*Supplementary Tables*

*Gleiss, Potvin & Goldbogen (2017)* Physical trade-offs shape the evolution of buoyancy control in sharks. *Proceedings of the Royal Society B*

**Table S1 Details of all species used in our phylogenetic analysis.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Species** | **Abbreviation** | **n\*** | **Standard Length (cm)** | **Mass (kg)** | **Overall Tissue Density (kg/m3)** | **Liver Mass (kg)** | **Liver Density****(kg/m3)** |
| ***Carcharhinus acronatus*** | CA | 2 | 77.7 ± 7.85 | 5.5 ± 1.5 | 1078 ± 1 | 0.24 ± 0.03 | 996 ± 6 |
| ***Carcharhinus brevipinna*** | CB | 1 | 153.13 | 44.2 | 1087 | 1.86 | 1040 |
| ***Carcharhinus falciformis*** | CF | 2 | 73.85 ± 12.72 | 5.13 ± 1.93 | 1076 ± 2 | 0.2 ± 0.06 | 1010 ± 14 |
| ***Carcharhinus leucas*** | CL | 6 | 178.24 ± 17.51 | 119.63 ± 36.92 | 1062 ± 6 | 13.2 ± 8.0 | 965 ±29 |
| ***Carcharhinus limbatus*** | CLi | 1 | 133.44 | 26.8 | 1081 | 1.43 | 973 |
| ***Sphyrna mokarran*** | SMo | 1 | 217.67 | 141 | 1074 | 13.4 | 963 |
| ***Carcharhinus obscurus*** | CO | 2 | 231.26 ±13.45 | 213.6 ± 34.9 | 1048 ± 0.007 | 38.3 ± 15.7 | 945 ± 6 |
| ***Carcharhinus plumbeus*** | CP | 7 | 173.84 ± 4.97 | 62.16 ± 5.45 | 1066 ± 5 | 7.83 ± 2.98 | 956 ± 11 |
| ***Rhizoprionodon terranovea*** | RT | 1 | 45.72 | 0.98 | 1079 | 0.04 | 1020 |
| ***Centrophorus squomosus*** | CS | 2 | 101.27 | 8.09 ± 0.79 | 1024 ± 1 | 1.73 ± 0.17 | 890 ± 9 |
| ***Centroscymnus coelolepis*** | CC | 2 | 68.52 ± 9.33 | 4.23 ± 1.46 | 1023 ± 2 | 1.17 ± 0.54 | 906 ± 3 |
| ***Cephaloscyllium isabellum*** | CI | 1 | 47.71 | 0.85 | 1059 | 0.04 | 1000 |
| ***Cephaloscyllium ventriosum*** | CV | 1 | 45.98 | 1.52 | 1071 | 0.11 | 1036 |
| ***Cetorhinus maximus*** | CM | 1 | 591.4 | 1677.98 | 1032 | 254.24 | 939 |
| ***Daliatis licha*** | DL | 1 | 90.65 | 18.02 | 1026 | 3.56 | 905 |
| ***Deania calcea*** | DC | 1 | 73.89 | 2.64 | 1025 | 0.54 | 890 |
| ***Echinorhinus brucus*** | EB | 1 | 120.6 | 36.32 | 1027 | 5.43 | 1027 |
| ***Etmopterus princeps*** | EP | 1 | 49.6 | 1.22 | 1026 | 0.24 | 891 |
| ***Galeocerdo cuvier*** | GC | 13 | 192.21 ± 65.79 | 73.37 ± 126.97 | 1035 ± 11 | 7.59 ± 22.12 | 956 ± 36 |
| ***Galeorhinus galeus*** | GG | 4 | 47.39 ± 11.02 | 0.83 ± 0.54 | 1062 ± 5 | 0.06 ± 0.05 | 952 ± 38 |
| ***Lamna nasus*** | LN | 3 | 128.9 ± 21.6 | 33.67 ± 14.37 | 1059 ± 10 | 2.13 ± 0.86 | 1006 ± 12 |
| ***Mustelus antarcticus*** | MA |  | 43.79 | 0.58 | 1062 | 0.03 | 1025 |
| ***Mustelus asterias*** | MAs | 4 | 61.38 ± 17.71 | 1.32 ± 0.95 | 1069 ± 4 | 0.08 ± 0.82 | 999 ± 20 |
| ***Mustelus norrisi*** | MN | 2 | 51.02 ± 0.00 | 0.89 ± 0.014 | 1076 ± 0 | 0.05 ± 0.00 | 952 ± 23 |
| ***Negaprion brevirostris*** | NB | 5 | 211.9 ± 7.01 | 110.56 ± 15.67 | 1066 ± 6 | 10.29 ± 4.84 | 952 ± 22 |
| ***Prionace glauca*** | PG | 6 | 131.28 ± 29.07 | 21.26 ± 13.98 | 1051 ± 9 | 1.89 ± 1.55 | 988 ± 21 |
| ***Scyliorhinus canicula*** | SC | 15 | 44.86 ± 6.77 | 0.51 ± 0.25 | 1075 ± 55 | 0.03 ± 0.03 | 996 ± 17 |
| ***Scyliorhinus stellaris*** | SS | 1 | 81.13 | 4.36 | 1080 | 0.46 | 984 |
| ***Sphyrna tiburo*** | ST | 2 | 55.79 ± 6.57 | 1.69 ± 0.43 | 1081 ± 5 | 0.04 ± 0.01 | 1035 ± 21 |
| ***Squalus acanthias*** | SA | 6 | 66.77 ±12 | 2.2 ± 1.5 | 1055 ± 34 | 0.19 ± 0.15 | 975 ± 17 |
| ***Squatina squatina*** | SSq | 5 | 70.05 ± 26.71 | 4.89 ± 4.85 | 1092 ± 9 | 0.15 ± 0.29 | 1041 ± 26 |
| ***Triakis semifasciata*** | TS | 1 | 104 | 8.31 | 1070 | 0.48 | 1014 |

