Supplementary Information S3

(all codes are from R's console environment)

Two-endmember mixing model

```
> library(readr)
> library(dplyr)
> library(ggplot2)
> consumers <- read_csv("ALL_data.csv", show_col_types = FALSE)
> period_order <- c("BA","EBA","EBA/MBA","MBA","MBA/LBA",
+                   "LBA","LBA/EIA","EIA","LIA","EIA/LIA","IA","BA/IA")
> stopifnot(all(c("Site","Period","Location","d13C") %in% names(consumers)))
> consumers <- consumers %>%
+   filter(Period %in% period_order) %>%
+   mutate(Period = factor(Period, levels = period_order))

> mu_C3_emp <- -21.0
> sd_C3_emp <-  0.6
> mu_dHH <- 2.5
> sd_dHH <- 0.5
> mu_dC4 <- 12.5
> sd_dC4 <- 2.0
> sd_meas <- 0.2
> n_draws <- 100000

> pC4_from_herbivores <- function(human_d13C,
+                                 mu_C3_emp, sd_C3_emp,
+                                 mu_dHH, sd_dHH,
+                                 mu_dC4, sd_dC4,
+                                 sd_meas,
+                                 n = 100000, seed = 1){
+   set.seed(seed)
+   C3_draws  <- rnorm(n, mu_C3_emp, sd_C3_emp) + rnorm(n, mu_dHH, sd_dHH)
+   dC4_draws <- rnorm(n, mu_dC4,   sd_dC4)
+   C4_draws  <- C3_draws + dC4_draws
+
+   summarize_one <- function(x_obs){
+     x <- rnorm(n, x_obs, sd_meas)
+     swap <- C4_draws <= C3_draws
+     C3 <- C3_draws; C4 <- C4_draws
+     if (any(swap)) { tmp <- C4[swap]; C4[swap] <- C3[swap]; C3[swap] <- tmp }
+     p <- (x - C3) / (C4 - C3)
+     p <- pmax(0, pmin(1, p))
+     c(med = median(p),
+       q25 = quantile(p, 0.25), q75 = quantile(p, 0.75),
+       q025 = quantile(p, 0.025), q975 = quantile(p, 0.975))
+   }
+
+   res <- t(vapply(human_d13C, summarize_one,
+                   FUN.VALUE = c(med=0,q25=0,q75=0,q025=0,q975=0)))
+   as.data.frame(res)
+ }

> ind_res <- pC4_from_herbivores(
+   human_d13C = consumers$d13C,
+   mu_C3_emp  = mu_C3_emp, sd_C3_emp = sd_C3_emp,
+   mu_dHH     = mu_dHH,    sd_dHH    = sd_dHH,
+   mu_dC4     = mu_dC4,    sd_dC4    = sd_dC4,
+   sd_meas    = sd_meas,
+   n          = n_draws,   seed      = 1
+ ) %>%
+   mutate(`%C4_median` = 100*med,
+          `%C4_50_lo`  = 100*q25,
+          `%C4_50_hi`  = 100*q75,
+          `%C4_95_lo`  = 100*q025,
+          `%C4_95_hi`  = 100*q975) %>%
+   select(`%C4_median`, `%C4_50_lo`, `%C4_50_hi`, `%C4_95_lo`, `%C4_95_hi`)
> consumers_out <- bind_cols(consumers, ind_res)
> write_csv(consumers_out, "individual_percent_C4_posteriors_all_periods.csv")

> summarise_group <- function(df){
+   df %>%
+     summarise(
+       n = n(),
+       mean_PctC4 = mean(`%C4_median`, na.rm = TRUE),
+       mean_50_lo = mean(`%C4_50_lo`, na.rm = TRUE),
+       mean_50_hi = mean(`%C4_50_hi`, na.rm = TRUE),
+       mean_95_lo = mean(`%C4_95_lo`, na.rm = TRUE),
+       mean_95_hi = mean(`%C4_95_hi`, na.rm = TRUE)
+     )
+ }
> by_location <- consumers_out %>% group_by(Location) %>% summarise_group() %>% ungroup()
> by_period   <- consumers_out %>% group_by(Period)   %>% summarise_group() %>% ungroup()
> write_csv(by_location, "group_percent_C4_by_location_all_periods.csv")
> write_csv(by_period, "group_percent_C4_by_period_all_periods.csv")

> consumers_out <- consumers_out %>%
+   mutate(
+     flag_mixed_or_higher   = d13C >= -18,
