumed that total costs increase by 12per cent from 2011 to 2012, by 10per cent from 2012 to 2013, and by 10per cent from 2013 to 2014. The private economic costs for the years 2015-2017, are based on Ostrea AB's predictions for total costs per kilogram of oysters (Ostrea AB, 2012).

5.6 Discount Benefits and Costs to Obtain Present Values

In general, the further away in time a benefit or cost arises, the less it is worth today. This can be understood through the reasoning that for example a payment is worth more today than in the future; most people would prefer to receive 10 000 SEK today rather than receiving the same amount one week later (Zerbe & Bellas, 2006, p. 215). In the case of farming *Ostrea edulis* in Sweden, the value of benefits for society, such as cleaner water and more jobs are worth more if they appear today than if they appear in a few years' time, since immediate improvements are considered better than an improvement in the future. If a new job is created today, it means that a person can stop being unemployed today rather than in, say, one year's time. Similarly, the cost of being prevented from being able to make use of the Koster Fjord is considered larger than if the cost does not arise until 2018.

To recalculate the value of a future payment in order to express it in terms of what it is worth today, the method of discounting is used. When the project at hand goes on for a very long time, for example over several generations, it is usually considered controversial to discount, the reason being that it is difficult to argue that a benefit granted to a future generation is worth less than a benefit granted to today's generation, specially considering the benefit can go to a 25-year old working class woman in one generation and then to another 25-year old working class woman 50 years later (Zerbe & Bellas, 2006). Since the inhabitants of Sweden have standing in this CBA, it would be difficult to argue that the benefits and costs of Swedes of one generation count more than the benefits and costs in a coming generation of Swedes. However, since our study only ranges from 2006-2018, this issue is not necessary for us to address.

The longer time frame we have at hand the smaller is the NPV. Also, the higher the discount rate, the smaller the NPV. The NPV of farming *Ostrea edulis* in Sweden will be the sum of the present values of its benefits minus the sum of the present values of its costs. In our case the NPV is not used in the traditional CBA sense to determine whether the project is worth carrying out or not, but to determine whether there exists market failure in the Swedish oyster industry.

Since the discount rate has significant impact on the NPV, it is important to choose it carefully. According to Zerbe & Bellas (2006), the ideal way to discount costs and benefits would be using the *social rate of time preference,* that is “the rate at which society discounts future time periods” (Zerbe & Bellas, 2006, p. 243). However, since everyone in society does not have the same preferences, different situations and approaches to life, this is virtually impossible to compute. Weitzman (1999) suggests that different discount rates should be used depending on when the cost or benefit occurs; for the first 25 years from present, 3-4 per cent is an appropriate discount rate, between 25 and 75 years should be discounted at 2 per cent and periods from 75 to 300 years from the present ought to be discounted with a rate of approximately 1 per cent. Since our “project” ranges from 2006 to 2018, 3.5 per cent is a good discount rate in accordance with Weitzman’s (1999) suggestion. In addition, according to Zerbe & Bellas (2006), a project conducted from a societal point of view should be discounted using a rate of 3-4 per cent, especially if it is not especially risky. It is concluded reasonable to use a discount rate of 3.5 per cent. For discounted values of socio-economic and private economic net benefits, please see *Appendix C*.

5.7 Compute the Net Present Value of Each Alternative

When computing the net present of farming *Ostrea edulis*, the discounted socio-economic and private economic net benefits respectively, for the years 2006 to 2018, are added together. For calculations, please see Table C1 and Table C2, *Appendix C*. The NPV of the private economic net benefits is 130.3 million SEK and the NPV of the socio-economic net benefits is 137.9 million SEK, translating into that the value of the socio-economic net benefits exceeds the value of the private economic net benefits by 7.6 million SEK. These results imply that market failure exists within the Swedish oyster industry. However, before a conclusion can be reached, a sensitivity analysis will be performed below.

