BATTELLE 2023 SEDIMENTS CONFERENCE

Effectiveness of Reactive Amendments to Reduce Porewater Sulphide in Esquimalt Harbour Wood Waste-Impacted Sediments

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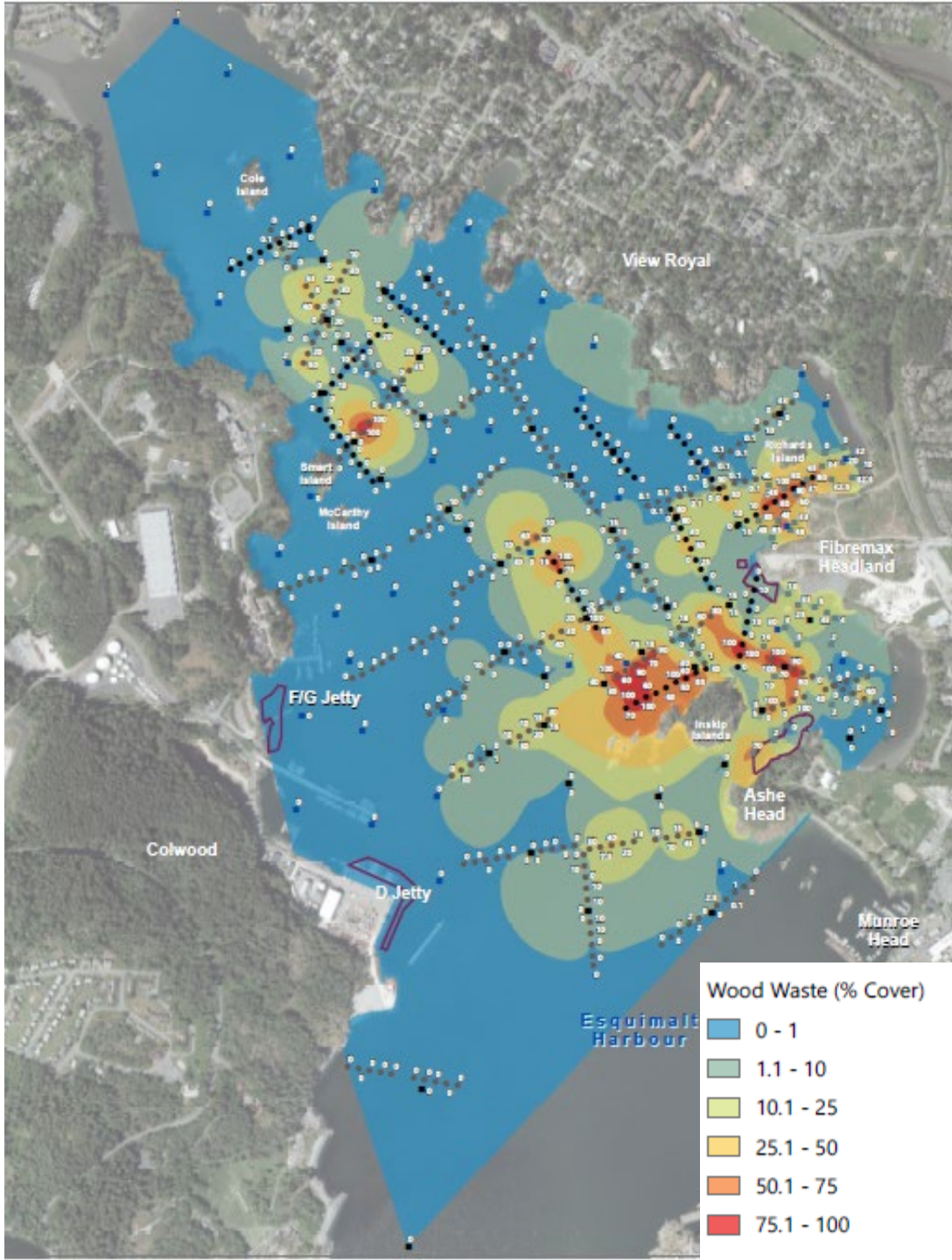
Canada

ANCHOR QEA

North Esquimalt Harbour



Physical Wood Waste Characteristics

- Can isolate benthic organisms from native sediment
- Slow to decay
- Can be highly flocculent

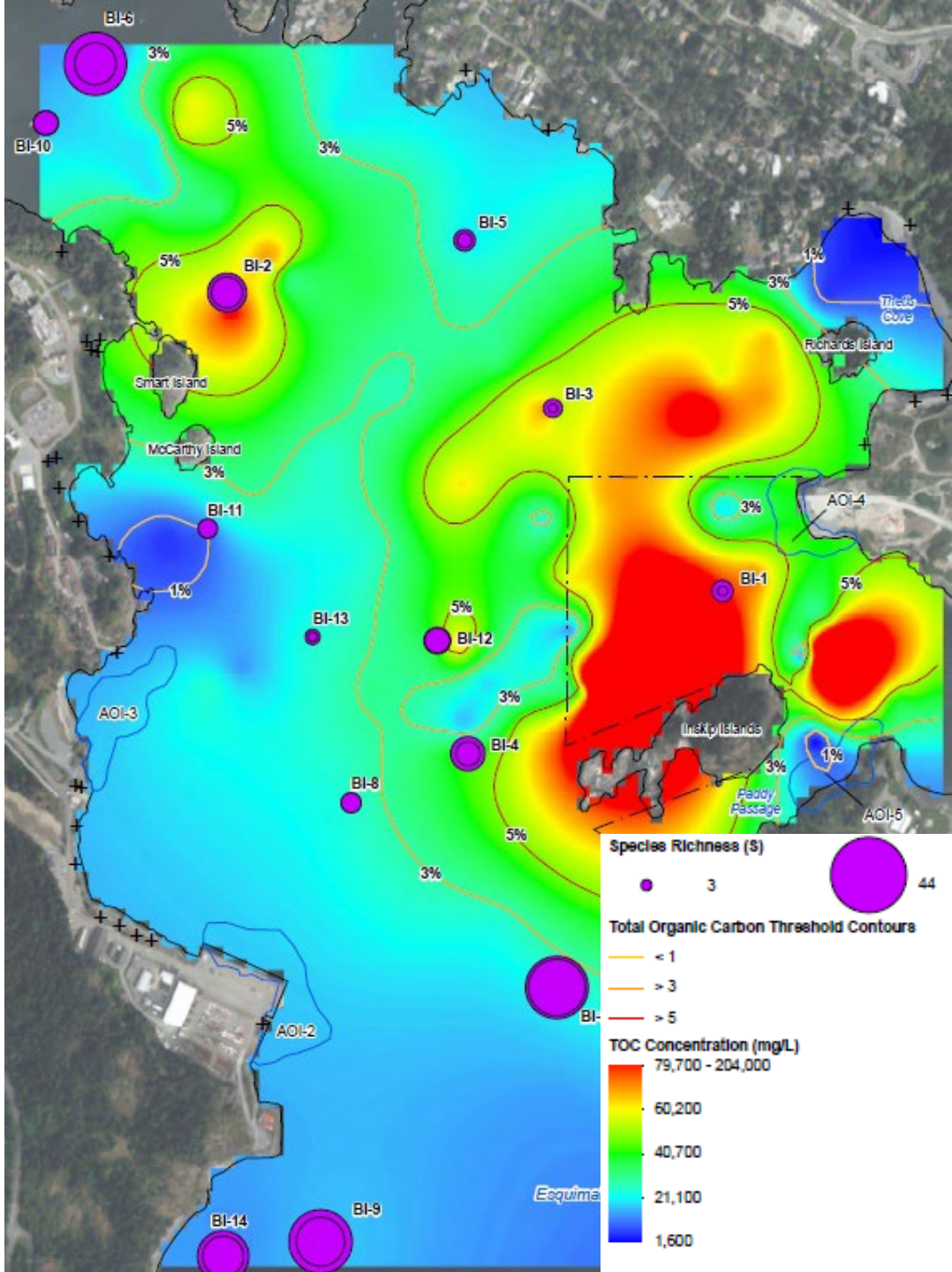
Core sample showing thickness of woody layer

