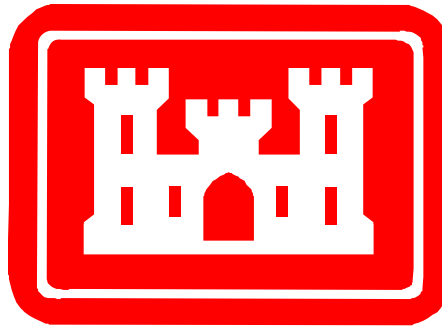


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# DREDGING RESUSPENSION: DEFINING THE ISSUES



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# Topics

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- Definitions
- Old issues
- Emerging issues
- Confounding factors
- Sources of uncertainty
- Conclusions



# Why Does Resuspension Matter?

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- **Fundamental determinant of impacts related to exposure to elevated suspended sediment concentrations, turbidity, and contaminants**
- **Longstanding concerns for a host of potentially sensitive receptors, including SAV, coral reefs, migratory fishes, etc.**
- **Critical consideration for the conduct of environmental/remedial dredging projects**
- **Substantial economic consequences**



# The 4 R's

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**RESUSPENSION**

**RELEASE**

**RESIDUALS**

**RISK**



# DEFINITIONS

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- **Resuspension** – Dislodging of bedded sediment particles during the dredging process, and consequent transport and settlement of those particles at a new location
- **Release** – Transport of dissolved constituents of disturbed pore water or constituents desorbed from sediment particles
- **Residuals** – Disturbed sediments remaining after cessation of dredging
- **Risk** – Consequences of resuspension, release, and creation of residuals



# Old Issues

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## Unanswered questions 39 years after NEPA

- What are the principal drivers affecting the rate of resuspension?
- What are the rates of resuspension associated with basic modes of dredging?
- What are the relevant spatial and temporal scales of resuspension?



# Old Issues

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## Unanswered questions 39 years after NEPA

- What thresholds of suspended and deposited sediment exposure trigger biologically meaningful detrimental responses?
- What management practices and control measures actually provide protection benefits?
  - The current practice of resorting to environmental windows underscores a need to explore new approaches and technologies



# Emerging Issues

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- **Concerns being extended to other sources, including ship traffic**
- **Increasing pressure for continuous, real time monitoring without established means of interpreting data or providing risk-based responses/controls**
- **Restrictions and controls applied to remedial projects are increasingly being incorporated into navigation dredging WQ certificates without a prior risk assessment or documented need**





# Confounding Factors and Sources of Uncertainty

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- **Diverse receptors and pathways**
- **Lack of standardized methodologies**
- **Many physical factors influence resuspension**
- **Many operational factors influence resuspension**
- **Regulatory inconsistencies**