5.8 Perform Sensitivity Analysis

Performing CBA includes some degree of imprecision and contingency as the true effects of a project cannot be calculated with certainty (Zerbe & Bellas, 2006). In order to examine the robustness of our results, a sensitivity analysis follows below. The aim is to acknowledge the uncertainty in the quantification and valuation of the variables in our analysis by examining how the results change when the variables and assumptions used change.

There are several ways to conduct a sensitivity analysis, of which Boardman, et al. (2011) describe three. In order to see how sensitive the results are to changes in one parameter specifically, partial sensitivity analysis is conducted (Boardman, et al., 2011, pp. 180-182). By varying the most important parameter or assumption, one can easily see how the results are changed. In our case, it could be of value to examine how the results change when, for example, future production volumes are changed or assumptions about monetary valuation of new jobs created are changed. Another way of performing sensitivity analysis is to picture worst- and best-case scenarios, where several parameters are changed simultaneously in order to see whether any combination of events might change the sign of the net benefits calculated (Boardman, et al., 2011, pp. 182-183). A third version of sensitivity analysis is called Monte Carlo sensitivity analysis, and takes probabilities of different assumptions into account (Boardman, et al., 2011, pp. 183-187). The riskiness of a project is thus calculated from a contexture of possible assumptions or scenarios. The strength of using this method is that the likelihood that an impact has a certain value is included, which gives a more realistic picture of the consequences of potential misjudgements.

In order to be able to evaluate the results from estimating the socio-economic and private economic net benefits in oyster production, a sensitivity analysis of the case follows below in the form of a partial analysis, in which we have chosen to examine the results deriving from a worst-case change in *one* specific factor, namely production volume. This parameter is chosen as it is considered to be the most uncertain assumption in our calculations. In addition, as previously mentioned, Ostrea AB is currently in a critical condition where it is vital for the company to reach its sales goals. This parameter affects the private economic calculations as well as the socio-economic calculations in a variety of ways, which implies that changes in volume are likely to change the results significantly. The scenario illustrated below will be referred to as a worst-case scenario (despite this being a partial sensitivity analysis) since we have used the lowest possible production volumes, which are considered to be still large enough to guarantee the company’s survival; it is worth noting that there is no value of performing a sensitivity analysis of a scenario that would cause Ostrea AB to file for bankruptcy, since this would mean that the socio-economic and private economic net benefits would never come into existence.

Due to the crucial position that Ostrea AB is currently in, it is of outmost importance that the business concept proves viable in order to keep the investors happy. The years 2012 to 2015 are considered critical for the survival of the company; if the company does not bring in money according to plan, it will not survive. Therefore, we have chosen a worst-case scenario in which business goes according to plan during 2012 to 2015, the company manages to secure continued faith from investors and other industry participants, but that something unexpected occurs in 2016 that causes production volume to be slashed in half for the two following years, 2017 and 2018. Furthermore, it is assumed that by 2016, Ostrea AB has hired workers according to plan in order to manage the originally predicted production volumes of 2017 and 2018. This implies large costs for production, technology and staff. Consequently, a 50 per cent reduction in production volume is likely to imply hardships in matching costs with revenues. In addition, a great deal of time, research and money necessary to solve the unexpected problem would take resources from the day-to-day activities. For these reasons, a production volume reduction greater than 50 per cent is assumed not to be manageable, and thus, this is the scenario used in our sensitivity analysis.

Other factors that are dependent on the volume produced and are calculated as a function of the volume, such as number of employees needed, are assumed to change in accordance with the 50 per cent volume cuts in 2017 and 2018. On the socio-economic side, both new jobs created as well as the amount of nitrogen removed, are changed in our sensitivity analysis model (presented in Table D3, *Appendix D*), while on the private economic side, changes in revenues follow. For simplicity, we have assumed that decreases in total costs due to fewer workers are outweighed by higher costs for technology and research to solve the unknown problem in the process. Thus, total costs do not change, despite changes to production volumes. For calculations and tables, please see *Appendix D*.

