STYRELSEN FÖR

VINTERSJÖFARTSFORSKNING

WINTER NAVIGATION RESEARCH BOARD

Research Report No 88

Victor Westerberg

EEDI AND FINNISH-SWEDISH ICE CLASS RULES

Finnish Transport Safety Agency

Finnish Transport Agency

Finland

Swedish Maritime Administration

Swedish Transport Agency

Sweden

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FOREWORD

In its report no 88, the Winter Navigation Research Board presents the outcome of the project on EEDI and Finnish-Swedish ice class rules.

The Energy Efficiency Design Index has been developed within IMO and MEPC. The purpose is to increase the energy efficiency of the world merchant fleet and to reduce the emissions of greenhouse gases. This study puts focus on EEDI and its consequences on the Baltic winter navigational operations. EEDI is calculated and compared to relevant baselines, ice class correction factors are investigated, interactions with the output power regulations in the Finnish-Swedish ice class are analysed and possible consequences are highlighted. Vessels included in the study have thoroughly been selected through traffic analysis, received by AIS-data, to represent a normal population sailing in the Bay of Bothnia and the Bothnian Sea during the winter season. The results of the performed calculations are presented and followed by discussion as well as conclusions on the possible effects of EEDI on the winter navigational operations.

The Winter Navigation Research Board warmly thanks Mr. Victor Westerberg for this report.

Helsinki and Norrköping

June 2014

Jorma Kämäräinen

Finnish Transport Safety Agency

Peter Fyrby

Swedish Maritime Administration

Tiina Tuurnala

Finnish Transport Agency

Stefan Eriksson

Swedish Transport Agency

REPORT

FINNISH-SWEDISH WINTER NAVIGATION RESEARCH BOARD
STYRELSEN FÖR VINTERSJÖFARTSFORSKNING

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Victor Westerberg

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Authors:
Victor Westerberg
victor.westerberg@sspa.se
+46(0)31 772 9134
Roger Karlsson

EEDI and Finnish-Swedish ice class rules
Impact study and operational aspects

The Energy Efficient Design Index (EEDI) has been developed within IMO and MEPC. The purpose is to increase the energy efficiency of the world merchant fleet and reducing the emissions of greenhouse gases (GHG).

This study puts focus on EEDI and its consequences on the Baltic winter navigational operations. EEDI is calculated and compared to relevant baselines, ice class correction factors are investigated, interactions with the output power regulations in the Finnish-Swedish ice class are analysed and possible consequences are highlighted.

Vessels included in the study have thoroughly been selected through traffic analysis, received by AIS-data, to represent a normal population sailing in the Bay of Bothnia and the Bothnian Sea during the winter season.

The results of the performed calculations are presented and followed by discussion as well as conclusions on the possible effects of EEDI on the winter navigational operations.

SSPA Sweden AB

Jim Sandkvist
Vice President
Maritime Operations

SSPA Sweden AB

Victor Westerberg
Project Manager
Maritime Operations

Summary and recommendations

The winter navigational operation is based on a balance between available assisting icebreakers, current ice conditions, the number and performance of merchant vessels in the area. A well balanced system ensures good logistics and safe operation with minor delays and waiting times at a reasonable cost to shipping and the society.

The performed study shows that existing vessels currently operating in the ice infested waters sometimes have more installed engine power than needed by its ice class notation. The reason is to increase and ensure good performance in ice.

The EEDI rules, with the purpose to increase energy efficient design, will affect the allowed engine power. However, there exist already today vessels fulfilling both the EEDI rules and ice class rules. Since the performance in ice may be limited to, or close to, the minimum criteria's of brash ice channel thicknesses set by the ice class rules, it is likely that the number of such vessels will increase in the future.

This introduces an unbalance in the total winter navigational operation system that needs to be taken care of. Possible actions to rebalance the system are to increase the number of available icebreakers, optimise icebreaker utilization and/or tighten the ice class restrictions.

The ice class correction factors which have been introduced in the EEDI rules are highly needed. They are suggested to be used as control means to balance the ice-going performance of the merchant vessels. Increased ice class correction factor allows higher installed engine power for ice classed vessels compared to similar non-ice classed vessels.

Contents

EEDI and Finnish-Swedish ice class rules 1

Impact study and operational aspects 1

Summary and recommendations 2

1 Introduction 5

2 Method 6

3 Selection of vessels included in the study 7
3.1 Area 1 - Bay of Bothnia 8
3.2 Area 1 + Area 2 - Bay of Bothnia and Bothnian Sea 8

4 EEDI regulations and Baltic winter navigation 9
4.1 Background and basic criteria 9
4.1.1 Required EEDI - Reference lines and included ship types 9
4.1.2 Attained EEDI 13
4.1.3 Correction factors for ice classed ships 13
4.1.4 Additional correction factors 15
4.2 EEDI calculations for certification and in this report 15
4.3 Finnish-Swedish Ice Class rules (FSIC) 16
4.3.1 Engine power requirement calculations 16

5 Attained vs. required EEDI and ice class correction factors 17
5.1 General cargo 18
5.2 Product/chemical tank 20
5.3 Container 22
5.4 Bulk (incl. cement) 24

6 Engine output power analysis – EEDI vs. FSIC 26
6.1 Attained FSIC to comply with EEDI 26

7 Operational consequences – Accessibility 28

8 Survey 30
8.1 Survey questions 31
8.2 Results 32

9 Discussion and conclusions 35

10 References.. 37

Appendix A Complete survey answers

Appendix B Vessels included in the study

Appendix C RESOLUTION MEPC.212(63)

Appendix D RESOLUTION MEPC. 231(65)

Appendix E RESOLUTION MEPC.203(62)

1 Introduction

EEDI is the acronym for *Energy Efficient Design Index*, it has been developed within the International Maritime Organization (IMO) with the purpose to increase the energy efficiency of the world fleet and to reduce the emissions of greenhouse gases (GHG).

All new ships will get a calculated *attained EEDI* value which has to meet the *required EEDI*. The required EEDI is determined from an, for each ship type, individual baseline which has been developed through regression of calculated EEDI for the world sailing fleet. The required EEDI level will gradually be tightened by introducing different phases with the purpose to push the development of energy efficient design forward.

The attained EEDI value is calculated to represent the vessels CO_2 emissions divided by the transport work, see eq. (1).

$$EEDI = \frac{CO_2\ emissions\ [g]}{\text{goods [t]} \times \text{distance [Nm]}} = \left[\frac{g}{t \times Nm}\right] \quad (1)$$

Within the calculation of the attained EEDI different correction factors have been introduced with the purpose to compensate for vessels built to serve special purposes such as navigation in ice. In the general EEDI calculation formula vessels with ice class notation have clear disadvantages. Higher installed main engine power which is crucial for winter navigation means increased CO_2 emissions at the design point. Ice strengthened hull and additional equipment means less cargo capacity (deadweight) for the same vessel size compared to non ice-going vessels. To compensate, two ice class correction factors, f_j and f_i have been introduced. The Finnish-Swedish Ice Class rules (FSIC) put requirements on installed engine output power and elsewise operational restrictions are set according to current ice conditions to restrict non-suitable vessels to enter the ice infested area. Using the correction factors included in the calculation, vessels with different particulars are thus aimed to be comparable and hence have to comply with the equal required EEDI.

In the present study a selection of vessels that frequently are operating in the Bay of Bothnia and the Bothnian Sea form the basis for analysing the impact of EEDI on the total winter navigational operation system. EEDI are calculated for the vessels and compared to the required EEDI and the effects of ice class correction factors are included.

Within the composition of vessels it is well known that some vessels do better than others. However, do they have a higher attained EEDI? This is investigated through a survey answered by icebreaker officers where focuses are put on the ice-going capabilities compared to the vessels FSIC. The interaction between EEDI and FSIC is also studied through an output power analysis. The effect on vessel accessibility to the Bay of Bothnia and the Bothnian Sea during normal winter conditions is highlighted and compared to the condition prior to and after the EEDI regulation in force.

2 Method

To ensure a realistic approach the selected vessels included in the study are chosen through an analysis of traffic during winter seasons in the Bay of Bothnia and the Bothnian Sea. The selection of vessels is based on ship movements registered through the AIS framework (Automatic Identification System). The three last seasons, 2010/11 – 2012/13, are included and unique vessels for each month between November and April are identified in the selection process. This procedure is used to ensure that vessels frequently operating in the area are selected. It was also crucial that well-known vessels were included so that they could be recognised by the icebreaker officers when answering the survey described below.

An extensive material of calculated attained EEDI compared to required EEDI for the different phases are presented and effect of ice class correction factors are also included. The scatter of attained EEDI compared to applicable baseline is analysed to investigate the validity of the EEDI calculations on ice-going vessels.

The installed engine output power, permitted by the EEDI rules, is calculated with other parameters fixed. The calculated engine power is then used to determine possible ice class notation according to the engine power output rules in the FSIC.

To highlight the effect of the present EEDI rules the accessibility for the selection of vessels are presented according to the new assigned ice class notation due to lowered installed engine power to meet the required EEDI values. Accessibility to the areas in the Bay of Bothnia and the Bothnian Sea are analysed against general ice class restrictions during a normal winter without the EEDI regulations (as today) and for the different phases of EEDI.

A survey was sent out to the Finnish and Swedish icebreaker officers. The survey was prepared in cooperation with experienced masters from Swedish icebreakers and the main purpose was to identify and highlight the actual ice-going performance of the selected vessels compared to its FSIC. The result from the survey is used to investigate ice-going performance of the vessels and whether or not energy efficient vessels, here interpreted as vessels with low attained EEDI, distinguish themselves.

The above described method analyses existing vessels currently operating. These vessels were assumed to represent a valid population for the study with realistic particulars for the winter navigational system. However, mind that the EEDI rules will not affect these vessels as only new built vessels are included in the EEDI regulations. The effect of EEDI on the winter navigational system is analysed according to engine power and the FSIC. It can be noted that design alternatives to meet the required EEDI besides reduced installed engine output power may be available. However, this is not analysed in the current study.

3 Selection of vessels included in the study

The selection of vessels included in the study is based on AIS data. Two geographical areas are used and vessels registered within the two partly overlapping areas are sorted out.

Unique vessels on a monthly basis between November and April for three last seasons (2010/11 – 2012/13) are identified. Unique merchant cargo carrying vessels which have been registered more or equal to three out of six months (n_reg. ≥ 3 months of 6 possible) for all three seasons are selected. The amount of vessels, average deadweight and ice class distribution for the two groups are presented in Table 1 and Table 2 below.

The geographical limits and traffic density for the three seasons are shown in Figure 1.

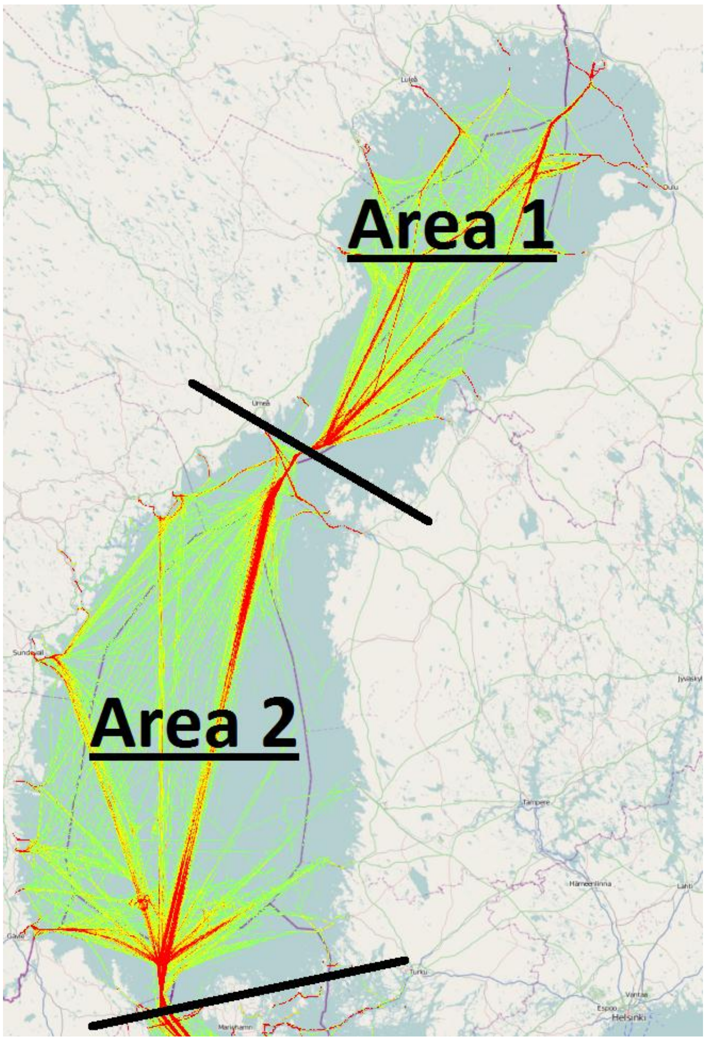


Figure 1 - Traffic density for three seasons and studied geographical areas.

Vessel particulars and other needed information for the selected vessels are based on the IHS Sea-web database (www.sea-web.com).

3.1 Area 1 - Bay of Bothnia

To ensure recognition from icebreaker officers the vessels registered in the Bay of Bothnia was used in the survey and therefore also in the study of ice-going capability according to its FSIC. In the Bay of Bothnia and due to constrains in the selection process only vessels with FSIC of IA or IA Super was sorted out. The most common vessel type is general cargo. The distribution of ice class, vessel type, number of selected vessels and average deadweight is shown in Table 1.

Table 1 - Vessel selection Area 1, Bay of Bothnia

Vessel type\FSIC	IAS	IA	IB	IC
General cargo	3	43	-	-
Product/chemical tank	3	9	-	
Container	-	2	-	-
Bulk (incl. cement)	-	2	-	-
Total number of vessels:	**62**		**Average DWT:**	**7827t**

3.2 Area 1 + Area 2 - Bay of Bothnia and Bothnian Sea

To increase the number of vessels and include the Bothnian Sea a greater area is chosen. This area is used for analysis of EEDI, ice class correction factors, installed output engine power, its effect on FSIC and accessibility to the northern parts of Swedish and Finnish waters during winter seasons. The distribution of ice class, vessel type, number of selected vessels and average deadweight is shown in Table 2.

Table 2- Vessel selection Area 1 + 2, Bay of Bothnia and Bothnian Sea

Vessel type\FSIC	IAS	IA	IB	IC
General cargo	11	249	28	9
Product/chemical tank	9	55	3	-
Container	1	48	-	-
Bulk (incl. cement)	1	3	-	-
Total number of vessels:	**417**	**Average DWT:**		**8122t**

4 EEDI regulations and Baltic winter navigation

Below follows a short description of the EEDI system. Attached are Resolution MEPC.212(63), Appendix C, with guidelines for calculation of attained EEDI and Resolution MEPC.231(65), Appendix D, containing guidelines for calculation of reference lines for use with the EEDI. The regulations for introduction of EEDI can be found in MARPOL Annex VI, as amended by Resolution MEPC.203(62), Appendix E.

Some text has been copied from the Resolutions as reference in the text, for better readability and a fuller description please refer to the original texts.

4.1 Background and basic criteria

EEDI is the acronym for *Energy Efficient Design Index* and has been developed within IMO with the purpose to increase the energy efficiency of the world fleet to reduce the emissions of greenhouse gases (GHG). In its basic form the EEDI can be described by the following formula, eq. 2.

$$EEDI = \frac{CO_2\ emissions\ [g]}{\text{goods [t]} \times \text{distance [Nm]}} = \left[\frac{g}{t \times Nm}\right] \tag{2}$$

As can be seen below in 4.1.2 to 4.1.4 a number of correction factors are however added making the equation somewhat more complex.

All new ships will get a calculated *attained EEDI* value which has to meet the *required EEDI*. The required EEDI is determined from an, for each ship type, individual baseline which has been developed through regression of calculated EEDI for the world sailing fleet.

The EEDI regulations came into force January 1st 2013 and are applicable to new ships falling under category 2.25 to 2.31 in Figure 3 on next page. At present some types of designs (apart from the non-covered vessel types) are not covered, among them vessels with diesel-electric propulsion. At MEPC 65 it was also decided that vessels with ice-breaking capacity (capacity of breaking level ice with 1.0 m thickness or more at a speed of at least 2 knots) shall not be covered by the EEDI rules.

4.1.1 Required EEDI - Reference lines and included ship types

The required EEDI is based on vessels built during the last (about) 10 years. Based on the statistics of vessels reference lines for different types have been developed as per below, Figure 2 and Figure 3.

3	The Reference line values shall be calculated as follows:
	Reference line value = $a \times b^{-c}$
	where a, b and c are the parameters given in Table 2.

Figure 2 - Basic equation for the reference line for required EEDI, MEPC.203(62).

Figure 3 below, from MEPC 65/4/4, gives values for a and c for different types of vessels. Ro-Ro cargo and Ropax figures are shaded since they are still under discussion.

Ship Type defined in Regulation 2	a	b	c
2.25 Bulk Carrier	961.79	DWT of the ship	0.477
2.26 Gas Carrier	1120.00	DWT of the ship	0.456
2.27 Tanker	1218.80	DWT of the ship	0.488
2.28 Container Ship	174.22	DWT of the ship	0.201
2.29 General Cargo Ship	107.48	DWT of the ship	0.216
2.30 Refrigerated Cargo Carrier	227.01	DWT of the ship	0.244
2.31 Combination Carrier	1219.00	DWT of the ship	0.488
2.34 Ro-Ro Cargo Ship	**1405.15**	**DWT of the ship**	**0.498**
2.35 Ro-Ro Passenger Ship	**752.16**	**DWT of the ship**	**0.381**

Figure 3 - Parameters for calculation of required EEDI, MEPC 65/4/4, (RoRo not included).

Below are figures of required EEDI for the different ship types with different DWT in tabular format, Table 3, and as a diagram, Figure 4. It is interesting to note that especially General Cargo vessels have a quite different characteristic, allowing quite small emissions for small vessel but high, compared to other ship types, for larger ones. Observe also that tankers and combination carriers have almost the same requirements.

Table 3 - Required EEDI, phase 0 for different vessel Deadweight

DWT kTon	1	2	3	4	5	10	15	20	40	80	120
2.25 Bulk Carrier						11.9	9.8	8.5	6.1	4.4	3.6
2.26 Gas Carrier		35.0	29.1	25.5	23.0	16.8	14.0	12.2	8.9	6.5	5.4
2.27 Tanker				21.3	19.1	13.6	11.2	9.7	6.9	4.9	4.0
2.28 Container Ship						27.4	25.2	23.8	20.7	18.0	16.6
2.29 General Cargo Ship			19.1	17.9	17.1	14.7	13.5	12.7	10.9	9.4	8.6
2.30 Refrigerated Cargo Carrier			32.2	30.0	28.4	24.0	21.7	20.3	17.1	14.4	13.1
2.31 Combination Carrier				21.3	19.1	13.6	11.2	9.7	6.9	4.9	4.0
2.34 Ro-Ro Cargo Ship	45.1	31.9	26.1	22.6	20.2	14.3	11.7	10.1	7.2	5.1	4.2
2.35 Ro-Ro Passenger Ship	54.1	41.6	35.6	31.9	29.3	22.5	19.3	17.3	13.3	10.2	8.7

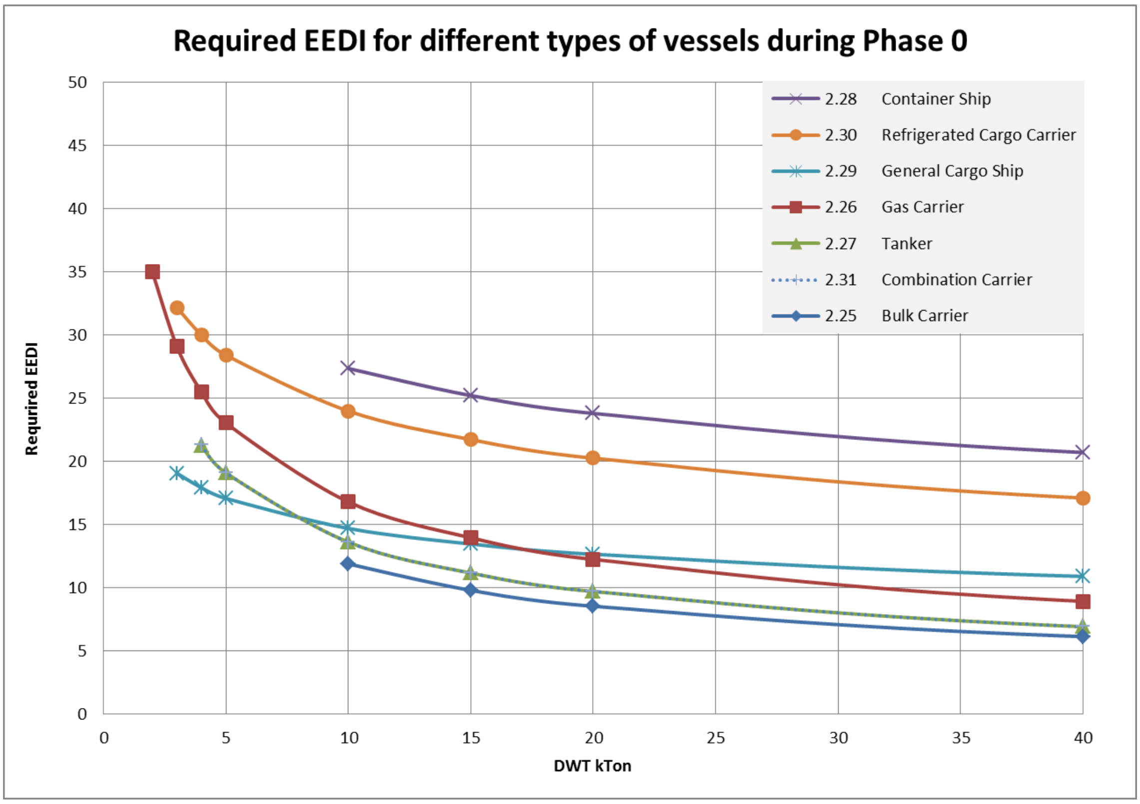


Figure 4 - Required EEDI Phase 0 (baselines) for different ship types.

The figures above are the required EEDI when the system starts, called Phase 0. There will then be a gradual reduction to push the development of energy efficient design forward, see Figure 5 from MEPC 65/4/4 below. As can be seen, in Table 4, small vessels are not included to the same extent during Phase 0 and the reductions at the later stages are smaller than for the larger ships. Also here Ro-Ro cargo and Ropax figures are shaded since these figures are still not decided.

Table 4 - Deadweight limits for ship types and EEDI phases

Ship Type	Deadweight limit Phase 0	Deadweight limit Phase 1-3
Bulk Carrier	20 000	10 000
Gas Carrier	10 000	2 000
Tanker	20 000	4 000
Containership	15 000	10 000
General Cargo Ship	15 000	3 000
Refrigerated Cargo Ship	5 000	3 000
Combination Carrier	20 000	4 000
Ro-Ro Cargo Ship	2 000	1 000
Ro-Ro Passenger Ship	4 000 GT	1 000 GT

Ship Type	Size	Phase 0 1 Jan 2013 – 31 Dec 2014	Phase 1 1 Jan 2015 – 31 Dec 2019	Phase 2 1 Jan 2020 – 31 Dec 2024	Phase 3 1 Jan 2025 and onwards
Bulk Carrier	20,000 DWT and above	0	10	20	30
	10,000 – 20,000 DWT	n/a	0-10*	0-20*	0-30*
Gas Carrier	10,000 DWT and above	0	10	20	30
	2,000 – 10,000 DWT	n/a	0-10*	0-20*	0-30*
Tanker	20,000 DWT and above	0	10	20	30
	4,000 – 20,000 DWT	n/a	0-10*	0-20*	0-30*

Ship Type	Size	Phase 0 1 Jan 2013 – 31 Dec 2014	Phase 1** 1 Jan 2015 – 31 Dec 2019	Phase 2 1 Jan 2020 – 31 Dec 2024	Phase 3 1 Jan 2025 and onwards
Containership	15,000 DWT and above	0	10	20	30
	10,000 – 15,000 DWT	n/a	0-10*	0-20*	0-30*
General Cargo Ship	15,000 DWT and above	0	10	15	30
	3,000 – 15,000 DWT	n/a	0-10*	0-15*	0-30*
Refrigerated Cargo Ship	5,000 DWT and above	0	10	15	30
	3,000 – 5,000 DWT	n/a	0-10*	0-15*	0-30*
Combination Carrier	20,000 DWT and above	0	10	20	30
	4,000 – 20,000 DWT	n/a	0-10*	0-20*	0-30*
Ro-Ro Cargo Ship	**2,000 DWT and above**	**n/a**	**5**	**20**	**30**
	1,000 – 2,000 DWT	**n/a**	**0-5***	**0-20***	**0-30***
Ro-Ro Passenger Ship	**4,000 GT and above**	**n/a**	**5**	**20**	**30**
	1,000 – 4,000 GT	**n/a**	**0-5***	**0-20***	**0-30***

* Reduction factor to be linearly interpolated between the two values dependent upon vessel size. The lower value of the reduction factor is to be applied to the smaller ship size.

** **In case of ro-ro cargo ships and ro-ro passenger ships, Phase 1 commences when the amendments to MARPOL Annex VI take effect for these ship types.**

Figure 5 - Reduction factors EEDI phases relative to reference line, MEPC 65/4/4.

4.1.2 Attained EEDI

The attained EEDI value is calculated to represent the vessels CO_2 emissions divided by transport work, eq. (3) and Figure 6.

$$EEDI = \frac{CO_2\ emissions\ [g]}{\text{goods [t]} \times \text{distance [Nm]}} = \left[\frac{g}{t \times Nm}\right] \qquad (3)$$

Within the calculation of the attained EEDI different correction factors have been introduced with the purpose to compensate for vessels built to serve special purposes such as navigation in ice.

The attained new ship Energy Efficiency Design Index (EEDI) is a measure of ships energy efficiency (g/t*nm) and calculated by the following formula:

$$\frac{\left(\prod_{j=1}^{n} f_j\right)\left(\sum_{i=1}^{nME} P_{ME(i)} \cdot C_{FME(i)} \cdot SFC_{ME(i)}\right) + \left(P_{AE} \cdot C_{FAE} \cdot SFC_{AE}*\right) + \left(\left(\prod_{j=1}^{n} f_j \cdot \sum_{i=1}^{nPTI} P_{PTI(i)} - \sum_{i=1}^{neff} f_{eff(i)} \cdot P_{AEeff(i)}\right) C_{FAE} \cdot SFC_{AE}\right) - \left(\sum_{i=1}^{neff} f_{eff(i)} \cdot P_{eff(i)} \cdot C_{FME} \cdot SFC_{ME}**\right)}{f_i \cdot f_c \cdot f_l \cdot Capacity \cdot f_w \cdot V_{ref}}$$

Figure 6 - The attained EEDI equation, MEPC.212(63).

With the correction factors vessels with different particulars are thus thought to be comparable and hence have to comply with the equal required EEDI. There are also parts taking into account PTI/PTO solutions, i.e. shaft generators or shaft booster units (second summation in equation above), as well as efficiency enhancements (last sum in the equation, Figure 6).

The capacity is normally the maximum deadweight of the vessel (70% of DWT for container vessels). P_{ME} is 75% of MCR and V_{ref} is the speed at P_{ME}.

4.1.3 Correction factors for ice classed ships

In the general EEDI calculation formula vessels with ice class notation have clear disadvantages. Higher installed main engine power which is crucial for winter navigation means an increased attained EEDI value. Ice strengthened hull and additional equipment means less cargo capacity (deadweight) for the same vessel size compared to non ice-going vessels. To compensate for this two ice class correction factors, f_j and f_i has been introduced. Below are some parts from MEPC.212(63) describing the calculation of f_j and f_i.

.8 f_j is a correction factor to account for ship specific design elements:

.1 The power correction factor, f_j, for ice-classed ships should be taken as the greater value of f_{j0} and $f_{j,min}$ as tabulated in Table 1 but not greater than $f_{j,max}$ = 1.0.

For further information on approximate correspondence between ice classes, see HELCOM Recommendation 25/7[2].

Table 1: Correction factor for power f_j for ice-classed ships

Ship type	f_{j0}	$f_{j,min}$ depending on the ice class			
		IA Super	IA	IB	IC
Tanker	$\frac{0.308L_{pp}^{1.920}}{\sum_{i=1}^{nME} P_{ME(i)}}$	$0.15L_{pp}^{0.30}$	$0.27L_{pp}^{0.21}$	$0.45L_{pp}^{0.13}$	$0.70L_{pp}^{0.06}$
Bulk carrier	$\frac{0.639L_{pp}^{1.754}}{\sum_{i=1}^{nME} P_{ME(i)}}$	$0.47L_{pp}^{0.09}$	$0.58L_{pp}^{0.07}$	$0.73L_{pp}^{0.04}$	$0.87L_{pp}^{0.02}$
General cargo ship	$\frac{0.0227 \cdot L_{pp}^{2.483}}{\sum_{i=1}^{nME} P_{ME(i)}}$	$0.31L_{pp}^{0.16}$	$0.43L_{pp}^{0.12}$	$0.56L_{pp}^{0.09}$	$0.67L_{pp}^{0.07}$

.2 The factor f_j, for shuttle tankers with propulsion redundancy should be f_j = 0.77. This correction factors applies to shuttle tankers with propulsion redundancy between 80,000 and 160,000 deadweight. The Shuttle Tankers with Propulsion Redundancy are tankers used for loading of crude oil from offshore installations equipped with dual-engine and twin-propellers need to meet the requirements for dynamic positioning and redundancy propulsion class notation.

.3 For other ship types, f_j should be taken as 1.0.

Figure 7 - Calculation of f_j, from MEPC.212(63).

.11 f_i is the capacity factor for any technical/regulatory limitation on capacity, and should be assumed to be one (1.0) if no necessity of the factor is granted.

.1 The capacity correction factor, f_i, for ice-classed ships should be taken as the lesser value of f_{i0} and $f_{i,max}$ as tabulated in Table 2, but not less than $f_{i,min}$ = 1.0. For further information on approximate correspondence between ice classes, see HELCOM Recommendation 25/7[5].

Table 2: Capacity correction factor f_i for ice-classed ships

Ship type	f_{i0}	$f_{i,max}$ depending on the ice class			
		IA Super	IA	IB	IC
Tanker	$\frac{0.00138 \cdot L_{pp}^{3.331}}{capacity}$	$2.10L_{pp}^{-0.11}$	$1.71L_{pp}^{-0.08}$	$1.47L_{pp}^{-0.06}$	$1.27L_{pp}^{-0.04}$
Bulk carrier	$\frac{0.00403 \cdot L_{pp}^{3.123}}{capacity}$	$2.10L_{pp}^{-0.11}$	$1.80L_{pp}^{-0.09}$	$1.54L_{pp}^{-0.07}$	$1.31L_{pp}^{-0.05}$
General cargo ship	$\frac{0.0377 \cdot L_{pp}^{2.625}}{capacity}$	$2.18L_{pp}^{-0.11}$	$1.77L_{pp}^{-0.08}$	$1.51L_{pp}^{-0.06}$	$1.28L_{pp}^{-0.04}$
Containership	$\frac{0.1033 \cdot L_{pp}^{2.329}}{capacity}$	$2.10L_{pp}^{-0.11}$	$1.71L_{pp}^{-0.08}$	$1.47L_{pp}^{-0.06}$	$1.27L_{pp}^{-0.04}$
Gas carrier	$\frac{0.0474 \cdot L_{pp}^{2.590}}{capacity}$	1.25	$2.10L_{pp}^{-0.12}$	$1.60L_{pp}^{-0.08}$	$1.25L_{pp}^{-0.04}$

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

Figure 8 - Calculation of f_i, from MEPC.212(63).

4.1.4 Additional correction factors

There are also a number of other correction factors for special features on specific vessels. Of interest for ice operation is that no correction for ice is suggested for Ro-Ro cargo and Ropax vessels. There is instead a correction factor f_{jRoRo} suggested for Ro-Ro cargo and Ropax vessels and also a correction factor f_{cRoPax} for Ropax vessels.

There is also a suggested speed dependent f_j for general cargo vessels. However this will not affect vessels with "normal" speeds.

There are also correction factors for chemical tankers, f_c, because of their higher steel weight compared to capacity as well as a correction for vessels built in accordance with the Common Structural Rules.

4.2 EEDI calculations for certification and in this report

The attained EEDI for new ships is calculated at different stages of the design/building process and will have to be verified during basic design, model testing and sea trials.

At the early stages all parameters for engines etc. will not be known, and therefore standard values are set. These are the same figures as those used for calculation of the reference lines.

- The carbon correction factor C_F=3.1144 g CO_2/g fuel for all engines.
- The Specific fuel consumption for the main engine is set to SFC_{ME}= 190 g/kWh
- The Specific fuel consumption for auxiliary engines is set to SFC_{ME}= 215 g/kWh.
- P_{AE}, the auxiliary engine power, is calculated as
  - 0.025*MCR+250 for Main Engine MCR>10000 kW
  - 0.05*MCR for Main Engine MCR<10000kW
- F_w = 1, i.e. there is no weather correction (this may be developed at a later stage)
- P_{ME}=75% of MCR at the corresponding V_{ref}

The assumptions above have also been used in this study with data on engine power, DWT and vessel speed taken from the IHS Sea-web database.

For the final attained EEDI value of new vessels the actual SFC, P_{AE}, C_F etc. from trials will be used. Possible correction due to differences between trial conditions and EEDI condition will have to be applied in accordance with Resolution MEPC.214(63).

4.3 Finnish-Swedish Ice Class rules (FSIC)

The Finnish-Swedish ice class rule includes requirements on vessels structural design and installed engine power. Ice class notations considered in this study is between IA Super and IC.

The notation requirement represents a minimum speed of 5kn in a brash ice channel with a brash ice thickness in the middle of the channel, H_m, of;

IA Super	H_m = 1.0m + 0.1m thick consolidated layer of ice
IA	H_m = 1.0m
IB	H_m = 0.8m
IC	H_m = 0.6m

The Finnish-Swedish ice class is thus not an *icebreaking* class. The rules have been developed to prevent not suitable vessels to enter ice infested areas and ensure that vessels operating have enough strength and power to safely be able to follow and get assistance of icebreakers.