# Effects of TSS and Turbidity

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**On spawning**

**On fish migration**

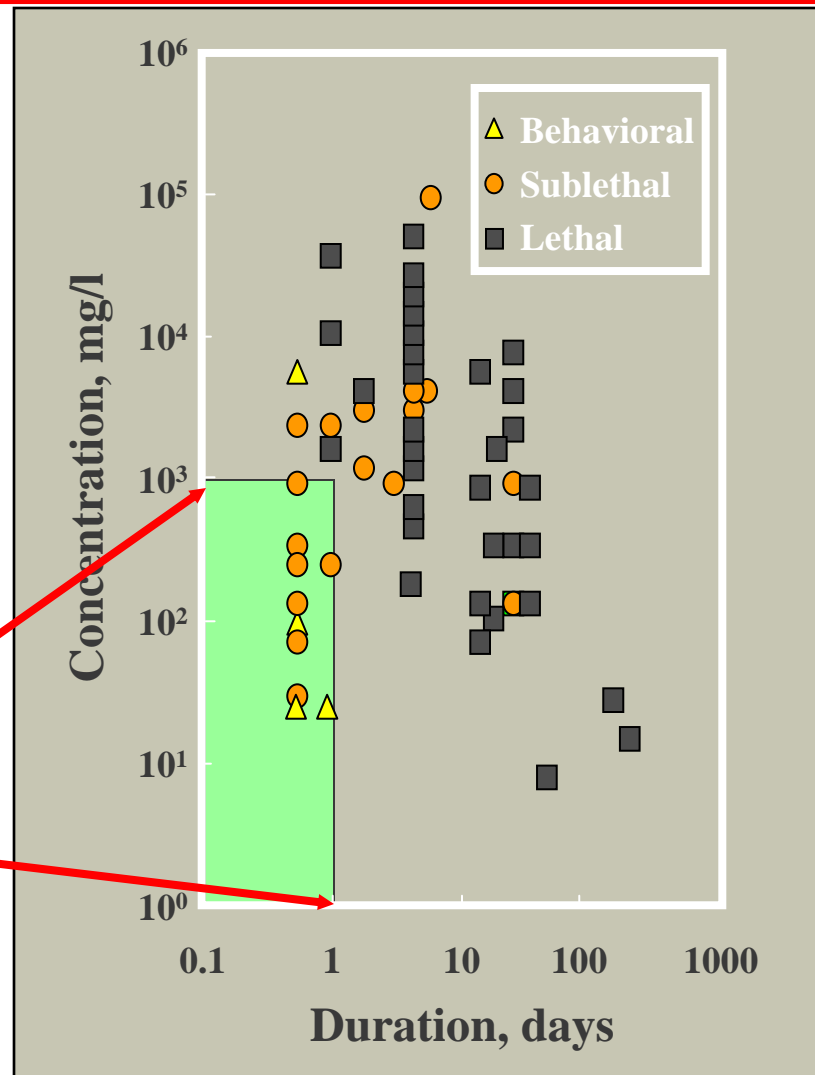
**On corals**

**On T&E Spp.**

**On seagrasses**



# Juvenile Salmonids



Many studies have not used protocols that establish dose-response relationships.



# Physical Factors That Influence Resuspension

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- **Mode of dredging**
  - Mechanical vs. hydraulic
- **Hydrodynamics**
  - Prevailing current velocities and vectors
  - Bathymetry
- ***In situ* sediment properties**
  - Grain size distribution
  - Water content/bulk density/liquidity
  - Atterberg Limits (Liquid and Plastic)
- **Depth and salinity**



# Operational Factors That Influence Resuspension (e.g., bucket dredge)

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- **Bucket type**
- **Size, volume, exposed surface area**
- **Ascent speed**
- **Descent speed**
- **Reset frequency**
- **Cycle time**
- **Production rate**
- **Sediment cohesion/adhesion**
- **Leakage from seals**
- **Debris**
- **Bottom sweeping/bed leveling**
- **Anchoring and spud movements**
- **Barge overflow**
- **Tug and tender maneuvering**
- **Operator skill**



# Perceptions vs. Reality

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- **Perception**

- **Resuspension controls provide environmental protection**
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- **Reality**

- **Controls frequently slow down production rates, but do not decrease mass loss**
- **Tradeoffs are often ignored**
  - e.g., many critters tolerate short, intense exposures better than chronic exposures
  - e.g., air quality effects due to prolonged emissions



