

Determination of Regression Formulas for Main Dimensions of Tankers and Bulk Carriers based on IHS Fairplay data

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Technical University
of Denmark



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On the following pages are shown the results of the analysis of IHS Fairplay data for tankers and bulk carriers. All possible outliers have been left out (obvious errors in data and vessels having unusual dimensions) as described in following document:

Data Analyses – Standard Vessel Determination. Tankers, Bulk Carriers and Container Vessels. Project no. 2010-56. Work Package 2, Report no. 01. University of Southern Denmark. Author: Marie Lützen

Tankers have been categorized in following 7 groups:

1. Small tankers (< 10000 DWT)
2. Handysize tankers (10000 - 25000 DWT)
3. Handymax tankers (25000 - 55000 DWT)
4. Panamax tankers (55000 - 80000 DWT)
5. Aframax tankers (80000 - 120000 DWT)
6. Suezmax tankers (120000 - 170000 DWT)
7. VLCC (170000 - 330000 DWT)

The equations found by regression analysis are shown for each individual ship sub type. The equations are basis for the generic ship design model for determination of main dimensions and propulsion characteristics for all types of tankers and bulk carriers – in the following called 'DTU and SDU model'.

There are no tankers in the range from 170000 DWT to 250000 DWT, but in this area a linear interpolation has been carried out in order to establish equations for the whole deadweight range from 1000 to 330000 DWT.

Regression equations for tankers can be found in App. A-G, bulk carriers in App. H-O and finally comments about water plane area coefficient and scantling and design draught in in app P.

Common Structural Rules

Most of the ships in the statistical analysis have been built before the introduction of Common Structural Rules (CSR) for tankers and bulk carriers for tankers longer than 150 m and bulk carriers longer than 90 m. These rules will increase the steel weight most probably by 5 – 10 %.

In order to take the CSR rules into account, all lightweight formulas has been corrected, such that the lightweight for tankers longer than 150 m for and bulk carriers longer than 90 m has been increased by 5 %, by adding a factor 1.05 to the formulas for the lightweight coefficient as these coefficient formulas represent the outcome of the actual ship data of which most of them are not constructed according to the relatively new CSR rules effective after 2005.

The resulting block coefficient and length displacement ratio in all the figures in this report have been determined after addition of the extra 5 % lightweight.

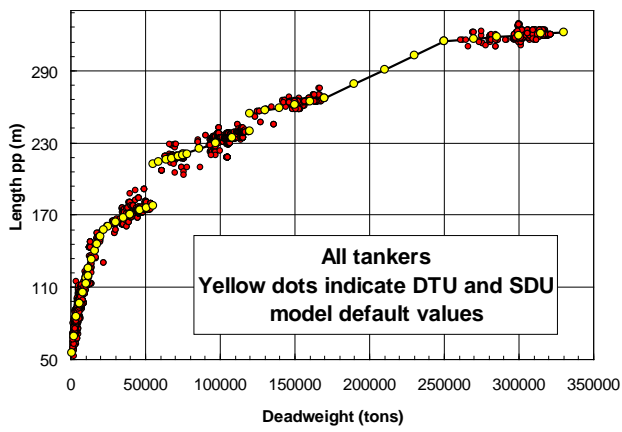


Fig. 1 Length between pp as function of DWT

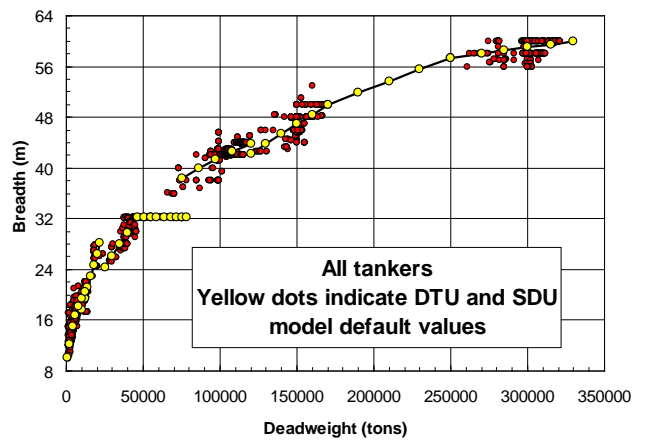


Fig. 2 Breadth as function of DWT

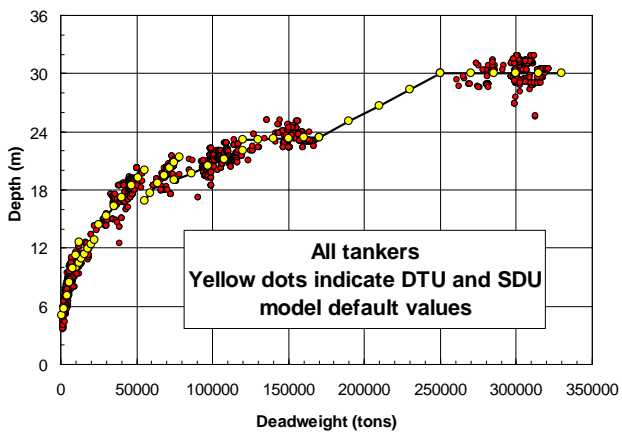


Fig. 3 Depth as function of DWT

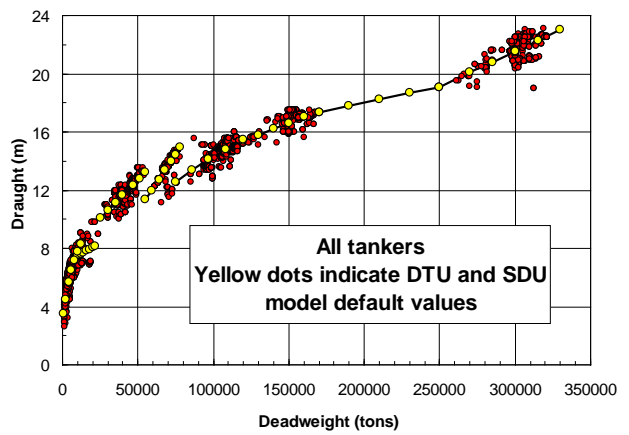


Fig. 4 Maximum draught as function of DWT

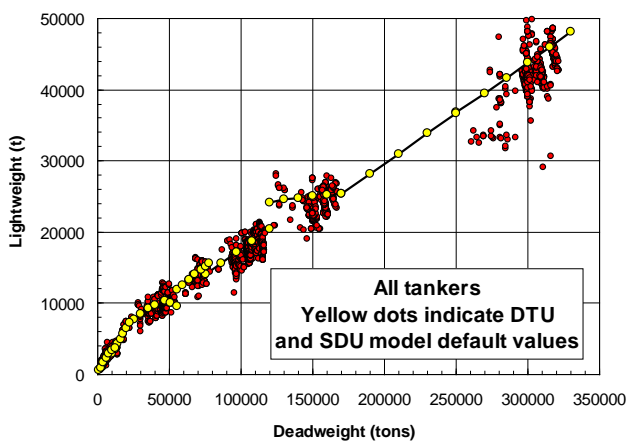


Fig. 5 Lightweight as function of DWT

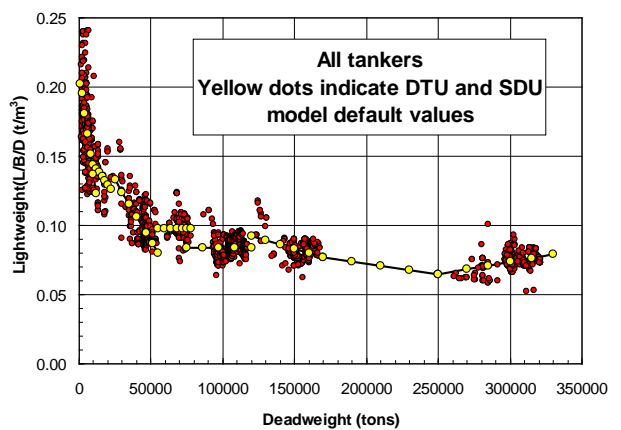


Fig. 6 Lightweight coefficient as function of DWT

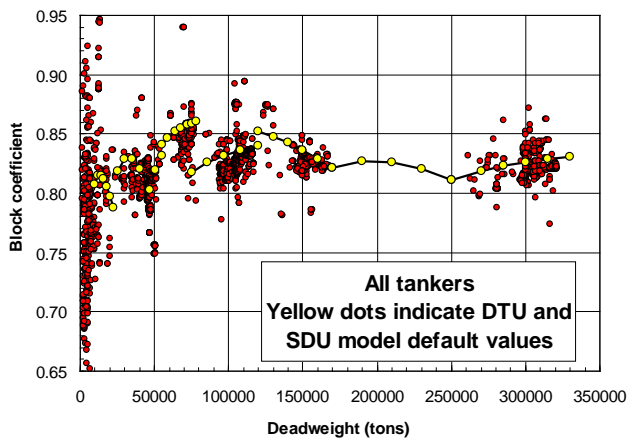


Fig. 7 Block coefficient as function of DWT

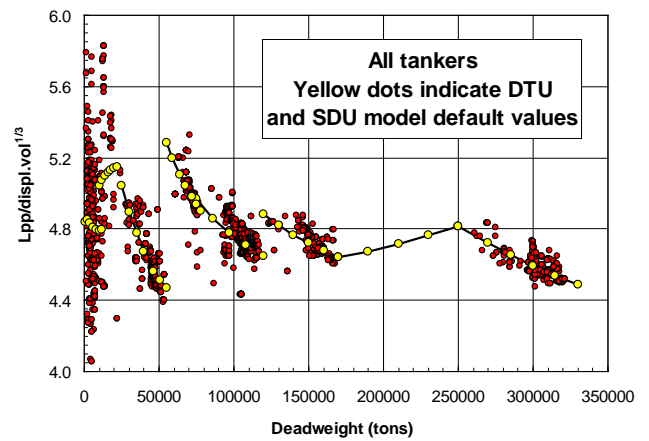


Fig. 8 Length displacement ratio as function of DWT

Appendix A - Small tankers (< 10000 DWT)

Length pp = $6.809 * DWT^{0.3048}$

Breadth = $1.406 * DWT^{0.285}$

Depth = $4.4 + 0.000681 * DWT$

Draught = $0.33 * DWT^{0.343}$

Lightweight/Lpp/B/D = $0.2096 - 0.00000724 * DWT$

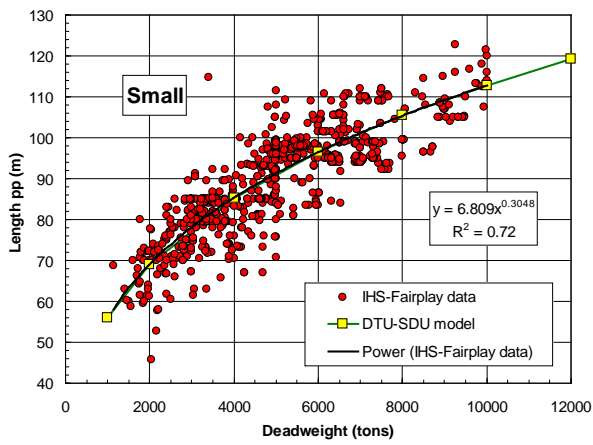


Fig. A1 Length between pp as function of DWT

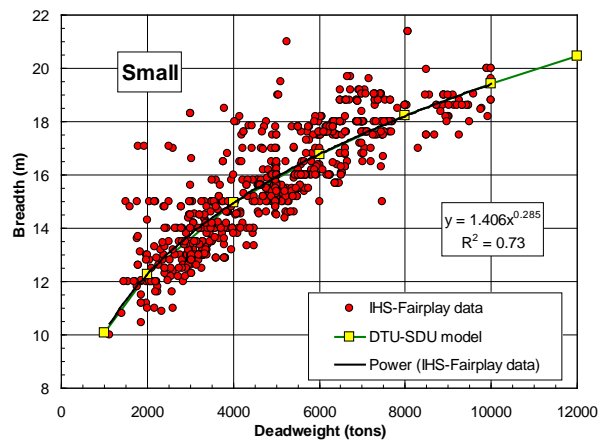


Fig. A2 Breadth as function of DWT

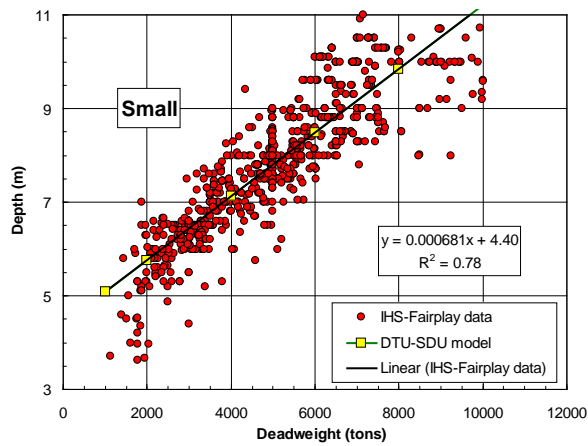


Fig. A3 Depth as function of DWT

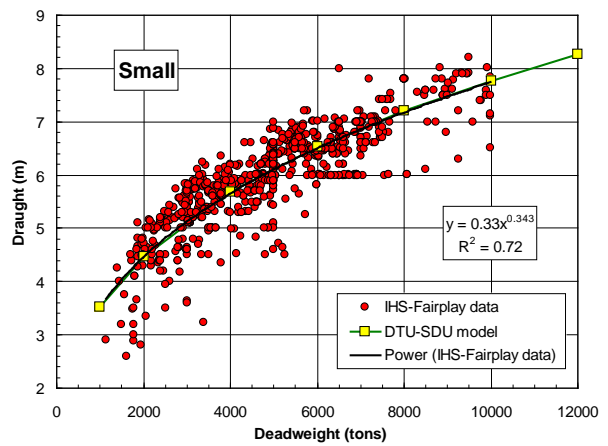


Fig. A4 Maximum draught as function of DWT

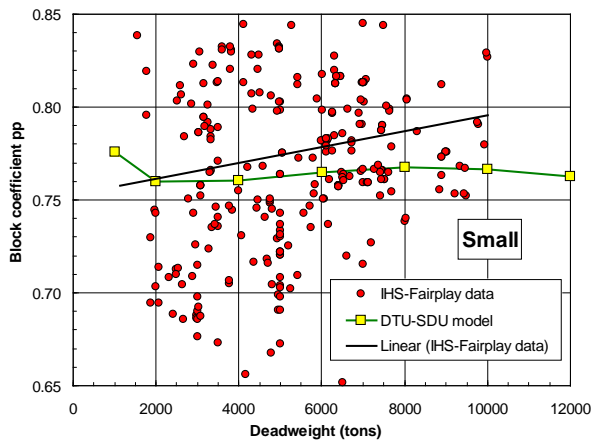


Fig. A5 Block coefficient as function of DWT

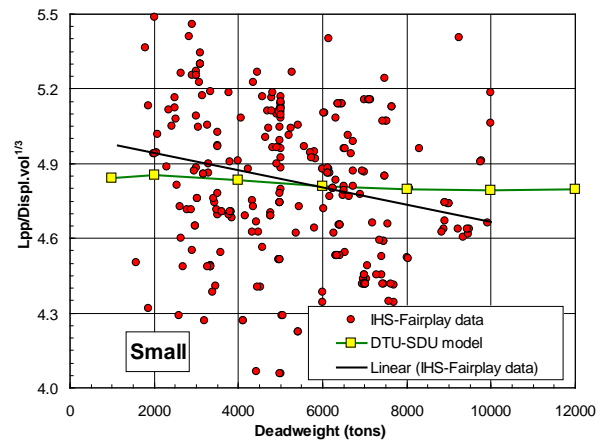


Fig. A6 Length displacement ratio as function of DWT

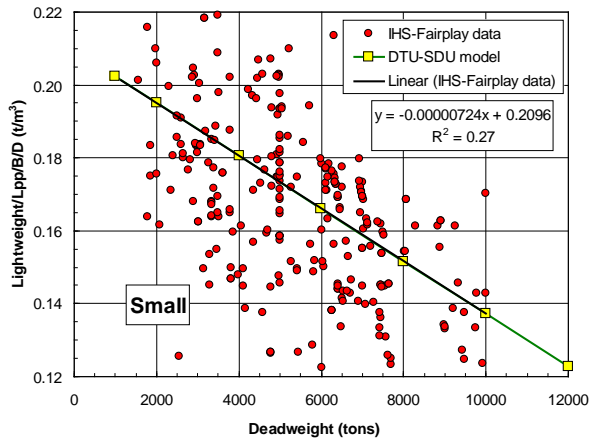


Fig. A7 Lightweight coefficient as function of DWT

Appendix B - Handysize tankers (10000 - 25000 DWT)

