Assessing the Potential for Human Impacts in Coastal Regions Through Organic Matter Proxies and Lignin Biomarkers

Kearney Fellowship Report

Sarah Flores, 2008

I. Research Problem

Coastal regions are unique natural habitats that are particularly sensitive to the effects of anthropogenic activities, as 50% to 70% of the world's population dwells within coastal areas. In consequence, human actions in coastal regions are likely to have large repercussions within nearby marine environments.

Sediments deposited within coastal regions and estuaries bear a record of changes in the local geochemistry. Hence, sediment cores can be used to investigate chronological changes in an estuary's geochemistry and to understand the processes associated with such changes.

To better understand the potential for anthropogenic activities and impacts on coastal regions, this study proposed to carry-out investigative analyses on the geochemistry of sediment organic matter and lignin polymer biomarkers from Tomales Bay, CA (Figure 1), a secluded estuary with a densely populated catchment area.

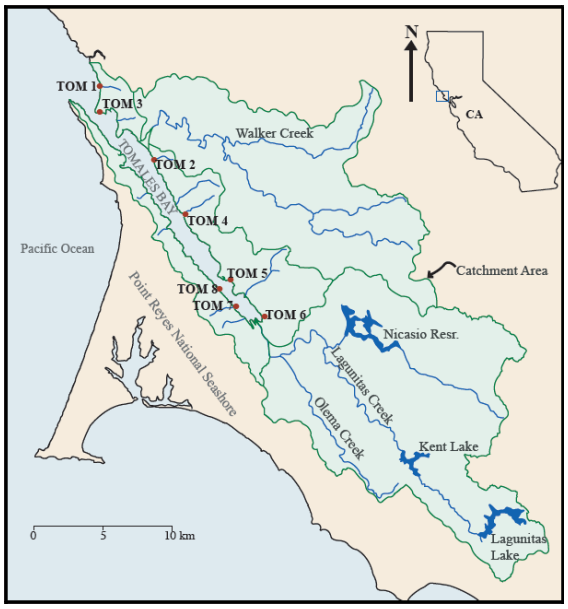


Figure 1: Tomales Bay, CA and sampling sites. Bay is ~ 60 km north of San Francisco Bay.

II. Research Objectives

Through the sampling of short (17-19 cm) sediment cores in Tomales Bay, CA, and subsequent analyses of organic matter (OM) C-isotopes and C:N ratios, as well as the quantification of lignin-polymer phenols, this research project aimed to achieve the following objectives:

1. Develop a temporal record of recent (approx. 50 yr) marine vs. terrestrial dominated deposition.
2. Discern the degree to which human activities within a watershed can change estuarine geochemistry.

III. Results

Of all the cores taken only TOM 2 (19 cm), TOM 7 (17 cm) and TOM 8 (19 cm) had enough OM in each sample for analyses, thus the data presented only represents these three cores. Previous analyses of maps and GIS data have reported a wide range of sedimentation rates in the area; the averages used for this study are TOM 2: 2.95 mm/yr, TOM 7: 6.75 mm/yr and TOM 8: 4.05mm/yr.

