

E-Companion: Industrial and Tramp Ship Routing Problems: Closing the Gap for Real-Scale Instances

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1 Detailed results

Tables 1 to 4 give the detailed results of B&P₂ and HGS₂ (with the set partitioning component) on each individual instance. For the B&P₂, Columns “Opt” and “T” represent the optimal value and the total CPU time (in minutes). For the HGS₂, Columns “Best”, “Avg” and “Worst” represent the best, average and worst cost found over 10 runs, column “T” gives the total CPU time in minutes, and column “T*” gives the *attainment* time (in minutes) needed to reach the final solution

2 Comparison with Hemmati and Hvattum (2016)

Hemmati and Hvattum (2016) have presented detailed results of six ALNS variants on a subset of the Hemmati et al. (2014) instances. Table 5 compares these results with those of HGS₂. Each line represents a group of instances, and the best results are highlighted in boldface. For each method, column “Gap” reports the percentage gap relative to the *optimal* solutions, and column “T” gives the total CPU time in minutes.

References

- Hemmati A, Hvattum LM (2016) Evaluating the importance of randomization in adaptive large neighborhood search. *International Transactions in Operational Research* 24(5):929–942.
- Hemmati A, Hvattum LM, Fagerholt K, Norstad I (2014) Benchmark suite for industrial and tramp ship routing and scheduling problems. *INFOR: Information Systems and Operational Research* 52(1):28–38.