Length pp $= 3.9537 * DWT^{0.3684}$

Breadth $= 8.99 + 0.000874 * DWT$

Depth $= 7.56 + 0.0002405 * DWT$

Draught $= 7 + 0.0000523 * DWT$

Lightweight/Lpp/B/D $= 0.1584 - 0.00000145 * DWT$

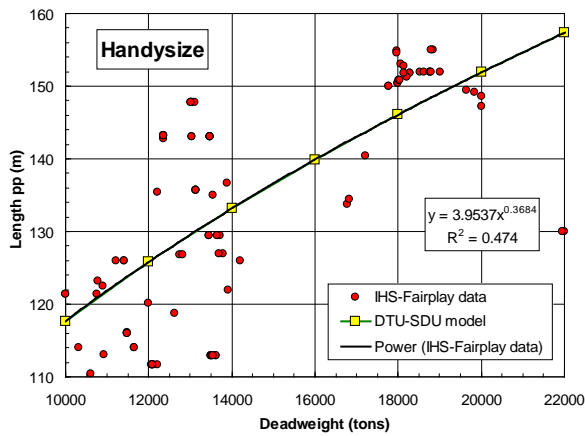


Fig. B1 Length between pp as function of DWT

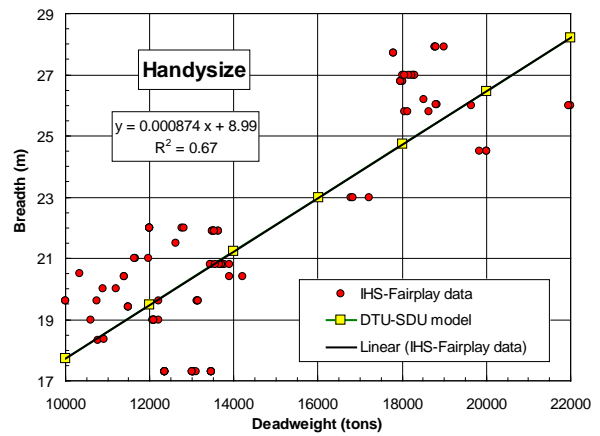


Fig. B2 Breadth as function of DWT

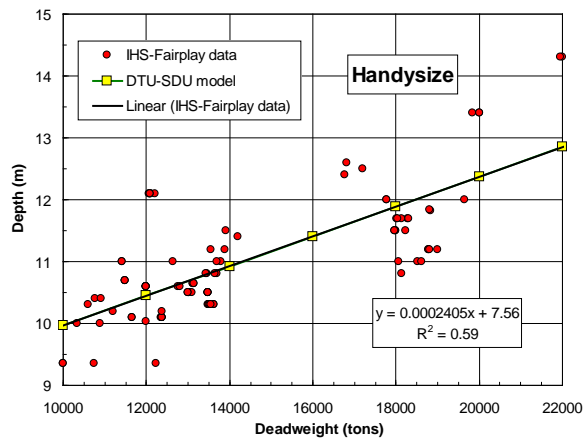


Fig. B3 Depth as function of DWT

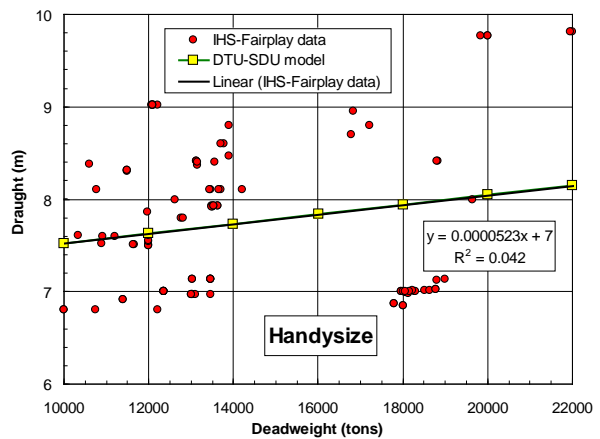


Fig. B4 Maximum draught as function of DWT

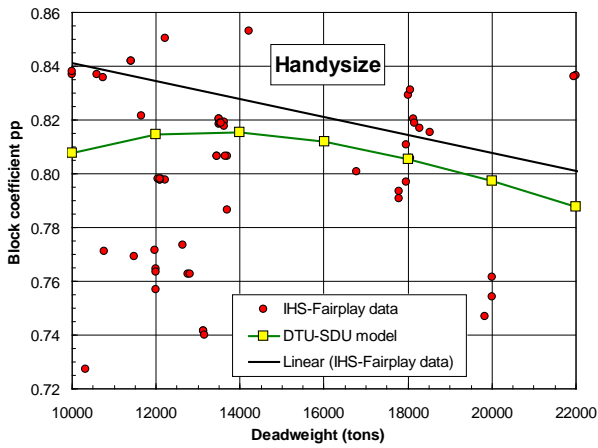


Fig. B5 Block coefficient as function of DWT

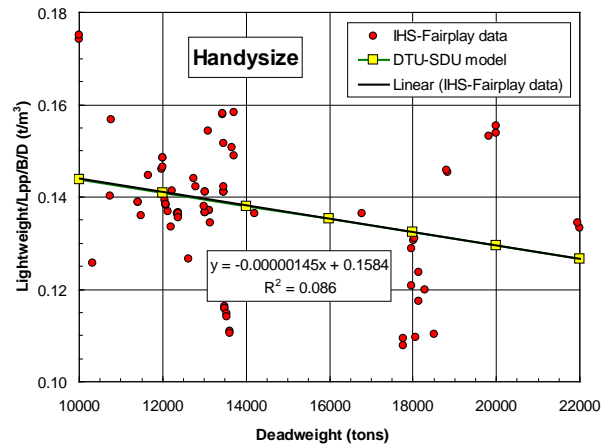


Fig. B6 Length displacement ratio as function of DWT

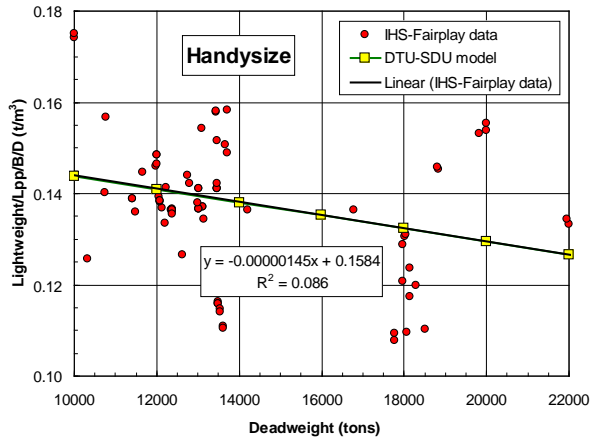


Fig. B7 Lightweight coefficient as function of DWT

Appendix C – Handymax tankers (25000 - 55000 DWT)

Length pp = $41.647 * DWT^{0.133}$

Breadth = $\text{MIN} [15.04 + 0.000369 * DWT; 32.2]$

Depth = $9.69 + 0.000188 * DWT$

Draught = $7.41 + 0.000106 * DWT$

Lightweight/Lpp/B/D = $1.05 * (0.1765 - 0.00000175 * DWT)$

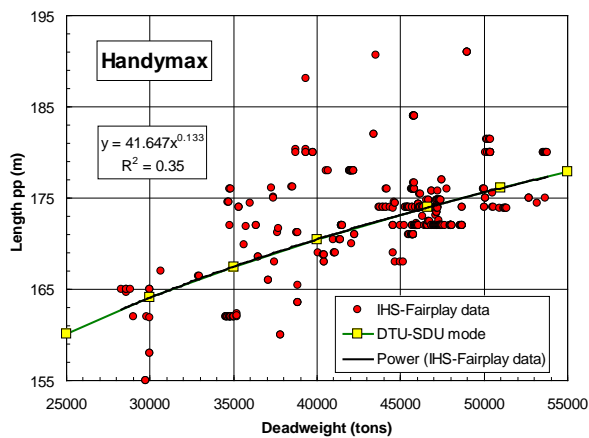


Fig. C1 Length between pp as function of DWT

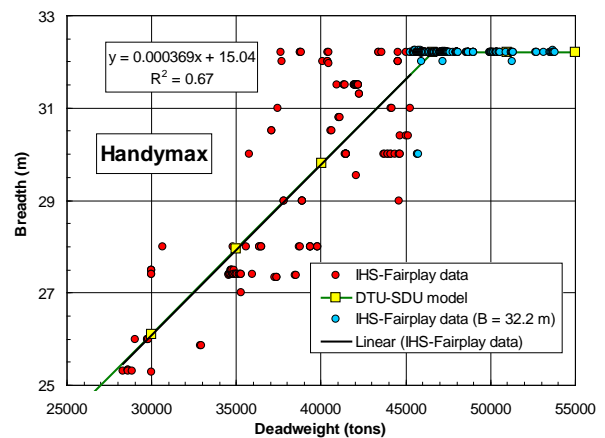


Fig. C2 Breadth as function of DWT

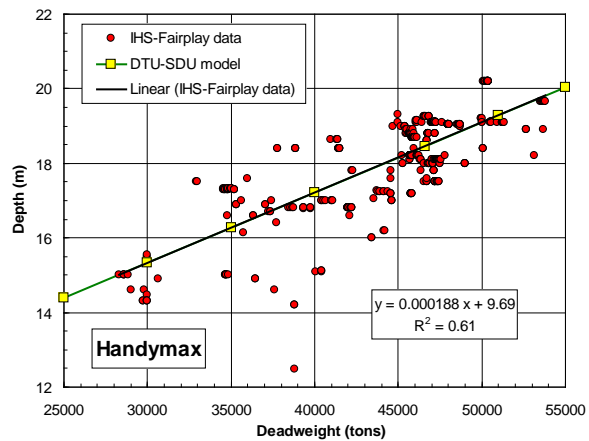


Fig. C3 Depth as function of DWT

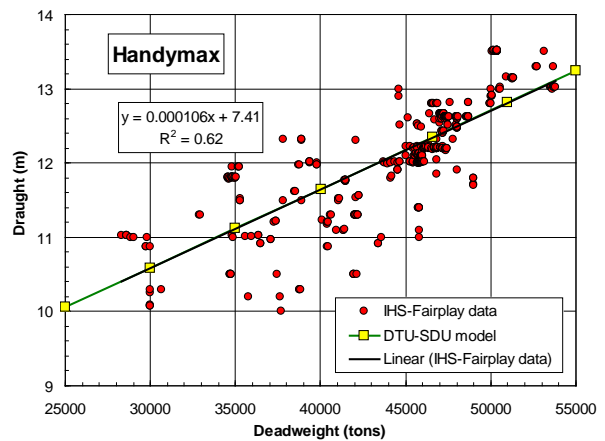


Fig. C4 Maximum draught as function of DWT

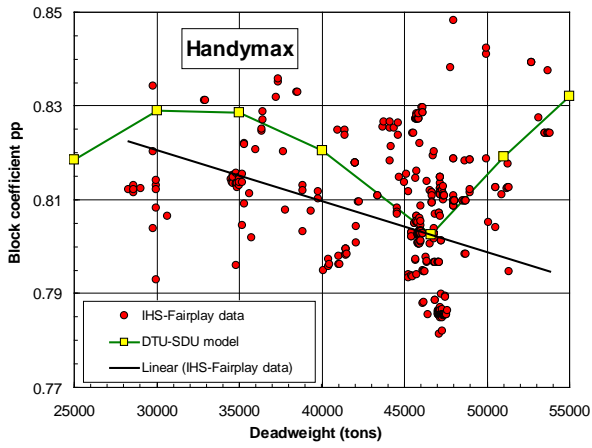


Fig. C5 Block coefficient as function of DWT

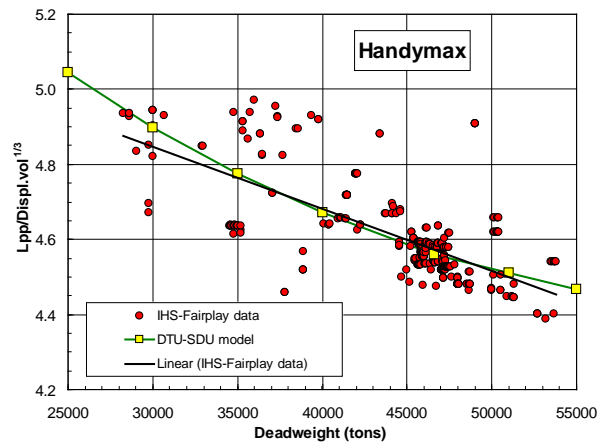


Fig. C6 Length displacement ratio as function of DWT

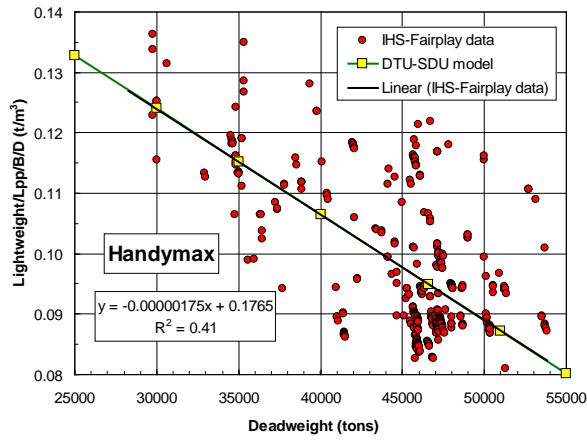


Fig. C7 Lightweight coefficient as function of DWT

Appendix D - Panamax tankers (55000 - 75000 DWT)

