CHALMERS

Methods of surveillance and level of compliance for current sulfur regulations within sulfur emission controlled area

With focus on the sulfur emission controlled area in Europe

Bachelor thesis in the Marine Engineer program

ANTON BRUN

TOBIAS FREIHOLTZ

Department of Mechanics and Maritime Sciences
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2020

Methods of surveillance and level of compliance for current sulfur regulations within sulfur emission controlled area

With focus on the sulfur emission controlled area in Europe

Bachelor thesis in Mechanics and Maritime Sciences

ANTON BRUN

TOBIAS FREIHOLTZ

Department of Mechanics and Maritime Sciences
Marine engineer program
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2020

Methods of surveillance and level of compliance for current sulfur regulations within sulfur emission controlled area

With focus on the sulfur emission controlled area in Europe

ANTON BRUN
TOBIAS FREIHOLTZ

Department of Mechanics and Maritime Sciences
Chalmers University of Technology
SE-412 96 Gothenburg
Sweden
Phone: + 46 (0)31-772 1000

Cover: Explicit ApS doing an airborne surveillance measurement (Explicit ApS, 2020, p.10).

Printing /Department of Mechanics and Maritime Sciences
Gothenburg, Sweden 2020

ABSTRACT

The typical marine fuels contain sulfur and as the fuel gets combusted in the engine, sulfur dioxide (SO_x) is created and emitted. Once emitted into the atmosphere, it affects both the environment and the physical health of the population. Through gradual restriction in certain areas called "Sulfur Emission Controlled Area (SECA)" within the maritime industry, an aspiration by International Maritime Organization (IMO) is to remove the emittance of SOx into the atmosphere. As restrictions enter into force, surveillance must be conducted to ensure the compliance of each vessel. In this study, different methods to survey the compliance within SECA are evaluated. Furthermore, as the new global Fuel Sulfur Content (FSC) restriction entered into force at the beginning of 2020, possible methods to survey global compliance are assessed. The study further highlights the compliance rate within SECA and what the sanctions could be if the vessels are not complying. The results showed that to survey the SECAs, there is today generally one method that could be used, fuel sample. Others are used as a first indication of non-compliance. Primarily, because of the slow pace of adding or changing the law to be able to use the new technology as evidence of non-compliance and file sanctions. The results further showed that the compliance rate within the European SECA is steady around 95%, where most non-compliant vessels have conducted a late fuel-changeover. Moreover, the 5% non-compliant vessels' sanctions are generally handled within Criminal Law or the Environmental Code. This depends on which Member State the vessel was located in.

Keywords: *Compliance, surveillance, SECA, shipping, FSC, sniffer, PSC,* SO_x.

Acknowledgements

The authors want to state a special thank you to the individuals who participated in this study. Thank you for taking the time to answer each question we had and for sharing your insights and knowledge that made this report fun and instructive to write. Furthermore, a big thank you to our supervisor, Kent Salo. Who with his great knowledge, guided the authors throughout the entire process of writing this report.

Table of Content

Table of figures

List of Tables

List of abbreviations

AIS Automatic Identification System – A *tracking system providing data about the specific vessel*.

Bgd Background – *Surrounding elements.*

CEF Connecting Europe Facility – *A EU funded instrument where it promotes growth and jobs.*

CRDS Cavity Ring-Down Spectrometer – *An optical spectroscopic technique.*

cSt Centistoke – *A unit of measurement of kinematic viscosity.*

DEPA Danish Environmental Protection Agency.

DOAS Differential Optical Absorption Spectroscopy.

ECA Emission Controlled Area – *An area where emission restrictions exist.*

FSC Fuel Sulfur Content – *The sulfur percentage content in a specific fuel.*

GHG Greenhouse Gases

HFO Heavy Fuel Oil – *A collective term for marine residual oils.*

IFO Intermediate Fuel Oil – *The industries name for pure residual fuel oils.*

IGPS Identification of Gross Polluting Ships – *A measuring research project at Chalmers Technical University.*

IMO International Maritime Organization – *An agency of the UN, who is responible for the regulation of shipping.*

ISO International Organization of Standardization – *An organization who develops international standards.*

MARPOL The International Convention for the Prevention of Pollution from Ships – *The convention is regulated under the IMO.*

MEPC Marine Environment Protection Committee – *A committee which investigates any case of control and prevention of pollution from ships by the IMO.*

MGO Marine Gas Oil – *A distilled diesel oil, similar characteristics as truck diesel but heavier.*

MT Metric ton

MW Molecular Weight

NO_2 Nitrogen Dioxide – *Appears during combustion in a engine due to heat.*

NO_x Nitrogen Oxides **-** *A collective term for NO and NO_2*

PPM *Parts Per Million*

PSC Port State Control – *Inspects vessels in ports to ensure compliance wihin regulations.*

RPAS Remotely Piloted Aircraft Systems – *Unmanned aircrafts e.g. drones.*

SECA Sulfur Emission Controlled Area – *An area where the emittance of sulfur is restricted.*

SO_2 Sulfur Dioxide – *Combusting a fuel with sulfur content will result in emittance of* SO_2.

SO_x Sulfur Oxides – *A collective term for* SO_2 *and* SO_3.

ULSFO Ultra-Low-Sulfur Fuel Oil – *A fuel which has a remarkably low (0.1 %) sulfur content.*

VLSFO Very-Low-Sulfur Fuel Oil – *The sulfur content in the fuel is low (0.5%).*

1 Introduction

As world trade continues to increase, the shipping industry flourishes as approximately 90% of the consumer goods are transported by container vessels (Singh et al., 2012). This increasing demand has made the seaborne trade grow from transporting 100 million Metric Ton (MT) of consumer goods in the late ‘80s to approximately 1.6 billion MT in 2014 (Wan et al., 2016). To sustain an efficient transportation of these billion MT of cargo the shipping industry has since the mid ‘50s been using a fuel called Heavy Fuel Oil (HFO) as the main fuel for its engines. HFO is a tar-like rest product in the refinery process of crude oil for fuel production and the reason HFO has been around for almost a century and is used by the majority of the vessels is the significant price difference from the distilled fuels such as Marine Gas Oil (MGO) (Cullinane & Bergqvist, 2014). A downside of HFO is its high emission of numerous different harmful pollutants such as SO_x and black carbons (Burel et al., 2013). SO_x is a well-known contributor to the breakdown of the environment with acid rain, acidification of land, and freshwater. Health effects on the earth’s population, such as premature mortality. Barregard et al., (2019) estimated in 2011, fourteen-thousand premature deaths annually in the Baltic Sea and The North Sea area as a result of the emittance of SO_x.

Because of the impacts to the environment and health effects listed above, the IMO added “The International Convention for the Prevention of Pollution from Ships” (MARPOL). In 1995, ANNEX VI - “Regulations for the Prevention of Air Pollution from Ships.” was adopted within MARPOL and entered into force in 2005. 1st of August 2006, the first SECA was implemented in the Baltic Sea and later expanded to the English Channel and the North Sea. The limit for the FSC within SECA has progressively decreased from 2006 to 2015 to where the threshold is today (0.1% FSC) (IMO, n.d.). As a result of the implemented restrictions from the IMO, there has been a need for new surveillance methods to ensure more of an equal level of playing field within the shipping sector (Mellqvist, Jacobo, et al., 2017b). Today, FSC compliance is monitored by sampling ships’ fuel in port, within the system for Port State Control (PSC). However, remote surveillance methods such as gas analyzing instruments and optical instruments are gradually being introduced, where it is possible to monitor the compliance of the ships during operation at open sea (Mellqvist, Jacobo, et al., 2017a).

1.1 Purpose

The aim of this report is to map the most common type of methods used by the governments for surveillance and compliance with SO_x emissions within the European SECA. Furthermore, to map what type of methods could be used globally with the new regulation put in force 1st of January 2020. The report will also highlight how the compliance rate has changed since the 2015 restriction of sulfur content in the fuel and the potential penalties of breaking said compliance.

1.2 Research questions

- *What kind of methods are available for surveillance of SO_x emissions?*

- *What methods are actively used by governments in the EU?*

- *What forms of sanctions are there against the non-complying vessels?*

- *How has the compliance level with respect to SECA regulations, developed since 2015?*

- *What methods could be used on a global scale?*

1.3 Delimitations

As the field within this research is broad and there are several areas where the emission is currently being controlled, the report was limited to the European Emission Controlled Area (ECAs) and the surveillance methods that are used within those areas (The Baltic Sea and The North Sea). Since the interest in environmental impact is of great importance and the development is constantly in progress, this research will only concern what types of methods are being used today and not upcoming or future systems within SECA. The details regarding the technology of the surveillance systems were limited to the basics and only focused on how the system is being used rather than how it works.

The report will only highlight the SO_x emission and therefore will not be presenting facts about other emissions such as Nitrogen Oxides (NO_x) or particulate matter. As mentioned above, the field of the topic is geographically wide which needs to be limited to focusing on Scandinavian experts within the field for upcoming interviews.

2 Theoretical background

This section will present data needed to ensure a good background knowledge to the result and discussion, this data is collected from journal articles, campaigns, and seminars. The information will include environmental, economic, legal, and technical aspects of the research questions.

2.1 Environmental impact of shipping

The demand for transportation has grown rapidly since the 1980s where the size of the merchant vessels has increased sixteen fold to 2014 (Wan et al., 2016). Where the environment and health of the population get affected by transportation growth. Anderson & Bows (2012) reported an increase by 200% between 2012 and 2050 in shipping emissions even after the IMO presented the scheduled restriction plans in 2010. Furthermore, there are several heavily discussed pollutants in society today because of the impact they have on the environment. Some pollutants are visible to the human eye such as soot and smoke, others are invisible but still just as harmful such as NO_x and SO_x (Andersson et al., 2016). The shipping sector impacts the environment not just by emission to air but through the spreading of non-indigenous species with ballast water, the discharge of oil into the sea, oil spills, antifouling paint, and litter. These pollutants affect the ecosystem, climate, environment, and the health of our population.