Table 1: Results for short sea mixed cargo instances

| Instance | B&P ₂ | | HGS ₂ | | | | |
|----------------------------|------------------|-------|------------------|----------|----------|-------|------|
| | Opt | T | Best | Avg | Worst | T | T* |
| SHORTSEA_MUN_C7_V3_HE.1 | 1476444 | 0.00 | 1476444 | 1476444 | 1476444 | 0.02 | 0.00 |
| SHORTSEA_MUN_C7_V3_HE.2 | 1134176 | 0.00 | 1134176 | 1134176 | 1134176 | 0.02 | 0.00 |
| SHORTSEA_MUN_C7_V3_HE.3 | 1196466 | 0.00 | 1196466 | 1196466 | 1196466 | 0.02 | 0.00 |
| SHORTSEA_MUN_C7_V3_HE.4 | 1256139 | 0.00 | 1256139 | 1256139 | 1256139 | 0.02 | 0.00 |
| SHORTSEA_MUN_C7_V3_HE.5 | 1160394 | 0.00 | 1160394 | 1160394 | 1160394 | 0.02 | 0.00 |
| SHORTSEA_MUN_C10_V3_HE.1 | 2083965 | 0.00 | 2083965 | 2083965 | 2083965 | 0.04 | 0.00 |
| SHORTSEA_MUN_C10_V3_HE.2 | 2012364 | 0.00 | 2012364 | 2012364 | 2012364 | 0.04 | 0.00 |
| SHORTSEA_MUN_C10_V3_HE.3 | 1986779 | 0.00 | 1986779 | 1986779 | 1986779 | 0.04 | 0.00 |
| SHORTSEA_MUN_C10_V3_HE.4 | 2125461 | 0.00 | 2125461 | 2125461 | 2125461 | 0.04 | 0.00 |
| SHORTSEA_MUN_C10_V3_HE.5 | 2162453 | 0.00 | 2162453 | 2162453 | 2162453 | 0.04 | 0.00 |
| SHORTSEA_MUN_C15_V4_HE.1 | 1959153 | 0.00 | 1959153 | 1959153 | 1959153 | 0.08 | 0.00 |
| SHORTSEA_MUN_C15_V4_HE.2 | 2560004 | 0.00 | 2560004 | 2560004 | 2560004 | 0.08 | 0.00 |
| SHORTSEA_MUN_C15_V4_HE.3 | 2582912 | 0.00 | 2582912 | 2582912 | 2582912 | 0.08 | 0.01 |
| SHORTSEA_MUN_C15_V4_HE.4 | 2265396 | 0.00 | 2265396 | 2265396 | 2265396 | 0.09 | 0.00 |
| SHORTSEA_MUN_C15_V4_HE.5 | 2230861 | 0.00 | 2230861 | 2230861 | 2230861 | 0.08 | 0.00 |
| SHORTSEA_MUN_C18_V5_HE.1 | 2374420 | 0.00 | 2374420 | 2374420 | 2374420 | 0.11 | 0.00 |
| SHORTSEA_MUN_C18_V5_HE.2 | 2987358 | 0.00 | 2987358 | 2987358 | 2987358 | 0.11 | 0.01 |
| SHORTSEA_MUN_C18_V5_HE.3 | 2301308 | 0.00 | 2301308 | 2301308 | 2301308 | 0.12 | 0.01 |
| SHORTSEA_MUN_C18_V5_HE.4 | 2400016 | 0.00 | 2400016 | 2402999 | 2414932 | 0.16 | 0.05 |
| SHORTSEA_MUN_C18_V5_HE.5 | 2813167 | 0.00 | 2813167 | 2813167 | 2813167 | 0.17 | 0.06 |
| SHORTSEA_MUN_C22_V6_HE.1 | 3928483 | 0.00 | 3928483 | 3928483 | 3928483 | 0.17 | 0.03 |
| SHORTSEA_MUN_C22_V6_HE.2 | 3683436 | 0.01 | 3683436 | 3683436 | 3683436 | 0.16 | 0.02 |
| SHORTSEA_MUN_C22_V6_HE.3 | 3264770 | 0.00 | 3264770 | 3264770 | 3264770 | 0.18 | 0.04 |
| SHORTSEA_MUN_C22_V6_HE.4 | 3228262 | 0.00 | 3228262 | 3228262 | 3228262 | 0.22 | 0.07 |
| SHORTSEA_MUN_C22_V6_HE.5 | 3770560 | 0.00 | 3770560 | 3770560 | 3770560 | 0.17 | 0.03 |
| SHORTSEA_MUN_C23_V13_HE.1 | 2276832 | 0.01 | 2276832 | 2276832 | 2276832 | 0.22 | 0.04 |
| SHORTSEA_MUN_C23_V13_HE.2 | 2255469 | 0.01 | 2255469 | 2255469 | 2255469 | 0.22 | 0.06 |
| SHORTSEA_MUN_C23_V13_HE.3 | 2362503 | 0.00 | 2362503 | 2362503 | 2362503 | 0.23 | 0.08 |
| SHORTSEA_MUN_C23_V13_HE.4 | 2250110 | 0.02 | 2250110 | 2250110 | 2250110 | 0.25 | 0.08 |