Length pp = $193.26 + 0.000353 * DWT$

Breadth = $32.06 + 0.0000023 * DWT$

Depth = $6.14 + 0.000196 * DWT$

Draught = $2.76 + 0.000156 * DWT$

Lightweight/Lpp/B/D = $1.05 * (0.0924 + 0.000000084 * DWT)$

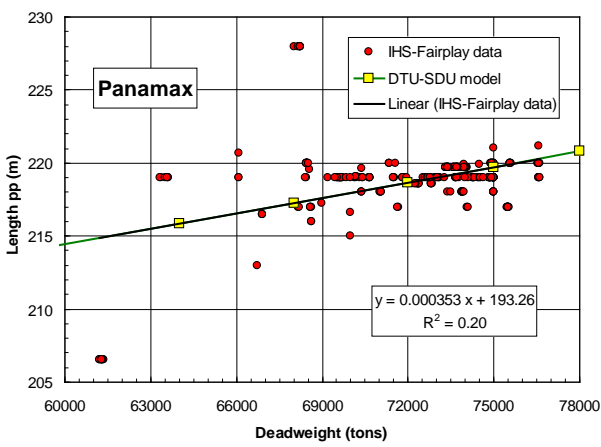


Fig. D1 Length between pp as function of DWT

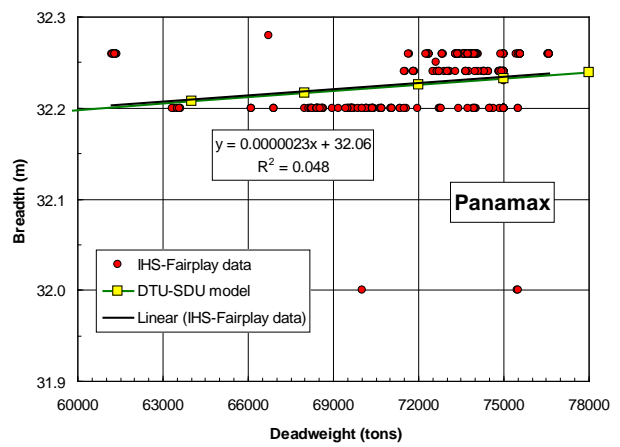


Fig. D2 Breadth as function of DWT

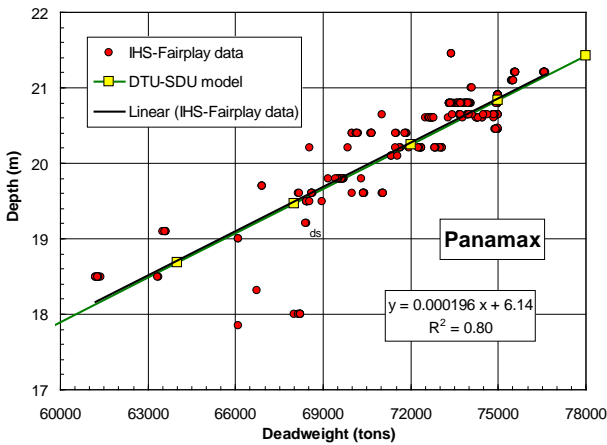


Fig. D3 Depth as function of DWT

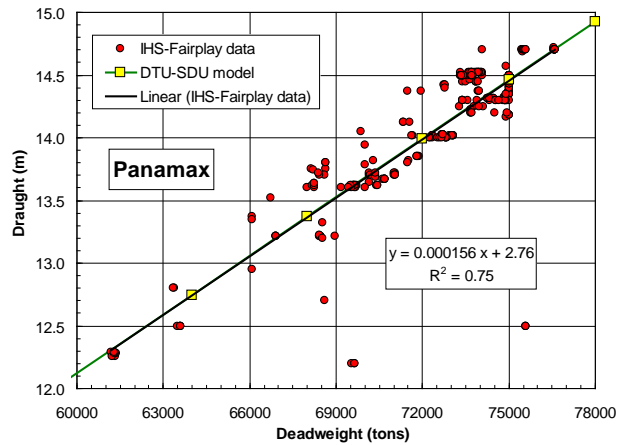


Fig. D4 Maximum draught as function of DWT

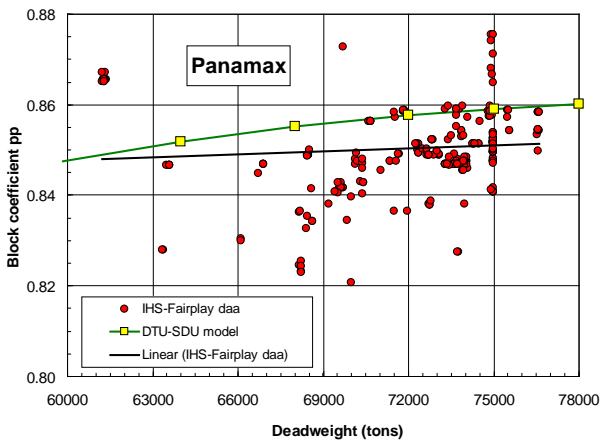


Fig. D5 Block coefficient as function of DWT

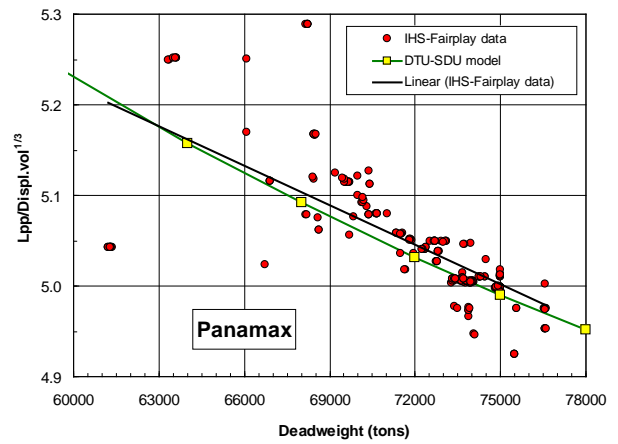


Fig. D6 Length displacement ratio as function of DWT

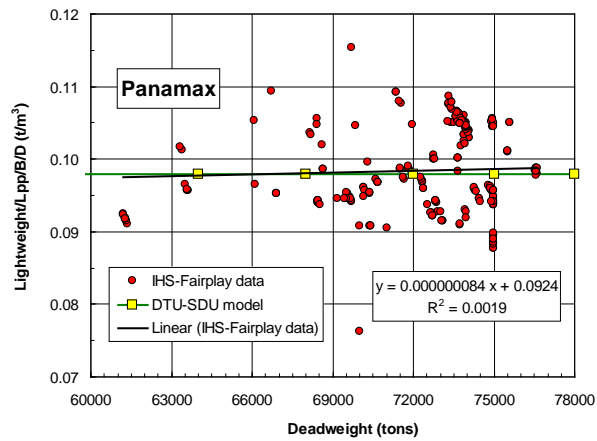


Fig. D7 Lightweight coefficient as function of DWT

Appendix E - Aframax tankers (75000 - 120000 DWT)

Length pp $= 187.92 + 0.000431 * DWT$

Breadth $= 1.5658 * DWT^{0.285}$

Depth $= 13.97 + 0.000067 * DWT$

Draught $= 0.0848 * DWT^{0.4454}$

Lightweight/Lpp/B/D $= 1.05 * (0.0859 - 0.0000000235 * DWT)$

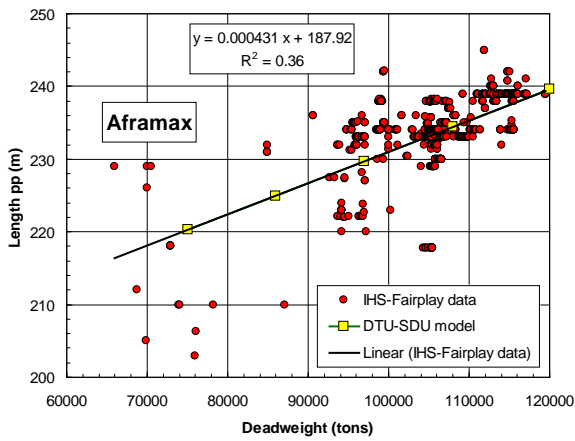


Fig. E1 Length between pp as function of DWT

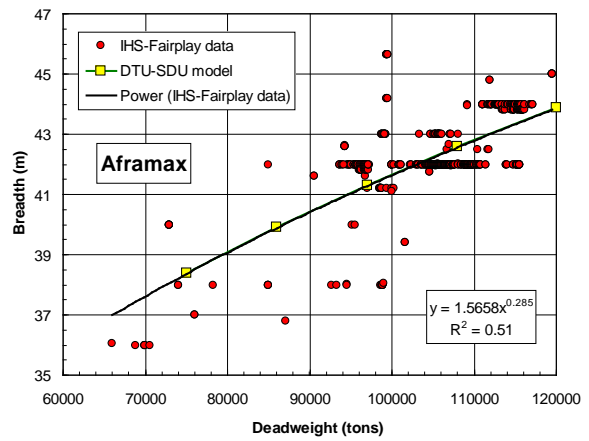


Fig. E2 Breadth as function of DWT

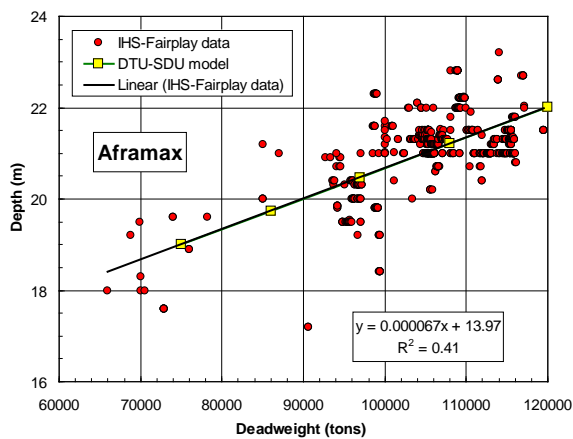


Fig. E3 Depth as function of DWT

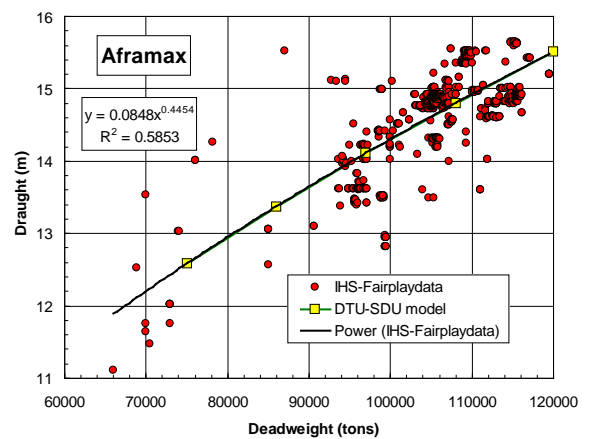


Fig. E4 Maximum draught as function of DWT

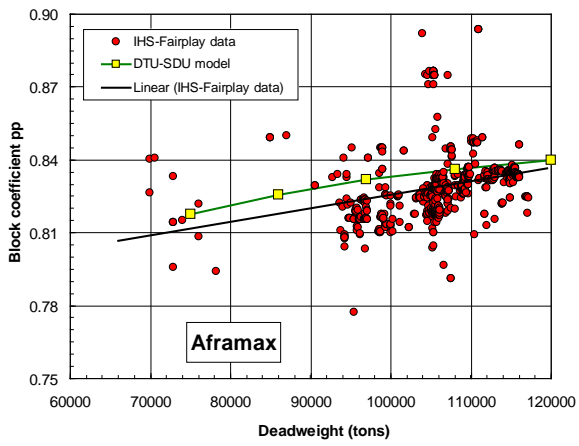


Fig. E5 Block coefficient as function of DWT

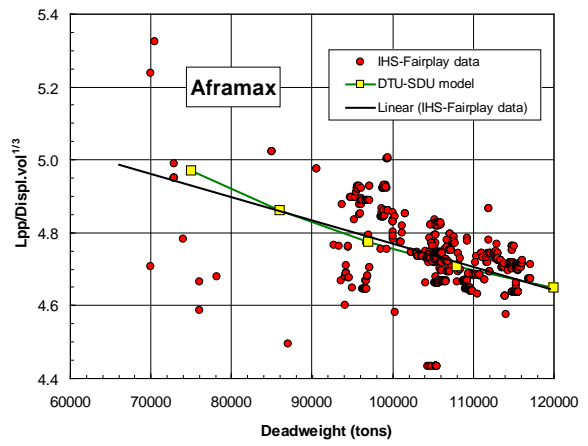


Fig. E6 Length displacement ratio as function of DWT

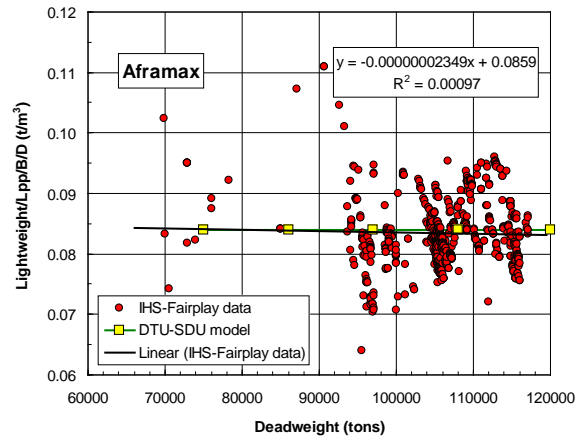


Fig. E7 Lightweight coefficient as function of DWT

Appendix F - Suezmax tankers (120000 - 170000 DWT)

