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Adding sustainability to salmon farming regulations

A comparative case study of salmon farming regulations and the ASC salmon standard

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Adding sustainability to salmon farming regulations– a comparative case study of salmon farming regulations and the ASC salmon standard

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Summary

Food scarcity is one of the main challenges related to our planet's growing population and changing environment. Furthermore, our current food production is aggravating and accelerating climate change, as almost 24% of global greenhouse gases derive from agriculture (Troell, Jonell, & Henriksson, 2017). Seafood is likely to become an even more important resource for animal protein than it already is, as the population grows, and the environment becomes less predictable which potentially could result in depleted yields. Aquaculture volumes have increased substantially during the last three decades, with increased production numbers from five million tons in 1980 to more than 106 million tons in 2017 (FishStat, 2013; Zhou, 2017). One species that have seen a rapid growth in production numbers is Atlantic salmon. The increased production in aquaculture has resulted in an increased environmental concern about the consequences of intensive farming. Consequentially, this has resulted in an influx of eco-certification schemes. One of which is the Aquaculture Stewardship Council (ASC). This study has compared the national/provincial legislation on aquaculture in the four biggest salmon producing regions; Norway, Chile, Scotland (UK), British Columbia (Canada) and the ASC's standard, to compare how different the legislations are from the guidelines set up by this eco-certification scheme. The study found that the ASC standard has stricter standards than the aforementioned regions. Furthermore, this study has compared the potential sustainability effects of using national standards versus international standards for salmon farming and found that international standards have an important role to play as they have the potential to make everyone abide by the same minimum requirement. However, in order for them to have a real effect they need to be legally binding and not just be voluntary guidelines.

Sammanfattning

Den globala livsmedelsförsörjningen är en av framtidens stora utmaningar. Med en växande global befolkning och med ett klimat under förändring är det svårt att veta hur livsmedelsförsörjningen i framtiden kommer att se ut. Fisk och skaldjur kommer sannolikt fortsätta växa i betydelse, eftersom det potentiellt har en mindre inverkan på klimatet än konventionellt jordbruk (Troell, Jonell, & Henriksson, 2017). Vattenbruk blir samtidigt en allt vanligare metod för att producera fisk eftersom fiskbeståndet i världens hav har minskat drastiskt de senaste årtiondena (D'amico, et al., 2016; Naylor & Burke, 2005). En av de arter som odlas flitigt är lax (*Salmo Salar*). Den ökade intensiteten av vattenbruk och laxodlingar har resulterat i en ökad oro för de potentiella effekter havsbruk har på lokala ekosystem och akvatiska miljöer. Det har i sin tur lett till ett ökat antal miljöcertifieringar, en av dessa är Aquaculture Stewardship Council (ASC). Den här studien jämför nationella/provinsiella lagar och policys hos de fyra största lax producerande länderna/provinserna Norge, Chile, Skottland (Storbritannien) och British Columbia (Kanada) och ASC standarden för hållbara laxodlingar. Studien visar att ASC certifieringen har striktare krav på laxodlingarna än vad respektive lag/policy har i de fyra regionerna. Vidare har den här studien fokuserat på om nationella standarder eller internationella standarder är att föredra för att uppnå en hållbar lax industri, och kommit fram till att internationella standarder är att föredra för att skapa en hög minimum standard, men att de saknar effekt då de, som i det här fallet, oftast endast är rekommendationer och inte bindande lagar.

Content

1. Introduction

The global population is continuously growing, and with an expected 9.8 billion people by 2050, and 11.2 billion by 2100 there will be some intricate challenges in the future (UNDESA, 2017). One of the more complex challenges that the world faces is combining the growing population with sustainable food producing practices whilst combating starvation and malnutrition. This is particularly difficult as agricultural industries exhaust the planetary boundaries and add severe stress to some of these boundaries, namely the nitrogen cycle (biochemical flow boundary), and biodiversity loss (Rockström, et al., 2009). The UN has through the Millennium Development Goals (MDGs) and its successor the Sustainable Development Goals (SDGs), created a global political framework in which all member states strive towards creating an environmentally-, socially-, and economically sustainable future (UNDP, 2015). By ratifying this agreement, the member states have declared their intentions to actively work towards ending the continuous unsustainable exploitation of our global resources and natural capital while working towards eradicating poverty and starvation from our societies (Weitz, Nilsson, & Davis, 2014). The SDG's have further emphasized the need for sustainable food production. The goals are all-encompassing and received a lot of attention as an unprecedented 193 signatures were collected (UNDP, 2015). Arguably, by achieving 193 sovereign state signatures, the agreement could not be too detailed, demanding or restricting, but would hopefully rather work as a spark of ingenuity and collaboration among countries, researchers and private sectors (Clémençon, 2016).

One fast growing industry of food production, with the potential to add to future food resilience is aquaculture (Edwards, 2015). Seafood and aquaculture add, in comparison to other agricultural animal husbandry practices, a relatively small fraction to the planetary boundaries. Even if it adds more stress on the boundaries than plant based food sources, it still holds great potential to feed many and could add resilience to food markets all over the globe (Troell, Jonell, & Henriksson, 2017). In 2016, aquaculture contributed to more than half of the global seafood volume (FAO, 2017).

Over 600 species are farmed through aquaculture processes today and there are businesses and farms set up all over the globe (Troell, Jonell, & Henriksson, 2017). During the last two and half decades the industry has increased exponentially, from only producing five million tons in 1980 to more than 106 million tons in 2017 (FishStat, 2013; Zhou, 2017). This rapid expansion was partly being driven by technological advancements and by stagnating capture fisheries where almost 90 percent of all wild fish stocks now are either depleted, overexploited or recovering (D'Amico, et al., 2016, p. 147; Naylor & Burke, 2005).

Farmed Atlantic salmon (*Salmo Salar*) is one of these rapidly increasing industries, with the two largest producers being on opposite sides of the planet, Norway and Chile. However, Atlantic salmon is produced in other regions as well, e.g. in Oceania, North America and other European countries (Asche, 2012). In 2013, salmonid fish represented 7.2 percent of the total production in live weight, and a staggering 16.6 percent of the value share of global aquaculture (FAO, 2016). Overall, the demand for salmon is growing steadily and there are significant economic incentives to farm salmon, with production numbers increasing from approximately 38 thousand tons in 1985 to approximately 2.3 million tons in 2014 (FAO, 2017). There are no signs of decline in production as techniques and methods are improving and becoming more efficient and sustainable (ASC, 2012, p. 37; The World Bank, 2013). As aquaculture industries have grown and the demand for sustainable foods have gone up, so has the number of certification schemes to help businesses distinguish themselves as sustainable and provide environmentally conscious consumers with directions to make sustainable choices (Washington & Ababouch, 2011; Foley & Havice, 2016). The outcomes beyond business as usual is a concept that Garrett et al., (2016) calls additionality and it is referring to the difference between operations/farms that have been certified and operations/farms that have not been certified.

This study is reviewing and analyzing the current regulations on conventional salmon farming in Norway, Chile, Scotland and Canada. Furthermore, it compares these regulations to the salmon standard of one of the biggest aquaculture certification organizations, namely the Aquaculture Stewardship Council (ASC), to identify the potential additionality, or differences between conventional regulations and the ASC standard. By comparing state regulations with the ASC standard this paper also hopes to add some clarity to the theoretical debate on whether stricter state-specific regulations or voluntary certification schemes are preferable in achieving more sustainable practices. The study compares two theories on how to incentivize sustainability, and what changes, in the conventional regulations, that would be necessary. One advocating for stricter state-specific standards and one that advocates for internationally applicable standards.

1.2 Background

Interest and research for sustainable and reliable food producing methods have been increasing as the climate change debate has gained traction in the global political debate. Intergovernmental organizations (IGOs) such as the Food and Agriculture Organization of the UN (FAO) and EU have, together with Non-Governmental Organizations (NGO) such as the World Wildlife Fund (WWF), been advocating for sustainable aquaculture for two decades. Whether or not this should be done through stricter international policies and guidelines on the aquaculture industry that all actors must abide by, or if it should be left to individual states to decide what sustainable aquaculture is and how it could be used as a competitive advantage, is an unresolved debate.

In 1995, the FAO (FAO) developed a Code of Conduct for Responsible Fisheries, that suggested that states should "[...] *Establish, maintain and develop an appropriate legal and administrative framework which facilitates the development of sustainable aquaculture* (FAO, 1995)." In 2010, the FAO released an updated technical guideline for Responsible Fisheries. The *Ecosystem Approach to Aquaculture* (EAA) was written as a strategy for countries to work towards establishing a sustainable aquaculture (FAO, 2010). The EAA was developed to not be restricted by only environmental sustainability, but also economic- as well as social- and their interactions with ecological considerations. The strategy advocates for nations/regions to consider their own potentials and restrictions and build their regulatory policies in collaboration with researchers on how to best tackle the difficulties or take advantage of the potential in their local geographical conditions (FAO, 2010, pp. 10-12).

In 2011 the FAO published a report on technical guidelines on aquaculture certification (2011), where they argue for using certification schemes as a possible market based solution in the efforts of creating a sustainable aquaculture business (FAO, 2011, p. 1). Furthermore, they argue for, what Jonell et al. (2013) call inclusive certifications schemes, that would enable farmers that might not have a completely sustainable practice to participate and produce certified products. This tactic would hopefully result in a larger cumulative change as farmers could make small changes, without making too costly alterations (Jonell, et al., 2013). In the 2011 report the FAO wrote:

"*Aquaculture certification schemes:* […] *should not discriminate against any group of farmers practicing responsible aquaculture based on scale, intensity of production or technology;*

promote cooperation among certification bodies, farmers and traders; incorporate reliable, independent auditing and verification procedures; and should be cost-effective to ensure inclusive participation of responsible farmers" (FAO, 2011).

Although salmon producing companies have tried to abide by the code of conduct and national policies have increased controlling mechanisms (Tecklin, 2016), as well as monitoring measures, and research has streamlined feed efficiency which has reduced the usage of wild caught fish, and antibiotics-, and chemical usage have decreased in some regions (Bridson, 2014), there still is according to some, an issue that there are not any binding international standards for nations to abide by (VanderZweeg, Chao, & Covan, 2002; Washington & Ababouch, 2011). The EU's eco-label is an example of how IGOs are trying to incentivize sustainable practices through eco-labeling and certifications to distinguish themselves as sustainable (EC, 2017). This is a generic standard that rewards good practices throughout the EU; however, it is not required for producers to abide by the eco-label standard, only if they wish to be certified. Incentivizing through eco-labeling and certifications is an efficient tactic to prevent excessive political and economic alterations on a larger, governmental scale, and instead put the responsibilities and workload on producers to revise their practices to better abide by a voluntary standard (Hopwood, Mellor, & O'Brien, 2005).

1.2.1 Defining sustainable development

The concept of sustainable development is one with many definitions; however, the most common one would probably be the UN definition in the Brundtland report: "*Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs* (UNWCED, 1987)." This vague definition allows for individual interpretations that may or may not be sustainable.

Even if we strive towards achieving the Brundtland definition of sustainability, we might not have all the information necessary to make the judgment of whether or not something truly is sustainable. Indeed, this definition gives leeway for actors to create a model that works for themselves whilst striving towards reaching the goal of a vaguely defined concept, "sustainability". Sustainability is usually divided into three different criteria, the biophysical (environmental), societal and economic (Fischer, et al., 2007; Connolly, 2007). Societies are dependent on a functioning life-support system, and without social structures and institutional order economies cannot thrive. Thus, the hierarchical order should follow; environment, society and economy (Fischer, et al., 2007). However, governments, people and companies differ in the prioritization of these criteria. These divergences might derive from political, cultural, financial or geographic factors (Burford, et al., 2013), e.g. economic shortsightedness that might give positive results today, but at the expense of tomorrow and a premature biophysical overshoot (Ricke, Millar, & MacMartin, 2017). Another common definition of sustainable development is "*development that improves the quality of human life within the context of earth's carrying capacity* (IUCN, 1991)."

Sustainable development can be divided into two subcategories "weak" versus "strong" sustainability (Neumayer, 2003). The weak paradigm argues that environmental degradation and loss of natural capital can be compensated through monetary and technological progress whereas the strong paradigm argues that the substitutability of natural capital is severely limited and that precautions should be applied to avoid irreversible environmental changes (Neumayer, 2003). Therefore, even with an increased debate concerning sustainable developments, there are still questions looming regarding the actual sustainability of some action plans and methods used to achieve sustainability.

Indeed, through political engagement, public awareness campaigns and through research, the issues surrounding sustainable development have had an increased importance for political parties, companies and people alike (Fleig & Tosun, 2017). However, the continuous deterioration of our environment and loss of biodiversity is a clear indication that there still is room for improvement, on a micro-, meso- and macro level (Fischer, et al., 2007).

1.2.2 Efforts to reach sustainable practices and the effects of seafood certifications

One market based tactic to incentivize sustainable practices has been to reward actors through eco-labeling and certification schemes by states, IGOs, private actors and Non-Governmental Organizations (NGOs). Markets for seafood eco-labeling and certifications have grown significantly since 1990, when the dolphin-safe tuna label was created. The dolphin-safe tuna label was created after news spread about dolphins getting entangled in tuna nets (Jacquet, et al., 2010). Eco-labels and certifications have increased the environmental and ethical awareness among consumers, retailers and states (Jacquet, et al., 2010). Since then, there has been a dramatic increase of seafood certification schemes worldwide. Certifications usually work as voluntary standards that go beyond the bare minimum requirements set up by governmental regulations and present companies with an opportunity to differentiate themselves and help consumers make conscious choices (Kuhfuss, et al., 2016). One of the most renowned seafood certifications, the Marine Stewardship Council (MSC), was established in 1997 as a non-profit organization (MSC, 2017). The council built their standard as a supplement to the FAO's Code of Conduct for Responsible Fisheries, which was signed in 1995 (FAO, 1995). Some countries tried to respond with competition and wanted to create a FAO-endorsed labeling schemes, this was, however, an unsuccessful venture that instead resulted in the FAO setting up non-binding guidelines for eco-labeling companies. These included transparency, third party assessments and standards specified for targeted species (FAO, 2005), requirements that the MSC and subsequently ASC have welcomed and applied to their own practices. The initial skepticism towards having a non-state actor setting the premises changed over time as more states and consumers became proponents of MSC rather than opponents (Gulbrandsen, 2014). The international recognition of the MSC standard, paved the way for a similar standard but for aquaculture, rather than fisheries, namely, the ASC standard.

However, there are still huge discrepancies between certification schemes in what they regard as sustainable. According to Jonell et al. (2013) there are two variations in certification tactics, one "golden" tactic and one "inclusive" tactic, these could be compared to weak versus strong sustainability. The difference between these two is stringency; the golden certification should guarantee consumers that the fish has been produced in a sustainable manner, whereas the inclusive is less stringent but might include larger quantities of producers (Jonell, et al., 2013). Furthermore, certifications usually benefit large scale fisheries that receive governmental subsidies and overlooks small-scale fisheries (Rashid & Pauly, 2006). Eco-labelling has according to Ward (2008) not had the great impacts it was set out to have. In some cases, certifications can even have the opposite effect as was the case in Western Australia where it handed fisheries leverage against proclamations of fish sanctuaries, on the grounds that it is unnecessary if the fisheries are already certified (Sutton, 2003). Additionally, there are cases of where the scope of certifications has proven insufficient, one such example is the potential effects fisheries, certified or not, have on local ecosystems (Jacquet, et al., 2010).

One question that should be posed to certification schemes is, what are the outcomes beyond business as usual (Milder, et al., 2015; Garrett, et al., 2016)? This outcome is what Garrett et al., calls *additionality*. Are certification schemes actually leading to any change or are they just regurgitating the challenges and reward good behavior (Milder, et al., 2015)? One possible way to study those questions is to compare the existing conventional regulations and the certification scheme standard to see where and with how much the standard actually differentiates from the conventional regulations.

1.2.2.1 Markets for salmon and the ASC certification

Initially, farmed salmon was a commodity almost exclusively available at high-end markets as a supplement during the down season for salmon fisheries (Pelletier., et al., 2009). It has since then grown exponentially and can now be found on markets worldwide all year round. However, it is still a rather expensive and resource intensive species to farm and is mostly produced to be consumed in wealthy parts of the world (Jonell, et al., 2013). Consumers in these parts are more likely to have the possibility to be environmentally conscious, which is one of the reasons why many certification schemes have standards for high maintenance fish like Atlantic salmon, such as Best Aquaculture Practices (BAP), GlobalG.A.P, (Good Agricultural Practice) the ASC and Global Aquaculture Alliance.

Certification schemes have been developed for different reasons, from ensuring the quality of the food to environmental or social impacts of the production techniques and management (Jonell, et al., 2013). Some of the certifications are focusing on a life-cycle assessment for the aquaculture products, and many use the International Organization for Standardizations (ISO) 14020 series as part of their assessment (Pelletier & Tyedmers, 2008; Jonell, et al., 2013). However, despite these efforts there are still critics arguing that the biophysical demands and environmental impacts are not fully addressed by certification schemes and that there still is room for improvement (Pelletier & Tyedmers, 2008).

The lack of reliable standards on a national as well as multinational level and environmental and public health concerns have been instrumental in the rapid increase of private standards and certifications for good- and sustainable aquaculture practices (Foley & Havice, 2016; Washington & Ababouch, 2011). These standards are supposed to add stringency to existing national/regional aquaculture regulations. One example of such a certification that is central to this paper is the Aquaculture Stewardship Council (ASC) certification.

1.2.3 The Aquaculture Stewardship Council

In 2009 the WWF and the IDH (Sustainable Trade Initiative), co-founded the Aquaculture Stewardship Council (ASC) as an independent not for profit organization (ASC, 2012). The council has since then become an internationally recognized certification body that is widely believed to have one of the most stringent requirements for sustainable practices (Seafood Watch Program, 2017, p. 1). To ensure an all-encompassing standard the WWF and the IDH invited people from the industry, conservationists, government officials and academics to roundtable discussions to write sustainable standards for nine different species cultured in aquaculture that could fill the void of lacking international standards and guidelines (WWF, 2017).

The abundance of seafood certification schemes has created an opportunity for other actors to guide and help retailers and consumers to make good, eco-conscious choices (Jacquet, et al., 2010), some of the these organizations are private, such as the Monterey Bay Aquarium's Seafood Watch program, Greenpeace and miljömärkning.se, but some governmental agencies also try to help consumers and retailers, such as the Swedish Board of Agriculture (Jordbruksverket) (Jordbruksverket, 2017; Miljömärkningar; Seafood Watch Program, 2017; Greenpeace, 2014).

All of these consumer-guides recommend the ASC as a certification scheme to trust, however there is still room for improvement, as has been voiced by the Swedish Society for Nature Conservation (SSNC) (Naturskyddsföreningen, 2013). There are other certification schemes, such as BAP and GlobalG.A.P., that are not as widely recommended as they are considered less stringent and do not necessarily set specific performance levels or require that particular performance targets are met (Seafood Watch Program, 2017). Another prominent reason why ASC certification ranks at the top, at least in the Seafood Watch Program, is because of its rather strict requirements on fish feed. The ASC had intended to have an updated version of the feed standards ready by the end of 2017; however, this standard has been delayed. A second draft of the new standard is available on ASC's website (ASC, 2017a). The previous standard and the new draft of the standard is pressuring farmers and companies to use feed where all of the fish meal and fish oil used, derive from fisheries with an International Social and Environmental

Accreditation and Labeling alliance (ISEAL) certification[1] (ASC, 2012). Other certifications such as BAP apply less stringent regulations on the use of fish meal and fish oil. They require 50 percent of the fish products used in the feed to derive from certified sustainable sources (BAP, 2016, p. 9).

