2023 Sediment Management Annual Review Meeting

May 3, 2023

Meeting Summary

Prepared by the DMMP Agencies:

United States Army Corps of Engineers

United States Environmental Protection Agency

Washington Department of Ecology

Washington Department of Natural Resources

LIST OF ACRONYMS AND ABBREVIATIONS

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	Chemicals of Concern
CY	Cubic yard
DMMO	Dredged Material Management Office
DMMP	Dredged Material Management Program
DMMU	Dredged Material Management Unit
DNR	Washington State Department of Natural Resources
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERDC	Engineer Research and Development Center (USACE)
MTCA	Model Toxics Control Act
NR	Natural recovery
PCB	Polychlorinated biphenyl
PFAS	Per- and polyfluoroalkyl substances
POM	Particulate Organic Matter
PSDDA	Puget Sound Dredged Disposal Analysis, the precursor to DMMP
PS-SRM	Puget Sound Sediment Reference Material
SCUM	Sediment Cleanup User's Manual
SMARM	Sediment Management Annual Review Meeting
SMS	Sediment Management Standards
TCP	Toxics Cleanup Program
TOC	Total organic carbon
USACE	United States Army Corps of Engineers
UST	Underground Storage Tanks
WA	Washington
WDFW	Washington Department of Fish and Wildlife
WRDA	Water Resources Development Act

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INTRODUCTION

Meeting Overview

The 35th annual review of sediment management issues in Washington State was held this year on May 3, 2023. This was a hybrid meeting with participants attending in-person (for the first time since the COVID-19 pandemic) as well as virtually.

The Sediment Management Annual Review Meeting (SMARM) is a joint meeting of the Dredged Material Management Program (DMMP) and the Washington Department of Ecology Toxics Cleanup Program (TCP) and is open to the public. The DMMP is an interagency cooperative program that includes the Seattle District of the U.S. Army Corps of Engineers (USACE), Region 10 of the Environmental Protection Agency (EPA), the Washington Department of Natural Resources (DNR); and the Washington Department of Ecology (Ecology). This annual meeting seeks to engage and inform all interested parties on sediment management issues in Washington.

There were 183 participants from throughout the United States and Canada (79 in-person / 104 virtual). Regulatory agencies and consultants represented the majority of participants, but many other stakeholders were represented as well, including laboratories, dredging proponents, Tribes, resource agencies, legal firms, and the public. See details in Appendix C.

The meeting moderators were Joy Dunay of USACE and Justine Barton of EPA. Joy introduced herself and the managers representing each agency. Those introduced were:

	USACE	DNR	Ecology	EPA
Manager	Brian Hart	Hannah Blackstock	Brenden McFarland	David Croxton

The presentations in 2023 covered a variety of topics, including presentations on PCB cleanups and ecosystem studies, beneficial use of sediment objectives and case studies, logistical challenges for sediment evaluations, and status reports of recent program activity,

This document provides a summary of each presentation, the questions and associated answers that followed the presentation, and reproductions of slides shown.

Attached as appendices are the following documents:

Appendix A: Meeting Announcement (distributed via e-mail 30 days before the meeting to known interested parties and previous attendees)

Appendix B: Final Agenda

Appendix C: Meeting attendees

DMMP Program Updates

All changes to the DMMP program since its inception have been made through the SMARM process: papers proposing updates are presented, public comments are taken, and proposals are then adopted as originally presented, modified based on comments, or not implemented at all.

DMMP identifies three kinds of papers: Issue, Clarification and Status. ***Issue papers*** propose substantive program-level changes that typically require approval by the directors or managers of all four DMMP agencies in order to implement. ***Clarification papers*** propose updates and modifications

to existing guidance that do not substantively change the program or policy. ***Status papers*** are for information only. Status papers may report on current investigations that could eventually result in an Issue or Clarification paper, or they may simply be information of interest to stakeholders.

No papers were submitted during this review period.

PRESENTATIONS

1. Sediment PCB Cleanup Remedy Effectiveness: Case Study Synthesis

Clay Patmont, Anchor QEA

Summary

The objective of the presentation was to explore effective approaches for managing polychlorinated biphenyls (PCBs) in river, lake, and estuary sediments, considering their persistence and potential risks to human health and the environment. Case studies of PCB-contaminated sediment cleanups in Puget Sound and North America were reviewed to evaluate the success of PCB-cleanup remedies in reducing PCB exposure. Over the past three decades, more than 30 large-scale cleanup projects were implemented, including "megasite" cleanups that removed over 15 million cubic yards of PCB-contaminated sediment at a cost exceeding $10 billion. Monitoring of PCB concentrations in sediment and fish tissue before and after remediation provided insights into the effectiveness of the cleanup measures. The results showed a mixed record of achieving remedial objectives, with challenges in controlling PCB sources in urban areas. While sediment remediation effectively reduced PCB concentrations, the connection between sediment and fish tissue PCB concentrations weakened as higher PCB sediment areas were addressed. Lower PCB levels were influenced more by factors such as water column exposures. The presentation concluded by summarizing the lessons learned from the case studies to inform future remediation projects.

Discussion

Q: Ken Patton (Apex Labs) – Atmospheric contribution of PCBs is high here. How about San Francisco?

A: Clay - There's a lot of PCBs in east coast air with the highest concentrations in urban areas. In San Francisco, and any area that had commercial industry in the 1950s, there are higher concentrations of PCBs in air and water. Puget Sound concentrations in air/water are lower but not by orders of magnitude.

Q: Dave Croxton (EPA) – Do you have more conclusions about the general conditions where natural recovery (NR) has been successful.

A: Clay - There have been quite a few cases from the east coast where NR was selected as control sufficiency determination is difficult to make. However, there are only a few systems that don't respond once source controls are in effect. NR has been very effective and there's more data to show this but didn't have time for this presentation.

Q: Andrew Schmeising (Suquamish tribe) – How were mg/L to ng/L consumption rate calcs performed (from earlier slide)?

A: Clay – Slide illustrated standard set of equations for Human Health Risk Assessment put forward in Federal guidance.

Q: Unknown - Are there similar sediment and tissue data for San Francisco Bay sites as what you provided from other projects?

A: Clay – Yes. It's a large system so difficult to pair up the sediment and tissue data. There is quite a bit of data, though. Also, there's data showing how sediments are acting as sinks and sources. There is tissue data from remediation monitoring, but most of the tissue data is from regional monitoring programs in San Francisco Bay.

Online chat questions and responses

Q: Jeremy Buck: What complications arose when you were trying to compare PCBs over time, when you may have had Aroclor data in early years and PCB congener data in the later years, with different congeners evaluated, etc?

A: Clay –Some of the long-term tissue PCB monitoring data sets have used different analytical methods over time. In many but certainly not all cases, algorithms were developed using side-by-side analyses specific to each monitoring station, and the algorithm applied to historical data collected from that station to improve data comparability over time. In situations where PCB analytical methods changed over time and side-by-side analyses were lacking, we generally excluded such uncertain historical data from the temporal plots.

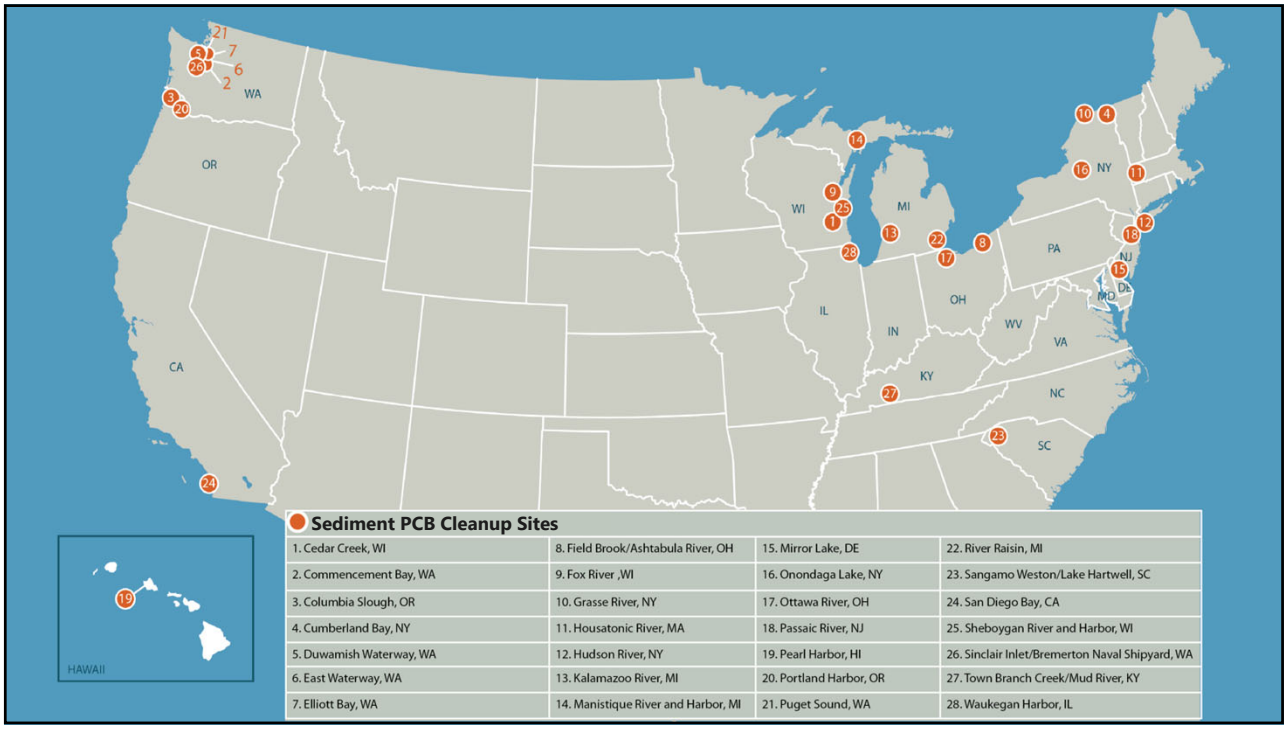
Q: Jessica Winter-Stoltzman: Source control can be a broad category- how different were the methods used from site to site? And were there some source control methods that were especially effective?

A: Clay – Effective PCB source control actions vary widely depending on the facility and environmental setting, but the more common methods have included: 1) industrial facility decontamination; 2) wastewater treatment; 3) upland and shoreline soil remediation; 4) cleaning storm drainage systems; and 5) passive stormwater treatment (e.g., infiltration).

2023 SEDIMENT MANAGEMENT ANNUAL REVIEW MEETING

Sediment PCB Cleanup Remedy Effectiveness: Case Study Synthesis

Presented by: Clay Patmont, Anchor QEA
Collaborators: Paul Doody and Betsy Henry, Anchor QEA
Suzanne Replinger, Windward



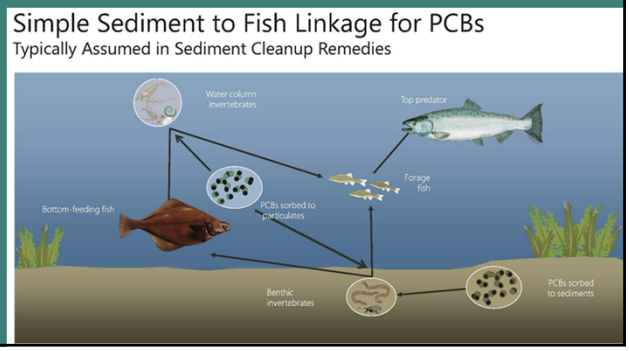
Sediment PCB Cleanup Sites

1. Cedar Creek, WI	8. Field Brook/Ashtabula River, OH	15. Mirror Lake, DE	22. River Raisin, MI
2. Commencement Bay, WA	9. Fox River ,WI	16. Onondaga Lake, NY	23. Sangamo Weston/Lake Hartwell, SC
3. Columbia Slough, OR	10. Grasse River, NY	17. Ottawa River, OH	24. San Diego Bay, CA
4. Cumberland Bay, NY	11. Housatonic River, MA	18. Passaic River, NJ	25. Sheboygan River and Harbor, WI
5. Duwamish Waterway, WA	12. Hudson River, NY	19. Pearl Harbor, HI	26. Sinclair Inlet/Bremerton Naval Shipyard, WA
6. East Waterway, WA	13. Kalamazoo River, MI	20. Portland Harbor, OR	27. Town Branch Creek/Mud River, KY
7. Elliott Bay, WA	14. Manistique River and Harbor, MI	21. Puget Sound, WA	28. Waukegan Harbor, IL

CHALLENGE

>15 million cubic yards dredged
>$10 billion spent (2022 dollars)

Was PCB sediment remediation successful?



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APPROACH

Sediment Remediation Case Study Reviews

- Retrospective reviews of completed projects with robust monitoring
  - To more broadly develop knowledge to inform future sediment cleanup remedies
- June 2019 Anchor QEA Seattle Workshop
  - 12 case study presentations (many Pacific Northwest sites; https://www.smwg.org/)
  - 66 participants (industry and federal, state, and local agencies)
- October 2022 SMWG Detroit Symposium
  - 12 case study and 4 summary presentations (https://www.smwg.org/)
  - 150 participants (industry and federal/state agencies)

APPROACH

Eight Common Topics for Each Case Study

1. Objectives of remediation
2. Summary of completed early actions and/or final remedy
3. Significant remedy scope or schedule deviations
4. When were external sources characterized and addressed?
5. Primary pre- and post-remedy effectiveness monitoring elements
6. Did the remedy achieve remediation objectives for surface sediment?
7. Is the remedy on track to achieve water/biota remediation objectives?
8. Key take-home messages on overall lessons learned

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LESSONS

Common Case Study Themes

- Cooperative partnerships get more done
- Source control in urban settings is difficult but critical
- Remedy flexibility and adaptive management improve success
- Remediation successfully reduces sediment concentrations
- Mixed remedy success reducing bioaccumulation exposures
  - Robust baseline and 7+ years postconstruction monitoring needed for evaluation
  - Only a subset of case studies currently have sufficiently robust monitoring data

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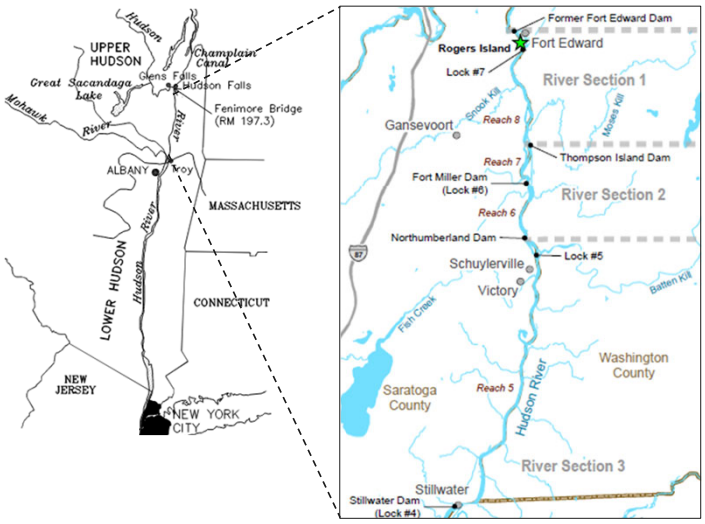
APPROACH

Robust PCB Remedy Effectiveness Case Studies

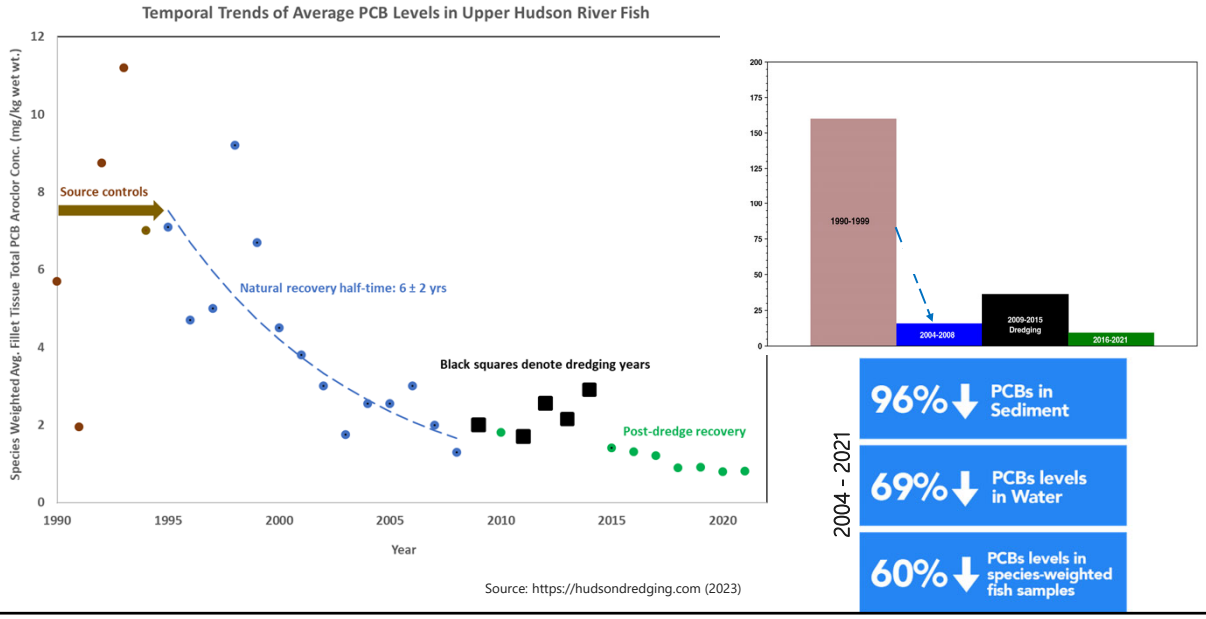
- Hudson River, New York
- Fox River, Wisconsin
- Hylebos Waterway, Washington
- Sinclair Inlet, Washington
- San Francisco Bay, California

Upper Hudson River, NY

- Direct PCB discharge from late 1940s - 1977
- Extensive upland source controls from 1974 - 1995
- 2.7 million cy sediments dredged from 2009 - 2013
  - 40 miles of River Sections 1 to 3
- Increasingly robust fish, surface water, and sediment monitoring from 1990 - 2021



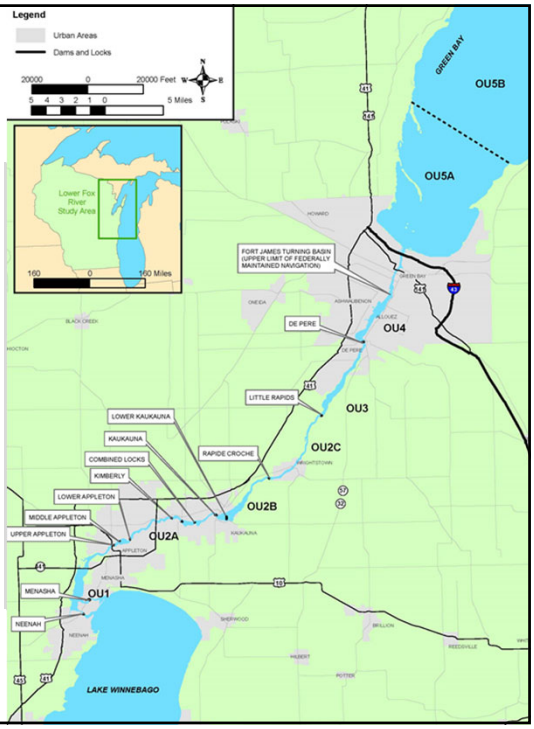
Hudson River PCB Monitoring (Sections 1 - 3)



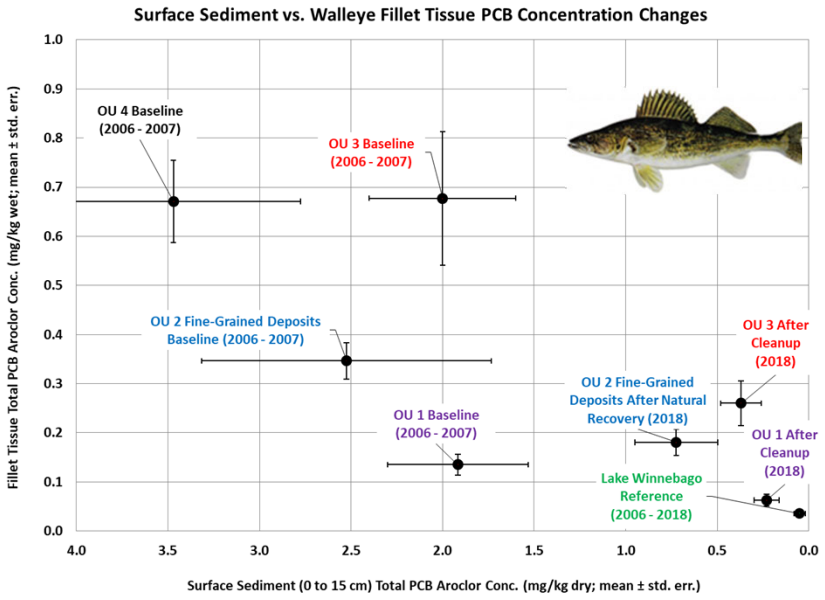
Source: https://hudsondredging.com (2023)

Fox River, Wisconsin

- Direct PCB discharge from 1954 - 1971
  - Upland source control by 1980s
- Limited monitoring from 1989 - 2005
  - Fish/water natural recovery half-times: 7 ± 3 yr
- 6.1 million cy dredged from 2004 - 2020
  - 30 miles of Operable Units (OUs) 1 - 5
  - Post-dredge capping and cover
  - OU 2 natural recovery remedy
- Robust fish, surface water, and sediment monitoring from 2006 - 2021

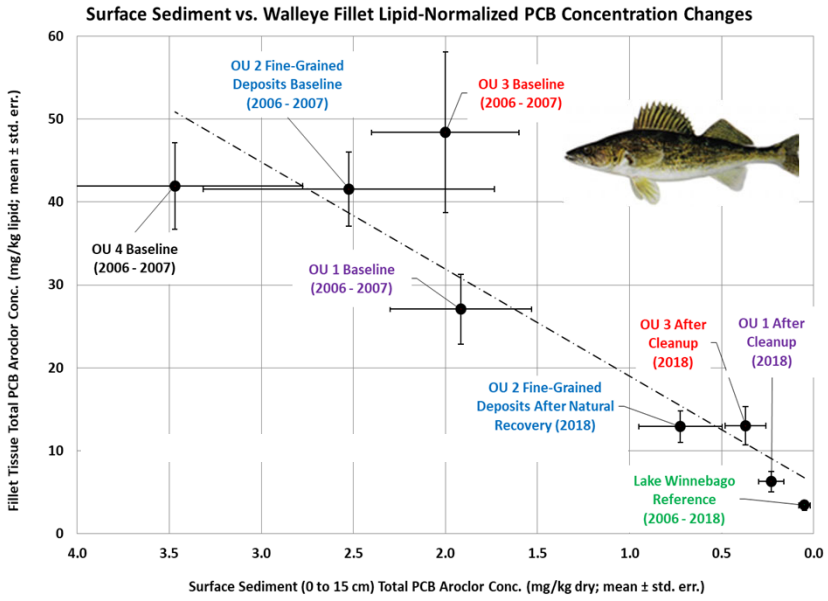


Fox River Remedy Effectiveness: Wet Weight Tissue



Sources: Anchor QEA (2007); Foth (2019); and Tetra Tech, Inc. et al. (2021)

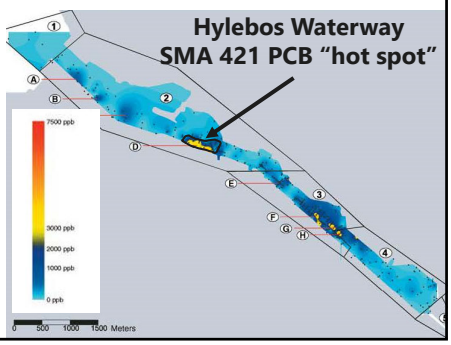
Fox River Remedy Effectiveness: Lipid Normalized Fish Tissue



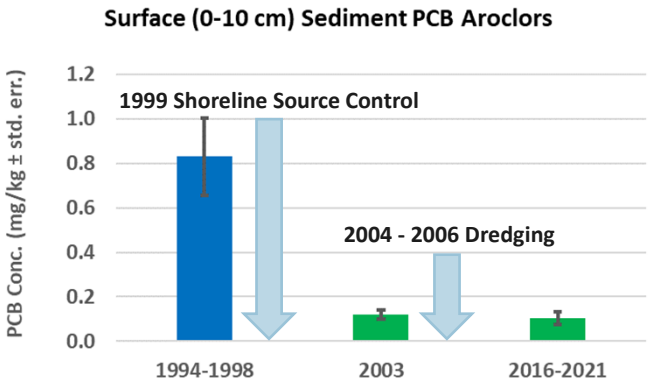
Sources: Anchor QEA (2007); Foth (2019); and Tetra Tech, Inc. et al. (2021)

Hylebos Waterway, Washington

- Numerous historical PCB sources
  - Extensive wastewater/stormwater controls and upland/shoreline cleanup from 1985 - 1999
  - Source control verified in 2001
- Sediment remediation from 2001 - 2006
  - 1.5 million cy sediment dredged (24 acres)
  - 8 acres monitored natural recovery
  - 3 acres capped
- Sediment Management Area (SMA) 421 historical PCB "hot spot" (9`acres)



Hylebos Waterway SMA 421 Sediment Monitoring



- 1999 shoreline source control
  - Failed wooden bulkhead
- Recovery half-time: 3 ± 1 yrs
  - Fluid mud/nepheloid layer flux
  - Similar to Bellingham Bay

Sources: Hylebos Cleanup Committee (1999); Anchor QEA (2003, 2021)

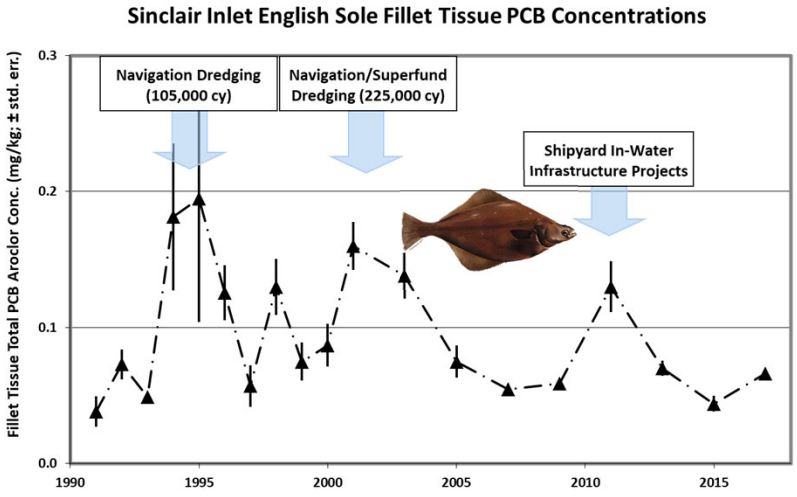
ANCHOR QEA

Sinclair Inlet, Washington

- Numerous historical shipyard PCB sources
  - Continuous source control improvements since 1992
- Navigation dredging in 1994/1995
- Navigation/Superfund actions in 2000/2001
  - 225,000 cy sediment dredged (32 acres)
  - 13 acres capped or sand covered
- Shipyard infrastructure projects in 2011
- Robust fish tissue sampling from 1991 - 2017

Sinclair Inlet Remedy Effectiveness Monitoring

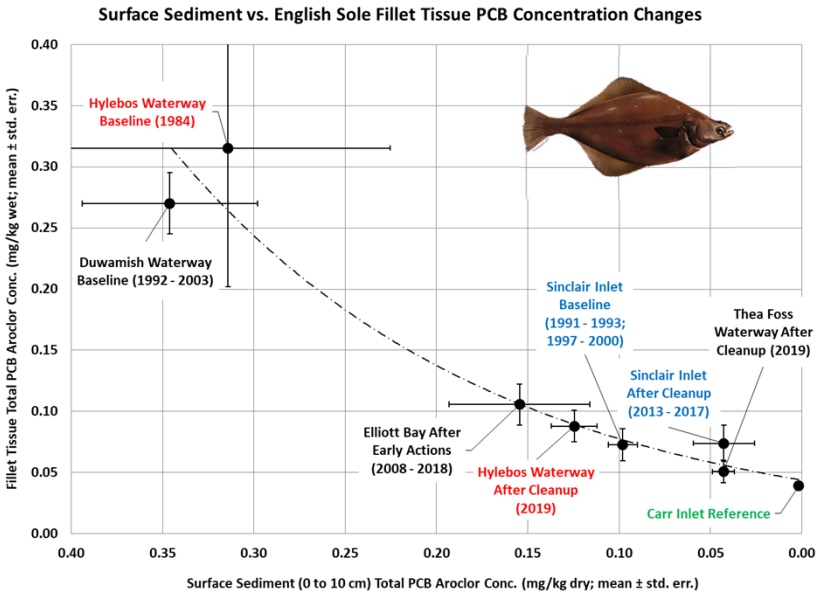
- Tissue peaks associated with in-water construction releases
  - Similar data from Thea Foss Waterway
- No net recovery of tissue PCB levels over 26 years



Source: West et al. (2017)

Puget Sound Remedy Effectiveness Monitoring

(robust tissue: sediment data pairs only)



Sources: Tetra Tech (1985); West et al. (2017); EPA (2020); Windward (2020); Anchor QEA (2022)

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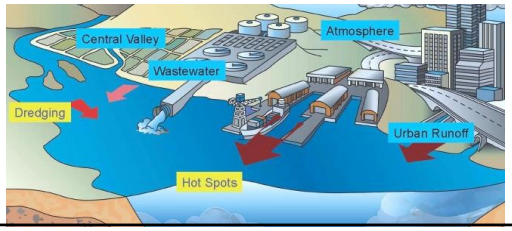
San Francisco Bay PCB Exposure Control Strategy

- Stormwater source control to achieve 0.01 mg/kg tissue criterion (and 0.17 ng/L in water)

Source Category	PCB Loading (kg/yr)
Stormwater runoff	20
Central Valley drainage	11
Municipal dischargers	2.3
Industrial discharges	0.035
Navigation dredging	Net Loss
Sediments	Net Sink

Source: California Regional Water Quality Control Board (2008)



California Regional Water Quality Control Board
San Francisco Bay Region
Municipal Regional Stormwater NPDES Permit

Order No. R2-2015-0049
NPDES Permit No. CAS612008
November 19, 2015

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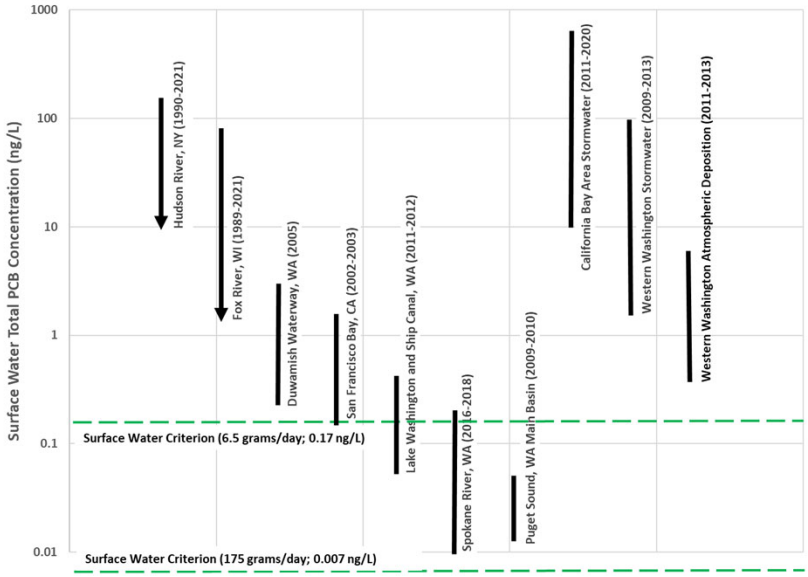
Surface Water PCB Concentration Comparison



Sources: California Regional Water Quality Control Board (2008), Windward (2010), Ecology (2011, 2015), King County (2013), LimnoTech (2017, 2019), Arconic (2018), Greenberg (2019), Rodenburg et al. (2019), San Francisco Estuary Institute (2022)

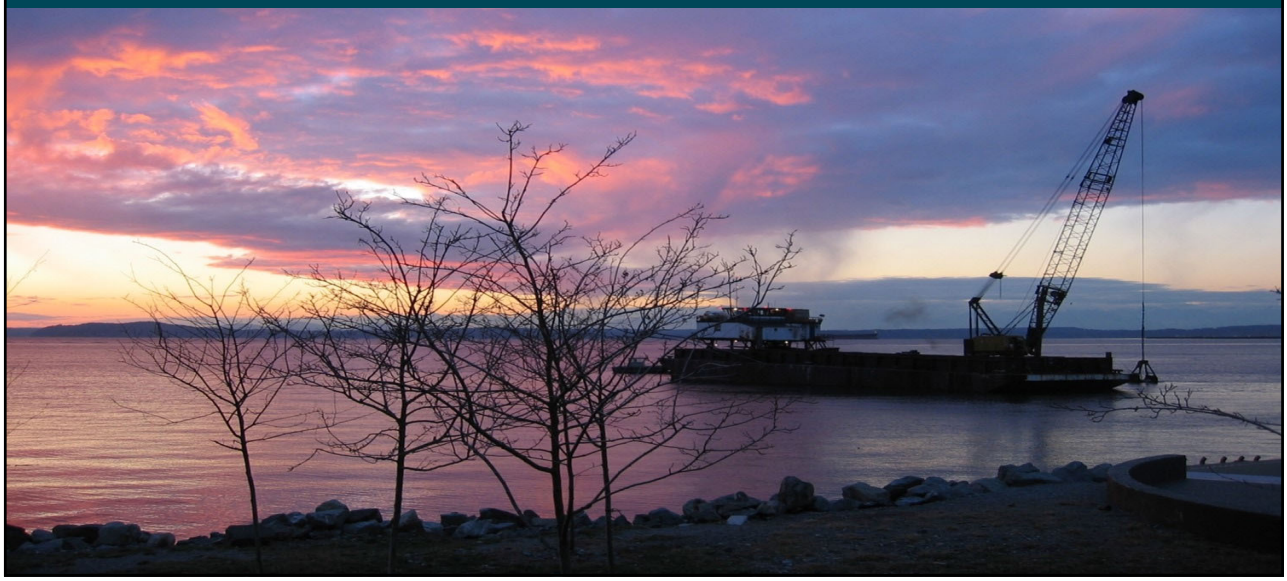
LESSONS

Summary

- As sediment concentrations decrease, sediment linkages with fish tissue PCB concentrations diminish
  - Non-sediment factors such as water column exposures become predominant
- Source (e.g., stormwater) control in urban settings is difficult
  - But source control has generally been more effective than sediment remediation after higher-concentration PCB sediments are addressed
  - Site-specific dynamic equilibrium of surface sediments with ongoing sources
- Robust site monitoring data currently being compiled to improve access

ANCHOR QEA

Questions/Discussion



2. The Potential Impact of PCBs From a Local Source (e.g., a CERCLA Site) on a Broader, Basin-Wide Ecosystem Scale

Jim West, WDFW

Summary

Jim discussed research conducted by the TBiOS team regarding PCB contamination in the Puget Sound ecosystem. The team monitored PCB levels in various habitats and species, such as English sole, Pacific herring, and juvenile chinook salmon. The data indicated that PCB concentrations remain a significant concern, surpassing established recovery goals in many areas. The findings emphasized the detrimental impact of PCBs on the health and population recovery of species like chinook salmon and the endangered southern resident killer whales. Ongoing monitoring and remediation initiatives are crucial to guarantee the ecosystem's recuperation and overall health.

Studies were recently conducted to examine the biomagnification of PCBs in the pelagic food web of Puget Sound. The studies aimed to investigate how PCBs enter and accumulate in the food web and identify potential sources and pathways. By analyzing PCB levels in different species and correlating them with trophic levels, the researchers found a substantial increase in PCBs as they moved up the food chain. This study focused on the central basin of Puget Sound, highlighting Elliott Bay as a hotspot for PCB contamination. The researchers proposed that PCBs enter the food web through particles associated with the microbial food web and marine snow, with krill playing a crucial role in transferring PCBs to higher trophic levels.

Discussion

Q: Mark Larson (Anchor) – Will TBiOS be collecting data for juvenile salmon and herring into the future? Will we be able to look at recovery trends?

A: Jim - TBiOS has been collecting fish tissue since 1989. Yes, the 5 species regularly sampled (Herring, Dungeness crab, mussels, English sole, juvenile chinook) will continue to be monitored in order to evaluate time trends in Puget Sound.

Q: Ken Patton (Apex) – Are Polychlorinated naphthalene and PCTs being considered for monitoring?

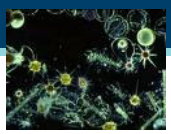
A: Jim – They are being considered. Additional money just arrived for Contaminants of Emerging Concern but other COCs are more important to the program right now.

Q: Pete Rude (Seattle Public Utilities) – In particulate organic matter (POM) is there an inorganic fraction that can be teased out? How do COCs in adult salmon in ocean compare with resident salmon?

A: Jim – We haven't measured inorganic vs organic fractions in POM separately. People predict that inorganic component is not a big driver. Could analyze archives. High PCBs in the inorganic fraction could indicate contribution of disturbed sediments.

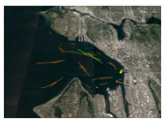
Jim - Ocean migrants returning after 3+ yrs have lower PCBs than residents but are 3-4x greater than non-Puget Sound ocean migrants. They are getting exposure but not as high as the ones that stay in Puget Sound.

The potential impact of PCBs from a local source on a basin-wide ecosystem scale; preliminary results from WDFW's 2021 pelagic food web study.



James West, Sandra O'Neill, Louisa Harding; Washington Dept. of Fish and Wildlife
Tarang Khangaonkar, L.T. Premathilake; Pacific Northwest National Laboratory
C.A. James, University of Washington (Tacoma)

Presentation to the 2023 Sediment Management Annual Review Meeting 3 May, 2023



Washington Department of FISH and WILDLIFE

WDFW's Toxics Biological Observation (TBiOS) Team

Jim West

Sandie O'Neill

Louisa Harding

Molly Shuman-Goodier

Andrea Carey

Mariko Langness

Rob Fisk

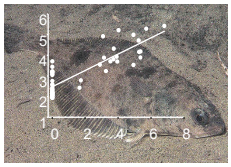
Danielle Nordstrom

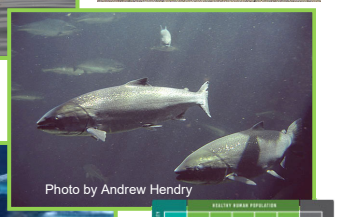
Andrew Beckman

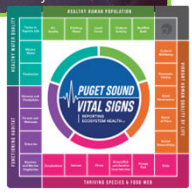
Outline for today...

1. Review PCB status – why are we still concerned about them?
2. Focus on the ***pelagic food web***
3. Introduce the Salish Sea Model (SSM) project with PNNL
4. Describe early results re: 2021 plankton field work -- the Lower Duwamish Waterway as a putative local source of PCBs in Puget Sound's pelagic food web.

Some conclusions from 30 years of TBiOS Monitoring PCBs



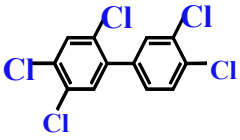




- PCBs remain ***one of most concerning toxic contaminants*** we know of in Puget Sound
- PCBs in Puget Sound-origin Chinook salmon, herring, and English sole are ***high enough to impair their health***
- PCBs in Puget Sound-resident Chinook salmon, Dungeness crab, spot prawn, rockfish, English sole and others are ***high enough to result in DOH consumption advisories***
- PCBs in southern resident killer whales (SRKW) are high enough to ***impair their health and population recovery***

Current status of PCBs in Puget Sound biota?


Juries award students, parents, teachers $247 million for toxic exposure at Sky Valley Education Center in Monroe




Monsanto will pay $95 million in PCB settlement with Washington state

Department of Fish and Wildlife

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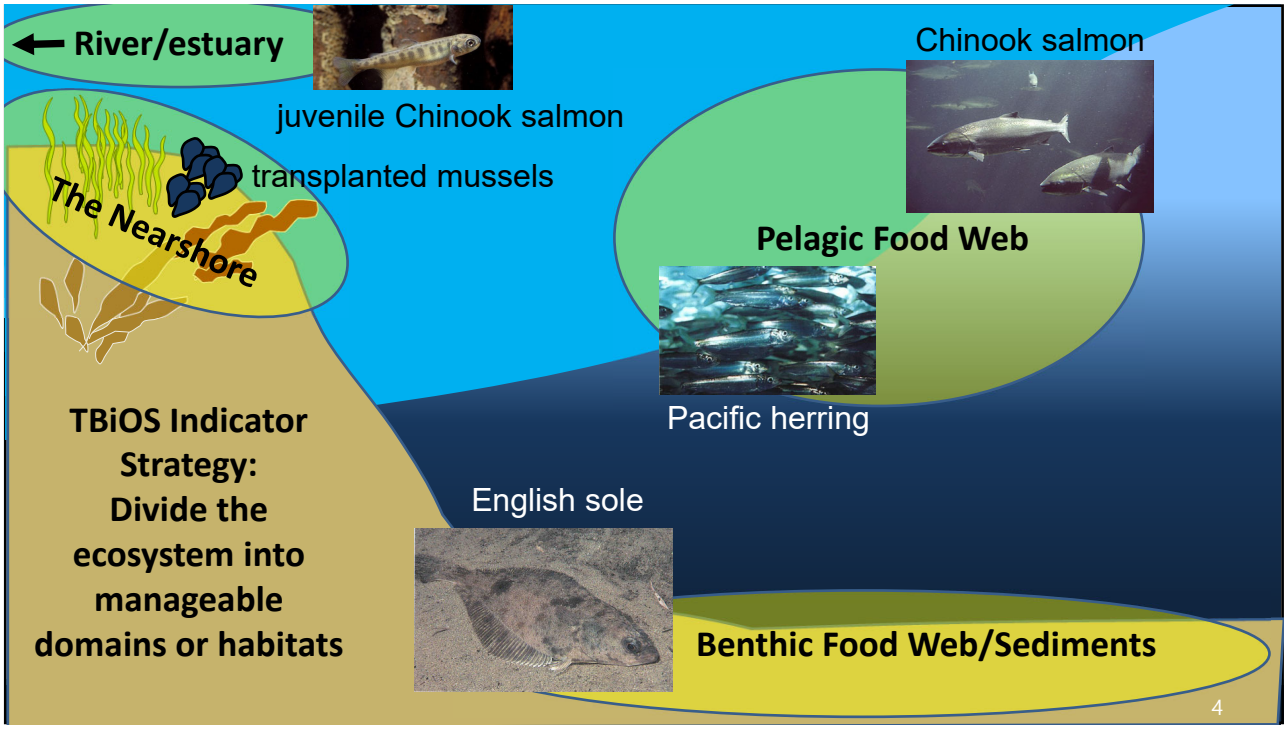

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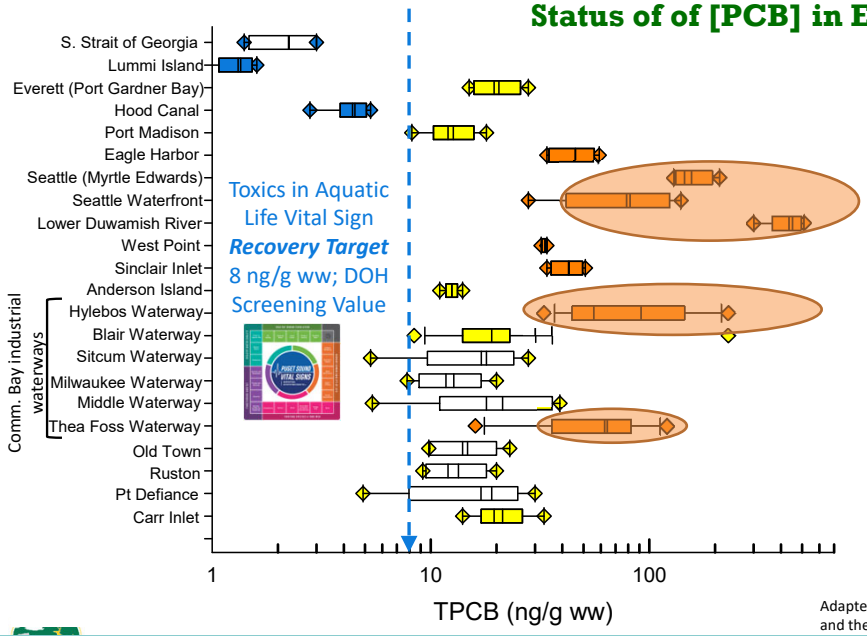
Status of of [PCB] in English sole (2019)



- 12 TBiOS Index sites
- 10 Comm. Bay Superfund evaluation sites

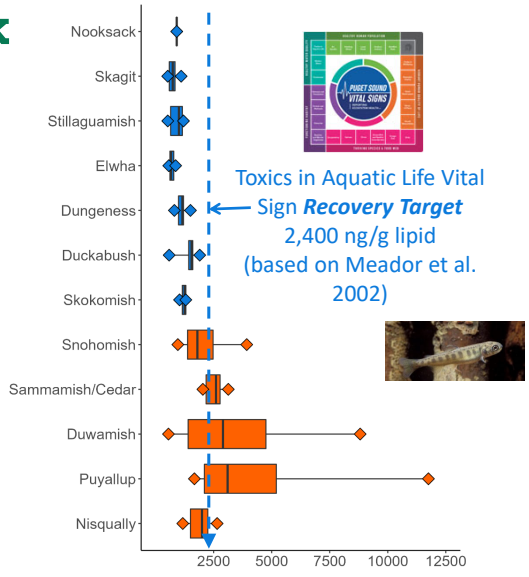
Adapted from West 2022, WDFW Report Number FPT 22-04 and the Toxics in Aquatic Life Vital Sign English sole Indicator

PCBs in Juvenile Chinook

Five river systems (of 12 monitored in 2013-2018) not meeting recovery target.