The climate gets affected by the greenhouse gases (GHG) that consist of methane (CH_4) and carbon dioxide (CO_2) amongst others (Andersson, Brynolf & Lindgren., p.170). The increasing percentage of CO_2 in the atmosphere give rise to the continious acidification of the oceans (Havs- och Vattenmyndigheten, 2014). SO_x and NO_x contribute to the continuous acidification of the environment both land and sea by lowering the pH-value in soil and waters. These harmful pollutants and particles can travel far, overseas, and land, which makes it not just affecting the local environment but the regional environments. Endersen et al., (2003) reported that 70% of the emission from shipping is emitted within a 400-kilometer radius of land. In 2013, the shipping industry stood for 18% of SO_x emission in Europe meanwhile aviation stood for 1% and 0% for road transport (Smith et al., 2014). Still, shipping is considered the most emission efficient means of transport to carry large portions of cargo (Wan et al., 2016) and is moving approximately 90% of the global goods volumes around the world (Balzani Lööv et al., 2014).

2.1.1 *Environmental and human health impact of SO_x emissions*

SO_x is emitted as a result of the combustion cycle in an engine where the fuel used in the engine has a certain level of sulfur content. This pollutant has an impact on both human health and the environment. This pollutant is in a gaseous form that will impinge the humans respiratory system when breathed in, which can lead to respiratory problems but also premature deaths. Since the pollutants enter the respiratory tract, the symptoms can be noticed within fifteen minutes of exposure through symptoms like shortness of breath, cough, or irritation of the throat and nose (Heritage, 2005). Brandt (2013) estimated that in Europe 2011, 50 000 premature deaths transpired whereas shipping in the Baltic Sea and the North Sea stood for 14 000 premature deaths annually. A decrease of a six percent decrease in 2020, has been estimated in regards to the 2015 FSC restriction (Brandt et al., 2013).

2.2 Environmental regulations

Environmental regulations exist to ensure the well-being of the environment and climate. This section will inform what types of regulations exist within the subject of the report.

2.2.1 *MARPOL Annex VI*

The MARPOL Convention was adopted in 1973 by the IMO to prevent pollution by ships from accidental or operational causes for the marine environment. Accidents regarding tanker ships in both 1976 and 1977 made Annex I put to force in 1983 together with Annex II which regulates the pollution by liquid substances onboard bulk carriers which are noxious (IMO, 2010).

The convention got amended in 1997 and the latest jurisdiction Annex VI was implemented, which entered into force in 2005. Annex VI aims at regulating air pollution from ships. The Annex is regularly updated with amendments to handle the continuous growth of the shipping industry (Wan et al., 2016). Furthermore, in 2011, it adopted a regulation where the operational drive and technical strive aimed at reducing the emissions of GHG from ships (IMO, 2010).

Annex VI has been gradually restricting the sulfur restrictions within the ECAs since 2005, where the FSC started at 1.5% and later was restricted to 1% within the ECA in 2010. During the four upcoming years, two new ECA's entered into force. North American ECA (2012) and the United States Caribbean Sea ECA (2014). One year later, in 2015, the FSC limit continued to get reduced within the ECA's to 0.1%. Globally, the first restriction got implemented in 2012, from 4.5% down to 0.5% of January 2020 as seen in figure 1 (IMO, n.d.; Kalli et al., 2009).

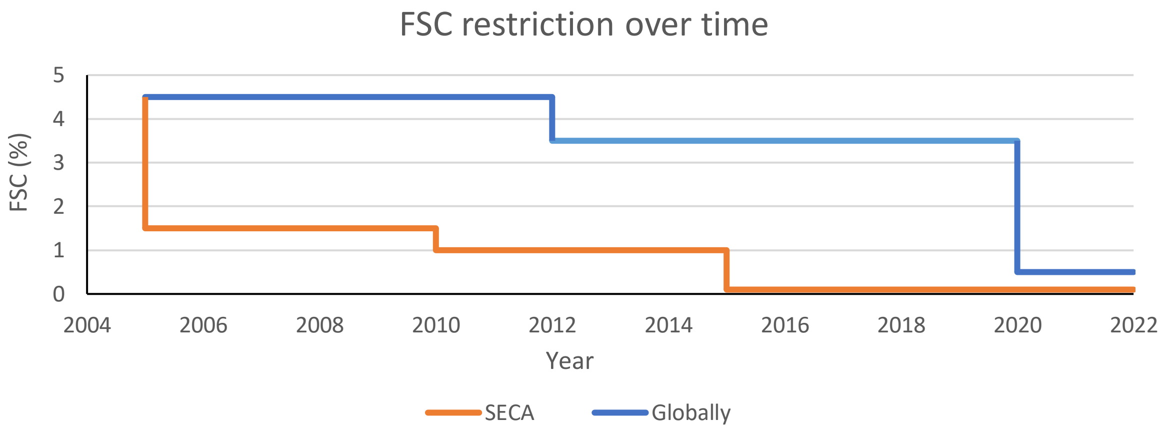

*Figure 1***.** The restriction of sulfur content in fuel both within ECA's and globally over time.

2.2.2 Sulfur Emission Controlled Area (SECA)

A revision was conducted by the IMOs' Marine Environment Protection Committee (MEPC) regarding the implementation of ECA. The purpose of the revision was "the aim of significantly strengthening the emission limits in light of technological improvements and implementation experience", which took place between the years 2005 to 2008 (IMO, n.d.). The result of said revision led to the name "Emission Controlled Area" or ECA which later got defined by IMO as the "area where the adoption of special mandatory measures for emissions from ships is required to prevent, reduce and control air pollution from NOx or SOx and particulate matter or all three types of emissions and their attendant adverse impact on human health and the environment" (IMO, 2010).

The European SECA is divided by the IMO into two locations; The Baltic Sea and the North Sea. Further areas are found in the US Caribbean coast also includes the US Virgin Islands and Puerto Rico and the North American coast (IMO, 2013).

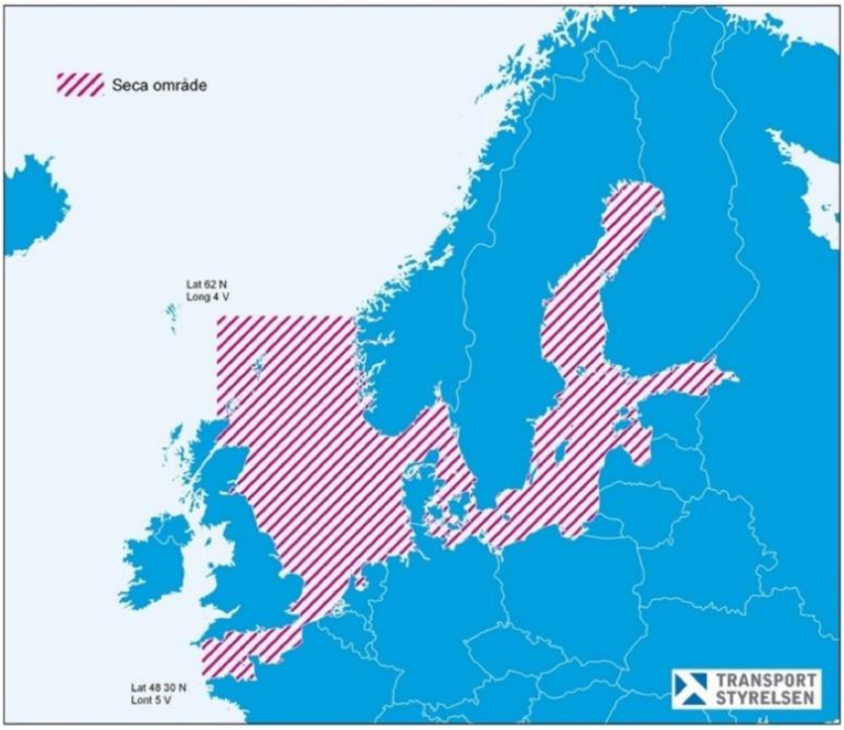

Figure 2. The established SECAs in the Baltic Sea and the North Sea, (Transportstyrelsen). Retrieved with permission.

2.2.3 European union regulations

The SO_x emission from ships in Europe is regulated under Directive (EU) 2016/802, hereafter referred to as the “Sulfur Directive”. Where it determines the highest level of sulfur content in fuel for both maritime and land-based operations. Moreover, it regulates the fuel allowed to use while entering European harbors. While it adapts to the jurisdiction under IMO and the continuous adaptation to fit the requirements developed by MARPOL the sulfur directive set a 0.1% FSC within European ports in 2010 if the vessel is planned to be in port for more than 2 hours (Kalli et al., 2009; *European Maritime Safety Agency*, n.d.)

European Maritime Safety Agency (EMSA) supports the European Commission where it acts as an operational source. EMSA supports the commission with developments in e.g. inspection guidance and technical assistance to the Commission as well as member states (*European Maritime Safety Agency*, n.d.). In accordance with the European Commission, each Member State shall perform a percentage of the total number of tests where the total number is determined by EMSA and the European Commission.

In 2010, a system named “THETIS” was introduced to the EU community as well as Canada, Norway, Russia, and Iceland. The purpose of the system is to collect information and support cooperation between EU member states and countries beyond. This system works together with the SafeSeaNet where the last is a program dedicated to providing information on ships in each Member State's ports. While THETIS will indicate ships that have a priority for port inspections. After an inspection is done by PSC, all tests and protocols are uploaded in THETIS which then can be used by the other Member States to view the vessels' history of inspections and information (EMSA, n.d.).

Furthermore, the European Union regulation makes guidelines and obligations to authorities for the implementation of surveillance by conducting bunkering samples which can indicate the compliance for the specific sulfur regulations. The percentage of vessels to be checked by each member state of the European Union consists of three different categories which also determines the quoted percentage divided amongst them (European Council, 2015);

- Member State that fully borders the SECA (40%)
- Member State that partly borders the SECA (30%)
- Member State that does not border SECA (20%)

2.2.4 Sanctions within the SECA

The European Member States have different approaches to determine the extent of sanctions for ships that violates the regulations, see Table 1. However, very few of the cases in which non-compliance has been observed has led to sanctions (International Transport Forum, 2017). The report further states that this could be due to the costly and complicated process in which the responsibility to gather evidence to prove the vessels' non-compliance lies with the authority and does not lie with the vessel to prove its innocence.

Moreover, MARPOL sets guidelines where the port or coastal states shall interpret these to fit their state, in MARPOL Annex VI Article 4 (4) it states that the sanction "Shall be adequate in severity to discourage violations of the present Convention and shall be equally severe irrespective of where the violations occur". The EU sulfur directive article 11 (2) states that to achieve a level playing field, the vessels that are exceeding the FSC restriction shall be deprived and further of their economic gain of being non-compliant which will continue to increase if the non-compliance persists.

Table 1

Financial penalties in EUR for non-compliance in the different Member States located in SECAs.

