MARINE ENVIRONMENT PROTECTION COMMITTEE 81st session Agenda item 7	MEPC 81/INF.40 12 January 2024 ENGLISH ONLY Pre-session public release: ☒

REDUCTION OF GHG EMISSIONS FROM SHIPS

Review of wind statistics approach of MEPC.1/Circ.896 for verification of wind propulsion systems

Submitted by RINA and IWSA

SUMMARY

Executive summary:	This document presents additional considerations when applying wind probability as used in MEPC.1/Circ.896 for the assessment of the performance of wind assistance propulsion systems (WAPS) in EEDI and EEXI. This document contributes to the review process of the methods adopted and outlines an approach that uses adjusted wind probability derived using global wind routing studies.
Strategic direction, if applicable:	3
Output:	3.7
Action to be taken:	Paragraph 17
Related documents:	MEPC.1/Circ.896; MEPC 62/INF.34; MEPC 76/6/2, MEPC 76/6/6, MEPC 76/6/7, MEPC 76/6/8, MEPC 76/6/10, MEPC 76/7/31; MEPC 77/6 and MEPC 79/INF.21

Introduction

1 The seventy-seventh session of the Marine Environment Protection Committee (MEPC 77) approved the *2021 Guidance on treatment of innovative energy efficiency technologies for calculation and verification of the attained EEDI and EEXI* (MEPC.1/Circ.896) with updated methods to quantify the effect of wind propulsion systems, into the EEDI and EEXI.

2 The guidance includes a global wind probability dataset dating back to document MEPC 62/INF.34 (Germany) in 2013. This global wind probability approach was perceived to be too conservative as ships with wind propulsion may sail on more favourable routes and also use wind routing on oceanic crossings, which would result in better wind statistics than the global average. To this end MEPC.1/Circ.896 specifies that only 50% of wind conditions with the largest thrust generated from the wind propulsion system are to be used.

Review of MEPC.1/Circ.896

3 Following the issuance of MEPC.1/Circ.896, as outlined in document MEPC 77/6 (Comoros et al.), there was continued discussion on appropriate measures that will help align simulation and in-service results with the provisions of the Circular, including the adoption of the 50% wind statistics method. It was generally accepted that an incentive for wind propulsion is appropriate considering the favourable treatment also given to other energy saving methods (as designated in MEPC.1/Circ. 896).

4 The Working Group on Air Pollution and Energy Efficiency established during MEPC 77 developed MEPC.1/Circ.896 taking into account documents MEPC 76/6/2 (China et al.), MEPC 76/6/6 (Finland and Germany), MEPC 76/6/7 (France), MEPC 76/6/8 (France), MEPC 76/6/10 (Comoros and RINA) and MEPC 76/7/31 (Comoros and RINA), and using the annex to document MEPC 77/6 (Comoros et al.) as a basis (MEPC 77/WP.8, paragraphs 30 to 36 and annex 4). The 50% wind statistics approach among other elements was deemed to be an appropriate interim measure before a full impact study could be undertaken. In document MEPC 77/6, paragraphs 10 and 11, it is stated that the guidance will be reviewed. MEPC 77 agreed to keep MEPC.1/Circ.896 under review in light of experience gained in its application. This document provides some additional material to be considered in such a review, covers aspects to be considered when scientifically justifying approaches taken to assess wind propulsion, and it highlights areas that require further analysis. The continued discussions revolve around the following:

.1 the need for further case studies and operational dataset analysis for various types and sizes of ships utilising a variety of wind propulsion systems and configurations to verify and align with the wind probability matrix and approaches outlined in MEPC.1/Circ.896; and

.2 ensure that the adopted criteria reflect a balanced assessment across the spectrum of wind propulsion technologies that have different operational profiles and characteristics. The size, configuration (and elevation when considering airborne systems such as kites) and whether these are active or passive systems are all items that need careful consideration.

Wind statistics

5 One of the objectives in the WiSP2 Joint Industry Project, run by the Maritime Research Institute Netherlands (MARIN) and American Bureau of Shipping (ABS), is to deliver suggestions for additional approaches and adjustments for performance standards, including those in MEPC.1/Circ.896. Various case studies were analysed as part of the project and this document shows the results for the WASP-Ecoliner concept. See figure 1 and table 1 for an illustration and main particulars. This concept, with Dynarig sails, developed by Dykstra Naval Architects is not yet sailing, however it has been the subject of substantial research with aerodynamic modelling based on wind tunnel tests and hydrodynamic performance using CFD. Its projected savings with wind propulsion, calculated with MEPC.1/Circ.896 methods, are significant and larger than ships presently sailing with wind-assist propulsion systems. It is thus considered relevant for the development of wind propulsion in the world shipping fleet. MEPC.1/Circ.896 does not include all modelling details to adequately reflect the performance of this type of ship and may overestimate savings. It is also a relatively small size ship for which wave added resistance may be significant. MEPC.1/Circ.896 neglects some effects, such as increased resistance due to leeway and changed efficiencies in main engine and propeller propulsion.

Figure 1: WASP-Ecoliner concept

Further details on the WASP-Ecoliner ship concept and the performance modelling are set out in annex 1 to this document.

Table 1: WASP-Ecoliner main particulars

DESIGNATION	SYMBOL	MAGNITUDE	UNIT
Length	L_{PP}	138.0	m
Beam	B	18.0	m
Draught	T	6.5	m
Displacement	Δ_{l}	11,916.3	t
Cargo capacity	DWT	8210	t
Ship speed	V_S	11.0	kn
Total sail area	A_{ref}	3,859	m^2

6 To maintain consistency the estimated overall greenhouse gas (GHG) emissions reductions are based on the MEPC.1/Circ.896 prediction methodology. When the full global MEPC.1/Circ.896 wind statistics are applied, this ship shows an overall reduction of 42% in GHG emissions, but when applying the specified upper 50% of the wind propulsion forces associated with the global wind statistics, the overall GHG emissions reduction increases substantially, to 75% for this ship.

7 The weather routing results in this analysis are ship dependent and depend on the type and configuration of wind propulsion system installed. Only the WASP-Ecoliner was considered in this study; for the same ship with other wind propulsion technologies (WPTs) and for other ships, the routing and resulting wind statistics will change to a certain extent. It is moreover mentioned that the modelling simplifications in the MEPC.1/Circ.896, means that some losses in e.g. engine efficiency and drag from hull and rudder are neglected.

Wind routing

8 The MEPC.1/Circ.896 wind statistics were derived for a global network of shipping routes on the assumption that ships will always maintain a fixed speed and course. However, ships with wind propulsion can substantially improve their fuel and emissions performance using voyage planning ('routing') on ocean crossings based on the wind forecast and statistical weather data while subject to common nautical constraints (e.g. maximum wave height or acceptable motions) and arriving in time. Routing simulations were carried out with the WASP-Ecoliner operating on a global shipping network. To this end, the route network from MEPC.1/Circ.896 was used; one addition was made with a leg from South Africa to Brazil (as a section on the now common route from Brazil to the Far East). The improved encountered wind conditions could potentially be used also for other ships in conjunction with or as an alternative to MEPC.1/Circ.896 global wind statistics.