| SHORTSEA_MUN_C23_V13_HE.5 | 2325941 | 0.00 | 2325941 | 2325941 | 2325941 | 0.22 | 0.06 |
| SHORTSEA_MUN_C30_V6_HE.1 | 4958542 | 0.00 | 4958542 | 4958542 | 4958542 | 0.31 | 0.10 |
| SHORTSEA_MUN_C30_V6_HE.2 | 4549708 | 0.01 | 4549708 | 4549708 | 4549708 | 0.34 | 0.13 |
| SHORTSEA_MUN_C30_V6_HE.3 | 4098111 | 0.02 | 4098111 | 4098111 | 4098111 | 0.33 | 0.11 |
| SHORTSEA_MUN_C30_V6_HE.4 | 4449449 | 0.02 | 4449449 | 4449485 | 4449812 | 0.36 | 0.15 |
| SHORTSEA_MUN_C30_V6_HE.5 | 4528514 | 0.01 | 4528514 | 4528514 | 4528514 | 0.29 | 0.09 |
| SHORTSEA_MUN_C35_V7_HE.1 | 4893734 | 0.03 | 4893734 | 4898168 | 4913975 | 0.59 | 0.32 |
| SHORTSEA_MUN_C35_V7_HE.2 | 4533265 | 0.21 | 4533265 | 4534290 | 4543518 | 0.53 | 0.23 |
| SHORTSEA_MUN_C35_V7_HE.3 | 4433847 | 0.03 | 4433847 | 4433847 | 4433847 | 0.46 | 0.20 |
| SHORTSEA_MUN_C35_V7_HE.4 | 4580935 | 0.05 | 4580935 | 4580935 | 4580935 | 0.51 | 0.23 |
| SHORTSEA_MUN_C35_V7_HE.5 | 5511661 | 0.01 | 5511661 | 5513389 | 5523201 | 0.61 | 0.35 |
| SHORTSEA_MUN_C60_V13_HE.1 | 8133385 | 0.96 | 8133385 | 8147211 | 8163045 | 2.71 | 1.70 |
| SHORTSEA_MUN_C60_V13_HE.2 | 7971476 | 0.88 | 7971476 | 7972935 | 7984871 | 1.84 | 1.05 |
| SHORTSEA_MUN_C60_V13_HE.3 | 7604198 | 0.75 | 7604198 | 7632301 | 7647547 | 2.56 | 1.74 |
| SHORTSEA_MUN_C60_V13_HE.4 | 8505125 | 0.87 | 8505125 | 8505971 | 8508321 | 2.09 | 1.24 |
| SHORTSEA_MUN_C60_V13_HE.5 | 8921750 | 1.08 | 8921750 | 8931618 | 8942531 | 2.08 | 1.11 |
| SHORTSEA_MUN_C80_V20_HE.1 | 10289573 | 1.67 | 10289573 | 10294261 | 10305785 | 5.04 | 3.37 |
| SHORTSEA_MUN_C80_V20_HE.2 | 10240618 | 0.91 | 10240618 | 10241641 | 10246354 | 3.64 | 2.32 |
| SHORTSEA_MUN_C80_V20_HE.3 | 9606530 | 2.84 | 9606530 | 9606573 | 9606961 | 2.91 | 1.66 |
| SHORTSEA_MUN_C80_V20_HE.4 | 11302476 | 0.45 | 11302476 | 11311027 | 11333280 | 4.78 | 3.21 |
| SHORTSEA_MUN_C80_V20_HE.5 | 10862563 | 0.31 | 10862563 | 10863032 | 10867254 | 2.85 | 1.63 |
| SHORTSEA_MUN_C100_V30_HE.1 | 12626988 | 2.53 | 12626988 | 12627602 | 12633126 | 4.59 | 2.48 |
| SHORTSEA_MUN_C100_V30_HE.2 | 12774864 | 2.98 | 12774864 | 12775623 | 12776760 | 5.80 | 3.23 |
| SHORTSEA_MUN_C100_V30_HE.3 | 11935332 | 7.82 | 11935332 | 11935349 | 11935502 | 5.14 | 2.92 |
| SHORTSEA_MUN_C100_V30_HE.4 | 13605352 | 1.82 | 13605352 | 13610213 | 13612134 | 5.20 | 2.96 |
| SHORTSEA_MUN_C100_V30_HE.5 | 13240648 | 1.20 | 13240648 | 13241314 | 13244485 | 5.83 | 3.54 |
| SHORTSEA_MUN_C130_V40_HE.1 | 16316051 | 13.45 | 16316388 | 16318379 | 16319526 | 13.31 | 8.71 |
| SHORTSEA_MUN_C130_V40_HE.2 | 16260579 | 27.23 | 16260579 | 16263866 | 16272543 | 12.64 | 8.63 |
| SHORTSEA_MUN_C130_V40_HE.3 | 15537963 | 17.97 | 15537963 | 15543748 | 15551928 | 12.68 | 9.03 |
| SHORTSEA_MUN_C130_V40_HE.4 | 17011065 | 6.65 | 17011065 | 17012795 | 17014853 | 11.82 | 7.84 |
| SHORTSEA_MUN_C130_V40_HE.5 | 18273893 | 10.11 | 18273893 | 18275423 | 18281922 | 11.71 | 7.75 |

