

Comparing VAST and sdmTMB GOA indices

Contents

```
#remotes::install_github("pbs-assess/sdmTMB", dependencies = TRUE)
library(VAST)
library(sp)
library(sdmTMB)
library(dplyr)
library(ggplot2)
library(here)
```

```
species <- "Gadus_macrocephalus" #Sebastes_alutus
```

We will fit geostatistical spatiotemporal models with VAST and sdmTMB for the purposes of index standardization and compare the outputs given the same data. We will use data from the GOA AFSC GAP bottom trawl survey for the species specified above. The density units are kg/km².

```
dat_ll <- readRDS(here("species_specific_code", "GOA", species, "production",
                      "data", paste0("Data_Geostat_", species, ".rds")))
```

```
dat_ll <- dplyr::transmute(dat_ll,
                           cpue_kg_km2 = Catch_KG,
                           year = as.integer(Year),
                           vessel = "missing",
                           effort = AreaSwept_km2,
                           lat = Lat,
                           lon = Lon,
                           pass = 0) %>%
  as.data.frame() # ensure not a tibble
```

We begin by specifying the VAST model. To specify the mesh used to approximate the spatial process, which is used in the SPDE calculations, we use the k-means method in VAST. Rather than specifying the cutoff distance, meshes in VAST are typically generated by specifying only the number of knots, which we will later pass, along with other model settings to the function `make_settings`. We will use 750 knots, the same number in the mesh created in the existing production VAST index for this stock and region.

We will include a factor predictor that represents the mean estimate for each time slice. Settings used for index standardization are applied by specifying `purpose = "index2"`.

Unlike in sdmTMB, the fitting and predicting steps are all accomplished with the function `fit_model()` and thus we need to specify the prediction grid (referred to as the “extrapolation grid” in VAST). Here, X and Y are coordinates in UTM zone 5.

```
GOAgrid <- read.csv(here("extrapolation_grids", "GOAThorsonGrid_Less700m.csv"))
input_grid <- cbind(Lat=GOAgrid$Latitude,
                   Lon=GOAgrid$Longitude,
```

```

        Area_km2=GOAgrid$Shape_Area/1000000)

settings <- make_settings(
  n_x = 750, # number of vertices in the SPDE mesh
  Region = "user",
  purpose = "index2", # index of abundance with Gamma for positive catches
  fine_scale = TRUE, # use bilinear interpolation from the INLA 'A' matrix
  zone = NA, # detects automatically
  Options = c("Calculate_Range" = TRUE, "Calculate_effective_area" = TRUE,
    "treat_nonencounter_as_zero" = FALSE),
  ObsModel = c(2, 1), # conventional logit-linked delta-Gamma; (2,4) if there are years with 100% encounter
  bias.correct = TRUE,
  use_anisotropy = TRUE,
  max_cells = Inf, # use all grid cells from the extrapolation grid, production model used 2000
  knot_method = "grid", # or "samples"
  strata.limits = data.frame(STRATA = as.factor('All_areas')) # customize to sp.
)

```

Next we will fit a GLMM (generalized linear mixed effects model).

```

# create folder for saved output:
dir.create(paste0(here("species_specific_code", "GOA", species,
  "index_comparison")), showWarnings = FALSE)

f <- here("species_specific_code", "GOA", species, "index_comparison", "VASTfit.RDS")
if (!file.exists(f)) {
  fit <- fit_model(
    settings = settings,
    Lat_i = dat_ll[, "lat"],
    Lon_i = dat_ll[, "lon"],
    t_i = dat_ll[, "year"],
    b_i = dat_ll[, "cpue_kg_km2"],
    a_i = dat_ll[, "effort"],
    input_grid = input_grid,
    working_dir = paste0(here("species_specific_code", "GOA",
      species, "index_comparison"), "/")
  )
  saveRDS(fit, file = f)
} else {
  fit <- readRDS(f)
  fit <- reload_model(fit)
}

#> Warning in .local(x, logarithm, ...): the default value of argument 'sqrt' of
#> method 'determinant(<CHMfactor>, <logical>)' may change from TRUE to FALSE as
#> soon as the next release of Matrix; set 'sqrt' when programming
#> Maximum absolute gradient of 6.16e-07: No evidence of non-convergence

```

We can look at parameter estimates. First we see estimates from the binomial component and second we see estimates from the positive Gamma component.

```

fit$parameter_estimates$diagnostics
#>           Param starting value Lower           MLE Upper final_gradient
#> 1      ln_H_input      0.48242841 -Inf  0.48243958  Inf  1.035286e-08

```

```

#> 2    ln_H_input      0.36549635 -Inf  0.36549402  Inf  5.622791e-09
#> 3    beta1_ft      -0.55240228 -Inf -0.55247295  Inf -5.460258e-09
#> 4    beta1_ft      -0.53101452 -Inf -0.53110946  Inf  1.456918e-09
#> 5    beta1_ft      -0.73818420 -Inf -0.73826412  Inf -1.337597e-09
#> 6    beta1_ft      -1.00062960 -Inf -1.00070730  Inf -3.676835e-09
#> 7    beta1_ft      -1.51016910 -Inf -1.51023671  Inf -5.058961e-09
#> 8    beta1_ft      -1.22327797 -Inf -1.22339176  Inf  4.441343e-09
#> 9    beta1_ft      -1.14028519 -Inf -1.14037007  Inf -1.126162e-09
#> 10   beta1_ft      -1.13056902 -Inf -1.13068163  Inf  5.179952e-09
#> 11   beta1_ft      -0.72378420 -Inf -0.72387763  Inf -1.385416e-10
#> 12   beta1_ft      -0.73144310 -Inf -0.73154977  Inf  3.380933e-09
#> 13   beta1_ft      -0.79529242 -Inf -0.79539104  Inf  1.561261e-09
#> 14   beta1_ft      -0.80073658 -Inf -0.80082836  Inf  1.030664e-09
#> 15   beta1_ft      -1.47051185 -Inf -1.47061109  Inf  1.960168e-09
#> 16   beta1_ft      -1.11217353 -Inf -1.11228315  Inf  4.138217e-09
#> 17   beta1_ft      -1.03036422 -Inf -1.03043810  Inf -2.591729e-09
#> 18   beta1_ft      -0.83247085 -Inf -0.83254542  Inf -1.788678e-09
#> 19   L_omega1_z      2.30397015 -Inf  2.30397270  Inf -1.803375e-08
#> 20   L_epsilon1_z    0.33301289 -Inf  0.33301725  Inf -7.780432e-08
#> 21   logkappa1     -3.96743218 -Inf -3.96743274  Inf  3.775915e-08
#> 22   beta2_ft       6.10704608 -Inf  6.10700599  Inf -4.863345e-09
#> 23   beta2_ft       5.96824448 -Inf  5.96824273  Inf -1.046423e-09
#> 24   beta2_ft       6.21112494 -Inf  6.21111560  Inf -2.283308e-09
#> 25   beta2_ft       5.91243309 -Inf  5.91239776  Inf -3.661853e-09
#> 26   beta2_ft       6.06038423 -Inf  6.06036328  Inf -3.626646e-09
#> 27   beta2_ft       6.06801927 -Inf  6.06801762  Inf -4.827854e-10
#> 28   beta2_ft       5.99669411 -Inf  5.99667626  Inf -2.453007e-09
#> 29   beta2_ft       5.95693023 -Inf  5.95694311  Inf  4.446719e-10
#> 30   beta2_ft       6.15315994 -Inf  6.15314929  Inf -1.268788e-09
#> 31   beta2_ft       6.05487537 -Inf  6.05487916  Inf  7.887522e-10
#> 32   beta2_ft       6.16071804 -Inf  6.16071724  Inf -6.678675e-10
#> 33   beta2_ft       5.88194032 -Inf  5.88193447  Inf -1.176375e-09
#> 34   beta2_ft       5.72384921 -Inf  5.72385281  Inf  3.547385e-11
#> 35   beta2_ft       5.72985376 -Inf  5.72986462  Inf  6.811689e-10
#> 36   beta2_ft       5.80003706 -Inf  5.80002497  Inf -1.572495e-09
#> 37   beta2_ft       5.75483730 -Inf  5.75483677  Inf -1.187551e-09
#> 38   L_omega2_z      0.83685770 -Inf  0.83685904  Inf -4.576824e-08
#> 39   L_epsilon2_z    1.27832071 -Inf  1.27833418  Inf -9.843492e-08
#> 40   logkappa2     -2.02115699 -Inf -2.02113532  Inf  6.799801e-08
#> 41   logSigmaM      0.04476912 -Inf  0.04476892  Inf -1.310735e-07

```

Now we fit the same model in sdmTMB:

```

dat <- dat_ll %>%
  rename(X = lon, Y = lat)

dat$year_f <- as.factor(dat$year)

coordinates(dat) <- ~ X + Y
proj4string(dat) <- CRS("+proj=longlat +datum=WGS84")
dat <- as.data.frame(spTransform(dat, CRS("+proj=utm +zone=5")))
# scale to km so values don't get too large
dat$X <- dat$coords.x1 / 1000
dat$Y <- dat$coords.x2 / 1000

```

```

f1 <- here("species_specific_code", "GOA", species,
           "index_comparison", "fit_sdmTMB.RDS")
if (!file.exists(f1)) {
  # make mesh and fit model
mesh <- make_mesh(dat, xy_cols = c("X", "Y"), mesh = fit$spatial_list$MeshList$anisotropic_mesh) #pass
#mesh <- make_mesh(dat, xy_cols = c("X", "Y"), n_knots = 50, type = "kmeans") #coarser mesh for experi

fit_sdmTMB <- sdmTMB(
  cpue_kg_km2 ~ 0 + year_f,
  data = dat,
  mesh = mesh,
  family = delta_gamma(type = "poisson-link"),
  time = "year",
  spatial = "on",
  spatiotemporal = "iid",
  silent = FALSE,
  anisotropy = TRUE,
  do_fit = TRUE
  #, do_index = TRUE (to compute index at same time, requires passing args)
)
fit_sdmTMB
saveRDS(fit_sdmTMB, file = here("species_specific_code", "GOA",
                                species, "index_comparison",
                                "fit_sdmTMB.RDS"))
} else {
fit_sdmTMB <- readRDS(f1)
}
#> outer mgc: 8725847
#> outer mgc: 3060856
#> outer mgc: 1788920
#> outer mgc: 613760.9
#> outer mgc: 352119.6
#> outer mgc: 113981.5
#> outer mgc: 61341.19
#> outer mgc: 17257.93
#> outer mgc: 8670.813
#> outer mgc: 2795.726
#> outer mgc: 1551.694
#> outer mgc: 3720.787
#> outer mgc: 629.6296
#> outer mgc: 3582.545
#> outer mgc: 1989.689
#> outer mgc: 1389.482
#> outer mgc: 203.056
#> outer mgc: 172.1405
#> outer mgc: 449.943
#> outer mgc: 498.8281
#> outer mgc: 218.7551
#> outer mgc: 239.5174
#> outer mgc: 150.3744
#> outer mgc: 118.4053
#> outer mgc: 154.0649
#> outer mgc: 101.1203

```

```

#> outer mgc: 46.25297
#> outer mgc: 61.19023
#> outer mgc: 40.94771
#> outer mgc: 13.6394
#> outer mgc: 20.21234
#> outer mgc: 34.02459
#> outer mgc: 36.55351
#> outer mgc: 8.033947
#> outer mgc: 3.584056
#> outer mgc: 3.556164
#> outer mgc: 4.429629
#> outer mgc: 3.191571
#> outer mgc: 1.815708
#> outer mgc: 0.8719515
#> outer mgc: 1.556649
#> outer mgc: 1.306352
#> outer mgc: 0.7608134
#> outer mgc: 0.7199028
#> outer mgc: 0.4280313
#> outer mgc: 0.07721701
#> outer mgc: 0.586065
#> outer mgc: 0.6398505
#> outer mgc: 0.05301387
#> outer mgc: 0.146642
#> outer mgc: 0.01767812
#> outer mgc: 0.04011161
#> outer mgc: 0.07556185
#> outer mgc: 0.02061207
#> outer mgc: 0.01535966
#> outer mgc: 0.04642589
#> outer mgc: 0.03063649
#> outer mgc: 0.004150351
#> outer mgc: 0.02490855
#> outer mgc: 0.01220162
#> outer mgc: 0.001900869
#> outer mgc: 0.00148403
#> iter: 1 value: -15357.12 mgc: 43.48399 ustep: 1
#> iter: 2 value: -15357.12 mgc: 0.4722795 ustep: 1
#> iter: 3 value: -15357.12 mgc: 4.116163e-05 ustep: 1
#> iter: 4 mgc: 4.618528e-13
#> iter: 1 mgc: 4.618528e-13
#> Matching hessian patterns... Done
#> outer mgc: 138.1386
#> iter: 1 value: 25692.76 mgc: 47.58176 ustep: 0.1336527
#> iter: 2 value: 25346.78 mgc: 106.2361 ustep: 0.3656489
#> iter: 3 value: 25323.75 mgc: 22.31134 ustep: 0.6047286
#> iter: 4 value: 25322.97 mgc: 4.488312 ustep: 0.7776652
#> iter: 5 value: 25322.97 mgc: 0.2176838 ustep: 0.8818651
#> iter: 6 value: 25322.97 mgc: 0.001585042 ustep: 0.9390828
#> iter: 7 value: 25322.97 mgc: 4.585978e-06 ustep: 0.969066
#> iter: 8 mgc: 6.991085e-09
#> iter: 1 mgc: 6.991085e-09
#> outer mgc: 1716.696
#> iter: 1 value: 81810.41 mgc: 26.67989 ustep: 0.4873439

```

```

#> iter: 2 value: 80162.4 mgc: 557.2488 ustep: 0.6981304
#> iter: 3 value: 79565.1 mgc: 204.9333 ustep: 0.8355584
#> iter: 4 value: 79370.57 mgc: 75.51353 ustep: 0.9140974
#> iter: 5 value: 79314.42 mgc: 27.90554 ustep: 0.9560888
#> iter: 6 value: 79297.73 mgc: 10.28402 ustep: 0.9778002
#> iter: 7 value: 79292.33 mgc: 3.800702 ustep: 0.9888389
#> iter: 8 value: 79290.67 mgc: 1.365324 ustep: 0.9944044
#> iter: 9 value: 79290.4 mgc: 0.4125451 ustep: 0.9971985
#> iter: 10 value: 79290.39 mgc: 0.06920236 ustep: 0.9985984
#> iter: 11 value: 79290.39 mgc: 0.002722293 ustep: 0.999299
#> iter: 12 value: 79290.39 mgc: 8.752427e-06 ustep: 0.9996495
#> iter: 13 mgc: 8.696239e-09
#> iter: 1 value: 43792.4 mgc: 24.4174 ustep: 1
#> iter: 2 value: 43744.91 mgc: 5.957532 ustep: 1
#> iter: 3 value: 43744.22 mgc: 1.671843 ustep: 1
#> iter: 4 value: 43744.22 mgc: 0.1197158 ustep: 1
#> iter: 5 value: 43744.22 mgc: 8.117455e-05 ustep: 1
#> iter: 6 mgc: 2.787548e-10
#> iter: 1 mgc: 2.787548e-10
#> outer mgc: 646.0713
#> iter: 1 value: 55121.74 mgc: 10.99194 ustep: 1
#> iter: 2 value: 55027.04 mgc: 63.06726 ustep: 1
#> iter: 3 value: 55007.8 mgc: 21.89412 ustep: 1
#> iter: 4 value: 55005.65 mgc: 5.54718 ustep: 1
#> iter: 5 value: 55005.55 mgc: 1.03866 ustep: 1
#> iter: 6 value: 55005.55 mgc: 0.06872573 ustep: 1
#> iter: 7 value: 55005.55 mgc: 0.0004011949 ustep: 1
#> iter: 8 value: 55005.55 mgc: 1.45056e-08 ustep: 1
#> mgc: 1.421085e-14
#> iter: 1 value: 48568.19 mgc: 4.545627 ustep: 1
#> iter: 2 value: 48567.78 mgc: 1.058064 ustep: 1
#> iter: 3 value: 48567.78 mgc: 0.03624179 ustep: 1
#> iter: 4 value: 48567.78 mgc: 0.0001501987 ustep: 1
#> iter: 5 mgc: 2.59379e-09
#> iter: 1 mgc: 2.59379e-09
#> outer mgc: 322.7915
#> iter: 1 value: 50173.65 mgc: 4.91336 ustep: 1
#> iter: 2 value: 50173.57 mgc: 0.4989267 ustep: 1
#> iter: 3 value: 50173.57 mgc: 0.01980322 ustep: 1
#> iter: 4 value: 50173.57 mgc: 3.303223e-05 ustep: 1
#> iter: 5 mgc: 8.784062e-11
#> iter: 1 mgc: 8.784062e-11
#> outer mgc: 435.5399
#> iter: 1 value: 71466.44 mgc: 8.565171 ustep: 1
#> iter: 2 value: 71451.96 mgc: 4.530843 ustep: 1
#> iter: 3 value: 71451.87 mgc: 0.5993321 ustep: 1
#> iter: 4 value: 71451.87 mgc: 0.01302035 ustep: 1
#> iter: 5 value: 71451.87 mgc: 7.001613e-06 ustep: 1
#> iter: 6 mgc: 1.964651e-12
#> iter: 1 value: 124893.5 mgc: 3.325916 ustep: 0.8994163
#> iter: 2 value: 124689.5 mgc: 4.287545 ustep: 0.9483808
#> iter: 3 value: 124652.4 mgc: 1.003267 ustep: 0.973851
#> iter: 4 value: 124645.4 mgc: 0.6449368 ustep: 0.9868402
#> iter: 5 value: 124644.3 mgc: 0.02679126 ustep: 0.993399