4.3.1 Engine power requirement calculations

The FSIC rules put requirements on installed output power. The requirements are based on an extensive theoretical R&D work and full scale measurements (Juva & Riska, 2002). The requirements are introduced based on calculation of hull resistance in a brash ice channel for the specified vessels size and hull form and ice channel thickness depending on ice class notation.

The engine output power should not be less than given by calculations using the formulas and for ice class IA, IB or IC not less than 1000kW and for IA Super not less than 2800kW.

For the engine power analysis in study, power requirement rule 3.2.4 has been used for ice class IA Super and IA and power requirement rule 3.2.3 has been used for ice class IB and IC.

The rules used are proposed for existing ships and for ships "*where some hull form parameters are difficult to obtain",* these parameters which are needed to be able to use rule 3.2.2. In the study were existing ships are used as reference hull parameters are difficult to find.

The diameter of the propeller, D_p, in the power output requirement calculations has been assumed to[1],

$$D_p = 0.54 \times T \; [m] \qquad (2)$$

Were T is the draught of the vessel.

[1] Reference from applicable vessels.

5 Attained vs. required EEDI and ice class correction factors

Attained and required EEDI for the selected vessels, Area 1+2, are calculated according to the regulation and formula described in section 4 above. To investigate the effect of the ice class correction factors attained EEDI is also calculated with and without the ice class correction factors f_i and f_j. The result is presented for each ship type and EEDI phase and ice class in tables and figures below (section 5.1 - 5.4).

A summary of the calculation results for all ship types is presented in Table 5, average ice class correction factors for all ship types in the study are presented in Table 6.

Table 5 - Attained EEDI vs. Required EEDI for all ship types included in the study.

	Phase 0**		Phase 1		Phase 2		Phase 3	
FISC	Fulfilling EEDI req.	Avg. diff.*	Fulfilling EEDI req.	Avg. diff.*	Fulfilling EEDI req.	Avg. diff.*	Fulfilling EEDI req.	Avg. diff.*
IAS	5/8 (63%)	-5.8%	10/22 (45%)	1.6%	6/22 (27%)	7.5%	4/22 (18%)	20.0%
IA	19/27 (70%)	-4.9%	188/355 (53%)	-0.8%	164/355 (46%)	1.7%	114/355 (32%)	7.0%
IB	-	-	7/31 (23%)	6.2%	7/31 (23%)	6.9%	7/31 (23%)	8.8%
IC	-	-	2/9 (22%)	6.3%	2/9 (22%)	6.8%	2/9 (22%)	8.2%
All	**24/35 (69%)**		**207/417 (50%)**		**179/417 (43%)**		**127/417 (30%)**	

** The relatively low number of vessels is due the non-applicability of EEDI for the majority of vessels in the study for EEDI Phase 0.

* Avg. diff. is the arithmetic mean value of the difference between *attained* and *required EEDI* for applicable vessels. Negative (-) value means that the *attained EEDI* is below *required EEDI,* i.e. pass EEDI requirements.

Table 6 – Average value of ice class correction factors, all ship types.

FSIC	F_j	f_i
IAS	0.857	1.160
IA	0.915	1.133
IB	0.987	1.083
IC	0.991	1.041

5.1 General cargo

A summary of the calculations for general cargo vessels is presented in Table 7. The result is also plotted in Figure 9 where analysis of ice class correction factors is included. Average ice class correction factors for general cargo vessels in the study are presented in Table 8.

Table 7 - Attained EEDI vs. Required EEDI for general cargo vessels in the study.

	Phase 0**		Phase 1		Phase 2		Phase 3	
FISC	**Fulfilling EEDI req.**	**Avg. diff.***	**Fulfilling EEDI req.**	**Avg. diff.***	**Fulfilling EEDI req.**	**Avg. diff.***	**Fulfilling EEDI req.**	**Avg. diff.***
IAS	2/4 (50%)	-4.3%	2/11 (18%)	8.6%	2/11 (18%)	12.8%	0/11 (0%)	28.6%
IA	14/14 (100%)	-15.4%	119/249 (48%)	-0.6%	110/249 (44%)	0.8%	72/249 (28%)	5.7%
IB	-	-	4/28 (14%)	8.2%	4/28 (14%)	8.8%	4/28 (14%)	10.7%
IC	-	-	2/9 (22%)	6.3%	2/9 (22%)	6.8%	2/9 (22%)	8.2%
All	**16/18 (89%)**		**127/297 (43%)**		**118/297 (40%)**		**78/297 (26%)**	

** The relatively low number of vessels is due the non-applicability of EEDI for the majority of vessels in the study for EEDI Phase 0.

* Avg. diff. is the arithmetic mean value of the difference between *attained* and *required EEDI* for applicable vessels. Negative (-) value means that the *attained EEDI* is below *required EEDI,* i.e. pass EEDI requirements.

Table 8 – Average value of ice class correction factors, general cargo vessels.

FSIC	F_j	f_i
IAS	0.921	1.168
IA	0.918	1.154
IB	0.990	1.087
IC	0.991	1.041

Attained vs. required EEDI - General Cargo

Attained vs. required EEDI is plotted for different FSIC in Figure 9.

<u>Note that two markers are plotted for one vessel</u>;

EEDI with ice class corrections	=>	Green circle
EEDI without ice class corrections	=>	Red cross

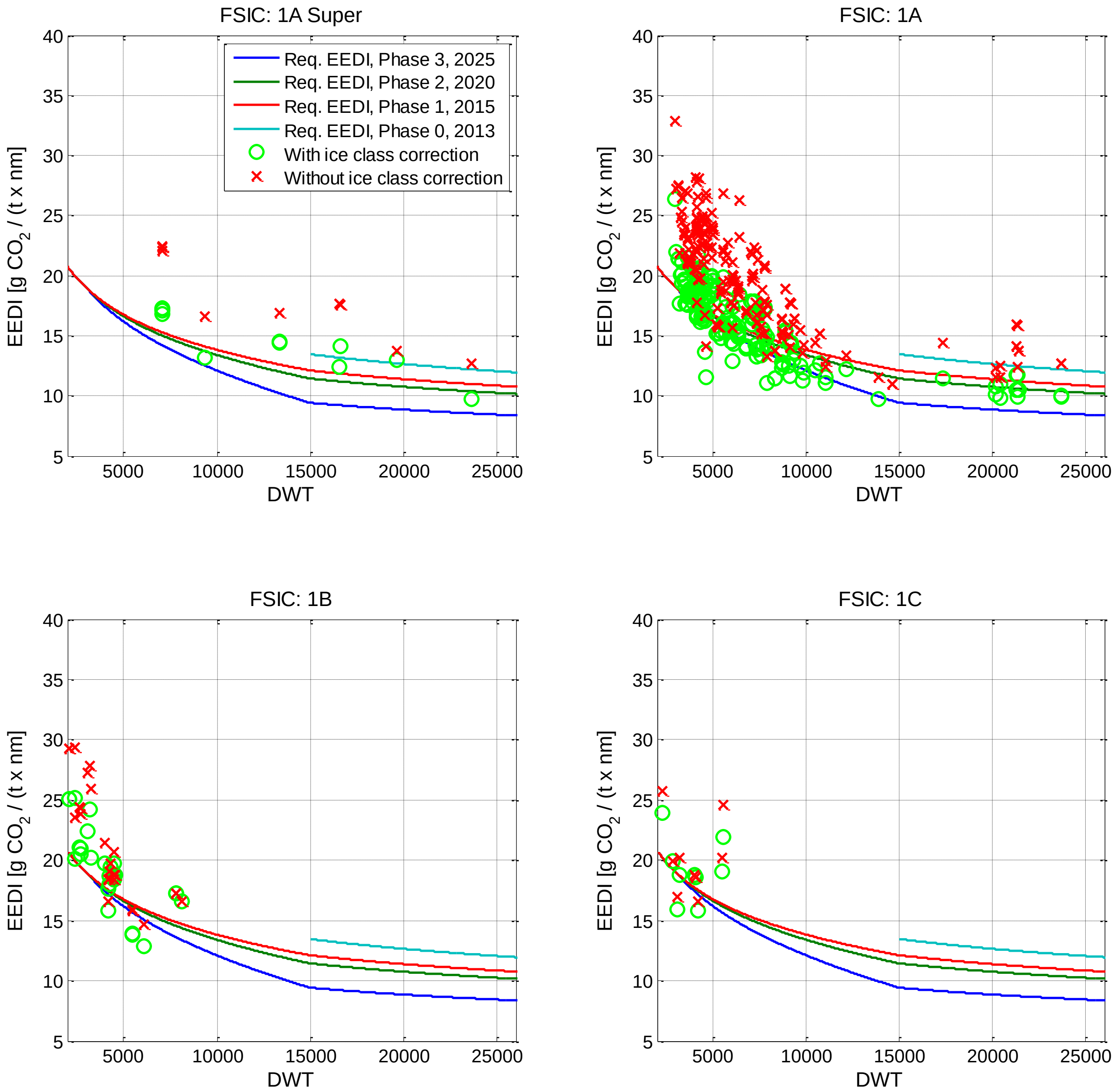


Figure 9 - Attained EEDI vs. Required EEDI general cargo vessels, with/without ice corrections factors and different ice classes. (1A refers to IA and so on)

5.2 Product/chemical tank

A summary of the calculation for product/chemical tank vessels is presented in Table 9. The result is also plotted in Figure 10 where analysis of ice class correction factors is included. Average ice class correction factors for product/chemical tank vessels in the study are presented in Table 10.

Table 9 - Attained EED vs. Required EEDI for tank vessels in the study.

	Phase 0**		Phase 1		Phase 2		Phase 3	
FISC	**Fulfilling EEDI req.**	**Avg. diff.***	**Fulfilling EEDI req.**	**Avg. diff.***	**Fulfilling EEDI req.**	**Avg. diff.***	**Fulfilling EEDI req.**	**Avg. diff.***
IAS	3/3	-17.1% (100%)	8/9 (89%)	-12.5%	4/9 (44%)	-5.2%	4/9 (44%)	3.8%
IA	1/1	-15.9% (100%)	50/55 (91%)	-9.3%	38/55 (69%)	-5.2%	34/55 (62%)	-0.5%
IB	-	-	3/3 (100%)	-11.4%	3/3 (100%)	-10.4%	3/3 (100%)	-9.3%
IC	-	-	-	-	-	-	-	-
All	**4/4 (100%)**		**61/67 (91%)**		**45/67 (67%)**		**41/67 (61%)**	

** The relatively low number of vessels is due the non-applicability of EEDI for the majority of vessels in the study for EEDI Phase 0.

* Avg. diff. is the arithmetic mean value of the difference between *attained* and *required EEDI* for applicable vessels. Negative (-) value means that the *attained EEDI* is below *required EEDI,* i.e. pass EEDI requirements.

Table 10 – Average value of ice class correction factors, tank vessels.

FSIC	F_j	f_i
IAS	0.777	1.161
IA	0.830	1.066
IB	0.962	1.047
IC	-	-

Attained vs. required EEDI – Product/chemical tank

Attained vs. required EEDI is plotted for different FSIC in Figure 10.

Note that two markers are plotted for one vessel;

EEDI with ice class corrections	=>	Green circle
EEDI without ice class corrections	=>	Red cross

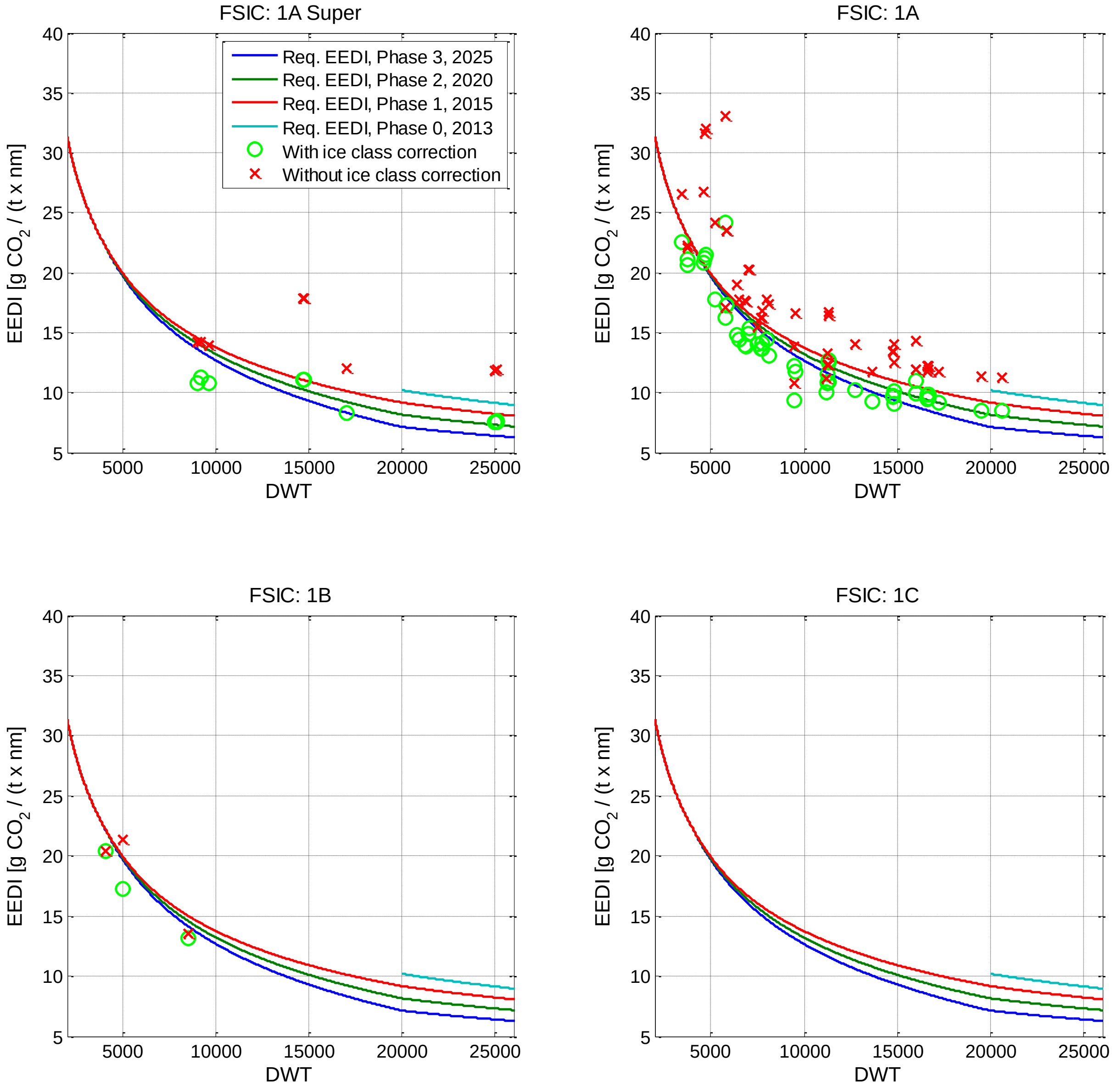


Figure 10 - Attained EEDI vs. Required EEDI tank vessels, with/without ice corrections factors and different ice classes. (1A refers to IA and so on)

5.3 Container

A summary of the calculation for container vessels is presented in Table 11. The result is also plotted in Figure 11 where analysis of ice class correction factors is included Average ice class correction factors for container vessels in the study are presented in Table 12.

Table 11 - Attained EEDI vs. Required EEDI for container vessels in the study.

	Phase 0**		Phase 1		Phase 2		Phase 3	
FISC	Fulfilling EEDI req.	Avg. diff.*	Fulfilling EEDI req.	Avg. diff.*	Fulfilling EEDI req.	Avg. diff.*	Fulfilling EEDI req.	Avg. diff.*
IAS	-	-	0/1 (0%)	18.1%	0/1 (0%)	18.1%	0/1 (0%)	18.1%
IA	4/10 (40%)	3.13%	19/48 (40%)	5.3%	16/48 (33%)	11.3%	4/48 (16.7%)	18.6%
IB	-	-	-	-	-	-	-	-
IC	-	-	-	-	-	-	-	-
All	**4/10 (40%)**		**19/49 (39%)**		**16/49 (33%)**		**4/49 (8%)**	

** The relatively low number of vessels is due the non-applicability of EEDI for the majority of vessels in the study for EEDI Phase 0.

* Avg. diff. is the arithmetic mean value of the difference between *attained* and *required EEDI* for applicable vessels. Negative (-) value means that the *attained EEDI* is below *required EEDI,* i.e. pass EEDI requirements.

Table 12 – Average value of ice class correction factors, container vessels.

FSIC	F_j	f_i
IAS	N/A (=1)	1.102
IA	N/A (=1)	1.098
IB	N/A (=1)	-
IC	N/A (=1)	-

Attained vs. required EEDI – Container

Attained vs. required EEDI is plotted for different FSIC in Figure 11.

<u>Note that two markers are plotted for one vessel</u>;

EEDI with ice class corrections	=>	Green circle
EEDI without ice class corrections	=>	Red cross

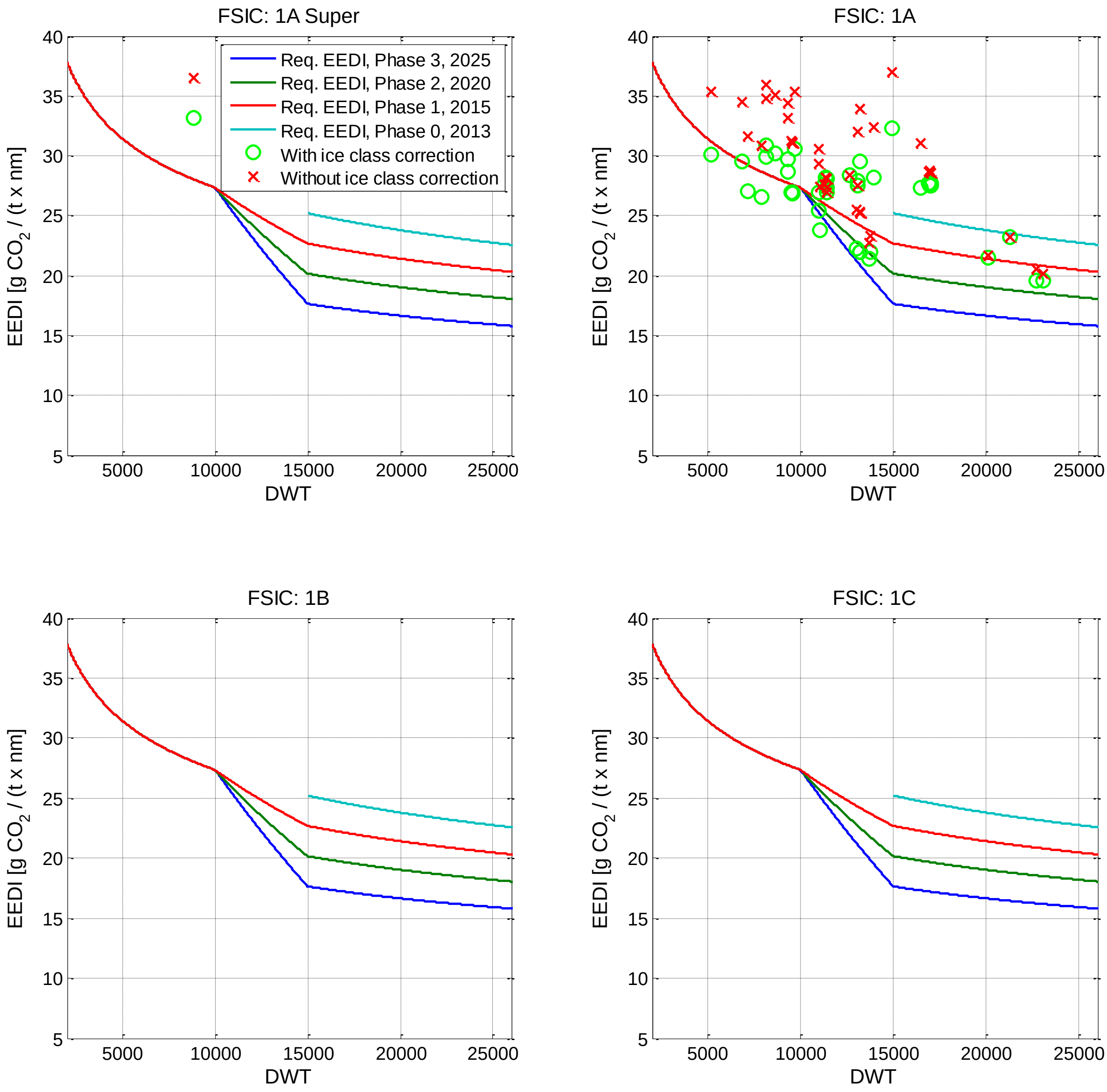


Figure 11 - Attained EEDI vs. Required EEDI container vessels, with/without ice corrections factors and different ice classes. (1A refers to IA and so on)

5.4 Bulk (incl. cement)

A summary of the calculation for bulk vessels is presented in Table 13. The result is also plotted in Figure 12 where analysis of ice class correction factors is included. Average ice class correction factors for bulk vessels in the study are presented in Table 14.

Table 13 - Attained EEDI vs. Required EEDI for bulk vessels in the study.

	Phase 0**		Phase 1		Phase 2		Phase 3	
FISC	**Fulfilling EEDI req.**	**Avg. diff.***	**Fulfilling EEDI req.**	**Avg. diff.***	**Fulfilling EEDI req.**	**Avg. diff.***	**Fulfilling EEDI req.**	**Avg. diff.***
IAS	0/1 (0%)	22.5%	0/1 (0%)	36.2%	0/1 (0%)	53.2%	0/1 (0%)	75.1%
IA	0/2 (0%)	34.7%	0/3 (0%)	37.4%	0/3 (0%)	49.8%	0/3 (0%)	65.9%
IB	-	-	-	-	-	-	-	-
IC	-	-	-	-	-	-	-	-
All	**0/3 (0%)**		**0/4 (0%)**		**0/4 (0%)**		**0/4 (0%)**	

** The relatively low number of vessels is due the non-applicability of EEDI for the majority of vessels in the study for EEDI Phase 0.

* Avg. diff. is the arithmetic mean value of the difference between *attained* and *required EEDI* for applicable vessels. Negative (-) value means that the *attained EEDI* is below *required EEDI,* i.e. pass EEDI requirements.

Table 14 – Average value of ice class correction factors, bulk vessels.

FSIC	F_j	f_i
IAS	0.736	1.129
IA	0.825	1.156
IB	-	-
IC	-	-

Attained vs. required EEDI – Bulk

Attained vs. required EEDI is plotted for different FSIC in Figure 12**.**

<u>Note that two markers are plotted for one vessel</u>;

EEDI with ice class corrections	=>	Green circle
EEDI without ice class corrections	=>	Red cross

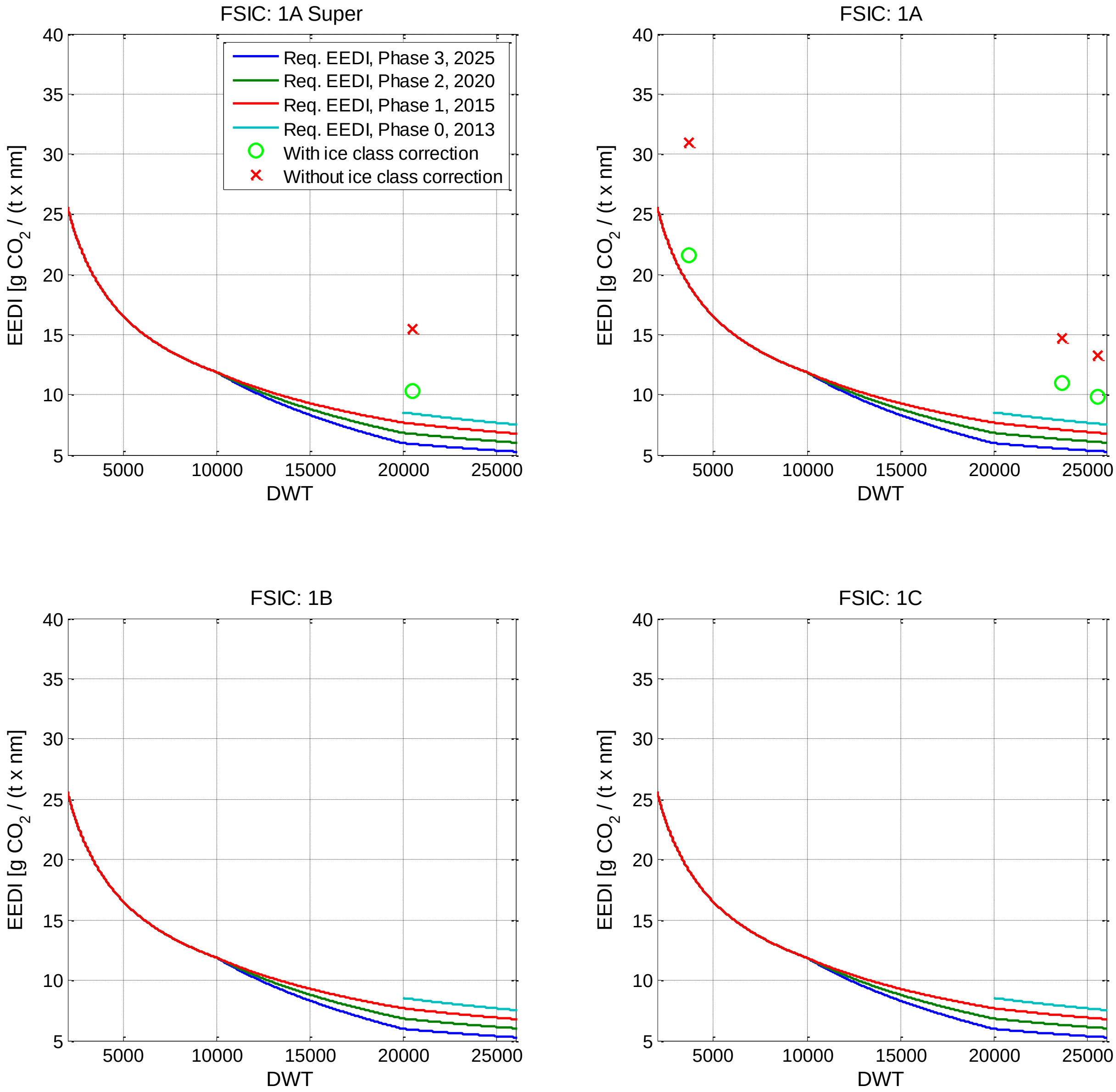


Figure 12 - Attained EEDI vs. Required EEDI bulk vessels, with/without ice corrections factors and different ice classes. (1A refers to IA and so on)

6 Engine output power analysis – EEDI vs. FSIC

There are several design alternatives to decrease the attained EEDI and thus to pass the required EEDI. One general and widely discussed alternative is to reduce the installed engine output power which is used to determine the amount of emitted CO_2 used in the calculation of attained EEDI.

In the engine output power analysis the permitted installed engine power is calculated by setting all other EEDI parameters fixed and use required EEDI as input. The results are later used in the analysis of operational consequences and accessibility, section 7.

A summary of the original installed engine power (as today) compared to the output power permitted by EEDI phases for all vessel types is presented in Table 15. Negative (-) difference means that average original installed engine power is below maximum required by the EEDI phase.

Table 15 - Summary of installed engine power analysis on existing vessels, all ship types.

EEDI:	Phase 0**	Phase 1	Phase 2	Phase 3
$\frac{P_{installed} - P_{EEDI}}{P_{EEDI}}$	-5.3%	0.4%	3.2%	9.4%
Standard deviation	17.4%	15.8%	16.9%	19.8%
Number of vessels	35	417	417	417

** The relatively low number of vessels is due the non-applicability of EEDI for the majority of vessels in the study for EEDI Phase 0.

6.1 Attained FSIC to comply with EEDI

Attained FSIC according to the engine output power regulations in the FSIC is calculated. The permitted, due to EEDI, installed engine power is used as input with all other parameters fixed to calculate appropriate FSIC with respect to engine output power.

Ice class distribution without EEDI and for the different phases is presented in Table 16 and Figure 13.

Table 16 - Change of FSIC due to power requirements and EEDI phases.

FSIC	NO EEDI, ref.	Phase 0**	Phase 1	Phase 2	Phase 3
IAS	22	45	94	70	31
IA	355	332	126	142	144
IB	31	31	124	131	144
≤ IB*	-	-	56	57	76
IC	9	9	17	17	20
< IC	-	-	-	-	2

** The relatively low number of changed FSIC is due the non-applicability of EEDI for the majority of vessels in the study for EEDI Phase 0. Note the increase of IAS which indicates that *over-powered* IA vessels are currently operating.

*Vessel displacement information which is needed for lower ice class notation calculations is missing for vessels in this category. However, vessels would be assigned FSIC ≤ IB.

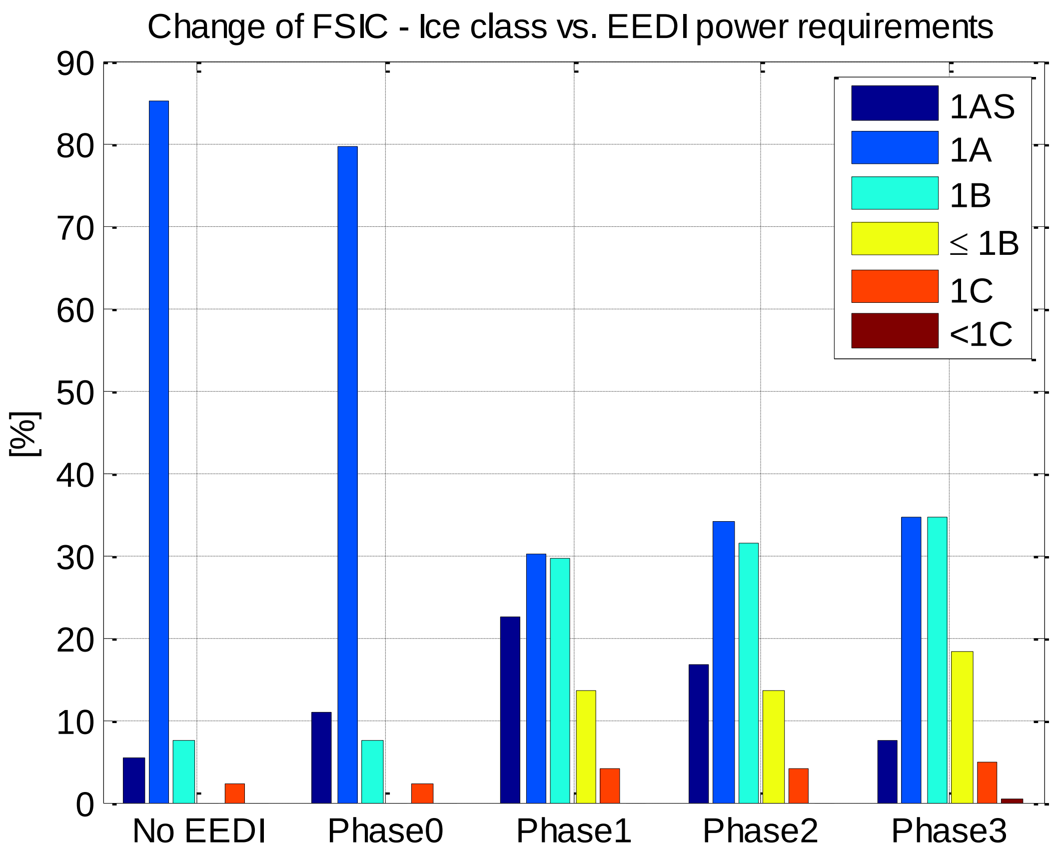


Figure 13 - FSIC distribution due to EEDI phases and power requirement analysis. (1A refers to IA and so on)

7 Operational consequences – Accessibility

To investigate the change of accessibility to the Bay of Bothnia and the Bothnian Sea due to EEDI general guidelines for *ice class restrictions during normal winters* are used as input.

Previously presented FSIC analysis due to power requirements for the EEDI phases is used, however, due to hull strength and other requirements in the ice class rules <u>no FSIC is increased in the accessibility analysis but decreased if the power requirements are not met by the vessel</u>.

Vessels assigned with *FSIC ≤IB* in section 6.1 (Table 16 and Figure 13) due to missing vessel displacement information have been assigned FSIC IB, or original FSIC if lower than FISC IB.

Accessibility is calculated for the vessels in the study prior EEDI regulations and for the different phases. Accessibility for the included vessels in study is presented as percentage of vessels that would be hindered to enter the studied areas. Current accessibility, without EEDI, is shown as <u>NO EEDI</u> followed by the EEDI phases in Table 17.

Table 17 - Accessibility NO EEDI and all EEDI phases, Area 1+2

	Ice class restrictions			Accessibility				
	Date	**FSIC**	**DWT**	**NO EEDI**	**Phase 0**	**Phase 1**	**Phase 2**	**Phase 3**
Bay of Bothnia - Area 1	**15-dec**	IC	1300	100.0%	100.0%	100.0%	100.0%	99.5%
	01-jan	IB	2000	97.8%	97.8%	95.9%	95.9%	94.7%
	15-jan	IA	3000	90.2%	90.2%	52.8%	50.8%	42.0%
	31-jan	IA	4000	79.4%	79.4%	52.5%	50.6%	41.7%
	10-apr	IA	3000	90.2%	90.2%	52.8%	50.8%	42.0%
	10-maj	IB	2000	97.8%	97.8%	95.9%	95.9%	94.7%
	15-maj	IC	1300	100.0%	100.0%	100.0%	100.0%	99.5%

	Ice class restrictions			Accessibility				
	Date	**FSIC**	**DWT**	**NO EEDI**	**Phase 0**	**Phase 1**	**Phase 2**	**Phase 3**
Bothnian Sea - Area 2	**15-jan**	IC	1300	100.0%	100.0%	100.0%	100.0%	99.5%
	01-feb	IB	2000	97.8%	97.8%	95.9%	95.9%	94.7%
	15-feb	IA	3000	90.2%	90.2%	52.8%	50.8%	42.0%
	01-apr	IB	2000	97.8%	97.8%	95.9%	95.9%	94.7%
	15-apr	IC	1300	100.0%	100.0%	100.0%	100.0%	99.5%

Accessibility due to the highest normal ice class restrictions and all EEDI phases are also illustrated in Figure 14 on next page where the results also are shown in number of vessels for the four scenarios. In Table 17 and Figure 14 it is clear that EEDI phase 0 don't affect the winter operations as a majority of the vessels are not included, however phase 1-3 would significantly affect the vessels in the reference group, especially during the higher ice class restrictions.