**Table S1 *contd.***

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Species** | **Volume (ml)** | **Liver Volume (ml)** | **Lean Volume (ml)** | **% Liver Volume** | **Lean Tissue Density (kg/m3)** | **Source** |
| ***Carcharhinus acronatus*** | 5096 ± 1430 | 240 ± 27 | 4855 ± 1402 | 4.72 ± 0.81 | 1082 ± 2 | [[1](#_ENREF_1)] |
| ***Carcharhinus brevipinna*** | 40674 | 1788 | 38885 | 4.4 | 1089 | [[1](#_ENREF_1)] |
| ***Carcharhinus falciformis*** | 4762 ± 1784 | 201 ± 62 | 4560 ±1722 | 4.3 ± 0.3 | 1079 ± 2 | [[1](#_ENREF_1)] |
| ***Carcharhinus leucas*** | 112770 ± 35334 | 13681 ± 8499 | 99088 ± 27771 | 11.27 ± 4.70 | 1076 ± 4 | [[1](#_ENREF_1)] |
| ***Carcharhinus limbatus*** | 24803 | 1469 | 23333 | 5.93 | 1087 | [[1](#_ENREF_1)] |
| ***Sphyrna mokarran*** | 131322 | 13914 | 117406 | 10.6 | 1087 | [[1](#_ENREF_1)] |
| ***Carcharhinus obscurus*** | 203941 ± 34789 | 40550 ± 16893 | 163390 ± 17895 | 19.49 ± 4.96 | 1073 ± 0 | [[1](#_ENREF_1)] |
| ***Carcharhinus plumbeus*** | 58337 ± 5242 | 8191 ± 3217 | 50145 ± 3333 | 13.86 ± 4.44 | 1084 ± 7 | [[1](#_ENREF_1)] |
| ***Rhizoprionodon terranovea*** | 905 | 39 | 865 | 4.35 | 1081 | [[1](#_ENREF_1)] |
| ***Centrophorus squomosus*** | 7903 ± 783 | 1946 ± 209 | 5957 ± 783 | 24.62 ± 0.20 | 1067 ± 2 | [[1](#_ENREF_1)] |
| ***Centroscymnus coelolepis*** | 4133 ± 1436 | 1294 ± 600 | 2839 ± 837 | 30.7 ± 3.81 | 1076 ± 8 | [[1](#_ENREF_1)] |
| ***Cephaloscyllium isabellum*** | 799 | 43 | 756 | 5.38 | 1062 | [[2](#_ENREF_2)] |
| ***Cephaloscyllium ventriosum*** | 1420 | 101 | 1319 | 7.13 | 1074 | [[3](#_ENREF_3)] |
| ***Cetorhinus maximus*** | 1625488 | 270789 | 1354698 | 16.66 | 1051 | [[3](#_ENREF_3)] |
| ***Daliatis licha*** | 17559 | 3927 | 13630 | 22.37 | 1061 | [[4](#_ENREF_4)] |
