Evaluation of the behavior of yttrium and lanthanum in surface seawater

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Abstract:

The biogeochemical cycling of trace metals in the ocean, as the name implies, is a cycle that describes the complex interplay of a broad range of physical and chemical processes that govern the behavior of metals in the ocean. Input of trace metals into surface ocean water can come from any of several sources including anthropogenic input from the continental surface, airbound particles, or upwelling from the deep ocean, among others. Metal concentrations for yttrium and lanthanum were obtained from surface Pacific Ocean water and the data sets were interpreted to evaluate the behavior of each of the two metals in the context of this cycling.

Introduction:

Rare Earth Elements (REEs), despite their name, may not actually be rare if measured by the total quantity on Earth. However they are rarely found in nature in a pure form and instead generally exist in a disperse form in low concentrations among other elements.

Yttrium is a rare earth metal that is primarily introduced into surface seawater from land-based inputs from sediments that are carried out to sea from rivers.[1] One significant sedimentary flow into the Gulf of Alaska comes from the Copper River, which pushes a plume of sediments several kilometers into the ocean.[2] The Copper River is at least partially glacier fed, and as early as 1971, yttrium has been identified in glacial rivers, indicating that sediments produced glacially are a likely vector for yttrium in surface seawater.[3]

Since lanthanum displays similar chemical behavior, it is expected that it enters the ocean by the same vector and once introduced, trends similarly.

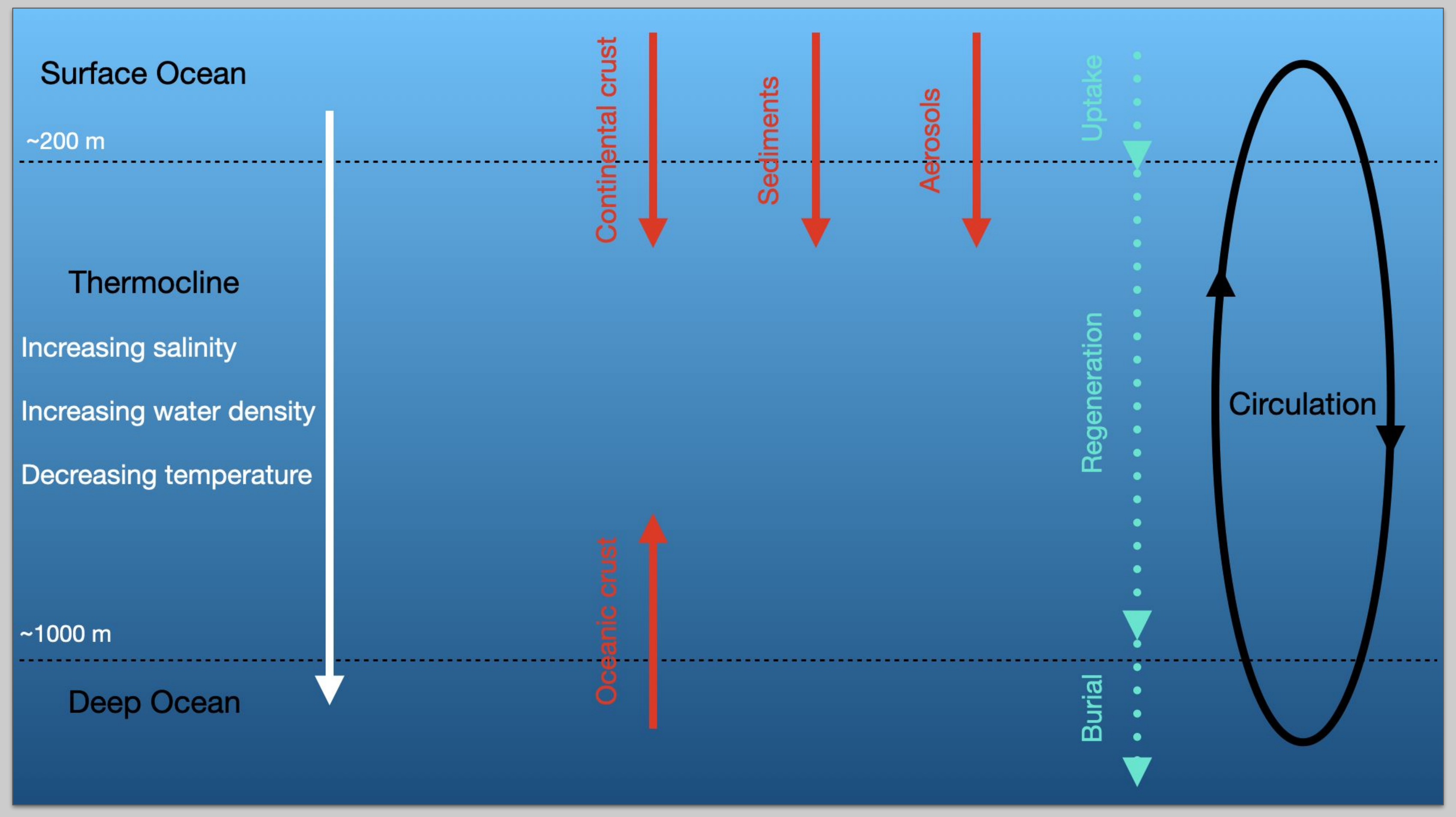

Figure 1: Graphic depicting external inputs (solid red) and internal cycling (dashed blue) in the various regions of the ocean.

