MRV for Mineral-Based Ocean Alkalinity Enhancement

National Academies of Science, Engineering and Medicine
mCDR Standing Committee Meeting

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HOURGLASS CLIMATE

HOURGLASS CLIMATE

Hourglass Climate is a US-based 501(c)3 nonprofit research organization.

Our mission is to strategically research the safety and efficacy of mineral-based **Ocean Alkalinity Enhancement** (OAE) for responsible carbon removal and climate impact at scale, and to disseminate our work for the public benefit.

TOOLS

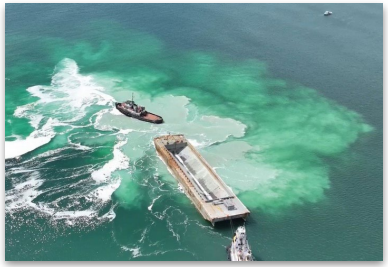
Modeling tools that facilitate responsible project planning, permitting, and impact quantification.

FIELD TRIALS

Field trials that ground-truth the efficacy and safety of mCDR, with transparent data sharing as a tenet of the work.

MINERAL-BASED OAE

Vesta PBC



Vesta PBC

Planetary Technologies

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Technologies that use the dissolution of

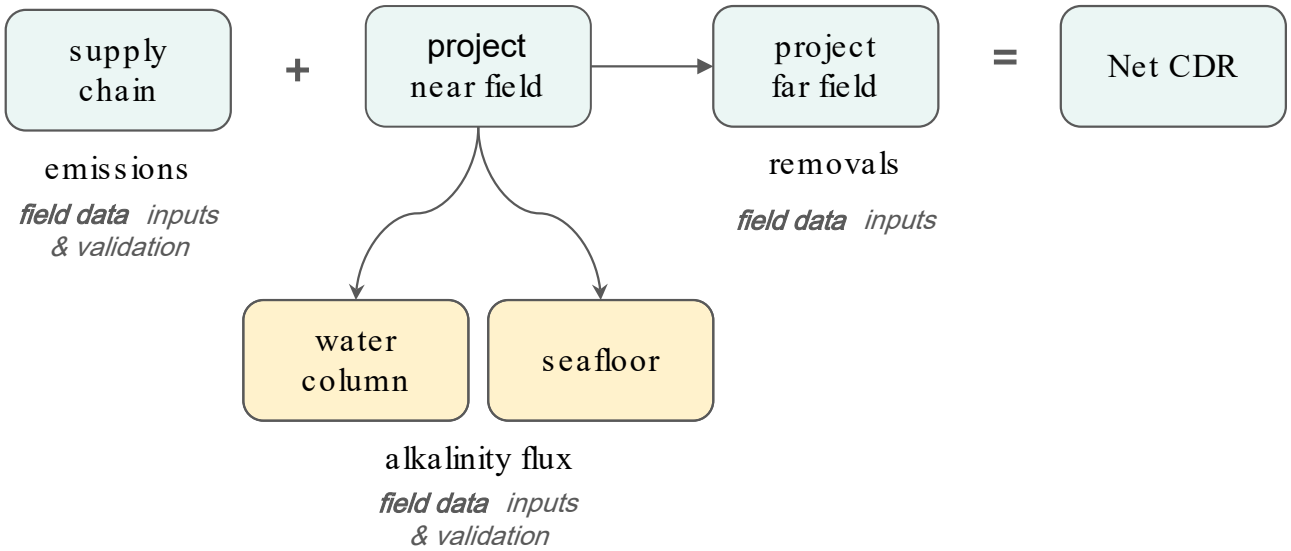
natural or synthetic rocks and minerals to generate alkalinity in the ocean and