Length pp = $222.41 + 0.000263 * DWT$

Breadth = $23.95 + 0.000153 * DWT$

Depth = $22.61 + 0.000004647 * DWT$

Draught = $0.2476 * DWT^{0.353}$

Lightweight/Lpp/B/D = $1.05 * (0.1296 - 0.000000308 * DWT)$

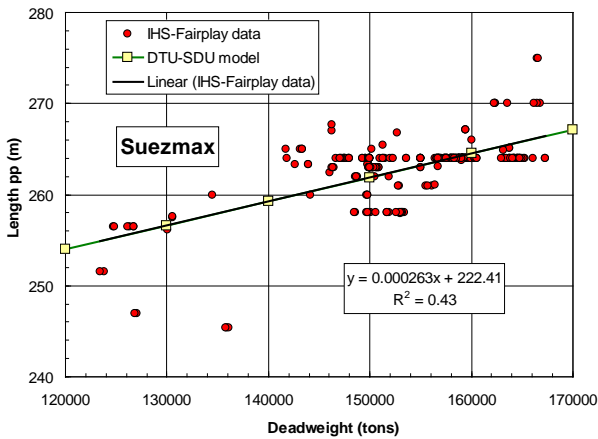


Fig. F1 Length between pp as function of DWT

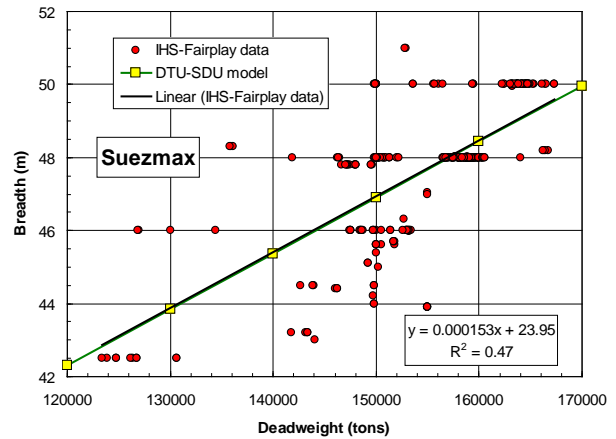


Fig. F2 Breadth as function of DWT

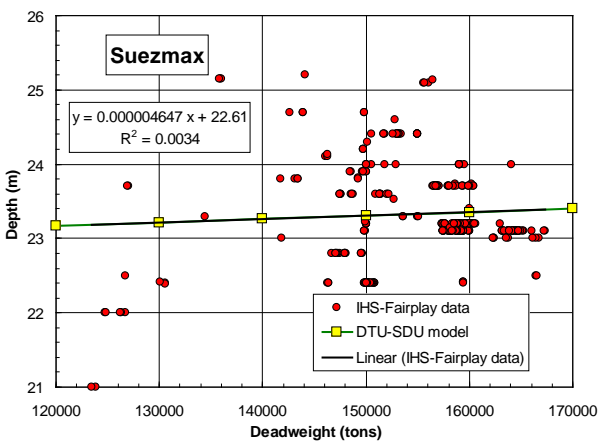


Fig. F3 Depth as function of DWT

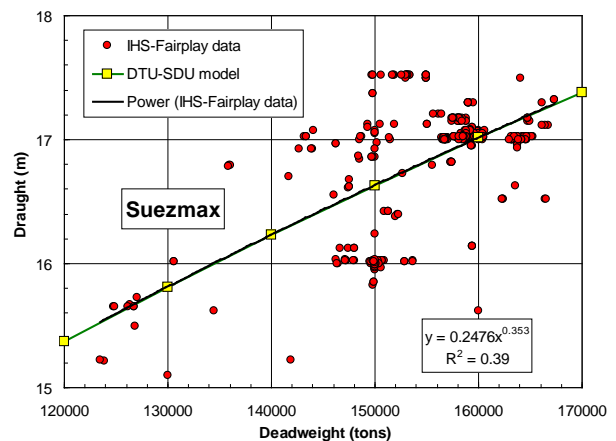


Fig. F4 Maximum draught as function of DWT

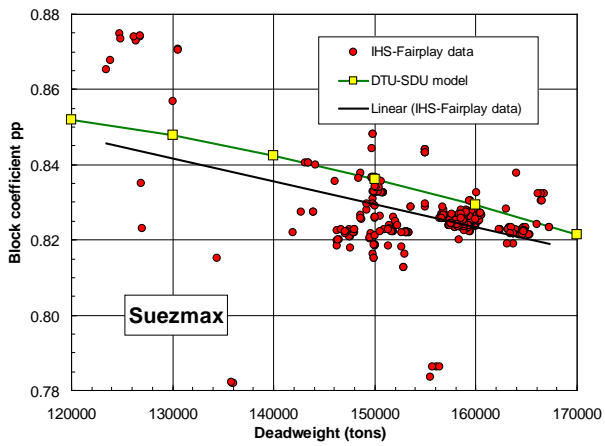


Fig. F5 Block coefficient as function of DWT

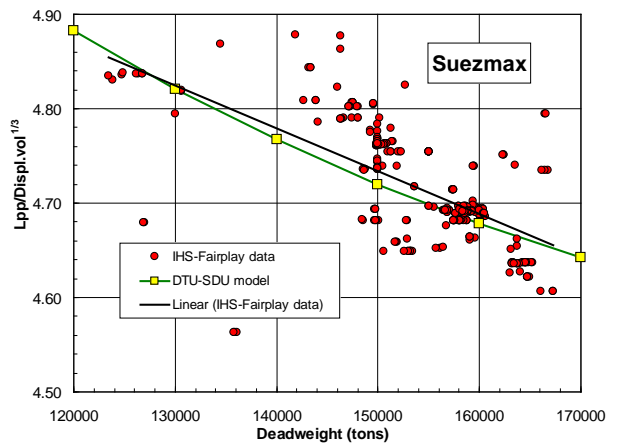


Fig. F6 Length displacement ratio as function of DWT

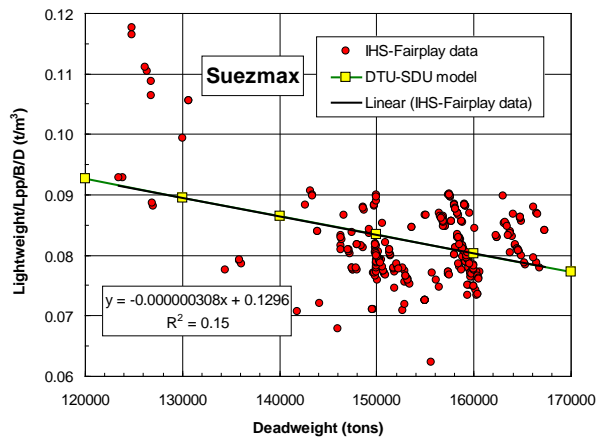


Fig. F7 Lightweight coefficient as function of DWT

Appendix G - VLCC (170000 - 250000 DWT)

$$\text{Length pp} = 267.12 + (\text{DWT} - 170000) * 0.0005975$$

$$\text{Breadth} = 49.96 + (\text{DWT} - 170000) * 0.00009219$$

$$\text{Depth} = 23.4 + (\text{DWT} - 170000) * 0.0000825$$

$$\text{Draught} = 17.38 + (\text{DWT} - 170000) * 0.00002147$$

$$\text{Lightweight/Lpp/B/D} = 1.05 * (0.0772 - (\text{DWT} - 170000) * 0.0000001574)$$

The above mentioned equations have been created based on a linear interpolation between tankers having a deadweight of 170000 t and 250000 t respectively

VLCC (250000 - 330000 DWT)

$$\text{Length pp} = 293.67 + 0.000085 * \text{DWT}$$

$$\text{Breadth} = 49.01 + 0.0000333 * \text{DWT}$$

$$\text{Depth} = 30 \text{ m}$$

$$\text{Draught} = 6.85 + 0.000049 * \text{DWT}$$

$$\text{Lightweight/Lpp/B/D} = 1.05 * (0.01912 + 0.00000018212 * \text{DWT})$$

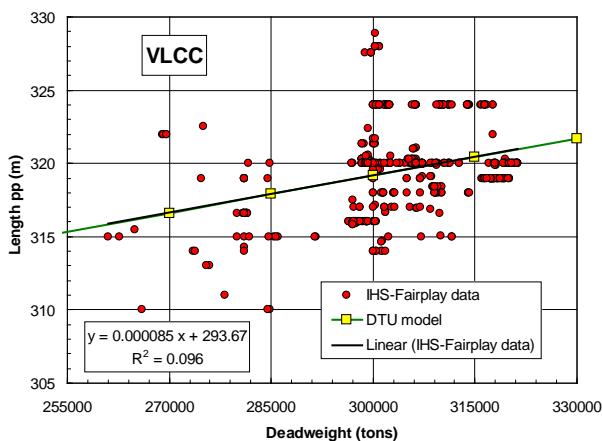


Fig. G1 Length between pp as function of DWT

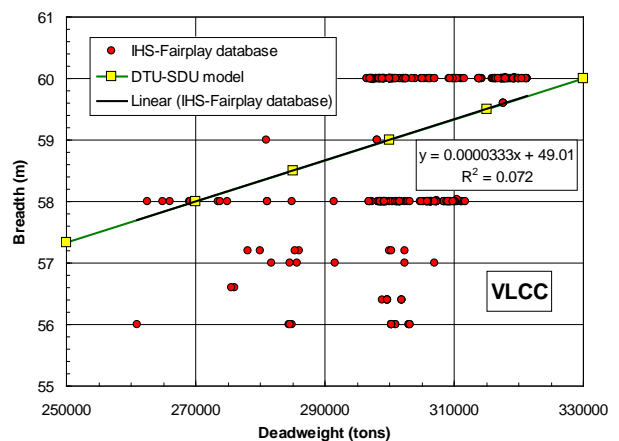


Fig. G2 Breadth as function of DWT

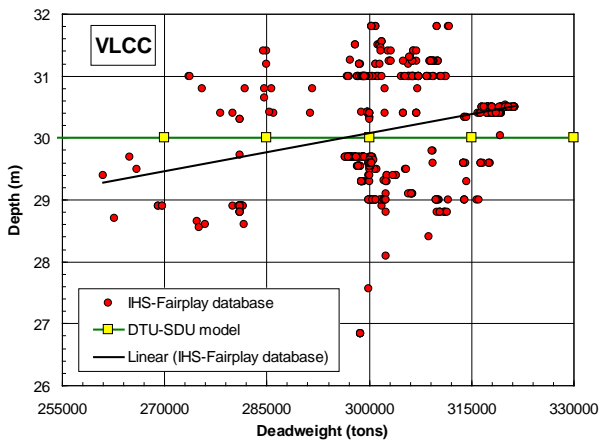


Fig. G3 Depth as function of DWT

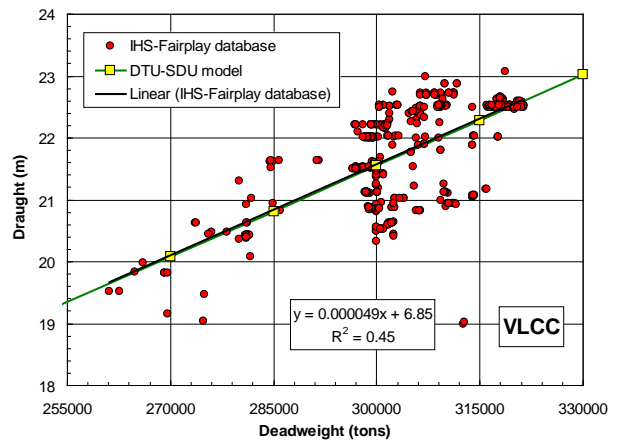


Fig. G4 Maximum draught as function of DWT

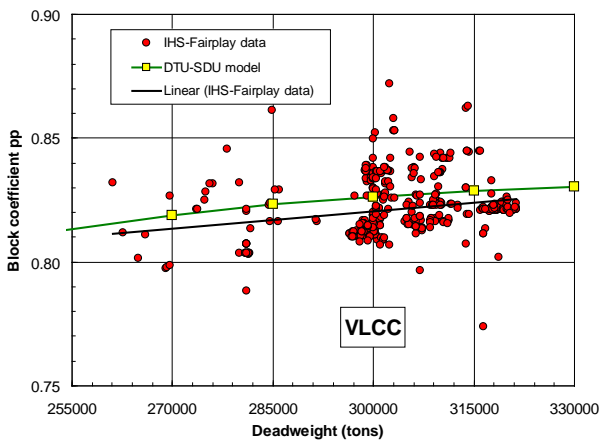


Fig. G5 Block coefficient as function of DWT

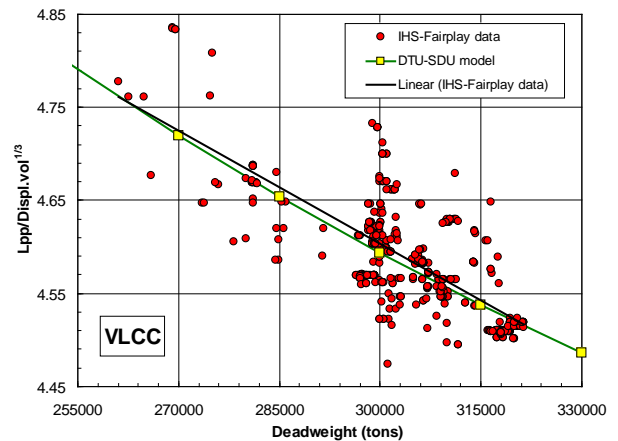


Fig. G6 Length displacement ratio as function of DWT

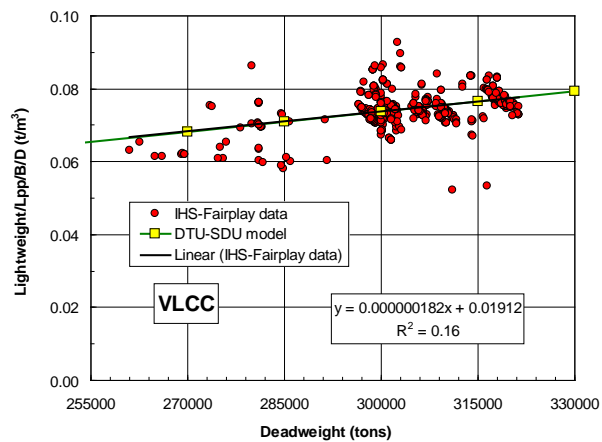


Fig. G7 Lightweight coefficient as function of DWT

Appendix H – All bulk carriers – summary of regression analysis

Bulk carriers have been categorized in following 6 groups:

1. Small bulk carriers (< 10000 DWT)
2. Handysize bulk carriers (10000 - 25000 DWT)
3. Handymax bulk carriers (25000 - 55000 DWT)
4. Panamax bulk carriers (55000 - 85000 DWT)
5. Capesize bulk carriers (85000 - 200000 DWT)
6. VLBC (200000 - 330000 DWT)

The equations found by regression analysis are shown for each individual ship sub type. The equations are basis for the generic ship design model for determination of main dimension and propulsion characteristics for all types of bulk carriers – in the following called ‘DTU and SDU model’.