Under the assumptions stated above, the NPV of the socio-economic net benefits is 24.8 million SEK, while the NPV of the private economic net benefits is 12.9 million SEK. The difference between the NPV of the two categories is thus 11.9 million SEK – an increase from the base case where the difference was calculated as 7.6 million SEK. Hence, a reduction in production volume by 50 per cent during the years 2017 and 2018 has significant consequences for our results. However, the sensitivity analysis shows that the assumed worst-case scenario does not change the conclusion that market failure does exist, since the socio-economic net benefits still exceed the private economic net benefits, now by even more than in the base case. Worth noting, however, is that the value of the socio-economic net benefits decreases by 82 per cent while the value of the private economic net benefits decreases by 90 per cent (see *Appendix D*). Thus, the private economic net benefits seem to be slightly more sensitive to changes in production volume than the socio-economic net benefits.

Given the assumptions made above, the results imply that market failure exists within the Swedish oyster industry, as a result of socio-economic net benefits exceeding private economic net benefits, as long as Ostrea AB manages to produce enough oysters for the business to survive.

5.9 Make a Recommendation

The last step in the process of conducting CBA is to make a recommendation to policy-makers. The results point towards the existence of market failure within the Swedish oyster industry. The results thus imply that policy-makers ought to take measures to change the fact that the socio-economic net benefits are larger than the private economic net benefits. The sensitivity analysis presented above supports this conclusion. For a more comprehensive discussion of the results of this paper, please see *Conclusion* below.

6. Conclusion

As shown under Section 5.7 above, the private economic NPV of farming oysters in Sweden between 2006 and 2018 amounts to 130.3 million SEK and the corresponding socio-economic NPV adds up to 137.9 million SEK. This reveals that, according to our study, market failure is found to exist within the Swedish oyster industry, translating into that the answer to the research question *Do the socio-economic net benefits of farming* Ostrea edulis *in Sweden exceed the private economic net benefits - that is - does market failure exist in the Swedish oyster industry?* is yes. However, as the difference between the two NPV's is small, only 7.6 million SEK, we must not be too quick to draw a conclusion regarding the existence of market failure.

The aim of this paper was to provide policy-makers and other industry participants with a foundation for deciding upon whether corrective measures ought to be taken or not to support the Swedish oyster industry. The positive social and environmental effects that the farming process displayed and the seemingly complex and arduous private economic conditions induced our starting point. The CBA indicates that, since market failure seems to prevail within this industry, it may be necessary for the Swedish government to intervene; within the chosen time-frame, the socio-economic net benefits exceed the private economic net benefits. Examples of corrective measure that could be taken are subsidies and environmental grants based on the volume of eutrophication-causing substances removed.

In addition, the performed sensitivity analysis shows that the results are sensitive. In the imagined worst-case scenario, where 50 per cent of the production volume and subsequent revenue for the years 2017 and 2018 is lost, the NPV of the socio-economic effects are reduced from 137.9 million SEK to 24.8 million SEK and the NPV of the private economic net benefits from 130.3 million SEK to 12.9 million SEK. The difference between the discounted net benefits in this scenario is 11.9 million SEK, which is an increase from the base scenario in which the difference was 7.6 million SEK. Despite the dramatic decrease in both private economic and socio-economic net benefits, following from the worst-case scenario, the results still imply that market failure exists. However, since these values are small, they are not considered to be as significant, making it harder to lend support to the conclusion of the existence of market failure in the oyster industry.

