



# Master's degree thesis

**LOG950 Logistics**

**The Aftermath: Sulphur emission control areas impact  
on ship-owners**

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Number of pages including this page: 63

Molde, 28.11.16



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## **Summary**

In January 1 2015 a new legislation entered into force. Reducing the sulphur limits vessels in certain areas could emit to air. For ship-owners operating in sulphur emission control areas this meant they had to change their fuel to a fuel type that complies with the new limits or install a scrubber system. This could mean the start of a domino effect due to increased costs accompanying the new measures to comply with the SECA-legislation. Which could affect the freight rates, demand, market distribution between road and sea transport. Other considerations was the future technologies and eventual regulations coming later. Due to low oil prices the expected changes was not quite as expected. And the affects SECA-legislation has had on ship-owners has been minimal

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## 1.0 Introduction

International shipping transports more than 80 per cent of global trade to people and communities all over the world. Shipping is the most efficient and cost-effective method of international transportation for most goods; it provides a dependable, low-cost means of transporting goods globally, facilitating commerce and helping to create prosperity among nations and peoples. **(IMO 2016b)**

Shipping in recent years has come to stricter rules and regulations, when it comes to environmental emission. Shipping in general are one of the transportation modes that dangers the environment in the least amount, when measured in distribution per unit weight. The awareness over shipping being one of the good actors when it comes to the environment may also be the reason for the slow development in focusing more on decreasing emission. There are, however, different emissions to air and particulate matter that are harmful for humans. (Bergqvist, Turesson, and Weddmark 2015) Of these air pollutants, the focus in this paper will be sulphur oxides (SO<sub>x</sub>). Ships that are functional and operates the waters, according to (Corbett et al. 2007), stands for 5-8% of global SO<sub>x</sub> emissions. These emissions are a big concern for decision-makers, which has led to legislations such as sulphur emission control areas (SECA).

## ***1.1 Focus and scope***

This paper will focus on the International Maritime Organisation's SECA-legislation that took effect 1 January 2015. This legislation sets boundaries for how much SO<sub>x</sub> and particulate matter a ship can emit in distinctive areas. These limits have gradually been lowered in the recent years from 1.50% m/m prior to 1 July 2010 to 0.10 % m/m after 1 January 2015. The emission limits in SECA are lower than other areas of sea passage, which forces ship-owners that operate in seawaters with emission limits to take action. Heavy Fuel Oil was the preferred fuel source for the majority of vessels prior to 1 January 2015. This is because Heavy Fuel Oil was the cheaper choice, but again more destroying from an environmental point of view. There are several measures available for ship-owners operating in SECAs to comply with these limits, but all of these measures was expected to lead to increased costs. The natural thought when one part meets increased costs, is that these costs will be transferred to other parties. For this case the customers; shippers, passengers etc. For shippers increased costs could mean a loss of competitive edge versus others providing the same product. From an environmental point of view the SECA-legislation and the stricter emission limits is very positive. However, from a financial aspect this could potentially be harmful for both ship-owners and industries with locations inside a SECA.

There are many sides affected by the SECA-legislation, but this paper will focus on the ship-owners and what they have done to comply with the new limits and how they have experienced from the time the legislation was set in motion and so far.

A sulphur emission control area is exactly what it is called. An area for controlling the emission of sulphur. Only a few areas of the sea that comes under this legislation, and they are located close to land (figure 1). With the reported harmfulness emissions from ocean-going vessels have on health and environment, this legislation will go a long way to help improving people's health and the environment in the nearby locations of SECA.

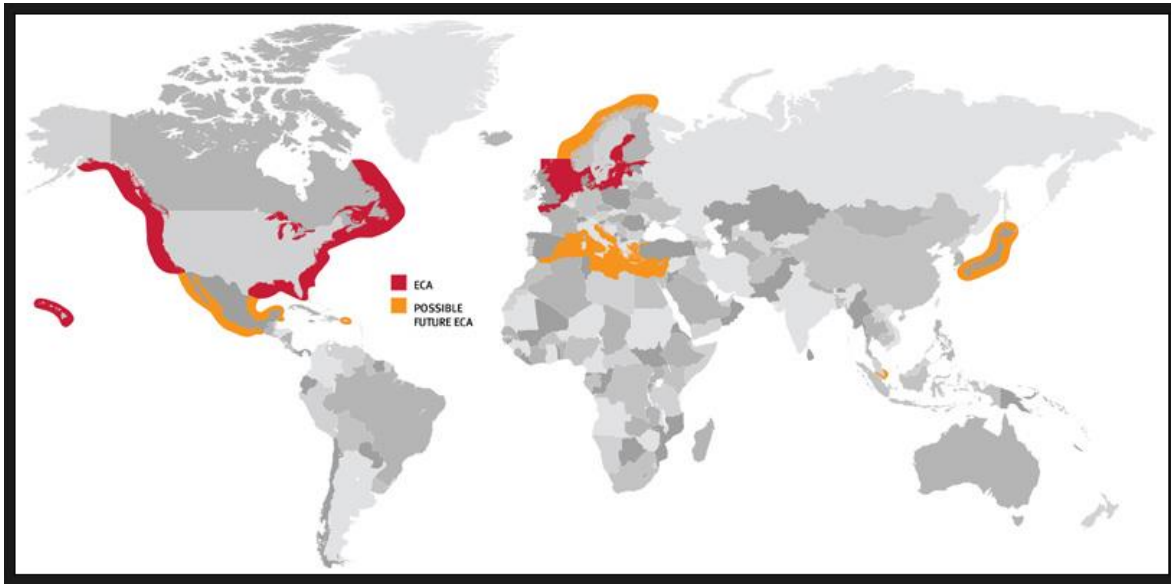


Figure 1. SECA and possible future SECAs. Source: (FT-M 2016)

As shown from the figure the areas included in SECA is the area coloured in red, the coasts of Canada and the United States of America including Hawaii. Moreover, an area in Northern Europe. In addition, other areas in the world could with time possibly come under SECA.

The scope of this paper will be on the European SECA (Figure 2). Going from west coast of Norway, on the 62-degree mark. Continuing south to the English Channel and east to the Baltic Sea affecting many countries.



Figure 2. North European SECA. Source: (KOG 2016)

## **1.2 Research questions**

With the knowledge on what to focus on and where the focus should be towards, a clear research question appear.

RQ 1: How has the new SECA-legislation affected ship-owners operations in Northern Europe?

This question is wide open, and there are many factors to take closer look on, as the legislation can have a domino effect for the ship-owners. The first and maybe most important point, is what have ship-owners done to comply with the new sulphur emission limits. There are several options available, and there are advantages and disadvantages with all choices. With this in mind, a sub-question for measure choice would be appropriate.

RQ 1.1: What kind of measures has been taken by the ship-owners to comply with stricter sulphur emission limits?

When realizing there where big expenditures tied to complying with the new legislation, another important question pops out. With increased costs for the ship-owners, they must offload these costs. The unlucky part in this case would most likely be the customers that could experience an increased rate for services provided.

RQ 1.2: In what degree has the new SECA-regime affected the freight rate?

In a scenario where increased freight rates is a fact, shippers in their own competition for market shares gets a disadvantage compared to their competitors that maybe are not in a SECA and do not incur an extra cost. With theories of the loss of competitiveness due to SECA, ship-owners could be effected in several ways. Companies could possibly make decisions such as changing production sites or choose to change their logistics routes. By using more road or rail transport. These dilemmas raises questions for how ship-owners is affected.

RQ 1.3: Has there been any changes in demand after the SECA-legislation entered into force?

RQ 1.4: How has the market distribution between sea transport and road transport changed in the time after the new legislation came into play?

There is also a futuristic point that needs to be acknowledged in this case, as stricter regulations may come into force. This factor may have an effect on the decision-making process for ship-owners. Both for deciding on which measures to use from 1 January 2015 and in what direction they want to go at the next crossroads. Many more alternative fuel sources are in the making, which may have more potential than the measures available today.

RQ 1.5: How has stricter regulations in the future affected ship-owners decision-making towards their ships today?

RQ 1.6 Which measures are the most likely choice for ship-owners in the future?

The theoretical review revealed several aspects on how the new SECA-legislation affects the ship-owners. With these sub-questions this paper should give an overview over different sides of the repercussions of SECA, and in that way sufficiently answer the main research question

### ***1.3 Limitations and assumptions***

To summarize, this paper will focus on how the ship-owners have complied with and reacted to the SECA-legislation in Northern Europe. Even though the paper focus specifically on the sulphur emissions, it have to be assumed that ship-owners when taking decisions on how to comply with the legislation also have other emissions in mind, as there are regulations for other emissions also. I.e. IMO regulation 13 on NO<sub>x</sub> emissions (IMO 2016c) and energy efficiency measures for reducing greenhouse gases (IMO 2016a).

The biggest limitation for this task is that it takes on a general approach not focusing on one segment alone. The idea was to get insight in all ships operating inside of the SECA; ferries, containerships etc. The same idea is also current when it comes to the different nations, all findings will be approached from an overall standpoint. This paper relies much on ship-owners willingness to respond, and the information available will be limited with a low respond tally.

## 2.0 Background and theories

### 2.1 MARPOL Annex VI

IMO or International Maritime Organisation is the United Nations own agency, this particular organisation focuses on and has the responsibility to prevent ships from marine pollution and for safety and security matters of shipping. With this authority, they have the power to make regulatory changes for the shipping industry that applies globally. One of these regulatory frameworks that they have created is MARPOL Annex VI, which focuses on the air pollution from ships.

Although air pollution from ships does not have the direct cause and effect associated with, for example, an oil spill incident, it causes a cumulative effect that contributes to the overall air quality problems encountered by populations in many areas, and also affects the natural environment, such as tough acid rain. (IMO 2016d)

IMO's MARPOL Annex VI was first adopted in 1997. The regulation sets limits for SO<sub>x</sub>, nitrous oxides (NO<sub>x</sub>) and the prohibition of deliberate emissions of ozone depleting substances. In addition to this, MARPOL Annex VI gives regulations for shipboard incineration and the emissions of volatile organic compounds from tankers. On 1 July 2010, the revised MARPOL Annex VI entered into force. The most crucial changes in the revised version, was the inclusion of emission control areas (ECAs). These areas are designed to reduce emissions of SO<sub>x</sub>, NO<sub>x</sub> and particulate matter into air in pre-selected areas (IMO 2016d). These areas are the Baltic Sea, the North Sea, the North American, and the United States Caribbean Sea (IMO 2014). The revised MARPOL Annex VI reduces the sulphur caps globally; the degree of reduction in emissions, and when it comes to effect depends on whether it is inside or outside of a SECA (Table 1). Table 1 also shows that the sulphur emission can be limited even more outside of emission control areas in 2020. Giving ship-owners more incentives to find good and effective solutions to keep emission down.

Outside an ECA established to limit SO <sub>x</sub> and particulate matter emissions	Inside an ECA established to limit SO <sub>x</sub> and particulate matter emissions
4.50% m/m prior to 1 January 2012	1.50% m/m prior to 1 July 2010
3.50% m/m on and after 1 January 2012	1.00% m/m on and after 1 July 2010
0.50% m/m on and after 1 January 2020*	0.10% m/m on and after 1 January 2015

*Table 1. Source: (IMO 2016e)*

\* This date will depend on a review; the conclusion of this review can postpone the date to 1 January 2025.