- **Up to 56%*** are above levels that can alter growth in 5 river estuaries
- **Up to 17%*** are above levels that can increase mortality

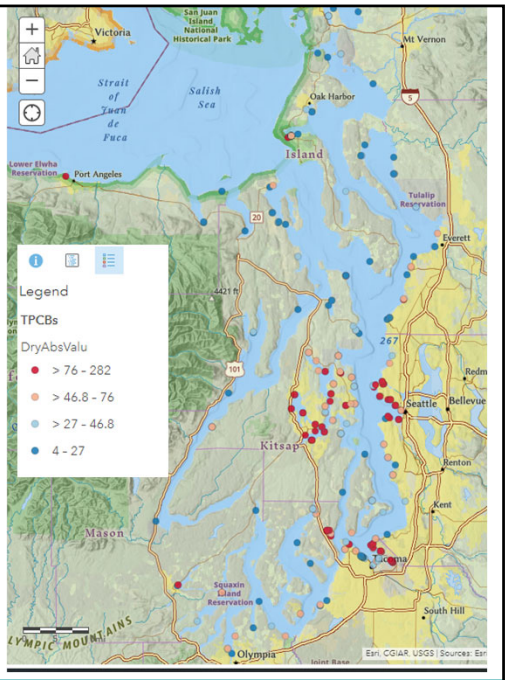
***calculated from Berninger and Tillitt, 2019**

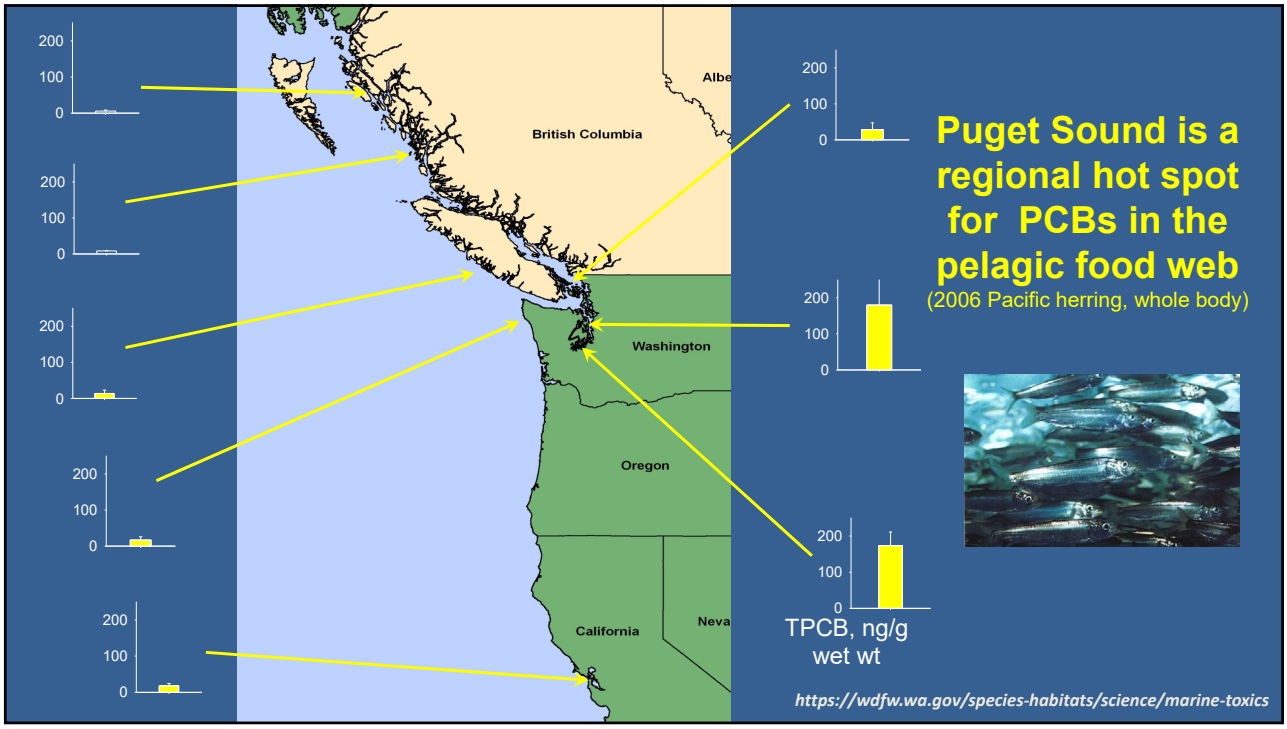


PCBs in Deployed* Mussels (2012/20)

- Similar pattern to benthic and estuary indicators
- Greatest concentration in urbanized embayments or near known sources
- Recovery target for nearshore/mussels TBD

*two to three month deployment





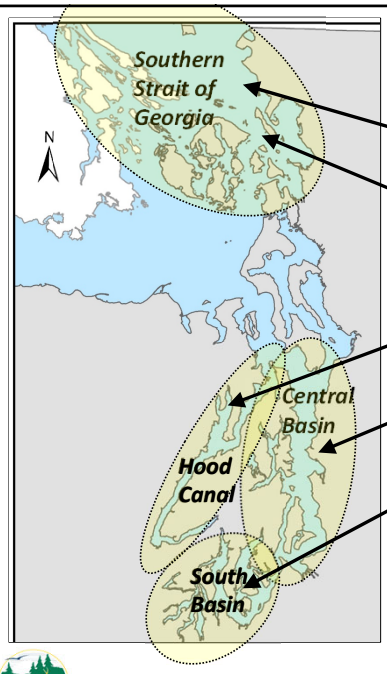
Puget Sound is a regional hot spot for PCBs in the pelagic food web

(2006 Pacific herring, whole body)

TPCB, ng/g wet wt

https://wdfw.wa.gov/species-habitats/science/marine-toxics

Current status of PCBs in Herring (2016-2020)

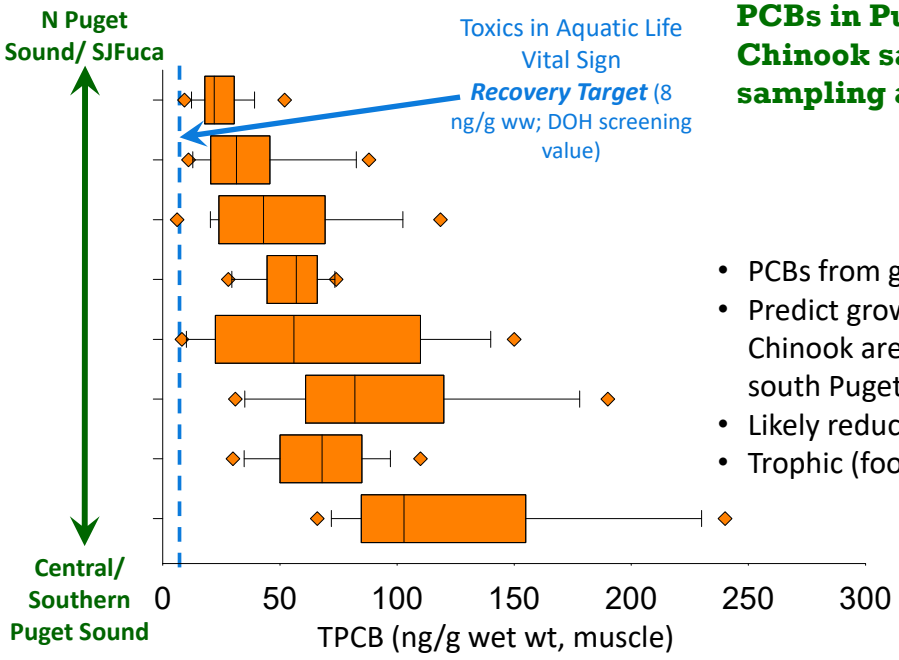


Toxics in Aquatic Life Vital Sign
Recovery Target
2,400 ng/g lipid
(based on Meador et al. 2002)

Department of Fish and Wildlife

xx

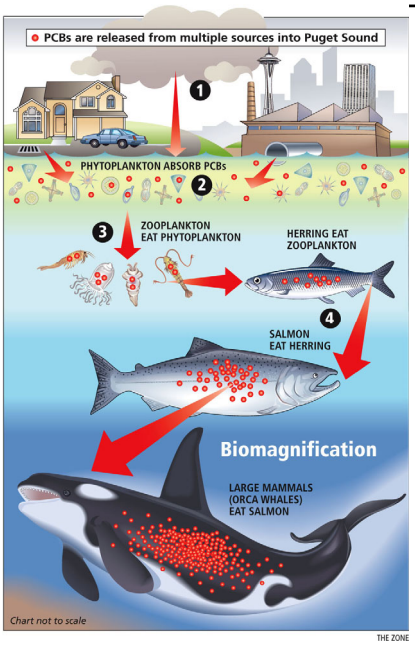
PCBs in Puget Sound-resident Chinook salmon from eight sampling areas



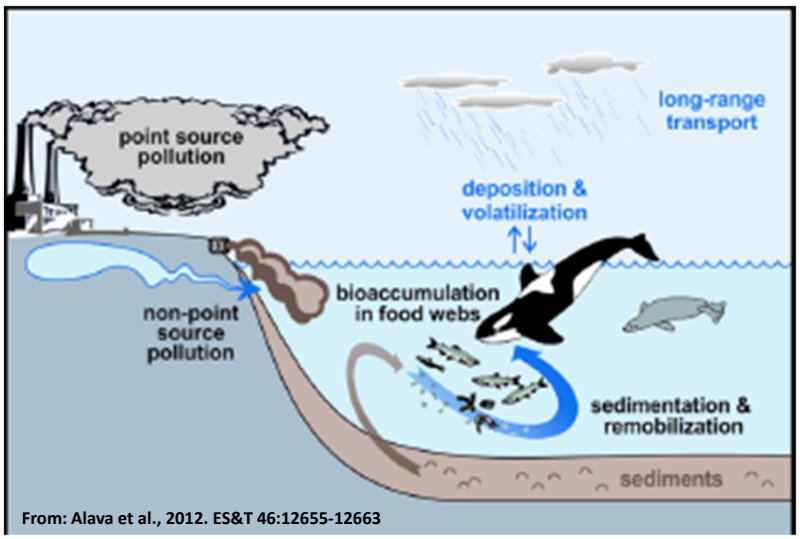
- PCBs from growth in Puget Sound
- Predict growth of 18% of resident Chinook are impacted overall (64% in south Puget Sound)
- Likely reduces prey base for SRKW
- Trophic (food web) transfer to SRKW

Adapted from Toxics in Aquatic Life Vital Sign (https://www.pugetsoundinfo.wa.gov/Indicator/Detail/47/VitalSigns#results)

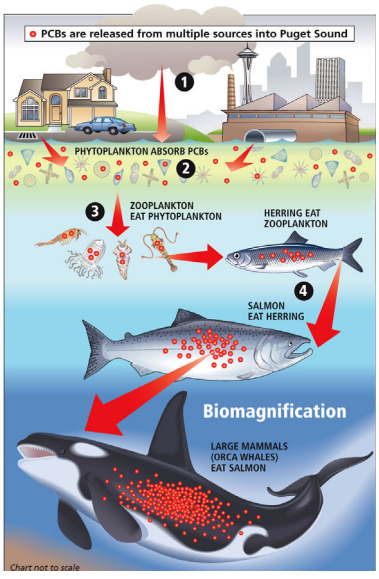
Trophic Magnification of PCBs in the Pelagic Food Web



Two models to conceptualize transfer of PCBs in the pelagic food web

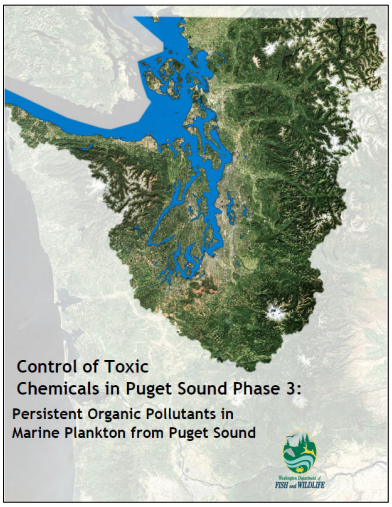


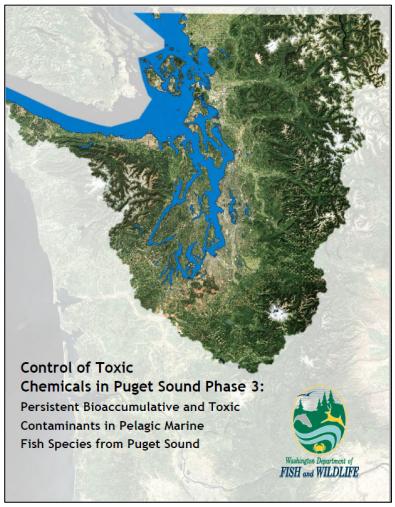
From: Alava et al., 2012. ES&T 46:12655-12663



WDFW illustration with the Seattle Post Intelligencer

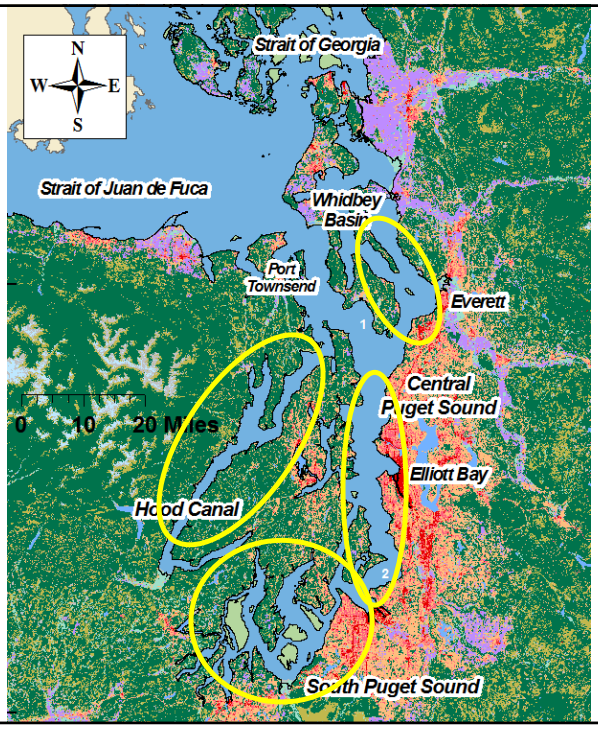
Early PCB/Pelagic Food Web Studies





NEP-funded studies to evaluate why existing mass balance models (Pelletier and Mohamedali, 2009) poorly predicted [PCB] in the pelagic food web – models based on a food web model connected primarily to sediment PCB sources

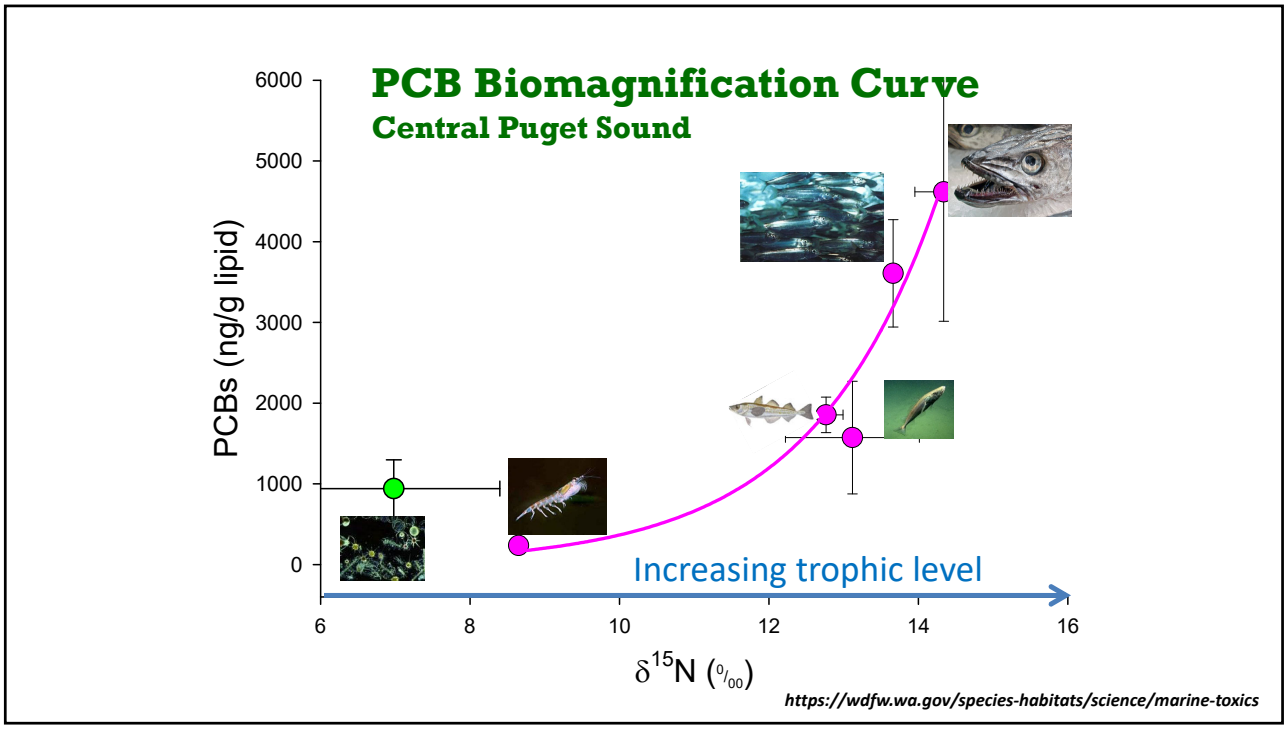
2009 Study: PCBs in the Pelagic Food Web

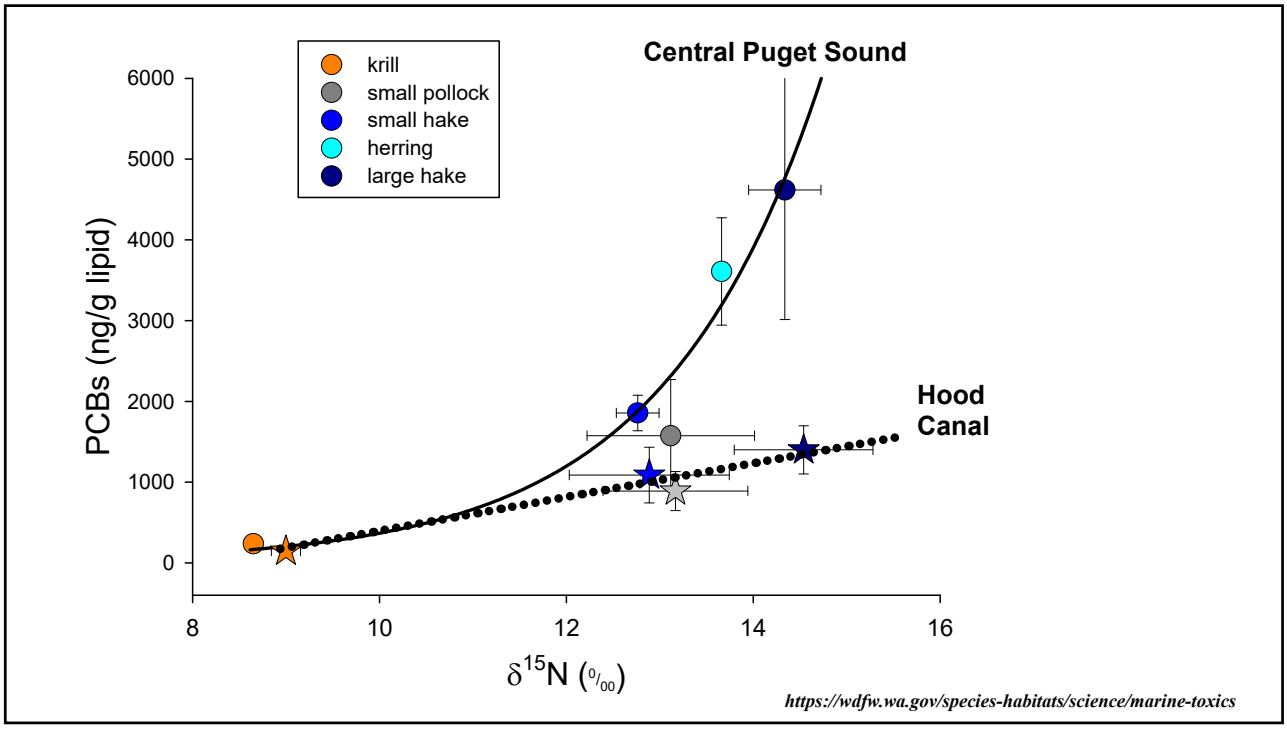


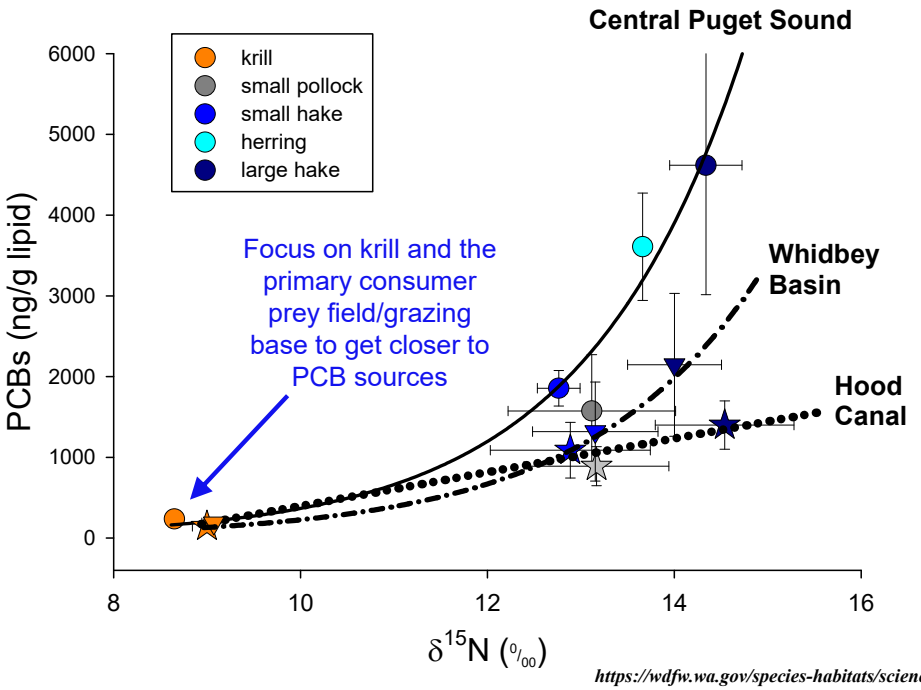
a comparison of ***PCB biomagnification*** in lower trophic levels from four Puget Sound basins, across a wide range of basin-specific land-use

West, J. E., et al. (2011). Persistent Organic Pollutants in Marine Plankton from Puget Sound, Washington Department of Ecology Publication No. 11-10-002. 70pp.

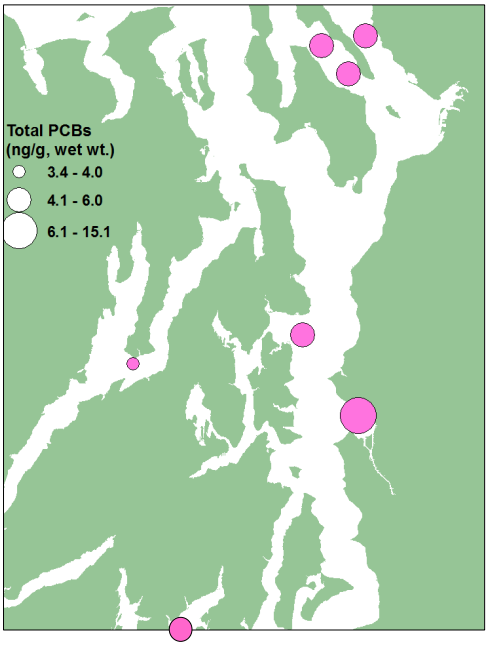
West, J. E., et al. (2011). Persistent, bioaccumulative and toxic contaminants in pelagic marine fish species from Puget Sound. Olympia Washington, Washington Department of Ecology. Publication N. 11-10-003.. 59 pp.


PCB Biomagnification Curve
Central Puget Sound
PCBs (ng/g lipid)
6000
5000
4000
3000
2000
1000
0
6
8
10
12
14
16
Increasing trophic level
δ15N (‰)
https://wdfw.wa.gov/species-habitats/science/marine-toxics


krill
small pollock
small hake
herring
large hake
Central Puget Sound
Hood Canal
PCBs (ng/g lipid)
6000
5000
4000
3000
2000
1000
0
8
10
12
14
16
δ15N (‰)
https://wdfw.wa.gov/species-habitats/science/marine-toxics



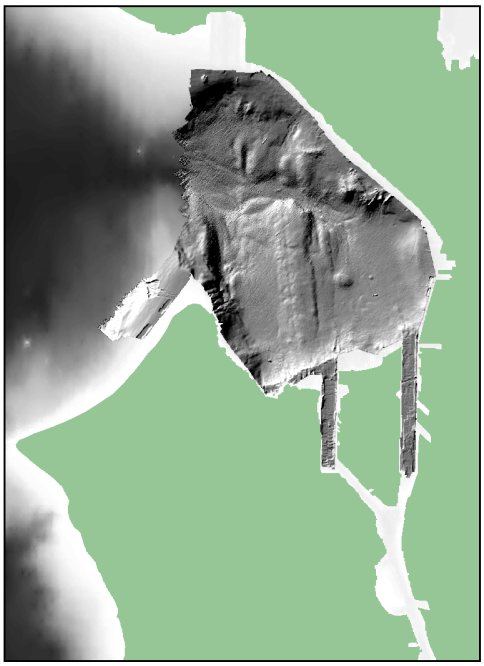
https://wdfw.wa.gov/species-habitats/science/marine-toxics



Concentration of Total PCBs in krill (*Euphausia pacifica*) across Puget Sound (West et al. 2011)

Elliott Bay is one of the few urbanized embayments deep enough to support krill (from Cooney 1971)

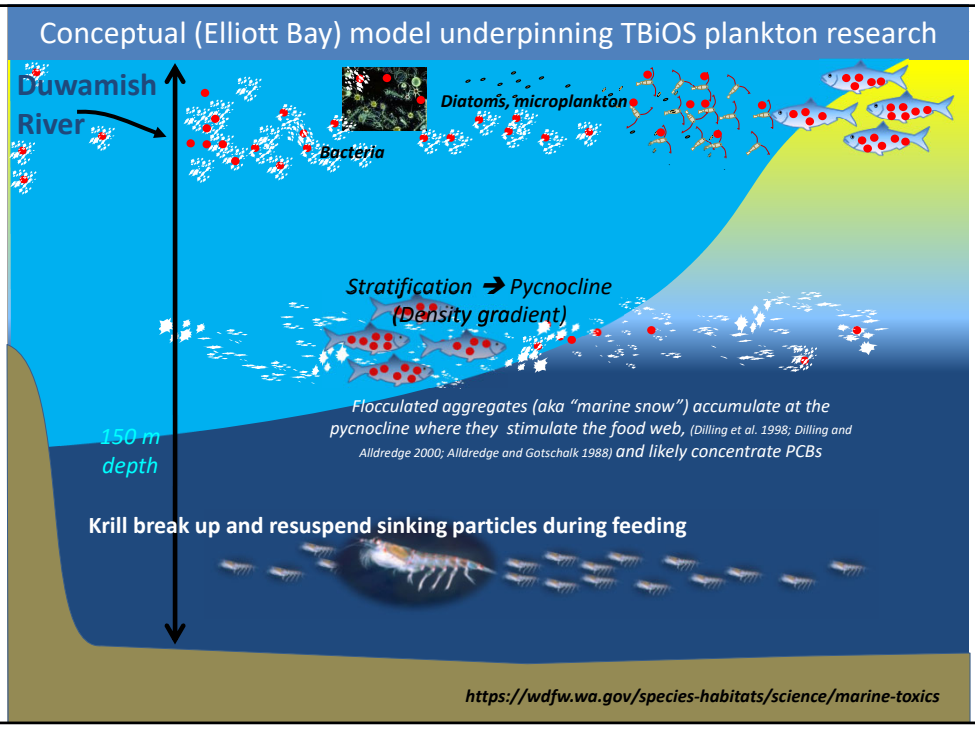
https://wdfw.wa.gov/species-habitats/science/marine-toxics



Focus on Elliott Bay

- Large urban embayment
- All indicator species more contaminated with PCBs here than anywhere else in Puget Sound
- Receives river (surface) water flowing through PCB Superfund

https://wdfw.wa.gov/species-habitats/science/marine-toxics



Pacific Northwest NATIONAL LABORATORY

Salish Sea Model (SSM)

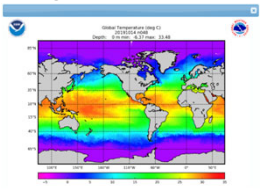
3D Unstructured Finite Volume Coastal Ocean Model

Hydrodynamic Model

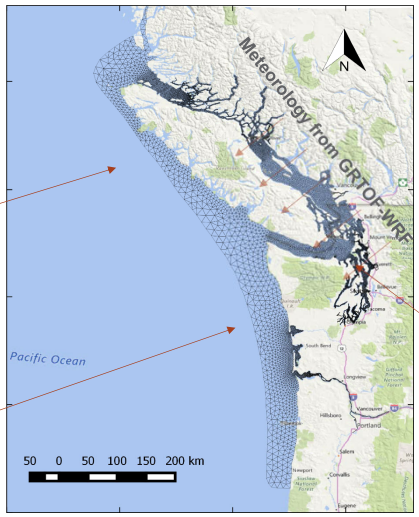
FVCOM (Chen et al 2003)

- Tides, Currents
- Salinity, Temperature

Ocean boundary T, S from HYCOM



Boundary Tides from NOAA & USACE / ENPAC

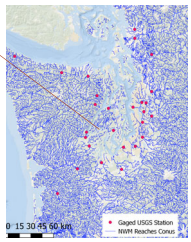


Water Quality Model

FVCOM-ICM (Kim & Khangaonkar 2011)

- Nutrients, carbon, algae
- Detritus, Zooplankton, larvae
- DO, pH, Toxics (PCBs),
- Sediments, Oil Spills, …

River and wastewater inflows from Ecology and NOAA Hydrology Models



https://ssmc-uw.org/

https://salish-sea.pnnl.gov

Development of a Toxics Module for the Salish Sea Model Using Polychlorinated Biphenyls (PCBs)

IPA IA Contract No. DW-089-92483101-0

September 2019

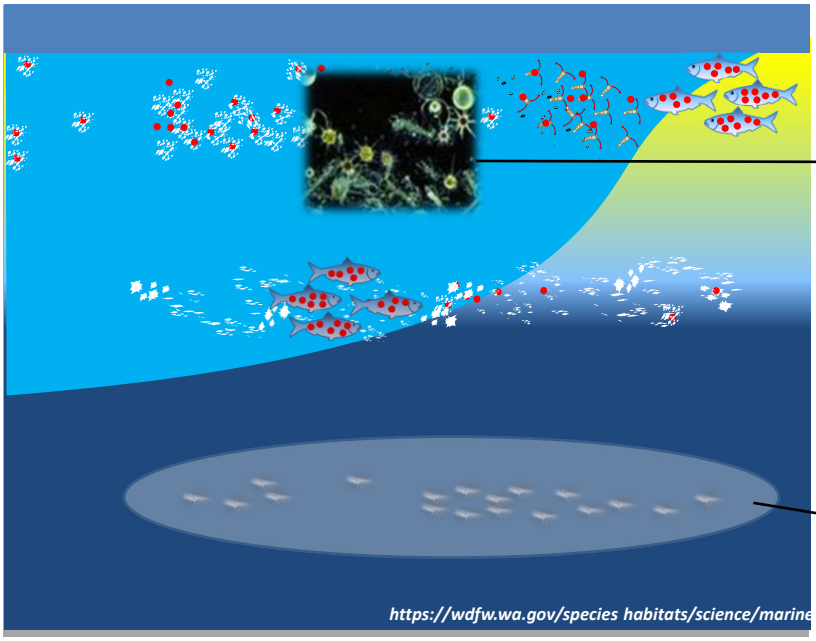
TP Khangaonkar
LT Premathilake

UW Tacoma
C.A. James
WDFW
S.M. O'Neill
L.B. Harding
J.E. West

- PNNL, UWT, and WDFW collaborating to develop a ***Toxics Module*** for the ***Salish Sea Model (SSM)***
- Incorporate PCB field observational data, PCB kinetics, and fate/transport into the existing SSM framework
- Where, how, and when do PCBs enter the pelagic food web?

Prepared for the U.S. Environmental Protection Agency under a Government Order with the U.S. Department of Energy
CONTRACT DE-AC05-76RL01830

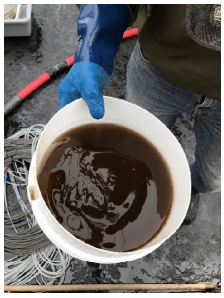
U.S. DEPARTMENT OF ENERGY

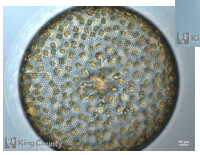


2021/22 Field studies focus on:

- POM (particulate organic matter)
  - Size-selected microplankton
  - targeting diatoms
  - the "prey field" for
- Krill (*Euphausia pacifica*) = "primary consumers"

Sampling POM



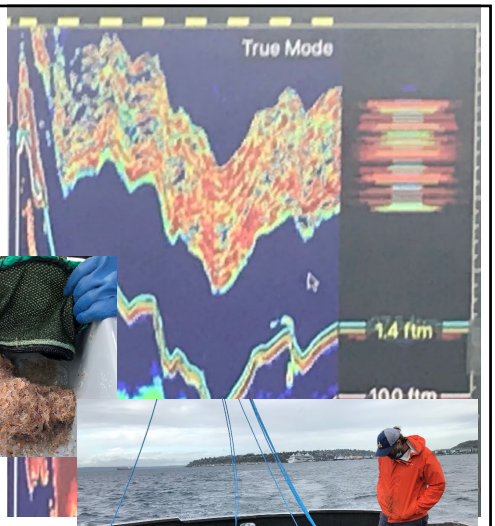


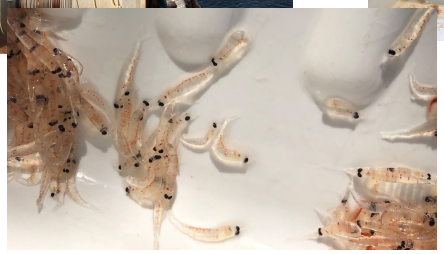
Primarily *Coscinodiscus* sp in 2021

(Gabriela Hannach/King County photos)
https://green2.kingcounty.gov/marine/Photo/Individual/1/375?photoId=1248

Sampling Krill



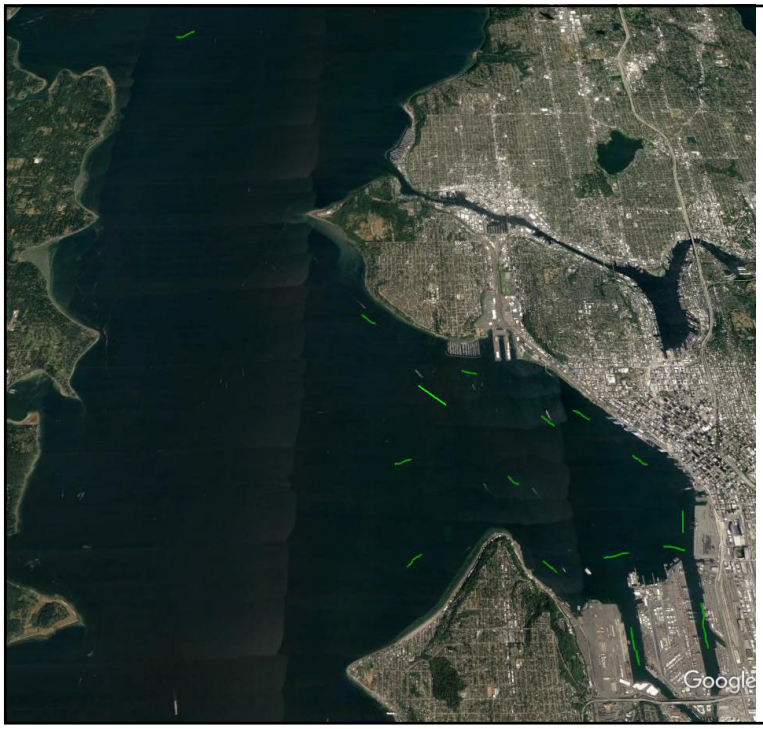





PCBs in Puget Sound's Pelagic Food Web: Hypotheses to be Tested

- **PCBs will exhibit a gradient of decreasing concentration in biota moving away from a putative primary source (is the Lower Duwamish Waterway a source of PCBs to a broader area?)**
- [PCB] in krill will correlate with POM.
- Degree of chlorination of PCBs in biota will decline with distance from LDW putative source (*sensu* Ross et al. 2004).

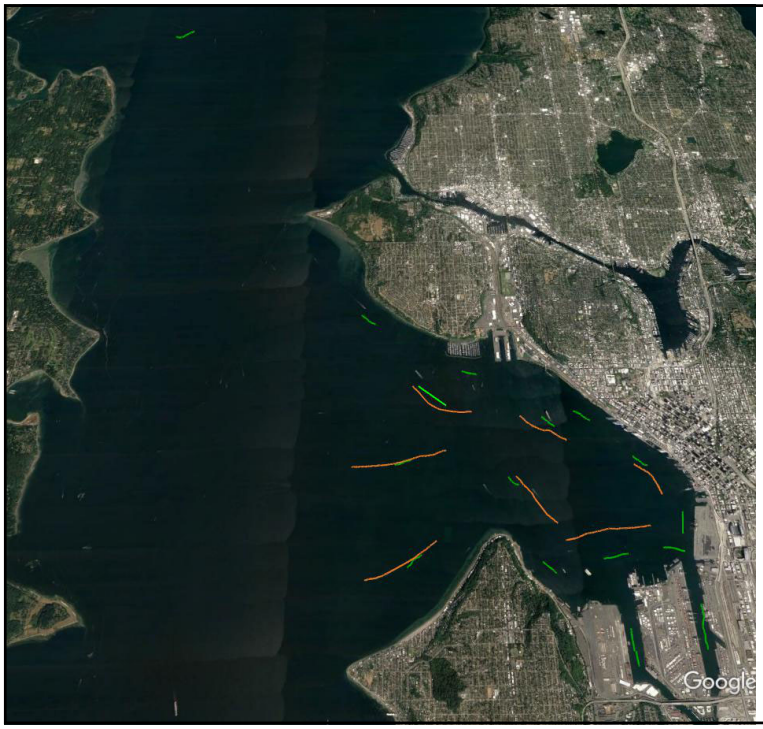
https://wdfw.wa.gov/species-habitats/science/marine-toxics



2021 Pelagic Food Web PCB Synoptic Gradient Study

Primary producers (POM) in surface waters
- green tracks
- phytoplankton, or Particulate Organic Matter (POM) => ***prey field for primary consumers***
- primarily diatoms in
- surface waters (<7m)

https://wdfw.wa.gov/species-habitats/science/marine-toxics



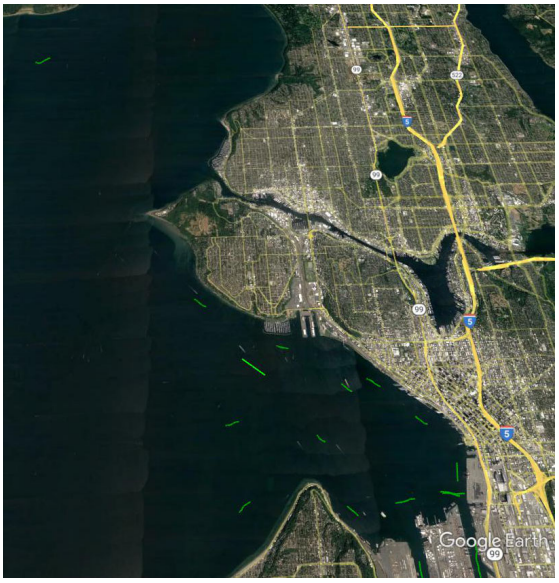
2021 Pelagic Food Web PCB Synoptic Gradient Study

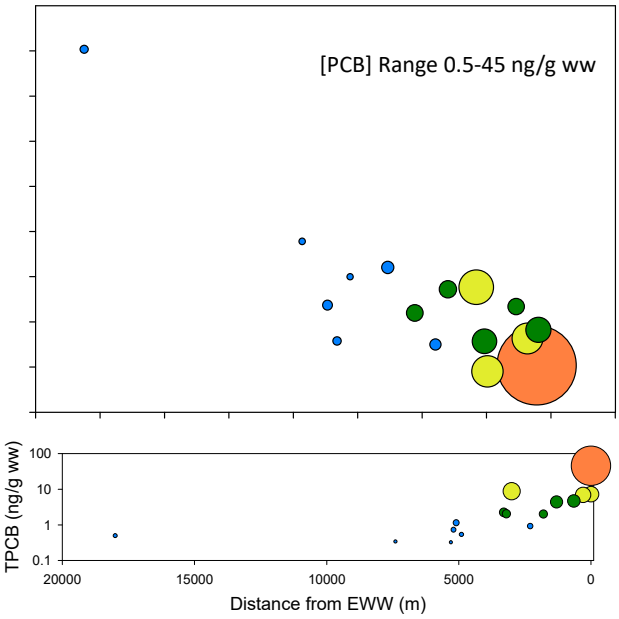
Surface primary producers (POM)
- green tracks
- phytoplankton, or Particulate Organic Matter (POM) => prey field for primary consumers
- primarily diatoms in
- surface waters (<7m)

Euphausia pacifica (krill)
- orange tracks
- deep depths (100 – 200m)

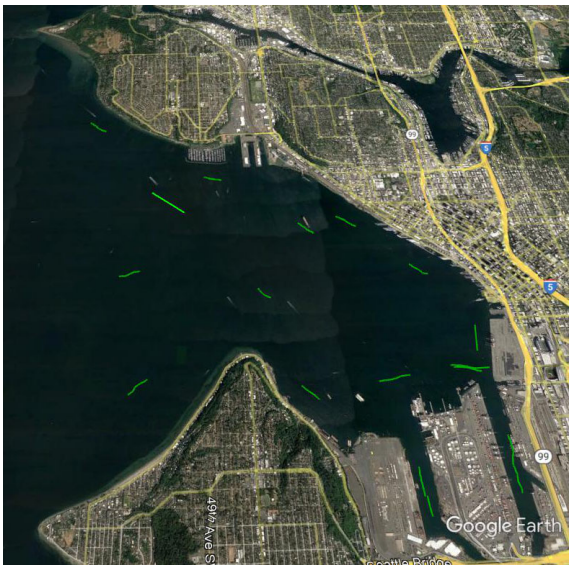
https://wdfw.wa.gov/species-habitats/science/marine-toxics

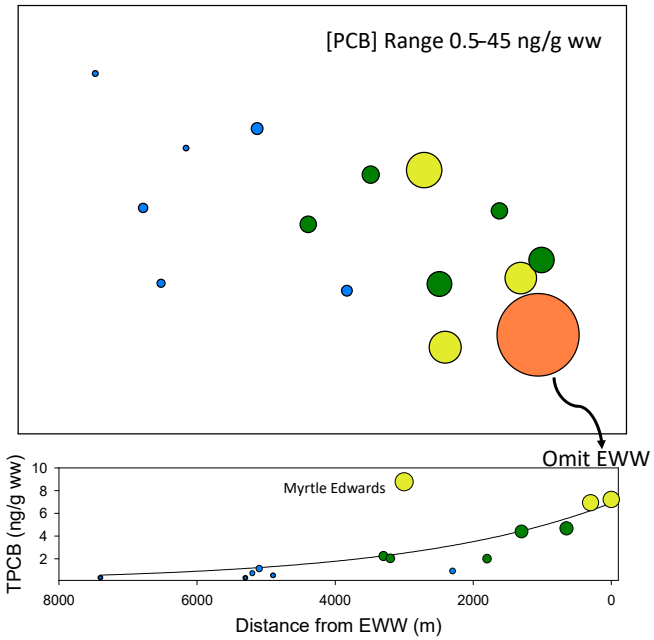
PCB Gradient: Surface POM All Sites



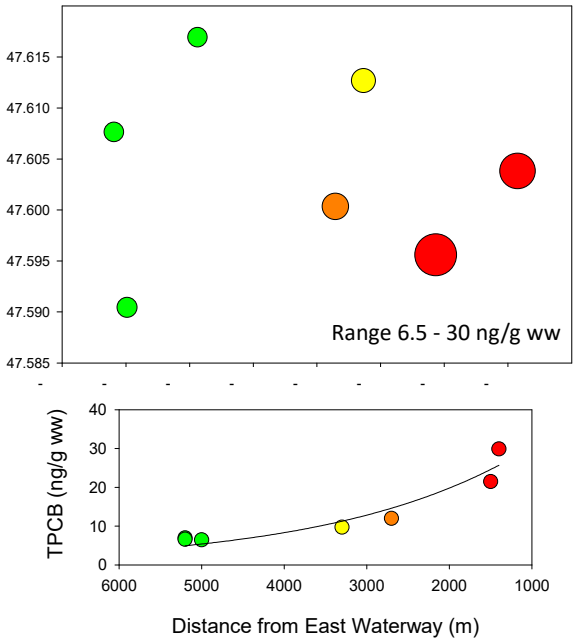


PCB Gradient: Surface POM omit Pt Madison





PCB Gradient: Krill

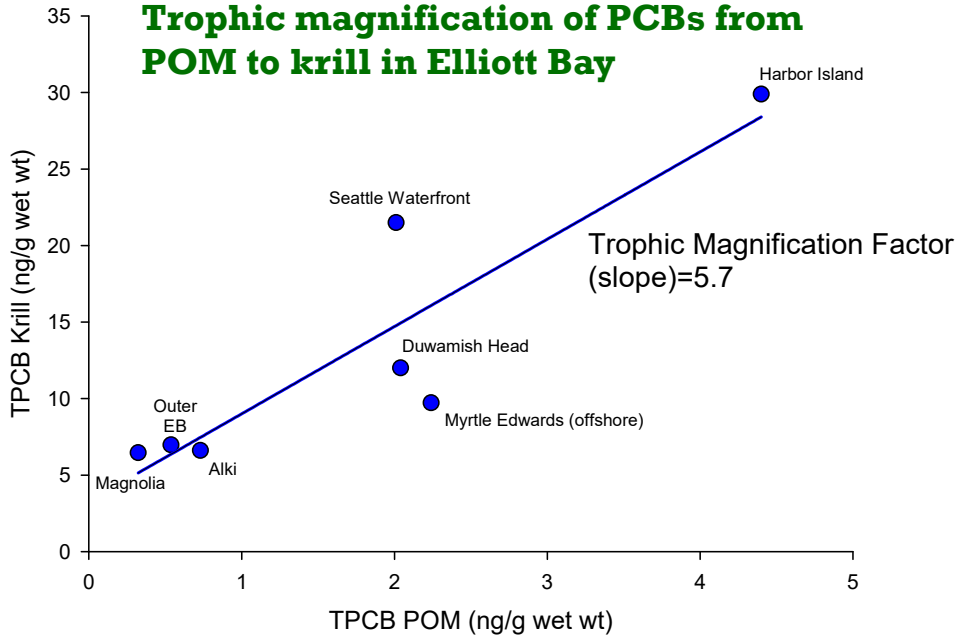


PCBs in Puget Sound's Pelagic Food Web: Hypotheses to be Tested

- PCBs will exhibit a gradient of decreasing concentration in biota moving away from a putative primary source (Lower Duwamish Waterway.
- **[PCB] in krill will correlate with POM** (testing conceptual connection between microbial food web in surface waters with primary consumers in the pelagic food web).
- Degree of chlorination of PCBs in biota will decline with distance from LDW putative source (*sensu* Ross et al. 2004).