```

```

#> iter: 6 value: 124644.1 mgc: 0.004594769 ustep: 0.9966944
#> iter: 7 value: 124644.1 mgc: 0.0009945504 ustep: 0.998346
#> iter: 8 value: 124644.1 mgc: 0.0001703053 ustep: 0.9991727
#> iter: 9 value: 124644.1 mgc: 1.809248e-05 ustep: 0.9995863
#> iter: 10 value: 124644.1 mgc: 1.139805e-06 ustep: 0.9997932
#> iter: 11 value: 124644.1 mgc: 4.05032e-08 ustep: 0.9998966
#> iter: 12 mgc: 7.934773e-10
#> iter: 1 mgc: 1.964651e-12
#> outer mgc: 1022.848
#> iter: 1 value: 102681.5 mgc: 7.749904 ustep: 0.4367355
#> iter: 2 value: 101993.2 mgc: 7.130732 ustep: 0.6608936
#> iter: 3 value: 101727.8 mgc: 1.395048 ustep: 0.8129723
#> iter: 4 value: 101658.6 mgc: 0.3950278 ustep: 0.9016596
#> iter: 5 value: 101646.5 mgc: 0.1323005 ustep: 0.9495626
#> iter: 6 value: 101645.2 mgc: 0.05088783 ustep: 0.9744576
#> iter: 7 value: 101645.1 mgc: 0.01358056 ustep: 0.9871475
#> iter: 8 value: 101645.1 mgc: 0.002282019 ustep: 0.9935536
#> iter: 9 value: 101645.1 mgc: 0.0003142108 ustep: 0.9967719
#> iter: 10 value: 101645.1 mgc: 2.312711e-05 ustep: 0.9983848
#> iter: 11 value: 101645.1 mgc: 8.833195e-07 ustep: 0.9991922
#> iter: 12 value: 101645.1 mgc: 1.721806e-08 ustep: 0.999596
#> iter: 13 mgc: 1.697339e-10
#> iter: 1 value: 74769.53 mgc: 3.27869 ustep: 1
#> iter: 2 value: 74768.64 mgc: 0.5017408 ustep: 1
#> iter: 3 value: 74768.64 mgc: 0.02573547 ustep: 1
#> iter: 4 value: 74768.64 mgc: 7.346271e-05 ustep: 1
#> iter: 5 mgc: 6.239169e-10
#> iter: 1 mgc: 6.239169e-10
#> outer mgc: 760.3543
#> iter: 1 value: 73915.44 mgc: 1.97771 ustep: 1
#> iter: 2 value: 73915.32 mgc: 0.1489177 ustep: 1
#> iter: 3 value: 73915.32 mgc: 0.001289698 ustep: 1
#> iter: 4 value: 73915.32 mgc: 1.756362e-07 ustep: 1
#> iter: 5 mgc: 1.310063e-14
#> iter: 1 mgc: 1.310063e-14
#> outer mgc: 222.8992
#> iter: 1 value: 77513.1 mgc: 2.671747 ustep: 1
#> iter: 2 value: 77512.18 mgc: 0.4970244 ustep: 1
#> iter: 3 value: 77512.18 mgc: 0.01011675 ustep: 1
#> iter: 4 value: 77512.18 mgc: 7.689373e-06 ustep: 1
#> iter: 5 mgc: 2.107392e-11
#> iter: 1 mgc: 2.107392e-11
#> outer mgc: 394.6821
#> iter: 1 value: 70472.89 mgc: 3.240938 ustep: 1
#> iter: 2 value: 70472.44 mgc: 0.3461074 ustep: 1
#> iter: 3 value: 70472.44 mgc: 0.004681904 ustep: 1
#> iter: 4 value: 70472.44 mgc: 8.571625e-07 ustep: 1
#> iter: 5 mgc: 2.842171e-14
#> iter: 1 value: 75427.3 mgc: 1.110976 ustep: 1
#> iter: 2 value: 75427.29 mgc: 0.05767749 ustep: 1
#> iter: 3 value: 75427.29 mgc: 0.0001603281 ustep: 1
#> iter: 4 mgc: 1.227755e-09
#> iter: 1 mgc: 1.227755e-09
#> outer mgc: 102.7322

```



```

#> iter: 1 value: 75481.56 mgc: 0.3674859 ustep: 1
#> iter: 2 value: 75481.56 mgc: 0.004017617 ustep: 1
#> iter: 3 value: 75481.56 mgc: 1.126928e-06 ustep: 1
#> iter: 4 mgc: 1.672551e-13
#> iter: 1 mgc: 1.672551e-13
#> outer mgc: 102.3702
#> iter: 1 value: 73867.22 mgc: 0.7224135 ustep: 1
#> iter: 2 value: 73867.22 mgc: 0.02242427 ustep: 1
#> iter: 3 value: 73867.22 mgc: 2.040331e-05 ustep: 1
#> iter: 4 mgc: 2.24003e-11
#> iter: 1 mgc: 2.24003e-11
#> outer mgc: 184.3634
#> iter: 1 value: 74640.2 mgc: 0.7808993 ustep: 1
#> iter: 2 value: 74640.2 mgc: 0.03359178 ustep: 1
#> iter: 3 value: 74640.2 mgc: 4.959654e-05 ustep: 1
#> iter: 4 mgc: 1.312949e-10
#> iter: 1 mgc: 1.312949e-10
#> outer mgc: 95.11953
#> iter: 1 value: 72623.89 mgc: 0.8366894 ustep: 1
#> iter: 2 value: 72623.89 mgc: 0.01067904 ustep: 1
#> iter: 3 value: 72623.89 mgc: 4.099657e-06 ustep: 1
#> iter: 4 mgc: 1.754374e-12
#> iter: 1 mgc: 1.754374e-12
#> outer mgc: 196.3053
#> iter: 1 value: 75437.18 mgc: 1.828319 ustep: 1
#> iter: 2 value: 75437.15 mgc: 0.1254078 ustep: 1
#> iter: 3 value: 75437.15 mgc: 0.0007213016 ustep: 1
#> iter: 4 value: 75437.15 mgc: 2.443211e-08 ustep: 1
#> iter: 5 mgc: 1.332268e-14
#> iter: 1 mgc: 1.332268e-14
#> outer mgc: 170.8716
#> iter: 1 value: 72461.32 mgc: 2.855418 ustep: 1
#> iter: 2 value: 72461.27 mgc: 0.2354517 ustep: 1
#> iter: 3 value: 72461.27 mgc: 0.001793986 ustep: 1
#> iter: 4 value: 72461.27 mgc: 1.063919e-07 ustep: 1
#> iter: 5 mgc: 1.465494e-14
#> iter: 1 mgc: 1.465494e-14
#> outer mgc: 153.0156
#> iter: 1 value: 72338.53 mgc: 1.62833 ustep: 1
#> iter: 2 value: 72338.5 mgc: 0.1138513 ustep: 1
#> iter: 3 value: 72338.5 mgc: 0.0004724223 ustep: 1
#> iter: 4 value: 72338.5 mgc: 3.636101e-08 ustep: 1
#> iter: 5 mgc: 9.006684e-15
#> iter: 1 mgc: 9.006684e-15
#> outer mgc: 309.1334
#> iter: 1 value: 75741.48 mgc: 1.612092 ustep: 1
#> iter: 2 value: 75741.4 mgc: 0.1694185 ustep: 1
#> iter: 3 value: 75741.4 mgc: 0.001139883 ustep: 1
#> iter: 4 value: 75741.4 mgc: 6.408964e-08 ustep: 1
#> iter: 5 mgc: 1.154632e-14
#> iter: 1 mgc: 1.154632e-14
#> outer mgc: 311.9021
#> iter: 1 value: 72799.67 mgc: 1.408165 ustep: 1
#> iter: 2 value: 72799.65 mgc: 0.06279149 ustep: 1

```



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#> iter: 3 value: 72799.65 mgc: 0.00016857 ustep: 1
#> iter: 4 mgc: 1.429677e-09
#> iter: 1 mgc: 1.429677e-09
#> outer mgc: 57.26482
#> iter: 1 value: 74435.46 mgc: 1.086684 ustep: 1
#> iter: 2 value: 74435.45 mgc: 0.0240946 ustep: 1
#> iter: 3 value: 74435.45 mgc: 1.814102e-05 ustep: 1
#> iter: 4 mgc: 1.42909e-11
#> iter: 1 mgc: 1.42909e-11
#> outer mgc: 109.6627
#> iter: 1 value: 73639.35 mgc: 2.578392 ustep: 1
#> iter: 2 value: 73639.34 mgc: 0.08508829 ustep: 1
#> iter: 3 value: 73639.34 mgc: 0.0001015517 ustep: 1
#> iter: 4 mgc: 2.321502e-10
#> iter: 1 mgc: 2.321502e-10
#> outer mgc: 249.8349
#> iter: 1 value: 73064.42 mgc: 2.156267 ustep: 1
#> iter: 2 value: 73064.4 mgc: 0.07823854 ustep: 1
#> iter: 3 value: 73064.4 mgc: 0.0002235458 ustep: 1
#> iter: 4 mgc: 1.773497e-09
#> iter: 1 mgc: 1.773497e-09
#> outer mgc: 132.7512
#> iter: 1 value: 72110.99 mgc: 2.224349 ustep: 1
#> iter: 2 value: 72110.83 mgc: 0.1973682 ustep: 1
#> iter: 3 value: 72110.83 mgc: 0.0009979715 ustep: 1
#> iter: 4 value: 72110.83 mgc: 3.131086e-08 ustep: 1
#> iter: 5 mgc: 1.287859e-14
#> iter: 1 mgc: 1.287859e-14
#> outer mgc: 295.2003
#> iter: 1 value: 74584.03 mgc: 1.913584 ustep: 1
#> iter: 2 value: 74583.97 mgc: 0.1555198 ustep: 1
#> iter: 3 value: 74583.97 mgc: 0.0009599488 ustep: 1
#> iter: 4 value: 74583.97 mgc: 5.559041e-08 ustep: 1
#> iter: 5 mgc: 1.398881e-14
#> iter: 1 mgc: 1.398881e-14
#> outer mgc: 94.15514
#> iter: 1 value: 73509.82 mgc: 2.190592 ustep: 1
#> iter: 2 value: 73509.81 mgc: 0.06389415 ustep: 1
#> iter: 3 value: 73509.81 mgc: 7.988287e-05 ustep: 1
#> iter: 4 mgc: 3.92899e-10
#> iter: 1 mgc: 3.92899e-10
#> outer mgc: 115.19
#> iter: 1 value: 75156.8 mgc: 1.52698 ustep: 1
#> iter: 2 value: 75156.79 mgc: 0.04541834 ustep: 1
#> iter: 3 value: 75156.79 mgc: 5.244764e-05 ustep: 1
#> iter: 4 mgc: 1.705236e-10
#> iter: 1 value: 75284.54 mgc: 1.738826 ustep: 1
#> iter: 2 value: 75284.54 mgc: 0.04417449 ustep: 1
#> iter: 3 value: 75284.54 mgc: 3.772441e-05 ustep: 1
#> iter: 4 mgc: 1.20516e-10
#> iter: 1 value: 72638.59 mgc: 9.274126 ustep: 1
#> iter: 2 value: 72636.01 mgc: 0.9329262 ustep: 1
#> iter: 3 value: 72636 mgc: 0.01396872 ustep: 1
#> iter: 4 value: 72636 mgc: 1.007432e-05 ustep: 1

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```

#> iter: 5 mgc: 8.678391e-12
#> iter: 1 value: 42249.83 mgc: 241.729 ustep: 1
#> iter: 2 value: 42189.03 mgc: 8.332172 ustep: 1
#> iter: 3 value: 42188.91 mgc: 0.70081 ustep: 1
#> iter: 4 value: 42188.91 mgc: 0.006318858 ustep: 1
#> iter: 5 value: 42188.91 mgc: 5.276705e-07 ustep: 1
#> iter: 6 mgc: 2.158011e-13
#> iter: 1 mgc: 8.678391e-12
#> outer mgc: 145.969
#> iter: 1 value: 56192.31 mgc: 20.784 ustep: 1
#> iter: 2 value: 56171.08 mgc: 3.506962 ustep: 1
#> iter: 3 value: 56171.04 mgc: 0.1902533 ustep: 1
#> iter: 4 value: 56171.04 mgc: 0.007897555 ustep: 1
#> iter: 5 value: 56171.04 mgc: 3.969122e-06 ustep: 1
#> iter: 6 mgc: 1.570299e-12
#> iter: 1 value: 73692.31 mgc: 3.217399 ustep: 1
#> iter: 2 value: 73690.41 mgc: 1.178389 ustep: 1
#> iter: 3 value: 73690.4 mgc: 0.05439401 ustep: 1
#> iter: 4 value: 73690.4 mgc: 0.0007585147 ustep: 1
#> iter: 5 value: 73690.4 mgc: 1.420594e-07 ustep: 1
#> iter: 6 mgc: 1.554312e-14
#> iter: 1 value: 76037.88 mgc: 2.567899 ustep: 1
#> iter: 2 value: 76037.42 mgc: 0.3543132 ustep: 1
#> iter: 3 value: 76037.42 mgc: 0.0161726 ustep: 1
#> iter: 4 value: 76037.42 mgc: 5.2456e-05 ustep: 1
#> iter: 5 mgc: 5.116844e-10
#> iter: 1 value: 74076.02 mgc: 1.368913 ustep: 1
#> iter: 2 value: 74076 mgc: 0.08331877 ustep: 1
#> iter: 3 value: 74076 mgc: 0.0005134436 ustep: 1
#> iter: 4 value: 74076 mgc: 3.144031e-08 ustep: 1
#> iter: 5 mgc: 1.110223e-14
#> iter: 1 mgc: 1.110223e-14
#> outer mgc: 46.58833
#> iter: 1 value: 71417.02 mgc: 0.639618 ustep: 1
#> iter: 2 value: 71417.02 mgc: 0.02113429 ustep: 1
#> iter: 3 value: 71417.02 mgc: 2.073572e-05 ustep: 1
#> iter: 4 mgc: 2.53495e-11
#> iter: 1 value: 72815.27 mgc: 0.2857282 ustep: 1
#> iter: 2 value: 72815.27 mgc: 0.004495902 ustep: 1
#> iter: 3 value: 72815.27 mgc: 9.993219e-07 ustep: 1
#> iter: 4 mgc: 6.861178e-14
#> iter: 1 mgc: 6.861178e-14
#> outer mgc: 107.6529
#> iter: 1 value: 73557.11 mgc: 0.4651737 ustep: 1
#> iter: 2 value: 73557.11 mgc: 0.01091664 ustep: 1
#> iter: 3 value: 73557.11 mgc: 6.861958e-06 ustep: 1
#> iter: 4 mgc: 3.87973e-12
#> iter: 1 mgc: 3.87973e-12
#> outer mgc: 81.42
#> iter: 1 value: 72635.36 mgc: 0.430279 ustep: 1
#> iter: 2 value: 72635.36 mgc: 0.007639556 ustep: 1
#> iter: 3 value: 72635.36 mgc: 2.879455e-06 ustep: 1
#> iter: 4 mgc: 7.578937e-13
#> iter: 1 mgc: 7.578937e-13

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```

#> outer mgc: 60.77354
#> iter: 1 value: 72874.52 mgc: 0.7194511 ustep: 1
#> iter: 2 value: 72874.52 mgc: 0.01006818 ustep: 1
#> iter: 3 value: 72874.52 mgc: 4.530236e-06 ustep: 1
#> iter: 4 mgc: 1.424666e-12
#> iter: 1 mgc: 1.424666e-12
#> outer mgc: 74.19066
#> iter: 1 value: 70898.46 mgc: 1.363988 ustep: 1
#> iter: 2 value: 70898.46 mgc: 0.03632192 ustep: 1
#> iter: 3 value: 70898.46 mgc: 2.409493e-05 ustep: 1
#> iter: 4 mgc: 4.312928e-11
#> iter: 1 mgc: 4.312928e-11
#> outer mgc: 119.3747
#> iter: 1 value: 70744.45 mgc: 1.20335 ustep: 1
#> iter: 2 value: 70744.44 mgc: 0.03763661 ustep: 1
#> iter: 3 value: 70744.44 mgc: 8.811105e-05 ustep: 1
#> iter: 4 mgc: 3.716756e-10
#> iter: 1 mgc: 3.716756e-10
#> outer mgc: 81.64
#> iter: 1 value: 70856.96 mgc: 1.102759 ustep: 1
#> iter: 2 value: 70856.95 mgc: 0.01574541 ustep: 1
#> iter: 3 value: 70856.95 mgc: 1.602301e-05 ustep: 1
#> iter: 4 mgc: 2.901598e-11
#> iter: 1 mgc: 2.901598e-11
#> outer mgc: 24.68771
#> iter: 1 value: 69672.63 mgc: 0.9658632 ustep: 1
#> iter: 2 value: 69672.63 mgc: 0.01114209 ustep: 1
#> iter: 3 value: 69672.63 mgc: 4.323758e-06 ustep: 1
#> iter: 4 mgc: 1.309119e-12
#> iter: 1 mgc: 1.309119e-12
#> outer mgc: 23.95876
#> iter: 1 value: 69858.95 mgc: 0.7798493 ustep: 1
#> iter: 2 value: 69858.94 mgc: 0.05032318 ustep: 1
#> iter: 3 value: 69858.94 mgc: 0.0002275184 ustep: 1
#> iter: 4 mgc: 6.374665e-09
#> iter: 1 value: 69644.2 mgc: 0.407869 ustep: 1
#> iter: 2 value: 69644.19 mgc: 0.02368276 ustep: 1
#> iter: 3 value: 69644.19 mgc: 3.04217e-05 ustep: 1
#> iter: 4 mgc: 1.599587e-10
#> iter: 1 value: 69668.59 mgc: 0.1590714 ustep: 1
#> iter: 2 value: 69668.59 mgc: 0.002923747 ustep: 1
#> iter: 3 value: 69668.59 mgc: 4.138145e-07 ustep: 1
#> iter: 4 mgc: 3.019807e-14
#> iter: 1 mgc: 3.019807e-14
#> outer mgc: 49.77106
#> iter: 1 value: 70167.01 mgc: 0.2302292 ustep: 1
#> iter: 2 value: 70167.01 mgc: 0.002625696 ustep: 1
#> iter: 3 value: 70167.01 mgc: 2.349601e-07 ustep: 1
#> iter: 4 mgc: 1.265654e-14
#> iter: 1 mgc: 1.265654e-14
#> outer mgc: 51.94973
#> iter: 1 value: 69771.82 mgc: 0.2132341 ustep: 1
#> iter: 2 value: 69771.82 mgc: 0.002034481 ustep: 1
#> iter: 3 value: 69771.82 mgc: 2.012277e-07 ustep: 1