drive a net increase in atmospheric CO_2 storage in seawater

****Image of lake liming for example purposes only. Conducted here not for the purposes of CDR.

CDR QUANTIFICATION

A measure and model approach



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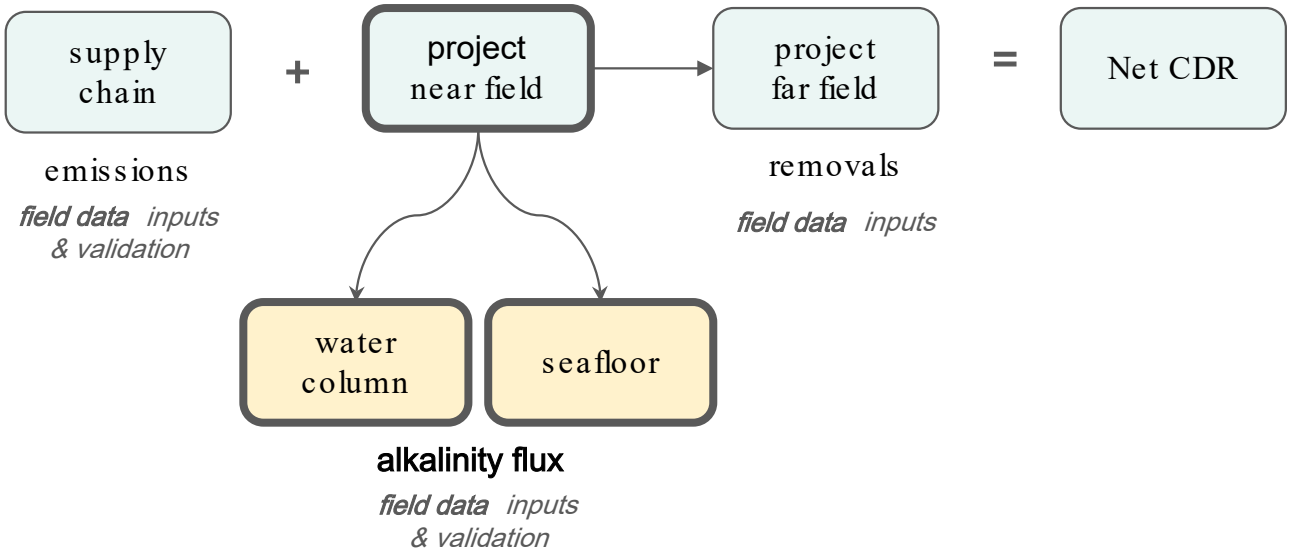

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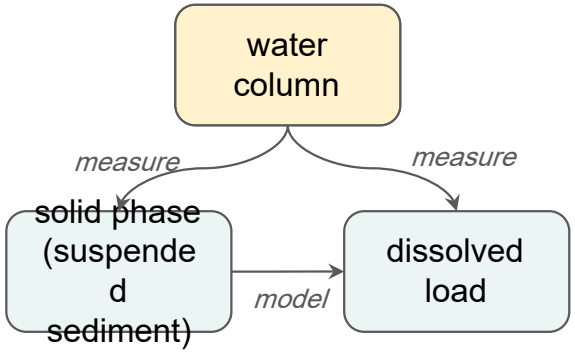

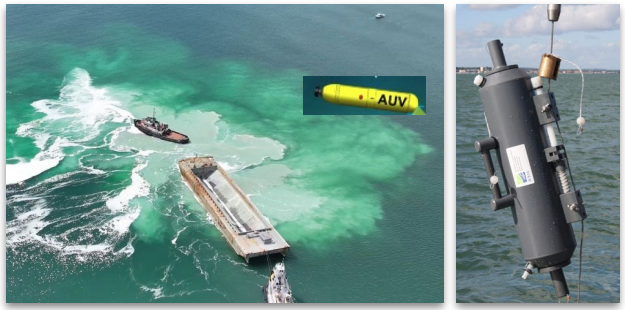

Vesta PBC

- Real-time counterfactual (i.e. outside plume)
- Alkalinity (and for some minerals, other trace elements) can be measured directly at addition site via sensors and/or bottle samples
  - Demonstrated at multiple field trials
- Suspended sediment and/or turbidity can be measured by sensors and/or bottle samples
  - Demonstrated at multiple field trials
- Measurements collected via manned and unmanned vehicles
- For pipe deployments, these measurements are continuous. For discrete (boat) deployments, these measurements are hours to days
- The transport of solid phase in the water column, and transformation to dissolved phase, can be modeled via a coupled particle transport + dissolution model
  - Active research