+     flag_predominantly_C4  = d13C >= -12,
+     flag_predominantly_C4_lo = d13C >= -14
+   )
> write_csv(consumers_out, "individual_percent_C4_with_flags_all_periods.csv")

> ggplot(by_period, aes(x = Period)) +
+   geom_boxplot(
+     stat = "identity",
+     aes(ymin = mean_95_lo,
+         lower = mean_50_lo,
```

```
+        middle = mean_PctC4,
+        upper = mean_50_hi,
+        ymax = mean_95_hi)
+   ) +
+   labs(x = "Period", y = "Mean % C4 (posterior summaries)") +
+   theme_classic(base_size = 12)
> ggplot(by_period, aes(x = Period)) +

+   geom_boxplot(
+     stat = "identity",
+     aes(ymin = mean_95_lo,
+         lower = mean_50_lo,
+         middle = mean_PctC4,
+         upper = mean_50_hi,
+         ymax = mean_95_hi),
+     fill = "lightgrey", alpha = 0.5
+   ) +
+   geom_jitter(
+     data = consumers_out,
+     aes(x = Period, y = `%C4_median`),
+     width = 0.15, size = 2, alpha = 0.7, colour = "black"
+   ) +
+   labs(y = "% C4") +
+   theme_classic(base_size = 12) +
+   theme(legend.position = "none", axis.title = element_text(size
= 16),
+         axis.text  = element_text(size = 14, color = "black")
```

```
library(readr)
> library(dplyr)
> library(ggplot2)
> consumers <- read_csv("ALL_data.csv", show_col_types =
FALSE)
> period_order <- c("BA","EBA","EBA/MBA","MBA","MBA/LBA",
+                   "LBA","LBA/EIA","EIA","LIA","EIA/LIA","IA","BA/IA")

> stopifnot(all(c("Site","Period","Location","d13C","For_MIXSIAR")
%in% names(consumers)))
> consumers <- consumers %>%
+   filter(Period %in% period_order) %>%
+   mutate(Period = factor(Period, levels = period_order))

> mu_C3_emp <- -21.0
> sd_C3_emp <-  0.6
> mu_dHH <- 2.5
> sd_dHH <- 0.5
> mu_dC4 <- 12.5
> sd_dC4 <- 2.0
> sd_meas <- 0.2
> n_draws <- 100000

> pC4_from_herbivores <- function(human_d13C,
+                                 mu_C3_emp, sd_C3_emp,
+                                 mu_dHH, sd_dHH,
+                                 mu_dC4, sd_dC4,
+                                 sd_meas,
+                                 n = 100000, seed = 1){
+   set.seed(seed)
+   C3_draws  <- rnorm(n, mu_C3_emp, sd_C3_emp) + rnorm(n,
mu_dHH, sd_dHH)
+   dC4_draws <- rnorm(n, mu_dC4,   sd_dC4)
+   C4_draws  <- C3_draws + dC4_draws
+
+   summarize_one <- function(x_obs){
+     x <- rnorm(n, x_obs, sd_meas)
+     swap <- C4_draws <= C3_draws
+     C3 <- C3_draws; C4 <- C4_draws
+     if (any(swap)) { tmp <- C4[swap]; C4[swap] <- C3; C3 <- tmp }
+     p <- (x - C3) / (C4 - C3)
+     p <- pmax(0, pmin(1, p))
+     c(med = median(p),
+       q25 = quantile(p, 0.25), q75 = quantile(p, 0.75),
+       q025 = quantile(p, 0.025), q975 = quantile(p, 0.975))
+   }
+
+   res <- t(vapply(human_d13C, summarize_one,
+                   FUN.VALUE =
c(med=0,q25=0,q75=0,q025=0,q975=0)))
+   as.data.frame(res)
+ }

> ind_res <- pC4_from_herbivores(
+   human_d13C = consumers$d13C,
+   mu_C3_emp  = mu_C3_emp, sd_C3_emp = sd_C3_emp,
+   mu_dHH     = mu_dHH,    sd_dHH    = sd_dHH,
+   mu_dC4     = mu_dC4,    sd_dC4    = sd_dC4,
+   sd_meas    = sd_meas,
+   n          = n_draws,   seed      = 1
+ ) %>%
+   mutate(`%C4_median` = 100*med,
+          `%C4_50_lo`  = 100*q25,
+          `%C4_50_hi`  = 100*q75,