Sealife colonizing log in Esquimalt Harbour

Dense wood coverage
Source: Hemmera (2018)

Chemical and Biological Effects

- Reduced benthic community abundance, diversity, and richness
- Degradation byproducts can be toxic to benthic organisms



Source: Hemmera (2018)

Sulphide Production

- Sulphate (SO_4^{2-}) is abundant in seawater
- Sulphate reduction to sulphide occurs primarily through microbial activity

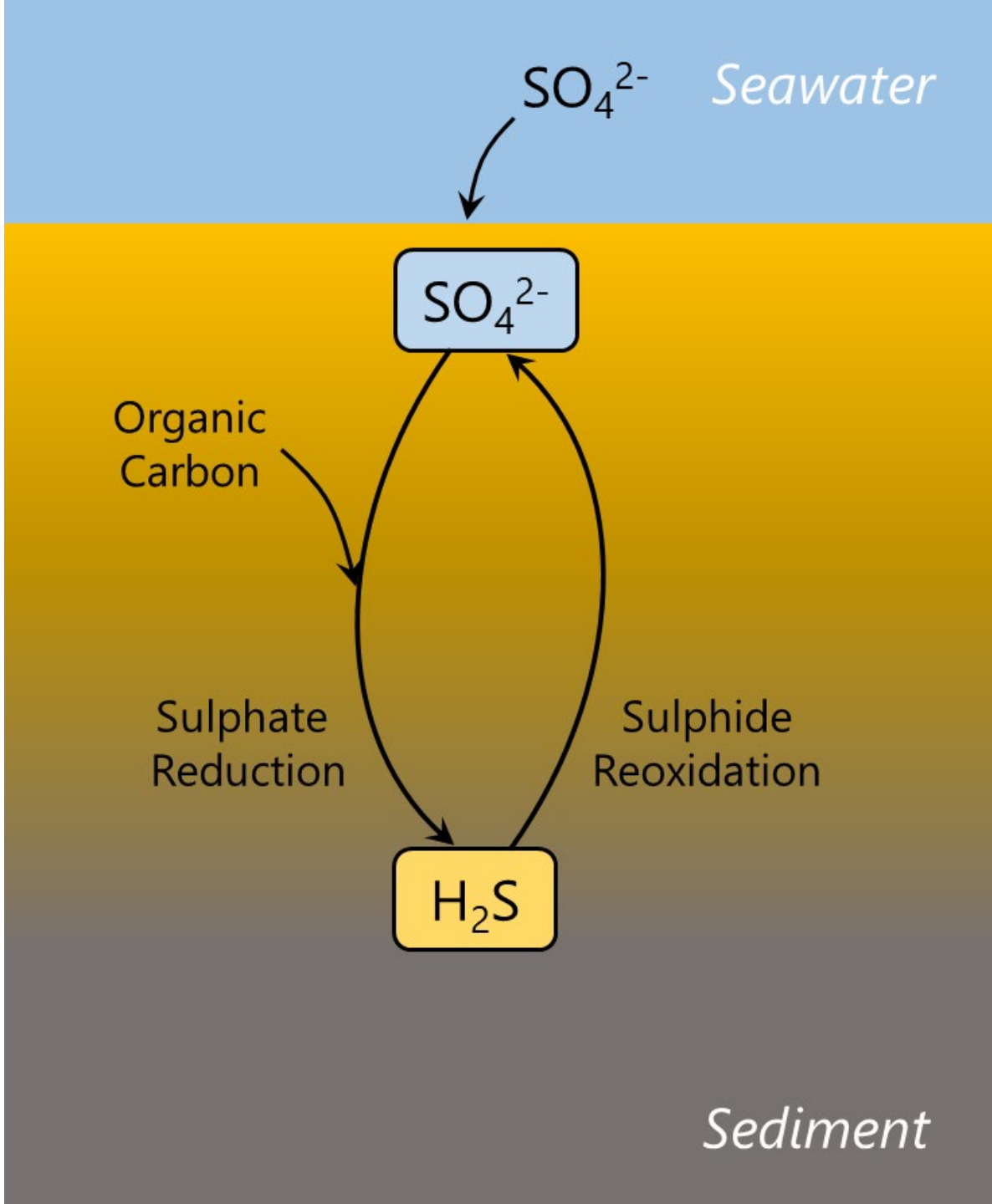


Figure modified from Jorgensen et al.

Seasonal Fluctuation

- Warmer temperatures = higher microbial activity
- Less water column mixing = lower dissolved oxygen