The ASC's new feed standard recognizes that wild caught seafood is a finite resource and that agricultural products must be used responsibly as much of it could be used for human consumption (ASC, 2017a). The standard argues that the best way to mitigate this problem is by implementing global standards where all feed producers must apply the same standards all over the globe (ASC, 2017a).

Global discussions concerning environmental and social sustainability have nations, farmers and companies attributing their own progress. By participating in global standard discussions actors are signaling a willingness to change, and attaining certifications is a way of proving that (Washington & Ababouch, 2011). However, criticism is still raised that standards sometimes are detrimentally flawed, or impose impossible demands. And that these standards, decided by international certification schemes, could be avoided by customizing and applying a more local perspective on sustainable practices (Foley & Havice, 2016; Jacquet, et al., 2010; Sutton, 2003). The four largest Atlantic salmon producing nations are all categorized as developed by the OECD (2017), which according to some, adds more pressure on them than developing countries, to lead the way in the global efforts to combat unsustainable practices (Eckersley, 2015).

1.2.4 Salmon farming techniques and development

Salmon is an omnivorous, anadromous fish; it is born in freshwater before it migrates to the ocean where it spends most of its adult life before it once again migrates upstream from the sea to spawn (Ellis, et al., 2016). Salmon farming start at hatcheries, where the roe is hatched before the juvenile fish are transferred to nurseries where they remain until they are twelve to eighteen months, before they are introduced in floating cages or open net pens in the ocean (FAO, 2017). The salmon is then bread in large cages in temperate waters between 6-16 degrees Celsius for another twelve months before they are harvested (FAO, 2017). Using open net pen cages in marine environments is by far the most common practice (Lekang, Salas-Bringas, & Bostock,

[1] ISEAL is an alliance working towards creating sustainable practices for aquaculture, agriculture as well as forestry businesses. Their standards are based on FAO frameworks.

2016). However, using open net pens enhances the risk of effluents, such as ammonium and phosphorus, feeds and fecal matter which effects the surrounding environments. The criticism towards open net pens and the risk of spreading diseases and or antibiotic resistant bacteria has in some instances been mitigated by vaccinations (Gjerde, et al., 2009). New techniques and technologies are under constant development to streamline a sustainable intensification of aquaculture practices (Edwards, 2015). Indeed, the closed containment system allow the farmers to control all the input and output from the farm, as well as the water quality (oxygen, CO^2, NH^3) and interaction with wildlife. However, the costs are much higher which preclude the farming method from competing with conventional open net pen farming, as prices go up and production numbers go down (Thorarensen & Farrell, 2011).

Salmon is and has been highly dependent on feed containing large quantities of fish oil and fish meal from small pelagic forage fish. Although, due to these finite resources becoming scarce and expensive, new formulas for fish feed where fish meal and oil can be replaced by e.g. soy protein, vegetable oil and yeast are being tested and increased efficiency on marine animal protein sources is researched (Klinger & Naylor, 2012; Huyben, et al., 2016; Crampton, et al., 2010). Recent research from feed producing company Skretting has showed that salmonid feed can be produced without any fishmeal which would have significant impacts on the Fish in: Fish out (FI:FO) ratio, and contribute to the sustainable intensification of the salmon producing industry (Skretting, 2016).

1.2.5 Is salmon farming sustainable?

Sustainability as a concept in salmon farming is dependent on several aspects throughout the production cycle. From feed contents, feed harvesting and fishing techniques, to the handling of roe and smolts, to effluents from the farm, to fish health, and energy consumption to keep the farm operational. Life-cycle assessments is a common methodology to try and create a holistic picture of the salmon farming industry and its effects on the environment and whether or not it is within earth’s carrying capacity (Pelletier & Tyedmers, 2008).

Salmon farming researchers usually raise five concerns or elements regarding potential environmental consequences from intensive farming; 1. Interaction with wildlife (Olesen, Myhr, & Rosendal, 2010; Sepulveda & Oliva, 2005). 2. Fish health, mainly focusing on antibiotic usage and chemical substances to battle sea lice and other epidemics (Burridge, et al., 2010). 3. Waste, from uneaten feed, feces, greenhouse gases, and other dissolved inorganic nutrients (Klinger & Naylor, 2012; Liu & Sumaila, 2010; Hu, et al., 2012). 4. Farm location (Cook, et al., 2008), and 5. contributing to the depleting stocks of wild fish populations, as fish meal and fish oil from wild caught pelagic fish is used in fish feed (Troell, et al., 2014).

The first of these concerns, *interaction with wildlife*, may vary depending on the location of the farm. For instance, an escaped Atlantic salmon in Chile and western Canada (British Columbia), where most of the Canadian Atlantic salmon is produced, is unwanted due to its unknown consequences on the local ecosystems, as it is an introduced species in these regions. An escaped Atlantic salmon (*Salmo Salar*) in Norway and Scotland, where they are regarded as a domestic species, is unwanted as the interaction with wild stocks can have behavioral effects on coming generations (Cook, et al., 2008). A study conducted by the Norwegian Institute for Natural Research (NINA) has shown that interbreeding between wild stock populations and farmed salmon can lead to lowered survival, and individual fitness as well as decreased reproductive abilities for at least two generations (Thorstad, et al., 2008, p. 110). Some would argue that escaped salmon is less dangerous where it is introduced and invasive, as it has not been able to establish a presence in the regions, whereas escaped salmon have replaced some wild populations in Norway (Bridson, 2014). However, if an invasive species establishes itself in a new environment it can have catastrophic consequences to the local ecosystems (Huxel, 1999). Thus, the issues surrounding escaped farmed salmon varies gravely between Norway, Scotland where there are natural stocks of *Salmo salar* and Chile, British Columbia where there are not.

Cultured salmon is a hotbed for sea lice outbreaks and other diseases or infections, which can have detrimental effects on wild fish populations if it disseminates. Furthermore, farm operations can have stressful impacts on the local wildlife in the surrounding environments, through effluents, noise pollution or constructions. It may also attract predatory animals which could cause mayhem and lead to damage on the property, stress the fish or even result in fatal incidents (Frazer, 2009; Sepulveda & Oliva, 2005).

The second, third and fourth issues are related to *effluents and pollution* of the surrounding environments around the farms. Pollutants and wastes released to the atmosphere and recipient waters contribute to climate change and the deterioration of the water quality. It can have permanent effects on ecosystems and should be kept at a minimum level. Nitrous Oxide (N_2O)

is produced as microbial nitrification and denitrification occurs from feeding the fish (Hu, et al., 2012). N $_2$ O is a poten

feces and other organic matter that are discharged from the open net pens can aggravate the environmental effects from the aquaculture practices and result in nitrogen and phosphorus pollution which leads to eutrophication and reduced oxygen levels (Klinger & Naylor, 2012; Weiner, 2008; Liu & Sumaila, 2010). According to research, producing one kilo of Atlantic salmon emits 2.9 kilos of CO^2, approximately the same as poultry and significantly less than beef and pork (Winther, et al., 2009).

The fifth issue is related to the overexploitation of small pelagic fish in order to make fish feed for cultured predatory fish, such as salmon. On an annual average, almost 27 percent (20 million tons) of the wild caught fish is used for other purposes than human consumption (Cashion, et al., 2017). Historically, salmon feed has been heavily reliant on fish meal and fish oil from pelagic forage fish, to ensure high levels of healthy *n-3* polyunsaturated fatty acids like extracted eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) (Olesen, Myhr, & Rosendal, 2010; Pelletier, et al., 2009). Overexploitation of smaller pelagic fish can have detrimental effects on a global, as well as on a local scale, especially in regions where households rely on pelagic fish as a key component of their diets (Troell, et al., 2014). Carnivorous farmed fish has traditionally been, and still is regarded as a fishery net "reducer" rather than "producer" (Naylor & Burke, 2005). However, as mentioned earlier, recent trends and research are pointing towards a change, where oils and protein can derive from plants, e.g. soy plants, canola and barley instead. Which would decrease the stress on wild stocks (Klinger & Naylor, 2012; Crampton, et al., 2010; Torstensen, et al., 2008; Troell, et al., 2014)? However, that does not necessarily make the feed sustainable, as the agricultural industry is one of the largest GHG emitters and contribute to the exhaustion of the aforementioned planetary boundaries (Troell, Jonell, & Henriksson, 2017). Thus, the replaced compounds in the feed must be grown, harvested and handled sustainably if it is to become properly sustainable.

1.2.5.1 Defining sustainable salmon farming

The concept of sustainable salmon farming is studied by not only certification schemes, but also by academic scholars and consumer guides. One of these is the Monterey Bay Aquarium Seafood Watch Program, an independent third-party consumer guide that aims to raise awareness and help consumers as well as businesses make environmentally conscious choices when buying seafood

(Monterey Bay Aquarium Seafood Watch Program, 2017). As part of the literature review, this study has looked at a Seafood Watch program study as well as other academic articles to define what issues and challenges there are for sustainable salmon farming. In 2014 Peter Bridson published a report for the Seafood Watch program on the salmon farming processes in the four regions of interest in this paper (2014). The overall judgment of the industry in all regions was listed as “Avoid” in the report as usage of chemicals and antibiotics as well as wildlife interactions and expanding areas of production was deemed too high (Bridson, 2014). The Seafood Watch program has ten criteria for sustainable aquaculture, which matches the five previously mentioned challenges well; those challenges are however identified from several sources and the literature review. The Seafood Watch program’s focus areas under observation are:

1. Data, referring to the availability and transparency.
2. Effluents, nutrient wastes beyond the immediate area of the farm.
3. Habitat, the wastes within the immediate area of the farm.
4. Chemicals, the use of chemicals, e.g. pesticides and antibiotics.
5. Feed, e.g. fish in: fish out ratio, feed conversion ratio and source of fish protein.
6. Escapes, how many escapees and their effects on the surrounding environment and wild stocks.
7. Disease, pathogen and parasite interactions, both in terms of captured fish health and wild populations.
8. Stocks, whether or not they are independent from wild populations.
9. Wildlife and predator mortalities, mortality rates of wildlife on the farm, or predatory attacks.
10. Escape of unintentionally introduced species, the risk of moving non-native species from hatcheries, smolts and into open net pens in the ocean (Bridson, 2014).

Other scholarly articles question the sustainability of using pelagic fish as ingredients in fish feed all together (Jacquet, et al., 2010; Troell, et al., 2014). Pelagic fish is regarded as high-grade feed, in that it can be consumed by itself by people, and therefore, it should not be used for any animal feeds (Jacquet, et al., 2010). Arguably, it should be a requirement in order for an aquaculture product to be called sustainable to have only low-grade feed ingredients that have been sustainably grown. The problem with low-grade food on the other hand is that salmon is a predatory fish who lives off high grade food like pelagic fish.

2. Problem statement

By using the aforementioned definitions of sustainable development from the Brundtland report and development to improve the quality of human life without overshooting earth's carrying capacity (Pelletier & Tyedmers, 2008), one can safely say that current human activities and production techniques, including salmon farming, are putting too much stress on the environment and local ecosystems (Fischer, et al., 2007). Some examples of how salmon farming can stress environments is through e.g. eutrophication from effluents and wastes (Folke, Kautsky, & Troell, 1997), or pandemic outbreaks such as the infectious salmon anemia virus (ISAV) (Cortez-San Martin, et al., 2012). However, there is a large political and private drive on local- and international levels as well as, several academic researchers and even university programs dedicated to solving and reversing this trend, both on a large scale such as with climate change and environmental degradation and on specific industries such as salmon farming (Chang, et al., 2017). This study has already mentioned some events and approaches relating to sustainable development on a large scale and smaller industry specific approaches, e.g. the UN's SDGs and eco-labels.

Even with a changing political debate that emphasizes the issues deriving from environmental degradation and climate change and even if market initiatives such as eco-labels and certifications have improved some businesses, and increased customer- as well as retailer awareness there still is a long way to go. Furthermore, there is an urgency to change and become sustainable as environmental degradation is irreversible and it will have consequences for future generations (Steffen, et al., 2015). For the aquaculture industries, the largest issues relating to sustainability are, as has been defined earlier, the interaction with wildlife, waste and effluent control, feed resources, fish health and farm location. As it can have severe negative impacts on aquatic and benthic environments in and around the farms, as well as on coastal environments and enhanced risks of negatively impacting wild populations of fish (Troell, et al., 2014).

In 2012 a group of CEOs from the salmon industry met to initiate talks on improving the environmental reputation of the industry. They realized that one flawed company harms the rest of the industry and decided to form the Global Salmon Initiative (GSI) (2017c). Among them were the two largest companies, Marine Harvest and Cermaq that have businesses and practices in all of the four regions that are studied in this thesis (Vormedal, 2017). These two companies have since then suggested more stringent regulations, compatible to the ASC standard to the Norwegian government to push the industry towards becoming more sustainable overall (Vormedal, 2017). Thus, arguing that states can further emphasize the importance of sustainable practices by adding stringency to current conventional regulations.

Arguably, states should strive towards implementing regulations that help safeguard ecosystems, wildlife and the environment in general. Whether or not that is by adding stringency to the existing regulations to better mimic the standards of certification schemes such as the ASC or to let such schemes, retailers, local communities and consumers use their own ingenuity and willpower to overcome these challenges is not yet established. Scholars, industry leaders and certification schemes have already started the process of changing the industry and are highlighting what issues and challenges that lies ahead. However, it is a rather slow process that although improved still struggles to achieve sustainability.

3. Research Questions

This study aims to pinpoint some of the main differences between the ASC salmon standard and the aquaculture regulations and policies in the four biggest salmon producing jurisdictions, namely: Norway, Chile, Scotland and British Columbia. The elements of interest for the comparison have been established through a literature review. Furthermore, this study aims to clarify whether these differences would best be handled by national-, or international standards.

1. Which of the five challenges would acquire the highest potential additionality if the ASC standard replaced the conventional national/provincial regulations?
2. What would be the best way to ensure sustainability on the challenge with the highest potential additionality? By applying state specific governmental regulations or by letting international market based mechanisms like eco-certifications set the standard for sustainability?

4. Theoretical/ conceptual framework

This thesis has used two different theories that strive towards the same *end*, but differ in their *means* to answer the second research question, what would be the best way to ensure sustainability on the challenge with the highest additionality? By applying state specific governmental regulations or by letting international market based mechanisms like eco-certifications set the standard of sustainability? The *end* being a sustainable aquaculture industry and the *means* being, either stricter governmental control through regulation or allowing for market based mechanisms such as eco-certifications to set an international standard for farmers to abide by. The first theory is advocating for stringent state-specific, environmental regulations to ensure an overall sustainable practice (Porter, 1990: 1991) that arguably would result in a competitive advantage as it incentivizes creativity and ingenuity among scientists and industry leaders. This, state controlling theory, does not completely oppose the previously mentioned criticism that there are no international regulations or mandatory standards for aquaculture practices to abide by (VanderZweeg, Chao, & Covan, 2002). However, it does advocate for states having more control over their own regulations and certifications than an international certification scheme. The other theory is one that advocates for more of an international standard that should be applicable to practices everywhere, much like what the ASC is advocating for in their new feed standard (ASC, 2017). However, this theory also recognizes the importance of local knowledge, but still argues for the possibility of having internationally applicable standards.

There are several aspects and theories surrounding the combination of environmental and economic sustainability, this study however, only focusses on environmental sustainability aspects. Some scholars would argue that it is impossible for international standards such as the ASC to determine sustainability as it might overlook local circumstances that aggravates the applicability of such a standard (Foley & Havice, 2016), and that governments controlling their own environmental regulations can be used as a competitive advantage as it could achieve proper sustainability (Porter, 1990; 1991). According to Porter's theory, stricter regulations and control mechanisms also work as an incentive for companies to upgrade their standards, as higher costs on emissions will result in higher costs for production (Brunel & Levison, 2013; Porter, 1990). One often cited example of this is the Clean Air Act that was passed as law in the United States in 1970 (EPA, 1970). The Clean Air Act was in many regards a success story in how stricter regulations can contribute to technological innovation as well as a better cared for environment (van Vorst & George, 1997). An interesting aspect of how the act was formulated was that the federal government set a national ambient air quality standard but allowed each state to create their own "state implementation plan" (Popp, 2003). Similarly, the UN have in their SDG's allowed for each state to come up with their own goals and implementation plans, although with less clarity on methods and on a voluntary monitoring basis (UN DESA, 2017). These theories are, in this study, operationalized as one advocating for strict state-specific regulations to force companies into becoming more sustainable (Porter, 1990), and the other advocating for international standards that rather incentivize sustainable practices by setting standards that does not necessarily take all local circumstances into consideration (Foley & Havice, 2016).

4.1 National regulations theory

"*The strongest proof that environmental protection does not hamper competitiveness is the economic performance of nations with the strictest laws* (Porter, 1991, p. 168)."

In Michael Porter's *the Competitive Advantage of Nations* (1990), he emphasizes the importance of governments to steer markets and industries towards economic, social and environmental sustainability. He argues that environmental protection does not hamper competitiveness but rather the opposite; it improves competition and incentivizes best practices (Porter, 1991). However, this does not justify strong regulations in all aspects of society, but rather where the "*... externalities causes firms to underinvest. Externalities occur where the benefits to the nation as a whole exceed those to any single firm or individual…*" (Porter, 1990, p. 620). One of these externalities is the environment. Marine Harvest and Cermaq are two examples of when companies collaborate with governments to try and increase the regulatory stringency to gain a competitive advantage, and safeguard the environment as well as the reputation of the industry (Vormedal, 2017).

Porter is also advocating for governments to strive towards development and to collaborate closely with research to ensure that science and policies are working coalesced. Policies and regulations should, according to Porter (1990) be adaptive, meaning that they can adapt to changing local conditions to avoid catastrophic events such as the overfishing in the North-West Atlantic region in the 80's and 90's, which caused detrimental effects for local communities (Crépin, et al., 2012). Adaptivity also implies that governments are required to work closely with academia, conservationists and actors from the private sector to ensure that the current policies and regulations are adapted to existing environmental conditions (Porter, 1990). And that they are able to take necessary precautions without violating existing regulations or agreements. This has been a problem for the EU in their efforts to take proactive action against e.g. deforestation

(Gulbrandsen, 2014). This is not saying that states can just abandon agreements or previous laws, but rather that it should not be impossible or discouraged to make necessary and significant changes when needed. In many cases governments with adaptive, stringent environmental regulations have had better economic outcomes than governments that apply laissez-faire policies (Porter, 1990, pp. 617-682).

Furthermore, having the state in charge of strong regulations that apply to the domestic aquaculture industry is a measurement to prevent similar problems as the one raised by Sutton (2003) and how lawmakers are prevented from protecting fish in Western Australia. However, for this to work the state will need to be in close collaboration with local agencies, researchers and conservationists to establish what is and what is not sustainable.

4.2 Private international initiatives

Eco-labels and certifications has since the early 1990's changed the attitudes of many seafood retailers, restaurants and individuals (Konefal, 2012; Jacquet, et al., 2010). Proponents of the neo-liberalization theory and free markets are usually arguing that the best way to maximize the good of society is through allowing people to maximize their self-interests, which requires a free market (Harvey, 2005). Eco-labels and certifications are proven methods to incentivize and create sustainable practices on a voluntary basis (Kuhfuss, et al., 2016). Furthermore, it incentivizes and facilitates flexibility and adaptivity in the industry, as it does not restrict farmers, companies or states from changing the practices when necessary as state regulations would. International organizations such as the MSC and ASC have, without saying that they are either for or against neoliberalism, within the current global economic framework, had great impacts on creating awareness about the challenges and potential dangers of overfishing and overexposing resources. Moreover, there is research that confirms that MSC certified fisheries perform better than others, and that MSC certified fisheries tend to avoid overfishing and overexploiting wild stocks (Gutiérrez, et al., 2012). The ASC's new feed standard is advocating for global standards for fish feed producers (ASC, 2017a), using international standards is also a way to prevent situations where countries exploit one another and use common resources to gain themselves and leave less to others (Hannesson, 2007).

