



# CLEAN SHIPPING INDEX

Methodology and Reporting Guidelines



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### About the Clean Shipping Index

Since 2021 the Clean Shipping Index is run by IVL Swedish Environmental Research Institute. The methodology and reporting guidelines are updated in collaboration with the CSI Technical committee.

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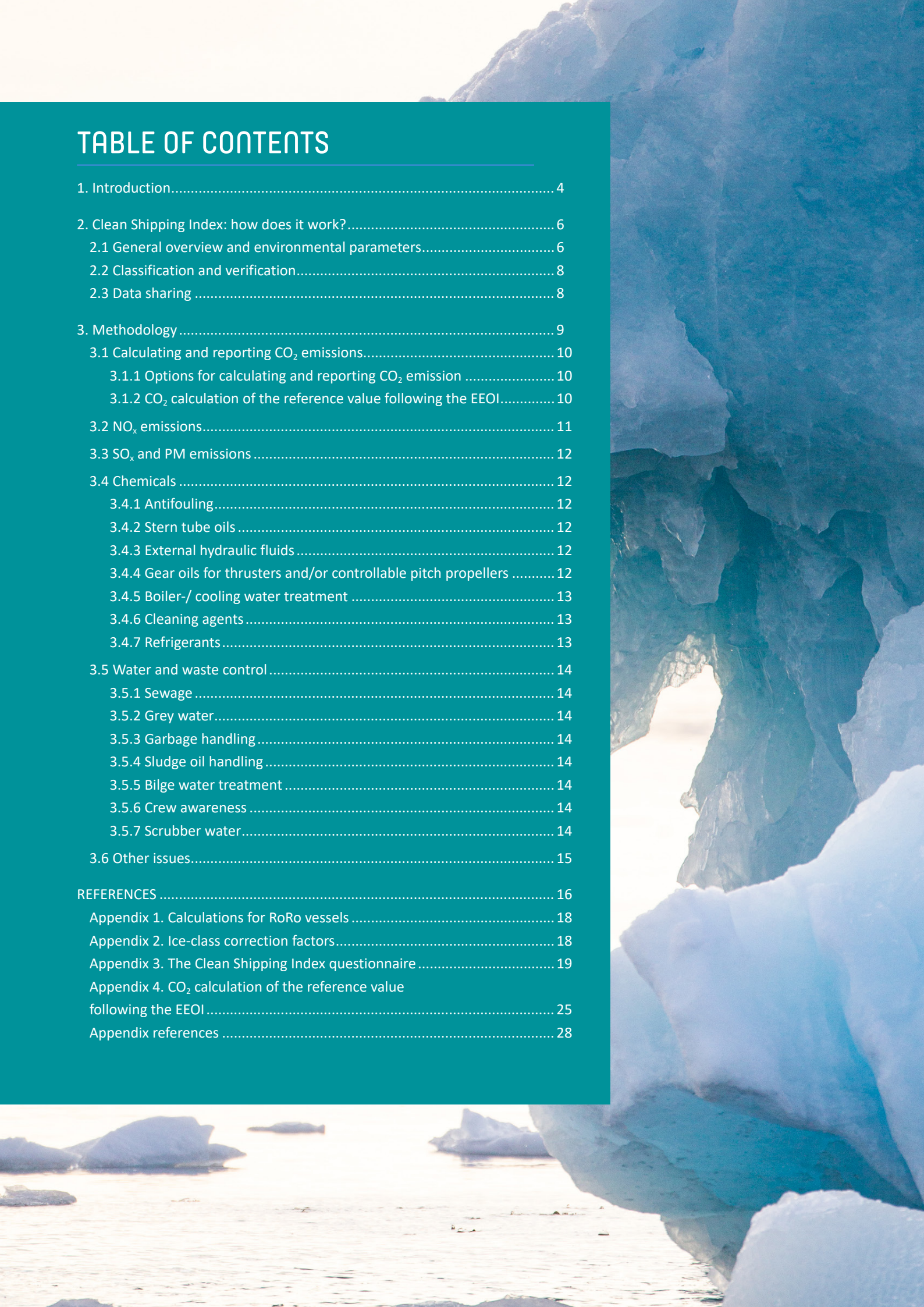


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# 1. The process for registering vessels in Clean Shipping Index

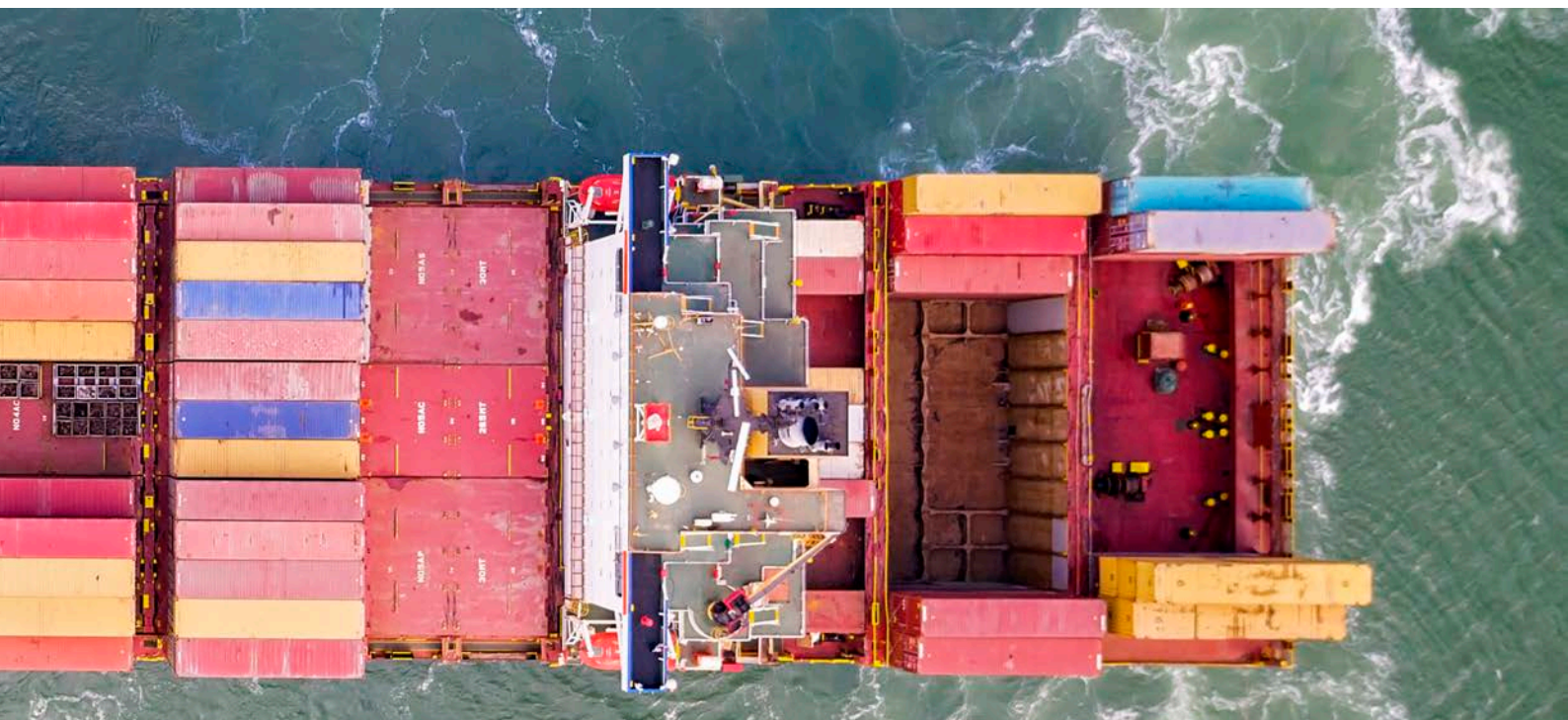
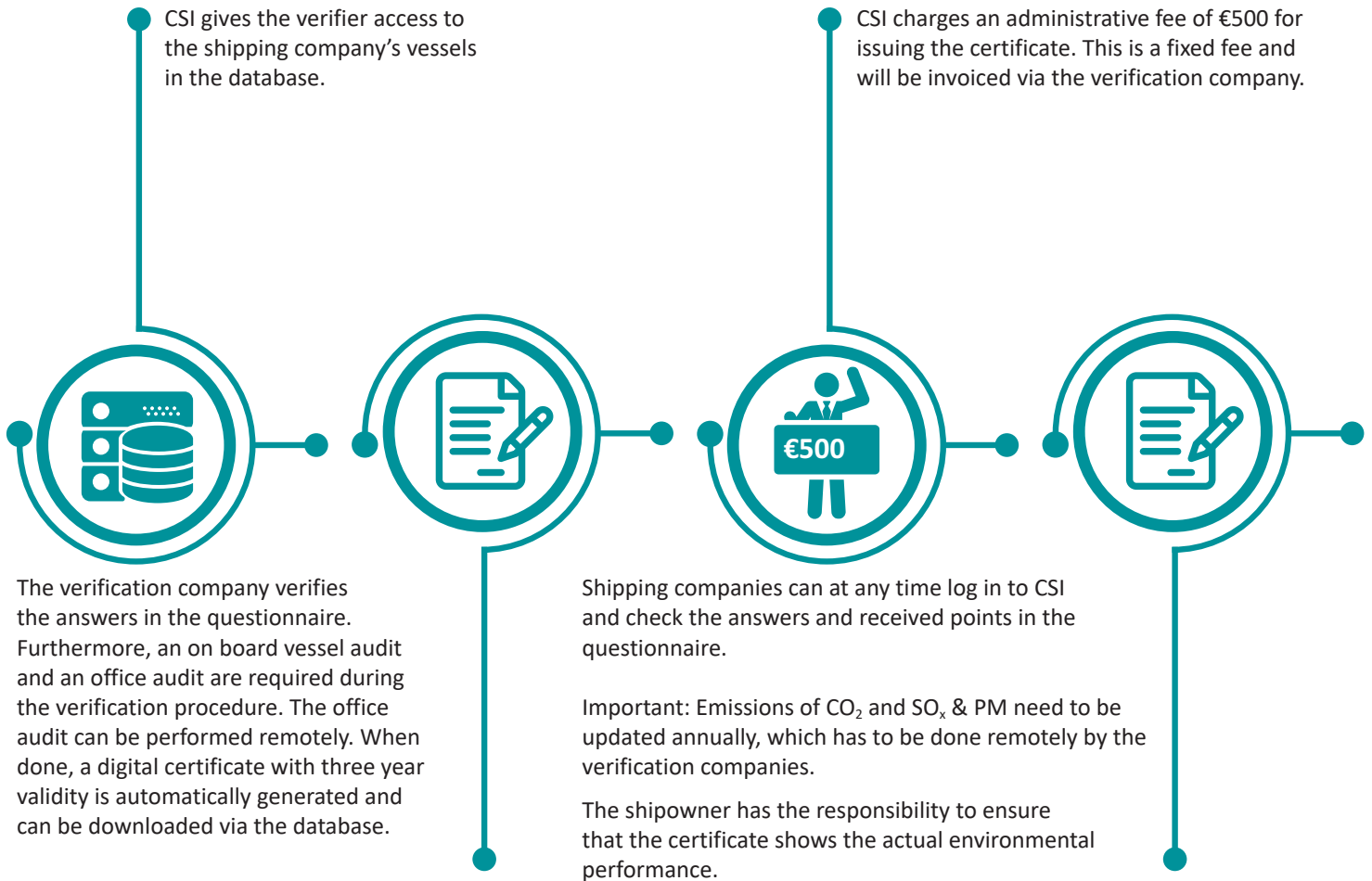
The shipping company requests a login via sending an email to [cleanshippingindex@ivl.se](mailto:cleanshippingindex@ivl.se).