9 Voyage simulations were performed on all legs of the global network for the WASP-Ecoliner. This included leeway and induced resistance effects as well as variable propulsion efficiency. An empirical estimate for wave added resistance was also included.

10 During routing the ship was allowed to vary its speed and course. The trip duration was fixed to the time required to reach the destination when sailing 11kn along the shortest route (or earlier). Simulations used ERA5 hindcast data [1] for wind in the period 1999 to 2019. For each route both directions were simulated with a departure interval of one month, leading to 480 simulations per route. The track plots of all combined simulations are shown in figure 2.

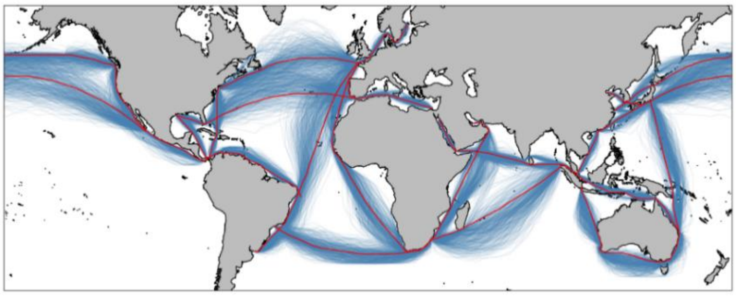

Figure 2: Voyage simulation track plot

11 To derive overall global wind statistics for the set of selected routes, a weighting is required per route. Several types of weighting were considered (see annex 1 to this document); the selected weighting values as a function of distance, AIS information, and Wind presence, as well as the combined weighting values, are shown in figure 3 for the different routes.

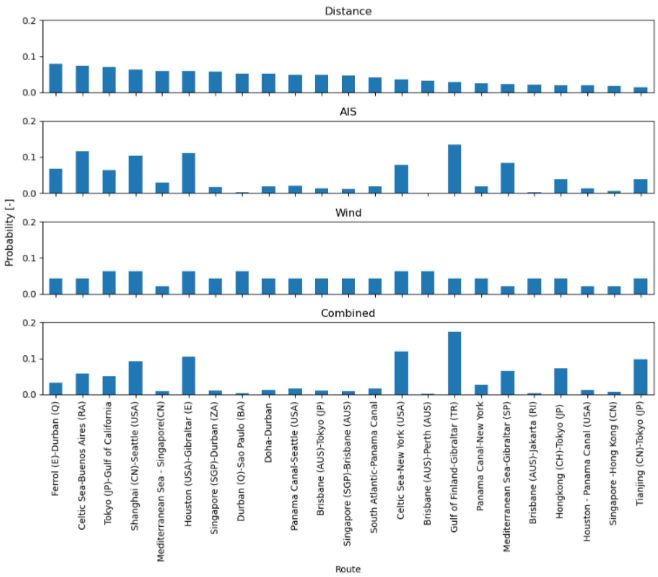

Figure 3: Selected weights for different routes

Improved wind statistics

12 Figure 4 shows the wind speed and direction probabilities according to the following approaches:

.1 MEPC.1/Circ.896;

.2 ERA5 database without voyage routing; and

.3 ERA5 with routing, both with combined weighting is shown in figure 4 along with the existing MEPC.1/Circ.896.

Wind probability matrices are presented in annex 2 to this document. ERA5 data without routing shows somewhat more dominant head and stern winds than MEPC.1/Circ.896, which can be attributed to the different data sets used (proprietary satellite data in MEPC.1/Circ.896), a different time period, and possibly due to different methods for weighting.

13 A distinct change in encountered wind conditions and probabilities is observed when routing is applied. The average wind speed increases from 7.1 to 7.4 m/s. The most significant change is the probabilities of wind angles: the occurrence of near-bow and following winds is reduced to a large extent, while bow-to-beam and stern quartering winds become most dominant. These wind conditions are clearly more favourable with wind propulsion.

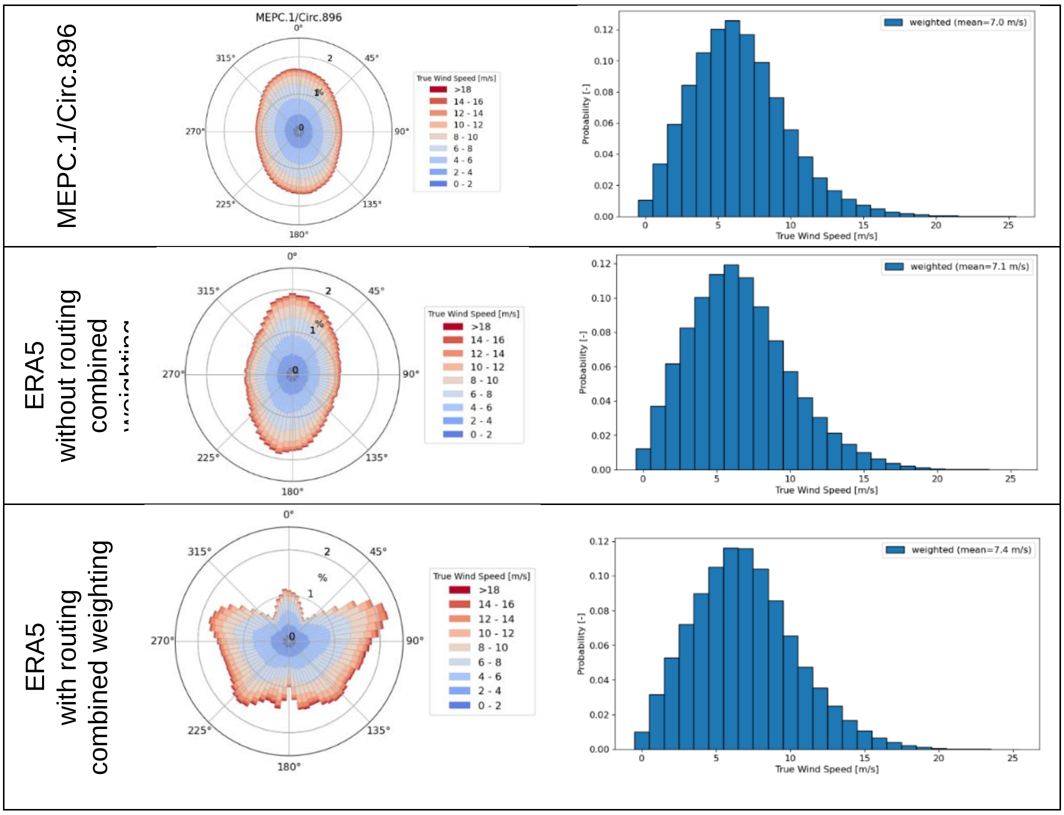

Figure 4: Wind speed and direction probability

14 The wind probability presented in figure 4 can be used to calculate the GHG emissions performance for EEXI / EEDI; figure 5 shows the results for the WASP-Ecoliner. In this case the calculation of the wind force matrix follows the MEPC.1/Circ.896 approach (i.e., leeway and variable propulsion efficiency effects are neglected). It is noted that the ERA5 simulation results reflect the full, global (100%) wind force matrix for all wind conditions encountered; for comparison purposes both the upper 50% and 100% of the wind force matrix from MEPC.1/Circ.896 are shown. The application of routing has a significant positive influence, as it reduces overall GHG emissions by 14 to 15%-point. Even with routing, the overall GHG savings is less than obtained using the upper 50% wind condition in line with MEPC.1/Circ.896, while routing gives a better GHG result than application of the global (100%) wind force dataset from the Circular.

