Modeling offshore mining turbidity sources

Towards Responsible Extraction of SUbmarine mineral REsources (TREASURE)

Funded by:

Frans van Grunsven
PhD student - Section Offshore and Dredging Engineering

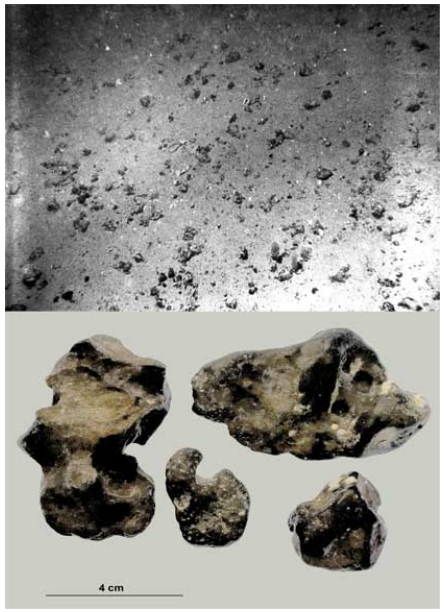
Overview

- Introduction to offshore mining
- Goal and scope of the research
- Research approach
- Progress and preliminary results
- Final overview and conclusions

Offshore mining

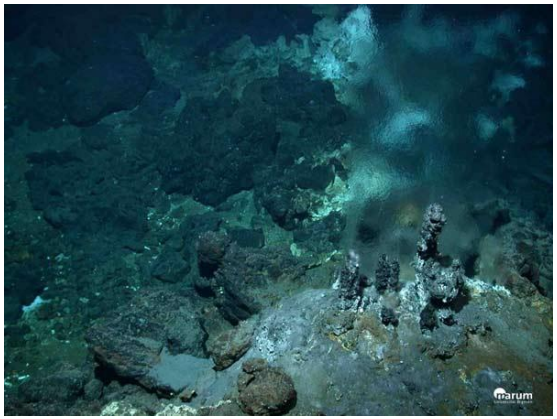
Main type of resources

Phosphorites



Source: NIWA – National Institute for Water and Atmospheric Research, New Zealand

Massive sulphides



Source: MARUM – Center for marine Environmental Research, University of Bremen, Germany