Table 2: Results for short sea full cargo instances

| Instance | B&P ₂ | | HGS ₂ | | | | |
|----------------------------|------------------|------|------------------|----------|----------|------|------|
| | Opt | T | Best | Avg | Worst | T | T* |
| SHORTSEA_FUN_C8_V3_HE_1 | 1391997 | 0.00 | 1391997 | 1391997 | 1391997 | 0.01 | 0.00 |
| SHORTSEA_FUN_C8_V3_HE_2 | 1246273 | 0.00 | 1246273 | 1246273 | 1246273 | 0.01 | 0.00 |
| SHORTSEA_FUN_C8_V3_HE_3 | 1698102 | 0.00 | 1698102 | 1698102 | 1698102 | 0.01 | 0.00 |
| SHORTSEA_FUN_C8_V3_HE_4 | 1777637 | 0.00 | 1777637 | 1777637 | 1777637 | 0.01 | 0.00 |
| SHORTSEA_FUN_C8_V3_HE_5 | 1636788 | 0.00 | 1636788 | 1636788 | 1636788 | 0.01 | 0.00 |
| SHORTSEA_FUN_C11_V4_HE_1 | 1052463 | 0.00 | 1052463 | 1052463 | 1052463 | 0.02 | 0.00 |
| SHORTSEA_FUN_C11_V4_HE_2 | 1067139 | 0.00 | 1067139 | 1067139 | 1067139 | 0.02 | 0.00 |
| SHORTSEA_FUN_C11_V4_HE_3 | 1212388 | 0.00 | 1212388 | 1212388 | 1212388 | 0.02 | 0.00 |
| SHORTSEA_FUN_C11_V4_HE_4 | 1185465 | 0.00 | 1185465 | 1185465 | 1185465 | 0.02 | 0.00 |
| SHORTSEA_FUN_C11_V4_HE_5 | 1310285 | 0.00 | 1310285 | 1310285 | 1310285 | 0.02 | 0.00 |
| SHORTSEA_FUN_C13_V5_HE_1 | 2034184 | 0.00 | 2034184 | 2034184 | 2034184 | 0.02 | 0.00 |
| SHORTSEA_FUN_C13_V5_HE_2 | 2043253 | 0.00 | 2043253 | 2043253 | 2043253 | 0.03 | 0.00 |
| SHORTSEA_FUN_C13_V5_HE_3 | 2378283 | 0.00 | 2378283 | 2378283 | 2378283 | 0.03 | 0.00 |
| SHORTSEA_FUN_C13_V5_HE_4 | 2707215 | 0.00 | 2707215 | 2707215 | 2707215 | 0.02 | 0.00 |
| SHORTSEA_FUN_C13_V5_HE_5 | 3011648 | 0.00 | 3011648 | 3011648 | 3011648 | 0.02 | 0.00 |
| SHORTSEA_FUN_C16_V6_HE_1 | 3577005 | 0.00 | 3577005 | 3577005 | 3577005 | 0.03 | 0.00 |
| SHORTSEA_FUN_C16_V6_HE_2 | 3560203 | 0.00 | 3560203 | 3560203 | 3560203 | 0.03 | 0.00 |
| SHORTSEA_FUN_C16_V6_HE_3 | 4081013 | 0.00 | 4081013 | 4081013 | 4081013 | 0.04 | 0.00 |
| SHORTSEA_FUN_C16_V6_HE_4 | 3667080 | 0.00 | 3667080 | 3667080 | 3667080 | 0.03 | 0.00 |
| SHORTSEA_FUN_C16_V6_HE_5 | 3438493 | 0.00 | 3438493 | 3438493 | 3438493 | 0.03 | 0.00 |
| SHORTSEA_FUN_C17_V13_HE_1 | 2265731 | 0.00 | 2265731 | 2265731 | 2265731 | 0.05 | 0.00 |
| SHORTSEA_FUN_C17_V13_HE_2 | 3154165 | 0.00 | 3154165 | 3154165 | 3154165 | 0.05 | 0.00 |
| SHORTSEA_FUN_C17_V13_HE_3 | 2699378 | 0.00 | 2699378 | 2699378 | 2699378 | 0.06 | 0.01 |
| SHORTSEA_FUN_C17_V13_HE_4 | 2806231 | 0.00 | 2806231 | 2806231 | 2806231 | 0.05 | 0.00 |
| SHORTSEA_FUN_C17_V13_HE_5 | 2910814 | 0.00 | 2910814 | 2910814 | 2910814 | 0.05 | 0.00 |
| SHORTSEA_FUN_C20_V6_HE_1 | 2973381 | 0.00 | 2973381 | 2973381 | 2973381 | 0.05 | 0.00 |
| SHORTSEA_FUN_C20_V6_HE_2 | 3206514 | 0.00 | 3206514 | 3206514 | 3206514 | 0.05 | 0.01 |
| SHORTSEA_FUN_C20_V6_HE_3 | 3197445 | 0.00 | 3197445 | 3197445 | 3197445 | 0.05 | 0.01 |
| SHORTSEA_FUN_C20_V6_HE_4 | 3342130 | 0.00 | 3342130 | 3342130 | 3342130 | 0.05 | 0.00 |
| SHORTSEA_FUN_C20_V6_HE_5 | 3156378 | 0.00 | 3156378 | 3156378 | 3156378 | 0.05 | 0.00 |
| SHORTSEA_FUN_C25_V7_HE_1 | 3833588 | 0.00 | 3833588 | 3833588 | 3833588 | 0.07 | 0.02 |
| SHORTSEA_FUN_C25_V7_HE_2 | 3673666 | 0.00 | 3673666 | 3673666 | 3673666 | 0.07 | 0.01 |
| SHORTSEA_FUN_C25_V7_HE_3 | 4238213 | 0.00 | 4238213 | 4238213 | 4238213 | 0.07 | 0.01 |
| SHORTSEA_FUN_C25_V7_HE_4 | 4260762 | 0.00 | 4260762 | 4260762 | 4260762 | 0.08 | 0.02 |
| SHORTSEA_FUN_C25_V7_HE_5 | 4069693 | 0.00 | 4069693 | 4069693 | 4069693 | 0.08 | 0.02 |
| SHORTSEA_FUN_C35_V13_HE_1 | 2986667 | 0.00 | 2986667 | 2986667 | 2986667 | 0.14 | 0.02 |
| SHORTSEA_FUN_C35_V13_HE_2 | 3002973 | 0.00 | 3002973 | 3002973 | 3002973 | 0.20 | 0.07 |
| SHORTSEA_FUN_C35_V13_HE_3 | 3084339 | 0.00 | 3084339 | 3084339 | 3084339 | 0.16 | 0.04 |
| SHORTSEA_FUN_C35_V13_HE_4 | 3952461 | 0.00 | 3952461 | 3952461 | 3952461 | 0.18 | 0.06 |
| SHORTSEA_FUN_C35_V13_HE_5 | 3293086 | 0.00 | 3293086 | 3293086 | 3293086 | 0.18 | 0.06 |
| SHORTSEA_FUN_C50_V20_HE_1 | 7258266 | 0.00 | 7258266 | 7258266 | 7258266 | 0.40 | 0.13 |
| SHORTSEA_FUN_C50_V20_HE_2 | 7452465 | 0.01 | 7452465 | 7452465 | 7452465 | 0.44 | 0.17 |
| SHORTSEA_FUN_C50_V20_HE_3 | 6922293 | 0.01 | 6922293 | 6922293 | 6922293 | 0.44 | 0.15 |
| SHORTSEA_FUN_C50_V20_HE_4 | 8933846 | 0.01 | 8933846 | 8933847 | 8933848 | 0.46 | 0.17 |
| SHORTSEA_FUN_C50_V20_HE_5 | 7322307 | 0.01 | 7322307 | 7322307 | 7322307 | 0.40 | 0.13 |
| SHORTSEA_FUN_C70_V30_HE_1 | 10051856 | 0.02 | 10051856 | 10051856 | 10051856 | 0.98 | 0.39 |
| SHORTSEA_FUN_C70_V30_HE_2 | 10455468 | 0.01 | 10455468 | 10455468 | 10455468 | 0.99 | 0.38 |
| SHORTSEA_FUN_C70_V30_HE_3 | 10172541 | 0.01 | 10172541 | 10172541 | 10172541 | 1.27 | 0.62 |
| SHORTSEA_FUN_C70_V30_HE_4 | 10854036 | 0.06 | 10854036 | 10854036 | 10854036 | 1.02 | 0.38 |
| SHORTSEA_FUN_C70_V30_HE_5 | 10886838 | 0.10 | 10886838 | 10886838 | 10886838 | 1.16 | 0.35 |
| SHORTSEA_FUN_C90_V40_HE_1 | 13361947 | 0.03 | 13361947 | 13362943 | 13371155 | 1.94 | 0.82 |
| SHORTSEA_FUN_C90_V40_HE_2 | 13828112 | 0.02 | 13828112 | 13828112 | 13828112 | 1.88 | 0.71 |
| SHORTSEA_FUN_C90_V40_HE_3 | 12627125 | 0.08 | 12627125 | 12627476 | 12628003 | 1.77 | 0.63 |
| SHORTSEA_FUN_C90_V40_HE_4 | 14406428 | 0.03 | 14406428 | 14406690 | 14409031 | 1.82 | 0.64 |
| SHORTSEA_FUN_C90_V40_HE_5 | 13560830 | 0.06 | 13560830 | 13560835 | 13560853 | 2.23 | 1.01 |
| SHORTSEA_FUN_C100_V50_HE_1 | 13800823 | 0.03 | 13800823 | 13800823 | 13800823 | 2.94 | 1.35 |
| SHORTSEA_FUN_C100_V50_HE_2 | 14644836 | 0.19 | 14644836 | 14645381 | 14647299 | 3.02 | 1.30 |
| SHORTSEA_FUN_C100_V50_HE_3 | 13135505 | 0.05 | 13135505 | 13135757 | 13136396 | 2.65 | 1.02 |
| SHORTSEA_FUN_C100_V50_HE_4 | 14841840 | 0.14 | 14841840 | 14841840 | 14841841 | 3.06 | 1.41 |
| SHORTSEA_FUN_C100_V50_HE_5 | 14009874 | 0.07 | 14009874 | 14009971 | 14010827 | 2.48 | 0.93 |