The shipping company downloads the Methodology and Verification Guidelines and familiarizes with the publication, logs in to CSI and adds vessel(s) through answering the questionnaire ("self-assessment"). Finished questionnaire gives CSI Score and CSI Class.

The Clean Shipping Index project manager creates a user account after user agreement is signed and login details are sent to the shipping company.

The shipping company asks accredited verification companies, listed under "registration & certification" on CSI's website, for quotes and e-mails [cleanshippingindex@ivl.se](mailto:cleanshippingindex@ivl.se).





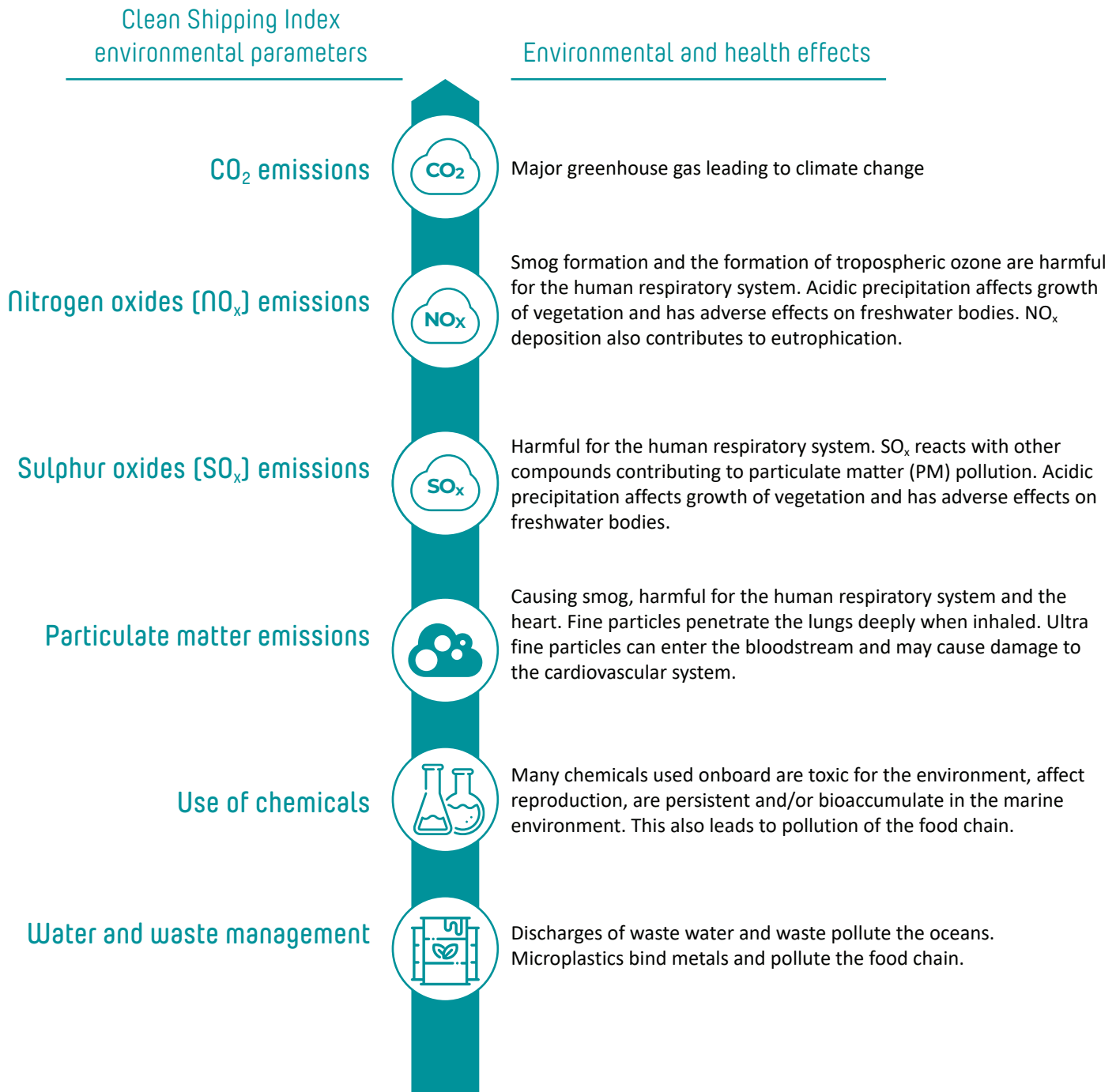


## 2. CLEAN SHIPPING INDEX: HOW DOES IT WORK?

### 2.1 General overview and environmental parameters

This section provides an overview of how the Clean Shipping Index works. For detailed guidance on the methodology please read chapter 3.

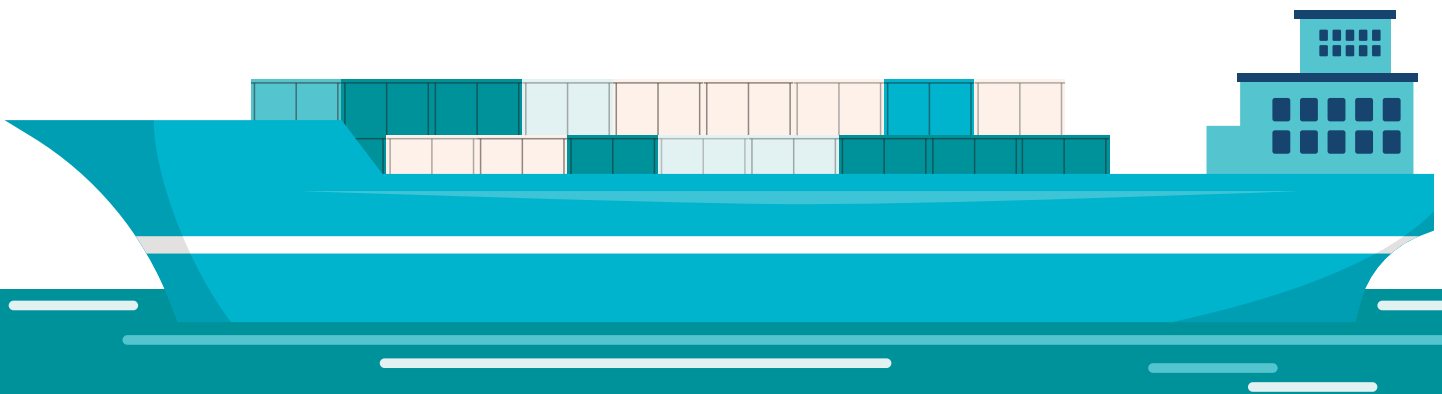
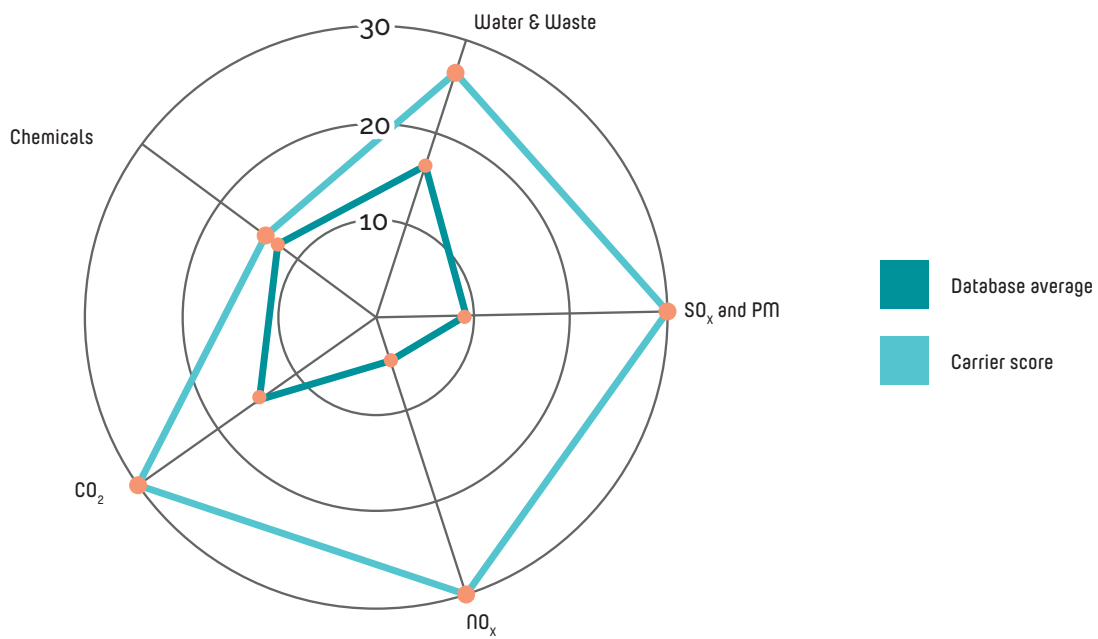
The Clean Shipping Index tool consists of a questionnaire on the environmental performance of ships. The aim is to go beyond existing rules and regulations and cover existing ships of different types.