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```

#> iter: 4 mgc: 1.776357e-14
#> iter: 1 mgc: 1.776357e-14
#> outer mgc: 15.94394
#> iter: 1 value: 69940.44 mgc: 0.2006178 ustep: 1
#> iter: 2 value: 69940.44 mgc: 0.001780472 ustep: 1
#> iter: 3 value: 69940.44 mgc: 1.186846e-07 ustep: 1
#> iter: 4 mgc: 1.24345e-14
#> iter: 1 value: 69884.72 mgc: 0.3416394 ustep: 1
#> iter: 2 value: 69884.72 mgc: 0.00304773 ustep: 1
#> iter: 3 value: 69884.72 mgc: 3.049042e-07 ustep: 1
#> iter: 4 mgc: 1.154632e-14
#> iter: 1 value: 69218.25 mgc: 1.721395 ustep: 1
#> iter: 2 value: 69218.24 mgc: 0.05887061 ustep: 1
#> iter: 3 value: 69218.24 mgc: 9.783762e-05 ustep: 1
#> iter: 4 mgc: 3.502394e-10
#> iter: 1 mgc: 3.502394e-10
#> outer mgc: 75.04892
#> iter: 1 value: 65216.09 mgc: 3.232974 ustep: 1
#> iter: 2 value: 65216.02 mgc: 0.138579 ustep: 1
#> iter: 3 value: 65216.02 mgc: 0.0007628181 ustep: 1
#> iter: 4 value: 65216.02 mgc: 8.668988e-08 ustep: 1
#> iter: 5 mgc: 2.109424e-14
#> iter: 1 mgc: 2.109424e-14
#> outer mgc: 145.3346
#> iter: 1 value: 66115.17 mgc: 1.818072 ustep: 1
#> iter: 2 value: 66115.12 mgc: 0.1548011 ustep: 1
#> iter: 3 value: 66115.12 mgc: 0.001499721 ustep: 1
#> iter: 4 value: 66115.12 mgc: 1.341151e-07 ustep: 1
#> iter: 5 mgc: 2.953193e-14
#> iter: 1 mgc: 2.953193e-14
#> outer mgc: 99.46522
#> iter: 1 value: 65302.82 mgc: 1.744294 ustep: 1
#> iter: 2 value: 65302.81 mgc: 0.04322143 ustep: 1
#> iter: 3 value: 65302.81 mgc: 6.012423e-05 ustep: 1
#> iter: 4 mgc: 1.278803e-10
#> iter: 1 mgc: 1.278803e-10
#> outer mgc: 122.8231
#> iter: 1 value: 66846.99 mgc: 1.505631 ustep: 1
#> iter: 2 value: 66846.98 mgc: 0.03999925 ustep: 1
#> iter: 3 value: 66846.98 mgc: 6.746651e-05 ustep: 1
#> iter: 4 mgc: 7.957097e-10
#> iter: 1 value: 66691.38 mgc: 0.6872417 ustep: 1
#> iter: 2 value: 66691.38 mgc: 0.02176759 ustep: 1
#> iter: 3 value: 66691.38 mgc: 2.669919e-05 ustep: 1
#> iter: 4 mgc: 3.450484e-11
#> iter: 1 mgc: 3.450484e-11
#> outer mgc: 151.5203
#> iter: 1 value: 66193.27 mgc: 0.8017548 ustep: 1
#> iter: 2 value: 66193.27 mgc: 0.01261342 ustep: 1
#> iter: 3 value: 66193.27 mgc: 5.208253e-06 ustep: 1
#> iter: 4 mgc: 4.597656e-12
#> iter: 1 mgc: 4.597656e-12
#> outer mgc: 36.7118
#> iter: 1 value: 66191.59 mgc: 0.6168069 ustep: 1

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```

#> iter: 2 value: 66191.59 mgc: 0.01431537 ustep: 1
#> iter: 3 value: 66191.59 mgc: 4.544344e-06 ustep: 1
#> iter: 4 mgc: 2.198464e-12
#> iter: 1 mgc: 2.198464e-12
#> outer mgc: 32.39465
#> iter: 1 value: 64180.81 mgc: 1.28035 ustep: 1
#> iter: 2 value: 64180.81 mgc: 0.02739228 ustep: 1
#> iter: 3 value: 64180.81 mgc: 3.905889e-05 ustep: 1
#> iter: 4 mgc: 8.090756e-11
#> iter: 1 mgc: 8.090756e-11
#> outer mgc: 30.27423
#> iter: 1 value: 63668.71 mgc: 1.250355 ustep: 1
#> iter: 2 value: 63668.7 mgc: 0.03537505 ustep: 1
#> iter: 3 value: 63668.7 mgc: 9.125276e-05 ustep: 1
#> iter: 4 mgc: 8.294825e-10
#> iter: 1 mgc: 8.294825e-10
#> outer mgc: 108.1621
#> iter: 1 value: 60877.11 mgc: 1.440354 ustep: 1
#> iter: 2 value: 60877.08 mgc: 0.06971747 ustep: 1
#> iter: 3 value: 60877.08 mgc: 0.0001660366 ustep: 1
#> iter: 4 mgc: 1.442761e-09
#> iter: 1 value: 61935.82 mgc: 0.7941147 ustep: 1
#> iter: 2 value: 61935.82 mgc: 0.03155414 ustep: 1
#> iter: 3 value: 61935.82 mgc: 3.294608e-05 ustep: 1
#> iter: 4 mgc: 1.071816e-10
#> iter: 1 value: 62321.87 mgc: 0.7284589 ustep: 1
#> iter: 2 value: 62321.86 mgc: 0.0241692 ustep: 1
#> iter: 3 value: 62321.86 mgc: 2.651214e-05 ustep: 1
#> iter: 4 mgc: 7.169687e-11
#> iter: 1 value: 63051.39 mgc: 0.3328069 ustep: 1
#> iter: 2 value: 63051.39 mgc: 0.005451824 ustep: 1
#> iter: 3 value: 63051.39 mgc: 1.144835e-06 ustep: 1
#> iter: 4 mgc: 1.474376e-13
#> iter: 1 mgc: 1.474376e-13
#> outer mgc: 25.68279
#> iter: 1 value: 63257.73 mgc: 0.1872679 ustep: 1
#> iter: 2 value: 63257.73 mgc: 0.001174881 ustep: 1
#> iter: 3 value: 63257.73 mgc: 7.421247e-08 ustep: 1
#> iter: 4 mgc: 3.078093e-14
#> iter: 1 mgc: 3.078093e-14
#> outer mgc: 22.21967
#> iter: 1 value: 62959.41 mgc: 0.2890118 ustep: 1
#> iter: 2 value: 62959.41 mgc: 0.002914412 ustep: 1
#> iter: 3 value: 62959.41 mgc: 1.966388e-07 ustep: 1
#> iter: 4 mgc: 3.101686e-14
#> iter: 1 mgc: 3.101686e-14
#> outer mgc: 33.5059
#> iter: 1 value: 63049.6 mgc: 0.3078084 ustep: 1
#> iter: 2 value: 63049.6 mgc: 0.002243705 ustep: 1
#> iter: 3 value: 63049.6 mgc: 3.000061e-07 ustep: 1
#> iter: 4 mgc: 3.808065e-14
#> iter: 1 mgc: 3.808065e-14
#> outer mgc: 18.04558
#> iter: 1 value: 62672.49 mgc: 0.2748436 ustep: 1

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#> iter: 2 value: 62672.49 mgc: 0.002108401 ustep: 1
#> iter: 3 value: 62672.49 mgc: 1.71262e-07 ustep: 1
#> iter: 4 mgc: 3.358425e-14
#> iter: 1 mgc: 3.358425e-14
#> outer mgc: 12.29407
#> iter: 1 value: 62527.18 mgc: 0.7573275 ustep: 1
#> iter: 2 value: 62527.18 mgc: 0.009169434 ustep: 1
#> iter: 3 value: 62527.18 mgc: 3.851965e-06 ustep: 1
#> iter: 4 mgc: 1.071254e-12
#> iter: 1 mgc: 1.071254e-12
#> outer mgc: 8.903252
#> iter: 1 value: 63145.11 mgc: 0.7682517 ustep: 1
#> iter: 2 value: 63145.1 mgc: 0.03371682 ustep: 1
#> iter: 3 value: 63145.1 mgc: 3.837595e-05 ustep: 1
#> iter: 4 mgc: 1.190725e-10
#> iter: 1 value: 62617.05 mgc: 0.1153644 ustep: 1
#> iter: 2 value: 62617.05 mgc: 0.0006686829 ustep: 1
#> iter: 3 value: 62617.05 mgc: 1.62488e-08 ustep: 1
#> iter: 4 mgc: 3.924638e-14
#> iter: 1 mgc: 3.924638e-14
#> outer mgc: 24.28538
#> iter: 1 value: 62424.57 mgc: 0.08922599 ustep: 1
#> iter: 2 value: 62424.57 mgc: 0.0005737106 ustep: 1
#> iter: 3 value: 62424.57 mgc: 1.277314e-08 ustep: 1
#> iter: 4 mgc: 3.222422e-14
#> iter: 1 mgc: 3.222422e-14
#> outer mgc: 11.19027
#> iter: 1 value: 62478.04 mgc: 0.08346303 ustep: 1
#> iter: 2 value: 62478.04 mgc: 0.0002075472 ustep: 1
#> iter: 3 mgc: 1.737007e-09
#> iter: 1 mgc: 1.737007e-09
#> outer mgc: 12.39308
#> iter: 1 value: 62269.88 mgc: 0.2038479 ustep: 1
#> iter: 2 value: 62269.88 mgc: 0.0003773608 ustep: 1
#> iter: 3 mgc: 3.575735e-09
#> iter: 1 mgc: 3.575735e-09
#> outer mgc: 9.669356
#> iter: 1 value: 62133.55 mgc: 0.5131314 ustep: 1
#> iter: 2 value: 62133.55 mgc: 0.001869709 ustep: 1
#> iter: 3 value: 62133.55 mgc: 1.00621e-07 ustep: 1
#> iter: 4 mgc: 3.649858e-14
#> iter: 1 mgc: 3.649858e-14
#> outer mgc: 6.004033
#> iter: 1 value: 61774.82 mgc: 0.8384336 ustep: 1
#> iter: 2 value: 61774.82 mgc: 0.006374909 ustep: 1
#> iter: 3 value: 61774.82 mgc: 2.224862e-06 ustep: 1
#> iter: 4 mgc: 1.759703e-13
#> iter: 1 mgc: 1.759703e-13
#> outer mgc: 5.858922
#> iter: 1 value: 60926.2 mgc: 0.5278342 ustep: 1
#> iter: 2 value: 60926.2 mgc: 0.00722547 ustep: 1
#> iter: 3 value: 60926.2 mgc: 3.0608e-06 ustep: 1
#> iter: 4 mgc: 6.119549e-13
#> iter: 1 value: 61417.63 mgc: 0.231313 ustep: 1

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```

#> iter: 2 value: 61417.63 mgc: 0.001309362 ustep: 1
#> iter: 3 value: 61417.63 mgc: 1.057194e-07 ustep: 1
#> iter: 4 mgc: 3.810841e-14
#> iter: 1 mgc: 3.810841e-14
#> outer mgc: 9.517435
#> iter: 1 value: 61571.88 mgc: 0.2293049 ustep: 1
#> iter: 2 value: 61571.88 mgc: 0.001210704 ustep: 1
#> iter: 3 value: 61571.88 mgc: 4.572904e-08 ustep: 1
#> iter: 4 mgc: 2.914335e-14
#> iter: 1 value: 61541.63 mgc: 0.04090366 ustep: 1
#> iter: 2 value: 61541.63 mgc: 7.143419e-05 ustep: 1
#> iter: 3 mgc: 3.108827e-10
#> iter: 1 value: 61463.2 mgc: 0.0151498 ustep: 1
#> iter: 2 value: 61463.2 mgc: 9.686031e-06 ustep: 1
#> iter: 3 mgc: 5.833223e-12
#> iter: 1 mgc: 5.833223e-12
#> outer mgc: 6.301363
#> iter: 1 value: 61404.47 mgc: 0.03835937 ustep: 1
#> iter: 2 value: 61404.47 mgc: 8.38133e-05 ustep: 1
#> iter: 3 mgc: 2.444115e-10
#> iter: 1 mgc: 2.444115e-10
#> outer mgc: 6.41264
#> iter: 1 value: 61448.2 mgc: 0.02936455 ustep: 1
#> iter: 2 value: 61448.2 mgc: 4.467932e-05 ustep: 1
#> iter: 3 mgc: 6.542489e-11
#> iter: 1 mgc: 6.542489e-11
#> outer mgc: 4.600719
#> iter: 1 value: 61378.17 mgc: 0.03395791 ustep: 1
#> iter: 2 value: 61378.17 mgc: 3.360424e-05 ustep: 1
#> iter: 3 mgc: 3.293898e-11
#> iter: 1 mgc: 3.293898e-11
#> outer mgc: 4.888875
#> iter: 1 value: 61355.95 mgc: 0.0750043 ustep: 1
#> iter: 2 value: 61355.95 mgc: 7.793566e-05 ustep: 1
#> iter: 3 mgc: 1.828721e-10
#> iter: 1 value: 61280.66 mgc: 0.08265244 ustep: 1
#> iter: 2 value: 61280.66 mgc: 6.179386e-05 ustep: 1
#> iter: 3 mgc: 9.311074e-11
#> iter: 1 value: 61114.14 mgc: 0.1817675 ustep: 1
#> iter: 2 value: 61114.14 mgc: 0.0003013973 ustep: 1
#> iter: 3 mgc: 2.198614e-09
#> iter: 1 mgc: 2.198614e-09
#> outer mgc: 9.562014
#> iter: 1 value: 60833.86 mgc: 0.4634913 ustep: 1
#> iter: 2 value: 60833.86 mgc: 0.001830888 ustep: 1
#> iter: 3 value: 60833.86 mgc: 1.413683e-07 ustep: 1
#> iter: 4 mgc: 4.17999e-14
#> iter: 1 mgc: 4.17999e-14
#> outer mgc: 6.789253
#> iter: 1 value: 60731.6 mgc: 0.4517947 ustep: 1
#> iter: 2 value: 60731.6 mgc: 0.002215242 ustep: 1
#> iter: 3 value: 60731.6 mgc: 1.288978e-07 ustep: 1
#> iter: 4 mgc: 4.048326e-14
#> iter: 1 mgc: 4.048326e-14

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#> outer mgc: 10.52764
#> iter: 1 value: 60442.93 mgc: 0.4178744 ustep: 1
#> iter: 2 value: 60442.93 mgc: 0.001358183 ustep: 1
#> iter: 3 value: 60442.93 mgc: 7.206689e-08 ustep: 1
#> iter: 4 mgc: 6.344925e-14
#> iter: 1 mgc: 6.344925e-14
#> outer mgc: 12.49672
#> iter: 1 value: 60495.84 mgc: 0.3682772 ustep: 1
#> iter: 2 value: 60495.84 mgc: 0.001631446 ustep: 1
#> iter: 3 value: 60495.84 mgc: 2.379676e-07 ustep: 1
#> iter: 4 mgc: 4.811429e-14
#> iter: 1 mgc: 4.811429e-14
#> outer mgc: 16.81047
#> iter: 1 value: 60265.22 mgc: 0.4439115 ustep: 1
#> iter: 2 value: 60265.22 mgc: 0.00186614 ustep: 1
#> iter: 3 value: 60265.22 mgc: 1.596596e-07 ustep: 1
#> iter: 4 mgc: 3.37369e-14
#> iter: 1 mgc: 3.37369e-14
#> outer mgc: 10.63393
#> iter: 1 value: 60242.03 mgc: 0.4333626 ustep: 1
#> iter: 2 value: 60242.03 mgc: 0.001594965 ustep: 1
#> iter: 3 value: 60242.03 mgc: 7.795899e-08 ustep: 1
#> iter: 4 mgc: 5.890427e-14
#> iter: 1 mgc: 5.890427e-14
#> outer mgc: 9.121623
#> iter: 1 value: 60076.23 mgc: 0.4272198 ustep: 1
#> iter: 2 value: 60076.23 mgc: 0.002436274 ustep: 1
#> iter: 3 value: 60076.23 mgc: 7.551847e-08 ustep: 1
#> iter: 4 mgc: 4.773959e-14
#> iter: 1 mgc: 4.773959e-14
#> outer mgc: 12.6872
#> iter: 1 value: 60145.5 mgc: 0.5529683 ustep: 1
#> iter: 2 value: 60145.5 mgc: 0.003507004 ustep: 1
#> iter: 3 value: 60145.5 mgc: 4.197691e-07 ustep: 1
#> iter: 4 mgc: 4.418688e-14
#> iter: 1 mgc: 4.418688e-14
#> outer mgc: 17.88408
#> iter: 1 value: 59929.23 mgc: 0.5337802 ustep: 1
#> iter: 2 value: 59929.23 mgc: 0.002080099 ustep: 1
#> iter: 3 value: 59929.23 mgc: 1.129363e-07 ustep: 1
#> iter: 4 mgc: 3.935741e-14
#> iter: 1 mgc: 3.935741e-14
#> outer mgc: 5.203766
#> iter: 1 value: 59693.51 mgc: 0.4407681 ustep: 1
#> iter: 2 value: 59693.51 mgc: 0.002443128 ustep: 1
#> iter: 3 value: 59693.51 mgc: 1.752109e-07 ustep: 1
#> iter: 4 mgc: 4.87943e-14
#> iter: 1 mgc: 4.87943e-14
#> outer mgc: 3.045819
#> iter: 1 value: 59745.15 mgc: 0.3141612 ustep: 1
#> iter: 2 value: 59745.15 mgc: 0.00440889 ustep: 1
#> iter: 3 value: 59745.15 mgc: 9.765145e-07 ustep: 1
#> iter: 4 mgc: 9.552081e-14
#> iter: 1 value: 59799.38 mgc: 0.1069231 ustep: 1

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```

#> iter: 2 value: 59799.38 mgc: 0.0006718703 ustep: 1
#> iter: 3 value: 59799.38 mgc: 1.670788e-08 ustep: 1
#> iter: 4 mgc: 4.718448e-14
#> iter: 1 value: 59729.33 mgc: 0.03629049 ustep: 1
#> iter: 2 value: 59729.33 mgc: 7.660195e-05 ustep: 1
#> iter: 3 mgc: 2.187952e-10
#> iter: 1 mgc: 2.187952e-10
#> outer mgc: 4.438155
#> iter: 1 value: 59660.22 mgc: 0.03842431 ustep: 1
#> iter: 2 value: 59660.22 mgc: 9.189052e-05 ustep: 1
#> iter: 3 mgc: 2.198678e-10
#> iter: 1 mgc: 2.198678e-10
#> outer mgc: 6.910552
#> iter: 1 value: 59688.02 mgc: 0.02549678 ustep: 1
#> iter: 2 value: 59688.02 mgc: 3.463082e-05 ustep: 1
#> iter: 3 mgc: 4.424894e-11
#> iter: 1 mgc: 4.424894e-11
#> outer mgc: 2.632314
#> iter: 1 value: 59646.91 mgc: 0.02221246 ustep: 1
#> iter: 2 value: 59646.91 mgc: 1.080056e-05 ustep: 1
#> iter: 3 mgc: 3.834266e-12
#> iter: 1 mgc: 3.834266e-12
#> outer mgc: 3.004069
#> iter: 1 value: 59641.96 mgc: 0.05332939 ustep: 1
#> iter: 2 value: 59641.96 mgc: 2.428631e-05 ustep: 1
#> iter: 3 mgc: 3.799139e-11
#> iter: 1 mgc: 3.799139e-11
#> outer mgc: 2.861203
#> iter: 1 value: 59575.92 mgc: 0.1460737 ustep: 1
#> iter: 2 value: 59575.92 mgc: 0.000138698 ustep: 1
#> iter: 3 mgc: 5.57708e-10
#> iter: 1 value: 59523.43 mgc: 0.1915936 ustep: 1
#> iter: 2 value: 59523.43 mgc: 0.0002444155 ustep: 1
#> iter: 3 mgc: 1.30562e-09
#> iter: 1 value: 59395.53 mgc: 0.4654477 ustep: 1
#> iter: 2 value: 59395.53 mgc: 0.001466583 ustep: 1
#> iter: 3 value: 59395.53 mgc: 4.621717e-08 ustep: 1
#> iter: 4 mgc: 4.618528e-14
#> iter: 1 mgc: 4.618528e-14
#> outer mgc: 5.815777
#> iter: 1 value: 59291.12 mgc: 0.8662911 ustep: 1
#> iter: 2 value: 59291.12 mgc: 0.005711363 ustep: 1
#> iter: 3 value: 59291.12 mgc: 5.892442e-07 ustep: 1
#> iter: 4 mgc: 4.669876e-14
#> iter: 1 mgc: 4.669876e-14
#> outer mgc: 2.874632
#> iter: 1 value: 59506.65 mgc: 0.8582585 ustep: 1
#> iter: 2 value: 59506.65 mgc: 0.005974399 ustep: 1
#> iter: 3 value: 59506.65 mgc: 9.962654e-07 ustep: 1
#> iter: 4 mgc: 6.193657e-14
#> iter: 1 value: 59515.02 mgc: 0.1743788 ustep: 1
#> iter: 2 value: 59515.02 mgc: 0.00189645 ustep: 1
#> iter: 3 value: 59515.02 mgc: 1.447517e-07 ustep: 1
#> iter: 4 mgc: 5.105301e-14