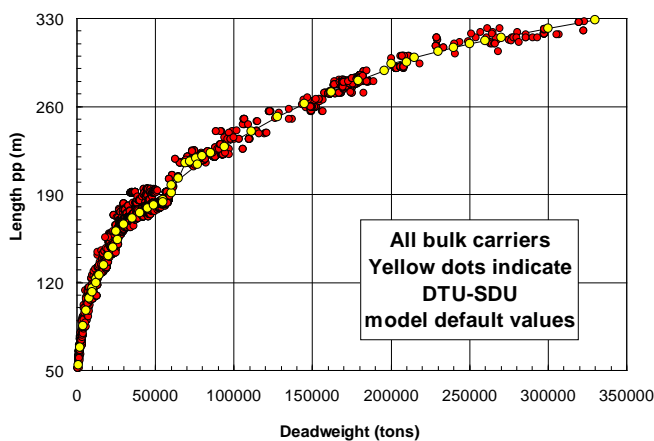


Fig. H1 Length between pp as function of DWT

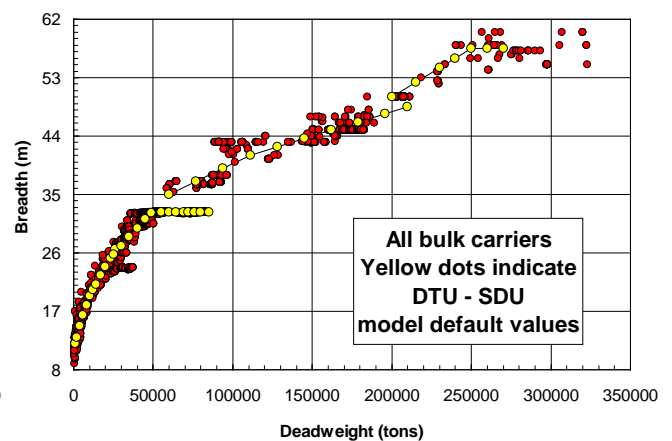


Fig. H2 Breadth as function of DWT

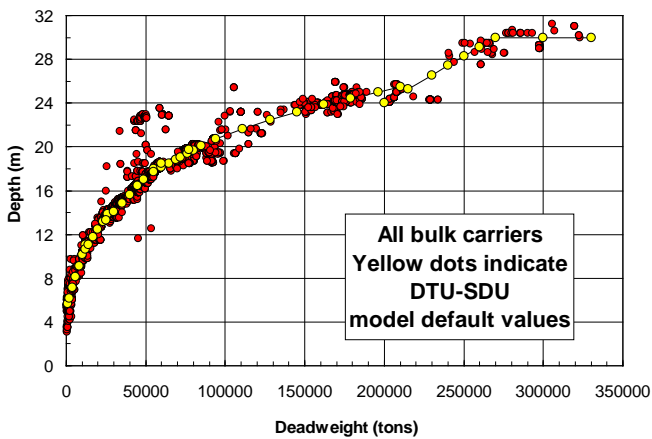


Fig. H3 Depth as function of DWT

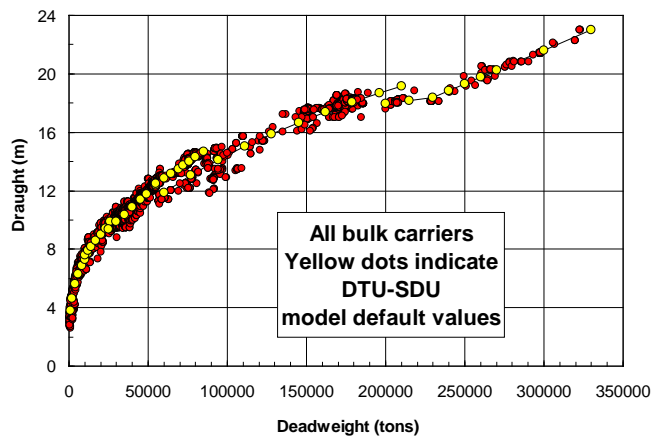


Fig. H4 Maximum draught as function of DWT

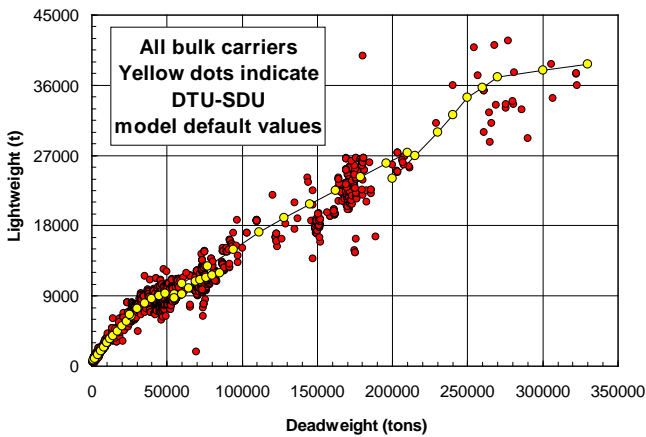


Fig. H5 Lightweight as function of DWT

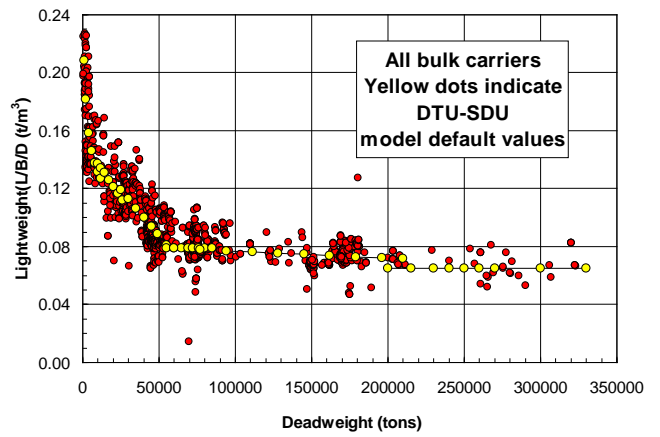


Fig. H6 Lightweight coefficient as function of DWT

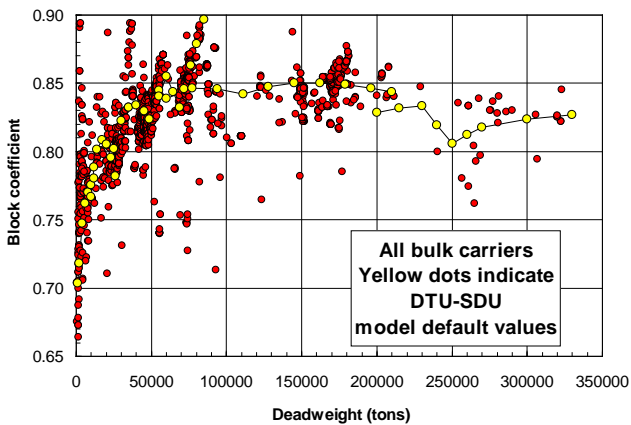


Fig. H7 Block coefficient as function of DWT

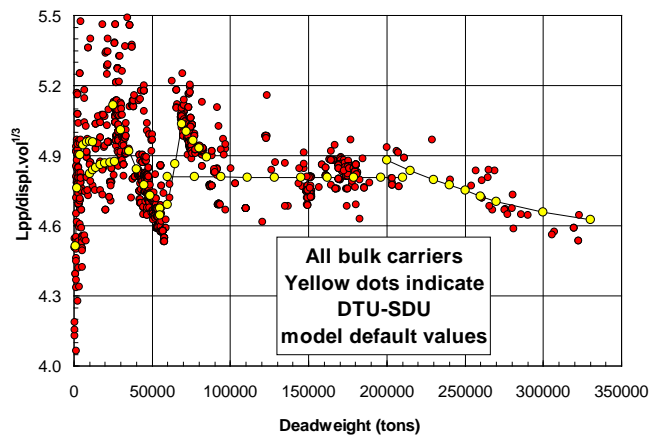


Fig. H8 Length displacement ratio as function of DWT

Appendix I - Small bulk carriers (< 10000 DWT)

Length pp = $5.582 * DWT^{0.329}$

Breadth = $11 + 0.001 * DWT - 0.00000001675 * DWT^2$

Depth = $5.22 + 0.000485 * DWT$

Draught = $0.529 * DWT^{0.285}$

Lightweight/Lpp/B/D = $0.831 * DWT^{-0.2}$

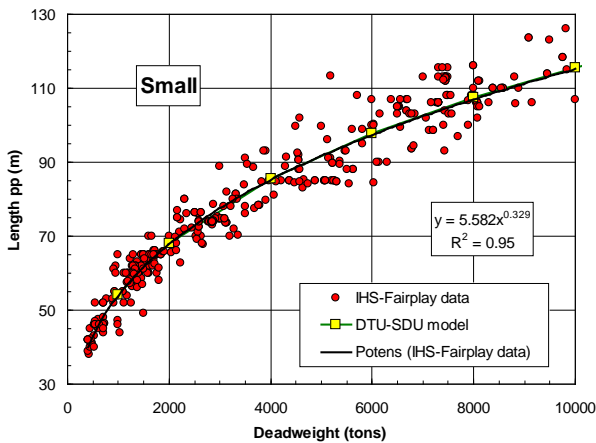


Fig. I1 Length between pp as function of DWT

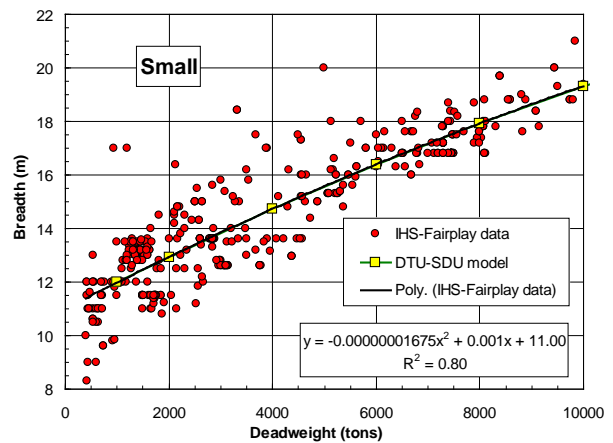


Fig. I2 Breadth as function of DWT

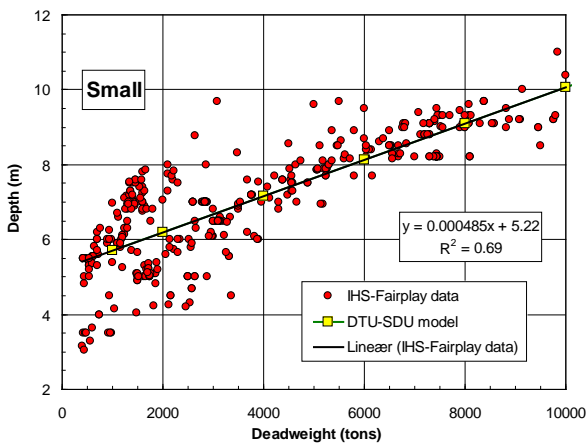


Fig. I3 Depth as function of DWT

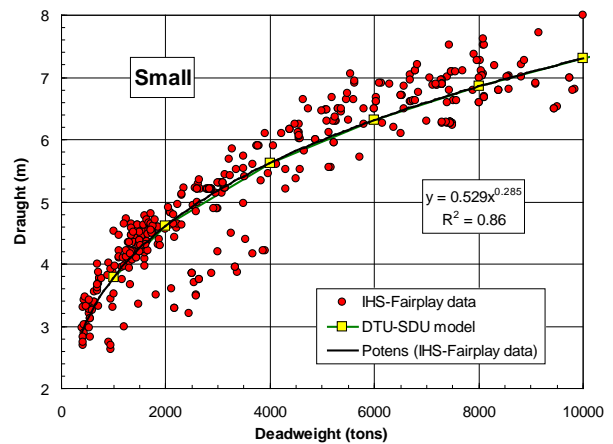


Fig. I4 Maximum draught as function of DWT

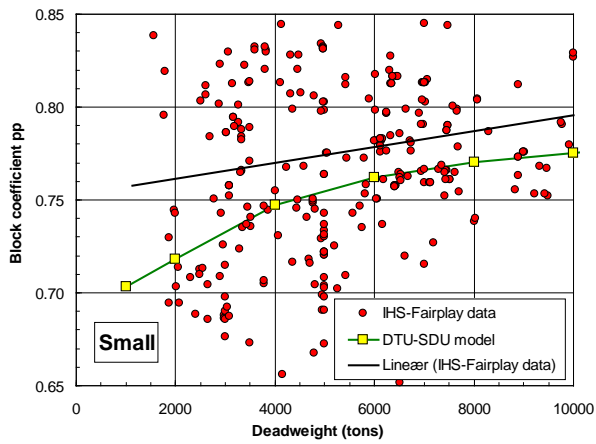


Fig. 15 Block coefficient as function of DWT

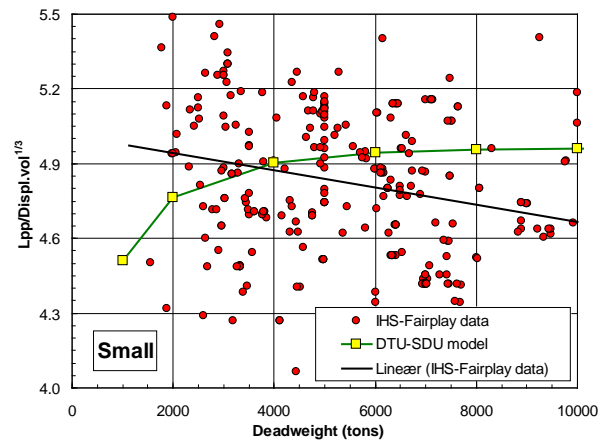


Fig. 16 Length displacement ratio as function of DWT

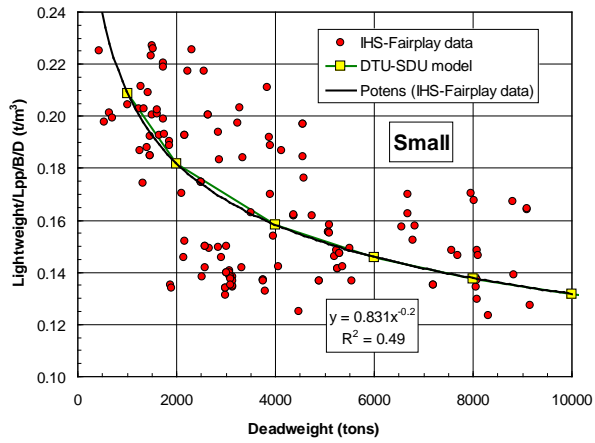


Fig. 17 Lightweight coefficient as function of DWT

Appendix J – Handysize bulk carriers (10000 - 25000 DWT)