For the scoring of CO<sub>2</sub>, the vessel efficiency is compared to a reference vessel of the same type and size, calculated mainly using data published by the International Maritime Organization (IMO). For all the other parameters, points are in principle given for exceeding legal compliance of environmental performance. For NO<sub>x</sub>, the level of NO<sub>x</sub> emissions defined by the Tier levels set by the IMO serve as the reference for scoring. The basis for scoring in SO<sub>x</sub> and PM is the emission levels, which is associated to the sulphur fuel content. In the chemicals section, shipping companies are asked to fill in questions about the chemical used in antifouling paint, the type of stern tube oil, hydraulic fluids and gear oils used, the type of boiler-/cooling water treatment system installed, the chemicals present in cleaning agents used and the type of refrigerants applied. Environmentally adapted solutions give a score. The waste water section covers the treatment of sewage and grey water, management of solid waste, sludge oil, scrubber waste water, use of residual oils and bilge water treatment.

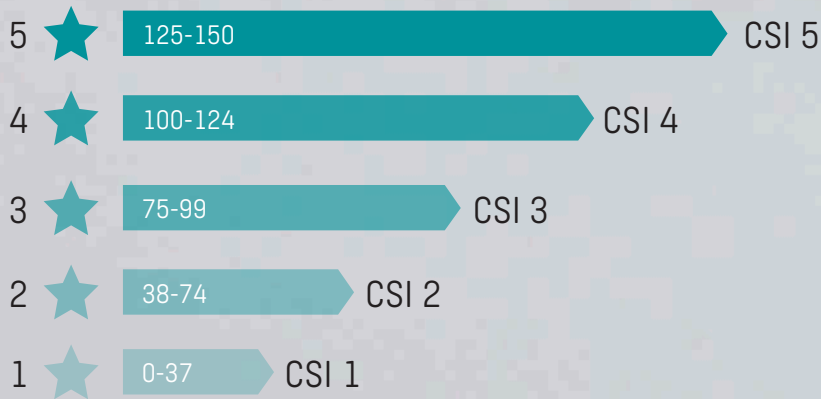
The weighting is based on the input data for the questions about environmental parameters in the questionnaire. Data is entered on a vessel by vessel basis. All vessels in a carrier's fleet add up to a total carrier score. The total carrier score is the average score of all owned vessels. For owned, but unreported vessels a null score is given. The scoring of a vessel on each of the environmental parameters can be viewed in comparison to the database average for that type of vessel and compared to the carriers average scores, as shown in the spider chart in Figure 1.

Figure 1. Representation of environmental scores on each of the different environmental parameters.



## 2.2 Classification and verification

Figure 2. Graphical representation of the points in the CSI scheme.



## 2.3 The Clean Shipping Index Label

As a shipowner you can view the scores of your vessels, also in comparison to vessels of other shipping companies. You may thus compare the performance to other vessels of the same type and identify areas for improvement. Contact the Clean Shipping Index project management for possibilities of receiving a feedback report with an analysis of the environmental performance of the vessels entered in the database. Members who have access to the database all sign a confidentiality agreement. The data can be viewed by the members who wish to provide economic incentives for clean shipping: shipowners, cargo owners, forwarders, ports, authorities and providers of clean technology. Banks and investors may use the Clean Shipping Index as guidance when investing in new ships. By submitting the data into the database, shipowners approve of sharing the data with the Clean Shipping Index.



# METHODOLOGY

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### 3.1 Calculating and reporting CO<sub>2</sub> emissions

#### 3.1.1 Options for calculating and reporting CO<sub>2</sub> emissions

Information needed is cargo carried, the distance travelled and the fuel consumption covering a 12-month period.

Calculated CO<sub>2</sub> emissions in grams per tonne-nautical mile (tonne-nm). The efficiency must be calculated according to IMO's Energy Efficiency Operational Indicator (EEOI) (1).

An MRV figure expressed in CO<sub>2</sub>/TonneNm (or TEUkm) is accepted, provided it represents 50% or more of the total (global) distance travelled during the period (i.e. the MRV reporting period).

Factors for RoPax; total CO<sub>2</sub> emissions and the combined transport work of freight (in tonne-Nm) and passengers (in passenger-Nm), for the 12-month period is concerned. The EEOI is automatically calculated by the database as follows:  $EEOI = \frac{gCO_2 \text{ per year}}{\text{transport work of freight} + 0.7 * \text{transport work of passengers}}$

#### Cruise & Passenger vessels

#### Container vessels

EEOI or MRV

RoPax

For Cruise and Passenger ships, the EEOI is calculated as grams CO<sub>2</sub> per passenger-nautical mile (passenger-nm).

It is possible for container vessels to report data in grams CO<sub>2</sub> per TEU-kilometer, calculated according to CCWG CO<sub>2</sub> formula (2). Contact the Clean Shipping Index project management for more information.

**Note:** Clean Shipping Index applies a carbon factor of zero (0) for renewable fuels when calculating CO<sub>2</sub> emissions per TonneNm (EEOI) or TEUkm (CCWG).

#### 3.1.2 CO<sub>2</sub> calculation of the reference value following the EEOI

See appendix 5 for description of CSI's reference value calculations, which are automatically performed and the basis for scoring.





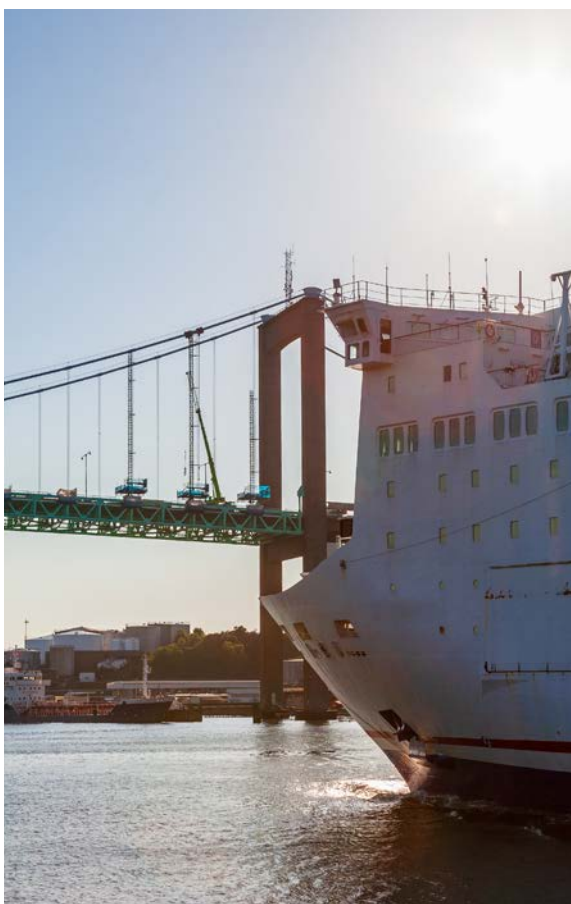
The scoring is based on how the vessel's EEDI relates to the EEDI requirement/regulatory limit, yet the figure is reported as an EEOI figure in CSI by following calculation (example): A vessel's EEDI is 20 gram CO<sub>2</sub>/DwtNm (or any other unit). The regulatory limit is set to 40 gram CO<sub>2</sub>/DwtNm. This gives a factor of 0,5 (20/40). Assuming CSI's EEOI reference line is set to 50 gram CO<sub>2</sub>/TonneNm, then your EEOI figure to report in CSI will be 25 gram CO<sub>2</sub>/TonneNm (0,5 x 50). To view CSI's EEOI reference line you'll need to enter all ship specifications required and enter a temporary fictive value for CO<sub>2</sub>/TonneNm. (The full method is also applicable for CO<sub>2</sub>/TEUkm).