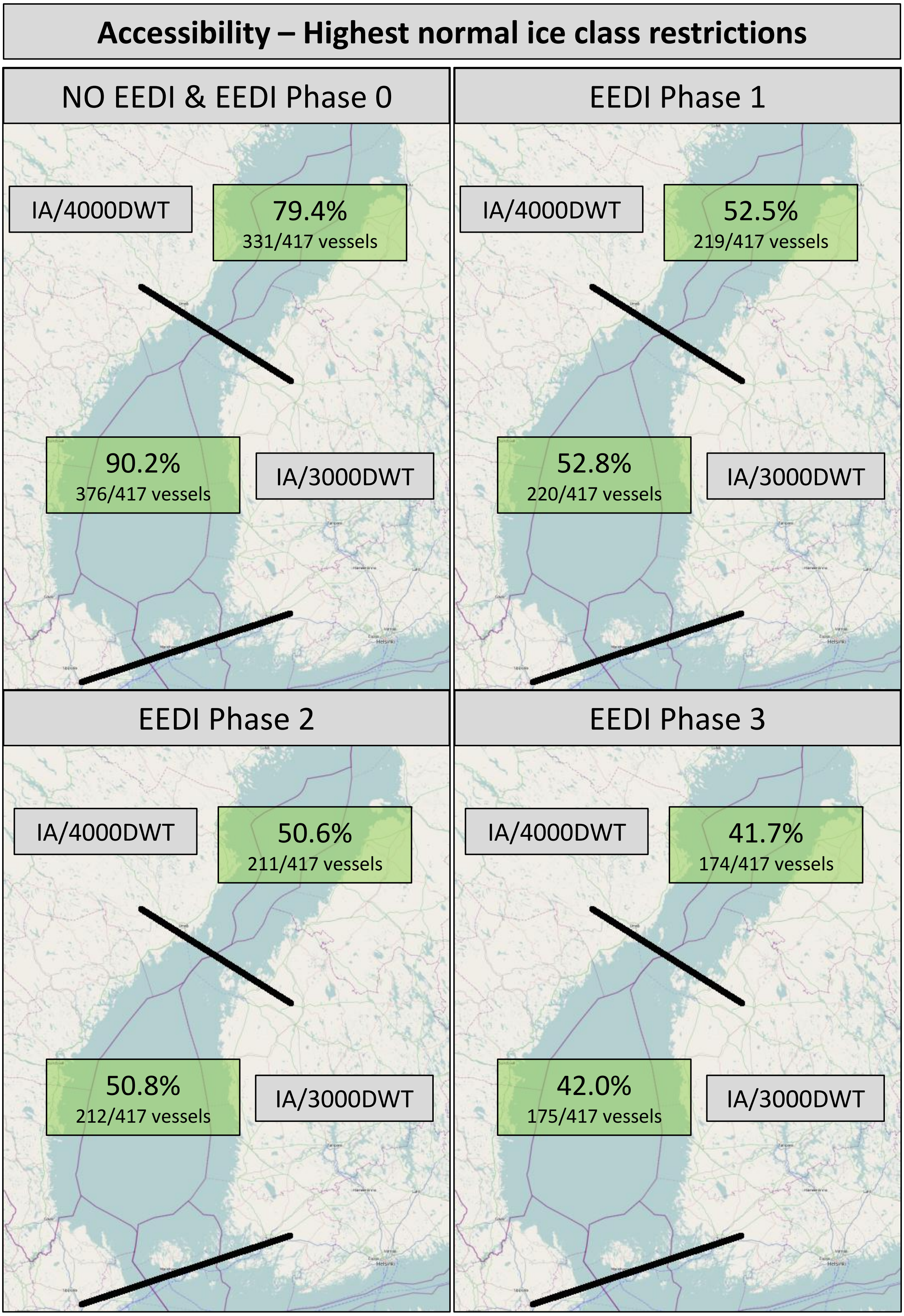


Figure 14 - Accessibility for NO EEDI and phases during highest normal winter restrictions.

8 Survey

A survey has been conducted with the aim to take advantage of the experience from the icebreaker officers and give the study a tight connection to the everyday icebreaker operation.

The main purpose of the survey was to investigate the actual ice-going capability according to FSIC notation for the frequently operating merchant vessels included in the study according to Area 1, the Bay of Bothnia. Two vessels with the same FSIC notation may perform totally different in ice infested waters which depends on a variety of variables not only associated with hull design and engine power but also the crew experience of sailing in ice, load conditions etc.

The survey was answered as a web survey divided into three different parts with approximately 25 vessels each. The survey was sent out to the captains of the 11 Finnish and Swedish icebreakers which were asked to circulate the survey to all navigational officers. A total of 34 answers were achieved which, unfortunately was less than expected according to the number of navigational officers.

One question of special interest when analysing the survey outcome is to study *"well performing vessels"* and their attained EEDI compared to other vessels.

The survey questions are presented in section 8.1 below. Aggregated results for all questions are presented in Table 18. Plotted graphs of question 3 and 4, for applicable ship types, required and attained EEDI are found in Figure 15, Figure 16 and Figure 17. Legend explaining interpretation of the graphs (colours and limits) is found in section 8.2 on page 32.

8.1 Survey questions

The survey started with a couple of control questions followed by vessel specific questions. The vessel specific part included a picture of the vessel and information of FSIC, DWT and installed main engine power.

The seven vessel-specific questions *Q1-Q7* and selectable answers were;

1. How well do you know this vessel? (If, not at all, please proceed to next vessel)

   (1) Not at all (2) Fairly (3) Good (4) Very good

2. How much experience do you think the crew of the vessel has in respect to ice navigation and operations in ice?

   (1) Unfamiliar (2) Some experience (3) Good experience (4) Very good experience

3. How well do you think the vessels ability in loaded condition is to navigate in ice according to its Finnish-Swedish ice class notation?

   (1) Worse than its FSIC (2) According to its FSIC (3) Better than its FSIC

4. How well do you think the vessels ability in ballast condition is to navigate in ice according to its Finnish-Swedish ice class notation?

   (1) Worse than its FSIC (2) According to its FSIC (3) Better than its FSIC

5. Do you think the vessel is suitable to be towed in loaded condition?

   (1) Yes (2) No

6. Do you think the vessel is suitable to be towed in ballast condition?

   (1) Yes (2) No

7. How do you think the vessels ability to operate in ice has changed over time?

   (1) Has become worse (2) Unchanged (3) Has become better

Other comments concerning the vessel, specialties, incidents with the vessel etc.

8.2 Results

A summary of the survey answers are presented in Table 18, a complete compilation of answers for each vessel and question is found in Appendix A.

Table 18 - Summary of survey answers.

Question (available answers)	Average answer	Standard deviation	Average answers/vessel
Q1 (1-4)	2.51	0.66	7.22
Q2 (1-4)	2.51	0.66	7.22
Q3 (1-3)	1.78	0.34	7.19
Q4 (1-3)	1.62	0.36	7.17
Q5 (1-2)	1.27	0.29	6.99
Q6 (1-2)	1.56	0.28	6.75
Q7 (1-3)	1.81	0.21	7.03

Q1, Vessel recognition; Between *Fairly* and *Good.* Note that crew members answering *Not at all* have not continued answering the following questions.

Q2, Experience of the crew; Between *Some Experience* and *Good Experience;* a bit surprising for vessels frequently operating in ice during winters.

Q3, Ice performance loaded condition according to FSIC; Relatively near *According to* however a bit towards *Worse*.

Q4, Ice performance ballast condition according to FSIC; Relatively near *According to* however a bit more towards *Worse* than Q3.

Answers on Q3 and Q4 indicates a general opinion of reduced performance of vessels compared to their FSIC. On the other hand, what are the expectations from the icebreaker crews on vessel performance for a certain ice class notation?

Q5, Suitable for towing, loaded condition; Relatively near *Yes* but a bit to *No.*

Q6, Suitable for towing, ballast condition; Between *Yes* than *No.*

Answers on Q5 and Q6 indicate that vessels in ballast condition generally are less suitable for towing, total capacity and operation of ballast water may be an issue.

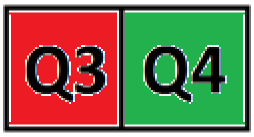
Q7, Change of vessel performance over time; In between unchanged and worse.

For analysis of question 3 and 4 (Q3/Q4) in relation to *attained and required EEDI* the average answer is plotted for each represented ship type, see Figure 15, Figure 16 and Figure 17.

Limits and visual presentation, evaluation Q3/Q4 (Figure 15 - Figure 17)

Q3 – Ability to navigate in ice according to its FSIC in <u>loaded condition</u>

Q4 – Ability to navigate in ice according to its FSIC in <u>ballast condition</u>



Question average < 1.67 => Red

1.67< Question average < 2.33 => White

Question average > 2.33 => Green

All vessels have FSIC IA except vessels marked with arrows for FSIC IA Super.

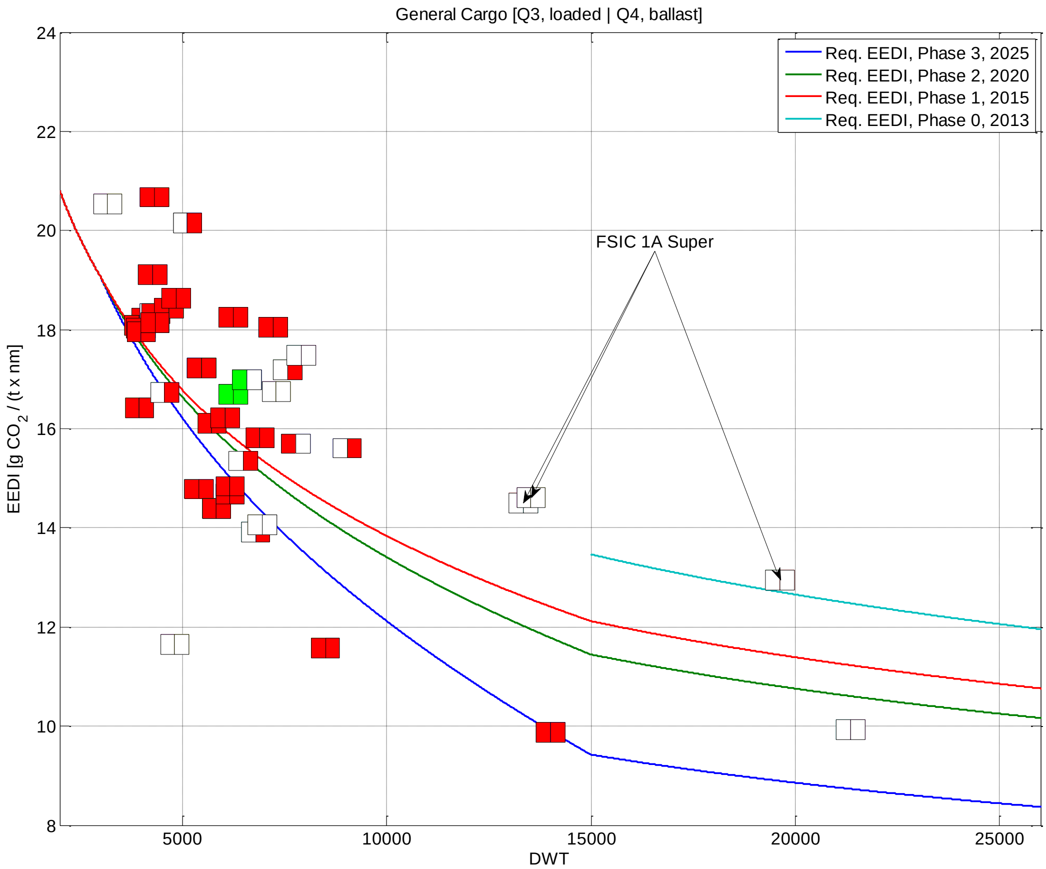


Figure 15 - Survey question Q3/Q4 vs. EEDI, General cargo (Area 1)
(1A refers to IA and so on)

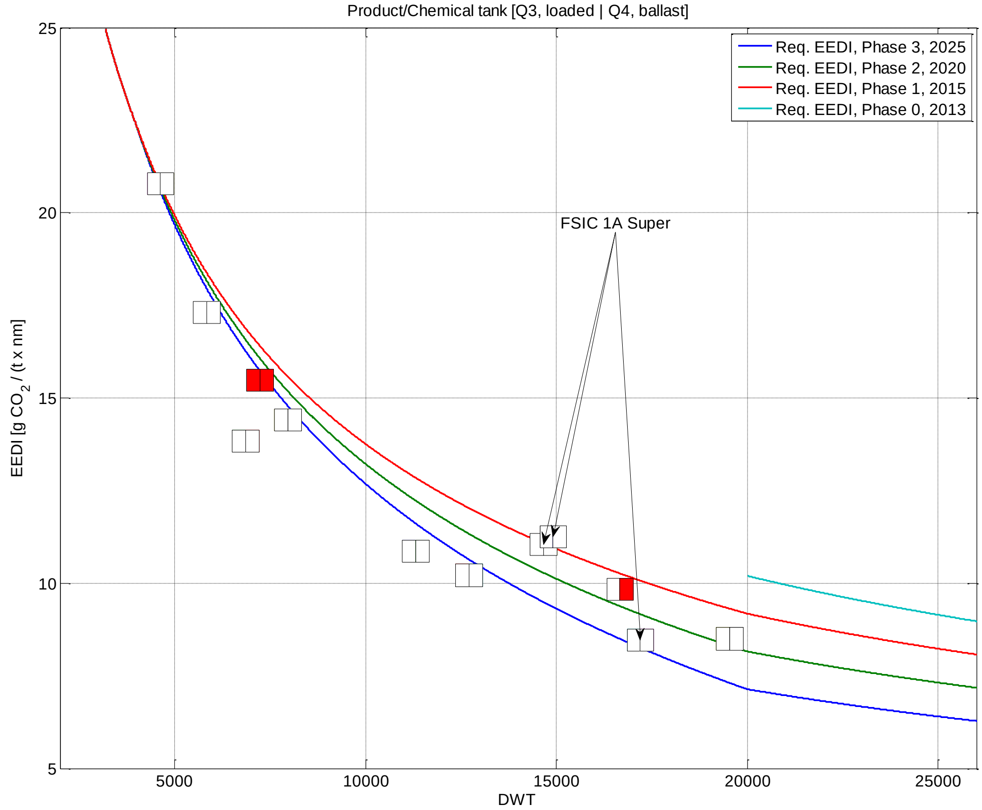


Figure 16 - Survey question Q3/Q4 vs. EEDI, Product/Chemical tank (Area 1)

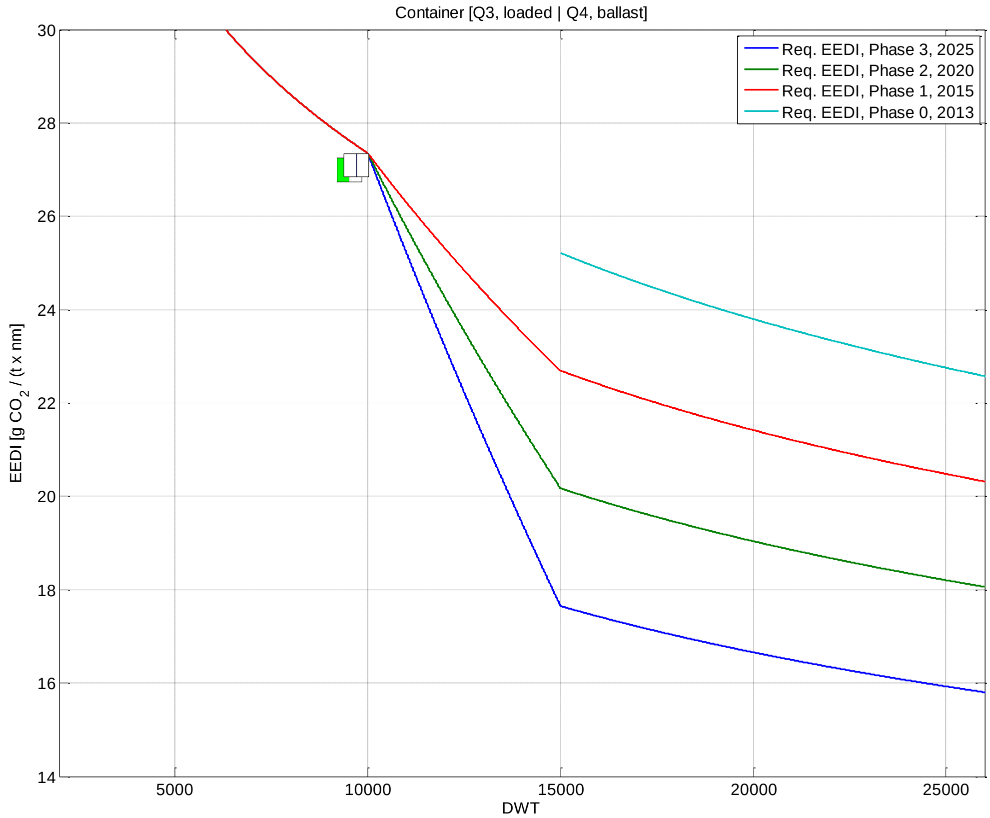


Figure 17 - Survey question Q3/Q4 vs. EEDI, Container (Area 1)

9 Discussion and conclusions

The study is based on the selection of existing vessels that are currently operating in the Bay of Bothnia and the Bothnian Sea. This ensures a realistic population according to distribution of vessel size, main particulars, vessel types, ice class notation etc. The average age of the selected vessels is about 14 years.

The analysis on EEDI and accessibility shows that the coming requirements will significantly affect the winter navigational fleet. Still currently existing vessels of different ship types, with different FSIC and different sizes would still be able to operate if included in the EEDI regulations.

When discussing the analysis mind that the existing vessels are not designed to comply with the coming EEDI regulations but to be able to trade all year round and thus fulfil needed ice class notation. Sometimes the ship owner has even increased the installed engine power above the required level (by FSIC) to ensure a good performance in ice.

Ice classed ships have clear disadvantages in the calculation of attained EEDI. Thus the ice class correction factors introduced in the EEDI system are assumed to be applicable as all ships of the same type, regardless of ice navigation, are forced to fulfil the same required EEDI value. The influence of the ice class correction factors seems to take care of this quite well. The distribution and spread presented in the graphs with attained EEDI according to required EEDI is similar to the scatter achieved when analysing the vessels without the ice class correction factors or non-ice classed vessels.

The level of the ice class correction factors are suggested to be used as control means and thus be set based on judgement of the cost in terms of ice-going capability and benefit in terms of energy efficiency. It is possible that the most energy efficient solution for the winter transport system may be to increase the ice class correction factors instead of increasing the need and size of the assisting icebreaker fleets.

According to the performed survey one may question the level of expectations that exist on vessels with a specific ice class notation. The existing fleet that is studied are in some cases over-powered. This is clear in the output power analysis were some vessels of ice class IA have enough power to comply with ice class IA Super. These vessels may raise the general expectation on performance of ice class IA vessels and remaining vessels with engine power according to FSIC are thought to be low performing. These over-powered vessels that previously have been built will, however, probably not be built in the future due to the EEDI regulations.

The ice class restrictions currently used for different areas will probably have to be tightened to keep the current level of needed assistance and maintain safe operation. The restrictions thus limit the number of vessels in the area and the need of icebreaker assistance. However this is not a wanted scenario for the trade and the affected companies in the area.

The power requirements in the FSIC have a theoretical foundation and are based on the ice class performance criteria's such as brash ice channel thickness. Hence future vessels are designed and optimized to comply with the FSIC and at the same time have low installed engine power. These vessels are then thought to be energy efficient vessels, provided validity of the theoretical background in the FSIC.

Considering the EEDI analysis in combination with the survey results, existing designs that fulfil the EEDI requirements and still performs according to its FSIC are currently operating. A vessel of this kind can also be built in the future. These vessels have, however not been identified and studied on an individual basis in this study.

The EEDI system only includes new built vessels which means that new designed vessels will be the result of a more thorough design optimisation with EEDI and FSIC as strong input parameters. Thus the result and performance of these optimised vessels have not yet given any impact on the winter navigational system.

A summary of the general conclusions are:

- Vessels fulfilling both FSIC power output requirements and the coming EEDI rules exist already today (i.e. fulfilling the rules, not necessarily performing well).
- A more thorough optimisation in the vessel (hull) design process will be needed.
- The new designed vessels will probably perform according to the criteria's in the FSIC. However, some vessels in the present existing fleet perform better than the coming standard. This means that a decreased performance of the total winter navigational fleet with the new designed vessels (same ice class notation) may be perceived.
- Ice class correction factors in the EEDI regulations are needed. The level of correction can be used as control measures to tune the needed ice-going performance of the winter navigational fleet.
- Increased icebreaker assistance is foreseen as the number of vessels operating independently will decrease. An even more optimised operation of the icebreaker fleets, increased number of icebreakers, increased ice class correction factors and/or tighter ice class restrictions are possible actions.

10 References

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Trafiksäkerhetsverket, 2010. *Isklassföreskrifter och tillämpning av dem.* Sjötrafikföreskrift, TRAFI/31298/03.04.01.00/2010. Trafiksäkerhetsverket, Helsingfors. (Authors comment, i.e. Finnish-Swedish Ice class rules)

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Juva Mikko, Riska Kaj, 2002. *On the power requirement in the Finnish-Swedish ice class rules.* Espoo.

Krav på isklass och tonnagestorlek (Authors comment, general ice class restrictions), 2013, http://www.sjofartsverket.se/sv/Sjofart/Isbrytning/Isklasser--krav/ (downloaded 2013-09)

IHS Sea-web, 2013, www.sea-web.com (downloaded 2013-09)

Appendix A Complete survey answers

Each row in the presentation of survey answers represents one vessel. Vessel name and precise DWT is left out. Description of available information is presented in Figure 18 (1A refers to IA).

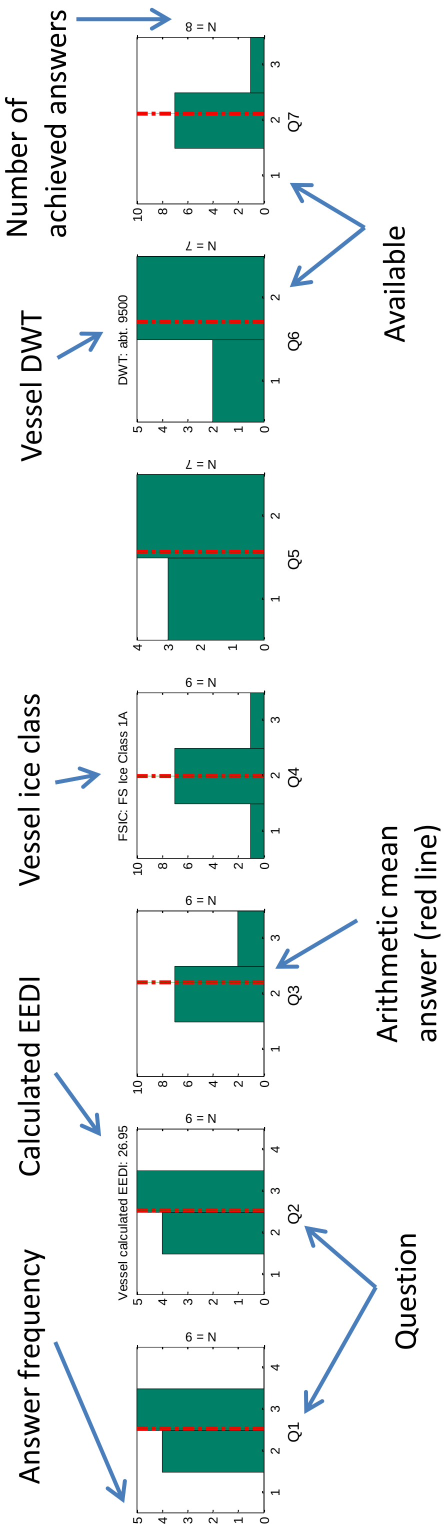
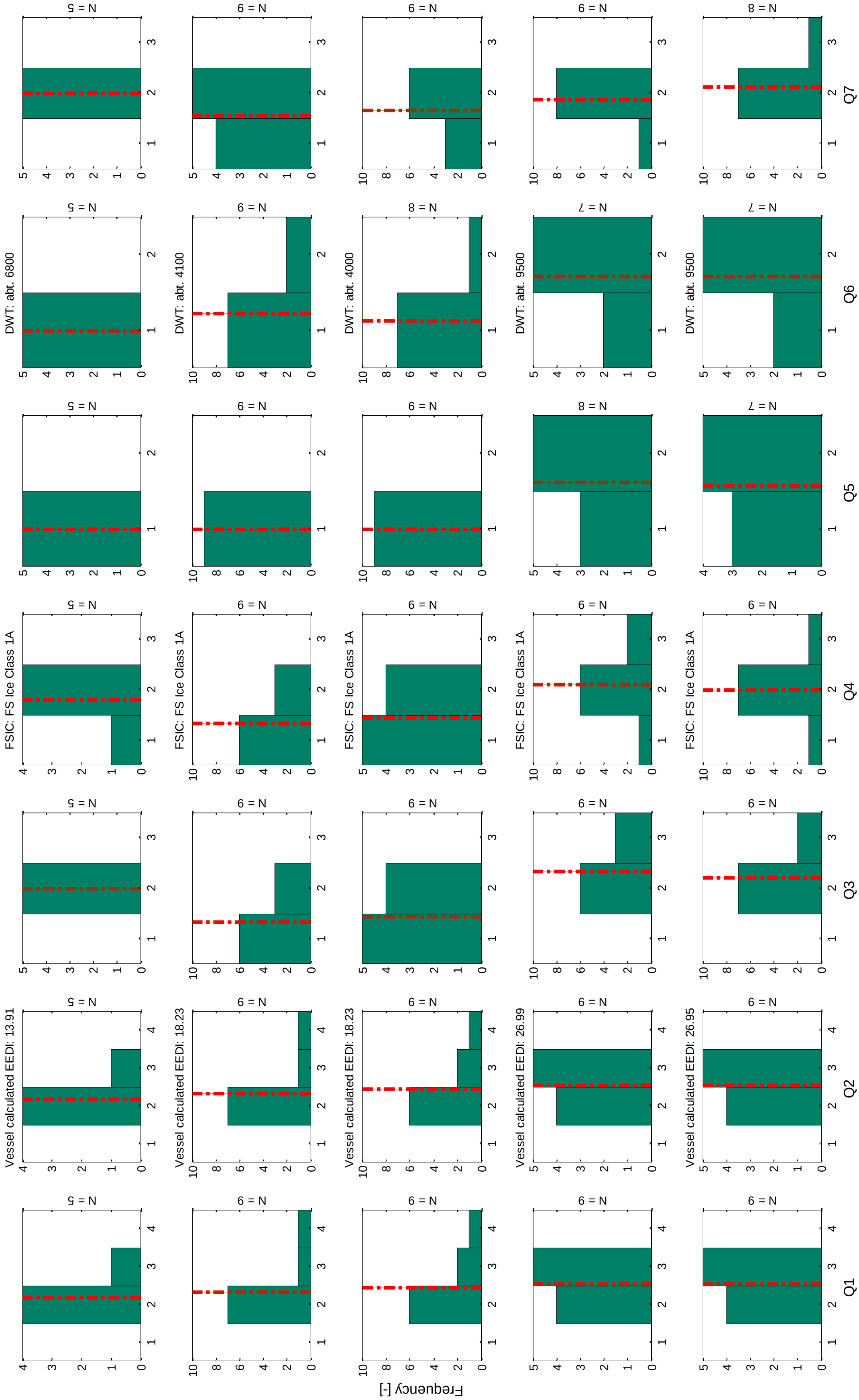