+          `%C4_95_lo`  = 100*q025,
+          `%C4_95_hi`  = 100*q975) %>%
+   select(`%C4_median`, `%C4_50_lo`, `%C4_50_hi`,
`%C4_95_lo`, `%C4_95_hi`)

> consumers_out <- bind_cols(consumers, ind_res)
> four_levels <- c("BA Coastal","BA Inland","IA Coastal","IA
Inland")
> consumers_out <- consumers_out %>%
+   mutate(For_MIXSIAR = factor(For_MIXSIAR, levels =
four_levels))
> summarise_group <- function(df){
+   df %>%
+     summarise(
+       n = n(),
+       mean_PctC4 = mean(`%C4_median`, na.rm = TRUE),
+       mean_50_lo = mean(`%C4_50_lo`, na.rm = TRUE),
+       mean_50_hi = mean(`%C4_50_hi`, na.rm = TRUE),
```

```
+      mean_95_lo = mean(`%C4_95_lo`, na.rm = TRUE),
+      mean_95_hi = mean(`%C4_95_hi`, na.rm = TRUE)
+    )
+ }
> by_four <- consumers_out %>%
+   group_by(For_MIXSIAR) %>%
+   summarise_group() %>%
+   ungroup()
> readr::write_csv(consumers_out,
"individual_percent_C4_posteriors_four_groups.csv")
> readr::write_csv(by_four,
"group_percent_C4_four_groups.csv")

> ggplot(by_four, aes(x = For_MIXSIAR)) +
+   geom_boxplot(
+     stat = "identity",
+     aes(ymin = mean_95_lo,
+         lower = mean_50_lo,
+         middle = mean_PctC4,
+         upper = mean_50_hi,
+         ymax = mean_95_hi),
+     width = 0.6
+   ) +
+   labs(x = NULL, y = "Mean % C4 (posterior summaries)") +
+   theme_classic(base_size = 12)

> ggplot(by_four, aes(x = For_MIXSIAR)) +
+   geom_boxplot(
+     stat = "identity",
+     aes(ymin = mean_95_lo,
+         lower = mean_50_lo,
+         middle = mean_PctC4,
+         upper = mean_50_hi,
+         ymax = mean_95_hi),
+     width = 0.6, alpha = 0.5
+   ) +
+   geom_jitter(
+     data = consumers_out,
+     aes(x = For_MIXSIAR, y = `%C4_median`),
+     width = 0.12, height = 0, size = 2, alpha = 0.7
+   ) +
+   labs(x = NULL, y = "% C4") +
+   theme_classic(base_size = 12) +
+   theme(legend.position = "none", axis.title = element_text(size
= 16),
+         axis.text  = element_text(size = 14, color = "black")
+   )
```

R code and results for one-way ANOVA + Tukey

```
> anova_c <- aov(d13C ~ Period, data = BA_MN)
> summary(anova_c)
            Df Sum Sq Mean Sq F value   Pr(>F)
Period      10  16.99  1.6994   3.993 0.000783 ***
Residuals   40  17.02  0.4256
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
> TukeyHSD(anova_c)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = d13C ~ Period, data = BA_MN)

$Period
                       diff         lwr        upr     p adj
BA/IA-BA          0.2000000 -1.72709361  2.12709361 0.9999995
EBA-BA           -0.1625000 -1.92168774  1.59668774 0.9999999
EIA-BA            0.9200000 -0.80364493  2.64364493 0.7612996
EIA/LIA-BA        1.0750000 -0.85209361  3.00209361 0.7119210
IA-BA             1.0800000 -0.64364493  2.80364493 0.5594137
LBA-BA            1.8833333 -0.14800169  3.91466836 0.0902087
LBA/EIA-BA       -0.0500000 -2.77532192  2.67532192 1.0000000
LIA-BA           -0.2000000 -2.42521603  2.02521603 0.9999999
MBA-BA            0.8500000 -0.96688128  2.66688128 0.8748462
MBA/LBA-BA        0.9500000 -1.77532192  3.67532192
0.9801860
EBA-BA/IA        -0.3625000 -1.72516096  1.00016096 0.9975021
EIA-BA/IA         0.7200000 -0.59645556  2.03645556 0.7347006