Polymetallic nodules

Source: WHOI – Woods Hole Oceanographic Institution, Massachusetts, USA

Depth: up to 400m

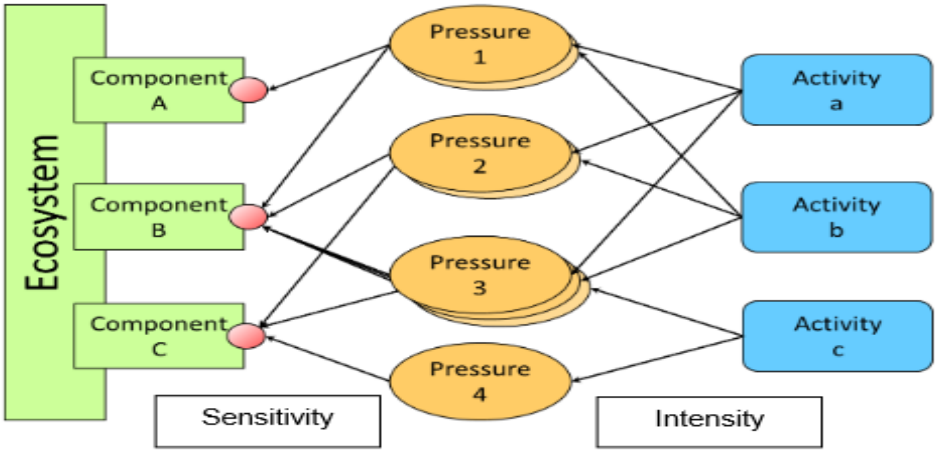
Depth: up to 3000m

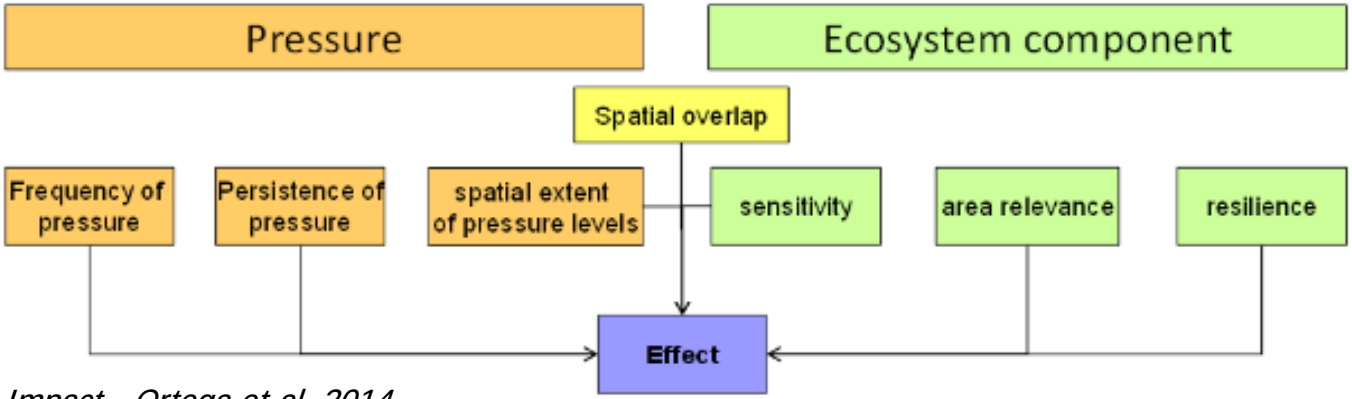
Depth: up to 6000m

Source: ISA – International Seabed Authority, Polymetallic Sulphides [PDF] & Polymetallic Nodules [PDF]