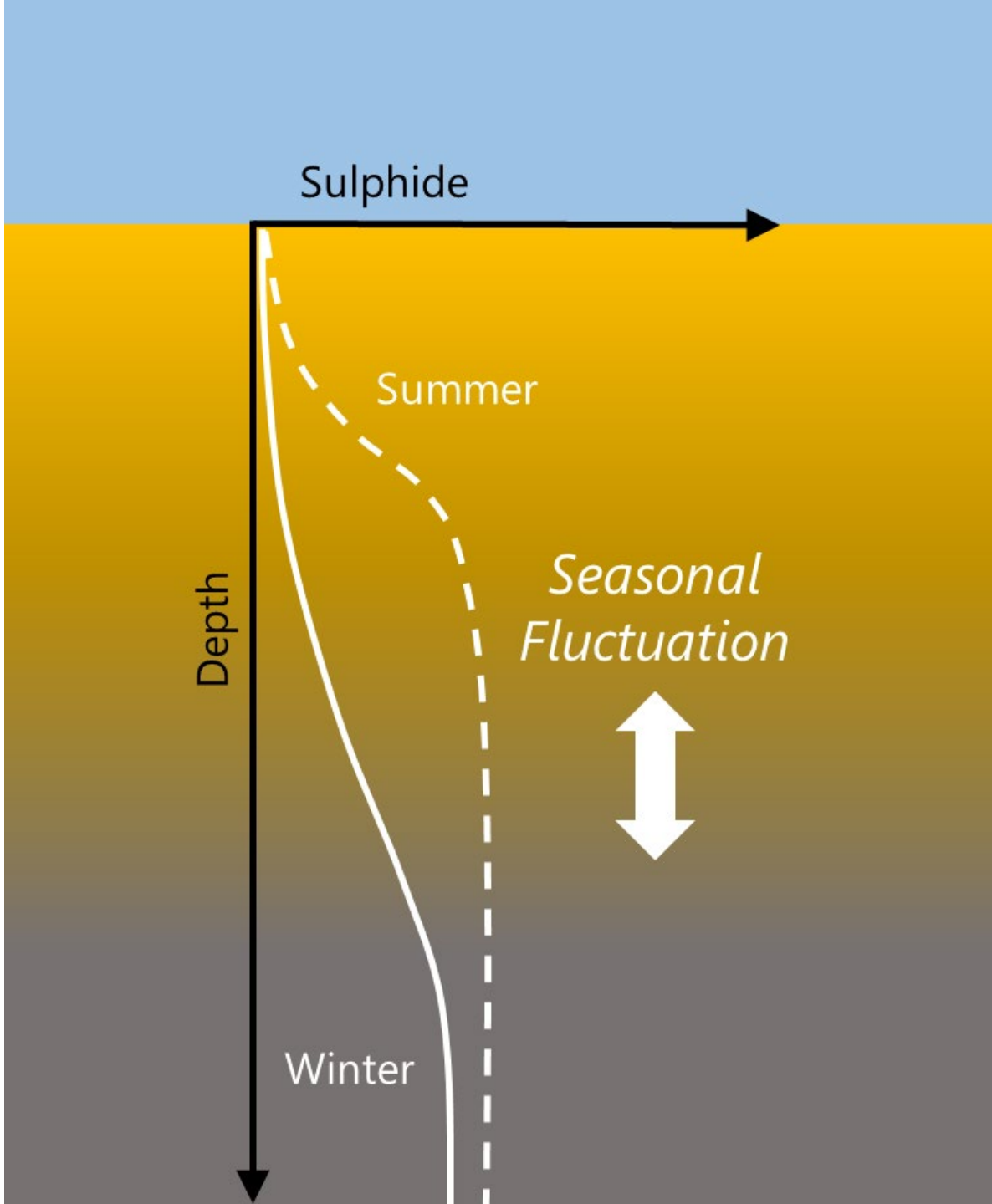
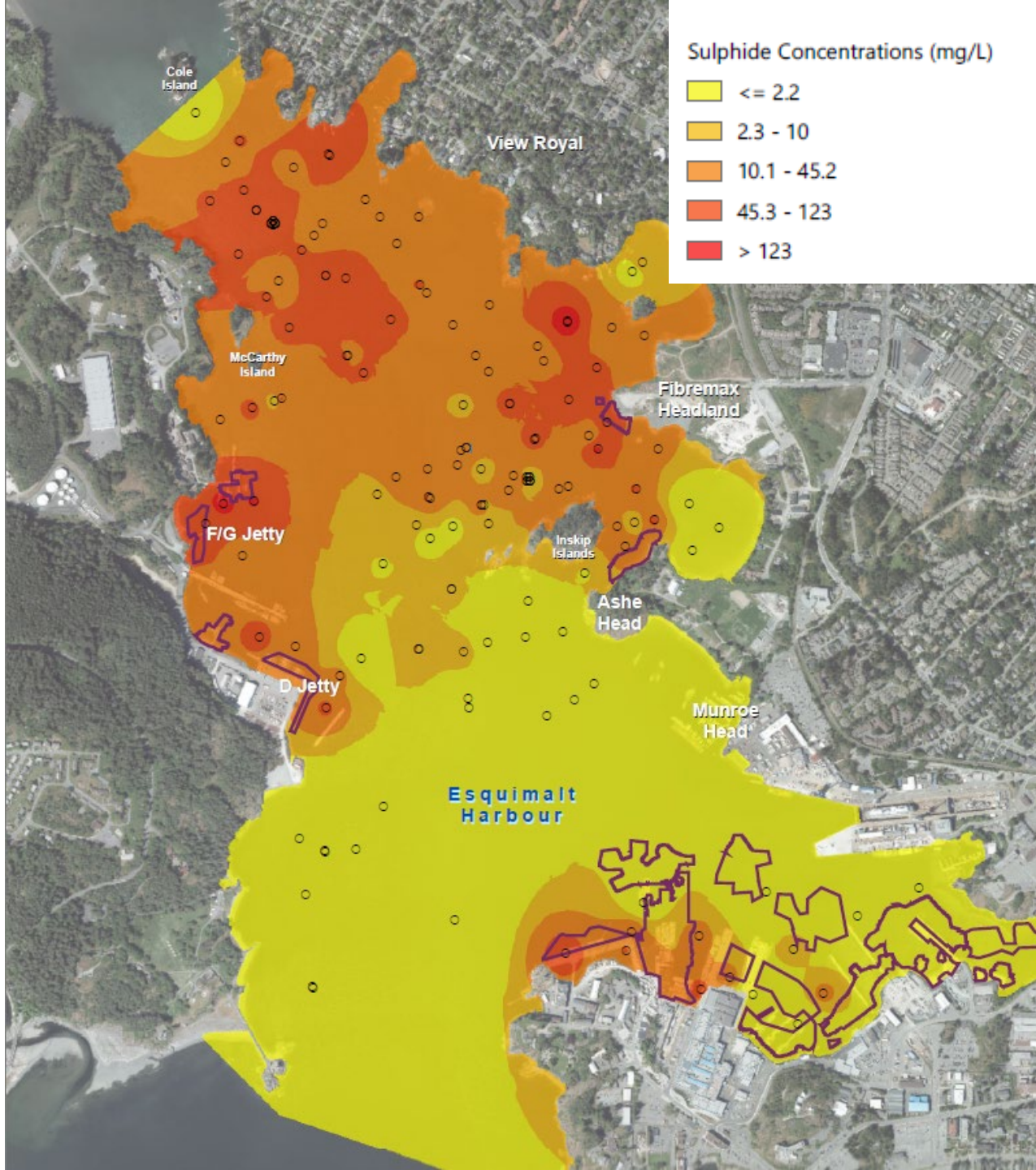
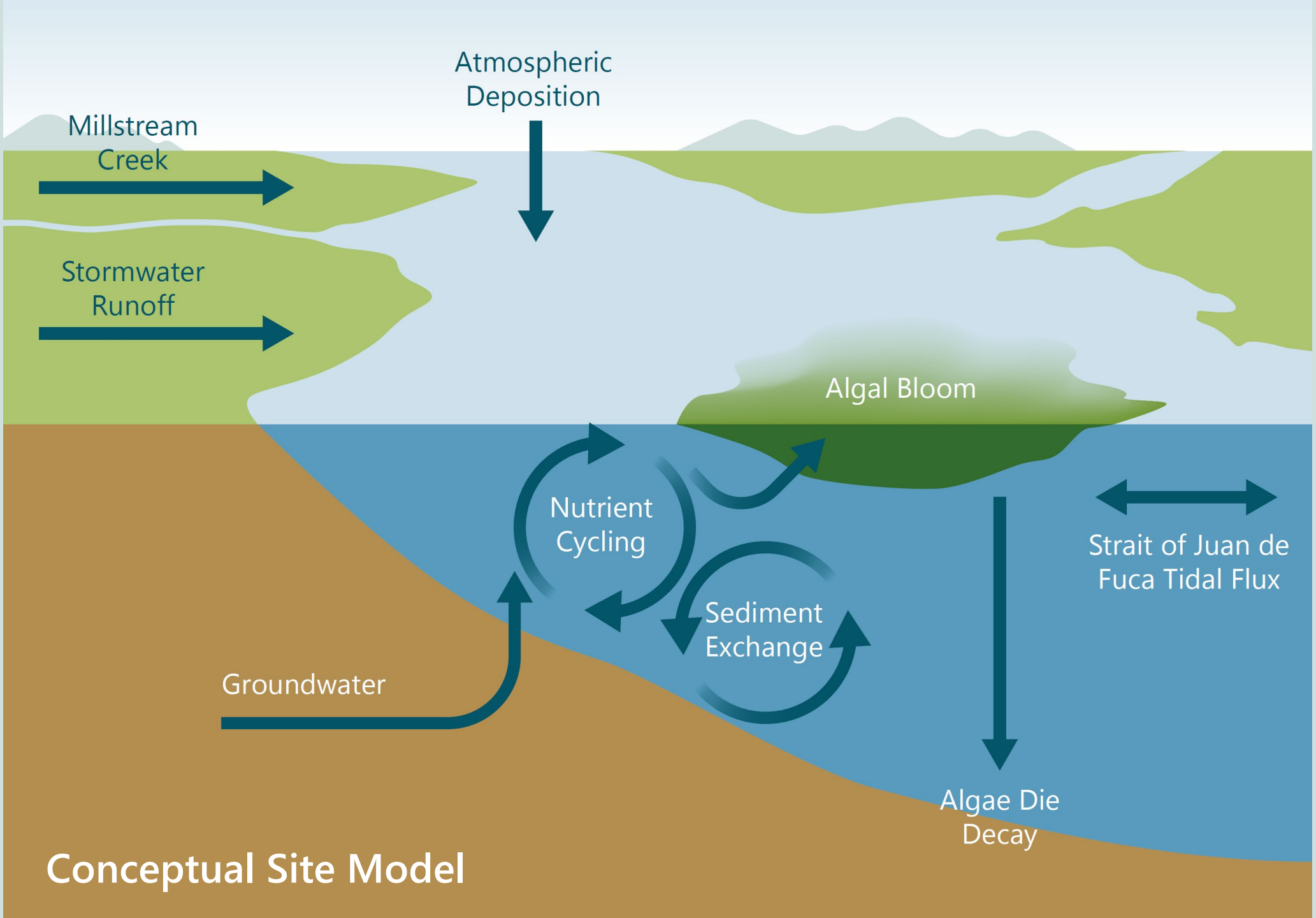