https://wdfw.wa.gov/species-habitats/science/marine-toxics

Trophic magnification of PCBs from POM to krill in Elliott Bay



PCBs in Puget Sound's Pelagic Food Web: Hypotheses to be Tested

- PCBs will exhibit a gradient of decreasing concentration in biota moving away from a putative primary source (Lower Duwamish Waterway.
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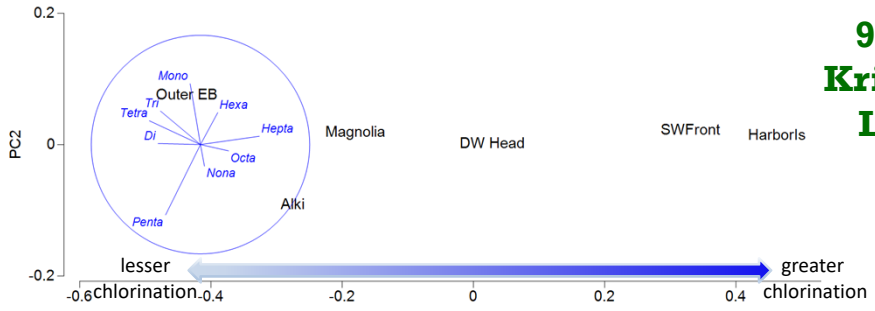
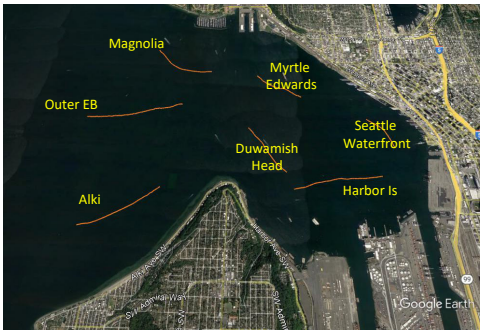
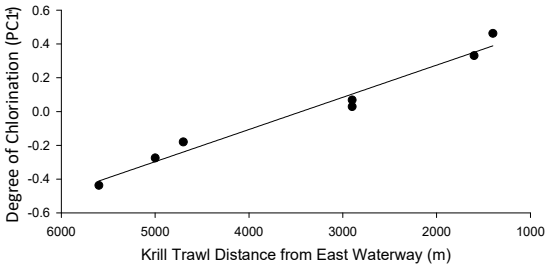
https://wdfw.wa.gov/species-habitats/science/marine-toxics

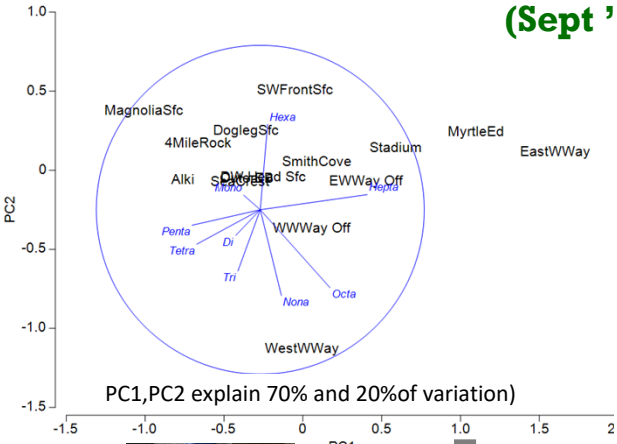
9 PCB Homologs in Krill from 7 Elliott Bay Locations (Sept '21)



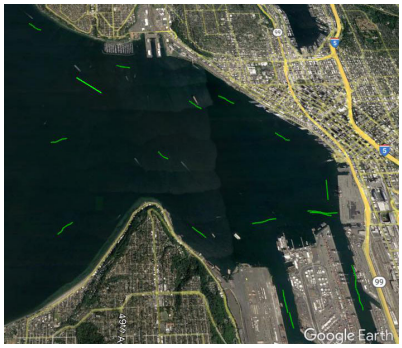


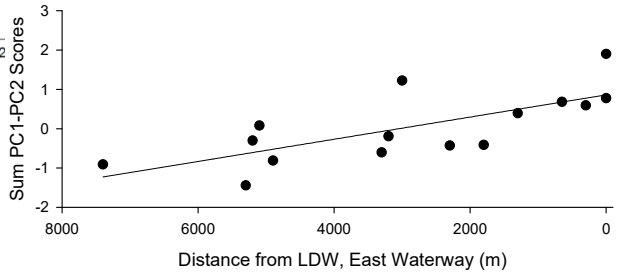


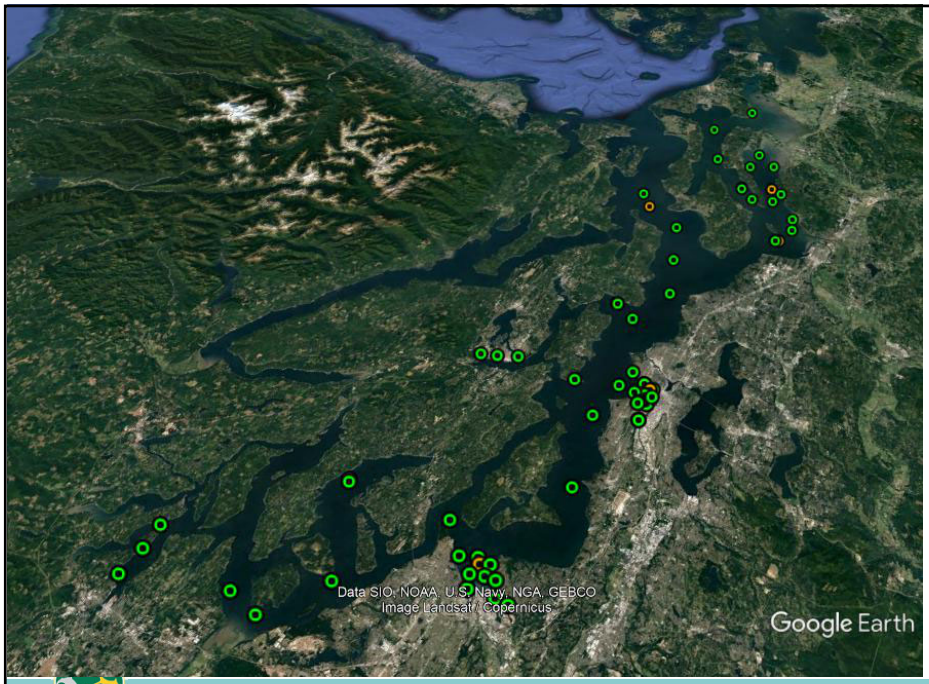
PCB Homologs in Surface POM from 15 Elliott Bay Locations (Sept '21)



PC1,PC2 explain 70% and 20%of variation)





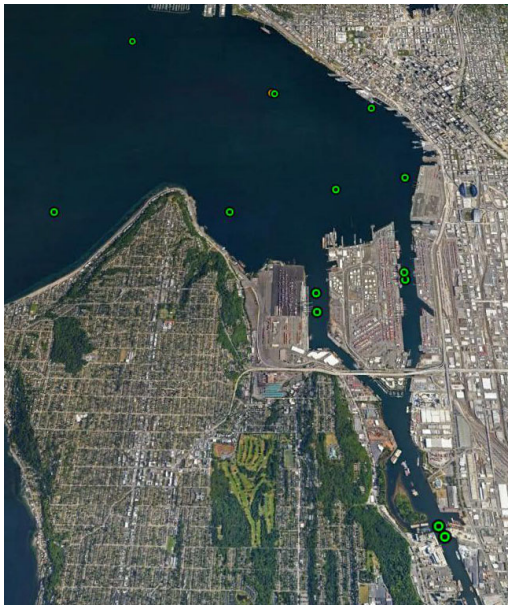


2022 Survey: expanded scope, focus on additional possible local sources

56 POM (green) samples, 7 krill (orange)

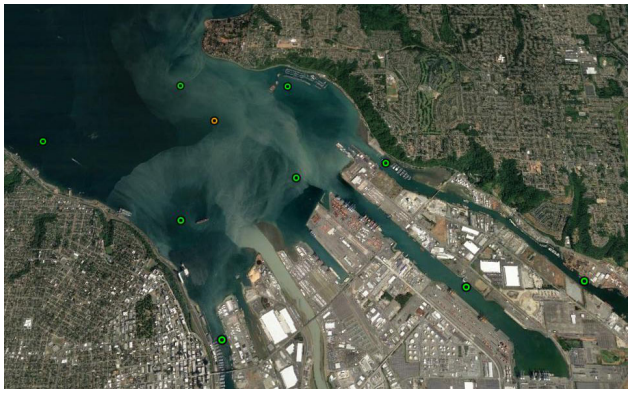
- Everett
- Comm. Bay Nearshore & Tidelands Superfund
- Sinclair Inlet
- Budd Inlet
- River mouths

39



Location of 2022 Elliott Bay Samples

Location of 2022 Commencement Bay Samples



In Summary….

1. Explained our focus on PCBs the pelagic food web
2. Introduced the Salish Sea Model/TBiOS PCB project
3. Focused attention on LDW in 2021, Sound-wide in 2022
4. Offered a way of looking at the potential impact of local PCB sources at a larger scale – the true Biological Impact Zone
5. ***How do we use this information to help recover Puget Sound?***

3. Toxics Cleanup Program Update: Sediment policy, guidance, legislative session, and budget

Chance Asher, Ecology

Summary

Chance presented updates on legislation, budget, and policy work. The recently passed Underground Storage Tanks Financial Assurance Bill aims to strengthen the insurance program for leaking underground storage tanks (USTs) that contribute to sediment pollution. This legislation is vital because almost half of the cleanup sites are associated with leaking USTs. The hazardous substances tax, dedicated to funding cleanup and pollution prevention, underwent changes in 2019 to stabilize funding. Funds have been allocated for remedial action grants, with approximately $115 million available for public entities, which requires a 50% matching requirement. Ecology also has $30 million for cleanup efforts and a $12 million grant program targeting affordable housing cleanup. Additionally, $9 million has been allocated for PFAS-related studies and research.

The Sediment Cleanup User Manual (SCUM) did not undergo revisions in 2023 due to a lack of significant updates. A revised SCUM document would next be released in 2025 to address policy changes, incorporate new scientific and technical information, and rectify any errors. The recently republished Sustainable Remediation guidance document provides direction on identifying climate change impacts and implementing resiliency measures at cleanup sites.

Efforts are underway to establish freshwater sediment natural background, focusing on the Lower Columbia River area and Puget Sound. The MTCA rulemaking process, which involves the incorporation of climate change resilience and environmental justice considerations, is anticipated to be finalized around August of 2023. The online SHARP tool replaces the previous ranking system and now includes sediments, while the wood waste guidance is also being updated. Additionally, PFAS-related guidance is being developed for establishing cleanup levels for groundwater, surface water, soil, and now sediment.

Discussion

Q: Clay Patmont (Anchor) –Regarding the Sustainable Remediation guidance, which sites are you referring to that were compromised from climate change and prompted the changes? Anything more we can do to accelerate regional background calculation for Elliott Bay?

A: No particular site prompted the Ecology from developing the Sustainable Remediation guidance. Ecology is merely trying to get ahead of the problem and prepare for impacts to cleanup sites to ensure they remain protective. EPA has some good case studies – e.g., from Commencement Bay where there were impacts to sites due to climate change – Breakwater Peninsula, Asarco Tacoma facility, St Paul CDF, Olympic View Resource Area were impacted from sea level rise and storms – the sites are particularly vulnerable when a King tide occurs during a storm, barometric pressure is low, and sea level rise exacerbates the effects – wave energy is greater and can erode caps and shorelines leaving the armoring and little else.

We do not have a plan as to when we will establish regional background for Elliott Bay. Now is not the right time since we have Lower Duwamish Waterway and East Waterway cleanups happening and a lot of issues surrounding those cleanups that are taking our time and attention. Ecology doesn't have the staff. Funding isn't the problem, rather logistics.

Q: Mary Ann Rempel-Hester (EcoAnalysts) – For PFAS in sediments, have you found different toxicity thresholds between fresh water and marine water?

A: Chance – We haven't found that yet, although part of the project for SCUM is understanding that difference. We also need to see if we even have a PFAS problem in sediments. Ecology may need to do sampling to better understand the concentrations in sediments. Currently doing the literature review. That will need to be completed and existing data reviewed to determine if we have a PFAS problem in sediments.

Q: Mark Larsen (Anchor) – Putting in a plug for allowing small sediment sites into – or remain in – the Voluntary Cleanup Program (VCP). There are some simple ones begging for Ecology staff oversight that isn't there. Is there any way to provide a path forward in VCP for some of the routine sediment sites?

A: Chance – Is there really such thing as a "routine" sediment cleanup site? Ecology is aware of this issue and trying to figure out how to help with these sites. ½ of TCP staff are new hires this past year. She'll pass on the comment to Pete Adolphson who is leading the VCP and Sediment policy.

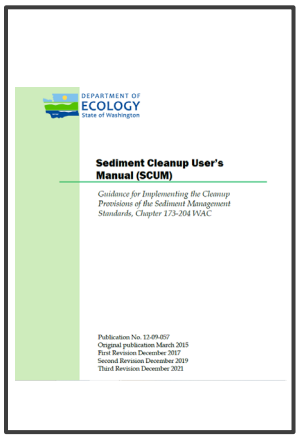
Sediment Management Annual Review Meeting

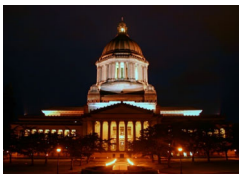
Department of Ecology Policy Updates

Chance Asher
Sediment Policy Program Lead
Toxics Cleanup Program

DEPARTMENT OF ECOLOGY
State of Washington

FOR TODAY





- Legislative updates
- Toxics Cleanup Program 2023-2025 Budget
- Toxics Cleanup Program Policy and guidance updates

HB 1175 - 2023-24

Creating a state financial assurance program for petroleum undergrou

Sponsors: **Doglio, Dye, Leavitt**

By Request: Pollution Liability Insurance Agency

Companion Bill: **SB 5233**

Bill Status-at-a-Glance

See **Bill History** for complete details on the bill

As of Saturday, April 15, 2023 12:39 PM

Current Version:	Current Status:
Engrossed Substitute - ESHB 1175	HSpkr Signed

Where is it in the process?

	Introduced	In Committee	On Floor Calendar	Passed Chamber
In the House:	●	●	●	●
In the Senate:	●	●	●	●
After Passage:	●	○	○	○
	Passed Legislature	On Governor's Desk	Governor Acted	Session Law

UNDERGROUND STORAGE TANKS

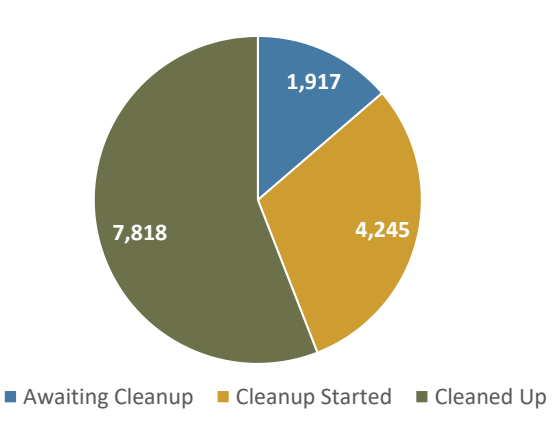
Financial Assurance Program HB 1175

- New state fund to insure leaking USTs
- Voluntary participation
- $3 million annual cap
- State authority to conduct remedial actions
- Funded by petroleum products taxes and UST fees

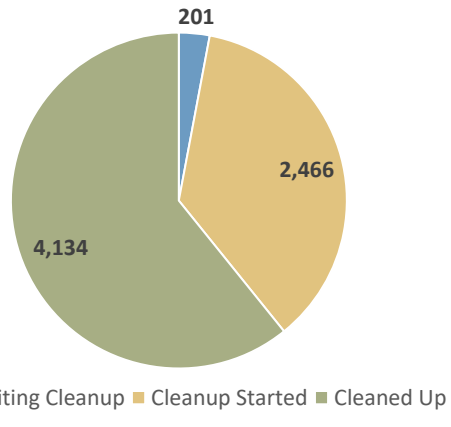
3

CONTAMINATED SITES IN WASHINGTON STATE

All Contaminated Sites in Washington



Leaking UST Sites in Washington



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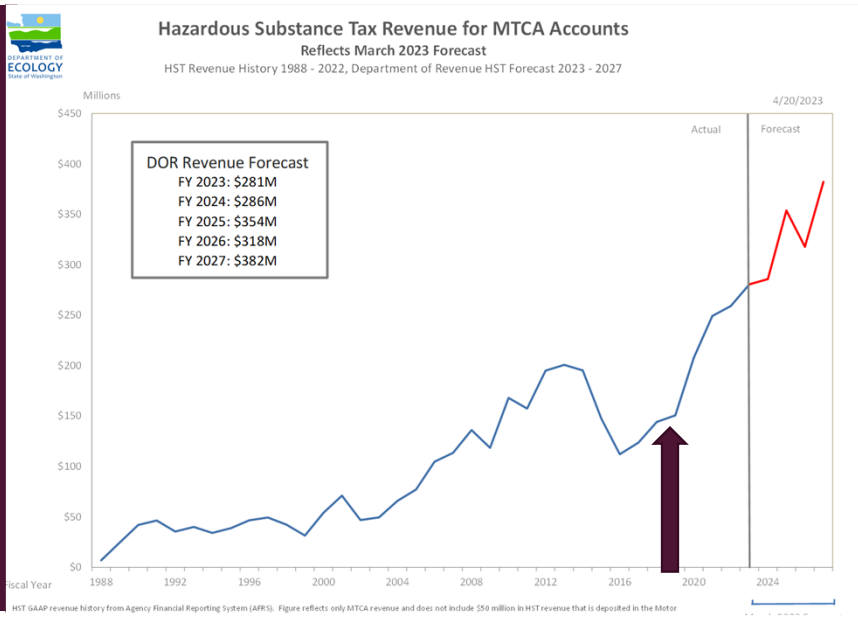
HAZARDOUS SUBSTANCES TAX REVENUE FORECAST

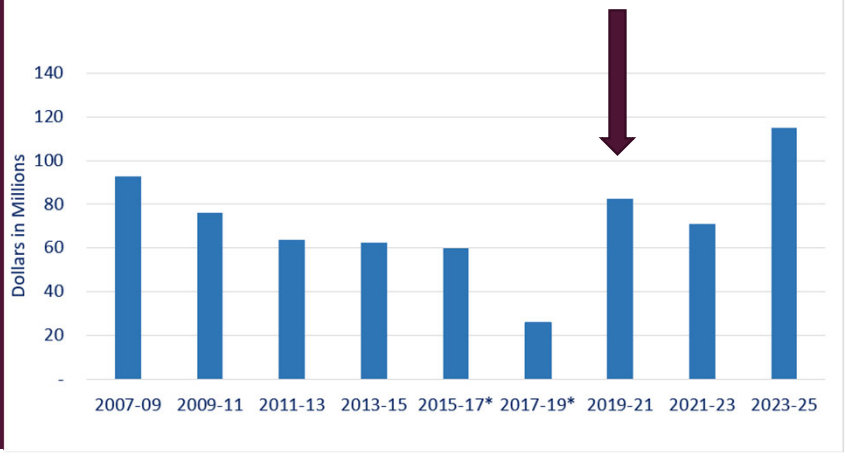
- Cleanup and prevent pollution
- 2019: Volumetric based
- Goal: Stabilize MTCA funding



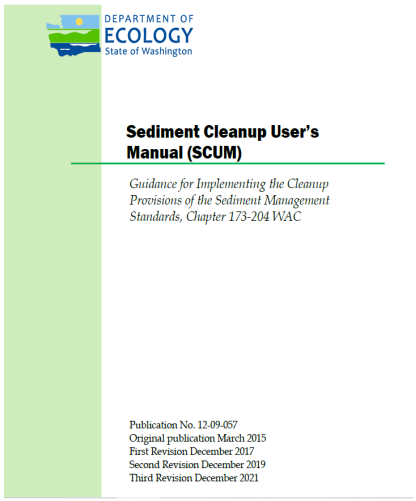
5

NEW APPROPRIATIONS

- $115 million Remedial Action Grants
- $30 million Ecology-TCP directed cleanup
- $12 million Affordable Housing Cleanup Grant Program
- $9 million PFAS



SEDIMENT CLEANUP USER'S MANUAL


DEPARTMENT OF ECOLOGY
State of Washington

Sediment Cleanup User's Manual (SCUM)

Guidance for Implementing the Cleanup Provisions of the Sediment Management Standards, Chapter 173-204 WAC

Publication No. 12-09-057
Original publication March 2015
First Revision December 2017
Second Revision December 2019
Third Revision December 2021

Targeted revisions

- New policy
- Best available science and technical information
- Errors and omissions
- Feedback from staff and external folks

2021

- Benthic criteria
- Risk assessment
- Data reporting
- Biologically active zone
- Porewater chemistry
- Sampling and analysis

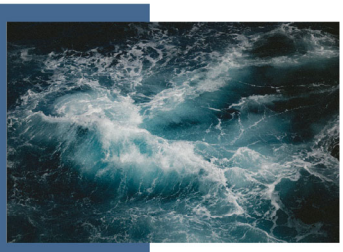
2025

- ADA compliant
- Update in Word 365
- QA/QC updates
- Analytical methods
- PFAS
- Clarifications

7

WHY?

- Protects Remedy
- Protects Environment
- Protects Investment
- Saves Money



Sustainable Remediation: Climate Change Resiliency and Green Remediation

A guide for Cleanup Project Managers to:

Increase resiliency of cleanup remedies to climate change impacts
-and-
Increase benefits and reduce impacts from the MTCA Cleanup Process

Toxics Cleanup Program
Washington State Department of Ecology
Olympia, Washington

Revised: January 2023
First published: November 2017

Publication 17-09-052

DEPARTMENT OF ECOLOGY
State of Washington

SUSTAINABLE REMEDIATION GUIDANCE

What is it?

- ❑ Identify climate change impacts and risks
- ❑ Implement resiliency measures
- ❑ Increase environmental benefits
- ❑ Reduce environmental impacts
- ❑ Reduce greenhouse gas emissions

8

VOLUNTARY CLEANUP PROGRAM SEDIMENT POLICY

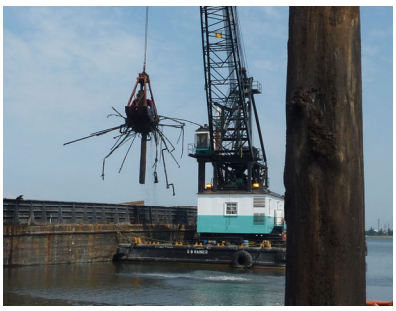
Why?

- Multi-jurisdiction permitting
- Complex cleanup

What?

- Decision process
- Sites in VCP now
- Future sites

When? 2023(ish)



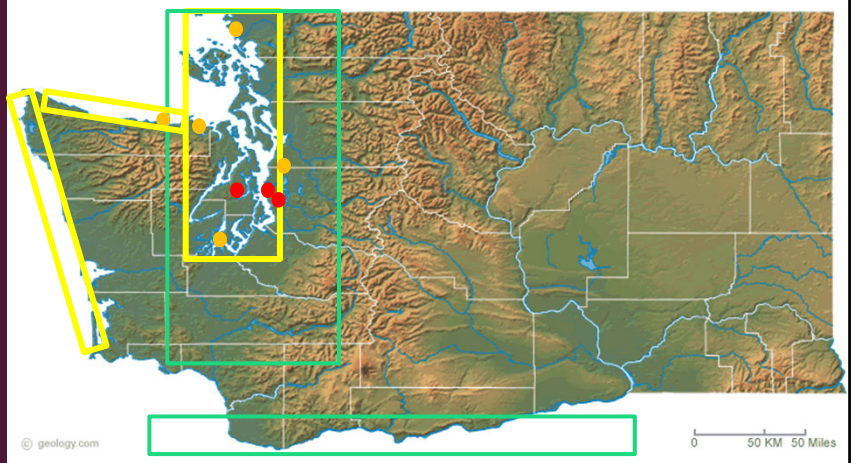
SMS SEDIMENT BACKGROUND

Established:

- Marine Natural Background
- Marine Regional Background

Future:

- Freshwater Natural Background
- Marine Regional Background

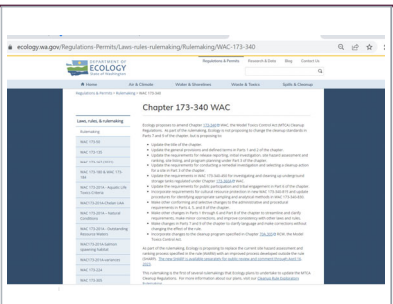


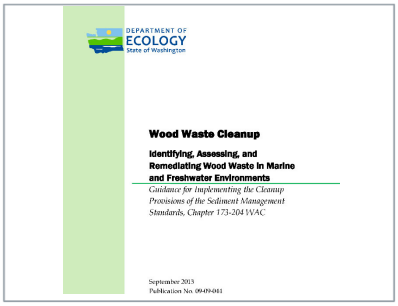
MTCA RULEMAKING

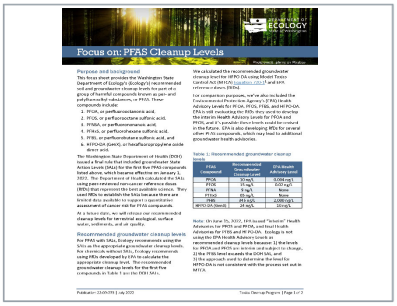
SHARP TOOL

WOOD WASTE GUIDANCE

PFAS



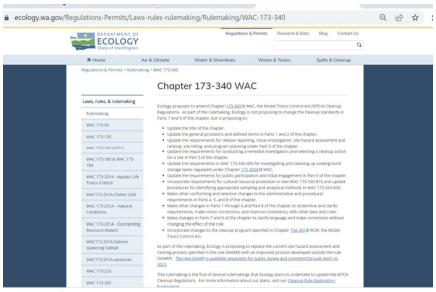


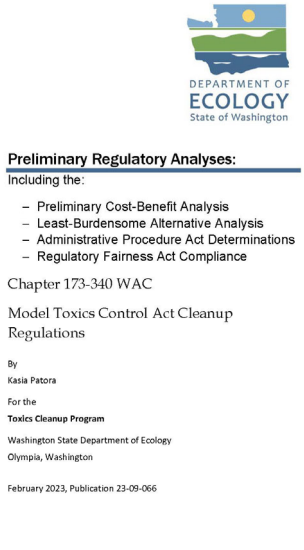


11

MTCA RULEMAKING

- Public Comment: April 16, 2023
- Finalize rule: August 2023
- Remedy Selection:
  - Consistent with SMS rule and SCUM
  - Climate change and Environmental Justice minimum requirements
  - Long-term effectiveness
  - Reasonable restoration timeframe





CONTACTS AND REFERENCES

Sediment Cleanup User's Manual
https://fortress.wa.gov/ecy/publications/SummaryPages/1209057.html

Sediment Management Standards Rule
https://fortress.wa.gov/ecy/publications/SummaryPages/0909044.html

Sustainable Remediation Guidance
https://fortress.wa.gov/ecy/publications/SummaryPages/1709052.html

MTCA Rulemaking
https://ecology.wa.gov/Regulations-Permits/Laws_rules-rulemaking/Rulemaking/WAC-173-340

SMS or SCUM Questions or Comments

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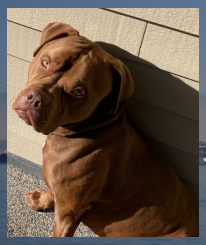
(360) 999-9420

Pete Adolphson
Pete.Adolphson@ecy.wa.gov
(360) 480-9801

MTCA Rulemaking Questions or Comments
Clint.Stanovsky@ecy.wa.gov
(360) 407-7193

13

Questions?



Teddy

Chance Asher
Sediment Policy Program Lead
Toxics Cleanup Program

DEPARTMENT OF ECOLOGY
State of Washington

4. Seattle District Beneficial Use in Action

Amy Reese and John Hicks, USACE

Summary

Amy Reese outlined the national program emphasis on beneficial use of dredged sediments, which is supported by language in Water Resources Development Act (WRDA) of 2020. The Corps of Engineers Chief, Lieutenant General Spellman, released a memo in January 2023 emphasizing the value of beneficial use and setting a goal of beneficially reusing 70% of material by 2030 (up from 20-30% currently). New reporting and tracking requirements are in place, including a nationally supported ArcGIS database for monitoring dredged material management. Continuing efforts will benefit from collaboration with external partners to develop approaches and technologies for increasing beneficial use.

John Hicks discussed the concept of beneficial use and its application in the Seattle District, providing an overview of the District's operating area, the various channels, and draft sizes present throughout the region. Beneficial use projects in Everett, Grays Harbor, Quileute, and Keystone/Lake Crockett were showcased. These projects demonstrated the application of innovative equipment and techniques, such as barge-mounted excavators and hydraulic dredging, to achieve desired outcomes. These examples showed the positive impact of beneficial use in terms of habitat creation, sediment management, erosion control, and safeguarding critical infrastructure like jetties and sea dikes.

Overall, the significance and success of beneficial use initiatives in the Seattle District were highlighted, demonstrating the collaborative efforts between the U.S. Army Corps of Engineers, contractors, and other stakeholders.

Discussion

Q: Chance Asher (Ecology) – The list of potential uses doesn't include cap/cover for cleanups. Is that USACE policy or set by the Biological Opinion? Ecology would like to use clean dredged material for state cleanups. Has there been any movement on this from your attorneys?

A: John – Potential uses discussed were from a USACE engineering manual. There are a few sites – e.g., Olympia – where navigation intersects with State run cleanups. If there is no Fed nexus, there is a concern about USACE incurring liability if they used clean navigation material at a state-run cleanup. This is a legal problem that could be reevaluated. The big question is whether the state would release the Feds of all liability. In the past, the State of WA won't indemnify the Feds, keeping them on the hook forever. Maybe Amy Reese or Brian Hart could help push things along. Is there a way to release Fed gov't from liability and not drag them into a cleanup?

Q: Hiram Arden – Who owns Site O (on the Snohomish River)? The location was used for many years as a log storage and processing yard. There was another site on right bank across from settling basin owned by DNR (who managed rehandling). That material was placed on Tulalip landfill. Some clean sandy material from this other site was used to help isolate contamination from a tire fire on I5 in Everett.

A: John – City of Everett owns Site O with use agreement with the USACE. There is restoration work happening at that other site.

BENEFICIAL USE IN ACTION

SMARM Presentation

May 3, 2023

John Hicks

Chief, Navigation
Seattle District

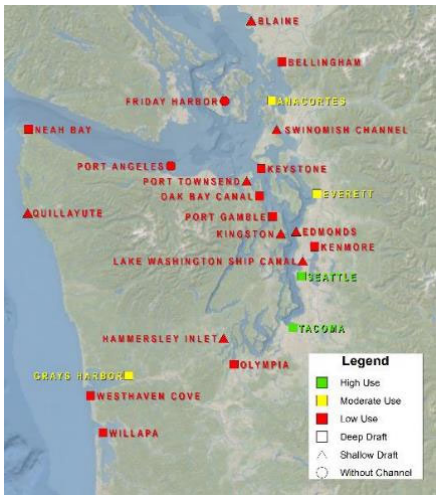
US Army Corps of Engineers

OVERVIEW OF SEATTLE DISTRICT PORTFOLIO

SEATTLE DISTRICT
NAVIGATION PROGRAM

24 Active Channels/Harbors

- 2 High-Use (>10M-tons)
- 3 Moderate Use (> 1M-tons)
- 19 Low-Use (< 1M-tons)
- 14 Deep Draft Channels (>14 ‘)
- 8 Shallow Draft
- 2 No Channel (breakwater/jetty/dike)
- Hydro Survey
- Debris Mission

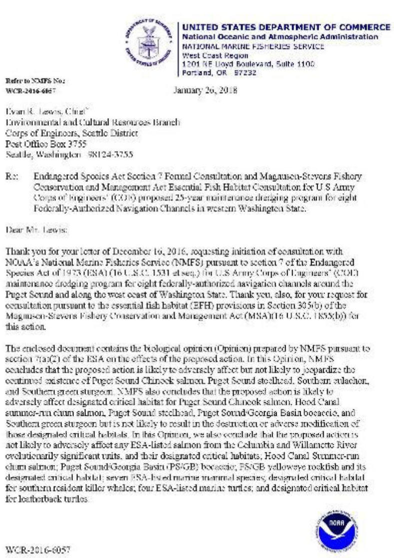


EM 1110-2-5026 BENEFICIAL USES OF DREDGED MATERIAL

Beneficial uses are defined as "productive and positive uses of dredged material, which cover broad use categories ranging from fish and wildlife habitat development, to human recreation, to industrial/commercial uses"

EXAMPLE Dredge Material Management Categories (Red are the types of sites we use in Navigation):
(1) Agriculture (includes Horticulture, Forestry and Aquaculture)
(2) Aquatic habitat
(3) Beach Nourishment (Jetty Island, Keystone beach, Quillayute Sites A and B, GH South Beach/Half Moon Bay)
(4) Confined (diked) placement
(5) Confined Aquatic Disposal (CAD)
(6) Construction/ Commercial
(7) Islands
(8) Multipurpose (Parcel O)
(9) Open-water - material stays in system (littoral / near shore dispersive open water sites) (GH Pt. Chehalis and GH South Jetty sites)
(10) Open-water – material removed from system
(11) Parks/Rec
(12) Strip-mine/Solid waste (includes Strip Mine Reclamation, Solid Waste Landfill, and Alternative Uses)
(13) Upland habitat
(14) Wetlands

ENVIRONMENTAL– 25 YEARS BIOP



UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
1201 NE Lloyd Boulevard, Suite 1100
Portland, OR 97232

Refer to NMFS No:
WCR-2016-6057

January 26, 2018

Evan R. Lewis, Chief
Environmental and Cultural Resources Branch
Corps of Engineers, Seattle District
Post Office Box 3755
Seattle, Washington 98124-3755

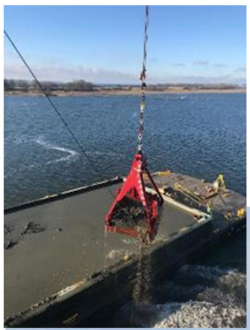
Re: Endangered Species Act Section 7 Formal Consultation and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for U.S Army Corps of Engineers' (COE) proposed 25-year maintenance dredging program for eight Federally-Authorized Navigation Channels in western Washington State.

Dear Mr. Lewis:

Thank you for your letter of December 16, 2016, requesting initiation of consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531 et seq.) for U.S Army Corps of Engineers' (COE) maintenance dredging program for eight federally-authorized navigation channels around the Puget Sound and along the west coast of Washington State. Thank you, also, for your request for consultation pursuant to the essential fish habitat (EFH) provisions in Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA)(16 U.S.C. 1855(b)) for this action.

The enclosed document contains the biological opinion (Opinion) prepared by NMFS pursuant to section 7(a)(2) of the ESA on the effects of the proposed action. In this Opinion, NMFS concludes that the proposed action is likely to adversely affect but not likely to jeopardize the continued existence of Puget Sound Chinook salmon, Puget Sound steelhead, Southern eulachon, and Southern green sturgeon. NMFS also concludes that the proposed action is likely to adversely affect designated critical habitat for Puget Sound Chinook salmon, Hood Canal summer-run chum salmon, Puget Sound steelhead, Puget Sound/Georgia Basin bocaccio, and Southern green sturgeon but is not likely to result in the destruction or adverse modification of those designated critical habitats. In this Opinion, we also conclude that the proposed action is not likely to adversely affect any ESA-listed salmon from the Columbia and Willamette River evolutionarily significant units, and their designated critical habitats; Hood Canal Summer-run chum salmon; Puget Sound/Georgia Basin (PS/GB) bocaccio; PS/GB yelloweye rockfish and its designated critical habitat; seven ESA-listed marine mammal species; designated critical habitat for southern resident killer whales; four ESA-listed marine turtles; and designated critical habitat for leatherback turtles.

WCR-2016-6057



BENEFICIAL USE OF DREDGE MATERIALS BY NWS PROJECTS

5

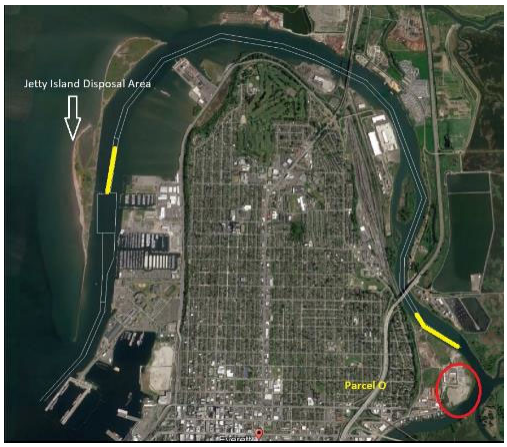
- Grays Harbor
- Quillayute
- Everett/Snohomish River
- Keystone/Lk Crockett
- Bellingham

5/8/2023

EVERETT

6

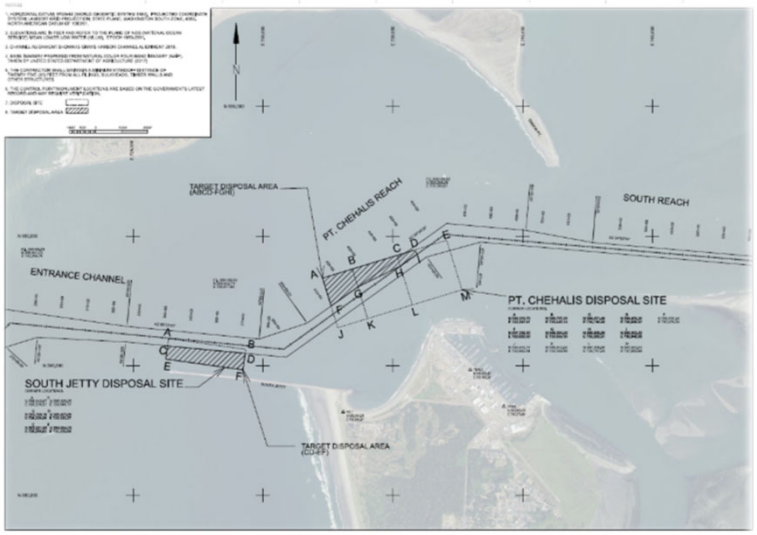
- Dredging Type: Hydraulic Pipeline
- Hydraulic Dredging every other year
- Placement Area:
  - Jetty Island – up to 40,000 CY/event
  - Parcel O – up to 150,000 CY/event
- Total Beneficially Use of 625,980 CY since 2014



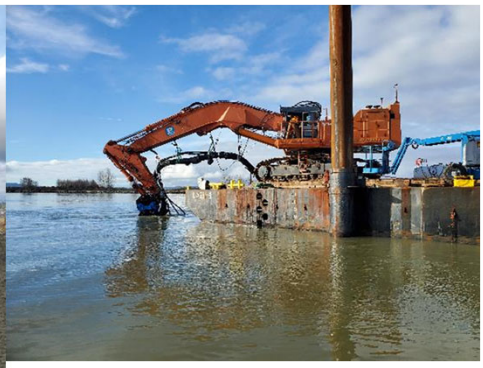
5/8/2023

GRAYS HARBOR

- Dredging Type: Clamshell & Hopper
- Beneficially Use: 21.5M CY last 10 yrs.
- Placement Area:
  - South Jetty Beneficial Placement Site
  - Pt. Chehalis Open Water Disposal Site.
  - South Beach
  - Half Moon Bay



EVERETT



EVERETT

Parcel O

5/8/2023

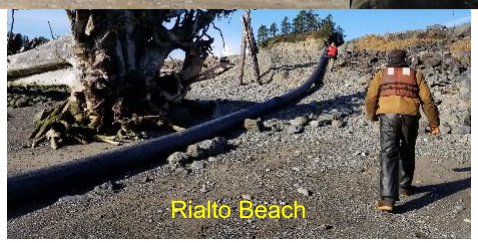
QUILLAYUTE

- Dredging Type: Hydraulic Pipeline
- Hydraulic Dredging every other year
- Placement Area:
  - Site A (First Beach) & Site B (Rialto Beach)

- Total Beneficially Use of 212,066 CY since 2015

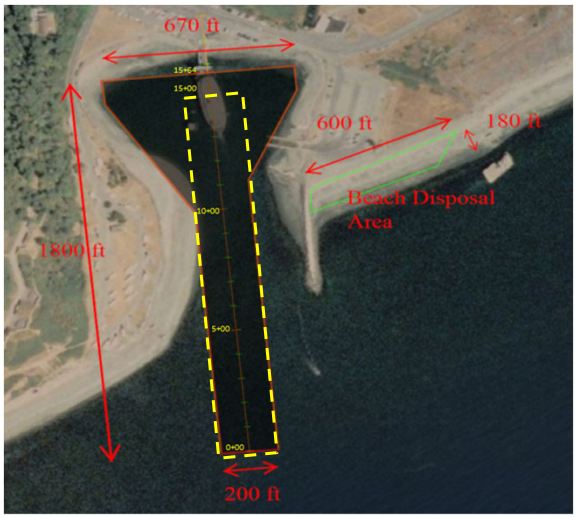
5/8/2023

QUILLAYUTE



KEYSTONE

- Dredging Type: Clamshell
- Placement Area:
  - Shoreline Nourishment
- Beneficial Use of 45,086 CY in FY20



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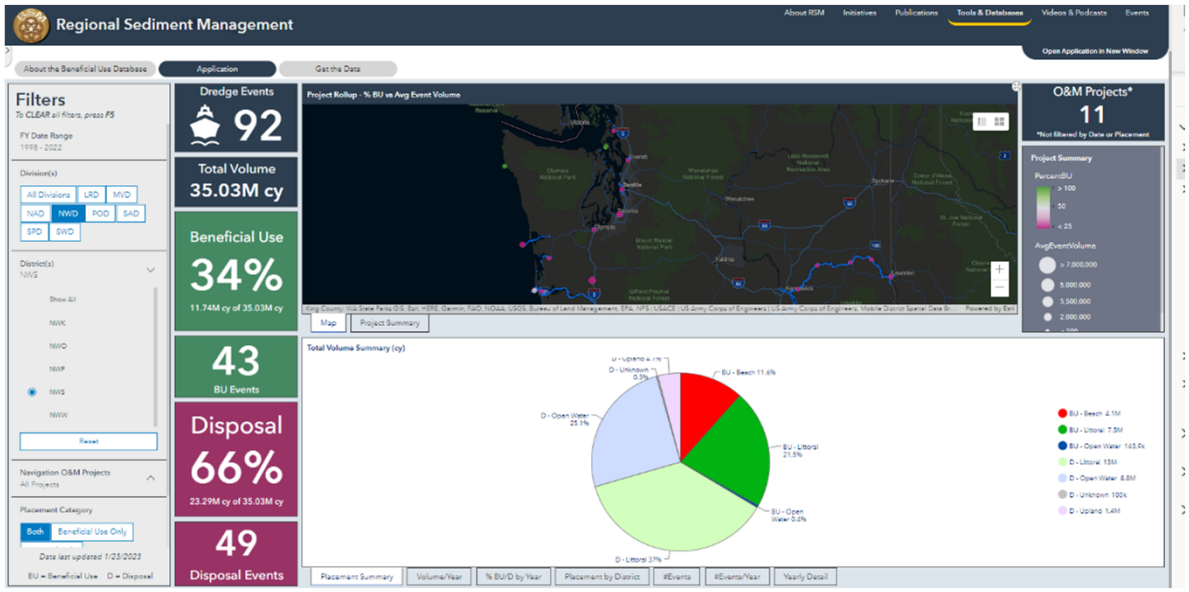
KEYSTONE

5/8/2023

14

RSM

SITE UNDER DEVELOPMENT- DATABASE COORDINATION ISSUES



5/8/2023

QUESTIONS?

