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Recent Observations of the Bottom Mixed Layer in the tropical NE Pacific: implications for deep-sea mining plume dispersal

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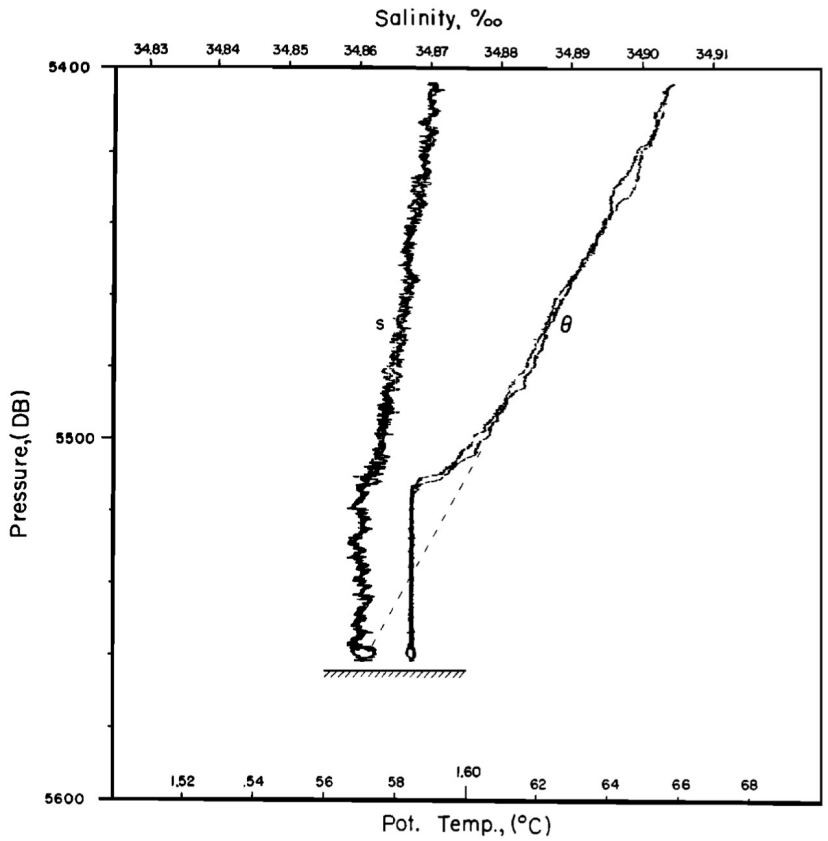
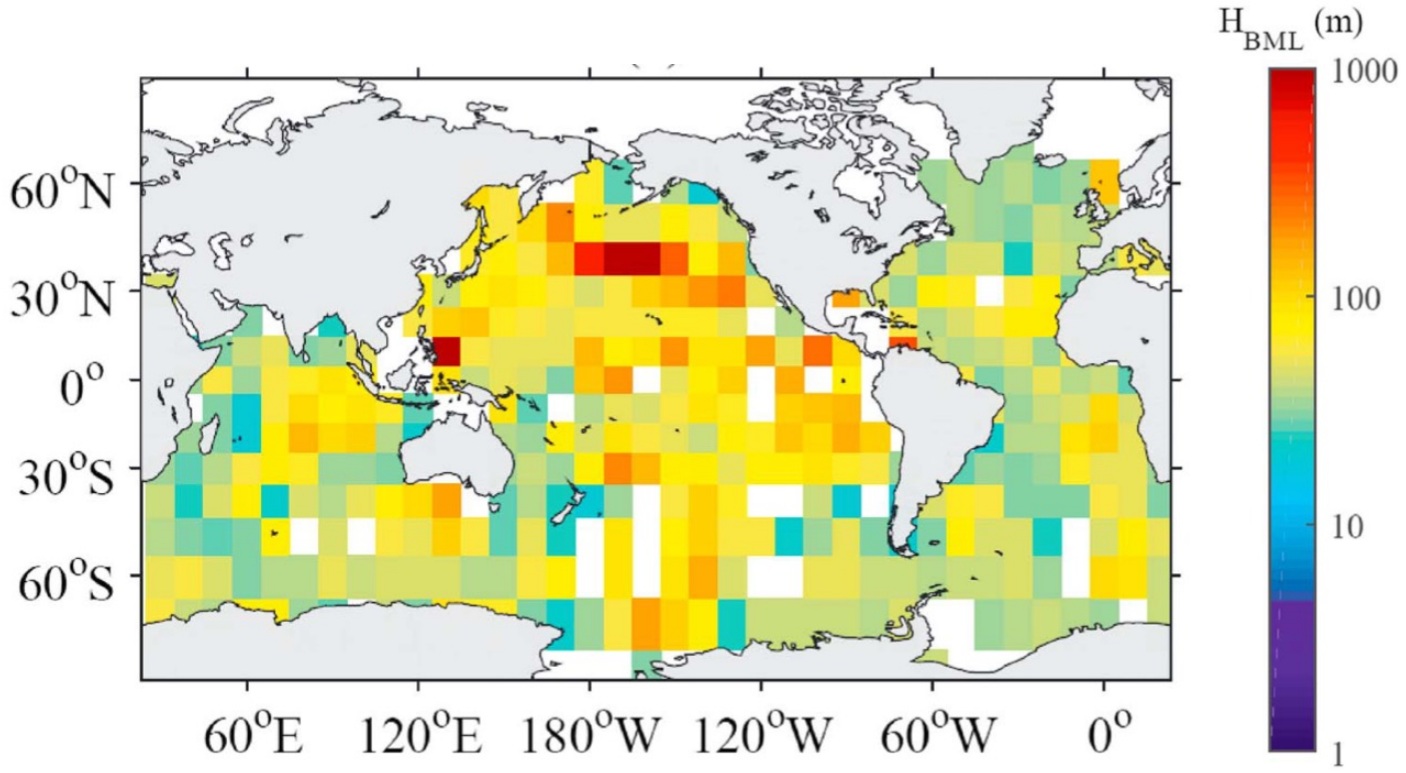
Bottom mixed layer, aka “benthic boundary layer”

