**Supplementary material to:**

**Wet and dry seasons modulate coastal coccolithophore dynamics off Southwestern Nigeria (Gulf of Guinea)**

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1. Carbonate chemistry variables

Seawater samples for carbonate chemistry analysis were carefully collected from the Niskin bottle into acid-washed 250ml borosilicate glass bottles and poisoned with 50µl saturated HgCl2 solution, as recommended by Dickson et al. (2007). Measurement of samples was performed at the Inorganic Chemical Oceanography (INOCEN) laboratory from the Instituto Español de Oceanografía (IEO-CSIC), Spain. All measurements were done within six months after sampling. While TA and DIC measurements were carried out on 2018 to 2020 samples, TA and pH measurements were performed on 2021 samples due to equipment failure. Derived carbonate system parameters were calculated with the CO2Sys package for MS Excel (Pierrot et al. 2006) using the combination of TA – DIC (2019) or TA – pH (2021) and ancillary data for temperature, salinity and inorganic nutrients. The set of carbonic acid apparent dissociation constants (K1 and K2) of Mehrbach et al. (1973) refitted by Dickson and Millero (1987), the KSO4 constants of Dickson (1990), and the borate constants of Uppström (1974) were chosen.

The DIC measurements were performed through a coulometric determination using a VINDTA 3D system coupled with a UIC 5011 coulometer. The accuracy of DIC measurements was ±2.0 µmol kg-1 as assessed by using Certified Reference Material (CRM, batch #177, DIC = 2067.67 ± 0.44 µmol kg-1) provided by Prof. Andrew Dickson, Scripps Institution of Oceanography, USA.TA was analysed following a double end point potentiometric technique by Pérez and Fraga (1987) further improved in Pérez et al. (2000) using an automatic potentiometric titrator Titrando 909 Metrohm, with a Metrohm Aquatrode Plus and a Pt-1000 probe to monitor the temperature. We used Certified Reference Material (CRM, batch #190, TA = 2218.3 ± 0.77 µmol kg-1) provided by Prof. Andrew Dickson, Scripps Institution of Oceanography, USA, for calibration. The overall analytical precision was ±2 µmol kg-1. In addition to the CRM calibration, an extra drift control was conducted by analyzing an in-house seawater substandard at the beginning and at the end of each analysis session.

Seawater pH was measured using a spectrophotometric procedure (Byrne, 1987), following the methodology described by Clayton and Byrne (1993). The indicator used for measuring absorbance (λA) was a solution of unpurified m-cresol purple (UNPUR mCP, Sigma Aldrich) prepared in NaCl (2 mM). Dry cylindrical optical glass 10-cm pathlength cells were filled to overflowing with the sample seawater and immediately stoppered. Cells were immediately stabilized at 25°C. All the absorbance measurements (λA) were obtained in the thermostatted cell compartment (25±0.2 ºC) of a SHIMADZU UV-2600 double beam spectrophotometer with a bandwidth of 1 nm. The temperature was controlled with a JULABO (12L) thermostatic bath. Assessment with Tris buffers and replicate analysis gave an overall analytical accuracy and precision of ±0.002 pH units. pH data is presented on the total scale for in situ cnditions.

1. Global coastal coccolithophore standing stocks analysis

Two datasets were used to extract coccolithophore standing stocks: de Vries et al. (2020) and O’Brien (2012). Before processing, the data were organized by station ID, geographic coordinates (latitude and longitude), water depth at which samples were collected, and standing stock values (cells/L). Samples missing one or more of these parameters were excluded, and duplicates were removed. Once the dataset was prepared, it was processed using RStudio (v4.3.1; RStudio Team, 2020). The following R packages were used: readxl (Wickham and Bryan, 2025), tidyverse (Wickham et al., 2019), raster (Hijmans, 2025), sf (Pebesma and Bivand, 2023; Pebesma, 2018), ncdf4 (Pierce, 2025), rnaturalearth (Massicotte and South, 2025), rnaturalearthdata (South et al., 2025), units (Pebesma et al., 2016), geosphere (Hijmans, 2024), and lwgeom (Pebesma, 2025). Bathymetry data were obtained from the GEBCO\_2024 Grid (sub-ice topo/bathy) dataset (GEBCO Compilation Group, 2024), and coastline boundaries were derived from the IHO Sea Areas dataset, version 3 (Flanders Marine Institute, 2018).