EIA/LIA-BA/IA     0.8750000 -0.69846535  2.44846535
0.7155889
IA-BA/IA          0.8800000 -0.43645556  2.19645556 0.4660931
LBA-BA/IA         1.6833333 -0.01620348  3.38287015 0.0541497
LBA/EIA-BA/IA    -0.2500000 -2.73786716  2.23786716
0.9999997
LIA-BA/IA        -0.4000000 -2.32709361  1.52709361 0.9996993
MBA-BA/IA         0.6500000 -0.78637077  2.08637077 0.8956648
MBA/LBA-BA/IA     0.7500000 -1.73786716  3.23786716
0.9932451
EIA-EBA           1.0825000  0.02698736  2.13801264 0.0402354
EIA/LIA-EBA       1.2375000 -0.12516096  2.60016096 0.1043986
IA-EBA            1.2425000  0.18698736  2.29801264 0.0101456
LBA-EBA           2.0458333  0.53935496  3.55231171 0.0016879
LBA/EIA-EBA       0.1125000 -2.24769802  2.47269802
1.0000000
LIA-EBA          -0.0375000 -1.79668774  1.72168774 1.0000000
MBA-EBA           1.0125000 -0.18925401  2.21425401 0.1682599
MBA/LBA-EBA       1.1125000 -1.24769802  3.47269802
0.8697357
EIA/LIA-EIA       0.1550000 -1.16145556  1.47145556 0.9999985
IA-EIA            0.1600000 -0.83514686  1.15514686 0.9999704
LBA-EIA           0.9633333 -0.50148319  2.42814985 0.4898164
LBA/EIA-EIA      -0.9700000 -3.30382626  1.36382626 0.9365776
LIA-EIA          -1.1200000 -2.84364493  0.60364493 0.5072630
MBA-EIA          -0.0700000 -1.21909662  1.07909662 1.0000000
MBA/LBA-EIA       0.0300000 -2.30382626  2.36382626
1.0000000
IA-EIA/LIA        0.0050000 -1.31145556  1.32145556 1.0000000
LBA-EIA/LIA       0.8083333 -0.89120348  2.50787015 0.8634005
LBA/EIA-EIA/LIA  -1.1250000 -3.61286716  1.36286716
0.8960950
LIA-EIA/LIA      -1.2750000 -3.20209361  0.65209361 0.4810663
```

```
MBA-EIA/LIA     -0.2250000 -1.66137077  1.21137077
0.9999768
MBA/LBA-EIA/LIA -0.1250000 -2.61286716  2.36286716
1.0000000
LBA-IA          0.8033333 -0.66148319  2.26814985 0.7316150
LBA/EIA-IA      -1.1300000 -3.46382626  1.20382626 0.8501588
LIA-IA         -1.2800000 -3.00364493  0.44364493 0.3169484
MBA-IA         -0.2300000 -1.37909662  0.91909662 0.9997823
MBA/LBA-IA     -0.1300000 -2.46382626  2.20382626
1.0000000
LBA/EIA-LBA    -1.9333333 -4.50279148  0.63612482
0.2994747
LIA-LBA        -2.0833333 -4.11466836 -0.05199831 0.0402250
MBA-LBA        -1.0333333 -2.60679868  0.54013201 0.4918572
MBA/LBA-LBA    -0.9333333 -3.50279148  1.63612482
0.9735912
LIA-LBA/EIA    -0.1500000 -2.87532192  2.57532192 1.0000000
MBA-LBA/EIA     0.9000000 -1.50350802  3.30350802
0.9675360
MBA/LBA-LBA/EIA  1.0000000 -2.14693069  4.14693069
0.9899124
MBA-LIA         1.0500000 -0.76688128  2.86688128 0.6685876
MBA/LBA-LIA     1.1500000 -1.57532192  3.87532192
0.9304710
MBA/LBA-MBA     0.1000000 -2.30350802  2.50350802
1.0000000

> anova_n <- aov(d15N ~ Period, data = BA_MN)
> summary(anova_n)
          Df Sum Sq Mean Sq F value Pr(>F)
Period      10  15.92  1.5919   1.617  0.137
Residuals   40  39.37  0.9842
> TukeyHSD(anova_n)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = d15N ~ Period, data = BA_MN)

$Period
                  diff       lwr       upr     p adj
BA/IA-BA        1.8750000 -1.0554312 4.8054312 0.5295260
EBA-BA          1.0375000 -1.6376055 3.7126055 0.9590468
EIA-BA          1.2400000 -1.3810574 3.8610574 0.8671800
EIA/LIA-BA      1.6500000 -1.2804312 4.5804312 0.7008112