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```

#> iter: 1 value: 59349.62 mgc: 0.04335565 ustep: 1
#> iter: 2 value: 59349.62 mgc: 0.0001257815 ustep: 1
#> iter: 3 mgc: 4.999494e-10
#> iter: 1 mgc: 4.999494e-10
#> outer mgc: 6.116542
#> iter: 1 value: 59294.21 mgc: 0.03908728 ustep: 1
#> iter: 2 value: 59294.21 mgc: 8.981839e-05 ustep: 1
#> iter: 3 mgc: 2.197252e-10
#> iter: 1 mgc: 2.197252e-10
#> outer mgc: 4.517009
#> iter: 1 value: 59325.83 mgc: 0.04391884 ustep: 1
#> iter: 2 value: 59325.83 mgc: 2.268341e-05 ustep: 1
#> iter: 3 mgc: 2.43261e-11
#> iter: 1 mgc: 2.43261e-11
#> outer mgc: 3.181743
#> iter: 1 value: 59300.51 mgc: 0.04616317 ustep: 1
#> iter: 2 value: 59300.51 mgc: 1.377458e-05 ustep: 1
#> iter: 3 mgc: 7.127632e-12
#> iter: 1 mgc: 7.127632e-12
#> outer mgc: 1.667531
#> iter: 1 value: 59312.27 mgc: 0.09524992 ustep: 1
#> iter: 2 value: 59312.27 mgc: 5.031555e-05 ustep: 1
#> iter: 3 mgc: 5.059841e-11
#> iter: 1 value: 59304.02 mgc: 0.1151449 ustep: 1
#> iter: 2 value: 59304.02 mgc: 8.087411e-05 ustep: 1
#> iter: 3 mgc: 1.335026e-10
#> iter: 1 value: 59275.63 mgc: 0.3939952 ustep: 1
#> iter: 2 value: 59275.63 mgc: 0.0009613784 ustep: 1
#> iter: 3 value: 59275.63 mgc: 1.862419e-08 ustep: 1
#> iter: 4 mgc: 5.422977e-14
#> iter: 1 value: 59214.21 mgc: 0.842978 ustep: 1
#> iter: 2 value: 59214.21 mgc: 0.004511134 ustep: 1
#> iter: 3 value: 59214.21 mgc: 4.015953e-07 ustep: 1
#> iter: 4 mgc: 6.995793e-14
#> iter: 1 mgc: 6.995793e-14
#> outer mgc: 6.090391
#> iter: 1 value: 58965.96 mgc: 1.388171 ustep: 1
#> iter: 2 value: 58965.96 mgc: 0.01486817 ustep: 1
#> iter: 3 value: 58965.96 mgc: 3.636494e-06 ustep: 1
#> iter: 4 mgc: 3.251288e-13
#> iter: 1 mgc: 3.251288e-13
#> outer mgc: 4.751763
#> iter: 1 value: 58657.43 mgc: 1.270893 ustep: 1
#> iter: 2 value: 58657.43 mgc: 0.01368201 ustep: 1
#> iter: 3 value: 58657.43 mgc: 3.708646e-06 ustep: 1
#> iter: 4 mgc: 3.371747e-13
#> iter: 1 mgc: 3.371747e-13
#> outer mgc: 17.63322
#> iter: 1 value: 58388.04 mgc: 1.374902 ustep: 1
#> iter: 2 value: 58388.04 mgc: 0.01383073 ustep: 1
#> iter: 3 value: 58388.04 mgc: 4.123581e-06 ustep: 1
#> iter: 4 mgc: 3.499423e-13
#> iter: 1 mgc: 3.499423e-13
#> outer mgc: 8.544591

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```

#> iter: 1 value: 58194.48 mgc: 1.31645 ustep: 1
#> iter: 2 value: 58194.48 mgc: 0.01316442 ustep: 1
#> iter: 3 value: 58194.48 mgc: 5.091129e-06 ustep: 1
#> iter: 4 mgc: 8.655299e-13
#> iter: 1 value: 58242.36 mgc: 0.4971559 ustep: 1
#> iter: 2 value: 58242.36 mgc: 0.002111784 ustep: 1
#> iter: 3 value: 58242.36 mgc: 1.195439e-07 ustep: 1
#> iter: 4 mgc: 5.373479e-14
#> iter: 1 mgc: 5.373479e-14
#> outer mgc: 12.33783
#> iter: 1 value: 58384.26 mgc: 0.5592337 ustep: 1
#> iter: 2 value: 58384.26 mgc: 0.002429299 ustep: 1
#> iter: 3 value: 58384.26 mgc: 1.578755e-07 ustep: 1
#> iter: 4 mgc: 5.706546e-14
#> iter: 1 mgc: 5.706546e-14
#> outer mgc: 12.93294
#> iter: 1 value: 58382.59 mgc: 0.271669 ustep: 1
#> iter: 2 value: 58382.59 mgc: 0.0005758624 ustep: 1
#> iter: 3 mgc: 9.816137e-09
#> iter: 1 mgc: 9.816137e-09
#> outer mgc: 3.345257
#> iter: 1 value: 58367.74 mgc: 0.1288753 ustep: 1
#> iter: 2 value: 58367.74 mgc: 0.000289299 ustep: 1
#> iter: 3 mgc: 3.304895e-09
#> iter: 1 mgc: 3.304895e-09
#> outer mgc: 2.018676
#> iter: 1 value: 58248.26 mgc: 0.1997443 ustep: 1
#> iter: 2 value: 58248.26 mgc: 0.0004238335 ustep: 1
#> iter: 3 mgc: 3.268238e-09
#> iter: 1 mgc: 3.268238e-09
#> outer mgc: 10.95548
#> iter: 1 value: 58305.01 mgc: 0.1225262 ustep: 1
#> iter: 2 value: 58305.01 mgc: 0.0001503277 ustep: 1
#> iter: 3 mgc: 9.413856e-10
#> iter: 1 mgc: 9.413856e-10
#> outer mgc: 4.050245
#> iter: 1 value: 58278.82 mgc: 0.1273234 ustep: 1
#> iter: 2 value: 58278.82 mgc: 0.0001286911 ustep: 1
#> iter: 3 mgc: 3.513739e-10
#> iter: 1 mgc: 3.513739e-10
#> outer mgc: 1.3072
#> iter: 1 value: 58294.1 mgc: 0.1349507 ustep: 1
#> iter: 2 value: 58294.1 mgc: 0.0001163505 ustep: 1
#> iter: 3 mgc: 3.348445e-10
#> iter: 1 mgc: 3.348445e-10
#> outer mgc: 1.01957
#> iter: 1 value: 58277.71 mgc: 0.1360106 ustep: 1
#> iter: 2 value: 58277.71 mgc: 0.0001219857 ustep: 1
#> iter: 3 mgc: 2.822695e-10
#> iter: 1 mgc: 2.822695e-10
#> outer mgc: 1.992416
#> iter: 1 value: 58293.33 mgc: 0.1370983 ustep: 1
#> iter: 2 value: 58293.33 mgc: 0.0001056502 ustep: 1
#> iter: 3 mgc: 2.277019e-10

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```

#> iter: 1 mgc: 2.277019e-10
#> outer mgc: 2.618361
#> iter: 1 value: 58268.57 mgc: 0.1365636 ustep: 1
#> iter: 2 value: 58268.57 mgc: 0.0001269065 ustep: 1
#> iter: 3 mgc: 3.699828e-10
#> iter: 1 mgc: 3.699828e-10
#> outer mgc: 0.7593925
#> iter: 1 value: 58264.92 mgc: 0.1290062 ustep: 1
#> iter: 2 value: 58264.92 mgc: 0.0001230922 ustep: 1
#> iter: 3 mgc: 2.678369e-10
#> iter: 1 mgc: 2.678369e-10
#> outer mgc: 0.7280219
#> iter: 1 value: 58252.24 mgc: 0.2758454 ustep: 1
#> iter: 2 value: 58252.24 mgc: 0.0004916386 ustep: 1
#> iter: 3 mgc: 4.77035e-09
#> iter: 1 value: 58252.46 mgc: 0.6031054 ustep: 1
#> iter: 2 value: 58252.46 mgc: 0.002393225 ustep: 1
#> iter: 3 value: 58252.46 mgc: 1.050438e-07 ustep: 1
#> iter: 4 mgc: 7.946421e-14
#> iter: 1 mgc: 7.946421e-14
#> outer mgc: 6.966128
#> iter: 1 value: 58175.98 mgc: 0.8660266 ustep: 1
#> iter: 2 value: 58175.98 mgc: 0.005272756 ustep: 1
#> iter: 3 value: 58175.98 mgc: 5.087292e-07 ustep: 1
#> iter: 4 mgc: 6.12288e-14
#> iter: 1 mgc: 6.12288e-14
#> outer mgc: 2.968675
#> iter: 1 value: 58132.54 mgc: 0.8728451 ustep: 1
#> iter: 2 value: 58132.54 mgc: 0.00520764 ustep: 1
#> iter: 3 value: 58132.54 mgc: 4.913967e-07 ustep: 1
#> iter: 4 mgc: 4.902993e-14
#> iter: 1 value: 58168.47 mgc: 0.4026649 ustep: 1
#> iter: 2 value: 58168.47 mgc: 0.001069947 ustep: 1
#> iter: 3 value: 58168.47 mgc: 2.004477e-08 ustep: 1
#> iter: 4 mgc: 5.086209e-14
#> iter: 1 mgc: 5.086209e-14
#> outer mgc: 1.544655
#> iter: 1 value: 58131.79 mgc: 0.4030908 ustep: 1
#> iter: 2 value: 58131.79 mgc: 0.00107883 ustep: 1
#> iter: 3 value: 58131.79 mgc: 2.309581e-08 ustep: 1
#> iter: 4 mgc: 6.533662e-14
#> iter: 1 mgc: 6.533662e-14
#> outer mgc: 3.205895
#> iter: 1 value: 58177.33 mgc: 0.3985389 ustep: 1
#> iter: 2 value: 58177.33 mgc: 0.001016869 ustep: 1
#> iter: 3 value: 58177.33 mgc: 1.850154e-08 ustep: 1
#> iter: 4 mgc: 6.786238e-14
#> iter: 1 value: 58178.62 mgc: 0.1742576 ustep: 1
#> iter: 2 value: 58178.62 mgc: 0.0001638068 ustep: 1
#> iter: 3 mgc: 7.680423e-10
#> iter: 1 value: 58179.22 mgc: 0.06936505 ustep: 1
#> iter: 2 value: 58179.22 mgc: 5.783526e-05 ustep: 1
#> iter: 3 mgc: 1.626801e-10
#> iter: 1 value: 58179.53 mgc: 0.02945694 ustep: 1

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```

#> iter: 2 value: 58179.53 mgc: 4.826222e-05 ustep: 1
#> iter: 3 mgc: 7.422141e-11
#> iter: 1 value: 58151.77 mgc: 0.01224869 ustep: 1
#> iter: 2 value: 58151.77 mgc: 8.518668e-06 ustep: 1
#> iter: 3 mgc: 2.104927e-12
#> iter: 1 mgc: 2.104927e-12
#> outer mgc: 1.232654
#> iter: 1 value: 58141.1 mgc: 0.00661755 ustep: 1
#> iter: 2 value: 58141.1 mgc: 1.783369e-06 ustep: 1
#> iter: 3 mgc: 1.091349e-13
#> iter: 1 mgc: 1.091349e-13
#> outer mgc: 1.05919
#> iter: 1 value: 58150.09 mgc: 0.01660533 ustep: 1
#> iter: 2 value: 58150.09 mgc: 2.990895e-06 ustep: 1
#> iter: 3 mgc: 2.933209e-13
#> iter: 1 mgc: 2.933209e-13
#> outer mgc: 1.149775
#> iter: 1 value: 58139.23 mgc: 0.03609933 ustep: 1
#> iter: 2 value: 58139.23 mgc: 9.113916e-06 ustep: 1
#> iter: 3 mgc: 1.947054e-12
#> iter: 1 mgc: 1.947054e-12
#> outer mgc: 1.028913
#> iter: 1 value: 58146.5 mgc: 0.0730553 ustep: 1
#> iter: 2 value: 58146.5 mgc: 3.498516e-05 ustep: 1
#> iter: 3 mgc: 2.112193e-11
#> iter: 1 mgc: 2.112193e-11
#> outer mgc: 1.048841
#> iter: 1 value: 58131.82 mgc: 0.1450594 ustep: 1
#> iter: 2 value: 58131.82 mgc: 0.0001455181 ustep: 1
#> iter: 3 mgc: 4.048384e-10
#> iter: 1 value: 58123.13 mgc: 0.2249571 ustep: 1
#> iter: 2 value: 58123.13 mgc: 0.0003525444 ustep: 1
#> iter: 3 mgc: 2.184907e-09
#> iter: 1 value: 58103.73 mgc: 0.501078 ustep: 1
#> iter: 2 value: 58103.73 mgc: 0.00177609 ustep: 1
#> iter: 3 value: 58103.73 mgc: 5.503391e-08 ustep: 1
#> iter: 4 mgc: 6.75085e-14
#> iter: 1 mgc: 6.75085e-14
#> outer mgc: 1.340748
#> iter: 1 value: 58079.44 mgc: 0.8922043 ustep: 1
#> iter: 2 value: 58079.44 mgc: 0.005596267 ustep: 1
#> iter: 3 value: 58079.44 mgc: 5.379714e-07 ustep: 1
#> iter: 4 mgc: 5.379031e-14
#> iter: 1 mgc: 5.379031e-14
#> outer mgc: 1.028294
#> iter: 1 value: 58104.68 mgc: 0.8656265 ustep: 1
#> iter: 2 value: 58104.68 mgc: 0.005585842 ustep: 1
#> iter: 3 value: 58104.68 mgc: 5.276023e-07 ustep: 1
#> iter: 4 mgc: 7.464168e-14
#> iter: 1 value: 58121.8 mgc: 0.3125427 ustep: 1
#> iter: 2 value: 58121.8 mgc: 0.0006555635 ustep: 1
#> iter: 3 mgc: 6.769409e-09
#> iter: 1 value: 58128.63 mgc: 0.0905824 ustep: 1
#> iter: 2 value: 58128.63 mgc: 9.893339e-05 ustep: 1

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```

#> iter: 3 mgc: 3.366218e-10
#> iter: 1 value: 58112.11 mgc: 0.02114535 ustep: 1
#> iter: 2 value: 58112.11 mgc: 2.371155e-05 ustep: 1
#> iter: 3 mgc: 2.49134e-11
#> iter: 1 value: 58088.17 mgc: 0.005660141 ustep: 1
#> iter: 2 value: 58088.17 mgc: 1.691519e-06 ustep: 1
#> iter: 3 mgc: 1.324496e-13
#> iter: 1 mgc: 1.324496e-13
#> outer mgc: 1.006512
#> iter: 1 value: 58078.74 mgc: 0.004794552 ustep: 1
#> iter: 2 value: 58078.74 mgc: 1.406416e-06 ustep: 1
#> iter: 3 mgc: 5.12021e-14
#> iter: 1 mgc: 5.12021e-14
#> outer mgc: 0.9913042
#> iter: 1 value: 58086.59 mgc: 0.00992204 ustep: 1
#> iter: 2 value: 58086.59 mgc: 1.746518e-06 ustep: 1
#> iter: 3 mgc: 1.135758e-13
#> iter: 1 mgc: 1.135758e-13
#> outer mgc: 0.9142161
#> iter: 1 value: 58077.38 mgc: 0.02172897 ustep: 1
#> iter: 2 value: 58077.38 mgc: 3.846152e-06 ustep: 1
#> iter: 3 mgc: 2.478573e-13
#> iter: 1 mgc: 2.478573e-13
#> outer mgc: 0.9160107
#> iter: 1 value: 58083.98 mgc: 0.04473687 ustep: 1
#> iter: 2 value: 58083.98 mgc: 1.307108e-05 ustep: 1
#> iter: 3 mgc: 2.716216e-12
#> iter: 1 mgc: 2.716216e-12
#> outer mgc: 0.9148533
#> iter: 1 value: 58073.25 mgc: 0.09113299 ustep: 1
#> iter: 2 value: 58073.25 mgc: 5.65141e-05 ustep: 1
#> iter: 3 mgc: 6.045808e-11
#> iter: 1 value: 58070.18 mgc: 0.1107548 ustep: 1
#> iter: 2 value: 58070.18 mgc: 8.477883e-05 ustep: 1
#> iter: 3 mgc: 1.193074e-10
#> iter: 1 value: 58061.27 mgc: 0.3200663 ustep: 1
#> iter: 2 value: 58061.27 mgc: 0.0007164125 ustep: 1
#> iter: 3 mgc: 8.436321e-09
#> iter: 1 mgc: 8.436321e-09
#> outer mgc: 1.583353
#> iter: 1 value: 58058.83 mgc: 0.5276252 ustep: 1
#> iter: 2 value: 58058.83 mgc: 0.001763929 ustep: 1
#> iter: 3 value: 58058.83 mgc: 5.855482e-08 ustep: 1
#> iter: 4 mgc: 7.688294e-14
#> iter: 1 mgc: 7.688294e-14
#> outer mgc: 0.3966415
#> iter: 1 value: 58040.59 mgc: 0.5365161 ustep: 1
#> iter: 2 value: 58040.59 mgc: 0.002018841 ustep: 1
#> iter: 3 value: 58040.59 mgc: 8.05599e-08 ustep: 1
#> iter: 4 mgc: 6.078471e-14
#> iter: 1 mgc: 6.078471e-14
#> outer mgc: 4.875219
#> iter: 1 value: 58056.54 mgc: 0.5234694 ustep: 1
#> iter: 2 value: 58056.54 mgc: 0.001865096 ustep: 1