Figure 18 - Legend histograms, survey answers (one vessel).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Vessel calculated EEDI: 18.23
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Vessel calculated EEDI: 26.95
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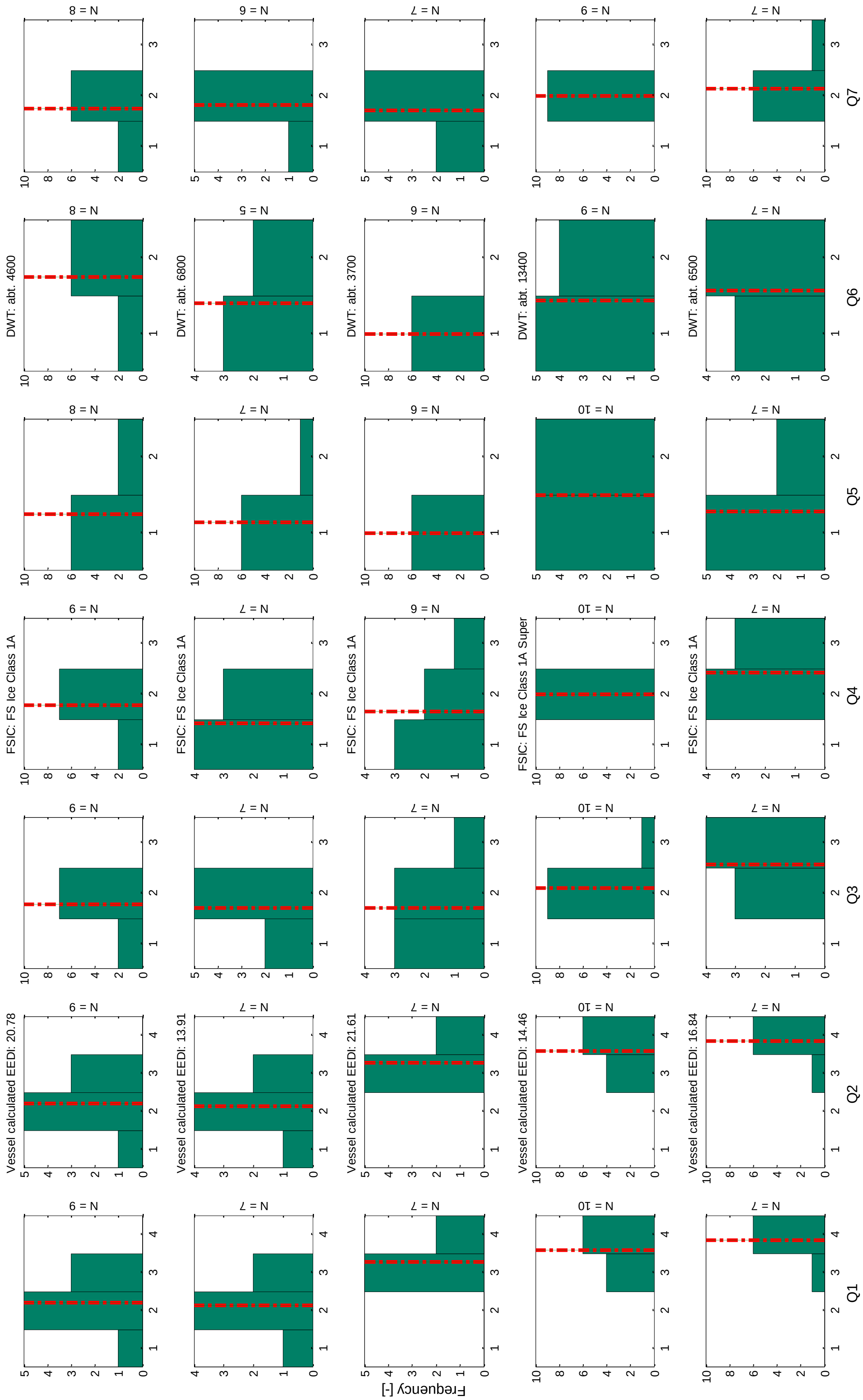
DWT: abt. 6800
DWT: abt. 4100
DWT: abt. 4000
DWT: abt. 9500
DWT: abt. 9500
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Frequency [-]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Q2
Q3
Q4
Q5
Q6
Q7
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Vessel calculated EEDI: 21.61
Vessel calculated EEDI: 14.46
Vessel calculated EEDI: 16.84
FSIC: FS Ice Class 1A
FSIC: FS Ice Class 1A
FSIC: FS Ice Class 1A
FSIC: FS Ice Class 1A Super
FSIC: FS Ice Class 1A
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DWT: abt. 6800
DWT: abt. 3700
DWT: abt. 13400
DWT: abt. 6500
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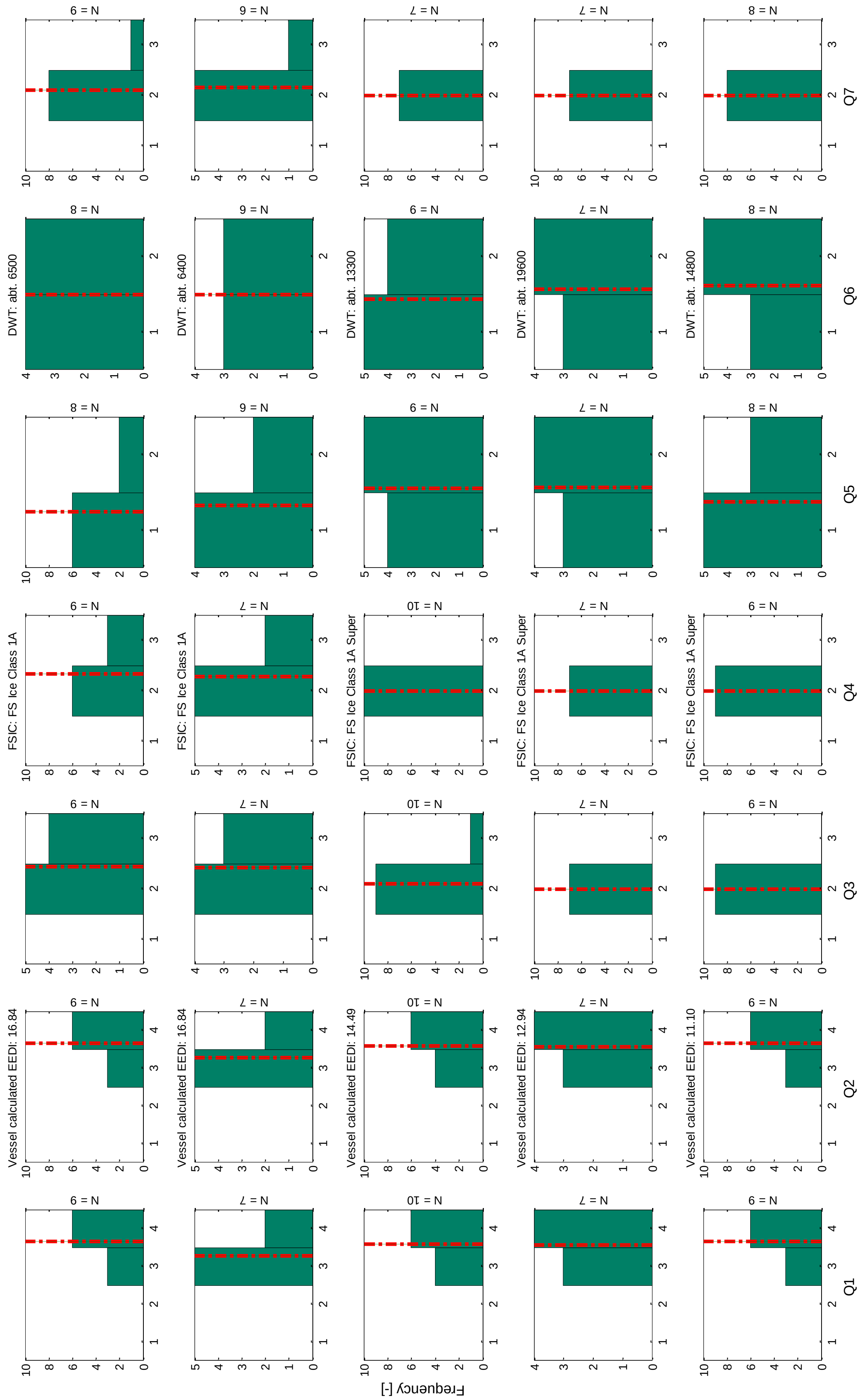
N = 7
N = 10
N = 6
N = 5
N = 8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Q2
Q3
Q4
Q5
Q6
Q7
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Vessel calculated EEDI: 12.94
Vessel calculated EEDI: 11.10
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FSIC: FS Ice Class 1A
FSIC: FS Ice Class 1A Super
FSIC: FS Ice Class 1A Super
FSIC: FS Ice Class 1A Super
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DWT: abt. 19600
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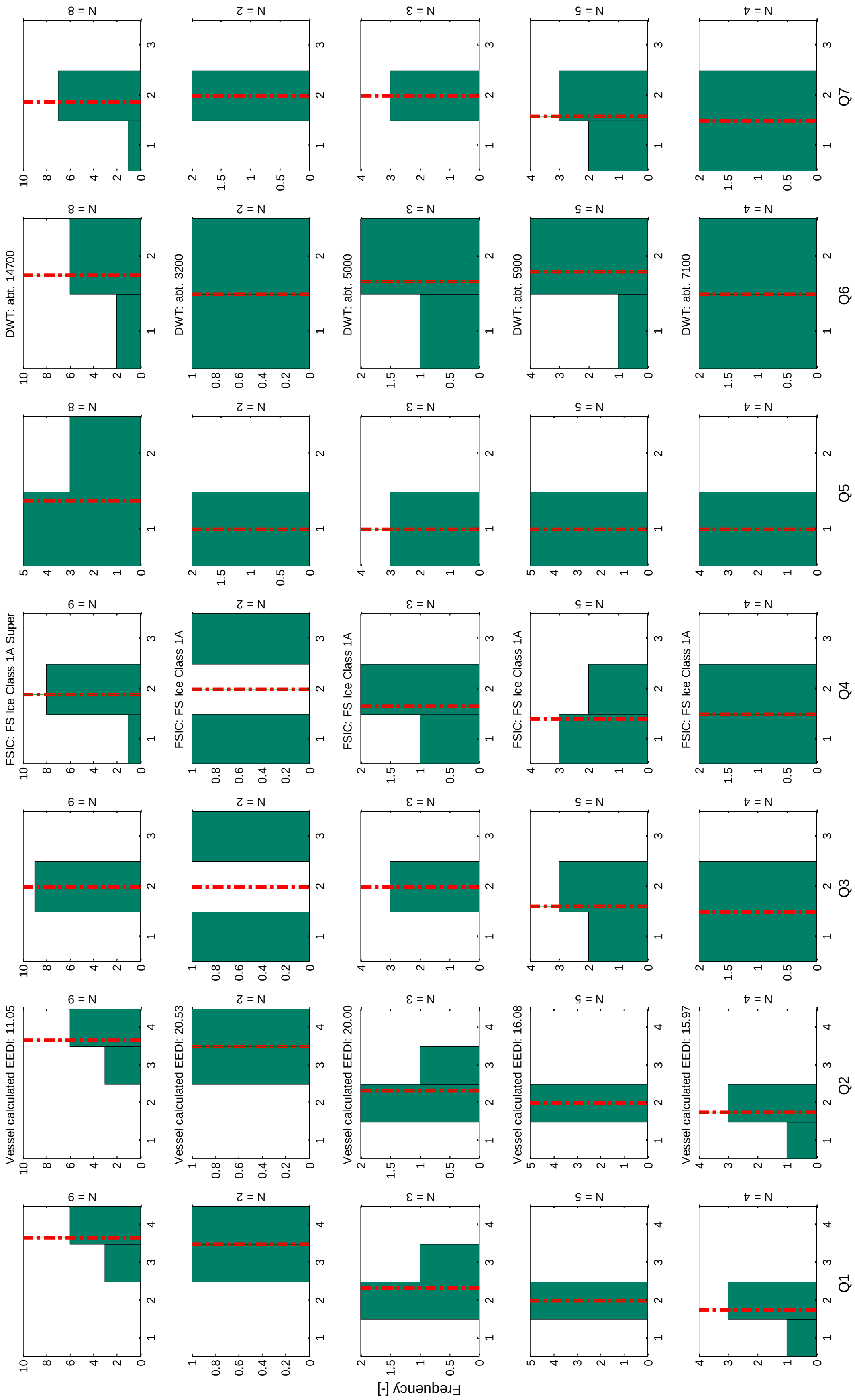
N = 7
N = 10
N = 7
N = 9
N = 8
N = 6
N = 9
N = 7
N = 8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N = 8
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FSIC: FS Ice Class 1A
DWT: abt. 5000
N = 3
Vessel calculated EEDI: 16.08
FSIC: FS Ice Class 1A
DWT: abt. 5900
N = 5
Vessel calculated EEDI: 15.97
FSIC: FS Ice Class 1A
DWT: abt. 7100
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Frequency [-]
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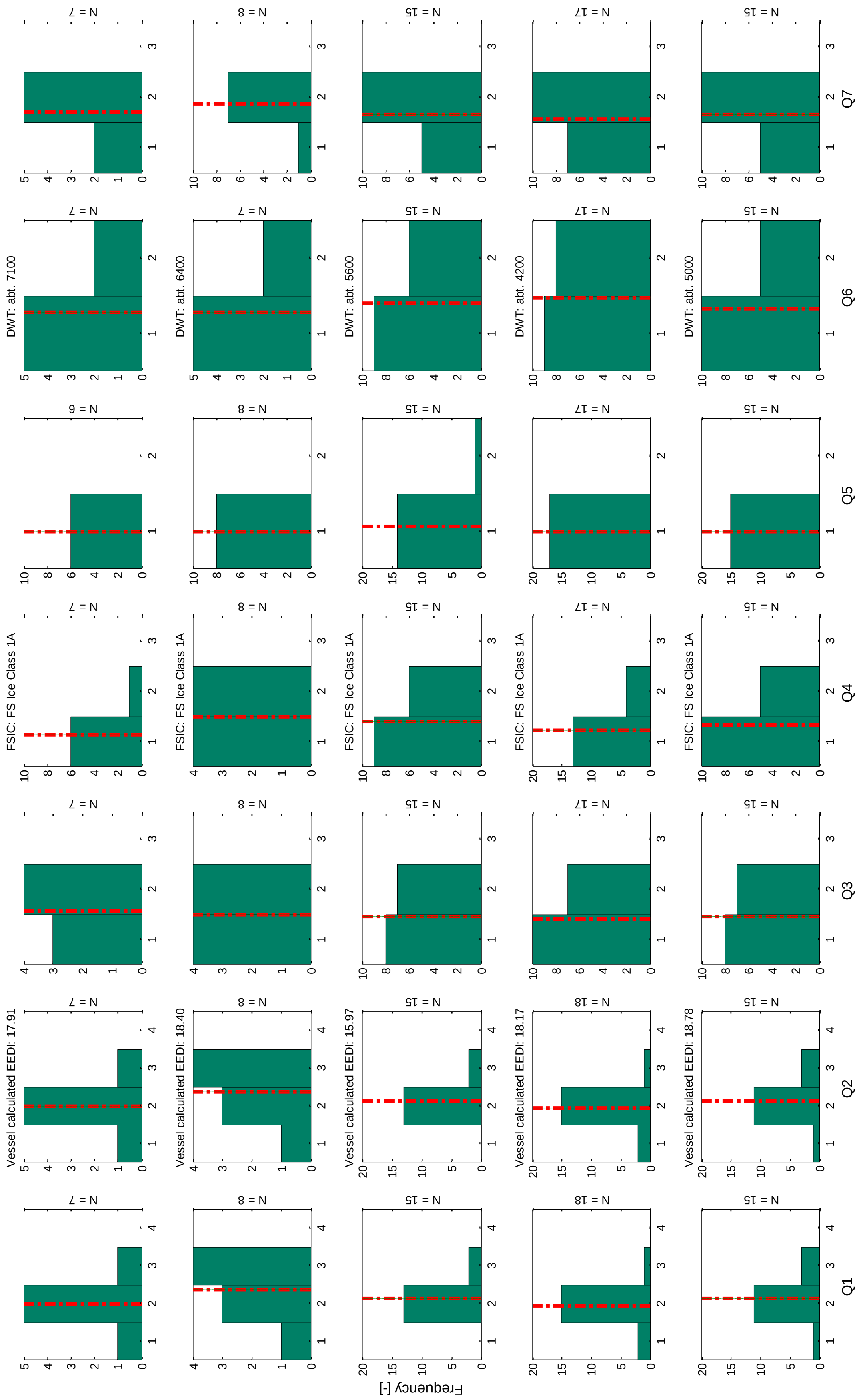
Q2
Q3
Q4
Q5
Q6
Q7


Q1
Q2
Q3
Q4
Q5
Q6
Q7
Frequency [-]
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Vessel calculated EEDI: 18.40
Vessel calculated EEDI: 15.97
Vessel calculated EEDI: 18.17
Vessel calculated EEDI: 18.78
FSIC: FS Ice Class 1A
DWT: abt. 7100
DWT: abt. 6400
DWT: abt. 5600
DWT: abt. 4200
DWT: abt. 5000
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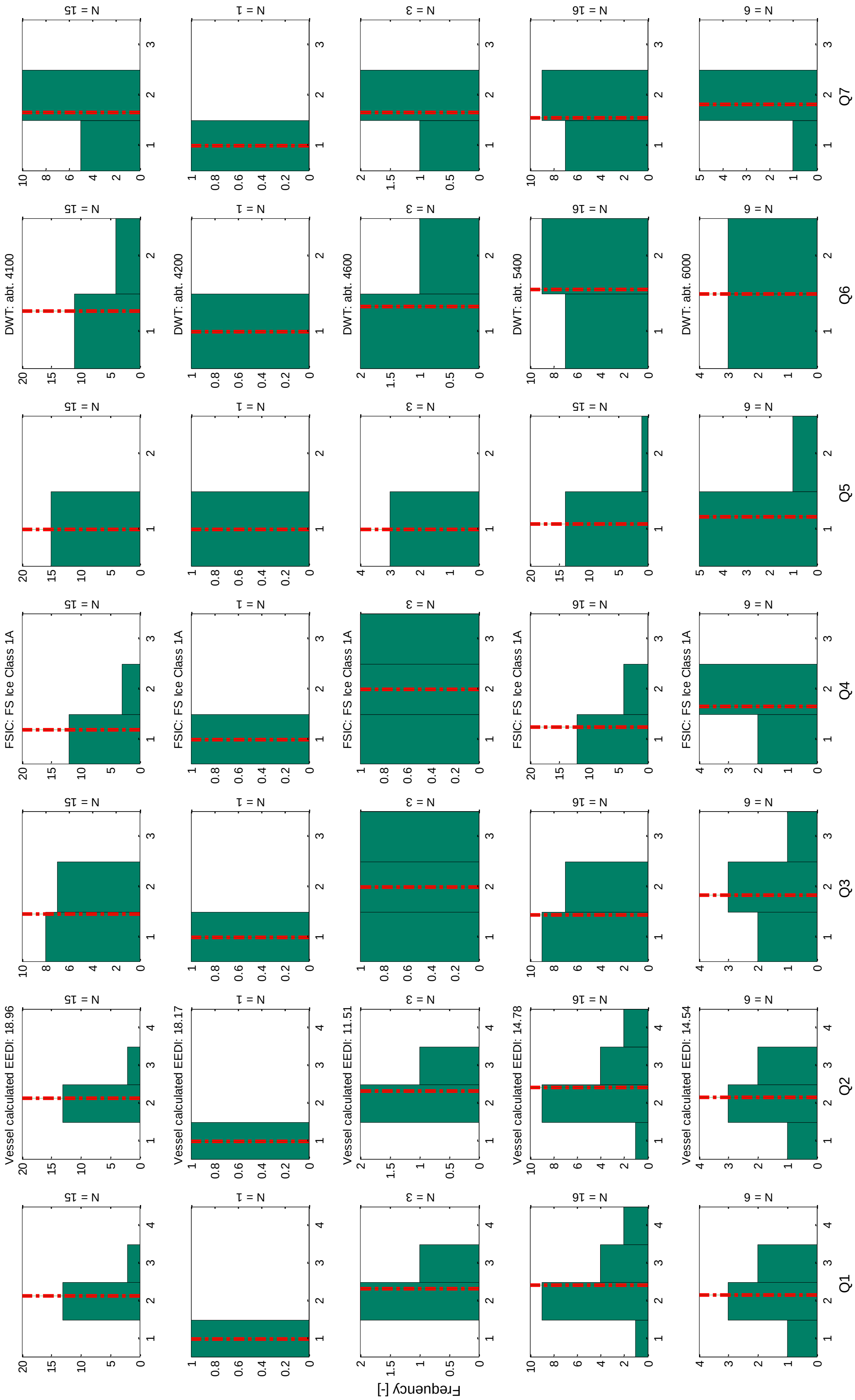
N = 8
N = 15
N = 18
N = 17
N = 6



Frequency [-]
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Q3
Q4
Q5
Q6
Q7
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Vessel calculated EEDI: 14.78
Vessel calculated EEDI: 14.54
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DWT: abt. 4100
DWT: abt. 4200
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N = 3
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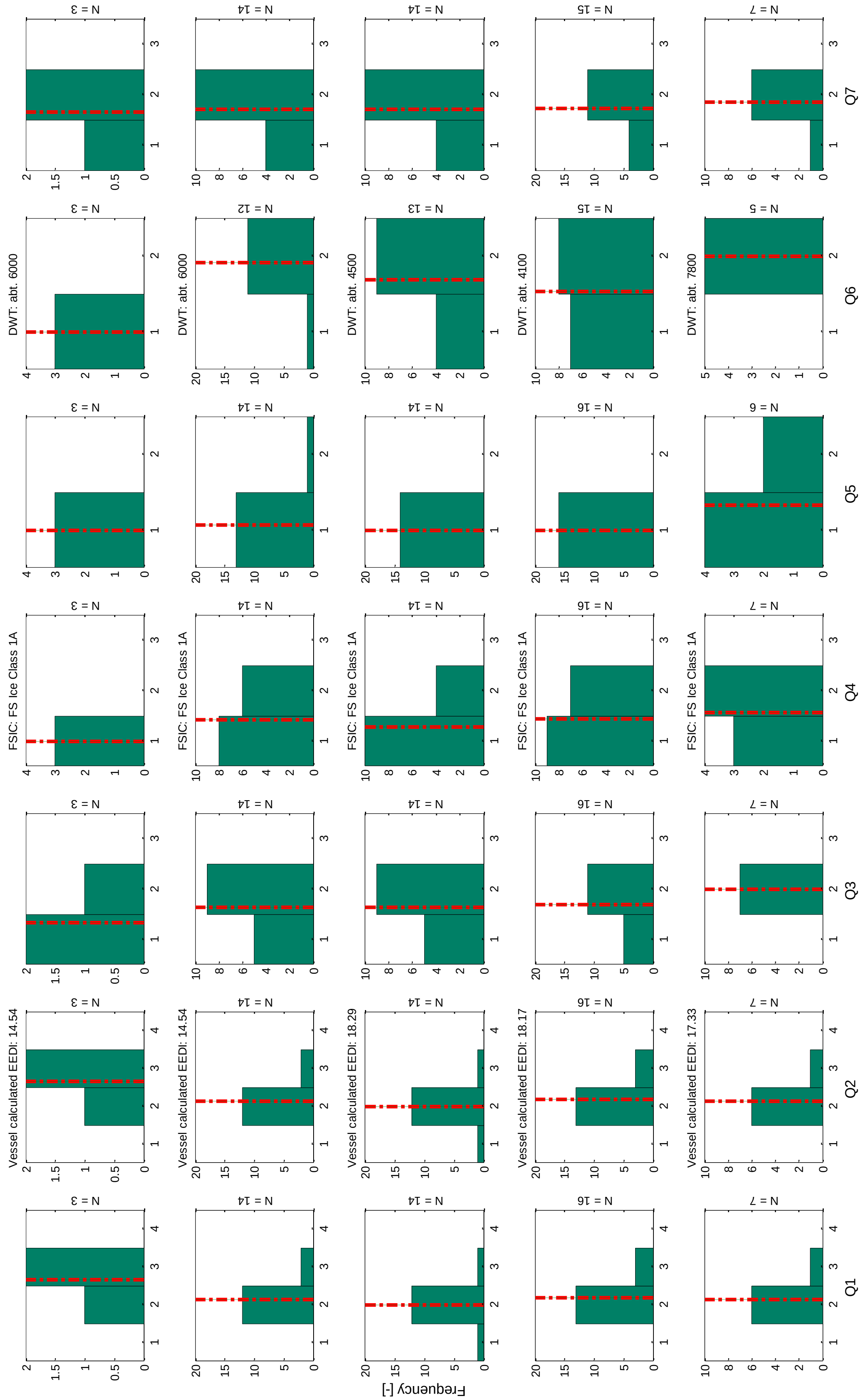
N = 6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Q3
Q4
Q5
Q6
Q7
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Vessel calculated EEDI: 18.17
Vessel calculated EEDI: 17.33
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FSIC: FS Ice Class 1A
FSIC: FS Ice Class 1A
FSIC: FS Ice Class 1A
FSIC: FS Ice Class 1A
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DWT: abt. 6000
DWT: abt. 4500
DWT: abt. 4100
DWT: abt. 7800
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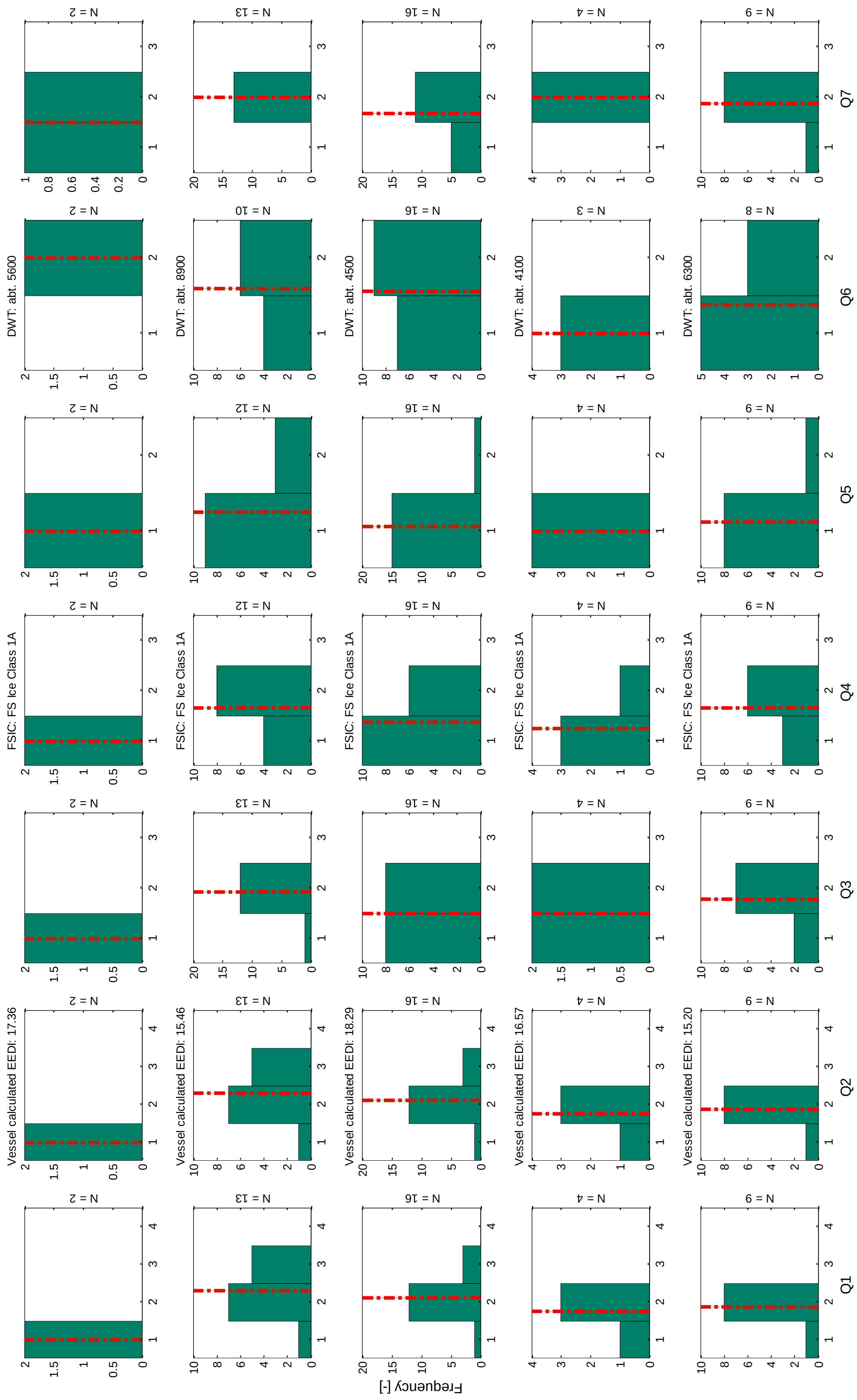
N = 14
N = 14
N = 16
N = 7
N = 12
N = 13
N = 15
N = 5
N = 6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DWT: abt. 4500
DWT: abt. 4100
DWT: abt. 6300
N = 2
N = 13
N = 16
N = 4
N = 9
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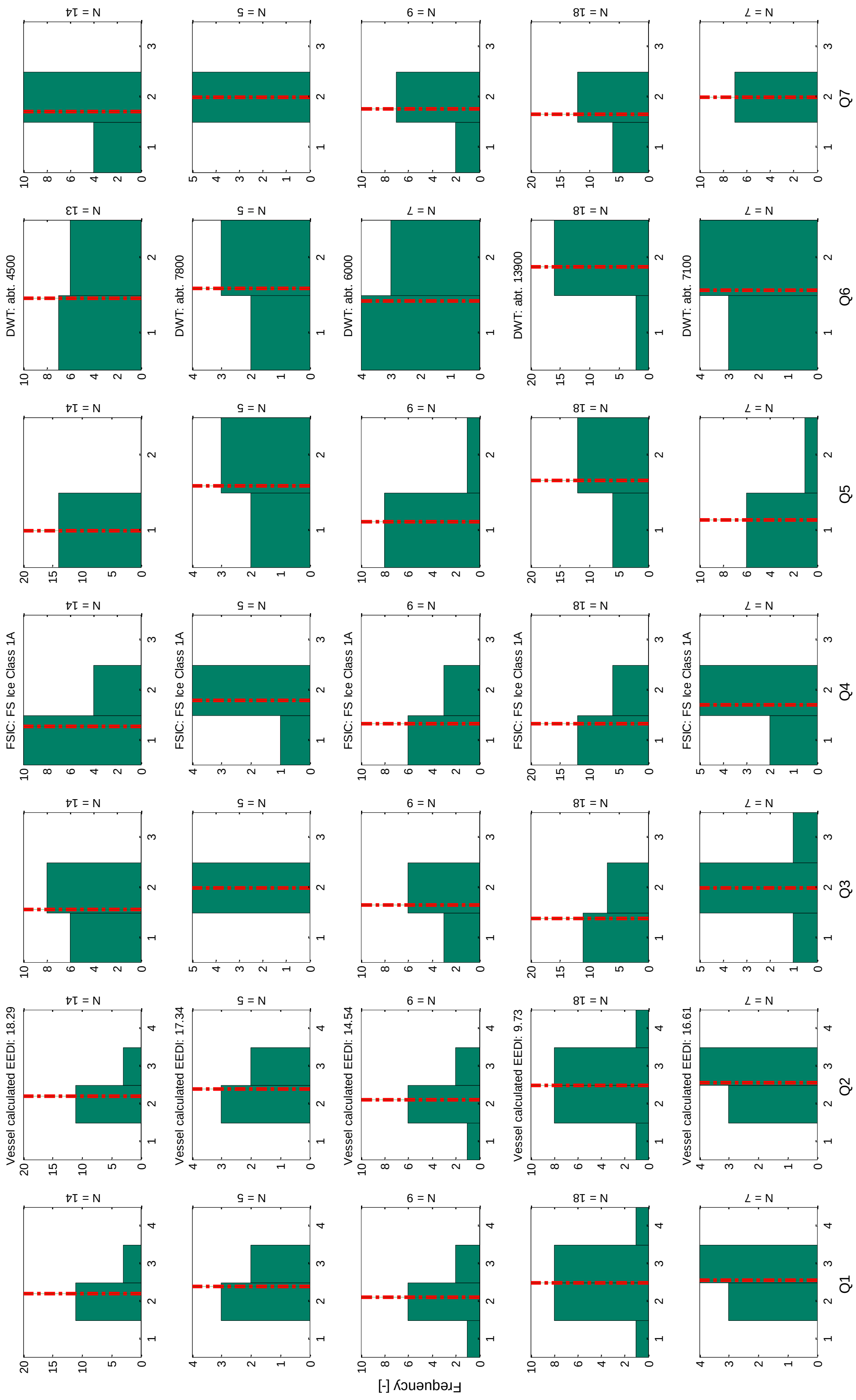
N = 10
N = 3
N = 8
Frequency [-]
Q1
Q2
Q3
Q4
Q5
Q6
Q7


Q1
Q2
Q3
Q4
Q5
Q6
Q7
Frequency [-]
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Vessel calculated EEDI: 9.73
Vessel calculated EEDI: 16.61
FSIC: FS Ice Class 1A
DWT: abt. 4500
DWT: abt. 7800
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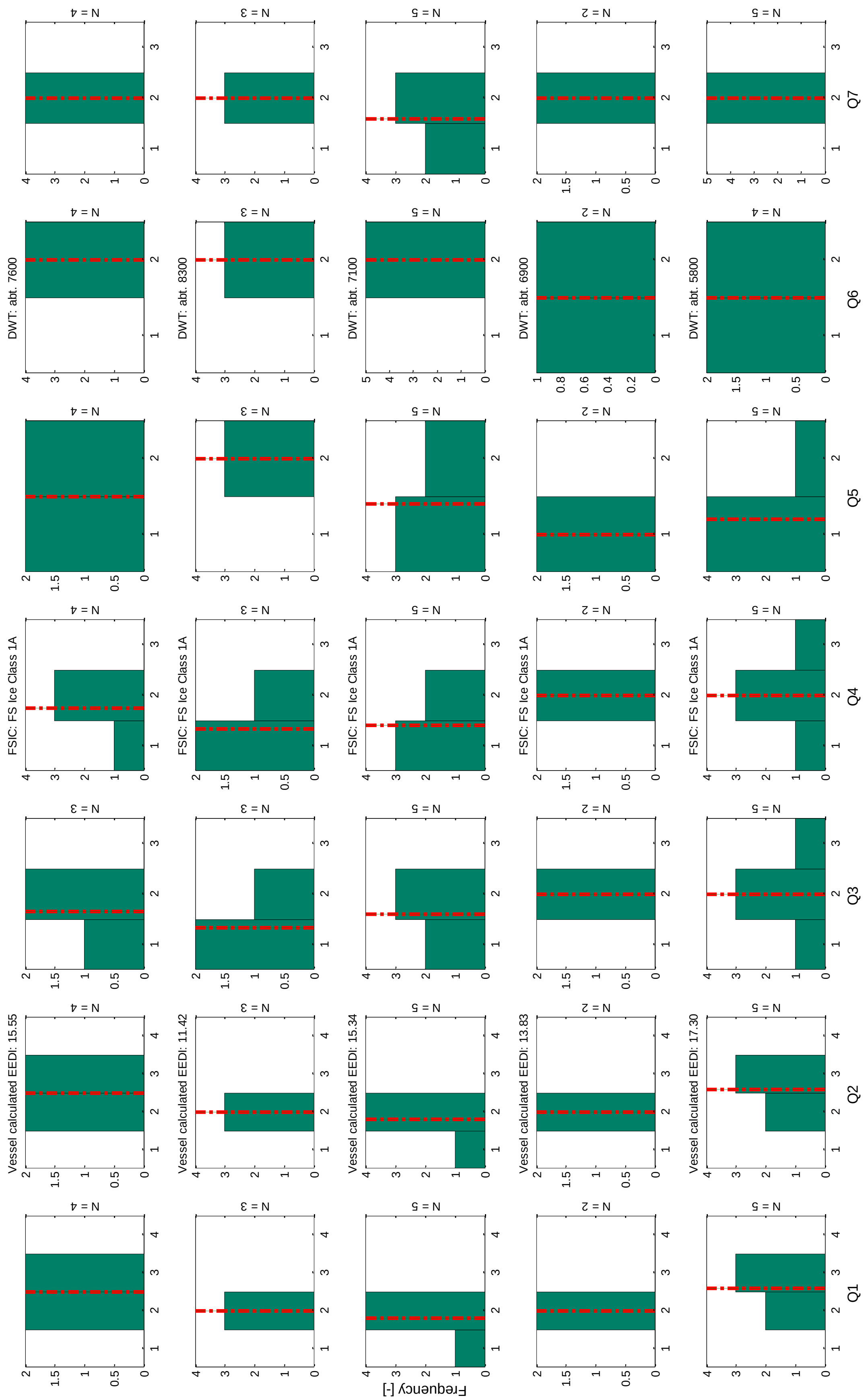
N = 13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DWT: abt. 8300
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FSIC: FS Ice Class 1A
DWT: abt. 7100
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FSIC: FS Ice Class 1A
DWT: abt. 6900
Vessel calculated EEDI: 17.30
FSIC: FS Ice Class 1A
DWT: abt. 5800
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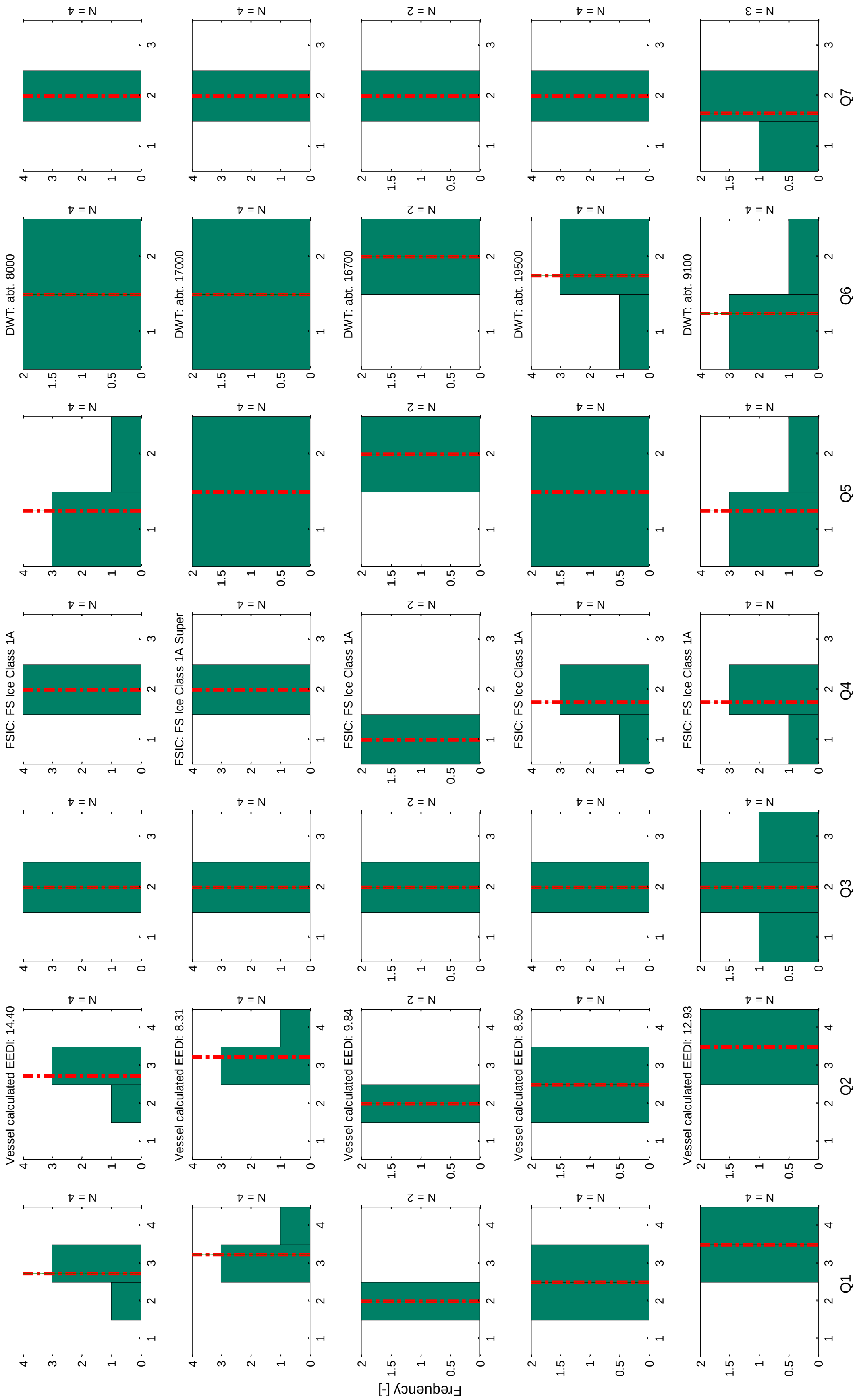
N = 2
N = 5
Frequency [-]
Q1
Q2
Q3
Q4
Q5
Q6
Q7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Vessel calculated EEDI: 12.93
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FSIC: FS Ice Class 1A Super
FSIC: FS Ice Class 1A
FSIC: FS Ice Class 1A
FSIC: FS Ice Class 1A
DWT: abt. 8000
DWT: abt. 17000
DWT: abt. 16700
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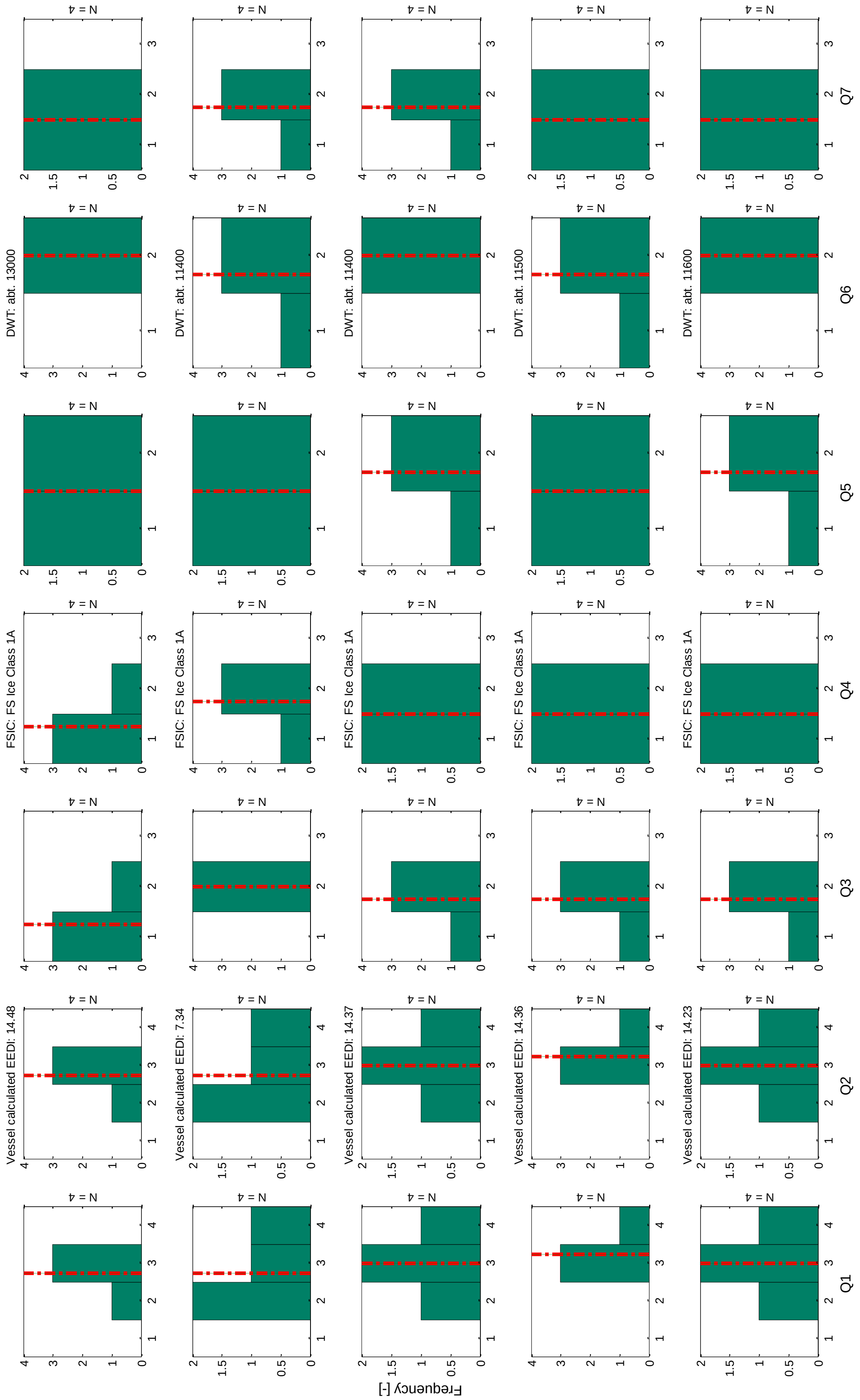
Frequency [-]
Q1
Q2
Q3
Q4
Q5
Q6
Q7