Country	Maximum level of financial penalty
Belgium	6 million
Canada	16 200
Denmark	No maximum
Finland	800 000
France	200 000
Germany	22 000
Latvia	2 900
Lithuania	14 481
Netherlands	81 000 & gains
Norway	No maximum
Sweden	924 000
UK	3.4 million
USA	23 000/day

Comment. Retrieved from "Corporate Partnership Board CPB" by the International Transport Forum, 2016, *OECD*, which was referenced to *Trident Alliance*.

2.3 Marine fuels

The marine fuel oils of today are generally representing two different qualities (*Alfa Laval - Marine fuels in the low-sulphur era*, n.d.). The MGO is a pure distilled fuel oil, similar to the fuel in trucks, and HFO made of pure residual oil. The industry calls the pure residual oil (i.e HFO) by the name intermediate fuel oil (IFO). Except that the viscosity of the specific oil will be written at the same time in centistoke (cSt), for example, the most common HFO with 3.5% FSC goes by the name "IFO380". MGO and IFO represent the most expensive and the cheapest fuels.

To keep down the cost of the fuel, hybrid oils are made. For example, the new global cap fuel of 0.5%, also called very-low-sulfur fuel oil (VLSFO), may contain up to 40% of residue oil but still make the 2020 sulfur regulation. Hybrids of the 0.1% sulfur fuels exist as well but are more commonly known as ultra-low-sulfur fuel oil (ULSFO). The hybrid fuels could give some complications both in stability, compatibility, and contamination (*Alfa Laval - Marine fuels in* *the low-sulphur era*, n.d.). However, the minor price difference of today makes it affordable to take the risk with stability problems of the fuel, shown in figure 3.

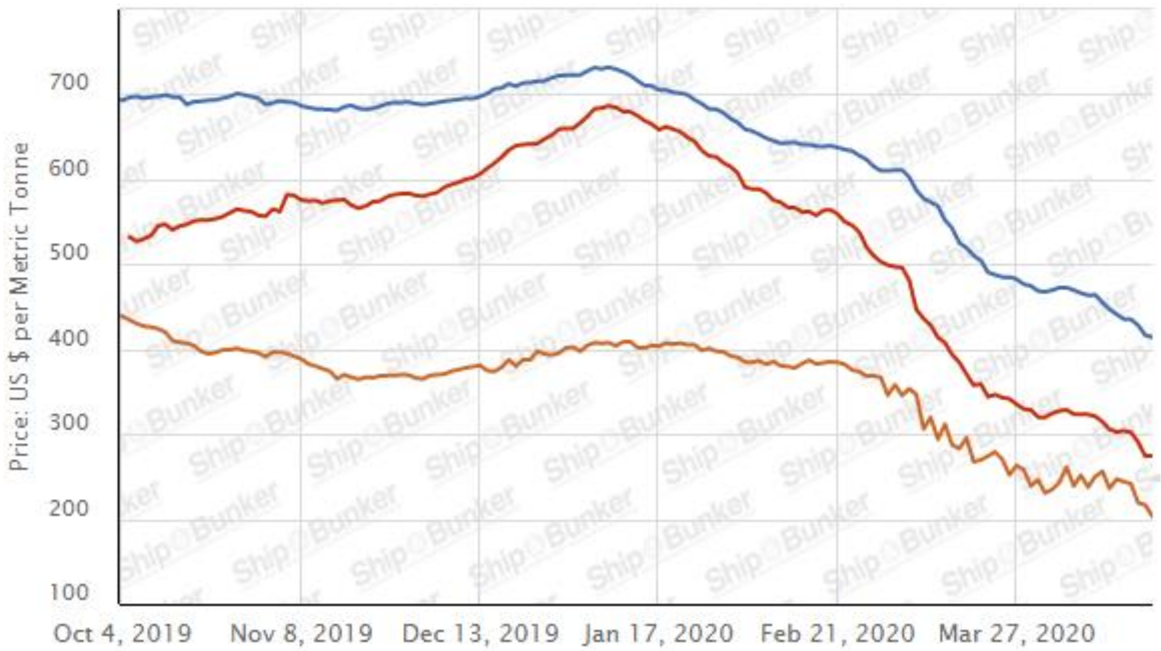

Figure 3. Global prize of IFO380 (Orange), VLSFO (Red) and MGO (Blue), (*Global Average Bunker Price Bunker Prices - Ship & Bunker*, n.d.).

When the VLSFO was introduced in early October in 2019, it was priced at 532 $/MT when at the same time the old 3.5% sulfur fuel oil IFO380, had a price of 434.5 $/MT. As the global FSC restriction came into force, the interest of the new VLSFO increased where the price followed the same increasing curve. When the global cap went into force, the price was the highest in early January of 686.5 $/MT (*Global Average Bunker Price Bunker Prices - Ship & Bunker*, n.d.).

2.4 Surveillance methods of the regulation compliance

The FSC can be determined by several different methods. Either the fuel samples are analyzed or the composition of the exhaust gases is analyzed.

2.4.1 Fuel samples

Fuel samples are primarily collected by authorities on commission of the PSC, such as Transportstyrelsen in Sweden. The fuel sample is done by an inspector taking a sample of the marine fuel that is used on board. Later the sample needs to be sent to a third party to analyze the content. This process is both time-consuming and costly and as a consequence, the number of onboard samples is limited (Beecken et al., 2019). As a result, the European Union

Commission implemented several decisions regarding the onboard inspection. European Council (2015) states that it is not necessary to collect a fuel sample at each onboard inspection but to inspect the ships' logbook and delivery notes of bunker fuel. There are two ways of collecting a fuel sample, which one to be used will be determined by the surveyor onboard. One part is to take a spot sample, this is collected in a spot where it is indicated by the ships fuel piping system, which normally is a valve before the main engine. The second way of collecting an appropriate fuel sample is to collect a sealed bunker sample that is taken by the crew during a bunker-operation onboard (European Council, 2015).

Furthermore, if the member state suspects possible fuel cross-contamination, or when several service tanks are in use, more than one spot sample is to be preferred at different sets of locations. Moreover, there are guidelines set in order to conduct a sample if there is no fitted sampling valve in the fuel system. For example "be as close to the fuel inlet of the fuel-oil combustion machinery item as feasible and safely possible taking into account the type of fuels, flow-rate, temperature, and pressure behind the selected sampling point" (European Council, 2015).

2.4.2 X-ray fluorescence (XRF)

X-ray fluorescence (XRF) is an analytical method that can be used to perform quick fuel analysis, amongst others, on many different types of samples, liquid, solids, or powder. It can analyze the percentage from 100% down to as small as parts per million (ppm) of any element from Beryllium to Uranium (Saleh, 2020).

The XRF uses X-radiation, which makes the sample produce X-ray fluorescence. This produced energy will eject electrons from the atom of which element that is interesting to observe. The vacancies in the atom layers will then be filled with electrons again from a higher energy shell. The created radiation by the X-ray fluorescence is proportional to the concentration of the element in the sample (Ribeiro et al., 2017).

2.4.3 Optical measurements

Differential Optical Absorption Spectroscopy (DOAS) is a technique that can be used by either ground-based or airborne vehicles (Balzani Lööv et al., 2014), this method can measure the density of NO_2 and Sulfur dioxide (SO_2) in the gas plume (Berg et al., 2012). This is done by using DOAS, which can estimate the absolute emissions rate (g/s) of the gases looked upon by combining the gas data with vessel and wind information (Mellqvist, Jacobo, et al., 2017a). The gas data is retrieved through a pair of telescopes that measures the solar light that has been reflected off the sea while passing the gas plume that is being created by the vessel. Which limits the measurement to only when solar light is present The optical measurement is usually carried out at a higher altitude, around 200-400 meters above the vessel (Mellqvist, Jacobo, et al., 2017a).. The optical measurement is usually carried out at a higher altitude, around 200-400 meters above the vessel (Mellqvist, et al., 2017a). This is visually explained in figure 4.

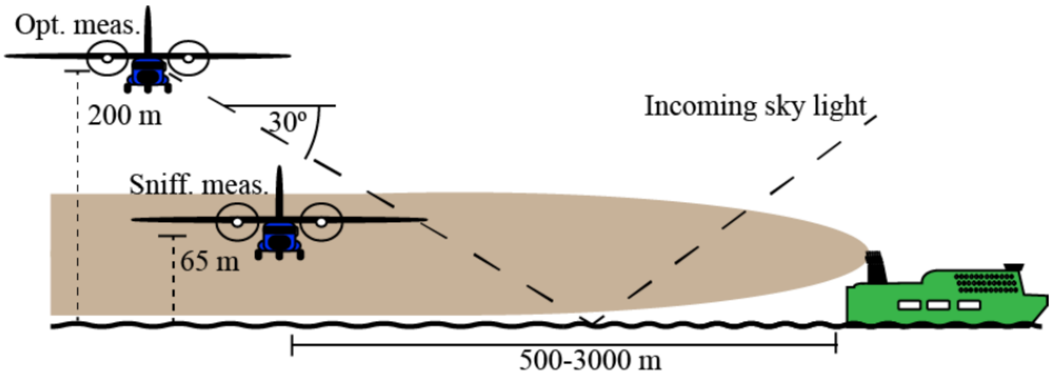

Figure 4. Remote measurement techniques optical and sniffer measurement, (Mellqvist, Jacobo, et al., 2017a). Retrieved with permission.