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#> iter: 3 value: 58056.54 mgc: 5.845543e-08 ustep: 1
#> iter: 4 mgc: 6.328271e-14
#> iter: 1 mgc: 6.328271e-14
#> outer mgc: 2.13062
#> iter: 1 value: 58044.85 mgc: 0.4181116 ustep: 1
#> iter: 2 value: 58044.85 mgc: 0.001253768 ustep: 1
#> iter: 3 value: 58044.85 mgc: 3.216679e-08 ustep: 1
#> iter: 4 mgc: 5.973e-14
#> iter: 1 value: 58052.75 mgc: 0.0809899 ustep: 1
#> iter: 2 value: 58052.75 mgc: 4.531891e-05 ustep: 1
#> iter: 3 mgc: 4.453216e-11
#> iter: 1 mgc: 4.453216e-11
#> outer mgc: 0.7426101
#> iter: 1 value: 58037.58 mgc: 0.08150044 ustep: 1
#> iter: 2 value: 58037.58 mgc: 6.009833e-05 ustep: 1
#> iter: 3 mgc: 7.268647e-11
#> iter: 1 mgc: 7.268647e-11
#> outer mgc: 1.99052
#> iter: 1 value: 58054.15 mgc: 0.1029045 ustep: 1
#> iter: 2 value: 58054.15 mgc: 6.422397e-05 ustep: 1
#> iter: 3 mgc: 9.040935e-11
#> iter: 1 mgc: 9.040935e-11
#> outer mgc: 0.9370948
#> iter: 1 value: 58054.35 mgc: 0.0953578 ustep: 1
#> iter: 2 value: 58054.35 mgc: 6.165258e-05 ustep: 1
#> iter: 3 mgc: 8.064577e-11
#> iter: 1 mgc: 8.064577e-11
#> outer mgc: 0.6927053
#> iter: 1 value: 58062.05 mgc: 0.1014458 ustep: 1
#> iter: 2 value: 58062.05 mgc: 6.515326e-05 ustep: 1
#> iter: 3 mgc: 7.651513e-11
#> iter: 1 mgc: 7.651513e-11
#> outer mgc: 1.113806
#> iter: 1 value: 58052.62 mgc: 0.1060218 ustep: 1
#> iter: 2 value: 58052.62 mgc: 6.909989e-05 ustep: 1
#> iter: 3 mgc: 1.006679e-10
#> iter: 1 mgc: 1.006679e-10
#> outer mgc: 0.8887738
#> iter: 1 value: 58054.97 mgc: 0.09807626 ustep: 1
#> iter: 2 value: 58054.97 mgc: 6.994325e-05 ustep: 1
#> iter: 3 mgc: 7.796197e-11
#> iter: 1 mgc: 7.796197e-11
#> outer mgc: 0.621684
#> iter: 1 value: 58053.18 mgc: 0.09796486 ustep: 1
#> iter: 2 value: 58053.18 mgc: 6.696218e-05 ustep: 1
#> iter: 3 mgc: 7.448014e-11
#> iter: 1 mgc: 7.448014e-11
#> outer mgc: 0.6452239
#> iter: 1 value: 58055.64 mgc: 0.1008091 ustep: 1
#> iter: 2 value: 58055.64 mgc: 6.872457e-05 ustep: 1
#> iter: 3 mgc: 9.034296e-11
#> iter: 1 mgc: 9.034296e-11
#> outer mgc: 0.6625122
#> iter: 1 value: 58047.32 mgc: 0.1013925 ustep: 1

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#> iter: 2 value: 58047.32 mgc: 6.872073e-05 ustep: 1
#> iter: 3 mgc: 9.775902e-11
#> iter: 1 mgc: 9.775902e-11
#> outer mgc: 1.444153
#> iter: 1 value: 58057.55 mgc: 0.1027711 ustep: 1
#> iter: 2 value: 58057.55 mgc: 6.804739e-05 ustep: 1
#> iter: 3 mgc: 7.470802e-11
#> iter: 1 mgc: 7.470802e-11
#> outer mgc: 1.003973
#> iter: 1 value: 58057.97 mgc: 0.1005519 ustep: 1
#> iter: 2 value: 58057.97 mgc: 6.98556e-05 ustep: 1
#> iter: 3 mgc: 8.785038e-11
#> iter: 1 mgc: 8.785038e-11
#> outer mgc: 0.2477721
#> iter: 1 value: 58053.16 mgc: 0.09768533 ustep: 1
#> iter: 2 value: 58053.16 mgc: 6.268272e-05 ustep: 1
#> iter: 3 mgc: 7.59954e-11
#> iter: 1 mgc: 7.59954e-11
#> outer mgc: 0.5021631
#> iter: 1 value: 58054.91 mgc: 0.1018165 ustep: 1
#> iter: 2 value: 58054.91 mgc: 6.907677e-05 ustep: 1
#> iter: 3 mgc: 8.125545e-11
#> iter: 1 mgc: 8.125545e-11
#> outer mgc: 0.8959923
#> iter: 1 value: 58052.24 mgc: 0.1018158 ustep: 1
#> iter: 2 value: 58052.24 mgc: 6.87429e-05 ustep: 1
#> iter: 3 mgc: 9.345785e-11
#> iter: 1 mgc: 9.345785e-11
#> outer mgc: 0.7848356
#> iter: 1 value: 58060.25 mgc: 0.09986806 ustep: 1
#> iter: 2 value: 58060.25 mgc: 6.693727e-05 ustep: 1
#> iter: 3 mgc: 7.357095e-11
#> iter: 1 mgc: 7.357095e-11
#> outer mgc: 0.5531883
#> iter: 1 value: 58055.55 mgc: 0.09492535 ustep: 1
#> iter: 2 value: 58055.55 mgc: 6.958344e-05 ustep: 1
#> iter: 3 mgc: 9.03867e-11
#> iter: 1 mgc: 9.03867e-11
#> outer mgc: 0.08714672
#> iter: 1 value: 58063.88 mgc: 0.0944047 ustep: 1
#> iter: 2 value: 58063.88 mgc: 5.809952e-05 ustep: 1
#> iter: 3 mgc: 7.091261e-11
#> iter: 1 value: 58066.73 mgc: 0.02532056 ustep: 1
#> iter: 2 value: 58066.73 mgc: 1.113674e-05 ustep: 1
#> iter: 3 mgc: 6.472746e-12
#> iter: 1 value: 58060.77 mgc: 0.003794471 ustep: 1
#> iter: 2 value: 58060.77 mgc: 1.627883e-06 ustep: 1
#> iter: 3 mgc: 1.294104e-13
#> iter: 1 mgc: 1.294104e-13
#> outer mgc: 0.993427
#> iter: 1 value: 58053.88 mgc: 0.01262697 ustep: 1
#> iter: 2 value: 58053.88 mgc: 1.045361e-06 ustep: 1
#> iter: 3 mgc: 6.128431e-14
#> iter: 1 mgc: 6.128431e-14

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#> outer mgc: 0.5715618
#> iter: 1 value: 58056.48 mgc: 0.01318438 ustep: 1
#> iter: 2 value: 58056.48 mgc: 1.037139e-06 ustep: 1
#> iter: 3 mgc: 5.638321e-14
#> iter: 1 mgc: 5.638321e-14
#> outer mgc: 0.1326929
#> iter: 1 value: 58056.22 mgc: 0.02668067 ustep: 1
#> iter: 2 value: 58056.22 mgc: 4.613616e-06 ustep: 1
#> iter: 3 mgc: 3.909698e-13
#> iter: 1 mgc: 3.909698e-13
#> outer mgc: 0.2113869
#> iter: 1 value: 58056.66 mgc: 0.05372598 ustep: 1
#> iter: 2 value: 58056.66 mgc: 1.844125e-05 ustep: 1
#> iter: 3 mgc: 6.137153e-12
#> iter: 1 value: 58055.65 mgc: 0.06522836 ustep: 1
#> iter: 2 value: 58055.65 mgc: 2.72144e-05 ustep: 1
#> iter: 3 mgc: 1.361296e-11
#> iter: 1 mgc: 1.361296e-11
#> outer mgc: 0.2789867
#> iter: 1 value: 58059.55 mgc: 0.1192394 ustep: 1
#> iter: 2 value: 58059.55 mgc: 9.029962e-05 ustep: 1
#> iter: 3 mgc: 1.465746e-10
#> iter: 1 mgc: 1.465746e-10
#> outer mgc: 0.5093624
#> iter: 1 value: 58057.46 mgc: 0.1120867 ustep: 1
#> iter: 2 value: 58057.46 mgc: 8.683708e-05 ustep: 1
#> iter: 3 mgc: 1.439666e-10
#> iter: 1 value: 58056.73 mgc: 0.0488908 ustep: 1
#> iter: 2 value: 58056.73 mgc: 1.640663e-05 ustep: 1
#> iter: 3 mgc: 5.338559e-12
#> iter: 1 mgc: 5.338559e-12
#> outer mgc: 0.05457823
#> iter: 1 value: 58047.89 mgc: 0.045693 ustep: 1
#> iter: 2 value: 58047.89 mgc: 1.590196e-05 ustep: 1
#> iter: 3 mgc: 4.827361e-12
#> iter: 1 value: 58050.29 mgc: 0.01230913 ustep: 1
#> iter: 2 value: 58050.29 mgc: 1.602326e-06 ustep: 1
#> iter: 3 mgc: 9.225953e-14
#> iter: 1 value: 58053.05 mgc: 0.002744167 ustep: 1
#> iter: 2 value: 58053.05 mgc: 6.792219e-07 ustep: 1
#> iter: 3 mgc: 6.988854e-14
#> iter: 1 mgc: 6.988854e-14
#> outer mgc: 0.569058
#> iter: 1 value: 58056.63 mgc: 0.006156025 ustep: 1
#> iter: 2 value: 58056.63 mgc: 4.662839e-07 ustep: 1
#> iter: 3 mgc: 7.76601e-14
#> iter: 1 mgc: 7.76601e-14
#> outer mgc: 0.225179
#> iter: 1 value: 58055.35 mgc: 0.006556872 ustep: 1
#> iter: 2 value: 58055.35 mgc: 3.033075e-07 ustep: 1
#> iter: 3 mgc: 6.750156e-14
#> iter: 1 mgc: 6.750156e-14
#> outer mgc: 0.1668316
#> iter: 1 value: 58056.33 mgc: 0.006613477 ustep: 1

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#> iter: 2 value: 58056.33 mgc: 2.899118e-07 ustep: 1
#> iter: 3 mgc: 8.484533e-14
#> iter: 1 mgc: 8.484533e-14
#> outer mgc: 0.03883746
#> iter: 1 value: 58055.79 mgc: 0.01321451 ustep: 1
#> iter: 2 value: 58055.79 mgc: 1.158955e-06 ustep: 1
#> iter: 3 mgc: 6.57252e-14
#> iter: 1 value: 58055.52 mgc: 0.03985593 ustep: 1
#> iter: 2 value: 58055.52 mgc: 1.04693e-05 ustep: 1
#> iter: 3 mgc: 2.004247e-12
#> iter: 1 value: 58054.29 mgc: 0.1413885 ustep: 1
#> iter: 2 value: 58054.29 mgc: 0.0001325993 ustep: 1
#> iter: 3 mgc: 3.207129e-10
#> iter: 1 mgc: 3.207129e-10
#> outer mgc: 0.1201923
#> iter: 1 value: 58051.14 mgc: 0.1947968 ustep: 1
#> iter: 2 value: 58051.14 mgc: 0.0002632415 ustep: 1
#> iter: 3 mgc: 1.140979e-09
#> iter: 1 mgc: 1.140979e-09
#> outer mgc: 0.2913805
#> iter: 1 value: 58049 mgc: 0.1904762 ustep: 1
#> iter: 2 value: 58049 mgc: 0.0002362146 ustep: 1
#> iter: 3 mgc: 1.099092e-09
#> iter: 1 value: 58052.57 mgc: 0.03432679 ustep: 1
#> iter: 2 value: 58052.57 mgc: 7.494014e-06 ustep: 1
#> iter: 3 mgc: 1.100655e-12
#> iter: 1 mgc: 1.100655e-12
#> outer mgc: 0.1524326
#> iter: 1 value: 58051.38 mgc: 0.03224346 ustep: 1
#> iter: 2 value: 58051.38 mgc: 7.00712e-06 ustep: 1
#> iter: 3 mgc: 1.028905e-12
#> iter: 1 mgc: 1.028905e-12
#> outer mgc: 0.08266734
#> iter: 1 value: 58056.14 mgc: 0.03178345 ustep: 1
#> iter: 2 value: 58056.14 mgc: 6.205104e-06 ustep: 1
#> iter: 3 mgc: 1.545875e-12
#> iter: 1 value: 58051.61 mgc: 0.005950687 ustep: 1
#> iter: 2 value: 58051.61 mgc: 2.195672e-07 ustep: 1
#> iter: 3 mgc: 6.827872e-14
#> iter: 1 mgc: 6.827872e-14
#> outer mgc: 0.1701015
#> iter: 1 value: 58053.12 mgc: 0.005986867 ustep: 1
#> iter: 2 value: 58053.12 mgc: 2.695592e-07 ustep: 1
#> iter: 3 mgc: 6.727952e-14
#> iter: 1 mgc: 6.727952e-14
#> outer mgc: 0.06632411
#> iter: 1 value: 58051.86 mgc: 0.004295424 ustep: 1
#> iter: 2 value: 58051.86 mgc: 2.491653e-07 ustep: 1
#> iter: 3 mgc: 6.480927e-14
#> iter: 1 mgc: 6.480927e-14
#> outer mgc: 0.06343723
#> iter: 1 value: 58051.69 mgc: 0.006169541 ustep: 1
#> iter: 2 value: 58051.69 mgc: 2.536983e-07 ustep: 1
#> iter: 3 mgc: 4.818368e-14

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#> iter: 1 mgc: 4.818368e-14
#> outer mgc: 0.01789575
#> iter: 1 value: 58051.94 mgc: 0.002599443 ustep: 1
#> iter: 2 value: 58051.94 mgc: 9.487221e-08 ustep: 1
#> iter: 3 mgc: 7.45539e-14
#> iter: 1 value: 58051.73 mgc: 0.001010507 ustep: 1
#> iter: 2 value: 58051.73 mgc: 1.494323e-08 ustep: 1
#> iter: 3 mgc: 5.301315e-14
#> iter: 1 mgc: 5.301315e-14
#> outer mgc: 0.03248117
#> iter: 1 value: 58051.54 mgc: 0.001935804 ustep: 1
#> iter: 2 value: 58051.54 mgc: 3.058355e-08 ustep: 1
#> iter: 3 mgc: 6.909751e-14
#> iter: 1 mgc: 6.909751e-14
#> outer mgc: 0.03103377
#> iter: 1 mgc: 6.909751e-14
#> attempting to improve convergence with optimHess
#> iter: 1 mgc: 6.909751e-14
#> outer mgc: 0.03103377
#> iter: 1 value: 58045.75 mgc: 0.005203403 ustep: 1
#> iter: 2 value: 58045.75 mgc: 5.095565e-07 ustep: 1
#> iter: 3 mgc: 8.448797e-14
#> outer mgc: 0.2456408
#> iter: 1 value: 58057.32 mgc: 0.005193871 ustep: 1
#> iter: 2 value: 58057.32 mgc: 5.094764e-07 ustep: 1
#> iter: 3 mgc: 6.198861e-14
#> outer mgc: 0.1831099
#> iter: 1 value: 58048.5 mgc: 0.004270602 ustep: 1
#> iter: 2 value: 58048.5 mgc: 3.145267e-07 ustep: 1
#> iter: 3 mgc: 5.084821e-14
#> outer mgc: 0.1375343
#> iter: 1 value: 58054.58 mgc: 0.004271179 ustep: 1
#> iter: 2 value: 58054.58 mgc: 3.137287e-07 ustep: 1
#> iter: 3 mgc: 6.056267e-14
#> outer mgc: 0.1351324
#> iter: 1 value: 58051.54 mgc: 0.005007919 ustep: 1
#> iter: 2 value: 58051.54 mgc: 1.365241e-06 ustep: 1
#> iter: 3 mgc: 2.442491e-13
#> outer mgc: 0.1043135
#> iter: 1 value: 58051.54 mgc: 0.00500794 ustep: 1
#> iter: 2 value: 58051.54 mgc: 1.367349e-06 ustep: 1
#> iter: 3 mgc: 2.453593e-13
#> outer mgc: 0.1084389
#> iter: 1 value: 58051.54 mgc: 0.004127543 ustep: 1
#> iter: 2 value: 58051.54 mgc: 1.35237e-06 ustep: 1
#> iter: 3 mgc: 1.927347e-13
#> outer mgc: 0.1058314
#> iter: 1 value: 58051.54 mgc: 0.004125631 ustep: 1
#> iter: 2 value: 58051.54 mgc: 1.350771e-06 ustep: 1
#> iter: 3 mgc: 1.973977e-13
#> outer mgc: 0.1077032
#> iter: 1 value: 58051.54 mgc: 0.004738042 ustep: 1
#> iter: 2 value: 58051.54 mgc: 1.456262e-06 ustep: 1
#> iter: 3 mgc: 2.147726e-13