The importance of engaging as many actors as possible is raised by Porter as well (1990). His theory argues that the environment is an externality that effects everyone, similar to what Garrett

Hardin (1968) called *common* in his famous theory, *The Tragedy of the Commons*. The tragedy of the commons theory is based on the idea that individuals acting independently could be contrary to the common good (Hardin, 1968). Although, Porter is not actively taking a stance against international collaboration it still could be argued that in order for the industry to become more sustainable, it is better if standards evolve equally rather than individually and with different recommendations that might be confusing or conflicting for farmers, retailers and individuals alike. This argument is raised in the new ASC feed standard as well, where they argue that global standards and regulations simplifies and streamlines the possibilities to ensure the quality of the feed and that others follow similar, sustainable regulations (ASC, 2017a). To exemplify how practical an international standard could be we can look to the U.S, where approximately 80 percent of the seafood is caught or cultured abroad (Jacquet, et al., 2010). Such a heavy reliance on imports makes it very difficult to control and safeguard that the seafood has been caught or cultured in a similarly sustainable fashion as the market demands. The bureaucratic challenges of knowing how the seafood is caught or cultured could be overwhelming. This makes having an international standard with a high minimum requirement preferable.

Big salmon producers, like Marine Harvest, Cermaq, SalMar or Leroy Seafood Group, have already adapted the idea of changing their practices and aim at becoming certified by the ASC. Members of the Global Salmon Initiative have ambitiously set out to have all of their operations ASC certified by 2020 (GSI, 2017b). The advantages of having similar standards everywhere are, apart from the avoided bureaucracy, that companies can apply the same changes on farms all over globe which would make their job easier and would avoid companies proliferating themselves as sustainable in one country, when they are less so elsewhere. The success story of the previously mentioned Clean Air Act was to a large degree due to the fact that carmakers all over the globe were incentivized to apply the same technological changes in every car, by installing a catalytic converter (Farrauto & Heck, 1999). If salmon farming companies can use similar techniques regardless of where the farms are located, it would make more financial sense for producers to restructure their practices to more sustainable ones.

Furthermore, if a company or a country wants to establish themselves as an exporter it would streamline their efforts if regulations are similar. Thus, without each country having individualized regulations but instead a similar platform of regulations and requirements, more people and businesses as well as countries can become salmon producers with the latest technologies and strive towards becoming competitive by receiving an ASC certificate like the big companies are trying to do through the Global Salmon Initiative (Deardoff & Park, 2010).

5. Methodology

5.1 Policy analysis and literature review

A policy analysis of the governmental regulations and the ASC standard was conducted to gather information on state regulations and create a holistic picture of the salmon farming industry. Milton Friedman acknowledged, in his book *Essays in Positive Economics* (1953), the importance of differentiating between positive analysis and normative analysis when one conducts a policy analysis. Positive analysis would be categorized as *what is* and normative analysis would be *what ought to be* (Friedman, 1953; Robert & Zeckhauser, 2011). Thus, by reviewing the regulations as they are this study uses what Robert and Zeckhauser (2011) calls a "dispassionate view", to retrieve fact-based information rather than value-based to help establish and quantify the first research question. Furthermore, the second research question is answered through a normative policy analysis; where the two theories and the literature review help identify the best practices associated with sustainable salmon farming. Finally, for the discussion, this study presents what possibilities and issues there are with the current order of aquaculture regulations.

The study operationalizes the current regulations or, business as usual through Friedman's *positive analysis* of the regulations and policies (Friedman, 1953), that is, what actually is required by the legislation and national policies. The retrieved information from national/provincial legislation and policies is what serves the basis for the comparison with the ASC standard. The second research question can only be answered through Friedman's *normative analysis* (1953), that focuses on what strategy, domestic or international, that would result in the best outcome. To ensure that this study has identified and evaluated comprehensive research relating to the environmental concerns around salmon farming, certification schemes and governmental regulations this study also conducted a literature review (Fink, 2010). A literature review enables researchers to evaluate existing research and contributes to theoretical development (Seuring & Müller, 2008). The literature review also helped identifying patterns, themes and issues relating to salmon farming and base the five elements of focus that are used to study each governmental/provincial aquaculture regulation and policy.

Governmental regulations, acts and policies as well as the ASC standard were gathered on their respective websites. Furthermore, the thesis used documents from the FAO and the GSI where the information from governmental documents were inconclusive or missing, as well as to triangulate and delve deeper into some aspects of the study. One example of such a triangulation is the verification of information obtained from Chile. Information from the FAO and GSI was also gathered from their respective websites. Through email correspondence with government officials working with aquaculture this study has triangulated the relevance of the policies and regulations that are used as the basis for the results. The governmental bodies that have collaborated and helped triangulate the legislative documents are; *Scotland's Aquaculture*, *the Fisheries and Oceans Canada* (*DFO*) and *Fiskeridirektoratet* in Norway. The Chilean regulations are not available in English or any other language than Spanish. Email correspondence with dr. Alejandro Harberto Buschmann Rubio from the University of Los Lagos in Chile has been used to retrieve the necessary information from Chile. Dr. Buschmann is a professor in Coastal Ecology and Seaweed Aquaculture at the Research and Development Center for Coastal Resources and Environments at the University of Los Lagos. The lack of original documentations and sources from Chile is a shortcoming in the thesis as it limits the information on Chilean salmon farming and the retrieved information is second-hand. However, it is necessary to try and create a holistic picture and include Chile in this thesis as it is the second largest producer of Atlantic salmon (SalmonChile, 2017). All of the questions and answers from the email correspondence with dr. Buschmann are presented in Appendix I.

The comparison between the ASC standard and governmental regulations is based on key focus areas defining sustainability concepts in aquaculture policies identified through the literature review (Hu, et al., 2012: Burridge, et al., 2010: Ytrestøyl, et al., 2015: Holmer, et al., 2008: Bridson, 2014). They are determined by a few questions to avoid subjective differentiations in the analysis and prioritization of one policy area over another. Furthermore, the study applies a small portion of content analysis to construct and structure the key elements to evade customizing the findings to each policy and thus skew the findings in a subjective matter (George & Bennett, 2005). The focus areas and questions are written to comply with the previously mentioned key elements raised in chapter 1.2.5. The five key elements concerning sustainability aspects and aquaculture have been gathered from the literature review and from the ASC standard itself.

1. Interaction with wildlife: What regulations are there concerning use of deterrence systems, managing predatory attacks, local wildlife and escaped fish numbers?
2. Waste control: Are there any specific provisions to safeguard the natural habitats in and around the farms or local biodiversity?
3. Feed: Are there any regulations to try and minimize the fish dependency in the fish feed? Are there any regulations promoting sustainably grown or harvested resources for the feed?
4. Fish Health: Are there any regulations concerning usage of antibiotics that could be important for human health? Are there any specifications regarding therapeutic treatments? How many treatments are allowed per production cycle? How often are farmers required to have their fish's health controlled and who is authorized to perform a health control?
5. Farm Location: What regulations are there concerning where and how to farm salmon? Are here any restrictions on farming in protected marine environments?

These key elements have been constructed after reviewing the policies and standard, they are all-encompassing in terms of what is mentioned and prioritized in the documents (ASC, 2012; Fiskeridirektoratet, 2017; BC Pacific Salmon Forum, 2007; Scottish Salmon, 2015). The difference in requirements between the standard and the regulations is then categorized as the potential additionality of applying an ASC-standard strictness to the salmon farming industry in each country respectively. This could also have reversed effects that the ASC standard has less stringent regulations concerning some aspects of the aquaculture industry.

5.2 Operationalization of the theories

Based on Porter's ideas, this study's theory that state specific regulations are preferable over international standards is operationalized as one that argues that only states and local knowledge of ecosystems and potential effects aquaculture could have on ecosystems could be sustainable. And that the ASC standard would risk miscalculating local carrying capacities that could have detrimental effects on wildlife and people living in that area. This theory would argue that strict environmental regulations set up by the state would increase ingenuity among local operators to avoid overshooting the carrying capacity of the local environment. Furthermore, if states apply stricter regulations, then companies and farmers would not have to make large alterations to receive certifications if they so wished, that is if the certification do not evolve.

The private international initiative theory would argue that international standards would set the tone for international markets, and that companies and farmers who want to expand on the international market would benefit greatly from having the same regulations and practices in different parts of the world. Furthermore, international standards such as the ASC is thoroughly processed and have taken experts, government officials and conservationists ideas and concerns into consideration and based the standard of the best overall solution.

5.3 Measuring potential additionality

One of the aims in this study is to identify the differences between ASC-certified practices and the conventional aquaculture regulations-, in Norway, Chile, Scotland and British Columbia in Canada respectively. For this study, conventional regulations imply the legal requirements that each country have on the domestic salmon farming industry. The added outcomes from ASC certified practices in comparison to the conventional requirements are what Garrett et al., (2016) would describe as "additionality". That is, the additional requirements to ensure the sustainability and wellbeing of the environment and the workers. Inspired by the formula created by Rachael Garrett et al., (2016) this study will try to quantify the potential added value of replacing the conventional regulations with the ASC salmon standard. Rachael Garrett's measures the *potential additionality* (*A*), which is determined by the *relative stringency* (*S*) times *business as usual* (*BAU*).

This study however, applies a simplified version to quantify the differences between conventional regulations and the ASC standard on the five aforementioned variables. These variables are (1) interaction with wildlife, (2) waste control, (3) feed regulations, (4) fish health, (5) farm location. The ASC standard (*S*) metric has been assigned a constant value of one. If state/provincial legislation matches the ASC standard it would result in zero potential additional stringency (*A*). *BAU* is assigned through policy (*p*) and enforcement (*e*). If the state/province is required by law to monitor the farms with the same frequency and accuracy as the ASC standard it translates (*e*) to one, if self-monitoring is acceptable but reporting mandatory it translates to 0.5 and if neither is necessary it translates to 0. (*p*) is determined through a comparison of the existing public information gathered from governmental policy documents and regulations related to the aquaculture industry. If the state/provincial requirements are the same, or if they exceed the ASC standard it translates to one. For instance, if the conventional regulation in a country/province has the same limitations on allowable escapees during a production cycle the (A) will be zero.

$$BAU = e + p$$

The potential additional stringency (A) is then calculated through subtracting (BAU) from (S).

$$A = S - BAU$$

Example: Regulations in Norway state that sediments must be tested with the same frequency and similar thoroughness as the ASC, thus their policy (p) is as high as the ASC. However, it can be conducted by the company and then reported back to Fiskeridirektoratet, which only translates to 0.5 in enforcement (e) as it is not monitored by someone employed by the governing agency.

The (p) value is decided through looking at whether or not state regulations match the ASC standard. If state regulations match the ASC standard it equals to one. If state regulations do not match the ASC standard it equals to zero. The (e) value can be either 1, 0.5 or 0, depending on the involvement in monitoring and enforcing by the governing agency. If the governing agency hires independent third-party professionals to monitor and test the sediment and then report back to the agency it equals to 1, if the company is in charge of hiring these professionals it equals to 0.5 and if neither is mandatory it equals to 0. The BAU is determined through adding each variable's score and then dividing that score with the number of variables.

(p)1+(p)0+(p)1+(e)0.5= 2.5
2.5/4= 0.625
BAU= 0.6

The *BAU* is then subtracted from the S which is the ASC standard to show the potential additionality for state/provincial regulations.

$(A)0.4 = (S)1 - (BAU)0.6$

5.4 Definition of concepts

The *Additionality* from voluntary environmental standards such as the ASC on current national legislation should be supplementary requirements on producers without contradicting current statutes and laws (Garrett, et al., 2016). An example of this could be, having pollution requirements below what national legislation deem legally justifiable. If there is a large discrepancy between legislation and voluntary certification standards the potential additionality would be large, whereas legislation that almost complies with the voluntary standards would have a smaller potential additionality. However, smaller additionality on individual farm sites could have a large effect on total emissions from the industry as a whole, as it would be less costly for producers to comply with the standard than it would be for producers with a big gap between their practices and the standards (Garrett, et al., 2016). This aggregated benefit is how the inclusive tactic works, as it could incorporate more actors (Jonell, et al., 2013).

Defining *Stringency* is and has been challenging for researchers since the environmental degradation debate really started to pick up speed in the 1970's (Abate, Nielsen, & Tveterås, 2016). However, there are several aspects of national legislations that could be reviewed to determine legislative stringency, e.g. regulations on inputs or outputs from industries (Van Beers & van den Bergh, 1997), such as pharmaceutical products used to combat diseases or sea lice, and the effects that has on the fish. This study used regulations on both inputs and outputs to determine the stringency of the legislations.

Policies are elaborate documents to guide and regulate actors. In the context of this paper that means; governmental/provincial recommendations that affect aquaculture practices, international binding agreements that affect aquaculture practices and the ASC standard on how to produce Atlantic salmon. *Regulations* are defined as the official documents to establish what is required of aquaculture farmers and what is needed before aquaculture operations can be approved.

How well the policies and regulations are *Enforced* is an important factor in determining how well controlled the industry is in each nation/region (Garrett, et al., 2016). It can also be considered as a sign of commitment if the authorities are monitoring and taking vigorous initiatives to ensure that the regulations are abided by. Thus, this study has been looking for any mentioning of state monitoring and what measures that entails to determine the stringency of the national/regional policy regulations.

6. Results and discussion

The findings from the Norwegian legislation are based on the national regulations and policies that are available. The Scottish and B.C. findings are a mix of specific regulations and policies in each jurisdiction and from the country (Canada) or union (UK and EU), where it applies. Finally, the Chilean findings are gathered through personal communications with Dr. A. Buschmann and through a literature review. The findings are summarized and divided to answer each of the five key elements that are studied in this thesis. Furthermore, these key element findings are also compared to the ASC standard (a full summary is available in appendix IV) to establish differences and potential additionality.

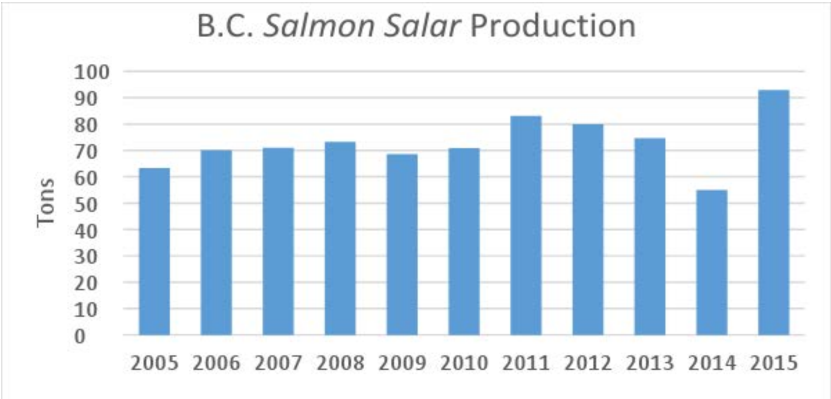
6.1 State stats

The number of Atlantic salmon farms and the number of ASC certified farms differ significantly between the regions that are under observation for this thesis. Table 1 presents the number of Atlantic salmon farms in each country/province and the number of ASC certified farms in each state/province (ASC, 2017b).

Table 1. The total amount of active licenses in each country/region.

	Nr. of farms	*Nr. of ASC-certified farms*	*% of certified farms*[2]
Norway	750	109	14,5
Chile	500	32	6,4
Scotland	230	2	0,8
B.C. (Canada)	130	22	16,9

The charts (1-4) show the production trajectories from 2005-2015 to illustrate how the Atlantic salmon farming industry has been developing in each country and province. The production numbers show that Norway produce more than all other nations/province combined, and that there is a significant difference in production numbers between the two highest producing nations and the two regions with the lowest production numbers.



[2]http://asc.force.com/Certificates/

Chart 1. B.C. salmon production numbers (DFO, 2017).

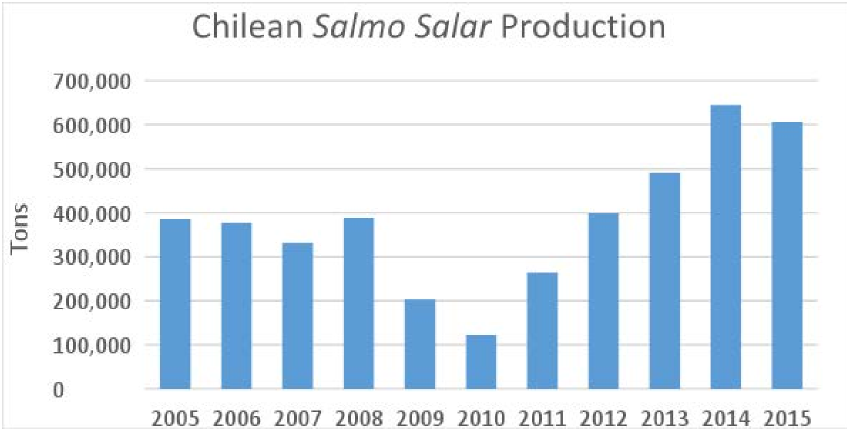


Chart 2: Chilean salmon production numbers (SalmonChile, 2016)

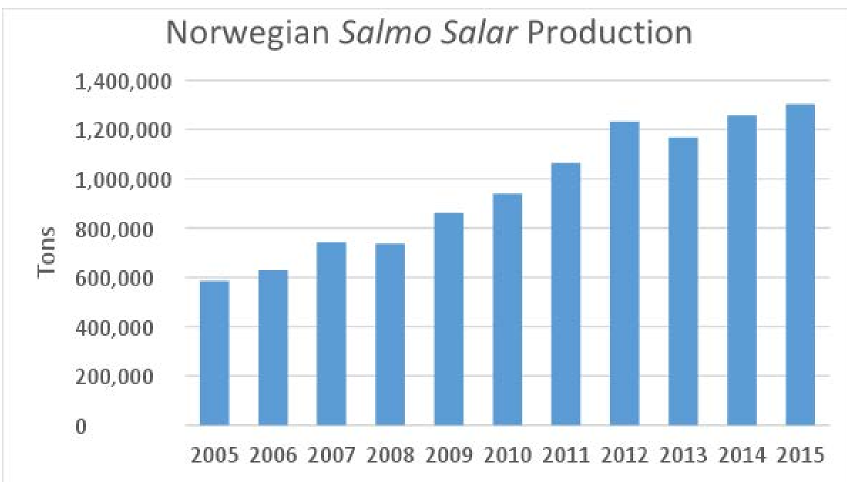


Chart 3: Norwegian salmon production numbers (SSB, 2017).

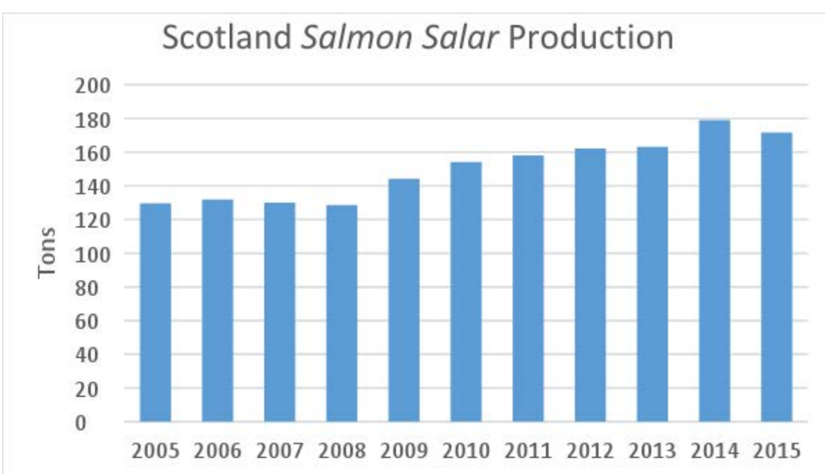


Chart 4. Scottish salmon production numbers (Scottish Government, 2017).

