CHALMERS

Inventory and Evaluation of Environmental Performance Indices for Shipping

(Utvärdering av energi och miljöindex för sjöfart)

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Sammanfattning

Bakgrund

Efterfrågan på energi-, miljö- och hållbarhetsinformation om produkter från ett livscykelperspektiv har stadigt ökat sedan 1990-talet när stora konsumentorienterade företag har ökat sina miljö- och/eller hållbarhetskrav på leverantörer. Samtidigt har luftmiljö och hälsoproblem i tätorter och städer kommit i fokus och åtgärder mot utsläpp från landbaserade källor håller på att åtgärdas. De miljömässiga aspekterna av sjötransporter, i synnerhet för linjesjöfart som transporterar konsumentvaror och för passagerarfärjor som trafikerar städer, har härigenom kommit starkt i fokus.

I takt med att allt fler intressenter efterfrågar hållbarhets- och miljöinformation har också behovet av att hitta standardiserade sätt att ta fram och kommunicera informationen ökat. Ett stort antal verktyg såsom databaser, miljömärkning och miljöindex har utvecklats för att användas som beslutsunderlag för olika intressenter inom transportsektorn. Verktygen gör det möjligt för befraktare och transportköpare att välja fartyg och rederier utifrån miljöprestanda och energieffektivitet. Dessutom ger de möjligheter för rederierna att kommunicera sitt miljöarbete i ett framtida affärsklimat där sjöfart inte bara mäts i kapacitet eller kostnader. Några av dessa system kan också användas i ekonomiska styrmedel för att minska miljöpåverkan i hamnar, t.ex. genom reducerade hamnavgifter vid god miljöprestanda. Miljöindex kan således förväntas vara en viktig del av miljöinformationen kring varor och tjänster i framtiden.

Floran av miljöindex som utvecklats varierar mycket i omfattning, kvalitet och transparens. Det saknas även vetenskapliga studier av miljöindex tillämpat för sjöfart. Majoriteten av tidigare studier om miljöindex för sjöfart har fokuserat på att jämföra index eller att hitta framgångsrika parametrar för att utveckla ett nytt index.

För att försöka ge ökad kunskap om miljöindex för sjöfarten och ta fram beslutsunderlag för transportköpare, sjöfartsindustrin och myndigheter har en studie har genomförts som ett delprojekt i ett tioårigt samarbete mellan Chalmers och Göteborg Energi AB. Denna rapport är resultatet av delprojektet ToE02 *Utvärdering av energi och miljöindex för sjöfart* som utförts vid institutionen för Sjöfart och marin Teknik på Chalmers. Projektresultatet utgör en startpunkt för att kunna utvärdera olika index vad avser användningsområde och användare.

Genomförande

I ett första steg genomfördes en inventering av relevanta initiativ att kommunicera miljöprestanda av fartyg och rederier. Resultatet av inventeringen visade på en stor mångfald av initiativ kopplade till en lika stor mångfald av aktörer. Totalt 38 olika initiativ kunde identifieras. De hade olika omfattning, målgrupper och tillämpning. De flesta befintliga initiativ bygger på ett antal miljökrav och standarder, där t.ex. specifik utrustning, operativa åtgärder eller efterlevnad av miljölagstiftning belönas på ett eller annat sätt. Sådana belöningar kan vara poäng i ett indexsystem eller ekonomiska incitament såsom reducerade hamnavgifter. Vissa initiativ var baserade på mätbara uppgifter om fartygs

miljöprestanda, t.ex. specifika utsläppsmängder. Ett flertal initiativ fokuserade på utsläpp av luftföroreningar eller en kombination av energieffektivitet och koldioxidutsläpp.

Definition av ”miljöprestanda index”

Baserat på inventeringens resultat identifierades ett antal "miljöprestanda index". Dessa index är alla frivilliga miljöinitiativ som baseras på indexeringssystem av fartygs eller rederiers miljöprestanda. Tio initiativ kunde i ett initialt skede identifieras enligt denna definition. I analysen diskuteras vidare kring vilka av dess som egentligen är att definiera som ”miljöprestanda index” och vilka som inte är det inte. Detta gav fem index som uppfyller definitionen av på huvudsakliga aspekter och kriterier för index som framkommit i en litteraturstudie om miljöindex och miljöindikatorer. Följande tre index utvärderades slutligen i mer detalj:

1. *Energy Efficiency Operational Indicator*
   – utvecklat av FN:s internationella sjöfartsorganisation
2. *Performance Metrics Tool*
   – utvecklat av Clean Cargo Working Group
3. *Clean Shipping Index*
   – utvecklat av Clean Shipping Project

Vart och ett av de tre bedömer miljöprestanda baserat på data för enskilda fartyg, som sedan sammanställs till ett slutligt index. De senare två indexen använder poängsystem för olika miljöområden och inkluderar prestandakrav för att få poäng.

Slutsatser

Studien i sig kan bidra till att förklara de olika begrepp för initiativ som ofta marknadsförs som miljöindex för fartyg. Dessutom kan det vara ett sätt att lösa de metodproblem som uppstått vid jämförelse mellan olika initiativ i tidigare studier.

Användningsområden för indexen

De tre index som detaljstuderats kan användas på olika sätt, exempelvis av ett rederi för att marknadsföra miljöprestanda av sina fartyg samt jämföra med industriprestanda eller av en transportköpare för att välja fartyg och rederier utifrån deras prestandaresultat. Tredjepartsverifiering finns tillgängligt för alla tre index, vilket medför kvalitetskontroll av de uppgifter som används för att utföra prestandabedömningen. De tre indexen har många likheter, även om de även visar en stor variation i deras konstruktion och tillämpning. Den stora variationen kan förklaras med att olika intressenter är knutna till indexen. En generell slutsats är att egenskaperna hos ett visst index beror på tänkt användning av indexet, vilket i sin tur beror på tänkt användare och vilka som utvecklat indexet. Valet av index inom denna grupp är således beroende av användning och kommunikation snarare än ”kvalité” hos själva indexet.

Generella användningsområden för denna rapport

För beslutsfattare inom sjöfartsnäringen kan denna rapport ge beslutsunderlag för val av index eller andra verktyg för miljökommunikation. Rapporten kan vidare ge underlag för företag att utvärdera sina leverantörers olika verktyg för marknadsföring av miljöprestanda. Den kan användas för att identifiera de verktyg som används av rederier och deras betydelse i relevant användningsområde,

omfattning och grad av miljöprestanda, samt kvalitetskontroll. Företag kan vidare använda resultaten som en del av en större miljöstrategi för hela sin leverantörskedja. De kan välja ett relevant index (eller andra initiativ som identifierats i rapporten) som ett miljökrav på sina leverantörer. Leverantörers miljöprestanda kan lätt bedömas av många av de funna verktygen, men i olika grad, med olika aspekter och olika nivåer av kvalitetskontroll. Genom att välja ett initiativ som tydligt visar miljöprestanda av sjötransporter kan företag välja sina leverantörer därefter eller kräva att de presterar bättre. Detta skulle kunna möjliggöra marknadsföringsmässiga fördelar. En annan möjlighet är att flertalet initiativ har potential att minska transportkostnaderna, särskilt genom att peka på åtgärder för energieffektivitet, men också genom reducerade hamnavgifter i exempelvis Göteborgs Hamn.

Användningsområden för Göteborg Energi som energileverantör till sjöfarten

Förutom de allmänna aspekterna på företags användning av miljöindex, ser vi ett par områden Göteborg Energi har möjlighet att bidra till minskning av miljöpåverkan från sjöfart och där detta kan mätas i index.

Göteborg Energi har en roll i miljöpåverkan från sjötransporter genom att vara leverantör av energi till fartyg. I dag finns möjlighet att leverera ”landström” (”cold ironing”) till fartyg vid kaj och på så sätt eliminera behovet av hjälpmotorer för elgenerering. I Clean Shipping Index kan cold ironing för hjälpmotorer tillgodoräknas.

För Göteborg Energi i egenskap av potentiell leverantör av naturgas, och i en framtid biogas, till sjöfartenligen kan nämnas att användningen av LNG som fartygsbränsle ger poäng i många indexsystem. Som tidigare nämnt kan ett bra resultat i ett index även innebära reducerade hamnavgifter. Användningen av LNG kan innebära minskade luftföroreningar i hamn och i t.ex. Göteborgs stad. Genom att investera i infrastruktur för LNG finns det alltså möjligheter för marknadssynergier mellan Göteborg Energi, rederier, hamnar och indexsystem.

Abstract

Increased demand for environmental, energy and sustainability information on products in a life cycle perspective has led to the development of a large number of different voluntary initiatives aimed at communicating the environmental performance of sea transport, such as databases, indices, labels and certificates. There is however a lack of scientific studies that applies the research area of environmental indices to shipping. The majority of previous studies on environmental indices for shipping have focused on comparing indices or to find successful parameters for developing a new index. This study has conducted an inventory of environmental initiatives applicable for communicating environmental performance of ships and shipowners. It has then identified and evaluated voluntary initiatives that are based on an indexing system; defined as 'environmental performance indices'. The evaluation was conducted on three indices based on principal aspects and criteria found in literature.

The results of the inventory showed a large diversity of 38 environmental performance initiatives related to a diversity of stakeholders. They had different scope, target groups and applications. Most existing initiatives are based on a set of environmental requirements or standards, where specific installed equipment, operational measures, management aspects or compliance with environmental legislation are rewarded in one way or another. Such rewards could be score points or for example reduced port dues. Some initiatives were however based on environmental performance data such as specific emission levels. Many further focused on air emissions and energy efficiency or carbon dioxide emissions. Ten initiatives were identified as environmental performance indices, though their inclusion within this definition was later discussed in further analysis.

The following three indices were evaluated: (1) the Energy Efficiency Operational Indicator developed by the International Maritime Organization, (2) the Performance Metrics Tool developed by Clean Cargo Working Group, and (3) the Clean Shipping Index developed by the Clean Shipping Project. The indices each assess environmental performance based on data for individual vessels, which then is aggregated into a final index. The last two indices use scoring systems for different environmental areas and include performance requirements. These indices could be used for a shipowner to benchmark and market environmental performance of their ships, and for a transport buyer to select the ships and shipowners according to their performance results. Third-party verification exists for all three indices, which provides quality control of the data used for the performance assessment.

It was concluded that the three indices have many similarities, though they show a large variation in their construction and application. The varieties of the three indices could be explained by the variety of stakeholders connected to them. It was concluded that the properties of a particular index depend on the indented use, which in turn depends on the intended users and the developer of the index. It was further concluded that the variety of different initiatives is problematic and shows a need for global standardized methods. The study could contribute to bring order to the variety of concepts of the different initiatives associated with environmental ship indices. It could also identify potential uses and users of the indices. In addition, it could be one way of solving methodological problems of comparison between different indices identified in earlier studies.

Keywords: environment, energy, performance, index, initiatives, shipping, inventory, evaluation

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1. Introduction

1.1. Background

Sustainability and environmental performance is becoming a day-to-day business for many companies. A variety of tools for communicating environmental and sustainability performance of products, services, activities and organizations exists today, e.g. environmental labels, *Environmental Product Declarations* (EPDs), *Life Cycle Assessments* (LCAs), *Environmental Performance Indicators* (EPIs), Ecological Footprints, *Environmental Management Systems* (EMS) and *Environmental Impact Assessments* (EIA). According to Laumer (2009), a consumer-oriented company can only become more sustainable if it engages its direct suppliers and encourage them to engage their suppliers in the supply chain. If large companies do so, it could have large positive effects on the overall environmental performance of companies worldwide. A strong trend is now seen among large consumer-oriented companies, demanding environmental or sustainability performance of their suppliers. In 2009, the large company Wal-mart started demanding that their over 60 000 suppliers perform against a Sustainable Product Index (Laumer, 2009; Sustainable Shipping Initiative, 2011).With an empirical study of 74 companies in eight sectors, Vandenbergh (2007) found that over half of the studied companies imposed environmental requirements down the supply chain. These represented over 76% "of the total sales of the top firms in the sectors" (Vandenbergh, 2007, p.4). This trend is driven by consumer preferences, which in turn is driven by campaigns or boycotts by environmental NGOs[i] (Vandenbergh, 2007).

About 80% of the world trade volumes are transported by sea (UNCTAD, 2008). As customers demand accounting of the overall environmental impacts of products and services, the environmental aspects of sea transportation has recently caught more attention, in particular for liner shipping (Sustainable Shipping Initiative, 2011). Recent technological development makes it possible to monitor environmental performance on board ships at an affordable level for shipowners (Sustainable Shipping Initiative, 2011). The need for standardisation of data has become essential in order to use and communicate comparable environmental information in shipping. A large number of databases and environmental initiatives, such as *environmental indices*, has been developed that can be used as a basis for decision-making within the transport sector. These will make it possible for charterers and shipping customers to select ships and shipowners on the basis of environmental performance and energy efficiency. Moreover, it will make it possible for the shipowners to communicate its environmental efforts in a future business climate were not only performance is measured in capacity or costs. Some of these systems could also be used as voluntary economic instruments to reduce the environmental impacts in ports, e.g. rebates on port dues (Sustainable Shipping Initiative, 2011).

Environmental performance index for shipping is in this report described as a tool for measuring and assessing environmental performance of ships and shipowners. The resulting index could be used as communication of the performance in the form of a certificate, a label, an award or a score in a rating system.

[i] NGO = Non-Governmental Organization

1.2. Terms of Reference

Chalmers University of Technology and Göteborg Energi AB has begun a ten-year co-operation with a shared vision of a sustainable society. In line with this vision, the project ToE02 *Utvärdering av energi och miljöindex för sjöfart* was established in 2011 and the main work was conducted from August to November 2011. The goal of this project has been to provide increased knowledge of environmental indices for shipping. The results could contribute to greater understanding of the present index systems and their underlying core values. It could be used as decision support for Göteborg Energi, shippers and shipping companies. It could also contribute to a research area of environmental indices, which lacks studies of indices applied to shipping. The contribution of this study is further elaborated in section 6.4.

1.3. Purpose and Research Questions

The first purpose of this study was to conduct an inventory of environmental initiatives applicable for communicating environmental performance of ships and shipowners. The second purpose was to identify and evaluate voluntary initiatives that are based on an indexing system; defined as 'environmental performance indices'. The evaluation of a selection of indices was conducted based on principal aspects and criteria found in literature.

The following research questions formed the basis of the study:

1. What tools exist for communicating environmental performance of ships and shipowners to costumers, ports and the public?
2. Which of the voluntary initiatives are based on an indexing system?
3. By evaluation of a selection of indices, how do they correspond with principal aspects and criteria found in literature?

1.4. Delimitations

The inventory was delimited to initiatives that could be used for the shipping industry to communicate environmental performance. Individual company initiatives were excluded if they only apply their own fleet. The evaluation was delimited to only include voluntary indices that measure and communicate the environmental performance of ships and shipowners. Individual port incentive systems were excluded for evaluation. Moreover, initiatives currently being developed or proposed were included in the inventory, but not in the evaluation. Further detailed information on delimitations, definitions, selection criteria and evaluation criteria is described in Chapter 3.