Length pp $= 5.463 * DWT^{0.3285}$

Breadth $= 14.86 + 0.00045 * DWT$

Depth $= 7.84 + 0.000232 * DWT$

Draught $= 6.2 + 0.000141 * DWT$

Lightweight/Lpp/B/D $= 1.05 * (0.153 - 0.00000158 * DWT)$

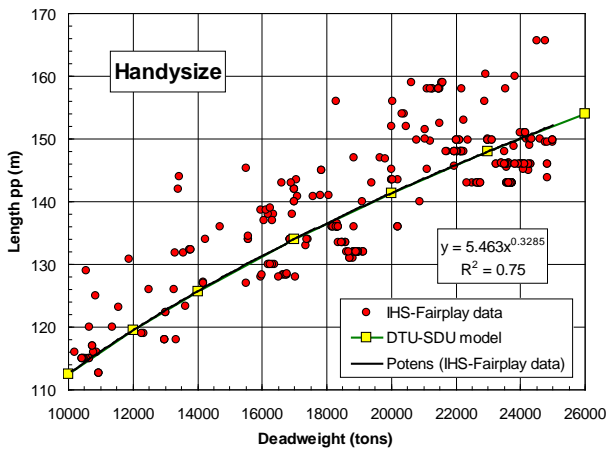


Fig. J1 Length between pp as function of DWT

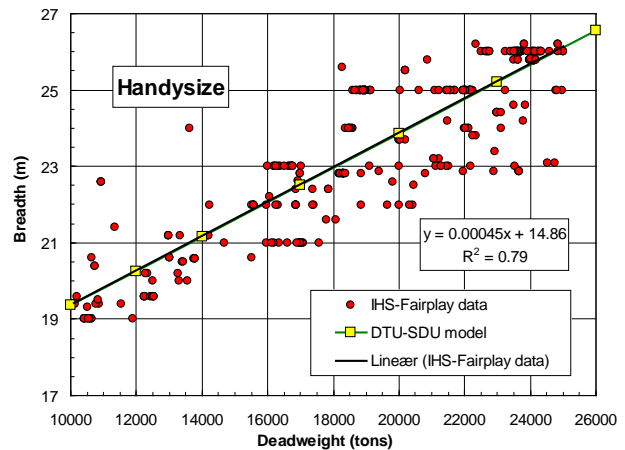


Fig. J2 Breadth as function of DWT

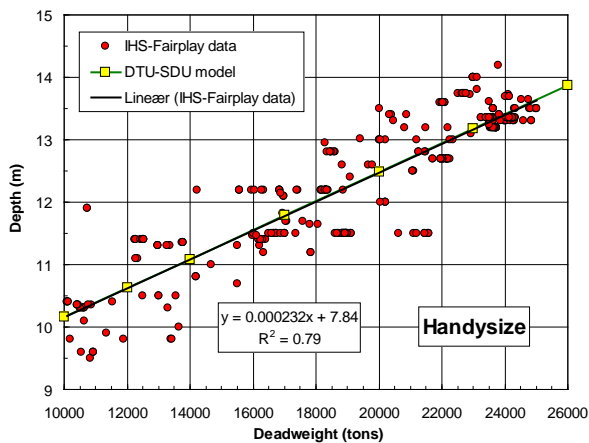


Fig. J3 Depth as function of DWT

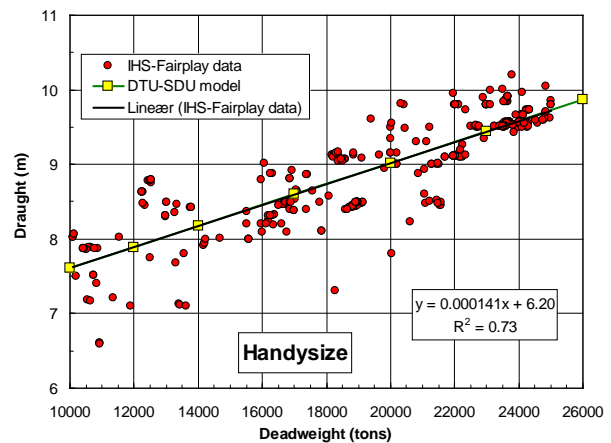


Fig. J4 Maximum draught as function of DWT

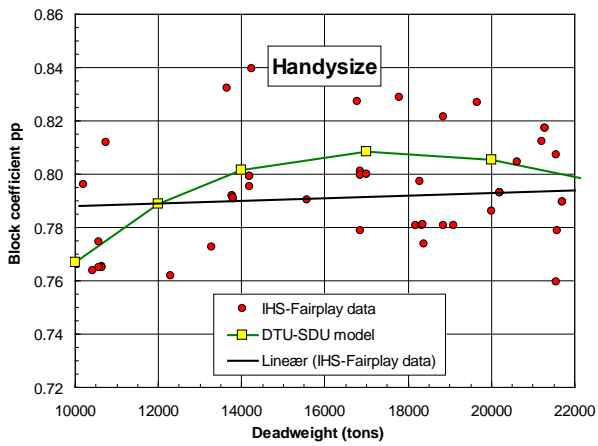


Fig. J5 Block coefficient as function of DWT

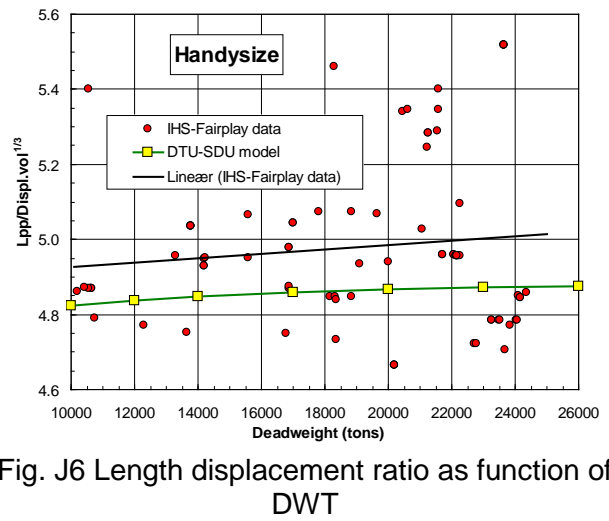


Fig. J6 Length displacement ratio as function of DWT

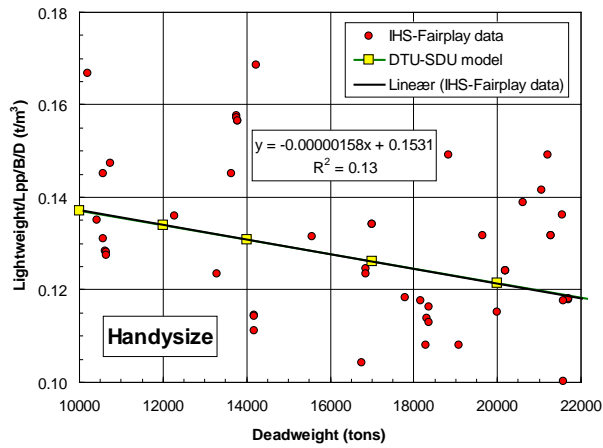


Fig. J7 Lightweight coefficient as function of DWT

Appendix K - Handymax bulk carriers (25000 - 55000 DWT)

Length pp = $25.66 * DWT^{0.1813}$

Breadth = $\text{MIN}(18.93 + 0.000272 * DWT; 32.2)$

Depth = $9.32 + 0.000158 * DWT$

Draught = $6.84 + 0.000101 * DWT$

Lightweight/Lpp/B/D = $1.05 * (0.151 - 0.00000127 * DWT)$

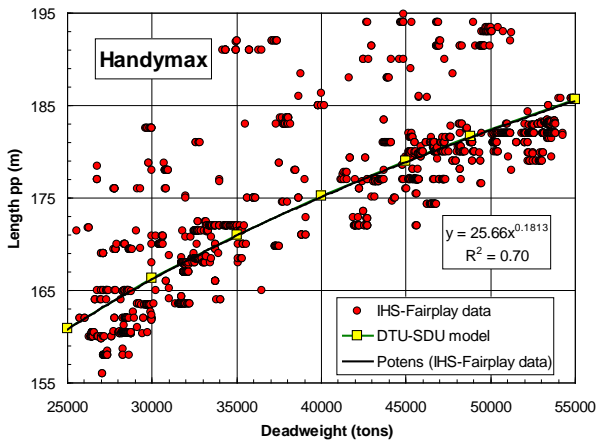


Fig. K1 Length between pp as function of DWT

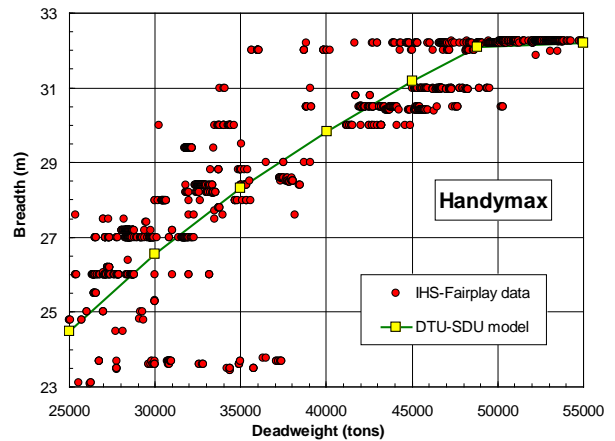


Fig. K2 Breadth as function of DWT

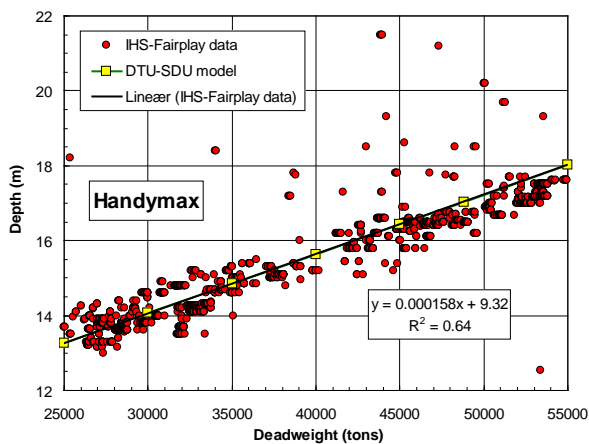


Fig. K3 Depth as function of DWT

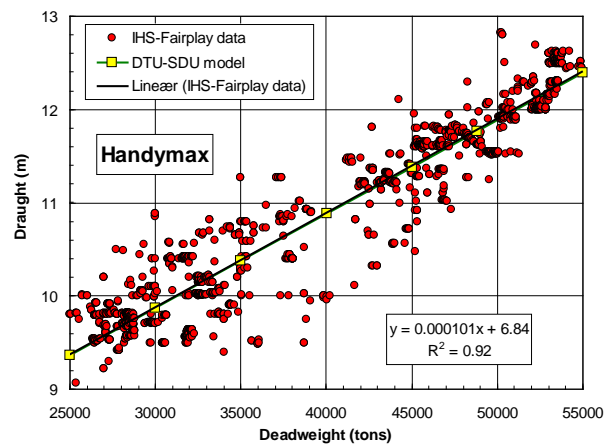


Fig. K4 Maximum draught as function of DWT

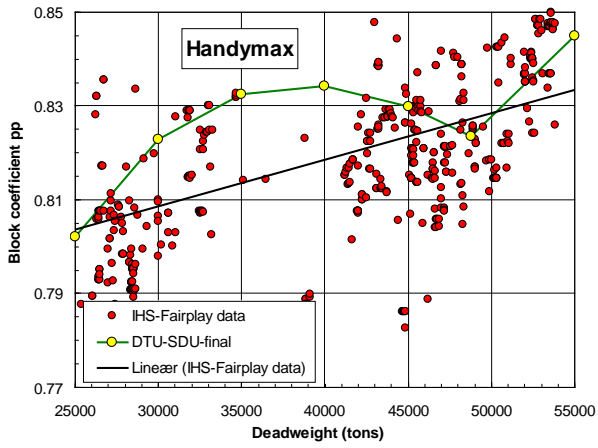


Fig. K5 Block coefficient as function of DWT

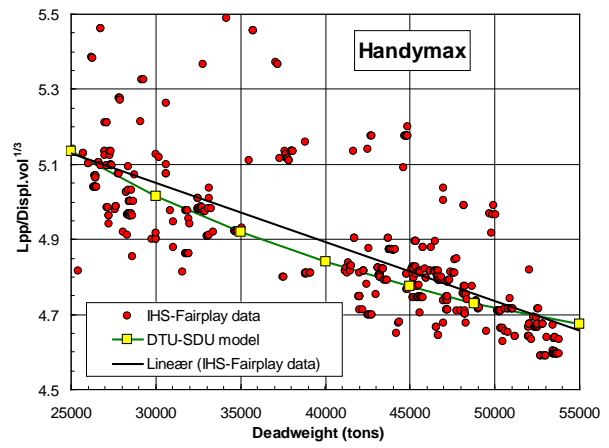


Fig. K6 Length displacement ratio as function of DWT

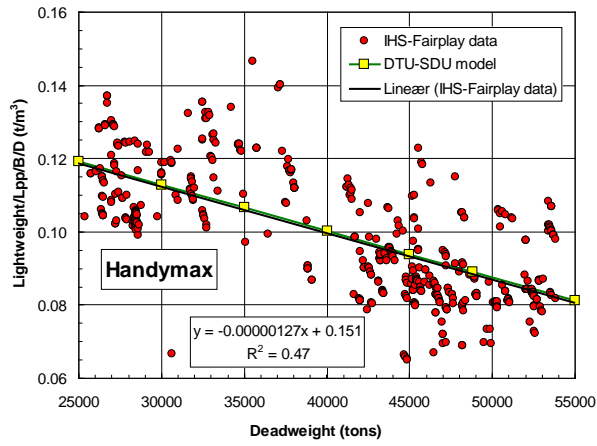


Fig. K7 Lightweight coefficient as function of DWT

Appendix L - Panamax bulk carriers (55000 - 85000 DWT)

Length pp = $107.00 + 0.0014 * DWT$ for $DWT < 60000$
 = $31.00 + 0.00267 * DWT$ for $60000 \leq DWT \leq 69000$
 = $180.50 + 0.0005 * DWT$ for $DWT > 85000$
 Breadth = 32.23
 Depth = $13.47 + 0.0000777 * DWT$
 Draught = $8.43 + 0.0000735 * DWT$
 Lightweight/Lpp/B/D = $1.05 * 0.079$

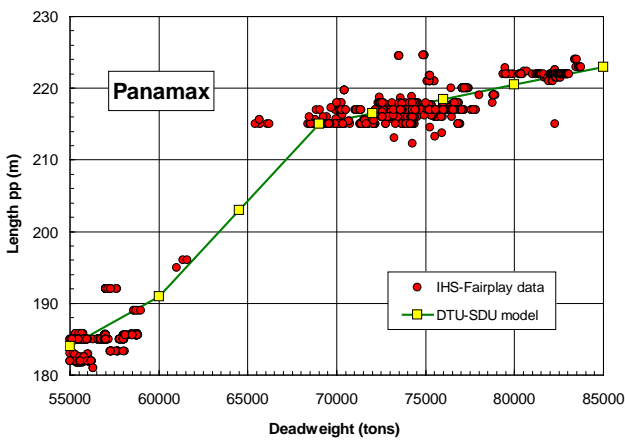


Fig. L1 Length between pp as function of DWT

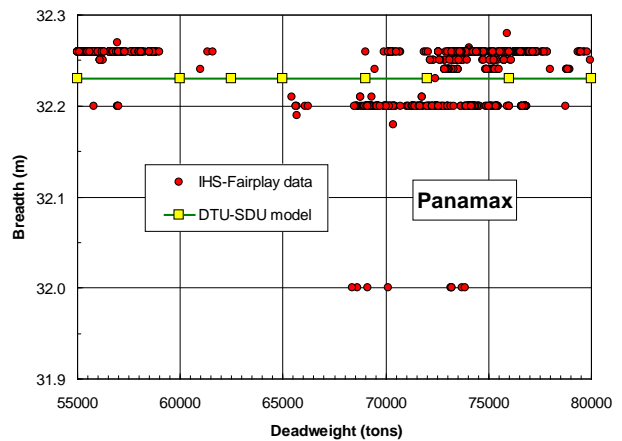


Fig. L2 Breadth as function of DWT

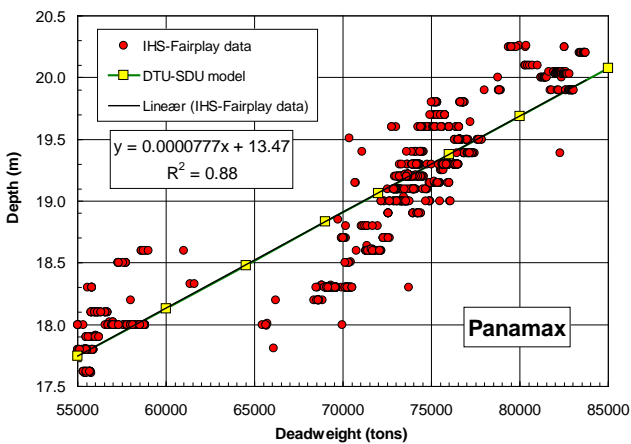


Fig. L3 Depth as function of DWT

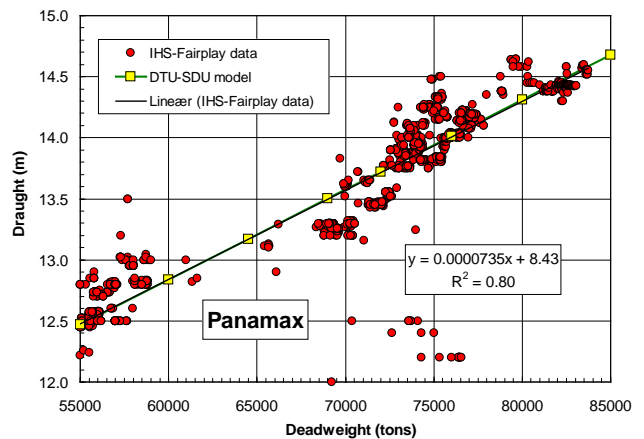


Fig. L4 Maximum draught as function of DWT

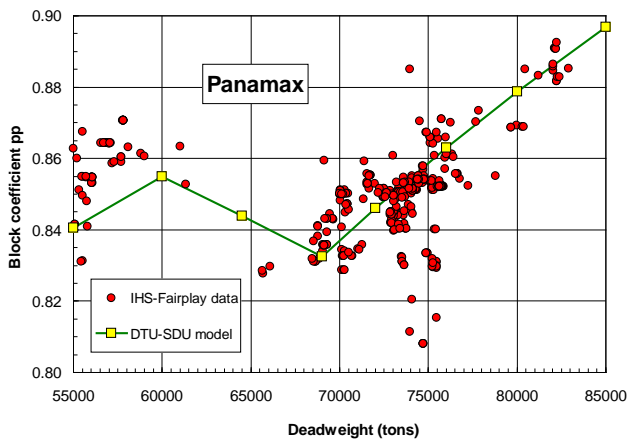


Fig. L5 Block coefficient as function of DWT

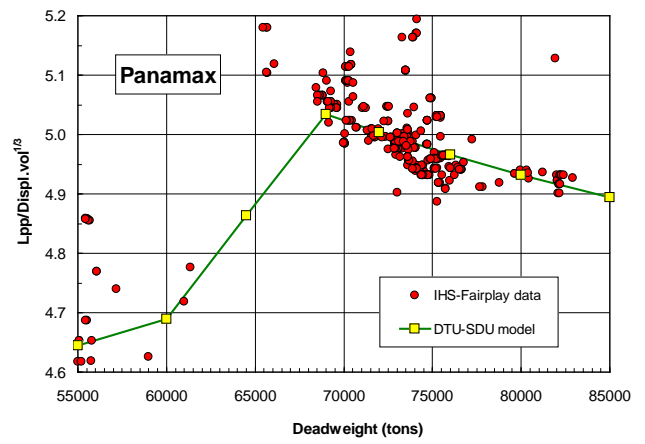


Fig. L6 Length displacement ratio as function of DWT

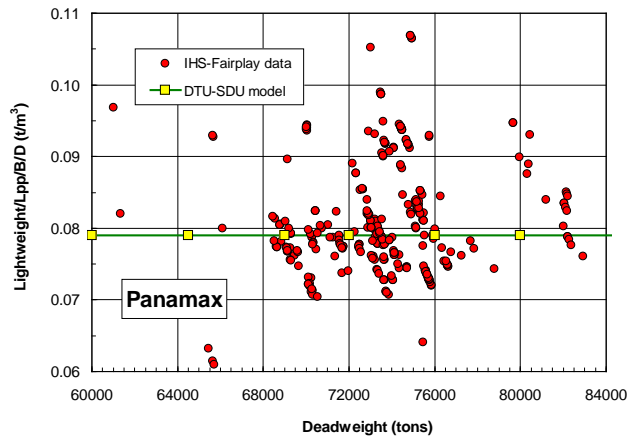


Fig. L7 Lightweight coefficient as function of DWT

Appendix M - Capesize bulk carriers (85000 - 200000 DWT)