| ***Deania calcea*** | 2573 | 608 | 1964 | 23.64 | 1067 | [[4](#_ENREF_4)] |
| ***Echinorhinus brucus*** | 35382 | 5289 | 30092 | 14.95 | 1027 | [[3](#_ENREF_3)] |
| ***Etmopterus princeps*** | 1185 | 265 | 918 | 22.45 | 1065 | [[4](#_ENREF_4)] |
| ***Galeocerdo cuvier*** | 71481 ± 123744 | 7944 ± 24845 | 63536 ± 98992 | 11.11 ± 5.18 | 1061 ± 6 | [1] |
| ***Galeorhinus galeus*** | 786 ± 509 | 65 ± 49 | 719 ± 461 | 8.36 ± 1.83 | 1072 ± 7 | [[2](#_ENREF_2)] |
| ***Lamna nasus*** | 31800 ± 13774 | 2117 ± 871 | 29682 ± 12919 | 6.66 ± 0.43 | 1062 ± 10 | [[3](#_ENREF_3)] |
| ***Mustelus antarcticus*** | 543 | 24 | 517 | 4.59 | 1063 | [[2](#_ENREF_2)] |
| ***Mustelus asterias*** | 1232 ± 889 | 79 ± 84 | 1152 ± 804 | 6.48 ± 2.03 | 1074 ± 3 | [[3](#_ENREF_3)] |
| ***Mustelus norrisi*** | 823 ± 12 | 47 ± 0 | 775 ± 13 | 5.8 ± 0.17 | 1084 ± 1 | [[1](#_ENREF_1)] |
| ***Negaprion brevirostris*** | 103786 ± 15148 | 10806 ± 4928 | 92900 ± 11615 | 10.41 ± 3.62 | 1078 ± 5 | [[1](#_ENREF_1)] |
| ***Prionace glauca*** | 20234 ± 13392 | 1912 ± 1575 | 18321 ± 11864 | 9.45 ± 2.64 | 1057 ± 5 | [[3](#_ENREF_3)] |
| ***Scyliorhinus canicula*** | 475 ± 234 | 31 ± 33 | 443 ± 204 | 6.67 ± 2.76 | 1073 ± 5 | [[3](#_ENREF_3)] |
| ***Scyliorhinus stellaris*** | 4034 | 462 | 3570 | 11.48 | 1093 | [[3](#_ENREF_3)] |
| ***Sphyrna tiburo*** | 1562 ± 398 | 39 ± 14.63 | 1522 ± 383 | 2.53 ± 0.23 | 1083 ± 5 | [[1](#_ENREF_1)] |
| ***Squalus acanthias*** | 2067 ± 1444 | 215 ± 156 | 1851 ±1305 | 10.45 ± 2.44 | 1064 ± 4 | [[1](#_ENREF_1)] |
| ***Squatina squatina*** | 4481 ± 4480 | 140 ± 288 | 4340 ± 4200 | 3.13 ± 1.18 | 1093 ± 9 | [[3](#_ENREF_3)] |
| ***Triakis semifasciata*** | 7760 | 475 | 7285 | 6.12 | 1074 | Unpubl. data |