However, there are a number of additional factors that need to be reviewed. Firstly, we conclude that it would have been desirable to include the impact of removing the eutrophication-causing substance phosphorus in our analysis, in order to gain a more realistic value of the socio-economic net benefits. Including this factor is presumed to add to the socio-economic benefits and ultimately, increase the NPV of the socio-economic net benefits of farming *Ostrea edulis*. Thus, the gap between the socio-economic and private economic net benefits is expected to increase. Secondly, the impacts that were judged to be significant but unquantifiable in the analysis need to be taken into account. In the case of the Swedish oyster industry, biodiversity is the only unquantifiable impact assessed to be significant, whereas the impacts from pollution from hatchery, emission and noise from boats, electricity consumption and less space for outdoor life are found to be insignificant. The net impact of biodiversity, taking the potential threat that *Ostrea edulis* poses to other species and the marine environment into consideration, is viewed as positive. Again, the conclusive effect is that including biodiversity will increase the gap between the private economic and socio-economic net benefits. As mentioned in the analysis above, biodiversity is often considered vital and few are willing to stand by while species become extinct. Biodiversity most likely adds high value to the socio-economic benefits, leading to the possibility that the socio-economic net benefits will more dramatically exceed the private economic net benefits. However, we believe it does not lie within our competence to make such an evaluation and leave this decision to experts and policy-makers. To sum up, it is believed that including phosphorus and biodiversity in this analysis would have increased the socio-economic net benefits, thus increasing the gap between the private economic and socio-economic net benefits and consequently lending greater support to the conclusion that market failure exists.

In addition to taking the substantial unquantifiable impacts into consideration, it is necessary to broaden the perspective in order to be able to conceive the true effects of an entire industry on society. A study limited to the private and socio-economic effects of farming oysters, excludes those of the suppliers and distributors. Emission from transportation distributing the oysters is a plausibly significant impact that would affect the results of the CBA. Transportation emissions are believed to lead to a decrease in the socio-economic net benefits due their negative impacts on the air and the environment. This effect would, however, to some extent be outweighed by the positive socio-economic effect of new jobs created within this sector, but all in all, the socio-economic net benefits are believed to decrease when the distribution side of the industry is accounted for. Following this discussion, it could seem useful to revisit the issue of who has standing. Based on the fact that Ostrea AB's annual reports and forecasts have been used a model for the oyster industry, and since the company aims at exporting the vast majority of production to France, it could very well be worth including the inhabitants of France, or even of Europe, into those with standing.

Similarly, investigating the suppliers is important to gain a comprehensive picture. For instance, the production of the equipment used in the farming process, i.e. tanks, pumps, filtering and cleaning systems and rafts, is likely to impact society in one way or another. However, we conclude that the supplier side of the industry is of less interest since it mainly consists of producers of the above-mentioned equipment and the jobs they entail. Being suppliers to Ostrea AB is probably not their only or main source of income and so their business is likely to exist and impact society no matter what. Nonetheless, broadening the frame of the study to the whole oyster industry could be of interest for further, more encompassing research.

Moreover, health effects ought to be acknowledged as an extension of an expanded oyster industry in Sweden. Being highly nutritious, containing both vital Omega 3 fats and minerals and vitamins, increased oyster consumption following the industry's expansion could entail positive health effects. However, it seems reasonable to assume that incorporating health issues into the picture would require a larger study, due to the complex nature of calculating health effects.

Other potentially interesting areas for further studies include the industry's spill-over effects, where tourism to the West Coast has been identified as the most important in question. We will however refrain from commenting on these effects here and refer to the previously mentioned study on sustainable oyster farming and seafood tourism, currently carried out at the University of Gothenburg.

Incorporating an extended time horizon into the study could also be appropriate, in order to study the ramifications of economies of scale. Although the Swedish oyster industry most certainly has increasing economies of scale, with increasingly large private economic benefits, it is worth noting that these benefits could to some extent be outweighed by negative impacts on the environment, especially in terms of the effect on the Koster Islands landscape; when the number of rafts increase substantially following an increase in production, the entire fjord could be crowded with rafts. Moreover, the positive impact of biodiversity concluded above, could very well diminish following on extremely large production volume; there is likely to be a tipping point where the advantages of using the Koster Fjord for farming oysters is overshadowed by the disadvantages from hindering other types of activities. However, it is not considered to be of likelihood that Ostrea AB or future oyster farmers will grow their business to such a large scale and exploit the Koster Fjord to that extent. Moreover, it is not likely to be possible to farm *Ostrea edulis* under such conditions, as the oysters cannot thrive when living too close to each other.