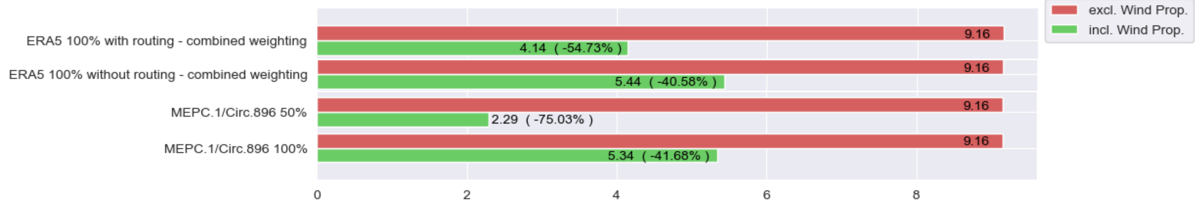

Figure 5: EEDI / EEXI [gCO_2/(t-nm)] for different wind probability (WASP-Ecoliner)

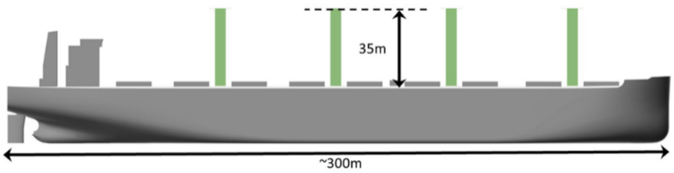

Figure 6: Newcastlemax bulk carrier - 4 rotors 35x5 m

15 The derived wind probabilities were also used to determine the overall GHG performance of a Newcastlemax bulk carrier, sailing at 11.1 knots with four Flettner rotors installed, see figure 6. The modelling is described in annex 1 to this document. This case has a different size, wind propulsion technology and configuration than the WASP-Ecoliner, so that the results cannot be used to compare the performance of the applied wind propulsion technologies. Figure 7 shows that the overall GHG performance for routing with ERA5 data also lies between the 50% method and 100% wind force datasets from MEPC.1/Circ.896, noting that in this case the differences in overall results are less pronounced than for the WASP-Ecoliner.

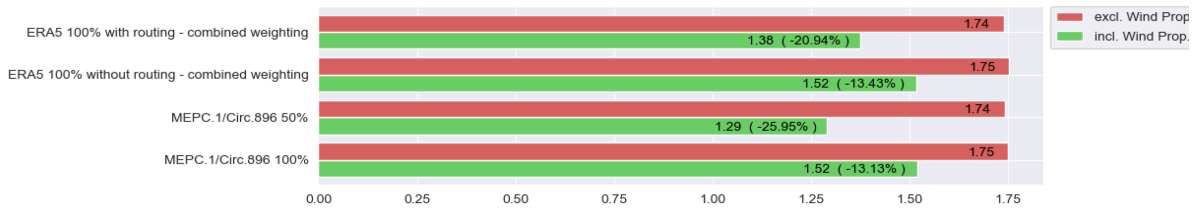

Figure 7: EEDI / EEXI [gCO_2/(t-nm)] for different wind probability (Newcastlemax bulk carrier)

16 The results from this study show that the wind probability datasets obtained using voyage routing globally can provide a substantial benefit to overall GHG performance (and EEDI/EEXI). The predicted performance using this wind probability datasets may be close to what can be achieved in practice on average by a ship of this type and designated WPT configuration. All encountered wind angles and wind speeds are included in this approach, which can be used in principle to assess the relative performance differences between wind propulsion technologies for a given ship. This approach may be considered as part of the MEPC.1/Circ.896 review process.

Action requested of the Committee

17 The Committee is invited to note the information in this document and its annexes, in particular the results from the study.

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ANNEX 1

DETAIL ON CASE SHIPS, PERFORMANCE MODELLING, ROUTING AND WEIGHTING

The work presented in this paper was conducted fully separately, but attention is given to Mason [1] who performed a similar study with generally similar conclusions.

WASP-Ecoliner

The particulars of WASP-Ecoliner have been adopted from Dykstra Naval Architects [2]. One addition at MARIN in the WiSP project is the inclusion of a skeg and rudder for good course keeping. The ship is modelled with a single controllable pitch propeller, gearbox and 4 stroke main engine.

Table 2 and Table 3 provide an overview of modelling methods. Higher fidelity methods (Tier2) were used as input for the routing study. The force matrix and final performance of the ship (in the main part) was based on more simple modelling in line with MEPC.1/Circ.896. Figure 8 shows the wind tunnel tests and primary aerodynamic sail coefficients as used from the NSR SAIL project.

Table 2: WASP-Ecoliner modelling and data

Topic	MEPC.1/Circ.896 modelling	Higher fidelity modelling ('Tier 2' in WiSP)
Sail forces	Wind tunnel results from NSR SAIL project [3], see also figure 8.	
Windage	Neglected	Wind tunnel results when sailing; Blendermann coefficients and rig drag estimate when sails are reefed
Righting moment	Heel neglected	Linear based on GM=1.65m
Hull forces in calm water	Resistance curve derived from CFD	Surge (ship speed), sway (leeway), roll and yaw forces/moments based on motions/speeds in those same directions (i.e. this includes leeway and heel induced resistance) derived from CFD
Wave added resistance	Neglected	Empirical according to SPA Wave method [4]; wind-wave relation according to NATO STANAG 4194 Annex D
Rudder forces	Viscous drag only	Surge, sway yaw, roll and heel forces/moments based on motion/speed in those same directions as well as rudder angle
Propeller, hull efficiency, shaft bearing and gearbox	Lumped together with fixed efficiency η_T=0.61	MARIN C-Series [5] with variable efficiency as function of advance and pitch, fixed hull efficiency, map model for shaft bearing and gearbox dependent on rotation rate and power
Main Engine	Fixed SFOC 186 g/kWh running on VLSFO.	SFOC map model dependent on rotation rate and power; nominal SFOC 180 g/kWh running on VLSFO.
Auxiliary Engine	Continuously running at 120 kW with a SFOC 215 g/kWh. running on MGO.	
Force balance	Only in surge direction	Surge, sway (leeway), roll (heel), yaw

Table 3: WASP-Ecoliner modelling and data (continued)

Topic	MEPC.1/Circ.896 modelling	Higher fidelity modelling ('Tier 2' in WiSP)
Constraints	Propeller thrust not below zero	Propeller torque not below zero Engine operating below torque limit and above minimum rotation rate (63% of nominal rate). Heel angle below 10 deg Rudder angle below 1t deg
Wind modelling	Atmospheric boundary layer with Hellmann exponent 1/9. Wind sampled at centre of effort height for sails and half of freeboard for windage.	