2.4.4 Exhaust gas analysis

Exhaust gas analyzer instrument, more often called sniffer system, is a method that is using the ship plume to directly sample the gas concentration. The sniffer system compares the change in concentration of emissions emitted by the ship (Beecken et al., 2019). The sniffer system is measuring the difference in SO_2 and CO_2 in the plume compared to the surrounding background (bgd). When converting SO_2 and CO_2 into molecular weights (MW) it has been proved that the relation between SO_2 and CO_2 is the same even if excess air is applied (IMO, 2009). Thereby, the ratio between sulfur and carbon is unaffected by the distance from the emission source, which makes it possible to calculate the FSC. The correlation between SO_2 and CO_2 is shown in the equation below, were the MW of sulfur divided by the MW of the carbon grants the value 0.232. To find out the sulfur and carbon that came from the exhaust plume, in the integral of the total sum the bgd sulfur and carbon has to be subtracted from the equation, for sulfur it is in the size of parts per billion (ppb) and for carbon parts per million (ppm) respectively (IMO, 2009).

$$FSC_{\%S_{m/m}} = \frac{M(S)_{g/mol} \cdot \int [SO_2]_{ppb} - [SO_{2,bgd}]_{ppb}\, dt}{\frac{M(C)_{g/mol}}{0.87} \cdot \int [CO_{2,bgd}]_{ppm} - [CO_{2,bgd}]_{ppm}\, dt} = 0.232 \cdot \frac{\int [SO_2]_{ppb} - [SO_{2,bgd}]_{ppb}\, dt}{\int [CO_2]_{ppm} - [CO_{2,bgd}]_{ppm}\, dt}$$

Equation 1. The correlation between CO_2 and SO_2 (Beecken et al., 2019)

The equation is true if all the sulfur is converted to SO_2 but that is not the case (Mellqvist, Beecken, et al., 2017). It has been proven that approximately 5% of the sulfur appears as sulfate particles (Moldanová et al., 2009). Because of this the calculated FSC will not be the same as in the marine fuel, instead somewhat lower than in reality (Mellqvist, Beecken, et al., 2017). However, the problem only starts to occur when the exhaust smoke is far away from its origin. As the smoke gets further away from the funnel, the more time it has to react to the oxygen which will create sulfate. This will result in it having less of an influence on the calculation and therefore it can be ignored, their weight has a very low importance in the correlation equation (Explicit ApS, 2018).

Also, laboratory tests have shown a cross sensitivity between the SO_2 analyser in the sniffer with NO_x. This could give in some occasions up to 0.1% FSC in overestimations (Mellqvist, Beecken, et al., 2017). To be able to correct for this overestimation, an incorporated UV fluorescence instrument to measure NO_x could be fitted in the sniffer system (Beecken et al., 2019). Furthermore, hydrocarbons have an impact on the analyser system, in the meaning of cross sensitivity. Instead of calculating it is removed before the sample air gets to the chamber in the analyser system. It could be removed by a so-called hydrocarbon kicker, which eliminates the hydrocarbons before the test is done (Beecken et al., 2019).

3 Methodology

This section will describe and motivate the method chosen for this report. This includes what type of method that was used and which type of data collection method. The method will be discussed regarding the validity and reliability in 5.2.

3.1 Choice of Method

The choice of data methodology is based on how Denscombe (2016) explains qualitative data. Denscombe (2016) states that the data is presented in a non-numerical sense with support from visual photos which supports the aimed goal for the presentation of data in this report. Denscombe (2016) further explains, conducting a qualitative method makes a more profound study of a limited area which is applicable to a smaller study.

3.2 Data Collection

To enable a more profound knowledge about the field of research, interviews were held in accordance to a semi-structured method. A semi-structured interview method can be explained as when the interviewer, prior to the interview, has made a complete list of subjects and questions that will be answered. However, the order in which the respondent answers the questions is flexible and more focus is laid on the interviewee to answer in a more open-ended and detailed fashion (Denscombe, 2016). This method is interpreted to be the most applicable method for the purpose of the report. The individuals asked to participate will be recognized later in this section.

A *systematic review* of the data was chosen to enable a search for relevant research studies to support the transparency, reliability, and validity of the reports' content in regard to the implications of conducting an interview-based method (further discussed in 5.2). The theoretical backgrounds' data was provided through scientific articles, case studies, campaigns. Extraction of relevant information from the existing data was provided through Chalmers University of Technology library database, Web of Science, ScienceDirect, SpringerLink, and Google Scholar. The main terms of what was found to gather the relevant data are listed below.

Search terms:

- SECA
- Sniffer
- Compliance
- Monitoring
- Exhaust gas analysis

Moreover, as the report has different aspects to consider since technology advances at a high speed but discoveries regarding environmental studies have moved slower, technology-based articles were deemed relevant between the years of 2015-2020. Environmental aspects of the study have set a time mark within 2005-2020. Journal Articles usually have their studies peer-reviewed by other experts within the same field which increases the validity. However, this is not an assurance of the references' validity and therefore, each reference got assessed according to Denscombe (2016).

Assurance of the validity and relevance for journal articles (Denscombe, 2016).

- Age of the article.
- Is a national attribute included in the title?
- Can there be a clear indication that the articles have been reviewed?
- Is the author distinguished within the field?

The report has also been using data from different websites where the assessment of validity is highly critical since there are few restrictions on what can be published. Consequently, each website was assessed according to Denscombe (2016).

The four categories of validation of a website (Denscombe, 2016).

- The authority of the webpage.
- The webpages' credibility.
- How frequent the webpage is being updated.
- Popularity of the webpage.

The result section consists of data provided primarily from interviews. The authors wanted to collect data from different perspectives, researchers, authorities, and businesses. Four individuals, with relevant expertise within the field, were asked to participate in the report. Two experts within the Swedish surveillance authority, Transportstyrelsen, were asked to participate. Tobias Baatz who works as a ship surveyor and Caroline Petrini, an expert on environmental issues with a focus on the sulfur directive. Furthermore, Johan Mellqvist who managed the Identification of Gross Polluting Ships (IGPS) project at Chalmers and have worked with different similar projects, such as Compliance Monitoring (CompMon) (see 4.1.1). Finally, an interview with the part-owner of Explicit ApS, Bettina Knudsen was held. Explicit is a company that conducts sniffer measurements for the Danish Environmental Protection Agency (DEPA). The interviews in this study were conducted through "Skype" and "Zoom" applications, primarily because of the distance between the authors and the participants. The questions asked during each interview were sent to the participants before the scheduled interview, this was done to ensure a good response to the questions.

The data from interviews were analyzed according to a thematic analysis where Denscombe (2016) describes that a thematic analysis main objective is to identify patterns and the dividing lines between the data. Thematic analysis exists to explain the reason behind the different conceptions (Denscombe, 2016). Thematic analysis is a flexible analyzing method where it can offer a highly detailed but complex data within many studies. It is an appropriate analyzing method for those who are beginners in the research sector (Nowell et al., 2017). Furthermore, the study relies on already existing ideas and therefore the orientation of the thematic analysis is done in a deductive form. Several steps are done to analyze the data according to a thematic analysis.

1. **Familiarization with the data**

After each held interview, the authors transcribed the audio, read through the written transcription, and took initial notes of the text.

2. **Coding**

This step consisted of generating labels/codes in sentences throughout the full data-set to identify important features of the data which could be relevant to the research questions. This could be data which has patterns of e.g. assumptions and facts regarding each method.

3. **Generating initial themes**

Within this step, the authors examined the labels to identify a broader pattern that could potentially be themed.

4. **Reviewing themes**

To continue from step 3, the different initial themes that are later on seen as subjects which can be used to answer research questions, are combined and handled into a broader theme.

5. **Defining and naming themes**

The data were divided with the reports' research questions in mind, where the different themes are listed below.

- *Compliance* – The text labeled according to a "compliance" theme was seen to be a potential answer to the research question concerning compliance within SECA.

- *Compliance contradiction* – Once a pattern was seen regarding how the participants were answering the compliance rate question asked during the interviews, answers that deviated from that were highlighted and evaluated.

- *Sanctions* – The theme was decided from before the interviews to highlight a research question. Multiple views of the theme were desired, and a pattern was found.

- *Methods on a global scale* – Patterns were seen of theories behind what methods that could be used as global surveillance between the and therefore used as a theme.

- *Methods in SECA* – As the different experts provided data, themes were gathered by how the method works and how it is used and are handled under the general theme stated above.

- *Difference between methods* – The theme was brought up because of the lack of pattern between the interviewees, in which methods to use or the quality of the methods result.

6. The writing

This stage consisted of the authors composing the extracts of data and comparing it to the data collected in the theoretical part of the study to ensure validity. Thereafter, the process of writing the results began.

3.3 Ethical consideration

Reports, where the data is provided by individuals through interviews, have to consider ethical rules where the interest of the participants has to be ensured. To guarantee the well-being of the interviewees, the four main ethical principles are described by Denscombe (2016). These principles are to encourage one shared goal, that researchers in its quest for knowledge should not, inconsiderately, use the given methods at their disposal (Denscombe, 2016).

Before each interview, the participants were informed about the purpose of the research and the head questions that were to be asked during the interview. The participants were also assured for the privacy of their answers where the recordings of the held interviews were mainly for analytical reasons on behalf of the authors. The participants were also informed about their right to withdraw from the study at any point of time without explanation. This was compiled in a written document and signed by the participants.

4 Results

The result is divided into five parts, which are based on the themes of the questions from the interviews and the research questions. The result consists of data primarily from interviews held but supported by academic reports and journals, non-academic data as news articles and seminars.

4.1 Methods available for surveillance of sulfur emissions

According to Van Roy, (2016), the ultimate surveillance-achievement is to eventually prosecute non-compliant ships with the help of only air samples. There is no maritime law that would stop legalization of surveillance overseas. The report continues to state that the validation of the technical aspect is the biggest issue with the sniffer systems and its measurements. Van Roy (2016) further states what could be done to help the MARPOL Annex VI monitoring to get a European Standard.

- Frequently perform validation/calibration of sensors in the field to further ensure traceability of the sensors' performance.
- Validating the capability of sensor systems to measure SO_2 and CO_2 ratios in the field by puffing premixed high concentration gas standards at the gas inlets to simulate plume measurements.
- Compare the sniffer data with PSC results and,
- Compare the sniffer data from fixed and remote platforms.
- Airborne monitoring campaigns in cooperation with the industry and maritime sector.

4.1.1 Mobile measurement

One of the projects to demonstrate and find new available remote surveillance methods is the CompMon project which is funded by the European program Connecting Europe Facility (CEF). In this project, a sensor was fitted to a Piper Navajo airplane. The sensor itself was certified for ship surveillance measurements, where it has monitored individual ship measurement of FSC. The certified surveillance equipment consists of an optical module and a sniffer system. Even though this project mainly tried exhaust sampling on an airplane, the same technique will work on ships, e.g. patrol vessels and fixed sites. The opportunities for surveillance in the heavy shipping lanes are more fitted for airplanes, with the advantage of getting measurement up to 200 nautical miles from shore (Mellqvist, Jacobo, et al., 2017a). The DEPA, which has the assignment to control the compliance within Danish waters has taken a similar approach with using airborne surveillance, where they were the first authority to use a mini sniffer system (Explicit ApS, 2018). DEPA's monitoring activities have been conducted by Explicit ApS, which are using a similar platform as in the CompMon project, but instead of an aircraft, they have used a twin-engine helicopter of the brand Airbus AS355NP. The company has a mini sniffer system with a dual configuration which gives the instruments' sensor working in tandem (Explicit ApS, 2020).