2. Literature Review

This chapter is a literature review on environmental and sustainability indicators and indices, followed by a brief review of two reports on environmental ship indices. It is not indented to be a complete literature review on these topics, but to act as a foundation of definitions, criteria and aspects used of this study. It is further the basis of the developed evaluation scheme described in section 3.3.

2.1. Environmental and Sustainability Indicators and Indices

2.1.1. Indicators

"*People can't respond to information they don't have. They can't react effectively to information that is inadequate. They can't achieve goals or targets of which they are not aware. They cannot work towards sustainable development if they have no clear, timely, accurate, visible indicators of sustainable development*" (Meadows, 1998, p.5).

Ness et al. (2007, p.499) defined indicators for use in sustainability assessment as "*simple measures, most often quantitative that represent a state of economic, social and/or environmental development in a defined region*". However, this definition gives a false view of what indicators are. It is often not possible to measure the complete state of a system but rather the perceived state from an indicator or several indicators. The exact population of a specific fish in the ocean cannot be measured, but the catch can be measured and the population can be estimated. Meadows (1998, p.6) wrote that "*no indicator is the real system. Indicators are abstractions from systems*". An indicator measures a specific factor, e.g. tonnes of nitrogen compounds released per year from land-based sources into the Baltic Sea. According to Hammond et al. (1995, p.1), the "*significance of indicators extends beyond what is actually measured to a larger phenomena of interest*". It could provide "*a clue to a matter of larger significance or makes perceptible a trend or phenomenon that is not immediately detectable*" (ibid). Tonnes of nitrogen compounds released per year into to the Baltic Sea may not say much of the state of the sea for policy-makers, but if the amount is shown in relation to the nitrogen *critical loads*[ii] for of the Baltic Sea, it could provide a clear indication of eutrophication and the need for action. The nitrogen indicator example could be included in the group *environmental indicators*, which often measure environmental pressures and conditions, but also societal responses. They could include physical, biological and chemical indicators (Niemeijer, 2002).

Sustainability indicators (SIs) are more complex than environmental indicators. Often several different indicators are needed to measure sustainability. The question of what is to be measured by SIs depends on the definition of sustainability. What is intended to be sustained and what is intended to be developed and for how long? *Sustainable development* and *sustainability* are terms lacking consensus with a variety of different and vague definitions (Bell and Morse, 2008; Kates et al., 2005). The 1987 Bruntland report contains the internationally accepted definition: "*development that meets the needs of the present without*

[ii] "*A quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge*" (Grennfelt and Nilsson, 1988, p. 9).

compromising the ability of future generations to meet their own needs" (WCED, 1987). After the Bruntland Report, many more detailed definitions have been developed. In the early literature, "development" has often been seen as "economic development". More recently, however, the attention has shifted to "human development", which adds factors such as life expectancy, education and equity. As a result of initiatives involving a large diversity of stakeholders with different views, most sustainability indicators are based on a broad list of what to be sustained and developed (Kates et al., 2005). Meadows (1998) stressed that, in addition to environmental indicators, SIs should be expressed in units of time or be related to carrying capacity, threshold of danger or to targets. They can be used to answer questions on how long an activity could last within the limits of resources or if the current policy is sustainable within a defined period. However, Kates et al (2006) observed that the time period is often short term in existing SIs. The *Global Reporting Initiative* (GRI) has developed a reporting framework for sustainability, which is used in business worldwide. It consists of principles and performance indicators aimed at sustainability (also referred to as *Sustainability Performance Indicators*, SPIs).The GRI indicators have three main categories; economic, environmental, and social. The social category is in turn dived into labour practices, human rights, society, and product responsibility (GRI, 2011a-b).

2.1.2. Aggregation and Indices

Indicators and indices help to simplify, understand and communicate complex scientific or statistical data. The information pyramid in Figure 2.1 (adapted from Hammond et al., 1995), shows that primary data can be analysed as a first step and then communicated in the form of indicators, which in turn can be is aggregated to indices. An *index* is a condensed description of a state (e.g. state of the environment) derived from aggregation of several indicators or variables and expressed in a single quantity (Ness et al., 2007; Ebert and Welsch, 2004). A large number of individual indicators send confusing and often conflicting signals. The use of an index is much easier to interpret and could "*provide decision-makers with clearer and more compelling information*" (Millennium Ecosystem Assessment, 2003, p.189, Box 8.1). The level of aggregation depends on the indented use and users (Hammond et al., 1995). Baumann and Tillman (2004, p.38) underlined that "t*oo much aggregation hides relevant information and introduces additional uncertainty, while too little aggregation drowns the interesting information in too much detail*".

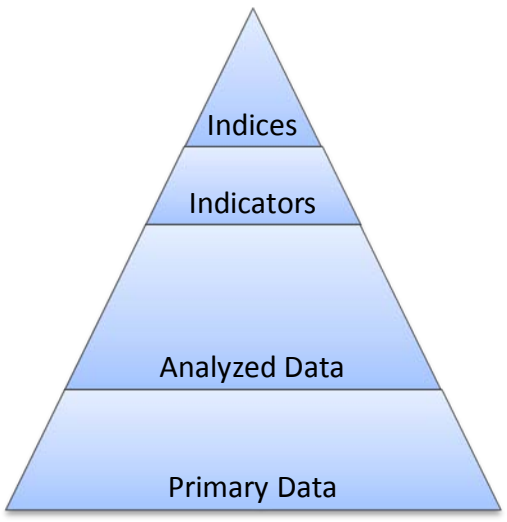

Figure 2.1. The Information Pyramid (adapted from Hammond et al., 1995, their figure 1)

Many indices have been developed to measure economic development and the most well-known indices to the public are the *Gross National Product* (GNP) and the Dow Jones Index (Meadows, 1998). Environmental indices include instruments for policy-makers, such as the *Environmental Vulnerability Index* (EVI) developed by the *South Pacific Applied Geoscience Commission* (SOPAC) and the *United Nations Environment Programme* (UNEP). The EVI is designed as an index for one of the three pillars for sustainable development; economic, environmental and social (Environmental Vulnerability Index, 2011). Another example is the *Environmental Performance Index* (EPI)[iii][iv], developed by Yale University and Colombia University in collaboration with the World Economic Forum. The EPI measures and ranks 163 countries' environmental policy performance based on 25 indicators. The index can be used as an instrument to show how close governments are to their environmental policy goals (Emerson et al., 2010).

A recent development is carbon footprints and CO_2 indices as tools for measuring and communicating greenhouse gas emissions for products, services or organizations. This is known as greenhouse gas accounting. The *Greenhouse Gas Protocol* by the *World Resources Institute* (WRI) and the *World Business Council for Sustainable Development* (WBCSD) provides a world-wide used accounting tool on greenhouse gases for governments and business organizations (The Greenhouse Gas Protocol Initiative, 2011). Energy (efficiency) indices are also common in business today. In the transport sector, energy and CO_2 labels are applied for cars (e.g. in g CO_2/km) or for truck engines (e.g. in g pollutant/kWh and the EURO standards) (den Boer et al., 2009). An example of sustainability indices is the Wellbeing Index, which was used for 180 countries of the *World Summit for Sustainable Development* (WSSD) in Johannesburg 2002. Based on aggregation of over 60 indicators, it consists of the *Human Wellbeing Index* (HWI) and *Ecosystem Wellbeing Index* (EWI). The results of the two indices are combined into the Barometer of Sustainability for illustration (Ness et al., 2006).

Meadows (1998) listed 15 characteristics for ideal indicators or indices based on typical lists found in studies developing indicators. However, Meadows stressed that all these ideal characteristics are difficult to meet in a single indicator/index. Since these ideal characteristics apply to sustainability indicators of primarily governmental use, only the ones relevant to this study are listed below (Meadows, 1998, p.17-18).

- *Clear in content* – easily understandable
- *Feasible* – measurable at a reasonable cost
- *Sufficient* – not too much or too little information
- *Appropriate in scale* – "not over- or under-aggregated"
- *Democratic* – People should be able affect the choice of indicators and get access to results.
- *Hierarchical* – The user should quickly get the general message, but also be able to view detailed information.
- *Physical* – Physical units are preferred before monetary units.
- *Leading* – Information should be given in time for action.
- *Tentative* – should be up for discussion and have the ability to change.

[iii] The EPI was preceded by the Environmental Sustainability Index (ESI) between 1999 and 2005.
[iv] The ESI was categorised as a sustainability index by Ness et al. (2007). It is noted in the work of the present study that the distinction between these categories is vague in practice.

Harger and Meyer (1996) listed six factors that should be taken into account when developing sustainability indicators.

- *Simplicity* – as simple as possible
- *Scope* – should cover a whole spectrum of activities
- *Quantification* – should include readily measurable elements
- *Assessment* – included elements should be capable of being monitored
- *Sensitivity* – sensitive enough to reflect changes
- *Timeliness* – frequency and time period should be sufficient for trend analysis

2.1.3. Environmental Performance Evaluation and ISO 14031

In business, it has become common to use *Environmental Performance Indicators* (EPIs) for measuring an organization's environmental impacts, to show how the organization is performing, and in which areas it can improve (DANTES, 2011). Moreover, so called *Environmental Key Performance Indicators* (environmental KPIs) focuses on the most important environmental impacts and measures for a particular business or company (DEFRA, 2006). Environmental Performance Evaluation (EPE) is dealt with under the standard ISO 14031. The standard contains principles for derivation of environmental indicators. Jasch (2000) listed these principles, as shown below.

- *Comparability* – The used indicators must be comparable.
- *Target-orientated* – The choice of indicators should be directed by company goals.
- *Balanced* – Environmental performance must be reflected with a balance of both problems and benefits.
- *Continuity* – The indicators must have the time series and time units.
- *Frequency* – The frequency of measurements must be sufficient for action to be taken in time.
- *Comprehensibility* – The indicators must be in correspondence with the needs of information, as well as understandable for the user.

2.2. Environmental Ship Indices

The Swedish study by Jivén (1999) was conducted as a feasibility study of a potential environmental ship index. The goal of the index should be that a reduction of environmental impact would provide positive outcome in the index. According to Jivén, the purpose of developing an index is that it should contribute to a reduced environmental impact of the activity it measures. I should identify areas where action is needed most and provide guidance to the choice of measures. It should enable the use of the index in the choice between different transports and between different ships or operators. I should also be applicable as a basis for reduces fees or taxes.

Relevant criteria could also be found in EMSA (2007), identified the following characteristics to be fulfilled by a proposed European "Clean Ship" Label.

1. Comprehensive.
It should not be restricted to certain vessel types or pollution types.

2. Complete.
The requirements of the label should be met by both the management of shipping companies and ships by ship design and technical equipment. It also should include on-board social and safety aspects.

3. High public visibility.
High public visibility could enable use of the label in environmental marketing strategies.

4. Flexible.
The system should be updated regularly for adaptation of technological developments and "ideas about environmental protection and pollution prevention" (EMSA, 2007, p.129).

5. Result-oriented.
EMSA highlighted that the possibilities for improvement of environmental performance are numerous. The proposed labels should thus be based on achievable results and not on specific technologies or measures.

6. Easily verifiable.
Compliance of the proposed system should be verifiable by either Port State Control or classification societies acknowledged by IACS.

7. Simple.
Complicated ranking systems should not be used. EMSA highlighted that too many and too ambitious criteria may lead to high bureaucracy. It was proposed that the system should be divided in a set of mandatory requirements and a set of optional requirements (with a certain percentage that needs to be fulfilled).

3. Method

This chapter describes the working procedure and methods of this study. It describes the methods used for data collection and analysis of data. It also shows the motivations for the choice of methods. The study was conducted in three phases shown below. As such, this chapter is divided in the same order.

1. Inventory of environmental performance initiatives
2. Identification of voluntary environmental performance indices and selection for evaluation
3. Evaluation of selected indices

3.1. Phase 1: Inventory

The inventory undertakes an exploratory approach, which is done to understand the nature of the problem when little is known or few studies have been made in the research area. The terms of reference for this study were to conduct an inventory and evaluation on environmental indices. The work thus started by searches on environmental indices for ships or shipping companies on Google and the database Scopus (Elsevier)[v] in order to explore the subject and to obtain an initial list of environmental indices. Nothing was found on the database searches, though several results were found on Google. Obtained index studies and reports were investigated. The initiatives found in these reports were listed and further information was gathered. Moreover, the reference lists of found reports were investigated. A matrix of brief info and information sources was developed during this initial period.

With regard to the terms of reference, the term 'index' was becoming a large data gathering delimitation. Some studies categorized them as indices and other with different terms. In order to not exclude systems which only can be defined as indices, an inventory of environmental initiatives was conducted. The condition for inclusion of initiatives in the inventory was that such an initiative could be used for the shipping industry to communicate environmental performance. The inventory was thus conducted to answer first research question:

- *What tools exist for communicating environmental performance of ships and shipowners to costumers, ports and the public?*

The inventory included already found initiatives during the initial period. Further searches and data gathering were conducted using the same exploratory approach. One specific study was used as a basis for the inventory. EMSA (2007) identified 47 different systems and initiatives. These were examined and the initiatives were categorised according to their relevance for this study (due to the delimitations described in section 1.5). Relevant initiatives were investigated further. Information was gathered on each found initiative of the inventory, and was found from webpages, brochures, flyers and reports. The information was collected and written in seven different tables, representing the below categories.

[v] http://www.scopus.com

1. IMO Instruments
2. National Instruments and Initiatives
3. Classification Societies
4. Ports and Port Associations
5. Cargo Owners, NGOs and Shipping Associations
6. Proposals and On-going Initiatives
7. On-board tools, Software and Calculators

The existing initiatives found were divided in the five first tables depending on the provider of service or developer. The last two tables represent on-going initiatives and proposals and various on-board tools, software and calculators found during the inventory. The tables were divided in the columns *Indented Use and Users* and *Basis / Scope.* These columns intend to briefly answer the following questions:

A. What is the intended use and who are the intended users?
B. What is the general basis and scope of the initiative?

The tables were chosen to be presented in Annex 2 to the thesis in order to simplify for the reader. It should be noted that the results shown in Annex 2 are a major part of the study's result. By putting this information in an annex, a reader that is only interested in the evaluation of the selected indices could skip the annex and only read the evaluation. It is however important to highlight that the evaluation and selection of indices is based on the inventory results.

3.2. Phase 2: Identification and Selection of Index Systems

The inventory constituted the data for the selection of indices to assess further. A literature review was conducted on environmental and sustainability indicators and indices, as well as existing studies and reports on environmental ship indices. The information found is briefly outlined in the previous chapter. Based on the literature review, a definition of environmental performance indices applied to shipping was first made in order to answer the second research question:

- *Which of the voluntary initiatives are based on an indexing system?*

Derived from the description in the introduction and the literature review, the following definition is used hereafter:

Environmental Performance Index for Shipping:

an index of aggregated environmental data or indicators for the purpose of communicating a ship's or shipping company's environmental performance

Ten of the 38 initiates found during the inventory were initially identified as environmental performance indices and selected for further evaluation. This initial identification was based on characteristics of the systems included as indices in the few studies found that actually focused on environmental ship 'indices' (Jivén, 1998; Jivén, 1999; CE Delft, 2009; Haukilehto, 2010), as well as the above definition of environmental performance indices. During the review of gathered data for the ten systems, the question arose if they all could be

placed within this definition. The above definition was thus elaborated further by developing figure 3.1. It shows an illustration of the main principles of an environmental performance index, using the information pyramid as basis. During the evaluation, it further became evident that not all ten systems could be evaluated in the limited time-frame of this study. Figure 3.1 was thus used for exclusions of initiatives.