Methods:

The data sets were obtained from a 2018 GEOTRACES sampling trip that launched from the coast of Alaska and covered a transect from Alaska to Tahiti. Samples of surface seawater were collected at intervals along the transect and analyzed for a broad range of trace metals. Regions of data with large features or broad trends were singled out for closer study. For yttrium and lanthanum, the region of particular interest was in the Gulf of Alaska and the area of ocean immediately to its south.

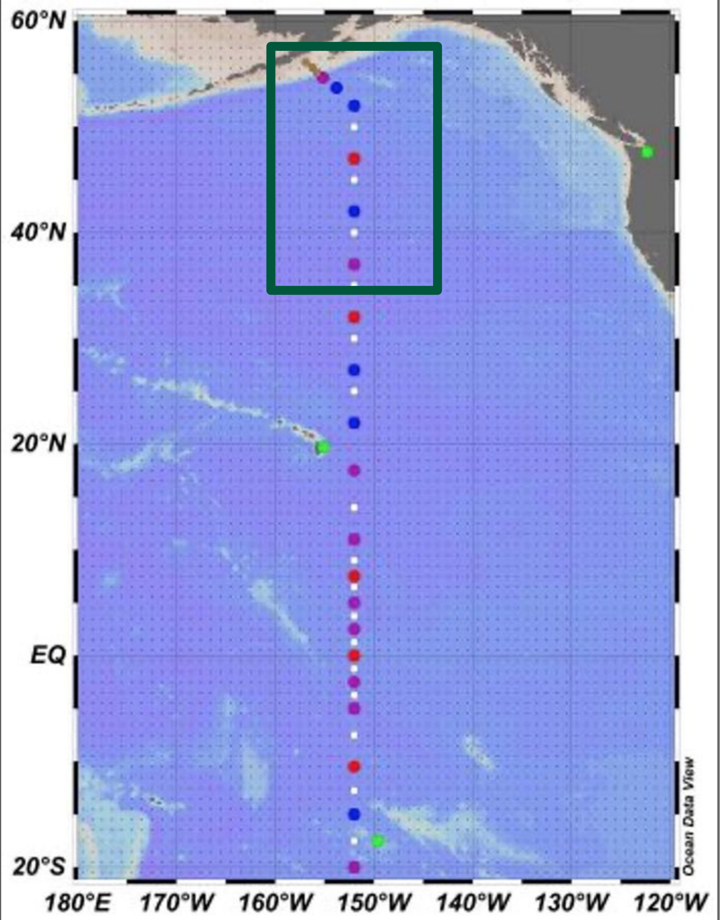

Figure 2: GEOTRACES cruise track.

Results:

Yttrium:

The data set obtained supports a land-borne introduction of yttrium into the surface ocean as we observe a steep ramping off of concentration as sampling points get further from shore, suggesting that an input from land is primarily responsible for observed yttrium concentrations along the sampled transect.

Lanthanum:

As anticipated, the trend observed in the data set for lanthanum matches that of yttrium which suggests a primarily freshwater riverine input. This is supported by the ambient existence of lanthanum in Alaskan rivers.[4]