IA-BA           1.4700000 -1.1510574 4.0910574 0.7055381
LBA-BA          2.1333333 -0.9556124 5.2222790 0.4187276
LBA/EIA-BA      0.3000000 -3.8442556 4.4442556 1.0000000
LIA-BA         -0.2000000 -3.5837705 3.1837705 1.0000000
MBA-BA          1.9000000 -0.8628370 4.6628370 0.4248854
MBA/LBA-BA      1.8000000 -2.3442556 5.9442556 0.9174682
EBA-BA/IA      -0.8375000 -2.9096278 1.2346278 0.9466654
EIA-BA/IA      -0.6350000 -2.6368656 1.3668656 0.9900464
EIA/LIA-BA/IA   -0.2250000 -2.6176871 2.1676871 0.9999998
IA-BA/IA       -0.4050000 -2.4068656 1.5968656 0.9997605
LBA-BA/IA       0.2583333 -2.3260641 2.8427307 0.9999997
LBA/EIA-BA/IA   -1.5750000 -5.3581704 2.2081704 0.9359304
LIA-BA/IA      -2.0750000 -5.0054312 0.8554312 0.3829486
MBA-BA/IA       0.0250000 -2.1592145 2.2092145 1.0000000
MBA/LBA-BA/IA   -0.0750000 -3.8581704 3.7081704 1.0000000
EIA-EBA         0.2025000 -1.4025633 1.8075633 0.9999970
EIA/LIA-EBA     0.6125000 -1.4596278 2.6846278 0.9942015
IA-EBA          0.4325000 -1.1725633 2.0375633 0.9972266
LBA-EBA         1.0958333 -1.1949901 3.3866568 0.8592402
LBA/EIA-EBA     -0.7375000 -4.3265306 2.8515306 0.9997249
LIA-EBA        -1.2375000 -3.9126055 1.4376055 0.8822214
MBA-EBA         0.8625000 -0.9649449 2.6899449 0.8688367
MBA/LBA-EBA     0.7625000 -2.8265306 4.3515306 0.9996308
EIA/LIA-EIA     0.4100000 -1.5918656 2.4118656 0.9997329
IA-EIA          0.2300000 -1.2832682 1.7432682 0.9999825
LBA-EIA         0.8933333 -1.3341371 3.1208038 0.9492096
LBA/EIA-EIA     -0.9400000 -4.4889284 2.6089284 0.9975895
LIA-EIA        -1.4400000 -4.0610574 1.1810574 0.7295920
MBA-EIA         0.6600000 -1.0873716 2.4073716 0.9656000
MBA/LBA-EIA     0.5600000 -2.9889284 4.1089284 0.9999752
IA-EIA/LIA     -0.1800000 -2.1818656 1.8218656 0.9999999
LBA-EIA/LIA     0.4833333 -2.1010641 3.0677307 0.9998817
LBA/EIA-EIA/LIA -1.3500000 -5.1331704 2.4331704 0.9766453
LIA-EIA/LIA     -1.8500000 -4.7804312 1.0804312 0.5487376
MBA-EIA/LIA     0.2500000 -1.9342145 2.4342145 0.9999988
MBA/LBA-EIA/LIA  0.1500000 -3.6331704 3.9331704 1.0000000
LBA-IA          0.6633333 -1.5641371 2.8908038 0.9938559
LBA/EIA-IA      -1.1700000 -4.7189284 2.3789284 0.9867456
LIA-IA         -1.6700000 -4.2910574 0.9510574 0.5355743
MBA-IA          0.4300000 -1.3173716 2.1773716 0.9986913
MBA/LBA-IA      0.3300000 -3.2189284 3.8789284 0.9999998
LBA/EIA-LBA     -1.8333333 -5.7405749 2.0739083 0.8728596
LIA-LBA        -2.3333333 -5.4222790 0.7556124 0.2943356
MBA-LBA        -0.2333333 -2.6260204 2.1593537 0.9999997
MBA/LBA-LBA     -0.3333333 -4.2405749 3.5739083 0.9999999
LIA-LBA/EIA     -0.5000000 -4.6442556 3.6442556 0.9999980
MBA-LBA/EIA     1.6000000 -2.0548899 5.2548899 0.9135984
MBA/LBA-LBA/EIA  1.5000000 -3.2853741 6.2853741
0.9908994
MBA-LIA         2.1000000 -0.6628370 4.8628370 0.2862605
MBA/LBA-LIA     2.0000000 -2.1442556 6.1442556 0.8526646
MBA/LBA-MBA     -0.1000000 -3.7548899 3.5548899 1.0000000
```

R code for Two-way ANOVA and Kruskal-Wallis tests

```
> aov_d13C <- aov(d13C ~ Period * Location, data = df)
> summary(aov_d13C)
            Df Sum Sq Mean Sq F value Pr(>F)
Period          11 263.51   23.96   30.80 <2e-16 ***
Location         1  74.27   74.27   95.50 <2e-16 ***