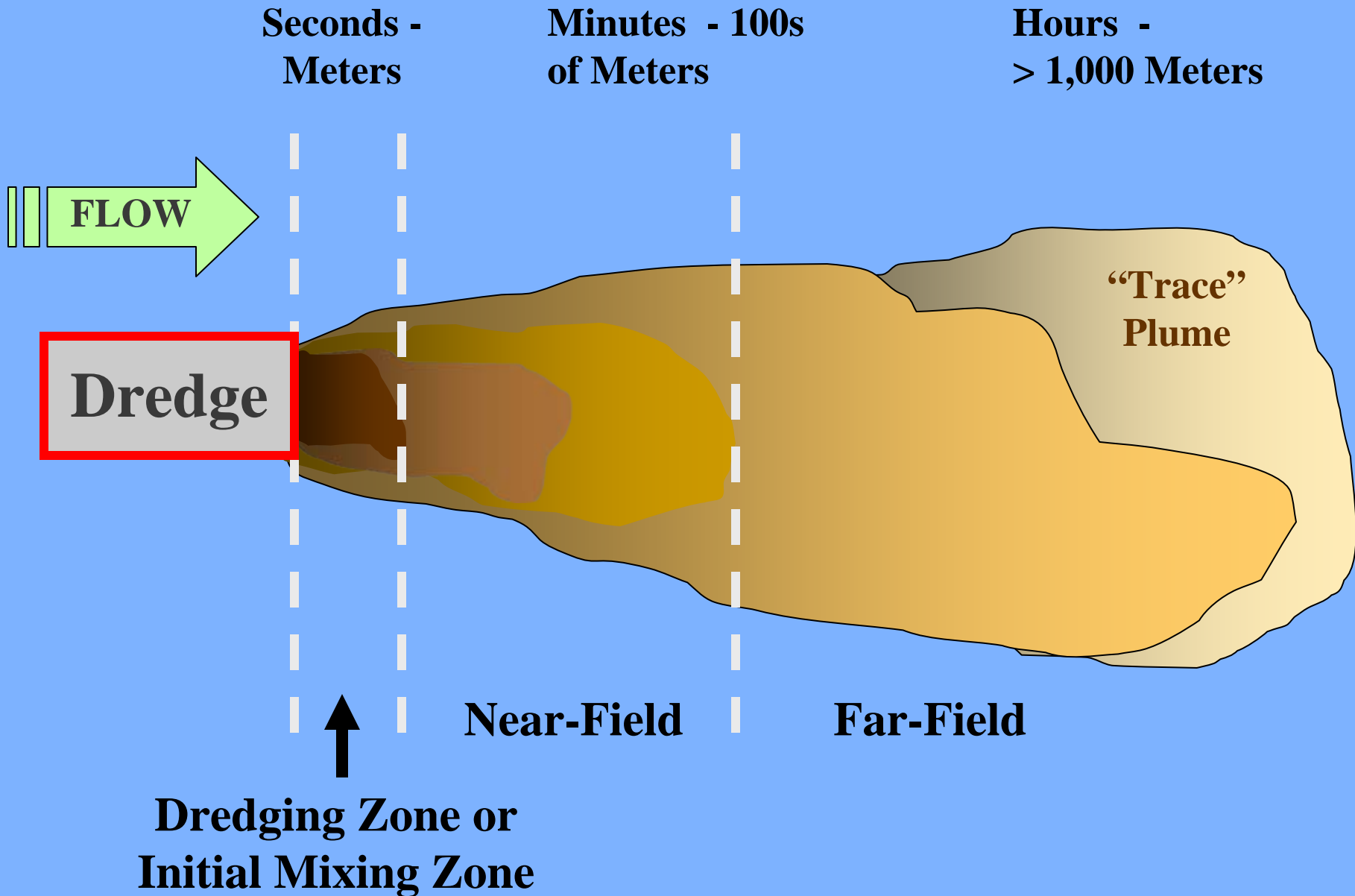
# Evaluation of Resuspension

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- Fate and transport models have become more sophisticated with improved understanding and handling of fundamental processes
- Uncertainty still surrounds source terms
- Empirically-derived source models exist only for a limited set of dredge types and equipment, site conditions, and sediment and operational characteristics
- Reliable, comprehensive dredging source models are needed for accurate assessment of risk associated with resuspension
- Monitoring is required to verify source term

