# Intact Polar Lipids in Surface Sediments of The Atacama Trench Point to In Situ Dominant Sources of Labile Organic Matter in the Hadal Seabed

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**Abstract**

Elevated organic matter (OM) concentrations are found in hadal surface sediments relative to the surrounding abyssal seabed. However, the origin of the biological material remains elusive. Here, we report the composition and distribution of cellular membrane intact polar lipids (IPLs) extracted from surface sediments around the deepest points of the Atacama Trench and adjacent bathyal margin to assess and constrain the sources of labile OM in the hadal seabed. Multiscale bootstrap resampling of IPLs' structural diversity and abundance indicates distinct lipid signatures in the sediments of the Atacama Trench that are more closely related to those found in bathyal sediments than to those previously reported for the upper ocean water column in the region. While the overall number of unique IPL structures in hadal sediments is limited and they contribute a small fraction of the total IPL pool, they include a high contribution of phospholipids with mono- and di-unsaturated fatty acids that are not associated with photoautotrophic sources. The diversity of IPLs in hadal sediments of the Atacama Trench suggests the presence of in situ microbial production and biomass that resembles traits of physiological adaptation to high pressure and low temperature, and/or the transport of labile OM from shallower sediment. We argue that the export of the most labile lipid component of the OM pool from the euphotic zone and the overlying oxygen minimum zone into the hadal sediments is neglectable. Our results contribute to the understanding of the mechanisms that control the delivery of labile OM to this extreme deep-sea ecosystem. Furthermore, they provide insights into some potential physiological adaptation of the in situ microbial community to high pressure and low temperature through lipid remodeling.

# Intact polar lipids reveal lateral sediment transport and *in situ* production as the dominant sources of organic matter in the Atacama Trench

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## ABSTRACT

Elevated organic matter (OM) concentrations are found in hadal surface sediments relative to the surrounding abyssal seabed. However, the origin of the biological material remains elusive. Here, we report the composition and distribution of cellular membrane intact polar lipids (IPLs) extracted from surface sediments around the deepest points of the Atacama Trench and adjacent bathyal margin to assess and constrain the sources of labile OM in the hadal seabed. Multiscale bootstrap resampling of IPLs' structural diversity and abundance indicates distinct lipid signatures in the sediments of the Atacama Trench that are more closely related to those found in bathyal sediments than to those previously reported for the upper ocean water column in the region. While the overall number of unique IPL structures in hadal sediments is limited and they contribute a small fraction of the total IPL pool, they include a high contribution of phospholipids with mono- and di-unsaturated fatty acids that are not associated with photoautotrophic sources. The diversity of IPLs in hadal sediments of the Atacama Trench suggests the presence of in situ microbial production and biomass that resembles traits of physiological adaptation to high pressure and low temperature, and/or the transport of labile OM from shallower sediment. We argue that the export of the most labile lipid component of the OM pool from the euphotic zone and the overlying oxygen minimum zone into the hadal sediments is neglectable. Our results contribute to the understanding of the mechanisms that control the delivery of labile OM to this extreme deep-sea ecosystem. Furthermore, they provide insights into some potential physiological adaptation of the in situ microbial community to high pressure and low temperature through lipid remodeling.

## MOTIVATION

- To determine the composition and sources of organic matter using lipid biomarkers.
- To characterize the surface sediments in the bathyal and hadal zone as a function of Intact Polar Lipids(IPLs).
- To determine the relative abundances of the main groups of IPL.