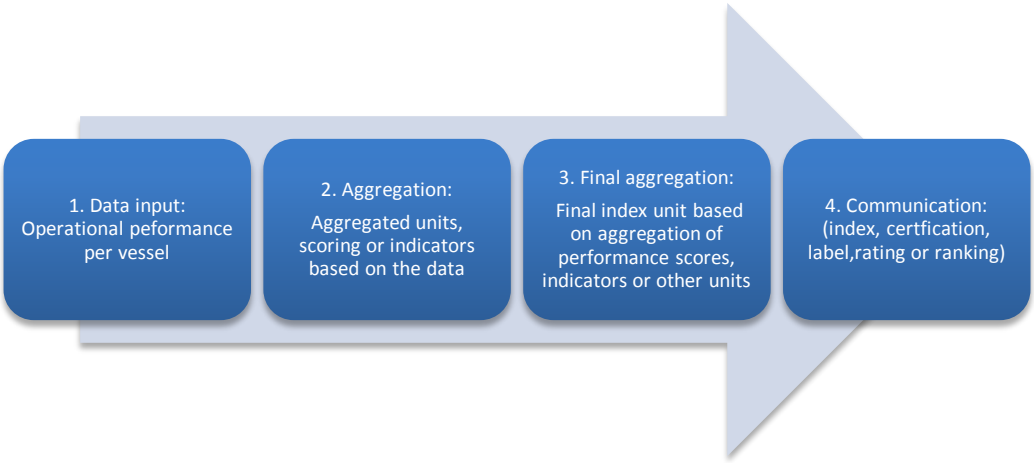

Figure 3.1. Main principles of an environmental performance index for shipping

1. Data input
The data used in an index system for shipping should be data needed to assess operational performance. It could either be entered by individual carriers (shipowners) or gathered by the organization of the system, e.g. in a database.

2. Aggregation
The data provided should be aggregated into units such as scores or by the use of indicators. Systems are not included that scores only based on a set of predetermined requirements or standards that are not based on ship specific data.

3. Final aggregation
The final index should be expressed in a unit and be based on aggregated scores, indicators or other aggregated units.

4. Communication
The index could be communicated in a final index format, a certificate, a label, a rating or a ranking.

3.3. Phase 3: Evaluation

The evaluation was aimed at answering the third research question:

- *By evaluation of a selection of indices, how do they correspond with principal aspects and criteria found in literature?*

After selecting the ten initiatives, an evaluation scheme was developed. The scheme is presented in Annex 1. It consists of a set of general principles and criteria found in the literature review, as outlined in Chapter 2. In summary, the evaluation scheme is based on principles and criteria found in the following literature: Meadows (1998), Harger and Meyer

(1996), Jasch (2000), EMSA (2007) and Jivén (1999). It is further based on the following seven questions formulated as relevant questions to consider during the work of the inventory and the literature review.

A. What ship types, shipping companies or geographical boundaries are included?
B. What environmental impacts are included?
C. Are the environmental impacts and performance of a vessel or transportation measured, or is the system based on set of criteria?
D. How is data obtained, aggregated and evaluated?
E. Does it include third party verification?
F. Is the system transparent and is it the data and procedure documented?
G. Is it easy to use?
H. Does it provide economic incentives and/or market incentives?

Data was then gathered for each of the ten initiatives based on the scheme. Only three indices were fully evaluated due to the limited time-frame of this study, though as discussed in Chapter 6, not all ten would had been possible to include with the developed criteria and evaluation scheme.

4. Inventory of Environmental Performance Initiatives

Environmental performance of maritime transport is generally covered by international regulations, national instruments, classification societies, industry standards and voluntary initiatives. A worldwide variety of voluntary initiatives can be used for measuring, communicating and improving the environmental performance of the maritime industry (EMSA, 2007). An inventory was conducted on existing environmental initiatives, which can be used for the shipping industry to communicate environmental performance to costumers, ports and the public. The 38 initiatives found are related to a diversity of stakeholders and were divided in the provider of service. The inventory results are presented in seven different tables found in Annex 2 of this report. This chapter shows a brief introduction to the tables of Annex 2. In addition to the 38 initiatives found, some on-going initiatives and proposals were found and presented in table A6. Moreover, various on-board tools, software and calculators were found during the inventory. An interested reader could find these tools in table A7. It should be noted that *Environmental Management Systems* (EMS) play a large part in environmental communication, as well as for the shipping industry. These systems are voluntary management programmes in companies with standards such as ISO 14001 and EMAS as frameworks. They do not require more of environmental performance than compliance with regulations and continuous improvement based on self-defined goals. Certification is often an end in itself, with little long-term environmental commitment (Christmann and Taylor, 2001; EMSA, 2007). Environmental Management Systems were thus excluded for further study.

Table A1. IMO Instruments

Due to the international nature of shipping, it is governed by a large variety of conventions and other international agreements. A few regulative instruments were included in the inventory, though only those regarded as applicable for use by other purposes than by complying with international regulations, e.g. green purchasing and communication. The *International Maritime Organization* (IMO) is responsible for international measures on safety, security and pollution prevention for international shipping. The MARPOL Convention (MARPOL 73/78)[vi] is the main international convention to prevent marine pollution from ships and applies to 99% of the world tonnage (merchant fleet) (Stopford, 1997; IMO, 2011a). In the work towards reducing greenhouse gases from ships, the IMO adopted a package of two energy efficiency instruments; *Energy Efficiency Design Index* (EEDI) and *Ship Energy Efficiency Management Plan* (SEEMP) in July 2011. These were adopted by the addition of a new Chapter 4 to MARPOL Annex VI. The amendments enter into force 1 January 2013 and will apply to all ships of 400 gross tonnage and above. In addition, the IMO has developed an *Energy Efficiency Operational Indicator* (EEOI) as a voluntary instrument (IMO, 2011b). Table A1 outlines the three efficiency instruments and an instrument on hazardous materials for ship recycling.

Table A2. National Instruments and Initiatives

There are different national instruments with different approaches to address environmental impacts from ships. The system of environmental differentiated fairway and port dues in Sweden and the Norwegian NO_x Fund are instruments providing economic incentives for air

[vi] A variety of certificates and on-board documentation are required under international conventions e.g. the International Air Pollution Prevention (IAPP) Certificate required under MARPOL Annex VI. No further information of such certificates will be dealt with here.

emissions performance. Although other studies on indices have included these systems, they are excluded in this study within the limited time-frame. The relevant national instruments and initiatives found are presented in table A2. They are provided by governmental institutions in Germany, Korea and United States, as well as a Washington State department. The different systems vary from eco-labels to coast guard inspection.

Table A3. Green Class Notations

The role of classification societies is to ensure that ships comply with classification standards (technical and operational) and national regulations. They develop requirements set in so called class notations according to ship type, service, navigation etc. The requirements mainly concern ship construction and maintenance, and are based on IMO conventions and guidelines, as well as technological developments. A ship is evaluated and inspected at the construction stage. If compliance with the notation is met, a class certificate is issued. Although classification is voluntary, an owner must classify its ships in order to obtain insurance, and sometimes due to requirements of the Flag State. Additional voluntary class notations which go beyond legislation are today offered by the societies (Stopford, 1997; IACS, 2011). Table A3 presents these so called 'green class notations' found during the inventory. They are offered by American Bureau of Shipping (ABS), Bureau Veritas (BV), Det Norske Veritas (DNV), Germanischer Lloyd (GL), Lloyds Register (LR), Nippon Kaiji Kyokai (ClassNK) and Registro Italiano Navale (RINA). Most of these notations are based on a set of environmental requirements or standards, though there are two exceptions that are based on environmental performance; DNV's Triple-E and RINA's Green Plus.

Table A4. Port Initiatives

Table A4 presents the initiatives from ports and port associations found during the inventory. The initiatives have been developed and are provided by the Port of San Francisco, Port of Vancouver, World Ports Climate Initiative (WPCI), The Green Award Foundation (Rotterdam Municipal Port Management and the Dutch Ministry of Transport) and Maritime and Port Authority of Singapore. The different systems vary from indices, awards and certificates obtained by performance data and/or surveys to individual ports initiatives which merely provide reduced port dues for ships with environmental improvements calling the port.

Table A5. Initiatives from Cargo Owners, NGOs and Shipping Associations

Table A5 presents the initiatives from cargo owners, NGOs and shipping industry associations found during the inventory. The initiatives have been developed and are provided by Business for Social Responsibility (BSR), Clean Shipping Project, Swedish Society for Nature Conservation (SSNC), Green Marine, Rightship and Carbon War Room. The different systems vary from indices, awards and certificates obtained by performance data and/or surveys to a website making the methodology of two other initiatives available for public use.

Table A6. Proposals and On-going Initiatives

Table A6 shows on-going initiatives and proposals found during the inventory. The on-going initiatives are developed by Deltamarin and Baltic Sea Action Group (BSAG), Aalborg University, Global Reporting Initiative (GRI) and WWF together with a Sustainable Shipping Working Group. The proposals found were made by HPTI Hamburg Port Training Institute GmbH in the EMSA (2007) report and by Norwegian Government submitted to the IMO in 1997. The different initiatives and proposals vary from environmental indices, labels and reporting to a global standard for sustainable shipping.

Table A7. On-board Tools, Software and Calculators

Table A7 lists various on-board tools, software and calculators found during the inventory, developed and provided by DNV Software, International Association of Ports and Harbors (IAPH), Martek Marine, Marorka and Network for Transport and Environment (NTM). These could tools could be used for data gathering and calculations needed for environmental performance indices.

5. Evaluation Results of Three Indices

This chapter shows the results of an evaluation of three selected index systems. In relation to the 38 existing environmental initiatives found in the inventory, the ten below were initially identified as voluntary environmental performance indices. This initial identification was based on characteristics of the systems included as indices in the few studies found that actually focused on environmental ship 'indices' (Jivén, 1998; Jivén, 1999; den Boer et al., 2009; Haukilehto, 2010), as well as the definition of environmental performance indices of the present study.

- The Blue Angel (both RAL-UZ 141 and RAL-UZ 110)
- Clean Cargo Working Group (CCWG): Performance Metrics Tool
- Clean Shipping Index (CSI)
- Energy Efficiency Operational Indicator (EEOI)
- Environmental Ship Index (ESI)
- Green Award
- Green Marine Environmental Program
- Rightship (CO_2 Rating and Environmental Rating)
- RINA Green Plus
- Triple-E

During the review of gathered data for the ten systems, the question arose if they all could be placed within the definition of environmental performance indices. Section 6.2 deals with this uncertainty. The following three indices will be evaluated in this chapter.

1. **Energy Efficiency Operational Indicator (EEOI)**
2. **Clean Cargo Working Group (CCWG): Performance Metrics Tool**
3. **Clean Shipping Index (CSI)**

The selection of these three indices was based on the selection criteria in section 3.2, an overall review of the ten systems, and the limited time-frame of this study.

5.1. Energy Efficiency Operational Indicator

5.1.1. Application and General Construction

The *Energy Efficiency Operational Indicator* (EEOI) is a tool for monitoring operational energy and CO_2 efficiency of ships. It was developed by the IMO as a voluntary instrument accompanied by the mandatory instruments EEDI and SEEMP in a package to reduce CO_2 emission from international shipping (see Chapter 4 and Annex 2). The EEOI could be used as a tool in the SEEMP, though application is much wider. Guidelines for voluntary use of the EEOI were adopted by the IMO in 2009 by MEPC.1/Circ.684, though interim guidelines were adopted already 2005 by MEPC/Circ.471. The current guidelines were developed to provide assistance to shipowners, operators and governments to develop a mechanism for evaluation of the CO_2 emissions performance of ships. The EEOI could be viewed as an example of calculation methodology for an objective, performance-based approach of such a mechanism. It could be described as an indicator of operational efficiency for ships expressed in CO_2 emissions per unit of transport work. It includes monitoring of ships CO_2 emissions and calculation of energy efficiency at each voyage or over a specific period. Shipowners and

operators can use it to evaluate the operational energy efficiency of their ships and fleet. This could be applied in environmental management systems or to market CO_2 performance of ships and shipowners. Another application is fuel efficiency assessment, due to the direct relation between CO_2 emissions and fuel consumption (MEPC.1/Circ.684; IMO, 2011c).

5.1.2. Scope, Data Quantification and Evaluation

The EEOI is applicable for all ships engaged in transport work, i.e. carrying cargo or transporting passengers. It thus applies to dry cargo carriers, tankers, ro-ro ships, passenger ships etc. Certain vessels which do not perform transport work are excluded such as service vessels, research vessels and tug boats. The environmental scope is limited to CO_2 emissions and energy efficiency. The EEOI is defined as the ratio of mass of CO_2 emitted per unit of transport work. It is calculated for each voyage of a ship. The basics of the EEOI formula is thus the actual CO_2 emissions of a vessel divided by the performed transport work, which is shown below. Smaller values of the index are more energy efficient.

$$EEOI = \frac{CO_2\ emissions}{performed\ transport\ work}$$

The CO_2 emissions part of the formula represents total CO_2 emissions from a ship's fuel combustion during a specific voyage. In order to calculate the CO_2 emissions, the total fuel consumption for each type of fuel used during the voyage needs to be calculated. The fuel consumption for each fuel type is multiplied with a conversion factor (C_F) between fuel consumption and CO_2 emissions, based on the carbon content of the fuel. The C_F for distillate fuels, Heavy fuel Oil (HFO), Liquefied Petroleum Gas (LPG) and Liquefied Natural Gas (LNG) are found in the guidelines. The performed transport work in the formula varies depending on the type of transport conducted. The guidelines list seven different units. Dry cargo carriers, liquid tankers, gas tankers, ro-ro and general cargo ships should use the unit metric tonnes of cargo carried. Containerships that only carry containers could either use the number of containers expressed in TEUs[vii] or metric tonnes of the total mass of cargo and containers. Whatever unit used to measure the transport work or mass of cargo, it is multiplied with the total distance sailed for the voyage expressed in nautical miles (nm). Depending on the type of transport work conducted, the calculated EEOI could be expressed in different units, e.g. tonnes CO_2/(tonnes · nautical miles), tonnes CO_2/(TEU · nautical miles).