## ***2.2 Sulphur oxides and its effect on health and environment***

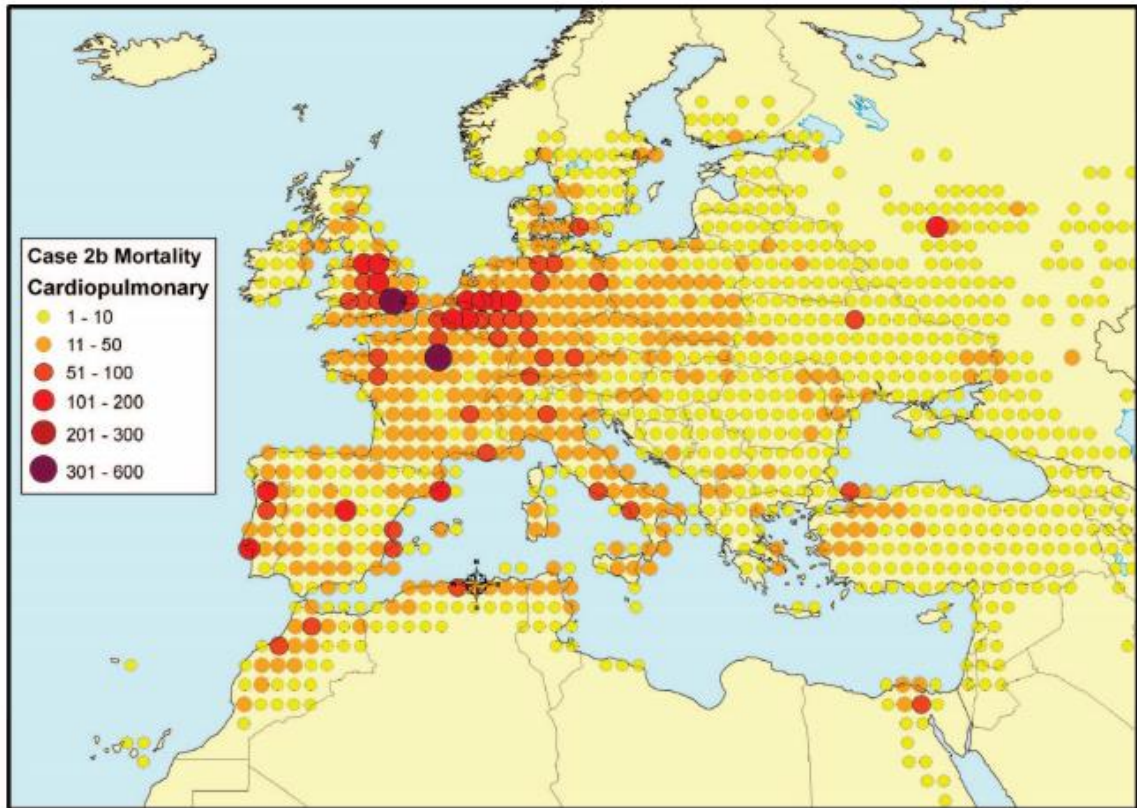
The emissions from sulphur that are most harmful for health and vegetation is sulphur dioxide in very high concentrations. High levels of sulphur dioxide can concentrate itself on ground level, due to different factors such as wind, temperature, humidity. (IFC 1998)

### **2.2.1 Health**

There are several effects a human being can incur when being in an environment where sulphur dioxide is highly concentrated, such as reduced lung functions, increased incidence of respiratory symptoms and diseases, irritation of the eyes, nose, and throat, and premature mortality. The exposure to sulphur dioxide can occur in different ways, a person can be exposed to sulphur dioxide alone, sulphur dioxide that has reacted with other substances in the air turning into sulphate aerosols and the adsorption of sulphur dioxide onto particulate matter. (IFC 1998)

Sulphur dioxide in its form dissolves in contact with water, when a person inhales air containing sulphur dioxide it will dissolve in the respiratory system and be absorbed into the bloodstream. When sulphur dioxide reacts with other elements in the atmosphere, it transforms to sulphate aerosols. When sulphur dioxide is adsorbed onto particulate matter, it can be transported deeply in the pulmonary system. (IFC 1998)

A large portion of all sulphate aerosols goes under  $PM_{2.5}$ , which means it is a fine particulate matter, with an aerodynamic diameter of less than 2.5 microns. Sulphur dioxide can therefore be a major factor for illness associated with fine particulates (IFC 1998). The issue with fine particulates has been further studied by (Corbett et al. 2007), which stated that 60 000 deaths, globally, could be related to shipping and the emissions of particulate matter. The areas with highest concentration of deaths are in locations where high populations and in the major trading routes where high emissions occur, such as Asia and Europe. Figure 3 shows the mortality rate due to  $PM_{2.5}$  in and around the SECA in Europe.



*Figure 3. Annual cardiopulmonary mortality attributable to ship PM<sub>2.5</sub> emissions for Europe/Mediterranean. Source: (Corbett et al. 2007)*

(Corbett et al. 2007) work shows that policy changes as, i.e. the SECA-legislation, can affect the mortality rates and improve the general health of people by driving ship emissions down.

## **2.2.2 Environment**

Vegetation, including forests and agricultural crops, can be negatively affected by sulphur oxide emissions. A high concentration of sulphur dioxide can be harmful for certain plants, especially when plants are vulnerably located closely to emission sources. Negative effects can be; foliage loss, the plants reduces their productivity, or a premature death of the plant. (IFC 1998)

For trees and forests, emission can have serious effect of the growth. In areas close to emission sources the forest growth are heavily effected. In locations further from the source, there are also potential risks for injuries on forests and plants. The effects sulphur emissions have on the forest ecosystem depends on certain factors such as; soil type, the species of the plant, the atmospheric condition, population of insects, and other factors where the effects are not fully understood. (IFC 1998)

Agricultural crops can also be in danger when exposed. More specifically two types of crops that are especially sensitive to exposure, alfalfa and rye grass. For most crops there has to be leaf damages. Such damages can make the crops more in risk when exposed. If soil is exposed by sulphur for a long-term period the risk increases for affecting the yields. Sulphur emission cannot take the full blame for any injuries occurring on plants. Other pollutants, such as ozone, may be equally or more at fault for harming plant life. (IFC 1998)

Freshwater lakes and the ecosystems in their streams can also be affected by acid deposition. In such instances the damages comes from the lowered pH of the water. Certain lakes that have a buffering capacity that are lower than usual, such lakes are more likely to be affected by depositions. The main reason is that the buffering capacity is an important contributor for neutralizing the acid rain, and with a lowered capacity, this may not be possible. There are not many fish species that can survive longer periods in waters with lowered pH, such lakes may lose all fish life. In situations with increased acidification, the amount of different fish species and the general diversity of animal life will decrease. (IFC 1998)

The aforementioned sulphate aerosols, which stems from sulphur dioxide that is converted in the atmosphere, can reduce the visibility as the light will disperse when sulphate aerosols is in the air. Depending on different factors, the sulphate aerosols also can create a mistiness over large areas. For this mistiness to occur there must be a combination of sulphate aerosols and; warm temperatures, abundant sunlight, high humidity and reduced vertical mixing. (IFC 1998)

### **2.3 Sulphur reduction measures**

There are different ways for ship-owners to comply with the sulphur emission levels stated in the SECA-legislation. Some technologies has come further in the development and these measures would be the most realistic choice for the fleet existing prior to the legislation took effect. (Panasiuk and Turkina 2015, Doudnikoff and Lacoste 2014) states these measures are:

Heavy Fuel Oil (HFO) and intermediate fuel oil (IFO) are the most used fuel for ships. In 2007, approximately 250 million tonnes out of almost 350 million tonnes of fuel consumed in the shipping segment was residual fuels. There are two different types of distillate fuels that is used, Marine Gas Oil (MGO) and Marine Diesel Oil (MDO). The sulphur content in the various grade of fuels depends on the sulphur levels in the crude oil and the particular refinery streams that are used to produce that one kind of fuel. The sulphur content in the fuel will be higher in the heaviest fractions from the distillation column. (Brynolf et al. 2014) The change from IFO, which contain less than 3.5% SO<sub>x</sub>, to low sulphur fuel. Low sulphur marine gas oil (LSMGO) contains less than 0.1 % of SO<sub>x</sub>, which means this fuel type is acceptable under the new legislation. (Panasiuk and Turkina 2015) The fuel types that are applicable with the new legislation are in production at a few refineries today. It is a possibility to produce low sulphur marine bunker fuels at refineries in Europe, but there are assessments showing that this will mean changes for the refinery, increased energy use and emissions from the refinery. (Brynolf et al. 2014)

Liquefied natural gas (LNG). “LNG is natural gas which becomes liquid at a temperature of  $-160^{\circ}\text{C}$ . Liquefied gas occupies a volume corresponding to 1/600 of the product in the gaseous state, which makes it space efficient to be stored onboard a ship as a bunker. Compared to conventional fuel oils used by ships, LNG has very low emissions of sulfur oxide (SO<sub>x</sub>), nitrogen oxide (NO<sub>x</sub>) and particle matter (PM). NO<sub>x</sub> emissions are reduced by up to 85–90% compared to HFO, SO<sub>x</sub> and PM by close to 100% and CO<sub>2</sub> by around 15–20%” (Bengtsson; Brett; Pitt as cited by (Wang and Notteboom 2014)).

The use of LNG as an option to comply with the new SECA-legislation is one of the three most viable suggestions for ship-owners. Studies on this subject, naturally, increased towards 2015.

Scrubbers. It exists two sorts of scrubbers. The wet and the dry. Testing for the use of dry scrubbers on ships exists but wet scrubbers are more desirable for ships as it costs less and it demands smaller dimensions of units. The dry scrubbers works in a way where calcium hydroxide reacts with sulphur in the flue gas making calcium sulphate. The solid product transports back to land for handling. Different kinds of wet scrubbers currently exist on the market. These are; the close loop, the open loop and the hybrid. The differences between the three types is that the open loop uses only sea water, in this situation the water is sometimes treated before finally being released back into the sea. (Brynolf et al. 2014) Where instead the close loop uses fresh water mixed with sodium hydroxide. By using this caustic soda, the alkalinity increases. The hybrid takes advantage of both open and closed loop. When considering the different types of wet scrubbers up against each other, there may be advantageous to use one type over another. I.e. the open loop scrubber have an easier system to manage and it is cheaper than the close loop. The disadvantage with this system and an important factor for this thesis is that it is not possible to operate in the Baltic Sea, due to the areas restricted water outlets. In terms of the advantages and disadvantages between the closed loop and the hybrid system, there are no noticeable differences in weight and form. (Panasiuk and Turkina 2015)

### 2.3.1 Advantages and disadvantages

The different measures will have different pros and cons, these factors will be decisive for ship-owners when choosing how they comply with the new sulphur limits.