Offshore mining

Environmental Impact Assessments

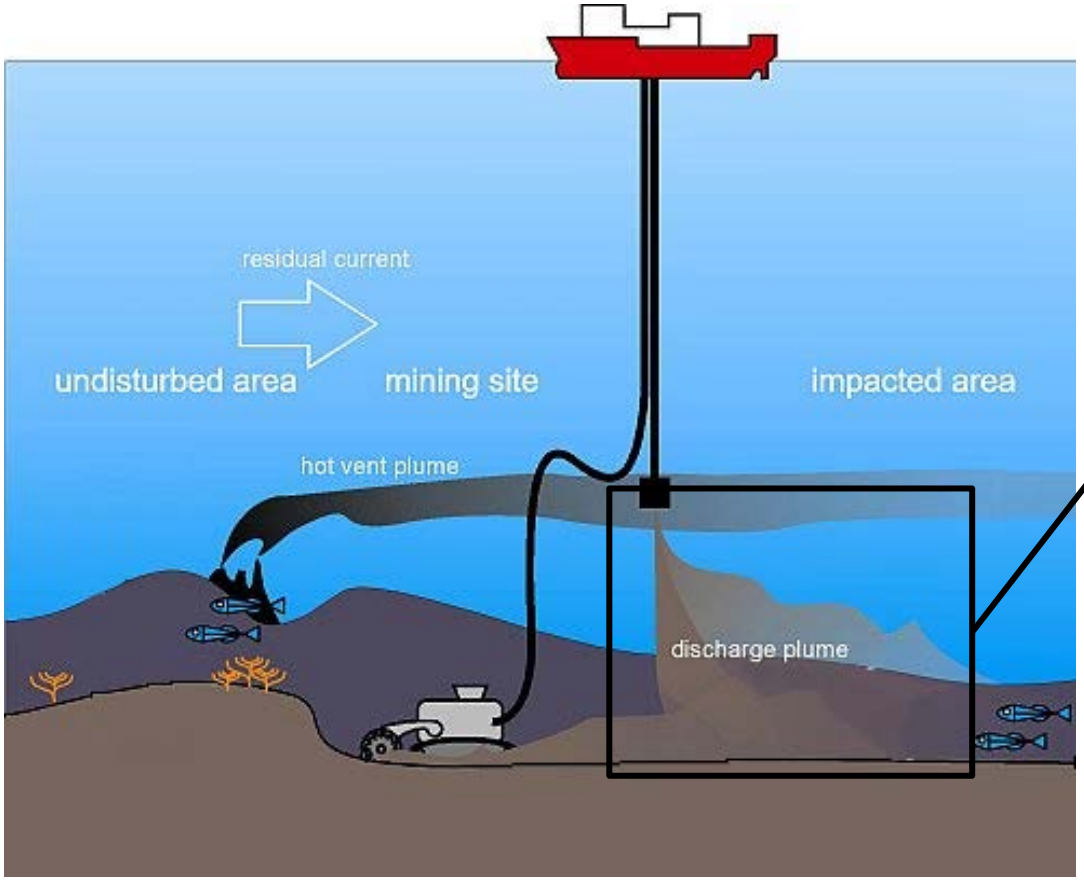




Towards Zero Impact - Ortega et al. 2014

Offshore mining

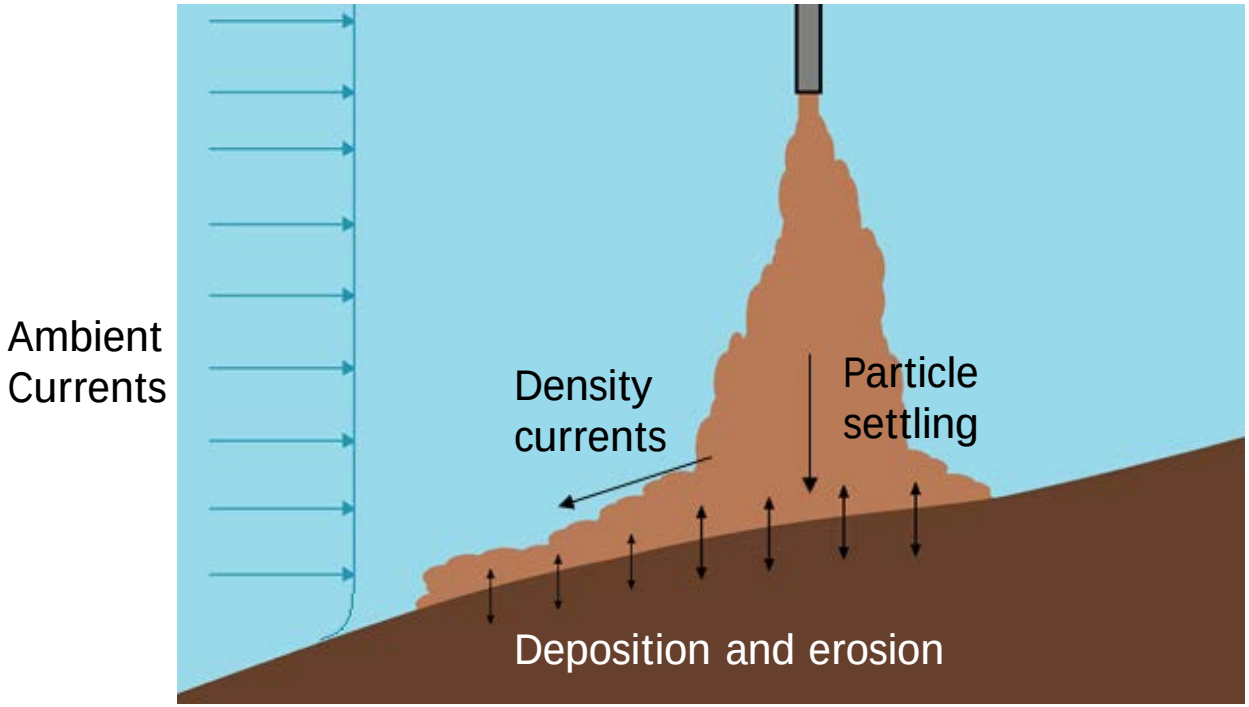
Technology



How to mitigate the **environmental impact** of a **discharge plume**?