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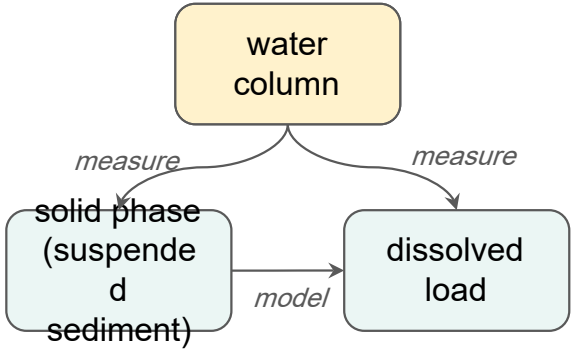
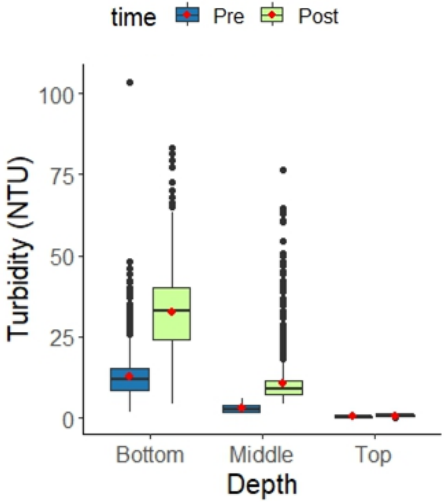
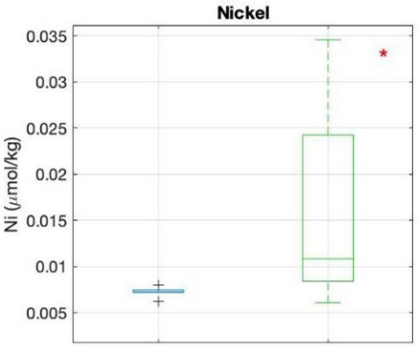
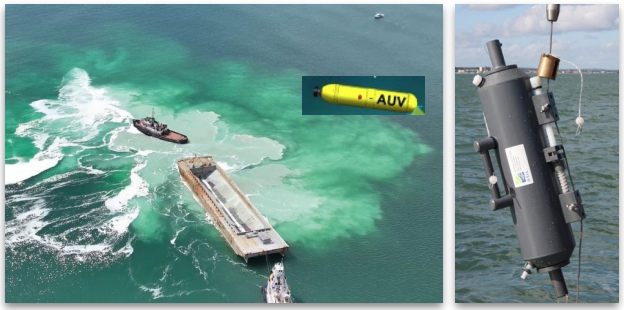
A measure and model approach







Note: EPA water quality guidelines: ~125 umol/kg



Vesta PBC

Preliminary Data *Leach et al. (in prep)*

- Short-lived (hours) but statistically significant increases in water column solid & dissolved phases

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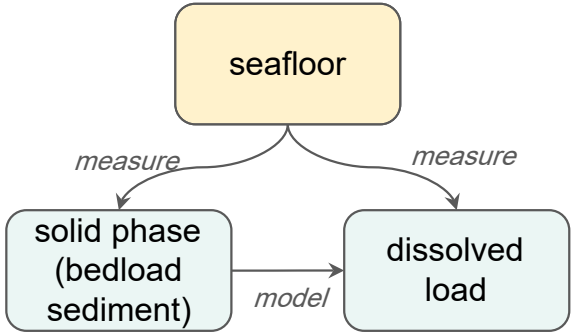