Period:Location   6  85.25   14.21   18.27 <2e-16 ***
Residuals      265 206.08    0.78
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

> kruskal.test(d13C ~ interaction(Period, Location), data = df)
```

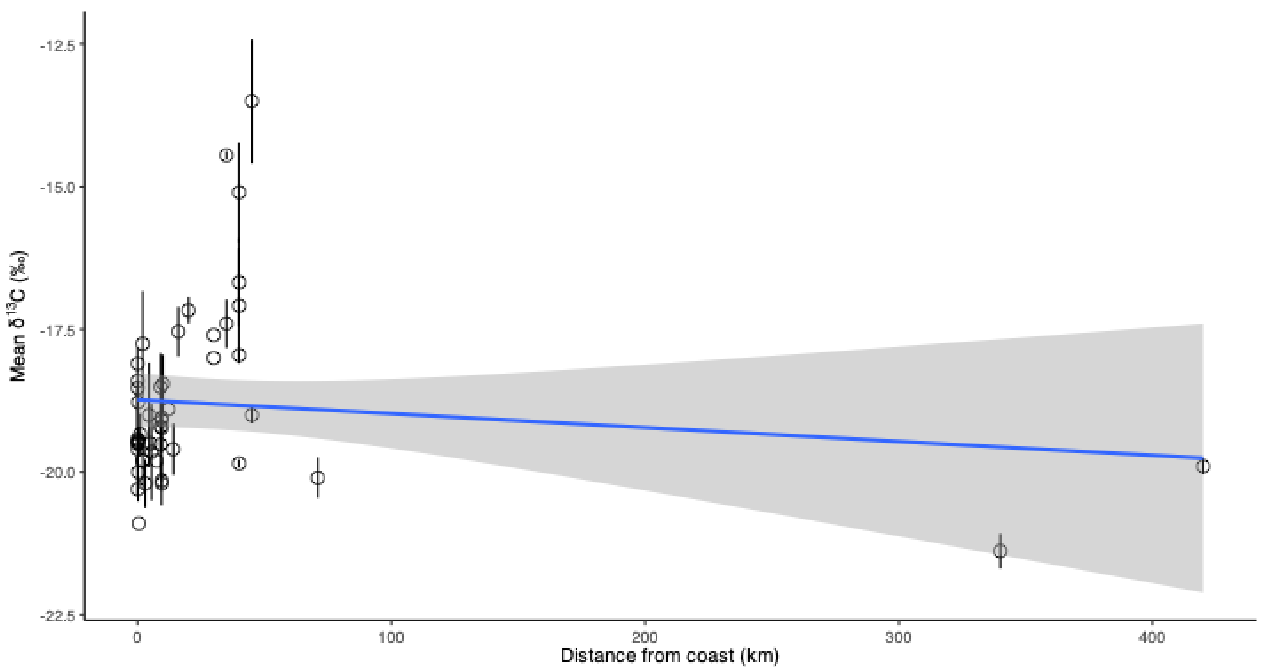
```
        Kruskal-Wallis rank sum test

data:  d13C by interaction(Period, Location)
Kruskal-Wallis chi-squared = 192.9, df = 18, p-value < 2.2e-16

> aov_d15N <- aov(d15N ~ Period * Location, data = df)
> summary(aov_d15N)
                 Df Sum Sq Mean Sq F value   Pr(>F)
Period           11  37.92   3.448   4.139 1.22e-05 ***
Location          1   0.00   0.002   0.002 0.965862
Period:Location   6  22.66   3.777   4.534 0.000214 ***
Residuals       265 220.75   0.833
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
> kruskal.test(d15N ~ interaction(Period, Location), data = df)

        Kruskal-Wallis rank sum test

data:  d15N by interaction(Period, Location)
Kruskal-Wallis chi-squared = 77.022, df = 18, p-value = 2.829e-09

> pairwise.wilcox.test(df$d13C, interaction(df$Period,
df$Location), p.adjust.method = "BH")

        Pairwise comparisons using Wilcoxon rank sum test
with continuity correction

data:  df$d13C and interaction(df$Period, df$Location)

     BA.Coast BA/IA.Coast EBA.Coast EBA/MBA.Coast
EIA.Coast EIA/LIA.Coast IA.Coast LBA.Coast LBA/EIA.Coast
LIA.Coast MBA.Coast
BA/IA.Coast    0.27416 -        -       -         -       -         -
-       -         -       -
EBA.Coast      0.19650  0.94969     -       -         -       -         -
-       -         -       -
EBA/MBA.Coast  0.03111  0.15110     0.20879   -         -       -
-       -       -         -       -
EIA.Coast      0.02808  0.03524     0.02432   0.02170     -       -
-       -       -         -       -
EIA/LIA.Coast  0.07463  0.04097     0.06758   0.04022
0.74991   -         -       -       -         -       -
IA.Coast       0.02612  0.01486     0.00701   0.00205     0.06758
0.19516     -       -       -         -       -
LBA.Coast      0.00284  0.01146     0.01234   0.01125
0.82113   0.31827     0.01125 -       -         -       -
LBA/EIA.Coast  0.00017  0.00443     0.00376   0.00860
0.16019   0.04022     3.6e-05  0.04380   -         -       -
LIA.Coast      0.40376  0.07895     0.04186   0.00962     0.04097
0.04079     0.09197  0.00423   0.00146     -       -
MBA.Coast      0.24023  0.14912     0.13214   0.04097
0.37286   0.72851     0.96522  0.20879   0.01486     0.56271   -
MBA/LBA.Coast  0.11882  0.24140     0.52232   0.80352
0.03975   0.06169     0.02787  0.02612   0.00860     0.09655
0.07755
BA.Inland      0.34531  0.91422     1.00000   0.30085     0.14644
0.18689     0.05493  0.07441   0.09268     0.07534   0.34406
BA/IA.Inland   0.15962  0.24140     0.25950   0.38776
0.81919   0.45600     0.14912  0.32673   1.00000     0.20628
0.34406
EBA.Inland     0.00146  0.05082     0.03663   0.32673
0.00162   0.01486     2.5e-06  0.00114   0.00046     0.00017
0.01125
EIA.Inland     0.00185  0.01125     0.00860   0.00805     0.15781
0.15944     0.00173  0.13214   0.72851     0.00171   0.04380
IA.Inland      0.00860  0.03059     0.01485   0.04022     0.04721
0.05748     0.00567  0.04022   0.14912     0.01241   0.02808
LIA.Inland     0.04967  0.09389     0.06025   0.14805     0.07004