In addition to the voyage-specific EEOI, the guidelines provide a formula for the calculation an average EEOI. This could be used to calculate a rolling average for a specific period. The average EEOI is not calculated as a simple average of a number of voyages, hence the specific formulas for both are shown below (from MEPC.1/Circ.684, p.8-9).

$$EEOI = \frac{\sum_i FC_j \times C_F}{m_{cargo} \times D}$$

$$Average\ EEOI = \frac{\sum_i \sum_j \left(FC_j \times C_F\right)}{m_{cargo} \times D}$$

j = fuel type
i = voyage number
F_{Cij} = the mass of consumed fuel j at voyage i
C_{Fj} = fuel mass to CO_2 mass conversion factor for fuel j
m_{cargo} = cargo carried or work done
D = the distance in nautical miles

[vii] TEU (Twenty-foot Equivalent Unit) is standard unit for container capacity, where the number of TEU means the number of containers of 20 feet length.

The distance travelled could be obtained by information in the logbook of the ship, and the quantities and types of fuel used could be fund in the bunker delivery notes required under MARPOL Annex VI. The guidelines further include a reporting sheet that could be used as a basis for the calculations (MEPC.1/Circ.684; IMO, 2011c). In addition to the guidelines, the IMO has developed a greenhouse gas module (GHG module) in their central database *Global Integrated Ship Information System* (GISIS). It was developed in 2007 to deal with submitted data of hundreds of ship trials of the CO_2 index found in the interim guidelines. Since 2008, shipping companies can login into the web-based database and enter data on fuel consumption, quantity of cargo carried and the voyage distance. CO_2 emissions and the EEOI are then calculated automatically (IMO, 2009; IMO, 2011c).

5.1.3. Quality Control

5.1.3.1. Documentation and Transparency

The guidelines emphasize the importance of a uniform data collection and that sufficient information is collected to enable a realistic assessment. A self-assessment with documented procedures to monitor and measure performance was recommended. It could include identification of activities with performance impacts, necessary data sources and measurements and the frequency of measurements. The guidelines further stress the importance of recording the sources of the obtained data and decisions made on grey areas of data. Furthermore, the GHG module in GISIS was developed in order to make EEOI data it available to the member states of IMO and the shipping industry. It is further available for public use with public user account at www.imo.org/GISIS (IMO, 2009; MEPC.1/Circ.684; IMO, 2011c).

5.1.3.2. Verification and Validation

Verification of EEOI is available from classicisation societies. Germanischer Lloyd (GL) has developed the Operational CO_2 Index Certification as a third-party verification of the data used to calculate an Operational CO_2 Index over the period of one year. The crew of a ship gather the necessary data and sends it to GL for analysis. The data is verified by an office audit. GL then calculate the index, first for each voyage, then the average for a year. The ship receives certification for one year. No more information on this certification was obtained during the study. Correspondence with EEOI methodology set in the guidelines could thus not be evaluated. In addition, Registro Italiano Navale (RINA) informed in 2010 that it has developed an operational CO_2 index certification based on the IMO interim guidelines from 2005 (MEPC/Circ.471). However, no more information was obtained (RINA, 2010).

5.1.3.3. Updates and Reviews

The guidelines inform that it may be updated occasionally. Such an update would to take operational experiences into account or other relevant developments. The shipping industry and Member Governments were invited to report back on experiences gained (MEPC.1/Circ.684). Since the EEOI is applied as self-assessment at shipowner level, updates and reviews were not further assessed.

5.1.4. End Results

The EEOI enables both assessment of current performance and performance trends. A shipping company could use the EEOI data for establishing a baseline and to set performance targets thereafter. If the EEOI is used with continuous monitoring, the results of technical changes to the vessel or operational changes would thus be shown. Comparison with the previous value would thus enable quantification of the achieved emissions reduction and energy efficiency. Another reason for the developing of the GHG module was to establish benchmarks for different ship types and sizes. Whether this has been accomplished could not be explained by obtained information. The IMO has earlier observed difficulties with the interim CO_2 index trials. Different results were found for identical ships in seemingly similar trades. A possible explanation could be different weather conditions or operational differences such as waiting times at port and whether or not the ship was fully loaded (IMO, 2009; MEPC.1/Circ.684; IMO, 2011c).

Since the methods described in the guidelines merely are of recommendatory nature, a variety of systems has evolved that uses the EEOI as a basis. EEOI could be used as self-assessment at shipowner level without a co-ordinating organization involved with the index system. It is thus difficult to assess the EEOI further. As we will see further on, the EEOI is used as part of the CO_2 evaluation in the other index systems studied. It could thus be viewed as a tool for larger indexing systems with higher aggregation and weighting into a final CO_2 score.

5.2. CCWG Performance Metrics Tool

5.2.1. Application and General Construction

The *Clean Cargo Working Group* (CCWG) is convened by the *Business for Social Responsibility* (BSR), which is a global network aimed at developing sustainable business strategies. The group is described by BSR as a business-to-business initiative. It is open for membership by ocean container *carriers* (defined as "transportation service providers, vessel owners, and vessel operators"), *shippers* (defined as "global retailers, manufacturers, and cargo owners utilizing transportation services") and logistics providers (BSR, 2011a, p.1). The group currently has 30 members, including carriers representing over 60% of the containers shipped in the world and some of the largest multinational brands such as Coca-Cola, Nike and Ikea. Membership gives access to environmental data and tools for measuring and reducing environmental impacts of goods transportation. The group enables fact-based dialogue between the buyers and providers of transportation services, but also sharing of best practices and technology investments. The CCWG highlights a drive towards performance improvement and becoming the industry standard where applicable (BSR, 2011a; Farrag, 2011).Three primary tools has been developed, as briefly outlined below. Only the Performance Metrics Tool was evaluated. However, the evaluation also included a few aspects of the other two tools related to the use and end results of the index.

Performance Metrics Tool

The Performance Metrics Tool is an Excel-based tool for assessing environmental performance for carriers by quantitative data from each vessel. It results in an environmental performance scorecard, which quantifies performance for each carrier. The scorecard can be used for benchmarking carriers against industry performance.

Environmental Performance Survey (EPS)
Before the introduction of the Performance Metrics Tool in 2008, the group used a survey of environmental performance submitted by the carriers. A survey still exists in the form of the EPS, though it is a qualitative survey to supplement the performance metrics tool. It collects qualitative data, such as best practices, in areas where quantitative performance metrics is not suitable for assessment.

Intermodal Calculator Tool
The Intermodal Calculator Tool is partially based on the data from the Performance Metrics Tool and partially for other data sources on other transport modes. It is applied for calculating CO_2 emissions of intermodal shipments.

5.2.2. Scope, Data Quantification and Evaluation

The CCWG tools apply to ocean container ships only, and only the member carrier fleet. The tools can however be used by non-members, though their data is not reported to CCWG. Geographically, the Performance Metrics Tool covers a total of 25 global trade lanes (when assessing CO_2 performance). The environmental performance is assessed in six categories: *CO_2*, *SO_x* and *NO_x emissions*, *Waste, water and chemicals*, *Environmental Management Systems* and *Transparency*. All carriers in the CCWG are required to submit vessel-by-vessel data for each of the six categories annually. This data is entered into standardized spreadsheets in the Excel-based tool. The data needed for each category are described as 'metrics', and represents environmental issues for the container shipping sector, but also issues considered important for supply chain sustainability assessment by the cargo owners. The data input thus varies from emission factors for CO_2 based on fuel use and distance travelled, to a set of criteria in each category (e.g. the use of specific ballast water treatment systems) (BSR, 2011a; Chase, pers. comm.). Table 6.1 shows an illustration of the metrics needed for each category.

For CO_2 emissions, the carriers submit data on emissions for each vessel and for each global trade lane. CCWG has developed a standardized methodology for its carrier members to calculate emissions from their vessels, expressed in g CO_2 per TEU-km. It is based on the IMO *Interim Guidelines for Voluntary Ship CO_2 Emission Indexing for Use in Trials* (MEPC/Circ.471;), adapted to dry container ships (BSR, 2011a; Shippingefficiency.org, 2011a). The calculation could be expressed in the following general formula (more detailed calculation formulas are provided as an annex in BSR (2011a)).

$$\frac{\text{Total kg fuel consumed} \times 3114.4\ \text{g}CO_2/\text{kg fuel}}{\text{maximum nominal TEU capacity} \times \text{total distance sailed}}$$

The number 3114.4 is the conversion factor C_F for heavy fuel oil (HFO) found in the EEOI guidelines (MEPC.1/Circ.684).[viii] The data needed to be provided by the carriers include TEU capacity, distance sailed, number of reefer plugs for *reefers*[ix], fuel consumed and the timeframe of data. HFO and marine distillate fuels are reported separately.

[viii] See previous section for explanation of the EEOI formula.
[ix] Reefers = refrigerated containers

Table 6.1 Metrics of the Performance Metrics Tool (from BSR, 2011a, p.10)

Category	**Metric**
CO_2 Emissions	g CO_2/ TEU-km, by trade lane
SO_x Emissions	Sulphur content of bunker fuel
NO_x Emissions	Performance expressed in percentage below MARPOL
Environmental Management Systems (EMS)	Percentage of owned vessels with third-party certified EMS (ISO 14001 or other EMS approved by BSR and CCWG members)
Waste, Water and Chemicals	Includes requirements on anti-fouling paints, lubricants, cleaning agents, refrigerants, water treatment , ballast water treatment, bilge water, sewage, garbage fuel quality, etc.
Transparency	Follow GRI reporting standards with core and additional indicators.

* see description on CO_2 calculation above

The Excel-sheets calculates environmental performance of entered data for each category. The carriers are scored in relation to baselines. The 2011 baseline is the performance average in 2008. The obtained scores take into account the reported data in percentage of owned and time-chartered fleet respectively. CCWG baselines are found in the output scorecard, where the total scores for a carrier are shown. Table 6.2 shows a brief summary of the baselines and the scoring system used based on an example scorecard for a typical carrier (CCWG, 2011). The scorecard first shows a table of the scores for each category, the reported percentage and the percentage of maximum possible scores. A second table show the carrier performance data in relation to the baselines. CO_2 performance details are shown separately in the third table, which is divided in performance of dry containers and reefers respectively. Performance is shown in g CO_2 / TEU-km for each trade lane. The emission factors are summed for overall fleet performance for dry containers and reefers. The table also shows baselines for each trade lane. The baselines are indexed averages of the CCWG carriers for each trade lane. Scores are obtained for each trade lane in relation with the baselines and the table sums an overall CO_2 performance score for dry containers and reefers (CCWG, 2011; BSR, 2011a).

Table 6.2. CCWG baselines and maximum scores (CCWG, 2011)

	CWG Baseline	**Maximum Score**
CO_2 Emissions	Details on CO_2 emissions were shown separately in a detailed matrix for each trade lane.	40
SO_x Emissions	Average sulphur content of fleet: 2.6%	20
NO_x Emissions	Average performance of fleet: 6% below IMO curve	10
Environmental Management Systems (EMS)	90% of fleet certified	10
Waste, Water and Chemicals	Not shown in the scorecard	10
Transparency	Baselines are not applicable. A carrier lists its reported core and additional indicators, and the sources to the reporting.	10
Overall Performance	-	100

5.2.3. Quality Control

5.2.3.1. Documentation and Transparency

The BSR (2011a) report used as a basis in this evaluation is a report that is published annually. The purpose of the report includes, *inter alia*:

- To explain how the CCWG tools work
- To share information for transparency reasons and for dialogue with sustainable supply chain stakeholders to facilitate continuous improvement
- To demonstrate the value of membership in CCWG

Although the BSR (2011a) report has been the basis of this evaluation, there are questions remaining regarding the calculation methodology and the basis of aggregation and weighting of scores. The obtained scorecard dummy is the only document that shows the scoring system, such as which baselines that were used for a specific category. Since the scorecard merely consists of tables, it does not explain the basis of calculations and baselines. It does not explain why for example SO_x emissions are scored higher than NO_x emissions. Moreover, it does not include any details on the *waste water and chemicals* category. One could thus not understand why a carrier has obtained a specific score within the *waste water and chemicals* category. This dummy scorecard is not available on the website, but was retrieved through personal communication when requesting more information. The tools can be downloaded upon joining the group and full access to calculation methodologies is granted. Members also get the opportunity to influence the development of the tools.

The access of the carrier scorecard results is restricted within the group. The environmental performance of the CCWG carriers could thus not be viewed by the public. The BSR (2011a) report shows some figures of the performance, such as the CO_2 fleet average per trade lane and the overall decrease in CO_2 emissions. As mentioned earlier, the tools can also be used by non-members, though their data is not reported to CCWG. The website *shippingefficiency.org* uses the CCWG methodology. This function is free for public use. Users could search a specific ship for benchmarking CO_2 efficiency of specific of ocean container ships against other ships in the same trade lane. Shippingefficiency.org has its own rating scheme from A to G based on the CCWG data. This rating is not associated with the methodology used by CCWG. Moreover, the data of the website tool is provided by Maersk Line. Hence, the data currently only applies to ships owned and operated Maersk Line (Shippingefficiency.org, 2011a-c).

Within the group, the transparency is high and the access to environmental data and scorecards enables performance assessment of carriers by the transport service buyers in the group. This is the primary and unique concept of the group. In addition to the score cards, the group members get access to overall carrier performance, which could be used to benchmark carrier performance and to assess and communicate measures for improvement. There is a restriction in the data transparency, however, that is not reported in BSR (2011a). The EPS survey, which is filled by carriers annually, provides options on file sharing and informs that it is optional. The carrier could choose to either share information to all CCWG shipper and/or all CCWG non-vessel-owning carriers, or to specific members. The carrier could also choose between sharing the EPS and/or the Performance Metrics Scorecard. The EPS is available for public download, though not the survey results from individual carriers (BSR, 2011b).

5.2.3.2. Verification and Validation

Third-party verification of the data is not required in the Performance Metrics Tool, though carriers can have their data verified (or reviewed) by an independent verifier in an office-based audit. About half of the CCWG carriers verified their data in 2011 (Chase, pers. comm.). The CCWG is currently finalizing the development of a verification protocol based

on industry leading practices. This will be used to verify annually submitted performance data (BSR, 2011a).

5.2.3.3. Updates and Reviews

According to BSR (2011a), the CCWG strives to continuously improve the tools and methodologies. Such improvements include adaptation to new and emerging standards (e.g. IMO or GHG standards), availability of improved emissions factors and more accurate data and expectations from stakeholders. Updates and changes of the tools are made each year to improve data and calculation accuracy. The updates encourage consistency and usability of environmental performance data in the supply chain.

5.2.4. End Results

Data on CO_2, SO_x and NO_x emissions from container ships has been gathered for the past eight years. In 2009, environmental data of 1,206 container ships was collected. According to (BSR, 2011, p. 6), the group has "*one of the most comprehensive environmental data sets in the shipping industry*". Aggregated data on CCWG carriers' environmental performance is accessed to members and released annually. By such, individual scorecards can be compared with industry performance. The CO_2 scorecard is used by the group to benchmark carrier performance on specific trade lanes and for calculation of emissions per cargo shipped with a specific trade lane. The CO_2 performance scorecard can also be used in the Intermodal Calculator Tool, which further includes other transport modes (road, rail, air, other ocean).[x] By such, the CO_2 emissions of goods transportation could be evaluated and compared with different transportation options. A member such as Coca-Cola or Ikea could thus choose to use the most CO_2 efficient total intermodal transportation and routes. For the carriers, it is evident that the use of the Performance Metrics Tool, and participation in the group as such, could provide market incentives several shippers in the group uses the data in contracting discussions with carriers. No economic incentives such as reduced port dues were found.