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DWT: abt. 11400
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DWT: abt. 11600
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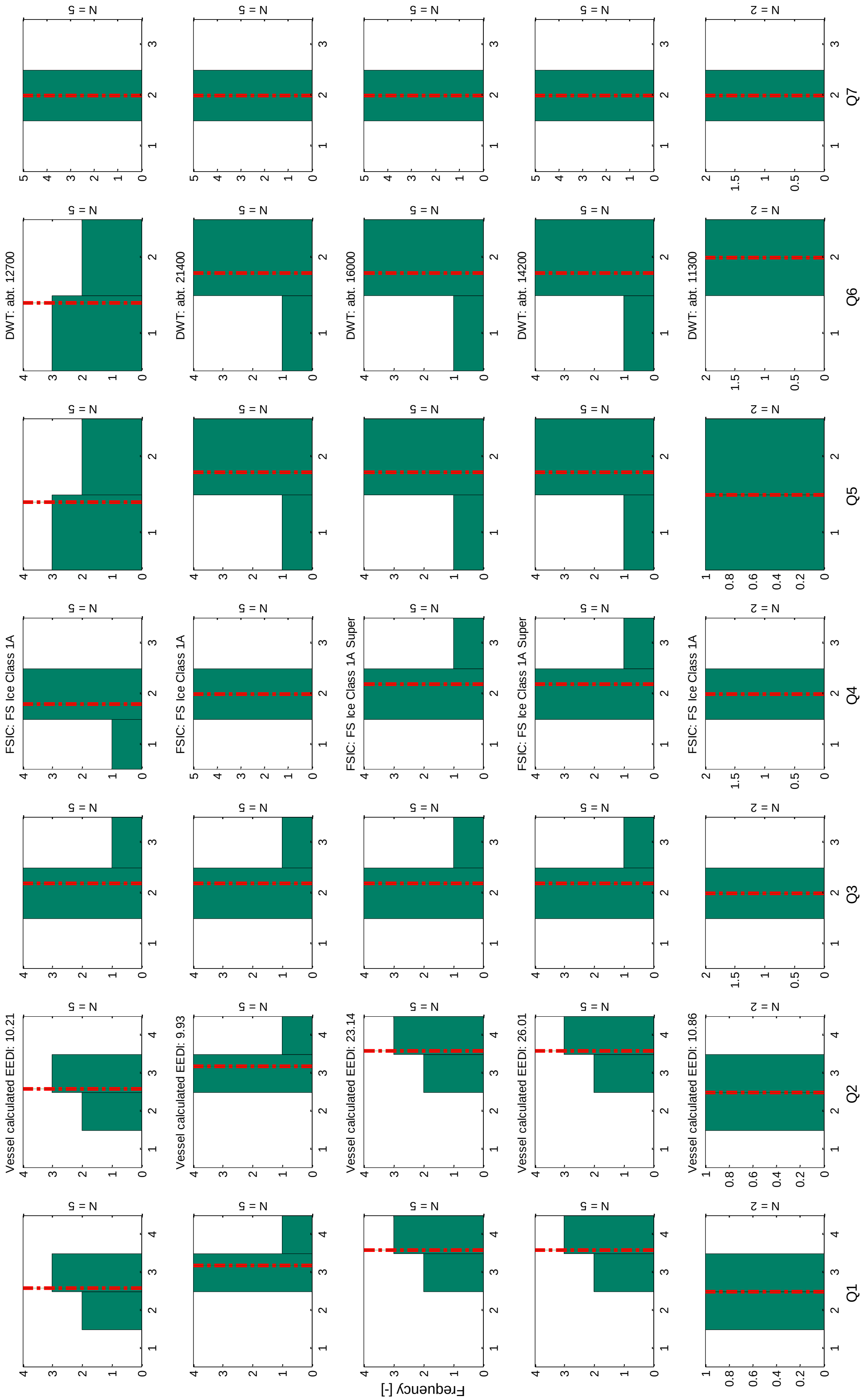
Q3
Q4
Q5
Q6
Q7



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Q2
Q3
Q4
Q5
Q6
Q7
Frequency [-]
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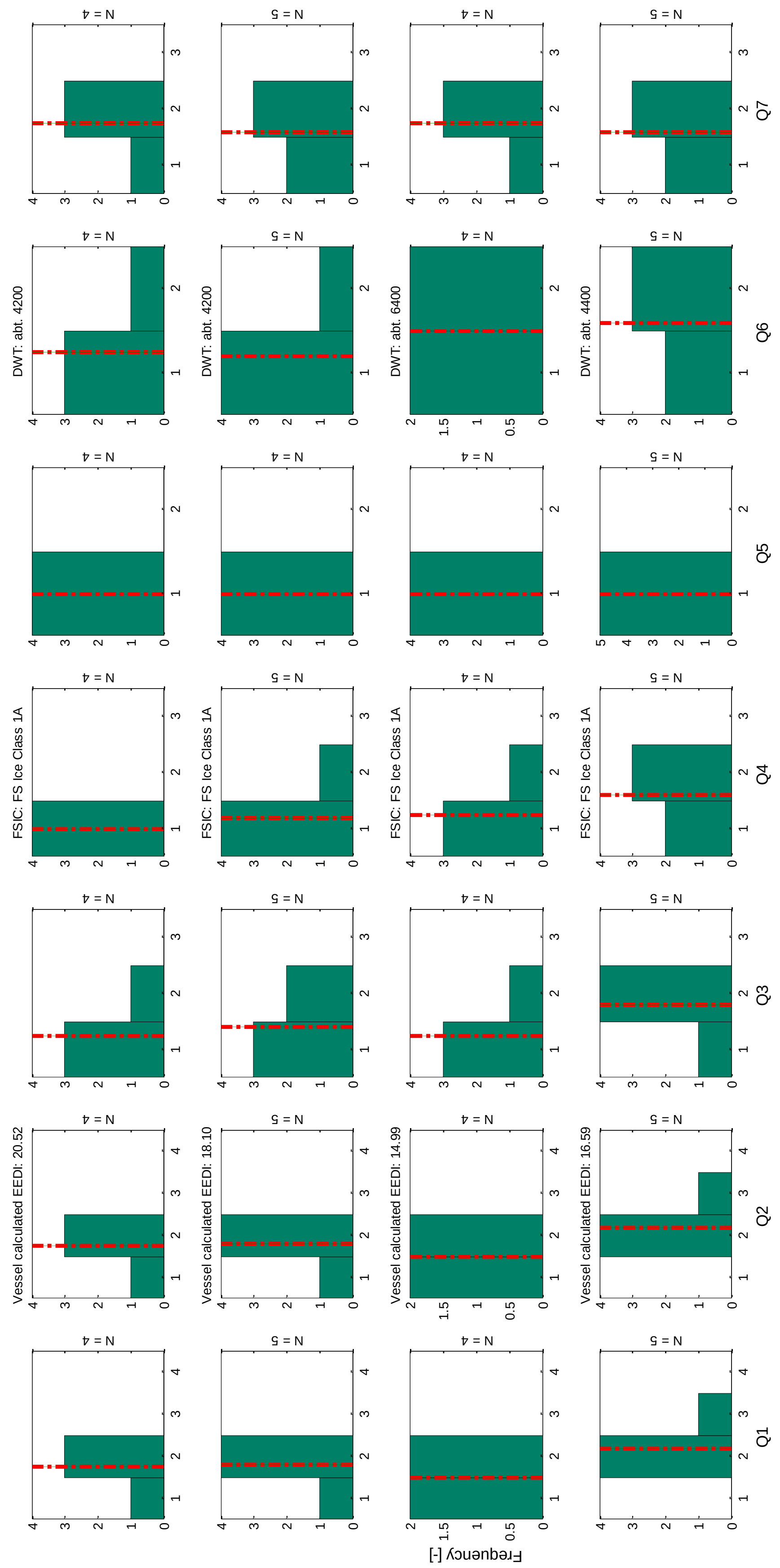
Q1
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Q3
Q4
Q5
Q6
Q7
Frequency [-]
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DWT: abt. 4200
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DWT: abt. 4400
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N = 4
N = 5

Appendix B Vessels included in the study

Table 19 - Included vessels – Bay of Bothnia & Bothnian Sea (Area 1 + 2)

Name	Ship type
SEACHALLENGER	General Cargo
SEAPROSPECT	General Cargo
SEADISCOVERY	General Cargo
SEAENTERPRISER	General Cargo
MEDALDAN	General Cargo
GAESTRIKLAND	General Cargo
ULTRAMAR	General Cargo
SOLYMAR	General Cargo
GRIMM	General Cargo
LANGBALLIG	General Cargo
SEAENDURANCE	General Cargo
PARAMAR	General Cargo
EMSRUNNER	General Cargo
KURLAND	General Cargo
PATRIOT	General Cargo
REBECCAHAMMANN	General Cargo
EVERTPRAHM	General Cargo
THULE	General Cargo
FINEX	General Cargo
BORNHOLM	General Cargo
HAELSINGLAND	General Cargo
TIM	General Cargo
MEDARCTIC	General Cargo
UPPLAND	General Cargo
NAJLAND	General Cargo
TRENLAND	General Cargo
KATI	General Cargo
BALTICBETINA	General Cargo
KAIRIT	General Cargo
CELINA	General Cargo
ANTONIA	General Cargo
NEDLAND	General Cargo
KLENODEN	General Cargo
PASILA	General Cargo
LAURA	General Cargo
HJORDIS	General Cargo
MARJATTA	General Cargo
NINA	General Cargo
BELLAND	General Cargo
TALI	General Cargo
EIRA	General Cargo
CARISSA	General Cargo
SABINA	General Cargo
SWEGARD	General Cargo
FINGARD	General Cargo
TIDAN	General Cargo
NOSSAN	General Cargo
VINGAREN	General Cargo
TORNEDALEN	General Cargo
ANGERMANLAND	General Cargo
SILVA	General Cargo
OSTERBOTTEN	General Cargo
ESTLAND	General Cargo
FINNLAND	General Cargo
SEELAND	General Cargo
FEMBRIA	General Cargo
ALAND	General Cargo
TIMBERLAND	General Cargo
NORRBOTTEN	General Cargo
ST.PAULI	General Cargo
CHOPIN	General Cargo
ALESIA	General Cargo
BAUMWALL	General Cargo
MIRAMAR	General Cargo
TRANSSONORO	General Cargo
TRANSVOLANTE	General Cargo
HELENEG.	General Cargo
TRANSLONTANO	General Cargo
TRANSDISTINTO	General Cargo
REYMAR	General Cargo
LIVLAND	General Cargo
FRISKIEN	General Cargo
FRIPORSGRUNN	General Cargo
TRANSFORTE	General Cargo
TRANSHAWK	General Cargo
DELFIN	General Cargo
CAPELLA	General Cargo
UNIMAR	General Cargo
TRANSBRILLIANTE	General Cargo

LISTER	General Cargo
VIGOROSO	General Cargo
BREMERJOHANNA	General Cargo
OSTEREMS	General Cargo
LETTLAND	General Cargo
TRANSMAR	General Cargo
TRANSOSPREY	General Cargo
DELAMAR	General Cargo
CALAMAR	General Cargo
ALTAMAR	General Cargo
FRISIANLADY	General Cargo
LADYMATHILDE	General Cargo
TANJA	General Cargo
STAVFJORD	General Cargo
MAINEBORG	General Cargo
VARNEBANK	General Cargo
FORTUNE	General Cargo
RIDER	General Cargo
ICESTAR	General Cargo
LAGANBORG	General Cargo
AMSTELBORG	General Cargo
HUNTEBORG	General Cargo
FLINTERSPIRIT	General Cargo
VLIELAND	General Cargo
AMBASSADEUR	General Cargo
SNEEKERDIEP	General Cargo
ANNIKABENITA	General Cargo
FLINTERBRIGHT	General Cargo
ANKIE	General Cargo
JEANETTE	General Cargo
MAASBORG	General Cargo
KEIZERSBORG	General Cargo
STATENGRACHT	General Cargo
ARTISGRACHT	General Cargo
FLINTERBAY	General Cargo
MARIETJEDEBORAH	General Cargo
DROGDENBANK	General Cargo
EEMSHORN	General Cargo
SCHELDEGRACHT	General Cargo
FLINTERBOTHNIA	General Cargo
VASADIEP	General Cargo
ISIS	General Cargo
LEONIE	General Cargo

FIDUCIA	General Cargo
LAUWERSBORG	General Cargo
SCHUITENDIEP	General Cargo
FOREST	General Cargo
SCHELDEBANK	General Cargo
ASPEN	General Cargo
SYDGARD	General Cargo
FLINTERDIJK	General Cargo
SCHOUWENBANK	General Cargo
SOAVE	General Cargo
UBCMONTREAL	General Cargo
DOUWE-S	General Cargo
FLINTEREEMS	General Cargo
MISSISSIPPIBORG	General Cargo
EMMA	General Cargo
LADYHESTER	General Cargo
LADYNONA	General Cargo
VEELERDIEP	General Cargo
VICTORIADIEP	General Cargo
VIKINGDIEP	General Cargo
DELFBORG	General Cargo
WISAFOREST	General Cargo
VRIESENDIEP	General Cargo
NOVACURA	General Cargo
NORDGARD	General Cargo
MISSOURIBORG	General Cargo
SPRINTER	General Cargo
OSTGARD	General Cargo
SYLVIA	General Cargo
FLEVOBORG	General Cargo
WARBER	General Cargo
DIEZEBORG	General Cargo
SPUIGRACHT	General Cargo
EEMSBORG	General Cargo
TINA	General Cargo
SKAGENBANK	General Cargo
VOSSDIEP	General Cargo
MOEZELBORG	General Cargo
LAMMY	General Cargo
DONGEBORG	General Cargo
AMBER	General Cargo
FIVELBORG	General Cargo
ALTENA	General Cargo

VOORNEBORG	General Cargo
LOIREBORG	General Cargo
FLINTERHAVEN	General Cargo
FLINTERBALTICA	General Cargo
SNOWSTAR	General Cargo
LADYNOVA	General Cargo
LADYNORA	General Cargo
BANIER	General Cargo
SYLVIA	General Cargo
NAMAI	General Cargo
FLINTERZEE	General Cargo
SNOEKGRACHT	General Cargo
ROBIJN	General Cargo
VENNENDIEP	General Cargo
LADYMAGDA	General Cargo
VANCOUVERBORG	General Cargo
EBROBORG	General Cargo
CITADEL	General Cargo
HUMBERBORG	General Cargo
JOLIEBRISE	General Cargo
THEAMARIEKE	General Cargo
LADYMENNA	General Cargo
SUOMIGRACHT	General Cargo
MYRTE	General Cargo
STEENBANK	General Cargo
MARIT	General Cargo
KLAVERBANK	General Cargo
NORDLAND	General Cargo
SCHELDEDIEP	General Cargo
WAVE	General Cargo
METSABORG	General Cargo
SAIMAAGRACHT	General Cargo
DAGNA	General Cargo
SAMPOGRACHT	General Cargo
FLINTERMAAS	General Cargo
NASSAUBORG	General Cargo
VAASABORG	General Cargo
SPAARNEGRACHT	General Cargo
WESTGARD	General Cargo
STADIONGRACHT	General Cargo
FLINTERDUIN	General Cargo
SPAARNEDIEP	General Cargo
NORDFJORD	General Cargo
FLINTERBIRKA	General Cargo
HUDSONBORG	General Cargo
IMKE	General Cargo
MILA	General Cargo
DOGGERSBANK	General Cargo
BEATRIX	General Cargo
NORDICERIKA	General Cargo
UBCMONTEGOBAY	General Cargo
AMELAND	General Cargo
SKYLGE	General Cargo
PIONEER	General Cargo
MARIETJEANDREA	General Cargo
FLINTERARCTIC	General Cargo
MARIETJEMARSILLA	General Cargo
SARDIUS	General Cargo
DIAMANT	General Cargo
KAISA	General Cargo
HELMA	General Cargo
ALEKSANDRSIBIRYAKOV	General Cargo
INZHENERPLAVINSKIY	General Cargo
KAIE	General Cargo
KAILI	General Cargo
KADRI	General Cargo
KARMEL	General Cargo
KATRE	General Cargo
LANDY	General Cargo
CREDO	General Cargo
RUSICH-3	General Cargo
INZHENERTRUBIN	General Cargo
AKVILE	General Cargo
ALKA	General Cargo
AFALINA	General Cargo
ARINA	General Cargo
HEIKELEHMANN	General Cargo
ANNALEHMANN	General Cargo
KARINLEHMANN	General Cargo
VISURGIS	General Cargo
NEMUNA	General Cargo
VOSSBORG	General Cargo
GERD	General Cargo
MARCHICORA	General Cargo
HANSEATICSPIRIT	General Cargo
ASKO	General Cargo

EMSMOON	General Cargo
SELGA	General Cargo
MARC-ANDRE	General Cargo
FURIOSO	General Cargo
EMSCARRIER	General Cargo
ODER	General Cargo
ALWIS	General Cargo
WARNOW	General Cargo
ERNSTHAGEDORN	General Cargo
BELIZIA	General Cargo
FRANKW	General Cargo
YVONNE	General Cargo
CECILIA	General Cargo
LEHMANNSOUND	General Cargo
VECHTBORG	General Cargo
LEHMANNBAY	General Cargo
VLISTBORG	General Cargo
TRINE	General Cargo
MARSTAL	General Cargo
EMSSKY	General Cargo
HAREN	General Cargo
ABUKLION	General Cargo
ANDREW	General Cargo
JRSMERKUR	General Cargo
KROONBORG	General Cargo
SEAVOYAGER	General Cargo
INDUSTRIALKAROLINE	General Cargo
EMSLAKE	General Cargo
GEULBORG	General Cargo
GOUWEBORG	General Cargo
LEHMANNBELT	General Cargo
LEHMANNFJORD	General Cargo
MARKBORG	General Cargo
MEDEMBORG	General Cargo
LEHMANNBALTIC	General Cargo
MERWEBORG	General Cargo
CATHMA	General Cargo
SYMPHONY	General Cargo
MARTHA	General Cargo
KARELIA	General Cargo
MALAGA	General Cargo
AMIRANTE	General Cargo
MELODY	General Cargo

LOENERDIEP	General Cargo
VECHTDIEP	General Cargo
BBCRHEIDERLAND	General Cargo
CHRISTIANESSBERGER	Chem./Prod. Tank
PATRICIAESSBERGER	Chem./Prod. Tank
STOCMARCIA	Chem./Prod. Tank
LISELOTTEESSBERGER	Chem./Prod. Tank
TERNHOLM	Chem./Prod. Tank
TERNVAG	Chem./Prod. Tank
TERNHAV	Chem./Prod. Tank
TERNVIK	Chem./Prod. Tank
SATURNUS	Chem./Prod. Tank
SCORPIUS	Chem./Prod. Tank
OLYMPUS	Chem./Prod. Tank
NORDICNORA	Chem./Prod. Tank
ORAHOLM	Chem./Prod. Tank
PURHA	Chem./Prod. Tank
KIISLA	Chem./Prod. Tank
SUULA	Chem./Prod. Tank
FUTURA	Chem./Prod. Tank
NESTE	Chem./Prod. Tank
STENSTRAUM	Chem./Prod. Tank
STENBERG	Chem./Prod. Tank
SILVERFREYA	Chem./Prod. Tank
DUTCHAQUAMARINE	Chem./Prod. Tank
LUCYESSBERGER	Chem./Prod. Tank
GRANATO	Chem./Prod. Tank
SMERALDO	Chem./Prod. Tank
CRYSTALPEARL	Chem./Prod. Tank
CRYSTALSKYE	Chem./Prod. Tank
CRYSTALTOPAZ	Chem./Prod. Tank
CRYSTALDIAMOND	Chem./Prod. Tank
BLUEGARNET	Chem./Prod. Tank
TRANSFJELL	Chem./Prod. Tank
PATRICIA	Chem./Prod. Tank
BESIKTASHALLAND	Chem./Prod. Tank
FJELLSTRAUM	Chem./Prod. Tank
MAINLAND	Chem./Prod. Tank
DUMLUPINAR	Chem./Prod. Tank
FJORDSTRAUM	Chem./Prod. Tank
PURPLEGEM	Chem./Prod. Tank
NIKE	Chem./Prod. Tank
GEORGESSBERGER	Chem./Prod. Tank

EDUARDESSBERGER	Chem./Prod. Tank
JOHANNESSBERGER	Chem./Prod. Tank
JOHNAUGUSTUSESSBERGER	Chem./Prod. Tank
SOLSTRAUM	Chem./Prod. Tank
LISTRAUM	Chem./Prod. Tank
HAVSTRAUM	Chem./Prod. Tank
LATANA	Chem./Prod. Tank
FINNSTRAUM	Chem./Prod. Tank
EK-RIVER	Chem./Prod. Tank
BOWBRASILIA	Chem./Prod. Tank
STENNORDIC	Chem./Prod. Tank
XANTHIA	Chem./Prod. Tank
CLIPPERSUND	Chem./Prod. Tank
STENHIDRA	Chem./Prod. Tank
GOLFSTRAUM	Chem./Prod. Tank
RYSTRAUM	Chem./Prod. Tank
BERGSTRAUM	Chem./Prod. Tank
CHRISTINA	Chem./Prod. Tank
STENSUOMI	Chem./Prod. Tank
STENBOTHNIA	Chem./Prod. Tank
STRAUM	Chem./Prod. Tank
DORIS	Chem./Prod. Tank
ASTORIA	Chem./Prod. Tank
ASTINA	Chem./Prod. Tank
ASTRAL	Chem./Prod. Tank
MCTSTOCKHORN	Chem./Prod. Tank
VARKANAKDENIZ	Chem./Prod. Tank
PICTORJ	Container
IDUNA	Container
AURORA	Container
SLEIPNER	Container
JORK	Container
VLADIMIR	Container
STEFANSIBUM	Container
TRANSANUND	Container
NORDICBREMEN	Container
TRANSJORUND	Container
BIANCARAMBOW	Container
HANNI	Container
CONTAINERSHIPSVI	Container
CONTAINERSHIPSVIII	Container
GRETESIBUM	Container
NORDICPHILIP	Container

KRISTINSCHEPERS	Container
VORONEZH	Container
HANNA	Container
HANSESPIRIT	Container
ANNASIRKKA	Container
IDARAMBOW	Container
CONTAINERSHIPSVII	Container
JOHANNA	Container
NORDEROOG	Container
SUDEROOG	Container
ROMYTRADER	Container
EMOTION	Container
FLINTERCAPE	Container
FENJA	Container
OOCLSTPETERSBURG	Container
RIJNBORG	Container
BALKAN	Container
LEONIEP	Container
HANSECOURAGE	Container
ALDEBARANJ	Container
BFVICTORIA	Container
SOPHIA	Container
NEUENFELDE	Container
ICERUNNER	Container
LANGENESS	Container
LAURAANN	Container
PHOENIXJ	Container
WESAMELIE	Container
MORSUM	Container
SYLT	Container
SANDYRICKMERS	Container
AALDERDIJK	Container
HELUAN	Container
ENVIK	Cement
ALPPILA	Bulk
SEVERNAYAZEMLYA	Bulk
HARRIETT	Bulk

ANNEX 8

RESOLUTION MEPC.212(63)

Adopted on 2 March 2012

2012 GUIDELINES ON THE METHOD OF CALCULATION OF THE ATTAINED ENERGY EFFICIENCY DESIGN INDEX (EEDI) FOR NEW SHIPS

THE MARINE ENVIRONMENT PROTECTION COMMITTEE,

RECALLING article 38(a) of the Convention on the International Maritime Organization concerning the functions of the Marine Environment Protection Committee (the Committee) conferred upon it by international conventions for the prevention and control of marine pollution,

RECALLING ALSO that, at its sixty-second session, the Committee adopted, by resolution MEPC.203(62), 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 (inclusion of regulations on energy efficiency for ships in MARPOL Annex VI),

NOTING the amendments to MARPOL Annex VI adopted at its sixty-second session by inclusion of a new chapter 4 for regulations on energy efficiency for ships, are expected to enter into force on 1 January 2013 upon their acceptance on 1 July 2012,

NOTING ALSO that regulation 20 (Attained EEDI) of MARPOL Annex VI, as amended, requires that the Energy Efficiency Design Index shall be calculated taking into account the guidelines developed by the Organization,

RECOGNIZING that the amendments to MARPOL Annex VI requires the adoption of relevant guidelines for smooth and uniform implementation of the regulations and to provide sufficient lead time for industry to prepare,

HAVING CONSIDERED, at its sixty-third session, the draft 2012 Guidelines on the method of calculation of the attained Energy Efficiency Design Index (EEDI) for new ships,

1. ADOPTS the 2012 Guidelines on the method of calculation of the attained Energy Efficiency Design Index (EEDI) for new ships, as set out at annex to the present resolution;

2. INVITES Administrations to take the annexed Guidelines into account when developing and enacting national laws which give force to and implement provisions set forth in regulation 20 of MARPOL Annex VI, as amended;

3. REQUESTS the Parties to MARPOL Annex VI and other Member Governments to bring the annexed Guidelines related to the Energy Efficiency Design Index (EEDI) to the attention of shipowners, ship operators, shipbuilders, ship designers and any other interested groups;

4. AGREES to keep these Guidelines under review in light of the experience gained; and

5. REVOKES the Interim Guidelines circulated by MEPC.1/Circ.681, as from this date.

ANNEX

2012 GUIDELINES ON THE METHOD OF CALCULATION OF THE ATTAINED ENERGY EFFICIENCY DESIGN INDEX (EEDI) FOR NEW SHIPS

CONTENTS

1 Definitions

2 Energy Efficiency Design Index (EEDI) including the equation

2.1 C_F ; conversion factor between fuel consumption and CO_2 emission
2.2 V_{ref} ; ship speed
2.3 *Capacity*
2.3.1 Bulk carriers, tankers, gas carriers, ro-ro cargo ships and general cargo ships
2.3.2 Passenger ships and ro-ro passenger ships
2.3.3 Containerships
2.4 *Deadweight*
2.5 *P* ; Power of main and auxiliary engines
2.5.1 P_{ME} ; power of main engines
2.5.2 P_{PTO} ; shaft generator
2.5.3 P_{PTI} ; shaft motor
2.5.4 P_{eff} ; output of innovative mechanical energy efficient technology
2.5.5 P_{AEeff} ; auxiliary power reduction
2.5.6 P_{AE} ; power of auxiliary engines
2.6 V_{ref}, *Capacity* and *P*
2.7 *SFC* ; Specific fuel consumption
2.8 f_j ; Correction factor for ship specific design elements
2.8.1 f_j ; ice-class ships
2.8.2 f_j ; shuttle tankers
2.8.3 f_j ; other ship types
2.9 f_w ; Weather factor
2.10 f_{eff} ; Availability factor of innovative energy efficiency technology
2.11 f_i ; Capacity factor
2.11.1 f_i ; ice-class ships
2.11.2 f_i ; ship specific voluntary structural enhancement
2.11.3 f_i ; bulk carriers and oil tankers under Common Structural Rules (CSR)
2.11.4 f_i ; other ship types
2.12 f_c ; Cubic capacity correction factor
2.12.1 f_c ; chemical tankers
2.12.2 f_c ; LNG carriers
2.13 *Lpp* ; Length between perpendiculars

APPENDIX 1 A generic and simplified power plant

APPENDIX 2 Guidelines for the development of electric power tables for EEDI (EPT-EEDI)

1 Definitions

MARPOL means the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto, as amended.

For the purpose of these Guidelines, the definitions in "REGULATIONS ON ENERGY EFFICIENCY FOR SHIPS" (RESOLUTION MEPC. 203(62)) apply.

2 Energy Efficiency Design Index (EEDI)

The attained new ship Energy Efficiency Design Index (EEDI) is a measure of ships energy efficiency (g/t*nm) and calculated by the following formula:

$$\frac{\left(\prod_{j=1}^{n} f_j\right)\left(\sum_{i=1}^{nME} P_{ME(i)} \cdot C_{FME(i)} \cdot SFC_{ME(i)}\right) + \left(P_{AE} \cdot C_{FAE} \cdot SFC_{AE} *\right) + \left(\left(\prod_{j=1}^{n} f_j \cdot \sum_{i=1}^{nPTI} P_{PTI(i)} - \sum_{i=1}^{neff} f_{eff(i)} \cdot P_{AEeff(i)}\right) C_{FAE} \cdot SFC_{AE}\right) - \left(\sum_{i=1}^{neff} f_{eff(i)} \cdot P_{eff(i)} \cdot C_{FME} \cdot SFC_{ME} **\right)}{f_i \cdot f_c \cdot Capacity \cdot f_w \cdot V_{ref}}$$

* If part of the Normal Maximum Sea Load is provided by shaft generators, SFC_{ME} and C_{FME} may – for that part of the power – be used instead of SFC_{AE} and C_{FAE}

** In case of $P_{PTI(i)}>0$, the average weighted value of ($SFC_{ME} \cdot C_{FME}$) and ($SFC_{AE} \cdot C_{FAE}$) to be used for calculation of P_{eff}

Note: This formula may not be able to apply to diesel-electric propulsion, turbine propulsion or hybrid propulsion system.