**Table S2 Minimum and maximum depth records used to calculate Median Depth of Occurrence (MDO)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Species** | **Min. Depth (m)** | **Max. Depth (m)** | **MDO (m)** | **N\*** | **Method\*** | **Source** |
| ***Carcharhinus acronatus*** | ***9*** | 64 | 36.5 |  | Data-base | [[5](#_ENREF_5)] |
| ***Carcharhinus brevipinna*** | ***0*** | 100 | 50 |  | Data-base | [[5](#_ENREF_5)] |
| ***Carcharhinus falciformis*** | ***0*** | 150 | 75 | 10, 13 | PSAT | [[6](#_ENREF_6),[7](#_ENREF_7)] |
| ***Carcharhinus leucas*** | ***0*** | 204.4 | 100 | 16, 18 | PSAT | [[8](#_ENREF_8),[9](#_ENREF_9)] |
| ***Carcharhinus limbatus*** | ***0*** | 30 | 15 |  | Data-base | [[5](#_ENREF_5)] |
| ***Sphyrna mokarran*** | ***1*** | 100 | 50.5 |  | Data-base | [[5](#_ENREF_5)] |
| ***Carcharhinus obscurus*** | ***0*** | 355 | 177.5 | 3 | PSAT | [[10](#_ENREF_10)] |
| ***Carcharhinus plumbeus*** | ***0*** | 287 | 143.5 | 8, 17 | PSAT | [[11](#_ENREF_11),[12](#_ENREF_12)] |
| ***Rhizoprionodon terranovea*** | ***0*** | 10 | 5 |  | Data-base | [[5](#_ENREF_5)] |
| ***Centrophorus squomosus*** | ***600*** | 1600 | 1100 | 8 | PSAT | [[13](#_ENREF_13)] |
| ***Centroscymnus coelolepis*** | ***400*** | 2000 | 1200 |  | Data-base | [[5](#_ENREF_5)] |
| ***Cephaloscyllium isabellum*** | ***5*** | 690 | 347.5 |  | Data-base | [[5](#_ENREF_5)] |
| ***Cephaloscyllium ventriosum*** | ***5*** | 37 | 21 |  | Data-base | [[5](#_ENREF_5)] |
| ***Cetorhinus maximus*** | ***0*** | 1000 | 500 | 4, 2, 18 | PSAT | [[14-16](#_ENREF_14)] |
| ***Daliatis licha*** | ***300*** | 600 | 450 |  | Data-base | [[5](#_ENREF_5)] |
| ***Deania calcea*** | ***400*** | 1400 | 900 |  | Data-base | [[5](#_ENREF_5)] |
| ***Echinorhinus brucus*** | ***900*** | 350 | 625 |  | Data-base | [[5](#_ENREF_5)] |
| ***Etmopterus princeps*** | ***300*** | 2000 | 1150 |  | Data-base | [[5](#_ENREF_5)] |
| ***Galeocerdo cuvier*** | ***0*** | 1136 | 568 | 5, 9, 8 | PSAT | [[17-19](#_ENREF_17)] |
| ***Galeorhinus galeus*** | ***0*** | 600 | 300 | 9 | Archival Tags | [[20](#_ENREF_20)] |
| ***Lamna nasus*** | ***0*** | 700 | 350 | 4, 3 | PSAT | [[21](#_ENREF_21),[22](#_ENREF_22)] |
| ***Mustelus antarcticus*** | ***0*** | 80 | 40 |  | Data-base | [[5](#_ENREF_5)] |
| ***Mustelus asterias*** | ***0*** | 350 | 175 |  | Data-base | [[5](#_ENREF_5)] |
| ***Mustelus norrisi*** | ***3*** | 40 | 21.5 |  | Data-base | [[5](#_ENREF_5)] |
| ***Negaprion brevirostris*** | ***0*** | 50 | 25 |  | Data-base | [[5](#_ENREF_5)] |
| ***Prionace glauca*** | ***0*** | 1160 | 580 | 13, 3 | PSAT | [[23](#_ENREF_23),[24](#_ENREF_24)] |
| ***Scyliorhinus canicula*** | ***80*** | 100 | 90 |  | Data-base | [[5](#_ENREF_5)] |
| ***Scyliorhinus stellaris*** | ***20*** | 63 | 41.5 |  | Data-base | [[5](#_ENREF_5)] |
| ***Sphyrna tiburo*** | ***10*** | 25 | 17.5 |  | Data-base | [[5](#_ENREF_5)] |
| ***Squalus acanthias*** | ***0*** | 600 | 300 | 3 | PSAT | [[25](#_ENREF_25)] |
| ***Squatina squatina*** | ***5*** | 150 | 77.5 |  | Data-base | [[5](#_ENREF_5)] |
| ***Triakis semifasciata*** | ***6*** | 156 | 81 |  | Data-base | [[5](#_ENREF_5)] |
| \*N refers to the number of individuals tracked in the respective study, with each individual contributing between 1 and >180 days of depth data\*\*Data-base records refer to species where no electronic tagging was available. These generally originate from large reference works [[e.g. see 26](#_ENREF_26)], which do not provide sample sizes. |
|  |