Contact:

John Hicks
Chief, Navigation
(206) 764-6908

john.a.hicks@usace.army.mil

5. Snohomish Estuary Beneficial Use Opportunities

Laura Gurley and Erik Gerking (Port of Everett); Larry Lehman (Grette Associates)

Summary

Laura Gurley, Director of Planning at the Port of Everett, presented information about the port's location and operations. The port, handles oversized products such as Boeing parts and serves as a direct connection to the Boeing plant via a rail line. While it is the third-largest container port after Seattle and Tacoma, it recently completed a new 34-acre upland cargo storage facility using dredged material for beneficial reuse. The presentation highlighted the concept of beneficial use, which includes habitat creation, restoration, and adaptation to climate change. The port has utilized material for site capping, remediation, backfilling roadbeds, and public benefit. By moving material directly to sites without second handling, the port aims to enhance habitat creation and restoration efforts for species like salmon, killer whales, and Dungeness crab.

Larry Lehman provided an overview of potential habitat restoration and mitigation actions in the Snohomish estuary, with a focus on reusing dredge material. The team identified suitable locations in the lower estuary, near Jetty Island, where dredge material could be utilized to construct salt marsh and eelgrass habitats. These areas lacked natural sediment delivery and appropriate elevation for habitat formation. Larry highlighted successful examples of beneficial reuse projects, such as the creation of eelgrass beds in Drayton Harbor and Fidalgo Bay using dredge material. Monitoring efforts demonstrated high crab utilization and a notable presence of juvenile salmon prey species in these sites. Puget Island was also mentioned as an example where dredge material was placed along the shoreline to support natural processes. Larry emphasized the importance of considering dredge material as a valuable resource and exploring different approaches to beneficial reuse.

Erik Gerking concluded the presentation by expressing gratitude to the Corps and EPA for their attention to the Everett Waterfront. A focus was placed on collaboration and utilizing resources in a positive manner in order to achieve the long-term goals for the region.

Discussion

Q: John Hicks (USACE) – Is Port of Everett (POE) willing to do all the necessary permitting for USACE to place sand along their shoreline?

A: Laura Gurley (Port of Everett) – POE would like to discuss that question with its collaborators. They own some tidelands that could be used and are willing to lean in and lead but also creates vulnerability.

Justine Barton (EPA) – Needs to be a collaborative effort although clearly the environmental documentation needs to be conducted by someone.

Comment: Hiram Arden – Creative ideas were used in Fidalgo Bay. The Swinomish channel is 11 miles long. Part of the channel is the responsibility of Seattle USACE. Determined that whoever receives funding first can conduct the maintenance dredging. By including the Port as a prospective dredger of the fed channel, the material was able to be used beneficially. This was a win for collaboration.

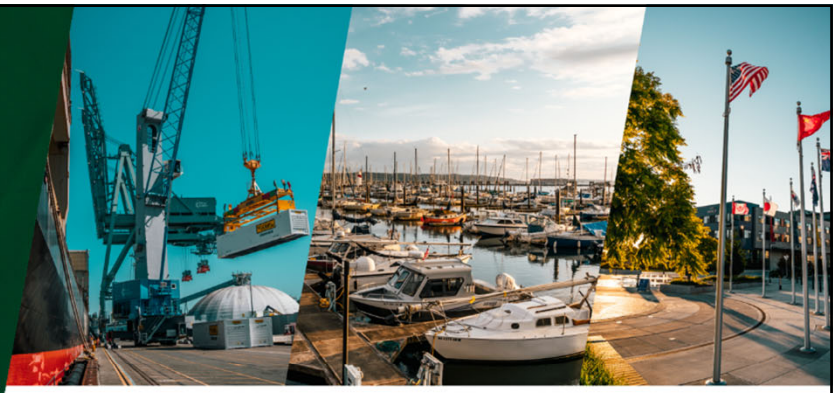
Port of EVERETT

Beneficial Use of Dredge Material

Laura Gurley, Erik Gerking and Larry Lehman, Grette Associates

May 3, 2023

About the Port of Everett



- The Port District and boundaries formed in 1918; serves nearly 100,000 people
- Not countywide
- Governed by three elected commissioners
- Special Purpose District 'economic development'
- Supports 40,000 jobs in the region
- Contributes $433M in state & local taxes
- Operate three lines of business; Seaport, Marina, Real Estate
- Homeport to Naval Station Everett
- Largest public marina on the West Coast
- Everett's customs district ranks 2nd in the state at $21 BILLION in exports (including airplanes)
- 3rd largest container port in the state

What is Beneficial Re-Use?

Clean, appropriately sized dredged material can be used for many things:

- Habitat creation
- Habitat restoration
- Beach nourishment
- Climate change adaptation
- Remediation site capping
- Public utility projects
- Public road projects
- Economic development projects

What is Beneficial Re-Use?

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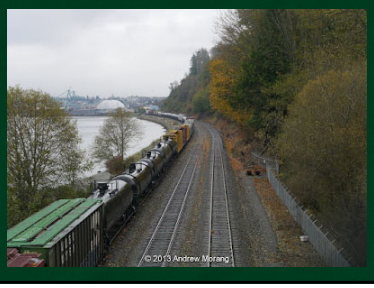
- Public utility projects
- Public road projects
- Economic development projects

What are the Benefits?

- Create or enhance forage fish spawning habitat
- Create/enhance substrate for aquatic macrovegetation to grow
- Mimic the natural cycle of slides and littoral drift cells on the shoreline where it's been interrupted (e.g. by railroad tracks)
- All good for ESA listed species

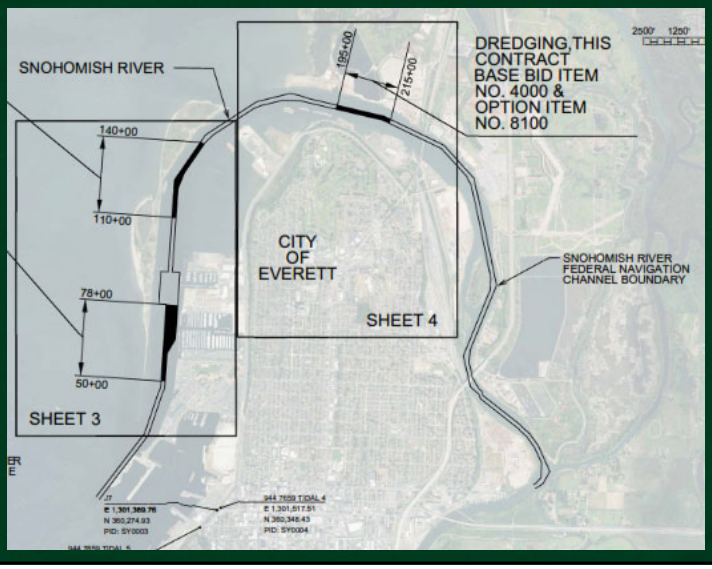


Background

- Quality material is actively being dredged each year
- Port maintenance dredging on a 2 to 10 year cycle, dredges approximately 20,000 to 70,000+ CY per event
- US Army Corps Navigation annually dredges approximately 40,000 to 200,000 CY/year maintaining the Snohomish River Federal Navigation Channel and Settling Basins
- There's a need for this material for habitat, restoration, climate change adaptation projects and more

Where Does the Port Dredge?

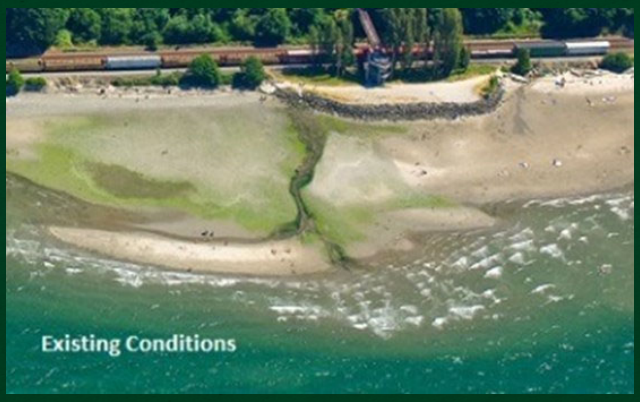
Where Does the Corps Dredge?



Snohomish County Nearshore Beach Nourishment Sites

Howarth Park & Nearshore Enhancement

- Snohomish County and Snohomish County Marine Resources Committee
- 19,000 CY from upper channel
- Double handling costs
- More monitoring needed to gauge success



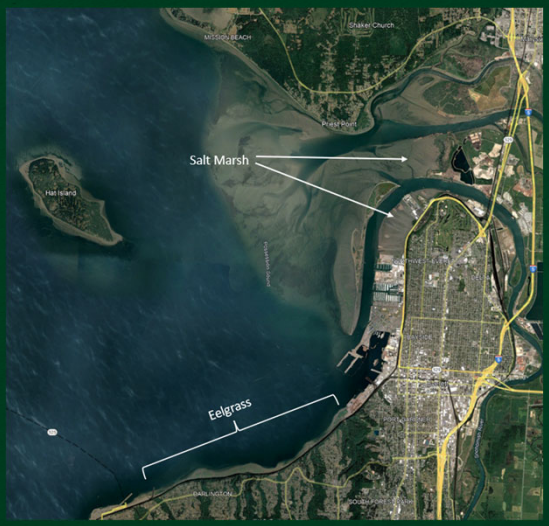
Howarth Park After Restoration

But Wait, There's More!

Snohomish Estuary
Existing Restoration Projects

Port of Everett

- Grette Associates is looking at restoration/mitigation options in Snohomish Estuary
- Salt marsh and eelgrass focus



Drayton Harbor
Port of Bellingham

- Beneficial reuse for new 15 acre eelgrass bed
- Eelgrass light limited due to depth
- Raised elevation with approx. 200,000 CY of dredged native materials
- Planted small clusters of eelgrass
- Native seed production primary colonization method

Fidalgo Bay Site
Port of Anacortes

- Based on success at Drayton Harbor
- Raised areas in Fidalgo Bay with dredged material
- Swinomish Federal Channel Source
- Port obtained permits and dredged Federal Channel

Puget Island
Wahkiakum County

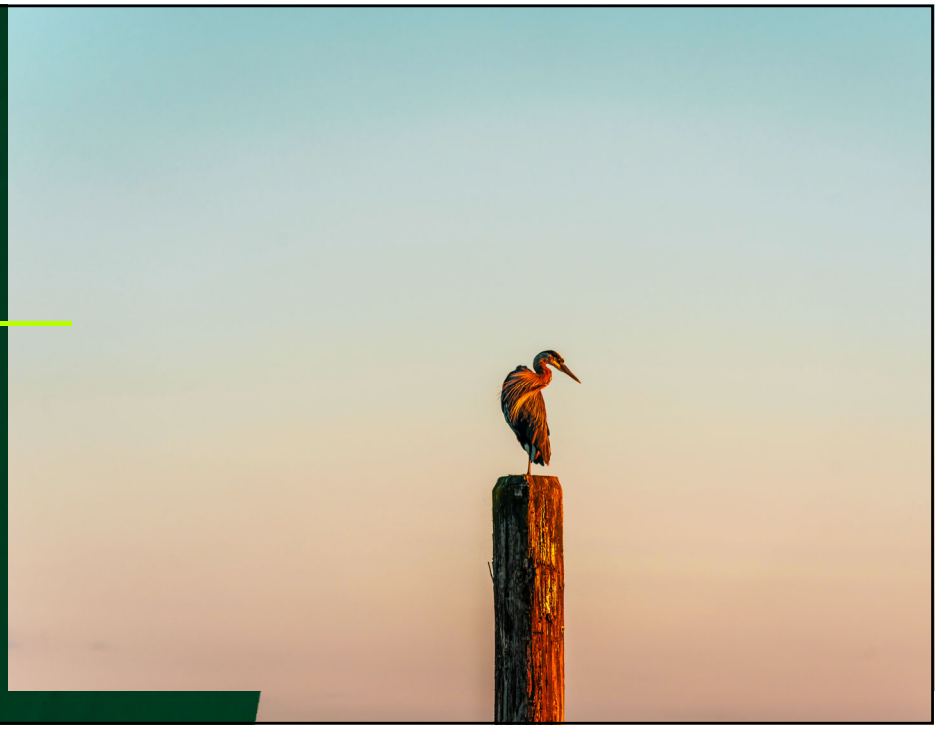
- The county permitted beach nourishment/soft bank protection
- Offered to Portland District as disposal site for Federal Channel material
- Four sites used over last 15 years
- Over 1 million CY placed to date

We Can Do It!

Thank You!

Questions?

Port of EVERETT



6. Novel 3D Printed Structures: Isolate Contaminant Effects in Complex Mixtures for Toxicity Reduction Evaluations

Alan Kennedy (USACE – ERDC)

Summary

Alan discussed the development of 3D printed resins for use in laboratory studies and environmental remediation. The focus was on their use for bioassays, particularly elutriate bioassays, in removing the confounding effects of ammonia to sensitive test organisms. Existing methods of managing ammonia's effects have included pH manipulation and the use of zeolite powder, which have been shown to negatively affect organism survival through the manipulations alone. An ammonia removal process was presented that involved 3D printing high surface area structures made from a zeolite polymer. The printed structures are then placed inside of test chambers and allowed to interact with the test solution for a period of time prior to test initiation (when the animals are added). Benchtop studies demonstrated the effectiveness of the 3D printed items in removing ammonia toxicity, while not removing other contaminants of concern. Additionally, the findings showed a high correlation between porosity of the printed structure and the removal of ammonia.

Alan also shared that ERDC has been using similar technology in regard to beneficial use by 3D printing dredge material into things like fish or bird habitats. This is part of The U.S. Army Corps of Engineers (USACE) Engineering with Nature® (EWN) Initiative. Learn more at their website and listen to their podcast: https://ewn.erdc.dren.mil/

Discussion

No questions.

NOVEL 3D PRINTED STRUCTURES:
ISOLATION OF CONTAMINANT EFFECTS IN COMPLEX MIXTURES FOR TOXICITY REDUCTION EVALUATIONS

Alan Kennedy[1,2]

Lauren May, Travis Thornell, Chris Griggs

[1] US Army Engineer Research and Development Center, Vicksburg, MS

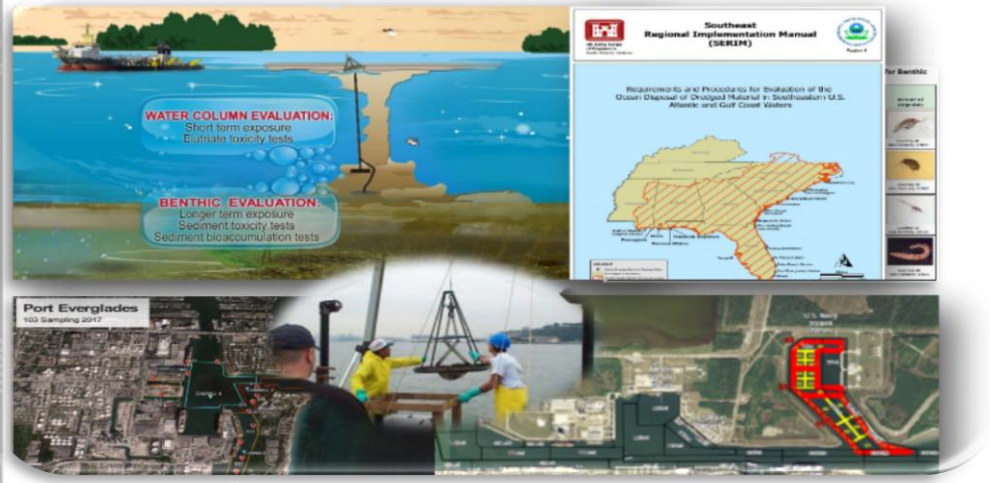
[2] Virginia Tech, Macromolecules Innovation Institute, Blacksburg, VA

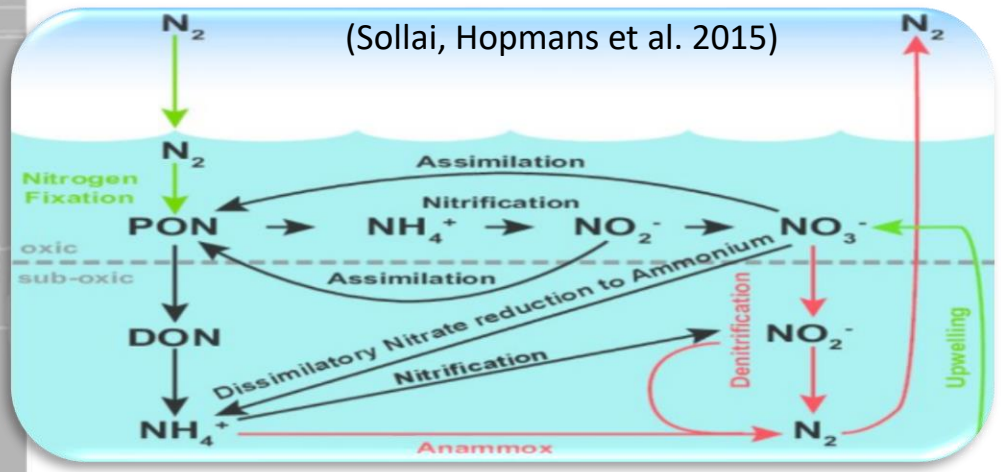
Michael Bortner, Stephen Martin, Chris Williams

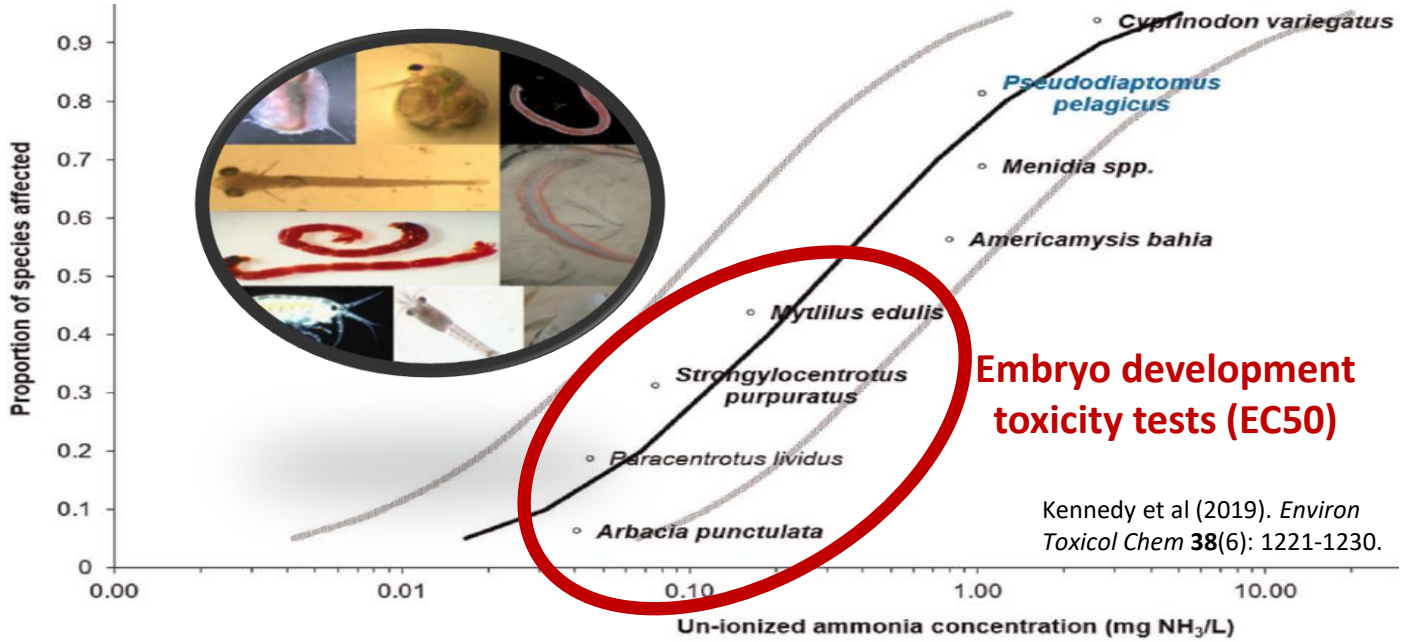
[2] Virginia Tech, Macromolecules Innovation Institute, Blacksburg, VA

Problem: Ammonia in Bioassays

Confounding other CoCs







Kennedy et al (2019). *Environ Toxicol Chem* **38**(6): 1221-1230.

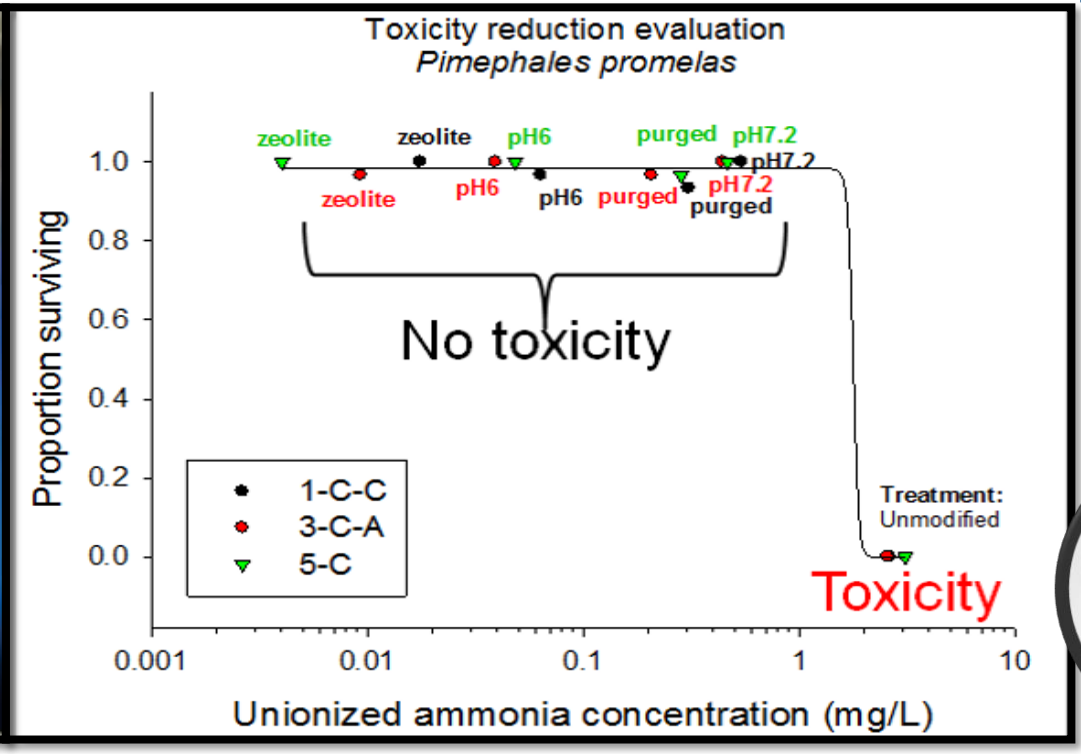
- Kennedy, A. J.; Biber, T. W.; May, L. R.; Lotufo, G. R.; Farrar, J. D.; Bednar, A. J., Sensitivity of the Marine Calanoid Copepod *Pseudodiaptomus pelagicus* to Copper, Phenanthrene, and Ammonia. *Environmental Toxicology and Chemistry* **2019,** *38* (6), 1221-1230.
- Kennedy, A. J.; Lotufo, G.; Laird, J. G.; Farrar, J. D. *Dredged material evaluations: review of zooplankton toxicity test methods for marine water quality evaluations*; 2016.
- Kennedy, A. J.; Lotufo, G. R.; Steevens, J. A. *Review of dredged elutriate application factors: relevance to acute-to-chronic protection, contaminant, and endpoint specificity*; US Army Engineer Research and Development Center, Vicksburg, MS, ERDC/EL TR-15-10: 2015.
- Kennedy, A. J.; Lindsay, J. H.; Biedenbach, J. M.; Harmon, A. R., Life stage sensitivity of the marine mussel *Mytilus edulis* to ammonia. *Environmental Toxicology and Chemistry* **2017,** *36*, 89-95.

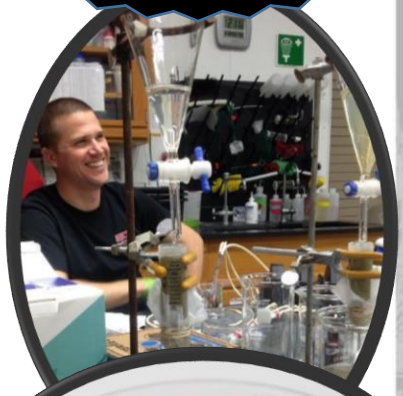
Toxicity Reduction Evaluations

Sediment Elutriates

Lines of evidence

1. [NH_3]
2. Zeolite
3. pH reduction
4. [other CoCs]

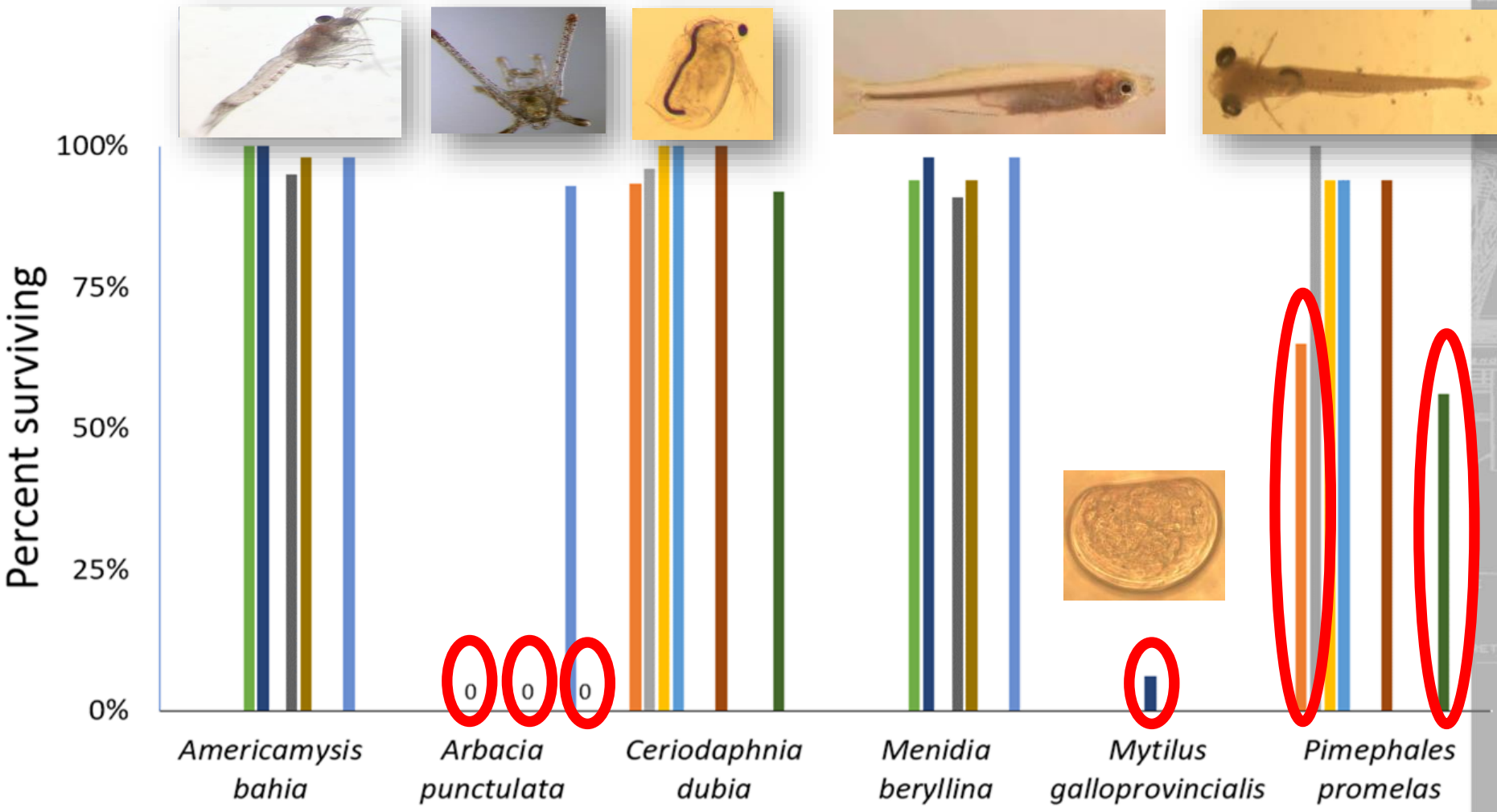




- USEPA, Methods for Aquatic Toxicity Identification Evaluations: Phase I Toxicity Characterization Procedures, 2nd ed. Development, Washington, D.C., 1991.
- USEPA, Toxicity Identification Evaluation: Characterization of Chronically Toxic Effluents, Phase I. Development, Washington, D.C., 1992; p 59.
- Kreitinger, J. P.; Farrar, D. J.; Lotufo, G. R., Application of Toxicity Identification and Evaluation Procedures for Dredged Material Management. Laboratory, E., Ed. US Army Engineer Research and Development Center Vicksburg United States: Vicksburg, MS, 2017.
- Melby, M. L.; Kennedy, A. J.; Farrar, J. D.; Bednar, A.; Moore, D.; Lehmann, W., Toxicity reduction (and identification) evaluation for dredging evaluations: methods for whole sediment elutriate bioassays. Laboratory, E., Ed. U.S. Army Engineer Research and Development Center: Vicksburg, MS., 2018; p 15.

Zeolite Particle Impacts on Organisms?

Zeolite Control Data only



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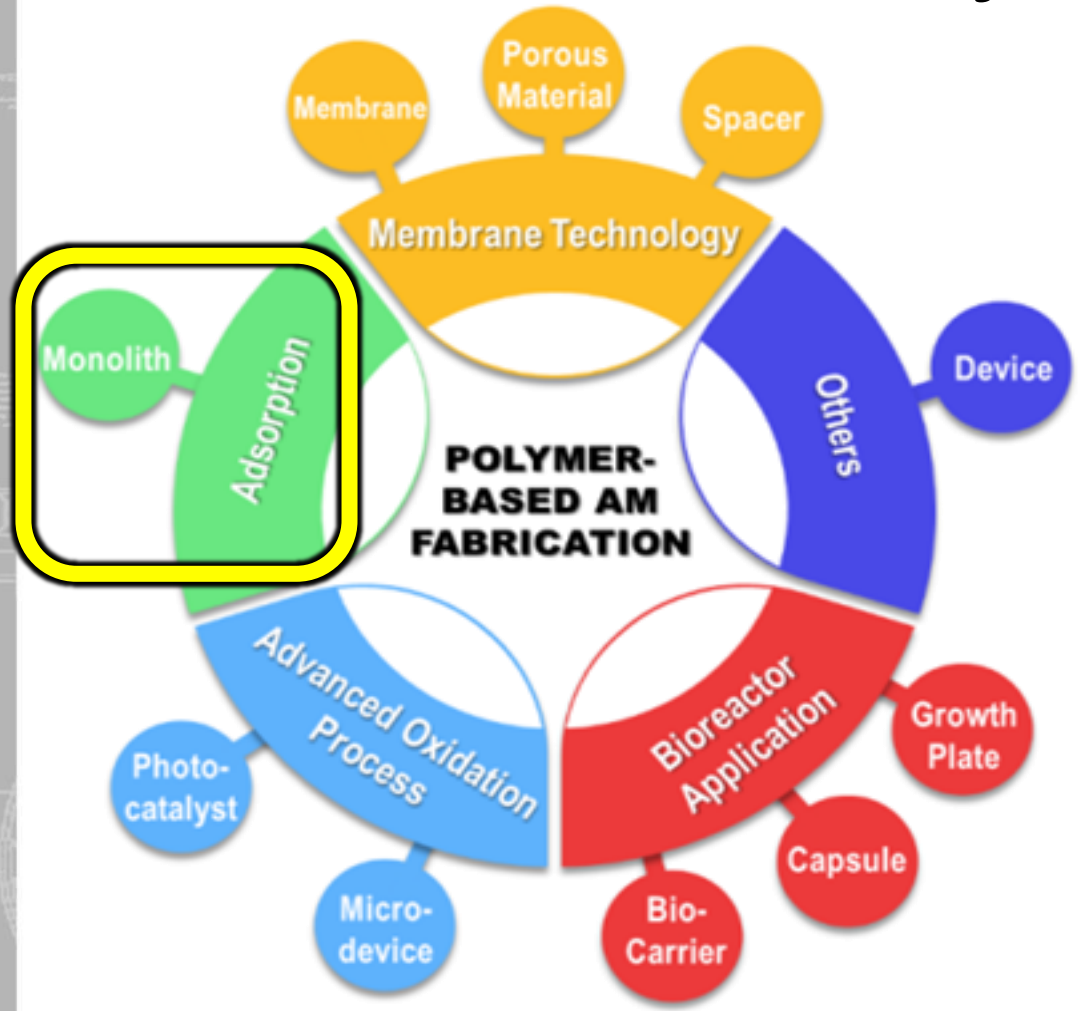
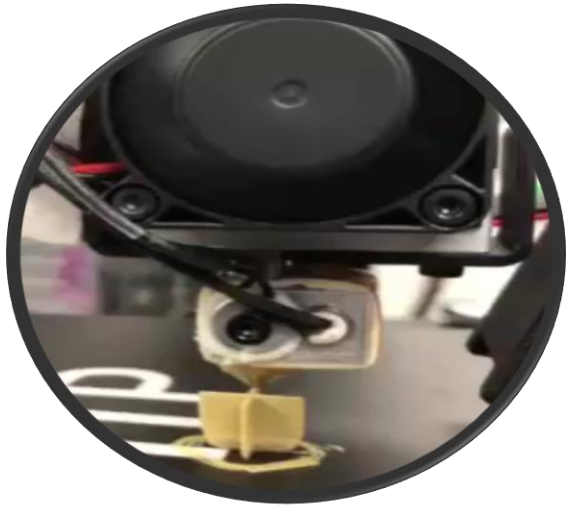
Overview

Additive Manufacturing & the Environment





Adsorption of contaminants

Adsorption of contaminants

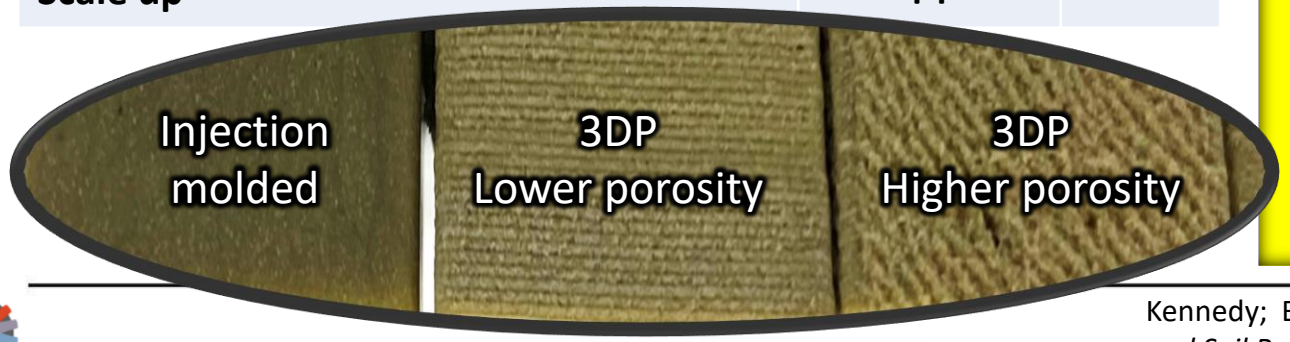
Degradation of PAHs, Microcystin, PFAS

Husna, M.; Irene Teo; Phang; Wong; Cheah; Lim, Recent Advances in Polymer-based 3D Printing for Wastewater Treatment Application: An Overview. *Chemical Engineering Journal* **2021**, 132311.

Motivation

Why AM for Environmental Applications?

Consideration	Traditional	AM
Complex geometry *Overlapping structure*	0	++
Design Freedom *Customization, prototypes, iteration*	--	++
On-site, On-demand *Printing on vessels at sea*	--	++
Multi-functionality *Adsorption & destruction*	-	+
Porosity *H_2O & chemical absorption*	--	++
Scale up	++	--

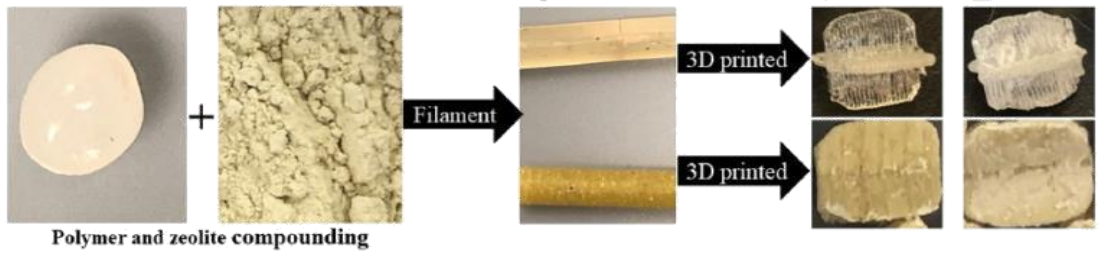


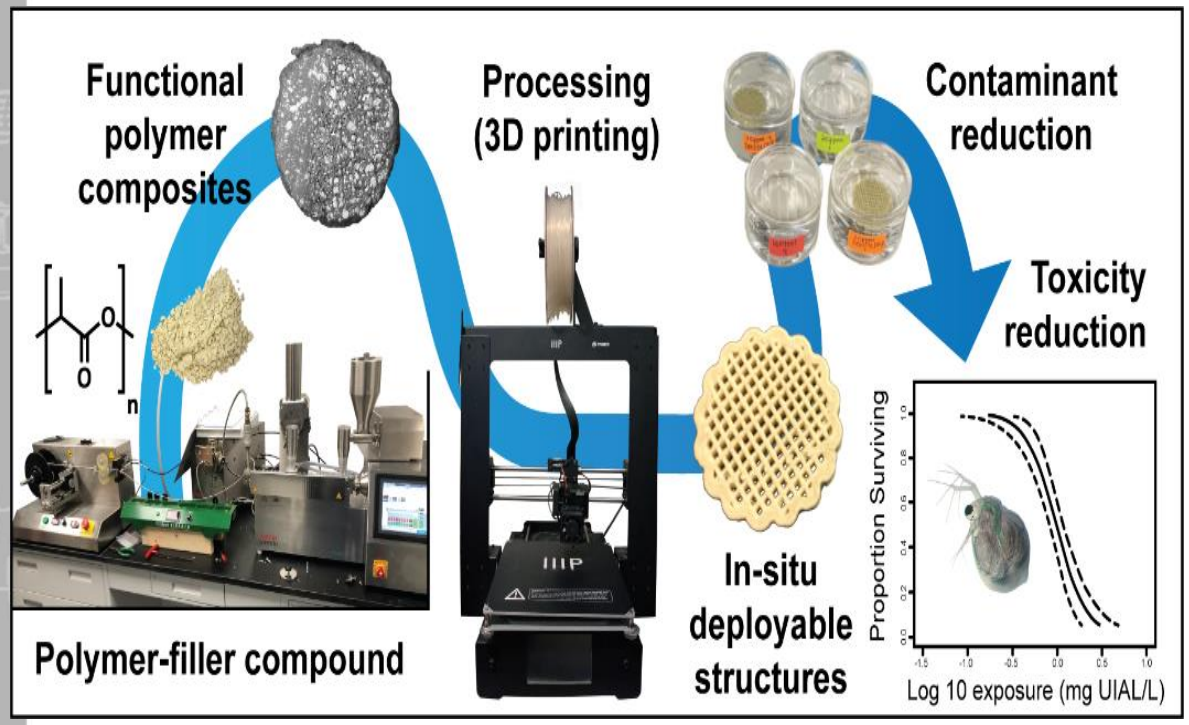
1. New research space
2. AM enables
   a) Immobilization
   b) Greater surface area
   c) Iterative design, complexity
   d) Tunable porosity
3. Environ AM missing
   a) Characterization
   b) Structure, property relation
   c) Process controls

Kennedy; Ballentine; May; Das; Bednar; Griggs; Hull; Bortner. *Water, Air and Soil Pollution* **2022,** *233* (5), 148.

Motivation

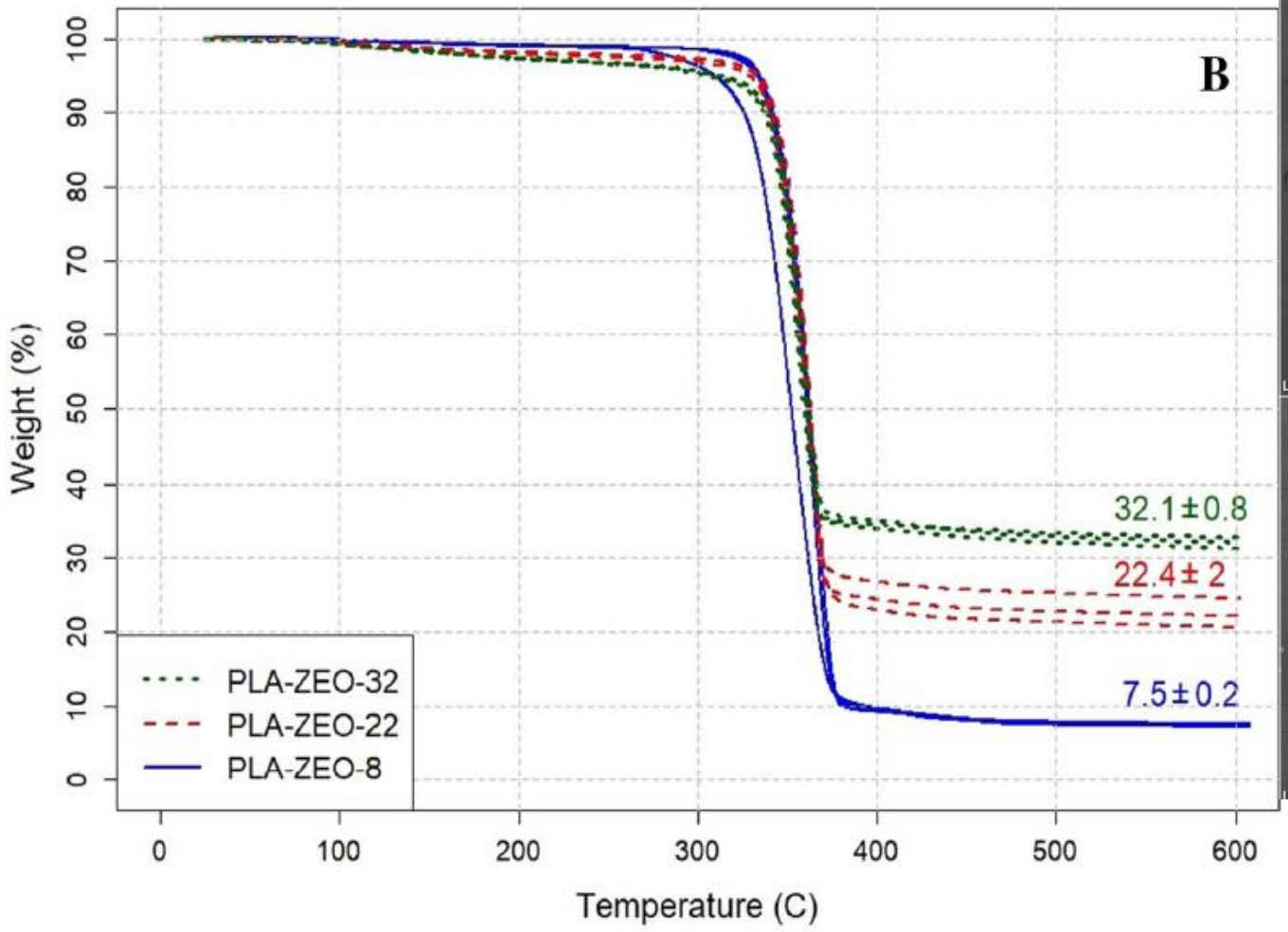
Why AM for environmental applications?

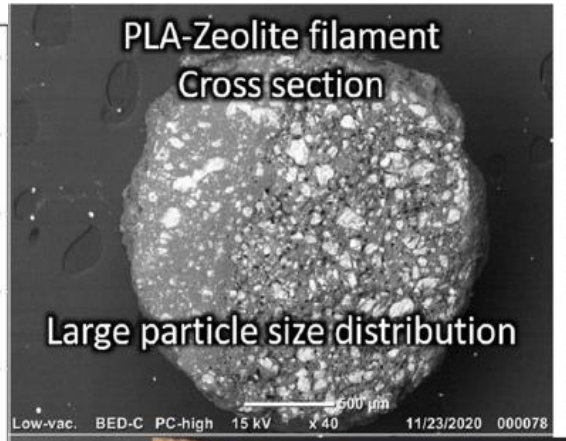


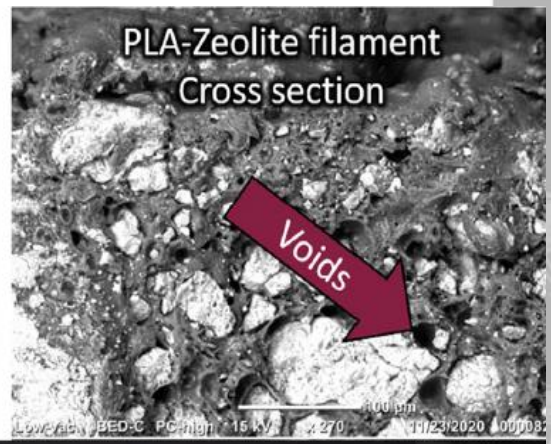


Kennedy; Ballentine; Das; Griggs; Klaus; Bortner. *ACS ES&T Water* **2021,** *1* (3), 621-629.
Kennedy; Ballentine; May; Das; Bednar; Griggs; Hull; Bortner. *Water, Air and Soil Pollution* **2022,** *233* (5), 148.