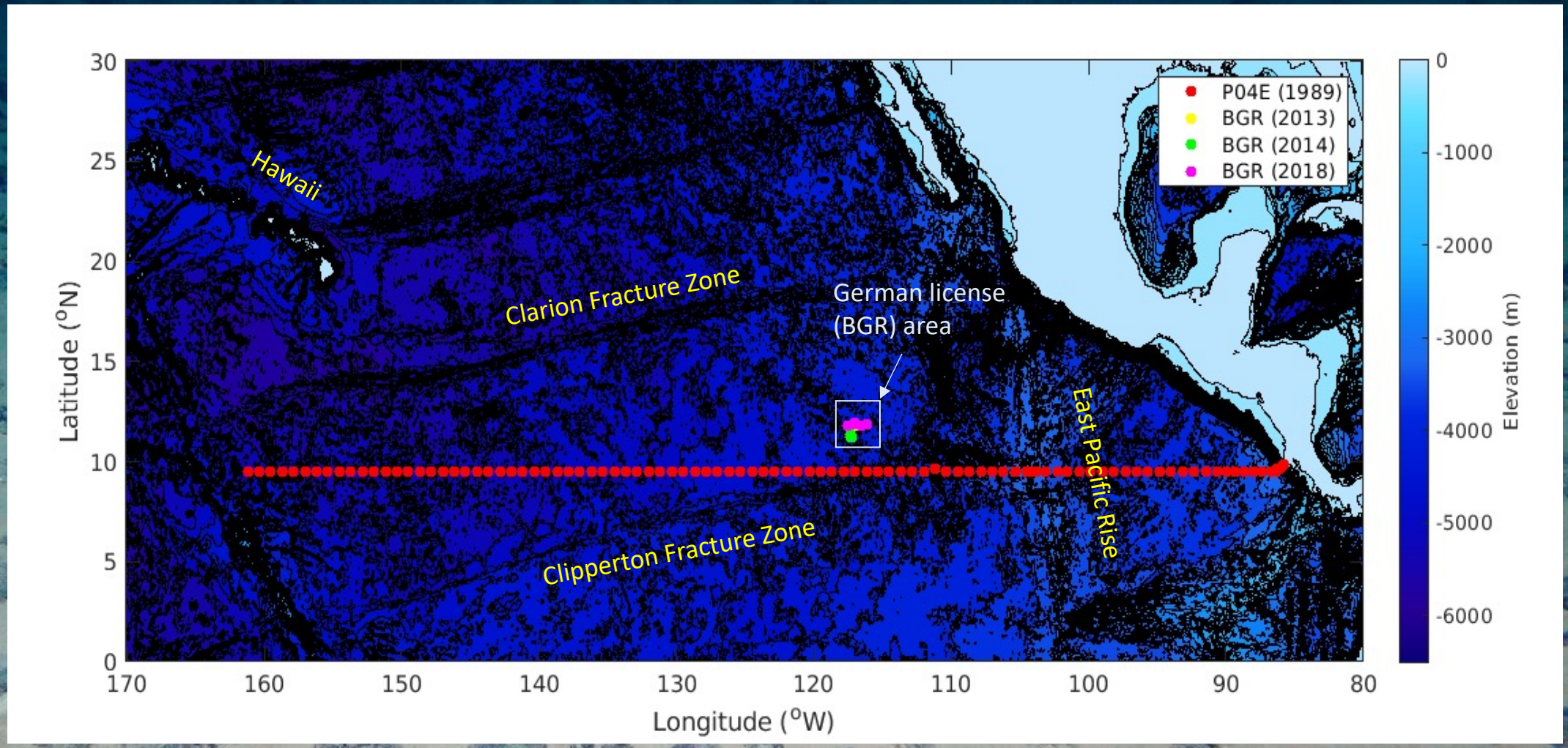


Armi & Millard 1976 JGR



Huang et al. 2019 GRL

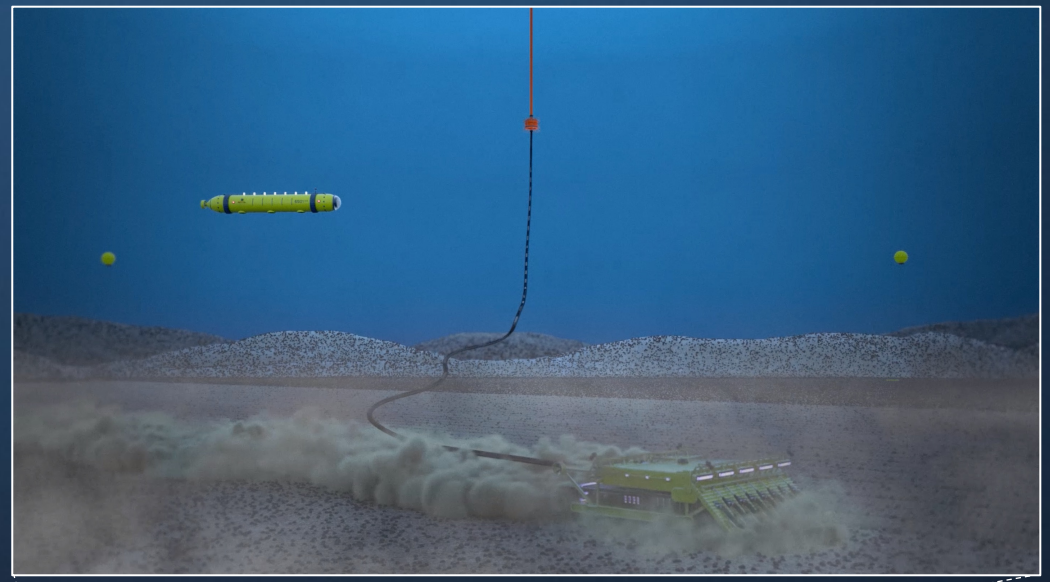