0.18689     0.04022  0.07441   0.06057     0.05082   0.11745
MBA/LBA.Inland 2.1e-10  0.00033     7.2e-05   0.00185
0.00185   0.00567     < 2e-16  0.00090   0.04022     7.0e-08
0.00171
     MBA/LBA.Coast BA.Inland BA/IA.Inland EBA.Inland
EIA.Inland IA.Inland LIA.Inland
BA/IA.Coast    -          -       -         -       -       -       -
EBA.Coast      -          -       -         -       -       -       -
EBA/MBA.Coast  -          -       -         -       -       -       -
EIA.Coast      -          -       -         -       -       -       -
EIA/LIA.Coast  -          -       -         -       -       -       -
IA.Coast       -          -       -         -       -       -       -
LBA.Coast      -          -       -         -       -       -       -
LBA/EIA.Coast  -          -       -         -       -       -       -
LIA.Coast      -          -       -         -       -       -       -
MBA.Coast      -          -       -         -       -       -       -
MBA/LBA.Coast  -          -       -         -       -       -       -
BA.Inland      0.43720    -       -         -       -       -       -
BA/IA.Inland   0.38776      0.72851   -         -       -       -       -
EBA.Inland     0.19398      0.22124   0.19449     -       -       -
-
EIA.Inland     0.02612      0.07755   1.00000     0.00185   -
-       -
IA.Inland      0.04022      0.18689   0.83415     0.01486
0.95441   -       -
LIA.Inland     0.14805      0.38776   0.72851     0.06758
0.83233   0.20893   -
MBA/LBA.Inland 0.00185      0.04097   0.61335     2.5e-06
0.74991   0.15781   0.04380

P value adjustment method: BH

> pairwise.wilcox.test(df$d15N, interaction(df$Period,
df$Location), p.adjust.method = "BH")

        Pairwise comparisons using Wilcoxon rank sum test
with continuity correction

data:  df$d15N and interaction(df$Period, df$Location)

     BA.Coast BA/IA.Coast EBA.Coast EBA/MBA.Coast
EIA.Coast EIA/LIA.Coast IA.Coast LBA.Coast LBA/EIA.Coast
LIA.Coast MBA.Coast
```

```
BA/IA.Coast   0.6388  -      -      -      -      -      -      -
-      -      -
EBA.Coast     0.9227  0.8401  -      -      -      -      -
-      -      -      -
EBA/MBA.Coast 0.8497  0.6853   0.9681  -      -      -
-      -      -      -      -
EIA.Coast     0.4498  0.8720   0.5533  0.5143  -      -
-      -      -      -      -
EIA/LIA.Coast 0.1875  0.5143   0.1875  0.1777   0.4342
-      -      -      -      -      -
IA.Coast      0.0011  0.4379   0.0091  0.0342   0.1845
0.9262   -      -      -      -      -
LBA.Coast     0.1320  0.4157   0.1777  0.1777   0.4379
0.9681   0.8991  -      -      -      -
LBA/EIA.Coast 0.8642  0.5705   0.4379  0.4282   0.8578
0.1799   0.0011  0.1553  -      -      -
LIA.Coast     0.8265  0.5143   0.9104  0.9681   0.4111
0.1845   0.0011  0.1320  0.5830  -      -
MBA.Coast     0.1320  0.3021   0.1777  0.1571   0.3038
0.7832   0.4379  0.7832  0.1320   0.1320  -
MBA/LBA.Coast 1.0000  0.6853   0.9104  0.9079   0.6098
0.2952   0.1320  0.2305  0.8480   0.9188  0.1777
BA.Inland     0.2264  0.2952   0.1777  0.2305   0.1777
0.2850   0.1320  0.1777  0.1765   0.3021  0.1939
BA/IA.Inland  0.2974  0.4111   0.4157  0.4524   0.4111
0.5143   0.3355  0.4157  0.2813   0.2570  0.9104