Length pp $= 5.705 * DWT^{0.322}$

Breadth $= 27.80 + 0.00012 * DWT$ for $DWT < 110000$
 $= 32.75 + 0.000075 * DWT$ for $DWT \Rightarrow 110000$

Depth $= 1.126 * DWT^{0.2545}$

Draught $= 0.179 * DWT^{0.3814}$

Lightweight/Lpp/B/D $= 0.0817 - 0.0000000486 * DWT$

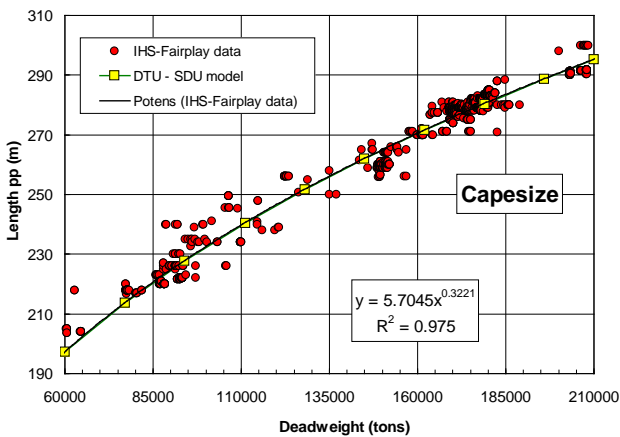


Fig. M1 Length between pp as function of DWT

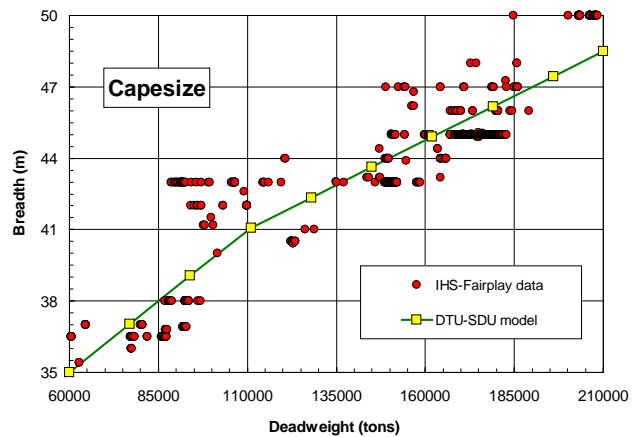


Fig. M2 Breadth as function of DWT

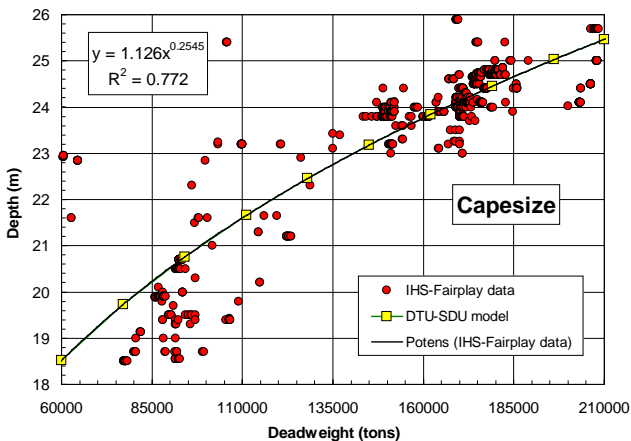


Fig. M3 Depth as function of DWT

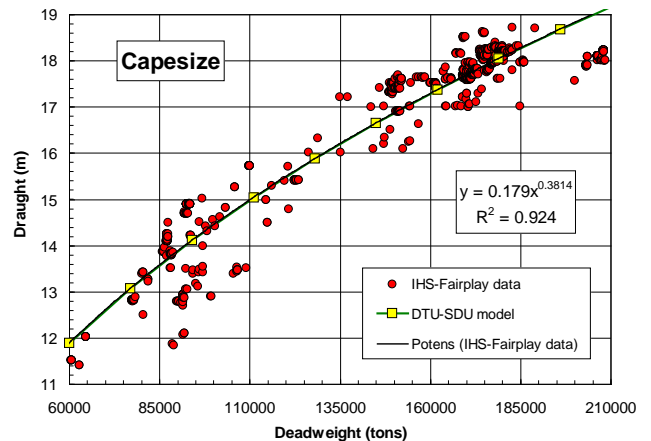


Fig. M4 Maximum draught as function of DWT

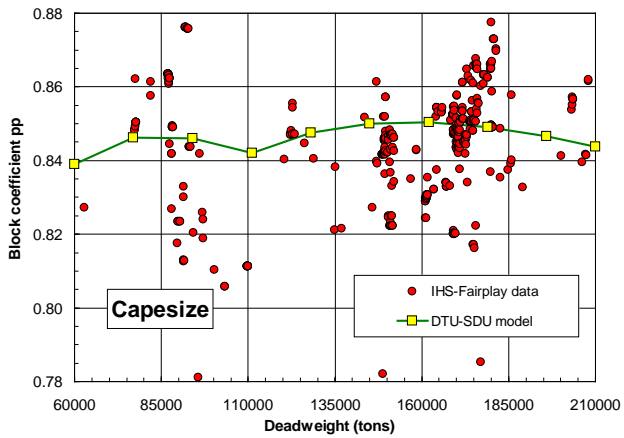


Fig. M5 Block coefficient as function of DWT

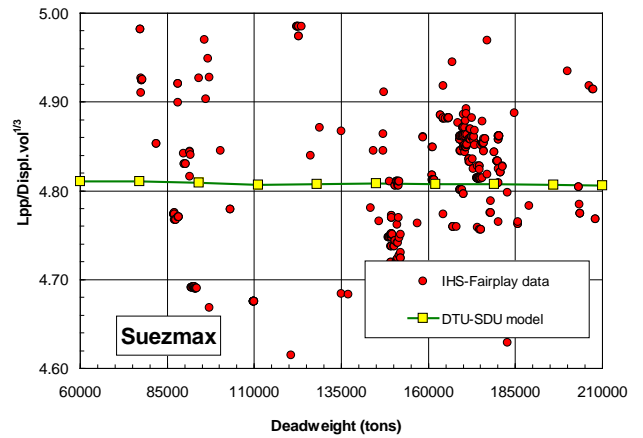


Fig. M6 Length displacement ratio as function of DWT

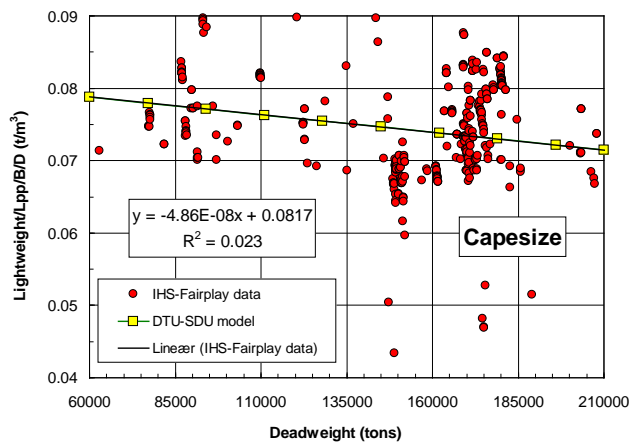


Fig. M7 Lightweight coefficient as function of DWT

Appendix N - VLBC (200000 - 330000 DWT)

Length pp = $230.00 + 0.00032 * DWT$ for $DWT < 250000$
 = $250.625 + 0.0002375 * DWT$ for $DWT \Rightarrow 250000$

Breadth = $\text{MIN}(57.5, 20 + 0.00015 * DWT)$

Depth = $\text{MIN}(6.86 + 0.0000857 * DWT, 30)$

Draught = $14.95 + 0.000015 * DWT$ for $DWT < 230000$
 = $7.82 + 0.000046 * DWT$ for $DWT \Rightarrow 230000$

Lightweight/Lpp/B/D = $1.05 * (0.076 - 0.0000000261 * DWT)$

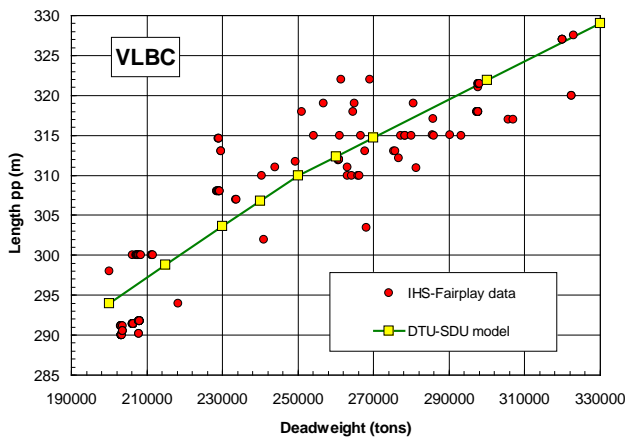


Fig. N1 Length between pp as function of DWT

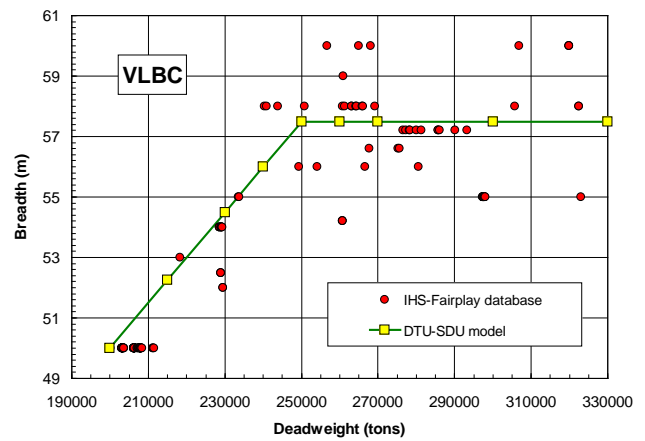


Fig. N2 Breadth as function of DWT

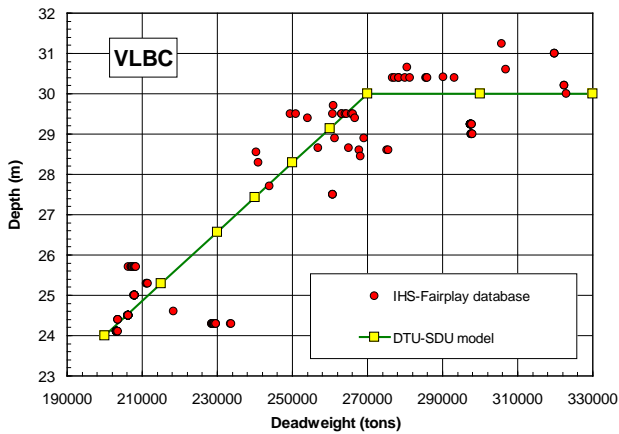


Fig. N3 Depth as function of DWT

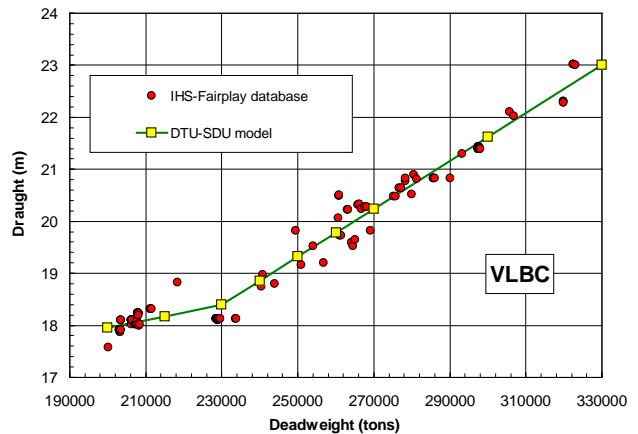


Fig. N4 Maximum draught as function of DWT

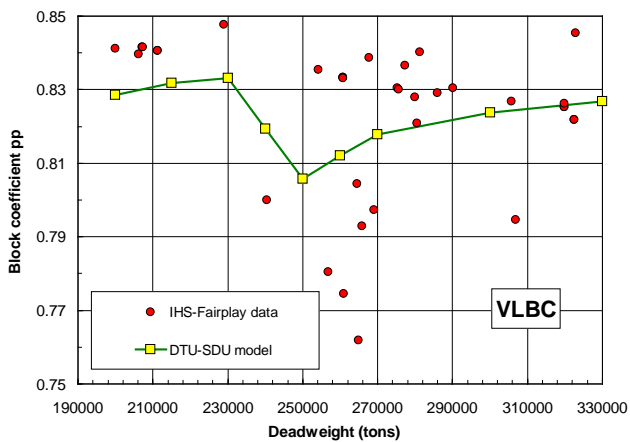


Fig. N5 Block coefficient as function of DWT

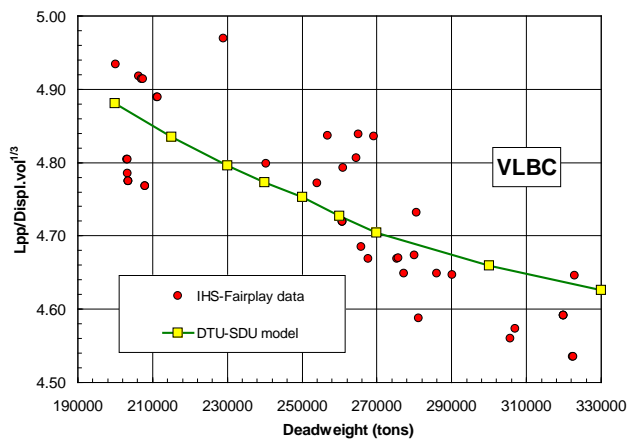


Fig. N6 Length displacement ratio as function of DWT

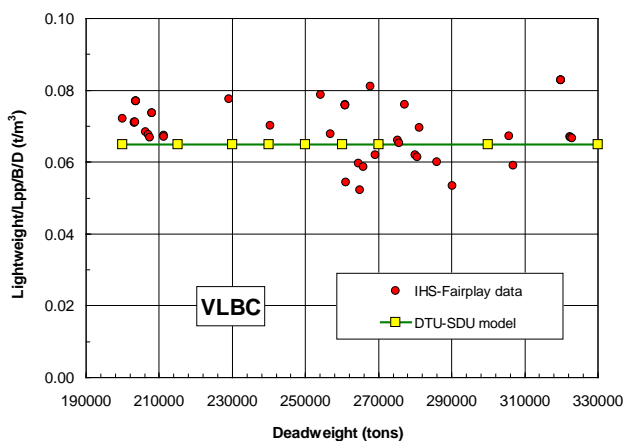


Fig. N7 Lightweight coefficient as function of DWT

Appendix O – Water plane area coefficient and draught change

The waterplane area coefficient, C_w , for tankers and bulk carriers is shown in Fig. O1.