The advantages of LSMGO is that it is simple to use, however, there may be some complications if there is necessary with modifications to use the fuel. The need for maintaining the engine will be less using this measure. Finally, it is suitable for both retrofits and new buildings. The disadvantages for LSMGO is that the availability is already limited. The cost for LSMGO is higher than with IFO. The increase in cost can be as high as 100% per ton of bunker fuel of average. The price difference between LSMGO and HFO can also increase considerably, from 25% to 30% (Notteboom 2010). The engines life cycle may be reduced, if not a conversion is performed. In a situation where the ship is operating inside and outside the SECA where IFO is preferred outside the area, there will be necessary with a changeover to LSMGO inside SECA. This can potentially lead to an addition to the ships journey. Lastly, LSMGO have a higher fuel consumption rate than IFO. (Panasiuk and Turkina 2015, Liping, Kronbak, and Christensen 2014)

With LNG the advantages is that it reduces the SO<sub>x</sub> emissions with 90-100%, it also reduces emission from other gases considerably. Using LNG alone will mean that no other abatement measure is necessary. The disadvantages with LNG is that ships needs notable alterations, i.e.:

- Engine replacement
- Systems that are specially designed for its task
- Larger fuel tanks
- Gas sensors

There are however, more uncertainties with LNG compared to the other measures. Modifications of the mentioned sorts, means retrofitting will be expensive and quite challenging to implement (Panasiuk and Turkina 2015). Meaning both manufacturers and ship-owners may be hesitant to choose this option before others. There are not many vessels with these kind of technology operating in the world, also very few ports can provide LNG as fuel for ships. (Panasiuk and Turkina 2015, Acciaro 2014, Wang and Notteboom 2014) On a positive note, several of the ports that can provide LNG is located in the SECA, mainly in Norway. Plans to develop bunkering facilities for LNG are,

however, in place. Which over time can reduce the uncertainties associated to LNG (Acciaro 2014, Wang and Notteboom 2014). LNG is today most established as ship fuel in ferries, supply vessels and tugboats. (Grindhaug, Slettemark, and Rummelhoff 2015)

(Wang and Notteboom 2014) states that more focus on environmental issues should speed things along, and give decision-makers a stronger incentive to give more policy support and reduce uncertainties in using LNG. There are supply chains that already have implemented LNG, and other options like LNG will have bigger issues to deal with before being competitive in the future. With this in mind (Wang and Notteboom 2014) conclusion is that LNG in the present will most likely be attractive in places with already functioning infrastructure, such as Norway. And in special markets, i.e. ferries.

For scrubbers the advantages is that it reduces the SO<sub>x</sub> from 90-99%. It also gives the ship the benefit of still using high-sulphur fuel. With the use of scrubbers there is a relatively fast payback period. Compared to LNG it is much more suitable for retrofit, and also an alternative for new building. The disadvantages with the use of scrubbers is firstly, the technology has not been well-proven and it is relatively new. The cost to implement this system on a ship demands large investments. (Panasiuk and Turkina 2015) Retrofitting a ship may cost 40% more than a new build (Liping, Kronbak, and Christensen 2014), as showed in figure 4

The costs of sea water scrubber.

	Capital costs (CAPEX) (Euro/kw installed)	Operating & maintenance costs <sup>a</sup> (OPEX) (Euro/MWh)	Lifespan (year)
New Build	118	0.3	15
Retrofit	168	0.3	12.5

a There are large variations in operating and maintenance costs for different ship sizes. The above value is for ships with a main engine capacity of more than 15,000 kw.

Figure 4. The costs of sea water scrubber. Source: Entec as cited by (Liping, Kronbak, and Christensen 2014)

Increased energy is required to perform the operations, such as the discharging of water. Cargo capacity may be reduced when a scrubber is installed, meaning a loss of income can occur. Eventhough the reduction of SO<sub>x</sub> is highly notable with a scrubber system, there are no noticable reductions for NO<sub>x</sub>. (Panasiuk and Turkina 2015)



### 2.3.2 Evaluation of measures

For operators payback time can be an important factor for choosing what kind of measure to take for complying with the new sulphur levels. The conclusions showed that HFO combined with a freshwater scrubber was the option that would be the cheapest investment. (Brynolf et al. 2014) When comparing using scrubbers versus LSMGO, the results show that scrubber-operating costs are less than the difference between LSMGO and IFO. These costs consists mainly of the costs of maintenance, reagents NaOH, fresh water and the extra energy needed. On the negative side, installation of scrubbers can lead to reduced cargo capacity, which may result in loss of profits. The highest costs from a scrubber investment happens at the beginning of the investment period, meaning the biggest loss of profits happens in year one, and possibly year two. From year three, it can even be earlier, the use of scrubbers can create profit for the ship-owner. There are possibilities for the scrubbers to generate a profit on an earlier stage; the outcome of potential profits will depend greatly on the fuel prices. The payback time of the scrubber investments will lessen, with greater price differences between LSMGO and IFO. The study from (Liping, Kronbak, and Christensen 2014) have also shown that the price difference between LSMGO and IFO/HFO are important for what measure can be the most viable to choose (Fig. 2).

<i>Environmental benefits (Euro/year)</i>			
	2,536,635	2,536,635	2,204,148
<i>Costs of reduction measures</i>			
Capital costs (Euro)	5,724,200	8,149,708	
Operating and maintenance costs (Euro/year)	23,417	23,417	
Lifespan (Year)	15	12	-
MGO-HFO price spread (Euro/tonne)			190
<i>Equivalent annual net benefits (Euro)</i>			
	1,961,735	1,593,723	10,260,584

Figure 2. Source: (Liping, Kronbak, and Christensen 2014)

Figure 2 shows the net benefits for the usage of Scrubbers on new builds (to the left), Scrubbers on retrofits, and LSMGO (to the right)

In (Liping, Kronbak, and Christensen 2014) study the negative net present value of LSMGO occurs when the spread between LSMGO and HFO is larger than 241 Euros per tonne. If the price spread is lowered to 231 Euros per tonne for new builds and 233 Euros

per tonne for retrofits, the option with LSMGO will be the most beneficial. With bigger differentials between LSMGO and HFO, the social cost benefits of the SECA-legislation would be 230% more costly than valuable, according to (Boholm 2010).

When considering the instalment of a scrubber on older vessels a ship-owner must take into account the lifespan of the vessel, as a ship with only few years left in operation will not pay back the investment costs of a scrubber. An investment to retrofit a ship with scrubbers will be more attractive, if the life expectancy of the ship are longer. A ship-owner can possibly break even if a vessel is expected to operate four or more years (Liping, Kronbak, and Christensen 2014). As shown in figure 5.

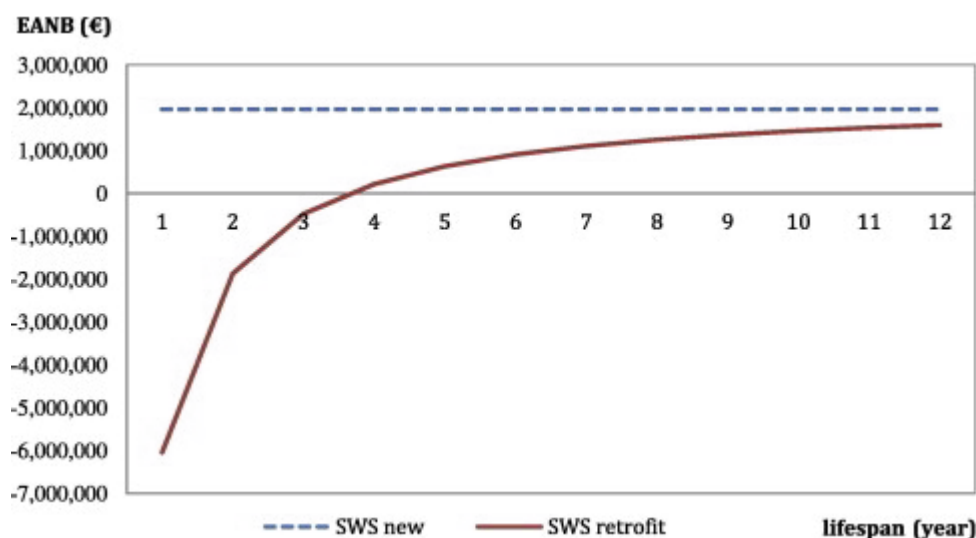


Figure 5. Equivalent annual net benefits between scrubber new vs retrofit. Source: (Liping, Kronbak, and Christensen 2014)

As LNG is a rather new concept, and very few vessels uses this technology. There are some uncertainties when making estimations for economic benefits for LNG. (Acciaro 2014) has studied the economic prospects for the use of LNG. The conclusions from that study is that a retrofitting for a vessel with LNG can be reimbursed by lowering the fuel costs with the low LNG prices. The other measures may still be considered as more interesting and beneficial options by ship-owners, as the prices for LNG are highly uncertain and can vary from place to place. In addition, there are high capital costs tied to the retrofitting of a vessel.

(Acciaro 2014) mentions an option for ship-owners can be to postpone their decisions on some ships, giving them a chance to make a more informed choice. This is off course

difficult with the emission limits they also have to consider, but by sitting tight LNG can give higher economic benefits than scrubbers and LSMGO. With time, there may be technological advances in the LNG-area and manufacturers will give this a more focused attention. Which in turn can reduce the high investment costs that are today. This can reduce the uncertainties, and for the future be an even clearer choice for ship-owners. (Acciaro 2014)

Even though studies show, there are possibilities for scrubbers and LNG to be more profitable for ship-owners the majority of vessels is expected to run on MGO or MDO when the SECA-legislation is entered into force. (Haraldson 2013) stated that over 95 % of ships operating in an SECA-area would be fuelled with MGO or MDO within 2015. MGO/MDO is also expected to be the preferred by (Bergqvist, Turesson, and Weddmark 2015). (Hämäläinen 2015) referred to an inquiry regarding 262 vessels operating in the Baltic Sea, where 88 % of the ship-owners answered they would use MDO/MGO as their preferred fuel sources as of 2015 and further on. (Fagerlund and Ramne 2013) gives an even higher number where they estimates that 99% of the fuel market will be MGO/MDO, with only 10-15 ships operating with HFO and a scrubber system. They also estimate that a modest number of 5 ships will operate with LNG outside of Norway

Seen from an environmental point of view the different measures mentioned above will not have a significant effect on reducing the life cycle impact on climate change compared to HFO. (Liping, Kronbak, and Christensen 2014, Brynolf et al. 2014) What they will contribute to is the reduction on certain matters, i.e. the sulphur levels. Scrubbers and the use of LSMGO can reduce the sulphur emissions by 98% for scrubbers and 90% with LSMGO. (Liping, Kronbak, and Christensen 2014). In addition to be the better option for reducing sulphur emissions the external costs by using scrubbers are lower in total than LSMGO and will give higher environmental benefits, according to (Liping, Kronbak, and Christensen 2014). As shown in figure 6.

A summary of the costs and benefits of the reduction measures.