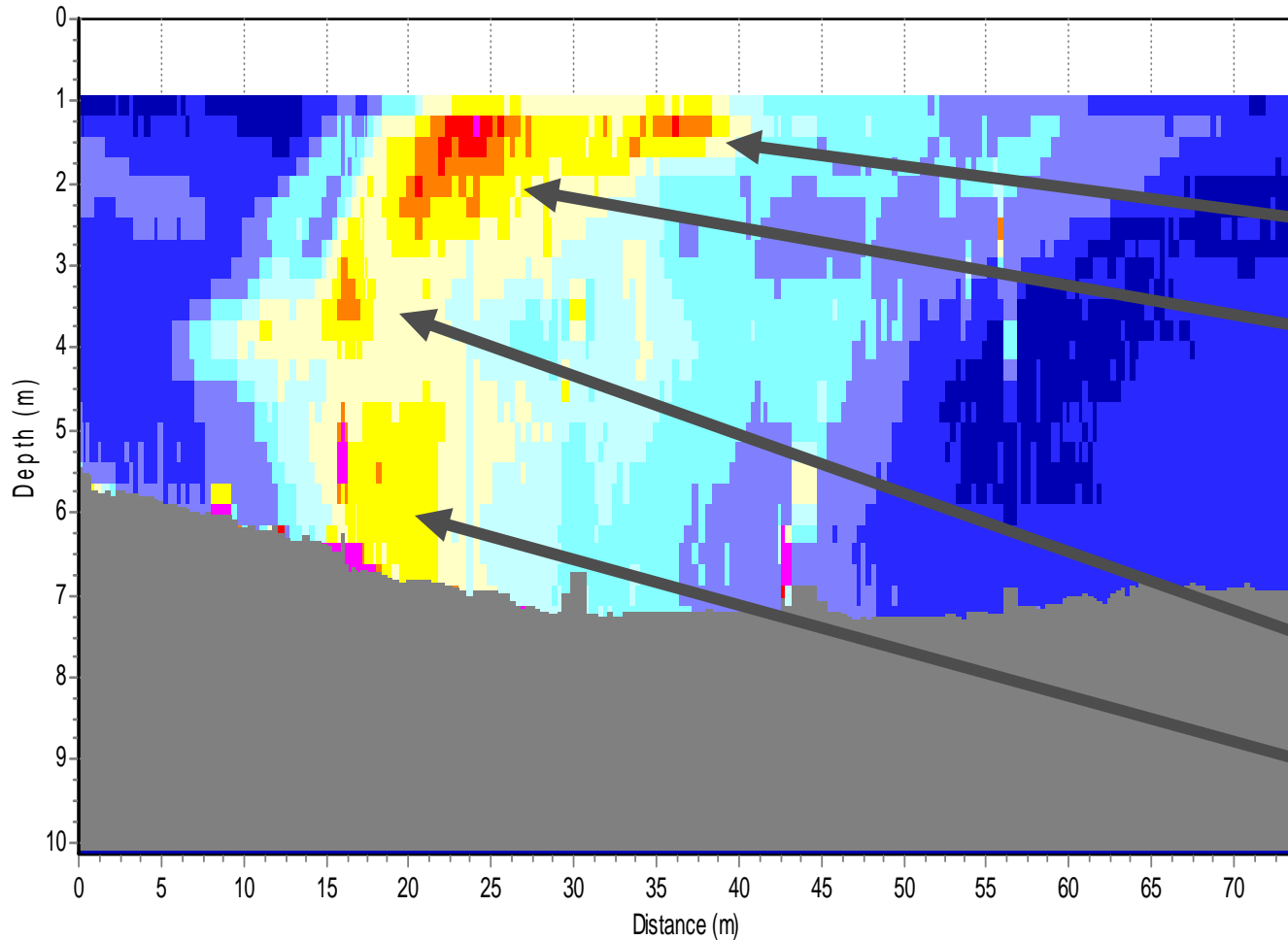


# Plume Spatial/Temporal Scales





# Bucket Dredge Plume Components



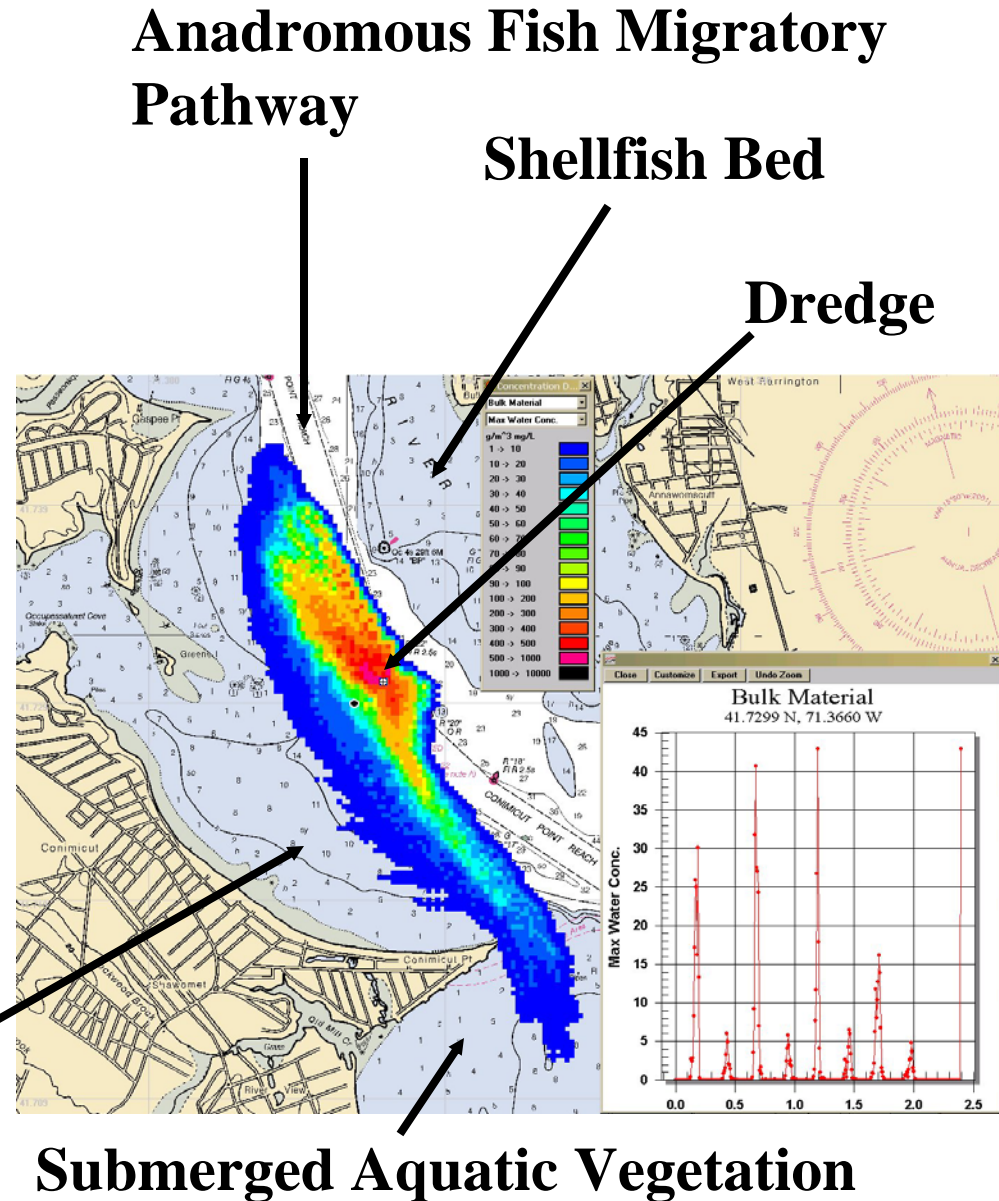
- slewing
- exit and initial leakage
- hoisting
- bed impact and separation

*Dredging Research Ltd*



# Characterization of Temporal Scales of Resuspension

- Difficult but necessary step in determination of exposures
- Exposures for different receptors may vary by orders of magnitude based on location in relation to the source over time
  - Even mechanical dredges are not stationary, but advance at a certain rate
  - Receptors may be mobile or sessile, thus exposures may change substantially based on the dredging scenario