The data collection history has resulted in the establishment of baselines, which now constitute the basis of the scoring system. The data also provides CCWG the availability to measure if the Performance Metrics Tool provides improvement in performance. The CO_2 scorecard with benchmarking of average performance encourages and drives improvements. (BSR 2011a) show an 8% average decrease in aggregated CCWG carrier CO_2 emissions from 2007 to 2008. The decrease was 17% compared to 2006. It should be taken into account that the Performance Metrics Tool was introduced in 2008, hence these figures tell little about the improvement results from the tool.

Regarding the level of simplicity vs. complexity of the Performance Metrics Tool, it could be considered as a straightforward data collection that is time-consuming to some extent. The data collection process is currently being simplified in order to reduce the time required (Chase, pers. comm.).

[x] Data for road, rail, air and other ocean transport modes are based on "best available public data" found in for example World Resources Institute (WRI).

5.3. Clean Shipping Index

5.3.1. Application and General Construction

The Clean Shipping Project started as a regional initiative on the Swedish west coast in 2006 to increase focus on the environmental issues of shipping. The project evolved into a network of large cargo owners (the Clean Shipping Network), which currently consists of 30 cargo owners such as Volvo and H&M. To date, these originate from Sweden, though the project is open for companies world-wide and an introduction in Germany is currently being considered. The project developed the Clean Shipping Index (CSI) as a web-based tool that ranks both ships and shipping companies (carriers) according to their environmental performance. The carriers enter the information on their ships through the web-based tool. The information is recorded in the Clean Shipping Database, which cargo owners have access to by joining the network. The cargo owners can use this tool to choose the providers of ship transportation based on the environmental performance. They can compare performance of either individual ships or the whole fleet of individual carriers. They could also choose to compare performance in each of the six environmental areas of the index (Clean Shipping Project, 2011a-c; Clean Shipping Project, 2010; SustainableShipping, 2011).

5.3.2. Scope, Data Quantification and Evaluation

The Clean Shipping Index applies to existing ships and covers 10 major ship types of all ages. Geographically, it has both a global and a regional approach. Besides the Swedish focus and global expansion, it includes a distinction between the regional operation in *Emission Control Areas* (ECAs)[xi] and global operation. It is focuses on the operational environmental impact of individual vessels covered in five areas: *SO_x and PM emissions*, *NO_x emissions*, *CO_2 emissions*, *Chemicals* and *Water and waste control*. Data input consists of the information entered by carriers online. A participating carrier first enters brief information about the company, such as total number operated vessels and total number owned or managed vessels. It then adds vessels and enters information in a questionnaire for each vessel added. The questionnaire consists of twenty questions on the vessels operational impact. According to the CSI guidance document, the questions are basic and "not so complicated" (Clean Shipping Project, 2010, p.1).

The index is based on a scoring system. The maximum total score for a vessel is 150. Each environmental area has a maximum score of 30 points, and contains a sub-scoring system. The sub-scoring system consists of different parameters depending on the environmental area, e.g. sulphur content intervals or specific equipment options. Scores are only obtained for measures which go beyond current regulation. No data results in zero points. The basis of data input requirements and sub-scoring for each environmental area are outlined below.

SO_x and PM

The data input for SO_x emissions consists of the annual average sulphur content in the fuel used. The methods for obtaining this information should follow MARPOL Annex VI. Particulate matter (PM) is not reported due to the close relation with SO_x emissions. The scoring is divided into main and auxiliary engines. The main engines are in turn divided into (1) total average for both ECAs and global operation, and (2) operation inside ECAs. As an example, the first category includes intervals of sulphur content ranging from ≥ 2.5% (0

[xi] ECAs are areas under MARPOL Annex VI with stricter regulation on air emissions.

points) to ≤ 0.5% (9 p). The use of sulphur free fuel (e.g. LNG) receives the highest score (11). The obtained score in this category doubles with operation only in ECAs.

NO_x

NO_x emissions are reported in g/kWh for engines larger than 130 kW. This data could be found in the EIAPP certificate required under MARPOL Annex VI or by verified measurements such as approved by the Swedish Maritime Administration. The scoring is based on how the reported emissions relate to the Tier I, II and III standards in MARPOL Annex VI. As an example, the highest reduction (Tier III) is currently rewarded with 21 points for main engines and 9 points for auxiliary engines.

CO_2

CO_2 emission data is reported for a period of one calendar year. This could be entered in two ways. The first method is to calculate the EEOI and report emissions in g/tonne-nm.[xii] The second method is to report the emissions in g/TEU-km by using the CCWG calculation method. The second only applies to container ships. The information needed for carrying out these calculations is described in section 6.1 and 6.2 of this study. Three points are first obtained for the reporting of emissions in one of the two ways. CO_2 performance is then scored based on percentage below the reference value of the method chosen; from 3 points to 27 points (40% below).

Chemicals

The chemicals area consists of a set of requirements to be fulfilled in order to obtain scores. It has seven sub-areas; *anti-fouling, stern tube oils, external hydraulic fluids, gear oils, boiler/cooling water treatment, cleaning agents* and *refrigerants*. These areas are weighted differently, with maximum scores ranging from 2 points (boiler/cooling water treatment) to 7 points (anti-fouling). This scoring system is depending on the environmental effects of the different types of chemicals. Taking anti-fouling as an example, the scores are only obtained for biocides approved in the EU Biocide Directive.

Water and Waste Control

The Water and Waste control area also consists of a set of requirements. It has six sub-areas; *ballast water treatment, sewage/black water treatment, garbage handling, sludge oil handling, bilge water treatment* and *crew awareness.* The sub-areas are weighted differently, with maximum scores ranging from 3 points (e.g. garbage handling) to 10 points (ballast water treatment). Taking ballast water treatment as an example, scores are obtained for specified methods and maximum scores are obtained for methods with final approval by IMO.

Weighting and Ranking

Figure 6.1 shows an example of how the performance of a vessel is illustrated visually by the index. The total score for a vessel shown is not the total score (max 150p), but instead expressed in percentage (max 100%). This is not explained by the obtained documentation of the CSI, though the figure indicates an average percentage calculation. The performance in each of the environmental areas is shown in percentage of maximum score. The total score shown is the total average percentage of the total scores in each area. The ships are ranked in three levels of environmental performance: low performance (red), medium performance (yellow) or good performance (green). The ranking is based on the scoring. In order to obtain

[xii] nm = nautical miles

the green rank, the vessel data must be verified and the vessel must obtain at least 50% of the total scores. Moreover, it must obtain at least 35% of the scores in each area, and scoring in all sub-areas under *Chemicals and Waste & Water*. Hence, a ship cannot obtain good overall performance if it only performs well in one of the areas. The yellow and red ranks are simpler; yellow for at least 20% of total score and red for below 20%.

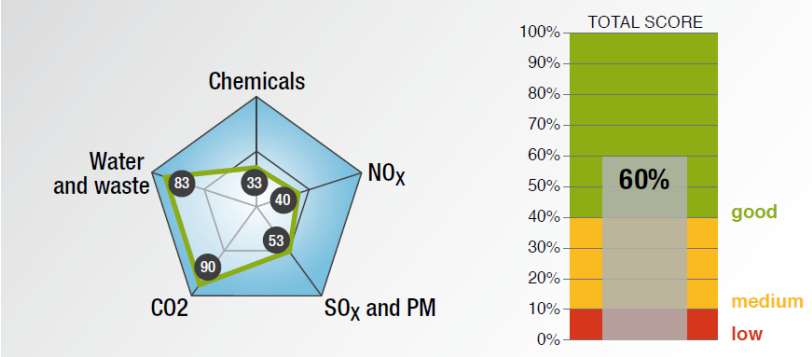

Figure 6.1 Example of performance illustration (from Clean Shipping Project, 2011b, p.5)

A final index score and ranking is further conducted for the carrier as a whole. This carrier score is termed 'total weighed score' and is the total average score multiplied with the percentage reported ships of the total ships included in its fleet (owned or managed). In order for a carrier to obtain overall green rank, at least 90% of the vessels in its fleet must be reported, the carrier must be verified and it must obtain be at least 40% of the total weighed score. In order to obtain the yellow rank, a carrier must obtain at least 10% of total weighted score and at least 20% of its fleet must be reported. A carrier with a red rank has a total weighted score less than 10% or it has reported less than 20% of its fleet. Table 6.3 summarizes the rating system of the CSI.

Table 6.3. Ranking system for Clean Shipping Index (from Clean Shipping Project, 2010, p.21)

Ranking	**Ranking for Vessels**	**Ranking for Carriers**
Good performance (green)	Vessel verified Total score > 50% > 35% score in all five areas Scoring in all subgroups under Chemicals and Waste & Water	Carrier verified > 90 % vessels reported, > 40% weighed total score
Medium performance (yellow)	Total score > 20%	> 20% vessels reported > 10% weighed total score
Low performance (red)	Total score < 20%	< 20% vessels reported or < 10% weighed total score

In addition to the above rankings, the cargo owners in the network could view performance of carriers in blue colouring, ranging from dark blue (low performance) to very light blue (good performance). This colouring system is independent from the ranking system above and is used for illustrative purposes. The carrier performance could further be viewed in group rankings, containing the same type of carriers. The carrier group index is based on the total average score for the same type of carriers, which is multiplied with the percentage reported ships of the total fleet. Another feature for the cargo owner is the possibility to view the average values for the same ship types on specific routes (Clean Shipping Project, 2010; Clean Shipping Project, 2011b).

5.3.3. Quality Control

5.3.3.1. Documentation and Transparency

The users of the index, i.e. the cargo owners in the Clean Shipping Network, have access to all the information in the database. The data can be analysed in detail, e.g. emissions from a specific engine entered in the questionnaire. The members of the network pay an administrative fee of currently 600 €. In order to get access to the database, a member has to sign a letter of intent and a confidentiality agreement. In addition to cargo owners, the project provides a forum for forwarders, ports or classification societies. The forum members receive newsletters and also get access to environmental performance data if a specific carrier agrees to share its information. The carriers that have entered the information in the database have limited access to detailed information other than for their own fleet, though they can make general comparisons of their own performance against other carriers in the index. The carriers could also add new vessels and edit the information already entered. The carriers pay no fee for entering their data or the use of the database (Clean Shipping Project, 2011c-e; Clean Shipping Project, 2010).

Similar to the CCWG, access to the Clean Shipping Database is restricted to membership, and specifically restricted to cargo owners. The transparency is high for these members, with access to detailed information. For the public, however, there is no access to view the carriers' environmental performance on the website. Finally, the transparency of how the index system works has proven to be high as the available information found on the website has been the basis of this evaluation.

5.3.3.2. Verification and Validation

Third-party verification of the entered data is available since 2010. So far, the class societies Lloyd's Register (LR) and Det Norske Veritas (DNV) has offered verification. The verification is voluntary and requires that a carrier apply and pay for it, though as seen in above, it is required in order to obtain the green rank for both vessels an carriers. The Clean Shipping Project has developed verification guidelines in cooperation with DNV and LR. These guidelines include guidance on the verification procedure, as well as lists of required documents for each area. The verifier first has to be accepted by the Clean Shipping Project. An exclusive login is then created for the verifier, by which it has access to all the vessel data. The required documents are submitted to the verifier for an initial review. An office audit is then conducted. The documents review and the office audit could be the basis before conducting a ship audit. The ship audit examines many items for accordance with the required documents. A Certificate of Verification is issued for a vessel and uploaded into the database by the verifier if the verification shows full compliance. On condition that the performance does not decrease, this certificate is valid for five years. If the results of the verification survey show non-compliance, a non-compliance document is shown in the database. The scoring has to be adjusted and an additional survey must be conducted for the non-compliance elements.

A recent development is the possibility to verify shipping companies in the CSI. In order to obtain a *Certificate of Verification of Shipping Company*, a specific number of vessels in its fleet are required to be verified with this verification process. The number of ships to verify depends on the square root of the size of its fleet, which then is rounded up. This verification process could be conducted either on only owned vessels or both owned and time-chartered vessels. All owned and/or chartered ships must have been entered into the database. This is

verified by an independent information source such as IHS Fairplay data. The verification procedure follows in principle the above procedure for vessels, though the certificate is only valid for three years (Clean Shipping Project, 2011b, Clean Shipping Project, 2011f).

5.3.3.3. Updates and Reviews

According to Clean Shipping Project (2011b), the index is dynamic, meaning that it shall adapt with new technology and stricter environmental legislation. The Clean Shipping Database was created in 2008. A revision of the index system was made in 2010 in order simplify for the user, adapt to technical and environmental conditions and to introduce the possibility for third-party verification. The changes were made in consultation with carriers, cargo owners, classification societies, authorities, the scientific community etc. It was further acknowledged that changes made must be in accordance with the information already entered in the database (Clean Shipping Project, 2010).

5.3.4. End Results

As with other voluntary environmental initiatives, participation and entering of data is voluntary for the shipping industry. However, the shippers in the network have started to require that data is entered, e.g. Volvo Logistics requires all carriers transporting their goods to enter data in the index. The network's inclusion of large cargo owners such as H&M, SKF, and Akzo Nobel provides marketing incentives for the shipowner to participate and perform well in the index. As such, the database now includes data from about 1500 ships, entered by eleven of the world's fourteen largest shipping companies. A recent campaign in the Port of Gothenburg further provides economic incentives for carriers ranked as green by the CSI. The first twenty 'green' ships calling the Port of Gothenburg during 2011 will share an award of SEK 600 000. As of 15 November 2011, four ships have been registered in the campaign (Clean Shipping Project, 2011b; Port of Gothenburg, 2011).

Regarding the use of current scoring system as an environmental assessment, the guidance document informs that "*it is difficult to scientifically compare different type of emissions with exact figures*" (Clean Shipping Project, 2010, p.18). It was emphasized that the scoring system could be viewed as a tool to estimate the environmental performance in the five areas. The weighting into a final index score "*gives a hint of the overall performance*" (ibid). It was further emphasized that the results must be judged with reason and that the index could be used as a platform for further discussions.

6. Analysis and Conclusions

This final chapter analyses the results of both the inventory and the evaluation, draws conclusions and discusses research contribution.

6.1. A Variety of Initiatives and Indices

The inventory found a large diversity of 38 environmental performance initiatives. They are provided by an equally large diversity of stakeholders, including international organisations, governmental institutions, classification societies, individual ports, cargo owners, NGOs, as well as shipping and port associations. The scope, target groups and applications of these initiatives showed an equally large diversity. The target groups ranged from cargo owners to Coca-Cola, as well as the general public. The initiatives were differently constructed and could be characterized as indices, labels, certificates, awards, rating schemes etc. In addition, the inventory showed a wide spread of incentives with reduced port dues as the primary incentive. The inventory further found various proposals and initiatives in development, including a global standard for sustainable shipping. Most existing initiatives are based on a set of environmental requirements or standards, where specific installed equipment, operational measures, management aspects or compliance with environmental legislation are rewarded in one way or another. Such rewards could be score points or for example reduced port dues. Some initiatives were however based on environmental performance data, such as specific emission levels. Ten initiatives were identified as environmental performance indices, though the next section questions their inclusion within the definition.