Where:

.1 C_F is a non-dimensional conversion factor between fuel consumption measured in g and CO_2 emission also measured in g based on carbon content. The subscripts $_{MEi}$ and $_{AEi}$ refer to the main and auxiliary engine(s) respectively. C_F corresponds to the fuel used when determining SFC listed in the applicable test report included in a Technical File as defined in paragraph 1.3.15 of NO_x Technical Code ("test report included in a NO_x technical file" hereafter). The value of C_F is as follows:

Type of fuel	Reference	Carbon content	C_F (t-CO_2/t-Fuel)
1 Diesel/Gas Oil	ISO 8217 Grades DMX through DMB	0.8744	3.206
2 Light Fuel Oil (LFO)	ISO 8217 Grades RMA through RMD	0.8594	3.151
3 Heavy Fuel Oil (HFO)	ISO 8217 Grades RME through RMK	0.8493	3.114
4 Liquefied Petroleum Gas (LPG)	Propane	0.8182	3.000
	Butane	0.8264	3.030
5 Liquefied Natural Gas (LNG)		0.7500	2.750

.2 V_{ref} is the ship speed, measured in nautical miles per hour (knot), on deep water in the condition corresponding to the *Capacity* as defined in paragraphs 2.3.1 and 2.3.3 (in case of passenger ships and ro-ro passenger ships, this condition should be summer load draught as provided in paragraph 2.4) at the shaft power of the engine(s) as defined in paragraph 2.5 and assuming the weather is calm with no wind and no waves.

.3 *Capacity* is defined as follows:

.1 For bulk carriers, tankers, gas tankers, ro-ro cargo ships, general cargo ships, refrigerated cargo carrier and combination carriers, deadweight should be used as *Capacity*.

.2 For passenger ships and ro-ro passenger ships, gross tonnage in accordance with the International Convention of Tonnage Measurement of Ships 1969, Annex I, regulation 3 should be used as *Capacity*.

.3 For containerships, 70 per cent of the deadweight (DWT) should be used as *Capacity*. EEDI values for containerships are calculated as follows:

.1 attained EEDI is calculated in accordance with the EEDI formula using 70 per cent deadweight for *Capacity*.

.2 estimated index value in the Guidelines for calculation of the reference line is calculated using 70 per cent deadweight as:

$$Estimated\ Index\,Value = 3.1144 \cdot \frac{190 \cdot \sum_{i=1}^{NME} P_{MEi} + 215 \cdot P_{AE}}{70\%\mathrm{DWT} \cdot V_{ref}}$$

.3 parameters a and c for containerships in Table 2 of regulation 21 of MARPOL Annex VI are determined by plotting the estimated index value against 100 per cent deadweight i.e. a=174.22 and c=0.201 were determined.

.4 required EEDI for a new containership is calculated using 100 per cent deadweight as:

Required EEDI = (1-X/100) · a · 100% deadweight $^{-c}$

Where X is the reduction factor (in percentage) in accordance with Table 1 in regulation 21 of MARPOL Annex VI relating to the applicable phase and size of new containership.

.4 *Deadweight* means the difference in tonnes between the displacement of a ship in water of relative density of 1,025 kg/m^3 at the summer load draught and the lightweight of the ship. The summer load draught should be taken as the maximum summer draught as certified in the stability booklet approved by the Administration or an organization recognized by it.

.5 P is the power of the main and auxiliary engines, measured in kW. The subscripts $_{ME}$ and $_{AE}$ refer to the main and auxiliary engine(s), respectively. The summation on i is for all engines with the number of engines ($_{nME}$). (See diagram in appendix 1.)

.1 $P_{ME(i)}$ is 75 per cent of the rated installed power (MCR*) for each main engine (i).

The influence of additional shaft power take off or shaft power take in is defined in the following paragraphs.

.2 **Shaft generator**

In case where shaft generator(s) are installed, $P_{PTO(i)}$ is 75 per cent of the rated electrical output power of each shaft generator.

For calculation of the effect of shaft generators two options are available:

Option 1:

.1 The maximum allowable deduction for the calculation of $P_{ME(i)}$ is to be no more than P_{AE} as defined in paragraph 2.5.6. For this case, $P_{ME(i)}$ is calculated as:

$$P_{ME(i)} = 0.75 \times \left(MCR_{ME(i)} - P_{PTO(i)} \right)$$

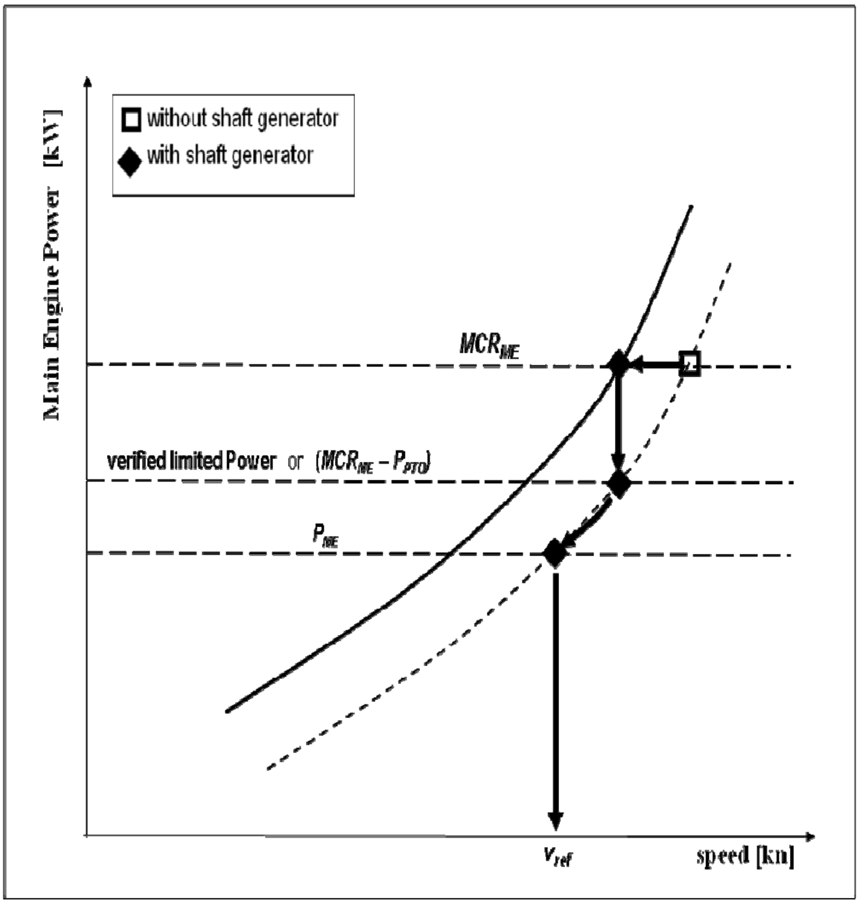
or

Option 2:

.2 Where an engine is installed with a higher rated power output than that which the propulsion system is limited to by verified technical means, then the value of $P_{ME(i)}$ is 75 per cent of that limited power for determining the reference speed, V_{ref} and for EEDI calculation.

* The value of MCR specified on the EIAPP certificate should be used for calculation. If the main engines are not required to have an EIAPP certificate, the MCR on the nameplate should be used.

The following figure gives guidance for determination of $P_{ME(i)}$:



.3 **Shaft motor**

In case where shaft motor(s) are installed, $P_{PTI(i)}$ is 75 per cent of the rated power consumption of each shaft motor divided by the weighted average efficiency of the generator(s).

The propulsion power at which V_{ref} is measured, is:

$$\sum P_{ME(i)} + \sum P_{PTI(i),Shaft}$$

Where:

$$\sum P_{PTI(i),Shaft} = \sum \left(P_{PTI(i)} \cdot \eta_{PTI(i)}\right) \cdot \eta_{\overline{Gen}}$$

$\eta_{PTI(i)}$ is the efficiency of each shaft motor installed

$\eta_{\overline{Gen}}$ is the weighted average efficiency of the generator(s)

Where the total propulsion power as defined above is higher than 75 per cent of the power the propulsion system is limited to by verified technical means, then 75 per cent of the limited power is to be used as the total propulsion power for determining the reference speed, V_{ref} and for EEDI calculation.

In case of combined PTI/PTO, the normal operational mode at sea will determine which of these to be used in the calculation.

Note: The shaft motor's chain efficiency may be taken into consideration to account for the energy losses in the equipment from the switchboard to the shaft motor, if the chain efficiency of the shaft motor is given in a verified document.

.4 $P_{eff(i)}$ is the output of the innovative mechanical energy efficient technology for propulsion at 75 per cent main engine power.

Mechanical recovered waste energy directly coupled to shafts need not be measured, since the effect of the technology is directly reflected in the V_{ref}.

In case of a ship equipped dual-fuel engine or a number of engines, the C_{FME} and SFC_{ME} should be the power weighted average of all the main engines.

.5 $P_{AEeff\ (i)}$ is the auxiliary power reduction due to innovative electrical energy efficient technology measured at $P_{ME(i)}$.

.6 P_{AE} is the required auxiliary engine power to supply normal maximum sea load including necessary power for propulsion machinery/systems and accommodation, e.g. main engine pumps, navigational systems and equipment and living on board, but excluding the power not for propulsion machinery/systems, e.g. thrusters, cargo pumps, cargo gear, ballast pumps, maintaining cargo, e.g. reefers and cargo hold fans, in the condition where the ship engaged in voyage at the speed (V_{ref}) under the condition as mentioned in paragraph 2.2.

.1 For ships with a main engine power of 10,000 kW or above, P_{AE} is defined as:

$$P_{AE(MCRME \geq 10000KW)} = \left(0.025 \times \left(\sum_{i=1}^{nME} MCR_{MEi} + \frac{\sum_{i=1}^{nPTI} P_{PTI(i)}}{0.75} \right) \right) + 250$$

.2 For ships with a main engine power below 10,000 kW, P_{AE} is defined as:

$$P_{AE(MCRME < 10000KW)} = \left(0.05 \times \left(\sum_{i=1}^{nME} MCR_{MEi} + \frac{\sum_{i=1}^{nPTI} P_{PTI(i)}}{0.75} \right) \right)$$

.3 For ship where the P_{AE} value calculated by paragraph 2.5.6.1 or 2.5.6.2 is significantly different from the total power used at normal seagoing, e.g. in cases of passenger ships (see NOTE under the formula of EEDI), the P_{AE} value should be estimated by the consumed electric power (excluding propulsion) in conditions when the ship is engaged in a voyage at reference speed (V_{ref}) as given in the electric power table[1], divided by the average efficiency of the generator(s) weighted by power (see appendix 2).

.6 V_{ref}, *Capacity* and *P* should be consistent with each other.

.7 *SFC* is the certified specific fuel consumption, measured in g/kWh, of the engines. The subscripts $_{ME(i)}$ and $_{AE(i)}$ refer to the main and auxiliary engine(s), respectively. For engines certified to the E2 or E3 test cycles of the NO_x Technical Code 2008, the engine Specific Fuel Consumption ($SFC_{ME(i)}$) is that recorded in the test report included in a NO_x technical file for the engine(s) at 75 per cent of MCR power of its torque rating. For engines certified to the D2 or C1 test cycles of the NO_x Technical Code 2008, the engine Specific Fuel Consumption ($SFC_{AE(i)}$) is that recorded on the test report included in a NO_x technical file at the engine(s) 50 per cent of MCR power or torque rating.

The *SFC* should be corrected to the value corresponding to the ISO standard reference conditions using the standard lower calorific value of the fuel oil (42,700kJ/kg), referring to ISO 15550:2002 and ISO 3046-1:2002.

For ships where the P_{AE} value calculated by paragraphs 2.5.6.1 and 2.5.6.2 is significantly different from the total power used at normal seagoing, e.g. conventional passenger ships, the Specific Fuel Consumption (SFC_{AE}) of the auxiliary generators is that recorded in the test report included in a NO_x technical file for the engine(s) at 75 per cent of MCR power of its torque rating.

SFC_{AE} is the power-weighted average among $SFC_{AE(i)}$ of the respective engines *i*.

For those engines which do not have a test report included in a NO_x technical file because its power is below 130 kW, the *SFC* specified by the manufacturer and endorsed by a competent authority should be used.

At the design stage, in case of unavailability of test report in the NO_x file, the *SFC* specified by the manufacturer and endorsed by a competent authority should be used.

For LNG driven engines of which *SFC* is measured in kJ/kWh should be corrected to the *SFC* value of g/kWh using the standard lower calorific value of the LNG (48,000 kJ/kg), referring to the 2006 IPCC Guidelines.

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[1] The electric power table should be examined and validated by the verifier. Where ambient conditions affect any electrical load in the power table the contractual ambient conditions leading to the maximum design electrical load of the installed system for the ship in general should apply.

.8 f_j is a correction factor to account for ship specific design elements:

.1 The power correction factor, f_j, for ice-classed ships should be taken as the greater value of f_{j0} and $f_{j,min}$ as tabulated in Table 1 but not greater than $f_{j,max}$ = 1.0.

For further information on approximate correspondence between ice classes, see HELCOM Recommendation 25/7[2].

Table 1: Correction factor for power f_j for ice-classed ships

Ship type	f_{j0}	$f_{j,min}$ depending on the ice class			
		IA Super	IA	IB	IC
Tanker	$\frac{0.308 L_{PP}^{1.920}}{\sum_{i=1}^{nME} P_{ME(i)}}$	$0.15 L_{PP}^{0.30}$	$0.27 L_{PP}^{0.21}$	$0.45 L_{PP}^{0.13}$	$0.70 L_{PP}^{0.06}$
Bulk carrier	$\frac{0.639 L_{PP}^{1.754}}{\sum_{i=1}^{nME} P_{ME(i)}}$	$0.47 L_{PP}^{0.09}$	$0.58 L_{PP}^{0.07}$	$0.73 L_{PP}^{0.04}$	$0.87 L_{PP}^{0.02}$
General cargo ship	$\frac{0.0227 \cdot L_{PP}^{2.483}}{\sum_{i=1}^{nME} P_{ME(i)}}$	$0.31 L_{PP}^{0.16}$	$0.43 L_{PP}^{0.12}$	$0.56 L_{PP}^{0.09}$	$0.67 L_{PP}^{0.07}$

.2 The factor *fj*, for shuttle tankers with propulsion redundancy should be *fj* = 0.77. This correction factors applies to shuttle tankers with propulsion redundancy between 80,000 and 160,000 deadweight. The Shuttle Tankers with Propulsion Redundancy are tankers used for loading of crude oil from offshore installations equipped with dual-engine and twin-propellers need to meet the requirements for dynamic positioning and redundancy propulsion class notation.

.3 For other ship types, f_j should be taken as 1.0.

.9 f_w is a non-dimensional coefficient indicating the decrease of speed in representative sea conditions of wave height, wave frequency and wind speed (e.g. Beaufort Scale 6), and is determined as follows:

.1 for attained EEDI calculated under regulations 20 and 21 of MARPOL Annex VI, f_w is 1.00;

.2 when f_w is calculated according to the subparagraph .2.1 or .2.2 below, the value for attained EEDI calculated by the formula in paragraph 2 using the obtained f_w should be referred to as "*attained EEDI$_{weather}$*";

.1 f_w can be determined by conducting the ship specific simulation on its performance at representative sea conditions. The simulation methodology should be based on the Guidelines developed by the Organization and the

[2] HELCOM Recommendation 25/7 may be found at http://www.helcom.fi.

method and outcome for an individual ship should be verified by the Administration or an organization recognized by the Administration; and

.2 in cases where a simulation is not conducted, f_w should be taken from the "Standard f_w " table/curve. A "Standard f_w " table/curve is provided in the Guidelines[3] for each ship type defined in paragraph 1, and expressed as a function of Capacity (e.g. deadweight). The "Standard f_w " table/curve is based on data of actual speed reduction of as many existing ships as possible under the representative sea condition.

f_w and *attained* $EEDI_{weather}$, if calculated, with the representative sea conditions under which those values are determined, should be indicated in the EEDI Technical File to make a distinction with the attained EEDI calculated under regulations 20 and 21 of MARPOL Annex VI.

.10 $f_{eff(i)}$ is the availability factor of each innovative energy efficiency technology. $f_{eff(i)}$ for waste energy recovery system should be one (1.0)[4].

.11 f_i is the capacity factor for any technical/regulatory limitation on capacity, and should be assumed to be one (1.0) if no necessity of the factor is granted.

.1 The capacity correction factor, f_i, for ice-classed ships should be taken as the lesser value of f_{i0} and $f_{i,max}$ as tabulated in Table 2, but not less than $f_{i,min}$ = 1.0. For further information on approximate correspondence between ice classes, see HELCOM Recommendation 25/7[5].

Table 2: Capacity correction factor f_i for ice-classed ships

Ship type	f_{i0}	$f_{i,max}$ depending on the ice class			
		IA Super	IA	IB	IC
Tanker	$\frac{0.00138 \cdot L_{PP}^{3.331}}{capacity}$	$2.10L_{PP}^{-0.11}$	$1.71L_{PP}^{-0.08}$	$1.47L_{PP}^{-0.06}$	$1.27L_{PP}^{-0.04}$
Bulk carrier	$\frac{0.00403 \cdot L_{PP}^{3.123}}{capacity}$	$2.10L_{PP}^{-0.11}$	$1.80L_{PP}^{-0.09}$	$1.54L_{PP}^{-0.07}$	$1.31L_{PP}^{-0.05}$
General cargo ship	$\frac{0.0377 \cdot L_{PP}^{2.625}}{capacity}$	$2.18L_{PP}^{-0.11}$	$1.77L_{PP}^{-0.08}$	$1.51L_{PP}^{-0.06}$	$1.28L_{PP}^{-0.04}$
Containership	$\frac{0.1033 \cdot L_{PP}^{2.329}}{capacity}$	$2.10L_{PP}^{-0.11}$	$1.71L_{PP}^{-0.08}$	$1.47L_{PP}^{-0.06}$	$1.27L_{PP}^{-0.04}$
Gas carrier	$\frac{0.0474 \cdot L_{PP}^{2.590}}{capacity}$	1.25	$2.10L_{PP}^{-0.12}$	$1.60L_{PP}^{-0.08}$	$1.25L_{PP}^{-0.04}$

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

3 Guidelines for the calculation of the coefficient *fw* for the decrease of ship speed in respective sea conditions will be developed.

4 EEDI calculation should be based on the normal sea-going condition outside Emission Control Area designated under paragraph 6 of regulation 13 in MARPOL ANNEX VI.

5 HELCOM Recommendation 25/7 may be found at http://www.helcom.fi.

.2 $f_{i\ VSE}$ for ship specific voluntary structural enhancement is expressed by the following formula:

$$f_{iVSE} = \frac{DWT_{reference\ design}}{DWT_{enhanced\ design}}$$

Where:

$$DWT_{reference\ design} = \Delta_{ship} - lightweight_{reference\ design}$$

$$DWT_{enhanced\ design} = \Delta_{ship} - lightweight_{enhanced\ design}$$

For this calculation the same displacement (Δ) for reference and enhanced design should be taken.

DWT before enhancements ($DWT_{reference\ design}$) is the deadweight prior to application of the structural enhancements. DWT after enhancements ($DWT_{enhanced\ design}$) is the deadweight following the application of voluntary structural enhancement. A change of material (e.g. from aluminum alloy to steel) between reference design and enhanced design should not be allowed for the $f_{i\ VSE}$ calculation. A change in grade of the same material (e.g. in steel type, grades, properties and condition) should also not be allowed.

In each case, two sets of structural plans of the ship should be submitted to the verifier for assessment. One set for the ship without voluntary structural enhancement; the other set for the same ship with voluntary structural enhancement. (Alternatively, one set of structural plans of the reference design with annotations of voluntary structural enhancement should also be acceptable.) Both sets of structural plans should comply with the applicable regulations for the ship type and intended trade.

.3 for bulk carriers and oil tankers, built in accordance with Common Structural Rules (CSR) of the classification societies and assigned the class notation CSR, the following capacity correction factor f_{iCSR} should apply:

$f_{iCSR} = 1 + (0.08 \cdot LWT_{CSR} / DWT_{CSR})$

Where, DWT_{CSR} is the deadweight determined by paragraph 2.4 and LWT_{CSR} is the light weight of the ship.

.4 for other ship types, *fi* should be taken as 1.0.

.12 f_c is the cubic capacity correction factor and should be assumed to be one (1.0) if no necessity of the factor is granted.

.1 for chemical tankers, as defined in regulation 1.16.1 of MARPOL Annex II, the following cubic capacity correction factor f_c should apply:

$f_c = R^{-0.7} - 0.014$, where R is less than 0.98

or

$f_c = 1.000$, where R is 0.98 and above;

where: *R* is the capacity ratio of the deadweight of the ship (tonnes) as determined by paragraph 2.4 divided by the total cubic capacity of the cargo tanks of the ship (m^3).

.2 for gas carriers having direct diesel driven propulsion system constructed or adapted and used for the carriage in bulk of liquefied natural gas, the following cubic capacity correction factor f_{cLNG} should apply:

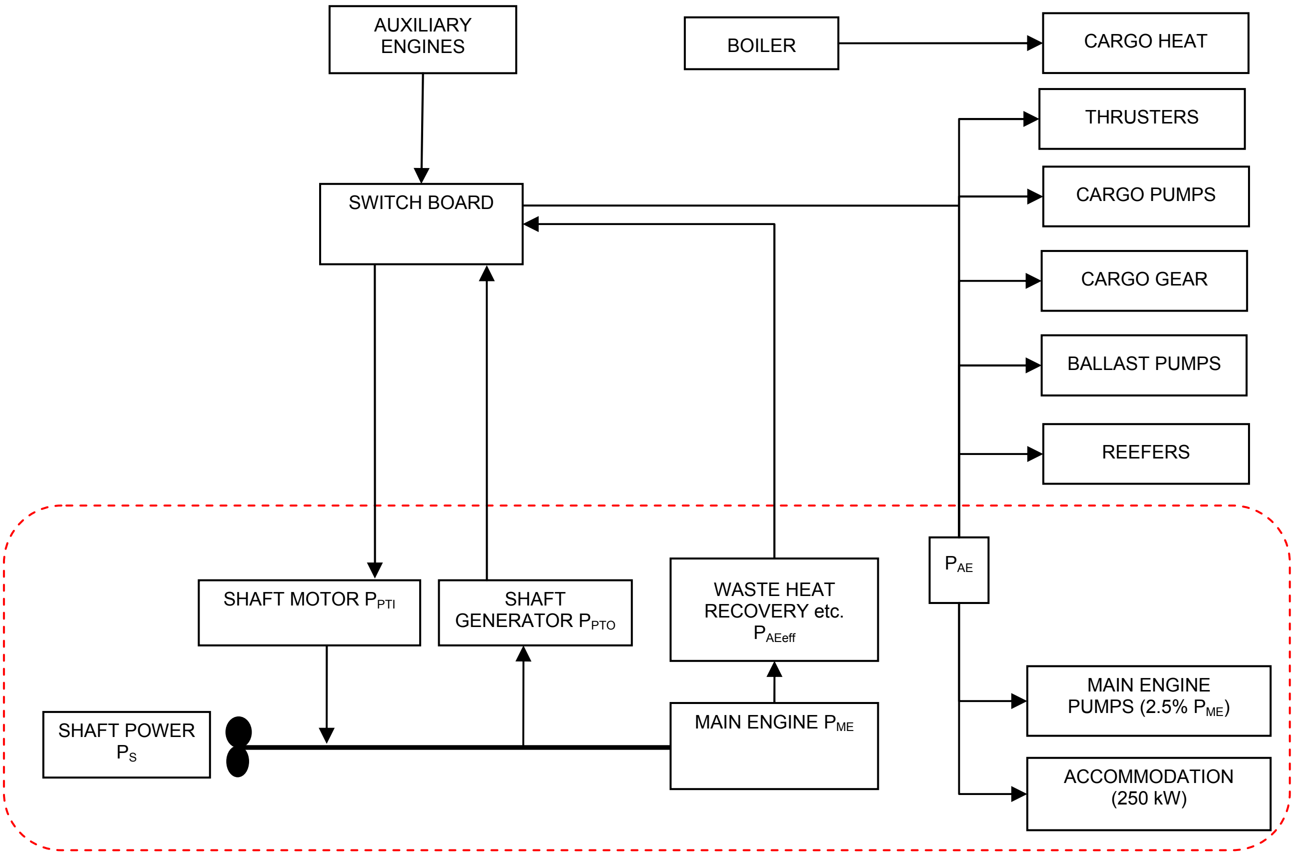
$$f_{cLNG} = R^{-0.56}$$

where, *R* is capacity ratio of deadweight of the ship (tonnes) as determined by paragraph 2.4 divided by the total cubic capacity of the cargo tanks of the ship (m^3).

.13 *Length between perpendiculars*, *Lpp* means 96 per cent of the total length on a waterline at 85 per cent of the least moulded depth measured from the top of the keel, or the length from the foreside of the stem to the axis of the rudder stock on that waterline, if that were greater. In ships designed with a rake of keel the waterline on which this length is measured should be parallel to the designed waterline. The length between perpendiculars (L_{pp}) should be measured in metres.

APPENDIX 1

A GENERIC AND SIMPLIFIED MARINE POWER PLANT



Note 1: Mechanical recovered waste energy directly coupled to shafts need not be measured, since the effect of the technology is directly reflected in the V_{ref} .

Note 2: In case of combined PTI/PTO, the normal operational mode at sea will determine which of these to be used in the calculation.

APPENDIX 2

GUIDELINES FOR THE DEVELOPMENT OF ELECTRIC POWER TABLES FOR EEDI (EPT-EEDI)

1 Introduction to the document "Electric Power Table for EEDI"

1.1 This appendix contains a guideline for the document "Electric Power Table for EEDI" which is similar to the actual shipyards' load balance document, utilizing well defined criteria, providing standard format, clear loads definition and grouping, standard load factors, etc. A number of new definitions (in particular the "groups") are introduced, giving an apparent greater complexity to the calculation process. However, this intermediate step to the final calculation of P_{AE} stimulates all the parties to a deep investigation through the global figure of the auxiliary load, allowing comparisons between different ships and technologies and eventually identifying potential efficiencies improvements.

2 Auxiliary load power definition

2.2 P_{AE} is to be calculated as indicated in paragraph 2.5.6 of the Guidelines, together with the following additional three conditions:

.1 no emergency situations (e.g. "no fire", "no flood", "no blackout", "no partial blackout");

.2 evaluation time frame of 24 hours (to account loads with intermittent use); and

.3 ship fully loaded of passenger and/or cargo and crew.

3 Definition of the data to be included in the Electric Power Table for EEDI

3.1 The Electric power table for EEDI calculation should contain the following data elements, as appropriate:

.1 Load's group;
.2 Load's description;
.3 Load's identification tag;
.4 Load's electric circuit Identification;
.5 Load's mechanical rated power "*Pm*" [*kW*];
.6 Load's electric motor rated output power [*kW*];
.7 Load's electric motor efficiency "*e*" [/];
.8 Load's Rated electric power "*Pr*" [*kW*];
.9 Service factor of load "*kl*" [/];
.10 Service factor of duty "*kd*" [/];
.11 Service factor of time "*kt*" [/];
.12 Service total factor of use "*ku*" [/], where $ku=kl \cdot kd \cdot kt$;
.13 Load's necessary power "*Pload*" [*kW*], where $Pload=Pr \cdot ku$;
.14 Notes;
.15 Group's necessary power [*kW*]; and
.16 Auxiliaries load's power P_{AE} [*kW*].

4 Data to be included in the Electric Power Table for EEDI

Load groups

4.1 The Loads are put into defined groups, allowing a proper breakdown of the auxiliaries. This eases the verification process and makes it possible to identify those areas where load reductions might be possible. The groups are listed below:

.1 A – Hull, Deck, Navigation and Safety services;
.2 B – Propulsion service auxiliaries;
.3 C – Auxiliary Engine and Main Engine Services;
.4 D – Ship's General services;
.5 E – Ventilation for Engine-rooms and Auxiliaries room;
.6 F – Air Conditioning services;
.7 G – Galleys, refrigeration and Laundries services;
.8 H – Accommodation services;
.9 I – Lighting and socket services;
.10 L – Entertainment services;
.11 N – Cargo loads; and
.12 M – Miscellaneous.

All the ship's loads have to be delineated in the document, excluding only *PAeff*, the shaft motors and shaft motors chain (while the propulsion services auxiliaries are partially included below in paragraph 4.1.2 B). Some loads (i.e. thrusters, cargo pumps, cargo gear, ballast pumps, maintaining cargo, reefers and cargo hold fans) still are included in the group for sake of transparency, however their service factor is zero in order to comply with rows 4 and 5 of paragraph 2.5.6 of the Guidelines, therefore making it easier to verify that all the loads have been considered in the document and there are no loads left out of the measurement.

4.1.1 A – Hull, Deck, Navigation and safety services

.1 loads included in the Hull services typically are: ICCP systems, mooring equipment, various doors, ballasting systems, Bilge systems, Stabilizing equipment, etc. Ballasting systems are indicated with service factor equal to zero to comply with row 5 of paragraph 2.5.6 of the Guidelines;

.2 loads included in the deck services typically are: deck and balcony washing systems, rescue systems, cranes, etc.;

.3 loads included in the navigation services typically are: navigation systems, navigation's external and internal communication systems, steering systems, etc.; and

.4 loads included in the safety services typically are: active and passive fire systems, emergency shutdown systems, public address systems, etc.

4.1.2 B – Propulsion service auxiliaries
This group typically includes: propulsion secondary cooling systems such as LT cooling pumps dedicated to shaft motors, LT cooling pumps dedicated to propulsion converters, propulsion UPSs, etc. Propulsion service Loads do not include shaft motors (*PTI(i)*) and the auxiliaries which are part of them (shaft motor own cooling fans and pump, etc.) and the shaft motor chain losses and auxiliaries which are part of them (i.e. shaft motor converters including relevant auxiliaries such as converter own cooling fans and pumps, shaft motor

transformers including relevant auxiliaries losses such as propulsion transformer own cooling fans and pumps, shaft motor Harmonic filter including relevant auxiliaries losses, shaft motor excitation system including the relevant auxiliaries consumed power, etc.). Propulsion service auxiliaries include manoeuvring propulsion equipments such as manoeuvring thrusters and their auxiliaries whose service factor is to be set to zero.

4.1.3 C – Auxiliary Engine and Main Engine Services
This group includes: cooling systems, i.e. pumps and fans for cooling circuits dedicated to alternators or propulsion shaft engines (seawater, technical water dedicated pumps, etc.), lubricating and fuel systems feeding, transfer, treatment and storage, ventilation system for combustion air supply, etc.

4.1.4 D – Ship's General services
This group includes Loads which provide general services which can be shared between shaft motor, auxiliary engines and main engine and accommodation support systems. Loads typically included in this group are: Cooling systems, i.e. pumping seawater, technical water main circuits, compressed air systems, fresh water generators, automation systems, etc.

4.1.5 E – Ventilation for Engine-rooms and Auxiliaries room
This group includes all fans providing ventilation for engine-rooms and auxiliary rooms that typically are: Engine-rooms cooling supply-exhaust fans, auxiliary rooms supply and exhaust fans. All the fans serving accommodation areas or supplying combustion air are not included in this group. This group does not include cargo hold fans, and garage supply and exhaust fans.

4.1.6 F – Air Conditioning services
All Loads that make up the air conditioning service that typically are: air conditioning chillers, air conditioning cooling and heating fluids transfer and treatment, air conditioning's air handling units ventilation, air conditioning re-heating systems with associated pumping, etc. The air conditioning chillers service factor of load, service factor of time and service factor of duty are to be set as 1 ($kl=1$, $kt=1$ and $kd=1$) in order to avoid the detailed validation of the heat load dissipation document (i.e. the chiller's electric motor rated power is to be used). However, kd is to represent the use of spare chillers (e.g. four chillers are installed and one out four is spare then $kd=0$ for the spare chiller and $kd=1$ for the remaining three chillers), but only when the number of spare chillers is clearly demonstrated via the heat load dissipation document.

4.1.7 G – Galleys, refrigeration and Laundries services
All Loads related to the galleys, pantries refrigeration and laundry services that typically are: Galleys various machines, cooking appliances, galleys' cleaning machines, galleys auxiliaries, refrigerated room systems including refrigeration compressors with auxiliaries, air coolers, etc.

4.1.8 H – Accommodation services
All Loads related to the accommodation services of passengers and crew that typically are: crew and passengers' transportation systems, i.e. lifts, escalators, etc., environmental services, i.e. black and grey water collecting, transfer, treatment, storage, discharge, waste systems including collecting, transfer, treatment, storage, etc., accommodation fluids transfers, i.e. sanitary hot and cold water pumping, etc., treatment units, pools systems, saunas, gym equipments, etc.

4.1.9 I – Lighting and socket services
All Loads related to the lighting, entertainment and socket services. As the quantity of lighting circuits and sockets within the ship may be significantly high, it is not practically feasible to list all the lighting circuits and points in the EPT for EEDI. Therefore circuits should be grouped into subgroups aimed to identify possible improvements of efficient use of power. The subgroups are:

.1 Lighting for 1) cabins, 2) corridors, 3) technical rooms/stairs, 4) public spaces/stairs, 5) engine-rooms and auxiliaries' room, 6) external areas, 7) garages and 8) cargo spaces. All have to be divided by main vertical zone; and

.2 Power sockets for 1) cabins, 2) corridors, 3) technical rooms/stairs, 4) public spaces/stairs, 5) engine-rooms and auxiliaries' room, 6) garages and 7) cargo spaces. All have to be divided by main vertical zone.