4.1.1.1 *Standard sniffer system*

The standard sniffer system has two systems integrated into the unit, one is a UV fluorescence instrument for the ability to measure SO_2 concentrations, described further in 2.4.4. The second is a Cavity Ring-Down Spectrometer (CRDS) to measure CO_2 concentrations (Mellqvist, Jacobo, et al., 2017a). The unit weighs approximately 80 kilograms and because of its highly sensitive sensors, it can be fitted to fixed-wing aircrafts. This system requires a fraction of a second in the plume with an uncertainty margin of 0.1-0.2% FSC in a low gas concentration down to parts per billion (Van Roy, 2016). This highly-sensitive sensor can measure the exhaust concentration with a distance of 500 meters to 3 kilometers which are visually explained by figure 4, (J. Mellqvist, personal communication, 26 Mars, 2020), thereby leading to a more accurate methodology of measuring the exhaust concentration (Mellqvist et al., 2017a).

To ensure the validity of the measurement done by the standard sniffer system, calibrations are done before each measurement session. This calibration routine consists of a premixed gas which is guided to the suction side of the system, the concentration of the calibration gas consists of SO_2, CO_2 and nitrogen dioxide (NO_2) where the SO_2 and CO_2 are mixed with synthetic air while the nitrogen is mixed with nitrogen.

4.1.1.2 *Mini-sniffer system*

The system is developed around the concept of a cheap and light weighted system and because of that, the sensitivity of the sensors decreases (J. Mellqvist, personal communication, 26 Mars, 2020). It is required for the sensors to be in the vessels' plume between 15-30 seconds to get a good reading of the gases. Furthermore, the system requires a range of 25-100 meters from the vessel to be able to measure. Having the ability to relocate the system results in the ability to move it to laboratories who can calibrate it under lab-controlled conditions and get it certified under International Organization of Standardization (ISO) and is easier to work with for services, etc. (B. Knudsen, personal communication, 3 April, 2020). The Mini-sniffer systems sensor lifespan is approximately 100 operating hours which could be higher but having the margin ensures the validity of the measurement. Every 100 operating hours, a new unit is bought and installed on the rotary aircraft; this can be done because of its low cost (B. Knudsen, personal communication, 3 April, 2020). By using a mini-sniffer system, a trade-off has to be done between low cost, low weight, and sensitivity, the decreased sensitivity also makes a demand for more validation in order to compare the resulting FSC to other instruments (B. Knudsen, personal communication, 3 April, 2020).

The sensors' uncertainty margin depends on whether the system is operating under a single or dual system, meaning, if there are two independent systems operating in parallel and comparing the results or just one system that is sampling the gases in the plume (B. Knudsen, personal communication, 3 April, 2020). The uncertainty margin decreases by the number of systems that are working together since comparing results, a mean value can be calculated and that mean value is closer to the real value. Since the units' weight is just 500 grams, a rotary aircraft could theoretically be fitted with several pairs of systems working in parallel but realistically not a necessity since a dual systems' uncertainty margin is approximately 25%, a single based system is 42% (B. Knudsen, personal communication, 3 April, 2020). Explicit ApS has set that at one Relative Standard Deviation (RSD), the company will report anything measured over 0.125 for the 0.1% sulfur restriction.

4.1.1.3 *Differential Optical Absorption Spectroscopy*

A measurement can be conducted between 200-400 meters above the desired vessel which beats the standard sniffer system where it usually measures within an altitude of 65 meters. Furthermore, since the measurement does not require any contact with the vessels' exhaust plume like the sniffer system, there will be a reduction of time measuring since there is not a need of finding the correct positioning inside the plume just like the sniffer system needs (Van Roy, 2016).

J. Mellqvist (2020), states that his research has determined that a significant negative difference in accuracy is observed when measuring above 200 meters altitude. This can be explained by dilution of the gases with the atmospheric gases, this dilution effect can be reduced with larger optic devices. At the altitude of 200 meters, the instrument can distinguish ships using above 1% FSC (i.e. considered high) or less than 1% with an accuracy of 50%. This is done by measuring the SO_2 and combining that with the wind speed and fuel consumption further explained in 2.4.3. One clear disadvantage with the DOAS system is the dependency of solar light which will make a restriction regarding when the measurements can be conducted. Although the strict disadvantages with this system, authorities are planning to use this technique on their patrol vessels and airborne crafts (J. Mellqvist, personal communication, 26 Mars, 2020). As it can be an effective source of measurement in good weather conditions to get the first indication of non-complying vessels' which then can be further examined during PSC using fuel sample.

4.1.2 Fixed measurements

One approach to emission surveillance is installation of a measurement system on strategic positions, such as bridges and in channels where the vessel traffic is heavy (Mellqvist, Jacobo, et al., 2017b). This fixed measurement technique is designed to sample the exhaust gas of vessels passing by and thereby evaluate the FSC. The system is based on the standard sniffer system which is used in fixed-wing aircrafts where a gas analyzer is installed to measure SO_2 and a CRDS is used to measure the CO_2 concentrations (J. Mellqvist, personal communication, 26 Mars, 2020, Mellqvist, Jacobo, et al., 2017a). One of the two positions where the fixed measurement system is fitted is The Great Belt Bridge in Denmark, where approximately 25 000 ships pass by each year where the area has beneficial predominant wind conditions (B. Knudsen, personal communication, Mellqvist, Beecken, et al., 2017). The Swedish authority uses the fixed system located at the Öresunds bron as an indication of compliance (C. Petrini, personal communication, 22 April, 2020).

Fixed measurement stations can also influence the behavior of ships according to Knudsen, B. as they tend to see non-compliant vessels very rarely within The Great Belt Bridge area when they do airborne measurements. The few times where they do see non-compliance within the said area is when the wind condition makes it impossible for the fixed sniffer system to get a sample of gas from the vessel to measure (Mellqvist, Jacobo, et al., 2017b).

4.2 Compliance of the lowered allowed sulfur content

Transportstyrelsen has to complete a minimum number of approximately 385 tests annually, 275 out of these are documentation control and 110 are fuel sample tests (C. Petrini, personal communication, 22 April, 2020). Documentation control consists of an inspection of the bunker delivery notes, oil record book, or the International Air Pollution Prevention (IAPP) certificate under IMO (European Council, 2015, C. Petrini, personal communication, 22 April, 2020). The fuel sample test procedure is described in 2.4.1. In the Commission-implemented decision by European Council, 2015, Article 3 (3a) it is stated that the percentage of vessels to be checked for FSC compliance can be reduced by a maximum of 50% if the Member State uses “remote sensing technologies or quick scan analyzing methods”. One form of “quick scan analysing method” is an XRF which is used on the fuel sample by the Swedish and The Netherlands PSC inspectors.

Within the Nordic Member States, the level of compliance has been observed to be steady around 95% (B. Knudsen, personal communication, 3 April, 2020; C. Petrini, personal communication, 22 April, 2020) where most non-compliance tends to have approximately 0.12

or 0.13% FSC, one explanation could be late fuel switch-over when entering SECA. This is noticed amongst the Member States located on the border of SECA which has observed a slightly lower compliance percentage, e.g. The Netherlands and Belgium have reported a compliance rate of 87% (C. Petrini, personal communication, 22 April, 2020). Furthermore, vessels that rarely enter SECAs have been observed to be more frequently non-compliant (Lähteenmäki-Uutela et al., 2019; B. Knudsen, personal communication, 3 April, 2020).

IMO implemented the 1st of March 2020 a total ban of fuels with higher than 0.5% sulfur onboard ships. Furthermore, the fuel costs stand for roughly 40-60% of the total operating costs of a ship, and thereby reducing the fuel cost, will give advantages to the non-compliant vessels (B. Knudsen, personal communication, 3 April, 2020). The fuels are categorized between their sulfur content, which currently is the SECA approved fuel (0.1%), ULSFO, 0,5% which is the new global cap limit, VLSFO, and the old 3,5% which only is approved for ships with installed scrubbers, IFO380. (*Alfa Laval - Marine fuels in the low-sulphur era*, n.d.). A similar price change for the marine fuel oils could be seen when the 2020 restriction entered into force as when SECAs FSC was lowered in 2015, see section 2.3. The reduction of price would make it easier for the marine industry to follow through with the restriction because the lowered price of crude oil made the cost of VLSFO similar or lower to the IFO380 (J. Mellqvist, personal communication, 26 Mars, 2020).

4.3 Sanctions against the non-complying vessels

Enforcement of IMOs restrictions is done in each country by the Port or Flag to fit the legislation of their own state. Therefore, the sanction systems can differ between the different member states, which may cause confusion. For example, the US Coast Guard has the authority to sanction any non-complying vessel within the North American coast whereas different sanction systems are in place, depending on which state border you are located within in the Northwest European ECA. Sweden, for example, has a maximum penalty for non-compliance regarding FSC in SECA of approximately 900 000 EUR whereas there is no maximum penalty in Norway and Denmark, shown in table 1 (Molloy, n.d.).

The sanctions are generally handled in two different ways where it has shown various efficiencies amongst the states. Sweden has tried both where sanctions started off being handled within criminal law (C. Petrini, personal communication, 22 April, 2020; Transportstyrelsen, 2014). I.e. the results of a measurement that has been proven to be non-compliant shall be reported by the supervising authority (Transportstyrelsen) to the environmental- and work environmental department within the public prosecution authority. The law then states, within the Swedish Penal Code, that a hearing with the captain of the non-compliant vessel is necessary. It is also required that there should be enough evidence to prove that the vessel was intentionally running on a sulfur content higher than the restricted threshold (C. Petrini, personal communication, 22 April, 2020). This complicated the process to sanction any vessel as the ship had time to leave the country before the analysis of the fuel sample was finished and the attorney was notified. This resulted in zero prosecutions out of 31 reports of non-complaint vessels by Transportstyrelsen, between the years of 2010 to May 2014 (Transportstyrelsen, 2014).

The latest sanction systems entered into force 2018 after an investigation lead by Transportstyrelsen in 2013 on behalf of the government to evaluate how effective supervision of the maritime compliance shall be conducted once the 2015 regulations got implemented. Furthermore, the latest sanction system is regulated within the Swedish Environmental Code, where the sanction can be dealt with even if non-compliance was unintentional (Transportstyrelsen, 2014). Moreover, the environmental fine depends on the vessels' engine output (kW), daily consumption (m^3), and the extent of non-compliance, FSC (%) (T. Baatz, personal communication, 19 April 2020; C. Petrini, personal communication, 22 April, 2020).