From the inventory results, it could be concluded that a majority (almost all) of the environmental initiatives include air emissions. EMSA (2007) found that emission-based initiatives were dominating among the environmental incentives and awards for shipping. This was explained by a shift of environmental concern for shipping in recent years from oil pollution to air emissions. Another dominant area found in the present inventory is energy efficiency or CO_2 emissions. The carbon and energy efficiency initiatives could be seen in context of the international climate policy, which today is "*one of the most important elements of national and international environmental policies*" (EMSA 2007, p. 73). Voluntary initiatives could be considered important for reducing greenhouse gases in relation to the failures of reaching overall international agreements.

For shipping, the voluntary carbon and energy efficiency initiatives could be put in the context of the recent adoption of the IMO instruments on energy efficiency. Several initiatives use the EEDI, EEOI and SEEMP in their assessment or requirements. Energy efficiency and CO_2 emissions are treated together with the use of these IMO tools. The IMO has considered greenhouse gases of shipping since 1997. Mandatory instruments were however not adopted until July 2011 and will not enter into force until 2013. The EEDI is further only required for new ships built after the entry into force and exceptions could be made for individual ships up to 2019. This slow legislation process strengthens the development and need for voluntary initiatives. An even slower IMO process has been air pollution, in particular SO_x and NO_x. Negations began in the late 1980s, but an effective global standard on sulphur that actually reduces global emissions will not be seen until 2020 or 2025 (Svensson, 2011). The high focus of SO_x and NO_x in the voluntary initiatives should thus be viewed in this context. It should also be seen in the context of air emissions being an important political issue today with an increasing awareness of health problems associated with the emissions. Voluntary

initiatives have the potential to result in reduction measures beyond these international regulations (i.e. MARPOL Annex VI) and to provide early compliance.

The large variation of different initiatives with different requirements and scope makes it difficult for both shipowners and transport buyers. It may not be possible to have an initiative for all environmental aspects and for all stakeholders. However, with the increased demand for environmental information, shipowners have a market advantage if they can show good overall environmental performance in several different environmental areas. The diversity of initiatives could thus result in a need for shipowners to marketing themselves with as much environmental 'labels' as possible. Since the foundation of these initiatives differs considerably with different requirements to be fulfilled and different and methods for compliance, it is difficult for the shipowner to implement several systems without heavy administrative and operational burden. Which initiatives could be used together without resulting in administrative and operational burden?

It is concluded that the different environmental initiatives that exists show a need for the development of a unified system, or at least internationally accepted standardized methods for the shipowner to use as basis for the environmental evaluation. Further research could be devoted to investigate how such a standard could be developed. The potential global standard being investigated by WWF and the Sustainable Shipping Working Group is thus of particular interest. The high support to develop a global standard expressed by the shipping industry present at the Sustainable Shipping Workshop should be seen in the contexts of the above discussion.

From the transport buyers' perspective, the large variety of systems could cause confusion and result in unnecessary administrative burden for choosing ships with high environmental performance. It could lead to the choice of not using any of these assessment tools. In fact, the very reasons for conducting this study have been identified by Göteborg Energi, a leading energy company in western Sweden. The goal of the project has been to provide greater understanding of the present index systems and their underlying core values, and to provide support for the selection of indices or environmental communication tools. Regarding the large variety of initiatives found, the confusion could be even higher for the general public. Within a mess of environmental labels, awards, rating schemes etc., it is difficult for a shipping company to reach out to the general public. Moreover, how would you be certain that a particular label used by a shipping company show as good performance as marketed by a shipping company if you never heard about the label or know its limitations such as the use in a single port? It could thus be further concluded that the need for a global standardized method is as important for the transport buyers and the general public.

6.2. Which are Indices and which are not?

Due to the limited time-frame of this study, only three of the ten identified indices were evaluated. However, sufficient information for an evaluation was gathered and reviewed for all ten systems. It was found that the list of identified indices in the introduction to Chapter 5 is inconsistent with the definition and main principles of an environmental performance index, as shown in figure 3.1. Some of these systems are not based on measurements of performance as the primary data. Instead they are based on a set of environmental requirements or standards. These could be viewed as indices if they aggregate the scores into a final score or if they use the requirements or standards as indicators of performance. They could however not be defined as environmental performance indices with the definitions used in this study since

they do not measure environmental performance and aggregate the data into a performance index. The question of which initiatives are indices and which are not needs to be further elaborated.

Next section will show that the three evaluated systems could be characterized as environmental performance indices with high confidence. When looking at information found on the seven remaining systems, there are merely two that could be concluded to be consistent with high confidence: the Environmental Ship Index (ESI) and Rightship's GHG Emissions Rating (which include the index EVDI). The ESI calculates two separate indices for NO_x and SO_x emissions. Data input consists of on-board documentation required under MARPOL Annex VI. As an example, the NO_x index gives an indication of the reduction of NO_x emissions below the MARPOL limits per unit of power. Each separate index provides score points and a formula then calculates the final ESI index score. In this calculation, NO_x is weighted twice as high as SO_x. CO_2 emissions are not included in the index, though the use of EEOI reporting or a SEEMP is rewarded with additional score points in the total index score. Rightship's GHG Emissions Rating is used to compare and rate CO_2 emissions from ships based on the *Existing Vessel Design Index* (EVDI). The EVDI is basically the EEDI formula applied to existing ships. It measures CO_2 emitted per tonne-miles based on ship design. Rightship gathers the needed data for the world's over 60 000 ships registered by IHS Fairplay. Based on the EVDI scores, the ships' CO_2 emissions are rated from A (the most efficient) to G (the least efficient).

The five other systems identified as indices are questionable for their inclusion. The Blue Angel initiative includes two eco-labels for environmentally friendly ship construction and ship operation respectively. A ship must meet a list of mandatory requirements and obtain a certain percentage of total score points for optional requirements. Since this scoring system is not based on aggregation of data, the two labels do not fit the definition and principles.

Green Award is a certification of ships and management based on a self-assessment. The self-assessment consists of list of basic criteria that has to be fulfilled. It further has additional requirements with a minimum total score that has to be obtained in in order to receive certification, as well as a minimum score for each main element (Green Award Foundation, 2011). Since the Green Award Foundation provides several documents with different requirements for mainly oil tankers, bulk carriers and LNG carriers, it was not possible to conclude how the scoring system works within the limited time-frame. Hence, it cannot be concluded if it could be included within the definition of an environmental performance index.

Green Marine Environmental Program is based on self-evaluation of environmental performance in seven areas, followed by verification and certification. The self-evaluation consists of a survey with a checklist of criteria for each area. The survey is divided in five levels of performance. All the criteria in a specific level must have been fulfilled in order to reach the level. Green Marine calls the criteria in each level as 'performance indicators', though the system as such is not consistent with the main principles of an environmental performance index used in this study.

RINA Green Plus is a voluntary class notation for design of large yachts. It is based on an environmental performance index with 12 pollution sources covered. Technical solutions and operational procedures have been identified for these sources. The measures are listed for each source and given a score and then added to a total index score. In order to obtain the

class notation, at least 100 points must be obtained as a total score and at least nine items from the twelve pollution sources must be selected. It is clear that the system uses an index, but environmental performance data from ships does not seem to be used as input. Rules for classification were obtained, though not reviewed due to the limited time-frame. Hence, it cannot be concluded if it could be included within the definition of an environmental performance index.

Triple-E is a rating scheme based on self-assessments by shipping companies and verification by DNV. The four rating levels each contains requirements of which all has to be fulfilled in order to reach the level. It requires measurements and monitoring, as well as improvement targets and plans for use in management decisions. The highest level does however require that the average sulphur content of the ship is lower than the average global sulphur content. The highest level further includes the development and implementation of a risk assessment system. This sub-system within the system makes it difficult to evaluate Triple-E further. The requirement to perform against targets has partial characteristics of performance indices, though the limited time-frame made it impossible to conclude if Triple-E is in consistence with the definition and main principles (DNV 2011a-b).

With the above analysis, it could be concluded that not all systems would had been possible to include in the study by using the developed evaluation scheme. In addition to the inconsistencies of identified indices, the different tools applicable for use in indices could as well be termed indices, such as the different calculators and software that were found. Equally, some identified indices could be used as tools in other index systems. In particular, the evaluation has shown that this true for EEOI and CCWG. The review of all ten systems revealed an even wider connection, such as the use of ESI is a requirement that provides scores in Green Award. Should these index systems within index systems be termed indicators, such as the Energy Efficiency Operational Indicator?[xiii]

6.3. Evaluation

The evaluation results showed that information for most of the elements of the evaluation scheme could be found by gathered data, though by more or less detailed quality. Despite the lack of information in some of the elements, the evaluated indices could be concluded to be consistent with the pattern of the evaluation scheme. It could be concluded with high confidence that they all could be characterized as environmental performance indices with the definition used in this study. The three evaluated indices each assess environmental performance based on data for individual vessels, which then is aggregated into a final index. These indices could be used for a shipowner to benchmark and market environmental performance of their ships, and for a transport buyer to select the ships and shipowners according to their performance results. Third-party verification exists for all three indices, which provides quality control of the data used for the performance assessment. They do however show a large variation in their construction and application.

The Energy Efficiency Operational Indicator (EEOI) uses a formula to calculate CO_2 emissions per unit of transport work of a specific ship for specific voyage. It is thus restricted as an energy efficiency index, or in another term a CO_2 index. It is merely a recommendation

[xiii] The information used in this section is based on the references in Annex 2. Additional references are listed in the text.

in guidelines from the IMO and could be used by almost every shipowner or operator with ships that conducts transport work, i.e. carrying cargo or passengers. By this tool, they can calculate their emissions and energy efficiency and use the results to market their performance. It could further be used as a tool in environmental management systems, as well as larger index systems, which has proven to be the case in the results of this study. The EEOI is found in the other two evaluated indices, as well as in many of the initiatives found in the inventory. Since the EEOI is applied as self-assessment at shipowner level, there were difficulties to fully evaluate certain parts of the scheme, primarily updates and reviews and end results. Regarding the different use by different shipowners, the evaluation as a whole was thus restricted to the guidelines. Further evaluation of practical implementation should be conducted at shipowner level or larger systems that have integrated the EEOI. Regarding the end results, the earlier difficulties found with the interim CO_2 index trials should be followed up for the current situation. Third-party certification of EEOI is available from classicisation societies, though lack of information made it impossible to evaluate the verification procedure and the quality control results of such verification.

The other two evaluated indices use scoring systems for different environmental areas. The CCWG Performance Metrics Tool uses an Excel-based tool for carriers to enter ship-specific data in six categories. It is only applicable for container ships. Dependent on the category, the data needed consists of emission levels or specific requirements. The CO_2 emissions category has the EEOI as basis and adapted to container ships. The scoring system is based on baselines for each category or specific requirements. The scores for each category are summed into a final score. The scores are shown in a scorecard that is available to shippers of the group, but only if the carrier chooses to share its data. It was however not possible to fully evaluate the scoring system due to lack of information. The lack of information could be explained by the restrictive use of the data within the group. The transparency is however high within the group. Third-party verification is not a requirement in the tool, though about half of the carriers had verified their information. The group initiative is unique in the context that it links carriers, shippers and logistics providers, enabling environmental data sharing and an open dialogue. It provides the opportunity for large international companies such as Coca-Cola or Ikea to select carriers according to their environmental performance. The membership of these large companies provides large incentives for carriers to participate, enter their environmental data and to improve their performance. Similar to EEOI, the tool is used in other initiatives such as the Clean Shipping Index.

The Clean Shipping Index (CSI) has similarities to the Performance Metrics tool. However, far more information was found on the CSI. It is applicable for ten major ship types in the world of all ages. It uses an online tool in which carriers enter ship-specific data in five environmental areas. As with the CCWG, the data needed consists of emission levels or specific requirements depending on the area. The CO_2 emissions area has either the EEOI or CCWG methodology as basis. The scoring system the CSI is complex. It is based on a sub-scoring system within each area. Each area has a maximum score that is 20% of the total score for the index. However, this total score is not used in the ranking system of ships, but rather a total average percentage calculation covering the obtained percentage of the total score of each area. The ranking system is complex and has a number of different criteria for the three ranks; red, yellow and green. The CSI further ranks carriers with an even more complex system, including a total weighed score, as well as an additional blue colouring system illustrating carrier performance and group rankings for the same type of carriers. Third-party verification is offered for both individual ships and carriers. Verification is further required for reaching the highest rank in both ships and carriers. This provides incentives for

verification. The transparency is high behind the methodology, though the complexity of it could be a problem for explaining the system to the general public. Similar to the CCWG, the transparency of the performance results are restricted to membership of cargo owners in a network. The transparency is high for these members, with detailed information down to entered data. Membership provides the opportunity for cargo owners to select carriers according to their environmental performance. With member such as H&M and Volvo Logistics, the CSI provides similar incentives for shipowners to enter their environmental data and to improve their performance as CCWG.

The varieties shown of the three different indices could be explained by the variety of stakeholders connected to the indices. It could be concluded that the properties of a particular index depend on the indented use, which in turn depends on the intended users and the developer of the index. The target group and developer thus control the scope and focus, and there is no index for them all.

6.4. Contribution of the Study

6.4.1. Decision Support

For decision-makers in the shipping industry, this report could provide support for the selection of indices or environmental communication tools. It could identify potential uses and users of the indices. It could further provide decision support for Göteborg Energi with increased knowledge of their suppliers' different environmental marketing tools. It can be used to identify the tools used by shipping companies and their relevance in application, environmental scope and quality control. Göteborg Energi could further use the results as part of a larger environmental strategy throughout their supply chain. They can choose a relevant index (or other initiatives identified in the report) as an environmental requirement for their suppliers of energy sources. Suppliers' environmental performance could be easily assessed by many of the tools found, but with different levels, aspects and quality control. By choosing an initiative that clearly shows environmental performance of ship transportation, Göteborg Energi could choose their suppliers thereafter or demand that they perform better. This would provide marketing advantages and show to the general public that, as a leading energy company in the western Sweden, it also puts itself in the forefront of energy or environmentally efficient transport of their energy sources.

Another opportunity for Göteborg Energi is that the initiatives further could reduce the transportation costs, in particular by energy efficiency measures, but also through reduced port dues, in for example the Port of Gothenburg. Finally, by investing in infrastructure for LNG, there are possibilities of market synergies between Göteborg Energi, shipping companies and ship indices. The use of LNG as fuel in ships would provide score points in some indices. Reduced port dues are then given for a good performance of a particular index. The use of LNG would further reduce air pollution in ports and in for example in the city of Gothenburg.