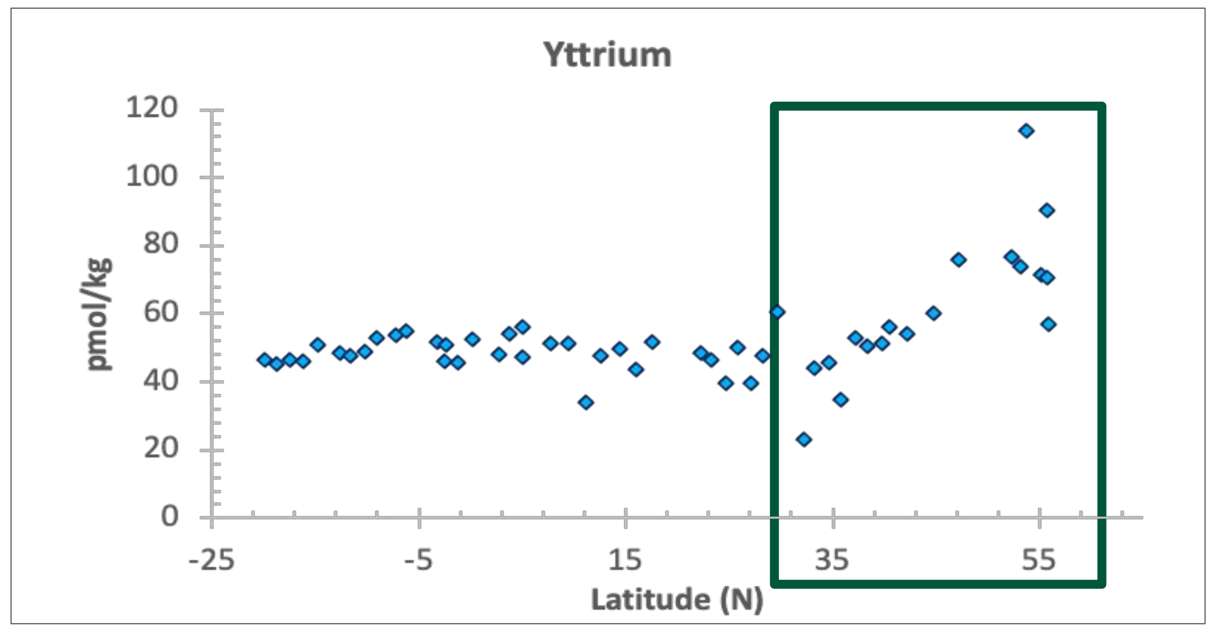

Figure 3: Yttrium data collected along the length of the transect. Boxed data indicates area of interest.

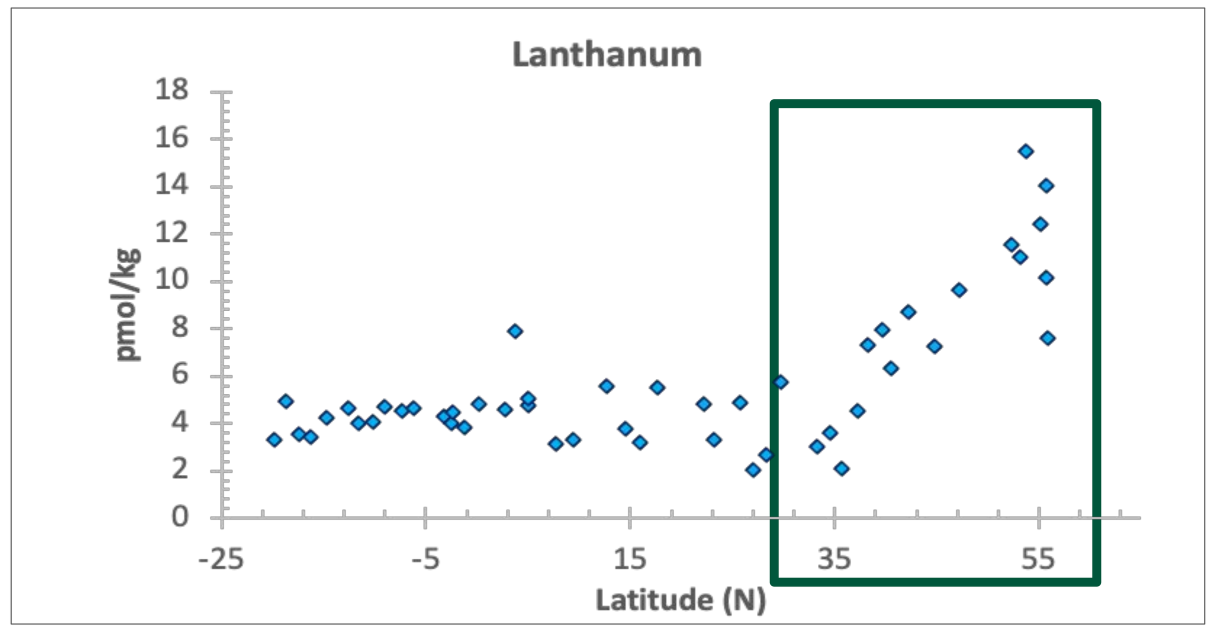

Figure 4: Lanthanum data collected along the length of the transect. Boxed data indicates area of interest.

Conclusion:

A probable explanation for the observed trends stems from the current behavior in the gulf. The first leg of the trip consisted of a jog to the east to reach the primary transect, so although the cruise track is getting farther from land north to south, as it travels east it is getting closer to the freshwater inputs carrying the Y and La containing sediments. It is in this portion of the cruise that a slight increase in concentration is observed.