**Table S3 Scaling of liver and lean tissue based on three different models of character evolution along three phylogenetic trees with different branch length transformations and one model ignoring phylogenetic dependence.** Naylor’s branch lengths refer to empirically determined molecular branch lengths, whereas Grafen’s and Punctuated models used arbitrary branch-lengths and the topology of Naylor. Λ denotes the amount of phylogenetic signal, with λ = 0 suggesting phylogenetic independence and λ=1 if the traits have evolved as expected under Brownian Motion. Models were compared on their basis of their small sample corrected AICc.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | **Naylor’s** | **Grafen’s** | **Punctuated** |
|   |   | **AICc** | **Exponent** | **Intercept** | **λ \*** | **AICc** | **Exponent** | **Intercept** | **λ \*** | **AICc** | **Exponent** | **Intercept** | **λ \*** |
|  | log(SL) ~ log(Vliver) | 18.96 | 3.77 ± 0.20 | -4.46 ± 0.42 | 0.8 | 20.91 | 3.73 **±** 0.21 | -4.47 **±** 0.44 | 0.5 | 20.28 | 3.77 **±** 0.20 | 4.51 **±** 0.42 | 0.6 |
|  | log(SL) ~ log(Vlean) | -18.81 | 3.07 ± 0.11 | -2.16 ± 0.22 | 0.9 | -14.14 | 3.12 **±** 0.11 | -2.39 **±** 0.22 | 0.2 | -17.03 | 3.08 **±** 0.11 | 2.21 **±** 0.23 | 0.7 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |

**Table S4 Summary of all analysis over the three different branch lengths for the evolution of tissue volume, buoyancy and Median Depth of Occurrence (MDO).** Naylor’s branch lengths refer to empirically determined molecular branch lengths, Grafen’s and Punctuated refer to the models ran with arbitrary branch-lengths, while retaining Naylor’s topology. Models were compared on their basis of their small sample corrected AICc.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  **Naylor’s** |  |  **Grafen’s** |  |  **Punctuated** |  |
|  |  | **AICc** | **Parameter Estimate**  | **λ** | **AICc** | **Parameter Estimate**  | **λ** | **AICc** | **Parameter Estimate** | **λ** |
|  | Density ~ VLiver | 6.1 | -6.93 ± 1.36\*\*\* | 0.77 | 4.9 | -8.87 ± 2.27\*\*\* | 0.46 | 4.9 | -8.78 ± 2.33\*\*\* | 0.59 |
| Density ~1 | 14.3 |  | 1.03 | 18.5 |  | 0.41 | 17.8 |  | 0.58 |
|  | Density ~ VLean | -23.2 | 0.25 ± 1.58 | 0.85 | -18.3 | 0.99 ± 1.51 | 0.22 | -20.8 | 0.00 ± 1.52 | 0.68 |
| Density ~ 1 | -25.8 |  | 0.85 | -17.8 |  | 0.23 | -20.8 |  | 0.68 |
|  | VLiver ~ VLean | 5.8 | 1.07 ± 0.28\*\* | 0.93 | 13.3 | 0.91 ± 0.27\* | 0.69 | 9.5 | 1.11 ± 0.28\*\*\* | 0.82 |
| VLiver ~ 1 | 14.3 |  | 0.76 | 18.5 |  | 0.46 | 17.8 |  | 0.58 |
|  | log (MDO) ~ Density | 77.1 | -58.32 ± 5.72\*\*\* | -0.11 | 79.1 | -60.96 ± 5.84\*\*\* | -0.06 | 79.0 | -60.94 ± 5.88 \*\*\* | -0.08 |
|  | Density ~1 | 112.8 |  | 0.59 | 111.36 |  | 0.62 | 112 |  | 0.6 |
| \*<0.05 \*\*<0.005 \*\*\*<0.0005 |

**Table S5. Drag in accelerated motions (eqns. 8 – 11). Surge time *ns = 1.0.***

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| SL (m) | FR | W (N) | CS (m/s, eqn. 6) | k | fpara | find | far | a (eqn. 7) [m/s2 (g’s)] | <Dtot> (N) |
| 1.0 | 6.3 | 0.4 | 0.75 | 0.045 | 0.00421 | 0.00004 | 0.00169 | 0.84 (0.086) | 1.70 |
| 1.0 | 7.0 | 3.4 | 0.75 | 0.035 | 0.00368 | 0.00108 | 0.00106 | 0.84 (0.086) | 1.68 |
| 2.0 | 6.3 | 3.21 | 1.11 | 0.045 | 0.00340 | 0.00000 | 0.00169 | 0.92 (0.094) | 12.78 |
| 2.0 | 7.0 | 27.4 | 1.11 | 0.035 | 0.00298 | 0.00093 | 0.00106 | 0.92 (0.094) | 12.48 |
| 4.0 | 6.3 | 25.7 | 1.59 | 0.045 | 0.00273 | 0.00000 | 0.00169 | 0.95 (0.097) | 92.30 |
| 4.0 | 7.0 | 218.0 | 1.59 | 0.035 | 0.00241 | 0.00087 | 0.00106 | 0.95 (0.097) | 89.98 |
| 7.0 | 6.3 | 137.8 | 2.10 | 0.045 | 0.00231 | 0.00000 | 0.00169 | 0.95 (0.097) | 446.63 |
| 7.0 | 7.0 | 1168.3 | 2.10 | 0.035 | 0.00204 | 0.00087 | 0.00106 | 0.95 (0.097) | 440.11 |