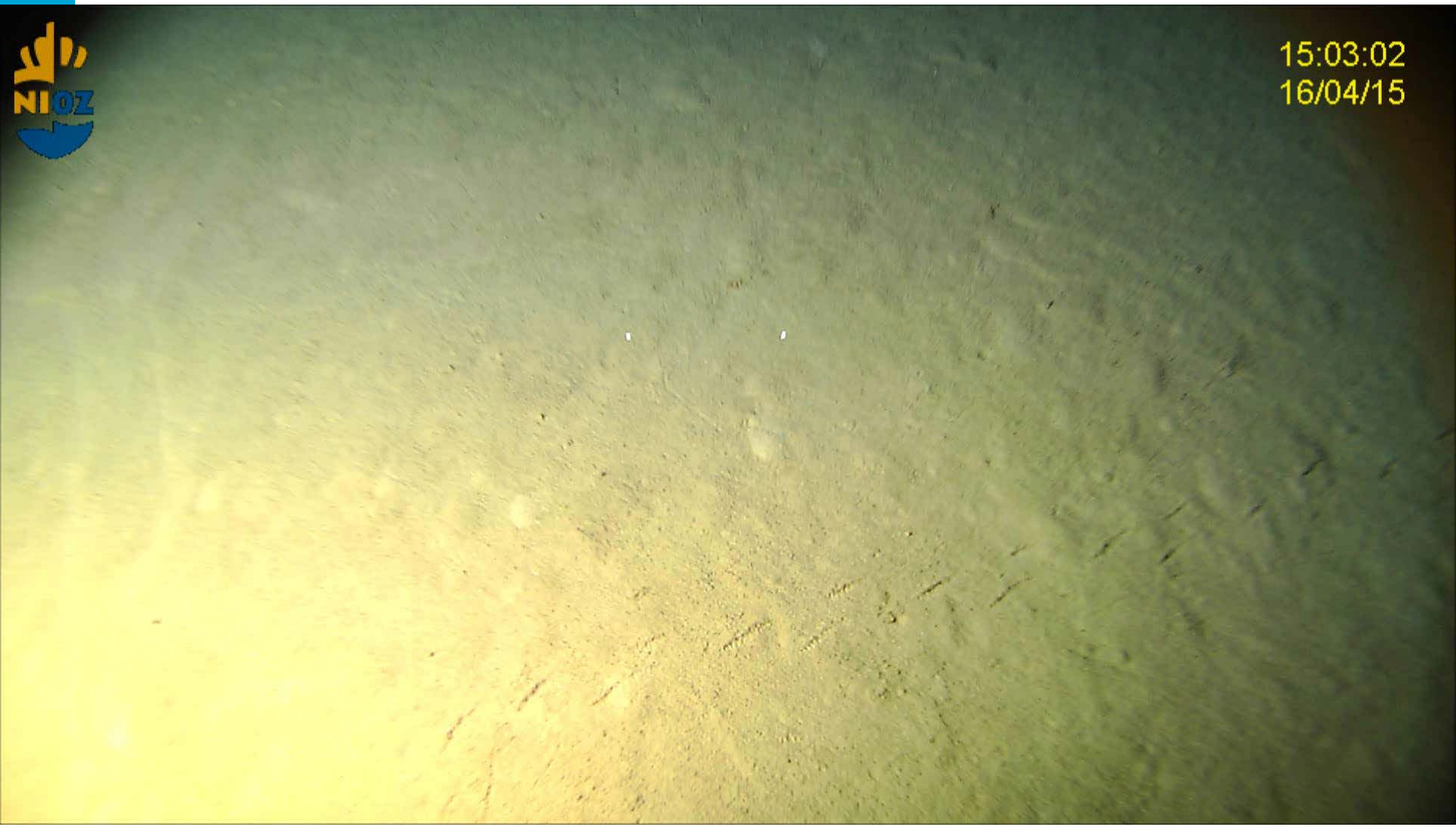
Offshore mining

Discharge plumes



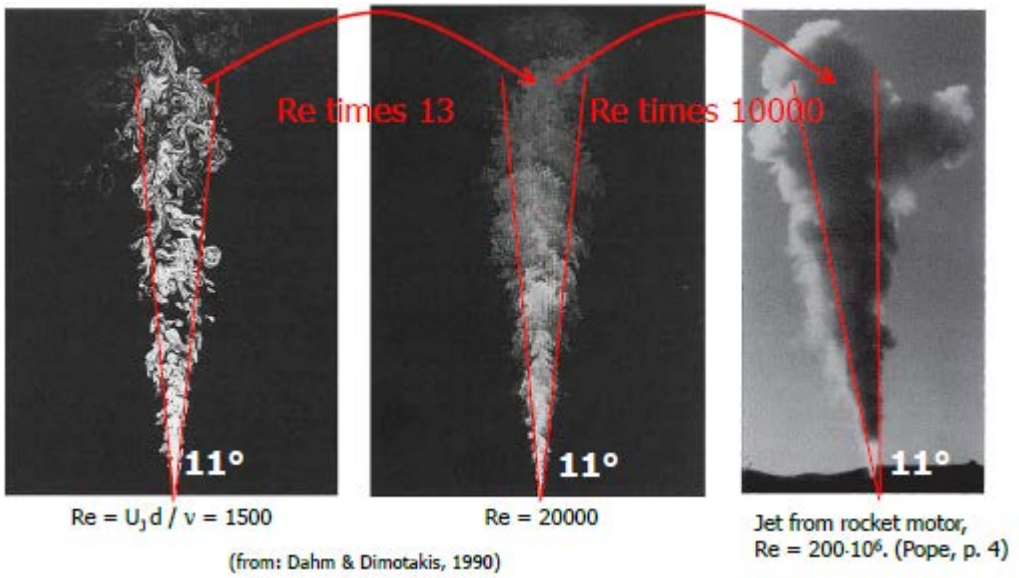
Offshore mining

Seabed disturbance



Jet and plume theory

Transition regimes

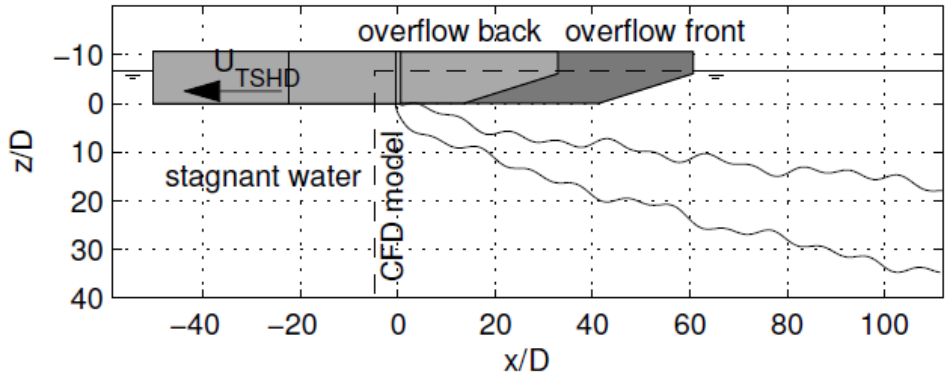