Figure modified from Jorgensen et al.

Porewater Sulphide Concentrations

- Risk assessment established 10 mg/L as adverse effects threshold
- 2 mg/L can cause toxicity to sensitive species
- Harbour median: 25 mg/L
- Usually but not always colocated with wood debris




Atmospheric Deposition
Millstream Creek
Stormwater Runoff
Algal Bloom
Nutrient Cycling
Sediment Exchange
Groundwater
Strait of Juan de Fuca Tidal Flux
Algae Die Decay
Conceptual Site Model

How can we improve benthic community health?

Sulphide Sequestration

- Sulphides can bind with metals and form less bioavailable precipitates such as iron sulphides (FeS and FeS2)
- Other metals such as manganese (Mn) can sequester sulphides

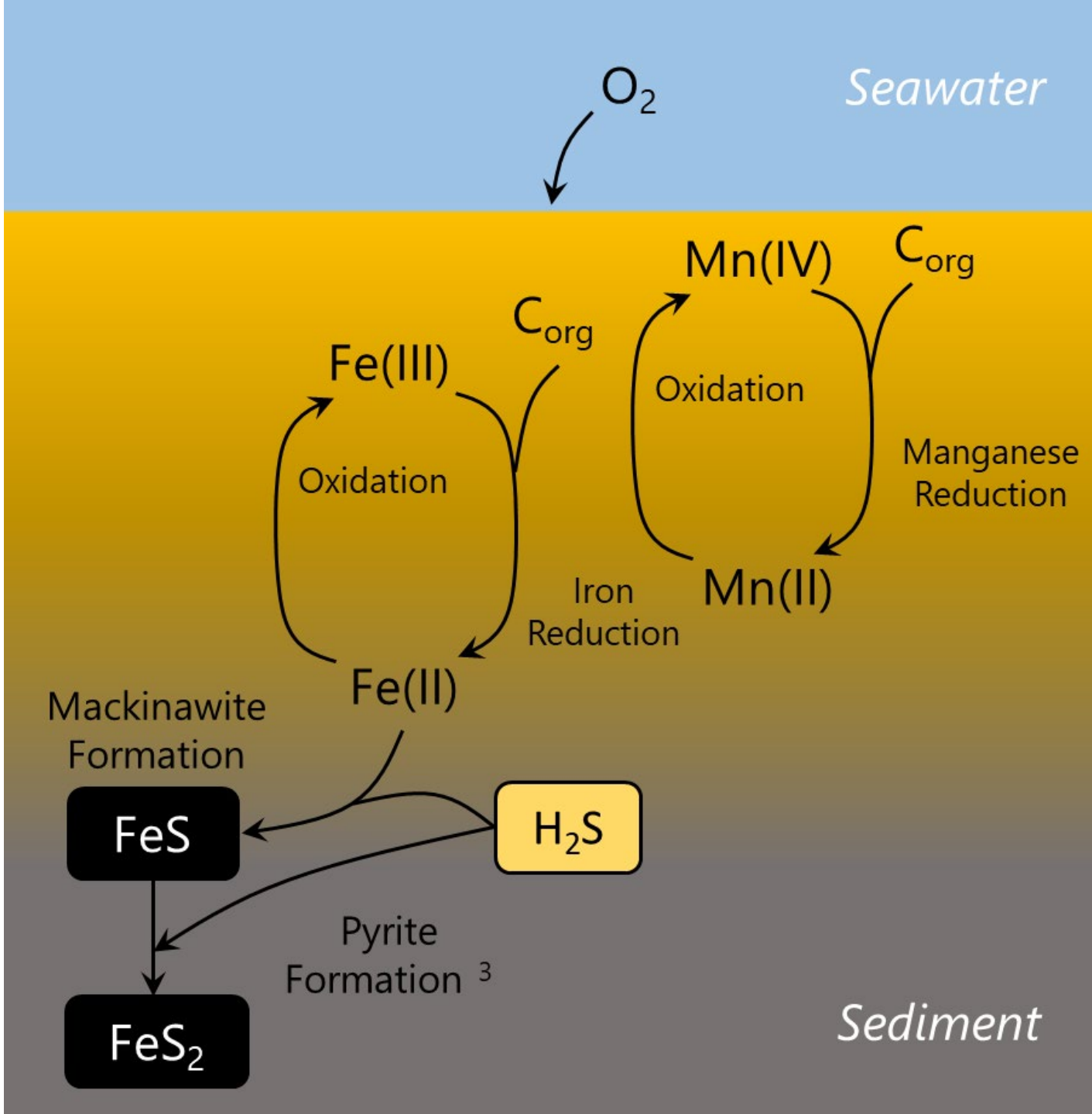


Figure modified from Jorgensen et al.