	Base case	SWS case, new build	SWS case, retrofit	MGO case
<i>Emission amount (kg/roundtrip)</i>				
NO <sub>x</sub>	4249	4249	4249	4249
SO <sub>2</sub>	4533	93	93	446
PM <sub>2.5</sub>	556	250	250	342
CO <sub>2</sub>	702,724	724,333	724,333	681,209
<i>External costs (Euro/roundtrip)</i>				
NO <sub>x</sub>	25,923	25,923	25,923	25,923
SO <sub>2</sub>	37,631	776	776	3,712
PM <sub>2.5</sub>	22,667	10,200	10,200	14,736
CO <sub>2</sub>	17,568	18,108	18,108	17,030
Total	103,788	55,007	55,007	61,401
<i>Number of round trips (per year)</i>				
	52	52	52	52
<i>Environmental benefits (Euro/year)</i>				
		2,536,635	2,536,635	2,204,148

Figure 6. Costs and benefits of scrubbers versus LSMGO. Source: (Liping, Kronbak, and Christensen 2014)

All three measures will be beneficial for reducing sulphur levels, but for ships, using LNG there may be other environmental considerations that has to be made before taking them into use. LNG has the potential to be the alternative with the lowest impact on climate change, but this would mean that there could not be any methane slip. If the methane slip is four wt percentage or more the LNG-alternative is the alternative with the highest climate impact (Brynolf et al. 2014). On modern engines, there are estimations that shows an equivalent emission reduction for carbon dioxide between 15% and 25 %, which is also positive for the decrease of accidental methane release. (Acciaro 2014) This is off course not a factor for complying with the SECA-legislation, but it raises a moral question for the ship operator.

To say which measure that would be the most beneficial from an economic and environmental standpoint is very complicated, many different factors can be decisive in which option is considered the most valuable for ship-owners. The potential that lies in the use of LNG in the future must also be taken into consideration. There are contradicting reports available on when LNG in general would be a feasible option (Entec 2009; Swedish MA 2009 as cited by (Holmgren et al. 2014)). LNG should also be looked at as a

more feasible choice for new builds, according to (Entec 2010; ISL 2010 as cited by (Holmgren et al. 2014) With technological advances, price differences between LNG and low sulphur fuel oil, stricter sulphur regulations, and further development of infrastructure there may be a bigger market for LNG available (Wang and Notteboom 2014).

### 2.3.3 Speed reduction as a way to save costs

There has also been done studies on how reducing the speed of vessels can contribute save costs for shipping operators, and subsequently how this reduction can affect the environmental emissions. (Chang and Wang 2014) states that it is important for ship operators to show awareness in regards to optimal speed reduction. They studied different scenarios for when speed reduction could be a beneficial strategy, and concluded that optimal speed is strongly correlated with fuel prices and freight rates. In a situation where fuel prices are high and freight rates are low, a speed reduction would be the more optimal move. (Doudnikoff and Lacoste 2014) applied a procedure to estimate cost-minimising speeds. This study contemplates vessels operating both inside and outside SECA, which may not be the case for all operators in this study. However, it is an interesting theory with economic potential. The idea was to separate the cruising speed between when vessels was inside SECA and outside SECA. In these scenarios the vessels are reducing speed inside SECA using LSMGO, the logic behind this is to make the fuel last longer in SECA as LSMGO are more expensive than HFO. The results from this study shows that a behaviour where ships differentiate speed can reduce costs, but the negative outcome may be increasing  $CO_2$  emissions. This increase in emissions stated in (Doudnikoff and Lacoste 2014) paper is due to the increase in speed outside of SECA. With a constant speed reduction the environmental benefits will be more positive (Chang and Wang 2014).

Even though (Doudnikoff and Lacoste 2014) concludes with a decrease in cost, they are hesitant to conclude with a behavioural change from the operators, as the gain in certain situations may be small. And speed differentiation could also mean the need for using more ships on routes, as vessels with lower speed would use longer time on their assignments (Chang and Wang 2014, Doudnikoff and Lacoste 2014). It will also be important to think about ship-owners environmental standpoint in all this. The main variable that could change ship-owners behaviour on speed differentiating could be an even bigger price difference between MGO and HFO. (Doudnikoff and Lacoste 2014)

### 2.3.4 The future

There exists several alternative measures to comply with the SECA-legislation that for the current time are not as realistic and developed as the three measures previously mentioned. However, when stricter limits for SO<sub>x</sub> and other emissions are set in motion. There may be a need for ship-owners to look at other alternatives to fuel their ships. Studies has been conducted for such alternatives and there are options available, which with more research and development can attract decisions maker over to these alternative fuels.

(Grindhaug, Slettemark, and Rummelhoff 2015) studied ethanol (table 2), methanol (table 3) and bio fuel (table 4) as three renewable energy alternatives that potentially can compete with the most established measures out there. Methanol has already been tested and also a pilot project for methanol has been started (Haraldson 2013). The biggest obstacle for these alternatives is that the availability is very low, and this must be the main priority to be competitive with current measures. Another alternative can be battery technology. On its own or in a hybrid solution with i.e. a diesel engine. The concept of electronics on ships is not a new one, as in the 1990s electronics has been instrumental for fuel saving on vessels, by enabling electrification of propulsion systems through Variable Speed Drives. Ådanes 2003 as cited by (Zahedi, Norum, and Ludvigsen 2014).

(Grindhaug, Slettemark, and Rummelhoff 2015) compared the three alternative fuels with HFO, MGO/MDO and LNG. The tables below gives an overview over what segments the alternative fuels are competitive in now and where there are potential for improvements.

The colours in the table has its own meaning, where red means that the alternative fuel is worse than the three fuel types it is compared to, blue means it is better and yellow means it is close to similar.

<i>Drivstoff</i>	HFO	MGO/MDO (LSMGO)	LNG
<i>Sammenlikning</i>			
<b>Pris på drivstoff</b>			
<b>Tilgjengelighet</b>			
<b>Klimagasser</b>			
<b>SO<sub>2</sub> (uten rensing)</b>			
<b>NO<sub>x</sub> (Uten rensing)</b>			
<b>Energitetthet</b>			
<b>Tilfredsstillere kravene i MARPOL Vedlegg VI Reg. 14 (uten rensing)</b>			
<b>Helsefare</b>			
<b>Brannfare</b>			
<b>Fornybar</b>			

Table 2.. Methanol compared to HFO, MGO/MDO and LNG. Source: (Grindhaug, Slettemark, and Rummelhoff 2015)

This table shows that methanol is on most areas better or as much as environmental friendly as the most established fuels. In comparison with SO<sub>x</sub>, methanol is as just as competitive. Which also means methanol complies with the SECA-legislation. What should be the focus for the future is that methanol is not competitive when it comes to pricing and availability, and there are security issues that needs to be improved.

(Grindhaug, Slettemark, and Rummelhoff 2015) stated that methanol has a lot of potential to compete with the current measures and for securing green and sustainable transport. Methanol can improve on the environmental benefits, but they would not change the climate changes in any degree compared to HFO (Brynolf, Fridell, and Andersson 2014). Methanol compared to ethanol and bio fuel is the most available fuel source and has the lowest emissions, and if the potential of using a larger amount of biological waste and other sorts of biomass is realized, there are good opportunities for competing in the future (Grindhaug, Slettemark, and Rummelhoff 2015). When using methanol produced from biomass there are bigger potential for reducing the impact shipping have on climate change (Brynolf et al. 2014). Methanol's biggest potential in the nearest future is for vessels that visits few harbours and have routes that are more direct. To reach bigger market segments there needs to be cooperation from several actors that are willing to invest, to develop infrastructure and bunkering opportunities. (Grindhaug, Slettemark, and Rummelhoff 2015) also stated that there may be lower investments costs attached to retrofitting for methanol than there are for retrofitting to LNG, but the only real example of a retrofit for



methanol shows that the costs were higher than expected. This shows that methanol not only has a fighting chance when stricter regulations come, but it is also a fuel source that can be used already today.

<i>Drivstoff</i>	<b>HFO</b>	<b>MGO/MDO (LSMGO)</b>	<b>LNG</b>
<i>Sammenlikning</i>			
<b>Pris på drivstoff</b>			
<b>Tilgjengelighet</b>			
<b>Klimagass utslipp</b>			
<b>SO<sub>2</sub> (uten rensing)</b>			
<b>NO<sub>x</sub> (Uten rensing)</b>			
<b>Energitetthet</b>			
<b>Tilfredsstillende kravene i MARPOL Vedlegg VI Reg. 14 (uten rensing)</b>			
<b>Helsefare</b>			
<b>Brannfare</b>			
<b>Fornybar</b>			

Table 3. Biofuel compared with HFO, MGO/MDO and LNG. Source: (Grindhaug, Slettemark, and Rummelhoff 2015)

This table shows that bio fuel has a good effect for reducing emission of climate gases and SO<sub>x</sub>, but bio fuel will have a lesser effect on improving NO<sub>x</sub> emission. The price for biofuel is also competitive when comparing to the fuel sources currently available. It is also a very safe fuel to use when it comes to health and fire. The flipside is that the availability is limited.

(Grindhaug, Slettemark, and Rummelhoff 2015) also stated that CO<sub>2</sub> emissions would increase with biofuel compared to the current alternatives, but these emissions come under the carbon cycle. In addition, it would not lead to increased greenhouse gases. The biggest obstacle here is also the availability and how it is produced. In today's situation the biofuel comes from farmland, and this method is the least optimal for bio fuel to be competitive in the future. To have a fighting chance against the other alternative fuels and the current, more of the production must come from algae and forestry. To avoid disrupting the food production. Their studies conclusion is that 100% bio fuel would not be a good alternative in the current time, but a possibility is to use bio fuel as an additive to the current marine diesel in the same way as it is used on cars. With this in mind, several

improvements needs to be done for bio fuel to be a competitive product, against the current alternatives and an alternative as methanol, in the future.

<i>Drivstoff</i>	HFO	MGO/MDO (LSMGO)	LNG
<i>Sammenlikning</i>			
<b>Pris på drivstoff</b>			
<b>Tilgjengelighet</b>			
<b>Klimagasser</b>			
<b>SO<sub>2</sub> (uten rensing)</b>			
<b>NO<sub>x</sub> (Uten rensing)</b>			
<b>Energitetthet</b>			
<b>Tilfredsstiller kravene i MARPOL Vedlegg VI Reg. 14 (uten rensing)</b>			
<b>Helsefare</b>			
<b>Brannfare</b>			
<b>Fornybar</b>			

Table 4. Ethanol compared with HFO, MGO/MDO and LNG. Source: (Grindhaug, Slettemark, and Rummelhoff 2015)

This table shows that ethanol is very beneficial when it comes to climate gases and SO<sub>x</sub> compared to current fuel sources, it is however not a good option when it comes to NO<sub>x</sub> where the current alternatives are more beneficial for the environment. With the good classification for SO<sub>x</sub> emissions, it is an option for complying with the SECA-legislation. The biggest problem with this fuel source, as it is with the others, is how available it is and ethanol is currently a much more expensive fuel than the current fuel sources. There are also some safety issues when it comes to the use of ethanol, specifically fire hazards that needs to me improved to make it a viable choice for the future.

(Grindhaug, Slettemark, and Rummelhoff 2015) stated that one area that can let down ethanol as a fuel price is the price, as both LSMGO and HFO with the use of a scrubber will ultimately give less costs than fuelling with ethanol. They conclude that ethanol is not a competitor for the current fuel sources in the nearest future, and the biggest segments for establishing ethanol as a fuel source would be ferries, supply vessels and tugboats. Where they would fight with LNG. LNG is also higher scoring in the environmental issues, as ethanol only advantage is climate gas emissions. Ethanol is in other words one of the least likely candidates for taking big market shares in the future when stricter regulations comes into the picture.