$$L_m = \frac{M_0^{3/4}}{J_0^{1/2}}$$

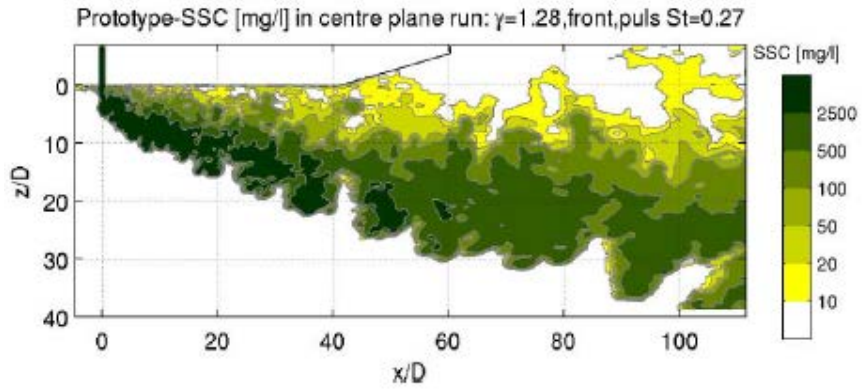
$$L_{b,\,plume} = \frac{J_0}{u_a^3}$$

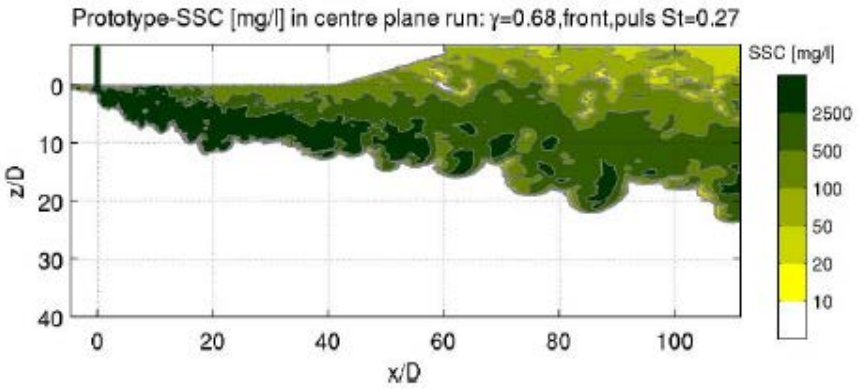
Approach

Trailing suction hopper dredger overflow plumes



De Wit (2015)