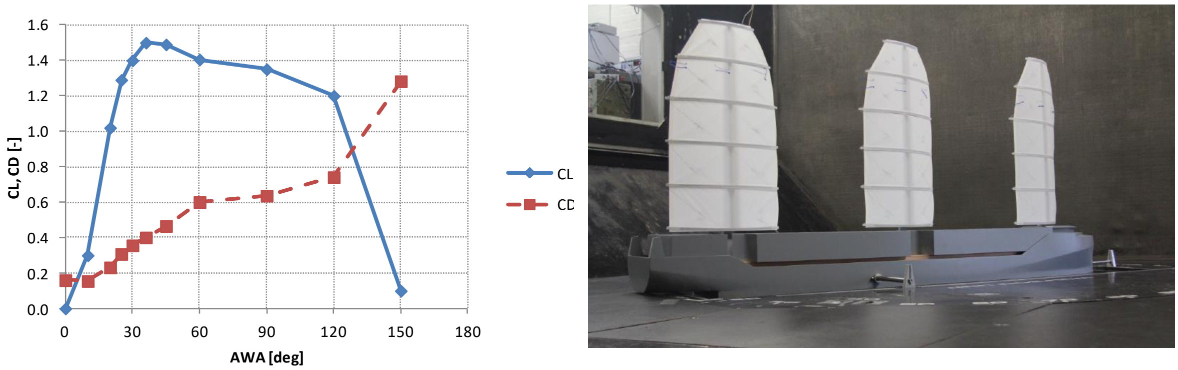

Figure 8: Aerodynamic coefficients and wind tunnel tests from NSR SAIL [3]

Figure 9 shows the polar plots of fuel consumption for the ship with Dynarigs. Multiple speeds are considered as the routing uses that. For the shortest route or when strictly following MEPC.1/Circ.896 only the polar plot for a ship speed of 11 kn is used.

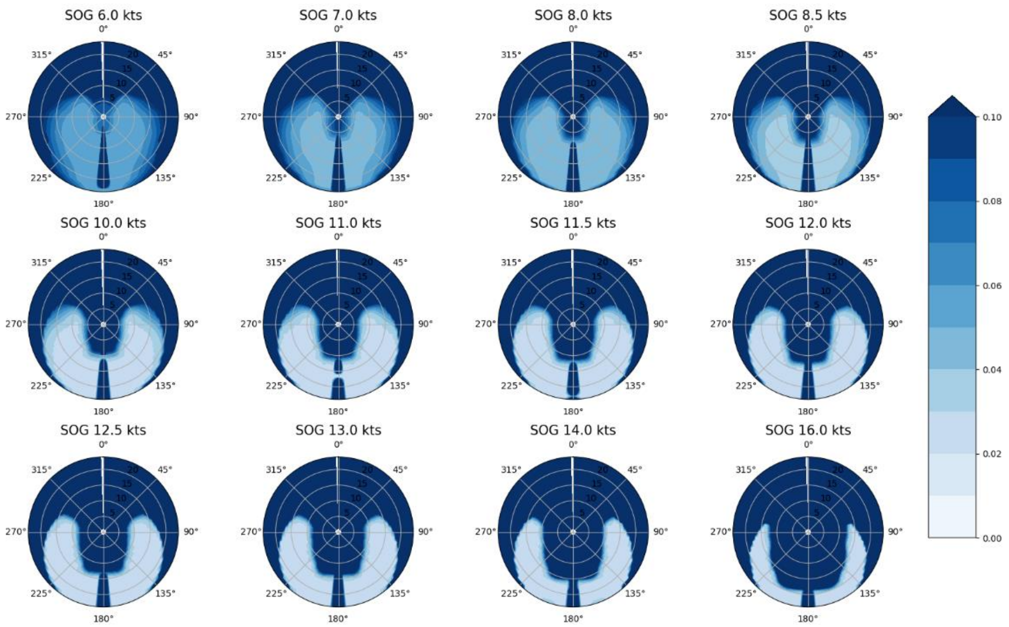

Figure 9: Polar plots of fuel consumption (t/h) with wind propulsion for various speeds (SOG)

Newcastlemax bulk carrier

A previous case study published by Eggers et al [7] was re-used and the description here uses some sections from that paper. Main particulars are shown in Table 4. The modelling of this ship is in line with MEPC.1/Circ.896 in terms of the type of physics that are modelled. However, it is noted that the Flettner rotor performance was not determined using wind tunnel tests. It was based on data from literature for basic lift, drag and power consumption. Lifting line and CFD calculations were done to account for aerodynamic interaction effects as described below.

Table 4: Newcastlemax main particulars (full load)

DESIGNATION	SYMBOL	MAGNITUDE	UNIT
Length	L_{PP}	295.0	m
Beam	B	50.0	m
Draught	T	18.0	m
Displacement	Δ_l	230,000	t
Cargo capacity	DWT	200,000	t
Ship speed	V_S	11	kn
Number of Flettner rotors	-	4	-
Flettner rotor height	h	35	m
Flettner rotor diameter	D	5	m

For the lift and drag a MARIN 'ensemble curve', as in
Figure 10, is used. This is an average through full scale Flettner rotor performance data from literature.

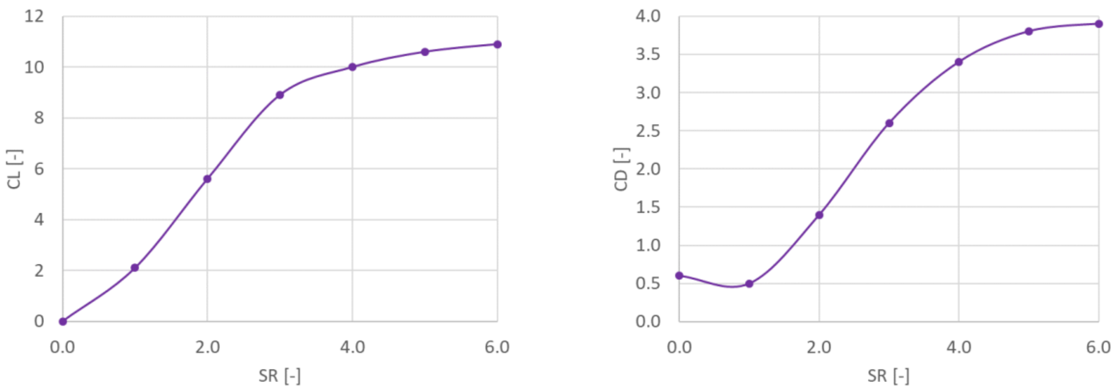

Figure 10: Flettner rotor ensemble curves for lift coefficient (CL) and drag coefficient (CD) versus Spin Ratio (SR)

Flettner rotor power consumption is accounted for. If the ship would be sailing fully on Flettner rotor propulsion, there is still a power consumption to run the rotors.