 ρw = 1025kg/m3, ν = 0.00000115m2/s, INT = - 0.25 (Ryan et al., 2015), δ = 0 and φ = 0.95

**Table S6. Drag in accelerated motions (eqns. 8 – 11). Surge time *ns = 0.2.***

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *SL (m)* | *FR* | *W (N)* | *CS (m/s, eqn. 6)* | *k* | *fpara* | *find* | *far* | *a (eqn. 7) [m/s2 (g’s)]* | *<Dtot> (N)* |
| *1.0* | *6.3* | *0.4* | *0.75* | *0.045* | *0.00421* | *0.00004* | *0.00845* | *4.20 (0.430)* | *3.66* |
| *1.0* | *7.0* | *3.4* | *0.75* | *0.035* | *0.00368* | *0.00108* | *0.00530* | *4.20 (0.430)* | *2.90* |
| *2.0* | *6.3* | *3.21* | *1.11* | *0.045* | *0.00340* | *0.00000* | *0.00845* | *4.60 (0.470)* | *29.74* |
| *2.0* | *7.0* | *27.4* | *1.11* | *0.035* | *0.00298* | *0.00093* | *0.00530* | *4.60 (0.470)* | *23.12* |
| *4.0* | *6.3* | *25.7* | *1.59* | *0.045* | *0.00273* | *0.00003* | *0.00845* | *4.74 (0.483)* | *232.4* |
| *4.0* | *7.0* | *218.0* | *1.59* | *0.035* | *0.00240* | *0.00086* | *0.00532* | *4.74 (0.483)* | *177.48* |
| *7.0* | *6.3* | *137.8* | *2.10* | *0.045* | *0.00231* | *0.00003* | *0.00845* | *4.72 (0.482)* | *1194.9* |
| *7.0* | *7.0* | *1168.3* | *2.10* | *0.035* | *.00204* | *0.00087* | *0.00532* | *4.72 (0.482)* | *911.10* |

 *ρw = 1025kg/m3, ν = 0.00000115m2/s, INT = - 0.25 (Ryan et al., 2015), δ = 0 and φ = 0.95*

**Table S7 Drag in steady state motions for a range of body sizes (eqns. 8 – 11).**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **SL (m)** | **FR** | **W (N)**  | **CS** (m/s, eqn. 6) | **k** | **fpara** | **find** | **far** | **a** (eqn. 7) [m/s2 (g’s)] | **<Dtot>** (N) |
| 1.0 | *6.3* | *0.4* | *0.75* | *0.* | *0.00198* | *0.00008* | *0.00000* | *0.00 (0.000)* | *0.59* |
| 1.0 | *7.0* | *3.4* | *0.75* | *0.* | *0.00173* | *0.00216* | *0.00000* | *0.00 (0.000)* | *1.12* |
| 2.0 | *6.3* | *3.21* | *1.11* | *0.* | *0.00159* | *0.00000* | *0.00000* | *0.00 (0.000)* | *3.99* |
| 2.0 | *7.0* | *27.4* | *1.11* | *0.* | *0.00140* | *0.00186* | *0.00000* | *0.00 (0.000)* | *8.18* |
| 4.0 | *6.3* | *25.7* | *1.59* | *0.* | *0.00128* | *0.00006* | *0.00000* | *0.00 (0.000)* | *27.88* |
| 4.0 | *7.0* | *218.0* | *1.59* | *0.* | *0.00113* | *0.00172* | *0.00000* | *0.00 (0.000)* | *59.13* |
| 7.0 | *6.3* | *137.8* | *2.10* | *0.* | *0.00109* | *0.00006* | *0.00000* | *0.00 (0.000)* | *127.13* |
| 7.0 | *7.0* | *1168.3* | *2.10* | *0.* | *0.00096* | *0.00173* | *0.00000* | *0.00 (0.000)* | *297.90* |

*ρw = 1025kg/m3, ν = 0.00000115m2/s, INT = - 0.25 [*[*27*](#_ENREF_27)*], δ = 0 and φ = 0.95*

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