EBA.Inland    0.0488  0.1571   0.1320  0.1320   0.1777
0.4010   0.2106  0.3047  0.1320   0.0273  0.4324
EIA.Inland    0.3047  0.4713   0.2315  0.3729   0.1845
0.1777   0.0273  0.1343  0.1777   0.4524  0.1629
IA.Inland     0.2570  0.2201   0.3021  0.4157   0.1875
0.1845   0.0771  0.1320  0.2305   0.2994  0.1553
LIA.Inland    0.2106  0.3838   0.1875  0.2621   0.1845
0.2850   0.1320  0.1777  0.2047   0.3021  0.1939
MBA/LBA.Inland 0.3291 0.9104   0.3852  0.4157   0.9681
0.4524   0.0488  0.3174  0.4157   0.1939  0.2453
         MBA/LBA.Coast BA.Inland BA/IA.Inland EBA.Inland
EIA.Inland IA.Inland LIA.Inland
BA/IA.Coast   -      -      -      -      -      -      -
EBA.Coast     -      -      -      -      -      -      -
EBA/MBA.Coast -      -      -      -      -      -      -
EIA.Coast     -      -      -      -      -      -      -
EIA/LIA.Coast -      -      -      -      -      -      -
IA.Coast      -      -      -      -      -      -      -
LBA.Coast     -      -      -      -      -      -      -
LBA/EIA.Coast -      -      -      -      -      -      -
LIA.Coast     -      -      -      -      -      -      -
MBA.Coast     -      -      -      -      -      -      -
MBA/LBA.Coast -      -      -      -      -      -      -
BA.Inland     0.3393     -      -      -      -      -      -
BA/IA.Inland  0.4524     0.7832  -      -      -      -      -
EBA.Inland    0.1741     0.1571  0.7832  -      -      -
-
EIA.Inland    0.4569     0.4342  0.4524   0.1073  -      -
-
IA.Inland     0.4157     1.0000  0.4222   0.1320  0.6098
-      -
LIA.Inland    0.3393     1.0000  0.7832   0.1571  0.5495
0.8984  -
MBA/LBA.Inland 0.5143    0.1777  0.3817   0.1320
0.1777   0.1571  0.1875

P value adjustment method: BH
```

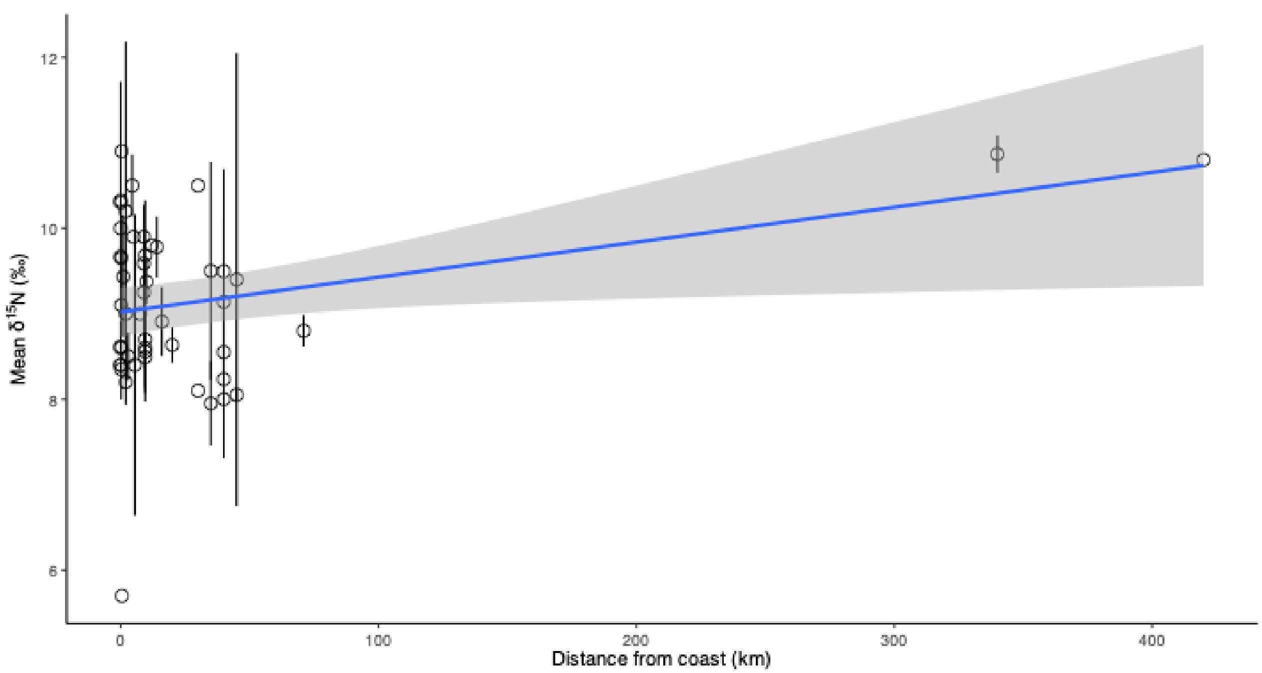
Linear regression analysis (isotope values vs distance from the coast per site)

```
> lm_d13C <- lm(mean_d13C ~ km_from_coast, data = km)
> summary(lm_d13C)

Call:
lm(formula = mean_d13C ~ km_from_coast, data = km)

Residuals:
    Min      1Q  Median      3Q     Max
-2.1660 -0.9038 -0.4453  0.6328  5.3424

Coefficients:
               Estimate Std. Error t value Pr(>|t|)
(Intercept)   -18.732755   0.235991 -79.379   <2e-16 ***
km_from_coast  -0.002437   0.002942  -0.828    0.412
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.538 on 47 degrees of freedom
Multiple R-squared:  0.01439,     Adjusted R-squared:  -0.006582
F-statistic: 0.6861 on 1 and 47 DF,  p-value: 0.4117

> lm_d15N <- lm(mean_d15N ~ km_from_coast, data = km)
> summary(lm_d15N)

Call:
lm(formula = mean_d15N ~ km_from_coast, data = km)

Residuals:
    Min      1Q  Median      3Q     Max
-3.3213 -0.5658 -0.0275  0.6299  1.8791

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)   9.019293   0.141370  63.799   <2e-16 ***
km_from_coast 0.004086   0.001762   2.318   0.0248 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.9216 on 47 degrees of freedom
Multiple R-squared:  0.1026,      Adjusted R-squared:  0.08353
F-statistic: 5.375 on 1 and 47 DF,  p-value: 0.02483
```

(graphs in the next page)



Mean δ13C (‰)
-12.5
-15.0
-17.5
-20.0
-22.5
0
100
200
300
400
Distance from coast (km)



Mean δ15N (‰)
12
10
8
6
0
100
200
300
400
Distance from coast (km)