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Investigating the trophic status of particles in surface water from contrasting nearshore-offshore transects

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Background.

In recent years, the characterization of particulate organic matter (POM) using compound-specific isotopic analysis of amino acids (CSIA-AA) has increased. From this measurement, the calculated trophic position (TP) of particles has been interpreted as a reflection of the relative contribution of autotrophic and heterotrophic biomass to particles. In some cases, the trophic position of particles has been found to increase between the near-surface and the upper mesopelagic. This pattern indicates an increasing contribution of heterotrophic biomass with depth but also suggests an overwhelming predominance of autotrophic biomass in near-surface waters, despite heterotrophic cells also being abundant. Here we examine the trophic position of particulate matter from the ocean surface in more detail, covering a range of productivity and ecosystem structure along two nearshore-offshore transects: a warm subtropical platform incised by a deep channel (southeast Florida) and a mid-latitude upwelling zone (southern California Bight). For comparison, we examine other recently described indicators for the sources and alteration of POM and plan to examine carbon isotopic indicators for the potential influence of terrigenous material, as well as cell counts for the relative abundance of photoautotrophic and heterotrophic cells.

Methods.

We collected POM from surface water from two contrasting oceanographic locations using underway shipboard seawater systems along nearshore-offshore transects conducted on R/V F.G. Walton Smith off of southeast Florida and R/V Sally Ride off of southern California, both in October 2023. Using inline filter holders, particles were filtered from approximately 20-200 L of seawater onto glass fiber filters, some with PETE prefilters (Table 1). Filters were freeze-dried and split quantitatively for each analysis. Dried filters were inspected under a dissecting microscope, and any intact zooplankton were removed.

We measured bulk $\delta^{15}N$ values and total nitrogen concentration using a Thermo Flash EA coupled to a MAT 253 Plus isotope ratio mass spectrometer (IRMS). We estimated trophic position and other indicators of degradative status of surface POM using nitrogen compound-specific isotope analysis (CSIA) of amino acids (AA). A Thermo Trace 1310 Gas Chromatograph was coupled to the same IRMS for CSIA. Methods were identical to those described by Wojtal et al. (2023).

Table 1.

Location	Oceanographic setting	Size fraction	Filter diameter
Southeast Florida	Warm subtropical Platform	>0.3µm	47mm
Southern California Bight	Mid-latitude upwelling zone	0.3-5µm, >5µm	150mm