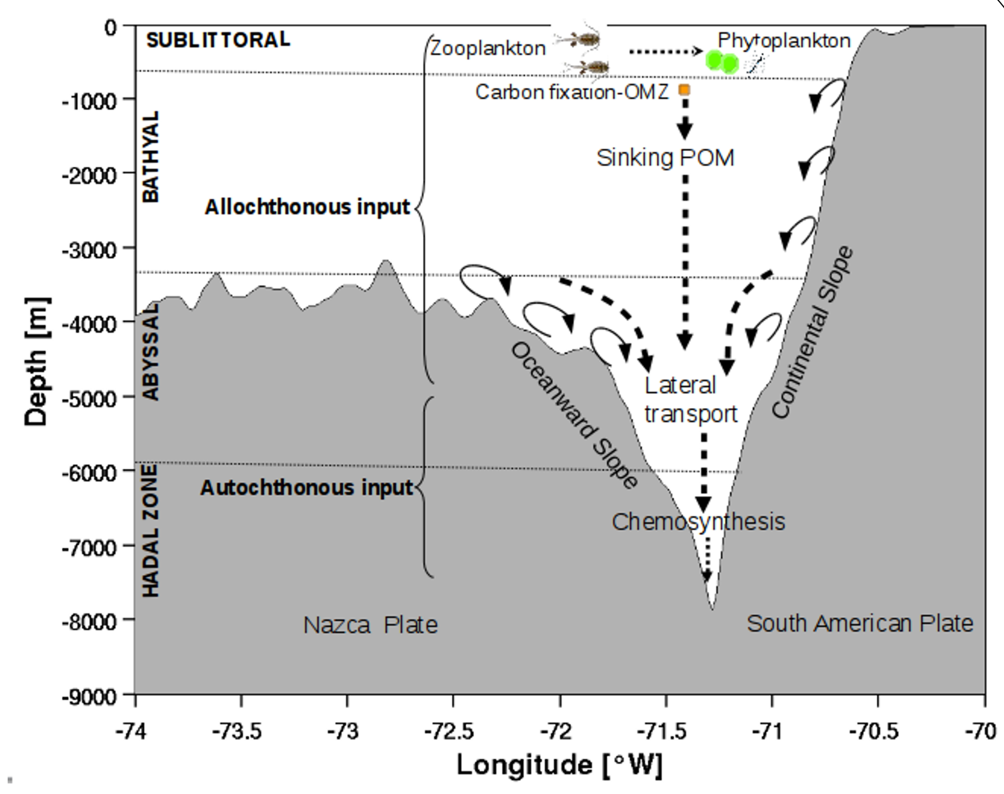


***Figure 1.*** *Representation of the main mechanisms of transport of organic matter to the inner trenches.*

## METHODS

Atacama Trench Study area

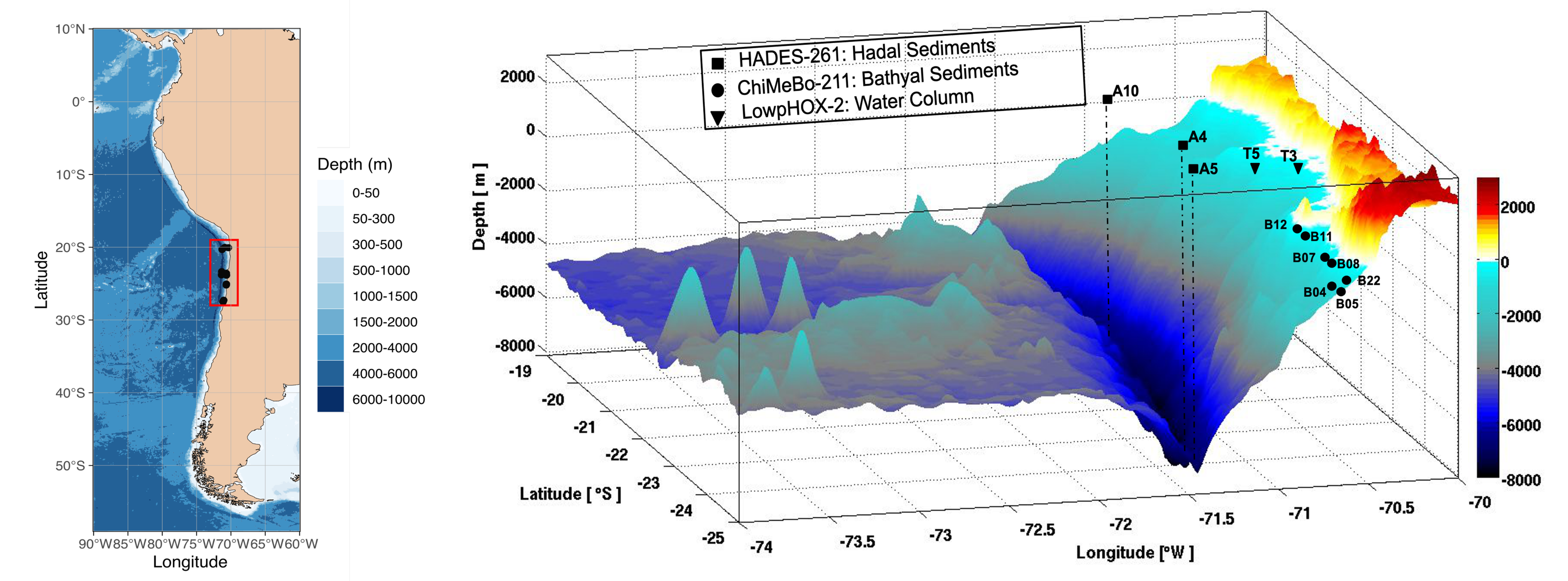


***Figure 2.*** *Three-dimensional map of the Atacama Trench showing the sampling locations of this study. The black squares indicate the hadal sediment sampling stations, the black circles indicate the bathyal sediment sampling stations, and the black triangles indicate water column sampling stations.*