- **Applicable when** : mineral dissolution timescale > particle settling timescale (days → years)
- Real-time counterfactual (i.e. control site)
- Alkalinity (and for some minerals, other trace elements) can be measured directly at seafloor via benthic flux chambers, discrete porewater samples
  - Demonstrated at multiple field trials
- Bedload can be measured directly through bathymetry + discrete sample collection (sediment grabs, cores), with novel proxies under development (e.g. backscatter)
  - Demonstrated at multiple field trials
- The transport of solid phase and transformation to dissolved phase can be modeled via a coupled sediment transport + sediment reaction transport model
  - Active research

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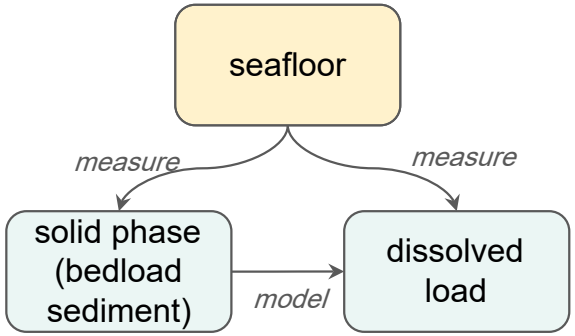

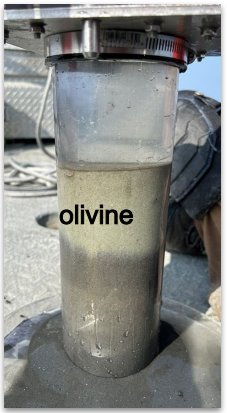

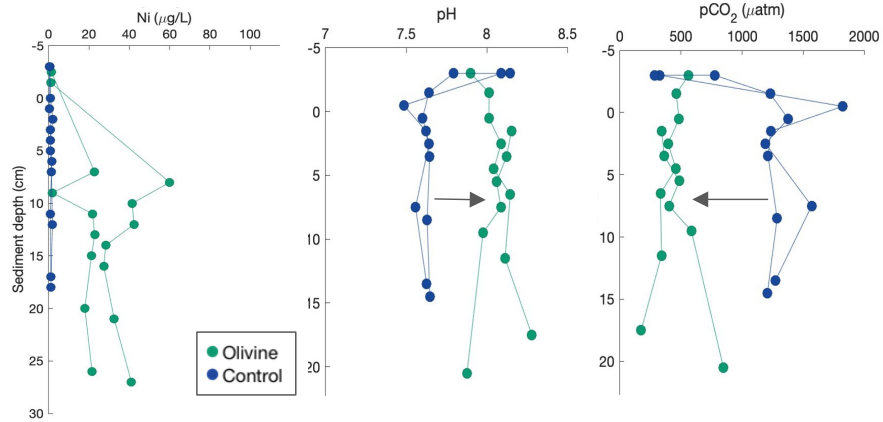

Preliminary Data; Cetiner et al. (in prep)

- Highly resolvable measurements of mineralogy (e.g. XRD)
- Highly resolvable dissolved phase signals of mineral dissolution & carbonate system perturbation

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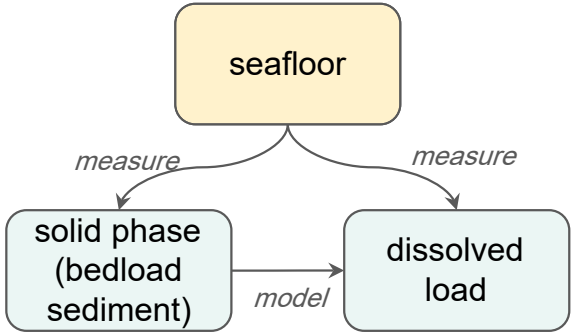