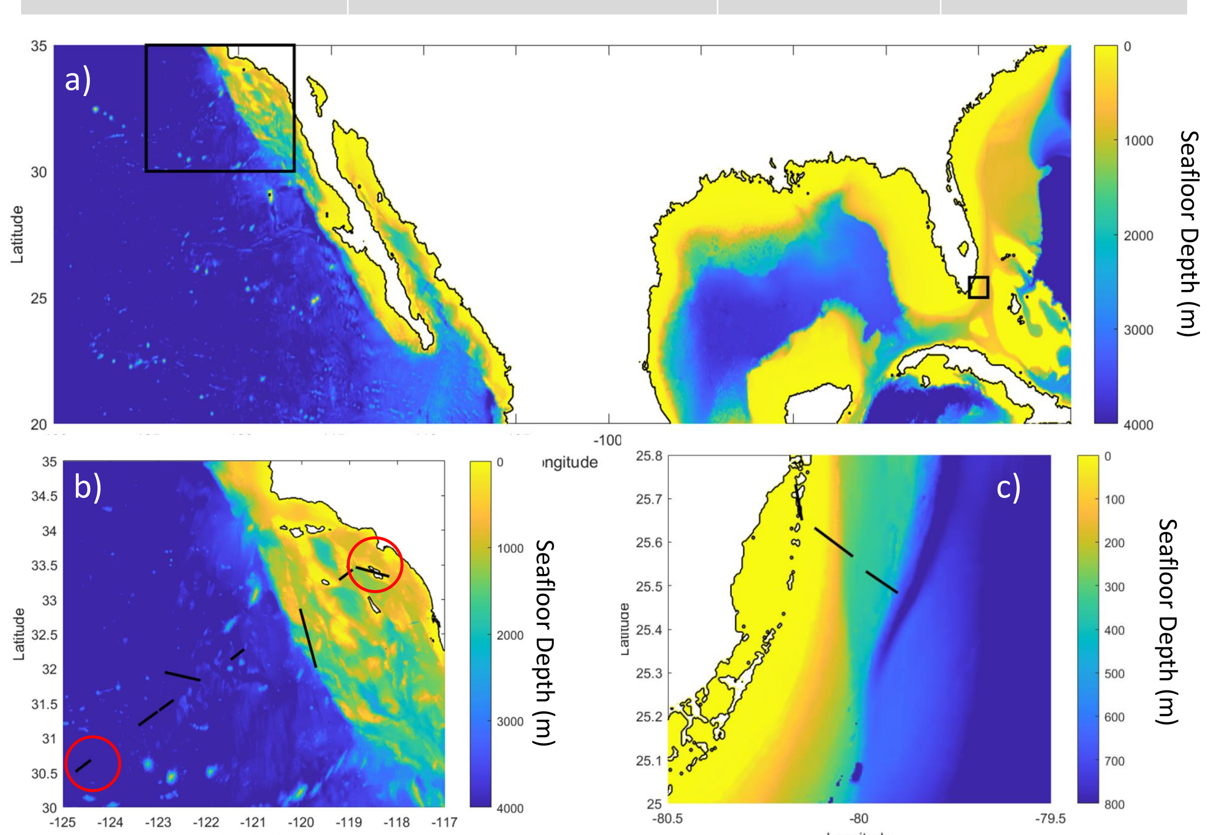

Figure 1. Sampling locations. Locations relative to North and Central America (black boxes; a). Location of individual underway sampling segments (black lines; b,c). Segments selected for analysis indicated with red circles (b). Background shading indicates seafloor depth; note different scale bars for (b) and (c).

Results & Interpretation.