Ship-Flettner rotor interaction effects are accounted for based on a calculation study by Garenaux [8]. It accounts for the change in wind speed as experienced by the rotors, which are in the zone of influence of the ships' structure. The correction used was not determined for specifically the case study ship, thus it only provides an indication, though it's impact on overall savings is modest at about 1 percent point less fuel saving. Rotor-rotor interaction effects are also accounted for using dedicated lifting line calculations with a methodology described by Garenaux and Schot [9].

In the calculations, the rotation rate of the rotors is optimized for best overall fuel and emission performance. It is constrained by the maximum rotation rate.

It is noted that the Newcastlemax bulk carrier has not been used in the routing study. Its existing force matrix has only been used to multiply with the wind statistics to get to overall results with the wind statistics as found with WASP-Ecoliner, as shown in
Figure 5 in the main part of this paper.

Routing simulations and wind data

Voyage simulations with routing have been with done the MARIN inhouse developed code GULLIVER using ERA5 hindcast data [10] for wind in the period 1999-2019. GULLIVER uses the Theta* path finding algorithm [11] to find the route with best fuel consumption for each departure while arriving on time or early.

Weighting of data from routes

Whereas the results from routing could be used directly, it is acknowledged that with different lengths of routes, a different number of ships on them and different wind statistics, some weighting of the results per route seems appropriate.

Several types of weighting were considered:

.1 Distance: Weight per route only based on route length;

.2 AIS: Weight per route based on route length times number of ships sailing on the route (based on AIS data, see below);

.3 Wind favourability: Weight per route based on route length times a simplified factor considering favourability of each route for wind propulsion and routing (see below for description of factors); and

.4 Combined: A combination of .1, .2 and .3, which accounts for route length, number of ships sailing on the route and an incentive considering favourability of the route.

With 'AIS' weighting the number of ship sailing on the defined routes are estimated. For this purpose the Global Shipping Traffic Density dataset [12] as used. The dataset includes a ship density raster of hourly AIS positions received between January 2015 and February 2021 and represents the total number of AIS positions that have been reported by ships in each grid cell with dimensions of 0.005 degree by 0.005 degree. The present study aggregated the data in larger cells and used the routing results to determine the cells that should be used to count ships, such that not only the ships following the shortest route are counted. The methods and data do not allow to filter out ships that sailed through a sampled area at an oblique course. Also, the data does not allow to identify larger and smaller ships. These two effects likely mean that in coastal areas the numbers are increased due to many smaller ships which may also be crossing the sampled areas with voyages not aligned with the routes that were defined.

'Wind favourability' is a subjective measure. It serves to favour routes where ships with wind propulsion are more likely to be deployed because of better wind and better options for routing. As a simple rule, routes at higher latitude (south of 23.3S or North of 23.3 N) were selected as favoured due to a higher probability for good wind. Routes longer than 3000nm are also favoured because there are likely better options for rerouting. The lowest weighting factor is 0.5, the highest 1.5. The route 'Mediterranean Sea – Singapore' would be partially favoured because of its long length. However, it has been given a weight of 0.5 because of generally unfavourable wind statistics. The resulting weighting values are shown in Figure 3 in the main part of this paper.

References

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ANNEX 2

GLOBAL WIND PROBABILITY MATRICES WI,J

Wind was sampled in intervals of 1 m/s for wind speed (with the row header at the top of the interval) and 5 degrees for wind angle (with the value in the column header as the centre of the interval). Matrices for other weighting are available from the author.

Table 5: Normalized global wind chart showing the probability of wind conditions relative to the ship's heading along the (updated) main global trading routes - without routing - weighting combined