Table 2. Short summary of national/regional policies. (Full comparison in Appendix II).

	ASC	Canada	Chile	Norway	Scotland
1. Interaction with wildlife					
1.1 Escapees	<300 per production cycle	No maximum	No maximum	No maximum	No maximum
1.2 Deterrent system	Not allowed	Frowned upon	Allowed	Allowed	Allowed
1.3 Lethal action against predators	Only after authorization from appropriate authorities, and never on endangered species	Only after authorization from appropriate authorities, and never on endangered species	Only after authorization from appropriate authorities, and never on endangered species	Only after authorization from appropriate authorities, and never on endangered species	Only after authorization from appropriate authorities, and never on endangered species
2. Waste Control					
2.1 AZE	Cage size +30 m	Usually the cage size + 30m			Usually the cage size + 25m
2.2 Benthic flora/fauna requirements	100 organisms / m²	Site specific requirements		Site specific requirements	Site specific requirements
2.3 Sediment measuring tests	ISO 8265, 7828 & 9391: Redox, S^2, Cu, P, Zn, CN-, F-, medicinal- and feed residue	Site specific, but the tests should always measure if there are gas bubbles, fish feces, uneaten feed, floculent material, sulphide, redox, pH, organic matter porosity and sediment grain size	Dissolved oxygen and reduced oxygen levels are measured. However, sulphide levels is not obligatory to measure.	NS-9410 & NS-9423: pH, eH, Redox, Fish feed residue, medicinal compounds	EQS: O, Cu, P, Zn, S^{2-}, CN-, F-, Beggiatoa, medicinal compounds, SLICE & Fish Feed residue
2.4 Frequency of tests	Depending on the test, and how well the last test went.	At least once during each production cycle		Depending on the previous test results, but as often as every three months in some cases.	Annually at least, but more frequent monitoring can occur.
3. Feed					
3.1 Certified sustainable feed	Yes, from MSC or ISEAL	Not a requirement	Not a requirement	Not a requirment	Not a requirement
3.2 Transgenic ingridients	Allowed	Allowed	Allowed	Not used	Allowed
4. Fish health					
4.1 Regulations against using critically important antibiotics for human health	Yes	Yes	No	No	No
4.2 Therepeutic treatment use	After consultation and prescription by a licensed veterinarian	After consultation and prescription by a licensed veterinarian	After consultation and prescription by a licensed veterinarian	After consultation and prescription by a licensed veterinarian	After consultation and prescription by a licensed veterinarian
4.3 Sea lice monitoring	Weekly or monthly, depending on wild stock populations in the proximity	Monthly	Weekly	Montly	Weekly
4.3 Veterinary checkups	4 times a year	Not specified	Not specified	4-6 times annually, depending on the size of the farm	Not specified
4.4 Number of antibiotic treatmens during last production cycle	< 3 times	No maximum	No maximum	No maximum	No maximum
4.5 Vaccination	Yes	Not a requirement	Not a requirement	Yes	Yes
5. Location					
5.1 Distance requirements from natural reserves	No, but a farm cannot operate in a preserve	1 km from a reserve		Farms can operate in Natural reserves, but with more stringent requirements	Farms can operate in Natural reserves, but with more stringent requirements
5.2 Distance from other farms	No	3 km from other finfish farms	1-3 km from other finfish farms	Site specific requirements	Site specific requirements

6.2 Presenting and comparing legislations and policies with the ASC

To provide contexts for the requirements set up by the standard and by national/provincial regulations it is important to summarize the background to which the policies/regulations and standard have been drafted. The ASC standard will not be thoroughly summarized in this section, a more comprehensive summary can be found in appendix IV.

The ASC standard

As was described earlier, the ASC standard has been compiled through round-table discussions by researchers, industry representatives, conservationists, and government officials (WWF, 2017). These representatives have all been consulted on how they would prefer the industry to proceed and what standards are plausible from an environmental, as well as economic and social standpoint. Feed usage, escapees, fish health and general pollution are some of the more elaborate criterion in the standard. Overcrowded net pens, temperatures fluctuations, resistance to treatments and insufficient oxygen levels have all been contributing factors to previous fish health crises (Vormedal, 2017) and are therefore considered in the ASC standard. Thus, the standard is intended to mitigate future outbreaks, avoid overfishing, and improve on site management of the environment as well as local engagements to combat environmental deterioration and combine all that with socially and economically sustainable practices. To be able to compare the standard to the governmental aquaculture regulations of relevance to this study, its specific component needs an explanation.

British Columbia regulations

The Canadian constitution divides legal power between the federal government and provincial governments (Wildsmith, 1982). For aquaculture regulations, it complicates things as the federal government oversees the administering of the Fisheries Act, the Oceans Act, the Canadian Environmental Assessment Act, the Species at Risk Act and habitat policies as well as aquaculture policy frameworks (The Legislative Assembly of British Columbia, 2007, p. 41). The provinces oversee the relicensing of aquaculture permits, and monitor and report back to the federal government on the state of local aquaculture practices.

The confusion surrounding the overlapping authoritative bodies and policies resulted in the government signing several memoranda of understanding, where it clarifies where collaboration is necessary and where the province or federal government has the sole legal right. These memoranda and the Canadian Council of Fisheries and Aquaculture Ministers (CCFAM), which is composed by federal as well as provincial ministers was formed as an effort to create a vertical structure for aquaculture policies (VanderZweeg, Chao, & Covan, 2002, p. 299). In 1999 the ministers in the CCFAM signed the Agreement on Interjurisdictional Cooperation with Respect to Fisheries and Aquaculture, the agreement intended to foster relations between the federal and provincial ministers and streamline the collaboration to ensure that fisheries and aquaculture is conducted in an ecologically and economically sustainable way (Canadian Intergovernmental Conference Secretariat). However, there could still, according to the Department of Fisheries and Oceans, be improvements as there are irregularities between regulations in different parts of the country (DFO, 1995, p. 8).

This study however, only focuses on British Columbia, as it is the largest salmon producing province in Canada, and is considered the fourth largest salmon producer in the world (VanderZweeg, Chao, & Covan, 2002; Stephen, DiCicco, & Munk, 2008).

There are approximately 130 farm sites in British Columbia; 60-80 of these are active at any given time (The Legislative Assembly of British Columbia, 2007). Out of the 130 farms, there are 22 with an ASC certification. Interestingly enough, all of the ASC certified salmon farms in Canada are located in British Columbia, and are all either Marine Harvest or Cermaq farms (ASC, 2017b). Marine Harvest have another five ASC certification applications pending. To date, 16.9 percent of all the salmon farms in BC are ASC certified, which is the highest number out of all of the states or provinces this study focuses on.

Before a proposed plan is licensed to operate they must submit an Environmental Impact Assessment that contains all possible impacts for the environment, nearby businesses and communities in the proximity of the proposed farm site (CEAA, 2012). In this, it also states that the government should consult with the First Nations to the extent it is possible.

Chile Regulations

Since 2009 the industry and government have made significant strides towards preventing outbreaks of contagious diseases and having history repeating itself. The previous laissez-faire approach has, according to Tecklin (2016), been replaced by more stringent governmental regulations. Chilean industry representatives have advocated for stronger governmental regulations as they believe that the best way to safeguard the quality requirements is to allow the government to regulate and monitor the salmon farming industries (Tecklin, 2016). This seems to have paid dividends as the Atlantic salmon production exceeded the previously highest recorded production number by 217 tons, from 388 840- to 606 453 tons in 2015 (SalmonChile, 2016).

Norway's regulations

Norway is the unchallenged leader of Atlantic salmon production, between 2015-2016 the Norwegian industry produced 1 235 263 tons of salmon for human consumption (SSB, 2017). Thus, the production is twice the size of Chile's who is the second largest producer. Commercial Norwegian salmon farming began in the 1970's and has since then grown into one of the biggest exporting industries of the country. All in all, farmed salmon constitutes seven percent of the total exports from Norway (SSB, 2017b; SSB, 2017). Approximately 95 percent of the total production is then exported to other EU countries, where Sweden is a major importer (FAO, 2016b). There are currently 750 operational licenses in Norway (Fiskeridirektoratet, 2017), 14,5 percent of these are ASC certified, that is 109 certified farms (ASC, 2017b).

The salmon industry is established as a very important and influential sector in Norway, there are examples of state policies being persuaded and influenced by some of the larger salmon farming companies, especially, Marina Harvest (Vormedal, 2017).

The fast growth of the industry since the 1970's is according to Asche et al., (2013), a result of an improved regulatory framework and a technological improvement. Up until the 1990's license holders cold only hold shares in one farm, which constrained the growth of the industry as no one could own and operate several farms. Since 1992, these constraints have been lifted which led to the industry experiencing an exponential growth (Asche, et al., 2013). This has in combination of growing net pens resulted in the boom of the industry. The Norwegian industry has, despite the fast growth, managed to decrease their usage of antibiotics and have implemented several precautionary measurements to prevent damaging the industry and its reputation (Burridge, et al., 2010).

Scotland's Regulations

Scotland is currently abiding by EU laws and regulation. Whether or not these will change as Scotland and the rest of the UK leaves the union remains to be seen. The salmon farming industry does not seem to have been negatively affected by the political turmoil of last year, as export value of farmed salmon has increased 70 percent since the same period last year, with the U.S.

and China as the two major importers (Scottish Salmon, 2017). Exports are expected to grow, as an intensification of the Scottish salmon production is under way with hopes of an increase with 28 percent from 2012-2020 (Marine Scotland, 2014).

The combination of EU-, UK- and Scottish regulations has made the influencing bodies in the processes of approving and monitoring aquaculture scattered over several agencies. The EU has a Marine Strategy Framework Directive that is in place to protect the marine environment all over Europe (2008). The main goal of this directive is to achieve Good Environmental Status by 2020, which includes the protection of biodiversity and ecosystems (Marine Strategy Framework Directive, 2008). Before a finfish farm can begin its operations, local authorities must determine whether or not an Environmental Impact Analysis (EIA) is necessary or not (The Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2011: Scotland's National Marine Plan, 2011). The EU also have regulations stating that before a large project such as building a highway or an airport, there must be an Environmental Impact Assessment. Smaller projects such as aquaculture farms are not required to conduct a full-scale assessment, unless the national government or local authorities demand it. If there are any suspicions from the government that a farm is underperforming or withholding information they are allowed to send a representative to perform checkups at any time (Aquaculture and Fisheries (Scotland) Act 2013, p. 4).

The EU's Marine Strategy Framework Directive, the Habitats Directive, Birds Directive and Natura 2000 directive all have effects on Scottish legislation, thus, most of the Aquaculture and Fisheries (Scotland) Act (2013), refers to EU legislation regarding interactions with wildlife or other aspects of aquaculture. However, in the Act (2013), they refer to the Code of Good Practice, a document that serves as a basis for the EIA's that are sent in for the appropriate authorities to consider. The Code of Good Practice is an evolving document that is updated and can be changed or updated at any time by the Scottish Ministers (Aquaculture and Fisheries (Scotland) Act 2013, 2013). SEPA are authorized to perform random tests at fish farms at any time (UK Government, 2011).

6.2.2.1 BC- Interaction with wildlife

Before a license is issued, the planners must submit an Environmental Impact Assessment, a *Best Management Plan* on the specific farm where the farmers have assessed the potential effects a farm might have on the surrounding environment, including a cumulative assessment on how the project is expected to interact and affect other projects in the area (Land Use Operation Policy: Aquaculture, 2011). Much like the ASC standard farmers are required to provide this information and information on predatory attack-, and escape prevention plans (ASC, 2012, p. 35). The province of British Columbia is striving towards zero escapees from salmon farms. However, that is merely a target and not a requirement. The ASC standard has a similar target, but they have also set at maximum escape count of 300 fish per production cycle (ASC, 2012, p. 34).

In keeping with the ASC standard, B.C. and Canadian legislation requires that the open net pens are inspected and maintained thoroughly, and that potential damages or risks are properly handled and reported (Land Use Operation Policy: Aquaculture, 2011; ASC, 2012, p. 35). These inspections and maintenance jobs should be conducted by professional divers that report back to the Fisheries and Oceans Canada (DFO) (Land Use Operation Policy: Aquaculture, 2011), furthermore records of these inspections and maintenance jobs must be kept and updated every 60th day (Land Use Operation Policy: Aquaculture, 2011).

The use of lethal force against endangered bird species is completely prohibited according to B.C. and Canadian law (Migratory Birds Convention Act, 1994). Furthermore, if a predatory attack would take place, the farmers must have been given authorization to use lethal action against the animal, and only as a last resort (Marine Mammal Regulations, 2015). This is very similar to the ASC standard where farmers must provide evidence that before lethal action is used against predators, all other options had been pursued, that authorization was given from a senior manager and that this authorization was sanctioned by a relevant regulatory authority (ASC, 2012, p. 26). The most common predatory attacks in B.C. are either by seals or birds. Killing endangered species such as Steller Sea Lions is completely prohibited (Marine Mammal Regulations, 2015). If a lethal incident would take place at a farm, it must be recorded and reported and available for inspection. The ASC standard has also set a maximum amount of wildlife killings to nine every two years, this kind of regulation cannot be found in the provincial legislation of British Columbia or in the national, Canadian legislation (ASC, 2012, p. 27). Using Acoustic Deterrence Devices (ADDs) or Acoustic Harassment Devices (AHDs) to deter predators from approaching the farm sites is strongly and actively discouraged by the government but not prohibited (BC Pacific Salmon Forum, 2007). These devices are completely prohibited by the ASC standard (ASC, 2012, p. 26).

When it comes to the interaction with wild stocks of salmonids, a farm must be at least one kilometer from spawning wild salmon streams or herring spawning areas (Land Use Operation Policy: Aquaculture, 2011). Once a year, there is another inspection from the DFO to ensure that all regulations are complied with at the farms, if not the farm will receive a fine. Recapturing is permitted and encouraged if there is a breach, however, this is only allowed for one kilometer from the farm site (Land Use Operation Policy: Aquaculture, 2011).

6.2.2.2 BC- Waste control

The government requires farmers to collect data consisting of comprehensive information regarding local currents, fish stock density and feed usage (BC Pacific Salmon Forum, 2007). This must be done before a site is accepted for aquaculture practices, and should be provided throughout the production cycles. However, the policies do not further specify a generic standard of what levels are acceptable in terms of water quality, fish stock density or feed usage. This is established by the DFO after performing tests on the suggested site to establish if the biotic and abiotic surrounding environments have the capacity to handle a farm. On sites where the seabed is unfit for sampling, e.g. hard rock bottoms, the farm must use underwater cameras to document seabed conditions (BC Pacific Salmon Forum, 2007). The farms are audited annually, if the farms are not complying with regulations they will be fined (Land Use Operation Policy: Aquaculture, 2011). However, there is no generic standard for the surrounding environment requirement either. But, the farmers should strive towards having ocean floor organisms around the farms that would adhere to local natural standards. A similar formulation is set for levels of chemicals, e.g. copper (Land Use Operation Policy: Aquaculture, 2011). This legislation differs from the ASC standard in that it does not provide a generic standard that the farmers should abide by. The ASC requires farmers to, within the AZE, keep toxicity levels low enough so that at least 100 organisms (plants or worms usually) can thrive per square meter, unless natural levels are lower than that (ASC, 2012, p. 20). Among these organisms, there should be at least two benthic macrofaunal species, such as sessile macrophytes or worms (ASC, 2012, p. 21). As for the benthic effects outside the AZE, the farms are supposed to use models to count and keep records of either redox potential or sulphide levels. Redox potential must not exceed 0 millivolts, and sulphide levels must be kept below 1,500 microMoles per liter (ASC, 2012, p. 20). As for keeping records of faunal abundance outside the AZE, it must be kept close to natural levels with as little effect on sensitive fauna as possible. Similar requirements can be found in the Canadian standards; however, they do not have generic levels on all of these monitoring areas (DFO, 2015).

In the *Best Management Plan* the license holder must include what operational practices they have to control and minimize effluents and discharges, such as disinfectants, antifouling components, fuel and net-cleaning residue. Farmers must also report the brand of the feed and how much of it that is used, as well as what medications have been applied to battle diseases. If a farm uses less than 630 tons of dry weight feed annually, it is not required for them to have a waste permit (BC Pacific Salmon Forum, 2007). If, on the other hand a farm uses more than that they must apply for a permit that regulates and governs discharges. Furthermore, there must be practices in place to avoid spillage, or strong odors from the waste that might discomfort people or have impacts on wildlife (Forum, BC Pacific Salmon, 2007).

B.C. legislation and policies have only limited water quality requirements (BC Pacific Salmon Forum, 2007), where there is no generic standard on salinity, dissolved oxygen or ammonia. The ASC standard on the other hand, requires farmers to measure their water quality twice a day, with less than five percent of the weekly measurements falling short of 2 mg/liter of dissolved oxygen (ASC, 2012, p. 22).

6.2.2.3 BC- Feed

There are no provincial or national requirements on having the feed content certified sustainable, or to minimize the usage of pelagic fish. In comparison, the ASC standard requires that the fish meal and fish oil used in the feed is fished by an MSC certified fishery or that the meal and oil derive from fish byproducts, in which it does not have to be sustainably fished (ASC, 2017a, p. 31). As for the plant based ingredients of the feed, the ASC in comparison to B.C. regulations requires farmers to use soy and palm oil from certified producers (ASC, 2017a, p. 53).

6.2.2.4 BC- Fish Health

First and foremost, in order for a farm to receive a license they must have a Fish Health Management Plan (FHMP) approved by the regulator in the region. In B.C. the issuance of such an approval would come from the DFO. In the FHMP, the operators must include information on the frequency of fish health check-ups, how they handle fishes that show signs of disease, how they treat groups with unusually high mortality rates and how groups are treated if a stressful event that could predispose them to diseases (BC Pacific Salmon Forum, 2007, p. 9). The operators must provide the public with quarterly updates on fish health, and in the case of an outbreak they must contact the federal authorities immediately. It is paramount that the fish can maintain their natural behavior, meaning that they have enough room per individual to swim freely (Land Use Operation Policy: Aquaculture, 2011). According to Stephen et al., (2008, p. 473), the average density in a net pen in B.C. is 5-13 kg of fish/m^3.

All incidents of disease must be reported to the provincial fish health veterinary, as well as all therapeutic treatments. Usage of antibiotic treatments must be sanctioned and prescribed by a licensed veterinarian (BC Pacific Salmon Forum, 2007, p. 9). Furthermore, in keeping with the ASC standard, B.C. legislation prohibits farmers from using antibiotics that the WHO deems important, very important or highest priority (Fisheries and Oceans Canada, 2017). Instead the DFO recommends farmers to vaccinate their animals to avoid usage of all antibiotics. B.C. legislation has in contrast to the ASC standard no limit to how many antibiotic treatments that are allowed during a production cycle. The ASC standard has three treatments as a maximum per production cycle (ASC, 2012, p. 48). Sea lice monitoring regulations in B.C. are very similar to those of the ASC standard, and must be conducted once a month and reported to the provincial government, which later will be made available to the public through the Fish Health Database. If there is an outbreak of sea lice the monitoring must be intensified to twice a month, the ASC standard requires once a week. Furthermore, if a farm is in the proximity of migrating routes for wild juvenile salmon, and if levels reach three or more lice per cultured fish, they should be harvested or removed to ensure that the lice are not transmitted to the wild population (BC Pacific Salmon Forum, 2007), the ASC standard allows no more than 0.1 mature female lice per farmed fish in a similar situation (ASC, 2012, pp. 30, 80). A common way to combat sea lice infestations in B.C. is through the use of Emamcetin Benzonate (SLICE), which is a regularly used insecticide in agricultural businesses as well (Fanigliulo & Sacchetti, 2008). Much like other therapeutic treatments, this requires a prescription ordered by a veterinarian.