(Zahedi, Norum, and Ludvigsen 2014) studied how a change from the traditional distribution systems that is found on ships today, to a more streamlined distribution system that optimizes processes and increases weight and space savings that can lead to notable fuel savings. Their study concludes with a major potential for fuel savings for vessels in the maritime sector, especially for vessels operating with varying load frequently or operations over a longer time-period under non-rated conditions.

However, these alternative fuels may not be as competitive for the eventual restrictions to SO<sub>x</sub> and other emissions that are expected to come in the future, such as the stricter regulations that may come in 2020 outside of the current SECAs. (Haraldson 2013) predicts that in 2020/2030 HFO with high sulphur and the use of scrubbers to clean it will be the most popular solution inside SECA, and HFO with a sulphur content of 0.5 % will be the most used alternative outside of SECAs. (Fagerlund and Ramne 2013) stated that 40% of vessels operating within the North European SECA will be using HFO and a scrubber system. MDO/MGO with a 0.1% sulphur content will account for 30% of the ships in the same SECA, and they also assume the last 30 % will use cheaper fuel types such as LNG and methanol. LNG will also be a more viable solution then, as the infrastructures are expected to be more developed. From the alternative fuels, is expected methanol to be one of the most competitive in this period (Haraldson 2013).

## **2.4 Freight rates**

Freight rates are a component of trade costs. Because shipping accounts for the greatest share of international trade, ocean rates help shape the patterns of international trade, even if they are a small part of cost of trade especially for manufactured products. (Slack and Gouvelal 2011)

As seen from the most realistic measures available, all demands an increase in cost in one way or another. I.e. 50% of total costs from shipping comes from fuel, which means a change from HFO/IFO to more expensive low sulphur types as LSMGO will cause worry for ship-owners (Lindstad, Asbjørnslett, and Jullumstrø 2012). The price increase of changing to LSMGO will heavily affect the transportation costs per ton (Hämäläinen 2015). (Panagakos, Stamatopoulou, and Psaraftis 2014) study on a possible SECA in the Mediterranean Sea shows that transport costs can increase with 6.95 €/tonne. A study relevant for North Europe and this paper is (Notteboom 2010). The writer states that a change from HFO to LSMGO on ro-ro ships on traditional short sea services can create an increase of freight rates from 8% to 20% depending on fuel prices. For services demanding higher speeds, the average is located at 25% for low fuel prices and 40% for high. Increased costs for ship-owners means a dilemma over how to compensate for the losses. They can try to absorb some of these costs. Such a strategy would according to (Notteboom 2010) have a dramatic and negative effect on both finances and the desirability of short sea shipping. Negative effect on desirability, meaning a slower innovation process and vessels that will have a longer life span. Which finally could result in reduction demand and attractiveness due to obsolete fleets. However, the most likely scenario is that these costs most likely will be paid forward to shippers, who then must pay an increased rate for shipping goods. This increase may come as a surcharge, as which can be added to the base rate (Slack and Gouvelal 2011, Andreoli 2014, Notteboom 2010, Holmgren et al. 2014).

## 2.5 Demand and modal shift

With this new legislation, a new situation will arise for shipping operators in regards of competitiveness also. Higher costs and rates, can force customers to go for other transportation modes. The most important factor for modal shifts is undoubtedly fuel prices, with higher prices the likeliness for modal shifts increases (Panagakos, Stamatopoulou, and Psaraftis 2014, Vierth, Karlsson, and Mellin 2015)

(Vierth, Karlsson, and Mellin 2015) stated that the new SECA-legislation could force modal shifts, but according to their paper the effect it will have on the demand for sea transport would be reasonably low when it comes to ton-kilometre. An important point is that the changes in modal choice will not only be effected by increased costs due to the sulphur limits, but also eventual cost increases for road and rail. The estimation on limited modal shifts and demand change is according to their paper is also the general belief of the literature.

There are however more negative estimations on the behalf of sea transport. (Boholm 2010) projected that the change to more expensive fuel would dramatically change the playing field and the conditions for sea transport to compete, where increased expenditure for ship-owners would reduce their competitiveness in such a degree that a change in how goods are transported was to be expected. In this situation providers of road transport would be the favourable party. Table 5 shows how different fuel prices of MGO could increase the costs for different industry sectors in Sweden.

	<b>662 USD/ton</b>	<b>+75% = 1,160 USD/ton</b>	<b>+150% = 1,655 USD/ton</b>
Chemical industry	5,459	9,553	13,647
Minerals and mining	3,586	6,275	8,965
Forest industry	1,497	2,619	3,742
Agriculture	1,275	2,230	3,186
Soil and rock	527	922	1,318
Metal industry	303	530	757
Technology industry	211	368	526
Food industry	108	189	270
Forestry	34	60	86
Textiles	1	3	4
Sum	13,001	22,749	32,501
Cost increase in percent of the total profit in the industry*	1,5	2,6	3,7

\* Gross profit from 2006

Table 5. Increased costs (million euros) in relation to the cost of MGO. Source: Johan Nyström as cited by (Boholm 2010).

(Hämäläinen 2015) researched how increased costs due to the SECA-legislation could affect the industries located in the SECA. The paper stated that industries, such as the paper industry, located in this area could lose market shares to competitors in other areas of Europe where they would not be affected by the SECA-legislation and did not have to worry about these increasing costs. For the pulp and paper industry these increasing costs could be 2-9 euros per tonne product (Boholm 2010). (Bergqvist, Turesson, and Weddmark 2015) looked at the Swedish forest industry, on how increasing costs because of SECA could affect their modal choice. The forest industry could risk to get a cost increase of 7% of value added, when using sea transport (Boholm 2010). The consequence of this could, according to (Fagerholt et al. 2015), be that certain industries would consider relocating to strengthen their competitiveness.

The paper of (Notteboom 2010) researched the impact of the new legislation, where the focus was on routes in the same area as this paper will concentrate on. What that paper concludes with is that when MGO is used on ships there are possibilities for goods that are transported with medium to long short sea sections will change to shorter sections on sea and longer truck haul, a truck-only option is considered. For certain type of goods a modal shift can occur due to changes in freight rates (Holmgren et al. 2014). Prices will change differently in the existing markets depending on transportation modes, distances and sea freights. (Hämäläinen 2015) The areas that are most uncertain for a continuous medium to long short sea section is the routes where there is a need to cross the English Channel and journeys between Western Europe and the Baltic States (Notteboom 2010). Items of high-value shipped in containers from Lithuania to the British Midlands are unlikely to force a modal shift to road transport (Notteboom 2010). The studies show that there are uncertainties on how this legislation can affect and force a modal shift. Where the conclusion from (Bergqvist, Turesson, and Weddmark 2015) was that due to the SECA-legislation, more shipments would be transported on land. How large quantum's that would be shipped on-land was uncertain, but the indications showed that large shares would be transferred using various modes. Geographical locations of ports and industry would be important factors for what modal choice was going to be used. Which could be beneficial for some ports and disadvantageous for ports located in areas, where land transport would be more beneficial. The results of (Panagakos, Stamatopoulou, and Psaraftis 2014) study showed that a possible SECA in the Mediterranean Sea could possibly result in a modal shift of 5.2% on a designated route in the current area. Another

strategy suggested by (Bergqvist, Turesson, and Weddmark 2015, Boholm 2010) is to transport the shipments on land to a port outside of the SECA-areas for then to be shipped on sea from these locations. (Bergqvist, Turesson, and Weddmark 2015, Vierth, Karlsson, and Mellin 2015) conclusions, where however that this was not going to be a viable option because of factors like; geographical inaccessibility, market structure and infrastructure.

In a scenario where short sea shipping's competitiveness is reduced due to decreasing demand and modal shifts, different repercussions may occur. (Notteboom 2010) also paints a dark picture of how 10% to 20% in traffic loss, may be enough to put short sea shipping in a downwards spiral. A situation with less short sea traffic could create a domino effect with a reduction of capacity, lower frequencies etc. The end piece of this domino would be a weak market position for short sea services, giving few investors incentives to put money into this market and the closure of shipping operators in the area.

This is of course farfetched but that there are possible routes that will be shut down is undoubtedly a risk. As reported from (Fagerholt et al. 2015) ferry operators in the SECA has already shut down routes, and Ro-Ro operators was on the time this was written on the fence on whether some routes would be unprofitable. When keeping in mind that different industries has the potential to be inflicted, with higher costs damaging their competitive capabilities. Forcing them to move business elsewhere, would increase the probability for ship-operators that is just scraping by to shut down (Fagerholt et al. 2015). To say that every party and variable is a domino is an accurate description, and these parties are dependent on each other to be competitive.

These studies shows that there are different opinions between the likeliness of a decrease in demand for shipping operators and a modal shift from sea to road. The SECA-legislation can possibly force a modal shift in certain situations. This will depend on different variables:

Aside from fuel costs, factors that influence modal shift consist of geographic locations, traffic mode alternatives, length of sea legs, ship types, and cargo categories. (Holmgren et al. 2014)

### **3.0 Method**

When looking into the literature and theory that was out there, many predictions was made for what was going to happen after the SECA-legislation entered into force. The purpose of this paper is to see if the different theories and opinions from before the legislation took effect, coincides with how the ship-owners themselves feel they have been effected by the SECA-legislation, too get an overview over how the present situation agrees with the literature review. By asking the ship-owners directly, on how they have perceived the time after the legislation took effect and concretely what they have done, the goal is to get both concrete answers and answers that are more reflectional for the research questions. As a result, possibly unveil some new questions and thoughts about the subject that can be researched further in the future.

To achieve this, the idea is to use an interviewing method. Mainly for getting considerations and answers on the different research questions. The research questions are mostly reflectional and wide, but the research also needs some concrete numbers. This means the interview process will involve the gathering of both qualitative and quantitative data. With the idea of perhaps reveal some new issues the theory did not reflect on or possibly ship-owners has some other thoughts on the different theories and projections considered in this paper. Bearing this in mind an adoption of (Auerbach and Silverstein 2003) “Hypothesis-Generating Research Using the Ground Theory Method” will be used if there are findings that is considered to be interesting to research in the future.

#### ***3.1 Collection of data***

The goal for the data collection is to get answer to every aspects being researched. In this case, that would be the research questions. For the credibility of the paper it will be important to get responds from various ship-owners with different market segments, operating from different ports. With a good spread, a better overview of the situation will be given to the reader as well as the papers validity will be stronger.

The method of data collection will for this paper be the interview form. To reach out to a large group of ship-owners operating in the SECA, the primary plan is to send out the interview questions through e-mails to the chosen ship-owners. An e-mail will be sent beforehand to describe the theme of the questions, clearly state that it is possible to answer



confidentially and finally an offer to get the final work sent to them as a thanks for taking the time to answer the questions. In addition, the mail would contain the questions sheet attached. (Appendix A and B). With the knowledge that surveys generally have a low answering percentage, the need to have a backup plan in the events of very few answering the e-mails is needed. If this will be necessary phone interviews will be performed. The same questions as in the e-mail interview sheet will be used.