Wind Speed [m/s] \ Wind Angle [°]	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115
< 1	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0001	0.0002	0.0001	0.0002	0.0002	0.0001	0.0002	0.0002	0.0001	0.0002	0.0001	0.0001	0.0002
< 2	0.0006	0.0005	0.0006	0.0005	0.0006	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0006	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
< 3	0.0010	0.0009	0.0010	0.0009	0.0009	0.0010	0.0009	0.0009	0.0010	0.0008	0.0008	0.0008	0.0008	0.0007	0.0008	0.0008	0.0008	0.0008	0.0008	0.0007	0.0008	0.0008	0.0009	0.0008
< 4	0.0013	0.0013	0.0013	0.0012	0.0012	0.0013	0.0013	0.0012	0.0012	0.0011	0.0012	0.0011	0.0011	0.0011	0.0010	0.0011	0.0011	0.0010	0.0011	0.0010	0.0010	0.0010	0.0011	0.0011
< 5	0.0018	0.0016	0.0018	0.0017	0.0015	0.0016	0.0016	0.0015	0.0014	0.0014	0.0014	0.0013	0.0013	0.0013	0.0011	0.0013	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012
< 6	0.0022	0.0021	0.0021	0.0019	0.0019	0.0018	0.0018	0.0017	0.0016	0.0016	0.0016	0.0015	0.0014	0.0014	0.0013	0.0014	0.0014	0.0013	0.0013	0.0013	0.0012	0.0013	0.0013	0.0012
< 7	0.0024	0.0023	0.0023	0.0023	0.0024	0.0021	0.0019	0.0018	0.0018	0.0016	0.0015	0.0015	0.0014	0.0013	0.0013	0.0014	0.0012	0.0013	0.0014	0.0013	0.0014	0.0014	0.0013	0.0014
< 8	0.0023	0.0024	0.0022	0.0021	0.0021	0.0020	0.0019	0.0017	0.0016	0.0015	0.0014	0.0013	0.0013	0.0011	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0013	0.0012	0.0012	0.0013
< 9	0.0020	0.0021	0.0020	0.0019	0.0018	0.0017	0.0016	0.0015	0.0012	0.0012	0.0012	0.0011	0.0011	0.0010	0.0011	0.0010	0.0009	0.0009	0.0009	0.0011	0.0010	0.0011	0.0011	0.0011
< 10	0.0015	0.0017	0.0016	0.0014	0.0015	0.0012	0.0012	0.0011	0.0010	0.0009	0.0010	0.0009	0.0009	0.0008	0.0008	0.0008	0.0007	0.0008	0.0007	0.0007	0.0008	0.0008	0.0007	0.0008
< 11	0.0012	0.0012	0.0011	0.0011	0.0009	0.0010	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008	0.0007	0.0008	0.0007	0.0007	0.0006	0.0007	0.0005	0.0006	0.0006	0.0006	0.0005	0.0005
< 12	0.0009	0.0008	0.0008	0.0007	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005	0.0005	0.0005	0.0004	0.0005	0.0004	0.0004	0.0004	0.0004
< 13	0.0006	0.0006	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003	0.0004	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
< 14	0.0004	0.0004	0.0004	0.0004	0.0003	0.0004	0.0004	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002	0.0003	0.0003	0.0003	0.0003	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
< 15	0.0002	0.0003	0.0003	0.0003	0.0003	0.0002	0.0002	0.0003	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0001	0.0002	0.0002	0.0001	0.0002
< 16	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0001	0.0002	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
< 17	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0001	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
< 18	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 19	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 20	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 21	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 22	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 23	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 24	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 25	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
>= 25	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Wind Speed [m/s] \ Wind Angle [°]	120	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200	205	210	215	220	225	230	235
< 1	0.0002	0.0002	0.0002	0.0002	0.0002	0.0001	0.0002	0.0002	0.0002	0.0002	0.0001	0.0002	0.0002	0.0002	0.0001	0.0002	0.0002	0.0002	0.0002	0.0001	0.0002	0.0002	0.0002	0.0002
< 2	0.0005	0.0006	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0006	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0006	0.0005	0.0005
< 3	0.0008	0.0008	0.0008	0.0008	0.0008	0.0009	0.0010	0.0009	0.0009	0.0009	0.0009	0.0010	0.0009	0.0009	0.0010	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0008	0.0008
< 4	0.0010	0.0010	0.0011	0.0010	0.0011	0.0012	0.0012	0.0012	0.0012	0.0012	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0012	0.0011	0.0011	0.0011	0.0011
< 5	0.0012	0.0012	0.0013	0.0013	0.0013	0.0015	0.0014	0.0015	0.0015	0.0016	0.0017	0.0017	0.0017	0.0018	0.0018	0.0017	0.0017	0.0016	0.0015	0.0015	0.0014	0.0015	0.0012	0.0012
< 6	0.0013	0.0014	0.0014	0.0014	0.0014	0.0015	0.0016	0.0018	0.0017	0.0019	0.0019	0.0020	0.0020	0.0021	0.0022	0.0021	0.0020	0.0020	0.0019	0.0018	0.0017	0.0016	0.0015	0.0014
< 7	0.0013	0.0013	0.0013	0.0014	0.0016	0.0016	0.0017	0.0017	0.0018	0.0019	0.0021	0.0021	0.0023	0.0022	0.0023	0.0023	0.0022	0.0021	0.0020	0.0018	0.0018	0.0016	0.0014	0.0014
< 8	0.0012	0.0011	0.0014	0.0014	0.0015	0.0015	0.0017	0.0017	0.0019	0.0020	0.0020	0.0021	0.0022	0.0021	0.0023	0.0022	0.0020	0.0020	0.0019	0.0017	0.0016	0.0014	0.0012	0.0012
< 9	0.0010	0.0011	0.0011	0.0011	0.0012	0.0012	0.0013	0.0016	0.0015	0.0017	0.0017	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0017	0.0015	0.0014	0.0013	0.0011	0.0011	0.0010
< 10	0.0008	0.0008	0.0008	0.0008	0.0009	0.0010	0.0010	0.0011	0.0013	0.0013	0.0016	0.0015	0.0015	0.0014	0.0015	0.0015	0.0014	0.0013	0.0012	0.0011	0.0010	0.0010	0.0009	0.0009
< 11	0.0006	0.0006	0.0007	0.0007	0.0007	0.0007	0.0007	0.0008	0.0009	0.0009	0.0011	0.0011	0.0012	0.0012	0.0011	0.0011	0.0010	0.0010	0.0008	0.0008	0.0008	0.0008	0.0007	0.0007
< 12	0.0004	0.0004	0.0005	0.0006	0.0005	0.0005	0.0005	0.0006	0.0006	0.0007	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0007	0.0008	0.0007	0.0006	0.0006	0.0006	0.0007	0.0005
< 13	0.0003	0.0004	0.0003	0.0004	0.0003	0.0004	0.0004	0.0005	0.0005	0.0005	0.0006	0.0005	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0004
< 14	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0003	0.0004	0.0004	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003	0.0003
< 15	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002	0.0003	0.0003	0.0003	0.0003	0.0002
< 16	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0001	0.0002	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0001
< 17	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
< 18	0.0001	0.0001	0.0000	0.0001	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
< 19	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 20	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 21	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 22	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 23	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 24	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 25	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
>= 25	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Wind Speed [m/s] \ Wind Angle [°]	240	245	250	255	260	265	270	275	280	285	290	295	300	305	310	315	320	325	330	335	340	345	350	355
< 1	0.0002	0.0002	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
< 2	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0006	0.0006	0.0006	0.0005	0.0006	0.0005
< 3	0.0008	0.0008	0.0008	0.0008	0.0008	0.0007	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0009	0.0008	0.0008	0.0008	0.0008	0.0009	0.0010	0.0009	0.0009	0.0010	0.0009	0.0009
< 4	0.0011	0.0011	0.0011	0.0009	0.0011	0.0010	0.0010	0.0010	0.0009	0.0010	0.0011	0.0010	0.0010	0.0010	0.0011	0.0012	0.0012	0.0012	0.0012	0.0012	0.0013	0.0013	0.0013	0.0014
< 5	0.0012	0.0012	0.0013	0.0012	0.0011	0.0012	0.0012	0.0011	0.0010	0.0011	0.0011	0.0011	0.0012	0.0011	0.0013	0.0014	0.0014	0.0014	0.0015	0.0016	0.0016	0.0016	0.0016	0.0017
< 6	0.0014	0.0013	0.0013	0.0012	0.0013	0.0013	0.0013	0.0012	0.0013	0.0012	0.0012	0.0013	0.0012	0.0013	0.0013	0.0014	0.0015	0.0015	0.0016	0.0017	0.0018	0.0020	0.0021	0.0020
< 7	0.0014	0.0014	0.0013	0.0013	0.0014	0.0014	0.0013	0.0014	0.0013	0.0014	0.0013	0.0013	0.0012	0.0014	0.0013	0.0014	0.0014	0.0014	0.0016	0.0017	0.0019	0.0022	0.0023	0.0023
< 8	0.0012	0.0011	0.0011	0.0013	0.0012	0.0012	0.0013	0.0013	0.0013	0.0011	0.0012	0.0011	0.0012	0.0013	0.0012	0.0013	0.0013	0.0013	0.0015	0.0016	0.0018	0.0021	0.0022	0.0022
< 9	0.0010	0.0010	0.0009	0.0010	0.0009	0.0010	0.0010	0.0010	0.0009	0.0011	0.0010	0.0011	0.0010	0.0010	0.0011	0.0011	0.0012	0.0011	0.0013	0.0014	0.0017	0.0018	0.0020	0.0020
< 10	0.0008	0.0008	0.0008	0.0008	0.0007	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0009	0.0008	0.0008	0.0009	0.0009	0.0010	0.0010	0.0011	0.0012	0.0015	0.0015	0.0015
< 11	0.0006	0.0007	0.0006	0.0006	0.0006	0.0006	0.0005	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0007	0.0006	0.0006	0.0008	0.0008	0.0009	0.0010	0.0011	0.0011	0.0012
< 12	0.0006	0.0005	0.0005	0.0004	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0005	0.0004	0.0005	0.0005	0.0006	0.0006	0.0007	0.0008	0.0009	0.0008
< 13	0.0004	0.0004	0.0003	0.0004	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0003	0.0003	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005	0.0006	0.0006
< 14	0.0003	0.0003	0.0003	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	0.0002	0.0003	0.0002	0.0003	0.0003	0.0003	0.0004	0.0004	0.0004
< 15	0.0002	0.0002	0.0002	0.0002	0.0001	0.0001	0.0001	0.0002	0.0002	0.0001	0.0001	0.0002	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
< 16	0.0001	0.0001	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0001
< 17	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0001	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
< 18	0.0001	0.0000	0.0001	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
< 19	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000
< 20	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 21	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 22	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 23	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 24	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 25	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
>= 25	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table 6: Normalized global wind chart showing the probability of wind conditions relative to the ship's heading along the (updated) main global trading routes – with routing – weighting combined