Table 3: Results for deep sea mixed cargo instances

| Instance | B&P ₂ | | HGS ₂ | | | | |
|---------------------------|------------------|--------|------------------|-----------|-----------|-------|-------|
| | Opt | T | Best | Avg | Worst | T | T* |
| DEEPSEA_MUN_C7_V3_HE_1 | 5233464 | 0.00 | 5233464 | 5233464 | 5233464 | 0.02 | 0.00 |
| DEEPSEA_MUN_C7_V3_HE_2 | 6053699 | 0.00 | 6053699 | 6053699 | 6053699 | 0.02 | 0.00 |
| DEEPSEA_MUN_C7_V3_HE_3 | 5888949 | 0.00 | 5888949 | 5888949 | 5888949 | 0.02 | 0.00 |
| DEEPSEA_MUN_C7_V3_HE_4 | 6510656 | 0.00 | 6510656 | 6510656 | 6510656 | 0.02 | 0.00 |
| DEEPSEA_MUN_C7_V3_HE_5 | 7220458 | 0.00 | 7220458 | 7220458 | 7220458 | 0.02 | 0.00 |
| DEEPSEA_MUN_C10_V3_HE_1 | 7986248 | 0.00 | 7986248 | 7986248 | 7986248 | 0.04 | 0.00 |
| DEEPSEA_MUN_C10_V3_HE_2 | 7754484 | 0.00 | 7754484 | 7754484 | 7754484 | 0.04 | 0.00 |
| DEEPSEA_MUN_C10_V3_HE_3 | 9499357 | 0.00 | 9499357 | 9499357 | 9499357 | 0.04 | 0.00 |
| DEEPSEA_MUN_C10_V3_HE_4 | 8617192 | 0.00 | 8617192 | 8617192 | 8617192 | 0.04 | 0.00 |
| DEEPSEA_MUN_C10_V3_HE_5 | 8653992 | 0.00 | 8653992 | 8653992 | 8653992 | 0.04 | 0.00 |
| DEEPSEA_MUN_C15_V4_HE_1 | 13467090 | 0.00 | 13467090 | 13467090 | 13467090 | 0.07 | 0.00 |
| DEEPSEA_MUN_C15_V4_HE_2 | 12457251 | 0.00 | 12457251 | 12457251 | 12457251 | 0.10 | 0.02 |
| DEEPSEA_MUN_C15_V4_HE_3 | 12567396 | 0.00 | 12567396 | 12567396 | 12567396 | 0.08 | 0.00 |
| DEEPSEA_MUN_C15_V4_HE_4 | 11764241 | 0.00 | 11764241 | 11764241 | 11764241 | 0.08 | 0.01 |
| DEEPSEA_MUN_C15_V4_HE_5 | 10833640 | 0.00 | 10833640 | 10833640 | 10833640 | 0.08 | 0.00 |
| DEEPSEA_MUN_C18_V5_HE_1 | 43054055 | 0.00 | 43054055 | 43054055 | 43054055 | 0.14 | 0.02 |
| DEEPSEA_MUN_C18_V5_HE_2 | 25068287 | 0.00 | 25068287 | 25068287 | 25068287 | 0.13 | 0.02 |
| DEEPSEA_MUN_C18_V5_HE_3 | 29211238 | 0.00 | 29211238 | 29211238 | 29211238 | 0.12 | 0.00 |
| DEEPSEA_MUN_C18_V5_HE_4 | 32281904 | 0.00 | 32281904 | 32281904 | 32281904 | 0.11 | 0.00 |
| DEEPSEA_MUN_C18_V5_HE_5 | 40718028 | 0.00 | 40718028 | 40718028 | 40718028 | 0.12 | 0.02 |
| DEEPSEA_MUN_C22_V6_HE_1 | 41176718 | 0.00 | 41176718 | 41176718 | 41176718 | 0.16 | 0.03 |
| DEEPSEA_MUN_C22_V6_HE_2 | 37236363 | 0.00 | 37236363 | 37236363 | 37236363 | 0.17 | 0.05 |
| DEEPSEA_MUN_C22_V6_HE_3 | 38215238 | 0.00 | 38215238 | 38215238 | 38215238 | 0.17 | 0.03 |
| DEEPSEA_MUN_C22_V6_HE_4 | 34129809 | 0.00 | 34129809 | 34129809 | 34129809 | 0.22 | 0.08 |
| DEEPSEA_MUN_C22_V6_HE_5 | 46379332 | 0.00 | 46379332 | 46379332 | 46379332 | 0.17 | 0.04 |
| DEEPSEA_MUN_C23_V13_HE_1 | 41002992 | 0.00 | 41002992 | 41002992 | 41002992 | 0.19 | 0.04 |
| DEEPSEA_MUN_C23_V13_HE_2 | 28014147 | 0.00 | 28014147 | 28014147 | 28014147 | 0.19 | 0.02 |
| DEEPSEA_MUN_C23_V13_HE_3 | 29090422 | 0.00 | 29090422 | 29090422 | 29090422 | 0.17 | 0.00 |
| DEEPSEA_MUN_C23_V13_HE_4 | 33685274 | 0.00 | 33685274 | 33685274 | 33685274 | 0.23 | 0.07 |