6.4.2. Research Contribution

The number of studies on environmental ship indices is few. The majority of previous studies on environmental indices for shipping have focused on developing a new index system. The evaluation part of these studies were thus limited to comparison of the indices, such as pros and cons as in EMSA (2007) or successful parameters for developing a new index in Jivén

(1999). The focus of developing new indices also limited the environmental scope thereafter, e.g. den Boer et al. (2009) focused on existing systems for air pollutants and CO_2 emissions from shipping in order to develop the *Environmental Ship Index* (ESI). In addition, EMSA (2007) showed methodological problems with comparing environmental initiatives for shipping. EMSA (2007, p.139) concluded that "*the incentive and awarding systems are not directly and quantitatively comparable, as they are not consistent with each other. This is of course explainable by the fact that in different geographical locations different problems occur, which have to be tackled first*". It could be concluded that the development of an evaluation criteria was necessary for comparison. One cannot just compare the indices, since they are differently constructed, have different scope and applying to different types of ship types and shipping companies.

No scientific study has been found that applies the research area of environmental indices or indicators to shipping. The information, knowledge and theory behind ship indices exist at industry level rather than academia. This study has first conducted an inventory of environmental initiatives for shipping in a broad spectrum. By then using an evaluation scheme for with a set of principles and criteria derived from literature, this study could contribute to bring order to the variety of concepts of the different initiatives associated with environmental ship indices. In addition, it could be one way of solving methodological problems of comparison as identified in EMSA (2007).

The evaluation scheme can be used for further studies on environmental ship indices. It could be further developed for more detailed analysis on a single system. It could furthermore be used in developing new index systems, taking the principles and criteria into account. Further research could be devoted to the seven unevaluated but reviewed initiatives in this study; in particular the two identified with high confidence as environmental performance indices. Further research could also asses the effectiveness of voluntary environmental initiatives for shipping in relation to international legislation. It is suggested to focus on the effectiveness of the identified environmental performance indices.

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PERSONAL COMMUNICATION

Marshall Chase, e-mail conversation, 16.11.2011
- Manager, Advisory Services, Business for Social Responsibility

Annex 1. Evaluation Scheme

The following evaluation scheme was used for the evaluation of selected environmental performance indices for shipping.

1. Application and General Construction

- Intended application
- Intended users
- System format and communication format
- Goal-oriented?

    The system should have improvement of environmental performance as a goal.

2. Scope and System Boundaries

- What environmental impacts and aspects are measured and evaluated?
- What ship types, shipping companies and geographical boundaries are included?
- Individual vessels, fleet, transport, and /or management?
- Operational or design?

3. Data Quantification and Prerequisites for Evaluation

- Required data
- How is data obtained?
    - Measurements, self-evaluation, survey, a set of criteria or standards?
    - Who is the data provider?
- Does the index measure and compare environmental performance across time?

4. Evaluation: Scaling and Aggregation

- Level of aggregation

    The index should not be over- or under-aggregated.
- Are different environmental aspects weighted differently?
    - Are such weighting explained?
- Are monetary values used?

    Physical units are preferred before monetary units.

5. Quality Control

A) Documentation and Transparency

- Access to results and data

    The user should be able to derive the results down to details, but also quickly get the general message.
- Does it cost to use the index or to participate?

    The index should be feasible for the user with reasonable costs.

B) Verification and Validation:

- Self-evaluation?
- Validation of data and/or self-evaluation
- Is third-party verification included?

C) Updates and Reviews

- Does the system include regular updates or a review scheme?
- Are developments in technology and legislation taken into account?

6. End Results

- Level of simplicity vs. complexity for the user

    The system and the final index should be as simple as possible and should be in a format for easy communication of environmental performance.
- Comparability between different transport options (e.g. if the user is a purchaser of transport)
- Market incentives?
- Economic incentives (e.g. reduces port dues)?
- Are improvements of performance shown in the index, e.g. higher scores for reduction of a pollutant?

    Improved environmental performance should provide a positive outcome of the index.

Annex 2. Inventory Results

Table A1. IMO Instruments

IMO Instrument	Indented Use and Users	Basis / Scope
Energy Efficiency Design Index (EEDI)[1,2,3]	The EEDI is a mandatory energy efficiency instrument for design of ships. The EEDI only required for new ships built after the entry into force (e.g. no exceptions of ships could be made for contracts placed in 2017 or deliveries in 2019). It also applies to existing ships which has undergone such a major conversion that it is regarded as a new ship. It is not applicable to all ship types, but covers 72% of emissions from new ships, including oil and gas tankers, bulk carriers, general cargo ships, refrigerated cargo carriers and container ships.	The EEDI is a performance-based mechanism that requires a minimum energy-efficiency level for new ships based on a formula, and leaves the technological solutions in ship design to the industry. The basics of the EEDI formula is CO_2 emissions divided by transport work, but it is more complex and calculations are found in IMO guidelines. Additional correction factors are applied for some ship types. The attained EEDI for a ship shall be ≦ the required EEDI for a particular ship type. The required and attained EEDI are accounted for in an International Energy Efficiency Certificate, as required under the MARPOL amendments. The certificate is issued after a survey.
Ship Energy Efficiency Management Plan (SEEMP) [4,5,6]	The SEEMP is a mandatory on-board management tool to monitor fuel efficiency for all ships as supplement to EEDI. The purpose of such a plan is "*to establish a mechanism for a company and/or a ship to improve the energy efficiency of a ship's operation*"[7]. It could also be used as an integrated element of a shipping company's environmental management systems, e.g. ISO 14001 or the new energy management standard, ISO 50001.	All ships under the provisions of the amendment are required to have a SEEMP on board. It is developed based on IMO guidelines and provides "*a possible approach for monitoring ship and fleet efficiency performance over time and some options to be considered when seeking to optimize the performance of the ship*"[8]. The SEEMP is accounted in the International Energy Efficiency Certificate (see above).
Energy Efficiency Operational Indicator (EEOI)[9,10]	The EEOI is a voluntary tool for monitoring operational energy efficiency of ships. Shipowners and operators can use it to evaluate the operational energy efficiency performance of their ships and fleet. It could be used as a tool for the SEEMP. The EEOI can be applied for almost all new and existing ships, though only ships that provide transport work.	The EEOI includes monitoring of ships CO_2 emissions and calculation of energy efficiency at each voyage or over a specific period. The EEOI formula is calculated as the actual CO_2 emissions divided by the performed transport work. Smaller values are more energy efficient. IMO Guidelines from 2009 provides assistance for establishing such an indicator, e.g. calculation of the indicator and data monitoring.
Green Passport (Inventory of Hazardous Materials)[11,12]	The Green Passport was first introduced through IMO Guidelines on Ship Recycling in 2003 and is a key requirement in the Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships, 2009. It has not entered in to force yet, but the passport can be used by the industry to enable early implementation of the Convention.	The inventory includes all materials of a ship that are potentially hazardous to human health or the environment. A document of the inventory (the Green Passport) is followed throughout the entire lifecycle of a ship. It is produced at construction by the shipyard and is then passed to the purchaser of the ship and subsequent owners. Changes in materials are recorded in the document. When the final owner delivers the ships for shipbreaking, the document is delivered with it. Classification Societies approve and verify the passport.

Table A2. National Instruments and Initiatives

Instrument / Initiative	Developed by / Provider of Service	Indented Use and Users	Basis / Scope
The Blue Angel 1) RAL-UZ 141 [13,14] 2) RAL-UZ 110 [15,16]	- German Federal Ministry for the Environment Nature Conservation and Nuclear Safety - The Federal Environment Agency - RAL gGmbH - The Environmental Label Jury (environmental and consumer associations, industry, science, media etc.)	**1) RAL-UZ 141** is an ecolabel for environmentally friendly ship design. It applies to merchant ships, research and authority ships. It is intended to make ships comply with standards already at the construction phase. **2) RAL-UZ 110** is an ecolabel for environmentally friendly ship operation. It only applies to ships under German flag. Ships under the High Speed Craft Code, tankers, fishing vessels and navy ships are excluded.	**1)** In order to receive certification, a ship must meet a list of mandatory requirements and obtain 50 points of optional requirements, ranging between 1-10 points each. The requirements include installation of air pollution abatement technology, double hull and on-board waste and wastewater treatment. **2)** Like above, a ship or shipping company must meet a list of mandatory requirements and obtain 28 points of optional requirements, which is about 30% of maximum achievable optional points. The requirements include MARPOL, the ISM Code and optional stricter measures such as low-sulphur fuels.
Green Ship Certificate and Green Ship Program [17,18]	Korea Coast Guard and Korea Finance Corporation (KoFC)	The Green Ship Certificate is intended to inspire the shipping industry to engage in voluntary pollution prevention. Qualified initiatives obtain a Green Ship Certificate. The Green Ship Program offers financing of green ship construction.	The Green Ship Certificate has been around since 1998. Ships obtain a certificate for fulfilling required equipment or technology for reducing GHG emissions and air pollutants. DNV Korea certifies these "green ships". Since 2011, the Green Ship Program subsidizes part of the building costs for newbuildings qualified as green ships. The certificate is needed for new ships in order to obtain the finance.
Qualship 21 [19,20]	United States Coast Guard	Inspection of all foreign ships at port. The initiative aims to identify high-quality ships and reward them with certificate reduced inspections.	US Coast Guard inspects all foreign vessels at least once a year. Typical characteristics for quality ships include no substandard detention and no Port State Control detentions in US waters in previous 36 months and 24 months respectively. Qualified ships receive a certificate, valid for two years. Tank and freight ships obtain reduced inspections during the period.
1) Voluntary Best Achievable Protection (VBAP) Programme 2) Exceptional Compliance (ECOPRO) Programme [21,22]	Washington State Department of Ecology	**1)** To protect Washington's natural resources from oil spills, Washington State first introduced mandatory *Best Achievable Protection* (BAP) standards for tank ships and tank barges, but INTERTANKO sued Washington and the US Supreme Court ruled in favour of INTERTANKO in 2000. The standards were then reintroduced in a voluntary programme. Tanker owners and operators can now commit to meet the	Both programmes consist of standards beyond US and international standards, divided in four categories; operating procedures, personnel policies, management practices, and marine safety technology. An applicant could first be given associate member status of VBAP after a review of its oil spill prevention plan. Full member status is obtained after inspections of the company's ships to verify that they operate according to the standards. The prevention plan is then kept complete and up-to-date in order to maintain the membership. Vessel inspections are conducted every three years for renewal

		BAP standards voluntarily, and to demonstrate it publicly at a website. **2)** The ECOPRO programme is aimed for companies that want to do more than the VBAP. ECOPRO thus consists of stricter standards for tankers than VBAP.	of the membership. The same procedure also applies for ECOPRO. Participant companies are posted at the "Spills Program" website. Since the website is visited by a diversity of people and organizations, participants demonstrate their commitments to costumers and the public. ECOPRO members also receive an ECOPRO award.

Table A3. Green Class Notations

Classification Society	Class Notation	Indented Use and Users	Basis / Scope
American Bureau of Shipping (ABS)	Enviro and Enviro + [23, 24]	ENVIRO is an additional notation aimed at compliance with adopted international regulations (regardless of ratification). ENVIRO+ has more stringent criteria.	In order to obtain the notations, compliance with MARPOL Annex I, II, IV, V and VI is a prerequisite. Enviro + is more stringent in design characteristics, management systems, sea discharges and air emissions.
Bureau Veritas (BV)	Cleanship and Cleanship Super [25]	Cleanship and Cleanship Super are additional notations for ships that comply with international regulations. Cleanship Super is for tanker ships.	The notations are obtained for compliance with MARPOL, the Anti-Fouling convention and Ballast Water Management guidelines.
Det Norske Veritas (DNV)	Clean[26,27]	Clean is an additional notation to show that a shipowner or operator uses a proactive environmental policy to reduce emissions and discharges from its ships.	The requirements include control and reduction of emissions and discharges in the following areas: NO_x and SO_x emissions, refrigerants, TBT-free antifouling, sewage and other waste water treatment. The requirements are based on MARPOL, including not yet ratified regulations, and additional criteria.
	Clean Design[28]	Clean-Design provides additional environmental protection by requiring defensive design, accident prevention and consequence limitation.	In addition to the requirements on control and reduction of emissions and discharges of the Clean notation, the Clean-Design notation includes stricter requirements. The following additional elements are included: protection of fuel tanks from grounding, ballast water and fuel oil handling, environmentally friendly antifouling, Green Passport etc.
	Triple-E[29,30,31]	Triple-E (Environmental and Energy Efficiency rating scheme) is different from additional class notations. It is not based on regulations. Instead, it rates ships based on their environmental performance. It applies to both new and existing ships, independent of class, age and flag. It can improve organisational performance, identify and minimise environmental impacts and optimise fuel consumption. It can be used for preparation	Triple-E provides shipowners and operators with a self-assessment tool of the ships' environmental performance. The self-assessment is based on the Triple-E guidelines. The assessment, and the performance, is then verified by DNV by an office visit and on board the ship if necessary. The assessment ends up with and environmental rating of ships from 4 to 1 (1 is highest). It consists of the following key elements: environmental management, energy efficient operation and design, and verifiable monitoring, measurements and documentation. A Triple-E Rating Declaration is

		of future stringent regulations or as a label for marketing environmental performance.	issued after the verification, and is valid for 15 months. It includes the vessels rating score. The declarations are published on the DNV website for transparency.
Germanischer Lloyd (GL)	GL's Operational CO_2 Index Certification[32,33]	The Operational CO_2 Index Certification is a third party verification of the data used to calculate an Operational CO_2 Index, i.e. the EEOI by IMO, over the period of one year. The verified index could be used in efficiency analyses or in EMS.	The crew of a ship gather the necessary data and sends it to GL for analysis. The data is then verified by an office audit. GL then calculate the index, first for each voyage, then the average for a year. The ship then receives certification for one year.
	Environmental Passport (EP)[34,35]	The Environmental Passport (EP) is an additional class-notation and a certificate with additional moderate requirements beyond existing regulation for reducing environmental impacts from ships. It can be used for voluntary early compliance of IMO regulations which not yet have entered into force. It is the main element of GL's Environmental Service System, in which the customer can supplement the passport with individual services from GL.	The requirements consist of two parts. The first is a general list of compliance with international regulations, required documentation, operational procedures and plans. The second part consists of technical requirements on discharges into the sea (e.g., garbage, ballast water) and air emissions (e.g. SO_x, NO_x, and GHG refrigerants). New requirements from 2011 include on discharge of bilge water, required ballast water treatment, attained EEDI for new ships and the Green Passport. The EP certificate is issued after meeting the requirements in the guidelines. Ships classed by GL obtain the class notation EP. Both are valid for a maximum of 5 years. An Interim EP for 5 months can be issued for newbuildings.
Lloyds Register (LR)	Environmental Protection (EP)[36]	The EP is the first environmental class notation. It applies to all ships classed with a society under IACS. The rules of EP go beyond existing regulation and can be used for publicly demonstrating a shipping company's proactive approach of improving the environmental performance.	The rules of the EP are based on an environmental risk assessment, and are updated regularly with operational feedback. The first part of the rules consists of core requirements above existing regulations in the following areas: NO_x and SO_x emissions, refrigerants and fire-fighting agents, oil pollution prevention, garbage, sewage, anti-fouling and ballast water. The second part consists of more stringent optional requirements. They include anti-fouling, ballast water management, NO_x and SO_x emissions etc.
Nippon Kaiji Kyokai (ClassNK)	Environmental Awareness (EA)[37]	Environmental Awareness is an additional class-notation for ClassNK classed ships. It was developed with the purpose to evaluate ships with environmental measures not required under existing regulations.	The requirements for EA are set in an "environmental guideline" and consist of minimum requirements and additional requirements. The minimum requirements consist of compliance with MARPOL regulations. The additional requirements are for ships that take more advanced environmental measures. These ships obtain additional marks to the notation. For example, in order to obtain the mark "EA + SOx" the ship shall use fuel with $\leq$0.1% sulphur content.
Registro Italiano Navale (RINA)	Green Star Design[38]	The Green Star Design is an additional class notation which could be used to show compliance with environmental regulations.	The notation consists of two sub-notations: Clean Seas and Clean Air. The notation is obtained for ships which meet the requirements of the two sub-notions, based on MARPOL Annex I, IV, V, VI.
	Green Plus[39,40]	Green Plus is presented by RINA as a goal-based	The goal-based approach of the notation means that designers and

		class notation, instead of a prescriptive. It is based on an environmental performance index with all aspects of environmental impacts from ships. It is however only applicable for yachts. New ships obtain the certificate for measures that improve the environmental performance of the ship beyond international regulation.	shipyards could choose design and operational measures, as long as they achieve an assigned value the environmental performance index. 12 pollution sources are covered in the index. Operative and design measures for pollution prevention are listed for each source. The index is calculated based on a scoring system, where each of the following items are given a score and then added to the total index; oil, sewage, grey water, garbage, other sea pollution (e.g. ballast water, antifouling), ozone-depleting substances, GHGs, air pollutants and materials and building procedures for yachts. Ships that go even beyond the included items could obtain, Green Plus Yacht Gold and Platinum certifications. Moreover, a shipping company can choose to quantify its CO_2 emissions and compensate by engaging in emission trading, approved by RINA.