The behavior of the data changes at 50°N where the concentrations of Y and La decrease until 35°N, after which they remain relatively stable.

There is a physical change in the ocean currents at 50°N, where the primary current is no longer keeping water isolated in the bay but has changed direction, introducing new water from the open ocean and sweeping remaining suspended sediments down into the water column.[5] The data suggests that the primary source of Y and La is from sediment plumes that feed into the gulf to the east of the origination point of the cruise and the primary transect. The current behavior near shore flows east to west and would contribute to sweeping dissolved metals into the path of the cruise. Additionally, salinity data supports this freshwater input, where there is an observed inverse relationship between salinity and concentration, demonstrating that the highest concentrations are likely carried into the surface ocean *via* freshwater riverine inputs.

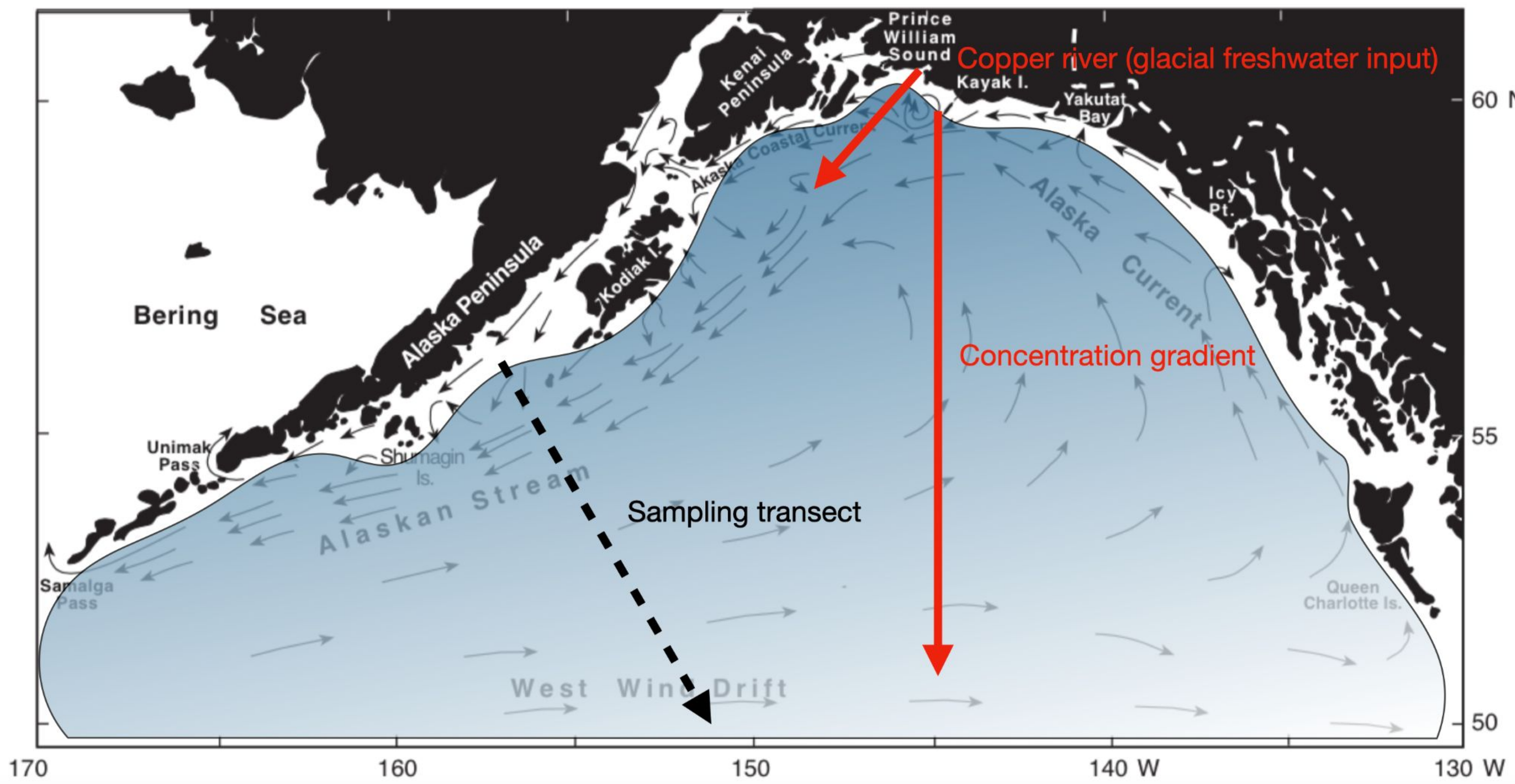

Figure 5: Map of currents in the Bay of Alaska indicating proposed primary input and sampling transect. Shaded area represents concentration gradient.

Citations

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