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#> outer mgc: 0.1086925
#> iter: 1 value: 58051.54 mgc: 0.004735757 ustep: 1
#> iter: 2 value: 58051.54 mgc: 1.453997e-06 ustep: 1
#> iter: 3 mgc: 2.151612e-13
#> outer mgc: 0.1053101
#> iter: 1 value: 58051.54 mgc: 0.003878591 ustep: 1
#> iter: 2 value: 58051.54 mgc: 8.379913e-07 ustep: 1
#> iter: 3 mgc: 7.904788e-14
#> outer mgc: 0.1015395
#> iter: 1 value: 58051.54 mgc: 0.003877712 ustep: 1
#> iter: 2 value: 58051.54 mgc: 8.381136e-07 ustep: 1
#> iter: 3 mgc: 7.704948e-14
#> outer mgc: 0.1034409
#> iter: 1 value: 58051.54 mgc: 0.004227995 ustep: 1
#> iter: 2 value: 58051.54 mgc: 1.044861e-06 ustep: 1
#> iter: 3 mgc: 1.467715e-13
#> outer mgc: 0.0699231
#> iter: 1 value: 58051.54 mgc: 0.004226336 ustep: 1
#> iter: 2 value: 58051.54 mgc: 1.044993e-06 ustep: 1
#> iter: 3 mgc: 1.476042e-13
#> outer mgc: 0.06872847
#> iter: 1 value: 58051.54 mgc: 0.006499416 ustep: 1
#> iter: 2 value: 58051.54 mgc: 2.340758e-06 ustep: 1
#> iter: 3 mgc: 2.738226e-13
#> outer mgc: 0.1010757
#> iter: 1 value: 58051.54 mgc: 0.006493686 ustep: 1
#> iter: 2 value: 58051.54 mgc: 2.342561e-06 ustep: 1
#> iter: 3 mgc: 2.744471e-13
#> outer mgc: 0.1020691
#> iter: 1 value: 58051.54 mgc: 0.00444129 ustep: 1
#> iter: 2 value: 58051.54 mgc: 1.220609e-06 ustep: 1
#> iter: 3 mgc: 1.561529e-13
#> outer mgc: 0.1038871
#> iter: 1 value: 58051.54 mgc: 0.004438183 ustep: 1
#> iter: 2 value: 58051.54 mgc: 1.223392e-06 ustep: 1
#> iter: 3 mgc: 1.590672e-13
#> outer mgc: 0.09862653
#> iter: 1 value: 58051.54 mgc: 0.005002179 ustep: 1
#> iter: 2 value: 58051.54 mgc: 1.583831e-06 ustep: 1
#> iter: 3 mgc: 1.978417e-13
#> outer mgc: 0.09937734
#> iter: 1 value: 58051.54 mgc: 0.004998151 ustep: 1
#> iter: 2 value: 58051.54 mgc: 1.585104e-06 ustep: 1
#> iter: 3 mgc: 1.965095e-13
#> outer mgc: 0.1006486
#> iter: 1 value: 58051.54 mgc: 0.005687247 ustep: 1
#> iter: 2 value: 58051.54 mgc: 2.134299e-06 ustep: 1
#> iter: 3 mgc: 3.323938e-13
#> outer mgc: 0.1058462
#> iter: 1 value: 58051.54 mgc: 0.005682735 ustep: 1
#> iter: 2 value: 58051.54 mgc: 2.129589e-06 ustep: 1
#> iter: 3 mgc: 3.307771e-13
#> outer mgc: 0.1026891
#> iter: 1 value: 58051.54 mgc: 0.005115999 ustep: 1

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#> iter: 2 value: 58051.54 mgc: 1.782349e-06 ustep: 1
#> iter: 3 mgc: 2.464695e-13
#> outer mgc: 0.1002785
#> iter: 1 value: 58051.54 mgc: 0.00511171 ustep: 1
#> iter: 2 value: 58051.54 mgc: 1.7799e-06 ustep: 1
#> iter: 3 mgc: 2.480238e-13
#> outer mgc: 0.09897291
#> iter: 1 value: 58051.54 mgc: 0.004366543 ustep: 1
#> iter: 2 value: 58051.54 mgc: 1.280101e-06 ustep: 1
#> iter: 3 mgc: 1.421085e-13
#> outer mgc: 0.09088002
#> iter: 1 value: 58051.54 mgc: 0.00436688 ustep: 1
#> iter: 2 value: 58051.54 mgc: 1.278617e-06 ustep: 1
#> iter: 3 mgc: 1.416645e-13
#> outer mgc: 0.09289095
#> iter: 1 value: 58051.54 mgc: 0.005137196 ustep: 1
#> iter: 2 value: 58051.54 mgc: 1.3407e-06 ustep: 1
#> iter: 3 mgc: 1.398881e-13
#> outer mgc: 0.1043807
#> iter: 1 value: 58051.54 mgc: 0.005135449 ustep: 1
#> iter: 2 value: 58051.54 mgc: 1.339357e-06 ustep: 1
#> iter: 3 mgc: 1.447731e-13
#> outer mgc: 0.1053139
#> iter: 1 value: 58051.54 mgc: 0.00245542 ustep: 1
#> iter: 2 value: 58051.54 mgc: 7.294656e-07 ustep: 1
#> iter: 3 mgc: 6.352904e-14
#> outer mgc: 0.08466199
#> iter: 1 value: 58051.54 mgc: 0.002452943 ustep: 1
#> iter: 2 value: 58051.54 mgc: 7.300101e-07 ustep: 1
#> iter: 3 mgc: 5.90205e-14
#> outer mgc: 0.08394752
#> iter: 1 value: 58051.54 mgc: 0.004232353 ustep: 1
#> iter: 2 value: 58051.54 mgc: 9.421933e-07 ustep: 1
#> iter: 3 mgc: 7.110978e-14
#> outer mgc: 0.09177518
#> iter: 1 value: 58051.54 mgc: 0.004229767 ustep: 1
#> iter: 2 value: 58051.54 mgc: 9.424256e-07 ustep: 1
#> iter: 3 mgc: 7.41629e-14
#> outer mgc: 0.08901055
#> iter: 1 value: 58051.54 mgc: 0.003822398 ustep: 1
#> iter: 2 value: 58051.54 mgc: 9.549188e-07 ustep: 1
#> iter: 3 mgc: 1.001838e-13
#> outer mgc: 0.08883063
#> iter: 1 value: 58051.54 mgc: 0.003820767 ustep: 1
#> iter: 2 value: 58051.54 mgc: 9.55182e-07 ustep: 1
#> iter: 3 mgc: 1.01745e-13
#> outer mgc: 0.09293559
#> iter: 1 value: 58051.54 mgc: 0.004028684 ustep: 1
#> iter: 2 value: 58051.54 mgc: 1.603122e-06 ustep: 1
#> iter: 3 mgc: 1.857403e-13
#> outer mgc: 0.09030372
#> iter: 1 value: 58051.54 mgc: 0.004032421 ustep: 1
#> iter: 2 value: 58051.54 mgc: 1.601248e-06 ustep: 1
#> iter: 3 mgc: 1.834088e-13

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#> outer mgc: 0.09052842
#> iter: 1 value: 58051.55 mgc: 0.00407091 ustep: 1
#> iter: 2 value: 58051.55 mgc: 1.623623e-06 ustep: 1
#> iter: 3 mgc: 2.551293e-13
#> outer mgc: 0.1103096
#> iter: 1 value: 58051.53 mgc: 0.004074983 ustep: 1
#> iter: 2 value: 58051.53 mgc: 1.62344e-06 ustep: 1
#> iter: 3 mgc: 2.564615e-13
#> outer mgc: 0.1142323
#> iter: 1 value: 58051.55 mgc: 0.004521245 ustep: 1
#> iter: 2 value: 58051.55 mgc: 1.751526e-06 ustep: 1
#> iter: 3 mgc: 2.43805e-13
#> outer mgc: 0.1181898
#> iter: 1 value: 58051.53 mgc: 0.004525768 ustep: 1
#> iter: 2 value: 58051.53 mgc: 1.751443e-06 ustep: 1
#> iter: 3 mgc: 2.483569e-13
#> outer mgc: 0.119749
#> iter: 1 value: 58051.55 mgc: 0.004247353 ustep: 1
#> iter: 2 value: 58051.55 mgc: 1.666334e-06 ustep: 1
#> iter: 3 mgc: 2.406964e-13
#> outer mgc: 0.1210356
#> iter: 1 value: 58051.54 mgc: 0.004251602 ustep: 1
#> iter: 2 value: 58051.54 mgc: 1.666203e-06 ustep: 1
#> iter: 3 mgc: 2.349232e-13
#> outer mgc: 0.1154352
#> iter: 1 value: 58051.55 mgc: 0.003284233 ustep: 1
#> iter: 2 value: 58051.55 mgc: 1.354524e-06 ustep: 1
#> iter: 3 mgc: 2.153833e-13
#> outer mgc: 0.1092838
#> iter: 1 value: 58051.53 mgc: 0.003287519 ustep: 1
#> iter: 2 value: 58051.53 mgc: 1.35427e-06 ustep: 1
#> iter: 3 mgc: 2.14273e-13
#> outer mgc: 0.1091938
#> iter: 1 value: 58051.54 mgc: 0.00412791 ustep: 1
#> iter: 2 value: 58051.54 mgc: 1.372417e-06 ustep: 1
#> iter: 3 mgc: 1.679767e-13
#> outer mgc: 0.07345569
#> iter: 1 value: 58051.54 mgc: 0.00413204 ustep: 1
#> iter: 2 value: 58051.54 mgc: 1.372788e-06 ustep: 1
#> iter: 3 mgc: 1.677547e-13
#> outer mgc: 0.07366093
#> iter: 1 value: 58051.55 mgc: 0.005749444 ustep: 1
#> iter: 2 value: 58051.55 mgc: 2.339605e-06 ustep: 1
#> iter: 3 mgc: 3.637091e-13
#> outer mgc: 0.1085673
#> iter: 1 value: 58051.54 mgc: 0.005755196 ustep: 1
#> iter: 2 value: 58051.54 mgc: 2.339191e-06 ustep: 1
#> iter: 3 mgc: 3.519407e-13
#> outer mgc: 0.1127785
#> iter: 1 value: 58051.55 mgc: 0.005029133 ustep: 1
#> iter: 2 value: 58051.55 mgc: 1.903227e-06 ustep: 1
#> iter: 3 mgc: 2.575717e-13
#> outer mgc: 0.110376
#> iter: 1 value: 58051.54 mgc: 0.005034165 ustep: 1

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#> iter: 2 value: 58051.54 mgc: 1.903169e-06 ustep: 1
#> iter: 3 mgc: 2.582656e-13
#> outer mgc: 0.109124
#> iter: 1 value: 58051.54 mgc: 0.005117971 ustep: 1
#> iter: 2 value: 58051.54 mgc: 2.125829e-06 ustep: 1
#> iter: 3 mgc: 3.557155e-13
#> outer mgc: 0.1089684
#> iter: 1 value: 58051.54 mgc: 0.005123091 ustep: 1
#> iter: 2 value: 58051.54 mgc: 2.125327e-06 ustep: 1
#> iter: 3 mgc: 3.652634e-13
#> outer mgc: 0.1075067
#> iter: 1 value: 58051.54 mgc: 0.005448463 ustep: 1
#> iter: 2 value: 58051.54 mgc: 2.270133e-06 ustep: 1
#> iter: 3 mgc: 3.739231e-13
#> outer mgc: 0.1159648
#> iter: 1 value: 58051.54 mgc: 0.005453915 ustep: 1
#> iter: 2 value: 58051.54 mgc: 2.269577e-06 ustep: 1
#> iter: 3 mgc: 3.688161e-13
#> outer mgc: 0.1088134
#> iter: 1 value: 58051.55 mgc: 0.004950786 ustep: 1
#> iter: 2 value: 58051.55 mgc: 2.013132e-06 ustep: 1
#> iter: 3 mgc: 3.153033e-13
#> outer mgc: 0.1043936
#> iter: 1 value: 58051.54 mgc: 0.004955739 ustep: 1
#> iter: 2 value: 58051.54 mgc: 2.012795e-06 ustep: 1
#> iter: 3 mgc: 3.133604e-13
#> outer mgc: 0.1046681
#> iter: 1 value: 58051.55 mgc: 0.00402595 ustep: 1
#> iter: 2 value: 58051.55 mgc: 1.475054e-06 ustep: 1
#> iter: 3 mgc: 2.067235e-13
#> outer mgc: 0.08915184
#> iter: 1 value: 58051.54 mgc: 0.004029978 ustep: 1
#> iter: 2 value: 58051.54 mgc: 1.474868e-06 ustep: 1
#> iter: 3 mgc: 2.129408e-13
#> outer mgc: 0.09410617
#> iter: 1 value: 58051.55 mgc: 0.004432708 ustep: 1
#> iter: 2 value: 58051.55 mgc: 1.715189e-06 ustep: 1
#> iter: 3 mgc: 2.460254e-13
#> outer mgc: 0.119342
#> iter: 1 value: 58051.53 mgc: 0.004437143 ustep: 1
#> iter: 2 value: 58051.53 mgc: 1.715061e-06 ustep: 1
#> iter: 3 mgc: 2.493561e-13
#> outer mgc: 0.1181298
#> iter: 1 value: 58051.55 mgc: 0.002443484 ustep: 1
#> iter: 2 value: 58051.55 mgc: 7.748482e-07 ustep: 1
#> iter: 3 mgc: 8.171241e-14
#> outer mgc: 0.078216
#> iter: 1 value: 58051.54 mgc: 0.002445928 ustep: 1
#> iter: 2 value: 58051.54 mgc: 7.751097e-07 ustep: 1
#> iter: 3 mgc: 7.349676e-14
#> outer mgc: 0.08178271
#> iter: 1 value: 58051.55 mgc: 0.005296417 ustep: 1
#> iter: 2 value: 58051.55 mgc: 1.712114e-06 ustep: 1
#> iter: 3 mgc: 1.589839e-13

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#> outer mgc: 0.08991257
#> iter: 1 value: 58051.54 mgc: 0.005301716 ustep: 1
#> iter: 2 value: 58051.54 mgc: 1.712535e-06 ustep: 1
#> iter: 3 mgc: 1.723066e-13
#> outer mgc: 0.08954848
#> iter: 1 value: 58051.55 mgc: 0.003331473 ustep: 1
#> iter: 2 value: 58051.55 mgc: 1.14779e-06 ustep: 1
#> iter: 3 mgc: 1.34337e-13
#> outer mgc: 0.0887186
#> iter: 1 value: 58051.54 mgc: 0.003334806 ustep: 1
#> iter: 2 value: 58051.54 mgc: 1.147963e-06 ustep: 1
#> iter: 3 mgc: 1.329492e-13
#> outer mgc: 0.08955394
#> iter: 1 value: 58051.55 mgc: 0.003910942 ustep: 1
#> iter: 2 value: 58051.55 mgc: 1.385477e-06 ustep: 1
#> iter: 3 mgc: 1.958433e-13
#> outer mgc: 0.09478763
#> iter: 1 value: 58051.54 mgc: 0.003914855 ustep: 1
#> iter: 2 value: 58051.54 mgc: 1.385749e-06 ustep: 1
#> iter: 3 mgc: 1.973977e-13
#> outer mgc: 0.09011038
#> iter: 1 value: 58050.98 mgc: 0.008054591 ustep: 1
#> iter: 2 value: 58050.98 mgc: 1.790795e-06 ustep: 1
#> iter: 3 mgc: 2.17576e-13
#> outer mgc: 0.3112824
#> iter: 1 value: 58052.11 mgc: 0.008038498 ustep: 1
#> iter: 2 value: 58052.11 mgc: 1.787905e-06 ustep: 1
#> iter: 3 mgc: 2.158274e-13
#> outer mgc: 0.3100656
#> iter: 1 value: 58050.85 mgc: 0.006805264 ustep: 1
#> iter: 2 value: 58050.85 mgc: 8.240601e-07 ustep: 1
#> iter: 3 mgc: 5.517808e-14
#> outer mgc: 0.6183387
#> iter: 1 value: 58052.24 mgc: 0.006791667 ustep: 1
#> iter: 2 value: 58052.24 mgc: 8.246406e-07 ustep: 1
#> iter: 3 mgc: 6.239453e-14
#> outer mgc: 0.5566174
#> iter: 1 value: 58036.05 mgc: 0.006680401 ustep: 1
#> iter: 2 value: 58036.05 mgc: 5.199186e-07 ustep: 1
#> iter: 3 mgc: 8.915091e-14
#> outer mgc: 0.1859582
#> iter: 1 value: 58067.03 mgc: 0.006667053 ustep: 1
#> iter: 2 value: 58067.03 mgc: 5.203142e-07 ustep: 1
#> iter: 3 mgc: 6.364353e-14
#> outer mgc: 0.1828387
#> iter: 1 value: 58037.35 mgc: 0.008653037 ustep: 1
#> iter: 2 value: 58037.35 mgc: 3.88544e-06 ustep: 1
#> iter: 3 mgc: 4.65683e-13
#> outer mgc: 2.525908
#> iter: 1 value: 58065.73 mgc: 0.008635749 ustep: 1
#> iter: 2 value: 58065.73 mgc: 3.884699e-06 ustep: 1
#> iter: 3 mgc: 4.758416e-13
#> outer mgc: 2.467249
#> iter: 1 value: 58047.72 mgc: 0.002838028 ustep: 1

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```

#> iter: 2 value: 58047.72 mgc: 1.25539e-06 ustep: 1
#> iter: 3 mgc: 9.955925e-14
#> outer mgc: 0.2834803
#> iter: 1 value: 58055.35 mgc: 0.002828989 ustep: 1
#> iter: 2 value: 58055.35 mgc: 1.252823e-06 ustep: 1
#> iter: 3 mgc: 9.611756e-14
#> outer mgc: 0.2801938
#> iter: 1 value: 58030.01 mgc: 0.01425971 ustep: 1
#> iter: 2 value: 58030.01 mgc: 1.195558e-05 ustep: 1
#> iter: 3 mgc: 3.639811e-12
#> outer mgc: 4.841083
#> iter: 1 value: 58073.06 mgc: 0.01420748 ustep: 1
#> iter: 2 value: 58073.06 mgc: 1.194359e-05 ustep: 1
#> iter: 3 mgc: 3.622325e-12
#> outer mgc: 4.780565
#> iter: 1 value: 58050.54 mgc: 0.004324355 ustep: 1
#> iter: 2 value: 58050.54 mgc: 1.328491e-06 ustep: 1
#> iter: 3 mgc: 6.833423e-14
#> outer mgc: 3.112166
#> iter: 1 value: 58052.54 mgc: 0.004320033 ustep: 1
#> iter: 2 value: 58052.54 mgc: 1.326145e-06 ustep: 1
#> iter: 3 mgc: 6.428191e-14
#> outer mgc: 3.109128
#> iter: 1 value: 58052.06 mgc: 0.0008917464 ustep: 1
#> iter: 2 value: 58052.06 mgc: 1.135082e-08 ustep: 1
#> iter: 3 mgc: 6.512846e-14
#> running TMB sdreport
#> iter: 1 mgc: 6.512846e-14
#> outer mgc: 5.454016e-07
#> iter: 1 value: 58046.27 mgc: 0.005203299 ustep: 1
#> iter: 2 value: 58046.27 mgc: 5.095475e-07 ustep: 1
#> iter: 3 mgc: 6.711298e-14
#> outer mgc: 0.2146047
#> iter: 1 value: 58057.84 mgc: 0.005193767 ustep: 1
#> iter: 2 value: 58057.84 mgc: 5.094673e-07 ustep: 1
#> iter: 3 mgc: 6.158962e-14
#> outer mgc: 0.2141402
#> iter: 1 value: 58049.02 mgc: 0.004270485 ustep: 1
#> iter: 2 value: 58049.02 mgc: 3.145236e-07 ustep: 1
#> iter: 3 mgc: 6.864062e-14
#> outer mgc: 0.136345
#> iter: 1 value: 58055.1 mgc: 0.004271062 ustep: 1
#> iter: 2 value: 58055.1 mgc: 3.137255e-07 ustep: 1
#> iter: 3 mgc: 6.74738e-14
#> outer mgc: 0.136325
#> iter: 1 value: 58052.06 mgc: 0.005007931 ustep: 1
#> iter: 2 value: 58052.06 mgc: 1.365244e-06 ustep: 1
#> iter: 3 mgc: 2.444711e-13
#> outer mgc: 0.106378
#> iter: 1 value: 58052.06 mgc: 0.005007951 ustep: 1
#> iter: 2 value: 58052.06 mgc: 1.367352e-06 ustep: 1
#> iter: 3 mgc: 2.444711e-13
#> outer mgc: 0.1063718
#> iter: 1 value: 58052.06 mgc: 0.004127529 ustep: 1