Approach

Numerical modeling

- Software: OpenFOAM
- 3 Dimensional Numerical model based on Navier-Stokes equations
- Combination of state-of-the-art models
  - Large eddy simulation to model turbulence
  - Drift-flux mixture model to model the slurry
- Calculated seabed erosion and deposition

Approach

Research

- Step 1: Turbulent jet in cross-flow or impinging

----------*validate with literature* ----------

- Step 2: Turbulent slurry-water jet in cross-flow or impinging
- Step 3: Include bed erosion and deposition

- Step 4: Dedicated laboratory experiments to validate the bed interaction

----------*validate with measurement data* ----------

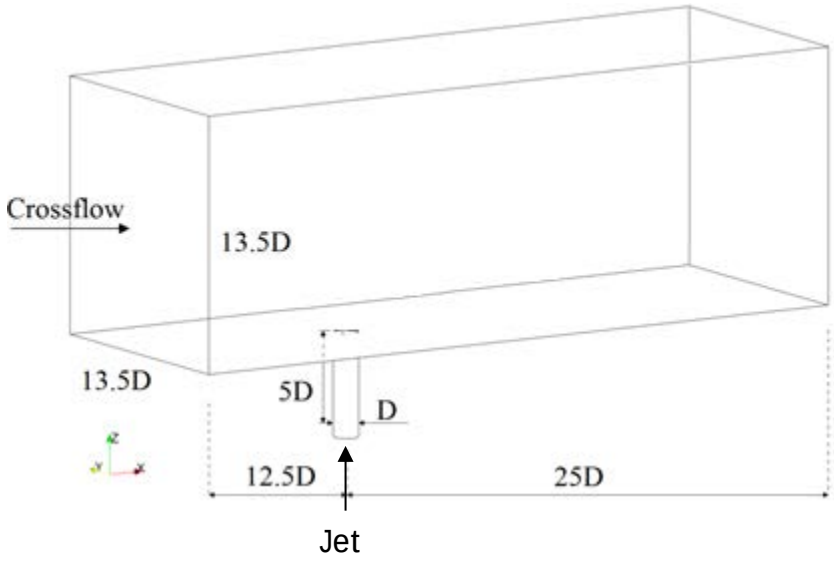
- Step 5: Run simulations to establish guidelines for best practice

Preliminary results

Single phase simulations – Round jet in cross-flow

Simulation details:

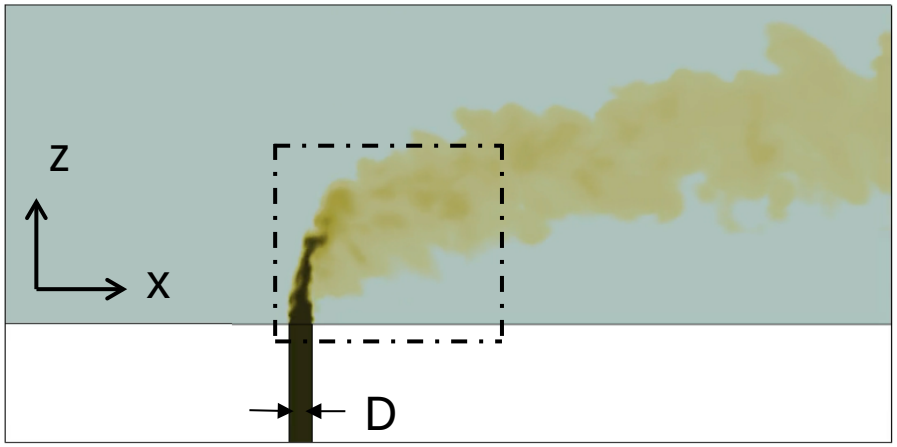
- Mesh order of 7 x 10^6 grid cells
- 2^{nd} order numerical accuracy
- WALE sub-grid scale stress model
- Uniform distributed & constant inflow