C_w depends on the block coefficient, C_b , as follows:

$$C_w = 0.24 + 0.81 C_b$$

where C_w and C_b are calculated on basis of the length between pp.

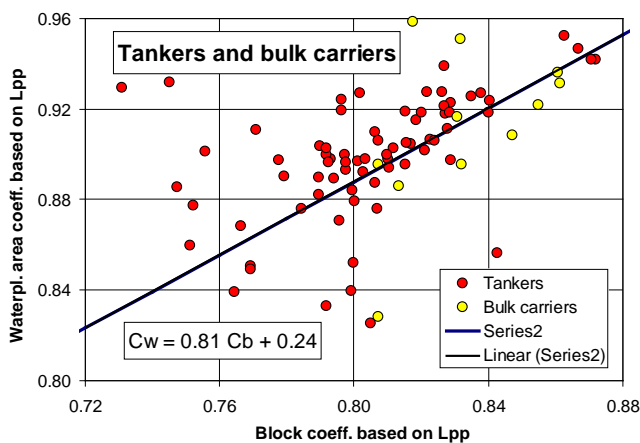


Fig. O1 Waterplane area coefficient as function of the block coefficient for tankers and bulk carriers

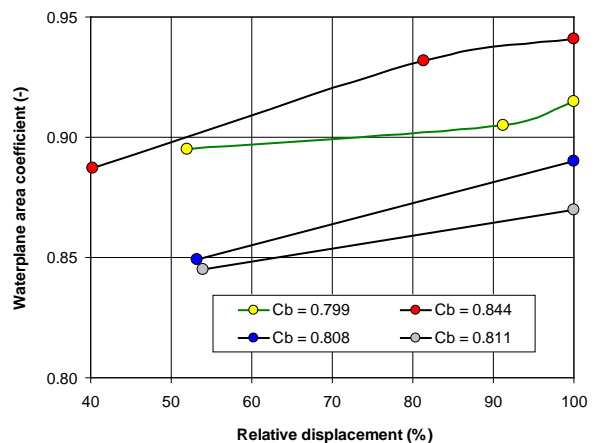


Fig. O2 Waterplane area coefficient as function the relative displacement

In Fig. O2 is shown the waterplane area coefficient as function of the relative displacement. Based on the results in Fig. O2, the waterplane area coefficient at a displacement $\Delta 2$ can be approximated as follows:

$$C_w(\Delta 2) = C_w(\Delta 1) - 0.08 \cdot \left(1 - \frac{\Delta 2}{\Delta 1}\right) = [0.24 + 0.81 \cdot C_b(\Delta 1)] - 0.08 \cdot \left(1 - \frac{\Delta 2}{\Delta 1}\right)$$

Scantling draught and design draught

All data presented in this report are presented as function of the maximum deadweight.

Normally two draughts are specified for tankers and bulk carriers, namely the design draught and the scantling draught. The design draught is the draught at which the ship is expected to operate normally, while the scantling draught is the maximum permissible draught according to the class rules. Comparison of scantling draught data (Significant Ships, 1990 – 2010) with summer load line draught data (denoted maximum draught in this report) shows that the summer load line draught is nearly identical with the scantling draught (Fig. O3 and O4).

The design deadweight and the scantling deadweight are shown in Fig. O5 as the ratio between design deadweight and scantling deadweight for 229 ships (181 tankers and 58 bulk carriers). The

ratio depends on the ship size, but the scatter is relatively large so a design to scantling deadweight ratio of 90 % is assumed.

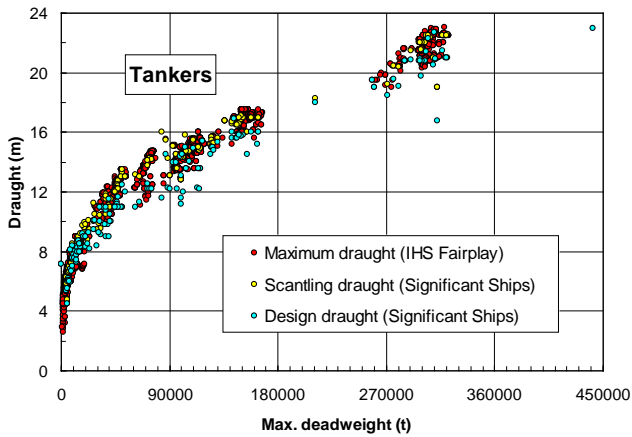


Fig. O3 Draught for tankers according to Significant Ships (1990 – 2010)

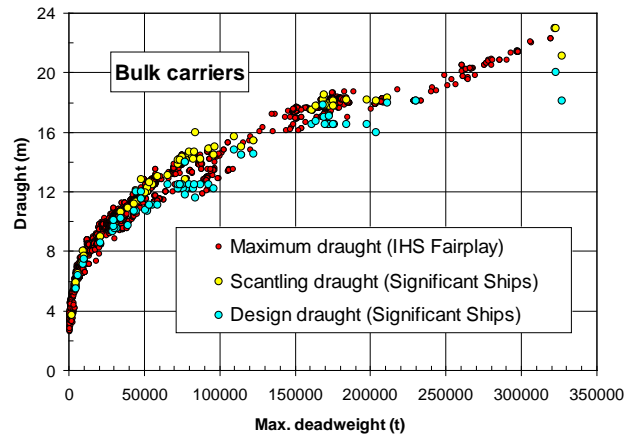


Fig. O4 Draught for bulk carriers according to Significant Ships (1990 – 2010)

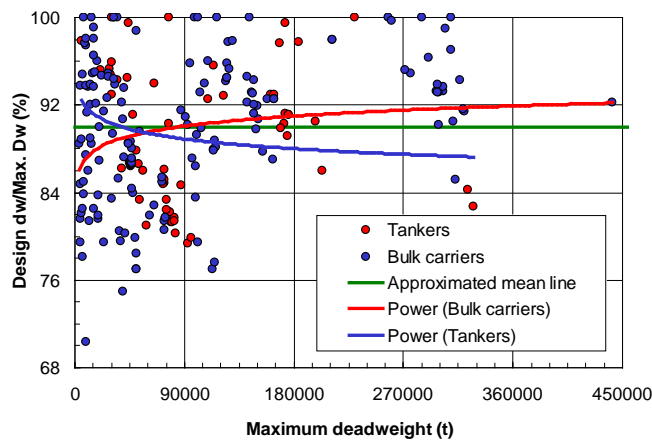


Fig. O5 Design deadweight as percentage of the scantling deadweight

The design draught can be calculated according to this approximate formula:

$$T_{design} = T_{scantling} - \frac{Dw_{scantling} - Dw_{design}}{[Cw_{scantling} - 0.04 \cdot (1 - \frac{\Delta_{scantling}}{\Delta_{design}})] \cdot Lpp \cdot B \cdot \rho_{salt\ water}}$$

Appendix P Service speed for tankers and bulk carriers

The speed for tankers according IHS Fairplay and Significant Ships are presented in Fig. P1.

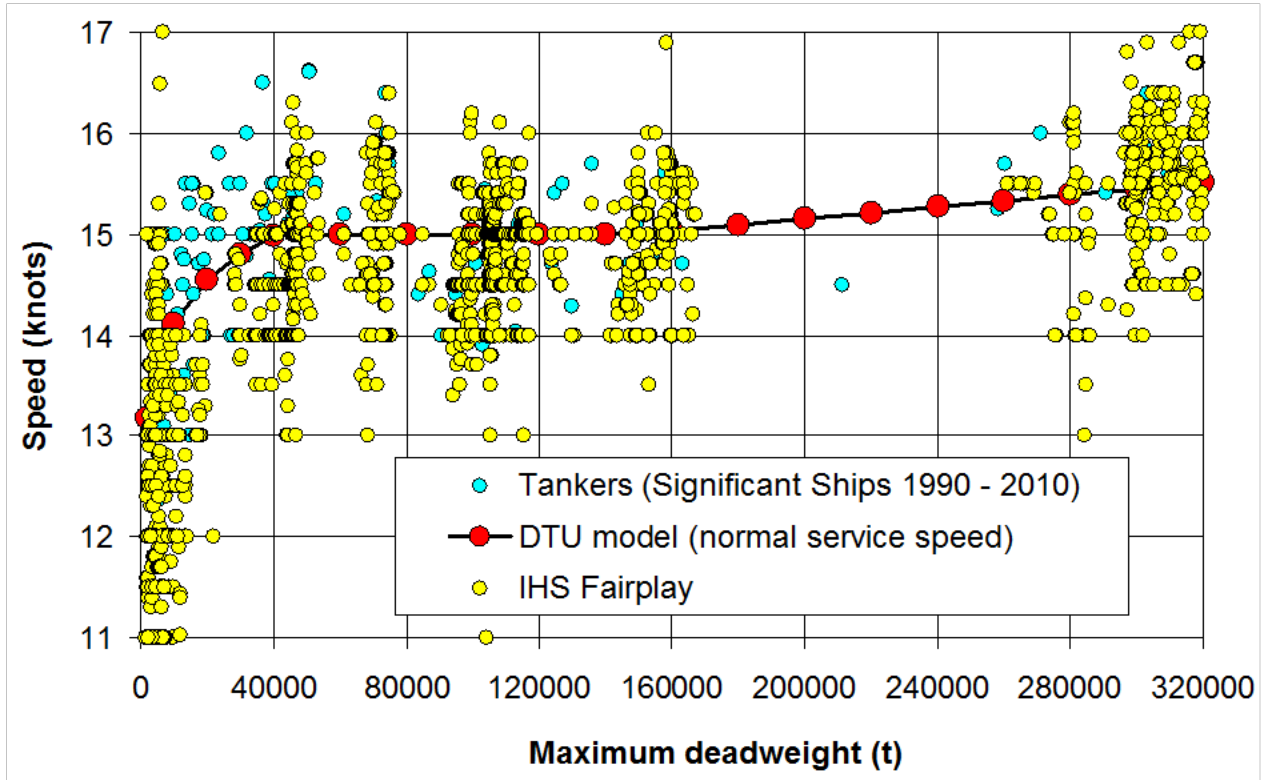


Fig. P1 Speed for tankers

Based on a regression analysis of the IHS Fairplay data, following speed assumptions have been made for calculation of a default service speed:

If deadweight (DWT) \leq 150000 t: Speed = $9.5 \cdot \text{DWT}^{0.043}$, but not more than 15 knots
 If deadweight $>$ 150000 t: Speed = $15 + (\text{DWT} - 150000) \cdot 0.000003$

The speed for bulk carriers according IHS Fairplay and Significant Ships are presented in Fig. P2. Based on a regression analysis of the IHS Fairplay data, following speed assumption has been made for calculation of a default service speed:

Speed = $0.613 \cdot \text{LN}(\text{DWT}) + 7.74$, but not more than 15 knots

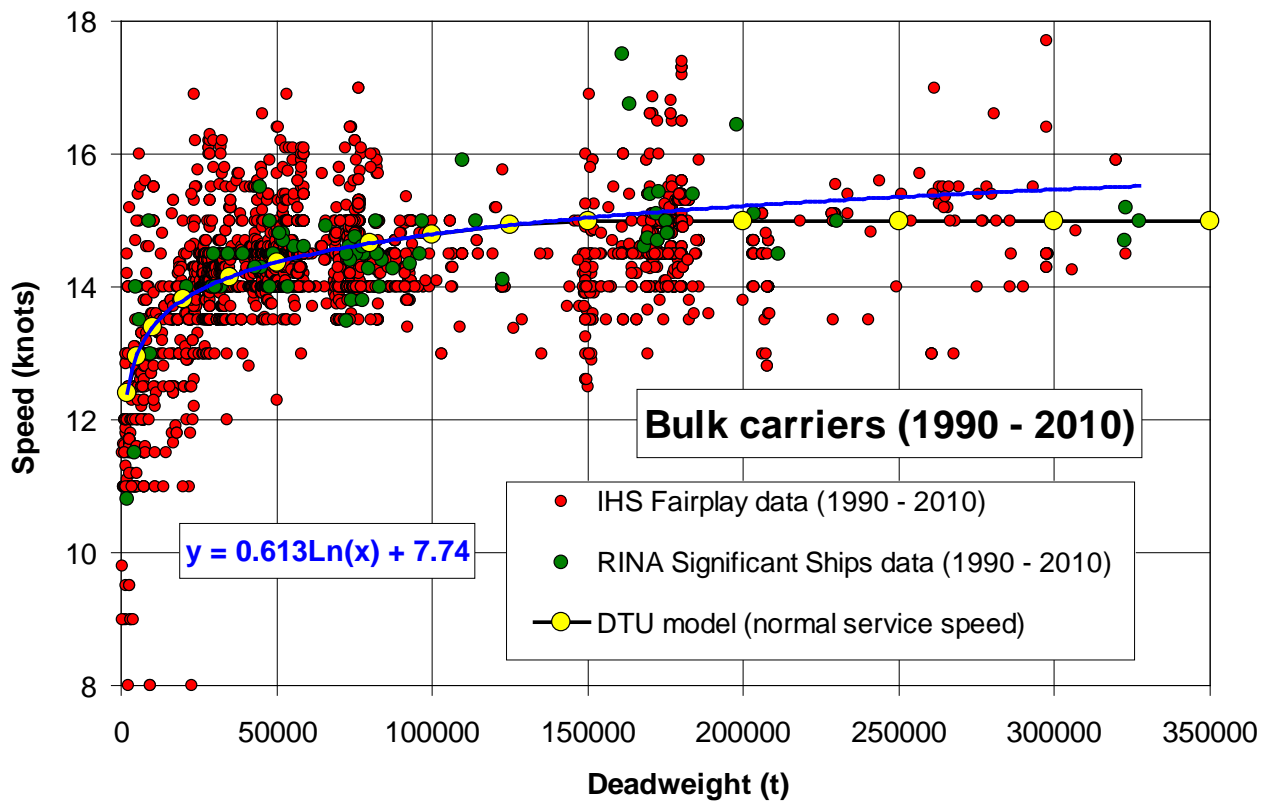


Fig. P2 Speed for bulk carriers