Immobilized Zeolite in PLA







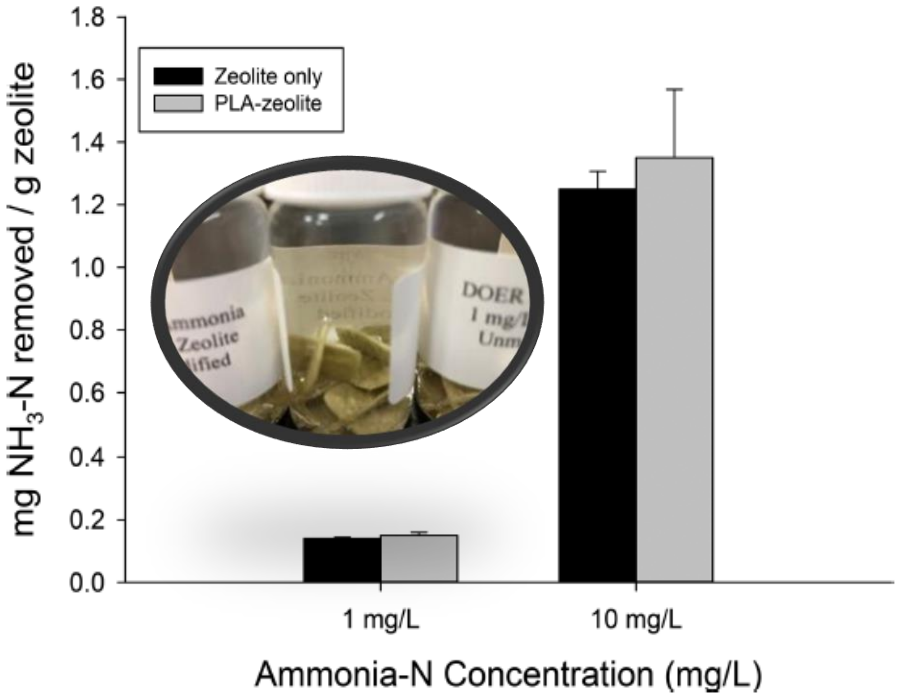
$$\phi_m = \frac{Bulk\ density\ of\ particles}{True\ density\ of\ particles}$$

Kennedy, A. J.; Ballentine, M. L.; May, L. R.; Das, A.; Bednar, A. J.; Griggs, C. S.; Hull, M. S.; Bortner, M. J., Simplifying Complex Contaminant Mixtures: Selective Ammonia Adsorption and Toxicity Reduction using 3D Printable Polymer-Zeolite. *Water, Air and Soil Pollution* **2022,** *233* (5), 148.

Adsorption Studies

- Treatments: (1) water-only; (2) Free zeolite; (3) neat PLA; (4) PLA-Zeolite
- Chemical spiking
  - NH_4Cl → MHRW (USEPA 2002)
  - Elutriates (USEPA/USACE 1998)
- Chemical exposures
  - Shaker table; 100 oscillation/min
  - 24 hr / 0, 2, 6, 24, 48 h
- Chemical analysis
  - Total-ammonia-N (TAN): ISE Probe
  - Metals: ICP-MS
  - PAHs: GC-MS
- *Ceriodaphnia dubia* (EPA 2002)

Kennedy et al (2022). Water, Air and Soil Pollution **233**(5): 148.



Kennedy, A. J., M. L. Ballentine, A. Das, C. S. Griggs, K. L. Klaus and M. J. Bortner (2021). "Additive Manufacturing for Contaminants: Ammonia Removal Using 3D Printed Polymer-Zeolite Composites." ACS ES&T Water **1**(3): 621-629.

USEPA (2002) Methods for measuring the acute toxicity of effluents and receiving waters to freshwater and marine organisms. EPA-821-R-02-012.

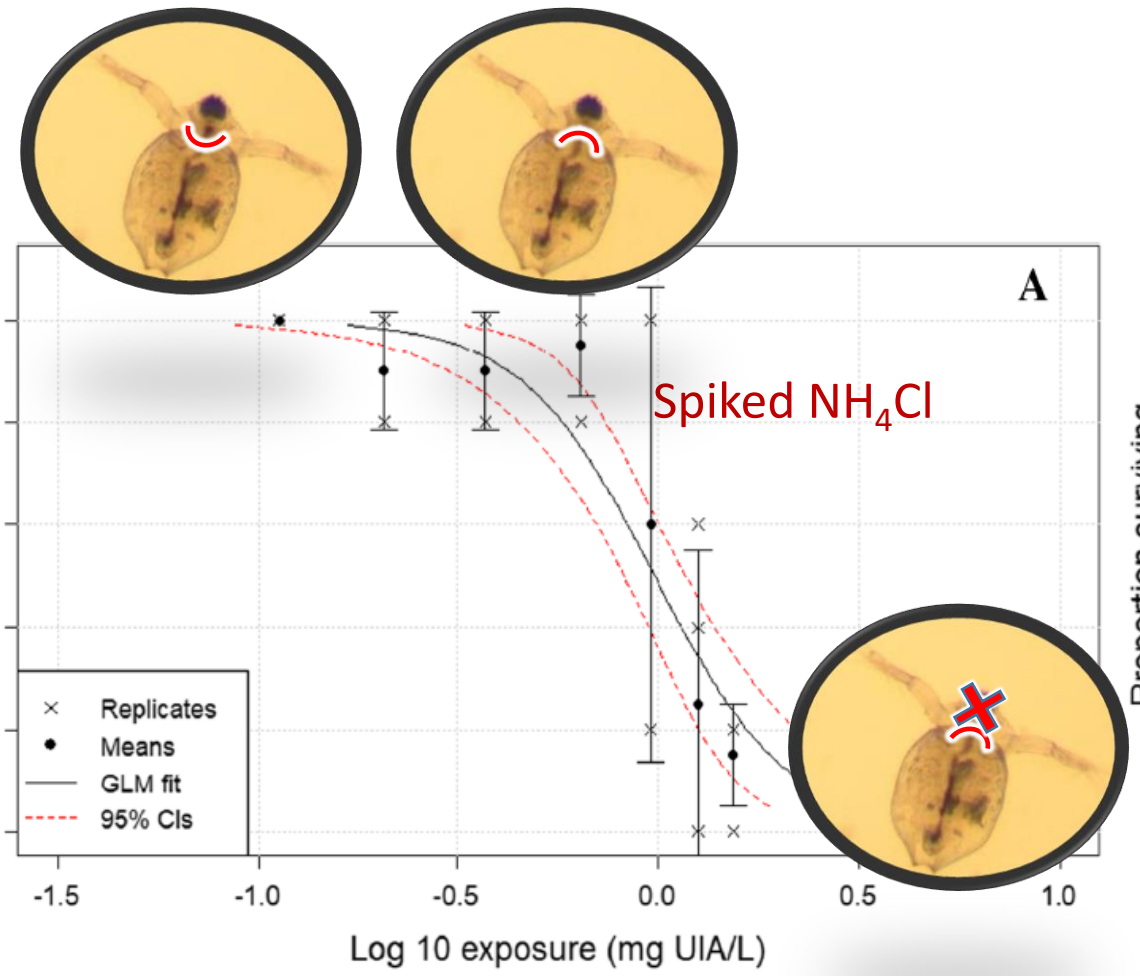
USEPA/USACE (1998) Evaluation of dredged material proposed for discharge in waters of the US-testing manual: Inland Testing Manual. EPA-823-B-987-004

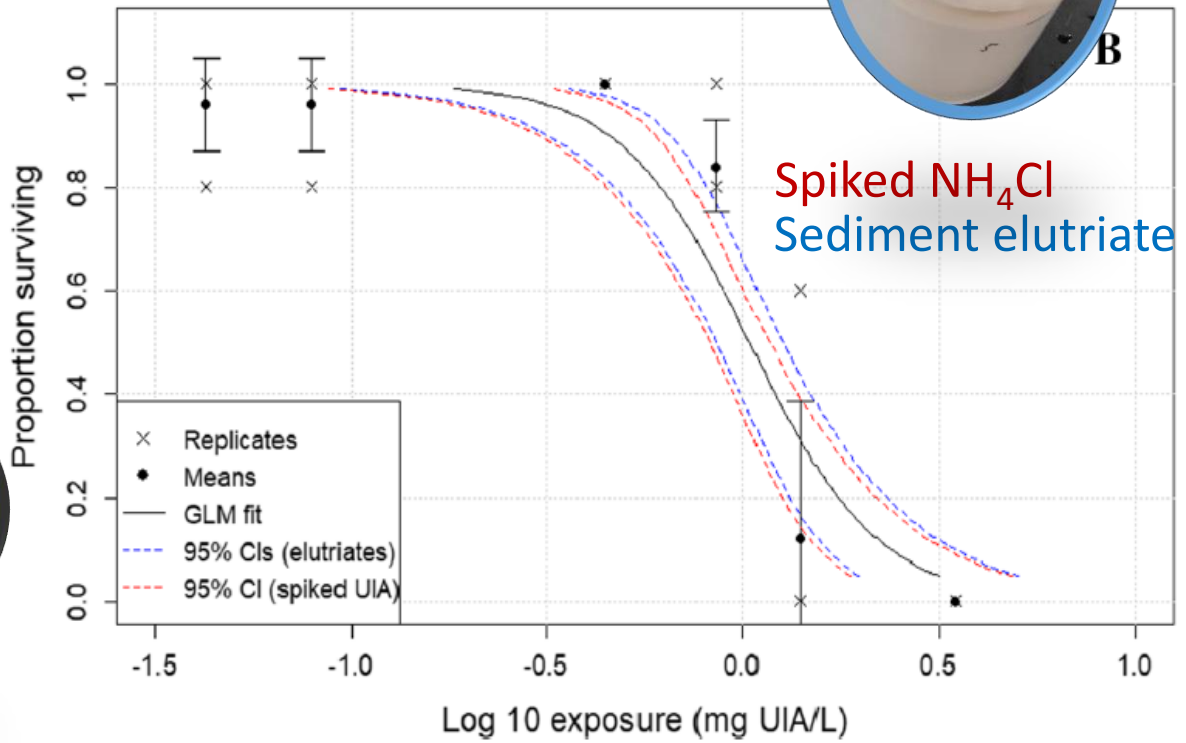
Elutriate Toxicity

Driven by ammonia

Composite sediment samples collected from Buffalo River, NY (25 July 2018)

Elutriate preparation: (EPA-823-B-987-004).





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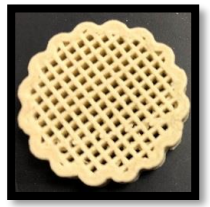
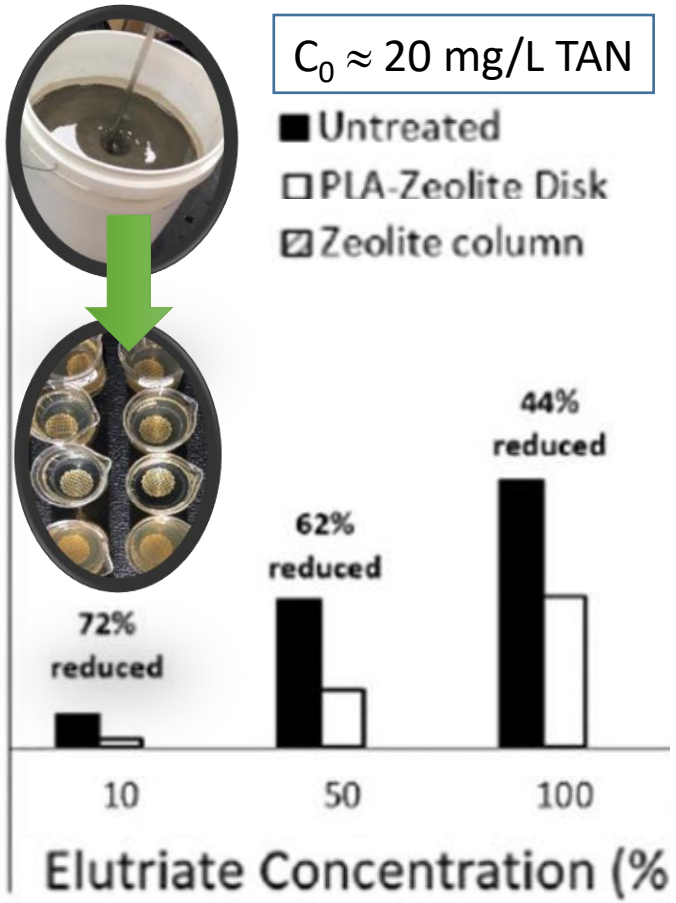
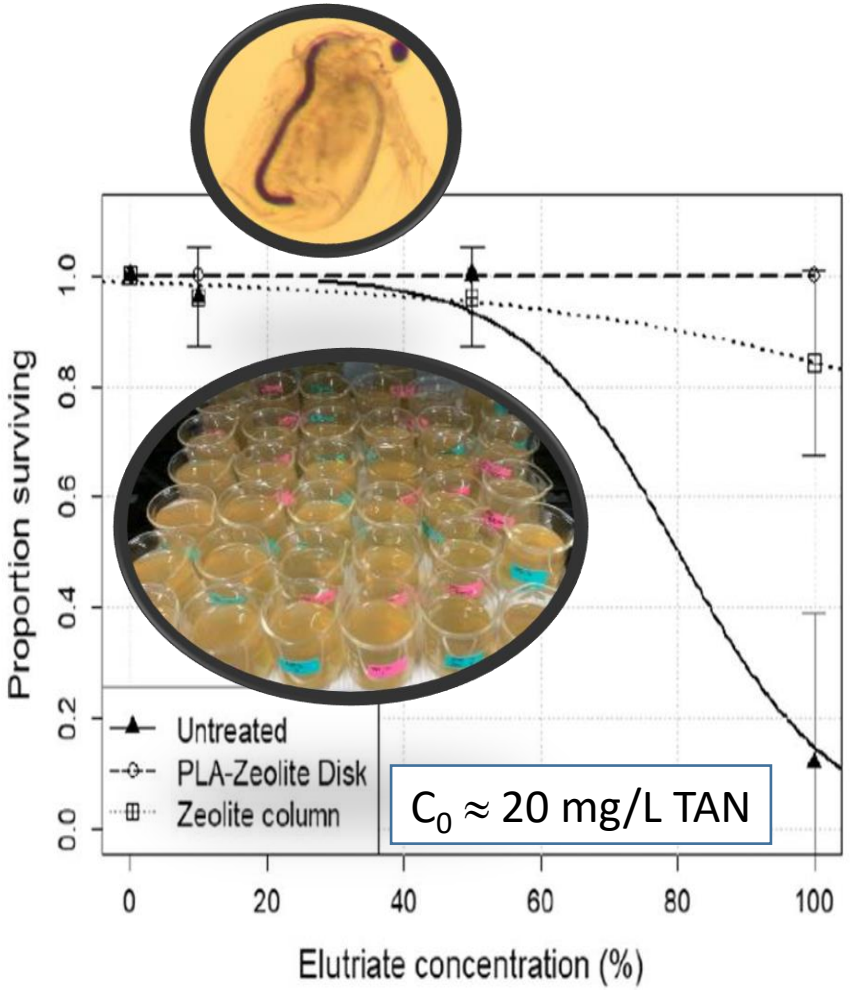
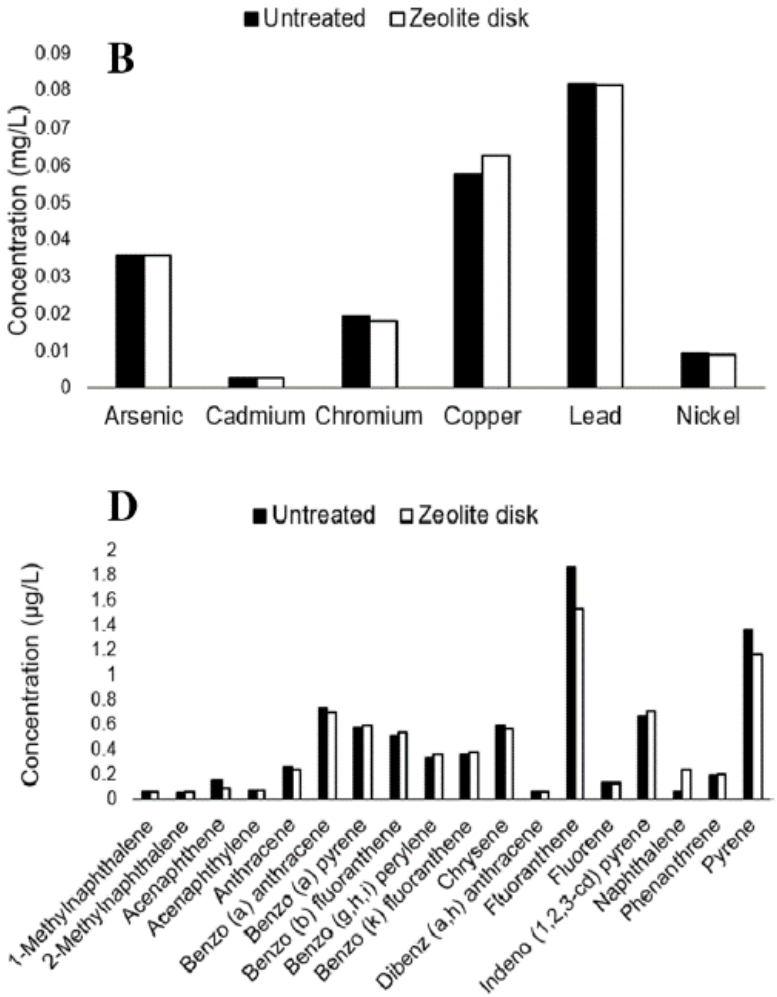
Does Printed Zeolite Work?





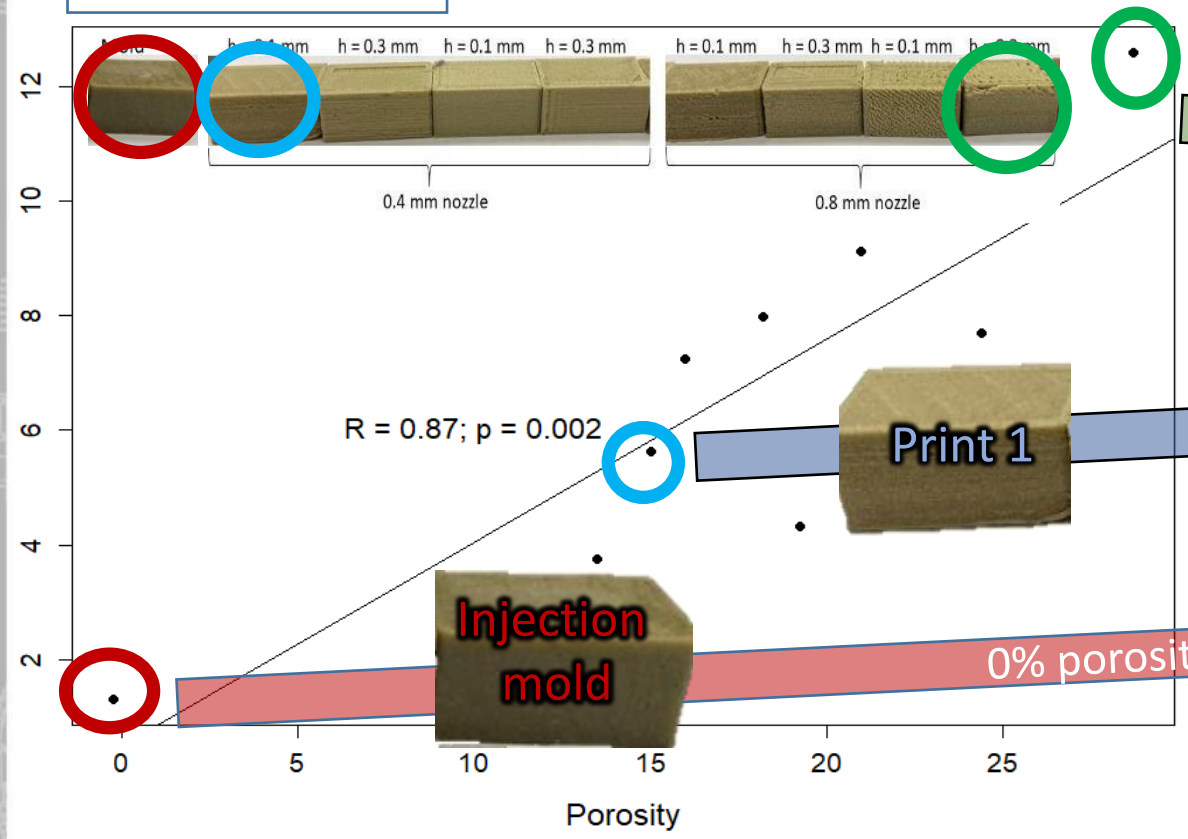




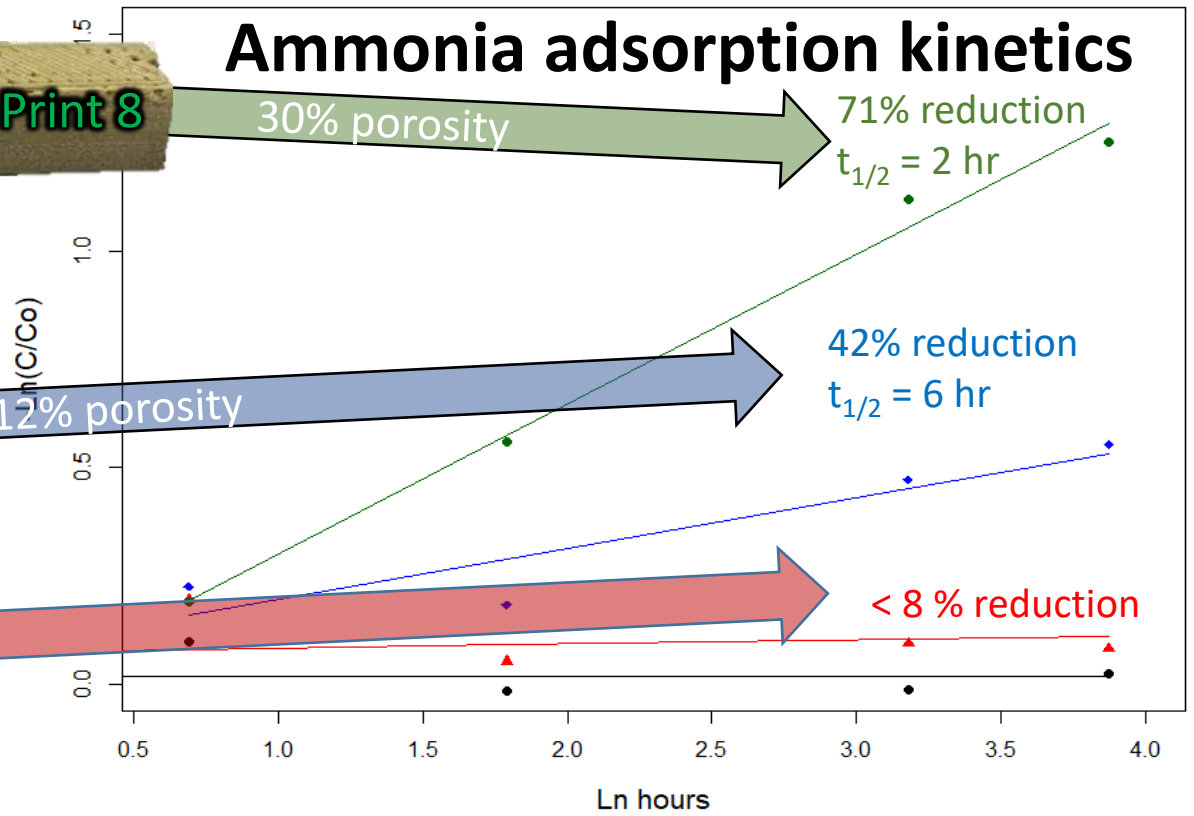
Kennedy, A. J.; Ballentine, M. L.; May, L. R.; Das, A.; Bednar, A. J.; Griggs, C. S.; Hull, M. S.; Bortner, M. J., Simplifying Complex Contaminant Mixtures: Selective Ammonia Adsorption and Toxicity Reduction using 3D Printable Polymer-Zeolite. *Water, Air and Soil Pollution* **2022,** *233* (5), 148.

Ammonia Removal vs. Porosity

$C_0 \approx 20$ mg/L TAN

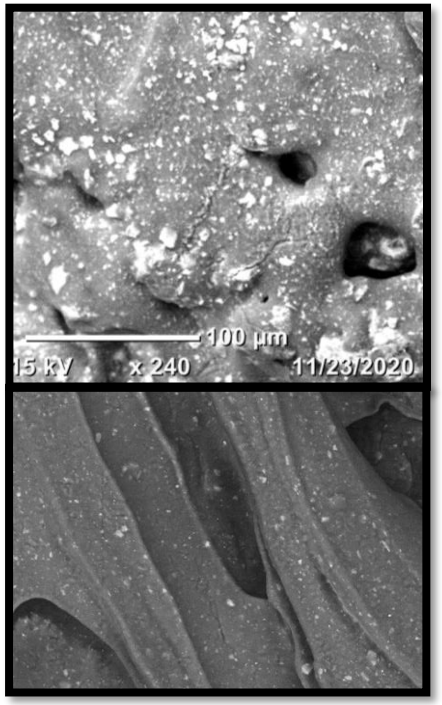


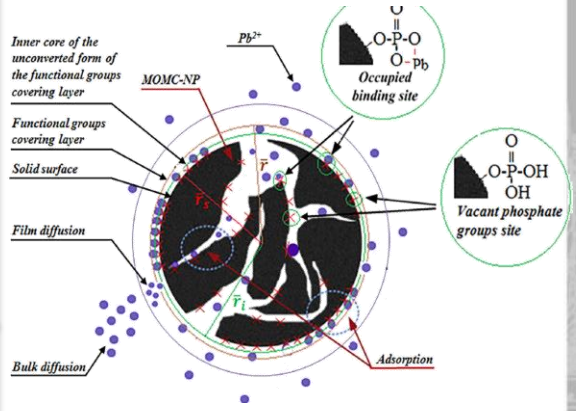
$C_0 = 22$ mg/L



Conclusions

- Zeolite adsorption in 3DP composites
  - ➢Immobilize/deployable/retrievable
  - ➢Reduce physical exposure
- Tunable hierarchical porosity by 3DP
- Reduce [NH_3]below toxic levels <24 h
  - ➢20 – 44 mg/L TAN (1.3 – 2.9 mg/L UIA)
  - ➢3X faster treatment (<8 h workday)
- Ammonia specific (other CoCs)
- Other applications, CoCs (PFAS)





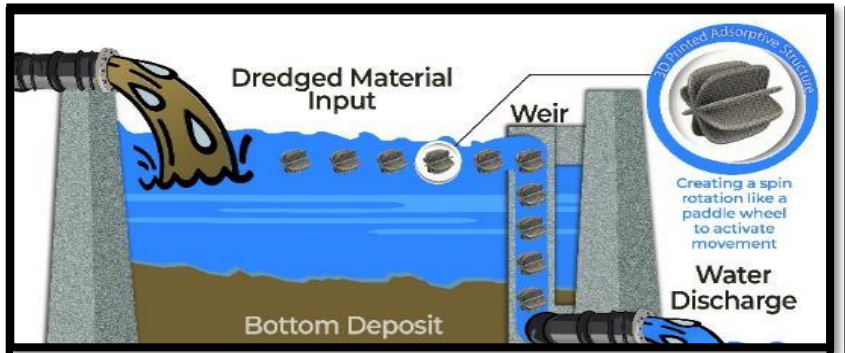
Lian et al. J *Contam Hydrology* **2020,** *228*, 103562.

Select levels from a list

Factor	Levels
Nozzle	0.4mm
Speed	30mms
Height	0.1mm
ExtTemp	220C

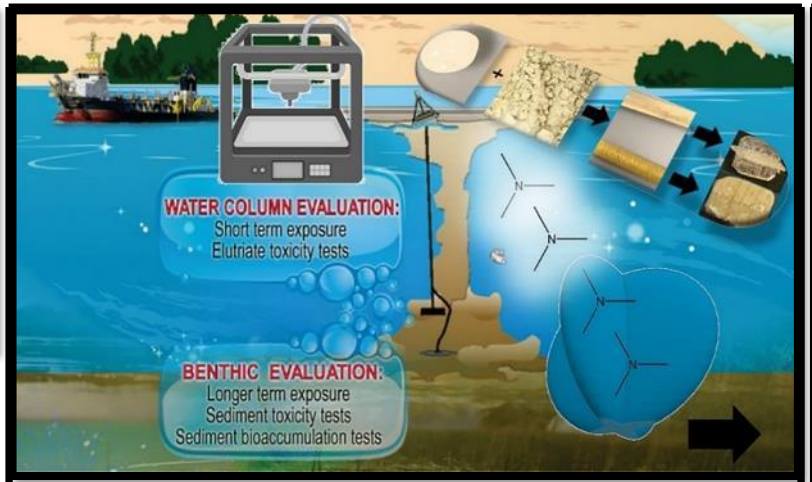
C14
PMEAN3
12.4606

Environmental Applications of AM

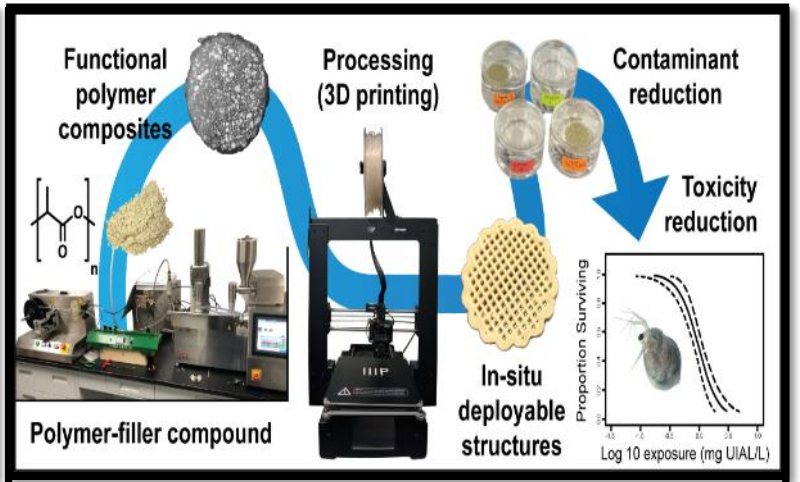


Kennedy, Ballentine, McQueen, Griggs, Das, Bortner. 2021. Environmental applications of 3D printing polymer composites for dredging operations. ERDC/TN DOER-C37. Army Engineer Research and Development Center, Vicksburg, MS.

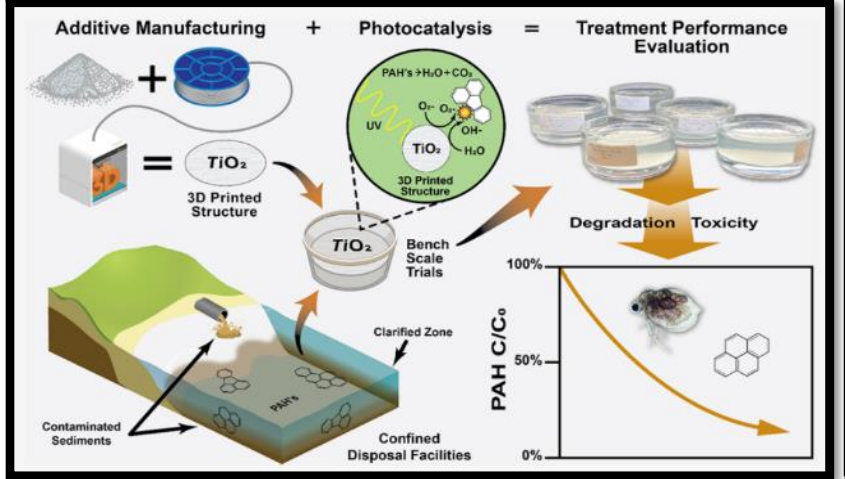
Kennedy, McQueen, Ballentine, Fernando, May, Boyda, Williams, Bortner. 2021. Sustainable harmful algal bloom mitigation by 3D printed photocatalytic oxidation devices (3D-PODs). ERDC/TN ANSRP-22-1 Engineer Research and Development Center: Vicksburg, MS, 2022



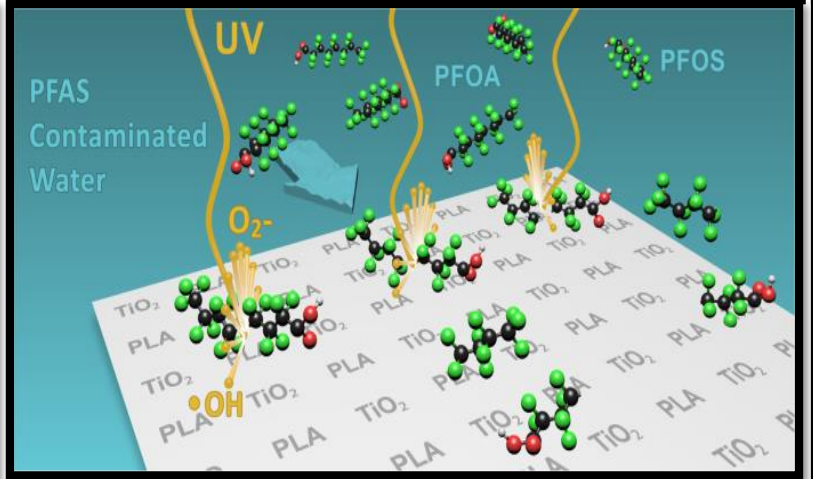
Kennedy, Ballentine, Das, Griggs, Klaus, Bortner. 2021. Additive Manufacturing for Contaminants: Ammonia Removal Using 3D Printed Polymer-Zeolite Composites. *ACS ES&T Water* 1:621-629.



Kennedy, Ballentine, May, Das, Bednar, Griggs, Hull, Bortner. 2022. Simplifying Complex Contaminant Mixtures: Selective Ammonia Adsorption and Toxicity Reduction using 3D Printable Polymer-Zeolite. *Water, Air and Soil Pollution* 233:148.



McQueen, Ballentine, May, Laber, Das, Bortner, Kennedy. 2022. Photocatalytic Degradation of Polycyclic Aromatic Hydrocarbons in Water by 3D Printed TiO_2 Composites. *ACS ES&T Water* 2:137-147.



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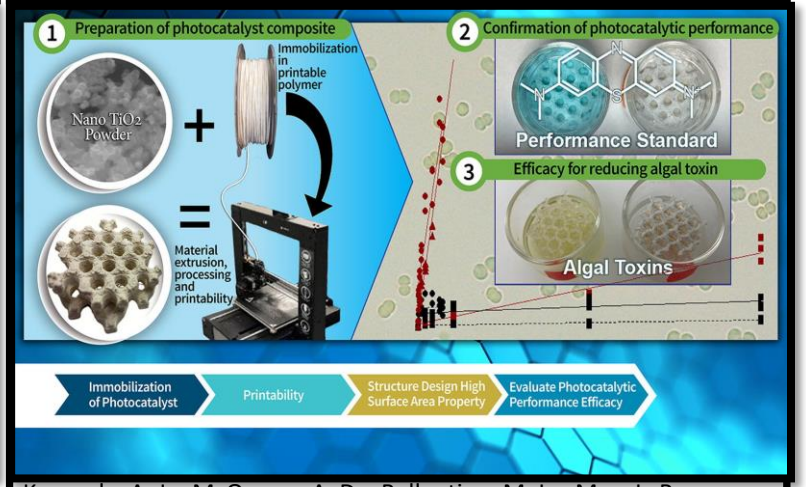
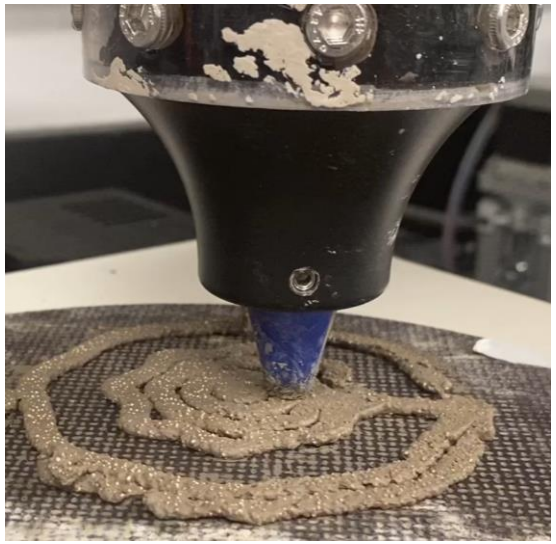
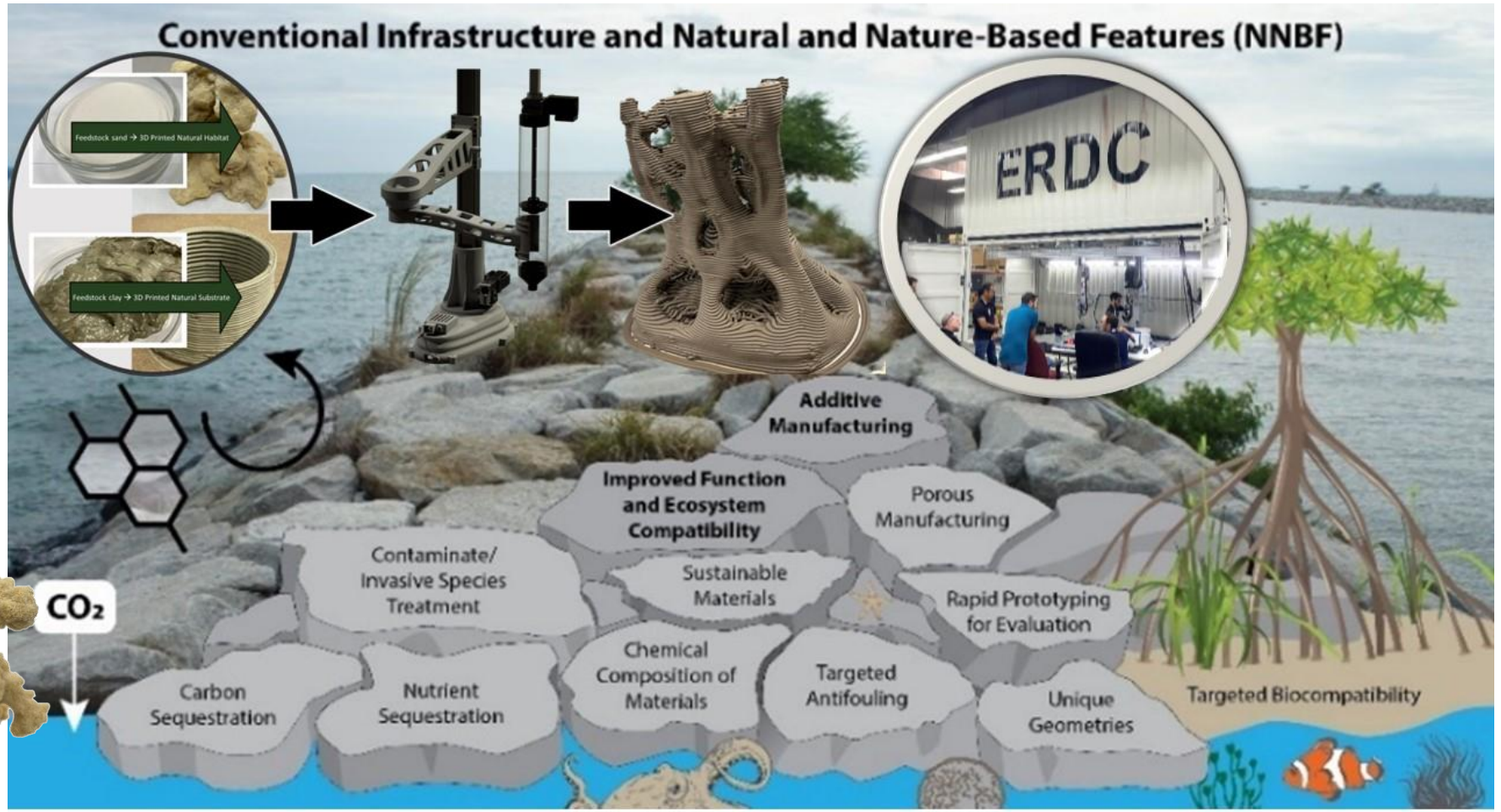


Kennedy, A. J.; McQueen, A. D.; Ballentine, M. L.; May, L. R.; Fernando, B. M.; Das, A.; Klaus, K. L.; Williams, C. B.; Bortner, M. J., Degradation of microcystin algal toxin by 3D printable polymer immobilized photocatalytic TiO2. *Chemical Engineering Journal* **2023,** *455*, 140866.

BUDM: 3D Printing sediment into Habitat





Questions?

Alan.J.Kennedy@usace.army.mil
601-634-3344

Dredging Operations Environmental Research (DOER) Program
https://doer.el.erdc.dren.mil/

ENVIRONMENTAL RISK ASSESSMENT
ADVANCED MATERIALS

https://nano.el.erdc.dren.mil/

7. Current Challenges for Sediment Characterization Projects – Panel Discussion

EcoAnalysts and ARI (Regina Edwards mod.)

Summary

This was a moderated panel discussion with Regina Edwards, Michelle Knowlen, Mary Ann Rempel-Hester and Jay Word (EcoAnalysts) and Sue Dunnihoo (ARI). Topics focused on analytical turn-around-times for data delivery, their impact on product delivery for tiered aspects of regional testing (such as bioassays), and bioassay and bioaccumulation test species availability. Factors affecting analytical laboratories included supply-chain shortages of supplies and reagents and employee retention. Supply chain has gotten better as we have emerged from the pandemic, but issues still arise regarding reagent availability. The amphipod species of *Leptocheirus plumulosus* was discussed as a possible alternate for the 10-day benthic test. This species offers the advantage of being cultured instead of field collected and is already an approved species for other USEPA/USACE programs around the nation. The marine clam *Macoma nasuta* is used for bioaccumulation testing for dredged material programs around the nation. There are limitations in availability of this species due to there being only one supplier and whose population was severely reduced in 2021 due to the unprecedented heat dome event coupled with extreme low tides. EcoAnalysts is currently exploring the use of two alternate clam species for use in Puget Sound related bioaccumulation exposures.

Discussion

Analytical Laboratory Questions

Q: Joy Dunay (USACE) – 1. Are labs dropping sediment analysis or just certain COCs? 2. How about reporting limits?

A: Sue – 1. ARI is one of the few labs still doing TBT. BPH in drinking water is another analysis that fewer labs are performing. Reporting Limits (RLs) create challenges for other labs. Detection limits were developed many years ago. 2. Many labs give RLs based on wet weight. Labs should determine total solids first and then report RLs based on dry weight (admittedly logistically challenging).

Q: Bill Gardiner (USACE) – Are there changes we can make to testing in order to anticipate issues? For example, for bioassay samples, why wait for all the chemistry data to come in once 1 COC triggers testing? There's no need to wait for data to be complete and validated when we could use preliminary data to trigger testing. Otherwise, hold times may expire.

A: Sue - Yes – such an approach would also give the lab the ability to prioritize COCs.

Q: Kent Patten (Apex) – Field schedule changes result in samples arriving late to the lab when it may not have adequate capacity. Coordination with the analytical labs is often not occurring. Question regarding Hg – non frozen 28-day hold time. If sediment has organic layer, labs are limited on mass associated with MDLs (10g). Is there flexibility about air drying (to reduce water weight) – Can build this into SAP beforehand. Predicting the % solids really helps.

A: Joy - SMS, Ecology and DMMP now allow a one-year frozen holding time for mercury. Other regions might not recognize that, but that is something that both of our programs allow. We issued a clarification paper on two years ago.

Q: Mark Rettman (Port of Tacoma) – We freeze everything when there are time issues with clients. Do you recommend that? Are there any other seasonality issues you can discuss?

A: Sue - All sediments at ARI are frozen in case something comes up. One of the worst times for lab turnaround is just after the 1st rain of the year.

Holding time issues with chemistry and toxicity testing

Q: Susie McGroddy (Windward) – What happens if you have a concurrent tox test running when the sediment chemistry comes back ok? Can you just break down the test and thereby money?

A: Mary Ann Rempel-Hester - Yes, especially for bioaccumulation testing. Note that most of the country runs chemistry and toxicity concurrently and use both for decision making.

Comment: Kimbrie Gobbi (WSP) – One possible solution is to plan for 2 mobilizations (chemistry and bioassay) even though this will cost more $$ if you sample a second time. Freeze a portion of sediments from the second deployment for possible chemistry testing. Also run grain size analysis up front.

Comment: Brian Hester (USACE) – Remember that chemical analysis also needs to be conducted within a prescribed holding time. Tiering means that bioassays don't start until after the chemical analysis holding time. Concurrent testing eliminates that variable.

Comment: Sue Dunnihoo (ARI). Heard that original holding times were "made up" by an EPA project manager who was tired of getting his data late.

Bioassay species availability

Q: Erika Hoffman (EPA) - Why are there no suppliers for *Rhepoxinius*?