## Plug-in battery powered vessels

### New vessels

*These vessels are considered to have zero CO<sub>2</sub> emissions. When a 12 month period has passed, the actual fuel consumption should be considered, if any bunker has been consumed.*

*The reported CO<sub>2</sub> emissions are compared against a reference value of vessels of the same type and size. The better the vessel performs compared to the reference value, the higher the score.*



### 3.2 NO<sub>x</sub> emissions

The NO<sub>x</sub> emission levels Clean Shipping Index uses as reference for scoring are the same levels as defined in the Tier III in MARPOL Annex VI. From 2021-01-01 Tier III levels are applied for new ships in the NECA's in the North- and Baltic Seas. The scoring is therefore changed from 2022-01-01 and only relate to the Tier III level. During a transition period older Tier III ships will receive points for NO<sub>x</sub> and ships with emissions lower than Tier III will receive more points. During this transition period, lasting between 2022 and 2026, ships that fulfilled Tier III levels before 2021-01-01 will still get points. The reason is to encourage early movers.

Data should be presented for both the main engine as well as the auxiliary engines. For ships without auxiliary engines, the scoring for the main engines is increased to get the same possible points. In case shore-side electricity is installed and used in all applicable harbours, the maximum score for auxiliary engines applies. In cases where a NO<sub>x</sub> reducing device is fitted but not part of an engine's NO<sub>x</sub>-certification, such systems are to be covered by verification procedures required by the NO<sub>x</sub> Technical Code 2008, demonstrating that the claimed application cycle value is being achieved (3).

Measurements performed in accordance with the NO<sub>x</sub> Technical Code 2008 that show low NO<sub>x</sub> emissions also score (75% load factor on ME and 50% load factor on AE). This might be the case for LNG-powered vessels with Tier II certificated engines. Measurements done by ISO 17025 accredited institutions are also accepted. The measurements have a three year validity. If Selective Catalytic Reduction (SCR) is installed as a post-combustion reduction technique, there must not be an ammonia-slip (NH<sub>3</sub>) above 20 ppm.

If there is more than one main engine or more than one auxiliary engine installed, the power weighted emission value should be presented. The principal calculation of this will be:

**Engine 1:  $x \text{ g/kWh} * y \text{ kW} = xy$ ;**

**Engine 2:  $z \text{ g/kWh} * a \text{ kW} = za$**

**Power weighted average:  $xy+za/(y+a)$ ;**

**where  $x$  and  $z$  are the NO<sub>x</sub> emission values;  $y$  and  $a$  are the engine powers.**

When plug-in battery power is claimed, its required utilization must be 90% of the operational time at minimum, or non-utilization must have been caused by external factors that can be proven. A 12-months rolling period is considered with an exemption for new ships and retrofits. For ships combining e.g. electric and diesel propulsion the total emission factor in g/kWh(total) for a year is calculated as an average value of zero emissions for the part of the year (as kWh power used) and the engine emissions for the part of the year the combustion engine was used for propulsion.

### 3.3 SO<sub>x</sub> and PM emissions

The basis for scoring in SO<sub>x</sub> and PM is the emission levels, which is associated to the sulphur fuel content. Total average of sulphur in all fuel used on board as percentage by weight, over a 12-month rolling period, are considered. Main engines and auxiliary engines are scored. A distinction in the scoring is made between the sulphur emitted in and outside Emission Control Areas (ECAs). For new vessels, the calculation is based on any fuel order basis.

Sulphur testing procedures should follow the Revised MARPOL Annex VI (3).

Highest points are given for operation with 'minimum sulphur fuels' with a weighted average of < 50 ppm. Minimum sulphur fuels refer to fuels such as LNG and methanol.

Since the amount of sulphur emissions and particulate matter emissions correlate, the basis for scoring in the PM section is the average sulphur content in fuels for main and auxiliary engines used during 12-month rolling period.

In addition, measured PM emissions are also accepted. Points are given for low PM emissions if the emission factors for the engines are measured using ISO 8178 and the weighted average of the engines is calculated.

When shore-side electricity or plug-in battery power is claimed, the same requirements as for NO<sub>x</sub> apply

### 3.4 Chemicals

In the Chemicals section, Clean Shipping Index rewards points to environmentally adapted solutions used. The criteria Clean Shipping Index applies are from an environmental point of view. The functional features are the responsibility of the producer.

#### 3.4.1 Antifouling

Antifouling paints can be divided into two different categories depending on their mode of action. The first category is traditional antifouling paints that contain and release biocides to the aquatic environment to prevent biofouling.

The second category is paints that are biocide-free and either prevent fouling through physical means or are abrasion resistant to allow e.g. operation in ice conditions. Since antifouling paints that contain biocides pose a risk to aquatic organisms no points are given to this category of paints. On the other hand, biocide-free paints will receive the highest point.

The data of the antifouling system used on the vessel is found in the antifouling system (AFS) certificate supplemented by the coating manufacturers, in the Safety Data Sheet (SDS) and in the Technical Data Sheet (TDS). In certain cases, a direct contact with the antifouling paint producer is needed.

#### 3.4.2 Stern tube oils

Traditionally, engine oils or gear oils based on mineral oil containing additives are used. Operational spillage occurs due to over-pressure of lubricants in the stern tube.

Alternatives such as lubricants based on biodegradable oil, water lubrication, or systems with technically advanced sealing systems ('air seal') have less impact on the marine environment and score in Clean Shipping Index.

The definition of a biodegradable oil is that each main component (>5% by weight) should have a biodegradation >60% within 28 days. Testing should be according to ISO 9439 (4) or ISO 10708 (5), but ISO 9408 (6) may be accepted if the theoretical oxygen demand (ThOD) and a period of maximum 28 days are chosen in the method.

The option 'Not applicable' may be chosen if the vessel does not have a stern tube, for example if the propulsion is dependent on azimuth thrusters only.

#### 3.4.3 External hydraulic fluids

In general, hydraulic fluids based on mineral oil are used. In external applications leakages may occur. There are several options for minimizing the risk for leakage. Biodegradable hydraulic fluids, the use of electrical power instead of hydraulic power or external hydraulic systems capped so that leakages will not reach the sea. These solutions score in the Clean Shipping Index. The definition of a biodegradable hydraulic fluid is the same as for stern tube oils as described above.

#### 3.4.4 Gear oils for thrusters and/or controllable pitch propellers

The use of biodegradable gear oils score in the Clean Shipping Index. The definition of biodegradable gear oil is the same as for stern tube oils (see above). The option 'Not applicable' also scores and should be selected when no thrusters and no CP propellers are installed.



### 3.4.5 Boiler-/cooling water treatment

The basis for scoring is the avoidance of the use of chemical products, or components in the products, classified as carcinogenic, mutagenic or toxic to reproduction (CMR), according to the CLP - Classification, Labelling and Packaging Regulation (EC) No 1272/2008. Additionally, the use of chemical products classified as sensitizing, toxic or dangerous for the environment has to be avoided, with the exclusion of nitrite. Nitrite is toxic, but is not bioaccumulating or persistent.

Information on the features mentioned above are stated in the Safety Data Sheet (SDS) for the chemical products in question.

### 3.4.6 Cleaning agents

As with boiler cooling water treatment, the basis for scoring on the use of cleaning agents is the avoidance of the use of chemical products or components in the products, classified as carcinogenic, mutagenic or toxic to reproduction (CMR), according to the CLP - Classification, Labelling and Packaging Regulation (EC) No 1272/2008. Additionally, the use of detergents with limitations in the EU Regulation on detergents (8) should be avoided.

Organic solvents classified and with risk phrases on health and environmental danger according to the CLP directive, also have to be avoided. The above information can be found in the Safety Data Sheet (SDS) for the products in question.