Furthermore, we want to point out that; all in all, when performing a CBA, it is necessary to focus on one particular industry or section of an industry in order to keep the analysis at a manageable level. Nevertheless, industries and sectors cannot really be seen as wholly separated from each other since society is complex and intertwined. In order for policy-makers to truly determine whether it is worth to invest time and tax payers' money into supporting an industry, a wider perspective needs to be undertaken and we must examine impacts that the oyster industry may have on other industries and identify potential chain reactions. Policy-makers are responsible for society as a whole and need to take all Swedish inhabitants into account, therefore, other industries and government projects ought to be studied in order to eliminate the possibility that they present society with even greater benefits. Therefore, if possible, it would be optimal to examine all industries at once.

To sum up, we conclude that, although our study brings us to the conclusion that market failure exists within the Swedish oyster industry, our findings are not strong enough to certify the existence of market failure in this industry. However, we believe that the outcome of our study clearly demonstrates that market failure could very well prevail in the Swedish oyster industry.

7. References

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Appendix A – Calculations Regarding Nitrogen Removed

Below follows explanations of calculations and assumptions underlying the values presented in Table 5.2.

<u>Calculations – Nitrogen removal from sea (tons):</u>

(Volume harvested)*((Nitrogen content per oyster)/(Average weight per oyster))=(Volume harvested)*(0.0002 kilograms / 0.100 kilograms)

Example - 2014: (25 tons oysters)*(0.0002/0.100)=0.05 tons nitrogen removed

<u>Calculations – Monetary value of nitrogen removal:</u>

(Amount of nitrogen removed expressed in tons)*(Value of nitrogen removal service per kilogram)

Value of nitrogen removal service=65.50 SEK per kilogram

Example - 2014: (0.05 tons)*(65.50*1000)=3275 SEK=3.275 Thousands of SEK

Appendix B – Calculations Regarding New Jobs Created

Below follows explanations of calculations and assumptions underlying the values presented in Table 5.3.

<u>Calculations – Number of jobs at Ostrea AB:</u>

According to Karl Johan Smedman (interview 8th of May 2012), the number of people needed in the production process in 2018 is estimated to be around 60. At the end of 2011, Ostrea AB employed 9 persons, corresponding to 6.5 full-time jobs. When estimating the number of people employed in the organisation in the future, i.e. for 2013-2017, the number of workers needed – in addition to the original 6.5 people - is estimated as a linear function of production volume. The numbers are adjusted one year ahead, as people need to be employed one year in advance of the increased sales volume. Thus, the number of people needed in 2018 (60) is employed already in 2017.

The calculations below are based on the following formula:

Number of employees 2011+(Number of employees 2018-Number of employees 2011)(Volume harvested next year/Volume harvested 2018)*

2018 (1200): 6.5+53.5 people=60 people (under the assumption that production will stabilise on 1200 tons)

2017 (700 tons): 6.5+53.5 people=60 people (given)

2016 (400 tons): 6.5+53.5*(700/1200)=38 people

2015 (160 tons): 6.5+53.5*(400/1200)=24 people

2014 (25 tons): 6.5+53.5*(160/1200)=14 people

2013 (0 tons): 6.5+53.5*(25/1200)=8 people

2012 (0 tons): 6.5 people (given)

2011 (0 tons): 6.5 people (given)

<u>Calculations – Number of new jobs created:</u> New jobs equal the increase in total number of jobs at Ostrea AB between two years.

Calculations – Number of new jobs going to unemployed: As described in the text, estimations are based on the scenario that all jobs created go to unemployed people.

Calculations – Monetary value of new jobs: Calculated as the average yearly reservation wage ((22.500*12)/2) times number of new jobs that go to unemployed people. Final results expressed in thousands of SEK.