Wind Speed [m/s] \ Wind Angle [°]	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115
< 1	0.0001	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0001	0.0001	0.0002	0.0001	0.0001	0.0001	0.0002	0.0001	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0002
< 2	0.0004	0.0004	0.0005	0.0004	0.0005	0.0005	0.0005	0.0004	0.0005	0.0005	0.0004	0.0004	0.0004	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0005	0.0004	0.0004	0.0004	0.0005
< 3	0.0008	0.0007	0.0008	0.0008	0.0008	0.0008	0.0007	0.0007	0.0006	0.0007	0.0007	0.0006	0.0006	0.0006	0.0007	0.0007	0.0008	0.0008	0.0007	0.0009	0.0008	0.0008	0.0008	0.0007
< 4	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0009	0.0008	0.0009	0.0008	0.0008	0.0010	0.0010	0.0011	0.0012	0.0012	0.0012	0.0012	0.0013	0.0013	0.0013	0.0012	0.0011	0.0011
< 5	0.0012	0.0012	0.0011	0.0011	0.0011	0.0010	0.0010	0.0009	0.0009	0.0009	0.0011	0.0012	0.0014	0.0014	0.0016	0.0017	0.0017	0.0017	0.0017	0.0018	0.0016	0.0016	0.0015	0.0013
< 6	0.0015	0.0014	0.0013	0.0012	0.0010	0.0008	0.0008	0.0008	0.0009	0.0011	0.0013	0.0015	0.0016	0.0019	0.0021	0.0024	0.0023	0.0022	0.0021	0.0019	0.0018	0.0019	0.0018	0.0016
< 7	0.0015	0.0014	0.0014	0.0011	0.0009	0.0008	0.0006	0.0006	0.0008	0.0011	0.0016	0.0017	0.0019	0.0024	0.0025	0.0026	0.0027	0.0026	0.0024	0.0022	0.0022	0.0020	0.0019	0.0018
< 8	0.0013	0.0013	0.0011	0.0009	0.0007	0.0006	0.0004	0.0005	0.0007	0.0010	0.0014	0.0017	0.0022	0.0025	0.0027	0.0026	0.0026	0.0023	0.0022	0.0021	0.0020	0.0021	0.0022	0.0019
< 9	0.0011	0.0009	0.0009	0.0007	0.0006	0.0004	0.0003	0.0003	0.0005	0.0008	0.0010	0.0017	0.0021	0.0025	0.0026	0.0024	0.0022	0.0021	0.0018	0.0018	0.0018	0.0018	0.0018	0.0019
< 10	0.0008	0.0007	0.0007	0.0005	0.0004	0.0003	0.0002	0.0002	0.0003	0.0005	0.0008	0.0013	0.0018	0.0022	0.0023	0.0020	0.0018	0.0017	0.0014	0.0013	0.0014	0.0014	0.0014	0.0014
< 11	0.0005	0.0005	0.0004	0.0004	0.0002	0.0002	0.0002	0.0001	0.0002	0.0002	0.0005	0.0007	0.0014	0.0018	0.0019	0.0017	0.0014	0.0013	0.0011	0.0010	0.0010	0.0010	0.0010	0.0011
< 12	0.0003	0.0004	0.0003	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0004	0.0009	0.0011	0.0014	0.0015	0.0012	0.0009	0.0008	0.0007	0.0007	0.0007	0.0008	0.0007
< 13	0.0002	0.0002	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0000	0.0001	0.0001	0.0003	0.0005	0.0009	0.0011	0.0011	0.0008	0.0007	0.0006	0.0006	0.0006	0.0005	0.0006	0.0006
< 14	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0001	0.0001	0.0002	0.0004	0.0005	0.0007	0.0009	0.0006	0.0005	0.0004	0.0004	0.0004	0.0005	0.0004	0.0004
< 15	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0003	0.0004	0.0005	0.0005	0.0004	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
< 16	0.0000	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0002	0.0003	0.0003	0.0003	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
< 17	0.0000	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0002	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001
< 18	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
< 19	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0000	0.0000
< 20	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 21	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 22	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 23	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 24	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 25	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
>= 25	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Wind Speed [m/s] \ Wind Angle [°]	120	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200	205	210	215	220	225	230	235
< 1	0.0001	0.0001	0.0001	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0001	0.0001	0.0001
< 2	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0005	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0005	0.0004	0.0005	0.0004	0.0004	0.0004
< 3	0.0008	0.0007	0.0008	0.0007	0.0007	0.0007	0.0008	0.0006	0.0007	0.0008	0.0007	0.0007	0.0007	0.0008	0.0007	0.0008	0.0008	0.0007	0.0007	0.0008	0.0007	0.0008	0.0007	0.0007
< 4	0.0011	0.0010	0.0010	0.0009	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0009	0.0009	0.0010	0.0009	0.0010	0.0008	0.0010	0.0009	0.0009	0.0010	0.0010	0.0009	0.0011	0.0010
< 5	0.0012	0.0012	0.0012	0.0013	0.0012	0.0011	0.0012	0.0011	0.0011	0.0012	0.0011	0.0011	0.0011	0.0010	0.0010	0.0011	0.0011	0.0011	0.0012	0.0011	0.0012	0.0013	0.0012	0.0012
< 6	0.0015	0.0014	0.0014	0.0014	0.0014	0.0013	0.0014	0.0014	0.0015	0.0012	0.0013	0.0012	0.0011	0.0012	0.0013	0.0011	0.0012	0.0015	0.0014	0.0016	0.0016	0.0015	0.0016	0.0015
< 7	0.0019	0.0017	0.0018	0.0017	0.0018	0.0016	0.0017	0.0017	0.0016	0.0015	0.0014	0.0011	0.0009	0.0011	0.0012	0.0014	0.0014	0.0016	0.0018	0.0017	0.0018	0.0020	0.0019	0.0018
< 8	0.0019	0.0020	0.0020	0.0019	0.0020	0.0019	0.0019	0.0019	0.0016	0.0016	0.0015	0.0010	0.0006	0.0011	0.0014	0.0013	0.0013	0.0016	0.0018	0.0020	0.0021	0.0021	0.0020	0.0018
< 9	0.0018	0.0018	0.0018	0.0019	0.0019	0.0019	0.0019	0.0016	0.0015	0.0015	0.0016	0.0011	0.0005	0.0011	0.0016	0.0014	0.0013	0.0014	0.0017	0.0019	0.0020	0.0019	0.0019	0.0017
< 10	0.0015	0.0016	0.0016	0.0017	0.0016	0.0018	0.0016	0.0012	0.0013	0.0015	0.0015	0.0013	0.0007	0.0011	0.0013	0.0013	0.0013	0.0013	0.0015	0.0017	0.0017	0.0015	0.0014	0.0013