<u>C/N Ratios</u>

C:N ratios in all cores (TOM 2, TOM 7, TOM 8) suggest a recent marine influence

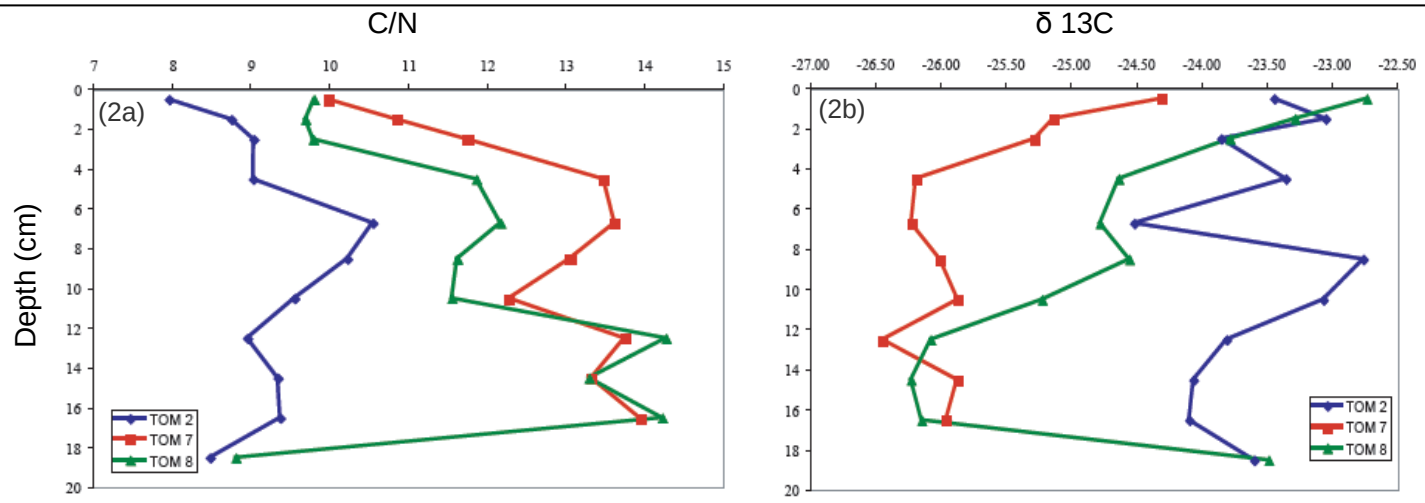


Figure 2a & 2b: (2a) C/N down-core at sites TOM 2, 7 & 8. Two decreases in C/N suggest marine-dominated deposit periods that bracket a longer-lived terrestrial-dominated deposit period. (2b) δ ^{13}C agree with C/N results, thus it can be said that C-fractionation and diagenesis have not been substantial in the environment.

within the last 5-7 years (0-3 cm) due to the low C/N values (Figure 2a). Soon after, there is an observed shift toward terrestrial-dominated inputs since the high C:N ratios are more indicative of vascular-plant deposits. At 20-30 years ago, the C:N ratios decrease again, suggesting a return to more marine-dominated deposits. At further depths ($\geq$ 14 cm) the C/N decrease, and it is not clear if there was a shift in the source of the deposits. The terrestrial-dominated period lasted approx. 19 years which suggests that activities on land have long-term potential of affecting the bay's water chemistry.

δ ^{13}C Analyses

The trends in OM δ ^{13}C down-core agree with the previous interpretation of the shifts in C/N values (Figure 2b). Since the OM C/N and δ ^{13}C data agree in trends, it is very unlikely that plankton C-fractionation or diagenesis took place. It is possible that OC burial occurs quickly where plankton do not have an opportunity to fractionate C and that environmental conditions in the sediments are not favorable for diagenesis.

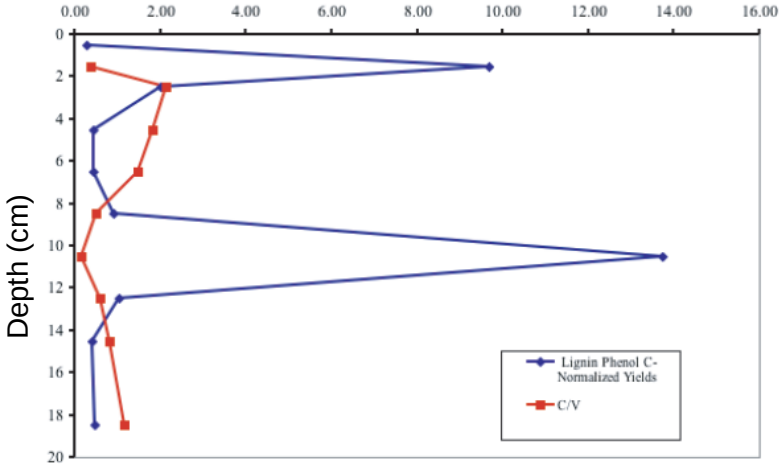
Lignin Biomarker Analyses

The high levels of lignin phenol carbon-normalized yields (terrestrial-source indicator) in TOM 2, TOM 7 and TOM 8 correspond with low cinnamyl:vanillyl phenol ratios (C:V), and vice-versa (Figure 3). The trend of increasing amounts of lignin deposits with low C/V values as a result in increasing amounts of total vanillyl phenols (found only in vascular plants, i.e. terrestrial in nature), is consistent with the notion that the deposits are land-derived.