In the planning phase some advantages and disadvantages was considered with gathering data from e-mail interviews compared to phone interviews. With e-mails the number of ship-owners in reach is wider. With this option there is possible to contact every ship-owner operating in the SECA, the biggest minus is that the answers will be shorter and not so in depth as it could be. The opposite can be said about phone interviews, as costs to contacting the ship-owners located in foreign countries will lead to a very small pool of potential interviewees. The upside is that follow-up questions are possible which means that a deeper insight and understanding of the material is possible.

Through interviews, the objective is to get both qualitative and quantitative data from the respondents. The majority of the interview will be with the idea that the respondents answers openly, and shares the information this person feels is fitting, making the interview less structured. Where the interviewer can change the arrangement of the interview during the conversation. There are, however one point that will go under quantitative data and that is to answer research question 1.1 about what measures they have taken. With only a limited pool of choices. Quantitative interviews is considered as much more structured, to avoid going of track before an answer to RQ 1.1 is given this will be the first question asked during the interview. When constructing the questions for the interview, it is important to formulate questions that cannot be wrongly interpreted and they should not be leading the respondents into a wished answer. Before the interview takes place it will be important to make sure that the respondent understands for what purpose the interviewee is answering the questions for. When combining a qualitative and quantitative arrangement it is important to have a strategy. By starting the interviews with the questions that will give the information for the quantitative data. The interviewer will get a better overview over the theme, but the deeper understanding over the choices will not be given before the questions that is more unstructured are asked. (Askheim and Grenness 2000, Fontana and Prokos 2016)

## **4.0 Findings and discussion**

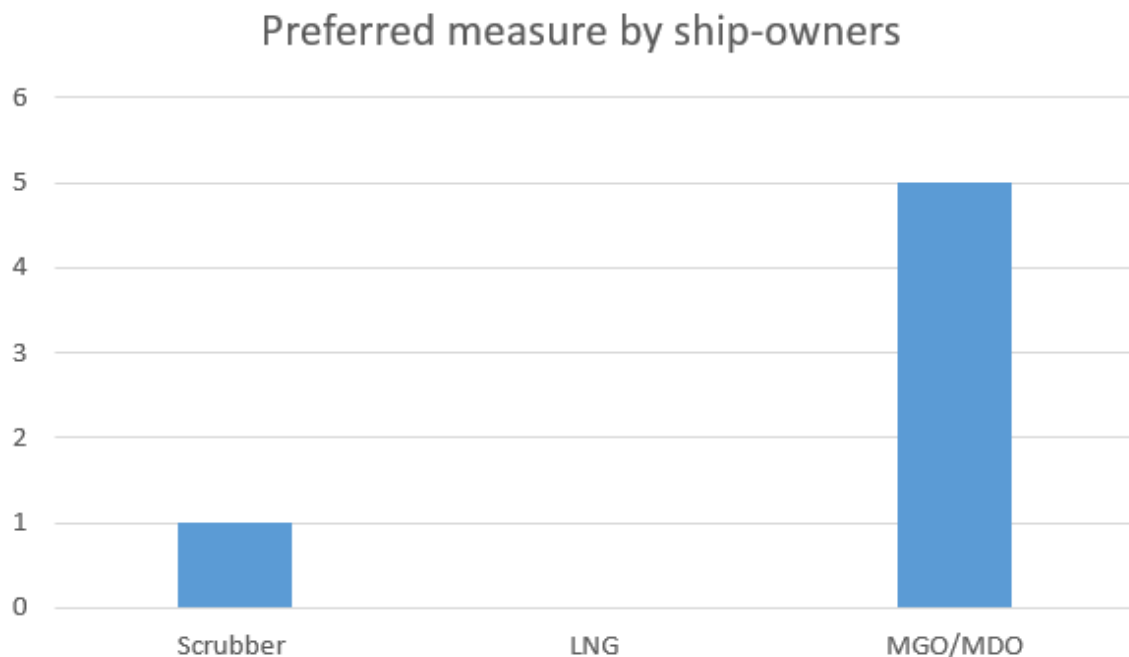
To answer the research question in the best way, a closer look on the sub-questions will be taken. By getting a deeper knowledge over the different aspects and pieces that may be affected by the SECA-legislation, a more profound answer can be given to the main research question.

To get the necessary insight in the various aspect, data from the interviews will be the main source. There was however, a setback for the size of the data collected. Of the 46 companies that received an e-mail with the attached interview questions, only one company responded. Giving minimal comprehension of ship-owners own look at how SECA has affected their business. To collect more data, several phone interviews where done to provide for more answers and a stronger foundation to answer the different sub-questions and ultimately the main research question. The advantage with the phone interviews was that there were possibilities to receive answers and a better perception of the situation. From the phone interviews, there were collected data from five more respondents. From the total of 6 respondents, 5 of the respondents offers various types of goods freight and 1 respondent offers a passenger service, in addition to the shipping of goods. All five companies are located with head offices in Norway, but they operate at several locations within SECA. This point should not discredit the validity in any large degree. The weakest point for this case in terms of validity will be the small sample of respondents. To get a stronger basis for giving a more insightful answer to the research question, secondary data from web pages and reports will also be used.

This section will, with the help of the respondents' answers and secondary data, give an answer to all sub-questions. With the end result being that these answers will give an understanding of how SECA has affected the ship-owners, in a way that an insightful and clear conclusion can be given to the main research question.

#### ***4.1 What kind of measures has been taken by the ship-owners to comply with stricter sulphur emission limits?***

Figure 7 shows what measure has been the preferred one by the respondents to comply with the stricter sulphur emission limits.



*Figure 7. Preferred measure by ship-owners.*

What was discovered by the interviews was that MGO/MDO was the preferred measure of choice, as five out of 6 said that the majority of their vessels was running on this kind of fuel. The last respondent answered scrubbers was used as their main alternative. They however stated that of the remainder of the fleet some was running on MGO/MDO. Of the five respondents saying MGO/MDO, two answered that they had vessels running on other types of fuel. One of these companies had in addition to changing to MGO, vessels that was running on LNG. The other company along with the company choosing scrubbers as their main alternative also had vessels operating with a so-called ultra-low sulphur fuel oil (ULSFO). The ULSFO is a type of fuel that can be classified as between HFO and MGO/MDO, this type of fuel is of course within the legal sulphur emission limits.

To summarize: 5 out of 6 uses MGO/MDO on the majority, and only 2 companies has opted to invest in LNG and scrubbers. That over 80 % of the respondents has gone for

MGO/MDO, shows that the literature stating that it would be the preferred choice on the majority of the vessels in SECA was correct (Fagerlund and Ramne 2013, Bergqvist, Turesson, and Weddmark 2015, Hämäläinen 2015, Haraldson 2013).

With approximately 1500 ships operating fully or mostly within the SECA, the amount of six respondents does not give a clear picture of today's situation. To get a stronger foundation and more insightful view of the situation the report from (Rozmarynowska-Mrozek 2016) will be used.

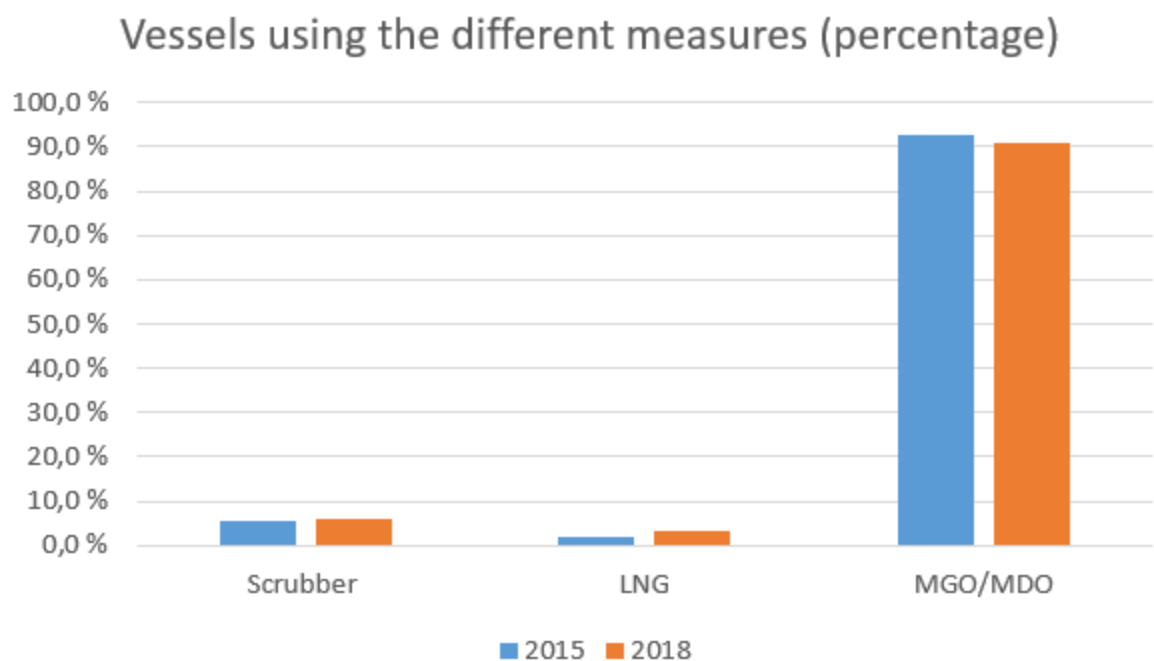


Figure 8. Vessels using the different measures. Source: (Rozmarynowska-Mrozek 2016)

Figure 8 shows that when accounting for all vessels operating only or mostly in the SECA, MGO/MDO stands as the fuel source for over 90% of the ships. Correlating even stronger with the literature mentioned above. Scrubbers are used on 5.5% of the ships and LNG are only at 1.8 % of the whole fleet. It is important to mention that there are also one vessel already running on methanol that is operating in SECA, and four more vessel running on the same fuel are expected to come within the year (Stensvold 2016). Looking at the numbers for expected deliveries up to 2018, there is a growth for both scrubbers and LNG. Where LNG will increase the most. The amount of vessels in the fleet comprising of LNG will be 3.1 %, a growth on 1.3 %. The use of scrubbers will also go up by 2018, but only

with 0.3 % to 5.8 %. MGO/MDO will reduce their amount in the fleet, but will still be around 90 %.

Why is MGO/MDO so clearly the most popular choice? The main reason for ship-owners to choose this fuel source is of course the prices.



Figure 9. IFO380 in Rotterdam from May 20 2015- May 20 2016. Source: (SB 2016a)



Figure 10. MGO in Rotterdam from May 20 2015 – May 20 2016. Source: (SB 2016b)

The summer 2014 prices for MGO and IFO380 was approximately 900 and 550 \$ per Metric Tonne. Around 1 January 2015 when the SECA-legislation entered into force, these prices had dropped down to around 475 \$ per Metric Tonne for MGO and 265 \$ per Metric Tonne for IFO380. Which means that the differential between MGO and IFO is 210 \$. With the exchange from US Dollars to Euros being on around 0.9 the differential between MGO and IFO should be approximately 189 Euros. According to the study of (Liping, Kronbak, and Christensen 2014) this would greatly benefit the use of MGO, as they stated that for other measures to be beneficial the price difference between MGO and IFO needed to be over 230 Euros.