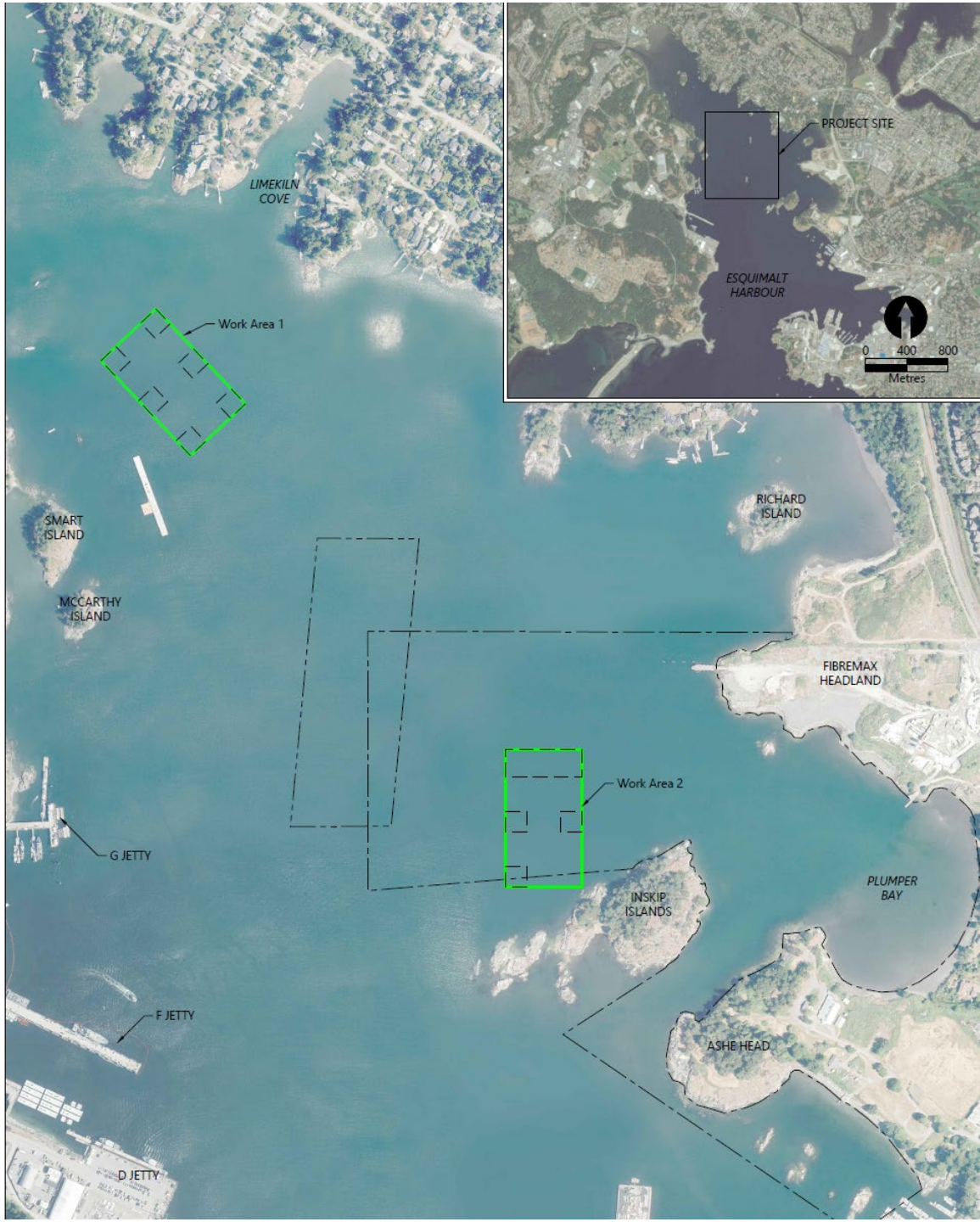
Bench Scale Test

- Amendments
  - Mn oxide
  - Mixed metal oxide
  - Siderite (iron carbonate)

Pilot Study

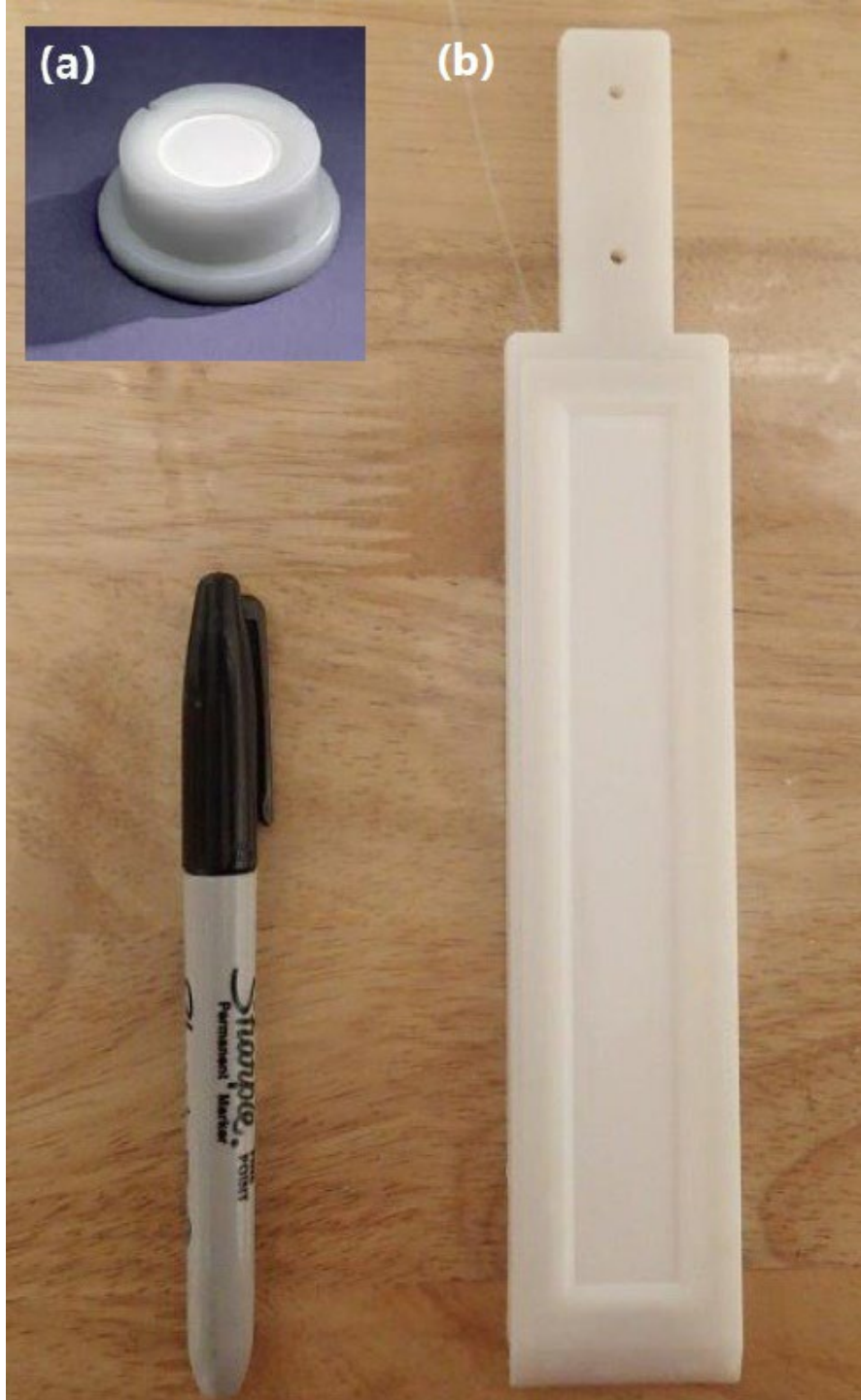
- Two work areas
  - Work Area 1: fine wood debris
  - Work Area 2: coarse wood debris