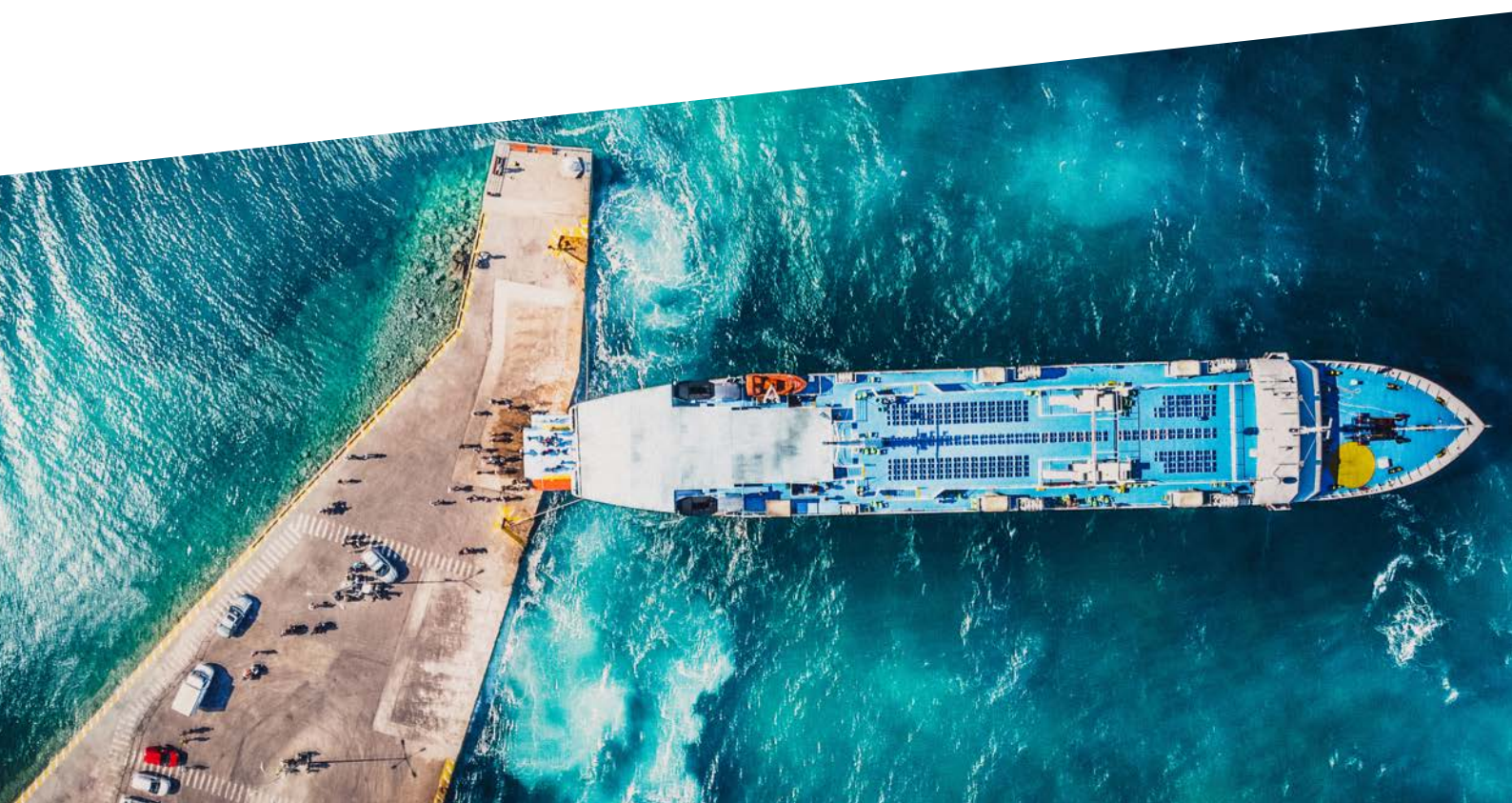
Detergents, surfactants or other components that disturb the installed bilge water treatment have to be avoided. Information on approved surfactants is usually found on the website of the bilge water cleaning equipment manufacturer.

### 3.4.7 Refrigerants

Clean Shipping Index considers the type of refrigerants that are used in cargo refrigerant plants, centralised air-conditioning and refrigeration systems installed on board. A score is given when all refrigerants applied comply with the Clean Shipping Index standard. Reefer refrigerants are not included.

The focus is put on ozone layer depletion potential (ODP) and global warming potential (GWP) as defined by the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer (9).

For scoring, the refrigerants should be natural (NH<sub>3</sub>, CO<sub>2</sub>) or HFC (Hydro Fluoro Carbon) with ODP number = 0 and the GWP number < 3500. Additional points are achieved if the GWP is below 1850. The information should be found in the Safety Data Sheet (SDS) and Technical Data Sheet (TDS) for the refrigerants in question.



## 3.5 Water and waste control

The waste water section covers the treatment of sewage and grey water, management of solid waste, sludge oil handling, bilge water treatment, crew awareness and scrubber water.

### 3.5.1 Sewage

The options that score are either 1) an approved sewage treatment plant according to MEPC (10) – Certificate of Type Approval for Sewage Treatment Plant – and a control of its usage and function through a maintenance record, or 2) all sewage is left to land for treatment.

### 3.5.2 Grey water

The options that score are either treating the grey water with the black water in an approved sewage treatment plant according to MEPC (10) – Certificate of Type Approval for Sewage Treatment Plant – and a control of its usage and function through a maintenance record. An alternative option is that no grey water discharge in Particularly Sensitive Sea Areas (PSSAs) can be shown through operation manuals. A list of PSSAs can be found on IMO website (11).

### 3.5.3 Garbage handling

For a score in CSI, there should be no incinerator on board or documentation of no incineration of garbage. Additionally, there should be no waste overboard – food waste excluded – and separate garbage handling for reuse, recycling and discharge. This information should be found in the Garbage Record Book on board and the Garbage Management Plan according to Annex V in MARPOL 73/78 (12).

### 3.5.4 Sludge oil handling

As with garbage, there should be no incinerator on board or documentation of no incineration of sludge oil for a CSI score. Additionally, there should be documented disposal of sludge oil to treatment facilities on shore. This information should partly be found in the IOPP (International Oil Pollution Prevention) Certificate according to MARPOL Annex I (13), or found in operating manuals on board.

### 3.5.5 Bilge water treatment

The basis for scoring is how the bilge water is treated on board or whether it is discharged to an onshore facility. The complexity of bilge water mixtures today often results in stable oil/water emulsions, hard to be broken down in traditional gravimetric separators. Scoring is received only if active treatment equipment is installed, calibrated and a documented emission of <5ppm oil in the disposed bilge water. This information should partly be found in the IOPP Certificate according to MARPOL Annex I (13), or found in operating manuals on board. Additional scoring can be received if an emission control box is installed. The box ensures that no oily water discharge occurs and will continuously register position and time.

### 3.5.6 Crew awareness

The basis for scoring is education of personnel on environmental awareness, health risks and adequate protective equipment.

### 3.5.7 Scrubber water

There are strong indications that the release of scrubber water has risks for the marine environment. Therefore, points are given to ships that do not release any scrubber water but rather meet the sulphur regulations through the use of either distillate oils, LNG or alcohols. Thus, the use of fuels containing residual oil, such as Very Low Sulphur Fuel Oil (VLSFO) or Ultra Low Sulphur Fuel Oil (ULSFO) do not render any points due to the impact on the marine environment and air quality.





### 3.6 Other issues

The environmental parameters described in section 3.1 to 3.5 are used to calculate a total CSI score. The parameters all concern operational emissions and leakages that occur during the normal use of a vessel. Apart from the operational questions, Clean Shipping Index also requires shipping companies to report about end-of-life vessel handling on a company policy level. The European Shiprecycling Regulation serves as the reference. It is not included in the CSI scores.

The Clean Shipping Index is a dynamic index. When regulations change, or when new techniques or solutions enter the shipping market, the criteria may need to change or be removed. During 2017, the question on ballast water management was removed from the CSI questionnaire due to the implementation of the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention).

After 2021 an update was made on antifouling, sewage and nitrogen oxides (NO<sub>x</sub>). An additional parameter was added in the Water and waste-category called Scrubber water.

Antifouling paints are used to prevent biofouling to attach and grow on the hull. Most paints contain and leach biocides to the marine environment. The efficacy of the paint depends on the prevailing fouling pressure in the areas where the ship operates, what biocide(s) are used in the paint formulation and the biocidal release rate from the painted surface to the ambient water. Globally, 25 substances are currently used as biocides in paint formulations, often in combination and with up to six different biocides included in a specific paint formulation (14). Moreover, it is difficult to predict the biocidal release rate(s) from a specific paint to the ambient water and risks for adverse environmental effects. Thus, it is a huge challenge to set up scoring criteria for biocidal antifouling coatings. Biocide-free alternatives do however exist, and recent studies (15) have shown biocide-free foul release coatings to be as effective as biocidal coatings in preventing biofouling on the Swedish west coast. Therefore, only non-biocidal paints, e.g. foul-release coatings or inert coatings without any active ingredients (biocides), will score points.

Scrubbers are used to remove sulphur oxides (SO<sub>x</sub>) by leading the engine exhaust through a fine spray of water (16). Thereby the emissions of SO<sub>x</sub> to the air can meet the emission levels corresponding to combustion of fuel, i.e. the global 0.5% sulphur content cap or 0.1 % sulphur inside sulphur emission control area (SECA), according to MARPOL Annex IV (3). However, the scrubbing process results in large volumes of acidic washwater, and while regulations are focused on SOX removal from the exhausts, other pollutants e.g., PAHs and metals are also transferred to the washwater and discharged to the marine environment (17). There are three types of scrubbers, open loop, closed loop and hybrid scrubbers that can be operated in either open- or closed-loop mode. Concerns have been raised that scrubbers, as a new direct source of PAHs and metals are causing additional pressures to the marine environment (18) (19) (20)

Researchers (21) showed emissions from scrubbers to pose the highest risk for marine ecotoxicological impact as compared to all other waste streams from ships, when determined through Life Cycle Impact Assessment (LCIA). The results also showed the marine ecotoxicological impact of open loop discharge water to be six times more severe compared to closed loop systems.