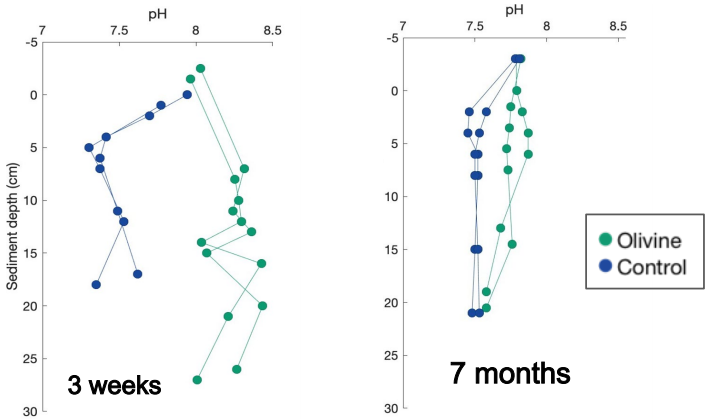

Preliminary Data; Cetiner et al. (in prep)

- Signals persist on moderate (weeks to years) timescales
- Eventually however, signals will fall below measurement capability (detection limits)

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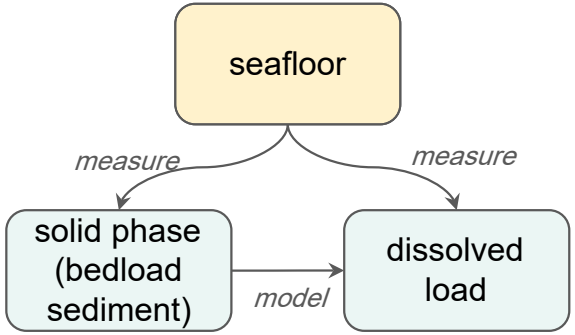

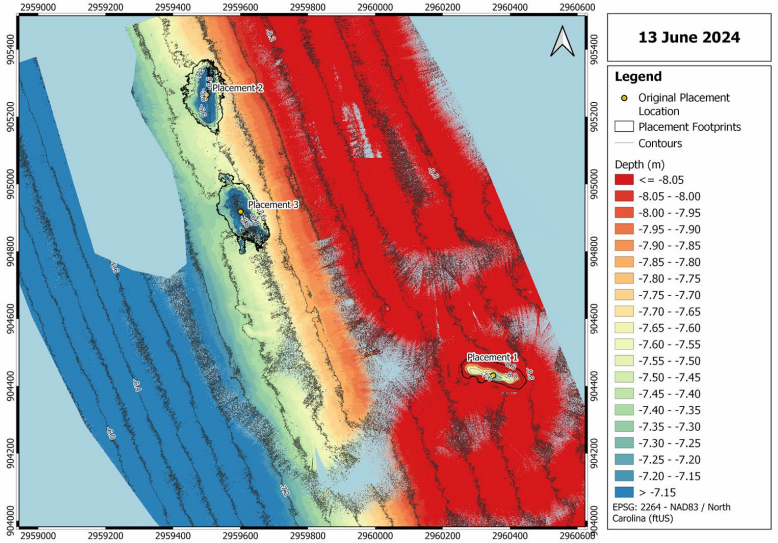

***Preliminary Data*; Leach et al. (in prep)**

- Field data validation of modeled long timescale processes
- Example: DELFT3D model of olivine berm redistribution over 1 year

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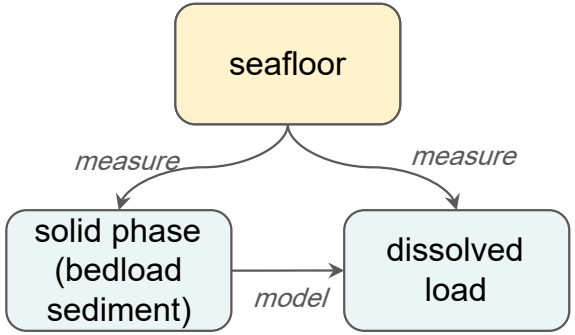