Fish farmers must strive towards keeping viral diseases at a minimum, B.C. regulations do not however, unlike the ASC have set limitations. The ASC have set a limit that $\leq$ 10 percent of the mortalities can be either from viral diseases or unexplained (ASC, 2012, p. 46). This is a precaution as unspecified causes of death might be unidentified viral diseases.

6.2.2.5 BC- Farm Location

A fish farm may not be closer than one kilometer from spawning routes for wild populations of salmon or herring, this applies to areas that are deemed vital for fauna, flora or people, as well as natural reserves (Land Use Operation Policy: Aquaculture, 2011). A farm must not infringe on existing fisheries' routes and cannot be closer than 150-300 meters from seabed floors sites where there is shellfish that commercial fisheries use. Commercial fishing grounds, aboriginal fishing grounds and other previously existing farms are all protected by the regulations, and must be included and accounted for in any project plans for the development of finfish farms such as salmon aquaculture (Land Use Operation Policy: Aquaculture, 2011). Competing farms are not supposed to be any closer than three kilometers from one another (Land Use Operation Policy: Aquaculture, 2011).

Any aquaculture plan proposal should be reviewed by the federal government, local government and by the First Nations in order to ensure that it will not disrupt an area of cultural, environmental or infrastructural importance (BC Pacific Salmon Forum, 2007).

Although licenses can stretch over long-time periods, sometimes up to 30 years, a farm must not be operational throughout this time, after a production cycle, the site must be cleaned and left for recuperation so as avoid putting too much pressure on the environment (Land Use Operation Policy: Aquaculture, 2011). There is no generic time frame on how long these sites must be left to recuperate.

Allowable zone of effect (AZE) is referred to as Intensive Areas in the Crown Land Use Operational Policy, and should be a 30 meters buffer zone between the cages, nettings and float camps (Land Use Operation Policy: Aquaculture, 2011).

6.2.3.1 Chile- Interaction with wildlife

The single most important wildlife protection arrangement in the Chilean regulation is to avoid interaction between aquaculture farms and sea lions (A. Buschmann, personal communication, 2017). The protection nets around the farms must be constructed in a way so as to avoid that any wildlife is trapped or entangled in the nets. Other species are also protected by the regulations to avoid fatal incidents, but sea lions receive special attention as there are an abundance of sea lions in these waters (A. Buschmann, personal communication, 2017). According to Buschmann Rubio, there are not many interactions between endangered species and net pens of the Chilean coast. Nor does it seem to be a significant threat that escaped invasive species such as Atlantic salmon would affect domestic species or the ecosystem in any significant way (A. Buschmann, personal communication, 2017). However, there are signs of Atlantic salmon establishing themselves in rivers, and feed off of native species as well as colonizing parts of the Argentinian Patagonia coast (Buschmann, et al., 2009).

Much like in Canada and in accordance with the ASC standard, farmers must provide the authorizing government with a contingency plan if there was to be an accident that resulted in a mass escape (A. Buschmann, personal communication, 2017). The Chilean legislation does not, however, have a maximum allowable escape count. The Chilean legislation does prevent farmers from having operations in waters with protected marine wildlife, such as whales. In comparison to the ASC, the Chilean legislation have stricter legislation in that regard, as the ASC allow for operations to take place in protected waters, if the environmental impacts are compatible with the conservation objectives (ASC, 2012, p. 25).

Much like the requirements set up by the ASC standard, regional or national environmental commissions that grants the applications must receive information on the potential effects on the local environment (biotic and abiotic), societies and what pathogens the species is especially prone to or sensitive to (FAO, 2016), as well as an Environmental Impact Assessment (ASC, 2012, p. 25). The Chilean legislation does not, in contrast to the ASC standard, prevent farmers from using ADDs or AHDs (A. Buschmann, personal communication, 2017).

6.2.3.2 Chile- Waste Control

After the ISAv outbreak the reconstruction of salmon farming policies demanded that farms should be further apart and that they must report any pathogenic development at their farms and that this information becomes publicly available so that the public and other neighboring farms can take appropriate measures towards the outbreak. Until recently, this information was not made public, which resulted in farmers being oblivious to what was happening in the surrounding farms and could not therefore, prepare themselves and their fish (Burridge, et al., 2010). This is expected to lead to closer collaboration between farmers and the local government as a mitigation effort to waste contamination and unnecessary or excessive chemical effluents.

The allowable zones of effect in Chile are dependent on the size of the farm and when the license was issued. There is no generic answer to how big a farm is allowed to be and thus, an individual assessment must be made before the government can establish how big an area a salmon farm can affect (A. Buschmann, personal communication, 2017). Similarly, to the ASC standard the Chilean legislations have requirements on the oxygen levels in the sediment around the farms, and on the abundance of biodiversity above the sediments, however, these levels and requirements are also site-specific. License holders must conduct an assessment where the sediment quality is studied for oxygen levels, as well as biodiversity and physio-chemical status twice a year. There is no generic answer as to what levels of biodiversity they must achieve or what levels of oxygen there must be in the surrounding sediment, these assessments are made individually for each farm (A. Buschmann, personal communication, 2017). The assessments are conducted right underneath the farms by a third party, independent consultant, to avoid result fabrications or unjust treatment.

Copper treated net pens can be cleaned in-situ, however, it must be conducted with a technology that removes the residues. Otherwise the net pens must be removed from the water before they are cleaned and the effluents from the cleaning process must be properly handled (A. Buschmann, personal communication, 2017). Furthermore, each aquaculture establishment must have adopted preventative measures to minimize solid or liquid waste and receive authorization from the General Department for the Maritime Territory and Merchant Marine to control the amount of waste effluents (FAO, p. 7, 2016). This includes therapeutic waste, byproducts from butcheries or any other form of waste originating from aquaculture processes (FAO, 2016). Antibiotics have been discovered in wild fish populations in the proximity of the farms, even prohibited compounds such as quinolones have been found (A. Buschmann, personal communication, 2017; Buschmann, et al., 2009).

After a production cycle (24 months), all net-pens must be emptied for three months; this must be coordinated with all of the other Salmon farming practices in the management area (A. Buschmann, personal communication, 2017).

6.2.3.3 Chile- Feed

There are no requirements on the feed contents being sustainable, or that the feed should have lessened dependency on fish products.

6.2.3.4 Chile- Fish Health

Due to the different climatic conditions in Chile compared to other salmon producing regions, the country experience a different disease profile (Henriksson, et al., 2017). The higher temperatures off of the Chilean coast have effects on sea lice infestations as the life cycle of the sea lice is much shorter, but they are greater in numbers (Buschmann, et al., 2009). The critical amount of sea lice per fish is by the regulations set at three egg laying females per fish (A. Buschmann, personal communication, 2017). In terms of fish health there are some requirements set up by the Chilean government, for one thing the license operator must include a fish health management plan and a sanitation plan in their application form (FAO, 2016; A. Buschmann, personal communication, 2017). The number of therapeutic treatments per production cycles is unlimited as long as they are justified and prescribed by a licensed veterinarian, this includes antibiotic treatments. Chilean regulations do not prevent farmers from using WHO listed as highly important antibiotics, such as quinolones (Burridge, et al., 2010). In 2017 policy makers made it obligatory for farmers and license holders to make all antibiotic treatments publicly available as a method to increase transparency and simplify collaborative efforts against disease (A. Buschmann, personal communication, 2017). Other treatments must be registered at a governmental database; this database is not yet publicly available. Most treatments are allowable in the net pens, however, if a case of ISAv would be discovered the farmer is responsible for extracting all the fish from the net pen without any delay (A. Buschmann, personal communication, 2017).

When unexpected and unidentified mortalities occur, the law requires license holders to allow for a post-mortem analysis to be made, to confirm the cause of death and be able to respond accordingly. The net pens must be monitored and emptied daily of potential diseased fish (A. Buschmann, personal communication, 2017). The monitoring and testing of fish welfare should be conducted on a weekly basis; however, this can be done by a trained employee and does not necessarily have to be carried out by a licensed veterinarian. As previously mentioned, the Chilean government are striving towards avoiding similar pandemic outbreaks as the one in the late 00’s, and have thus created health management zones, to synchronize treatments and fish health management strategies (Alvial, et al., 2012).

6.2.3.5 Chile- Farm Location

The Chilean government has declared the southern coast of Patagonia as pristine waters that should not be exploited for aquaculture purposes. However, these protected waters are being infringed upon as production numbers expand at the same time as distances between farms are increasing (Bridson, 2014b). New licenses are not allowed to be any closer than three kilometers from an already existing salmon farm, and 400 meters from a mussel or seaweed farm (Buschmann, et al., 2009). However, previous to 2009, the regulations were much laxer, and many license holders have farms that are closer than one kilometer from one another (Buschmann, et al., 2009).

The industry is moving and expanding south towards the pristine waters of Patagonia, that provide excellent conditions for intensive salmon farming (Bridson, 2014b). The areas of special interest or protected areas are mostly located in the south, in and around the Patagonian coastline. These waters are crucial for migrating whales and birds. The Chilean government has zones of exploitation where farmers are allowed to operate, these zones should not overlap with natural reserves, or other protected areas (A. Buschmann, personal communication, 2017).

6.2.4.1 Norway- Interaction with wildlife

Norwegian requirements on wildlife interaction are perhaps the least transparent and thorough in the Norwegian legislation. Naturally, they want to prevent fatal accidents and interactions with wildlife, but if a farmer has the necessary authorizations they are allowed to take such actions against predatory attacks (Bridson, 2014c). If a farmer has the necessary authorization they are not required to report the fatal incident with e.g. seals, otters or other predators (Bridson, 2014c). This is contradictory to the ASC standard, where farmers must report all incidents and where there cannot be more than nine lethal incidents in a two-year period (ASC, 2012, p. 27).

In keeping with the ASC standard, each farm must have an individually customized emergency plan for recapturing escaped fish, or if there are algae blooms, jellyfish invasion or if there has been a predatory attack. The emergency plan should also include a strategy to handle disease outbreaks, especially if there is a risk of wild populations being infected with a pandemic (Fiskeridirektoratet § 7, 2006).

If there is an extensive risk for interaction between algae blooms, jelly fishes or predatory attacks, the farmers are obliged to safeguard the cultured fish (§ 30, 2006). To prevent interactions with wild stocks of Atlantic salmon the farmers must keep meticulous reports and monitoring of the cages and prevent escapes as best they can, however the legislation does not specify how frequently this monitoring must take place (§ 37, 2006). If an escape were to happen, or if there is a suspicion of an escape, the farmers must notify Fiskeridirektoratet. Furthermore, Fiskeridirektoratet must be informed about when the recapturing efforts begin and when they are terminated. Farmers are not allowed to recapture fish that have strayed further away than 500 meters from the net pens (§ 38-39, 2006). The legislation differs from the ASC standard as they too do not have a maximum allowable escape count, or any explicit legislation preventing the usage of ADDs or AHDs.

6.2.4.2 Norway- Waste Control

In their efforts to combat diseases and other plagues such as sea lice, farmers are allowed to use some insecticides, however if there are other organisms such as shrimp within the proximity of the farm they cannot (§15a, 2006). The farmers must conduct a proper assessment before any insecticides or pesticides can be used around a farm (§ 15-15a, 2006). Particles from chemical treatments, feed, fecal matter or other byproducts that might occur from a salmon farm must be kept at a "warrantable" level (§ 22, 2006). That is there is no generic answer for what is warrantable, rather that the farms are individually assessed from their vantage point. Before a farm is warranted to operate, an assessment must be performed to ensure that the water quality in the projected area is sufficient and that there is a decent run through (§ 23, 2006).

Farmers are obliged to have the sediments around the farm tested for organic matter, chemicals or faunal abundance when the strains on the environment are estimated to be the highest, or when the biomass in the pens are the highest (§ 35, 2006). These tests should be conducted by a professional who has the proper training and education to monitor and report about the findings in the sediment. The tests could be done by personnel at the farms or by third party consultants, either way, the shire and Fiskeridirektoratet must jointly accept the supervising body and review the findings (§ 35, 2006). The commonly used standard for these tests is the Norwegian Standard-9410 (NS-9410) (Holmer, et al., 2008). The standard does not give a generic quality for all farms to comply by, but rather what methods should be used for the measuring of the sediment quality at and in the vicinity of the farms (Holmer, et al., 2008).

The tests should monitor pH and eH levels, the overall environmental performance at a farm are established through three different tests, A, B, and C. The A test must be conducted every third month if levels are up to standards, and every month if not. The B test is conducted in the direct vicinity of the farm and should be conducted every second year if qualities are good and every sixth month if not. The test measures; 1) the presence or absence of animals that are bigger than 1mm. 2) pH and redox potential and 3) the general quality of the sediment. These parameters are then transformed into numbers and a score sheet that either gives a positive or negative result for the farm Finally, the C test consider the surrounding environments around the farm, focusing mainly on water quality and faunal density (§ 35, 2006; Holmer, et al., 2008). If all tests fail, Fiskeridirektoratet have the authority to, after consultation with the local government, shut a farm down (§ 36, 2006). These requirements are similar to the ones set up by the ASC standard (ASC, 2012, p. 20).

The water quality has some set standards that farmers need to consider, namely salinity and temperatures. Anadromous fishes like salmon cannot thrive if temperatures below 7 degrees Celsius, or if salinity levels exceed 35 promille, and are therefore not allowed to be introduced in open water unless these requirements are met (§ 26, 2006). Additionally, the requirements on water quality differs depending on the needs of the species (§ 28, 2006).

Farms must be emptied for two months after each production cycle in order for the environment to recuperate and reach closer to normal levels (§ 40, 2006).

6.2.4.3 Norway- Feed

There are no requirements in the Norwegian legislation on using sustainable contents in the feed or that the feed should strive towards using less fish products or other animal proteins.

6.2.4.4 Norway- Fish Health

Requirements on fish health and stocking density are quite thorough in the Norwegian aquaculture policy. The net pen cages should ensure the safety and wellbeing of the fish; thus, sharp edges are forbidden, the fish should be able to move freely, any materials or chemicals that could harm the fish is strictly forbidden and it must be easy to do inspections of the cages (§ 19, 2006). Every farm should have a backup system if oxygen levels are below acceptable levels (§ 20, 2006). Any therapeutic treatment, hormones or disinfectant used must not change the natural behavior of the fish, no harm to the animals mental or physical health is accepted (§ 32, 2006).

Before roe or fishes are moved from one unit to another they-, as well as the cages must be disinfected to ensure that any disease or other vermin are contained (§ 11, 2006). Throughout the production circle the legislation requires license holders to arrange for several fish health controls. For salmon farms with net pens containing more than 3 000 individuals but less than 50 000 the farmers must have an authorized veterinarian or fish health manager to conduct a health control four times a year, with no more than four months between the inspections. If a farm has pens with greater numbers than 50 000, a health control should be conducted six times a year, with no more than three months in between the controls (§ 50, 2006). If unusual and undefined casualties are find in the pens a veterinarian or marine biologist should be notified and conduct a control without delay (§ 13, 2006). Moreover, the farmers must have daily inspections of the pens, unless extreme circumstances prevent such measures, to look for any signs of infections and to remove casualties as quickly as possible (§ 12, 2006).

Antibiotic treatment or any other type of therapeutic treatment must be prescribed by a veterinarian, furthermore, every treatment must be deployed with extreme caution so as not to harm the surrounding environments (§ 15, 2006). All of the treatments must be reported to Fiskeridirektoratet and the National Food administration, the information should also be made available for the public (§. 13-14, 2006). In contradiction to the ASC standard, Norway and other EU countries, still use critically- and highly important antibiotic residues, such as Quinolones and Tetracyclines to combat disease outbreaks at salmon farms (The Norwegian Veterinary Institute, 2016). All salmon must be vaccinated against furunculosis, vibriosis and cold water vibriosis which has resulted in sharp decline of antibiotic usage in Norway (§ 63, 2006) (Maroni, 2000). To further avoid the spreading of diseases and provide the animals with the opportunity to move in accordance with their physiology the pens must not have more than 25 kg fish per m³ (§ 46, 2006). And a farm may not have more than 200 000 fish in one net pen.

According to the Norwegian Animal Welfare Act, all animals have intrinsic value and should be treated accordingly (Norwegian Government, 2009). Thus, salmon must be treated and handled with care, avoiding moving them unnecessarily or exposing the animals for stressful situations (§12, 20, 28, 2006). During the harvest and slaughter of the fish these cautions still apply. When transporting the animals from their net pens to the slaughter the pools on the vessels must ensure that the temperature is not below six degrees and that the oxygen levels and pH levels are adapted for the salmon (§ 28, 2006). Before euthanizing the fish, they must be given anesthesia as a measure to avoid stress and harm to the animal (§34, 2006).

6.2.4.5 Norway- Farm Location

There are different requirements in different regions of the country in terms of allowed biomass at the farms. In Finnmark and Troms, the farms are allowed to carry a biomass of 945 tons, whereas in the rest of the country they may not exceed 780 tons (§ 11, 2013). The Norwegian Environmental Protection Agency (NEPA) is working towards incorporating more marine areas into the OSPAR convention (the Convention for the Protection of the marine Environment of the North-East Atlantic) (Norwegian Environmental Protection Agency, 2017). In 2003 and 2007 the Norwegian Parliament decided to establish protected areas in 52 rivers and 29 fjords that were considered to be crucial for wild populations of Atlantic salmon (Fiskeridirektoratet, 2015). In most of these areas aquaculture practices are prohibited, and existing ones had to be moved. Furthermore, a salmon farm must never be located any closer than five kilometers from waters where wild stocks migrate and spawn (§ 6, 2009).

There is no generic answer for the required distances between farms, each permit application will be individually considered, and a proper environmental assessment will be made before a permit is issued (§ 6, 2003).

6.2.5.1 Scotland- Interaction with wildlife

Most of the Scottish salmon farming is conducted on the west coast of Scotland, due to most of the wild populations are on the east coast (Fraser, 2017). All escaped salmon must be registered and reported by the farmer to the Scottish Government. The information must entail, how many expected escapees there were and what recapturing plan they have initiated (Scottish Government, 2012). However, there is no requirement on keeping the escape numbers below 300.

The most common wildlife interactions are with grey-, and harbor seals (Bridson, 2014d, p. 4). In order to deter the seals from approaching the net pens, some farmers are using acoustic deterrence advices (ADDs) (Code of Good Practice, 2015), which contradicts the ASC standard.