# REFERENCES

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1. MEPC. 2009. Guidelines for voluntary use of the ship energy efficiency operational indicator (EEOI): MEPC.1/Circ. 684. 17 August 2009. [www.imo.org](http://www.imo.org) ([www.imo.org/includes/blastData.asp/doc\\_id=11788/684.pdf](http://www.imo.org/includes/blastData.asp/doc_id=11788/684.pdf))
2. BSR. 2015. Clean Cargo Working Group. Methodology 2015. [https://www.bsr.org/reports/BSR\\_CCWG\\_Carbon\\_Emissions\\_Methodology\\_2015.pdf](https://www.bsr.org/reports/BSR_CCWG_Carbon_Emissions_Methodology_2015.pdf)
3. MEPC. 2008. Revised MARPOL Annex VI. Amendments to the Annex of the Protocol of 1997 to amend the international Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto. MEPC 176 (58). [www.imo.org](http://www.imo.org)
4. ISO 9439:1999. Water quality – Evaluation of ultimate aerobic biodegradability of organic compounds in aqueous medium – Carbon dioxide evolution test.
5. ISO 10708:1997. Water quality – Evaluation in an aqueous medium of the ultimate aerobic biodegradability of organic compounds – Determination of biochemical oxygen demand in a two-phase closed bottle test.
6. ISO 9404:1999. Water quality – Evaluation of ultimate aerobic biodegradability of organic compounds in aqueous medium by determination of oxygen demand in a closed respirometer.
7. Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006
8. EU. 2004. Regulation (EC) No 648/2004 of the European Parliament and of the Council of 31 March 2004 on detergents.
9. Montreal. 1987. The Montreal Protocol on Substances that Deplete the Ozone Layer. <http://ozone.unep.org>
10. MEPC. 2006. Revised guidelines on implementation of effluent standards and performance test for sewage treatment plants. Resolution MEPC. 159 (55). [www.imo.org](http://www.imo.org)
11. IMO. 2021 Marine Environment Particularly Sensitive Sea Areas (PSSA) <https://www.imo.org/en/OurWork/Environment/Pages/PSSAs.aspx>
12. MARPOL. 1988. Annex V; Prevention of Pollution by Garbage from Ships. [www.imo.org](http://www.imo.org)
13. MARPOL. 2007. Annex I; Prevention of Pollution by Oil [www.imo.org](http://www.imo.org)
14. Paz-Villarraga, C.A., Braga Castro, I., Fillmann, G., 2021. Biocides in Antifouling Paint Formulations Currently Registered For Use. Preprint under consideration at Environmental Science and Pollution Research. <https://doi.org/10.21203/rs.3.rs-704342/v1>.
15. Oliveira, D.R., Granhag, L., 2020. Ship hull in-water cleaning and its effects on fouling-control coatings. *Biofouling* 36, 332-350.
16. Turner, D.R., Hasselov, I.-M., Ytreberg, E., A, R., 2017. Shipping and the environment: Smokestack emissions and scrubbers. *Elementa* 5
17. Endres, S., Maes, F., Hopkins, F., Houghton, K., Mårtensson, E.M., Oeffner, J., Quack, B., Singh, P., Turner, D., 2018. A New Perspective at the Ship-Air-Sea-Interface: The Environmental Impacts of Exhaust Gas Scrubber Discharge. *Frontiers in Marine Science*
18. Hassellöv, I.M., Koski, M., Broeg, K., Marin-Enriquez, O., Tronczynski, J., Dulière, V., Murray, C., Bailey, S., Redfern, J., de Jong, K., Ponzevera, E., Belzunce-Segarra, M.J., Mason, C., Iacarella, J.C., Lyons, B., Fernandes, J.A., Parmentier, K., 2020. ICES Viewpoint background document: Impact from exhaust gas cleaning systems (scrubbers) on the marine environment (Ad hoc). *ICES Scientific Reports*. 2:86. 40 pp. <http://doi.org/10.17895/ices.pub.7487>
19. Thor, P., Granberg, M.E., Winnes, H., Magnusson, K., 2021. Severe Toxic Effects on Pelagic Copepods from Maritime Exhaust Gas Scrubber Effluents. *Environmental Science & Technology* 55, 5826-5835.
20. Ytreberg, E., A, R., 2017. Shipping and the environment: Smokestack emissions and scrubbers. *Elementa*
21. Ytreberg, E., Åström, S., Fridell, E., 2021. Valuating environmental impacts from ship emissions – The marine perspective. *Journal of Environmental Management* 282, 111958

## APPENDIX 1. CALCULATIONS FOR RORO VESSELS

Following MEPC 64/4/14 and MEPC 64/4/4,  $f_{j_{\text{RoRo}}}$  is calculated as follows:

$$F_{\text{RoRo}} = \frac{1}{F_{nL}^{\alpha} \times \left(\frac{L_{pp}}{B_s}\right)^{\beta} \times \left(\frac{B_s}{D_s}\right)^{\gamma} \times \left(\frac{L_{pp}}{\Delta^{\frac{1}{\delta}}}\right)^{\delta}};$$

where  $F_{nL}$  is the Froude's number:

$$F_{nL} = \frac{0.5144 \times V_{\text{ref}}}{\sqrt{L_{pp} \times G}};$$

$G$  is the gravitational acceleration;

$L_{pp}$  is the Length between perpendiculars in m;

$v_{\text{ref}}$  is the ship's reference Speed in knots;

$B_s$  is the Breadth in m;

$d_s$  is the Draught (at summer load) in m;

$\Delta$  is the Volumetric displacement in  $\text{m}^3$  (multiply by 1.025 to get  $\Delta$  in tonnes).

The exponents  $\alpha$ ,  $\beta$ ,  $\gamma$  and  $\delta$  are 2.00, 0.50, 0.75 and 1.00, respectively, for RoRo ships; and 2.50, 0.75, 0.75 and 1.00, respectively, for RoPax ships.

## APPENDIX 2. ICE-CLASS CORRECTION FACTORS

$f_i$  values for ice-classed ships adopted by the IMO. Note that the minimum value is 1.

Ship type	$f_i$	Limits depending on the ice class			
		IA Super	IA	IB	IC
Tanker	$\frac{0.00138 L_{pp}^{3.331}}{\text{capacity}}$	$\begin{cases} \max 2.10 L_{pp}^{-0.11} \\ \min 1.0 \end{cases}$	$\begin{cases} \max 1.71 L_{pp}^{-0.08} \\ \min 1.0 \end{cases}$	$\begin{cases} \max 1.47 L_{pp}^{-0.06} \\ \min 1.0 \end{cases}$	$\begin{cases} \max 1.27 L_{pp}^{-0.04} \\ \min 1.0 \end{cases}$
Bulk carrier	$\frac{0.00403 L_{pp}^{3.123}}{\text{capacity}}$	$\begin{cases} \max 2.10 L_{pp}^{-0.11} \\ \min 1.0 \end{cases}$	$\begin{cases} \max 1.80 L_{pp}^{-0.09} \\ \min 1.0 \end{cases}$	$\begin{cases} \max 1.54 L_{pp}^{-0.07} \\ \min 1.0 \end{cases}$	$\begin{cases} \max 1.31 L_{pp}^{-0.05} \\ \min 1.0 \end{cases}$
General cargo ship	$\frac{0.0377 L_{pp}^{2.625}}{\text{capacity}}$	$\begin{cases} \max 2.18 L_{pp}^{-0.11} \\ \min 1.0 \end{cases}$	$\begin{cases} \max 1.77 L_{pp}^{-0.08} \\ \min 1.0 \end{cases}$	$\begin{cases} \max 1.51 L_{pp}^{-0.06} \\ \min 1.0 \end{cases}$	$\begin{cases} \max 1.28 L_{pp}^{-0.04} \\ \min 1.0 \end{cases}$
Containership	$\frac{0.1033 L_{pp}^{2.329}}{\text{capacity}}$	$\begin{cases} \max 2.10 L_{pp}^{-0.11} \\ \min 1.0 \end{cases}$	$\begin{cases} \max 1.71 L_{pp}^{-0.08} \\ \min 1.0 \end{cases}$	$\begin{cases} \max 1.47 L_{pp}^{-0.06} \\ \min 1.0 \end{cases}$	$\begin{cases} \max 1.27 L_{pp}^{-0.04} \\ \min 1.0 \end{cases}$
Gas carrier	$\frac{0.0474 L_{pp}^{2.590}}{\text{capacity}}$	$\begin{cases} \max 1.25 \\ \min 1.0 \end{cases}$	$\begin{cases} \max 2.10 L_{pp}^{-0.12} \\ \min 1.0 \end{cases}$	$\begin{cases} \max 1.60 L_{pp}^{-0.08} \\ \min 1.0 \end{cases}$	$\begin{cases} \max 1.25 L_{pp}^{-0.04} \\ \min 1.0 \end{cases}$

Note: containership capacity is defined as 70% of the DWT.




### APPENDIX 3. THE CLEAN SHIPPING INDEX QUESTIONNAIRE

A total of 150 points can be obtained, 30 points in each of the different environmental areas. This means 30 points for good performance on CO<sub>2</sub> emissions, 30 on low NO<sub>x</sub> emissions etc. Points are granted only for exceeding legal compliance performance on SO<sub>x</sub>, PM, NO<sub>x</sub>, chemicals and Water and waste management. For CO<sub>2</sub> emissions there are no binding regulations yet for the existing fleet.