| DEEPSEA_MUN_C23_V13_HE_5 | 38664843 | 0.00 | 38664843 | 38664843 | 38664843 | 0.20 | 0.06 |
| DEEPSEA_MUN_C30_V6_HE_1 | 19227093 | 0.00 | 19227093 | 19227093 | 19227093 | 0.31 | 0.12 |
| DEEPSEA_MUN_C30_V6_HE_2 | 16784810 | 0.02 | 16784810 | 16784810 | 16784810 | 0.35 | 0.11 |
| DEEPSEA_MUN_C30_V6_HE_3 | 21183928 | 0.01 | 21183928 | 21213101 | 21298546 | 0.35 | 0.16 |
| DEEPSEA_MUN_C30_V6_HE_4 | 21076728 | 0.00 | 21076728 | 21076728 | 21076728 | 0.28 | 0.09 |
| DEEPSEA_MUN_C30_V6_HE_5 | 24490671 | 0.01 | 24490671 | 24490671 | 24490671 | 0.33 | 0.12 |
| DEEPSEA_MUN_C35_V7_HE_1 | 65082675 | 0.01 | 65082675 | 65086315 | 65119078 | 0.50 | 0.21 |
| DEEPSEA_MUN_C35_V7_HE_2 | 54810586 | 0.03 | 54810586 | 54810586 | 54810586 | 0.45 | 0.18 |
| DEEPSEA_MUN_C35_V7_HE_3 | 56182502 | 0.00 | 56182502 | 56182502 | 56182502 | 0.42 | 0.14 |
| DEEPSEA_MUN_C35_V7_HE_4 | 61354812 | 0.02 | 61354812 | 61354812 | 61354812 | 0.46 | 0.16 |
| DEEPSEA_MUN_C35_V7_HE_5 | 63904705 | 0.00 | 63904705 | 63904705 | 63904705 | 0.39 | 0.15 |
| DEEPSEA_MUN_C60_V13_HE_1 | 80649895 | 3.25 | 80649895 | 80696507 | 80708160 | 2.13 | 1.14 |
| DEEPSEA_MUN_C60_V13_HE_2 | 74881109 | 0.10 | 74881109 | 74881109 | 74881110 | 1.86 | 1.21 |
| DEEPSEA_MUN_C60_V13_HE_3 | 91766747 | 0.03 | 91766747 | 91768529 | 91782830 | 1.47 | 0.78 |
| DEEPSEA_MUN_C60_V13_HE_4 | 89702352 | 0.05 | 89702352 | 89763856 | 89863541 | 1.90 | 1.17 |
| DEEPSEA_MUN_C60_V13_HE_5 | 88486544 | 0.08 | 88486544 | 88498545 | 88606550 | 1.71 | 1.00 |
| DEEPSEA_MUN_C80_V20_HE_1 | 70718084 | 0.33 | 70718084 | 70799786 | 70922338 | 3.20 | 1.78 |
| DEEPSEA_MUN_C80_V20_HE_2 | 73558165 | 1.95 | 73558165 | 73589043 | 73603212 | 5.07 | 3.47 |
| DEEPSEA_MUN_C80_V20_HE_3 | 78250612 | 0.12 | 78250612 | 78251002 | 78254512 | 2.56 | 1.43 |
| DEEPSEA_MUN_C80_V20_HE_4 | 75962439 | 0.32 | 75962439 | 75994306 | 76061556 | 3.67 | 2.34 |
| DEEPSEA_MUN_C80_V20_HE_5 | 74162521 | 0.22 | 74162521 | 74169783 | 74207930 | 3.29 | 1.97 |
| DEEPSEA_MUN_C100_V30_HE_1 | 150481912 | 1.25 | 150481912 | 150508649 | 150525751 | 10.03 | 7.17 |
| DEEPSEA_MUN_C100_V30_HE_2 | 150826322 | 0.52 | 150826322 | 150834993 | 150866157 | 12.08 | 9.54 |
| DEEPSEA_MUN_C100_V30_HE_3 | 151027805 | 1.83 | 151027805 | 151036771 | 151039246 | 8.58 | 4.48 |
| DEEPSEA_MUN_C100_V30_HE_4 | 151193009 | 6.33 | 151193009 | 151218564 | 151331951 | 10.65 | 7.34 |
| DEEPSEA_MUN_C100_V30_HE_5 | 159789021 | 0.75 | 159789021 | 159799749 | 159828402 | 8.02 | 5.67 |
| DEEPSEA_MUN_C130_V40_HE_1 | 232582224 | 5.30 | 232625726 | 232672619 | 232835502 | 14.74 | 12.29 |
| DEEPSEA_MUN_C130_V40_HE_2 | 228036360 | 265.06 | 228205988 | 228285255 | 228365518 | 15.00 | 13.56 |
| DEEPSEA_MUN_C130_V40_HE_3 | 235657072 | 9.49 | 235666249 | 235772248 | 236033885 | 15.00 | 13.66 |
| DEEPSEA_MUN_C130_V40_HE_4 | 220357686 | 6.40 | 220360711 | 220564141 | 220783879 | 14.31 | 11.66 |
| DEEPSEA_MUN_C130_V40_HE_5 | 235381937 | 7.03 | 235487434 | 235739525 | 235849521 | 15.01 | 13.23 |