- Test conditions in each work area
  - Sand cover (30 cm)
  - Siderite-amended sand cover (30 cm)
  - Control (no action)



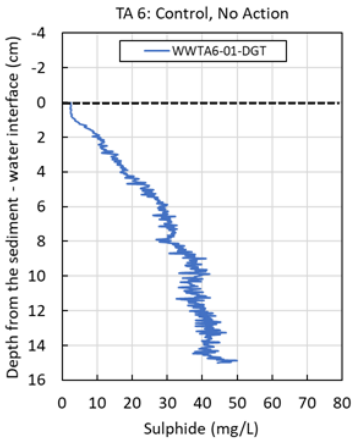
Porewater Sulphides Using Diffusive Gradient in Thin Film (DGT)

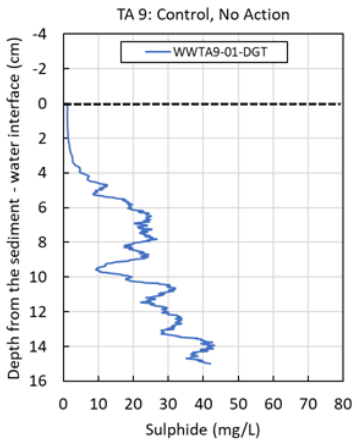
- Reliable in situ measure of porewater sulphide
- Reaction of sulphide with silver iodide gel (white) to produce silver sulphide (black)
- Intensity of color is proportional to sulphide on the gel and exposure duration



DGT Monitoring: Control Areas 6 and 9

March 2020





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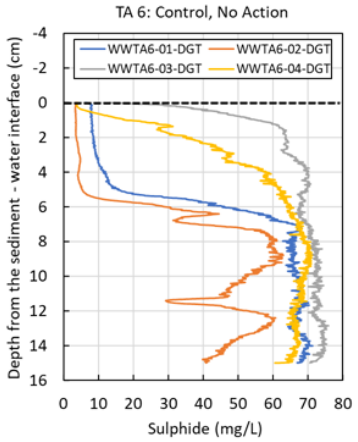

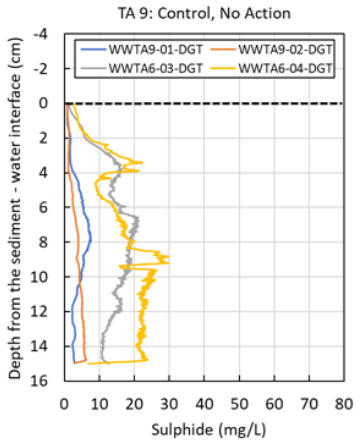

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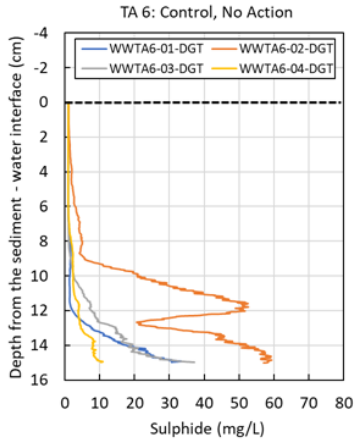

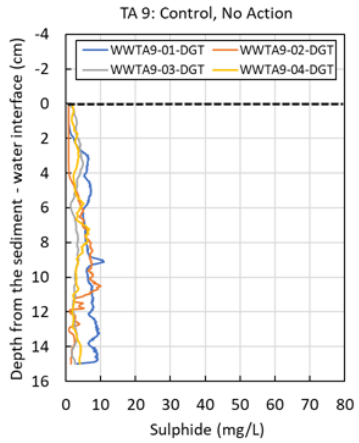

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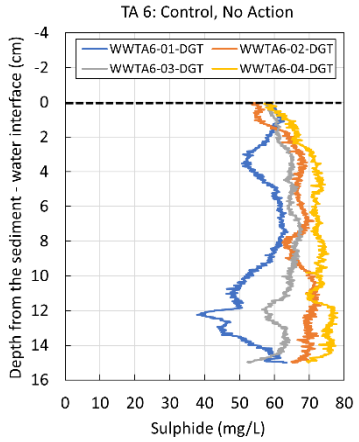

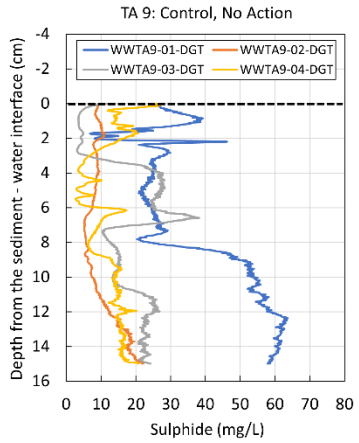

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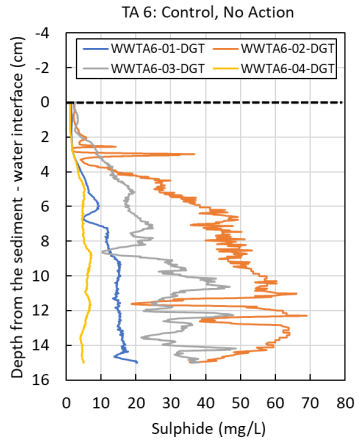