The prices has in the last year been lower than when the SECA-legislation was set in motion, but the latest trends from figure 9 and figure 10 shows that so far in 2016 the prices has increased. The last reported prices in the figures shows that the price for MGO is 427 \$ per Metric Tonne and for IFO380 the price is 214 \$ per metric tonne. Converted to Euros the price difference between MGO and IFO380 should therefore be approximately 192. This shows that the variations in price for the two fuel types is very similar, both from the latest price reports and from when the SECA-legislation first was entered into force. If a bigger raise in orders for LNG and scrubbers is to happen the MGO price must increase with a higher rate than what it has done in the time after the new sulphur emission limits came into play. Both IFO and MGO prices has varied in the same ratio, giving ship-owners no incentives for changing to other alternatives.

This cannot be the only answer, as the fuel prices did not drop significantly before after the legislation was entered into force. There were different reasons for the ship-owners not to choose scrubbers and LNG. The causes for not using scrubbers was according to the respondents that on smaller boats in was totally undesirable to implement as it would demand to much space storing the water, and to release the water was not an option as it was not as environmental friendly as expected. Their conclusions was that the costs to implement was not low enough, compared to the environmental reward. They would rather wait for more advanced measures that would come in the future, and stated that scrubbers is only a temporary solution. The respondent that has mainly scrubbers on their ships started early in the planning to implement scrubbers. Their first vessel with a full size scrubber system was installed in 2009, and the experiences this vessel had with the

scrubbers system was used as a factor for the decisions made later by the ship-owner. This shows that the thoughts on scrubbers vary between the ship-owners. Only one of the respondents has LNG vessels in their fleet, and these vessels were new builds. The reason for ordering these vessels was their companies profile on green solutions. For the other respondents the choice of LNG did not seem like a viable option. Due to costs, doubt on how environmental friendly LNG really was and the potential time delays that could occur due to limited fuelling possibilities. There also was some worry about CO2 and methane emissions from LNG, as new regulations that could come would make LNG non-compatible in the future.

Why is there so little faith in these two measures from the respondents? Costs and uncertainty seems to be the two biggest issues. As (Liping, Kronbak, and Christensen 2014) and (Panasiuk and Turkina 2015) calculated there were high investment costs for these two options, with the uncertainty the ship-owners felt for environmental gain it is understandable that they chose the most safe and later proven to be the most economical solution. Another factor may be the market they are in, with more fierce competition they may not have the leeway to take risks to invest on technology that could take 2-3 years to payback. The respondent that answered scrubbers as the measure taken on most of their fleet vessels is operating in an entirely different market where competition is not as fierce, and this could well be the most important factor for the different ways of thinking and choices regarding the choice of measures.

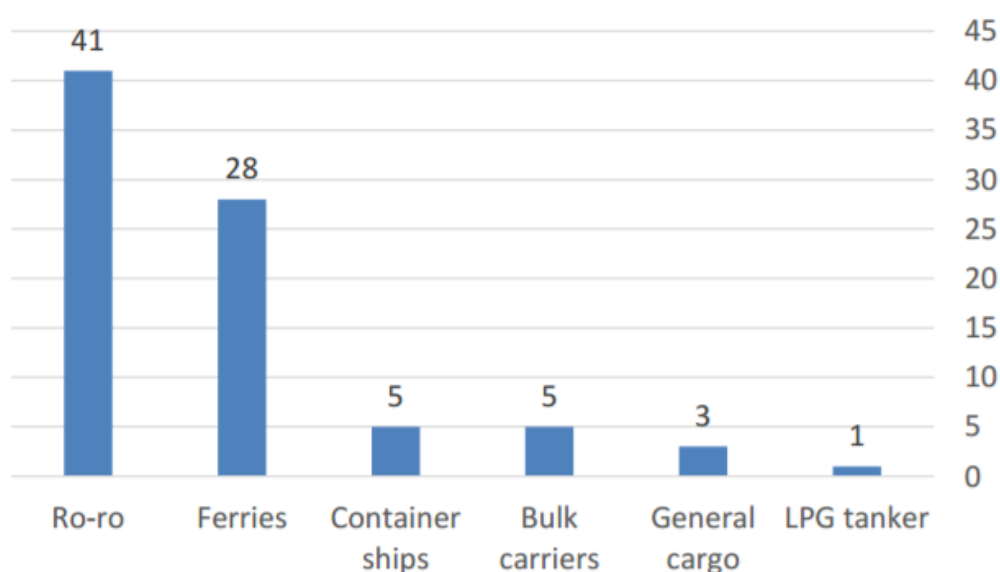


Figure 11. Ships with scrubbers. Source: (Rozmarynowska-Mrozek 2016)

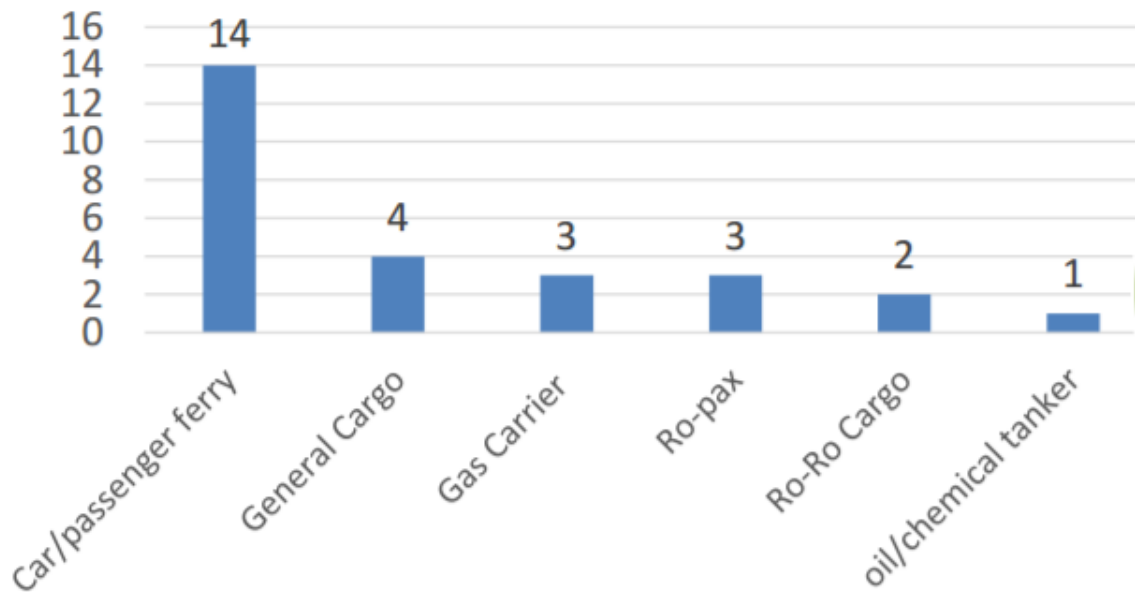


Figure 12. Ships powered by LNG. Source: (Rozmarynowska-Mrozek 2016)

Figure 11 and figure 12 shows that ferries and ro-ro vessels is the main users of scrubbers and LNG, the thoughts of smaller competition does not seem to be farfetched. On any given route there are very limited choices for cars and passenger to choose from, giving the ship-owners that small room to take bigger risks on investments. In addition, have a “greener” concept through the whole organisation compared to ship-owners in markets where rates are more uncertain and the margins smaller.



## ***4.2 In what degree has the new SECA-regime affected the freight rate?***

In the theory found and used in this paper, it was expected that due to the change to alternative fuels or the instalment of scrubbers the transportation costs would be increase for the ship-owners. To compensate for this increase, the costs for these changes would be forwarded to the shippers. The results from the interviews showed that these theories was in a way accurate. They stated that to equalize the expected increase in transportation costs the plan was to increase the surcharge called bunker adjustment factor (BAF). Due to the sudden decline in fuel prices, there did not occur any increase in the transportation costs and the freight rates has been stable. Due to the new SECA-legislation, it was expected that it would be tough times in the freight markets, and according to the respondents, this is the actual situation also. However, this can not be traced back to the new SECA-regime as it is more due to the falling oil prices.

Due to the unforeseen drop in oil prices, the SECA-legislation and its expected increase in costs for both ship-owners and shippers has not been very evident.

Since the oil prices gives a scenario where SECA has little to no effect on the freight rates, a follow up question was given to the respondents of the telephone interview.

What if the oil prices had remained stable? The consensus was that the increased bunker adjustment factor surcharge would have mattered. The freight rates would have increased giving another kind of disadvantage. Where other forms of transport would be more competitive.

The theory used in this paper estimated correctly when stating that ship-owners would send the increased transportation costs to the shippers in form of surcharges, but what it did not expect was the sudden drop in oil prices, which gives a whole new ballgame for the ship-owners. Where the least of the worry is the SECA-legislation. The effects of the new legislation will perhaps become more evident in the future, if the situations with fuel prices and freight rates changes.

### ***4.3 Has there been any changes in demand after the SECA-legislation entered into force?***

The theories regarding demand after the SECA-legislation entered into force varied between minor changes to very dark times regarding demand for sea transport. However, the consensus was that it would not have big effects on demand in general. Factors like geographical location, distance, competition, fuel prices, commodities and markets would be decisive for the demand.

With the fuel prices being so low, the expected increase in fuel costs has been neutralized. This was one of the main factors for an eventual demand change, and in general the demand has been stable according to the respondents. In the oil industry, there has been a decline in demand, but the causes for drop in demand in that particular case is again with the oil prices and not because of SECA.

Statistic from (Eurostat 2016a) corroborates the answers given in the interviews where ports located in the SECA, shows stable figures for goods transported to/from the selected ports years before to the year after the legislation entered into force.

Again, there has been very few repercussions due to the new SECA-legislation. With prices being lower than the theory expected there has been no evident change. However, in this case dramatic changes was not expected either.

#### ***4.4 How has the market distribution between sea transport and road transport changed in the time after the new legislation came into play?***

Demand and the change in market distribution between sea transport and road transport is connected, and for that reason most of the theories and projections for this section was similar to the demand section. Where in the case of higher prices there could be changes in the market distribution, but even though the SECA-legislation would possibly, increase costs for ship-owners and shippers' eventual costs for road transport could also occur. Meaning there could be a neutralization in costs, giving no reason to believe there would be big alterations in market distribution. Of course there were a minority that believed the increased costs for sea transport would give road transport a bigger advantage.

The respondents had some different views and experiences with a change in market distribution. The responses varied from no changes at all to there has been a change in favour of road transport. Where the conclusions for this change was that road transport offers more flexibility for customers and that road transport has become more competitive. Two points that were beneficial for road transport was mentioned. Cargo that was more adjusted for road transport, and centralization was important factors for shippers that choose road transport over sea transport.

Again there were no indications for that the changes directly was impacted by the SECA-legislation. Centralization would however, lead to more options for shippers. As it can lessen the need for medium to long hauls with sea transport. A point (Notteboom 2010) made when discussing possible effects the SECA-legislation could have for ship-owners.

(Eurostat 2016b) shows that road transport has been stable for the last years, meaning road and sea transport has not incurred any dramatic changes whatsoever. There are however, some interesting points especially with the increased competitiveness from road transport, and the centralization that some ship-owners have seen the effect of there is reason to believe that an increase in oil prices leading to higher costs for ship-owners can give an even larger edge for road transport.