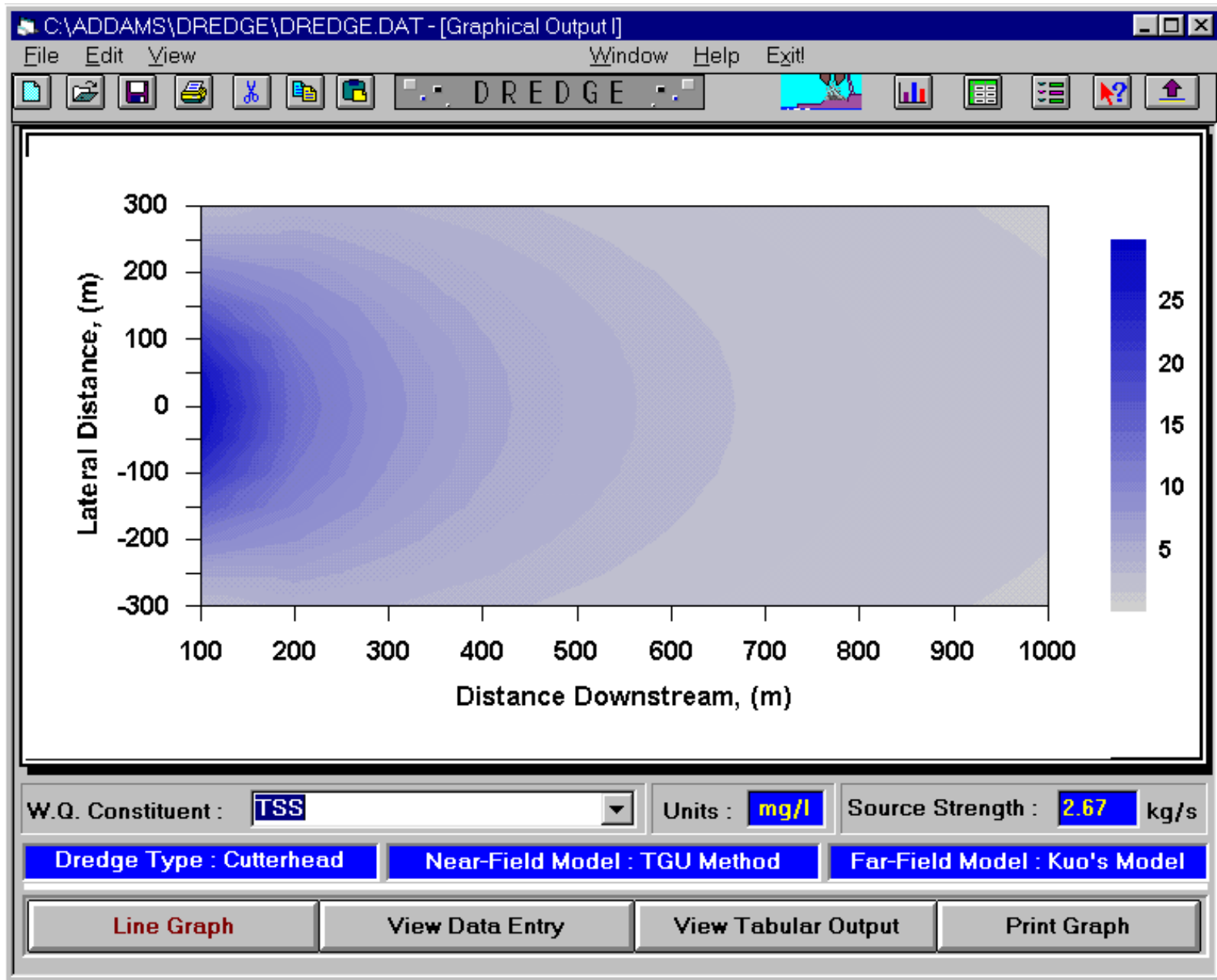
# Technical Challenges

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- **Effects of resuspension are difficult to characterize quantitatively because acute effects are seldom observed**
  - **Harm, if any, occurs at sublethal levels**
- **Predictive near- and far-field models have many advantages in support of risk-informed decisions**
  - **Require validation, calibration, and verification**
  - **Very few empirical data sets exist**
  - **Data expensive to obtain**