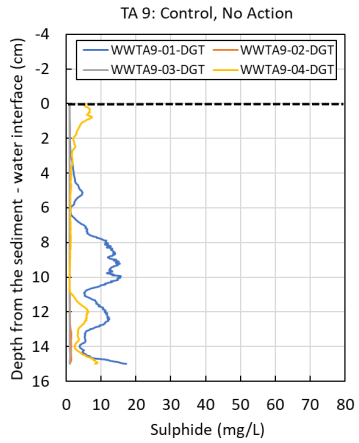

DGT Monitoring: TA-2 and TA-4

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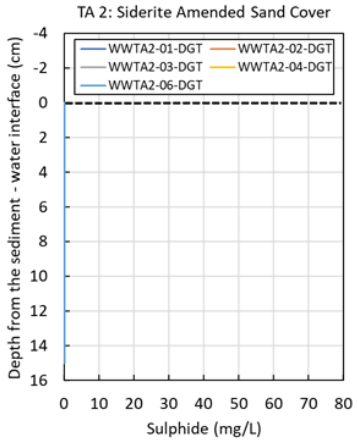

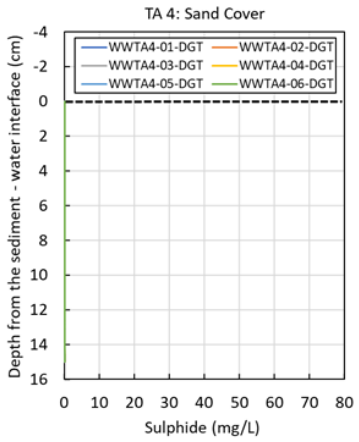

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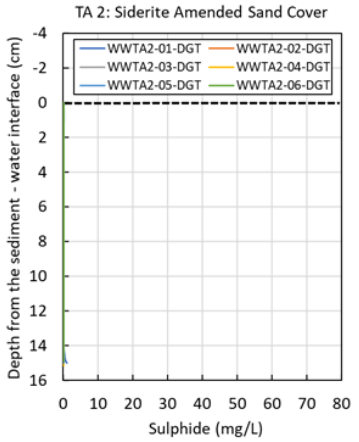

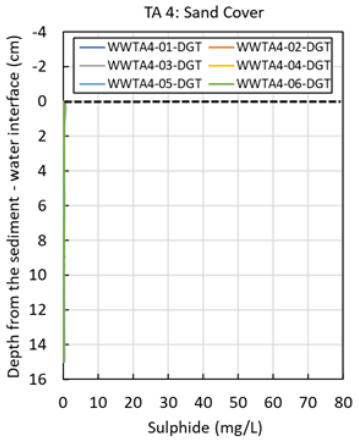

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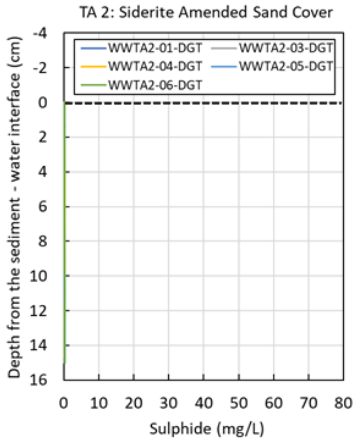

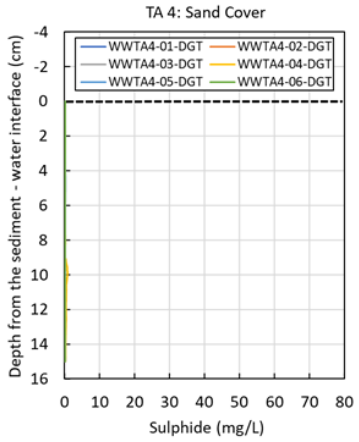

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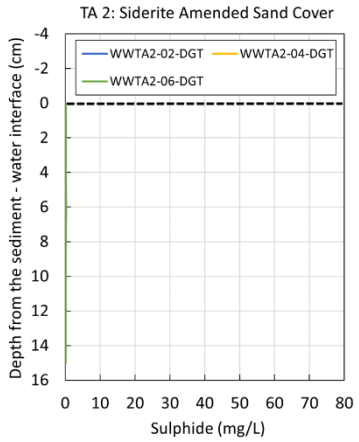

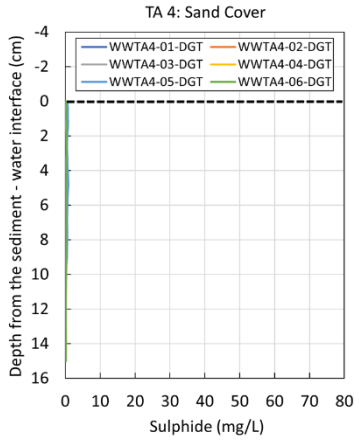

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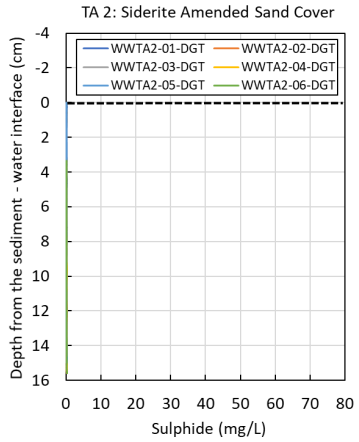

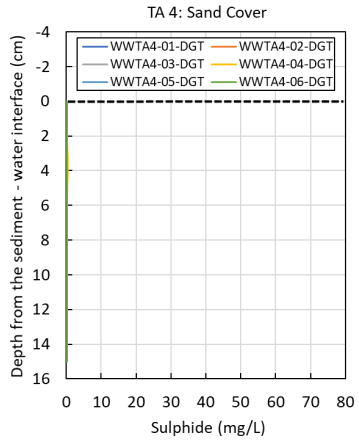

DGT Monitoring: TA-7 and TA-8

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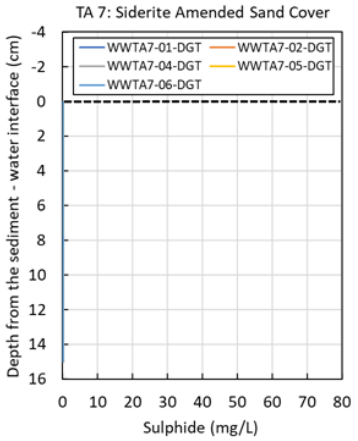