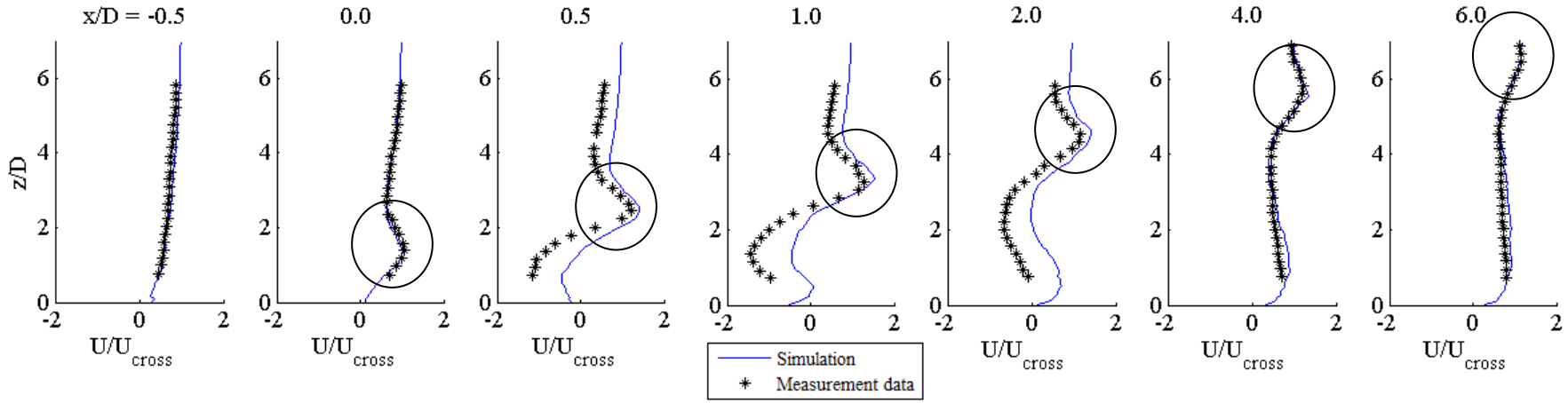


After measurements of Galeazzo *et al.* (2013)