Baseline N isotopes and concentrations

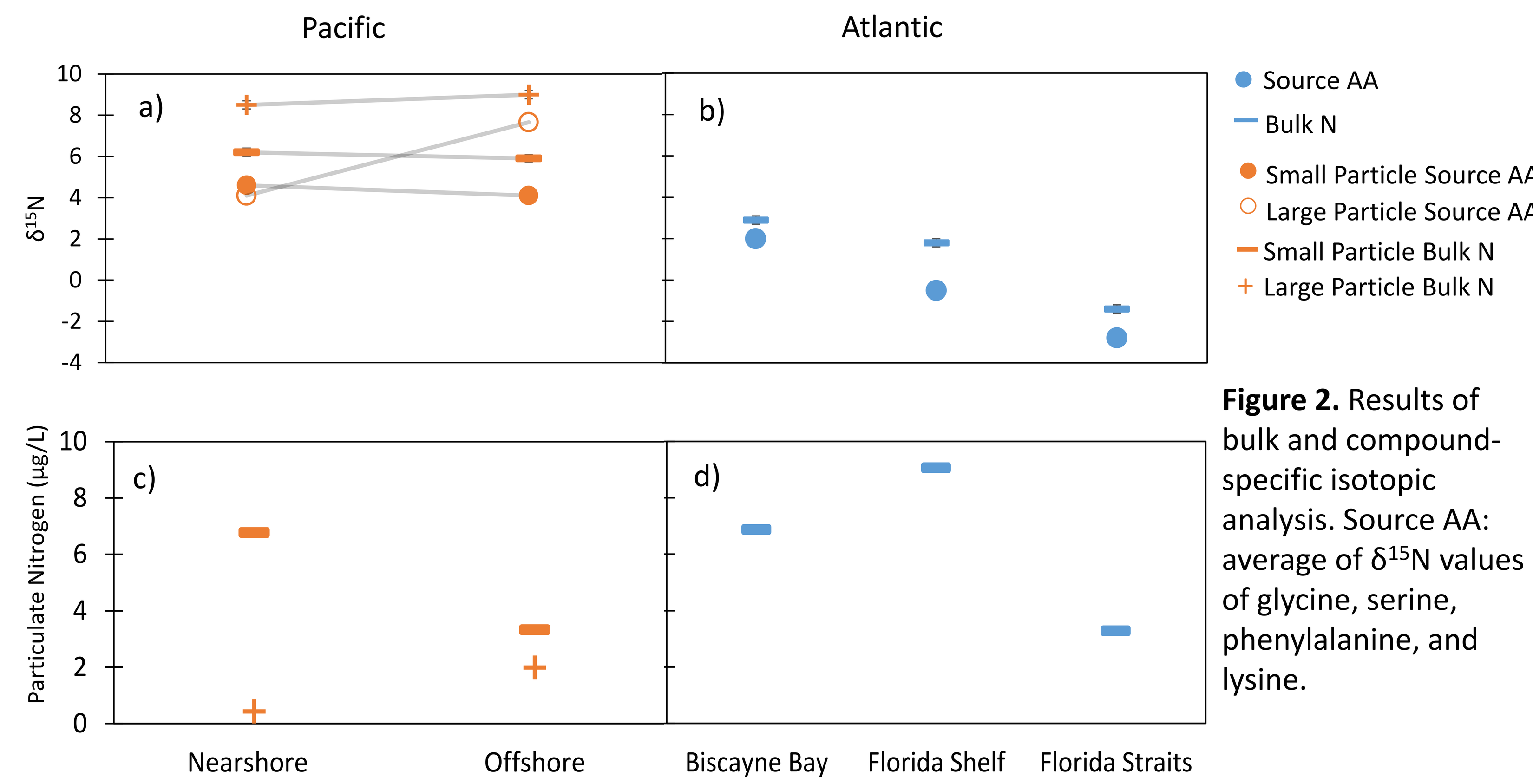

Figure 2. Results of bulk and compound-specific isotopic analysis. Source AA: average of $\delta^{15}N$ values of glycine, serine, phenylalanine, and lysine.

Pacific and Atlantic:

- $\delta^{15}N$ values of source amino acids (AA) reflect baseline source of N to primary producers (e.g,. Ohkouchi et al. 2017)
  - ➢ Patterns in bulk $\delta^{15}N$ values closely reflect those of baseline (Fig. 2a,b)
- Overall higher $\delta^{15}N$ values in Pacific compared to Atlantic (Fig. 2a,b)
  - ➢ Consistent with measured and modeled differences in $\delta^{15}N$ values of surface and subsurface nitrate in the two sampling regions (Rafter et al. 2019)

Pacific:

- Nearshore→offshore decrease in $\delta^{15}N$ values of small particles (Fig. 2a), but small difference, despite differences in productivity and particulate N concentrations (Fig. 2c)

Atlantic:

- Strong decreasing trend in $\delta^{15}N$ values nearshore (Biscayne Bay) → offshore (Florida Straits, Fig. 2b)
  - ➢ Consistent with lower productivity and lower particulate N concentrations in offshore location (Fig. 2d)
  - ➢ Possibly greater reliance on recycled N or N fixation in offshore location, and/or anthropogenic sources of N in nearshore location