The Clarion-Clipperton Fracture Zone of the NE Pacific



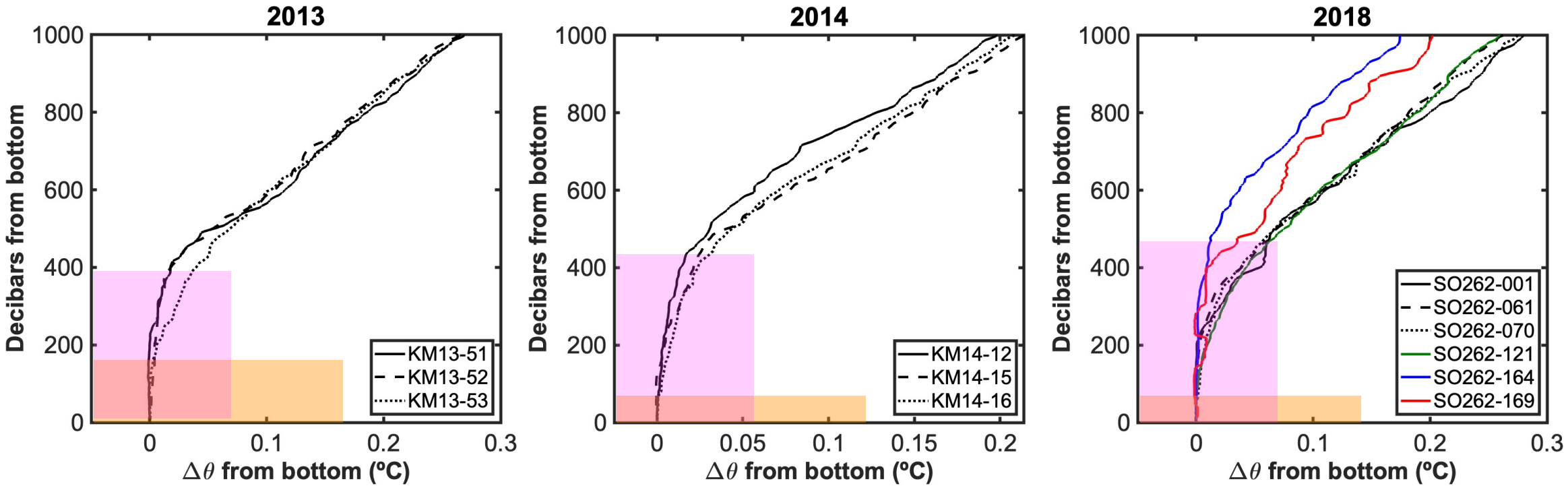
Motivation: deep-sea mining plume dispersal