Appendix C – Calculations of Total Socio-Economic Net Benefits and Private Economic Net Benefits

Below are overviews of the quantification, monetisation and calculation of the NPV of the net benefits of all socio-economic and private economic impacts.

SOCIO-ECONOMIC IMPACTS														
		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
BENEFITS	Nitrogen removal (ton)	0	0	0	0	0	0	0	0	0.05	0.32	0.8	1.4	2.4
	Monetary value	0	0	0	0	0	0	0	0	3.3	21.0	52.4	91.7	157.2
	New jobs to unemployed	3	2	0	0	1	0.5	0	1.5	6	10	14	22	0
	Monetary value	405.0	270.0	0	0	135.0	67.5	0	202.5	810.0	1 350.0	1 890.0	2 970.0	0
	Private economic benefits*	0	0	0	0	0	0	0	0	3 750.0	24 000.0	60 000.0	105 000.0	180 000.0
	TOT BENEFITS	405.0	270.0	0	0	135.0	67.5	0	202.5	4 563.3	25 350.0	61 890.0	107 970.0	180 157.2
COSTS	Private economic costs*	875.7	2 260.0	4 901.7	6 461.0	7 745.2	8 933.7	10 005.8	11 006.4	12 107.0	21 000.0	10 220.0	39 375.0	67 500.0
	TOT COSTS	875.7	2 260.0	4 901.7	6 461.0	7 745.2	8 933.7	10 005.8	11 006.4	12 107.0	21 000.0	10 220.0	39 375.0	67 500.0
NET BENEFITS		-470.7	-1 990.0	-4 901.7	-6 461.0	-7 610.2	-8 866.2	-10 005.8	-10 803.9	-7 543.7	4 350.0	51 670.0	68 595.0	112 657.2
NPV		-578.7	-2 363.5	-5624.8	-7163.4	-8 152.3	-9 176.5	-10 005.8	-10 438.5	-7 042.1	3 942.4	45 073.1	57 832.4	91 646.7

Table C1. *Calculations of the NPV of the socio-economic net benefits of oyster farming in Sweden. All monetary values in table are in thousands of SEK.*

Total NPV of socio-economic net benefits = 137 949 000 SEK

*Further explanation regarding calculations of private economic benefits and costs can be found in Table C2 below.

PRIVATE ECONOMIC IMPACTS														
		2006*	2007*	2008*	2009*	2010*	2011*	2012**	2013**	2014**	2015***	2016***	2017***	2018****
REVENUE	Volume sold (ton)	0	0	0	0	0	0	0	0	25	160	400	700	1200
	Sales price in SEK/kg	0	0	0	0	0	0	0	0	150	150	150	150	150
	TOTAL REV in TKR	0	0	0	0	0	0	0	0	3 750.0	24 000.0	60 000.0	105 000.0	180 000.0
COSTS	Oth Ext Expenses	477.6	958.1	2 027.4	2 585.3	3 305.9	4 298.3	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Total Staff Costs	398.1	1 171.9	2 309.3	2 810.1	3 151.4	3 256.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Depreciation Costs	0	130.0	565.0	1 065.6	1 287.9	1 379.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	TOT COSTS	875.7	2 260.0	4 901.7	6 461.0	7 745.2	8 933.7	10 005.8	11 006.4	12 107.0	21 000.0	10 220.0	39 375.0	67 500.0
NET BENEFITS	(EBIT)	- 875.7	-2 260.0	-4 901.7	-6 461.0	- 7 745.2	- 8 933.7	- 10 005.8	- 11 006,.4	- 8 357.0	+3 000.0	+ 49 780	+ 65 625.0	+112 500.0
NET PRESENT VALUE		-1 076.5	-2 684.2	-5 624.8	-7 163.4	-8 296.9	-9 246.4	-10 005.8	-10 634.2	-7 801.3	2 705.8	43380.4	55 254.5	91 518.8