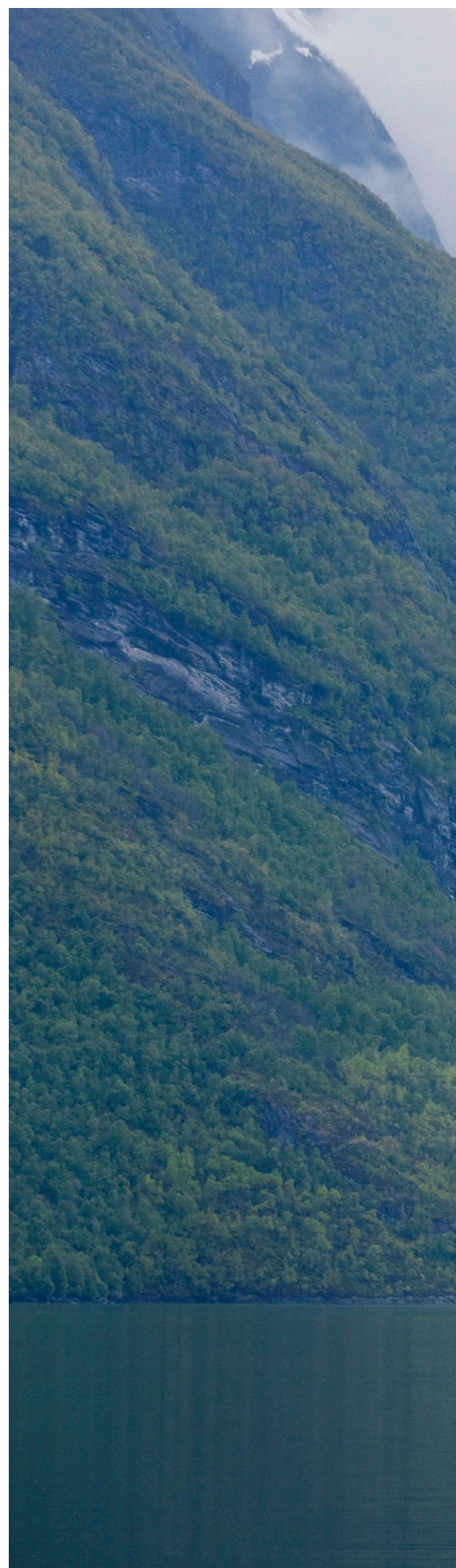
CO<sub>2</sub> therefore scores for good performance compared to a calculated reference vessel of the same type and size. The number of points that can be earned are set by the Clean Shipping Index project management and the Technical Committee.

The overall score indicates how well a vessel is performing compared to legislative requirements and compared to other vessels of the same type and size.

SO <sub>x</sub> 		
Main engines Operations in non-ECAs (yearly average)	No data/compliance or use of scrubbers	0
	Operation only in ECAs*	0
	Fuel quality < 0.1% S	3
	'Minimum Sulphur fuels' (<50 ppm)	5
	Plug-in battery power, fuel cell, wind power or similar	5
<i>*When answering Operation only in ECAs, the score doubles for the questions on operation in ECAs. Otherwise the vessel cannot reach the same score as vessels operating in- and outside ECAs.</i>		
Main engines Operations in ECAs (yearly average)	No data/compliance or use of scrubbers	0
	Operation only in non-ECAs*	0
	<500 ppm S	2
	'Minimum Sulphur fuels' (<50 ppm)	5
	Plug-in battery power, fuel cell, wind power or similar	5
<i>*When answering Operation only in non-ECAs, the score doubles for the questions on operation in non-ECAs. Otherwise the vessel cannot reach the same score as vessels operating in- and outside ECAs.</i>		



Auxiliary engines		
Aux. engines (yearly average)	No auxiliary engines*	0
	No data/compliance or use of scrubbers	0
	Fuel quality < 0.1% S outside SECAs	2
	Shore-side electricity	5
	'Minimum Sulphur fuels' (<50 ppm)	5
	Plug-in battery power, fuel cell, wind power or similar	5
<i>*If no Auxiliary engine, report the fuel quality used in main engine when in non-propulsion mode.</i>		
PM		
Main engines Operations in non-ECAs (yearly average)	No data/compliance or use of scrubbers	0
	Operation only in ECAs (ECA scoring doubles)	0
	Fuel quality < 0.1% S	3
	PM < 0.2 g/kWh	3
	PM < 0.1 g/kWh	5
	'Minimum Sulphur fuels' (<50 ppm)	5
	Plug-in battery power, fuel cell, wind power or similar	5
Main engines Operations in ECAs (yearly average)	No data/compliance or use of scrubbers	0
	Operation only in non-ECAs (non-ECA scoring doubles)	0
	<500 ppm S	1
	PM < 0.2 g/kWh	3
	PM < 0.1 g/kWh	5
	'Minimum Sulphur fuels' (<50 ppm)	5
	Plug-in battery power, fuel cell, wind power or similar	5








PM		
PM Aux. engines (yearly average)	No auxiliary engines*	0
	No data/compliance or use of scrubbers	0
	Fuel quality < 0.1% S in harbour areas outside SECA	2
	PM < 0.2 g/kWh	3
	PM < 0.1 g/kWh	5
	Shore-side electricity	5
	'Minimum Sulphur fuels' (<50 ppm)	5
	Plug-in battery power, fuel cell, wind power or similar	5
*If no Auxiliary engine, report the fuel quality used (or specific PM emission value) in main engine when in non-propulsion mode.		
NO <sub>x</sub>		
Main engines	No data	0
	25% below Tier III level	10
	50% below Tier III level	18
	Plug-in battery power, fuel cell, wind propulsion or similar no-NO <sub>x</sub> propulsion method	21
	Tier III levels with proven emissions before 2021-01-01	18 <sup>+</sup>
Aux. engines	No auxiliary engines*	0
	No data	0
	25% below Tier III level	4
	50% below Tier III level	7
	Plug-in battery power, shore-side electricity, fuel cell, wind propulsion or similar no-NO <sub>x</sub> method	9
	Tier III levels with proven emissions before 2021-01-01	6 <sup>+</sup>
*If no Auxiliary engine, report the fuel quality used in main engine when in non-propulsion mode.		
+Only valid up to 2026-12-31		
Ships with only main engine	No data	0
	25% below Tier III level	14
	50% below Tier III level	25
	Plug-in battery power, shore-side electricity, fuel cell, wind propulsion or similar no-NO <sub>x</sub> propulsion method	30
	Tier III levels with proven emissions before 2021-01-01	24 <sup>+</sup>

CO <sub>2</sub> 		
Emission performance EEOI	No data	0
	20% above reference or more	0
	<20% above reference	3
	<15% above reference	6
	<10% above reference	9
	<5% above reference	12
	Reference value or below	15
	>5% below reference	18
	>10% below reference	21
	>15% below reference	24
	>20% below reference	27
	>25% below reference	30







Chemicals 		
Antifouling	No data	0
	Other	0
	Biocidal antifouling paints	0
	Non-biocidal antifouling paints	7
Stern tube oil	No data	0
	Mineral oil based	0
	Based on biodegradable oil	5
	Air seal	7
	Water lubrication	7
	Not applicable	7
External hydraulic fluids	No data	0
	Mineral oil based	0
	External hydraulics exchanged to electrical power	3
	Based on biodegradable oil	3
	External hydraulic system capped	3
Gear oils for thrusters and Controllable pitch propellers	No data	0
	Mineral oil based	0
	Based on biodegradable oil	5
	Not applicable	5
Boiler/ cooling water treatment	No data	0
	Classified as CMR, toxic, sensitizing or dangerous to the environment	0
	Not classified as above (nitrite exclusive)	2
Cleaning agents	No data	0
	Classified as CMR, dangerous to the environment or toxic	0
	Not classified as above	3
Refrigerants	No data	0
	Non-natural (excluding the HFCs below)	0
	HFCs complying with GWP < 3500 and ODP = 0	1
	Natural (NH <sub>3</sub> , CO <sub>2</sub> ) or HFCs complying with	
	GWP < 1850 and ODP = 0	3

Water and waste 		
Grey water	No data	0
	No treatment	0
	No discharge in sensitive areas (PSSA) or treatment in sewage plant onboard	3
Sewage / black water	No data	0
	No treatment	0
	Sewage treatment plant onboard	4
	All sewage left on land for treatment	5
Garbage handling	No data	0
	Incinerator used on board	0
	No incinerator onboard or documented no incineration of garbage and separate garbage handling for reuse, recycling and disposal	4
Sludge handling	No data	0
	Incinerator used onboard	0
	No incinerator onboard or documentation of no incineration of sludge and disposal of sludge to treatment on shore	4
Bilge water treatment	No data	0
	Gravimetric separation	0
	Active treatment installed and < 15ppm oil in outgoing water	3
	Active treatment installed and < 5ppm oil in outgoing water	4
	Active treatment installed and < 5 ppm oil in outgoing water and emission control box in place	6
	Discharge to onshore facility	6
Crew awareness	No data	0
	Education of personnel on environmental awareness, health risks and adequate protective equipment	3
Scrubber water	Release of either open-loop or closed loop scrubber water to the sea	0
	Use of residual oil or mixed fuels containing residual oil, such as VLSFO or ULSFO	0
	Use of distillate oil such as MGO, LNG or alcohols as fuel or plug-in battery power, fuel cell, wind power or similar	5



## APPENDIX 4. CO<sub>2</sub> calculation of the reference value following the EEOI

The actual reported CO<sub>2</sub> emissions of the vessel are compared to a reference vessel of the same type and size. This section describes how Clean Shipping Index calculates the value for the reference vessel. The calculations use the EEDI reference lines from the IMO as a starting point. The following is relevant for options 1-3 mentioned under section 3.1.1.