The calculation criteria for complex groups (e.g. cabin lighting and power sockets) subgroups are to be included via an explanatory note, indicating the load composition (e.g. lights of typical cabins, TV, hair dryer, fridge, etc., typical cabins).

4.1.10 L – Entertainment services
This group includes all Loads related to the entertainment services that typically are: public spaces audio and video equipments, theatre stage equipments, IT systems for offices, video games, etc.

4.1.11 N – Cargo Loads
This group will contain all cargo loads such as cargo pumps, cargo gear, maintaining cargo, cargo reefers loads, cargo hold fans and garage fans for sake of transparency. However, the service factor of this group is to be set to zero.

4.1.12 M – Miscellaneous
This group will contain all loads which have not been associated to the above-mentioned groups but still are contributing to the overall load calculation of the normal maximum sea load.

Loads description

4.2 This identifies the loads (for example "seawater pump").

Loads identification tag

4.3 This tag identifies the loads according to the shipyard's standards tagging system. For example, the "PTI1 fresh water pump" identification tag is "SYYIA/C" for an example ship and shipyard. This data provides a unique identifier for each load.

Loads electric circuit Identification

4.4 This is the tag of the electric circuit supplying the load. Such information allows the data validation process.

***Loads mechanical rated power* "*Pm*"**

4.5 This data is to be indicated in the document only when th electric load is made by an electric motor driving a mechanical load (for example a fan, a pump, etc.). This is the rated power of the mechanical device driven by an electric motor.

Loads electric motor rated output power [kW]

4.6 The output power of the electric motor as per maker's name plate or technical specification. This data does not take part of the calculation but is useful to highlight potential over rating of the combination motor-mechanical load.

***Loads electric motor efficiency* "*e*" [*/*]**

4.7 This data is to be entered in the document only when the electric load is made by an electric motor driving a mechanical load.

Loads rated electric power* "*Pr*" *[kW]

4.8 Typically the maximum electric power absorbed at the load electric terminals at which the load has been designed for its service, as indicated on the maker's name plate and/or maker's technical specification. When the electric load is made by an electric motor driving a mechanical load the load's rated electric power is: *Pr=Pm/e [kW].*

Service factor of load* "*kl*" *[/]

4.9 Provides the reduction from the loads rated electric power to loads necessary electric power that is to be made when the load absorb less power than its rated power. For example, in case of electric motor driving a mechanical load, a fan could be designed with some power margin, leading to the fact that the fan rated mechanical power exceeds the power requested by the duct system it serves. Another example is when a pump rated power exceed the power needed for pumping in its delivery fluid circuit. Another example in case of electric self-regulating semi-conductors electric heating system is oversized and the rated power exceeds the power absorbed, according a factor *kl.*

***Service factor of duty* "*kd*" [*/*]**

4.10 Factor of duty is to be used when a function is provided by more than one load. As all loads have to be included in the EPT for EEDI, this factor provides a correct summation of the loads. For example when two pumps serve the same circuit and they run in duty/stand-by their *Kd* factor will be ½ and ½. When three compressors serves the same circuit and one runs in duty and two in stand-by, then *kd* is 1/3, 1/3 and 1/3.

***Service factor of time* "*kt*" [*/*]**

4.11 A factor of time based on the shipyard's evaluation about the load duty along 24 hours of ship's navigation as defined at paragraph 3. For example the Entertainment loads operate at their power for a limited period of time, 4 hours out 24 hours; as a consequence *kt=4/24.* For example, the seawater cooling pumps operate at their power all the time during the navigation at *Vref*. As a consequence *kt=1*.

***Service total factor of use* "*ku*" [*l*]**

4.12 The total factor of use that takes into consideration all the service factors: *ku=kl·kd·kt.*

Loads necessary power* "*Pload*" *[kW]

4.13 The individual user contribution to the auxiliary load power is *Pload=Pr·ku.*

Notes

4.14 A note, as free text, could be included in the document to provide explanations to the verifier.

***Groups necessary power* [*kW*]**

4.15 The summation of the "Loads necessary power" from group A to N. This is an intermediate step which is not strictly necessary for the calculation of *PAE*. However, it is useful to allow a quantitative analysis of the *PAE*, providing a standard breakdown for analysis and potential improvements of energy saving.

***Auxiliaries load's power PAE* [*kW*]**

4.16 Auxiliaries load's power *PAE* is the summation of the "Load's necessary power" of all the loads divided by the average efficiency of the generator(s) weighted by power.

PAE=ΣPload(i)/(average efficiency of the generator(s) weighted by power)

Layout and organization of the data indicated in the "Electric power table for EEDI"

5 The document "Electric power table for EEDI" is to include general information (i.e. ship's name, project name, document references, etc.) and a table with:

.1 one row containing column titles;

.2 one Column for table row ID;

.3 one Column for the groups identification ("A", "B", etc.) as indicated in paragraphs 4.1.1 to 4.1.12 of this guideline;

.4 one Column for the group descriptions as indicated in paragraphs 4.1.1 to 4.1.12 of this guideline;

.5 one column each for items in paragraphs 4.2 to 4.14 of this guideline (e.g. "load tag", etc.);

.6 one row dedicated to each individual load;

.7 the summation results (i.e. summation of powers) including data from paragraphs 4.15 to 4.16 of this guideline; and

.8 explanatory notes.

An example of an Electric Power Table for EEDI for a cruise postal vessel which transports passenger and have a car garage and reefer holds for fish trade transportation is indicated below. The data indicated and the type of ship is for reference only.

ELECTRIC POWER TABLE FOR EEDI HULL "EXAMPLE" PROJECT "EXAMPLE" (NMSL=Normal Maximun Sea Load)

id	Load group	Load description	Load identification tag	Load electric circuit Identification	Load mechanical rated power *"Pm" [kW]*	Load electric motor rated output power *[kW]*	Load electric motor efficiency *"e" [/]*	Load Rated electric power *"Pr" [kW]*	service factor of load *"kl" [/]*	service factor of duty *"kd" [/]*	service factor of time *"kt" [/]*	service total factor of use *"ku" [/]*	Load necessary power *"Pload" [kW]*	Note
1	A	Hull cathodic protection Fwd	xxx	yyy	n.a.	n.a.	n.a.	5.2	1	1	1*	1	5.2	*in use 24hours/day
2	A	Hull cathodic protection mid	xxx	yyy	n.a.	n.a.	n.a.	7.0	1	1	1*	1	7	*in use 24hours/day
3	A	Hull cathodic protection aft	xxx	yyy	n.a.	n.a.	n.a.	4.8	1	1	1*	1	4.8	*in use 24hours/day
4	A	Ballast pump 3	xxx	yyy	30	36	0.92	32.6	0.9	0.5	1	0*	0	*not in use at **NMSL** see para 2.5.6 of Circ.681
5	A	Fwd Stb mooring winch motor n.1	xxx	yyy	90	150	0.92	97.8	0.8	1	0*	0*	0	*not in use at **NMSL** see para 2.5.6 of Circ.681
6	A	WTDs system main control panel	xxx	yyy	n.a.	n.a.	n.a.	0.5	1	1	1*	1	0.5	*in use 24hours/day
7	A	WTD 1, deck D frame 150	xxx	yyy	1.2	3	0.91	1.3	0.7	1	0.104*	0.0728	0.096	*180 secs to open/close x 100 opening a day
8	A	WTD 5, deck D frame 210	xxx	yyy	1.2	3	0.91	1.3	0.7	1	0.156*	0.1092	0.14	*180 secs to open/close x 150 opening a day
9	A	Stabilisers control unit	xxx	yyy	n.a.	n.a.	n.a.	0.7	1	1	1*	1	0.7	*in use 24hours/day
10	A	Stabilisers Hydraulic pack power pump 1	xxx	yyy	80	90	0.9	88.9	0.9	1	0*	0	0	*NMSL=> calm sea,=> stabiliser not in use
11	A	S-band Radar 1 controller	xxx	yyy	n.a.	n.a.	n.a.	0.4	1	1	1*	1	0.4	*in use 24hours/day
12	A	S-band Radar 1 motor	xxx	yyy	0.8	1	0.92	0.9	1	1	1*	1	0.9	*in use 24hours/day
13	A	Fire detection system bridge main unit	xxx	yyy	n.a.	n.a.	n.a.	1.5	1	1	1*	1	1.5	*in use 24hours/day
14	A	Fire detection system ECR unit	xxx	yyy	n.a.	n.a.	n.a.	0.9	1	1	1*	1	0.9	*in use 24hours/day
15	A	High pressure water fog contol unit	xxx	yyy	n.a.	n.a.	n.a.	1.2	1	1	1*	1	1.2	*in use 24hours/day
16	A	High pressure water fog engines rooms pump 1a	xxx	yyy	25	30	0.93	26.9	0.9	0.5	0*	0	0	*NMSL=> not emergency =>Load not in use
17	A	High pressure water fog engines rooms pump 1b	xxx	yyy	25	30	0.93	26.9	0.9	0.5	0*	0	0	* not emergency situations
18	B	PTi port fresh water pump 1	xxx	yyy	30	36	0.92	32.6	0.9	0.5*	1	0.45	14.7	* pump1,2 one is duty and one is stand-by
19	B	PTi port fresh water pump 2	xxx	yyy	30	36	0.92	32.6	0.9	0.5*	1	0.45	14.7	* pump1,2 one is duty and one is stand-by
20	B	Thrusters control system	xxx	yyy	n.a.	n.a.	n.a.	0.5	1	1	1*	1	0.5	in use 24hours/day (even if thruster motor isn't)
21	B	Bow thruster 1	xxx	yyy	3000	3000	0.96	3125.0	1	1	0*	0	0	*NMSL=>thrusters motor are not in use
22	B	PEM port cooling fan 1	xxx	yyy	20	25	0.93	21.5	0.9	1	n.a.	n.a	n.a.*	*this load is included in the propulsion chain data
23	C	HT circulation pump 1 DG 3	xxx	yyy	8	10	0.92	8.7	0.9	0.5*	1	0.45	3.9	* pump1,2 one is duty and one is stand-by
24	C	HT circulation pump 2 DG 3	xxx	yyy	8	10	0.92	8.7	0.9	0.5*	1	0.45	3.9	* pump1,2 one is duty and one is stand-by
25	C	DG3 combustion air fan	xxx	yyy	28	35	0.92	30.4	0.9	1	1*	0.9	27.4	*in use 24hours/day
26	C	DG3 exhaust gas boiler circulationg pump	xxx	yyy	6	8	0.93	6.5	0.8	1	1*	0.8	5.2	*in use 24hours/day
27	C	Alternator 3 external cooling fan	xxx	yyy	3	5	0.93	3.2	0.8	1	1*	0.8	2.75	*in use 24hours/day
28	C	fuel feed fwd booster pump a	xxx	yyy	7	9	0.92	7.6	0.9	0.5*	1	0.45	3.4	* pump1,2 one is duty and one is stand-by
29	C	fuel feed fwd booster pump b	xxx	yyy	7	9	0.92	7.6	0.9	0.5*	1	0.45	3.4	* pump1,2 one is duty and one is stand-by
30	D	Fwd main LT cooling pump 1	xxx	yyy	120	150	0.95	126.3	0.9	0.5*	1	0.45	56.8	* pump1,2 one is duty and one is stand-by
31	D	Fwd main LT cooling pump 2	xxx	yyy	120	150	0.95	126.3	0.9	0.5*	1	0.45	56.8	* pump1,2 one is duty and one is stand-by
32	E	FWD engine room supply fan 1	xxx	yyy	87.8	110	0.93	94.4	0.95	1	1*	0.95	89.7	*in use 24hours/day
33	E	FWD engine room exhaust fan 1	xxx	yyy	75	86	0.93	80.6	0.96	1	1*	0.96	77.4	*in use 24hours/day
34	E	purifier room supply fan 1	xxx	yyy	60	70	0.93	64.5	0.96	0.5	1*	0.48	31.0	*in use 24hours/day
35	E	purifier room supply fan 2	xxx	yyy	60	70	0.93	64.5	0.96	0.5	1*	0.48	31.0	*in use 24hours/day
36	F	HVAC chiller a	xxx	yyy	1450	1600	0.95	1526.3	1	2/3*	1	0.66	1007.4	*1 Chiller is spare; see heat load dissipation doc.
37	F	HVAC chiller b	xxx	yyy	1450	1600	0.95	1526.3	1	2/3*	1	0.66	1007.4	*1 Chiller is spare; see heat load dissipation doc.
38	F	HVAC chiller C	xxx	yyy	1450	1600	0.95	1526.3	1	2/3*	1	0.66	1007.4	*1 Chiller is spare; see heat load dissipation doc.
39	F	A.H.U. Ac station 5.4 supply fan	xxx	yyy	50	60	0.93	53.8	0.9	1	1*	0.9	48.4	*in use 24hours/day
40	F	A.H.U. Ac station 5.4 exhaust fan	xxx	yyy	45	55	0.93	48.4	0.9	1	1*	0.9	43.5	*in use 24hours/day
41	F	Chilled water pump a	xxx	yyy	80	90	0.93	86.0	0.88	0.5*	1	0.44	37.8	* pump1,2 one is duty and one is stand-by
42	F	Chilled water pump b	xxx	yyy	80	90	0.93	86.0	0.88	0.5*	1	0.44	37.8	* pump1,2 one is duty and one is stand-by
43	G	Italian's espresso coffee machine	xxx	yyy	n.a.	n.a.	n.a.	7.0	0.9	1	0.2*	0.18	1.3	*in use 4.8hours/day
44	G	deep freezer machine	xxx	yyy	n.a.	n.a.	n.a.	20.0	0.8	1	0.16*	0.128	3.2	*in use 4hours/day
45	G	washing machine 1	xxx	yyy	n.a.	n.a.	n.a.	8.0	0.8	1	0.33*	0.264	3.2	*in use 8hours/day
46	H	lift pax mid 4	xxx	yyy	30	40	0.93	32.3	0.5	1	0.175*	0.0875	0.9	*in use 4hours/day
47	H	vaccum collecting system 4 pump a	xxx	yyy	10	13	0.92	10.9	0.9	1	1*	0.9	8.7	*in use 24hours/day
48	H	sewage treatmet system 1 pump 1	xxx	yyy	15	17	0.93	16.1	0.9	1	1*	0.9	8.7	*in use 24hours/day
49	H	Gym running machine	xxx	yyy	n.a.	n.a.	n.a.	2.5	1	1	0.3*	0.3	0.8	*in use 7.2hours/day
50	I	Cabin's lighting MVZ3	n.a.	n.a.	n.a.	n.a.	n.a.	80*	1	1	1	1	80.0	* see explainatory note
51	I	corridors ligthing MVZ3	n.a.	n.a.	n.a.	n.a.	n.a.	10*	1	1	1	1	10.0	* see explainatory note
52	I	Cabin's sockets MVZ3	n.a.	n.a.	n.a.	n.a.	n.a.	5*	1	1	1	1	5.0	* see explainatory note
53	L	Main Theatre audio booster amplifier	xxx	yyy	n.a.	n.a.	n.a.	15.0	1	1	0.3*	0.3	4.5	*in use 7.2hours/day
54	L	Video wall atrium	xxx	yyy	n.a.	n.a.	n.a.	2.0	1	1	0.3*	0.3	0.6	*in use 7.2hours/day
55	M	Car Garage supply fan1	xxx	yyy	28	35	0.92	30.4	0.9	1	1*	0*	0	*not in use at **NMSL** see para 2.5.6 of Circ.681
56	M	Fish transportation refeer hold n.2	xxx	yyy	25	30	0.93	26.9	0.9	0.5	0*	0*	0	*not in use at **NMSL** see para 2.5.6 of Circ.681
57	N	Sliding glass roof	xxx	yyy	30	40	0.93	32.3	0.9	1	0.3*	0.27	0.2	*in use 7.2hours/day
											ΣPload(i)=		**3764**	

***PAE* =3764/(weighted average efficiency of generator(s)) [kW]** Group's necessary power (group A=22.9kW, B=29.8kW,C=49.9kW, D=113.7kW, E=229kW , F=3189kW, G=7.6kW, H=19kW, I=95kW, L=5.1kW, M=0kW, N=0.22kW)

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ANNEX 14

RESOLUTION MEPC. 231(65)

Adopted on 17 May 2013

2013 GUIDELINES FOR CALCULATION OF REFERENCE LINES FOR USE WITH THE ENERGY EFFICIENCY DESIGN INDEX (EEDI)

THE MARINE ENVIRONMENT PROTECTION COMMITTEE,

RECALLING Article 38(a) of the Convention on the International Maritime Organization concerning the functions of the Marine Environment Protection Committee (the Committee) conferred upon it by international conventions for the prevention and control of marine pollution,

RECALLING ALSO that, at its sixty-second session, the Committee adopted, by resolution MEPC.203(62), 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 (inclusion of regulations on energy efficiency for ships in MARPOL Annex VI),

NOTING that regulation 21 (required EEDI) of MARPOL Annex VI, as amended, requires reference lines to be established for each ship type to which regulation 21 is applicable,

NOTING ALSO that Guidelines for calculation of reference lines for use with the Energy Efficiency Design Index (EEDI) were adopted at its sixty-third session,

HAVING CONSIDERED, at its sixty-fifth session, the draft amendments to Guidelines for calculation of reference lines for use with the Energy Efficiency Design Index (EEDI) for extension of the application of the EEDI to LNG carrier, ro-ro cargo ship (vehicle carrier), ro-ro cargo ship and ro-ro passenger ship,

1. ADOPTS the *2013 Guidelines for calculation of reference lines for use with the Energy Efficiency Design Index (EEDI)*, as set out at annex to the present resolution;

2. AGREES to keep these Guidelines under review in light of the experience gained; and

3. REVOKES the Guidelines for calculation of reference lines for use with the Energy Efficiency Design Index (EEDI), adopted by resolution MEPC.215(63), as from this date.

2013 GUIDELINES FOR CALCULATION OF REFERENCE LINES FOR USE WITH THE ENERGY EFFICIENCY DESIGN INDEX (EEDI)

1 The reference lines are established for each ship type to which regulation 21 (Required EEDI) of MARPOL Annex VI is applicable. The purpose of the EEDI is to provide a fair basis for comparison, to stimulate the development of more efficient ships in general and to establish the minimum efficiency of new ships depending on ship type and size. Hence, the reference lines for each ship type is calculated in a transparent and robust manner.

2 Ship types are defined in regulation 2 of MARPOL Annex VI. The reference line for each ship type is used for the determination of the required EEDI as defined in regulation 21 of MARPOL Annex VI.

3 These guidelines apply to the following ships types: bulk carrier, gas carrier, tanker, containership, general cargo ship, refrigerated cargo carrier, combination carrier, ro-ro cargo ship, ro-ro cargo ship (vehicle), ro-ro passenger ship and LNG carrier. It is noted that a method of calculating reference lines has not been established for passenger ships other than cruise passenger ship having non-conventional propulsion.

Definition of a reference line

4 A reference line is defined as a curve representing an average index value fitted on a set of individual index values for a defined group of ships.

5 One reference line is developed for each ship type to which regulation 21 of MARPOL Annex VI is applicable, ensuring that only data from comparable ships are included in the calculation of each reference line.

6 The reference line value is formulated as $\textit{Reference line value} = a\,(100\%\ \textit{deadweight})^{-c}$ where "a" and "c" are parameters determined from the regression curve fit.

7 Input data for the calculation of the reference lines is filtered through a process where data deviating more than two standard deviations from the regression line are discarded. The regression is then applied again to generate a corrected reference line. For the purpose of documentation, discarded data is listed with the ships IMO number.

Data sources

8 IHS Fairplay (IHSF) database is selected as the standard database delivering the primary input data for the reference line calculation. For the purpose of the EEDI reference line calculations, a defined version of the database is archived as agreed between the Secretariat and IHSF.

9 For the purpose of calculating the reference lines, data relating to existing ships of 400 GT and above from the IHSF database delivered in the period from 1 January 1999 to 1 January 2009 are used. For ro-ro cargo and ro-ro passenger ships, data relating to existing ships of 400 GT and above from the IHSF database delivered in the period from 1 January 1998 to 1 January 2010 are used.

10 The following data from the IHSF database on ships with conventional propulsion systems is used when calculating the reference lines:

.1 data on the ships' capacity is used as *Capacity* for each ship type as defined in MEPC.212(63);

.2 data on the ships' service speed is used as reference speed V_{ref}; and

.3 data on the ships' total installed main power is used as $MCR_{ME(i)}$.

11 For some ships, some data entries may be blank or contain a zero (0) in the database. Datasets with blank power, capacity and/or speed data should be removed from the reference line calculations. For the purpose of later references, the omitted ships should be listed with their IMO number.

12 To ensure a uniform interpretation, the association of ship types defined in regulation 2 of MARPOL Annex VI, with the ship types given by the IHSF database and defined by the so-called Stat codes, is shown in the appendix to this guideline. Table 1 in the appendix 1 lists the ship types from IHSF used for the calculation of reference lines. Table 2 lists the IHSF ship types not used when calculating the reference lines.

Calculation of reference lines

13 To calculate the reference line, an estimated index value for each ship contained in the set of ships per ship type is calculated using the following assumptions:

.1 the carbon emission factor is constant for all engines, i.e. $C_{F,ME} = C_{F,AE} = CF$ = 3.1144 g CO_2/g fuel;

.2 the specific fuel consumption for all ship types is constant for all main engines, i.e. $SFC_{ME} = 190$ g/kWh;

.3 $P_{ME(i)}$ is 75% of the total installed main power ($MCR_{ME(i)}$);

.4 the specific fuel consumption for all ship types is constant for all auxiliary engines, i.e. $SFC_{AE} = 215$ g/kWh;

.5 P_{AE} is the auxiliary power and is calculated according to paragraphs 2.5.6.1 and 2.5.6.2 of the annex to MEPC.212(63);

.6 for ro-ro passenger ships, P_{AE} is calculated as follows:

$$P_{AE} = 0.866 \cdot GT^{0.732}$$

.7 no correction factors are used except for f_{jRoRo} and f_{cRoPax}; and

.8 innovative mechanical energy efficiency technology, shaft motors and other innovative energy efficient technologies are all excluded from the reference line calculation, i.e. $P_{AEeff} = 0$, $P_{PTI} = 0$, $P_{eff} = 0$.

14 The equation for calculating the estimated index value for each ship (excluding containerships and ro-ro cargo ships (vehicle carrier) – see paragraph 15) is as follows:

$$Estimated\ \ Index\ Value = 3.1144 \cdot \frac{190 \cdot \sum_{i=1}^{NME} P_{MEi} + 215 \cdot P_{AE}}{Capacity \cdot V_{ref}}$$

15 For containerships, 70 per cent of the deadweight (70% DWT) is used as *capacity* for calculating the estimated index value for each containership as follows:

$$Estimated\ \ Index\ Value = 3.1144 \cdot \frac{190 \cdot \sum_{i=1}^{NME} P_{MEi} + 215 \cdot P_{AE}}{70\%\mathrm{DWT} \cdot V_{ref}}$$

16 For ro-ro cargo ship (vehicle carrier), the following equation is used:

$$Estimated\, Index\, Value = f_{roroV} \cdot 3.1144 \cdot \frac{190 \cdot \sum_{i=1}^{nME} P_{MEi} + 215 \cdot P_{AE}}{Capacity \cdot V_{ref}}$$

Where:

$$f_{roroV} = \frac{-15571 \cdot F_n^2 + 5538.4 \cdot F_n - 132.67}{287}$$

17 For ro-ro cargo ships the estimated index value for each individual ship is calculated as follows:

$$Estimated\, Index\, Value = \frac{3.1144 \cdot (f_{jRoRo} \cdot 190 \cdot \sum_{i=1}^{nME} P_{MEi} + 215 \cdot P_{AE}}{Capacity \cdot V_{ref}}$$

18 For ro-ro passenger ships the estimated index value for each individual ship is calculated as follows:

$$Estimated\, Index\, Value = \frac{3.1144 \cdot (\mathrm{f_{jRoRo}} \cdot 190 \cdot \sum_{i=1}^{nME} P_{MEi} + 215 \cdot P_{AE}}{f_{cRoPax} \cdot Capacity \cdot V_{ref}}$$

19 For LNG carriers, the equation set out in appendix 2 is used.

Calculation of reference line parameters "a" and "c"

20 For all ship types to which these guidelines apply except for ro-ro passenger ships, parameters "a" and "c" are determined from a regression analysis undertaken by plotting the calculated estimated index values against 100 per cent deadweight (100% DWT).

21 For ro-ro passenger ships, parameters "a" and "c" are determined from a regression analysis undertaken by plotting the calculated estimated index values against corrected deadweight, DWT, for ships to which the capacity correction factor, f_{cRoPax}, applies and against 100 per cent deadweight (100% DWT) for ships to which the capacity correction factor does not apply.

Documentation

22 For purposes of transparency, the ships used in the calculation of the reference lines should be listed with their IMO numbers and the numerator and denominator of the index formula, as given in paragraphs 14 to 19. The documentation of the aggregated figures preserves the individual data from direct access but offers sufficient information for possible later scrutiny.

* * *

Appendix 1

1 To ensure a uniform interpretation, ship types defined in regulation 2 of MARPOL Annex VI are compared to the ship types given in the IHSF database.

2 The IHSF Stat code system provides several levels of definition as follows:

.1 Highest level:

A Cargo carrying
B Work vessel
W Non-seagoing merchant ships
X Non-merchant
Y Non-propelled
Z Non-ship structures

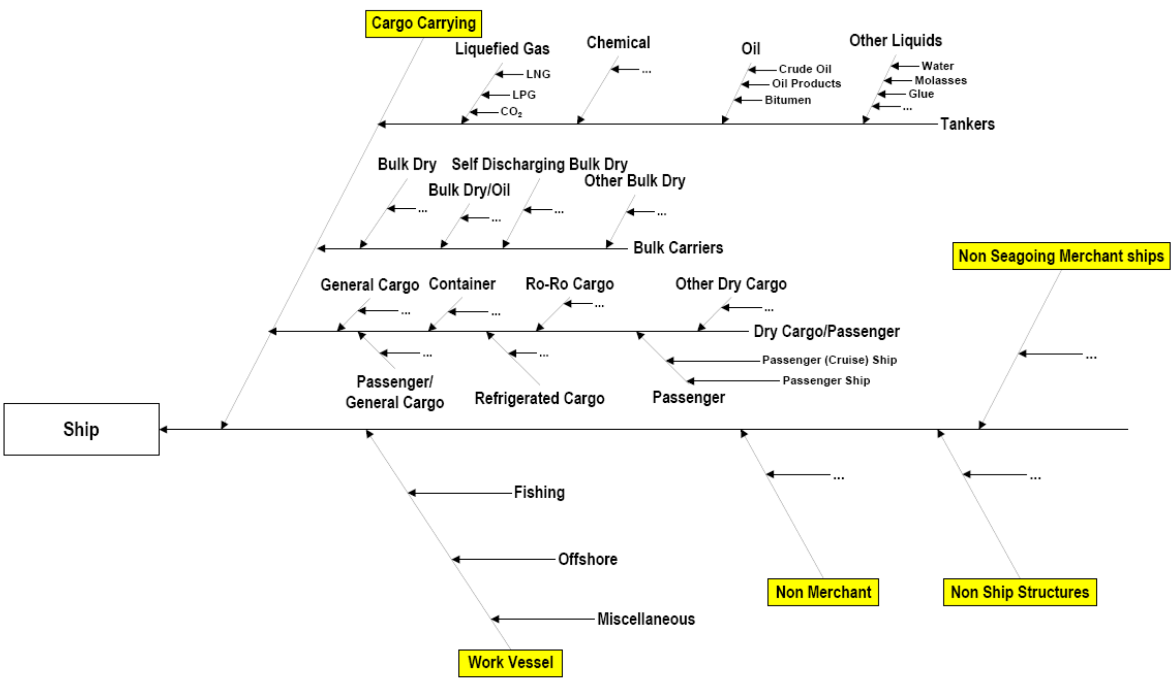
For the purpose of the EEDI, only group "A cargo carrying" needs to be considered. A graphical representation of this is given below.

.2 The next level comprises:

A1 Tankers
A2 Bulk carriers
A3 Dry cargo/passenger

There are further differentiations until level five, e.g. "A31A2GX General Cargo Ship", and each category is described.

The complete list is attached.



3 The ship types from the IHSF Stat code 5 (Statcode5v1075) used for the calculation of reference lines for the following ship types: bulk carrier, gas carrier, tanker, containership, general cargo ship, refrigerated cargo carrier and combination carrier, are set out in table 1. The IHSF database ship types, not used in the calculation of reference lines for the specific ship types, are set out in table 2, e.g. ships built for sailing on the Great Lakes and landing craft.

Table 1: Ship types from IHSF used for the calculation of reference lines for use with the EEDI

.1 Bulk carrier	Bulk dry	A21A2BC	Bulk carrier	A single deck cargo vessel with an arrangement of topside ballast tanks for the carriage of bulk dry cargo of a homogeneous nature.
	Bulk dry	A21B2BO	Ore carrier	A single deck cargo ship fitted with two longitudinal bulkheads. Ore is carried in the centreline holds only.
	Self-discharging bulk dry	A23A2BD	Bulk cargo carrier, self-discharging	A bulk carrier fitted with self-trimming holds, a conveyor belt (or similar system) and a boom which can discharge cargo alongside or to shore without the assistance of any external equipment.
	Other dry bulk	A24A2BT	Cement carrier	A single deck cargo vessel fitted with pumping arrangements for the carriage of cement in bulk. There are no weather deck hatches. May be self-discharging.
		A24B2BW	Wood chips carrier, self-unloading	A single deck cargo vessel with high freeboard for the carriage of wood chips. May be self-discharging.
		A24C2BU	Urea carrier	A single deck cargo vessel for the carriage of urea in bulk. May be self-discharging.
		A24D2BA	Aggregates carrier	A single deck cargo vessel for the carriage of aggregates in bulk. Also known as a sand carrier. May be self-discharging.
		A24E2BL	Limestone carrier	A single deck cargo vessel for the carriage of limestone in bulk. There are no weather deck hatches. May be self-discharging.
.2 Gas carrier	Liquefied gas	A11A2TN	LNG tanker	A tanker for the bulk carriage of liquefied natural gas (primarily methane) in independent insulated tanks. Liquefaction is achieved at temperatures down to -163 deg C.
		A11B2TG	LPG tanker	A tanker for the bulk carriage of liquefied petroleum gas in insulated tanks, which may be independent or integral. The cargo is pressurized (smaller vessels), refrigerated (larger vessels) or both ("semi-pressurized") to achieve liquefaction.
		A11C2LC	CO_2 tanker	A tanker for the bulk carriage of liquefied carbon dioxide.
		A11A2TQ	CNG tanker	A tanker for the bulk carriage of compressed natural gas. Cargo remains in gaseous state but is highly compressed.

.3 Tanker	Chemical	A12A2LP	Molten sulphur tanker	A tanker for the bulk carriage of molten sulphur in insulated tanks at a high temperature.
		A12A2TC	Chemical tanker	A tanker for the bulk carriage of chemical cargoes, lube oils, vegetable/animal oils and other chemicals as defined in the International Bulk Chemical Code. Tanks are coated with suitable materials which are inert to the cargo.
		A12B2TR	Chemical/ products tanker	A chemical tanker additionally capable of the carriage of clean petroleum products.
		A12C2LW	Wine tanker	A cargo ship designed for the bulk transport of wine in tanks. Tanks will be stainless steel or lined. New vessels will be classified as chemical carriers.
		A12D2LV	Vegetable oil tanker	A cargo ship designed for the bulk transport of vegetable oils in tanks. Tanks will be stainless steel or lined. New vessels will be classified as chemical carriers.
		A12E2LE	Edible oil tanker	A cargo ship designed for the bulk transport of edible oils in tanks. Tanks will be stainless steel or lined. New vessels will be classified as chemical carriers.
		A12F2LB	Beer tanker	A tanker for the bulk carriage of beer.
		A12G2LT	Latex tanker	A tanker for the bulk carriage of latex.
		A12H2LJ	Fruit juice tanker	A tanker for the bulk carriage of fruit juice concentrate in insulated tanks.
	Oil	A13A2TV	Crude oil tanker	A tanker for the bulk carriage of crude oil.
		A13A2TW	Crude/oil products tanker	A tanker for the bulk carriage of crude oil but also for carriage of refined oil products.
		A13B2TP	Products tanker	A tanker for the bulk carriage of refined petroleum products, either clean or dirty.
		A13B2TU	Tanker (unspecified)	A tanker whose cargo is unspecified.
		A13C2LA	Asphalt/ Bitumen tanker	A tanker for the bulk carriage of asphalt/bitumen at temperatures between 150 and 200 deg C.
		A13E2LD	Coal/oil mixture tanker	A tanker for the bulk carriage of a cargo of coal and oil mixed as a liquid and maintained at high temperatures.
	Other liquids	A14A2LO	Water tanker	A tanker for the bulk carriage of water.
		A14F2LM	Molasses tanker	A tanker for the bulk carriage of molasses.
		A14G2LG	Glue tanker	A tanker for the bulk carriage of glue.
		A14H2LH	Alcohol tanker	A tanker for the bulk carriage of alcohol.
		A14N2LL	Caprolactam tanker	A tanker for the bulk carriage of caprolactam, a chemical used in the plastics industry for the production of polyamides.
	Chemical	A12A2TL	Parcels tanker	A chemical tanker with many segregated cargo tanks to carry multiple grades of chemicals as defined in the International Bulk Chemical Code. Typically these can have between 10 and 60 different tanks.

.4 Containership	Container	A33A2CC	Containership (fully cellular)	A single deck cargo vessel with boxed holds fitted with fixed cellular guides for the carriage of containers.
.5 General cargo ship	General cargo	A31A2GX	General cargo ship	A single or multi-deck cargo vessel for the carriage of various types of dry cargo. Single deck vessels will typically have box-shaped holds. Cargo is loaded and unloaded through weather deck hatches.
	Other dry cargo	A38H2GU	Pulp carrier	A vessel designed for carrying paper pulp.
.6 Refrigerated cargo carrier	Refrigerated cargo	A34A2GR	Refrigerated cargo ship	A multi-deck cargo ship for the carriage of refrigerated cargo at various temperatures.
.7 Combination carrier	Bulk dry/oil	A22A2BB	Bulk/oil carrier (OBO)	A bulk carrier arranged for the alternative (but not simultaneous) carriage of crude oil.
	Bulk dry/oil	A22B2BR	Ore/oil carrier	An ore carrier arranged for the alternative (but not simultaneous) carriage of crude oil.
	Bulk dry/oil	A22A2BP	Ore/bulk/ products carrier	A bulk carrier arranged for the alternative (but not simultaneous) carriage of oil products.