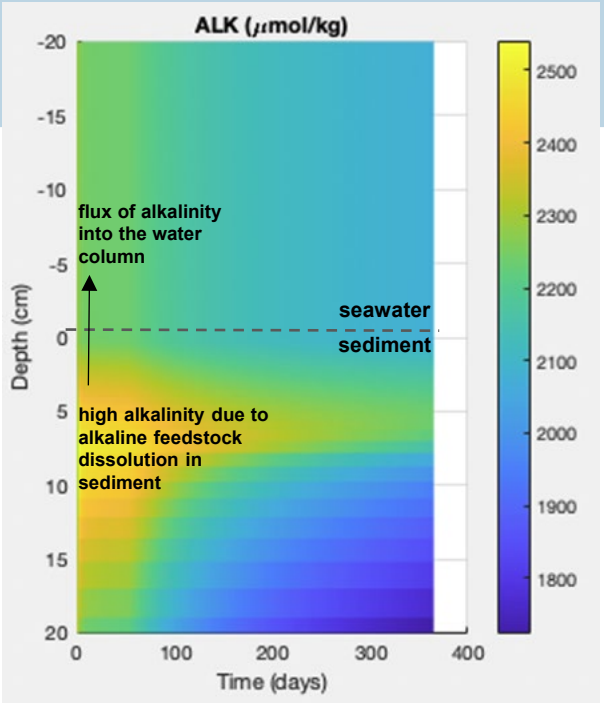

Preliminary Data; Cole et al. (in prep)

- Field data validation of modeled long timescale processes
- Example: RADI-O model of olivine dissolution & alkalinity flux over 1 year

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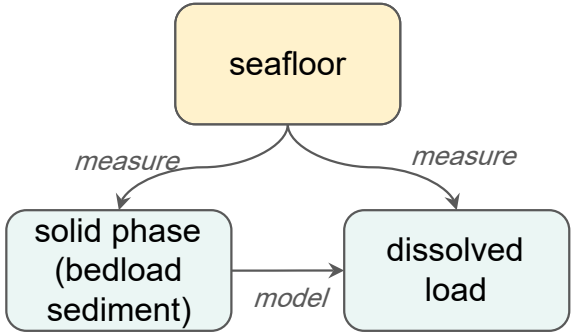
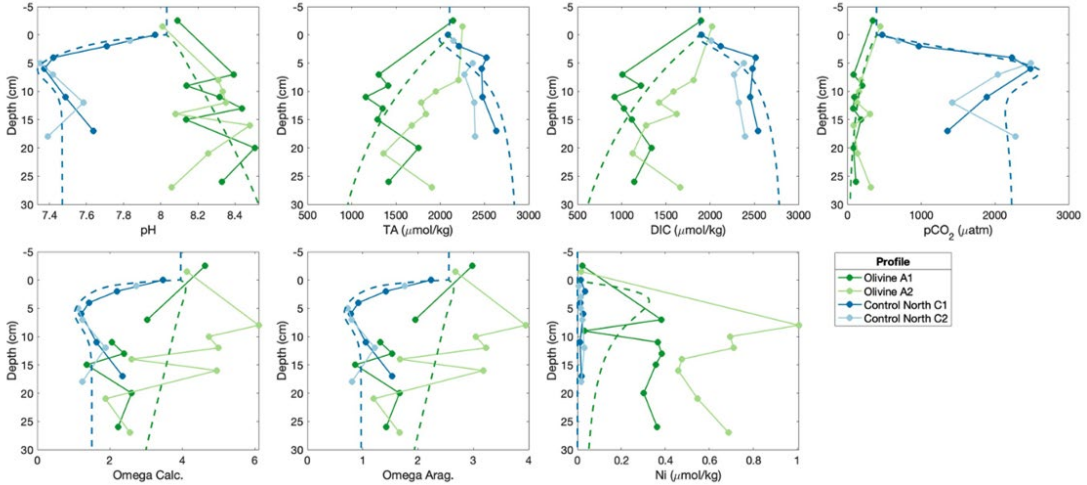
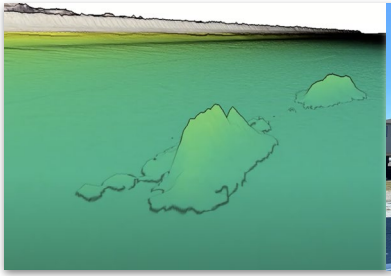
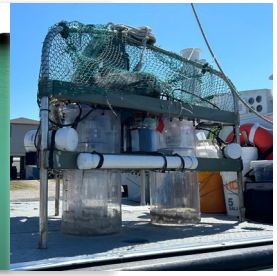