A: Mary Ann Rempel-Hester (EcoAnalysts) - US Supplier retired. Canadian supplier had difficulties with collecting, weather, and shipping across the border.

Panel Discussion: Current Challenges for Sediment Characterization Projects

EcoAnalysts & ARI

1

Panel (Who We Are)

Sue Dunnihoo

Analytical Resources, LLC
Director, Client Services
ACS Certified B.A. Chemistry

Mary Ann Rempel-Hester

EcoAnalysts, Inc.
Senior Aquatic Toxicologist
Ph.D. Environmental Toxicology
B.A. Biology

Jay Word

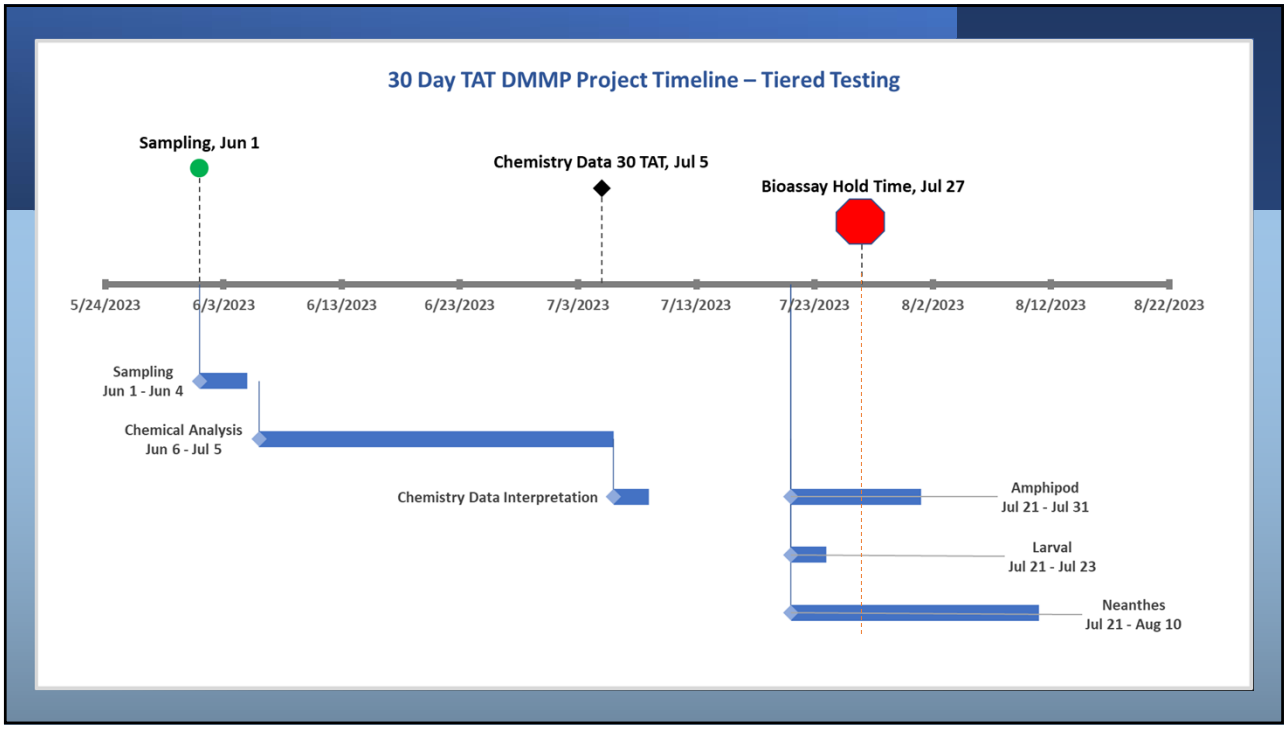
EcoAnalysts, Inc.
Senior Aquatic Toxicologist/Ecologist
B.S. Environmental Science

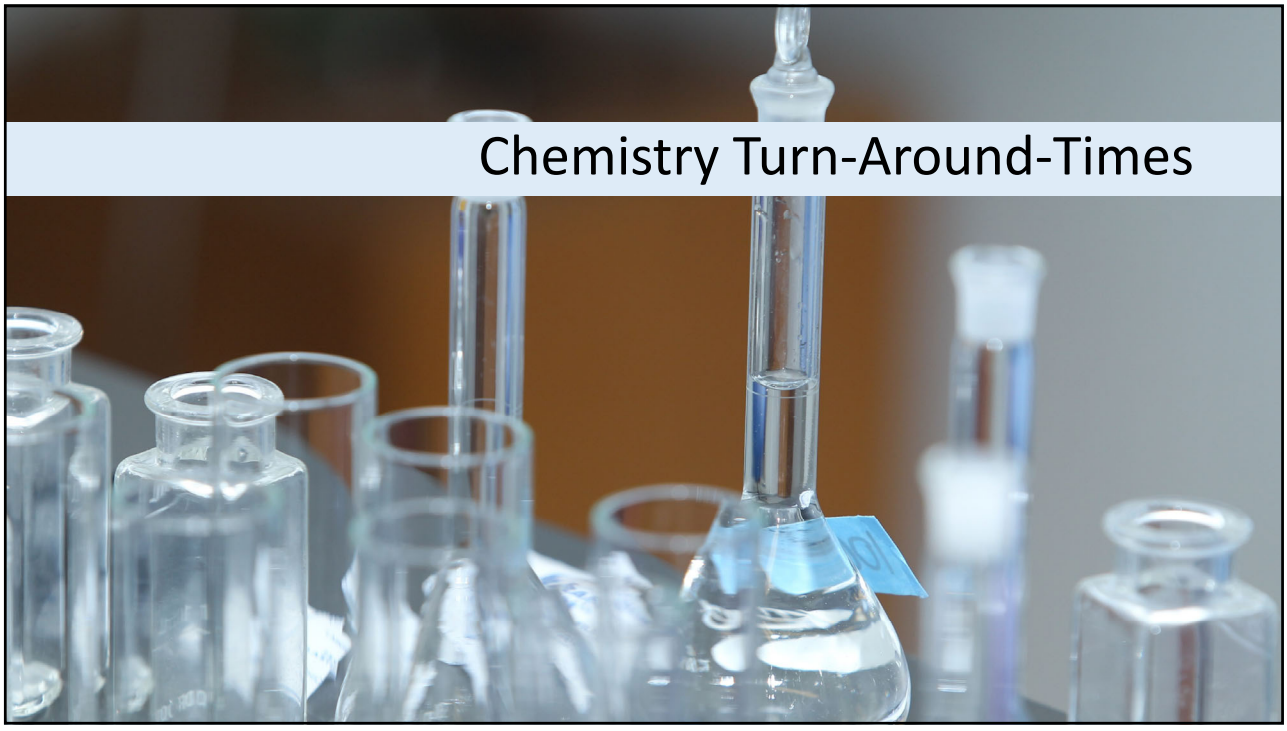
Michelle Knowlen

EcoAnalysts, Inc.
Senior Aquatic Toxicologist/Benthic Ecologist
B.S. Environmental Science

Panel and Discussion Topics

- Chemistry Turn-Around-Time
- Bioassay Hold Times
- Bioassay Test Species Availability





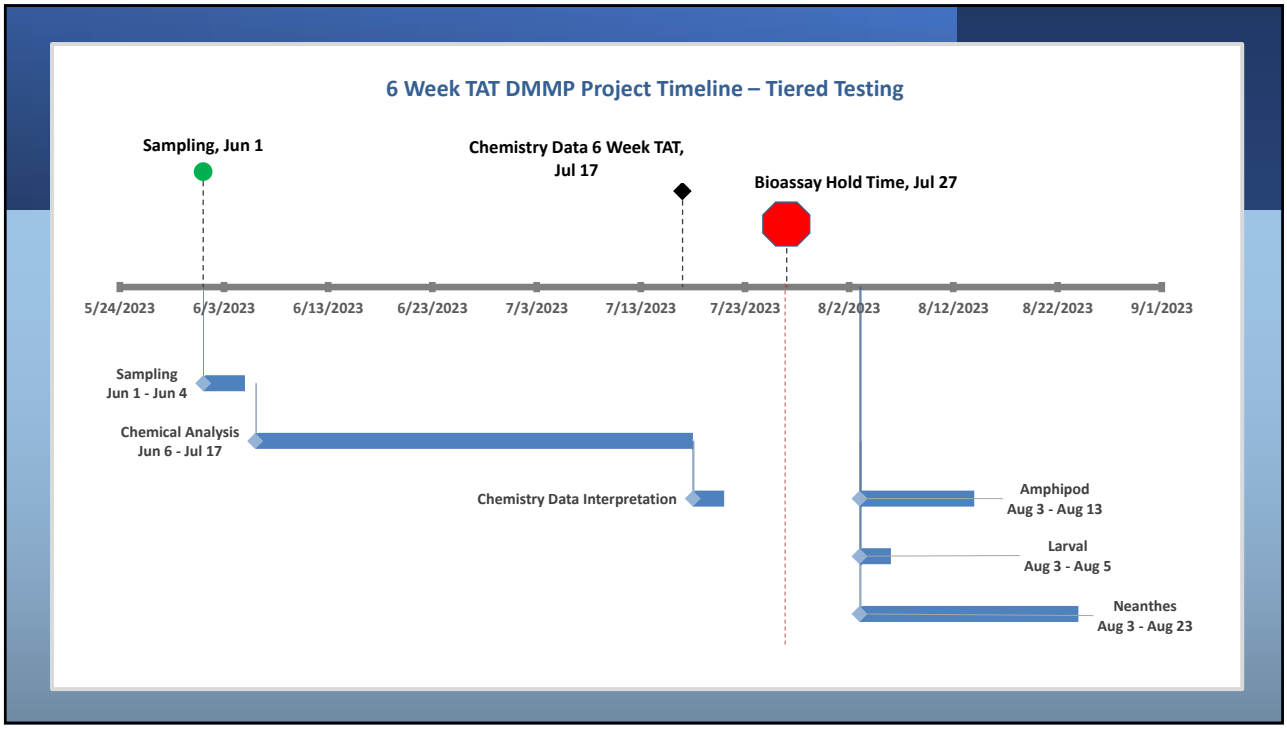
Chemistry Turn-Around-Times

30-day TAT standard DMMP request

6 – 8 weeks new normal

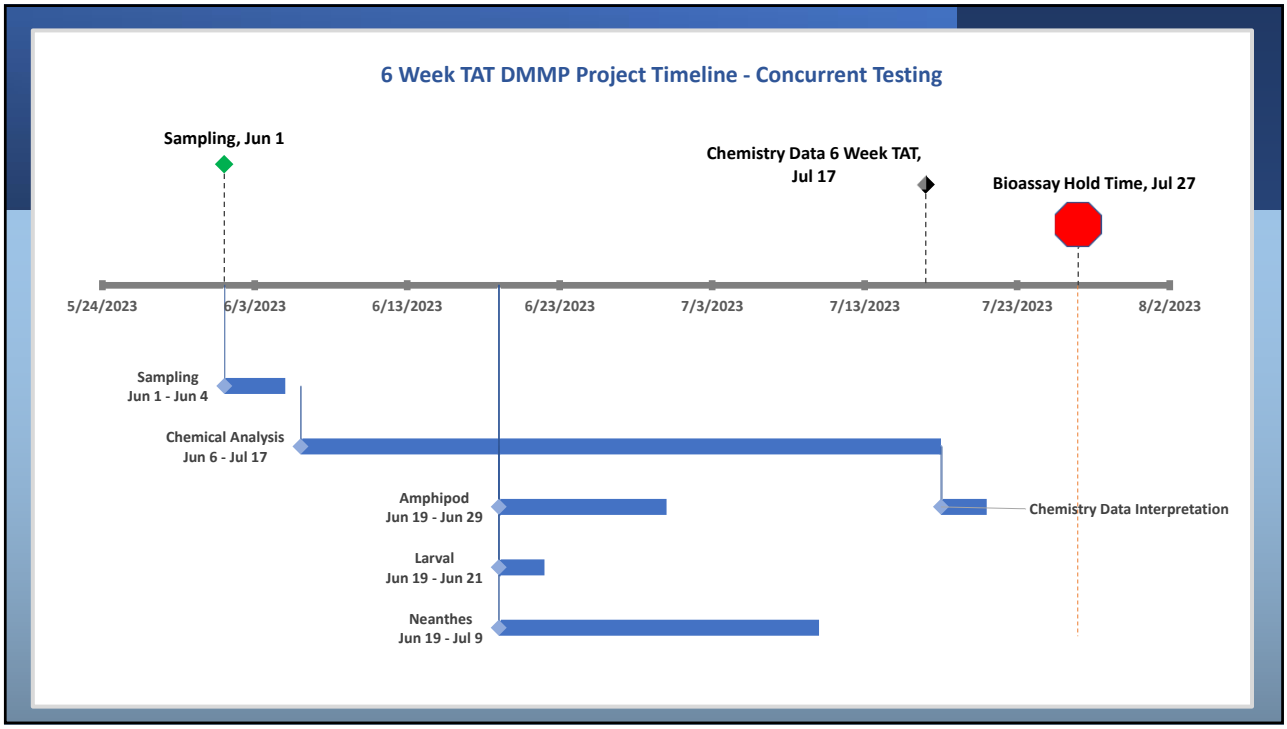
- Laboratory staffing issues
- Supplies and reagent shortages
- Tighter regulations
- Larger investigations
- Laboratories offering fewer services

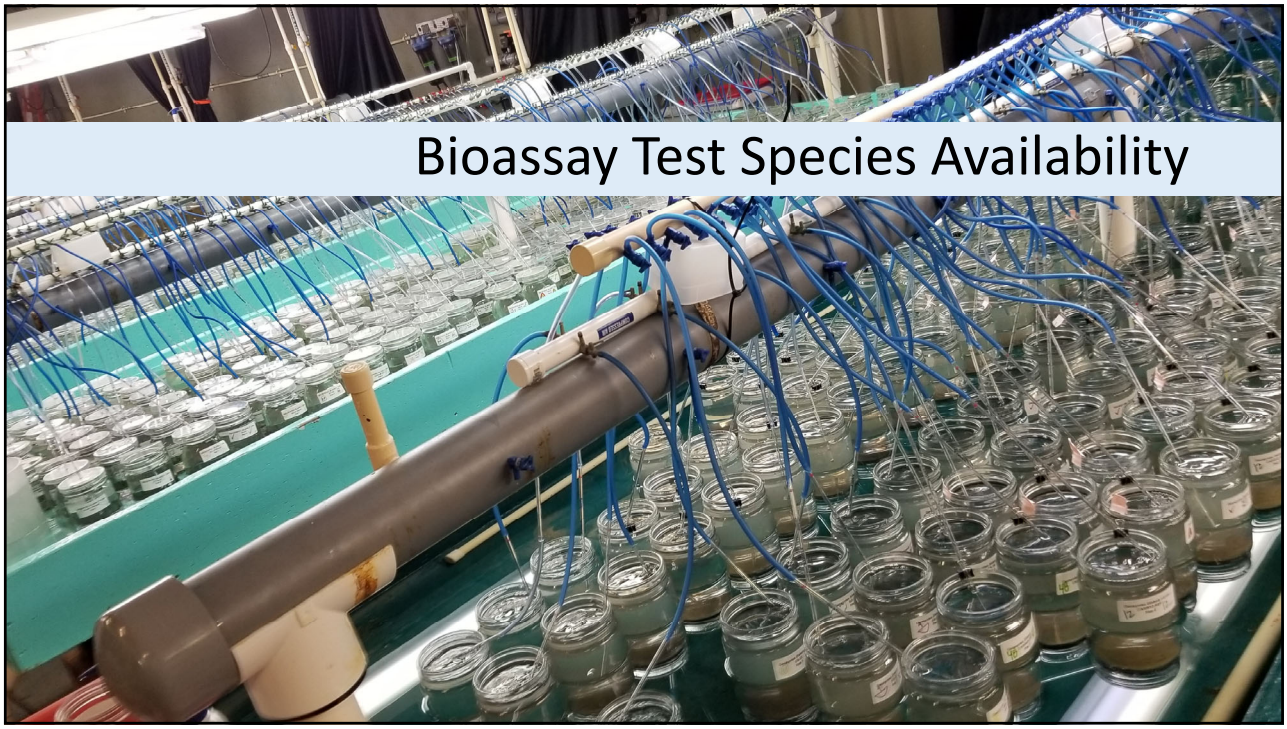

Bioassay Hold Times


6 Week TAT DMMP Project Timeline – Tiered Testing
Sampling, Jun 1
Chemistry Data 6 Week TAT, Jul 17
Bioassay Hold Time, Jul 27
5/24/2023
6/3/2023
6/13/2023
6/23/2023
7/3/2023
7/13/2023
7/23/2023
8/2/2023
8/12/2023
8/22/2023
9/1/2023
Sampling Jun 1 - Jun 4
Chemical Analysis Jun 6 - Jul 17
Chemistry Data Interpretation
Amphipod Aug 3 - Aug 13
Larval Aug 3 - Aug 5
Neanthes Aug 3 - Aug 23

Bioassay Hold Times Potential Solutions

- Concurrent Testing
  - Concurrent testing is the least time consuming and is likely the most economical when the need for biological testing is expected, because the need to collect (and re-analyze) additional sediment for bioassays is eliminated (DMMU 2021).
- Tiered Concurrent Testing
  - Use existing ranking to determine which sites are most appropriate for concurrent testing.
- Extended bioassay hold time
  - 56-day hold time starts the day first sample collected representing DMMU
- Other ideas?





Bioassay Test Species Availability

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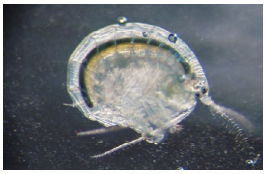
Bioassay Test Species Availability: Marine Amphipods

Eohaustorius estuarius:

- Recognized in PSEP, User Manual, SCUM, SEF
- If sample grain size < 60% fines (PSEP, SCUM) or < 20% clay (User Manual)
- Field collected
- Currently only 1 supplier
- Seasonality issues: smaller adults less available Feb-March



Ampelisca abdita:

- Recognized in PSEP, User Manual, SCUM, SEF
- If sample grain size > 60% fines (PSEP, SCUM) or > 20% clay (User Manual)
- Field collected
- Currently only 1 supplier
- Seasonality issues: not usable from April-July

Rhepoxynius abronius:

- Recognized in PSEP, User Manual, SCUM, SEF
- If sample grain size < 60% fines (PSEP, SCUM, User Manual)
- Field collected
- No suppliers
- Not a good alternate candidate

Proposed alternate amphipod

Leptocheirus plumulosus:

- Not recognized in PSEP, User Manual, or SCUM …but recognized in SEF, OTM, etc.
- Grain size prefs: ≥ 5% fines (ASTM)
- Cultured
- Multiple suppliers
- Seasonality issues: none

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Bioaccumulation Test Species Availability: Bivalves

Issue

- Primary test species - *Macoma nasuta*
- Field collected
- Only one supplier
- 2021 climate impact
- remains reduced today

Potential Solution

- Identify another bivalve species
- Bioaccumulation is based on exposure and species-specific factors
- Ideally an alternative species should
  - Feed similarly
  - Have similar lipid content
  - Accumulate compounds similarly
  - Occupy different habitat
- Opportunity to compare bioaccumulation

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Potential Alternatives

Varnish Clam (*Nuttallia obscurata*)

Positives
- Facultative feeder – like Macoma
- Occupies different part of intertidal zone
- Readily commercially available
- Non-native species

Negatives and Questions
- Has not (to our knowledge) been used for bioaccumulation testing
- Will it survive well enough during testing?
- Will it accumulate compounds similar to Macoma?

Littleneck (*Leukoma staminea*)

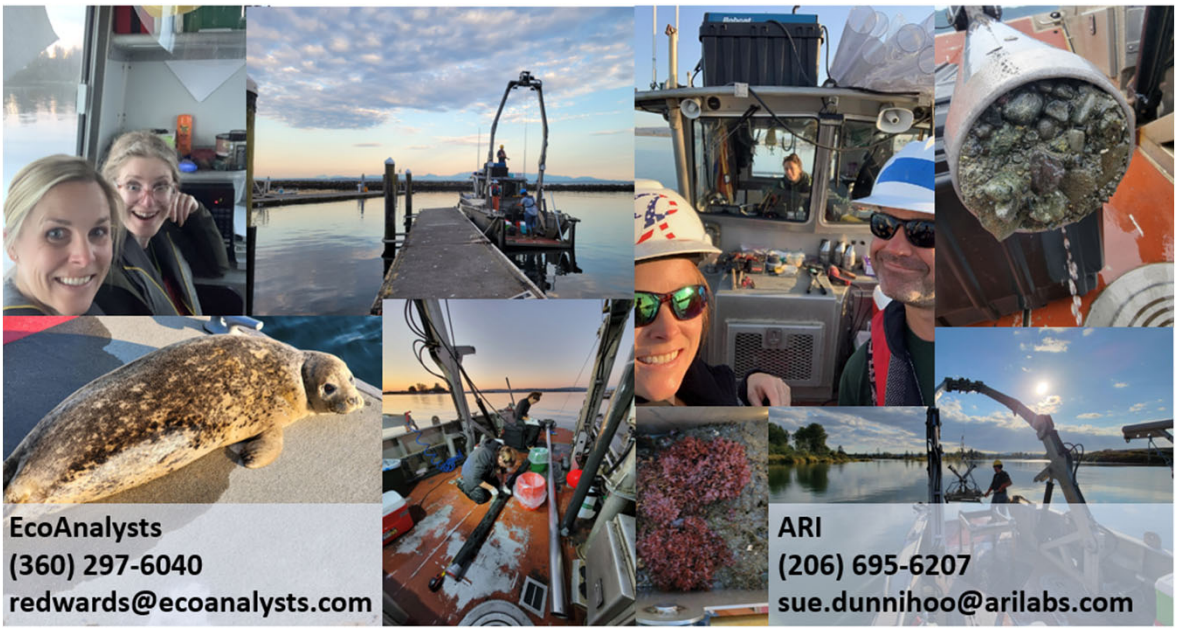
Positives
- Occupies different part of intertidal zone
- Readily commercially available
- Has been used in laboratory testing

Negatives and Questions
- Filter feeder? Is this a real negative
- Will it accumulate compounds similar to Macoma?

Photos taken from WDFW Website https://wdfw.wa.gov/species-habitats/species/

14

Thank you!



Bioaccumulation Test Species Availability: Bivalves

Regulatory Background

- USACE Seattle District User Manual - bioaccumulation species should be selected based on the assimilation rate of a specific compound.
- "the time to reach or approach steady-state varies among different compounds and, to a lesser extent, among species." USACE Inland Testing Manual
- Two marine clams were identified as "candidate test species" in the USACE Inland Testing Manual.
  - *Macoma nasuta*
  - *Yoldia limatula*
- USACE Inland testing manual recommends testing with at least one benchmark species
  - Marine benchmark species are *Macoma nasuta* (**bivalve**), *Neanthes Arenaceodentata* (**polychaete**), and *Alitta virens* (**polychaete**).
- USACE Seattle District User Manual identifies *Nephtys caecoides* as the primary polychaete species but also identifies *Alitta virens* as an alternative.

8. 2022 Shoalwater Bay Barrier Dune Repair: Incorporating Natural and Nature-Based Features to Reduce Flood/Erosion Risk While Maintaining Critical Shorebird Habitat

Dave Michalsen (USACE)

Summary

Dave summarized a project that was aimed at protecting a coastal area of Willapa Bay including the Shoalwater Bay Indian Tribe reservation from flooding and erosional processes. Initiated in the late nineties, the project involved the placement of dredge material on the barrier island. Additional restoration included development of a cobble beach as a wave energy dampener, a salt marsh acting as a buffer, and maintenance of the barrier island for storm protection. The project faced challenges such as ongoing erosion and endangered shorebird breeding areas. An emergency repair was declared in 2022, and funding of $40 million was secured in January 2023. Environmental considerations included protecting critical shorebird habitat and maintaining tidal flow through the slough. The project was completed successfully, showcasing the effectiveness of natural nature-based features and engineering with nature.

Discussion

Q: Justine Barton (EPA)- Has there been erosion on back side of the sand fencing?

A: Dave – The fencing has two purposes: Maintain elevations by keeping material in the dune system and protecting the wetland behind the fence by keeping material from burying it.

Q: Unknown. Was climate change considered?

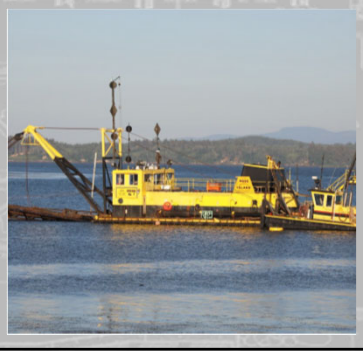
A: Dave – The natural interface solution used in this design was more adaptive to climate change. Dynamic revetment (vs rock revetment) moves material up the intertidal. With the design used USACE can make adjustments over time.

2022 SHOALWATER BAY BARRIER DUNE REPAIR:
INCORPORATING NATURAL AND NATURE-BASED FEATURES TO REDUCE FLOOD/EROSION RISK WHILE MAINTAINING CRITICAL SHOREBIRD HABITAT

David R. Michalsen, P.E.
Coastal Engineer
USACE, Seattle District
3 MAY 2023

SMARM 2023 - Annual Meeting

US Army Corps of Engineers



COASTAL STORM RISK MANAGEMENT

SHOALWATER BAY AT WILLIPA BAY, WASHINGTON

The Shoalwater Bay Shoreline Erosion, Washington, study was conducted in accordance with Section 545 of the Water Resources Development Act (WRDA) of 2000, and amended by Section 5153 of WRDA 2007.

Directed the Secretary of the Army to conduct a study to determine the feasibility of providing coastal erosion protection for the tribal reservation of the Shoalwater Bay Indian Tribe in the State of Washington. Section 545(b) provides that the Secretary shall construct and maintain a project at Federal expense if the Secretary determines that the project:

(a) **Is a cost-effective means of providing coastal erosion protection;**
(b) **Is environmentally acceptable and technically feasible; and**
(c) **Will improve the economic and social conditions of the Shoalwater Bay Indian Tribe.**

Barrier island erosion and rollover since 1984

Project Construction timeline

1. 2013: Initial breach closure and dune restoration - 709 KCY dredged material (DM)
2. 2018: Renourishment of dune (937 KCY DM)
3. 2022: Emergency dune repair (445 KCY DM) and dynamic revetment construction (192.8 KTONS)

NATURAL AND NATURE-BASED FEATURES (NNBF)

Table 1. Examples of NNBF relevant to coastal systems (USACE 2013).

NATURAL AND NATURE-BASED FEATURES AT A GLANCE				
				
Dunes and Beaches	Vegetated Features (e.g., Marshes)	Oyster and Coral Reefs	Barrier Islands	Maritime Forests/Shrub Communities
Benefits/Processes Breaking of offshore waves Attenuation of wave energy Slow inland water transfer	**Benefits/Processes** Breaking of offshore waves Attenuation of wave energy Slow inland water transfer Increased infiltration	**Benefits/Processes** Breaking of offshore waves Attenuation of wave energy Slow inland water transfer	**Benefits/Processes** Wave attenuation and/or dissipation Sediment stabilization	**Benefits/Processes** Wave attenuation and/or dissipation Shoreline erosion stabilization Soil retention
Performance Factors Berm height and width Beach slope Sediment grain size and supply Dune height, crest, and width Presence of vegetation	**Performance Factors** Marsh, wetland, or SAV elevation and continuity Vegetation type and density Spatial extent	**Performance Factors** Reef width, elevation, and roughness	**Performance Factors** Island elevation, length, and width Land cover Breach susceptibility Proximity to mainland shore	**Performance Factors** Vegetation height and density Forest dimension Sediment composition Platform elevation
General coastal risk reduction performance factors include: Storm surge and wave height/period, and water levels				

Shoalwater Bay Project

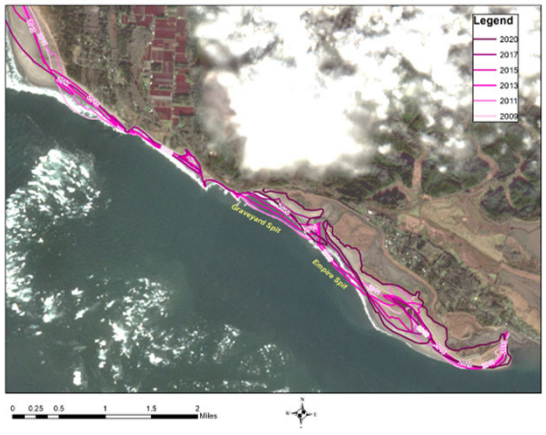
- ✓ Barrier island
- ✓ Dune and beach
- ✓ Salt marsh
- ✓ Dynamic revetment (cobble beach)

PROJECT BACKGROUND

Storm damage 2020/21

1. Northern 4,000 feet of beach dune eroded/breached during storms in Nov. 2020, Jan 2021
2. Emergency Action under PL 84-99 recommended in Project Information Report completed in Oct 2021
3. $40M in funding received for repair under DRSAA 2022 in Jan. 2022

Figure 5. Drone video still frame of wave overwash and formation of breaches through north section (at Sta. 25+00 looking toward Sta. 3+00)



2022 EMERGENCY REPAIR SCHEDULE

Contract Required Dates	Actual Dates Completed
Site Preparation: Occurs after post award and after environmental compliance clearance	16 May 2022 – Contract Award 01 June 2022 – Wetlands Delineation & Avian Monitoring Start
The contractor cannot construct the temporary causeway (with proposed culverts) across Cannery Slough until 01 June 2022	06 June 2022 - Temporary Road Construction Starts 12 July 2022 – Slough Crossing/Culvert Starts
Dredging will be completed between 16 July 2022 through 01 October 2022	17 July 2022 – Dredging Starts 30 October 2022 – Dredging Completed
Cobble transport, staging, placement can occur after culvert construction is completed and culvert construction can commence between 01 June 2022 and 28 January 2023, per environmental compliance requirements	05 August 2023 – Culverts Construction Completed 08 August 2022 – Temporary Road Completed 23 August 2022 – Revetment Construction Starts
Construction Completed by 28 January 2023	10 November 2022 – Construction Completed
Site Restoration Completed by 28 February 2023	22 December 2022 – Site Restoration Completed
Draft final report, As-Builts by 28 March 2023	23 December 2022 – In-Progress Draft Report Submitted 15 March 2023 – Draft Report Submitted

ECC Environmental LLC
1240 Bay Shore Hwy STE 317
Burlingame, CA 94010-1805

Ross Island Sand & Gravel Co.
4315 SE McLoughlin Blvd STE 2
Portland, OR 97202

Rognlin's Inc.
321 West State Street
Aberdeen, WA 98520

Jacobs
Challenging today. Reinventing tomorrow.
1100 112th Avenue NE, STE 500
Bellevue, WA 98004

Contract Awarded 16 May 2022 under USACE Omaha Districts Rapid Infrastructure MATOC.

1. ECC Environmental, LLC - Prime Contractor
2. Ross Island Sand & Gravel – Dredging and dune grading
3. Rognlins Construction – Haul road construction, slough crossing, and dynamic revetment construction, sand fence installation
4. Jacobs – Avian Monitoring and Wetland Delineation

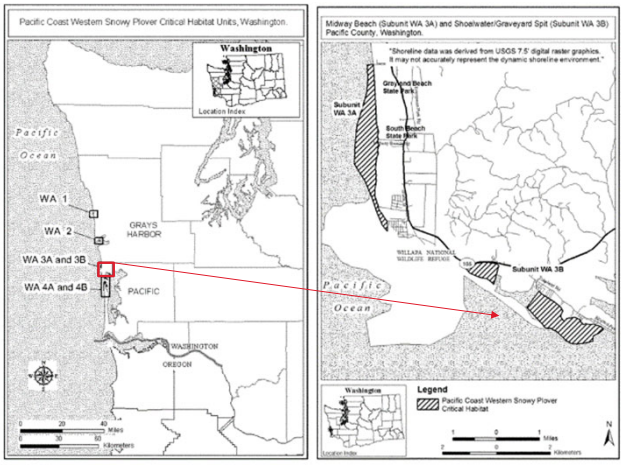
ENVIRONMENTAL CONSIDERATIONS

1. **Minimizing impacts to ESA-threatened species - critical shorebird habitat (W. Snowy Plover; Streaked horn lark)**
   a. Dedicated avian monitoring team to ensure nests were avoided during construction, escorts required for all construction staff during nesting window between March – August
   b. May-June adjusted haul road configuration on Graveyard Spit to avoid nests
   c. temporary shutdown of dredging in August 2022 on Empire Spit for nests to hatch and migrate out of construction region

2. **Protection and Avoidance of Class I coastal wetlands (tidal salt marsh)**
   a. Detailed wetland delineation on Graveyard and Empire Spit
   b. Nimble adjustments to design dune footprint to avoid wetlands
   c. Installation of sand fencing on backside of dune to control aeolian transport

3. **Maintaining tidal slough crossing for fish passage during construction**
   a. Installation of 9 – 144” corrugated metal pipe (CMP) culverts to pass full tidal prism of backside embayment

WESTERN SNOWY PLOVER USAGE IN WA STATE



Federal Register, Vol. 77, No. 118, June 2012

Table 1. Mean counts[a] (range) of breeding adults at nesting areas in Washington, 2008-2020 (Pearson and others 2019; Ritchie and others 2020; Sundstrom and others 2021).

Year	Midway	Graveyard	Leadbetter Pt.	Long Beach	Ocean Shores/ City	Connor Crk	Copalis Spit	Total
2008	14 (10–19)	1 (0–2)	32 (23–40)	ns[a]	ns	ns	ns	47 (33–60)
2009	15 (13–17)	0	17 (10–24)	ns	ns	ns	ns	31 (23–39)
2010	14 (11–18)	0	21 (17–26)	ns	ns	ns	ns	36 (33–38)
2011	19 (8–30)	0	12 (6–19)	ns	ns	ns	ns	31 (15–47)
2012	14 (5–23)	2 (0–3)	18 (6–29)	ns	ns	ns	ns	33 (15–52)
2013	20 (16–24)	4 (1–6)	20 (19–20)	ns	ns	ns	ns	43 (41–45)
2014	11(9–13)	7 (6–8)	24 (21–28)	ns	ns	ns	ns	41(40–43)
2015	24 (19–33)	8 (3–11)	43 (34–54)	ns	ns	ns	ns	77 (65-98)
2016	37 (33–40)	21 (18–25)	33 (25–32)	2 (0–2)	0	0	1	93 (85–103)
2017	36 (35–36)	21 (18–24)	21 (14–32)	13 (0–13)	0	0	0	78 (70–86)
2018	31 (23–40)	35 (28–42)	21 (13–29)	1 (0–1)	1 (0-3)	1(1–2)	0	87 (80–91)
2019	33 (28–39)	31 (30–32)	16 (7–21)	11 (7–19)	1	0	0	93 (78–100)[b]
2020	33 (29–37)	33 (30–35)	ns	ns	2	4(3–4)	4(2–6)	65 (47–76)[c]
2021	33 (29–36)	43 (35–49)	14 (12–17)	1 (0–4)	ns	2(2-3)	6(5-7)	100

[a]Breeding window protocol with ~3 replicates; ns= no survey.
[b]Includes 1 bird at Ocean Shores, and 1 bird on Gunpowder Sands Island, north of Leadbetter.
[c] Reduced survey effort due to COVID restrictions.

Stinson (2022). https://wdfw.wa.gov/publications/02320

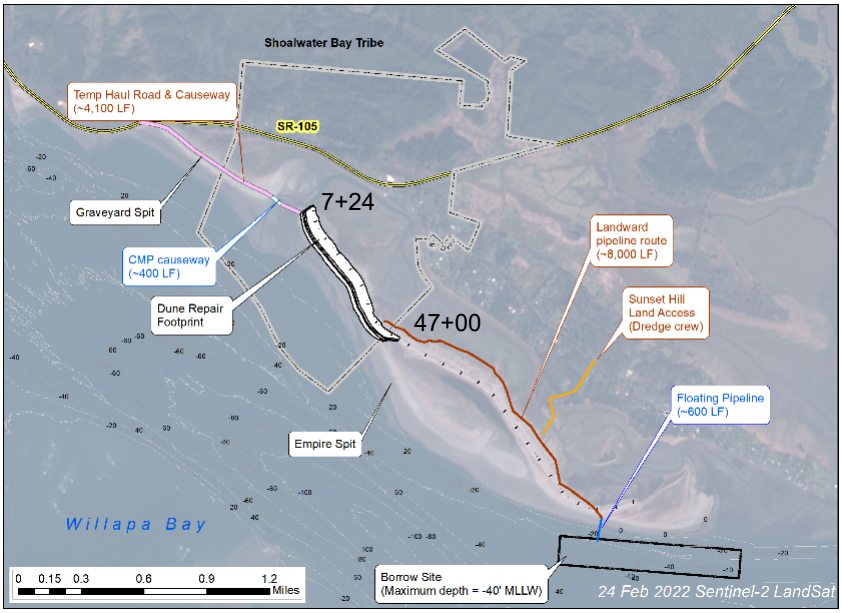
WETLAND DELINEATION & W. SNOWY PLOVER NESTS

1. Nest 26 & 29 delayed dredging and construction of 2nd settling basin from 27 July – 8 Aug (paid standby time)

2. Wetland delineation required design changes to dune footprint in 3 locations

3.Monitoring/Reseeding wetland areas impacted by pipeline operations – March 2023

ACCESS AND CONSTRUCTION AREA



Graveyard Spit:
Temporary haul road
Material staging areas (2)

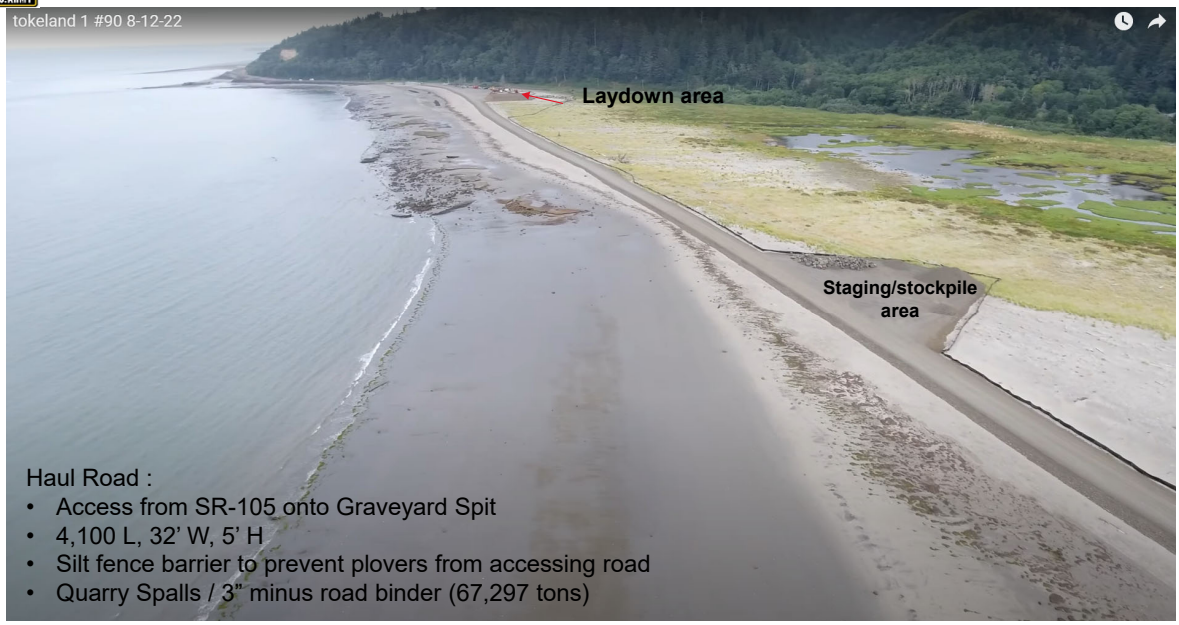
Cannery Slough:
Temporary fill causeway with nine - 144” arched CMP culverts and slope protection

Empire Spit:
Dune repair and dynamic revetment construction area

Borrow Site:
Hydraulically dredge 455,000 CY and pump ashore sand for dune fill

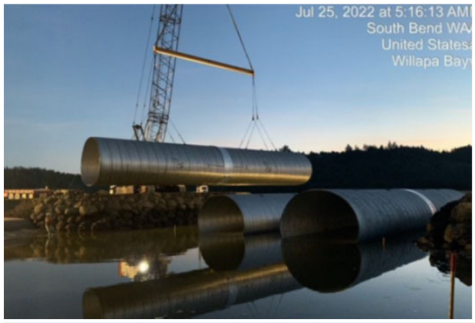
Sunset Hill Access:
Dredge crew changes and pipeline mob/demob

GRAVEYARD SPIT HAUL ROAD & STAGING AREAS



Haul Road :
- Access from SR-105 onto Graveyard Spit
- 4,100 L, 32’ W, 5’ H
- Silt fence barrier to prevent plovers from accessing road
- Quarry Spalls / 3” minus road binder (67,297 tons)

CANNERY SLOUGH TEMP. CAUSEWAY – JUL 2022



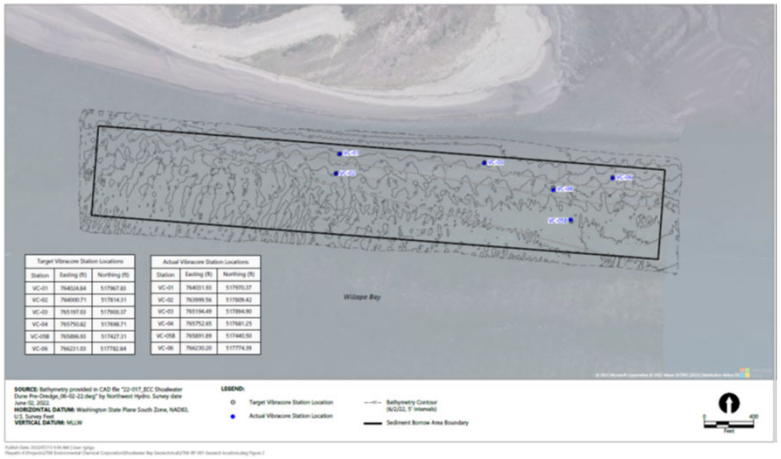
- Installation of nine – 144” Corrugated metal pipes with crane
- 3 rip rap columns to support CMPs in a trench
- Backfill trench around CMPs with 1.5” minus ballast rock using conveyor / tremie sock
- Turbidity curtains used on upstream / downstream side during construction

CANNERY SLOUGH TEMP. CAUSEWAY – JUL 2022

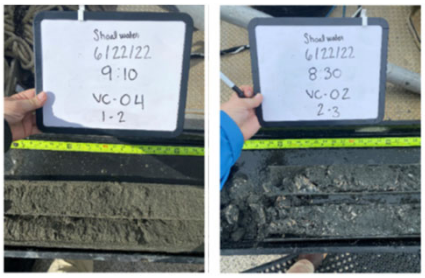
CMPs conveying full tidal prism from backshore embayment

OFFSHORE BORROW SITE CHARACTERIZATION

13



>95% sand/gravel at dredge locations
Areas with large amounts of shell.
Bulk density (91 – 106 lb/ft^3)

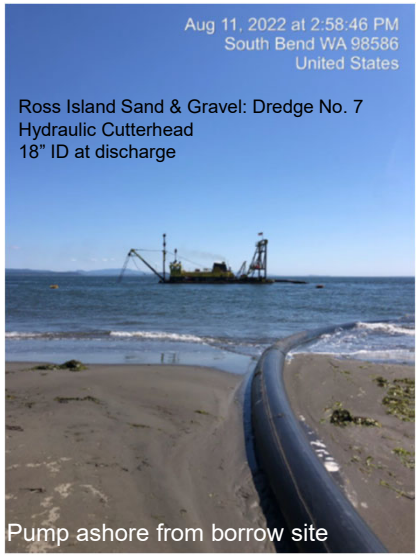


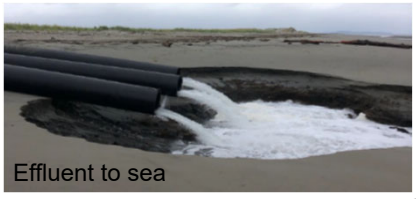
- Grain size (ASTM D422)
- Moisture content (ASTM D2216)
- Bulk Density

Suitability determination completed 14-July 2022: Tier 1 status

OFFSHORE BORROW SITE AND PUMP-ASHORE

14

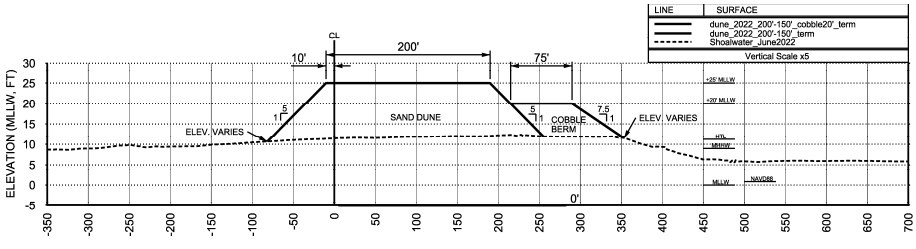




OFFSHORE BORROW SITE AND PUMP-ASHORE

- Dredging: 17 July – 30 Oct 2022
- Constructed 4 separate settling basins ~1000’ in length
- Perimeter dikes built with dozers to facilitate settling of solids
- Effluent released from upper water column – No turbidity exceedances during operations
- Production rates: highly variable based on shell presence and equipment repair downtime:
  - AVG over job: 5,511 CY/day

DUNE CONSTRUCTION

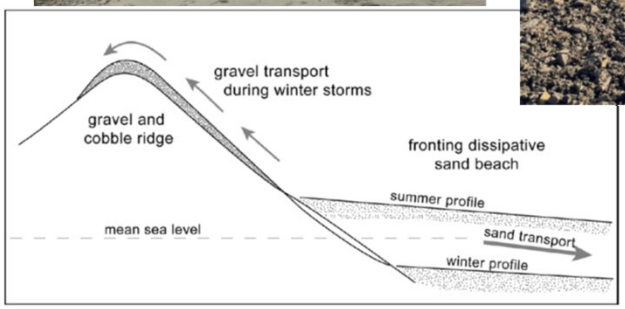


STA. 7+24 TO 35+00

- Total volume: 444,958 CY
- Dune crest ht: +25’ MLLW
- Dune crest width: 150-200’
- Dune side slopes: 1V:5H

- Sand fencing: Spaced 25’ along landward dune sideslope from Sta. 7+00 to 37+00

DYNAMIC REVETMENT CONSTRUCTION

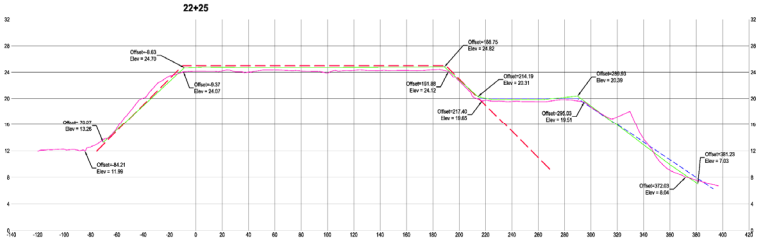


- 192,800 tons of 8” minus angular sized cobble
- 6,173 truck loads from 23 Aug – 10 Nov (56 d)

SITE RESTORATION – GRAVEYARD SPIT

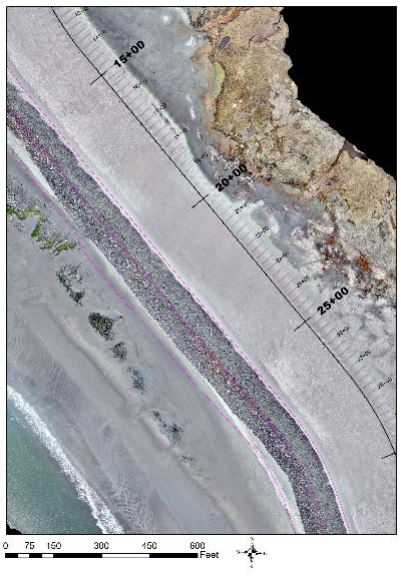
SITE RESTORATION – CANNERY SLOUGH

PERFORMANCE IN WINTER 2022/2023



1. Dynamic revetment performed very well. Formed a secondary berm during the winter months
2. Dynamic revetment recruited large woody debris
3. Sand buried dynamic revetment in areas (e.g. northern terminus)
4. Sand fencing reduced wind-blown sand transport on landside (salt marsh area)

Shoalwater Bay Dune - March 30, 2023 photogrammetric survey



SUMMARY AND CONCLUSIONS

1. Successfully executed Emergency Repair under a compressed schedule (<8 mo. from award to completion)
2. Project Presented a complex set of constraints:
   - Access (Real Estate),
   - Environmental (ESA- shorebirds),
   - Arranging equipment and materials (hydraulic dredge, procuring/delivering large amounts of quarry material, CMPs)

3. Highly functional Project Delivery Team (PDT),
   - Leveraged strengths of USACE, Omaha District Rapid Response Center of Expertise with key technical staff at Seattle District (Real estate, environmental, cultural resources, engineering)
   - Prime contractor subcontracted with local Construction Team, provided knowledge, logistical, and cost advantages

4. Delivered level of protection to Shoalwater Bay Tribe prior to Winter 2022/2023 Storm Season.
5. Successful example of incorporation of Engineering With Nature, using Natural and Nature Based features

9. DMMP Highlights for Dredging Year 2023

Lauran Warner and Kelsey van der Elst (USACE); Laura Inouye (Ecology)

Summary

Lauran Warner, USACE: Around a million cubic yards of dredged material were characterized for suitability determinations, primarily from the Snohomish River. Only one project encountered unsuitable material. Despite difficulties in core sampling, progress was made across various ongoing projects.