Isotopic indicators for trophic status and reworking

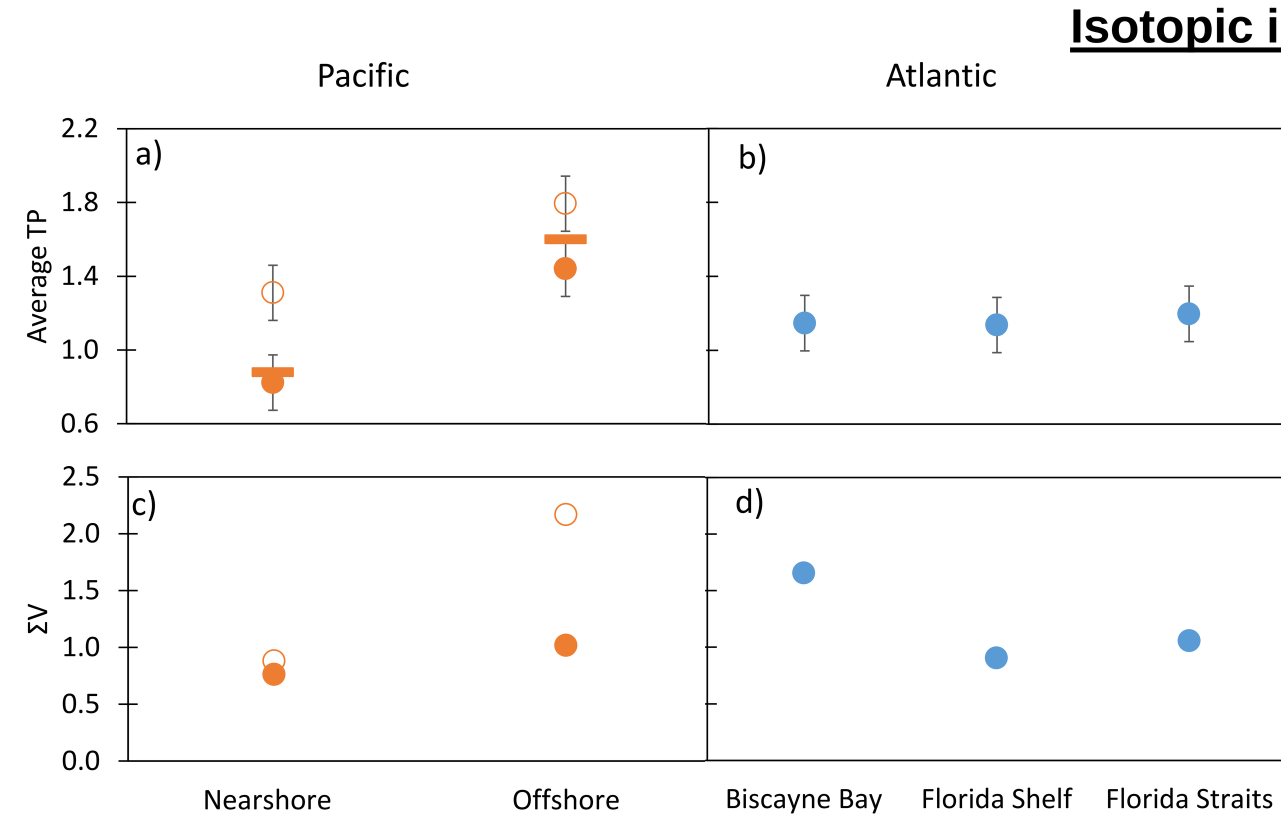

Figure 3. Calculated indicators from compound-specific isotopic analysis. Trophic position (TP) is the average of three different calculations (Bradley et al., 2015; Chikaraishi et al. 2009; Décima et al. 2017). ΣV is a potential indicator of microbial reworking, calculated according to McCarthy et al. (2007).