Preliminary Data; Cetiner et al. (in prep)

- Field data validation of modeled long timescale processes
- Example: RADI-O model of olivine dissolution & carbonate system

ENVIRONMENTAL IMPACT

A measure and model approach

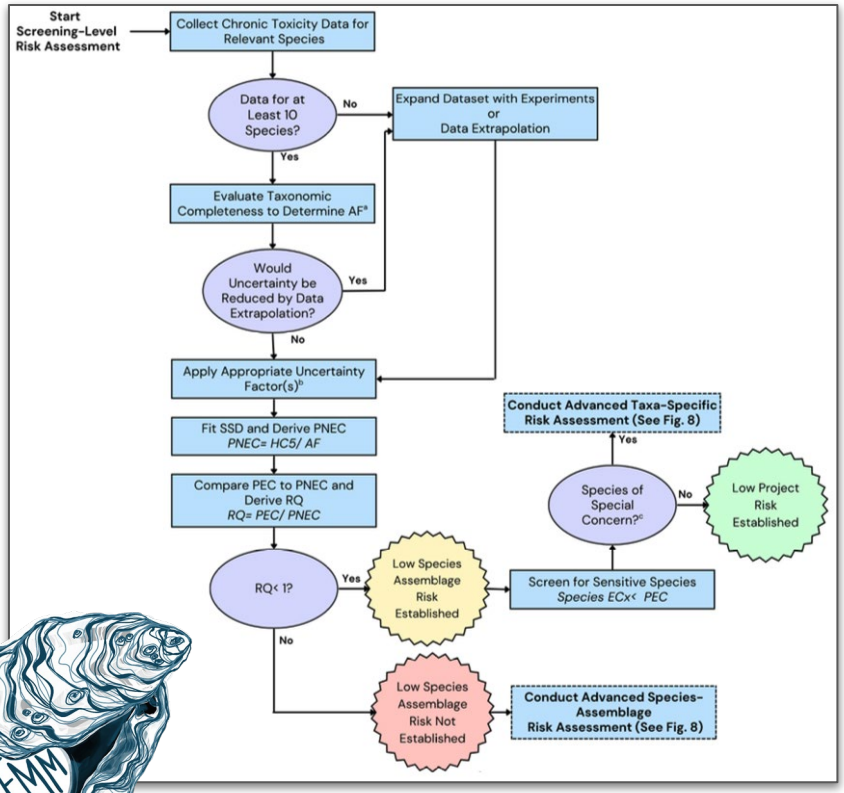
water column

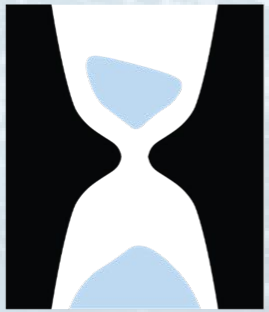
seafloor

Framework for Ecotoxicological Modeling of mCDR (FEMM)

Weighman et al. (in prep)

- "eMRV" is an essential component of MRV
- FEMM is an actionable **process** for quantifying near field ecotoxicological risk of mCDR projects
- FEMM demonstrates how to combine lab & field data with appropriate modeling approach(es)
- Suitable for solid and dissolved phases
- Based on environmental risk assessment (ERA) approaches with widespread regulatory precedent





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