Kelsey van der Elst, USACE, reviewed the sampling and characterization details of a project in the Lake Washington Ship Canal, just downstream of the Hiram M. Chittenden Locks in Seattle. Challenges encountered included difficulty collecting representative samples, long delays in receiving analytical results, and the need for additional characterization of the project, especially with respect to antidegradation.

Laura Inouye, Ecology: There have been numerous instances of over-dredging, which can lead to minor or even significant consequences. A list has been maintained since 2008, revealing a significant number of over-dredging events, some occurring in contaminated areas. The repercussions varied based on factors such as contamination presence, material disposal location, anti-degradation concerns, and the severity of the over-dredging. Responses from agencies included fines imposed by the Department of Natural Resources (DNR) and requirements for bathymetric surveys or evaluations of potential problems caused by exposed materials. In some cases, post-dredge sampling or monitoring of disposal sites was necessary. To prevent over-dredging, careful consideration of allowances and characterization during the permitting process is crucial. Communication with contractors is essential, especially when precision is required. Attention to calibration and backup methods, as well as caution regarding nighttime shifts, is advised. Immediate investigation and communication with the DMMP agencies must occur if over-dredging is suspected to ensure efficient resolution.

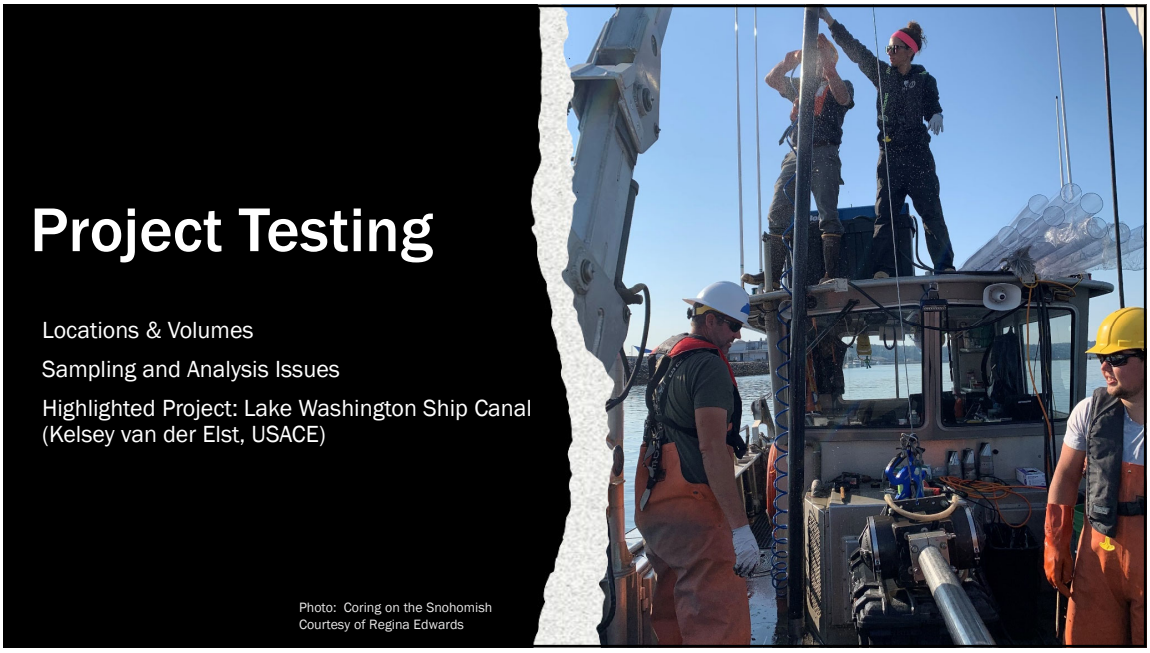
Additional program updates included:

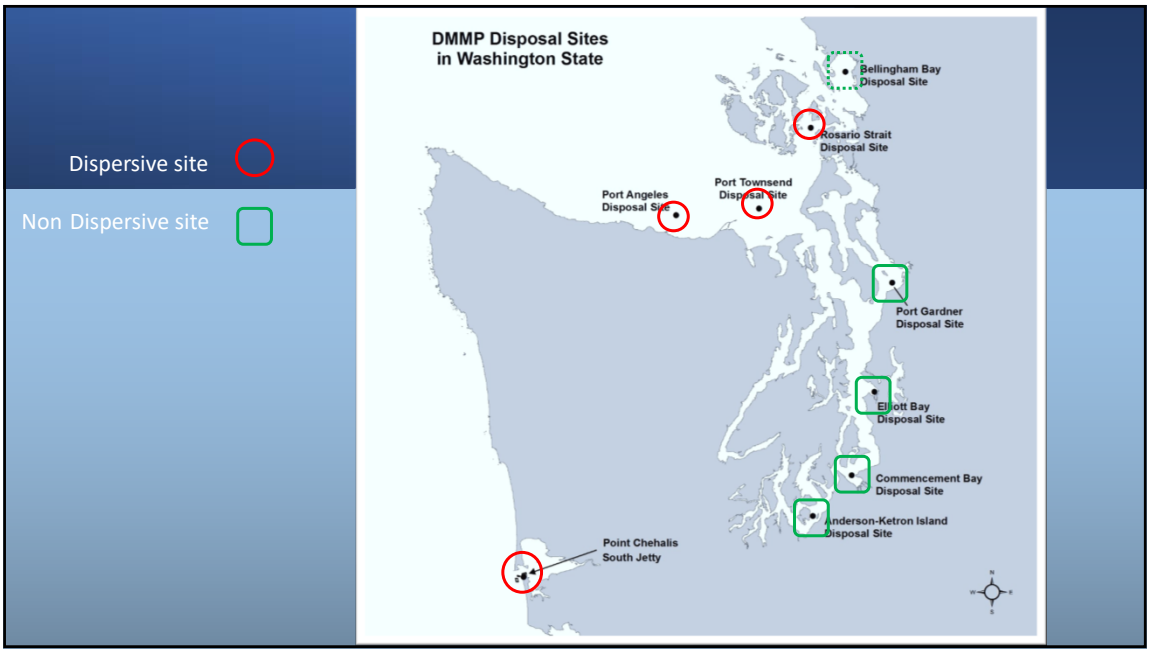
- The Puget Sound Sediment Reference Material (PS-SRM) samples have been relocated to the EPA Manchester lab. Reminder that when the PS-SRM is used to please submit the data and reference the bottle number.
- Environmental Information Monitoring (EIM) Database: Updates have been made to the spreadsheets related to PCB congener results. Use the updated template as of June 28, 2023
- Lab accreditation: Due to long lab turn-around-times, DMMP now accepting data from labs accredited through authorized bodies other than WDOE, such as under the National Environmental Laboratory Accreditation Program (NELAP).

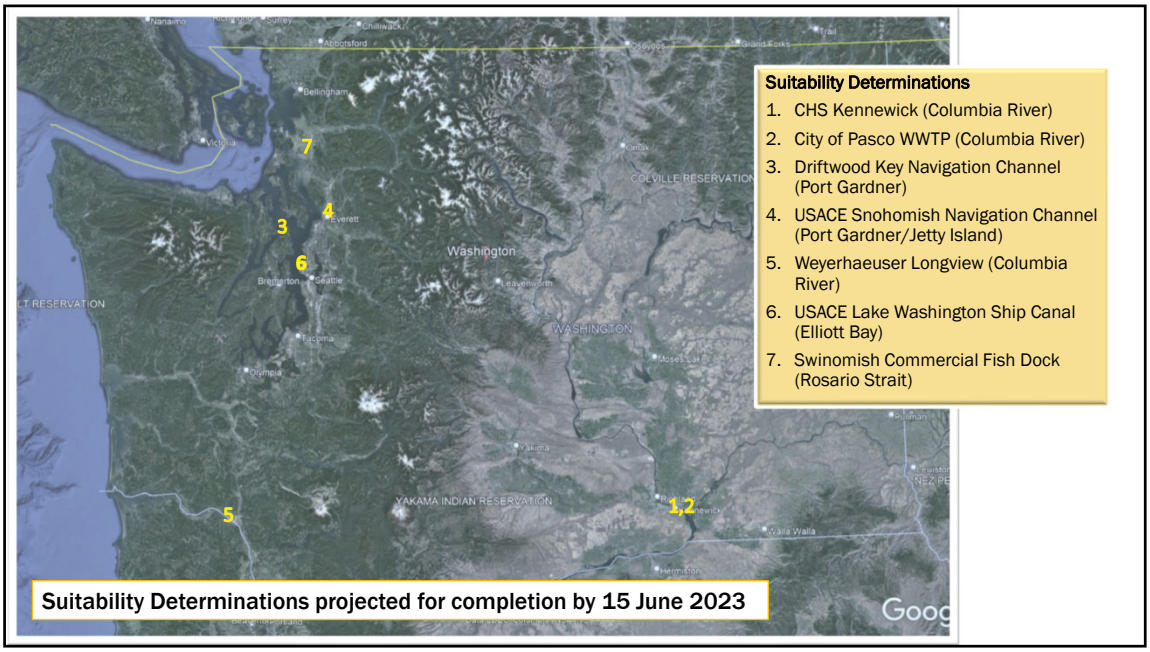
Discussion

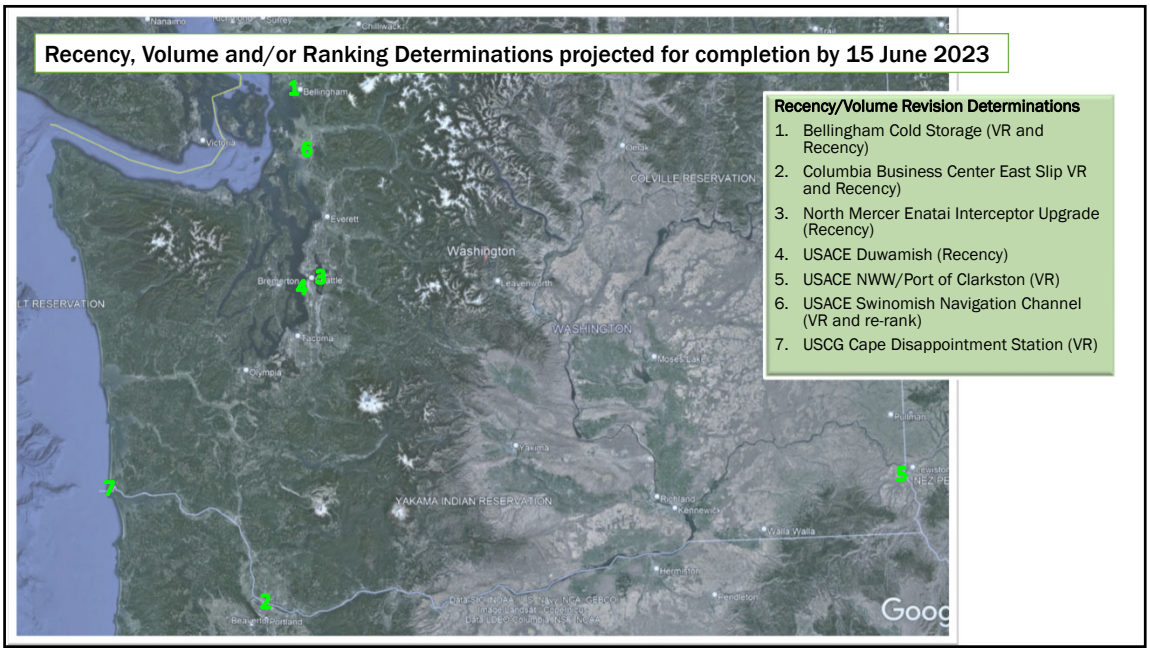
No questions

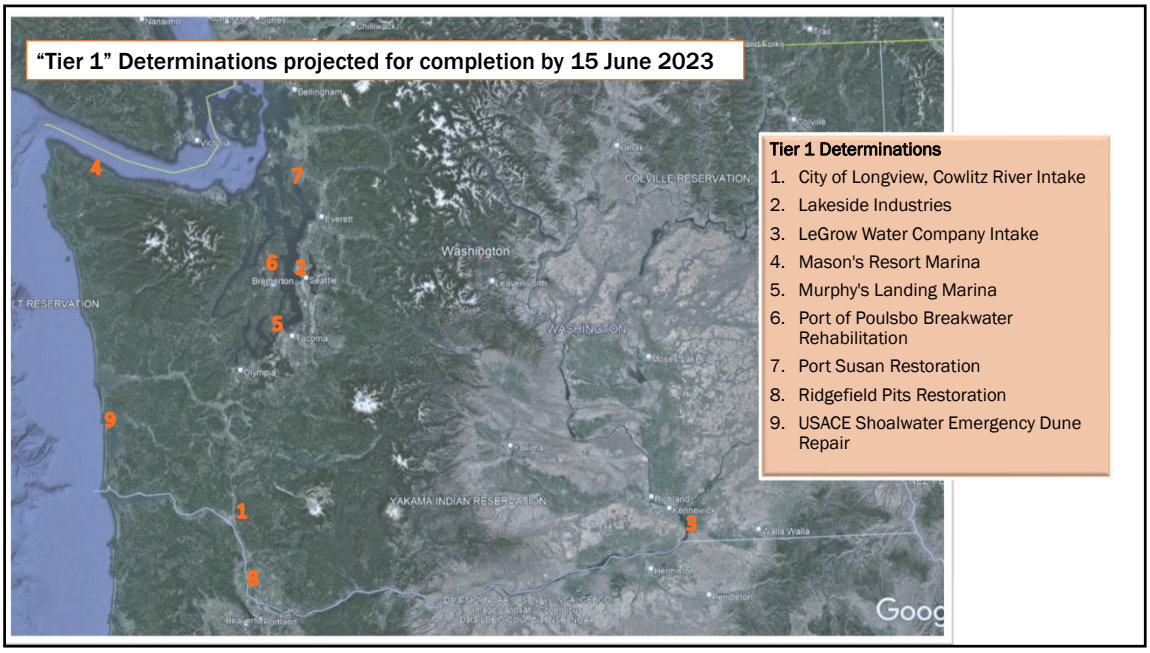

US Army Corps of Engineers
Seattle District
DEPARTMENT OF ECOLOGY
State of Washington
EPA
United States Environmental Protection Agency
WASHINGTON STATE DEPT OF NATURAL RESOURCES
Lauran Warner
U.S. Army Corps of Engineers
SMARM May 3, 2023
Dredging Year 2023
June 16, 2022 – June 15, 2023
DMMP Year in Review

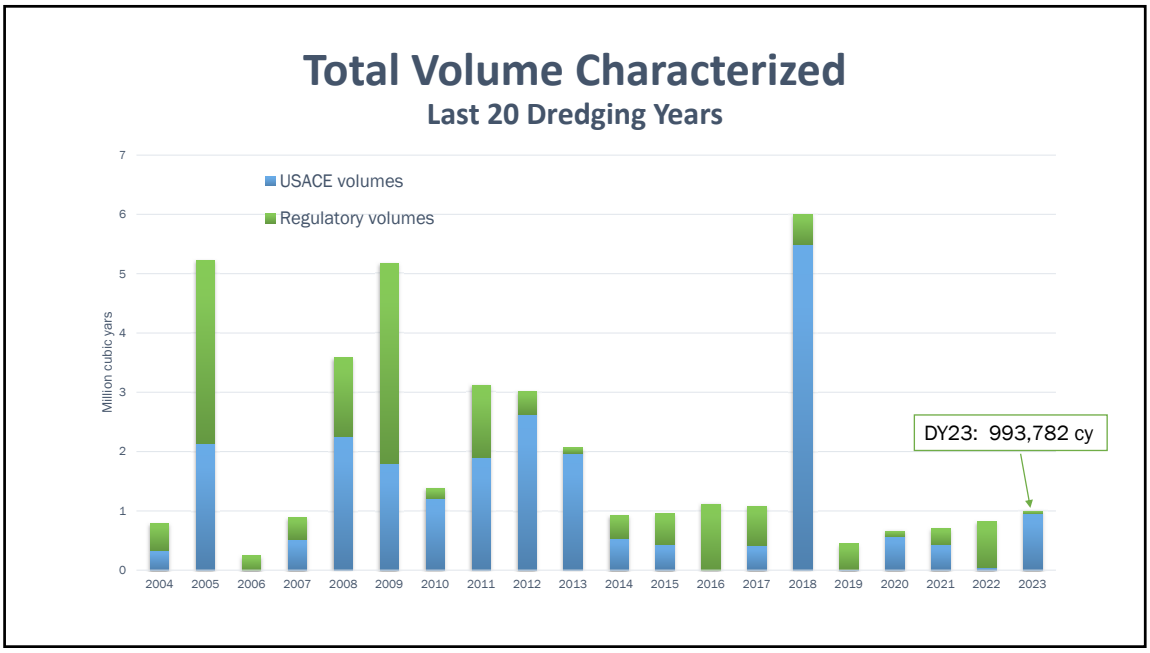

Project Testing
Locations & Volumes
Sampling and Analysis Issues
Highlighted Project: Lake Washington Ship Canal
(Kelsey van der Elst, USACE)
Photo: Coring on the Snohomish
Courtesy of Regina Edwards

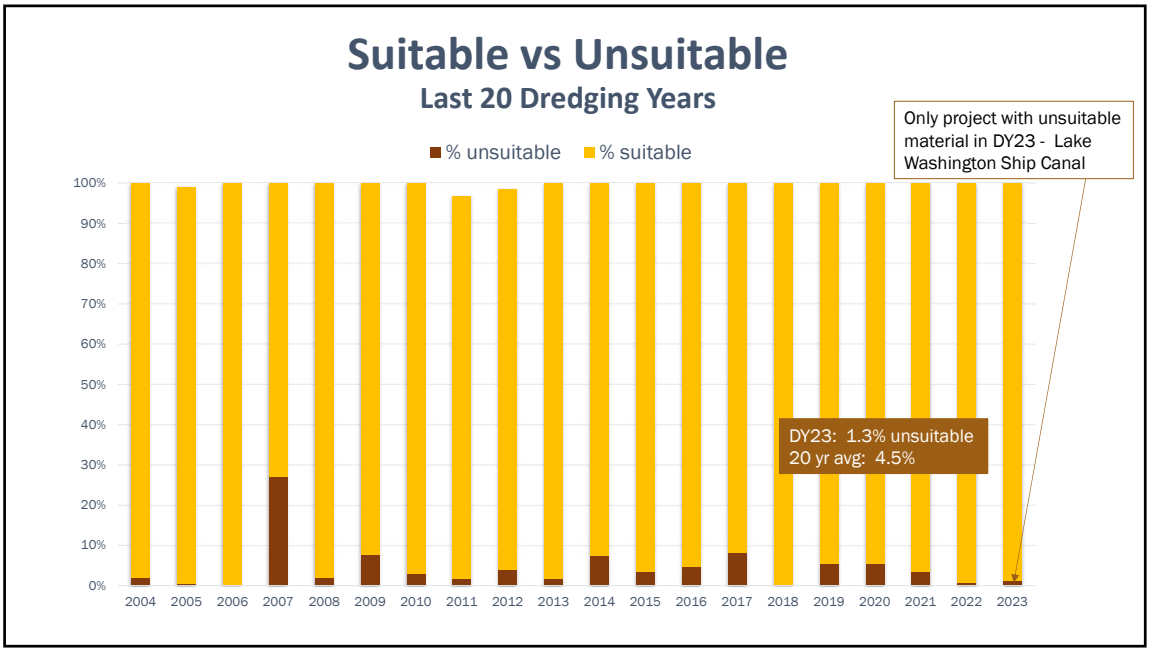

Dispersive site
Non Dispersive site
DMMP Disposal Sites
in Washington State
Bellingham Bay
Disposal Site
Rosario Strait
Disposal Site
Port Angeles
Disposal Site
Port Townsend
Disposal Site
Port Gardner
Disposal Site
Elliott Bay
Disposal Site
Commencement Bay
Disposal Site
Anderson-Ketron Island
Disposal Site
Point Chehalis
South Jetty


Suitability Determinations
1. CHS Kennewick (Columbia River)
2. City of Pasco WWTP (Columbia River)
3. Driftwood Key Navigation Channel (Port Gardner)
4. USACE Snohomish Navigation Channel (Port Gardner/Jetty Island)
5. Weyerhaeuser Longview (Columbia River)
6. USACE Lake Washington Ship Canal (Elliott Bay)
7. Swinomish Commercial Fish Dock (Rosario Strait)
Suitability Determinations projected for completion by 15 June 2023


Recency, Volume and/or Ranking Determinations projected for completion by 15 June 2023
Recency/Volume Revision Determinations
1. Bellingham Cold Storage (VR and Recency)
2. Columbia Business Center East Slip VR and Recency)
3. North Mercer Enatai Interceptor Upgrade (Recency)
4. USACE Duwamish (Recency)
5. USACE NWW/Port of Clarkston (VR)
6. USACE Swinomish Navigation Channel (VR and re-rank)
7. USCG Cape Disappointment Station (VR)
Washington
WASHINGTON
COLVILLE RESERVATION
YAKAMA INDIAN RESERVATION


"Tier 1" Determinations projected for completion by 15 June 2023
Tier 1 Determinations
1. City of Longview, Cowlitz River Intake
2. Lakeside Industries
3. LeGrow Water Company Intake
4. Mason's Resort Marina
5. Murphy's Landing Marina
6. Port of Poulsbo Breakwater Rehabilitation
7. Port Susan Restoration
8. Ridgefield Pits Restoration
9. USACE Shoalwater Emergency Dune Repair
Washington
WASHINGTON
COLVILLE RESERVATION
YAKAMA INDIAN RESERVATION


Total Volume Characterized
Last 20 Dredging Years
USACE volumes
Regulatory volumes
Million cubic yars
0
1
2
3
4
5
6
7
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
DY23: 993,782 cy


Suitable vs Unsuitable
Last 20 Dredging Years
% unsuitable
% suitable
Only project with unsuitable material in DY23 - Lake Washington Ship Canal
DY23: 1.3% unsuitable
20 yr avg: 4.5%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023

Ongoing and Proposed Characterizations (*proposed disposal site for suitable material*)

Permitted Projects

- TOTE Maritime (*Commencement Bay*)
- Vancouver Boat Launch (*Columbia River Flowlane*)
- Nippon Dynawave (*Columbia River Flowlane*)
- Sandy Hook Marina (*Port Gardner*)
- Anchor Cove Marina (*Rosario Strait*)
- Meydenbauer Bay Yacht Club (*Elliott Bay*)
- Port of Tacoma, PCT (*Commencement Bay*)
- Duwamish Yacht Club (*Elliott Bay*)
- Camas Slough (*Columbia River Flowlane*)
- Port of Bellingham Squalicum Harbor (*Rosario Strait*)

Federal Projects

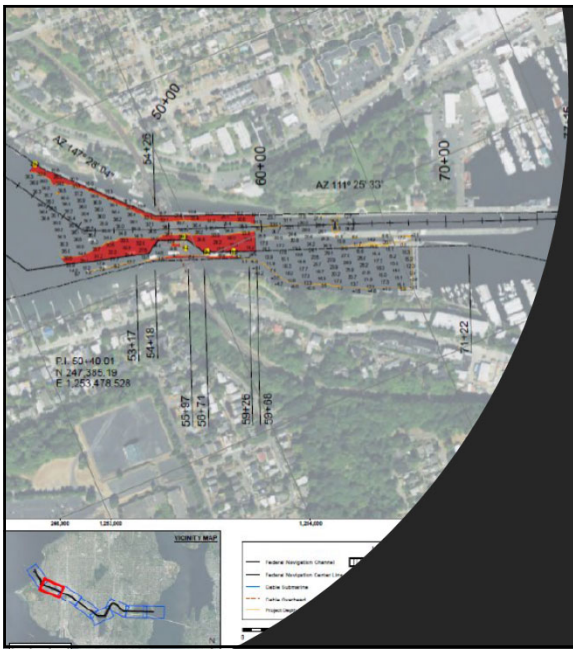
- USACE Duwamish (*Elliott Bay*)
- USACE Quillayute (*local BU*)
- USACE Swinomish Channel (*Rosario Strait*)
- USACE Grays Harbor (*Pt Chehalis and South Jetty Dispersive sites; Half Moon Bay and South Beach BU*)
- US Navy PSNS (*Elliott Bay*)

Characterization issues

Vibracores: poor penetration and recovery

Laboratory Turn-Around-Times

Biological Test Species Availability



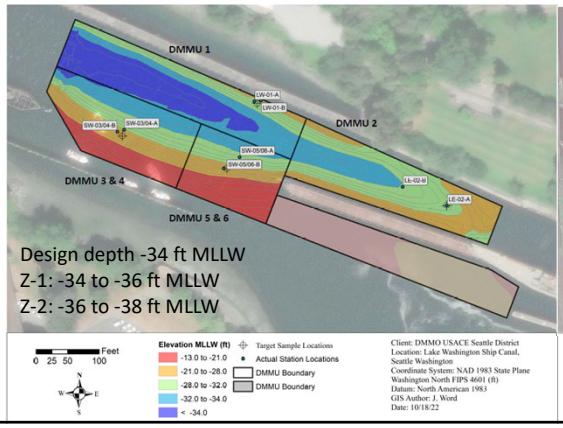
Lake Washington Ship Canal USACE Federal Navigation Channel

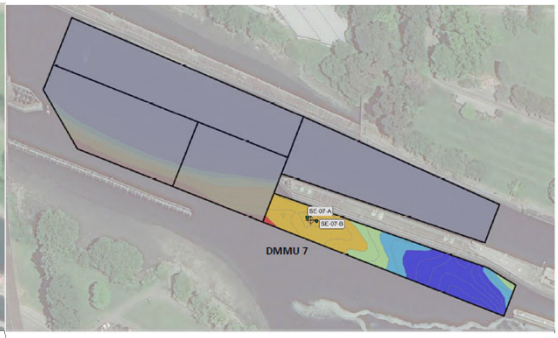
2022 Sediment Characterization

Project Details

August 1-3, 2022

- Vibracore, 2 cores per DMMU
- Heavy vessel traffic due to preparation for Seafair
- Difficulty with penetration and percent recovery





Design depth -20 ft MLLW
Z-1: -20 to -22 ft MLLW
Z-2: -22 to -24 ft MLLW

Sampling and Analysis Summary

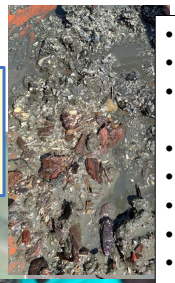
DMMU 1:
83/64% recovery
Shell hash, wood debris, sulfide odor at top

DMMU 2:
62/52% recovery
Shell hash, sand, sulfide odor at depth, refusal on wood debris
Z-sample from one core only: 0-0.1 ft

DMMU 3/4:
78/78% recovery
Silty sand with shells, organic, sulfide odor throughout
Z-sample from one core only: 0-1.5 ft.

DMMU 5/6:
80/69% recovery
Sandy shell hash at top. Wood debris, sulfide and petroleum odor at bottom of 05/06-b
Z-sample from one core only: 0-0.5 ft

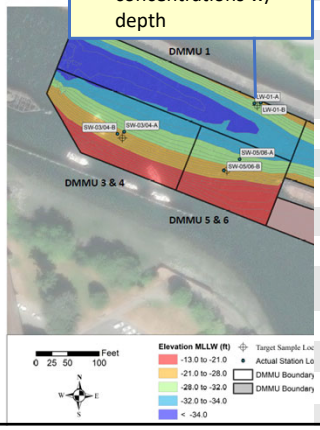
DMMU 7:
41/59% recovery
Shell & sand, sulfide odor and wood debris at bottom
Z-sample from one core only: 0-0.7 ft



- Shell hash and sulfide odor throughout
- Wood debris throughout
- Petroleum odor at bottom of core 05/06-b
- Challenges meeting % recovery
- Incomplete z-sample collection
- No second z-sample collected
- Representativeness unclear
- Analytical results delayed
- Bioassays analyzed on all 7 DMMUs
- Majority of data J-flagged due to holding time exceedances

Characterization Results

DMMU 1:
- Bioassays triggered
- Increasing concentrations w/ depth



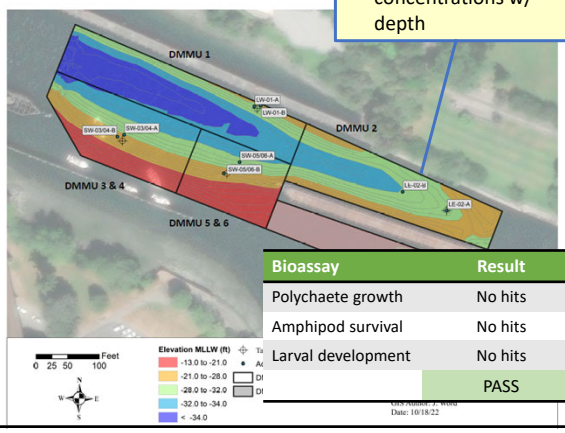
Summary of exceedances

Parameter	DMMU 1	Z sample (DMMP)	Z sample (SMS)
Acenapthene			SCO
Fluorene			SCO
Fluoranthene	SL	SL	SCO
Pyrene	SL	SL	
Benz(a)anthracene		SL	SCO
Chrysene	SL	SL	SCO
Dibenz(a,h)anthracene			SCO
Total Benzofluoranthenes		SL	SCO
Benzo(a)pyrene		SL	SCO
Ideno(1,2,3-c-d)pyrene	SL	SL	SCO
Total HPAHs	SL 16,800 ug/kg	SL 23,140 ug/kg	SCO
Dibenzofuran			SCO
Dieldrin	SL		
Total PCBs	SL		
Total Chlordane	SL/U	SL/U	

Bioassay	Result
Amphipod survival	No hits
Larval development	No hits
	PASS

Characterization Result

DMMU 2:
- Bioassays triggered
- Increasing concentrations w/ depth

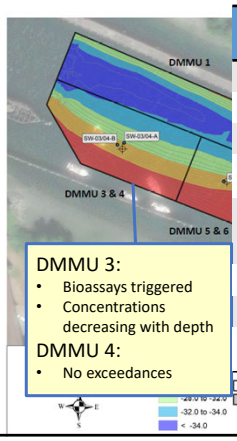


Bioassay	Result
Polychaete growth	No hits
Amphipod survival	No hits
Larval development	No hits
	PASS

Summary of exceedances

Parameter	DMMU 2	Z sample (DMMP)	Z sample (SMS)
Phenanthrene		SL	SCO
Fluoranthene	SL	**BT**	SCO
Pyrene		SL	
Benz(a)anthracene		SL	SCO
Chrysene		SL	SCO
Total Benzofluoranthenes		SL	SCO
Benzo(a)pyrene		SL	SCO
Ideno(1,2,3-c-d)pyrene		SL	**CSL**
Dibenz(a.h)anthracene		SL	SCO
Benzo(g,h,i)perylene		SL	SCO
Total HPAHs		SL	SCO
1,2-Dichlorobenzene		SL/U	
1,2,4-Trichlorobenzene		SL/U	**CSL/U**
Hexachlorobenzene		SL/U	**CSL/U**
2,4-Dimethylphenol		SL/U	**CSL/U**
Benzyl alcohol		SL/U	SCO/U
Benzoic acid		**ML/U**	**CSL/U**
Hexachlorobutadiene		SL/U	
N-		SL/U	

Characterization Results



DMMU 3:
- Bioassays triggered
- Concentrations decreasing with depth

DMMU 4:
- No exceedances

Summary of exceedances

Parameter	DMMU 3	DMMU 4	Z sample (DMMP)	Z sample (SMS)
Fluorene	SL			
Pyrene	SL			
Benzo(a)pyrene	SL			
Ideno(1,2,3-c-d)pyrene	SL			
Total HPAHs	SL 15,000 ug/kg			
4,4'-DDT	SL/U			
Total Chlordane	SL/U			
Hexachlorobenzene				SCO/U

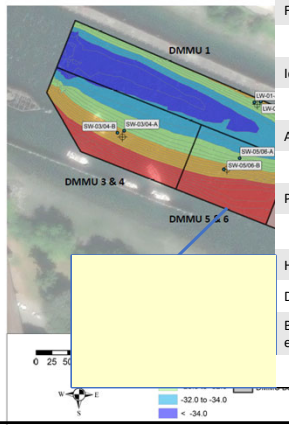
DMMU 3

Bioassay	Result
Polychaete growth	No hits
Amphipod survival	No hits
Larval development	No hits
	PASS

DMMU 4

Bioassay	Result
Polychaete growth	No hits
Amphipod survival	No hits
Larval development	No hits
	PASS

Characterization Results



Summary of exceedances

Parameter	DMMU 5	DMMU 6	Z sample (DMMP)	Z sample (SMS)
Fluoranthene		SL		
Ideno(1,2,3-c-d)pyrene		SL		
Acenaphthene		SL		
Phenanthrene		SL		
Hexachlorobenzene				SCO/U
Dibenzofuran		SL		
Bis(2-ethylhexyl)phthalate	SL			

DMMU 5

Bioassay	Result
Polychaete growth	No hits
Amphipod survival	No hits
Larval development	Minor hit (2-hit)

DMMU6

Bioassay	Result
	No hits
Amphipod survival	Minor hit (2-hit)
Larval development	No hits

17

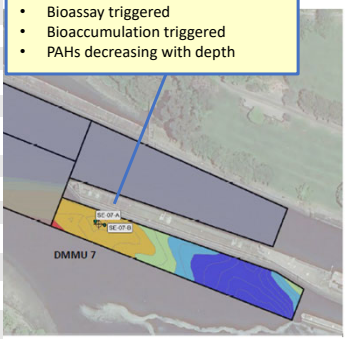
Characteriz

Summary of exceedances

Parameter	DMMU 7	Z sample (DMMP)	Z sample (SMS)
Fluoranthene	**BT**		na
Pyrene	**BT/ML**		na
Benz(a)anthracene	**ML**		na
Chrysene	SL		na
Total Benzofluoranthenes	**ML**		na
Benzo(a)pyrene	**ML**		na
Ideno(1,2,3-c-d)pyrene	**ML**		na
Benzo(g,h,i)perylene	SL		na
Phenanthrene	SL		na
Anthracene	SL		na
1,2,4-Trichlorobenzene	SL/U		na
2,4-Dimethylphenol	SL/U		
Benzyl alcohol	SL/U		
Hexachlorobutadiene	SL/U		

Bioassay	Result
Polychaete growth	No hits
Amphipod survival	No hits
Larval development	Major hit
	FAIL

DMMU 7:
- Bioassay triggered
- Bioaccumulation triggered
- PAHs decreasing with depth



Suitability Determination

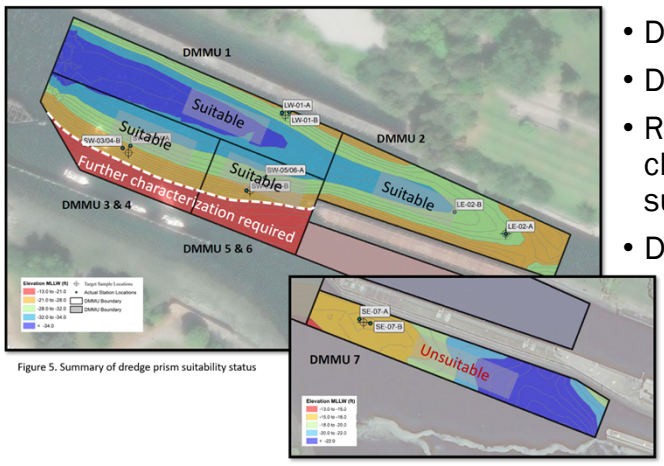


Figure 5. Summary of dredge prism suitability status

- DMMUs 1 and 2 suitable
- DMMUs 3-6 suitable as shown
- Red shoaled area needs further characterization to determine suitability
- DMMU 7 is unsuitable

Antidegradation Determination

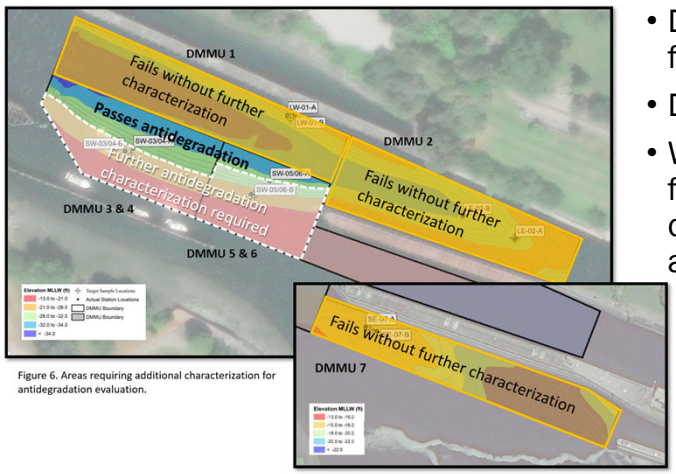


Figure 6. Areas requiring additional characterization for antidegradation evaluation.

- DMMUs 1 and 2 fail – needs further characterization
- DMMUs 3-6 suitable as shown
- White outlined area needs further characterization to determine suitability and antidegradation
  - DMMU 7 needs further characterization

Back to Lauran!

Programmatic Updates

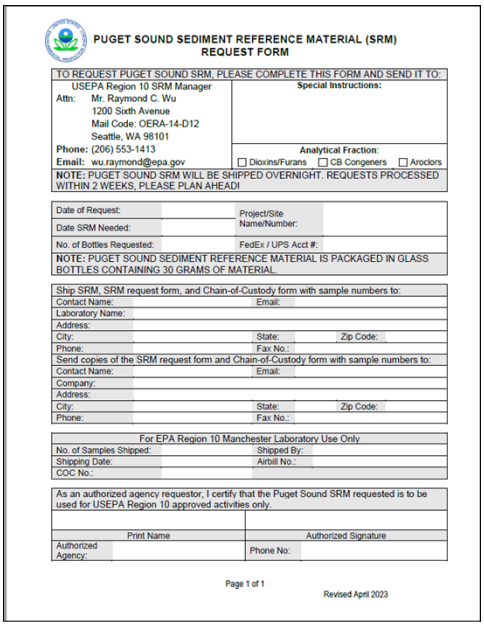
Puget Sound Sediment Reference Material

Laboratory Accreditation

Environmental Information Management

Over-dredging (Laura Inouye, Ecology)

Photo: Dredging on the Snohomish
Courtesy of JE McAnnis, Inc.



PUGET SOUND SEDIMENT REFERENCE MATERIAL (SRM)
REQUEST FORM

TO REQUEST PUGET SOUND SRM, PLEASE COMPLETE THIS FORM AND SEND IT TO:

USEPA Region 10 SRM Manager
Attn: Mr. Raymond C. Wu
1200 Sixth Avenue
Mail Code: OERA-14-D12
Seattle, WA 98101
Phone: (206) 553-1413
Email: wu.raymond@epa.gov

Special Instructions:

Analytical Fraction:
☐ Dioxins/Furans ☐ CB Congeners ☐ Aroclors

NOTE: PUGET SOUND SRM WILL BE SHIPPED OVERNIGHT. REQUESTS PROCESSED WITHIN 2 WEEKS, PLEASE PLAN AHEAD!

Date of Request:	Project/Site Name/Number:
Date SRM Needed:	
No. of Bottles Requested:	FedEx / UPS Acct #:

NOTE: PUGET SOUND SEDIMENT REFERENCE MATERIAL IS PACKAGED IN GLASS BOTTLES CONTAINING 30 GRAMS OF MATERIAL.

Ship SRM, SRM request form, and Chain-of-Custody form with sample numbers to:

Contact Name:		Email:	
Laboratory Name:			
Address:			
City:		State:	Zip Code:
Phone:		Fax No.:	

Send copies of the SRM request form and Chain-of-Custody form with sample numbers to:

Contact Name:		Email:	
Company:			
Address:			
City:		State:	Zip Code:
Phone:		Fax No.:	

For EPA Region 10 Manchester Laboratory Use Only

No. of Samples Shipped:		Shipped By:	
Shipping Date:		Airbill No.:	
COC No.:			

As an authorized agency requestor, I certify that the Puget Sound SRM requested is to be used for USEPA Region 10 approved activities only.

Print Name		Authorized Signature	
Authorized Agency:		Phone No:	

Page 1 of 1

Revised April 2023

Puget Sound Sediment Reference Material (PS-SRM)

- Regionally relevant SRM for dioxins/furans and CB congeners
- 2,525 remaining bottles now at EPA Manchester lab
- Allow 2 weeks for processing – plan ahead!
- Not required for all projects – see DMMP User Manual
- EPA obtained $$$ to recalculate acceptance limits for dioxins/furans and Aroclors
- For questions or data submittal, contact Raymond Wu, EPA Region 10 SRM Manager (wu.Raymond@epa.gov)
  - Include project name in subject line

Please:
- **Submit data!**
- **Record and report bottle number – even if bottle shared or reused.**

A Couple Quick Updates

Environmental Information Monitoring Database (EIM):

- Results spreadsheet changing as of 28 June 2023
- Adding 4 columns for method blank data for low-level PCB congeners
- **DMMP will NOT use blank corrected data**
- Update your templates!