Here is the script that was used:

# Install necessary packages (run only once, skip if already installed)

install.packages(c("readxl", "tidyverse", "raster", "sf", "ncdf4",

"rnaturalearth", "rnaturalearthdata", "units",

"geosphere", "lwgeom"))

# Load libraries

library(readxl)

library(tidyverse)

library(raster)

library(sf)

library(ncdf4)

library(rnaturalearth)

library(rnaturalearthdata)

library(units)

library(geosphere)

library(lwgeom)

# Load dataset that contains coccolithophore standing stocks along with station ID, coordinates and depth

df <- read\_excel("C:/Coccolithophore\_Standing\_Stocks.xlsx")

# Filter out rows with missing coordinates (important for sf conversion)

df <- df %>%

filter(!is.na(Longitude), !is.na(Latitude)) %>%

filter(between(Longitude, -180, 180), between(Latitude, -90, 90))

# Load GEBCO bathymetry raster to retrieve seafloor depth from coordinates

bathy <- raster("C:/gebco\_2024\_sub\_ice\_topo/gebco\_2024\_sub\_ice\_topo.nc")

# Unique station coordinates

stations <- df %>%

distinct(StationID, Latitude, Longitude)

# Convert to spatial object

stations\_sf <- st\_as\_sf(stations, coords = c("Longitude", "Latitude"), crs = 4326, remove = FALSE)

# Extract bathymetry

stations$WaterDepth <- raster::extract(bathy, stations\_sf)

# Merge bathymetry with full dataframe

df\_with\_depth <- left\_join(df, stations, by = "StationID")

# Download coastline (natural earth)

coastline <- ne\_download(scale = 10, type = "coastline", category = "physical", returnclass = "sf")

# Re-create stations\_sf for distance calc (with .x columns)

stations\_sf <- st\_as\_sf(df\_with\_depth, coords = c("Longitude.x", "Latitude.x"), crs = 4326, remove = FALSE)

# Compute distance to nearest coastline

dist\_matrix <- st\_distance(stations\_sf, coastline)

df\_with\_depth$DistanceToCoast\_km <- apply(dist\_matrix, 1, min) / 1000 # km

# Save intermediate output

write\_csv(df\_with\_depth, "C:/data\_with\_bathymetry\_and\_distance.csv")

# Disable s2 for spatial join (avoids geometry errors in some shapefiles)

sf\_use\_s2(FALSE)

# Load and process ocean basins shapefile

basins\_raw <- st\_read("C:/World\_Seas\_IHO\_v3.shp")

# Ensure geometries are valid and projected

basins <- basins\_raw %>%

st\_make\_valid() %>%

st\_collection\_extract("POLYGON") %>%

st\_transform(4326)

# Ensure clean spatial object for join (with same coordinate column names)

stations <- df\_with\_depth %>%

distinct(StationID, Longitude.x, Latitude.x)

stations\_sf <- st\_as\_sf(stations, coords = c("Longitude.x", "Latitude.x"), crs = 4326, remove = FALSE)

# Perform spatial join with IHO basins

stations\_with\_basin <- st\_join(stations\_sf, basins["NAME"])

# Merge basin names into full dataframe

df\_final <- left\_join(df\_with\_depth, st\_drop\_geometry(stations\_with\_basin), by = "StationID")

# Save final result with depth, coast distance, and ocean basin

write\_csv(df\_final, "C:/data\_with\_bathymetry\_distance\_basins.csv")

1. Principal Component Analysis (PCA)

The PCA between the environmental parameters and the coccolithophore data was conducted with RStudio (v4.3.1, RStudio Team, 2020). The packages FactoMineR (Le et al. 2008) and Factoextra (Kassambra and Mundt, 2020) were used to process the data.

Here is the script that was used:

# Load required libraries for PCA and visualization

library(FactoMineR)

library(factoextra)

# Read and process dataset: All samples combined

PCA\_All <- read\_excel("C:/PCA\_All.xlsx") # Read complete dataset

PCA\_All.active <- PCA\_All[1:75, 2:15] # Select active variables (rows 1–75, columns 2–15)

res.PCA\_All <- PCA(PCA\_All.active, graph = FALSE)

fviz\_eig(res.PCA\_All, addlabel = TRUE, main = "PCA\_All", ylim = c(0, 60))

fviz\_pca\_biplot(res.PCA\_All, col.var = "purple")

# Read and process dataset: Dry season samples

PCA\_Dry <- read\_excel("J:/PCA\_Dry.xlsx ") # Read dry season dataset

PCA\_Dry.active <- PCA\_Dry[1:44, 2:15] # Select active variables (rows 1–44, columns 2–15)

res.PCA\_Dry <- PCA(PCA\_Dry.active, graph = FALSE)

fviz\_eig(res.PCA\_Dry, addlabel = TRUE, main = "PCA\_Dry", ylim = c(0, 60))

fviz\_pca\_var(res.PCA\_Dry, col.var = "brown")

# Read and process dataset: Wet season samples

PCA\_Wet <- read\_excel("J:/GoG/PCA\_Wet.xlsx ") # Read wet season dataset

PCA\_Wet.active <- PCA\_Wet[1:33, 2:15] # Select active variables (rows 1–33, columns 2–15)

res.PCA\_Wet <- PCA(PCA\_Wet.active, graph = FALSE)

fviz\_eig(res.PCA\_Wet, addlabel = TRUE, main = "PCA\_Wet", ylim = c(0, 60))

fviz\_pca\_var(res.PCA\_Wet, col.var = "blue")

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