Table 2: Ship types from IHSF not included in the calculation of reference lines for use with the EEDI

.1 Bulk carrier	Bulk dry	A21A2BG	Bulk carrier, laker only	A single deck cargo vessel with dimensions suited to the limitations of Great Lakes of North America trade, unsuitable for open sea navigation. Hatches are more numerous than standard bulk carriers, and much wider than they are long.
	Bulk dry	A21A2BV	Bulk carrier (with vehicle decks)	A bulk carrier with movable decks for the additional carriage of new vehicles.
	Bulk dry/oil	A22A2BB	Bulk/oil carrier (OBO)	A bulk carrier arranged for the alternative (but not simultaneous) carriage of crude oil.
	Bulk dry/oil	A22B2BR	Ore/oil carrier	An ore carrier arranged for the alternative (but not simultaneous) carriage of crude oil.
	Bulk dry/oil	A22A2BP	Ore/bulk/products carrier	A bulk carrier arranged for the alternative (but not simultaneous) carriage of oil products.
	Self-discharging bulk dry	A23A2BK	Bulk cargo carrier, self-discharging, laker	A Great Lakes bulk carrier fitted with a conveyor belt (or similar system) and a boom which can discharge cargo alongside or to shore without the assistance of any external equipment.
	Other bulk dry	A24H2BZ	Powder carrier	A single deck cargo vessel for the carriage of fine powders such as fly ash. There are no weather deck hatches.
	Other bulk dry	A24G2BS	Refined sugar carrier	A single deck cargo vessel for the carriage of refined sugar. Sugar is loaded in bulk and bagged in transit (BIBO – Bulk In – Bag Out).
.2 Gas carrier	Liquefied gas	A11B2TH	LPG/chemical tanker	An LPG tanker additionally capable of the carriage of chemical products as defined in the International Bulk Chemical Code.
.3 Tanker	Oil	A13A2TS	Shuttle tanker	A tanker for the bulk carriage of crude oil specifically for operation between offshore terminals and refineries. Is typically fitted with bow loading facilities.
.4 Containership	Container	A33B2CP	Passenger/ containership	A containership with accommodation for the carriage of more than 12 passengers.

.5 General cargo ship	General cargo	A31A2GO	Open hatch cargo ship	A large single deck cargo vessel with full width hatches and boxed holds for the carriage of unitized dry cargo such as forest products and containers. Many are fitted with a gantry crane.
	General cargo	A31A2GS	General cargo/tanker (container/oil/bulk – COB ship)	A general cargo ship with reversible hatch covers; one side is flush and the other is fitted with baffles for use with liquid cargoes. Containers can be carried on the hatch covers in dry cargo mode.
	General cargo	A31A2GT	General cargo/tanker	A general cargo ship fitted with tanks for the additional carriage of liquid cargo.
	General cargo	A31C2GD	Deck cargo ship	A vessel arranged for carrying unitized cargo on deck only. Access may be by use of a ro-ro ramp.
	Passenger/general cargo	A32A2GF	General cargo/ passenger ship	A general cargo ship with accommodation for the carriage of more than 12 passengers.
	Other dry cargo	A38A2GL	Livestock carrier	A cargo vessel arranged for the carriage of livestock.
	Other dry cargo	A38B2GB	Barge carrier	A cargo vessel arranged for the carriage of purpose built barges (lighters) loaded with cargo. Typically loading is by way of a gantry crane. Also known as Lighter Aboard SHip vessels (LASH).
	Other dry cargo	A38C3GH	Heavy load carrier, semi-submersible	A heavy load carrier which is semi-submersible for the float on loading/unloading of the cargoes.
	Other dry cargo	A38C3GY	Yacht carrier, semi-submersible	A semi-submersible heavy load carrier specifically arranged for the carriage of yachts.
	Other dry cargo	A38D2GN	Nuclear fuel carrier	A cargo vessel arranged to carry nuclear fuel in flasks.
	Other dry cargo	A38D2GZ	Nuclear fuel carrier (with ro-ro facility)	A nuclear fuel carrier which is loaded and unloaded by way of a ro-ro ramp.
	Other dry cargo	A38B3GB	Barge carrier, semi-submersible	A barge carrier which is semi-submersible for the float on loading/unloading of the barges.
	Other dry cargo	A38C2GH	Heavy load carrier	A cargo vessel able to carry heavy and/or outsized individual cargoes. Cargo may be carried on deck or in holds and may be loaded by crane and/or ro-ro ramps.

* * *

Appendix 2

EQUATION FOR CALCULATING THE INDEX VALUE OF REFERENCE LINE FOR LNG CARRIERS

	Direct Drive Diesel	Dual Fuel Diesel – Electronic (DFDE)	Steam Turbine
Margins	$Engine: 10\%$ $Sea: 20\%$	$Engine: -$ $Sea: 20\%$	$Engine: -$ $Sea: 20\%$
Design Margin	$M\arg in = \frac{0.9}{1.2}$ $M\arg in = 75\%$	$M\arg in = \frac{1}{1.2}$ $M\arg in = 83\%$	$M\arg in = \frac{1}{1.2}$ $M\arg in = 83\%$
P_{ME} Formula[1]	$P_{ME(i)} = 0.75 \cdot (MCR_{ME(i)} - P_{PTO(i)})$	$P_{ME(i)} = 0.83 \cdot \frac{MPP_{(i)}}{\eta_{Electrical(i)}}$	$P_{ME(i)} = 0.83 \cdot (MCR_{ME(i)} - P_{PTO(i)})$
SFC_{ME} in g/kWh (Fuel)	$190\ (HFO)$	$175\ (FBO)$	$285\ (FBO)$
P_{AE} Formula[2]	$P_{AE} = 0.025 \cdot \sum_{i=1}^{nME} MCR_{ME(i)} + 250 + Capacity \cdot BOR \cdot 15$	$P_{AE} = (0.025 + 0.02) \cdot \sum_{i=1}^{nME} P_{ME(i)} + 250$	$P_{AE} = 0$
Index Formulae	$3.1144 \cdot \frac{190 \cdot \sum_{i=1}^{nME} P_{ME(i)} + 215 \cdot P_{AE}}{Capacity \cdot V_{ref}}$	$2.75 \cdot \frac{175 \cdot \sum_{i=1}^{nME} P_{ME(i)} + 175 \cdot P_{AE}}{Capacity \cdot V_{ref}}$	$2.75 \cdot \frac{285 \cdot \sum_{i=1}^{nME} P_{ME(i)}}{Capacity \cdot V_{ref}}$

NOTES:

1. $MPP_{(i)}$ of DFDE is calculated as 66% of MCR of engines.
2. BOR of Direct Drive Diesel is 0.15 (%/day).

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ANNEX 19

RESOLUTION MEPC.203(62)

Adopted on 15 July 2011

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

(Inclusion of regulations on energy efficiency for ships in MARPOL Annex VI)

THE MARINE ENVIRONMENT PROTECTION COMMITTEE,

RECALLING Article 38(a) of the Convention on the International Maritime Organization concerning the functions of the Marine Environment Protection Committee (the Committee) conferred upon it by international conventions for the prevention and control of marine pollution,

NOTING article 16 of the International Convention for the Prevention of Pollution from Ships, 1973 (hereinafter referred to as the "1973 Convention"), article VI of the Protocol of 1978 relating to the International Convention for the Prevention of Pollution from Ships, 1973 (hereinafter referred to as the "1978 Protocol") and article 4 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 (hereinafter referred to as the "1997 Protocol"), which together specify the amendment procedure of the 1997 Protocol and confer upon the appropriate body of the Organization the function of considering and adopting amendments to the 1973 Convention, as modified by the 1978 and 1997 Protocols,

NOTING ALSO that, by the 1997 Protocol, Annex VI entitled Regulations for the Prevention of Air Pollution from Ships was added to the 1973 Convention (hereinafter referred to as "Annex VI"),

NOTING FURTHER that the revised Annex VI was adopted by resolution MEPC.176(58) and entered into force on 1 July 2010,

RECOGNIZING that the amendments to Annex VI and inclusion of a new chapter 4 intend to improve energy efficiency for ships through a set of technical performance standards, which would result in reduction of emissions of any substances that originate from fuel oil and its combustion process, including those already controlled by Annex VI,

RECOGNIZING ALSO that adoption of the amendments to Annex VI in no way prejudges the negotiations held in other international fora, such as the United Nations Framework Convention on Climate Change (UNFCCC), nor affect the positions of the countries that participate in such negotiation,

HAVING CONSIDERED draft amendments to the revised Annex VI for inclusion of regulations on energy efficiency for ships,

1. ADOPTS, in accordance with article 16(2)(d) of the 1973 Convention, the amendments to Annex VI, the text of which is set out in the annex to the present resolution;

2. DETERMINES, in accordance with article 16(2)(f)(iii) of the 1973 Convention, that the amendments shall be deemed to have been accepted on 1 July 2012, unless prior to that date, not less than one third of the Parties or Parties the combined merchant fleets of which constitute not less than 50 per cent of the gross tonnage of the world's merchant fleet, have communicated to the Organization their objection to the amendments;

3. INVITES the Parties to note that, in accordance with article 16(2)(g)(ii) of the 1973 Convention, the said amendments shall enter into force on 1 January 2013 upon their acceptance in accordance with paragraph 2 above;

4. REQUESTS the Secretary-General, in conformity with article 16(2)(e) of the 1973 Convention, to transmit to all Parties to the 1973 Convention, as modified by the 1978 and 1997 Protocols, certified copies of the present resolution and the text of the amendments contained in the Annex;

5. REQUESTS FURTHER the Secretary-General to transmit to the Members of the Organization which are not Parties to the 1973 Convention, as modified by the 1978 and 1997 Protocols, copies of the present resolution and its Annex; and

6. INVITES the Parties to MARPOL Annex VI and other Member Governments to bring the amendments to MARPOL Annex VI to the attention of shipowners, ship operators, shipbuilders, ship designers, marine diesel engine and equipment manufacturers as well as any other interested groups.

ANNEX

AMENDMENTS TO MARPOL ANNEX VI ON REGULATIONS FOR THE PREVENTION OF AIR POLLUTION FROM SHIPS BY INCLUSION OF NEW REGULATIONS ON ENERGY EFFICIENCY FOR SHIPS

CHAPTER 1

GENERAL

Regulation 1

Application

1 The regulation is amended as follows:

"The provisions of this Annex shall apply to all ships, except where expressly provided otherwise in regulations 3, 5, 6, 13, 15, 16, 18, 19, 20, 21, 22 and 23 of this Annex."

Regulation 2

Definitions

2 Paragraph 21 is amended as follows:

"21 *Tanker* in relation to regulation 15 means an oil tanker as defined in regulation 1 of Annex I or a chemical tanker as defined in regulation 1 of Annex II of the present Convention."

3 The following is added at the end of regulation 2:

"For the purpose of chapter 4:

22 "Existing ship" means a ship which is not a new ship.

23 "New ship" means a ship:

.1 for which the building contract is placed on or after 1 January 2013; or

.2 in the absence of a building contract, the keel of which is laid or which is at a similar stage of construction on or after 1 July 2013; or

.3 the delivery of which is on or after 1 July 2015.

24 "Major Conversion" means in relation to chapter 4 a conversion of a ship:

.1 which substantially alters the dimensions, carrying capacity or engine power of the ship; or

.2 which changes the type of the ship; or

.3 the intent of which in the opinion of the Administration is substantially to prolong the life of the ship; or

.4 which otherwise so alters the ship that, if it were a new ship, it would become subject to relevant provisions of the present Convention not applicable to it as an existing ship; or

.5 which substantially alters the energy efficiency of the ship and includes any modifications that could cause the ship to exceed the applicable required EEDI as set out in regulation 21.

25 "Bulk carrier" means a ship which is intended primarily to carry dry cargo in bulk, including such types as ore carriers as defined in SOLAS chapter XII, regulation 1, but excluding combination carriers.

26 "Gas carrier" means a cargo ship constructed or adapted and used for the carriage in bulk of any liquefied gas.

27 "Tanker" in relation to chapter 4 means an oil tanker as defined in MARPOL Annex I, regulation 1 or a chemical tanker or an NLS tanker as defined in MARPOL Annex II, regulation 1.

28 "Container ship" means a ship designed exclusively for the carriage of containers in holds and on deck.

29 "General cargo ship" means a ship with a multi-deck or single deck hull designed primarily for the carriage of general cargo. This definition excludes specialized dry cargo ships, which are not included in the calculation of reference lines for general cargo ships, namely livestock carrier, barge carrier, heavy load carrier, yacht carrier, nuclear fuel carrier.

30 "Refrigerated cargo carrier" means a ship designed exclusively for the carriage of refrigerated cargoes in holds.

31 "Combination carrier" means a ship designed to load 100% deadweight with both liquid and dry cargo in bulk.

32 "Passenger ship" means a ship which carries more than 12 passengers.

33 "Ro-ro cargo ship (vehicle carrier)" means a multi deck roll-on-roll-off cargo ship designed for the carriage of empty cars and trucks.

34 "Ro-ro cargo ship" means a ship designed for the carriage of roll-on-roll-off cargo transportation units.

35 "Ro-ro passenger ship" means a passenger ship with roll-on-roll-off cargo spaces.

36 "Attained EEDI" is the EEDI value achieved by an individual ship in accordance with regulation 20 of chapter 4.

37 "Required EEDI" is the maximum value of attained EEDI that is allowed by regulation 21 of chapter 4 for the specific ship type and size."

CHAPTER 2

SURVEY, CERTIFICATION AND MEANS OF CONTROL

Regulation 5

Surveys

4 Paragraph 1 is amended as follows:

"1 Every ship of 400 gross tonnage and above and every fixed and floating drilling rig and other platforms shall to ensure compliance with chapter 3 be subject to the surveys specified below:

.1 An initial survey before the ship is put into service or before the certificate required under regulation 6 of this Annex is issued for the first time. This survey shall be such as to ensure that the equipment, systems, fittings, arrangements and material fully comply with the applicable requirements of chapter 3;

.2 A renewal survey at intervals specified by the Administration, but not exceeding five years, except where regulation 9.2, 9.5, 9.6 or 9.7 of this Annex is applicable. The renewal survey shall be such as to ensure that the equipment, systems, fittings, arrangements and material fully comply with applicable requirements of chapter 3;

.3 An intermediate survey within three months before or after the second anniversary date or within three months before or after the third anniversary date of the certificate which shall take the place of one of the annual surveys specified in paragraph 1.4 of this regulation. The intermediate survey shall be such as to ensure that the equipment and arrangements fully comply with the applicable requirements of chapter 3 and are in good working order. Such intermediate surveys shall be endorsed on the IAPP Certificate issued under regulation 6 or 7 of this Annex;

.4 An annual survey within three months before or after each anniversary date of the certificate, including a general inspection of the equipment, systems, fittings, arrangements and material referred to in paragraph 1.1 of this regulation to ensure that they have been maintained in accordance with paragraph 5 of this regulation and that they remain satisfactory for the service for which the ship is intended. Such annual surveys shall be endorsed on the IAPP Certificate issued under regulation 6 or 7 of this Annex; and

.5 An additional survey either general or partial, according to the circumstances, shall be made whenever any important repairs or renewals are made as prescribed in paragraph 5 of this regulation or after a repair resulting from investigations prescribed in paragraph 6 of this regulation. The survey shall be such as to ensure that the necessary repairs or renewals have been effectively made, that the material and workmanship of such repairs or renewals are in all respects satisfactory and that the ship complies in all respects with the requirements of chapter 3."

5 Paragraph 2 is amended as follows:

"2 In the case of ships of less than 400 gross tonnage, the Administration may establish appropriate measures in order to ensure that the applicable provisions of chapter 3 are complied with."

6 A new paragraph 4 is added after existing paragraph 3 as follows:

"4 Ships to which chapter 4 applies shall also be subject to the surveys specified below, taking into account Guidelines adopted by the Organization[1]:

.1 An initial survey before a new ship is put in service and before the International Energy Efficiency Certificate is issued. The survey shall verify that the ship's attained EEDI is in accordance with the requirements in chapter 4, and that the SEEMP required by regulation 22 is on board;

.2 A general or partial survey, according to the circumstances, after a major conversion of a ship to which this regulation applies. The survey shall ensure that the attained EEDI is recalculated as necessary and meets the requirement of regulation 21, with the reduction factor applicable to the ship type and size of the converted ship in the phase corresponding to the date of contract or keel laying or delivery determined for the original ship in accordance with regulation 2.23;

.3 In cases where the major conversion of a new or existing ship is so extensive that the ship is regarded by the Administration as a newly constructed ship, the Administration shall determine the necessity of an initial survey on attained EEDI. Such a survey, if determined necessary, shall ensure that the attained EEDI is calculated and meets the requirement of regulation 21, with the reduction factor applicable corresponding to the ship type and size of the converted ship at the date of the contract of the conversion, or in the absence of a contract, the commencement date of the conversion. The survey shall also verify that the SEEMP required by regulation 22 is on board; and

.4 For existing ships, the verification of the requirement to have a SEEMP on board according to regulation 22 shall take place at the first intermediate or renewal survey identified in paragraph 1 of this regulation, whichever is the first, on or after 1 January 2013."

1 Refer to Guidelines on Survey and Certification of the Energy Efficiency Design Index.

7 Paragraph 4 is renumbered paragraph 5.

8 Paragraph 5 is renumbered paragraph 6.

Regulation 6

Issue or endorsement of a Certificate

9 The heading is amended as follows:

"***Issue or endorsement of Certificates***"

10 The following sub-heading is added at the beginning of the regulation:

"International Air Pollution Prevention Certificate"

11 Paragraph 2 is amended as follows:

"2 A ship constructed before the date Annex VI enters into force for that particular ship's Administration, shall be issued with an International Air Pollution Prevention Certificate in accordance with paragraph 1 of this regulation no later than the first scheduled dry-docking after the date of such entry into force, but in no case later than three years after this date."

12 The following is added at the end of the regulation:

"International Energy Efficiency Certificate

4 An International Energy Efficiency Certificate for the ship shall be issued after a survey in accordance with the provisions of regulation 5.4 to any ship of 400 gross tonnage and above before that ship may engage in voyages to ports or offshore terminals under the jurisdiction of other Parties.

5 The certificate shall be issued or endorsed either by the Administration or any organization duly authorized by it[2]. In every case, the Administration assumes full responsibility for the certificate."

Regulation 7

Issue of a Certificate by another Party

13 Paragraph 1 is amended as follows:

"1 A Party may, at the request of the Administration, cause a ship to be surveyed and, if satisfied that the applicable provisions of this Annex are complied with, shall issue or authorize the issuance of an International Air Pollution Prevention Certificate or an International Energy Efficiency Certificate to the ship,

2 Refer to the Guidelines for the authorization of organizations acting on behalf of the Administration, adopted by the Organization by resolution A.739(18), as may be amended by the Organization, and the Specifications on the survey and certification functions of recognized organizations acting on behalf of the Administration, adopted by the Organization by resolution A.789(19), as may be amended by the Organization.

and where appropriate, endorse or authorize the endorsement of such certificates on the ship, in accordance with this Annex."

14 Paragraph 4 is amended as follows:

"4 No International Air Pollution Prevention Certificate or International Energy Efficiency Certificate shall be issued to a ship which is entitled to fly the flag of a State which is not a Party."

Regulation 8

Form of Certificate

15 The heading is amended as follows:

"***Form of Certificates***"

16 The following subheading is added, and the existing regulation is renumbered as paragraph 1:

"International Air Pollution Prevention Certificate"

17 The following new paragraph 2 is added at the end of the regulation:

"International Energy Efficiency Certificate

2 The International Energy Efficiency Certificate shall be drawn up in a form corresponding to the model given in appendix VIII to this Annex and shall be at least in English, French or Spanish. If an official language of the issuing Party is also used, this shall prevail in case of a dispute or discrepancy."

Regulation 9

Duration and Validity of Certificate

18 The heading is amended as follows:

"***Duration and Validity of Certificates***"

19 The following subheading is added at the beginning of the regulation:

"International Air Pollution Prevention Certificate"

20 The following is added at the end of the regulation:

"International Energy Efficiency Certificate

10 The International Energy Efficiency Certificate shall be valid throughout the life of the ship subject to the provisions of paragraph 11 below.

11 An International Energy Efficiency Certificate issued under this Annex shall cease to be valid in any of the following cases:

.1 if the ship is withdrawn from service or if a new certificate is issued following major conversion of the ship; or

.2 upon transfer of the ship to the flag of another State. A new certificate shall only be issued when the Government issuing the new certificate is fully satisfied that the ship is in compliance with the requirements of chapter 4. In the case of a transfer between Parties, if requested within three months after the transfer has taken place, the Government of the Party whose flag the ship was formerly entitled to fly shall, as soon as possible, transmit to the Administration copies of the certificate carried by the ship before the transfer and, if available, copies of the relevant survey reports."

Regulation 10

Port State Control on Operational Requirements

21 A new paragraph 5 is added at the end of the regulation as follows:

"5 In relation to chapter 4, any port State inspection shall be limited to verifying, when appropriate, that there is a valid International Energy Efficiency Certificate on board, in accordance with article 5 of the Convention."

22 A new chapter 4 is added at the end of the Annex as follows:

"CHAPTER 4

REGULATIONS ON ENERGY EFFICIENCY FOR SHIPS

Regulation 19

Application

1 This chapter shall apply to all ships of 400 gross tonnage and above.

2 The provisions of this chapter shall not apply to:

.1 ships solely engaged in voyages within waters subject to the sovereignty or jurisdiction of the State the flag of which the ship is entitled to fly. However, each Party should ensure, by the adoption of appropriate measures, that such ships are constructed and act in a manner consistent with chapter 4, so far as is reasonable and practicable.

3 Regulation 20 and regulation 21 shall not apply to ships which have diesel-electric propulsion, turbine propulsion or hybrid propulsion systems.

4 Notwithstanding the provisions of paragraph 1 of this regulation, the Administration may waive the requirement for a ship of 400 gross tonnage and above from complying with regulation 20 and regulation 21.

5 The provision of paragraph 4 of this regulation shall not apply to ships of 400 gross tonnage and above:

.1 for which the building contract is placed on or after 1 January 2017; or

.2 in the absence of a building contract, the keel of which is laid or which is at a similar stage of construction on or after 1 July 2017; or

.3 the delivery of which is on or after 1 July 2019; or

.4 in cases of a major conversion of a new or existing ship, as defined in regulation 2.24, on or after 1 January 2017, and in which regulation 5.4.2 and regulation 5.4.3 of chapter 2 apply.

6 The Administration of a Party to the present Convention which allows application of paragraph 4, or suspends, withdraws or declines the application of that paragraph, to a ship entitled to fly its flag shall forthwith communicate to the Organization for circulation to the Parties to the present Protocol particulars thereof, for their information.

Regulation 20

Attained Energy Efficiency Design Index (Attained EEDI)

1 The attained EEDI shall be calculated for:

.1 each new ship;

.2 each new ship which has undergone a major conversion; and

.3 each new or existing ship which has undergone a major conversion, that is so extensive that the ship is regarded by the Administration as a newly constructed ship

which falls into one or more of the categories in regulations 2.25 to 2.35. The attained EEDI shall be specific to each ship and shall indicate the estimated performance of the ship in terms of energy efficiency, and be accompanied by the EEDI technical file that contains the information necessary for the calculation of the attained EEDI and that shows the process of calculation. The attained EEDI shall be verified, based on the EEDI technical file, either by the Administration or by any organization[3] duly authorized by it.

2 The attained EEDI shall be calculated taking into account guidelines[4] developed by the Organization.

[3] Refer to the Guidelines for the authorization of organizations acting on behalf of the Administration, adopted by the Organization by resolution A.739(18), as may be amended by the Organization, and the Specifications on the survey and certification functions of recognized organizations acting on behalf of the Administration, adopted by the Organization by resolution A.789(19), as may be amended by the Organization.

[4] Guidelines on the method of calculation of the Energy Efficiency Design Index for new ships.

Regulation 21

Required EEDI

1 For each:

.1 new ship;

.2 new ship which has undergone a major conversion; and

.3 new or existing ship which has undergone a major conversion that is so extensive that the ship is regarded by the Administration as a newly constructed ship

which falls into one of the categories defined in regulation 2.25 to 2.31 and to which this chapter is applicable, the attained EEDI shall be as follows:

Attained EEDI ≦ Required EEDI = (1-X/100) × Reference line value

where X is the reduction factor specified in Table 1 for the required EEDI compared to the EEDI Reference line.

2 For each new and existing ship that has undergone a major conversion which is so extensive that the ship is regarded by the Administration as a newly constructed ship, the attained EEDI shall be calculated and meet the requirement of paragraph 21.1 with the reduction factor applicable corresponding to the ship type and size of the converted ship at the date of the contract of the conversion, or in the absence of a contract, the commencement date of the conversion.

Table 1. Reduction factors (in percentage) for the EEDI relative to the EEDI Reference line

Ship Type	Size	Phase 0 1 Jan 2013 – 31 Dec 2014	Phase 1 1 Jan 2015 – 31 Dec 2019	Phase 2 1 Jan 2020 – 31 Dec 2024	Phase 3 1 Jan 2025 and onwards
Bulk carrier	20,000 DWT and above	0	10	20	30
	10,000 – 20,000 DWT	n/a	0-10*	0-20*	0-30*
Gas carrier	10,000 DWT and above	0	10	20	30
	2,000 – 10,000 DWT	n/a	0-10*	0-20*	0-30*
Tanker	20,000 DWT and above	0	10	20	30
	4,000 – 20,000 DWT	n/a	0-10*	0-20*	0-30*
Container ship	15,000 DWT and above	0	10	20	30
	10,000 – 15,000 DWT	n/a	0-10*	0-20*	0-30*

Ship Type	Size	Phase 0 1 Jan 2013 – 31 Dec 2014	Phase 1 1 Jan 2015 – 31 Dec 2019	Phase 2 1 Jan 2020 – 31 Dec 2024	Phase 3 1 Jan 2025 and onwards
General Cargo ships	15,000 DWT and above	0	10	15	30
	3,000 – 15,000 DWT	n/a	0-10*	0-15*	0-30*
Refrigerated cargo carrier	5,000 DWT and above	0	10	15	30
	3,000 – 5,000 DWT	n/a	0-10*	0-15*	0-30*
Combination carrier	20,000 DWT and above	0	10	20	30
	4,000 – 20,000 DWT	n/a	0-10*	0-20*	0-30*

* Reduction factor to be linearly interpolated between the two values dependent upon vessel size. The lower value of the reduction factor is to be applied to the smaller ship size.

n/a means that no required EEDI applies.

3 The Reference line values shall be calculated as follows:

Reference line value = $a \times b^{-c}$

where a, b and c are the parameters given in Table 2.

Table 2. Parameters for determination of reference values for the different ship types

Ship type defined in regulation 2	**a**	**b**	**c**
2.25 Bulk carrier	961.79	DWT of the ship	0.477
2.26 Gas carrier	1120.00	DWT of the ship	0.456
2.27 Tanker	1218.80	DWT of the ship	0.488
2.28 Container ship	174.22	DWT of the ship	0.201
2.29 General cargo ship	107.48	DWT of the ship	0.216
2.30 Refrigerated cargo carrier	227.01	DWT of the ship	0.244
2.31 Combination carrier	1219.00	DWT of the ship	0.488

4 If the design of a ship allows it to fall into more than one of the above ship type definitions, the required EEDI for the ship shall be the most stringent (the lowest) required EEDI.

5 For each ship to which this regulation applies, the installed propulsion power shall not be less than the propulsion power needed to maintain the manoeuvrability of the ship under adverse conditions as defined in the guidelines to be developed by the Organization.

6 At the beginning of Phase 1 and at the midpoint of Phase 2, the Organization shall review the status of technological developments and, if proven necessary, amend the time periods, the EEDI reference line parameters for relevant ship types and reduction rates set out in this regulation.

Regulation 22

Ship Energy Efficiency Management Plan (SEEMP)

1 Each ship shall keep on board a ship specific Ship Energy Efficiency Management Plan (SEEMP). This may form part of the ship's Safety Management System (SMS).

2 The SEEMP shall be developed taking into account guidelines adopted by the Organization.

Regulation 23

Promotion of technical co-operation and transfer of technology relating to the improvement of energy efficiency of ships

1 Administrations shall, in co-operation with the Organization and other international bodies, promote and provide, as appropriate, support directly or through the Organization to States, especially developing States, that request technical assistance.

2 The Administration of a Party shall co-operate actively with other Parties, subject to its national laws, regulations and policies, to promote the development and transfer of technology and exchange of information to States which request technical assistance, particularly developing States, in respect of the implementation of measures to fulfil the requirements of chapter 4 of this annex, in particular regulations 19.4 to 19.6."

23 A new appendix VIII is added at the end of the Annex as follows:

"APPENDIX VIII

Form of International Energy Efficiency (IEE) Certificate

INTERNATIONAL ENERGY EFFICIENCY CERTIFICATE

Issued under the provisions of the Protocol of 1997, as amended by resolution MEPC.203(62), to amend the International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 related thereto (hereinafter referred to as "the Convention") under the authority of the Government of:

....
(Full designation of the Party)

by ....
(Full designation of the competent person or organization
authorized under the provisions of the Convention)

Particulars of ship[5]

Name of ship ....

Distinctive number or letters ....

Port of registry ....

Gross tonnage ....

IMO Number[6] ....

THIS IS TO CERTIFY:

1 That the ship has been surveyed in accordance with regulation 5.4 of Annex VI of the Convention; and

2 That the survey shows that the ship complies with the applicable requirements in regulation 20, regulation 21 and regulation 22.

Completion date of survey on which this Certificate is based: .... (dd/mm/yyyy)

Issued at ....
(Place of issue of certificate)

(dd/mm/yyyy): ....
(Date of issue) (Signature of duly authorized official issuing the certificate)

(Seal or stamp of the authority, as appropriate)

5 Alternatively, the particulars of the ship may be placed horizontally in boxes.

6 In accordance with IMO ship identification number scheme, adopted by the Organization by resolution A.600(15).

Supplement to the International Energy Efficiency Certificate (IEE Certificate)

RECORD OF CONSTRUCTION RELATING TO ENERGY EFFICIENCY

Notes:

1 This Record shall be permanently attached to the IEE Certificate. The IEE Certificate shall be available on board the ship at all times.

2 The Record shall be at least in English, French or Spanish. If an official language of the issuing Party is also used, this shall prevail in case of a dispute or discrepancy.

3 Entries in boxes shall be made by inserting either: a cross (x) for the answers "yes" and "applicable"; or a dash (-) for the answers "no" and "not applicable", as appropriate.

4 Unless otherwise stated, regulations mentioned in this Record refer to regulations in Annex VI of the Convention, and resolutions or circulars refer to those adopted by the International Maritime Organization.

1 Particulars of ship

1.1 Name of ship ....

1.2 IMO number ....

1.3 Date of building contract ....

1.4 Gross tonnage ....

1.5 Deadweight ....

1.6 Type of ship* ....

2 Propulsion system

2.1 Diesel propulsion .... ☐

2.2 Diesel-electric propulsion .... ☐

2.3 Turbine propulsion .... ☐

2.4 Hybrid propulsion .... ☐

2.5 Propulsion system other than any of the above .... ☐

* Insert ship type in accordance with definitions specified in regulation 2. Ships falling into more than one of the ship types defined in regulation 2 should be considered as being the ship type with the most stringent (the lowest) required EEDI. If ship does not fall into the ship types defined in regulation 2, insert "Ship other than any of the ship type defined in regulation 2".

3 Attained Energy Efficiency Design Index (EEDI)

3.1 The Attained EEDI in accordance with regulation 20.1 is calculated based on the information contained in the EEDI technical file which also shows the process of calculating the Attained EEDI. …. ....☐

The Attained EEDI is: .... grams-CO_2/tonne-mile

3.2 The Attained EEDI is not calculated as:

3.2.1 the ship is exempt under regulation 20.1 as it is not a new ship as defined in regulation 2.23 .... ☐

3.2.2 the type of propulsion system is exempt in accordance with regulation 19.3 …. ......☐

3.2.3 the requirement of regulation 20 is waived by the ship's Administration in accordance with regulation 19.4 .... ☐

3.2.4 the type of ship is exempt in accordance with regulation 20.1 .... ☐

4 Required EEDI

4.1 Required EEDI is: .... grams-CO_2/tonne-mile

4.2 The required EEDI is not applicable as:

4.2.1 the ship is exempt under regulation 21.1 as it is not a new ship as defined in regulation 2.23 .... ☐

4.2.2 the type of propulsion system is exempt in accordance with regulation 19.3 …. ..... ☐

4.2.3 the requirement of regulation 21 is waived by the ship's Administration in accordance with regulation 19.4 .... ☐

4.2.4 the type of ship is exempt in accordance with regulation 21.1 …............................ ☐

4.2.5 the ship's capacity is below the minimum capacity threshold in Table 1 of regulation 21.2 …. .... ☐

5 Ship Energy Efficiency Management Plan

5.1 The ship is provided with a Ship Energy Efficiency Management Plan (SEEMP) in compliance with regulation 22 .... ☐

6 EEDI technical file

6.1 The IEE Certificate is accompanied by the EEDI technical file in compliance with regulation 20.1 .... ☐

6.2 The EEDI technical file identification/verification number ....

6.3 The EEDI technical file verification date ....

THIS IS TO CERTIFY that this Record is correct in all respects.

Issued at ....
(Place of issue of the Record)

(dd/mm/yyyy): ....
(Date of issue) (Signature of duly authorized official issuing the Record)

(Seal or stamp of the authority, as appropriate)"

***