The Energy Efficiency Operational Indicator (EEOI<sub>ref</sub>) for the reference ship is obtained in two steps. First the Energy Efficiency Design Index reference value (EEDI<sub>ref</sub>) is calculated. This is done using methods outlined by the Greenhouse Gas Working Group of the IMO (i). In an MEPC resolution baselines are defined for the most common ship types, expressing ideal technical circumstances but not including operational parameters. The baselines are for most ship types presented as functions between deadweight (dwt) and emitted grams CO<sub>2</sub> per tonne-nm (ii).

The EEDI<sub>ref</sub> gives a typical fuel consumption for a specific ship of a certain type and size. The EEDI<sub>ref</sub> can be calculated as a function of dwt for different categories of ships, as shown in Table 3 below. Clean Shipping Index automatically calculates the EEDI<sub>ref</sub> to be able to compare the efficiency of the reported CO<sub>2</sub> emissions to the reference.



Table 3.  $EEDI_{ref}$  formula per ship type derived from the IMO MEPC74 (ii)

Type of vessel	Size, dwt (GT for Cruise/Passenger)	Reference EEDI from 2020-01-01
General cargo	0-3000	$EEDI_{ref} = 107.48dwt^{-0.216}$
	3000-15000	$EEDI_{ref} = (111.51-0.0013435dwt)dwt^{-0.216}$
	15000-	$EEDI_{ref} = 91.358dwt^{-0.216}$
Reefer (gen. Cargo)	0-3000	$EEDI_{ref} = 227.01dwt^{-0.244}$
	3000-5000	$EEDI_{ref} = (278.0873-0.0170258dwt)dwt^{-0.244}$
	5000-	$EEDI_{ref} = 192.9585dwt^{-0.244}$
Bulk	0-10000	$EEDI_{ref} = 961.79dwt^{-0.477}$
	10000-20000	$EEDI_{ref} = (1154.147-0.0192358dwt)dwt^{-0.477}$
	20000-	$EEDI_{ref} = 961.79dwt^{-0.477}$
Tanker	0-4000	$EEDI_{ref} = 1218.8dwt^{-0.488}$
	4000-20000	$EEDI_{ref} = (1279.74-0.0152350dwt)dwt^{-0.488}$
	20000-	$EEDI_{ref} = 975.04dwt^{-0.488}$
Gas carrier	0-2000	$EEDI_{ref} = 1120 dwt^{-0.456}$
	2000-10000	$EEDI_{ref} = (1176-0.0280dwt)dwt^{-0.456}$
	10000-	$EEDI_{ref} = 896 dwt^{-0.456}$
Container	0-10000	$EEDI_{ref} = 174.22dwt^{-0.201}$
	10000-15000	$EEDI_{ref} = (243.908-0.0069688dwt)dwt^{-0.201}$
	15000-	$EEDI_{ref} = 139.376dwt^{-0.201}$
RoRo	0-1000	$EEDI'_{ref} = 1405.15dwt^{-0.498}$
	1000-2000	$EEDI'_{ref} = (1686.18-0.28103dwt')dwt^{-0.498}$
	2000-	$EEDI'_{ref} = 1124.12dwt^{-0.498}$
RoPax	0-250	$EEDI'_{ref} = 752.16dwt'^{-0.381}$
	250-1000	$EEDI'_{ref} = (802.304-0.200576dwt')dwt'^{-0.381}$
	1000-	$EEDI'_{ref} = 601.728dwt'^{-0.381}$
Car carrier (RoRo)	0-10000	$EEDI_{ref} = 11554dwt^{-0.6565}$
	10000-	$EEDI_{ref} = 9820.9dwt^{-0.6565}$
Cruise/Passenger	0-25000	$EEDI_{ref} = 2279.7PC^{-0.209}$
	25000-85000	$EEDI_{ref} = (2469.9-0.00760GT)PC^{-0.209}$
	85000-	$EEDI_{ref} = 1823.9PC^{-0.209}$



Dwt is the deadweight in tonnes and  $EEDI_{ref}$  is the design index value in grams CO<sub>2</sub>/ dwt nautical mile. For Car carriers, the IMO uses a correction factor that is not applied here. For RoRo and RoPax ships, the  $EEDI'_{ref}$  value should be divided by  $f_{jRoRo}$  for each ship to obtain the  $EEDI_{ref}$ . The calculation of  $f_{jRoRo}$  is described in appendix 1. For RoPax ships, the  $EEDI'_{ref}$  value is calculated using the parameter  $dwt' = f_{cRoPax} * dwt$ , where  $f_{cRoPax} = 1$  for ships with  $dwt/GT > 0.25$  and  $f_{cRoPax} = ((dwt/GT)/0.25) - 0.8$  for ships with  $dwt/GT < 0.25$ .

For RoPax ships, a parameter that describes the combined capacity for freight and passengers has been identified. This parameter, called L, is a linear function of the number of available lanemeters and the passenger capacity so that:

$$L = 2 * (\text{number of lanemeters}) + 0.7 * (\text{passenger capacity}).$$

Analysis of RoPax ship data gives that L is proportional to dwt' for RoPax ships so that:

$$L = 0.6 * dwt'. \text{ Using the IMO EEDI function we then get RoPax } EEDI'_{ref} = 619.14L^{-0.381}$$

An  $EEDI_{ref}$  function was developed for Cruise ships using empirical data:

$$\text{Cruise } EEDI_{ref} = 2279.7PC^{-0.209}$$

where PC is the passenger capacity. This function is also used for Passenger ships.

In the second step of calculating the  $EEOI_{ref}$  value for the reference ship, operational factors are accounted for. This means that estimated average load factors and estimated payload factors are considered.

The load factors, the ratio of actual load to maximum load on mass basis, assumed for the reference ships are taken according to the Second IMO GHG study (iii).

Table 4. Load factors for different types of vessels according to the second IMO GHG study (iii)

Type of vessel	Load factor
General cargo	0.6
Reefer	0.5
Bulk dwt > 100,000	0.5
Bulk dwt 10,000-100,000	0.55
Bulk dwt 0-10,000	0.6
Product tanker dwt > 20,000	0.55
Product tanker dwt 10,000-20,000	0.50
Product tanker dwt 0-10,000	0.45
Gas carrier	0.48
Oil tanker	0.48
Chemical tanker	0.64
Container	0.7
RoRo	0.7
Car carrier	0.7

For Cruise ships the following capacity utilisation is assumed:

**Cruise** 0.94 (this is a preliminary assumption, it may change after more data modelling)

For RoPax ships the capacity utilisation is a combination of passenger and lanemeter utilisation (i.e. "L-utilisation"):

**RoPax** 0.37 (this is a preliminary assumption, it may change after more data modelling)

For some types of vessels, the payload ratio (ratio of maximum weight commercial cargo to the deadweight) is an important factor when calculating the  $EEOI_{ref}$  for the reference ships. General payload ratios are given for the main type of ships below. The values used here are based on information from ship constructors and ship operators. For tankers, different payload ratio may occur depending on the large differences in the specific weight of the cargo predominantly carried. Gas carriers are assumed to have the same payload ratio as tankers with light products.

Table 5. General payload ratios for main ship type

Type of vessel	Payload ratio
General cargo	0.9
Reefer	0.9
Bulk	0.9
LNG carrier	0.8
Container	0.8
RoRo	0.5
Car carrier	0.25

Ships carrying products with densities below 0.9 tonne/m<sup>3</sup> should use a payload factor of  $\rho/0.9$  where  $\rho$  is the average density of the product carried over the year (calculating the average should reflect distance) while for  $\rho > 0.9$  the payload ratio of 0.95 is used as before.

For RoPax ships, this ratio is accounted for when using the relationship between dwt' and L (see above).

Cruise ships use significant amounts of fuel while at berth. To account for this the EEDlref value is multiplied by a 'berth factor' of 1.09. Using the EEDI baseline functions and considering load factors and payload factors, the calculation for an operational reference value will generally look like this:

for cargo ships:

$$EEOI_{ref}(dwt) = EEDI_{ref}(dwt) / (\text{load factor} * \text{payload ratio});$$

for RoPax vessels:

$$EEOI_{ref}(L) = EEDI_{ref}(L) / (\text{L-utilisation factor});$$

for Cruise ships:

$$EEOI_{ref}(PC) = EEDI_{ref}(PC) * (\text{berth factor}) / (\text{capacity utilisation factor}).$$

The actual calculated EEOI for the vessel is compared with the calculated  $EEOI_{ref}$  for the vessel. Depending if and how much above or below the reference the actual EEOI is, a scoring is obtained.

For ice-classed ships, the  $EEOI_{ref}$  value is increased by multiplying with the factor  $f_i$  as defined for the calculation of attained EEDI for ice-classed ships.  $f_i$  is given in appendix 2.

## APPENDIX REFERENCES

- i. GHG-WG. 2009. Considerations of the energy efficiency design index for new ships. Recalculation of energy efficiency design index baselines for cargo ships. IMO GHG-WG 2/2/7. 4 Feb. 2009.
- ii. Fridell, E. 2011. Emission calculations for sea transportation of cargo. IVL Swedish Environmental Research Institute, Gothenburg
- iii. IMO. 2009. Second IMO GHG Study, 2009. London





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