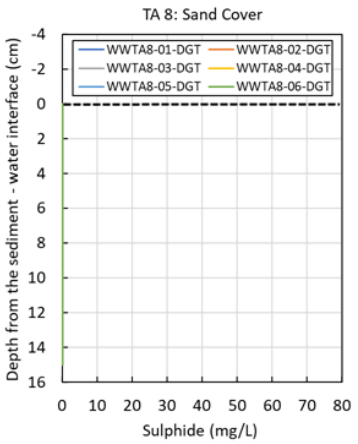

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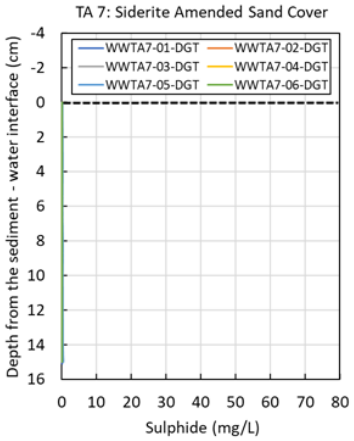

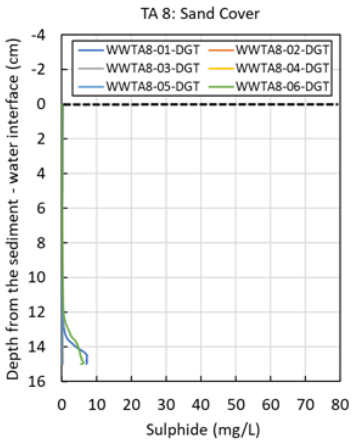

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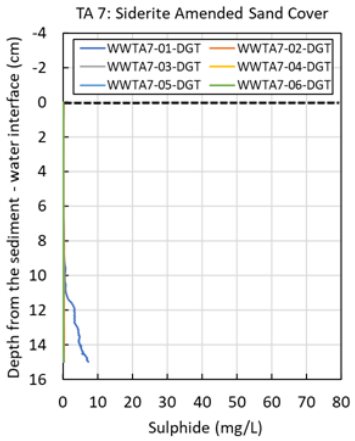

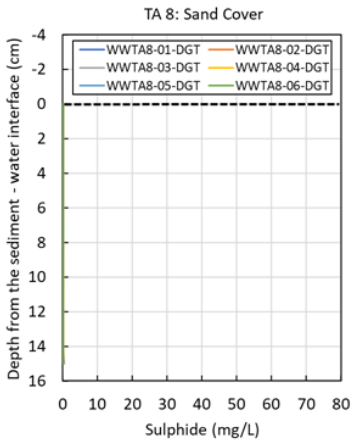

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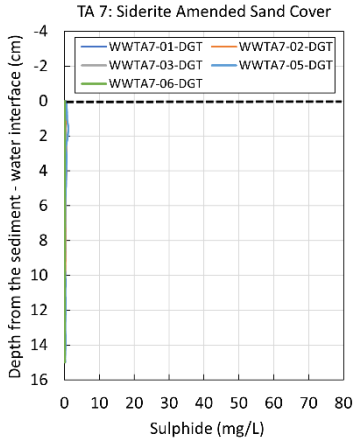

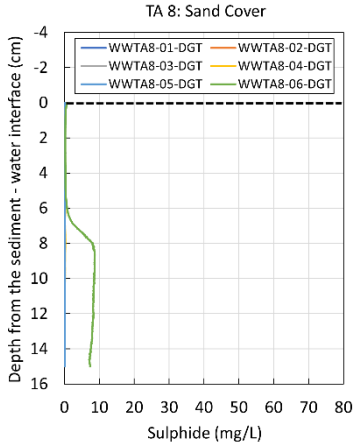

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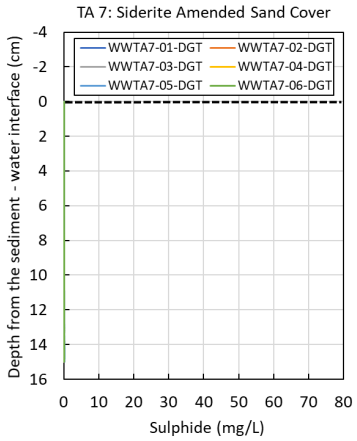
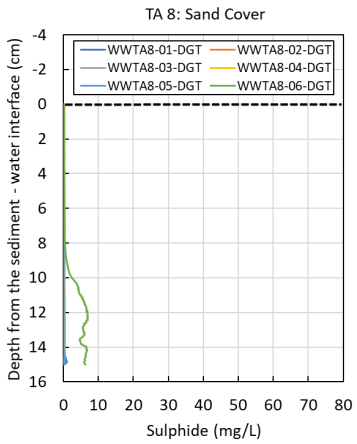
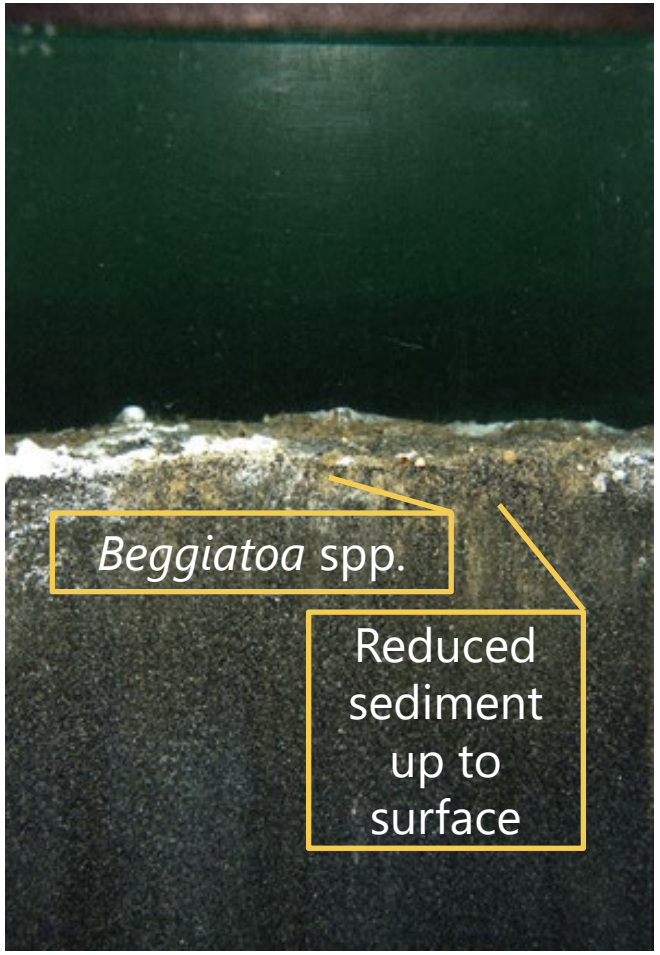




Sediment Profile Imaging

TA 3: Siderite-amended sand cover

TA 4: Sand cover



TA 8: Sand cover

Sand and Amended Sand Were Effective

- In the fine wood area:
  - Low sulphides during all events for both cover types
- In the coarse wood area:
  - Sand-only cover had sulphide breakthrough during 3 events and *Beggiatoa* spp. growth
  - Amended sand cover only had one elevated sulphide result
- Sediment characteristics and diagenetic modeling will be used to optimize cover design

ANCHOR QEA

THANK YOU

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REFERENCES

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