Much like the ASC standard and the other countries/province in this study, Scottish farmers are required to have an updated practice standard with a predatory prevention plan, furthermore, they should document any sightings of predators in the area (Code of Good Practice, 2015). Farmers should have appropriate deterrent systems in place to avoid predatory attacks, and if an interaction with wildlife would occur, they must have a permit from the local authorities to use lethal force (Code of Good Practice, 2015, p. 40). However, there are no restrictions on the number of wildlife incidents with lethal outcomes on each farm, which differs from the ASC standard. All incidents with wildlife must be shared in the Farm Management Statement or Agreement that all farms must partake in, to ensure the stability and transparency of the practices in a certain region (Scottish Salmon, 2015). The Scottish maintenance and monitoring requirements on the pen constructions are similar to the ASC standard. As the local District Salmon Fisheries Board can authorize inspections at the farm at any time, where they would look at the net pen constructions and escape prevention plans. These need to be updated and documentations that the pens were constructed by authorized personnel (Aquaculture and Fisheries (Scotland) Act 2013, 2013, p. 4B).

6.2.5.2 Scotland- Waste Control

As a member of the European Union, Scotland are required to minimize the use and spreading of list II substances in aquatic environments. These substances vary from; metals, such as copper, zinc and lead, to biocides, and compounds that affect oxygen levels such as ammonia (EC, 2016). All member states are required to limit the usage of these compounds through legislation and monitoring. In Scotland this is done through the issuance of allowable pollution to each farmer by the Scottish Environmental Protection Agency (SEPA). The pollution should be measured and monitored by the SEPA annually and by the farmers themselves on a more continuous basis (Control of Pollution Act, 1974). The allowable effects, or Controlled Activities Regulations (CAR) licenses, are controlled and monitored by SEPA and is determined through site-specific assessments (Scottish Government, 2017). This will determine the allowable biomass, the minimum requirement on fauna and flora in the sediment inside the AZE, which is typically the size of the cage plus 25 meters, as well as outside (SEPA, 2008).

SEPA monitoring includes; underwater cameras, benthic faunal community assessments, sediment chemistry (redox, sulphide levels, zinc and copper levels, medicine residues), presence of feed pellets (SEPA, 2008). From these tests SEPA will know if any alterations are necessary for the farmer, to minimize the effects on the benthic environment. Emamcetin Benzoate (SLICE) is used to combat sea lice in Scotland as well, however, SEPA are trying to minimize the effects of SLICE on the marine sediments through the Environmental Quality Standards (SEPA, 2017).

6.2.5.3 Scotland- Feed

There are no requirements in the Scottish, UK or EU legislations on using sustainable contents in the feed or that the feed should strive towards using less fish products or other animal proteins.

6.2.5.4 Scotland- Fish health

Each farm must have a customized Veterinary Health Plan (VHP) and a Biosecurity Plan (BP), these plans are mandatory and should incorporate how the farm is working towards; preventing the introduction and spreading of diseases, the elimination of factors that might predispose diseases, the establishment of disease prevention procedures, monitoring devices in place to be able to report on the wellbeing of the salmon, monitor if there are any signs or warnings that the fish health might be deteriorating and a response procedure (ANNEX 2: Guidelines for a Veterinary Health Plan (VHP) and Biosecurity Plan(BP), 2015). To ensure a good environmental standard, the farms should have monitoring devices to report on water quality and algae blooms or jellyfish infestations (ANNEX 2: Guidelines for a Veterinary Health Plan (VHP) and Biosecurity Plan(BP), 2015).

If the salmon would die unexpectedly and unexplainably the farmers should notify the appointed veterinarian for that farm, to come and perform a health check on the fish (Scottish Salmon, 2015). Furthermore, if cages of salmon where the individuals weigh less than 750 grams each have a weekly mortality rate at 1.5 percent or if larger fishes at > 750 grams have weekly mortality rates at 1 percent, the farm is required to contact their appointed veterinarian (Scottish Salmon, 2015). Dead fish should be removed daily if possible. All therapeutic treatments must be prescribed by a licensed veterinarian, as well as regular visits by an appointed veterinarian, this information should be made publicly available (ANNEX 2: Guidelines for a Veterinary Health Plan (VHP) and Biosecurity Plan(BP), 2015). The prescriptions and usage of therapeutic treatments and discharge grants must be submitted to SEPA on a monthly basis (Burridge, et al., 2010).

Perhaps because of all the different and overlapping regulations that affect the Scottish salmon industry it has become a crucial factor that everything is recorded and made publicly available, all of the incidents with wildlife, disease outbreaks, medical treatments, if clean fish have been used to combat sea lice or if pesticides have been used, vaccinations, what feed has been used and how much of it, veterinary visits, recordings and agreed action plans (ANNEX 2: Guidelines for a Veterinary Health Plan (VHP) and Biosecurity Plan(BP), 2015). Scottish salmon industry has much like Norwegian adopted to the idea of vaccinating salmon which has resulted in a steep decline of antibiotic usage (Code of Good Practice, 2015, p. 28: Burridge, et al., 2010). Scottish salmon farmers abide by EU regulations concerning antibiotic usage, where it is allowed to use critically important antimicrobials, but only as a last resort (European Medicines Agency and European Food Safety Authority, 2016). A compound that has been found in Scottish salmon is oxytetracycline, which is a Tetracycline group of antibiotics and is deemed highly important by the WHO (World Health Organization, 2017).

The stocking density of the net pens is dependent on the water quality and fish health, it can be adjusted during the lifetime of the fish to encourage natural behavior and that the wellbeing of the fish is ensured (Code of Good Practice, 2015, p. 45).

6.2.5.5 Scotland- Farm Location

In order for a farm to become operational the farmer must have a CAR license and a Crown Estate Lease. Almost the entire seabed in and around the UK is owned by the Crown Estate, because of this, farmers must apply for a lease and pay rent to be able to install and operate a fish or shellfish farm (Scottish Government, 2016). Furthermore, all potential farms must submit an Environmental Impact Assessment to the government. The assessment must entail the potential effects on the farms surroundings, and if there are other options to minimize the risks or effects on the surrounding environment (The Environmental Impact Assessment (Fish Farming in Marine Waters) Regulations, 1999). This is in unison with the EU directive on Environmental Impact Assessments as a prerequisite before a farm can be considered. Furthermore, the EU has the Habitats and Birds directives as well as Natura 2000 that are deemed to be of significant importance to wildlife and especially migrating birds. In these areas it is not prohibited to farm finfish or shellfish, however, there are more restrictions and the need to perform thorough investigation before production can begin (EC, 2012). The Natura 2000 framework, the Habitats and Birds directives as well as Water Framework Directive2000/60/EC, and Marine Strategy Framework Directive 2008/56/EC, all effect where aquaculture practices should be located. Furthermore, the UK is part of the OSPAR Convention that entails legal requirements from member states to make strides towards protecting their marine environments (OSPAR, 2015). Scotland has 31 nature conservation Marine Protected Areas (MPAs). Many of these are created to protect sensitive benthic species and or habitats (Marine (Scotland) Act 2010). The protected areas cover approximately 20 percent of the Scottish marine environments (Scottish Government, 2017). Even if the legislation does not explicitly prohibit aquaculture in biologically important areas or MPAs, they use a precautionary approach as to where and how the farms can be operational. However, there is no generic standard or emission allowance, it is all determined through individual assessments on the farms by the SEPA.

6.3 Results

The differences in the regulations are not reflective of the difference in the number of certified farms. Scotland who only has two certified farms out of their 230 operational licenses do not have a significantly different judicial framework than that of Norway or British Columbia, who both have a much higher percentage of certified farms. Clearly, all of the states/province that have been studied for this thesis are striving towards becoming more sustainable, there are several policy papers, strategies and papers on how they are working towards these ends (Fiskeridirektoratet, 2006; Code of Good Practice, 2015; B.C. Finfish Aquaculture Regulation: An Information Review and Progress Report, 2007). However, there are some aspects of the regulatory framework in each state/province that still have some significant room for improvements and work ahead of them.

6.3.1 Finding the highest potential additionality

As was mentioned earlier, finding the highest additionality by analyzing state/provincial legislation could overlook some criteria and result in an oversimplification. This is due to the fact that there are requirements that vary between farms, and therefore, there are some criteria without a generic regulation attached to it but instead an individual assessment for that particular farm proposal. However, it is one of the main requirements in the ASC standard that farms should have complete transparency (ASC, p. 13, 2012). This should apply to state regulations as well, and nowhere was there an explanation as to how the individual assessments for salmon farming proposals are conducted. This chapter of the analysis will highlight the criteria with the highest and the lowest potential additionality from each state/province, a full calculation of all the elements is found in appendix III.

Table 3 is showing the potential additionality on each key element (See appendix II for quotations and references and appendix III for a more thorough presentation).

Key elements	***B.C.***	***Chile***	***Norway***	***Scotland***
Interaction with wildlife	0,4	0,4	0,4	0,4

Waste management	0,5		0,5	0,5
Feed	0,5	0,5	0,5	0,5
Fish Health	0,5	0,6	0,4	0,4
Farm Location	0	0,3	0,5	0,5

B.C.'s potential additionality

One of the elements that were least in accordance with the ASC standard in British Columbia was the waste management criteria. This is because of the less frequent monitoring of the sediment in and around the farm. Where there were no indications as to what kind of measurements or monitoring devices that was needed to monitor and prevent pollution in the surrounding environments.

$$(A\ waste)\ 0{,}5 = (S)1 - (BAU)0{,}5$$

The regulations around feed and feed content are another element where there is a rather high potential additionality. B.C. regulations do not have any specific requirements regarding the usage of fish meal and oil that have been captured in an unsustainable fashion. Nor did they specify on the sustainability aspects of other contents.

$$(A\ feed)\ 0{,}5 = (S)1 - (BAU)0{,}5$$

Another element that scored high on the potential additionality was fish health, as there are no requirements on how often a veterinarian or fish health manager should visit the farms to perform health controls on the fish, unless there is a sea lice outbreak. Nor were there any requirements on how many antibiotic treatments that are allowed during a production cycle. Furthermore, B.C. legislation has not adopted vaccinations as a standard procedure to avoid disease spreading and decrease antibiotic usage.

$$(A\ health)\ 0{,}5 = (S)1 - (BAU)0{,}5$$

Wildlife interactions are fairly regulated as authorization must be given before lethal action is taken towards predators or other wildlife at the farm sites and endangered species are protected against any form of lethal action (Migratory Birds Convention Act, 1994: Marine Mammal Regulations, 2015). However, the legality of using acoustic deterrent systems and the lack of restrictions on the total amount of escapees adds to the potential additionality of the B.C. regulations.

$$(A\ wildlife)\ 0{,}4 = (S)1 - (BAU)0{,}63$$

B.C. legislation exceeds the ASC standard as the B.C. legislation has a generic standard as to how far away finfish farms must be from one another and that a farm must not be closer than a kilometer from a natural preserve or a Marine Protected Area (MPA) (BC Pacific Salmon Forum, 2007, pp. 11-12).

$$(A\ location)\ 0 = (S)1 - (BAU)1$$

Chile's potential additionality

From the correspondence with dr. Buschmann and from the literature review, the highest additionality for the Chilean regulations would be on the fish health criterion. As the Chilean government do not seem to have a set number of mandatory visits from veterinarians or fish health managers. Nor do they have a maximum amount of antibiotic treatments or a requirement of vaccinations to prevent disease spreading.

$$(A\ health)\ 0{,}6 = (S)1 - (BAU)0{,}4$$

As for the fish feed requirement, the Chilean regulations have a potential additionality of 0,5. Much like the rest of the nations/province that has been review for this paper the Chilean legislation do not have any requirements on the fish used for the feed or how sustainably the contents of the feed have been produced or captured.

$$(A\ feed)0{,}5 = (S)1 - (BAU)0{,}5$$

On the interaction with wildlife criterion the Chilean regulations matches that of British Columbia, where there are prohibitions in using lethal force against endangered animals and where authorization must be given if lethal action is taken towards other predators on the farm (A. Buschmann, personal communication, 2017). And much like in B.C. there are no restrictions on the total amount of escapees that is allowed per production cycle.

$$(A\ wildlife)\ 0{,}4 = (S)1 - (BAU)0{,}6$$

Much like the British Columbian legislation, the Chilean regulations clearly constitutes that a new farm must not be closer than three kilometers from one another (Buschmann, et al., 2009).

However, according to the literature review conducted for this study there seems to be some leeway when it comes to farming in marine protected areas, and licenses being granted in pristine waters along the Patagonian coast (Tecklin, 2016).

$$(A\ location)\ 0{,}3 = (S)1 - (BAU)0{,}7$$

Norway's potential additionality

Norway's regulatory framework was the most transparent out of the national/provincial legislation that was reviewed in this thesis. Almost all of the relevant information was gathered in one document *Akvakulturloven- Sentrale foreskrifter* (Aquaculture regulations- key regulations). However, the information did lack somewhat in regard to where a farm could operate. According to Norwegian law, it is allowed to operate a farm in a marine protected area, just with higher requirements than in other areas (Fiskeridirektoratet, 2015).

$$(A\ location)0{,}5 = (S)1 - (BAU)0{,}5$$

Norway has, like the rest of the nations/province in this study no requirements on using sustainable contents or any regulations or policies regarding using less fish meal or oil in the fish feed.

$$(A\ feed)\ 0{,}5 = (S)1 - (BAU)0{,}5$$

Another criterion where Norway has a rather high potential additionality is waste management. They do have standardized tests on water quality and the sediment that they perform on a rather frequent basis (§ 35, 2006). However, they have no regulations that explicitly mention the allowable zone of effect or a minimum requirement on the biodiversity underneath the AZE or around the farm.

$$(A\ waste)\ 0{,}5 = (S)1 - (BAU)0{,}5$$

Norwegian regulation does not set a maximum amount of escaped salmon, and the government relies on self-reporting on incidents from the farms. In accordance with the ASC standard, farmers are required to have an authorization from the government before using lethal force against predators.

$$(A\ wildlife)\ 0{,}4 = (S)1 - (BAU)0{,}6$$

Furthermore, Norway's fish health score is fairly close to that of the ASC standard. However, the regulation does not prevent usage of important antibiotics for human health, which is a very important shortcoming in their legislation. Another difference between Norwegian legislation and the ASC standard is that Norway does not have a maximum amount of antibiotic treatments during each production cycle.

$$(A\ health)\ 0{,}4 = (S)1 - (BAU)0{,}6$$

Scotland's highest and lowest additionality

Scottish regulations allow aquaculture operations to take place in Marine Protected Areas (MPAs), much like Norwegian and EU legislation (EC, 2012: Fiskeridirektoratet, 2015). Even if it is with further, stricter, precautionary requirements, it still differs from the ASC standard and has no clear definition of what these stricter regulations actually translate to in practice.

$$(A\ location)\ 0{,}5 = (S)1 - (BAU)0{,}5$$

The Scottish feed regulations are similarly to the rest of the regions observed in the study non-existent.

$$(A\ feed)\ 0{,}5 = (S)1 - (BAU)0{,}5$$

Scotland's waste management receives the same score as B.C., where the frequencies of the tests and the benthic flora and or fauna requirements are lower than the ASC standard.

$$(A\ waste)\ 0{,}5 = (S)1 - (BAU)0{,}5$$

The fish health criterion has a potential additionality of 0.4. Their requirements are similar to that of Norway only that they do not have a generic requirement on the frequency of health controls by veterinarian and/or marine biologists.

$$(A\ health)\ 0{,}4 = (S)1 - (BAU)0{,}6$$

Scottish regulations on interaction with wildlife have the same potential additionality as the rest of the countries/province in this study.

$$(A\ wildlife)\ 0{,}4 = (S)1 - (BAU)0{,}6$$

6.3.2 Working towards sustainability

Every region has its own problems and advantages in terms of salmon farming. E.g. Chilean salmon farmers experience a different disease profile than northern European and West Canadian farmers. This could be due to local environmental conditions, but it could also be due to better management in B.C. or in Europe, or the quality of the smolts (Henriksson, et al., 2017). Either way, it is problematic as it causes Chilean farmers to use more antibiotics than farmers in the other high-producing nations/province.

According to Porter's theory state/provincial regulations should use strict environmental regulations as a competitive advantage. Therefore, they should arguably, update their aquaculture regulations to either outperform, or at least match the same level of strictness as the ASC standard, in the areas where the standard has more rigorous environmental regulations (Porter, 1990). Applying stricter regulations would, based on Porter's theory result in an overall increase in revenue and production numbers in the long run as it would force industrial actors to apply more sustainable practices, which would minimize risks of pandemic outbreaks as well as mitigate overfishing and prevent marine environmental degradation. A clear case where Porter's theory has been accurate is Chile, where peak production numbers before the ISAv outbreak were 388 847 tons in 2005 (SalmonChile, 2016). Since then the Chilean state has intervened with a firmer and more rigorous legislation, and the production numbers have increased to 644 459 tons in 2014, despite the impaired reputation of Chilean salmon industry after the ISAv outbreak (SalmonChile, 2016).

However, the private international standard theory could argue that the ASC is an example of how fast-moving global standards are working. More and more farms are striving towards becoming ASC certified which might not have been the case if the standard differentiated too much between countries and regions. The fact that an organization such as the GSI and its members all has promised that their practices will be ASC certified by 2020 is proof that international standards such as the ASC can have significant influences (GSI, 2017c). By applying an inclusive, international standard, companies could change their practices without making alterations that seems too big, e.g. use less antibiotics and only use feed that has been MSC certified it makes a large accumulative difference, and it does not have to cost too much for farmers to make these changes. Furthermore, it is not a guarantee that the states do what is best for the environment, since the Chilean government intervened with stricter regulations the usage of antibiotic treatments have gone up significantly (Buschmann, et al., 2009). However, inclusive standards might not be strict enough. And much like weak sustainability, inclusive standards do not, in a gratifying way, consider that environmental degradation is irreversible.

According to the ASC website, there currently are 37 Atlantic salmon farms under assessment in B.C., Chile, Norway and Scotland (ASC, 2017b).

Table 3. Farms under initial assessment by the ASC (ASC, 2017b).

	Farms under assessment
Norway	15
Chile	10
Scotland	4
B.C. (Canada)	8

If these farms receive certifications, it would imply a ≈36 percent increase of ASC certified farms in B.C., and a total of ≈23 percent certified farms in the region. A ≈14 percent increase in Norway, with a total of ≈17 percent of the Norwegian salmon farms certified. A 200 percent increase in Scotland, which would result in 3 percent of the Scottish farms having an ASC certificate. Finally, a ≈31 percent increase in Chile, which would total at ≈8 percent of the countries salmon farms having an ASC certificate. One of the GSI members and also the biggest salmon producing company, with operations in all countries/province under observation in this study is Marine Harvest. They reported in 2016 that 25 percent of their operations are certified by the ASC (Marine Harvest, 2016, p. 9). Furthermore, GSI members have accumulated ASC certifications on 20 percent of their operational farms (GSI, 2017d). Since 2014 GSI members have gone from having ten certified farms to having 144 certified farms (GSI, 2017e).

Opponents to the theory of private international standards would argue that these numbers show how far away the GSI are from achieving 100 percent certified by 2020. One argument for Porter's theory is that increasing the stringency on a judicial level would probably achieve the 100 percent goal faster, and that they could add to it.

Combining increasing production numbers and sustainability

The ASC standard is not a complete product, it is, much like the rest of the industry under construction and development (ASC, 2015). As long as technologies, policies and the environment changes, the standard and arguably the national/provincial standards need to change with it. This kind of flexibility, or adaptability, is what both Porter and the international standard theory advocates for. Industrial leaders must collaborate with researchers, government officials and other interest groups and remain adaptive to change and new knowledge. This is especially important as the overall trajectory of salmon farming is showing that production numbers will continue to climb, and the improvements of the technologies as well as public awareness indicate that it is feasible that this increase could be done in a rather sustainable fashion (Edwards, 2015).