Table 4: Results for deep sea full cargo instances

| Instance | B&P ₂ | | HGS ₂ | | | | |
|---------------------------|------------------|------|------------------|-----------|-----------|------|------|
| | Opt | T | Best | Avg | Worst | T | T* |
| DEEPSEA_FUN_C8_V3_HE_1 | 9584863 | 0.00 | 9584863 | 9584863 | 9584863 | 0.01 | 0.00 |
| DEEPSEA_FUN_C8_V3_HE_2 | 9369654 | 0.00 | 9369654 | 9369654 | 9369654 | 0.01 | 0.00 |
| DEEPSEA_FUN_C8_V3_HE_3 | 4596681 | 0.00 | 4596681 | 4596681 | 4596681 | 0.01 | 0.00 |
| DEEPSEA_FUN_C8_V3_HE_4 | 6899730 | 0.00 | 6899730 | 6899730 | 6899730 | 0.01 | 0.00 |
| DEEPSEA_FUN_C8_V3_HE_5 | 6815253 | 0.00 | 6815253 | 6815253 | 6815253 | 0.01 | 0.00 |
| DEEPSEA_FUN_C11_V4_HE_1 | 34854819 | 0.00 | 34854819 | 34854819 | 34854819 | 0.02 | 0.00 |
| DEEPSEA_FUN_C11_V4_HE_2 | 25454434 | 0.00 | 25454434 | 25454434 | 25454434 | 0.02 | 0.00 |
| DEEPSEA_FUN_C11_V4_HE_3 | 29627143 | 0.00 | 29627143 | 29627143 | 29627143 | 0.02 | 0.00 |
| DEEPSEA_FUN_C11_V4_HE_4 | 33111680 | 0.00 | 33111680 | 33111680 | 33111680 | 0.02 | 0.00 |
| DEEPSEA_FUN_C11_V4_HE_5 | 28175914 | 0.00 | 28175914 | 28175914 | 28175914 | 0.03 | 0.00 |
| DEEPSEA_FUN_C13_V5_HE_1 | 11629005 | 0.00 | 11629005 | 11629005 | 11629005 | 0.04 | 0.00 |
| DEEPSEA_FUN_C13_V5_HE_2 | 11820655 | 0.00 | 11820655 | 11820655 | 11820655 | 0.04 | 0.00 |
| DEEPSEA_FUN_C13_V5_HE_3 | 9992593 | 0.00 | 9992593 | 9992593 | 9992593 | 0.04 | 0.00 |
| DEEPSEA_FUN_C13_V5_HE_4 | 12819619 | 0.00 | 12819619 | 12819619 | 12819619 | 0.03 | 0.00 |
| DEEPSEA_FUN_C13_V5_HE_5 | 10534892 | 0.00 | 10534892 | 10534892 | 10534892 | 0.03 | 0.00 |
| DEEPSEA_FUN_C16_V6_HE_1 | 51127590 | 0.00 | 51127590 | 51127590 | 51127590 | 0.04 | 0.00 |
| DEEPSEA_FUN_C16_V6_HE_2 | 44342796 | 0.00 | 44342796 | 44342796 | 44342796 | 0.03 | 0.00 |
| DEEPSEA_FUN_C16_V6_HE_3 | 45391842 | 0.00 | 45391842 | 45391842 | 45391842 | 0.03 | 0.00 |
| DEEPSEA_FUN_C16_V6_HE_4 | 39687114 | 0.00 | 39687114 | 39687114 | 39687114 | 0.04 | 0.00 |
| DEEPSEA_FUN_C16_V6_HE_5 | 42855603 | 0.00 | 42855603 | 42855603 | 42855603 | 0.04 | 0.00 |
| DEEPSEA_FUN_C17_V13_HE_1 | 17316720 | 0.00 | 17316720 | 17316720 | 17316720 | 0.04 | 0.00 |
| DEEPSEA_FUN_C17_V13_HE_2 | 12194861 | 0.00 | 12194861 | 12194861 | 12194861 | 0.05 | 0.00 |
| DEEPSEA_FUN_C17_V13_HE_3 | 12091554 | 0.00 | 12091554 | 12091554 | 12091554 | 0.05 | 0.00 |
| DEEPSEA_FUN_C17_V13_HE_4 | 12847653 | 0.00 | 12847653 | 12847653 | 12847653 | 0.05 | 0.01 |
| DEEPSEA_FUN_C17_V13_HE_5 | 13213406 | 0.00 | 13213406 | 13213406 | 13213406 | 0.05 | 0.00 |
| DEEPSEA_FUN_C20_V6_HE_1 | 16406738 | 0.00 | 16406738 | 16406738 | 16406738 | 0.05 | 0.00 |
| DEEPSEA_FUN_C20_V6_HE_2 | 16079401 | 0.00 | 16079401 | 16079401 | 16079401 | 0.05 | 0.00 |
| DEEPSEA_FUN_C20_V6_HE_3 | 17342200 | 0.00 | 17342200 | 17342200 | 17342200 | 0.04 | 0.00 |
| DEEPSEA_FUN_C20_V6_HE_4 | 16529748 | 0.00 | 16529748 | 16529748 | 16529748 | 0.05 | 0.01 |
| DEEPSEA_FUN_C20_V6_HE_5 | 17449378 | 0.00 | 17449378 | 17449378 | 17449378 | 0.05 | 0.00 |
| DEEPSEA_FUN_C25_V7_HE_1 | 22773158 | 0.00 | 22773158 | 22773158 | 22773158 | 0.07 | 0.01 |
| DEEPSEA_FUN_C25_V7_HE_2 | 20206329 | 0.00 | 20206329 | 20206329 | 20206329 | 0.08 | 0.01 |
| DEEPSEA_FUN_C25_V7_HE_3 | 19108952 | 0.00 | 19108952 | 19108952 | 19108952 | 0.07 | 0.01 |
| DEEPSEA_FUN_C25_V7_HE_4 | 22668675 | 0.00 | 22668675 | 22668675 | 22668675 | 0.07 | 0.01 |
| DEEPSEA_FUN_C25_V7_HE_5 | 23036603 | 0.00 | 23036603 | 23036603 | 23036603 | 0.08 | 0.02 |
| DEEPSEA_FUN_C35_V13_HE_1 | 86951609 | 0.00 | 86951609 | 86951609 | 86951609 | 0.22 | 0.09 |
| DEEPSEA_FUN_C35_V13_HE_2 | 83422071 | 0.00 | 83422071 | 83422071 | 83422071 | 0.19 | 0.07 |
| DEEPSEA_FUN_C35_V13_HE_3 | 83898591 | 0.00 | 83898591 | 83898591 | 83898591 | 0.21 | 0.08 |
| DEEPSEA_FUN_C35_V13_HE_4 | 91970481 | 0.00 | 91970481 | 91970481 | 91970481 | 0.23 | 0.09 |
| DEEPSEA_FUN_C35_V13_HE_5 | 91123040 | 0.00 | 91123040 | 91123040 | 91123040 | 0.20 | 0.07 |
| DEEPSEA_FUN_C50_V20_HE_1 | 41310946 | 0.00 | 41310946 | 41310946 | 41310946 | 0.46 | 0.18 |
| DEEPSEA_FUN_C50_V20_HE_2 | 37784994 | 0.00 | 37784994 | 37784994 | 37784994 | 0.46 | 0.18 |
| DEEPSEA_FUN_C50_V20_HE_3 | 39841724 | 0.00 | 39841724 | 39841724 | 39841724 | 0.41 | 0.13 |
| DEEPSEA_FUN_C50_V20_HE_4 | 43941098 | 0.00 | 43941098 | 43941098 | 43941098 | 0.47 | 0.20 |
| DEEPSEA_FUN_C50_V20_HE_5 | 41947437 | 0.00 | 41947437 | 41947437 | 41947437 | 0.46 | 0.18 |
| DEEPSEA_FUN_C70_V30_HE_1 | 142679953 | 0.01 | 142679953 | 142679953 | 142679953 | 1.03 | 0.38 |
| DEEPSEA_FUN_C70_V30_HE_2 | 135031988 | 0.02 | 135031988 | 135031988 | 135031988 | 1.06 | 0.36 |
| DEEPSEA_FUN_C70_V30_HE_3 | 162759203 | 0.01 | 162759203 | 162759203 | 162759203 | 1.02 | 0.40 |
| DEEPSEA_FUN_C70_V30_HE_4 | 155855123 | 0.01 | 155855123 | 155855123 | 155855123 | 1.06 | 0.44 |
| DEEPSEA_FUN_C70_V30_HE_5 | 156557723 | 0.01 | 156557723 | 156557723 | 156557723 | 0.95 | 0.35 |
| DEEPSEA_FUN_C90_V40_HE_1 | 190627186 | 0.06 | 190627186 | 190630993 | 190641592 | 2.08 | 0.83 |
| DEEPSEA_FUN_C90_V40_HE_2 | 189770977 | 0.02 | 189770977 | 189771678 | 189777990 | 2.63 | 1.45 |
| DEEPSEA_FUN_C90_V40_HE_3 | 211038412 | 0.02 | 211038412 | 211038684 | 211041136 | 2.15 | 0.94 |
| DEEPSEA_FUN_C90_V40_HE_4 | 210449287 | 0.02 | 210449287 | 210449655 | 210451528 | 2.02 | 0.93 |
| DEEPSEA_FUN_C90_V40_HE_5 | 197804917 | 0.05 | 197804917 | 197805398 | 197809727 | 2.11 | 0.87 |
| DEEPSEA_FUN_C100_V50_HE_1 | 205826535 | 0.08 | 205826535 | 205831891 | 205844919 | 2.96 | 1.24 |
| DEEPSEA_FUN_C100_V50_HE_2 | 207809147 | 0.03 | 207809147 | 207813970 | 207833395 | 4.33 | 2.62 |
| DEEPSEA_FUN_C100_V50_HE_3 | 217000928 | 0.02 | 217000928 | 217000928 | 217000928 | 3.08 | 1.41 |
| DEEPSEA_FUN_C100_V50_HE_4 | 220879632 | 0.03 | 220879632 | 220879794 | 220880172 | 2.49 | 0.83 |
| DEEPSEA_FUN_C100_V50_HE_5 | 223265017 | 0.02 | 223265017 | 223265584 | 223270683 | 2.79 | 1.10 |