Laboratory Accreditation:

- Due to long lab turn-around-times, DMMP now accepting data from some labs not accredited by Ecology
- All data must come from NELAP-accredited labs
- Please coordinate with DMMP before using

Overdredging - Agency responses

Year	contamination issue	Follow up
2008	yes	post-dredge sampling
2015	yes	post-dredge sampling
2019	yes	post-dredge sampling, disposal site sampling
	yes	post-dredge sampling
2020	yes	post-dredge evaluation (memorandum)
	no	bathymetry series
	no	no follow up
	no	bathymetry series
2021	no	bathymetry series
	no	no follow up
2023	no	in progress
	yes	in progress, post-dredge sampling

Responses vary, based on
- Presence of contamination
- Disposal location
- Antidegradation
- Severity of overdredge

Responses can include:
- DNR fines
- Bathymetric survey requirements
- Evaluation of potential antidegradation risks
- Post-dredge sampling
- Disposal site monitoring

Laura Inouye, Ecology

Overdredging - Prevention

Careful consideration of overdredge allowances in characterization and permits

Communication with contractors, especially when tight precision required

Contractor attention to calibration, both horizontal and vertical; have a backup method such as manual lead line

Caution with 24/7 dredging night-time shifts

Laura Inouye, Ecology

Overdredging - Follow up

Progress surveys should be evaluated and when over dredging is suspected, immediate investigation should ensue

Early notification is beneficial to all parties

Direct communication with all DMMP agencies

Laura Inouye, Ecology

Coming in DY24

Elliott Bay Monitoring

Finalized Disposal Site Monitoring Plan (DSMP)

Updated User Manual

Photo: Lake Washington Ship Canal

For more information

- DMMO Website: https://www.nws.usace.army.mil/Missions/Civil-Works/Dredging/
- Email: CENWS-DMMOTeam@usace.army.mil

Photo Courtesy of Brian Hester

10. DNR Year in Review

Shannon Soto (DNR)

Summary

Five site use authorizations were issued for dredging projects in Puget Sound and the Outer Coast. Projects were completed at Shelter Marina, Bellingham Cold Storage, and Terminal 5 by Port of Seattle, as well as the lower settling basin by the Port of Everett. The Port of Grays Harbor also conducted routine maintenance dredging. Revenue from dredging funds the monitoring and management of disposal sites, amounting to approximately $216,000 this year. Elliot Bay has reached its monitoring trigger and will undergo monitoring using sediment profile imaging, plan view survey, chemistry, and bioaccumulation testing. A passive sampling study will explore the use of sediments as a proxy for bioaccumulation. For further information, visitors can refer to the Army Corps DMMO and DNR websites.

Discussion

No questions

SMARM 2023 Year in Review

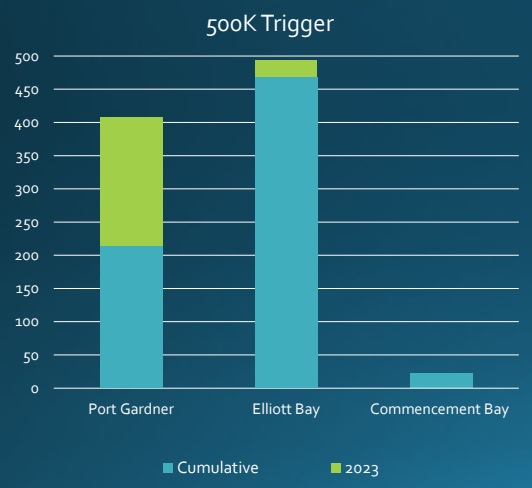
Shannon Soto, DNR DMMP Program Manager

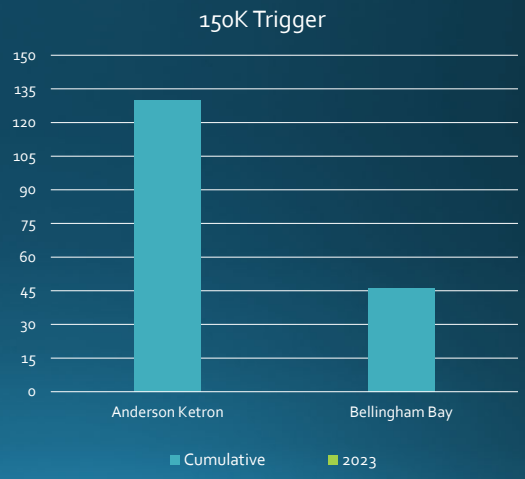
DY 2023: Site Use Authorization

SUA GRANTEE	DISPOSAL SITE	VOLUME DISPOSED (CY)	REVENUE
Shelter Bay Marina	Rosario	31,169	$23,377
Bellingham Cold Storage	Rosario	4,206	$3,155
Port of Seattle Terminal 5	Elliott Bay	24,781	$32,236 *
Port of Everett Lower Settling Basin	Port Gardner	192,914	$144,686
Port of Grays Harbor Terminals	Pt. Chehalis	80,926	$12,139
			$215,593

* Includes over dredge disposal fee

Disposed Volume and Monitoring Triggers





Elliott Bay Monitoring 2023

Sediment Profile Imaging & Plan View Survey

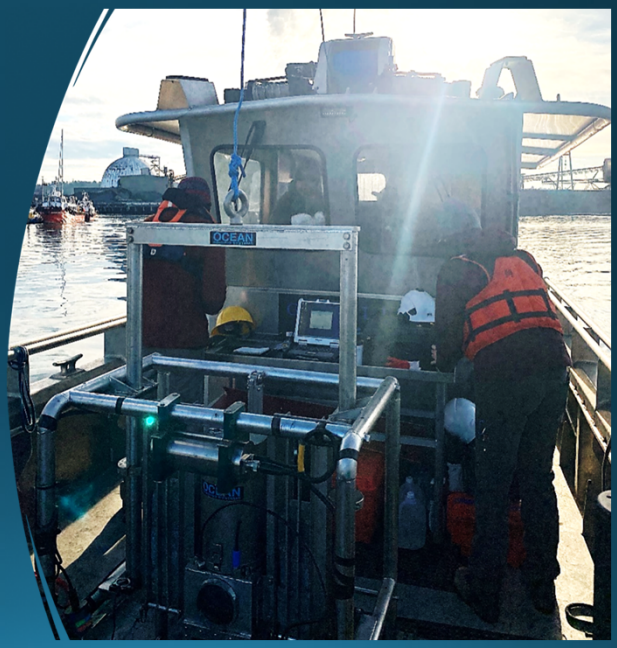
NuGlobal Solutions (NewFields)

March 7-9

Chemistry & Bioaccumulation

Summer 2023

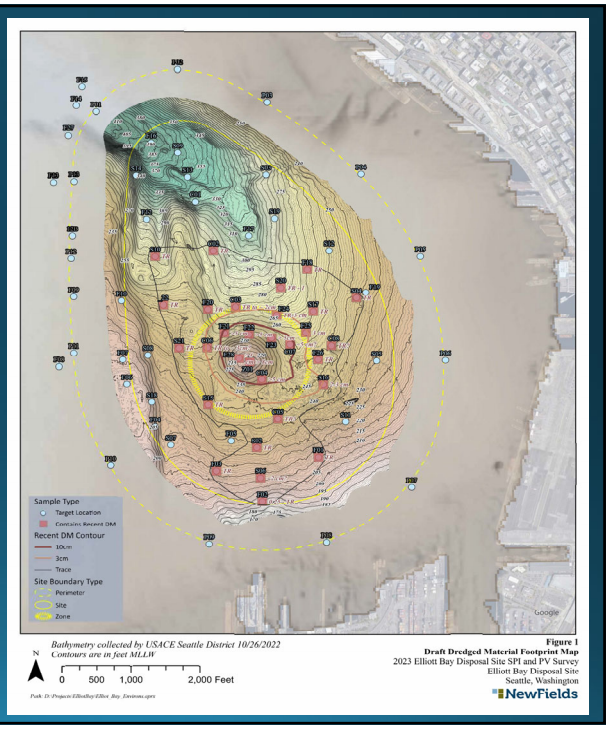
Passive Sampling Study



Elliott Bay SPI/PV
Recent Dredged Material
Footprint
(draft)

No off-site material

Bulk of material within target zone.

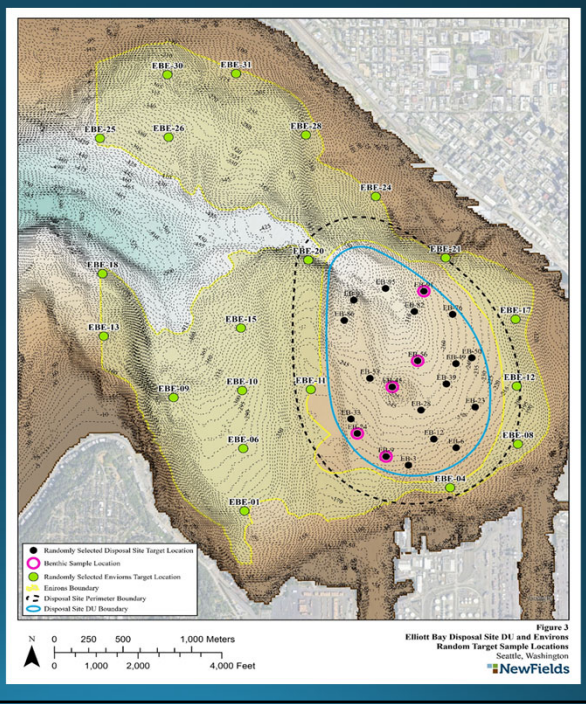


Chemistry and Bioaccumulation

Five discrete grab samples from within the disposal site will be collected for chemistry.

Twenty composited samples from within the disposal site will be collected for bioaccumulation.

Twenty composited samples from the environs outside the disposal site will be collected for bioaccumulation.



Passive Sampling Study

Ongoing study for an alternative to using live organisms for bioaccumulation.

- Lower costs
- Potential use in sediment where organism survival is in question
- When test species abundance and tissue mass in decline

2020 Port Gardner

Co-exposure with *Alitta virens* & *Macoma nasuta*

PCBs and Dioxin /Furan

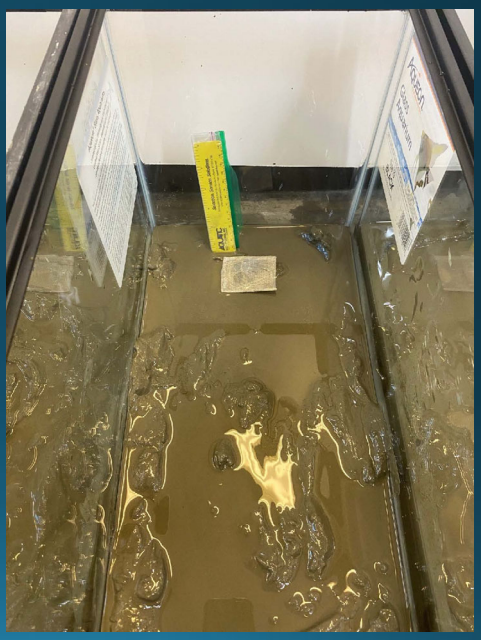
SPME Fibers

2023 Elliott Bay

No co-exposure with live organisms

PCBs and Dioxin/Furan

PE Film



Information & Resources

USACE DMMO Website	• **2021 Biennial Report** • **2020 Port Gardner Final Monitoring Report** • **2020 Port Gardner Passive Sampling Pilot Study**
DNR DMMP Website	• DNR Disposal Fee Structure • Site Use Authorization • Reporting Forms

11. Development of Elliott Bay Environs for Disposal Site Monitoring

Kelsey van der Elst (USACE)

Summary

Kelsey van der Elst, USACE, described the approached used by the DMMP to develop the sampling locations for the Elliott Bay Environs Decision Unit for monitoring the Elliott Bay disposal site.

The approach was based on the approach used to develop Environs DU for the Port Gardner pilot monitoring in 2020, and will be documented in the upcoming Disposal Site Monitoring Plan. Briefly, the following parts, or layers, are evaluated and combined to establish the boundary for the Environs sampling area:

- Depths: The Environs area should not include areas 50 ft shallower or 50 ft deeper than the shallowest and deepest, respectively, elevations of the disposal site prior to use as such. For Elliott Bay the environs area should be between -150 to -410 ft MLLW.
- Inner Boundary: A 150 ft buffer around the disposal site and the cumulative footprint of trace dredged material is removed from the environs area to create the center of the donut hole.
- Outer Boundary: Areas less than 500 ft from the shoreline were removed from the Environs area, and a western boundary cutoff was established as a north-south line between Duwamish Head and Smith Cove based on historical boundary between inner and outer Elliott Bay.
- Exclusions: A 250ft buffer around the Denny Way CSO, Pier 55/56 Cap, and the Puget Sound Resources CERCLA cite were established and removed from the Environs area.

A 500m sampling grid was placed over the final Elliott Bay Environs Decision Unit area, creating 31 sampling stations.

Discussion

No questions

Kelsey van der Elst, USACE

and

Leon Delwiche, NewFields

SMARM

May 3, 2023

Development of Elliott Bay Environs Decision Unit for DMMP Monitoring

Updated Monitoring Framework

DMMP Issue Paper **June 10, 2022**

Revised Monitoring Framework for Puget Sound DMMP Non-Dispersive Disposal Sites

Prepared by Laura Inouye (Ecology), Heather Fourie and Joy Dunay (USACE) for the DMMP Agencies

Introduction

The Puget Sound Dredged Disposal Analysis (PSDDA) was a comprehensive, multi-year, multi-million-dollar public process in the late 1980s that culminated in an interagency program to oversee dredged material management in Washington State. This Dredged Material Management Program (DMMP) brought together the following agencies with roles in management and regulation of dredged material to streamline project evaluation and disposal: the U.S. Army Corps of Engineers, Seattle District

Table 1-2. Revised Monitoring Framework

Part 1: Routine Monitoring and Testing				
Question	**Goal**	**Metric**	**Method**	**Goal Achievement Guideline[3]**
1. Does the deposited dredged material stay on site?	A. Dredged material stays within site boundaries	SPI/PV quantitative assessment	Conduct SPI/PV survey of site and surrounding area	< 10 cm at or beyond site boundary OR < 3 cm at or beyond site perimeter
2. Does deposited dredged material cause unacceptable[1,2] adverse impacts to biological conditions on site?	B. No long-term adverse effects to on-site benthic biological resources and habitat as defined by SCII	SPI/PV qualitative assessment	Review SPI/PV parameters including successional stage, apparent redox potential discontinuity, and others	Benthic community shows expected levels of recovery based on historical data
		Sediment chemistry	Collect 5 individual 0-10 cm samples from stratified random grid within the Disposal Site DU; analyze for benthic DMMP COC list	All COCs ≤ DMMP SL
		Sediment bioassays (Tiered)	Run on all samples with any COC > SL	No bioassay toxicity test exhibits a 1-hit (major) response or two 2-hit (minor) responses
	C. No long-term adverse bioaccumulative risk to on-site resources as defined by SCII and SMS	Tier 1 analysis	Review existing on-site bioaccumulation data, project data and other relevant data[4]	Sufficient evidence of no bioaccumulative risk > SCII and SMS
		Laboratory bioaccumulation tests (Tiered)	• Composite 20 subsamples from stratified random grid within the Disposal Site DU into a single sample; analyze for sediment chemistry and bioaccumulation • Composite 20 subsamples from random grid within the Environs DU into a single sample; analyze for sediment chemistry and bioaccumulation • Analyze sediment and tissue for relevant DMMP List 1 BCOCs	1. SCII: Sediment BCOCs ≤ DMMP BT; Tissue BCOCs ≤ DMMP TTLs 2. SMS: BCOCs from Disposal Site DU-exposed tissues are ≤ the highest of: • Risk-based values (including relevant TTLs) • Background including Environs DU tissue data • PQLs if available

General Approach: Layer Cake

- Layer 1: Define Depths
- Layer 2: Define Inner Boundary
- Layer 3: Define Outer Boundary
- Layer 4: Define Exclusions

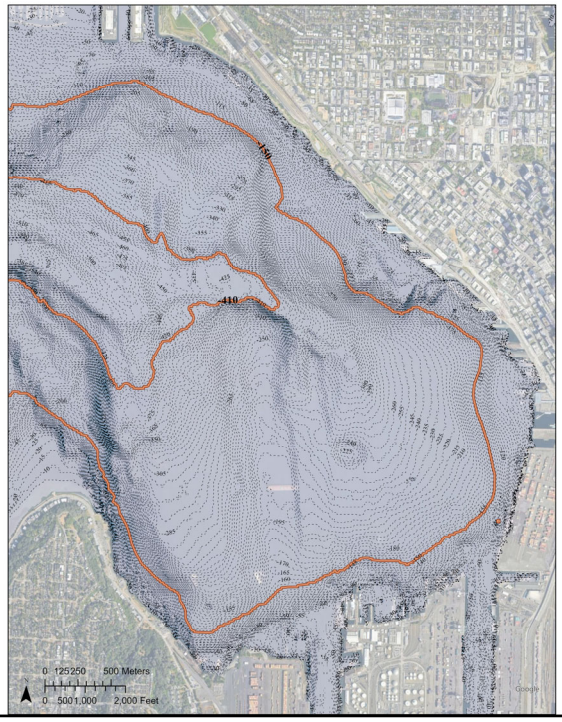
Layer 1: Depths

+/- 50 ft from original elevation

-150 ft to -410 ft MLLW

TABLE II.10-1 INFORMATION ON THE PREFERRED AND ALTERNATIVE DISPOSAL SITES.

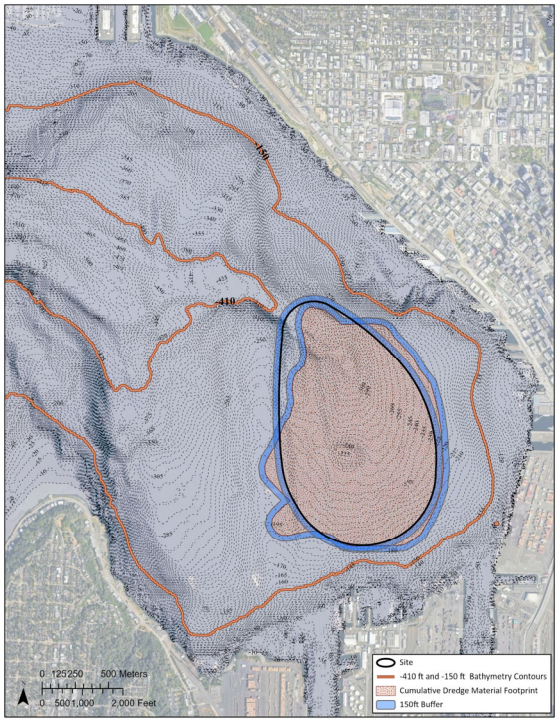
	Latitude	Longitude	Area (acre)	Depth (ft)	Dimensions (ft)
Saratoga Passage					
Alternate	48° 5.43	122° 27.35	318	350	4200
Port Gardner					
Preferred	47° 58.86	122° 16.67	318	420	4200
Alternate	47° 58.26	122° 15.55	375	330-425	3800 x 3833
Elliott Bay*					
Preferred	47° 36.03	122° 21.34	415	200-360	6200 x 4000
Alternate	47° 37.09	122° 24.85	480	500-600	4500 x 6000
Commencement Bay					
Preferred	47° 18.22	122° 27.84	310	540-560	4600 x 3800
Alternate	47° 18.72	122° 27.95	310	540-560	4600 x 3800



Layer 2: Inner Boundary

150 ft buffer:

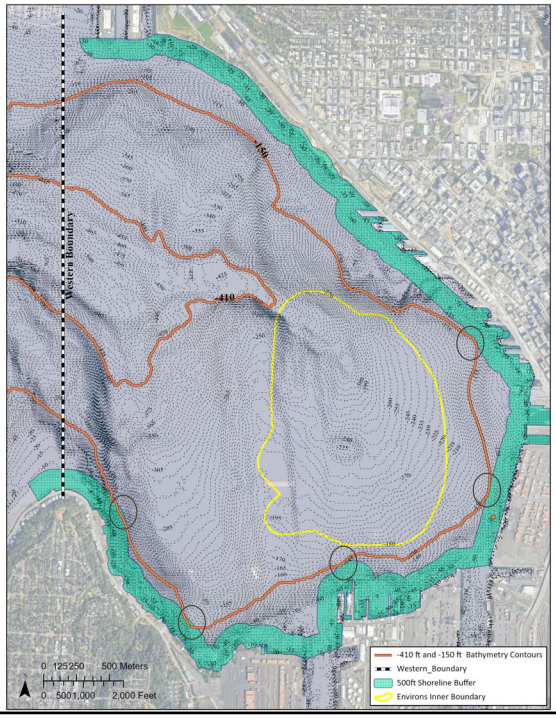
- Disposal site
- Cumulative dredged material footprint



Layer 3: Outer Boundary

500 ft shoreline buffer

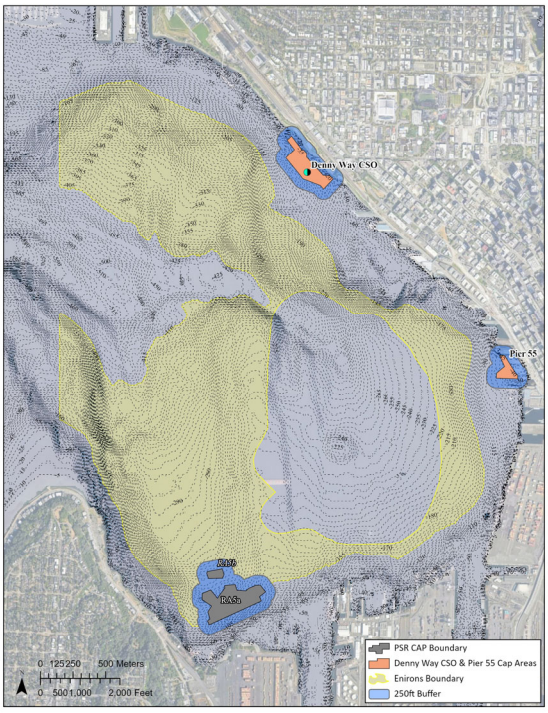
Western edge cutoff



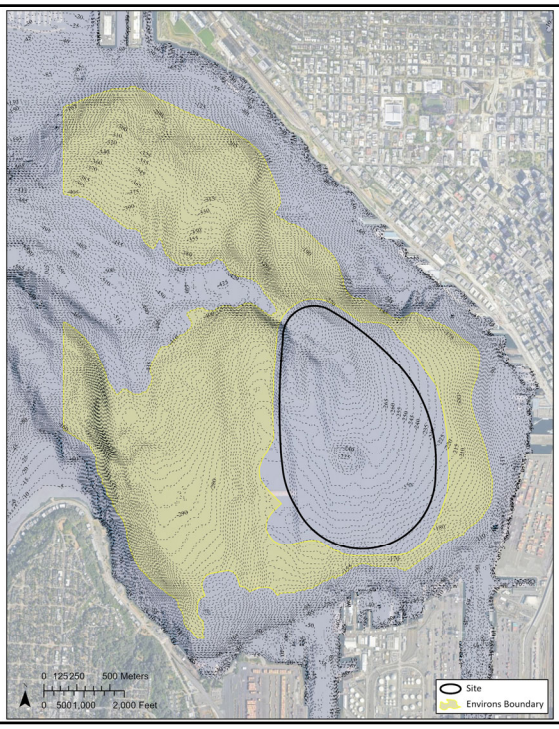
Layer 4: Exclusions

250 ft buffer

- Puget Sound Resources
- Denny Way CSO
- Pier 55/56

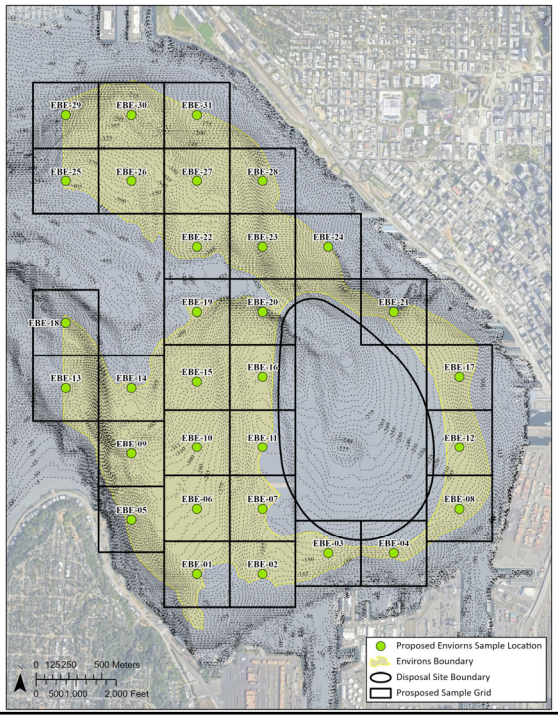


Elliott Bay Environs Decision Unit



EB Environs Sampling Grid

500m grid
31 stations



Questions?

Port Gamble site visit, circa 2014

Thank You Lauran!!!

Fish rescue at LWSC, 2021

Dave Kendall's retirement, 2013

Please stay for cake

Dave Fox's retirement, 2020

11

Appendix A. Meeting Announcement

YOU ARE INVITED:

35TH SEDIMENT MANAGEMENT ANNUAL REVIEW MEETING

MAY 3RD, 2023 • 9:00 AM – 3:30 PM

FEDERAL CENTER SOUTH
SEATTLE, WASHINGTON

Topics will include:

- Sediment PCB Cleanup Remedy Effectiveness
- Food Web Cycling of PCBs in Elliott Bay
- Special Session on Beneficial Use of Dredged Material
- DMMP Sediment Characterizations: Laboratory Challenges and New Technologies
- Development of Elliott Bay Environs Sampling Grid for DMMP Monitoring

RSVP for in-person attendance is requested to get a head count. Click e-mail link below to RSVP.

CENWS-DMMOTeam@usace.army.mil

If you can't make it in person, virtual attendance is available, registration is required. Click below to register

REGISTER for virtual SMARM

See the DMMO Website for agenda and additional information

FOOD TRUCKS WILL BE AVAILABLE FOR LUNCH!

Thai-U-Up

https://thaiuup.com/menu/

&

Mexicuban

https://www.mexicuban.com/

US Army Corps of Engineers Seattle District

WASHINGTON STATE DEPT OF NATURAL RESOURCES

EPA United States Environmental Protection Agency

DEPARTMENT OF ECOLOGY State of Washington

Appendix B. Agenda

35th Sediment Management Annual Review Meeting Agenda

May 3, 2023

In-Person Meeting at the USACE Seattle District Office (RSVP to DMMO Team email below)

8:30 am	Arrival and Check-in	All times given in PDT; Q&A period included for each presentation
MORNING SESSION		
9:00 am	Welcome and Logistics	Joy Dunay, USACE and Justine Barton, EPA
9:05 am	Sediment PCB Cleanup Remedy Effectiveness: Case Study Synthesis	Clay Patmont, Anchor QEA
9:35 am	The Potential Impact of PCBs From a Local Source (e.g., a CERCLA Site) on a Broader, Basin-Wide Ecosystem Scale	Jim West, WDFW
10:20 am	**Break**	
10:30 am	Welcome Message from Seattle District Commander	Colonel Xander Bullock, USACE
10:35 am	Toxics Cleanup Program Update: Sediment policy, guidance, legislative session, and budget	Chance Asher, Ecology
10:50 am	Seattle District Beneficial Use in Action	Amy Reese and John Hicks, USACE
11:15 am	Snohomish Estuary Beneficial Use Opportunities	Laura Gurley and Erik Gerking, Port of Everett; Larry Lehman, Grette Associates
11:45 am	**Lunch**	
AFTERNOON SESSION		
1:00 pm	Novel 3D Printed Structures: Isolate Contaminant Effects in Complex Mixtures for Toxicity Reduction Evaluations	Alan Kennedy, USACE ERDC
1:20 pm	Current Challenges for Sediment Characterization Projects – Panel Discussion	EcoAnalysts and ARI (moderated by Regina Edwards)
2:05 pm	2022 Shoalwater Bay Barrier Dune Repair: Incorporating Natural and Nature-Based Features to Reduce Flood/Erosion Risk While Maintaining Critical Shorebird Habitat	Dave Michalsen, USACE
2:25 pm	**Break**	
2:40 pm	DMMP Highlights for Dredging Year 2023	Lauran Warner, USACE
2:55 pm	DNR Year in Review	Shannon Soto, DNR
3:05 pm	Development of Elliott Bay Environs for Disposal Site Monitoring	Kelsey van der Elst, USACE
3:30 pm	**Closing remarks and adjourn**	Joy Dunay, USACE and Justine Barton, EPA

Webex Meeting also available (Register here)

Comments on SMARM and Issue Papers accepted through June 2, 2023

email to CENWS-DMMOTeam@usace.army.mil

Appendix C. Meeting Registrants

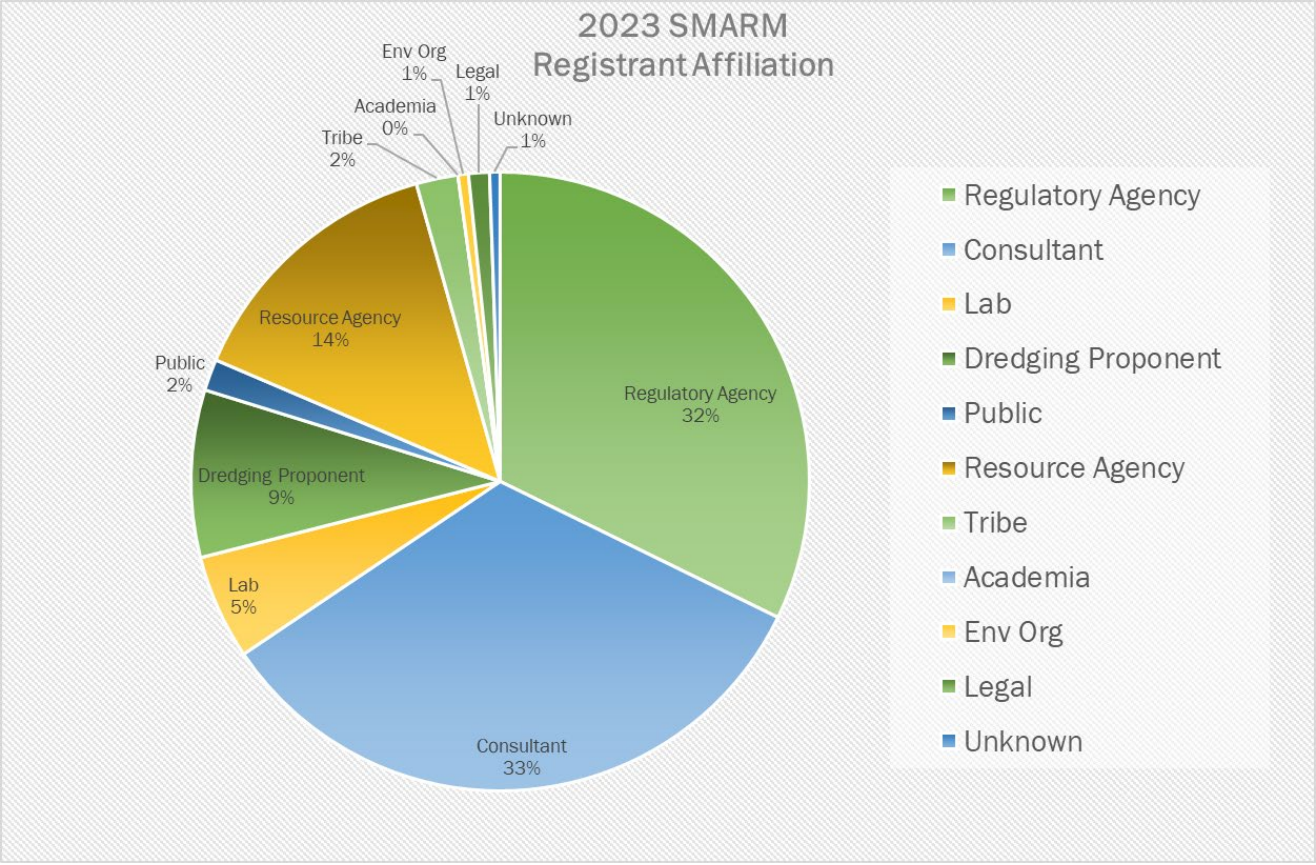
Sue Dunnihoo	Analytical Resources, Inc.	**Jessica Winter-Stoltzman**	EcoChem
Michelle Rau	ANAMAR Environmental Consulting	**Peter Adolphson**	Ecology
Ross Thomas	ANAMAR Environmental Consulting	**Chance Asher**	Ecology
Mark Larson	Anchor QEA	**Bonnie Brooks**	Ecology
Clay Patmont	Anchor QEA	**Susannah Edwards**	Ecology
Delaney Peterson	Anchor QEA	**Erica Fot**	Ecology
Nathan Soccorsy	Anchor QEA	**Connie Groven**	Ecology
Kent Patton	Apex Labs	**Laura Inouye**	Ecology
Teresa Michelsen	Avocet Consulting LLC	**Kevin Kalefern**	Ecology
Joe Flaherty	Boeing	**Corey King**	Ecology
Pete Stoltz	CalPortland	**Jing Liu**	Ecology
Mary Henley	City of Tacoma	**Sandy Smith**	Ecology
Laura Nokes	City of Tacoma	**Brook Swensen**	Ecology
Daniel Giroux	Compliance Specialist	**Steven Teel**	Ecology
Don Laford	Duwamish Yacht Club	**Priscilla Tomlinson**	Ecology
Regina Edwards	EcoAnalysts	**Molly Ware**	Ecology
Michelle Knowlen	EcoAnalysts	**Katie Payne**	Enthalpy Analytical
Julia Levengood	EcoAnalysts	**Kasey Skrivseth**	Enthalpy Analytical
Mary Ann Rempel-Hester	EcoAnalysts	**Roanna Leung**	Environment and Climate Change Canada
Marisa Seibert	EcoAnalysts	**Alexa Sterling**	EPA - Region 1
Jay Word	EcoAnalysts	**Steven Wolf**	EPA - Region 1

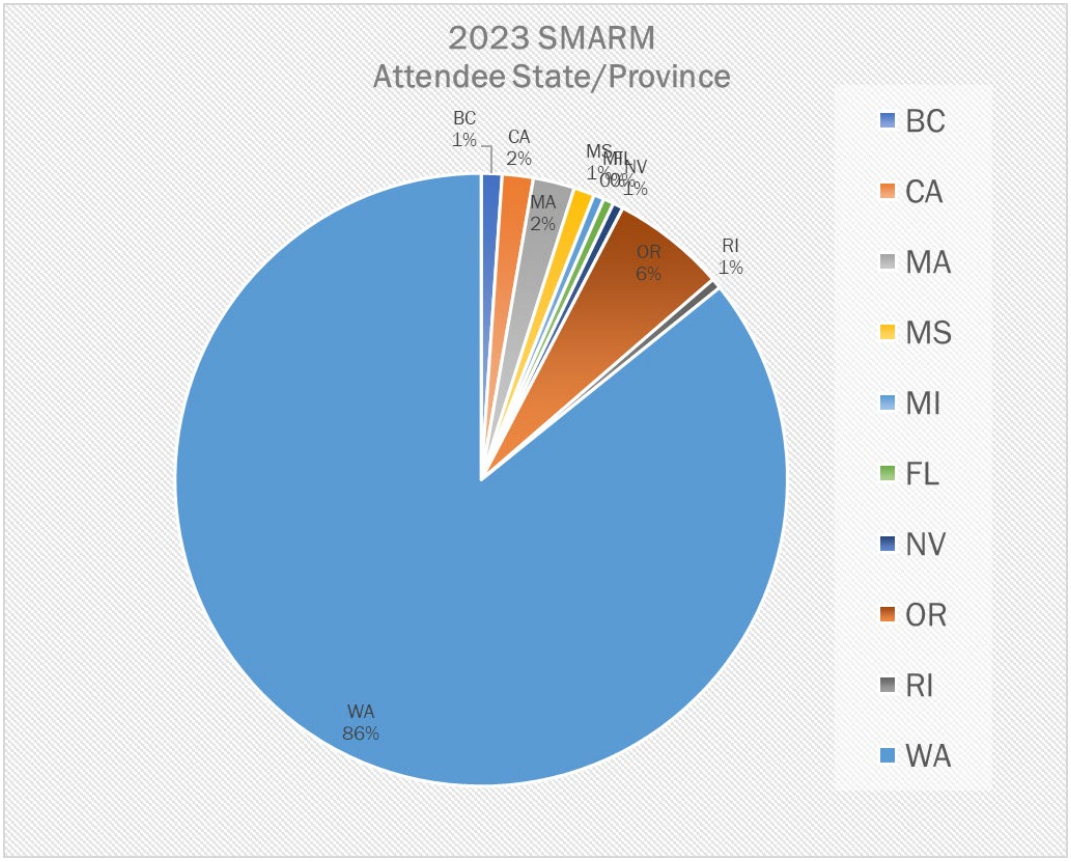
Elizabeth Allen	EPA - Region 10	**Michael Tweiten**	Exa Data & Mapping Services
Justine Barton	EPA - Region 10	**Phil Cordell**	Farallon Consulting
Sarah Burgess	EPA - Region 10	**Sabine Datum**	Floyd|Snider
Charles Clabaugh	EPA - Region 10	**Terry Duncan**	Floyd|Snider
David Croxton	EPA - Region 10	**Daniel Hennessy**	Floyd|Snider
Cindy Fields	EPA - Region 10	**Emily Jones**	Floyd|Snider
Patrick Hickey	EPA - Region 10	**Evan Malczyk**	Floyd|Snider
Erika Hoffman	EPA - Region 10	**Cheronne Oreiro**	Floyd|Snider
Carolyn Huynh	EPA - Region 10	**Sean Galloway**	Fremont Analytical
Kristine Koch	EPA - Region 10	**Katy Atakturk**	GeoEngineers
Bridgette Lohrman	EPA - Region 10	**Brian Tracy**	GeoEngineers
Elisabeth Novak	EPA - Region 10	**Anne Fitzpatrick**	GeoSyntec
Chan Pongkhamsing	EPA - Region 10	**Giovanna Pagnozzi**	Geosyntec
Kim Prestbo	EPA - Region 10	**Bruce Rummel**	Great Water Assoc
Ravi Sanga	EPA - Region 10	**Larry Lehman**	Grette Associates LLC
Bernadette Wright	EPA - Region 10	**Helder Costa**	Haley & Aldrich
Hunter Young	EPA - Region 10	**Mike Ehlebracht**	Haley & Aldrich
Fadwa Bouhedda	EPA - Region 9	**Joshua Collins**	Hatch
Whitney Conrad	EPA Wetlands & Oceans	**Rob Zisette**	Herrera Environmental Consultants
James Keithly	ERM	**Kaitlin Sylvester**	INSPIRE Environmental - Consultant
Tracy Dutton	Eurofins	**Shannon Ashurst**	Integral Consulting
Darla Smith	Eurofins	**Olivia Hargrave**	Integral Consulting

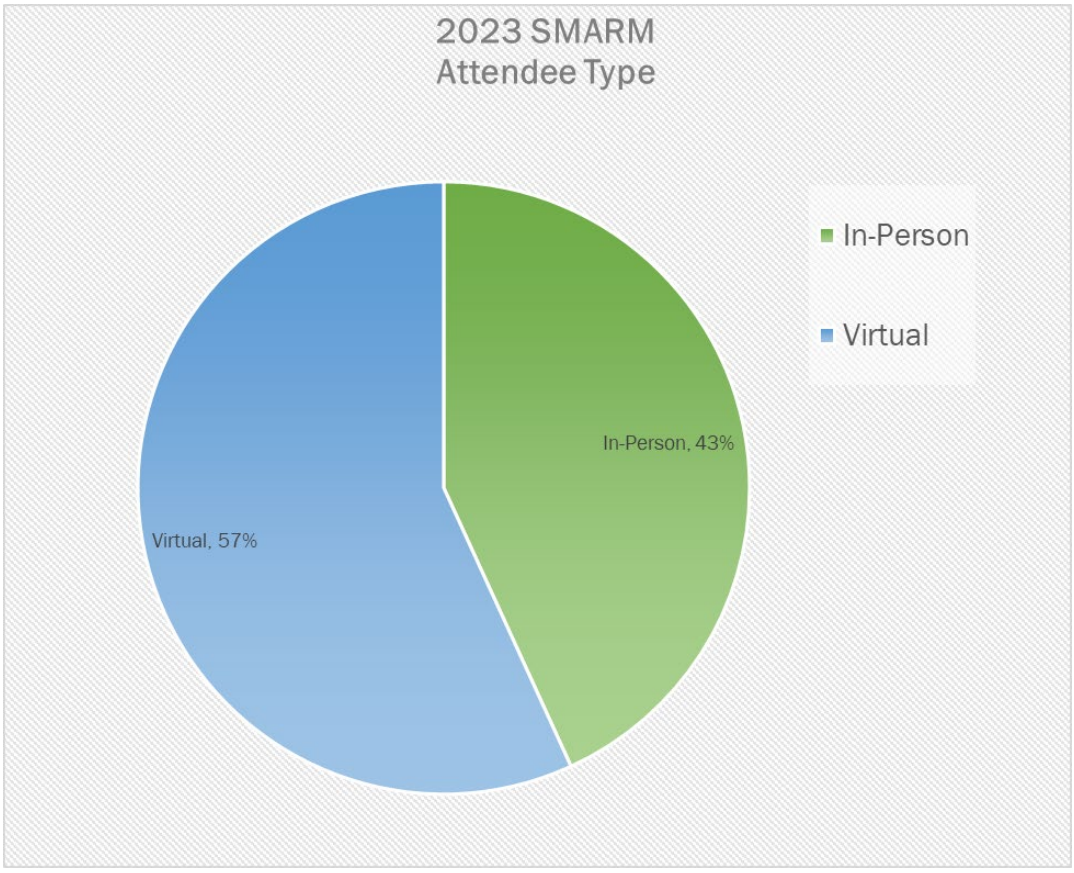
Kris Ivarson	Jacobs	**Terill Hollweg**	NOAA
Raymond Krahe	Jacobs	**David Baumeister**	OnSite Environmental, Inc.
Liz Luecker	Jacobs	**Nichelle Biffin**	OnSite Environmental, Inc.
Kim Johannessen	Johannessen & Associates P.S.	**Peter Anderson**	Oregon DEQ
Wendy Eash-Loucks	King County	**Heidi Nelson**	Oregon DEQ
Erin McCabe	King County	**Dena Horton**	Pacific Northwest Waterways Association
Jeff Stern	King County	**Anthony Pena**	Pacific Northwest Waterways Association
Carolyn Carlstrom	Landau Associates	**Permveer Bains**	Pacific Rim Laboratories
Jeffrey Fellows	Landau Associates	**Ben Howard**	Port of Bellingham
Dylan Frazer	Landau Associates	**Erik Gerking**	Port of Everett
Peter Leon	Leon Environmental, LLC	**Laura Gurley**	Port of Everett
Whitney Fraser	Lodestone Env. Consulting	**Joanna Florer**	Port of Seattle
Winn McEnery	Marine Surveys & Assessments	**Norman Gilbert**	Port of Tacoma
Amy Leitman	Marine Surveys & Assessments	**Robert Healy**	Port of Tacoma
Victoria England	Moffat & Nichol	**Mark Rettmann**	Port of Tacoma
Younes Nouri	Moffat & Nichol	**Stanley Sasser**	Port of Tacoma
Randy Jordan	Natural Spectrum LLC	**Suzanne Dolberg**	Puget Sound Energy
Joy Gryzenia	NAVFAC NW	**James Mc Ateer**	QA/QC Solutions, LLC
Ron Malec	NAVFAC NW	**Scott Mazzone**	Quinault Indian Nation
Pamela Sargent N/A	NAVFAC NW	**Bill Beckley**	RIDOLFI Environmental
Philip Nenninger	NAVFAC NW	**Allison Crowley**	Seattle City Light
John Nakayama	NewFields	**Pete Rude**	Seattle Public Utilities

Amy Boehm	SGS	**Alana Mesenbrink**	USACE - Seattle
Ryan Sutlifke	SGS	**Dave Michalsen**	USACE - Seattle
Tim Stott	Shannon&Wilson	**Jarod Norton**	USACE - Seattle
Will Hafner	SoundEarth Strategies	**Amy Reese**	USACE - Seattle
Andrew Schmeising	Suquamish Tribe	**Kelsey Van Der Elst**	USACE - Seattle
Denice Taylor	Suquamish Tribe	**Lauran Warner**	USACE - Seattle
Gary Braun	Tetra Tech	**Hiram Arden**	USACE (Retired)
Jeremy Buck	US Fish and Wildlife Service	**David Kendall**	USACE (Retired)
Alan Kennedy	USACE - ERDC	**Valerie Chu**	USFWS
John Farrar	USACE - ERDC	**Katie Byrnes**	Washington Conservation Action
Sarah Turner	USACE - NAE	**Carly Michiels**	Washington Public Ports Association
James Holm	USACE - Portland	**Adrienne Stutes**	Washington State Ferries
James McMillan	USACE - Portland	**Marsha Tolon**	Washington State Ferries
Dominic Yballe	USACE - Portland	**Jim West**	WDFW
Alexander Bullock	USACE - Seattle	**Abby Barnes**	WDNR
Joy Dunay	USACE - Seattle	**Hannah Blackstock**	WDNR
William Gardiner	USACE - Seattle	**Shayne Cothern**	WDNR
Danette Guy	USACE - Seattle	**Birdie Davenport**	WDNR
Brian Hart	USACE - Seattle	**Tim Goodman**	WDNR
Brian Hester	USACE - Seattle	**Thomas Gorman**	WDNR
John Hicks	USACE - Seattle	**Vivian Roach**	WDNR
Kristen Kerns	USACE - Seattle	**Erika Shaffer**	WDNR

Shannon Soto	WDNR	**Brad Helland**	WSP
Kathy Godtfredsen	Windward Environmental	**Morvarid Khazraee**	WSP
Susie McGroddy	Windward Environmental	**Grace Roberts**	WSP
Suzanne Repinger	Windward Environmental	**Elena Ramirez Groszowski**	Yakama Nation Fisheries Superfund Section
Kimbrie Gobbi	WSP		




2023 SMARM
Attendee State/Province
BC
1%
CA
2%
MA
2%
MS
1%
MI
0%
FL
0%
NV
1%
OR
6%
RI
1%
WA
86%
BC
CA
MA
MS
MI
FL
NV
OR
RI
WA


2023 SMARM
Attendee Type
In-Person, 43%
Virtual, 57%
In-Person
Virtual