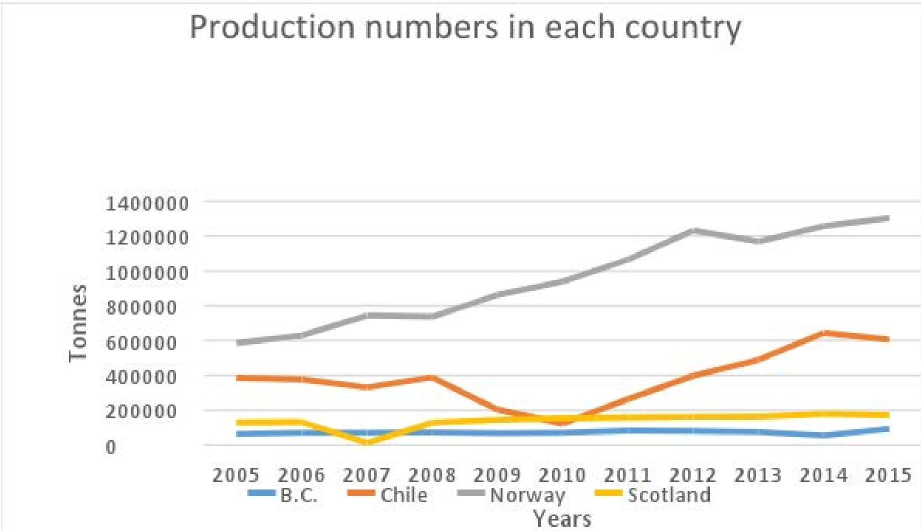


Chart 5: Production trajectory between 2005-2015 (DFO, 2017; SalmonChile, 2016; SSB, 2017; Scottish Government, 2017).

The increased production and the demand for sustainably produced seafood can perhaps increase the transition to sustainable intensification that could improve food resilience and help feeding the growing global population. That is if the key elements raised in this study are properly dealt with. If the ASC standard would replace the legislations and policies in each state/province under observation in this study, they would need to make these alterations to their conventional regulations:

(1) Control and monitor fish feed to ensure that the ingredients are sustainably grown or from certified sustainable fisheries,
(2) Restricting the number of antibiotic treatments during the production cycles, and the type of antimicrobial compounds that are used,
(3) Apply stricter regulations on escapee numbers,
(4) Apply strict, publicly available standards for levels of pollution in terms of medical waste, feed and fecal matter in and around the farms,
(5) And remove all acoustic deterrence devices.

So how well are these *alterations* relating back to the *elements* that have been raised by several scholars and in this background, namely, (1) interaction with wildlife, (2) waste control, (3) feed contents, (4) fish health, and (5) farm location? *Alterations* in the national/provincial regulations regarding acoustic deterrence devices, and escape numbers would help for the first *element*, interaction with wildlife. The second *alteration* and the fourth *element* are compatible, so is the fourth *alteration* and second *element*. The third *element*, to minimize the dependency on fish products in the feed and to only use sustainably certified ingredients is not solved by replacing the existing regulations with the ASC standard. However, it could mitigate overexploitation of forage fish and it would guarantee that other ingredients are sustainably grown. Finally, the fifth *element* would slightly change the current practices in Scotland and Norway where companies are allowed to farm in protected areas as long as they have a special permit. Currently, the B.C. legislation on farm locations is stricter than that of the ASC standard as they have requirements on distances between farms and natural reserves (BC Pacific Salmon Forum, 2007). Chile's current regulations would be unchanged, since they decided that new farms cannot be closer than 3 km from one another (Buschmann, et al., 2009).

The risk of ignoring the third element and continue to rely and overexploit forage fish can snowball into rapid biodiversity loss which would have unknown consequences on societies and potentially detrimental effects for coming generations. If current state/provincial legislation would be replaced by the ASC standard it would reduce the overexploitation of fish stocks. However, it would not solve the dependency on forage fish to feed cultured fish, and would therefore not be completely sustainable (Troell, et al., 2014; Jacquet, et al., 2010). The good news is that mitigation efforts regarding the overexploitation of smaller pelagic fish and improvements on the feed conversion ratio (FCR) has been promising as the amount of wild fish required to produce cultured salmon decreased with 25 percent between 1997 and 2001 (Naylor & Burke, 2005).

The problem with fish protein in feed dependency though, is if production numbers are increasing simultaneously the amount of fish used for feed is likely to stay the same if not continue to grow. The increasing prices of these resources is due to the increasing scarcity and due to the competition from other animal husbandry practices that use fish meal and oil in their feeds (The

World Bank, 2013). Skretting's potentially trailblazing feed without fish meal or oil has the potential to quickly put an end to this fish as food for cultured fish dependency problem. However, it is still not a finished product and there are still concerns regarding the potential effects it would have on growth rates. Furthermore, as an all vegetarian diet would increase the reliance on terrestrial resources, it should be produced in a sustainable manner to not put further stress on them (Troell, et al., 2014; Torstensen, et al., 2008). Indeed, governmental/provincial regulations could streamline sustainable feed developments by requiring feed producers to only use sustainably grown ingredients and/or fish meal and oil from sustainable fisheries and fish processing wastes (Porter, 1990), but so could international standards if states allowed for them to do so. The EU is a good example of where an intergovernmental organization, successfully, regulate the food- and chemical markets (EC, 2002; EC, 2006). The EU example is a testament to the idea that for some challenges it is better to have intergovernmental regulations and controlling mechanisms, as would be the case for feed content regulations.

As for the other criteria, there are several new technologies to prevent escapees, there is also a number of vaccinations that have been helpful in preventing furunculosis (*Aeromonas salmonicida*), vibriosis (*Vibrio anguillarum*), cold-water vibriosis (*Vibrio salmonicida*), winter ulcer (*Moritella viscosa*) and infectious pancreatic necrosis (IPN), and much research on new vaccinations that could prevent resistant bacteria or viruses (Gjerde, et al., 2009). Furthermore, a study from Norway showed that much of the escaped salmon could have been avoided if monitoring and maintenance routines were more meticulous (Lekang, Salas-Bringas, & Bostock, 2016). There are several other potential measures that could be taken to limit escapees, and prevent predatory attacks, e.g. thicker nets or using double nets (Lekang, Salas-Bringas, & Bostock, 2016), or closed containment systems that would control all inputs and outputs of the farm as well as temperatures, oxygen levels and minimize the effects on marine wildlife (Thorarensen & Farrell, 2011). However, all of these measures would result in higher costs for the farmers, as more staff to monitor and maintain the cages would result in more employees. Thicker nets or double nets would acquire more material which also could have negative effects on the health of the animals if it affected the water circulation, and closed containment systems are much more expensive than open net pens.

Table 4: *Development trajectory in tons produced and increased production numbers in percent between 2005-2015* (DFO, 2017; SalmonChile, 2016; SSB, 2017; Scottish Government, 2017).

	2005	2015	Increase in %
B.C.	63 370	92 926	42
Chile	385 779	606 453	46
Norway	586 357	1 303 346	55
Scotland	129 588	171 722	25
Total	**1 165 094**	**2 174 447**	**46**

The ten-year trajectory shows that the Scottish salmon farming industry is indeed developing slower than the rest, which is in line with the criticism raised by the European Commission (EC, 2009). However, the argument that this is due to the strictness of the regulations rather than that there are several different institutions and agencies that regulate and control the development of aquaculture is tenuous. Norway, who has had the steepest increase-, as well as the highest production numbers to begin with have in many instances even stricter regulations than the UK and EU. One such area, which also better complies with the ASC, is the use of medicines and hormones to combat diseases (Maroni, 2000, p. 195). Chilean production numbers have increased with approximately 80 percent since their lowest production numbers in 2010, caused by the ISAv outbreak. This is while the state has imposed stricter regulations to avoid such an outbreak from happening again, which is another clear case of how production numbers and stricter state regulations work, both for the environment and for the economy.

Chart six shows one of the sustainability indicators that has been considered in this study to exemplify the difficulty of applying a global standard and why it would be difficult for states to abide by the exact same standard.

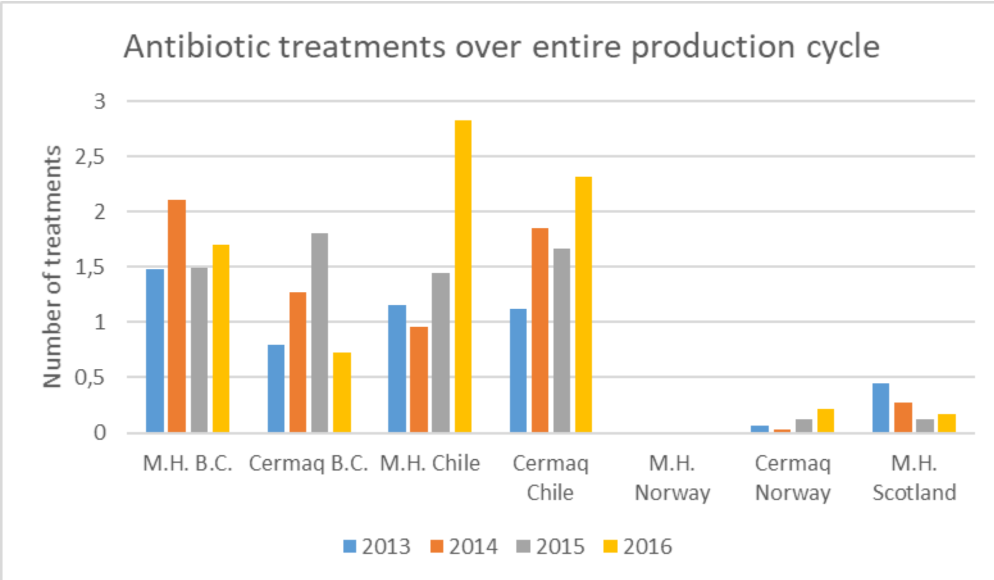


Chart 6. Number of antibiotic treatments during one production cycle, at Marine Harvest and Cermaq (GSI, 2017e).

Even within the same companies that strive towards becoming ASC certified, there still is a discrepancy in how many antibiotic treatments that are being used. This could, as was mentioned earlier, be due to several different factors. E.g. Chilean Atlantic salmon farming is more susceptible to a bacterial disease called *Piscirickettsia salmonis* (Henriksson, et al., 2017). This has large effects on the usage of antimicrobials. Thus, some regions are more dependent on antibiotic usage than others (Henriksson, et al., 2017). But this discrepancy could also be due to management issues when handling the smolts or the fish (Henriksson, et al., 2017). The number of treatments could also be affected by the public perception in the regions, where in Norway antibiotics might be a bigger concern for consumers and retailers than in Chile.

As is shown in chart 6, both Cermaq and Marine Harvest use, in keeping with the ASC standard, less than three antibiotic treatments during each production cycle. Marine Harvest have not used any antibiotic treatments in Norway during the last four years, and Cermaq has used less than half a treatment on average. As the Norwegian regulation allow for more than three antibiotic treatments per production cycle it is reasonable to expect that there are other factors that have resulted in this low antibiotic use. One of the reasons is likely due to the success rates of vaccinations, which has decreased the reliance on antibiotics (Burridge, et al., 2010). However, the problem is that compounds of antibiotics that have been deemed critically important to human health has been found, which could become a massive problem if resistant bacteria develop as a result. Some of the elements studied for this thesis are easier to control on a local or regional scale, e.g. wildlife interactions. Other aspects are more difficult and needs to be solved on an international level, e.g. what antibiotic compounds that can be used and restrictions on feed contents.

7. Conclusion

In conclusion, each country/province has its own challenges regarding sustainable salmon farming. These challenges are dependent by geographic location, disease profile or political governance. In B.C. it was the waste management, feed and fish health elements that had the highest potential additionality, something that could be solved through more frequent testing of the sediment in and around the farm and a stricter benthic flora and fauna requirements, and more frequent visits by a veterinarian, and limiting the number of antibiotic treatments. Chile's element with the highest potential additionality is fish health, something that could be solved by having farms more frequently visited by a veterinarian or some other qualified personnel. Furthermore, they would need to add legislative prohibitions on using antibiotics that are crucial to human health and limit the number of antibiotic treatments during a production cycle. Norway and Scotland have the same elements with the highest additionality, namely waste management, feed and farm location. Waste management could be solved by applying standardized requirements on faunal and floral abundance around the farms, as well as establishing an AZE in Norway and having a more frequent test schedule in Scotland. Farm locations could also be fixed by adding generic regulations on distances between different farms or natural reserves. As for the feed element, all countries/province had similar legislation that does not prevent using fish products or other ingredients that might have been produced or caught in an unsustainable manner. This is arguably, something that should be solved on an international level.

By comparing the ASC standard with the national/provincial legislation it is apparent that the best way to create a sustainable salmon farming industry would be to set an international bare minimum requirement that safeguards a certain level of sustainability. However, this should not prevent national regulations to have even stricter standards and use environmental sustainability as a competitive advantage on the international market (Porter, 1990). A big problem with eco-certifications is that they are not legally binding, they are merely market based eco-certifications which limits their actual effects. International organizations such as the UN have tried to create an international movement towards becoming more sustainable, through the Brundtland report, the SDGs and through the FAO's EEA (UNDP, 2015; FAO, 2010). However, these efforts have not imposed strong sustainability requirements equally strict or specific as the ASC standard. Therefore, it is still up to each nation/province to set the standard in their own regions, and if they chose to replace their current salmon farming legislation with the ASC standard it would have significant impacts on the sustainability aspects of salmon farming. However, it is still within their own right to decide how sustainable the salmon farming industry should be.

In his study Bridson found that the common practices in each country/province studied in this thesis is insufficient (Bridson, 2014). However, the Seafood Watch program argues that salmon produced at ASC certified farms is "A Good Alternative" (Seafood Watch Program, 2017). As contradictory as it may sound, it seemingly implies that salmon farming could be conducted in a, according to the Seafood Watch program, sustainable fashion, if the rigorous conditions of the ASC would be applied on all farms. However, for the standard and the industry to become even more sustainable, they would need to transition towards using low grade food resources to feed the fish and not high-grade resources that would, could and arguable should be used for human consumption (Jacquet, et al., 2010). To avoid aggravating planetary boundaries such as biodiversity loss and to prevent starvation this aspect should, at least if one advocates for strong sustainability, be a major concern for governments as well as certification schemes (Jacquet, et al., 2010; Neumayer, 2003; Troell, et al., 2014). Until certification schemes, governments or intergovernmental organizations apply standards against the use of fish meal and oil in fish feed, it would at least mitigate the problem if states applied a similar standard to that of the ASC as it would prevent overfishing. The new feed standard from the ASC clearly advocates international regulations to solve this issue (ASC, 2017), which seems to be a better option than state specific regulations and monitoring.

Other elements where an international standard would be preferable or if the states/province tried to mimic the ASC standard is in terms of definite limits, such as escapees, dissolved oxygen levels or lethal incidents with wildlife. This would, however, not be without difficulty. E.g. if a storm results in more than 300 escaped salmon, what would the punishment or reprimand from the state be? Should it result in the closing down of the farm? BBC reported in September that the total amount of escaped salmon from Scottish farms in 2016 were 311 000 escaped fish from five farms (BBC, 2017). Norway had, during the same period, 128 000 escaped salmon

(Fiskeridirektoratet, 2017). Both policies have similar requirements on farmers and employees to have proper training in prevention and maintaining of escaped fish (Fiskeridirektoratet, 2006, p.49; Aquaculture and Fisheries (Scotland) Act 2013, p. 4), yet Norway has far less escaped fish, even if they culture almost ten times the amount of Salmon. In terms of their regulations and policies it is not much difference between these countries. So, the question would be whether or not the differences in escape numbers were due to harsher weather in Scotland or if Norwegian farms control their farms more vigorously. If the latter is the reason behind this difference, it could prove that similar standards would also be preferable elsewhere. However, if it is not, enforcing such restrictions on farmers when they are unable to mitigate or do anything about it would be pointless.

One common denominator between the theories of national vs. international regulations/policies and standards is that they advocate for adaptive legislation, and the importance of incorporating different aspects of environmental sustainability in the legislation and in policies.

8. Future studies and limitations

Aquaculture is a fast-evolving industry, certification schemes such as the ASC are continuously working to spearhead sustainable practices and help create and maintain a sustainable industry. The ASC are currently working on an updated salmon standard to complement the original one used for this thesis. In their new standard they are working on some of the issues raised in this study and have updated the feed requirements to try and decrease the use of fish meal and oil in the feeds. Therefore, in a rather short period of time it will be interesting to compare how the new salmon standard and the old differentiate, and see if the new standard tackles sustainability issues like high grade food in feeds, and how the new standard compares with national/provincial policies and regulations.

Furthermore, there are information gaps from the studies where there was no available information in the national/provincial legislation or policies. Thus, it would be of great interest to study the individually assessed farms to see how they differ from the standards or national legislations.

8.1 Methodological limitations

First and foremost, determining stringency involve obstacles and conceptual problems. It is very difficult to determine the effects of regulatory environmental stringency and how sustainable a country's industries are. Brunel and Levison (2013) has identified four conceptual problems with determining stringency: "(1) *multidimensionality* – environmental regulations cannot easily be captured by one measure of "stringency"; (2) *simultaneity* – countries with strong economies or bad pollution may impose the most stringent regulations; (3) *industrial composition* – countries where the mix of industries is on average more pollution intensive have higher average abatement costs and measured regulatory stringency; and (4) *capital vintage* – regulatory standards are typically tighter for new sources of pollution, with implication to the environment, the economy, and measures of regulatory stringency (Brunel & Levison, pp. 5-6)."

The correlation between stringent regulations and the number of ASC-certified farms in each country/province might indicate that stricter regulations leads to less additionality of implementing certification standards than in a country with more lax regulations. But other factors, such as the biophysical conditions and the prevalence of certain diseases are also important factors that this study is not considering.

Another critique of determining the stringency is that this study bases its findings solely on the available information, provided by the governments. This is a problem as each state requires individual applications before a salmon farming license will be provided, and presumably, in some of the categories that are reviewed in this study there is no generic silver bullet standard for operators to abide by, as the environmental impact assessment, or business plan must be reviewed and judged with existing, local conditions of the proposed farm site in mind.

The simplified version of quantifying additionality is, unintentionally, subjective. The metrics assigned to each variable are determined through the *positive policy analysis,* and not by measured values. Similarly, the enforcement metrics are assigned after the *positive policy analysis,* where government monitoring is valued higher than monitoring conducted by private actors. Furthermore, the method cannot account for variations between the nations/province or how well the national/provincial standards are followed (Garrett, et al., 2016). This study has interpreted the lack of information in the policy documents as less stringent and loosely regulated, when in fact it might be the opposite, just that no official, generic requirement is available. To incorporate such information, this study would have to include interviews with state regulators and license granting officials in each country respectively. Furthermore, all variables are valued equally for this quantification. The study does not differentiate or value variables differently in terms of importance for sustainability. The potential additionality findings should therefore be interpreted as quantified guidelines to understand approximately how different the ASC standard is compared to national standards.

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Appendix I

1. Interaction with wildlife:

Ola: Are there any regulations regarding interactions with wildlife?

Alejandro: YES, the farmers are not allowed to kill or harm wildlife, especially sea lions. They use protection nets that do not allow that sea lions get entangled.

Ola: Are there any regulations on predatory attacks or endangered species?

Alejandro: We do not have endangered species interacting strongly with net pens. Mostly are the sea lions a species rather common in this part of the ocean.

Ola: Or on migrating birds, or fish, or other species?

Alejandro: As previously the farmers cannot use any structure or nets that kill the organisms. However, I have not seen any study with native fishes.

Ola: Are there any regulations on acoustic deterrence devices or acoustic harassment devices?

Alejandro: There are no regulations on the use of aquatic methods.