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```

#> iter: 2 value: 58052.06 mgc: 1.352376e-06 ustep: 1
#> iter: 3 mgc: 1.966899e-13
#> outer mgc: 0.1067685
#> iter: 1 value: 58052.06 mgc: 0.004125617 ustep: 1
#> iter: 2 value: 58052.06 mgc: 1.350777e-06 ustep: 1
#> iter: 3 mgc: 1.983969e-13
#> outer mgc: 0.1067632
#> iter: 1 value: 58052.06 mgc: 0.004738045 ustep: 1
#> iter: 2 value: 58052.06 mgc: 1.456262e-06 ustep: 1
#> iter: 3 mgc: 2.166045e-13
#> outer mgc: 0.1070029
#> iter: 1 value: 58052.06 mgc: 0.00473576 ustep: 1
#> iter: 2 value: 58052.06 mgc: 1.453997e-06 ustep: 1
#> iter: 3 mgc: 2.19269e-13
#> outer mgc: 0.1069965
#> iter: 1 value: 58052.06 mgc: 0.003878588 ustep: 1
#> iter: 2 value: 58052.06 mgc: 8.379998e-07 ustep: 1
#> iter: 3 mgc: 7.61613e-14
#> outer mgc: 0.1024932
#> iter: 1 value: 58052.06 mgc: 0.003877709 ustep: 1
#> iter: 2 value: 58052.06 mgc: 8.381221e-07 ustep: 1
#> iter: 3 mgc: 7.69107e-14
#> outer mgc: 0.1024847
#> iter: 1 value: 58052.06 mgc: 0.004227998 ustep: 1
#> iter: 2 value: 58052.06 mgc: 1.04487e-06 ustep: 1
#> iter: 3 mgc: 1.469935e-13
#> outer mgc: 0.06932794
#> iter: 1 value: 58052.07 mgc: 0.004226339 ustep: 1
#> iter: 2 value: 58052.07 mgc: 1.045002e-06 ustep: 1
#> iter: 3 mgc: 1.448563e-13
#> outer mgc: 0.06932166
#> iter: 1 value: 58052.06 mgc: 0.006499409 ustep: 1
#> iter: 2 value: 58052.06 mgc: 2.340768e-06 ustep: 1
#> iter: 3 mgc: 2.711303e-13
#> outer mgc: 0.101576
#> iter: 1 value: 58052.06 mgc: 0.006493678 ustep: 1
#> iter: 2 value: 58052.06 mgc: 2.342571e-06 ustep: 1
#> iter: 3 mgc: 2.757794e-13
#> outer mgc: 0.1015661
#> iter: 1 value: 58052.06 mgc: 0.004441285 ustep: 1
#> iter: 2 value: 58052.06 mgc: 1.22061e-06 ustep: 1
#> iter: 3 mgc: 1.599554e-13
#> outer mgc: 0.1012599
#> iter: 1 value: 58052.06 mgc: 0.004438178 ustep: 1
#> iter: 2 value: 58052.06 mgc: 1.223393e-06 ustep: 1
#> iter: 3 mgc: 1.521283e-13
#> outer mgc: 0.1012505
#> iter: 1 value: 58052.06 mgc: 0.005002207 ustep: 1
#> iter: 2 value: 58052.06 mgc: 1.583835e-06 ustep: 1
#> iter: 3 mgc: 1.960654e-13
#> outer mgc: 0.1000162
#> iter: 1 value: 58052.06 mgc: 0.004998179 ustep: 1
#> iter: 2 value: 58052.06 mgc: 1.585109e-06 ustep: 1
#> iter: 3 mgc: 1.99063e-13

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```

#> outer mgc: 0.1000072
#> iter: 1 value: 58052.06 mgc: 0.005687252 ustep: 1
#> iter: 2 value: 58052.06 mgc: 2.134336e-06 ustep: 1
#> iter: 3 mgc: 3.320053e-13
#> outer mgc: 0.1042698
#> iter: 1 value: 58052.06 mgc: 0.00568274 ustep: 1
#> iter: 2 value: 58052.06 mgc: 2.129627e-06 ustep: 1
#> iter: 3 mgc: 3.323938e-13
#> outer mgc: 0.1042624
#> iter: 1 value: 58052.06 mgc: 0.005115978 ustep: 1
#> iter: 2 value: 58052.06 mgc: 1.782352e-06 ustep: 1
#> iter: 3 mgc: 2.535749e-13
#> outer mgc: 0.09962825
#> iter: 1 value: 58052.06 mgc: 0.00511169 ustep: 1
#> iter: 2 value: 58052.06 mgc: 1.779902e-06 ustep: 1
#> iter: 3 mgc: 2.597367e-13
#> outer mgc: 0.09962037
#> iter: 1 value: 58052.06 mgc: 0.004366544 ustep: 1
#> iter: 2 value: 58052.06 mgc: 1.28009e-06 ustep: 1
#> iter: 3 mgc: 1.483258e-13
#> outer mgc: 0.09188877
#> iter: 1 value: 58052.06 mgc: 0.004366882 ustep: 1
#> iter: 2 value: 58052.06 mgc: 1.278606e-06 ustep: 1
#> iter: 3 mgc: 1.427747e-13
#> outer mgc: 0.09187998
#> iter: 1 value: 58052.06 mgc: 0.005137198 ustep: 1
#> iter: 2 value: 58052.06 mgc: 1.340714e-06 ustep: 1
#> iter: 3 mgc: 1.454392e-13
#> outer mgc: 0.1048497
#> iter: 1 value: 58052.06 mgc: 0.005135452 ustep: 1
#> iter: 2 value: 58052.06 mgc: 1.339371e-06 ustep: 1
#> iter: 3 mgc: 1.438849e-13
#> outer mgc: 0.1048422
#> iter: 1 value: 58052.06 mgc: 0.002455424 ustep: 1
#> iter: 2 value: 58052.06 mgc: 7.294726e-07 ustep: 1
#> iter: 3 mgc: 6.199034e-14
#> outer mgc: 0.08431003
#> iter: 1 value: 58052.06 mgc: 0.002452947 ustep: 1
#> iter: 2 value: 58052.06 mgc: 7.300171e-07 ustep: 1
#> iter: 3 mgc: 6.304852e-14
#> outer mgc: 0.08429731
#> iter: 1 value: 58052.06 mgc: 0.004232347 ustep: 1
#> iter: 2 value: 58052.06 mgc: 9.421966e-07 ustep: 1
#> iter: 3 mgc: 7.184531e-14
#> outer mgc: 0.09039747
#> iter: 1 value: 58052.06 mgc: 0.004229761 ustep: 1
#> iter: 2 value: 58052.06 mgc: 9.424289e-07 ustep: 1
#> iter: 3 mgc: 1.024458e-13
#> outer mgc: 0.09038571
#> iter: 1 value: 58052.06 mgc: 0.003822415 ustep: 1
#> iter: 2 value: 58052.06 mgc: 9.549302e-07 ustep: 1
#> iter: 3 mgc: 1.003052e-13
#> outer mgc: 0.09088756
#> iter: 1 value: 58052.06 mgc: 0.003820784 ustep: 1

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```

#> iter: 2 value: 58052.06 mgc: 9.551934e-07 ustep: 1
#> iter: 3 mgc: 1.021683e-13
#> outer mgc: 0.09087691
#> iter: 1 value: 58052.06 mgc: 0.00402869 ustep: 1
#> iter: 2 value: 58052.06 mgc: 1.603147e-06 ustep: 1
#> iter: 3 mgc: 1.831868e-13
#> outer mgc: 0.0904198
#> iter: 1 value: 58052.06 mgc: 0.004032427 ustep: 1
#> iter: 2 value: 58052.06 mgc: 1.601273e-06 ustep: 1
#> iter: 3 mgc: 1.887379e-13
#> outer mgc: 0.09041017
#> iter: 1 value: 58052.07 mgc: 0.004070901 ustep: 1
#> iter: 2 value: 58052.07 mgc: 1.62363e-06 ustep: 1
#> iter: 3 mgc: 2.549905e-13
#> outer mgc: 0.1122642
#> iter: 1 value: 58052.06 mgc: 0.004074974 ustep: 1
#> iter: 2 value: 58052.06 mgc: 1.623446e-06 ustep: 1
#> iter: 3 mgc: 2.600142e-13
#> outer mgc: 0.1122736
#> iter: 1 value: 58052.07 mgc: 0.004521243 ustep: 1
#> iter: 2 value: 58052.07 mgc: 1.751538e-06 ustep: 1
#> iter: 3 mgc: 2.471356e-13
#> outer mgc: 0.1189632
#> iter: 1 value: 58052.06 mgc: 0.004525767 ustep: 1
#> iter: 2 value: 58052.06 mgc: 1.751455e-06 ustep: 1
#> iter: 3 mgc: 2.383649e-13
#> outer mgc: 0.1189713
#> iter: 1 value: 58052.07 mgc: 0.004247342 ustep: 1
#> iter: 2 value: 58052.07 mgc: 1.666341e-06 ustep: 1
#> iter: 3 mgc: 2.375877e-13
#> outer mgc: 0.1182293
#> iter: 1 value: 58052.06 mgc: 0.004251591 ustep: 1
#> iter: 2 value: 58052.06 mgc: 1.666209e-06 ustep: 1
#> iter: 3 mgc: 2.333689e-13
#> outer mgc: 0.118238
#> iter: 1 value: 58052.07 mgc: 0.00328422 ustep: 1
#> iter: 2 value: 58052.07 mgc: 1.354525e-06 ustep: 1
#> iter: 3 mgc: 2.171596e-13
#> outer mgc: 0.1092312
#> iter: 1 value: 58052.06 mgc: 0.003287506 ustep: 1
#> iter: 2 value: 58052.06 mgc: 1.354271e-06 ustep: 1
#> iter: 3 mgc: 2.113865e-13
#> outer mgc: 0.1092427
#> iter: 1 value: 58052.07 mgc: 0.004127861 ustep: 1
#> iter: 2 value: 58052.07 mgc: 1.372408e-06 ustep: 1
#> iter: 3 mgc: 1.685319e-13
#> outer mgc: 0.07355238
#> iter: 1 value: 58052.06 mgc: 0.004131991 ustep: 1
#> iter: 2 value: 58052.06 mgc: 1.372779e-06 ustep: 1
#> iter: 3 mgc: 1.709743e-13
#> outer mgc: 0.07356194
#> iter: 1 value: 58052.07 mgc: 0.005749415 ustep: 1
#> iter: 2 value: 58052.07 mgc: 2.339604e-06 ustep: 1
#> iter: 3 mgc: 3.639311e-13

```



```

#> outer mgc: 0.1106645
#> iter: 1 value: 58052.06 mgc: 0.005755167 ustep: 1
#> iter: 2 value: 58052.06 mgc: 2.339189e-06 ustep: 1
#> iter: 3 mgc: 3.563816e-13
#> outer mgc: 0.1106771
#> iter: 1 value: 58052.07 mgc: 0.005029119 ustep: 1
#> iter: 2 value: 58052.07 mgc: 1.903236e-06 ustep: 1
#> iter: 3 mgc: 2.549072e-13
#> outer mgc: 0.1097427
#> iter: 1 value: 58052.06 mgc: 0.005034151 ustep: 1
#> iter: 2 value: 58052.06 mgc: 1.903178e-06 ustep: 1
#> iter: 3 mgc: 2.553513e-13
#> outer mgc: 0.1097537
#> iter: 1 value: 58052.07 mgc: 0.005117982 ustep: 1
#> iter: 2 value: 58052.07 mgc: 2.125836e-06 ustep: 1
#> iter: 3 mgc: 3.567147e-13
#> outer mgc: 0.1082305
#> iter: 1 value: 58052.06 mgc: 0.005123102 ustep: 1
#> iter: 2 value: 58052.06 mgc: 2.125333e-06 ustep: 1
#> iter: 3 mgc: 3.590461e-13
#> outer mgc: 0.1082408
#> iter: 1 value: 58052.07 mgc: 0.005448468 ustep: 1
#> iter: 2 value: 58052.07 mgc: 2.270148e-06 ustep: 1
#> iter: 3 mgc: 3.705924e-13
#> outer mgc: 0.1123839
#> iter: 1 value: 58052.06 mgc: 0.005453919 ustep: 1
#> iter: 2 value: 58052.06 mgc: 2.269591e-06 ustep: 1
#> iter: 3 mgc: 3.717027e-13
#> outer mgc: 0.1123911
#> iter: 1 value: 58052.07 mgc: 0.004950774 ustep: 1
#> iter: 2 value: 58052.07 mgc: 2.013137e-06 ustep: 1
#> iter: 3 mgc: 3.189671e-13
#> outer mgc: 0.104525
#> iter: 1 value: 58052.06 mgc: 0.004955727 ustep: 1
#> iter: 2 value: 58052.06 mgc: 2.0128e-06 ustep: 1
#> iter: 3 mgc: 3.170797e-13
#> outer mgc: 0.1045333
#> iter: 1 value: 58052.07 mgc: 0.00402595 ustep: 1
#> iter: 2 value: 58052.07 mgc: 1.475047e-06 ustep: 1
#> iter: 3 mgc: 2.159384e-13
#> outer mgc: 0.09162257
#> iter: 1 value: 58052.06 mgc: 0.004029978 ustep: 1
#> iter: 2 value: 58052.06 mgc: 1.474862e-06 ustep: 1
#> iter: 3 mgc: 2.178258e-13
#> outer mgc: 0.09163213
#> iter: 1 value: 58052.07 mgc: 0.004432713 ustep: 1
#> iter: 2 value: 58052.07 mgc: 1.715198e-06 ustep: 1
#> iter: 3 mgc: 2.458034e-13
#> outer mgc: 0.1187284
#> iter: 1 value: 58052.06 mgc: 0.004437148 ustep: 1
#> iter: 2 value: 58052.06 mgc: 1.715071e-06 ustep: 1
#> iter: 3 mgc: 2.429168e-13
#> outer mgc: 0.1187393
#> iter: 1 value: 58052.07 mgc: 0.002443465 ustep: 1

```

```

#> iter: 2 value: 58052.07 mgc: 7.748494e-07 ustep: 1
#> iter: 3 mgc: 6.949996e-14
#> outer mgc: 0.07999201
#> iter: 1 value: 58052.06 mgc: 0.002445909 ustep: 1
#> iter: 2 value: 58052.06 mgc: 7.751109e-07 ustep: 1
#> iter: 3 mgc: 7.643886e-14
#> outer mgc: 0.08000382
#> iter: 1 value: 58052.07 mgc: 0.005296343 ustep: 1
#> iter: 2 value: 58052.07 mgc: 1.712098e-06 ustep: 1
#> iter: 3 mgc: 1.625367e-13
#> outer mgc: 0.08972341
#> iter: 1 value: 58052.06 mgc: 0.005301642 ustep: 1
#> iter: 2 value: 58052.06 mgc: 1.71252e-06 ustep: 1
#> iter: 3 mgc: 1.527667e-13
#> outer mgc: 0.08973501
#> iter: 1 value: 58052.07 mgc: 0.003331476 ustep: 1
#> iter: 2 value: 58052.07 mgc: 1.147805e-06 ustep: 1
#> iter: 3 mgc: 1.303402e-13
#> outer mgc: 0.08912932
#> iter: 1 value: 58052.06 mgc: 0.003334809 ustep: 1
#> iter: 2 value: 58052.06 mgc: 1.147977e-06 ustep: 1
#> iter: 3 mgc: 1.373346e-13
#> outer mgc: 0.08914024
#> iter: 1 value: 58052.07 mgc: 0.003910953 ustep: 1
#> iter: 2 value: 58052.07 mgc: 1.385496e-06 ustep: 1
#> iter: 3 mgc: 1.84297e-13
#> outer mgc: 0.09244296
#> iter: 1 value: 58052.06 mgc: 0.003914866 ustep: 1
#> iter: 2 value: 58052.06 mgc: 1.385769e-06 ustep: 1
#> iter: 3 mgc: 1.882938e-13
#> outer mgc: 0.09245262
#> iter: 1 value: 58051.5 mgc: 0.008054522 ustep: 1
#> iter: 2 value: 58051.5 mgc: 1.790782e-06 ustep: 1
#> iter: 3 mgc: 2.141343e-13
#> outer mgc: 0.3105944
#> iter: 1 value: 58052.63 mgc: 0.008038429 ustep: 1
#> iter: 2 value: 58052.63 mgc: 1.787892e-06 ustep: 1
#> iter: 3 mgc: 2.213507e-13
#> outer mgc: 0.3107588
#> iter: 1 value: 58051.37 mgc: 0.006805218 ustep: 1
#> iter: 2 value: 58051.37 mgc: 8.240468e-07 ustep: 1
#> iter: 3 mgc: 6.307455e-14
#> outer mgc: 0.5872991
#> iter: 1 value: 58052.76 mgc: 0.006791621 ustep: 1
#> iter: 2 value: 58052.76 mgc: 8.246272e-07 ustep: 1
#> iter: 3 mgc: 7.123468e-14
#> outer mgc: 0.5876444
#> iter: 1 value: 58036.57 mgc: 0.006680372 ustep: 1
#> iter: 2 value: 58036.57 mgc: 5.199215e-07 ustep: 1
#> iter: 3 mgc: 8.348877e-14
#> outer mgc: 0.1842439
#> iter: 1 value: 58067.55 mgc: 0.006667024 ustep: 1
#> iter: 2 value: 58067.55 mgc: 5.203171e-07 ustep: 1
#> iter: 3 mgc: 8.004708e-14

```

