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

Kearney Fellowship Report
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Background

- Coastal regions are unique natural habitats:  
  → merge of terrestrial and marine environment

- 50% to 70% of the world's population dwells within coastal areas

- Sensitive to anthropogenic activities
Background

- Sediments deposited record temporal changes geochemistry.
- Used to establish time-series of:
  
  (1) An estuary’s geochemistry
  
  (2) Understand the processes associated with such changes
Background

• Understanding the extent to which human activities impact a coastal region is important to address:

(1) Estuarine problems changing water geochemistry

(2) Potential ecological responses to such changes
Background

For example:

(1) Increases in land run-off may decrease a bay’s salinity which is related to a decrease water pH
   → create a negative environment for calcifying organisms

(2) Increases in nutrient inputs from an export of farming and agricultural waste through run-off, can change the nutrient budget within a bay
   → alter organism populations
   → further impact food-web interactions
Proposed Research

Sample for short sediment cores (17-19 cm) that reveal recent changes in estuarine geochemistry to:

(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
Methods

- Obtain push-cores at low tide in Tomales Bay, CA
- Analyze organic matter (OM) C-isotopes and C:N ratios
- Quantify lignin polymer phenols
Sampling Sites

• Eight (8) cores were taken along the bay

• Only three (3) were used

  TOM 2: outer bay
  TOM 7: inner bay
  TOM 8: inner bay
Methods Background

C/N Ratios

• Useful for distinguishing between marine and terrestrial dominated deposition:

• Marine plankton and algal production → low C:N ratios (6 to 7)

• Terrestrial leaves → higher ratios (30 to 50)

• Terrestrial plants → higher ratios (100)

Therefore:

• Lower C/N values suggest a marine signature
• Higher ratios suggest a more terrestrial-influenced deposition
Methods Background

δ 13C Analyses

• Useful to determine system’s influence of marine vs. vascular deposits.

• In systems where fractionation of C is minimal and C-diagenesis is not dominant,

• Vascular plant tissue deposition
  → 13C depleted values (δ 13C = -27 to -28 ‰)

• Marine plankton deposition
  → 13C enriched values (δ 13C = -18 to -22 ‰)
Methods Background

Lignin Biomarker Phenols:

- Useful for ID of terrestrial-derived deposits within marine sediments
- Only vascular terrestrial plants are composed of lignin
- Characterization of lignin phenols
  → used to distinguish between angiosperm and gymnosperm vascular plants
• TOM 2 shows more marine-dominated deposits while
• TOM 7 and TOM 8 are more terrestrial
  → indicative of relative placement
Results

TOM 2, TOM 7, TOM 8

→ recent marine influence within the last 5-7 years
→ Mid-core, observed shift toward terrestrial-dominated inputs
→ Return to more marine-dominated deposits 20-30 years ago
→ Trend unclear at base of sediment cores (older deposits)
Results

- Since $\delta^{13}C$ agree with C/N results:
  
  $\rightarrow$ plankton C-fractionation and C-diagenesis have not been substantial in the environment
Results

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

- Two observed increases in terrestrial inputs possibly due to:

  (1) Two warming episodes (??)
  (2) Two periods of sharp increases in land run-off (??)

\[ \text{*cinnamyl:vanillyl lignin-derived phenols} = C:V \]
Results

- Lack of correlation throughout the cores despite sediment proximity
  → spatial heterogeneity cannot be assumed
Conclusions

- C/N shows two marine influenced deposition periods bracketing a single terrestrial-dominated period

- $\delta^{13}C$ records agree with C/N data

- $\delta^{13}C$ records suggest low C-fractionation and low diagenetic alteration

- Records of total lignin amounts and C:V phenols suggest two episodes of increased terrestrial deposits

- Spatial heterogeneity in a system cannot be assumed

**Terrestrial-influenced deposition in Tomales Bay is common and long-lived**

→ human activities have a large potential for altering the estuary’s water chemistry and in turn, affecting its ecology
Future Work

- Obtain a record of precipitation and land run-off to better understand two episodes of terrestrial deposits in records

- More core samples in the inner bay to understand inner-bay variability

- Establish a record of syringyl:vanillyl phenol data to reconstruct changes in terrestrial sources