Table A4. Port Initiatives

System / Project	Provider of Service	Indented Use and Users	Basis / Scope
Cruise Ship Environmental Award[41]	Port of San Francisco Cruise Terminal Environmental Advisory Committee (CTEAC)	Annual award for cruise ships that reduces air and water pollution when they operate in the San Francisco bay. It is given for ships that call the port twice or more per year.	The requirements of the award are measures beyond regulation and industry standards in the following categories: air emissions, wastewater treatment, recycling and disposal of solid waste. The criteria are assed with a scoring system in a survey. After fulfilling the required scores, an award is given and published on the website of the Port of San Francisco.
EcoAction Program and the Blue Circle Award[42,43,44]	Port of Vancouver, Canada	The EcoAction Program for Shipping provides economic incentives for shipping companies that reduce air emissions from their ocean-going vessels. Efforts are rewarded with reduced port dues and the Blue Circle award, which is given for the highest emission reduction achievements in the program.	The EcoAction Program includes three port due reduction rates; bronze, silver and gold. Each rate has a number of technology and fuel options in different categories, including sulphur content of fuel, green class notations, abatement technology, alternative fuels etc. Ships have to implement one of each category to obtain the rate. Awards are then given for the strongest efforts in the ratings, including fuel quality and overall air emission reductions.
Environmental Ship Index (ESI) [45,46,47]	World Ports Climate Initiative (WPCI)	Used for identifying seagoing ships that goes beyond regulation in air emissions and CO_2. Intended to be used by ports to reward ships with ESI or by shipowners to communicate clean shipping.	Quantities of NO_x and SO_x emissions from ships (all types) are evaluated in separate indices and weighted in the ESI index. IMO and EU regulations are baselines. Score points are obtained for ships that perform beyond the baselines. CO_2 emissions are not included in the index, though the use of EEOI reporting or a SEEMP is rewarded by 10 points in the total index score. Rewards in port could be based the total

			score or on each of its parts.
Green Award [48,49,50]	The Green Award Foundation (Rotterdam Municipal Port Management and the Dutch Ministry of Transport)	An environmental certificate for office management and for ships: oil tankers and dry bulk carriers ≥ 20.000 DWT, LNG carriers and inland navigation vessels. It is used for reduced port dues in Belgium, Canada, Latvia, Lithuania, the Netherlands, Oman, New Zealand, Portugal and South Africa.	An Office Certificate is issued after an audit. After sufficient score in a survey, and after verification, a ship is certified. The requirements include safety, quality, environment and technical areas of a ship and the office of the manager. The environmental areas include: exhaust emissions, ballast water, anti-fouling, ship breaking, sensitive areas and waste management. Certification is made by the Bureau Green Award. The certificate is valid in three years with annual audits.
Maritime Singapore Green Initiative: 1) Green Ship Programme[51] 2) Green Port[52] Programme	Maritime and Port Authority of Singapore	Ships calling the Port of Singapore with air pollution abatement or measures beyond EEDI obtain economic incentives and awards. The programmes run in 5 years from 1 July 2011.	**1) Green Ship Programme:** Singapore-flagged ships which go beyond the requirements of EEDI will receive a 50% reduction of Initial Registration Fees and a 20% rebate on Annual Tonnage Tax. A ship is qualified if the International Energy Efficiency (IEE) Certificate show that a ship's EEDI exceeds IMO's requirements for a specific ship type and size. Qualified ships and shipowners receive a "Green Letter of Recognition". **2) Green Port Programme: O**cean-going ships calling the Port of Singapore with air pollution abatement technology or fuels with sulphur content less than 1% obtain 15% reduction on port dues.

Table A5. Initiatives from Cargo Owners, NGOs and Shipping Associations

System / Project	Provider of Service	Indented Use and Users	Basis / Scope
Clean Cargo Working Group (CCWG): 1) The Performance Metrics Tool 2) Environmental Performance Survey (EPS) 3) Intermodal Calculator Tool [53]	Business for Social Responsibility (BSR)	**1-2)** Environmental performance scorecard for ocean container ships. Can be used for benchmarking individual carriers. The members represent over 60% of the containers shipped in the world. **3)** CO_2 Calculator for Intermodal shipments	**1) The Performance Metrics Tool** is an Excel-based, quantitative tool for measuring environmental performance by each vessel. The data includes: CO_2, SO_x, NO_x, waste/water/chemicals management, EMS and transparency. Each category is scored based on set performance thresholds (indexed average for CO_2), and included in a final scorecard. **2) The EPS** is a qualitative survey to supplement the performance metrics tool. **3) The Intermodal Calculator Tool** uses data from the performance metrics tool and best available data for other modes to calculate CO_2 from intermodal shipments.

Clean Shipping Index (CSI) [54,55]	Clean Shipping Project	Cargo owners could use the CSI to evaluate the environmental performance of ships (major types of all ages) and shipping companies and choose providers of shipping.	A web-based tool that ranks ships or shipping companies according to their environmental performance in CO_2, SO_x, NO_x and PM emissions, chemical products and water/waste. Third party verification is included. Data input consists of a questionnaire to shipowners. The ships are ranked (low, medium or good) based on scores obtained for measures beyond regulation. A shipowner obtains a final index for the total average score multiplied with the percentage of ships included in its fleet. Data can be analysed in detail, e.g. emissions from a specific engine.
Good Environmental Choice[56,57]	Swedish Society for Nature Conservation (SSNC)	Ecolabel on freight transports including shipping. Goals: to accelerate environmental or efficiency development and switch to renewables in the transport sector.	The criteria include amount of non-renewable energy consumption in kWh/tonne/km. Emissions have to be measured in EU standards and cannot exceed defined limits (in g/tonne/km). After an audit, the label (licence) is obtained. SSNC Claims it to be "the world's toughest environmental label"
Green Marine Environmental Program[58,59,60, 61]	Green Marine	Voluntary program for shipowners, ports, terminals and stevedoring companies operating in Canada and USA. It was first developed for the Great Lakes and St. Lawrence corridor, but now covers the entire North America. It is intended to improve the participants' environmental performance beyond regulations.	Requires participants to adopt for concrete action (practices and technologies) beyond regulation and continuously improve the environmental performance in seven areas: aquatic invasive species, SO_x and NO_x emissions, GHG, cargo residues, oily waters, sensitivities at ports (noise, dust etc.) and environmental leadership. Each area is self-evaluated with performance indicators on a rating from 1 to 5. The results are then validated by third party audits every two years. The results are also published for transparency. The Green Marine Seal Certificate is issued when requirements are fulfilled.
Rightship:[62,63] *1) Existing Vessel Design Index* (EVDI) 2) *GHG Emissions Rating* 3) *Environmental Rating*	Rightship	**1)** An efficiency design index similar to EEDI, but also for existing ships. It is used as a basis for GHG Emission Rating. **2)** CO_2 rating of existing ships. Can be used for comparison with similar size and type. **3)** Developed to supplement 1 and 2 with a holistic environmental rating of ships.	**1) EVDI** measures CO_2 emitted per tonne-miles based on ship design. Can be summarised as an EEDI for the world's over 60 000 ships. Data is provided from RightShip's *Ship Vetting Information System* (SVIS), IHS Fairplay, classification societies, shipowners and ship-sourced data. **2) GHG Emissions Rating** is a rating scheme of ships' CO_2 emissions from A (the most efficient) to G (the least efficient) based on EVDI scores.

			3) Environmental rating rates environmental performance and management of ships and rates based on scores. The calculations are based on analysis of data input from a 3-year rolling review of the environmental performance of the yard, flag and class of the ship and the ship's violation history of MARPOL. Each factor is given a score. Scores are also obtained if specific criteria are met, including ISO 14001, Green Award, green class notations, Green Passport, SEEMP and retrofitted equipment. The scores are then calculated to a rating scale of 1-5 stars, where 5 clearly show performance above regulations.
Shippingefficency.org[64]	Carbon War Room and partners	Web-based energy efficiency rating of existing ships and CO_2 rating for container ships. For all internet users.	Rating of around 60 000 ships from A to G, based on the EEDI formula and data from IHS Fairplay. Shipowners and operators can update the data with new efficiency implementation. The website also uses the CCWG index for benchmarking CO_2 efficiency of ocean container ships with other ships on major container routes.

Table A6. Proposals and On-going Initiatives

Project	Developer	Indented Use and Users	Basis / Scope
Baltic Region Environmental Efficiency (Design) Index (BREE(D)I)[65,66]	Deltamarin and Baltic Sea Action Group (BSAG)	To compare ship types in Baltic Sea region, to develop operational guidelines and for port fees etc.	For all commercial ships (>400GT) in the Baltic Sea Region. For all emission types. For all emission stages. The final index will completed November 30, 2011 and presented to HELCOM and maritime authorities.
ECOSHIP-UP[67]	NORDEN Energy and Transport Programme Project Leader: Aalborg University	Research proposal on Nordic co-operation	Aims at developing a network for innovation in ship eco-labelling. Expected results: Harmonization of a common ship eco-labelling scheme in the participant countries.
European Clean Ship Awarding System[68]	Proposition by consultants in EMSA (2007): HPTI Hamburg Port Training Institute GmbH	Overall European environmental clean ship label for ship operation	Existing environmental initiatives in 2005 were evaluated with pros and cons, after which a better system was proposed to be applied for the whole EU, financed by member states. It was proposed to be comprehensive, complete, flexible and with high public visibility. The Blue Angel was an inspiration for this label. No subsequent developments were found.
Formal Safety Assessment: Criteria for environmental differentiating of ships[69,70]	Norwegian Green Ship Research Program Submitted by the Norwegian delegation to IMO 1997.	Norwegian proposal of an environmental index to IMO (MEPC 40/16/2).	It was proposed to include reduced port fees. The Norwegian Green Ship Research Program also proposed to include an environmental related tonnage tax in 1999. No subsequent developments were found.
The Logistics and Transportation Sector Supplement to Global Reporting Initiative[71]	Global Reporting Initiative (GRI)	Pilot available for reporting.	A sector supplement to GRI with indicators and guidelines for adapted for companies in logistics and transportation sector. Developed by a multi-stakeholder working group, including UNDP, Stena and ITF.
The Sustainable Shipping Council (SSC)[72]	Initiative from the Sustainable Shipping Workshop) hosted by WWF on April 14th 2011. Current work is conducted by WWF and a Sustainable Shipping Working Group, consisting of 16 participants from various organizations, e.g. LR, Green Award, Clean Shipping Project and IMO.	The initiative intends to develop a global sustainable shipping frame-work government by a Sustainable Shipping Council (SSC). The work includes the potentiality of introducing a globally standardized certification label for shipping, similar to Forest Stewardship Council (FSC) for forest products and Marine Stewardship Council (MSC) for fish and seafood.	The workshop had 24 participants, representing almost every major sector of the shipping industry. There was general consensus that a global sustainable shipping framework has to be developed. As a first phase of developing such a framework, WWF conducted an overview on sustainable shipping initiatives. A second phase will investigate and compare the key global sustainable frameworks currently in operation. The investigation is conducted in relation to the applicability for the shipping industry. A detailed action plan will then be presented to the shipping industry.

Table A7. On-board Tools, Software and Calculators

Tool	Provider of Service	Indented Use and Users	Basis / Scope
Environmental Performance System (EPS)[73,74,75]	DNV Software	Software to measure environmental performance and calculate CO_2 index.	Web-based reporting tool. Supports GRI and ISO 14001 standards. Emissions are calculated by DNV verified formulas. Consists of two modules: **1) Nauticus Air:** measures SO_x , NO_x, CH_4, fuel consumption, transported cargo and distance sailed, and calculates operational CO_2 index. **2) Nauticus Environment:** extension of Nauticus Air with, *inter alia,* discharges, ballast water and chemicals.
IAPH Air quality and Greenhouse Gas Tool Box[76]	International Association of Ports and Harbors (IAPH)	Tools and guidance for ports to ESI and Carbon footprinting	Tools for ports to address air quality and climate change, with case studies etc. **1) Priority Pollutants Tool Box** **2) Greenhouse Gas Tool Box**
MariNOx[77]	Martek Marine	On-board equipment and software. Can be used for a tool for CO_2 index.	On-board NO_x, SO_x & CO_2 emissions monitoring system for engines, boilers or gas turbines. Recording and trends in software. Has received type approval by LR and DNV.
Marorka[78]	Marorka	On-board monitoring of fuel and energy. Fleet management tools.	**1) Maren:** on-board energy management system with monitoring and decision support. **2) Fuel Manager:** on-board measurement and calculation of fuel performance. **3) SPM (Ship Performance Monitor):** touch panel computer showing measurement data and performance analysis. **4) Marorka Portal**: energy fleet management system for shipowners and operators.
NTMCalc[79]	Network for Transport and Environment, (NTM)	Calculators and databases for freight transport	Includes: - Online emission calculators and comparison between transport modes - A database for freight transportation in (introduced in 1997) was updated with the user interface NTMCalc in 2002. - An evaluation tool of transport services

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