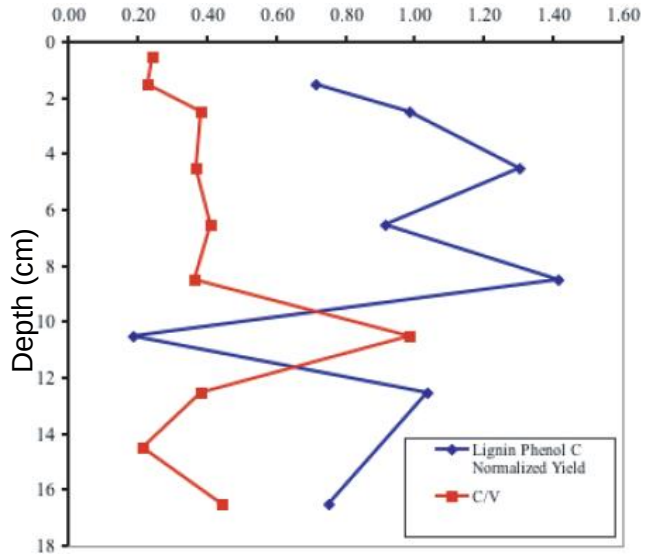
The two periods of observed increases in terrestrial inputs can be attributed to either two warming episodes (because warmer periods are associated with wetter weather) or two periods of sharp increases in land run-off. The very large and sharp increases in the amounts of lignin phenol carbon-normalized yields possibly indicate the presence of discrete wood fragments within the sample.

Despite spatial proximity of TOM 7 & TOM 8, the lignin phenol carbon-normalized yields and C:V ratios down-core show a lack of correlation throughout the cores (0-17 cm). It is still unclear why data from two cores that are proximal in location differ so much, however, it is very evident that spatial heterogeneity within a system cannot be assumed.

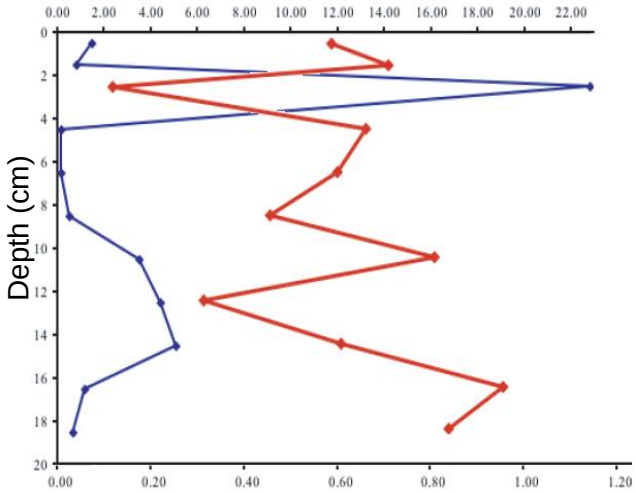
Lignin Phenol C-Normalized Yields (mg/100 mg OC) and C/V Ratios for TOM 2



Lignin Phenol C-Normalized Yields (mg/100 mg OC) and C/V Ratios for TOM 7



Lignin Phenol C-Normalized Yields (mg/100 mg OC) for TOM 8



C/V Ratios for TOM 8

Figure 3: Lignin phenol carbon-normalized yields in TOM 2, TOM 7 and TOM 8, and cinnamyl:vanillyl phenol ratios (C:V) down-core.

IV. Overcoming Major Challenges in Future Investigation:

To continue the investigation it is necessary to:

- Obtain a record of precipitation and land run-off to address the findings that there were two observed episodes of increased terrestrial deposition
- Sample for more cores in the inner bay to understand the differences observed in the cores that were so close to one another.
- Establish a record of syringyl:vanillyl phenol data to better understand the sources of terrestrial run-off.