4.4 Methods used by governments within European emission controlled area

Several monitoring systems are operated by the different Member States within the European SECAs (Beecken et al., 2019). Germany has three fixed standard sniffer systems on land. These instruments are located in the port of Hamburg, Bremerhaven and the Kiel fjord. Plans on expansion are in progress where there will be a ship-borne system monitoring exhaust concentration from vessels in the German territory of The North Sea and The Baltic Sea. Other countries such as The Netherlands, Denmark, Sweden (C. Petrini, personal communication, 22 April, 2020; B. Knudsen, personal communication, 3 April, 2020) and The United Kingdom are using fixed standard sniffer systems to monitor compliance (Beecken et al., 2019). Finland has done similarly, with installing six identical standard sniffers around the coast. They have also installed the same platform onboard a boat as an alternative to airborne sampling (Beecken et al., 2019). Except the fixed monitoring system, the airborne platforms are used in a variety throughout the European SECA Member States. Belgium has been using airborne measurement where the state has conducted roughly 400 flight hours above Belgian and Dutch waters. Furthermore, DEPA uses the same method but in a different approach as they are, with the help from Explicit ApS, carrying out aerial surveillance with their mini-sniffer system. During their years of operation, they have done measurements of over 2000 vessels over the north-west of Europe. They have also done surveillance for Dutch government and EMSA (Beecken et al., 2019).

4.5 Methods to use on a global scale

Since mobile or fixed methods would be difficult to use as a global surveillance instrument, On-board monitoring on each ship is a method that could be theoretically and even practically possible (International Transport Forum, 2017). The device can gather information about what type of fuel that the specific vessel is using at any point of time and place with the help of Automatic Identification System (AIS) which are transmitted to authorities, possibly THETIS. Although the risk of on-board personnel interfering with the device and the company being able to cheat would increase. Therefore, the installation would need to become more complicated as there would be a need to make the instrument safe from being tampered with. Furthermore, the device would then be located close to the fuel tanks or funnel where it has to withstand great heat (International Transport Forum, 2017).

Conducting measurements using satellites has also been a suggested method. As mentioned in 4.1.1.3, the DOAS technique is used in satellites to measure different emissions in the atmosphere where some satellites can measure an area of 7x7 kilometers in one pixel (J. Mellqvist, personal communication, 26 Mars, 2020). However, there are issues with using this method to measure SO_x as most of the solar light does not reach fully down to the vessels' plume as it is dispersed by particles along the way in the atmosphere and back to the instrument. This leads to a high uncertainty of what is being measured. The method is instead a promising way to measure the emission of NO_x from individual ships as it is easier to measure (J. Mellqvist, personal communication, 26 Mars, 2020).

5 Discussion

In this chapter, the result and method of the report will be discussed, divided into two subchapters. The first subchapter will discuss possible explanations and consequences of the result, followed by the method discussion where the validity and reliability will be discussed.

5.1 Result discussion

To survey the SECAs, there is today generally one method that are allowed to be handled as evidance; fuel sample analysis. Others are mainly used as a first indication of non-compliance. Primarily, because of the slow pace of adding or changing the law to be able to file sanctions against the non-complying vessels. As many are opposed to relying on new technology for a verdict of compliance, implementation of a law where results from these instruments can be used in court will likely take time to form. However, according to the respondents, data has shown that the technology is ready for it, having a more decisive part in verdicts and possibly handled as evidence. Even though fuel sample analysis is the method used to determine compliance, the exhaust gas analyzing instrument shows, according to respondents, similar if not the same results.

5.1.1 Fixed versus mobile measurement

The shipping industry is a global industry where mainly Europe has progressed within air sampling development, which creates a vacuum outside the European SECAs. In European waters, the remote surveillance gives valuable intel of the compliance behavior and generally about the emissions, which the rest of the world does not have (B. Knudsen, personal communication, 3 April, 2020). Of the different methods that are brought up in this report the most convenient one is the mobile, even though it is the most expensive since it needs an airborne craft that has high expenses in terms of fuel and personnel. Furthermore, this investment contributes to flexible compliance monitoring as the personnel can decide where the measuring will be located each day depending on the vessel traffic. Compared to fixed that mainly has an initial cost. However, weather conditions make it hard for the fixed measuring stations to gather exhaust gas samples of the vessels which highlights the weakness of the measurement instrument. This makes it obvious that the key to fixed instruments is the positioning of the measuring station. It appears that the closer to the port, the more eager it is for the vessels to follow the compliance level (C. Petrini, personal communication, 22 April, 2020). Therefore, positioning the fixed measuring stations at choke points could be more effective. The instrument located at the Great Belt Bridge has shown to contribute to a higher compliance rate within the area. Although, discussion occurred whether the fixed station mainly influenced the compliance rate in the specific area where it is located. Compared to the mobile measurement method, where the instrument is dependent on the element of surprise. This was shown when Explicit ApS was measuring at the Great Belt Bridge while it was easterly winding (i.e. impossible for the fixed instrument to measure the exhaust gas), the element of surprise let the company indicate that the vessel shows potential knowledge in the weakness of the fixed measuring instrument since a higher non-compliance was measured around the area.

There was a strong difference between these two methods through the interviews even though they are built on the same system. The sensors and mounting platforms are the only mechanics that differ between them, which gives them different pros and cons in their performance.

Table 2

Difference in performance between mini sniffer and standard sniffer systems.

	Mini sniffer	Standard sniffer
Distance to plume	25-100m	0.5-3km
Time to sample plume	15-30 seconds	Fraction of a second
Weight	0.5kg	80kg
Ability to move around	Yes, mounted	No, built inside
Service time	100h before change of sensor	Calibration gas before each measurement

The uncertainty in the measurement is at a similar level, but at different lengths from the plume, mini sniffer at 25 meters, and the standard at 3000 meters. Furthermore, the mini sniffer needs to be steady inside the plume for at least 15 seconds when the standard sniffer only needs to do a slow pass through the plume. The mini sniffers' low weight and size makes it easy to mount anywhere, which potentially in the future could enable a more flexible handling of the system where the unit could be mounted on e.g drones. Although, because of its required time spent in the plume it is primarily for rotary aircrafts such as Remotely Piloted Aircraft Systems (RPAS) e.g. drones. Because a mini-sniffer unit is substantially cheaper it is affordable to switch them every 100 hours. The units weight and size makes the mini sniffer a potential future system if the compliance monitoring systems should be ISO certified to have an influential role in the court.

Compliance needs to be surveyed throughout the global waters and not just within the SECAs. Even though airborne measurements could theoretically be done world-wide, it is too costly and impractical (International Transport Forum, 2017). Airborne based sniffer systems could reach far out at sea and cover large areas, but the maritime traffic is usually spread out and not travel in a typical column or straight line (J. Mellqvist, personal communication, 26 Mars, 2020). However, UAV methods are being tested and developed which could be a candidate for global compliance ensuring. Although, the drone systems are still highly restricted in form of airspace regulations (B. Knudsen, personal communication, 3 April, 2020) and fuel or battery life since the drone needs to be active out at sea for a long period of time (J. Mellqvist, personal communication, 26 Mars, 2020). If these problems were to be solved, it would make a good candidate for a global method regarding cost efficiency.

Sweden aimed to create a similar surveillance system as Denmark and Finland, but because of the economic restrictions, authorities made the settlement to use a fixed standard sniffer system on the Öresund bridge. As C. Petrini said, the cost has to be in relation to the demand, and today there is not a big deviation in the compliance. The observed deviation in Sweden is at the same level as Finland and Denmark at roughly 5%, which means 4-5 ships a year that get caught. However, Swedish authorities have recently started to investigate cooperation with companies which are doing airborne surveillance for oil spill where they potentially could install a standard sniffer system onboard (C. Petrini, personal communication, 22 April, 2020). A similar collaboration is conducted by a company that is monitoring oil spill within the waters outside Holland, Belgium, English Channel, and parts of the North Sea (C. Petrini, personal communication, 22 April, 2020).

5.1.2 Global sulfur restriction cap affecting SECA

The global restriction has had a positive impact on the compliance within SECA. Since the cap for FSC has been lowered globally, the high FSC non-compliance (i.e. vessels operating above 0.8% FSC) has shown a decrease within SECA (B. Knudsen, personal communication, 3 April, 2020). An earlier problem, in 2015, with ships that were about to enter the SECA border, tended to conduct a late fuel changeover. The same result showed once the vessels were about to leave the SECA border where the vessel shifted too early. This to save the consumption of the approved SECA fuel. Moreover, this behavior was further observed by J, Mellqvist in 2017 , and something B, Knudsen has observed as well. (Mellqvist, Jacobo, et al., 2017a; B. Knudsen, personal communication, 3 April, 2020). Due to the big fuel system some of the vessels have, measuring the FSC of vessels along the SECA border is shown to be problematic. It takes approximately three to six hours to burn off the residuals of the last operated fuel to see a decrease in the values in the exhaust gas. Therefore, the ship will indicate non-compliant even though the fuel switch to SECA approved fuel was conducted successfully onboard. This has to be taken into consideration when measuring the exhaust gases (B. Knudsen, personal communication, 3 April, 2020). Since the legislation demands that the vessels are operating on the correct fuel rather than what they are emitting out to the atmosphere.

5.1.3 Sanctions systems

The effectiveness of the different sanction system seems to be, amongst others, dependent on the efficiency of the state of conducting fuel analysis. Countries, where the analysis can be processed within a few hours, are seen to be able to handle the sanctions within the Criminal

Law more efficiently since the vessels do not have time to leave the country. Those countries where the fuel analysis takes more than a few hours could potentially risk the vessel leaving the country which complicates the sanctioning of the non-complying vessel. While Sweden handled the sanction system within Criminal Law, results showed that zero out of 31 non-compliant vessels were sanctioned between the years of 2010 – 2014. Sweden has since the implementation of the new sanction system been able to fine more vessels since the process has become easier to handle which could translate into a more effective sanction system.

It is unclear whether the companies get more affected by the *social* or *economic* consequences of non-compliance. Based on table 1, where the maximum financial penalties between different states are compared, these numbers would probably not have the financial impact as the intent of the sanction, for large shipping companies. Contrarily, social consequences in the form of a damaged reputation might be what motivates larger companies to comply (Lähteenmäki-Uutela et al., 2019).