Table 5: Performance comparison with Hemmati and Hvattum (2016)

| | | ALNS ₁ | | ALNS ₂ | | ALNS ₃ | | ALNS ₄ | | ALNS ₅ | | ALNS ₆ | | HGS ₂ | |
|----------|---------|-------------------|------|-------------------|------|-------------------|------|-------------------|------|-------------------|------|-------------------|------|------------------|------|
| | | Gap | T | Gap | T | Gap | T | Gap | T | Gap | T | Gap | T | Gap | T |
| SHORTSEA | C22-V6 | 0.29 | 0.18 | 0.29 | 0.20 | 0.23 | 0.19 | 0.17 | 0.19 | 0.35 | 0.20 | 0.53 | 0.18 | 0.00 | 0.18 |
| | C23-V13 | 0.82 | 0.25 | 0.34 | 0.25 | 0.35 | 0.26 | 0.28 | 0.26 | 0.24 | 0.25 | 0.46 | 0.25 | 0.00 | 0.23 |
| | C30-V6 | 1.32 | 0.35 | 0.66 | 0.40 | 1.14 | 0.41 | 0.90 | 0.42 | 1.04 | 0.39 | 1.95 | 0.38 | 0.00 | 0.33 |
| | C35-V7 | 1.40 | 0.51 | 1.51 | 0.58 | 1.69 | 0.58 | 1.21 | 0.58 | 1.03 | 0.55 | 1.97 | 0.53 | 0.01 | 0.53 |
| | C60-V13 | 2.89 | 2.05 | 2.29 | 2.18 | 2.83 | 2.29 | 2.30 | 2.42 | 2.63 | 2.06 | 1.81 | 1.95 | 0.13 | 2.14 |
| | Overall | 1.34 | 0.67 | 1.02 | 0.72 | 1.25 | 0.75 | 0.97 | 0.77 | 1.06 | 0.69 | 1.34 | 0.66 | 0.03 | 0.68 |
| DEEPSEA | C22-V6 | 0.35 | 0.18 | 0.31 | 0.19 | 0.15 | 0.20 | 0.15 | 0.20 | 0.19 | 0.19 | 1.66 | 0.18 | 0.00 | 0.18 |
| | C23-V13 | 0.00 | 0.26 | 0.00 | 0.26 | 0.02 | 0.28 | 0.01 | 0.28 | 0.00 | 0.25 | 0.00 | 0.24 | 0.00 | 0.20 |
| | C30-V6 | 0.67 | 0.36 | 0.34 | 0.42 | 0.36 | 0.42 | 0.34 | 0.42 | 0.42 | 0.39 | 0.58 | 0.37 | 0.03 | 0.33 |
| | C35-V7 | 0.61 | 0.52 | 0.51 | 0.60 | 0.50 | 0.60 | 0.58 | 0.63 | 0.37 | 0.54 | 0.69 | 0.51 | 0.00 | 0.43 |
| | C60-V13 | 4.37 | 2.18 | 3.50 | 2.41 | 4.11 | 2.39 | 4.12 | 2.39 | 3.23 | 1.99 | 3.41 | 1.85 | 0.02 | 1.73 |
| | Overall | 1.20 | 0.70 | 0.93 | 0.78 | 1.03 | 0.78 | 1.04 | 0.78 | 0.84 | 0.67 | 1.27 | 0.63 | 0.01 | 0.57 |