< 11	0.0011	0.0011	0.0012	0.0014	0.0013	0.0013	0.0011	0.0010	0.0010	0.0011	0.0012	0.0012	0.0010	0.0012	0.0013	0.0011	0.0010	0.0010	0.0012	0.0013	0.0013	0.0012	0.0011	0.0011
< 12	0.0009	0.0008	0.0009	0.0010	0.0010	0.0009	0.0008	0.0007	0.0008	0.0010	0.0010	0.0009	0.0007	0.0009	0.0009	0.0008	0.0008	0.0008	0.0009	0.0010	0.0009	0.0009	0.0008	0.0008
< 13	0.0005	0.0006	0.0007	0.0007	0.0007	0.0007	0.0006	0.0006	0.0007	0.0008	0.0008	0.0007	0.0004	0.0006	0.0007	0.0007	0.0006	0.0006	0.0007	0.0008	0.0007	0.0007	0.0006	0.0006
< 14	0.0004	0.0004	0.0005	0.0005	0.0005	0.0004	0.0004	0.0005	0.0005	0.0006	0.0006	0.0004	0.0003	0.0005	0.0006	0.0005	0.0004	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
< 15	0.0002	0.0002	0.0003	0.0004	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0003	0.0001	0.0002	0.0004	0.0004	0.0003	0.0004	0.0004	0.0003	0.0004	0.0004	0.0004	0.0003
< 16	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0002	0.0002	0.0001	0.0001	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002
< 17	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0001	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0001	0.0002	0.0001	0.0001
< 18	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
< 19	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0001	0.0001	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0001	0.0001	0.0001	0.0000
< 20	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 21	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 22	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 23	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 24	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 25	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
>= 25	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Wind Speed [m/s] \ Wind Angle [°]	240	245	250	255	260	265	270	275	280	285	290	295	300	305	310	315	320	325	330	335	340	345	350	355
< 1	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0001	0.0002	0.0001	0.0001	0.0002	0.0001	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001
< 2	0.0005	0.0004	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0005	0.0004	0.0004	0.0004	0.0004	0.0003	0.0004	0.0004	0.0005	0.0004	0.0005	0.0005	0.0005	0.0005	0.0004	0.0005
< 3	0.0007	0.0008	0.0007	0.0008	0.0007	0.0007	0.0008	0.0007	0.0007	0.0008	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0009
< 4	0.0010	0.0011	0.0011	0.0010	0.0012	0.0011	0.0012	0.0011	0.0011	0.0011	0.0010	0.0010	0.0009	0.0009	0.0009	0.0009	0.0008	0.0008	0.0009	0.0009	0.0009	0.0010	0.0010	0.0010
< 5	0.0012	0.0014	0.0014	0.0015	0.0015	0.0015	0.0015	0.0014	0.0015	0.0015	0.0014	0.0013	0.0012	0.0012	0.0012	0.0010	0.0009	0.0009	0.0010	0.0010	0.0012	0.0011	0.0013	0.0013
< 6	0.0016	0.0016	0.0016	0.0017	0.0019	0.0018	0.0017	0.0019	0.0019	0.0020	0.0017	0.0015	0.0014	0.0013	0.0012	0.0011	0.0009	0.0008	0.0009	0.0009	0.0012	0.0013	0.0013	0.0014
< 7	0.0019	0.0018	0.0018	0.0018	0.0020	0.0020	0.0020	0.0022	0.0021	0.0021	0.0020	0.0018	0.0017	0.0015	0.0013	0.0012	0.0009	0.0007	0.0008	0.0008	0.0010	0.0012	0.0013	0.0015
< 8	0.0018	0.0020	0.0018	0.0017	0.0018	0.0018	0.0020	0.0020	0.0022	0.0021	0.0020	0.0020	0.0020	0.0017	0.0014	0.0011	0.0009	0.0006	0.0005	0.0007	0.0009	0.0010	0.0012	0.0014
< 9	0.0016	0.0015	0.0015	0.0015	0.0016	0.0016	0.0016	0.0018	0.0021	0.0020	0.0021	0.0020	0.0018	0.0017	0.0013	0.0009	0.0006	0.0004	0.0003	0.0004	0.0005	0.0008	0.0009	0.0010
< 10	0.0013	0.0012	0.0012	0.0012	0.0011	0.0012	0.0014	0.0014	0.0015	0.0016	0.0017	0.0017	0.0017	0.0014	0.0009	0.0006	0.0004	0.0003	0.0003	0.0003	0.0004	0.0005	0.0007	0.0008
< 11	0.0009	0.0009	0.0009	0.0010	0.0009	0.0010	0.0009	0.0010	0.0012	0.0012	0.0013	0.0014	0.0012	0.0009	0.0006	0.0004	0.0003	0.0002	0.0002	0.0002	0.0003	0.0003	0.0004	0.0005
< 12	0.0008	0.0007	0.0006	0.0007	0.0006	0.0006	0.0007	0.0007	0.0008	0.0011	0.0011	0.0010	0.0009	0.0006	0.0003	0.0002	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0003	0.0004
< 13	0.0006	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0006	0.0006	0.0008	0.0008	0.0007	0.0006	0.0003	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002
< 14	0.0004	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0004	0.0005	0.0005	0.0006	0.0005	0.0004	0.0002	0.0001	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001	0.0002	0.0001	0.0002
< 15	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0002	0.0003	0.0003	0.0004	0.0004	0.0004	0.0002	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001
< 16	0.0001	0.0002	0.0002	0.0002	0.0001	0.0001	0.0002	0.0001	0.0002	0.0003	0.0002	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001
< 17	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001
< 18	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 19	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 20	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 21	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 22	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 23	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 24	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
< 25	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
>= 25	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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