Mid-water discharge plume

Collector plume



Field Data: CTD



Spatially and temporally varying BBL thicknesses **between 68 m and 475 m**, with an average of 277m, 298 m, and 236m and based on three different methods of quantification.

Theoretical Estimates

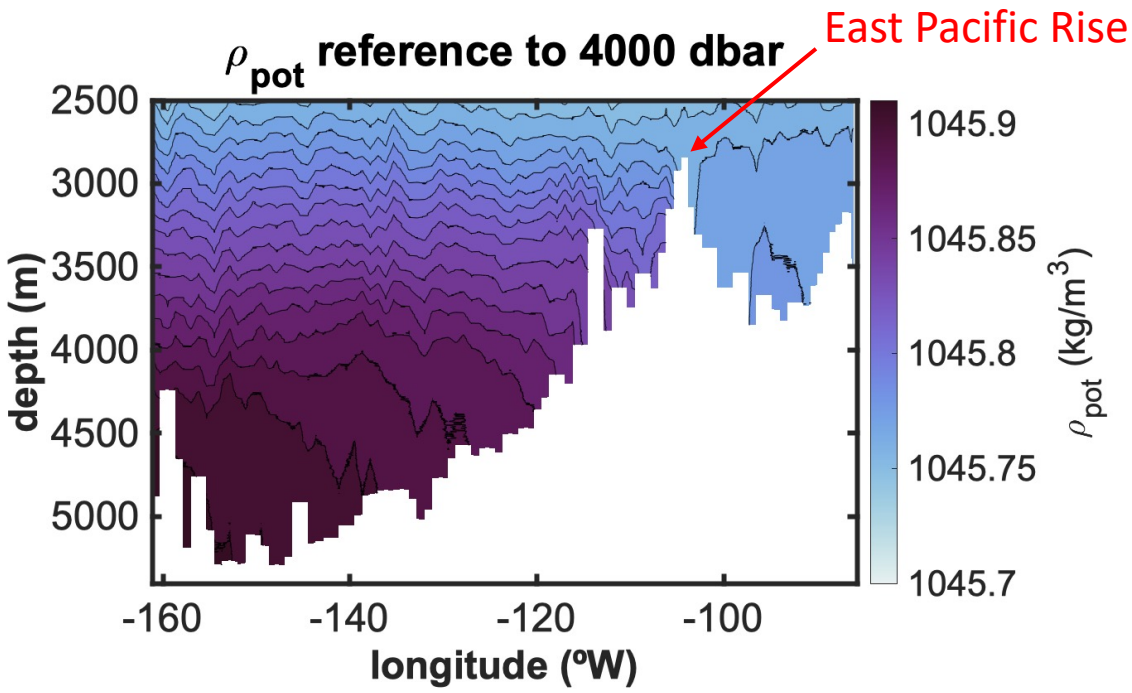
Weatherly & Martin, 1978 JPO:

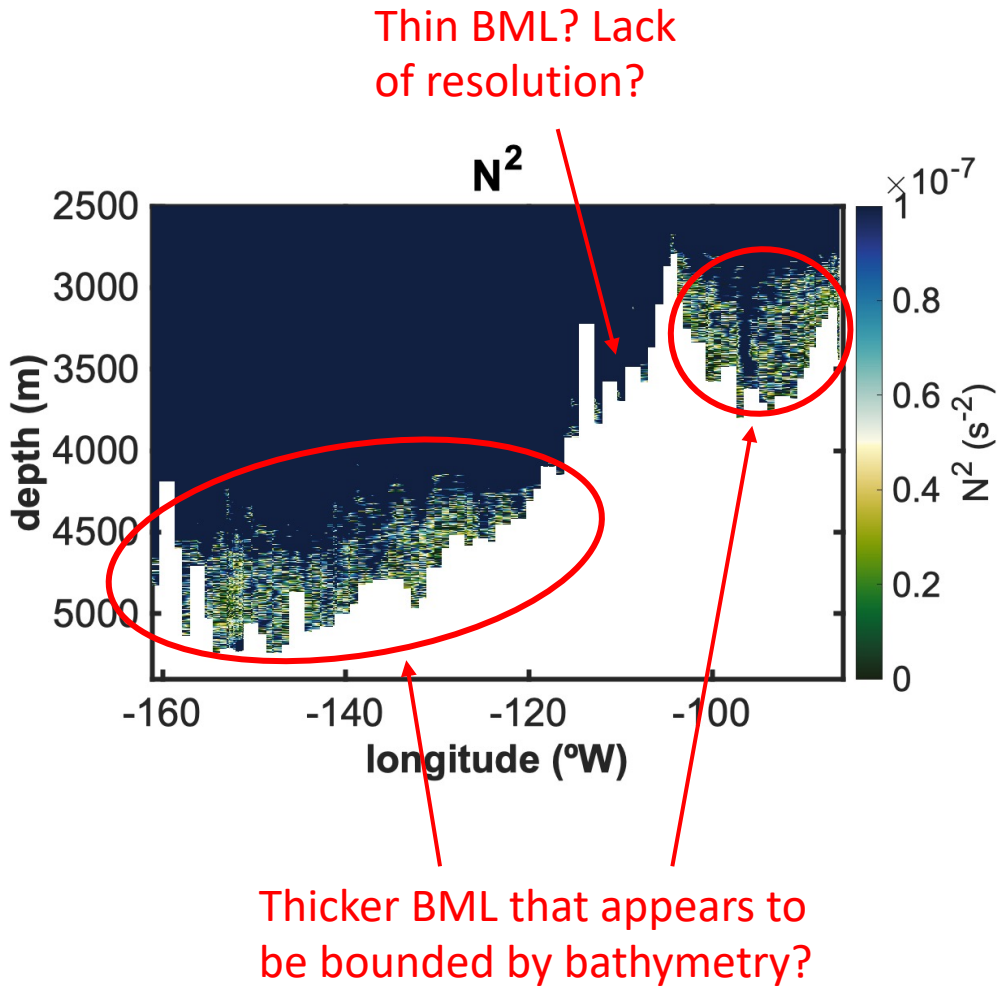
$$h_{BBL} = A\,U_*/f\left[1 + N^2/f^2\right]^{1/4}$$

Where A is a constant with an approximate value of 1.3
U* is frictional velocity ($U_* = U/30$, U is flow velocity)
f is inertial frequency ($f = 3\times10^{-5}\ s^{-1}$)
N is buoyancy frequency ($N = 3\times10^{-4}\ s^{-1}$)

→ For BGR area, this scaling relationship yields an estimate of 227 m.