## MAIN FINDINGS

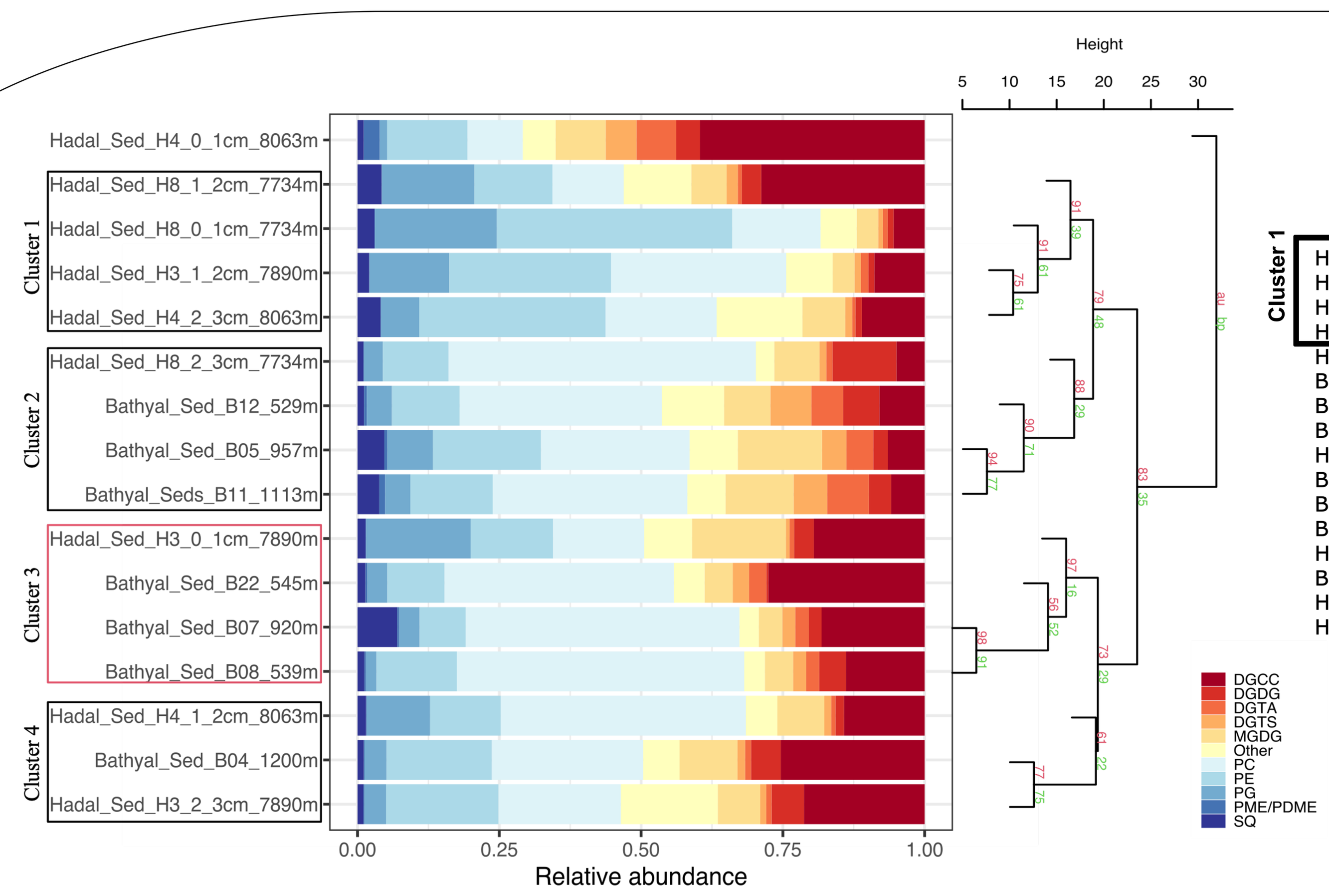


***Figure 3.*** *Figure 2. Cumulative bar charts of the fractional abundance of IPL classes in each surface sediment sample from the bathyal and hadal regions (left panel). Samples were grouped according to arithmetic mean (UPGMA) hierarchical clustering based on Euclidean distances. The p-values are shown at branches, AU in red and BP in green (right panel). Clusters 3 with an AU ≥ 95% confidence are indicated by the red rectangles (left) and are considered to be strongly supported by the data.*