Ola: How many fatal incidents with wildlife is accepted at the farm sites?

Alejandro: SERNAPESCA (the governmental control agency) maintain a database of all the mortalities events that are reported or found during controls. If they found illegal killings of sea lions for example) they must report this to the Chilean court system to investigate and if there is somebody found behind these actions the government can open a legal demand and the case goes into the court.

Ola: Are there any regulations on escaped salmon?

Alejandro: The state demands certain specification of the culture system to reduce risks. If after a storm a massive escape happen the farmers must have a contingency plan to take the fish out of the water.

Ola: How many salmon can escape per production cycle?

Alejandro: The best assessment is still in the paper of Niklitschek et al Reviews in aquaculture

Ola: Are the farmers required to have a retaining plan if salmon escape from the farms?

Alejandro: Yes, every farmer must have a contingency plan to recover the escapees. If they are not able to recover the escapes the government can apply some fines.

Ola: Are transgenic fishes allowed?

Alejandro: NO!!

2. Waste control:

Ola: Must a farm establish an Allowable Zone of Effect? (AZE).

Alejandro: In the licensed area they cannot have Zero oxygen levels. These is assessed by an independent consultant.

Ola: How big in that case?

Alejandro: The area can vary depending the time that the license was provided to the farmers.

Ola: In the AZE, do they have any requirements on the quantity of living organisms in the sediment? Ex. worms, or fauna.

Alejandro: YES, besides physio-chemical characterization (and oxygen in the sediment is the most important) they must do twice per year a biodiversity assessment.

Ola: Are there any regulations regarding sulphide levels or reduction of oxygen levels outside the farms?

Alejandro: Mostly oxygen is the parameter that makes that some action is taken (production reduction). Ox-redox and oxygen measurements in the sediments are the measurements that must be taken. Sulphids are not obligatory

Ola: Are there any regulations on water quality? And levels of dissolved oxygen?

Alejandro: No, most is being done in the sediments. The impact assessment considers water quality, but this data is not taken much into account.

Ola: Are neighboring farms in an area required to collaborate to minimize waste? That is full, transparency of the therapeutic treatments used, feed used, chemicals used etc.

Alejandro: The issue around collaboration between neighboring farms do not apply to waste discharges directly. The farms in an aquaculture area (what is called a neighborhood in Chile) they need to coordinate the use of medications (antibiotics, sea-lice products, etc.) to be more effective in the control of diseases. this may imply a better performance in waste, but the regulation driver is disease control. In addition, the following of each “neighborhood” requires also coordination. this mean that all the farms in one of this area must stop production for a certain time and reassume production coordinated.

3. Feed:

Ola: What regulations are there in terms of feed usage and content?

Alejandro: There are no regulation on feed composition.

Ola: Can they use Genetically modified organisms in the food?

Alejandro: Yes, soybean

Ola: Do farmers have to be transparent about the feed they use?

Alejandro: NO

Ola: Are there any regulations on what fishes that can be used and how much of it to make feed? (in terms of fish oil and fish meal).

Alejandro: NO

Ola: Are there any regulations on how much spillage there can be from feeding processes?

Alejandro: No, the control is in the sediment quality.

4. Fish Health:

Ola: Are there any regulations concerning the health of the animals?

Alejandro: Yes. There is a whole sanitary regulation that is additional to the environmental aspects.

Ola: How many times can farm use antibiotic treatments during a production cycle?

Alejandro: Depends from the veterinary prescription. First is fish wellbeing in concern of this subject.

Ola: How many sea lice can there be per fish?

Alejandro: You will need to remember that the Chilean sea lice has a very different size and then the densities are completely different than in northern hemisphere. The critical point is measured after the sea lice treatment and the amount of sea lice that is critical is 3 female egg-carrying individuals per fish. If this is not achieved, then all the members of management area must treat again.

Ola: Are there any regulations to prevent sea lice from spreading?

Alejandro: Treatment coordination from the farmers that are in the same farming area.

Ola: Are there any regulations concerning what antibiotics that is used in farms?

Alejandro: There are some prohibited antibiotics (quinolones), and Flumequines was prohibited a year ago.

Ola: Are there any regulations on cleaning copper-treated pens?

Alejandro: They are not allowed to be cleaned in the sea. The farmers must take than out and be cleaned on land and the residues must be placed in official waste places. It seems that some technologies are allowed to have in-situ net-cleaning. These techniques should have a system to remove residues and wastes out of the water. However, there is no data about the effectiveness of these technologies.

Ola: Who can prescribe medication for the fishes?

Alejandro: Authorized Vets.

Ola: Is it required to have a fish health expert or veterinarian to come and visit the farm? If so, how often?

Alejandro: I do not thing that this is regulated but most farmers they have permanent control.

Ola: Are there any regulations on what to do with fish that have died?

Alejandro: Mortalities is taken from the net pens DAILY. Than they are put in closed containers and taken to official disposal sites.

Ola: Do they require post-mortem analysis?

Alejandro: There is a procedure protocol and the farmers must report to the governmental agencies.

Ola: Are there any requirements regarding how many fish that can die per production cycle?

Alejandro: I do not think that there is a general regulation for this and depends from the disease. For example, if ISAv is detected than the farmers must immediately take the entire production out of the water, without any delay. For other disease you are allowed to treat your fishes. The regulations indicate that every farmer must report any mortality and the pathogen agent.

Ola: Do the regulations require that farms monitor and report on fish health?

Alejandro: Yes, weekly.

- If so, how often? is the information public?

Alejandro: For some disease (e.g. ISAv) yes. The sanitary protocol indicates that if any farms cross the limit of 15 ton of mortality in 7 days this automatically generates an alarm and the sanitary agency assess the risks depending the disease and can take action that can go as far as eliminating the complete biomass.

Ola: Must farmers report usage of medication? Is that available to the public?

Alejandro: Yes, there is a data base in the hand of the governmental agency. The discussion goes if this should be public. The Chilean Supreme Court indicated last year that in the case of antibiotics this information must be public.

5. Location:

Ola: Are there areas where farming is prohibited?

Alejandro: Yes, they are areas determined by the government were aquaculture can be allowed. If you ask for any aquaculture license you need to be inside this area.

Ola: Can they use the same location over and over or are farmers required to leave the site for a while and let the surrounding environment recuperate?

Alejandro: There are following regulations. This are for individual famers but for certain regions that the production cycle needs to stop completely. This is only for salmon and not for other farming activities (e.g. mussels). The regulation indicates, that in a production cycle of 24 months, 3 moths should be free of fishes. This period without fishes must be coordinated with all the other salmon farmers of the management area.

Ola: Are farmers required to join Area Based Management groups to keep track of the surrounding environment and the water quality?

Alejandro: There is a type of Area Management that was established in 2010 after the ISAv outbreak. The area management is to control diseases and do not take care of other uses of the area.

Ola: Are there any protected areas?

Alejandro: Yes, they are some in southern Chile, mainly thinking of whale protection.

Appendix II

Synopsis\Comparing regulations and the standard.xlsx

Appendix III

State monitoring and enforcement that reaches or exceeds the ASC standard = 1. Self-monitoring but with same- or exceeding standards as the ASC and reporting back to the relevant governmental body = 0,5. No monitoring or reporting 0.

Criteria:

Interaction with wildlife: Escapees and lethal force against endangered species.

Waste management: AZE, benthic flora/fauna requirements, sediment measuring tests and frequency of tests.

Fish feed: Certified sustainable feed and use of transgenic content.

Fish health: Prohibitions to use antibiotics deemed of importance to human health by the WHO, therapeutic treatment use (prescription requirements), sea lice monitoring, frequency of veterinary (marine biologist) checkups, vaccination use to prevent disease and minimize antibiotic usage and number of antibiotic treatments during a production cycle.

Location: Distances to natural reserves and distances from other farms.

B.C. Calculations

	Total score	*BAU*
B.C. interaction with wildlife:	2,5	0,6
B.C. waste management:	2,5	0,5
B.C. Feed:	2	0,5
B.C. fish health:	2,5	0,4
B.C. Location:	3	1

Chile Calculations

	Total score	*BAU*
Chile interaction with wildlife:	2,5	0,6
Chile waste management:		
Chile Feed:	2	0,5
Chile fish health:	3	0,5
Chile Location:	2	0,7

Norway calculations

	Total score	*BAU*
Norway interaction with wildlife:	2,5	0,6
Norway waste management:	2,5	0,5
Norway Feed:	2	0,5
Norway fish health:	4,5	0,7

Norway Location:	1	0,3

Scotland Calculations

	Total score	*BAU*
Scotland interaction with wildlife:	2,5	0,6
Scotland waste management:	2,5	0,5
Scotland Feed:	2	0,5
Scotland fish health	4	0,7
Scotland Location:	1	0,3

Credit system

The values accredited to each variable is decided by the positive policy analysis. For references to each variable see the link in appendix II.

	B.C.	Chile	Norway	Scotland
Escapees	0	0	0	0
Legal authorization to use force against predators	1	1	1	1
Lethal force against endangered species	1	1	1	1
Government monitoring	0,5	0,5	0,5	0,5
AZE	1	0	0	1
Benthic flora/fauna requirements	0	0	0	0
Sediment measuring tests	1		1	1
Frequency of measuring tests	0		1	0
Government monitoring	0,5		0,5	0,5
Use of certified sustainably fished fishmeal and fish oil	0	0	0	0

Certified sustainable content	0	0	0	0
Transgenic use	1	1	0	1
Government monitoring	1	1	1	1
Regulations against using critically important antibiotics for human health	1	0	0	0
All therapeutic treatments must be prescribed by a veterinarian or marine biologist	1	1	1	1
Frequency of health check-ups by veterinarian or marine biologist	0	0	1	0
Use of vaccinations to combat known diseases in the area	0	0	1	1
Limited antibiotic treatments during a production cycle	0	0	0	0
Sea lice monitoring	0,5	1	0,5	1
Government monitoring	1	1	1	1
Required distance to natural reserves	1		0	0
Required distance from other finfish farms	1	1	0	0
Government monitoring	1	1	1	1

Appendix IV

ASC- Interaction with wildlife

Escapees can have detrimental effects on wild populations of salmon. Therefore, the best way to protect wild populations of salmon is to minimize the escapees from farms. However, due to external factors it might be hard to ensure a zero-escape policy. The ASC, have thus set the standard for acceptable loss or escapes at 300 fish in the latest production cycle (ASC, 2012, p. 34). The license holders are also expected have an updated risk assessment for fish escapes as well as a strategy for recapturing escapees. They must also have the nets' robustness tested as well as a predator attack prevention plan. Furthermore, they must be able to provide proof that they have accurate counting mechanisms for escaped fish and that the staff have proper training for mitigation efforts and recapturing missions (ASC, 2012, p. 35). As for transgenic fish, ASC standards does not allow any production of transgenic fish.

Predatory deterrence systems are more or less necessary depending on the surrounding environments. Since most farmers want to avoid predatory attacks on the farms, and due to regulations from states regarding mortality rates on endangered predatory species, some farmers have used acoustic deterrence devices (ADD), or acoustic harassment devices (AHD). These devices send out high pitched signals that deter predators from approaching the net pens. However, research has shown that these devices cause unnecessary harm to dolphins, seals and wales, therefore a farm must not use these systems or similar ones if they want to attain an ASC certificate (ASC, 2012, p. 26). The ASC does not allow any lethal violence against an endangered species on the farms. Furthermore, the standard has set an overall limit to nine lethal incidents with any type of wild life during the span of two years (ASC, 2012, p. 27). However, if a situation develop were lethal action is necessary, it must be sanctioned by a relevant government body before.

ASC- Waste control

Farms are supposed to keep records of their greenhouse gas emissions and an annual assessment, however, there have not been enough studies conducted for the ASC to have set reasonable limits on the total emissions allowed from the farms (ASC, 2012, p. 42). In order to set limits for these emissions in the future, the ASC must receive enough data to be able to set a preferable limit to the emissions. However, currently, the standard has limits and requirements regarding oxidation-reduction (redox) and sulphide levels, that are set to keep a healthy respiratory level of the sediments in and around the farms (Weiner, 2008, p. 62).

The redox potential and sulphide level precaution is set to ensure a healthy benthic area in and around the cages and the farms. All cages on a farm should have an Allowable Zone of Effect (AZE), in accordance with the ASC standards, and this zone should be no bigger than 30 meters in diameter around the cages, unless there is a thoroughly calculated site-specific AZE, in that case that AZE should be used (ASC, 2012, p. 20). Within this zone the toxicity must be kept at a level where at least 100 organisms can thrive per square meter, or that the AZE coincides with the natural abundance if it is lower than 100. Among these organisms, there should be at least two benthic macrofaunal species, such as sessile macrophytes or worms (ASC, 2012, p. 21). As for the benthic effects outside the AZE, the farms are supposed to use models to count and keep records of either redox potential or sulphide levels. Redox potential must not exceed 0 millivolts, and sulphide levels must be kept below 1,500 mM per liter (ASC, 2012, p. 20). As for keeping records of faunal abundance outside the AZE, it must be kept close to natural levels with as little effect on sensitive fauna as possible.

As for the water quality in and around the farms the ASC have set a minimum of 70 percent of dissolved oxygen on a weekly average. The water quality should be measured twice a day, with less than five percent of the weekly measurements falling short of 2mg/liter of dissolved oxygen (ASC, 2012, p. 22).

In addition to the monitoring on the farm, the farm must be located in an area that is deemed to have good or very good water quality. These standards are set after the EU's standards for good or very good water quality (EC, 2008). If the farm is located in an area that have the EU standards or similar third parties will automatically run tests to determine the water quality, if the farm is in a region where there are no such services they must provide evidence of weekly measurements of nitrogen and phosphorous (ASC, 2012, p. 22). Phosphorous and nitrogen contribute to eutrophication, which leads to dissolved oxygen shortages. To mitigate eutrophication ASC certified farms must measure and calculate how many fine particles of feed that are lost during feeding procedures, these fine particles cannot exceed one percent of the total weight from the feed (ASC, 2012, p. 24).

ASC- Feed

Pelagic small forage fish are used to a large extent in salmon feed. ASC certified farms must have full transparency on what the salmon feed contains, and how much of it. Every ingredient that make up more than one percent of the total weight must be accounted for. Transgenic products are allowed in the feed, but they too must be accounted for and disclosed as transgenic produce (ASC, 2012, p. 40). The ASC have set a maximum amount of omega 3 acids derived from marine resources directly from industrial fisheries (EPA and DHA), to <30 grams/kilo (ASC, 2012, p. 37). The standard's ratio for fish meal and fish oil are set to further the trend of moving away from the heavy dependency on wild caught pelagic forage fish. Fishmeal Forage Fish Dependency Ratio (FFDRm) is set at < 1.35 and the Fish Oil Forage Fish Dependency Ratio (FFDRo) is set at < 2.95. This measures the quantity of wild fish used per quantity of cultured fish produced (ASC, 2012, p. 82).

$$1\, cultured\ fish = 1.35\, wild\ caught\ fish\ for\ fishmeal + 2.95 wild\ caught\ fish\ for\ fish\ oil.$$

All other raw materials in the feed must derive from feed producers with a sustainable sourcing policy, i.e. the soy products must be certified by the Roundtable for Responsible Soy (RTRS) or equivalent (ASC, 2012, p. 40).

Furthermore, the feed must not contain any trace of vulnerable or endangered listed species. The feed that is used at a certified farm must only contain fish meal and fish oil that has been harvested in a sustainable way, from a Marine Stewardship Council (MSC) fishery or an ISEAL certified fishery (ASC, 2012, p. 38).

ASC- Fish health

Densely populated net pens are hotbeds for sea lice and other disease outbreaks if not properly cared for. Prescribed compounds, such as pesticides and drugs, antifoulants, anesthetics and disinfectants are commonly used to battle the spreading of such pandemics (Burridge, et al., 2010). Even with tighter regulations on the usage of these chemicals, many farmers still rely heavily on them to ensure the health of their yield.

Farmers who use copper (Cu)-treated nets must provide evidence that the nets are not cleaned in the water, this is important as elevated copper levels becomes toxic for the surrounding environment. It is, therefore, paramount that farms using copper-treated nets have cleaning mechanisms in place to capture net effluents (ASC, 2012, p. 43). The sediments around the farms using copper-treated net pens must be tested for copper levels and show similar levels of copper abundance in and around the farm as it occurs naturally or weigh less than 34 mg/kg of dry sediment.

In accordance with the countries of focus in this study, the ASC require each farm to have a fish health management plan for the identification and monitoring of fish diseases and parasites. Furthermore, they require that a veterinarian make four visits to each farm annually and that a fish health manager visits once a month. A fish health manager is someone with expertise on fish health, without having the authority to prescribe medication (ASC, 2012, p. 46). Fish mortalities in the pens must be removed and disposed of in a responsible manner, and all of the mortality incidents must result in a post-mortem analysis by a qualified professional to keep records of cause of death and react appropriately if there is a potential disease outbreak (ASC, 2012, p. 45). Effluents from open net-pens as well as escaped salmon can cause serious harm to wild populations and spread viral diseases that could have detrimental consequences to wild stocks. Fish farmers must therefore strive towards keeping viral diseases at a minimum, the ASC have set limitations at $\leq$ 10 percent of the mortalities as viral diseases or unexplained, unspecified causes of death as they might be related to viral diseases (ASC, 2012, p. 46).

Antibiotic usage in animal husbandry is widely criticized and may cause resilience in bacteria that could cause serious harm to people and animals in the future. The World Health Organization (WHO) have several types of antibiotics that are classified as crucial to human health (WHO, 2017), and none of these antimicrobial medicines can be used to combat infections according to the ASC standard (ASC, 2012, p. 47). To avoid resilience development against treatments of antibiotics there can be no more than three treatments per production cycle. The farms need to keep meticulous records available to the public and make sure to include what treatments have been used and how many before selling the fish.

One individual farm may not cause much of a problem to its surrounding environment, at least if they abide by the national regulations and try to follow the ASC standard. However, in some areas, there can be a cumulative effect from the practices of several farms. Therefore, ASC certified farms should engage in Area Based Management (ABM) schemes for managing diseases and resistance to treatments. The ABM should share all information as well as coordinate their stocking, fallowing and therapeutic treatments (ASC, 2012, p. 29). Not only does this enlighten farmers in the area about the byproducts that flows through their farms and help them coordinate to ensure good water quality, but it also streamlines mitigation efforts to parasitic outbreaks such as sea lice on wild stocks of salmon. The farmers need to keep public records on sea lice developments, they must perform tests at a monthly rate except for migration season for wild salmon when they must perform weekly tests. During which time there can be no more than 0.1 mature female lice per farmed fish (ASC, 2012, pp. 30, 80).

ASC- Farm Location

Farms located in areas where there are wild populations of salmon or sea trout have additional requirements. Some of these have been mentioned earlier, such as ABM. Other requirements include, collaborating more intensely with researchers and regulators to ensure that migrating wild populations are not affected by the farm (ASC, 2012, p. 31). Furthermore, the requirements on transparency is greater in areas with wild populations. Especially in terms of sea lice quantities on the farm. They must also participate in monitoring projects of wild out-migrating juvenile salmon, or other relevant species in the area. Another requirement, is that a farm must not be located in a natural reserve or a high conservation value areas (HCVA), unless the environmental impacts are compatible with the conservation objectives. A HCVA is a natural habitat assigned through a multi-stakeholder approach that provides a systematic basis for identifying critical conservation values (ASC, 2012, p. 25). Farmers and companies are also expected to let local communities have a say, and include them in the assessments of the farm site. This is called a social impact assessment, where communities can partake in the process and raise concerns or other questions (ASC, 2012, p. 63).