Historical Observations from the Region



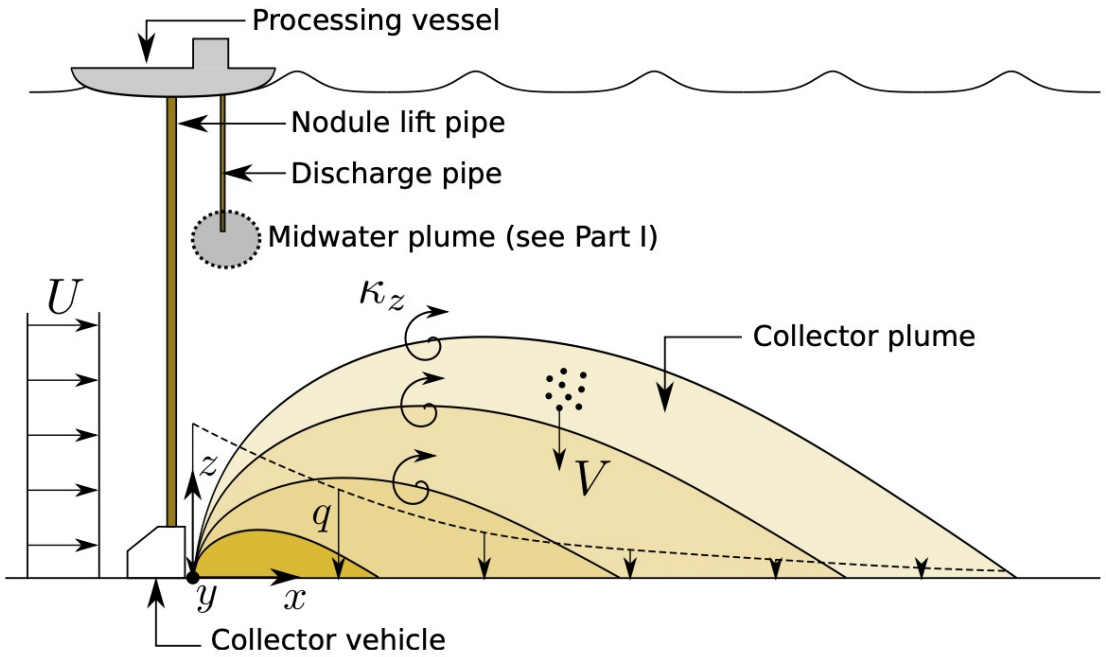


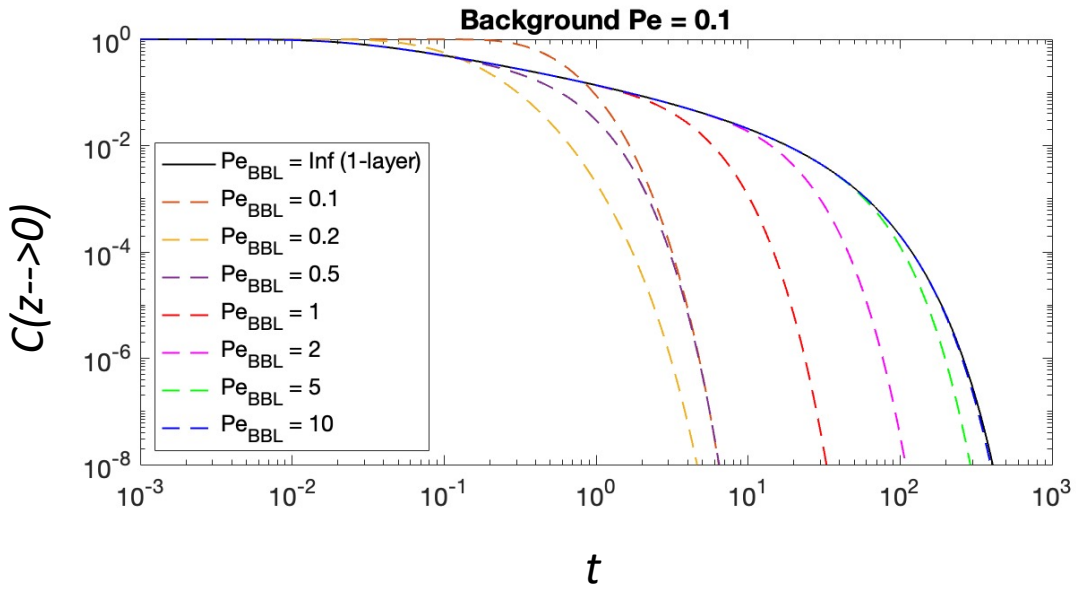
Data from R/V Moana Wave 1989, archived in World Ocean Circulation Experiment Hydrographic Programme (WHP).

Modelling the Effect of BML on Plume Dispersal

$$\frac{\partial C}{\partial t} - \frac{\partial C}{\partial z} = \frac{1}{Pe_z}\frac{\partial^2 C}{\partial z^2}, \qquad Pe_z = \frac{HV}{\kappa_z}$$

$$Pe_{z\_BBL} = \frac{H_{BBL}V}{\kappa_z}$$





Ouillon et al. *FLOW in review*

Conclusions & Outstanding Questions

BML highly variable ~O(100 m)

Mean thickness of approximately 250 m, consistent with historical observations and theoretical estimates

Local topography likely play a role in the thickness

A 1-dimensional model shows that the effect of BML on the redeposition of the dispersed plume is noticeable when Pe of the boundary layer is smaller than 10, with a typical background plume Pe of O(0.01 – 1)

What controls the variability of BML?

On what spatial scales do they affect the dispersal of sediment plumes?


Thank you!
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