5.1.4 Global surveillance method

One effective method regarding global surveillance instruments would be to install an FSC measuring device on board each ship. This device could be fitted for example in a tank, at the pump in the fuel system before or after the tank, or maybe a similar device as a sniffer system inside the funnel of the vessel (C. Petrini, personal communication, 22 April, 2020). We discussed whether it is possible to then reverse the responsibility of collecting the evidence to the vessel. This is used e.g. to determine whether the vessel is complying with the oil in water discharge, regulated in MARPOL Annex 1 Regulation 4. During a PSC the inspector would then compare the notes in the Oil Record Book and the flowmeter on the overboard valve. Furthermore, reversing the responsibility puts more emphasis on the personnel on board the vessel to comply with the FSC regulations.

However, to get the FSC measuring instrument out of the testing phase would mean that the company has to cover expenses in order to install the device. Furthermore, installing these systems would result in more maintenance for the crew. This together with the investment cost, could potentially make the maritime industry resist this type of development (B. Knudsen, personal communication, 3 April, 2020).

One way to overcome a global surveillance method was the new fuel ban implementation from IMO means you are not allowed to carry fuel above FSC restrictions onboard in the vessel’s bunker tanks. This would have been a restriction that would potentially get rid of the need for global surveillance methods since the PSC could survey the vessel based on the fluids in their tanks. However, IMO implemented a decision where fuels that are above the global FSC restriction could be operated, if the vessel is using exhaust after-cleaning methods (i.e. scrubber technique, which lowers the emittance of SO_x to the atmosphere).

5.2 Method discussion

A struggle regarding data collection through qualitative research is expressed by Denscombe (2016) where the data analysis used in the results could be influenced by the authors' own interest and speculations. Stated in 3.2, this reports' data were analyzed through a thematic analysis. The data is therefore processed and evaluated out of themes from the participants' data, the authors find that it could eliminate the influential downsides of qualitative research.

Furthermore, studies, where the data is extracted from interviewees, could not be considered fully trustworthy (Bryman & Bell, 2017). In order to establish trustworthiness (i.e. validity and reliability) within qualitative research, certain criteria have to be satisfied (Nowell et al., 2017);

- Credibility/Internal validity
- Transferability/External validity
- Dependability/Reliability
- Confirmability/Objectivity

Credibility is described as the correlation between the data/view of the respondents and the authors' representation of it. In order to enhance the credibility of the report, the authors assessed the data through reference triangulation. This is where the individuals have different perspectives within the field (i.e. researcher, business, and authority). Even though an increased number of interviewed individuals from the respective field could have further increased the credibility, data saturation was achieved where the participants answered in a similar pattern. *Transferability* is where other authors are interested to transfer the findings of specific articles to their own. Transferability can be judged through a rich description of the study which the authors consider to be achieved in this report. Furthermore, *Dependability/Reliability* is whether the authors have conducted the study in a trustworthy way. Reliability can be affected by the way the interviews were conducted since the authors did not have experience with interviews beforehand. Therefore, research was conducted on how to lead an organized interview to get the best data collection possible. However, based on the lack of experience one can argue that the result could vary depending on the researchers' skill of conducting an interview. *Confirmability* is achieved once all three criteria above are fulfilled. Furthermore, the last criteria refer to if the findings of the study were clearly derived from the data and not have been interpreted by the authors to impact the result. As the authors deem the criteria above are fulfilled, confirmability, and an overall validity and reliability of the study is achieved.

Denscombe (2016) states that a positive aspect of interview-based studies is the ability to easily capture insights within the field and the expertise that the participants withhold is shown. As the research questions were dependent on a study where a broader perspective into the field was captured, which interview-based methods get, the authors decided that an interview method would be most applicable for this report. As the interviews were conducted, a pattern was seen with the answers which indicated data saturation. Although data saturation, more emphasis could have been laid on interviewing further into the legal aspect of the study to get a wider perspective. Furthermore, using an interview method does have its issues. Denscombe (2016) describes one downside of using an interview method where the "interviewer-effect" is one issue to consider when conducting said method. This effect is explained to be when the interviewees' data get influenced by the interviewers' identity. Denscombe (2016) further states that this effect could be eliminated by conducting interviews through applications such as "Skype" where the interviews were held in this report. As the authors did not get the chance to interview the participants in person, discussion arose whether the data which the participants contributed would be more or less detailed if the participant were to be interviewed in person.

The authors also want to highlight whether the number of research questions made the study too general/broad. A study that is more delimited with just a one or two comprehensive research questions enables the authors to get a further thorough answer and acquire more in-depth knowledge about the specific field.

6 Conclusions

In the wake of the result, the shackling of the jurisdiction makes the fuel sample method the primary technique in order to sanction or file compelling evidence. Furthermore, a fuel sample is conducted in the PSC, handled by the surveillance authority in the specific region. Each fuel sample data is gathered within a program named “THETIS” which enables cooperation between the different Member States in SECA. However, in order to get a possible indication of which vessel that needs to be controlled by the PSC, measurements around the coast can be achieved by either conducting a *fixed* or *mobile* exhaust gas analysis in which several Member States within the SECA borders conduct.

Within the exhaust gas analysis methodology, two different techniques are used to measure the FSC. *Fixed measurement technique*, where the concept lies in locating the instrument to chokepoints in the shipping routes to influence compliance within an area. Furthermore, the *mobile measurement technique* originates on two similar, yet unlike systems, the standard and the mini-sniffer exhaust gas analysis. The standard instrument has an identical instrument as the fixed measurement station but fitted to an airborne vehicle, mainly fix-winged aircrafts because of its size and weight. Mini-sniffer, a cheaper version of the standard instrument where the price can be reduced. This price reduction can be achieved by the instruments’ less sensitive sensors which increases the time to measure the exhaust gas in the plume. Although, its low weight makes it able to be fitted on an unmanned aircraft (i.e. drone).

These instruments could be used on a global scale. The deciding factor of which system that could be used more efficiently, is based on which range the measurement should be conducted. Fixed-wing aircraft could cover large areas within a small time-zone, although, is the marine traffic too dense for it to be effective? Could it be more effective to focus on surveillance of the coastal borders and have a device on board each vessel that would log the fuel used and send that data to THETIS? One potential global method could be a measuring device installed onboard where authorities could follow the vessels’ operational fuel, live. This could then increase the efficiency of the PSC where the targeted vessel inspections can be more justified. Those vessels who violate the FSC regulation are sanctioned differently depending on which Member state they are located in. Sanctions are more commonly handled within the Environmental Code or Criminal Law where the maximum financial fines vary between the States. Although, the suffering from a social consequence could outweigh the financial suffering from an economical consequence in the form of a fine for maritime companies.

Authorities and surveillance personnel within the European SECA border states that the compliance rate has been high since 2015 (95%) where the majority of the non-complying vessels do not overstep a non-compliance of 20-30% above the allowed FSC. One explanation could be that the vessels conduct late fuel change-overs. I.e. the onboard personnel operates on the allowed fuels, although, residuals from the fuel before the change-over are still in the system and are burnt off which then will indicate for non-compliance with the exhaust gas analysis instruments.

Environmental research and development are important the current society, which brings up reflections on potential further research regarding the functionality of the exhaust gas analysis and optical measurements as the new NO_x emittance regulation enters into force 2021.

7 References

Air Emissions - Air pollution - Sulphur Directive - EMSA - European Maritime Safety Agency. (n.d.). Retrieved April 24, 2020, from http://www.emsa.europa.eu/main/air-pollution/sulphur-directive.html

Alfa Laval - Marine fuels in the low-sulphur era. (n.d.). Retrieved April 26, 2020, from https://www.alfalaval.com/industries/marine-transportation/marine/oil-treatment/fuel-line/marine-fuels-in-the-low-sulphur-era/

Andersson, K., Brynolf, S., Lindgren, J. F., & Wilewska-Bien, M. (2016). Shipping and the Environment: Improving Environmental Performance in Marine Transportation. In *Shipping and the Environment: Improving Environmental Performance in Marine Transportation*. https://doi.org/10.1007/978-3-662-49045-7

Balzani Lööv, J. M., Alfoldy, B., Gast, L. F. L., Hjorth, J., Lagler, F., Mellqvist, J., Beecken, J., Berg, N., Duyzer, J., Westrate, H., Swart, D. P. J., Berkhout, A. J. C., Jalkanen, J. P., Prata, A. J., Van Der Hoff, G. R., & Borowiak, A. (2014). Field test of available methods to measure remotely SOx and NOx emissions from ships. *Atmospheric Measurement Techniques*, *7*(8), 2597–2613. https://doi.org/10.5194/amt-7-2597-2014

Beecken, J., Irjala, M., Weigelt, A., Conde, V., Mellqvist, J., Proud, R., Deakin, A., Knudsen, B., Timonen, H., Sundström, A. M., Louie, P., Smyth, T., & Duyzer, J. (2019). *THE SCIPPER PROJECT Shipping Contributions to Inland Pollution Push for the Enforcement of Regulations*. https://www.scipper-project.eu/wp-content/uploads/2020/01/scipper_d2_1_20191220.pdf

Berg, N., Mellqvist, J., Jalkanen, J. P., & Balzani, J. (2012). Ship emissions of SO 2 and NO 2: DOAS measurements from airborne platforms. *Atmospheric Measurement Techniques*, *5*(5), 1085–1098. https://doi.org/10.5194/amt-5-1085-2012

Brandt, J., Silver, J. D., Christensen, J. H., Andersen, M. S., Bønløkke, J. H., Sigsgaard, T., Geels, C., Gross, A., Hansen, A. B., Hansen, K. M., Hedegaard, G. B., Kaas, E., & Frohn, L. M. (2013). Assessment of past, present and future health-cost externalities of air pollution in Europe and the contribution from international ship traffic using the EVA model system. *Atmospheric Chemistry and Physics*, *13*(15), 7747–7764. https://doi.org/10.5194/acp-13-7747-2013

Bryman, A., & Bell, E. (2017). *Företagsekonomiska forskningsmetoder*.

Burel, F., Taccani, R., & Zuliani, N. (2013). *Improving sustainability of maritime transport through utilization of Liquefied Natural Gas (LNG) for propulsion*. https://doi.org/10.1016/j.energy.2013.05.002

Cullinane, K., & Bergqvist, R. (2014). Emission control areas and their impact on maritime transport. In *Transportation Research Part D: Transport and Environment* (Vol. 28, pp. 1–5). Elsevier Ltd. https://doi.org/10.1016/j.trd.2013.12.004

Denscombe, M. (2016). *Forskningshandboken* (3:2).