#### ***4.5 How has stricter regulations in the future affected ship-owners decision-making towards their ships today? And which measures are the most likely choice for ship-owners in the future?***

With the possibility of even stricter regulations, ship-owners may need to think many years ahead, when planning for what measures they should choose for complying with the legislation that took effect in 2015. With 5 out of 6 choosing the MGO or MDO as the main fuel source on their fleet, the message is quite clear. Scrubbers and LNG was not seen as a viable option for their operations, and they would rather sit back and wait for better options that are more appealing are available. The last respondent, which chose another strategy with most of their fleet on scrubbers, felt this was a good choice also in the long term. The respondent acknowledged that factors like prices for the different fuel sources, stricter regulations and new technology could change their perspective in the long run. But was positive that the choice of scrubbers could be good for years to come.

With the doubt the majority of respondents had to the two other options, it's understandable that they did not want most of their fleet running on these alternatives. Nevertheless, are there any futuristic options that have caught their eye? Earlier in the paper, some theories for what the next big thing for complying with the emissions was shown. Four different measures was suggested earlier in the paper; ethanol, methanol, bio fuel and battery technology on its own or in a hybrid solution. There where pros and cons with everybody. Low availability was seen as the biggest turn off. However, vessels running on methanol is already built and can be a competitor for the three other measures. (Methanex 2016)

Is these measures interesting for the ship-owners or are they looking at other options? Of the mentioned alternatives, only battery technology in its own form or in a hybrid solution is mentioned. Hydrogen would also be a more appealing solution. The reasoning behind this is that there is higher potential for no emission at all with these options. Ethanol, methanol and bio fuel does not reduce the emission enough or the availability would be minimal too even consider them. Two of the respondents do not see any changes in their operations in the near future and states than MGO or MDO would be the preferred choice also in the future.

## **4.6 Discussion**

With the answers from the ship-owners down on paper, some interesting points has been revealed. Bearing in mind the theory review there is a logical and common thread behind the research questions. With the data available when the projections from the theories were made. The increased costs of choosing to install scrubber systems on the vessels, retrofitting or build new LNG-ships or choosing the more expensive MGO/MDO fuel. These extra costs was expected to give ship-owners some worry. What is the best solution to deal with these costs? Yes, to forward them to the shippers making them pay surcharges such as BAF. The possible domino effect of this was the theory that demand would be reduced for sea transport. Goods would rather be transported on land by road or rail. Giving a change in the market distribution from sea transport to road transport. The theories and projections on this was however, positive for sea transport as changes was unlikely. The possibility was still there. Ship-owners could not only think of the legislation taking effect in 2015, but they also had to keep in mind that stricter limits could come in the future. Making the choice possibly tougher, with more research and development in the future what is best now may not be what is best tomorrow.

The measures that was actually chosen by the ship-owners was quite accurate to the projections given, as around 90% chose MDO/MGO as the preferred fuel source. The reasoning for choosing the two other options was that they in the long run could prove to be more economical, but this would depend on the difference between MDO/MGO and the heavier kinds of fuel oil. It is not that hard to believe that MDO/MGO would become more expensive and prices for HFO would go down. Supply and demand, would normally give these two fuel sources opposite curves. The actual results tells another story, which starts with a low oil price. Where both the heavier fuel oils and MDO/MGO has had similar curves, keeping the differential within the margins for where ship-owners choosing MDO/MGO can be satisfied with their choice. Looking at the response it is evident that making big changes on the vessels was not a good option for most of the ship-owners, but looking on it at a different perspective it can also be said that choosing this was the least bad choice. In theory it looks like the other two has a lot more potential, but the belief in those two products where reportedly very low. With too many uncertainties involved. In this case the easiest solution was the best solution. Why is it so? The answer on that question may well be as easy. Sea transport has been very gentle on the environment

compared to other modes of transport. Making the research and development for better and greener solutions not very prioritized. When stricter regulations started to come in action, the technology was too far behind to follow up on the tempo on the stricter emission limits. However, bigger focus on the topic and more resources given into it will speed up the process. An important factor for the research and development could also be on what measures the focus should be on i.e., LNG with the challenges they are having as infrastructure for refuelling is not available at many ports. Ship-owners are reluctant to use it as they see better options in the future that also has better effect on the environment. The investments seems too big for minimal gain in a competitive situation. When 90% of all vessels are MDO/MGO, the statement is turn the focus on other kinds of technology. Solutions that are more appealing may very quickly turn the ship-owners into believers.

Looking further on the theoretical domino effect started by the change to another fuel source, the general respond is that the domino effect stopped at the first brick. As the low oil prices changed the whole picture for the ship-owners. The impacts SECA has had on ship-owners has not been visible due to this event. This situation can change in the future, and BAF can be a factor again. Giving shippers more incentives to look at other option. With responds from the interviews stating that road transport has been more competitive, due to more optimal cargo solutions and increased centralization opting for shorter hauls between locations, possibilities for more goods being transported on roads is present. The main factor for more road transport is shorter distances between locations. In general there are many medium to long routes that is very dependent on sea transport, and the difference between the goods originating there with goods from more centralized areas will be a factor for the demand for sea transport. Nothing special from the responds given would indicate that very dramatic changes would occur.

The future depends on the previously discussed developments in the technology. When two of the respondents answered that they still would use MDO/MGO, a lack of belief exists that a good solution can occur in the near future. Battery technology is maybe the most viable option for the nearest future. The most important thing for the future, in the eyes of the ship-owner seems to have options that is competitive both economically and with almost no emissions to air. Competitiveness is perhaps the key word here. With the stricter regulations, there is necessary to make adjustments to comply with the new rules. What is the ultimate goal for the ship-owners? To choose the solutions that helps the

environment most or what gives the highest profit. The answer for the majority is of course the most money in the bank. In the competitive markets some of these ship-owners are in there are not much room to take risks that potentially reduces the emissions slightly more than MDO/MGO. A risk like that can be the difference between shutting down or to live another day, fighting in a tough market. Does this mean they are not interested in taking responsibility to preserve the environment? Most certainly not, it just means that they may want to hold back and see if there are any options out there that gives more back to the investment for their own economy and for the welfare of the whole environment. Ferries and ro-ro vessels is also overwhelmed by ships using MDO/MGO, but the percentage of scrubbers and LNG is significantly higher than the rest of the fleet operating in SECA. Again the thought of competitiveness in the market occurs. Is it big competition on different routes for these kinds of vessels? Probably not. This gives an opportunity to experiment and test out if there is economical gains to be made with these options. There are no doubts that regulations to reduce emissions is important, but the pace of the regulations has been faster than the evolvement of the technology and possibly the ship-owners mind-set. Making hard to go all-in where the risk seems higher than the reward.

## 5.0 Conclusion

There was one main research question for this paper and that was: How has the new SECA-legislation affected ship-owners operations in Northern Europe?

To get an answer on this question several sub-questions was made. With the responds from the interviews and some additional data to fill in the gaps. A general overview of the situation has been revealed. Firstly, the biggest change for ship-owners operations in Northern Europe is the switch in what fuel the vessels are using. From heavier fuel oils to marine diesel oil and marine gas oil. The majority of vessels is running on one these fuel types. The reason for not using other options is simply that there are too many uncertainties with these possibilities. In congested markets, it would be too big a risk to take. The general thought is that it may come better options in a later stage that will have the capabilities of zero emissions, and these options may have better economic conditions, be better for the environment and be a safer choice if stricter regulations should come into play.

The current measures available to comply with the new legislation, was expected to give an increase in costs for the ship-owners. Which potentially could lead to an domino effect. However, due to the low oil prices that occurred in the early phases of the new SECA limits. There has not been big changes in freight rates, demand and market distribution between road and sea transport. If there has been any changes, none of them can be directly linked back to SECA.

The ship-owners has been affected by the SECA-legislation in limited extent at this time. Low oil prices has led to very little change in bunkering costs for ship-owners which again has held the other factors stable.



## ***5.1 Future research***

The fuel prices can increase again and if that situation occurs, there may appear some side effects from the SECA-legislation. The question of whether or not the SECA-legislation has affected ship-owners can be more relevant.

Another point that could be interesting is to see if there are correlations between competitiveness in the market and the amount of scrubbers and LNG that is operating in said market.

With the lack of interest from the majority of ship-owners, an interesting question can be raised about the benefits of LNG or scrubbers versus potential new technology i.e. battery.

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# Appendix A

Hi

I am writing a master thesis at Høgskolen i Molde, Norway on SECA in Europe and how it has affected the short sea shipping in the area.

Would your company be interested in looking over and answering the questions attached?

For your cooperation i can offer you a copy of the finished thesis. The name of the company can be held confidential if you wish.

Best Regards  
Bjørn Louis Stranden

# Appendix B

## How has SECA affected short sea shipping in Europe

### Anonymity

Thank you for taking the time to answer these questions. The answers from this interview will be used as data to answer my research questions, which is similar to the questions under. If you want the name of your company to be anonymous, just write it under.

Do you want to remain anonymous?

### Questions

1. **Could you please tell me about the company you represent and how you are involved in European short sea shipping?**
  - a. Which are your core business activities in this market?
  - b. How have your operations changed over the last years?
2. **Could you please tell me about your position, background and current responsibilities?**
  - a. Which are your current responsibilities?
  - b. Have you had other responsibilities within or outside the company before?
  - c. To what extent are you involved in the strategic adaptations and decisions related to the SECA-regime?
3. **What have you done to comply with the new SECA-legislation in Europe?**
  - a. What measures did you end up with implementing for your ships?
  - b. As the new SECA-legislation was known in good time before it was taken in effect, how did you plan and land on exactly this/these measures?
  - c. Will there be another approach used in potential new ships you are planning to invest in or hire?
4. **Have the new SECA-regime affected your freight rates?**
  - a. If so, how have the freight rates been changed after the new legislation took effect in January 2015?
  - b. Could these changes be linked back to the legislation itself, or are other factors more important? If so, which other factors?

5. **Have you experienced any changes in the demand for short sea / maritime feeder services after the SECA-regulations were imposed?**
  - a. Has there been any changes in demand in the time after the legislation took effect?
  - b. If so, can this be explained by increased rates and the legislation, or are other factors more important? If so, which other factors?
6. **Have you seen any changes in the market distribution between road transport and short sea / maritime feeder transport in the time after the legislation took effect?**
  - a. Do you have some indications that shippers have chosen road transport over maritime transport after the implementation of the SECA?
  - b. If so, what do you think is the main reasons for this change?
7. **In what way did you think the new legislation would affect your business before it took effect?**
  - a. Can you say that the first year after has gone as you thought, and what has been different from the expectations?
  - b. How do you see the future for you with the new SECA-regime? Would you choose other ways of meeting the sulphur regulations in the future?
  - c. To what extent would the development in fuel prices play an important role in the way you adapt to the regulatory regime?
8. **In 2020 new and stricter sulphur regulations may be implemented in the rest of the world (outside the SECA areas). Would your technology choices be affected by this new regime outside the SECA areas?**
9. **Do you have any other comments or thoughts that you'd like to share regarding these issues?**

Slutten av dokumentet ■