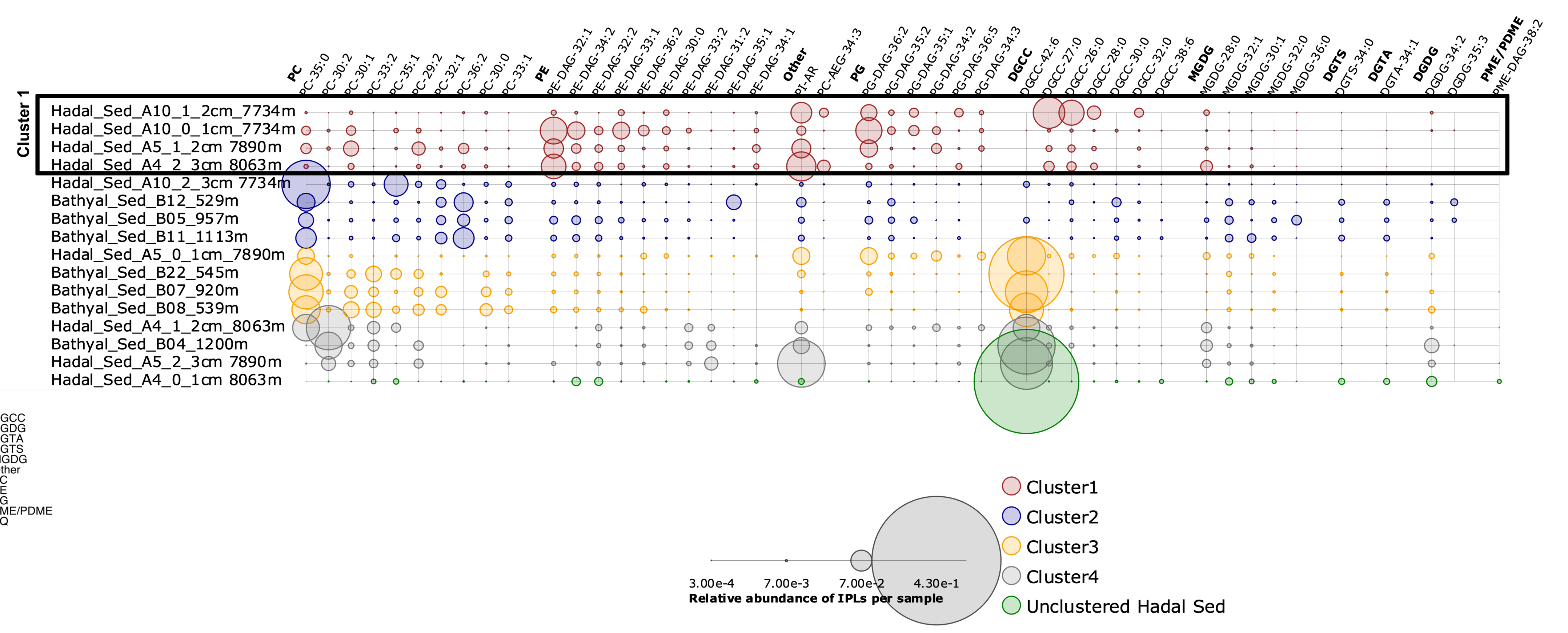


***Figure 4.*** *Relative abundance of individual IPLs contributing most of the dissimilarity between the 4 clusters shown in Fig. 2. Sampling stations were organized from top to bottom and are shown using the same order from hierarchical clusters in Fig. 3, and were organized from left to right by IPL classes. The circle ratios are proportional to the relative abundance of IPLs in each sample (bottom panel).*