EMSA. (n.d.). *THETIS - EMSA - European Maritime Safety Agency*. Retrieved April 26, 2020, from http://www.emsa.europa.eu/psc-main/thetis.html

European Council. (2015). *COMMISSION IMPLEMENTING DECISION (EU) 2015/ 253 - of 16 February 2015 - laying down the rules concerning the sampling and reporting under Council Directive 1999/ 32/ EC as regards the sulphur content of marine fuels*. http://data.europa.eu/eli/dec_impl/2015/253/oj

Explicit ApS. (2018). *Airborne Monitoring of Sulphur Emissions from Ships in Danish Waters*. https://www2.mst.dk/Udgiv/publications/2018/04/978-87-93710-00-9.pdf

Explicit ApS. (2020). *Airborne Monitoring of Sulphur Emissions from Ships in Danish Waters*. https://www2.mst.dk/Udgiv/publications/2018/04/978-87-93710-00-9.pdf

Global Average Bunker Price Bunker Prices - Ship & Bunker. (n.d.). Retrieved April 26, 2020, from https://shipandbunker.com/prices/av/global/av-glb-global-average-bunker-price

Havs- och Vattenmyndigheten. (2014). *Havsförsurning - Havsmiljö och vattenmiljö - Miljöpåverkan - Havs- och vattenmyndigheten*. https://www.havochvatten.se/hav/fiske--fritid/miljopaverkan/havsforsurning.html

Heritage, D. of the E. and. (2005). *Sulfur dioxide (SO2) - Air quality fact sheet*. https://www.environment.gov.au/protection/publications/factsheet-sulfur-dioxide-so2

IMO. (n.d.). *Air Pollution*. Retrieved February 26, 2020, from http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Air-Pollution.aspx

IMO. (2009). GUIDELINES FOR EXHAUST GAS CLEANING SYSTEMS. *RESOLUTION MEPC*, *184*(59). http://www.imo.org/en/KnowledgeCentre/IndexofIMOResolutions/Marine-Environment-Protection-Committee-%28MEPC%29/Documents/MEPC.184%2859%29.pdf

IMO. (2010). *AMENDMENTS TO THE ANNEX OF THE PROTOCOL OF 1997 TO AMEND THE INTERNATIONAL CONVENTION FOR THE PREVENTION OF POLLUTION FROM SHIPS, 1973, AS MODIFIED BY THE PROTOCOL OF 1978 RELATING THERETO (Revised MARPOL Annex VI)*.

IMO. (2013). Sulphur oxides (SOx) – Regulation 14. *Air Pollution and GHG Emissions*, 1. http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Sulphur-oxides-(SOx)-–-Regulation-14.aspx

International Transport Forum. (2017). *Corporate Partnership Board CPB* (pp. 1–42). https://www.itf-oecd.org/sites/default/files/docs/transition-shared-mobility.pdf

Kalli, J., Karvonen, T., & Makkonen, T. (2009). Sulphur content in ships bunker fuel in 2015 A study on the impacts of the new IMO. In *English*. Ministry of Transport and Communications.

Lähteenmäki-Uutela, A., Yliskylä-Peuralahti, J., Repka, S., & Mellqvist, J. (2019). What explains SECA compliance: rational calculation or moral judgment? *WMU Journal of Maritime Affairs, 18*(1), 61–78. https://doi.org/10.1007/s13437-019-00163-1

Mellqvist, J., Beecken, J., Conde, V., Jacobo, A. V. C., Ekholm, J., & Conde, V. (2017). *Surveillance of Sulfur Emissions from Ships in Danish Waters*. https://doi.org/10.17196/DEPA.001

Mellqvist, J., Jacobo, A. V. C., Beecken, J., & Ekholm, J. (2017a). *Certification of an aircraft and airborne surveillance of fuel sulfur content in ships at the SECA border*. https://doi.org/10.17196/COMPMON.002

Mellqvist, J., Jacobo, A. V. C., Beecken, J., & Ekholm, J. (2017b). *Fixed remote surveillance of fuel sulfur content in ships from fixed sites in the Göteborg ship channel and Öresund bridge*. https://doi.org/10.17196/COMPMON.001

Moldanová, J., Fridell, E., Popovicheva, O., Demirdjian, B., Tishkova, V., Faccinetto, A., & Focsa, C. (2009). Characterisation of particulate matter and gaseous emissions from a large ship diesel engine. *Atmospheric Environment*, *43*(16), 2632–2641. https://doi.org/10.1016/j.atmosenv.2009.02.008

Molloy, N. (n.d.). *THE IMO'S 2020 GLOBAL SULFUR CAP WHAT A 2020 SULFUR-CONSTRAINED WORLD MEANS FOR SHIPPING LINES, REFINERIES AND BUNKER SUPPLIERS*. Retrieved April 21, 2020, from https://www.isemar.fr/wp-content/uploads/2017/01/SR-IMO-2020-Global-sulfur-cap-102016.pdf

Nowell, L. S., Norris, J. M., White, D. E., & Moules, N. J. (2017). Thematic Analysis. *International Journal of Qualitative Methods*, *16*(1), 160940691773384. https://doi.org/10.1177/1609406917733847

Ribeiro, B. T., Silva, S. H. G., Silva, E. A., & Guilherme, L. R. G. (2017). Aplicações da fluorescência de raios-X portátil (pXRF) na Ciência do Solo tropical. In *Ciencia e Agrotecnologia* (Vol. 41, Issue 3, pp. 245–254). Federal University of Lavras. https://doi.org/10.1590/1413-70542017413000117

Saleh, T. A. (2020). Characterization, determination and elimination technologies for sulfur from petroleum: Toward cleaner fuel and a safe environment. In *Trends in Environmental Analytical Chemistry* (Vol. 25, p. e00080). Elsevier B.V. https://doi.org/10.1016/j.teac.2020.e00080

Singh, S. P., Saha, K., Singh, J., & Sandhu, A. P. S. (2012). Measurement and Analysis of Vibration and Temperature Levels in Global Intermodal Container Shipments on Truck, Rail and Ship. *Packaging Technology and Science*, *25*(3), 149–160. https://doi.org/10.1002/pts.968

Smith, T. W. P., Jalkanen, J. P., Anderson, B. A., Corbett, J. J., Faber, J., Hanayama, S., O'Keeffe, E., Parker, S., Johansson, L., Aldous, L., Raucci, C., Traut, M., Ettinger, S., Nelissen, D., Lee, D. S., Ng, S., Agrawal, A., Winebrake, J. J., & Hoen, M., A. (2014). Third IMO Greenhouse Gas Study 2014. *International Maritime Organization (IMO),*

327. https://doi.org/10.1007/s10584-013-0912-3

Transportstyrelsen. (2014). *Tillsyn och efterlevnad av de skärpta reglerna för svavelhalt i marint bränsle Slutrapport*. www.transportstyrelsen.se

Van Roy, W. (2016). *Best Practices Airborne MARPOL Annex VI Monitoring*. https://www.trafi.fi/filebank/a/1482762219/d80cdd7de80e58885ce5a4dd0af86c02/23541-Best_Practices_Airborne_MARPOL_Annex_VI_Monitoring.pdf

Wan, Z., Zhu, M., Chen, S., & Sperling, D. (2016). Pollution: Three steps to a green shipping industry. In *Nature* (Vol. 530, Issue 7590, pp. 275–277). Nature Publishing Group. https://doi.org/10.1038/530275a

8 Annex 1

Questions asked during interview with Johan Mellqvist

Why is it not possible to use the gas analyzing instrument in court? What makes it unreliable?

Why is “sniffer” technique the most common method of remote measurement and not “DOAS”?

What is the negative aspects to “DOAS”? Could it be used regularly?

Which method would be most applicable for sulfur surveillance globally, in your mind?

What kind of impacts do you think the new global sulfur content in fuel restriction on SECA?

How is the compliance within SECA since 2015?

What is the negative/positive aspects to the different mobile measurement systems?

9 Annex 2

Questions asked during interview with Bettina Knudsen, Explicit ApS

You're using the technique called "sniffer", what are the positive aspects with using the "mini-sniffer" technique compared to e.g. DOAS? Can you see any negative aspects?

Explicit ApS has been testing out measurements done by drones. Can you see different results using a helicopter compared to a drone?

What do you think is the negative and positive aspects of mobile surveillance and fixed surveillance?

How many measurements are done each year? How is the level of compliance?

Explicit is using the mini-sniffer system as the measurement method, how come you're using that and not, for example, the "standard" sized sniffer technique?

How do you guarantee the validity of your measurements?

What type of method do you think can be used on a global scale for the compliance of the sulfur restriction in the future?

What impact will the new global sulfur-restrictions have in the future for SECA?

How does it work when you notice or "red flag" a ship that is over the limit? Can you use your measurements as evidence in court?

10 Annex 3

Questions asked during interview 1 with Tobias Baatz, Transportstyrelsen

How is Sweden/EU conducting the compliance measurements within SECA today?

How many measurement controls are conducted annually?

What happens when vessels do not comply with the regulations? What kind of sanctions exist?

Is there a collaboration between the member states within SECA?

How do you know which vessels is next to inspect?

What is the distinction between the validity of taking a fuel sample and mobile measurements?

Questions asked during interview 2 with Tobias Baatz, Transportstyrelsen

How many of the inspections you conduct are based on indications from remote gas analysis?

Where do you take this fuel sample onboard?

How is the compliance rate within SECA?

Can you see any patterns of vessels that tend to not comply?

Is there any plans on implementing similar surveillance system as Denmark and Finland?

Has the authority made any preparations regarding the new global restrictions in 2020?

How do you think the surveillance methods will be conducted globally in the future, and also in SECA?

11 Annex 4

Questions asked during interview with Caroline Petrini, Transportstyrelsen

How many of the inspections are conducted through indications from e.g. “sniffer” technique?

How is Sweden/EU conducting the compliance measurements within SECA today?

How is the compliance rate within SECA?

What happens if the vessels do not comply?

How many vessels are sanctioned each year in Sweden for not complying to FSC restrictions?

Can you see a pattern where vessels from the same flag state/company tend to be more non-compliant?

Are there any plans on implementing similar surveillance system as Denmark and Finland?

Has the authority made any preparations regarding the new global restrictions in 2020?

How do you think the surveillance methods will be conducted globally in the future, and also in SECA?

Is there a collaboration between the Member States within SECA?