```

#> outer mgc: 0.184561
#> iter: 1 value: 58037.87 mgc: 0.008652884 ustep: 1
#> iter: 2 value: 58037.87 mgc: 3.88544e-06 ustep: 1
#> iter: 3 mgc: 4.687362e-13
#> outer mgc: 2.494895
#> iter: 1 value: 58066.25 mgc: 0.008635596 ustep: 1
#> iter: 2 value: 58066.25 mgc: 3.884699e-06 ustep: 1
#> iter: 3 mgc: 4.684031e-13
#> outer mgc: 2.498302
#> iter: 1 value: 58048.25 mgc: 0.002838012 ustep: 1
#> iter: 2 value: 58048.25 mgc: 1.255383e-06 ustep: 1
#> iter: 3 mgc: 9.486856e-14
#> outer mgc: 0.2817665
#> iter: 1 value: 58055.88 mgc: 0.002828973 ustep: 1
#> iter: 2 value: 58055.88 mgc: 1.252816e-06 ustep: 1
#> iter: 3 mgc: 9.861556e-14
#> outer mgc: 0.2819166
#> iter: 1 value: 58030.53 mgc: 0.01425938 ustep: 1
#> iter: 2 value: 58030.53 mgc: 1.195542e-05 ustep: 1
#> iter: 3 mgc: 3.630485e-12
#> outer mgc: 4.810038
#> iter: 1 value: 58073.59 mgc: 0.01420716 ustep: 1
#> iter: 2 value: 58073.59 mgc: 1.194344e-05 ustep: 1
#> iter: 3 mgc: 3.625544e-12
#> outer mgc: 4.811586
#> iter: 1 value: 58051.07 mgc: 0.004324279 ustep: 1
#> iter: 2 value: 58051.07 mgc: 1.32849e-06 ustep: 1
#> iter: 3 mgc: 7.51621e-14
#> outer mgc: 3.111158
#> iter: 1 value: 58053.06 mgc: 0.004319957 ustep: 1
#> iter: 2 value: 58053.06 mgc: 1.326144e-06 ustep: 1
#> iter: 3 mgc: 7.268898e-14
#> outer mgc: 3.110114
#> outer mgc: 149.4786

# diagnose estimation issues due to model structure
#TMBhelper::check_estimability(fit_sdmTMB$tmb_obj)

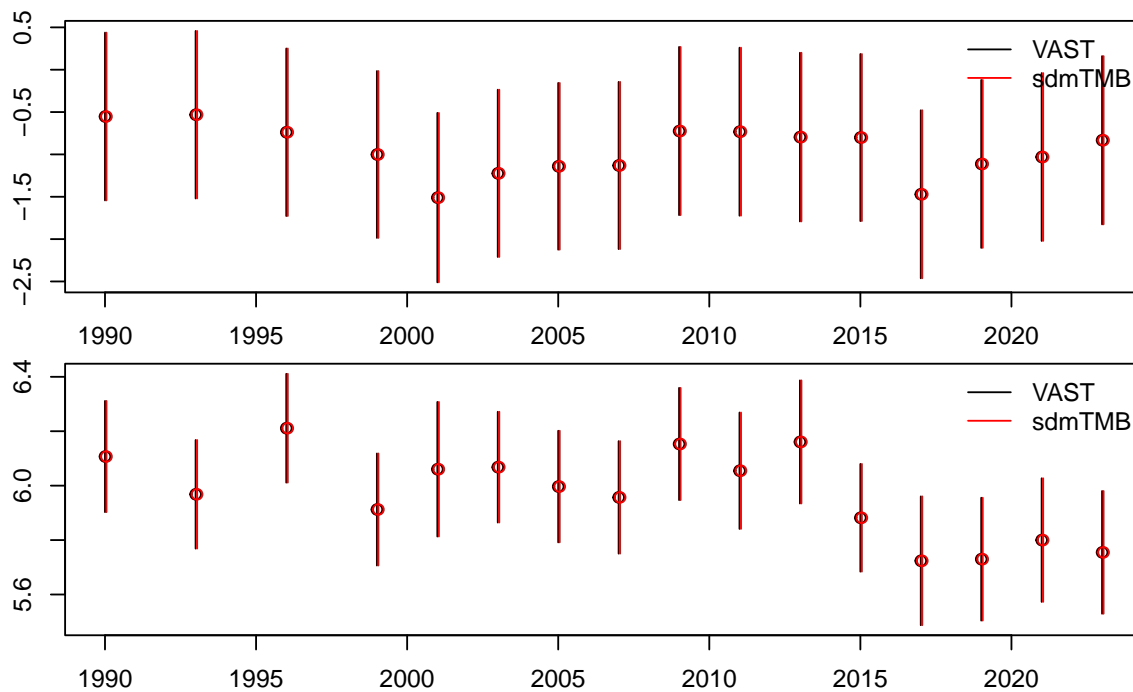
```

We wrote some custom code to extract comparable parameters (not shown above). Here are the annual mean estimates in link space with 95% confidence intervals for the two components to the delta model:

```

par(mfrow = c(2, 1), cex = 0.8, mar = c(1.5, 1, 1, 1), oma = c(2, 3, 1, 1))
plot_betas(fit, fit_sdmTMB, "beta1_ft", sdmTMB_pars = 1)
plot_betas(fit, fit_sdmTMB, "beta2_ft", sdmTMB_pars = 2)

```



We can compare the index we would get using sdmTMB.

```
# prep prediction grid and transform to UTM projection
grid_ll <- as.data.frame(input_grid)
names(grid_ll) <- tolower(names(grid_ll))
coordinates(grid_ll) <- ~ lon + lat
proj4string(grid_ll) <- CRS("+proj=longlat +datum=WGS84")
grid <- as.data.frame(spTransform(grid_ll, CRS("+proj=utm +zone=5")))

# rename and scale to km so values don't get too large
grid$X <- grid$coords.x1 / 1000
grid$Y <- grid$coords.x2 / 1000

# or with sf:
# grid_ll <- sf::st_as_sf(
#   x = grid_ll,
#   coords = c("lon", "lat"),
#   crs = "+proj=longlat +datum=WGS84"
# )
# grid <- sf::st_transform(grid_ll, crs = "+proj=utm +zone=5")

# replicate extrapolation grid for each year in data
pred_grid <- replicate_df(grid, "year_f", unique(dat$year_f))
pred_grid$year <- as.integer(as.character(factor(pred_grid$year_f)))

# make predictions and get index
f2 <- here("species_specific_code", "GOA", species,
           "index_comparison", "predictions.RDS")
if (!file.exists(f2)) {
```

```

p <- predict(fit_sdmTMB, newdata = pred_grid, return_tmb_object = TRUE)
saveRDS(p, file = here("species_specific_code", "GOA", species, "index_comparison", "predictions.RDS"))
} else {
p <- readRDS(f2)
}

f3 <- here("species_specific_code", "GOA", species,
           "index_comparison", "index.RDS")
if (!file.exists(f3)) {
ind <- get_index(p, bias_correct = TRUE, area = p$data$area_km2)
saveRDS(ind, file = here("species_specific_code", "GOA", species, "index_comparison", "index.RDS"))
} else {
ind <- readRDS(f3)
}

```

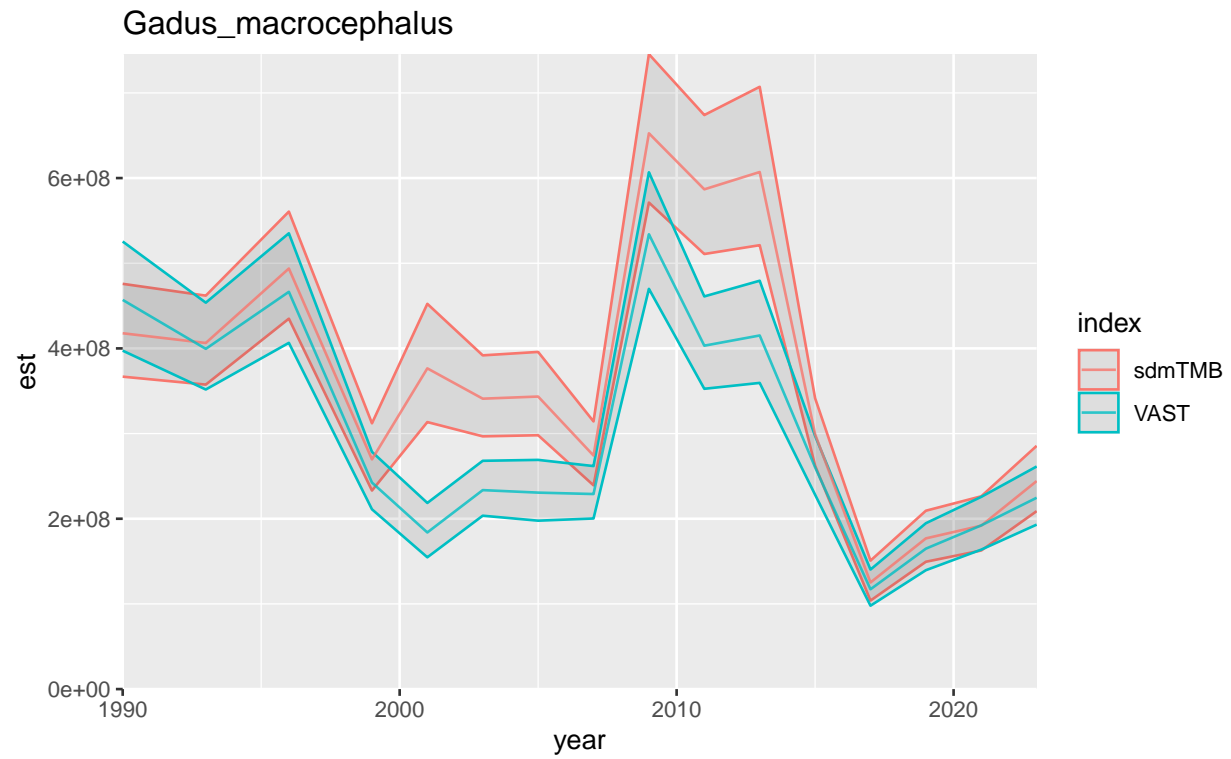
Now, we can compare the indices.

```

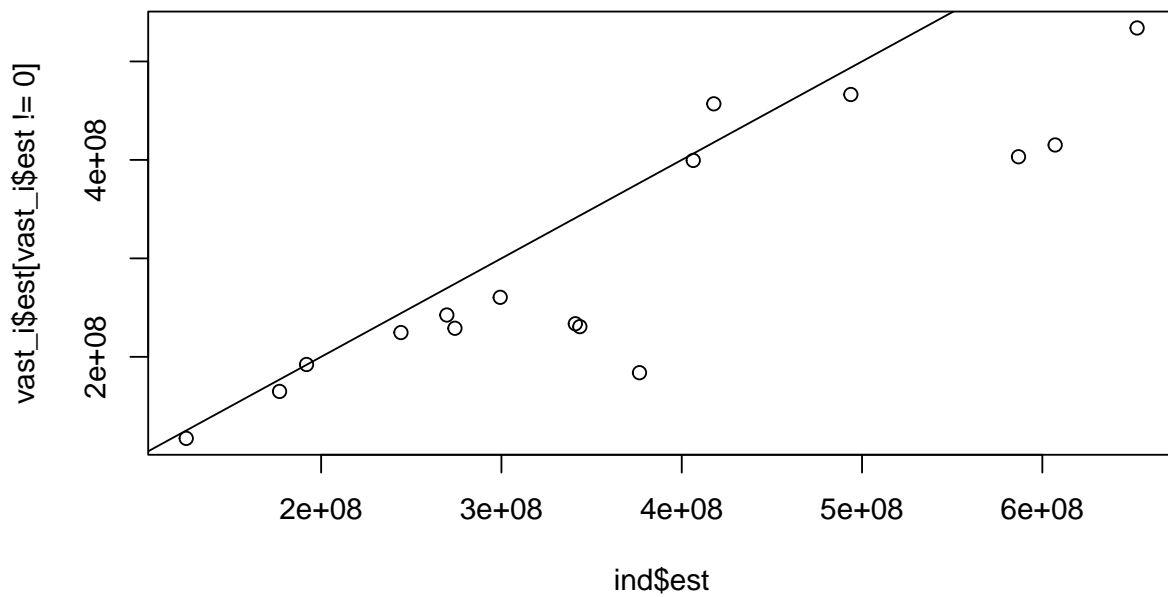
vast_i <- read.csv(here("species_specific_code", "GOA", species, "index_comparison", "Index.csv")) %>%
  mutate(index = "VAST", year = as.numeric(Time), est = Estimate,
         se = Std..Error.for.ln.Estimate.) %>%
  select(index, year, est, se) %>%
  mutate(lwr = exp(log(est) + qnorm(0.025) * se)) %>%
  mutate(upr = exp(log(est) + qnorm(0.975) * se))
sdm_i <- ind %>% mutate(index = "sdmTMB")
both_i <- bind_rows(sdm_i, vast_i) %>% filter(est > 0)

ggplot(both_i, aes(x = year, y = est, ymin = lwr, ymax = upr, colour = index)) +
  geom_ribbon(alpha = 0.1) +
  geom_line(alpha = 0.8) +
  ylim(0, max(both_i$upr)) +
  ggtitle(species) +
  coord_cartesian(expand = FALSE)

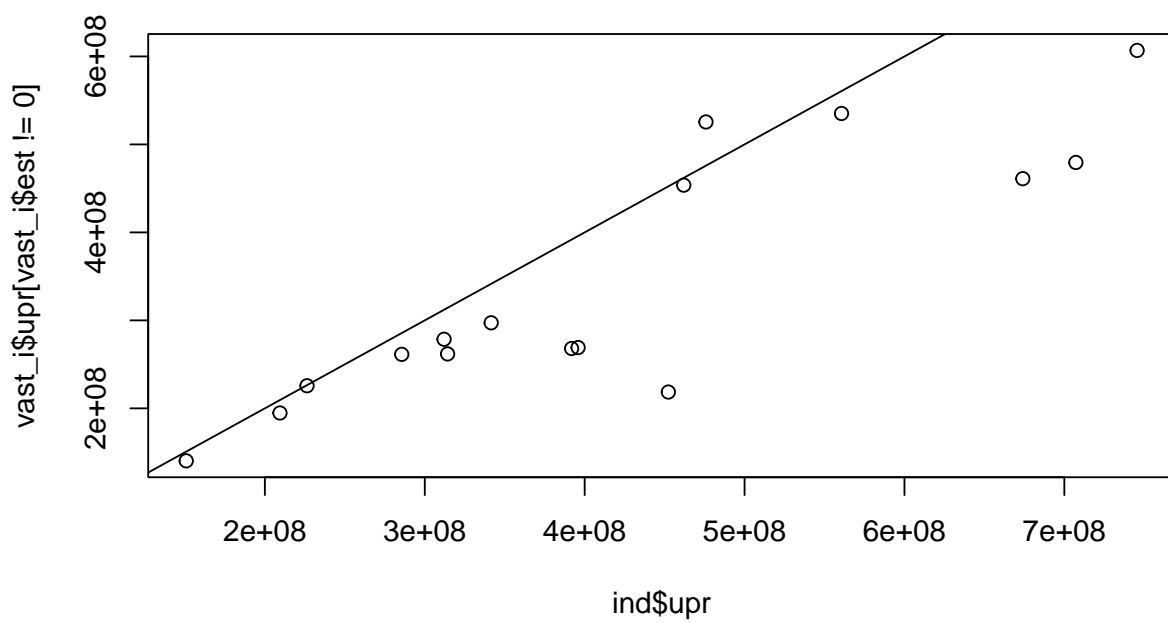
```



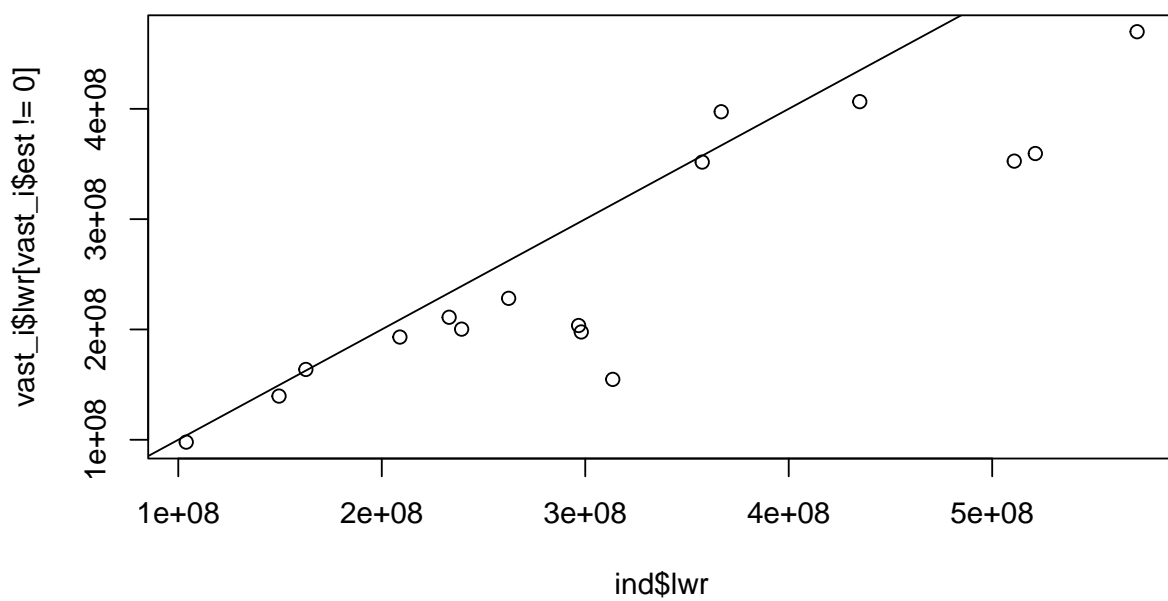
```
plot(ind$est, vast_i$est[vast_i$est != 0]);abline(0, 1)
```



```
plot(ind$upr, vast_i$upr[vast_i$est != 0]);abline(0, 1)
```



```
plot(ind$lwr, vast_i$lwr[vast_i$est != 0]);abline(0, 1)
```



```
(ind$est - vast_i$est[vast_i$est != 0]) / vast_i$est[vast_i$est != 0]
```



```

#> [1] -0.085734329 0.017272839 0.058654506 0.112355963 1.047740498
#> [6] 0.459709390 0.489071685 0.197380848 0.222014407 0.455317083
#> [11] 0.462295665 0.149277170 0.068018618 0.073242851 -0.001760198
#> [16] 0.087218410
(ind$supr - vast_i$supr[vast_i$est != 0]) / vast_i$supr[vast_i$est != 0]
#> [1] -0.094540207 0.018210021 0.047595785 0.120388830 1.069702237
#> [6] 0.461805388 0.471098394 0.200241187 0.228529651 0.461869089
#> [11] 0.474932887 0.148961352 0.074550092 0.075410053 0.002873784
#> [16] 0.092665826
(ind$lwr - vast_i$lwr[vast_i$est != 0]) / vast_i$lwr[vast_i$est != 0]
#> [1] -0.076842811 0.016336520 0.069829966 0.104380689 1.026011797
#> [6] 0.457616396 0.507264567 0.194527326 0.215533716 0.448794443
#> [11] 0.449766718 0.149593075 0.061526844 0.071080016 -0.006372767
#> [16] 0.081798152

```

This document was built using:

```

R.Version()$version.string
#> [1] "R version 4.3.0 (2023-04-21 ucrt)"
packageVersion("VAST")
#> [1] '3.11.2'
packageVersion("FishStatsUtils")
#> [1] '2.13.1'

```