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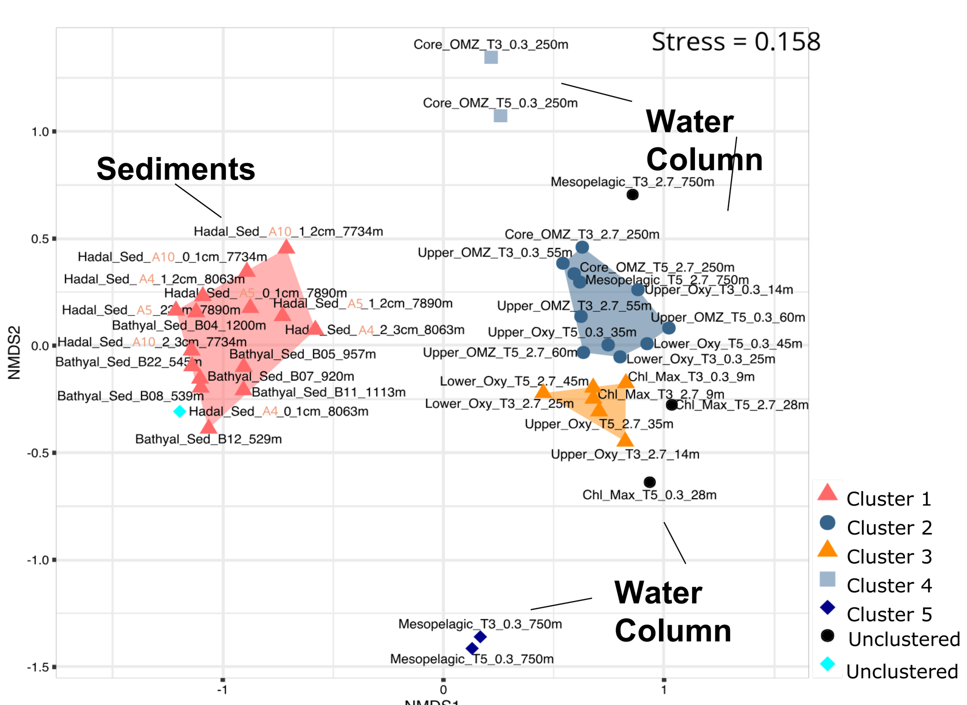


***Figure 5.*** *Non-metric multidimensional scaling (NMDS) analysis of IPLs at each sampling station. The distance matrix was calculated based on the Bray–Curtis dissimilarity. The stress value of the final configuration was 15.8 %. Different symbols and colors represent the sample grouping from hierarchical clusters shown in panel a.*

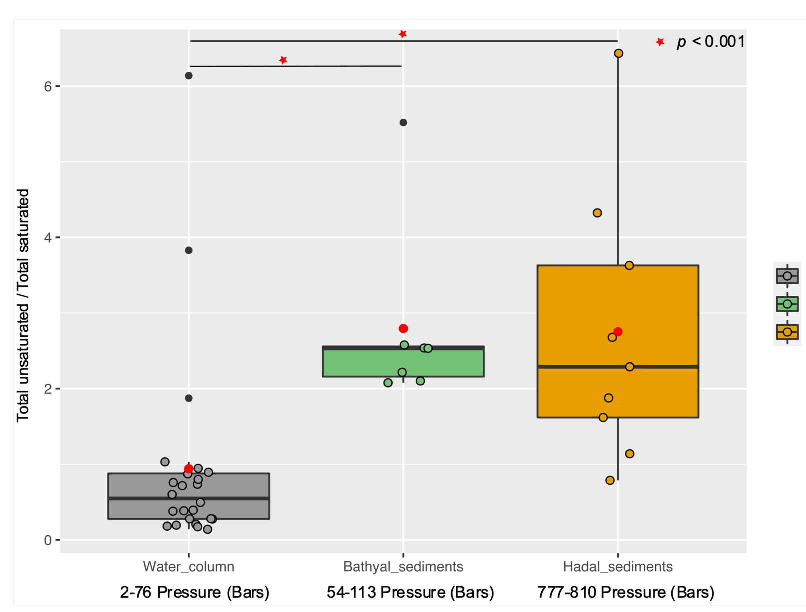


***Figure 6.*** *Boxplot showing difference in ratio of total unsaturated fatty acids to total saturated fatty acids derived from IPL across water column (Cantarero et al., 2020) and sediments of Atacama Trench (this study). The average in each environment were shown in red circles and Wilcoxon test (p-value < 0.001) shows that the sediments have statistical ratios higher than the water column.*

## CONCLUSIONS

1. The high statistical similarity of ester-bound IPLs between Bathyal and Hadal sediments may indicate that these environments are host to the similar microbial communities.

2. Most IPLs that would be common to the upper water column appear to get almost entirely degraded during their descent to the hadal seafloor suggesting the highly labile lipids are derived from ocean floor microbial communities.

3. The ratio of total instated/total saturated IPLs suggested an adaptation to the high pressures and low temperatures of the hadal environment.

**Check out our work for more juicy details!**

Flores et al., 2021 in preprint a Biogeosciences https://bg.copernicus.org/preprints/bg-2021-232/

Cantarero et al., 2020 at Frontiers in Marine Science https://www.frontiersin.org/articles/10.3389/fmars.2020.540643/full