Table C2. *Calculations of the NPV of the private economic net benefits of oyster farming in Sweden. All monetary values in table are in thousands of SEK.*

- *Ostrea AB's annual reports 2006-2011 (Ostrea AB, n.d.)
- **Personal communication with Lena Hölscher (Controller at Ostrea AB) and Karl Johan Smedman (CEO Ostrea AB)
- ***Ostrea AB Memorandum (Ostrea AB, 2012)
- ****Based on cost per kilogram oysters produced in the year 2017

Assumption: Costs are assumed to increase by 12% 2011-2012, by 10% 2012-2013, and by 10% 2013-2014.

Total NPV of private economic impacts = 130 326 000 SEK

Calculations of NPV – Example: NPV of private economic impacts:

$$NPV = (-875.7) * 1.035^6 + (-2260.0) * 1.035^5 + (-4901.7) * 1.035^4 + (-6461.0) * 1.035^3 + (-7745.2) * 1.035^2 + (-8933.7) * 1.035^1 + (-10005.8) + \frac{(-11006.4)}{1.035^1} + \frac{(-8357.8)}{1.035^2} + \frac{3000.0}{1.035^3} + \frac{49780.0}{1.035^4} + \frac{65625.0}{1.035^5} + \frac{112500}{1.035^6} = 130\ 326\ 000$$

Appendix D – Calculations Regarding Sensitivity Analysis

As mentioned in Section *5.8 Perform Sensitivity Analysis*, the partial analysis is based on an assumption that something happens in 2016 that causes production volume (and thus sales volume) to decrease by 50 per cent in 2017 and 2018 respectively. This is the worst-case scenario used. All other factors depending on the sales volume are assumed to change as a result of the decrease. The number of employees needed in the production under such assumptions is calculated as shown below (see calculations for each year and Table D1):

2016: 38 people (the volume is expected to be 700 tons the following year, just as in the base case)

2017: 6.5+53.5*(600/1200) people=33 people (calculated in the same way as in the base case, basing the calculations on the original plan with 60 people needed per 1200 ton)

2018: 33 people (under the assumption that production volume is uncertain for 2019, and the producer decides not to hire more workers in advance)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Volume harvested and sold (tons)	0	0	0	0	0	0	0	0	25	160	400	350	600
Number of jobs at Ostrea AB	3	5	5	5	6	6.5	6.5	8	14	24	38	33	33
Number of new jobs created	3	2	0	0	1	0.5	0	1.5	6	10	14	-5	0
Number of new jobs to unemployed	3	2	0	0	1	0.5	0	1.5	6	10	14	-5	0
Value of new jobs to unemployed (thousands of SEK)	405.0	270.0	0	0	135.0	67.5	0	202.5	810.0	1 350.0	1 890.0	-675.0	0

Table D1. *Quantification and monetisation of new jobs created by the oyster farming processes, under worst-case production volume.*

Similarly, the amount of nitrogen removed from the sea is changed due to the decrease of oysters produced, harvested and sold (see Table D2 below).

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Volume harvested and sold (tons)	0	0	0	0	0	0	0	0	25	160	400	350	600
Nitrogen removal (tons)	0	0	0	0	0	0	0	0	0.05	0.32	0.8	0.7	1.2
Monetary value (thousands of SEK)	0	0	0	0	0	0	0	0	3.3	21.0	52.4	45.9	78.6

Table D2. *Quantification and monetisation of nitrogen removal caused by the oyster farming processes, under worst-case production volume.*

Under the assumptions stated above, the total socio-economic impacts are valued as shown in Table D3 below:

SOCIO-ECONOMIC IMPACTS														
		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
BENEFITS	Nitrogen removal (ton)	0	0	0	0	0	0	0	0	0.05	0.32	0.8	0.7	1.2
	Monetary value	0	0	0	0	0	0	0	0	3.3	21.0	52.4	45.9	78.6
	New jobs to unemployed	3	2	0	0	1	0.5	0	1.5	6	10	14	-5	0
	Monetary value	202.5	135.0	0	0	67.5	33.8	0	101.3	405.0	675.0	945.0	-675.0	0
	Private economic benefits	0	0	0	0	0	0	0	0	3 750.0	24 000.0	60 000.0	52 500.0	90 000.0
	TOT BENEFITS	202.5	135.0	0	0	67.5	33.8	0	101.3	4 158.3	24 696.0	60 997.4	51 870.9	89 921.4
COSTS	Private economic costs	875.7	2 260.0	4 901.7	6 461.0	7 745.2	8 933.7	10 005.8	11 006.4	12 107.0	21 000.0	10 220.0	39 375.0	67 500.0
	TOT COSTS	875.7	2 260.0	4 901.7	6 461.0	7 745.2	8 933.7	10 005.8	11 006.4	12 107.0	21 000.0	10 220.0	39 375.0	67 500.0
NET BENEFITS		-673.2	-2 125.0	-4 901.7	-6 461.0	-7 677.7	-8 899.9	-10 005.8	-10 905.1	-7 948.7	3 696.0	50 777.4	12 495.9	22 421.4
NPV		-827.5	-2 523.8	-5 624.8	-7 163.4	-8 224.5	-9 210.5	0	-10 536.3	-7 420.2	3 333.6	44 249.6	10 521.2	18 239.8

Table D3. *Calculations the NPV of socio-economic net benefits of oyster farming in Sweden, under worst-case production volume. All monetary values in table are expressed in thousands of SEK.*

Total NPV of socio-economic impacts under worst-case production volume = 24 813 200 SEK

A similar overview of private economic impacts is presented in Table D4:

PRIVATE ECONOMIC IMPACTS														
		2006*	2007*	2008*	2009*	2010*	2011*	2012**	2013**	2014**	2015***	2016***	2017***	2018****
REVENUE	Volume sold (ton)	0	0	0	0	0	0	0	0	25	160	400	350	600
	Sales price in SEK/kg	0	0	0	0	0	0	0	0	150	150	150	150	150
	TOTAL REV in TKR	0	0	0	0	0	0	0	0	3 750.0	24 000.0	60 000.0	52 500.0	90 000.0
COSTS	Oth Ext Expenses	477.6	958.1	2 027.4	2 585.3	3 305.9	4 298.3	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Total Staff Costs	398.1	1 171.9	2 309.3	2 810.1	3 151.4	3 256.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Depreciation Costs	0	130.0	565.0	1 065.6	1 287.9	1 379.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	TOT COSTS	875.7	2 260.0	4 901.7	6 461.0	7 745.2	8 933.7	10 005.8	11 006.4	12 107.0	21 000.0	10 220.0	39 375.0	67 500.0
NET BENEFITS	(EBIT)	- 875.7	-2 260.0	-4 901.7	-6 461.0	- 7 745.2	- 8 933.7	-10005.8	-11006.4	- 8 357.0	3 000.0	49 780.0	13 125.0	22 500.0
NET PRESENT VALUE		-1 076.5	-2 684.2	-5 624.8	-7 163.4	-8 296.9	-9246.4	-10005.8	-10634.2	-7 801.3	2 705.8	43 380.4	11 050.9	18 303.8

Table D4. *Calculations of the NPV of the private economic net benefits of oyster farming in Sweden, under worst-case production volume. All monetary values in table are expressed in thousands of SEK.*

Total NPV of private economic impacts under worst-case production volume = 12 907 400 SEK

Comparison between base case and sensitivity analysis regarding values of socio-economic net benefits versus changes in private economic net benefits:

Socio-economic net benefits:

Sensitivity analysis value/Base case value=24 813 200 /137 949 000=0.1798=18%

Decrease in value: 100-18=82%

Private economic net benefits:

Sensitivity analysis value/Base case value=12 907 400/130 326 000=0.099=10%

Decrease in value: 100-10=90%