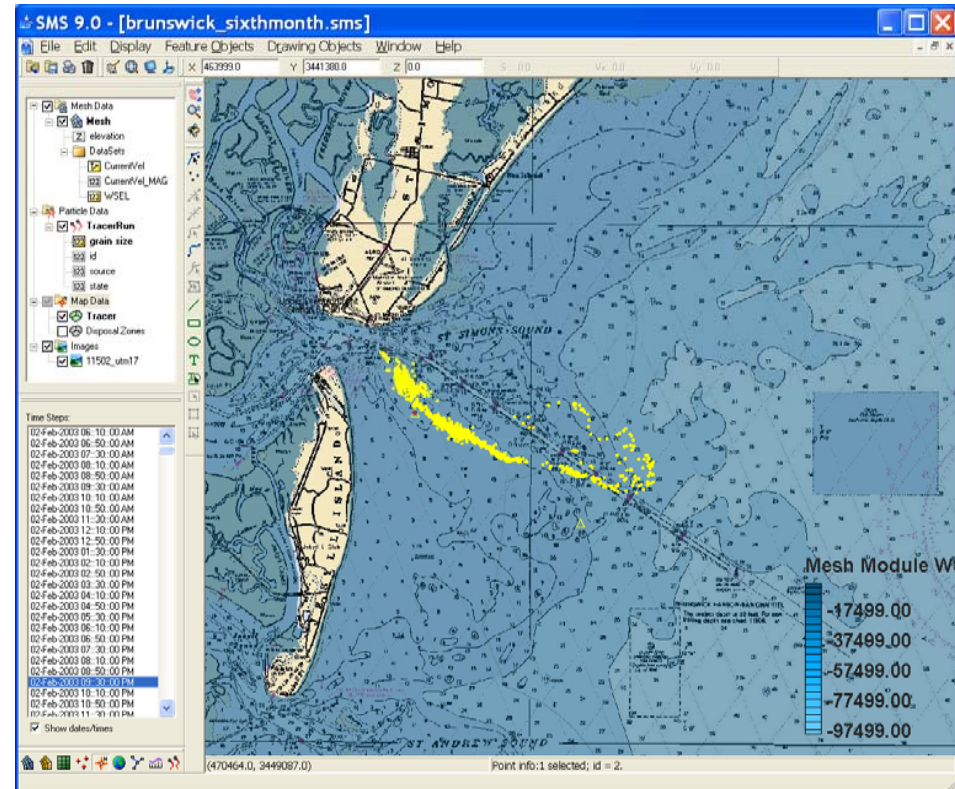


# DREDGE Model

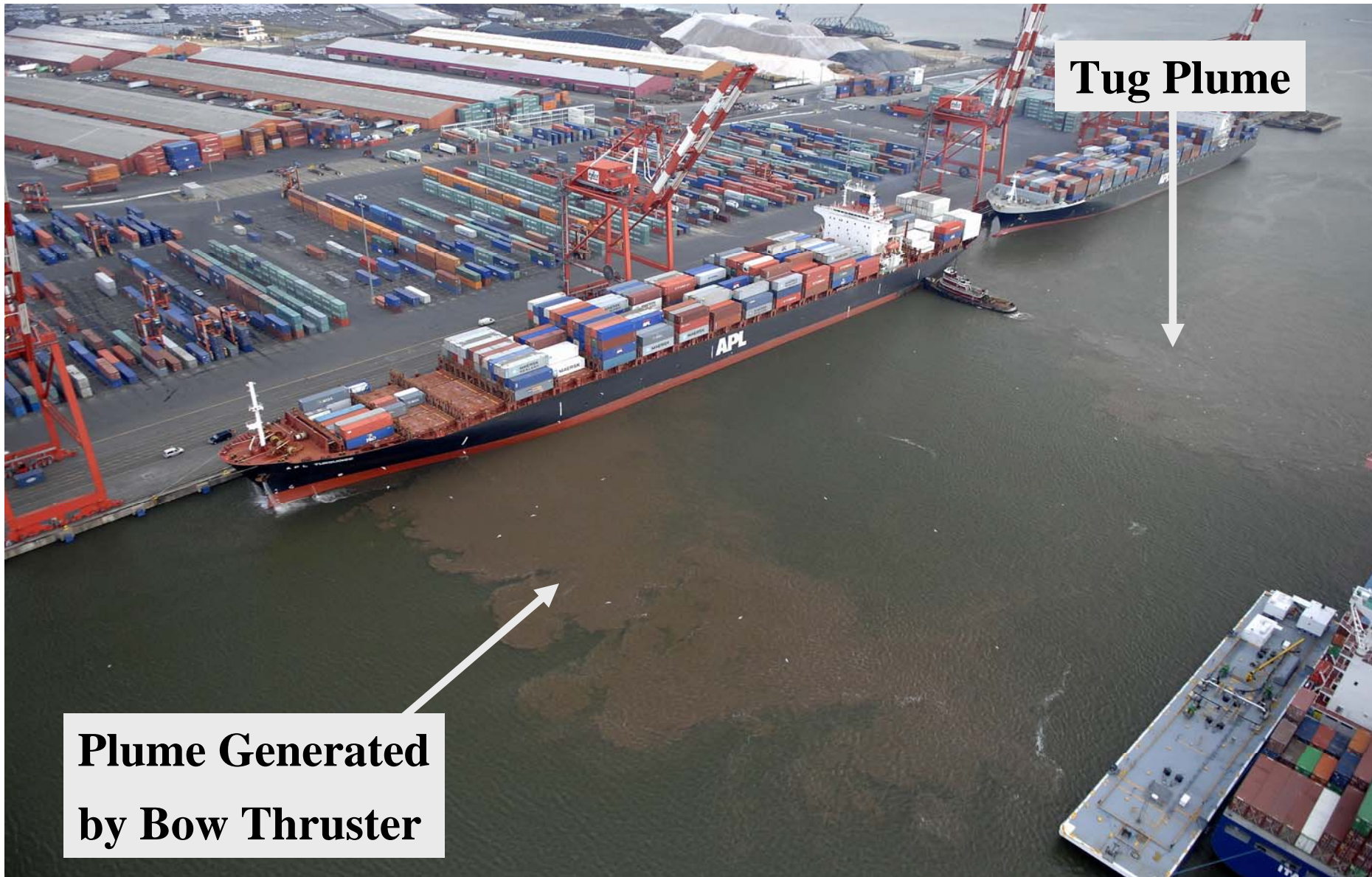


# Particle Tracking Model (PTM)

- 3D dynamic transport
- Follows size classes of sediment through complex grids
- Accepts external source term
- Ability to compute sediment deposition and re-entrainment
- Adding modules to track water quality and contaminants
- Adding module to calculate exposures of organisms to suspended or deposited sediment



# **Ships as a Source of Resuspension**



# Conclusions

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- **Resuspension issues form a basis for a majority of problematic environmental concerns associated with dredging and dredged material disposal**
- **These issues have proven to be exceedingly difficult to resolve**
- **Many sources of uncertainty exist regarding critical aspects of the process**
- **Risk-informed approaches represent a promising direction for instigating progress in an otherwise stagnant arena**



**The End**





# References

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- Bridges, T., Ells, S., Hayes, D., Mount, D., Nadeau, S., Palermo, M., Patmont, C., and Schroeder, P. 2008. The four Rs of environmental dredging: Resuspension, Release, Residues, and Risk. U.S. Army Engineer Research and Development Center, Environmental Lab ERDC/EL TR-08-4, 56pp. <http://el.erd.c.usace.army.mil/elpubs/pdf/trel08-4.pdf>
- Clarke, D. 2004. Environmental windows and the precautionary principle: Does practice make perfect? Proceedings of the 17<sup>th</sup> World Dredging Congress (WODCON XVII), Hamburg, Germany