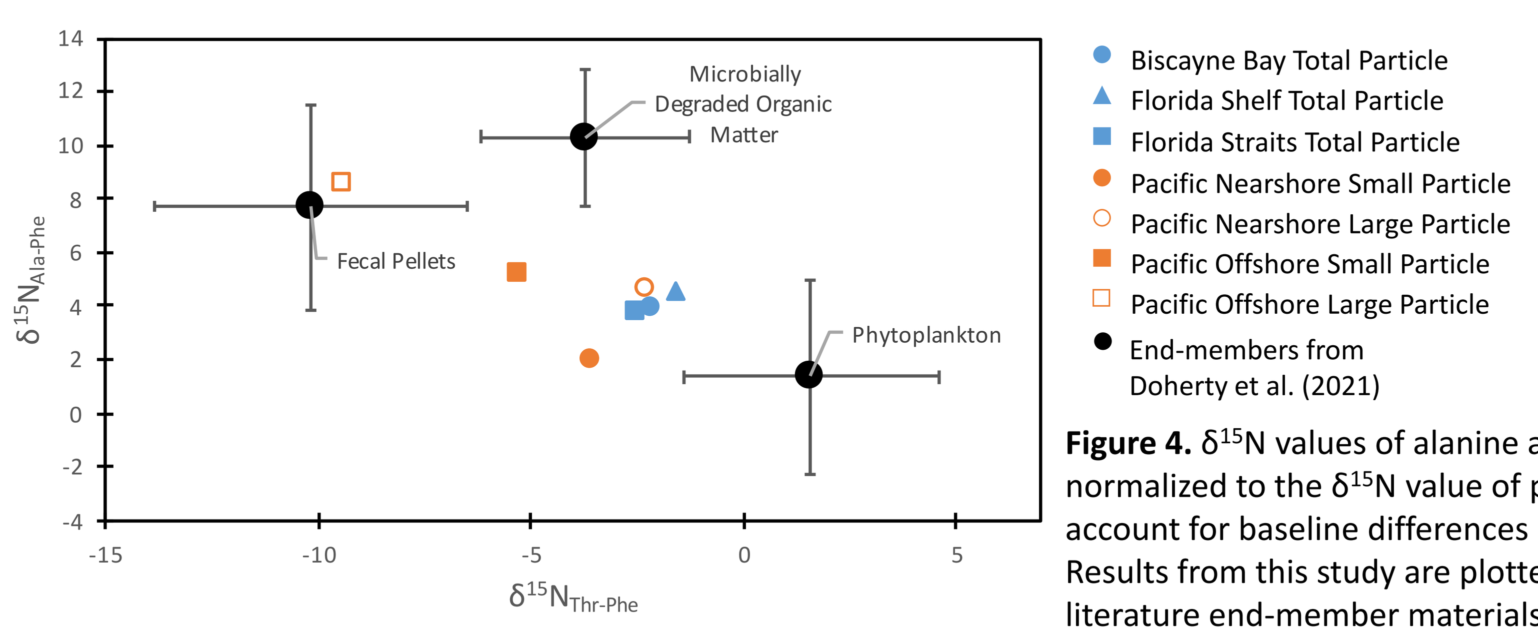

Figure 4. $\delta^{15}N$ values of alanine and threonine, each normalized to the $\delta^{15}N$ value of phenylalanine to account for baseline differences between locations. Results from this study are plotted in comparison to literature end-member materials that may contribute to POM, as described by Doherty et al. (2021) and implemented by Wojtal et al. (2023).

Pacific:

- Nearshore→offshore increase in trophic position of all particles (Fig. 3a)
  - ➢ Alanine and threonine data suggest the importance of fecal pellets in elevated TP of large, offshore particles (Fig. 4)
- Low TP of nearshore small particles possibly indicative of efficient recycling of N between autotrophic and heterotrophic microbes

Atlantic:

- Consistent low TP at all sites (Fig. 3b), alanine and threonine data (Fig. 4) suggest largely phytoplankton composition
  - ➢ TP around 1.2 may reflect a balance of autotrophy and animal-like heterotrophy in the microbial communities

Remaining questions and continuing work.

- Cell count data: autotrophs and heterotrophs
  - Does measured composition of phytoplankton and heterotrophic bacteria match the trophic position calculations?
- Measure particle $\delta^{13}C$ (acidified, organic) to examine impact of terrigenous material on marine surface POM.
- Comparison of baseline $\delta^{15}N$ values and nutrient concentrations– effect of upwelling?
- Comparison of trophic indicators and chlorophyll concentrations.
- Samples are available from additional sampling points between the nearshore and offshore Pacific.

Figure 5. Filtering manifold fabricated and operated by Paul Wojtal on SR2323.

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