Simulations

Single phase simulations – Round jet in cross-flow

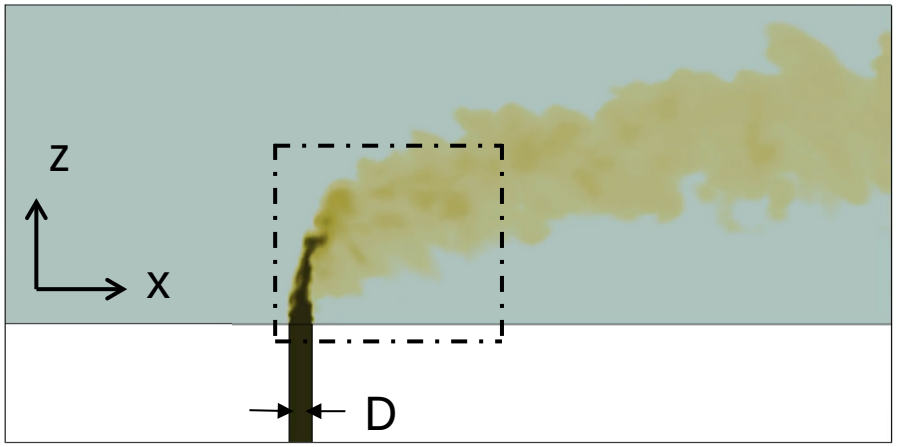


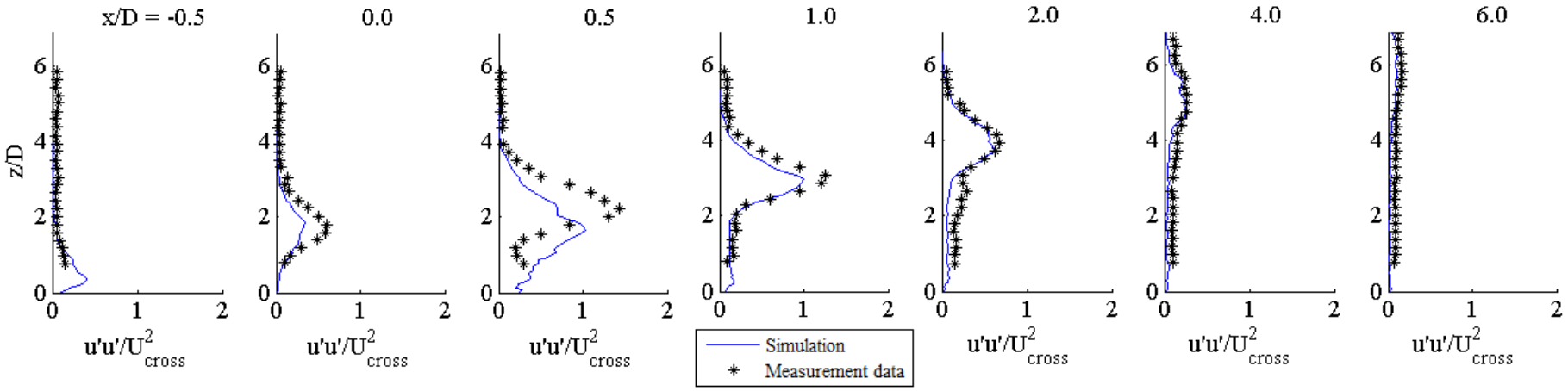


Measurement data from Galeazzo *et al.* (2013)

Simulations

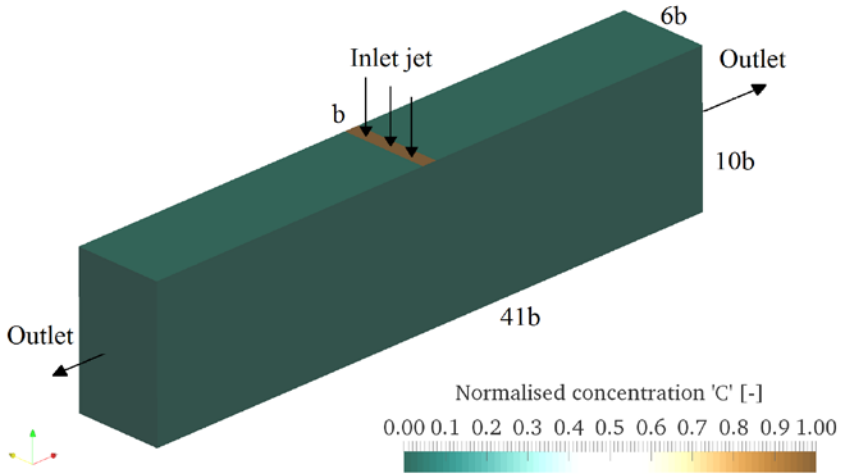
Single phase simulations – Round jet in cross-flow

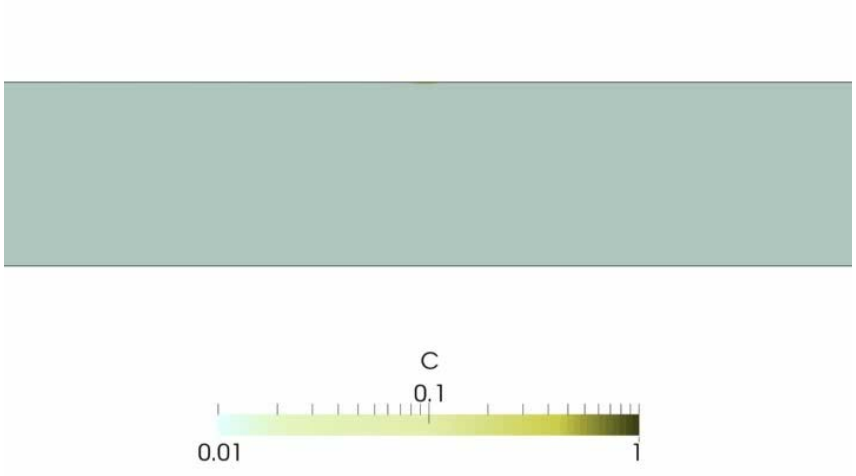




Simulations

Single phase simulations – Impinging slot jet

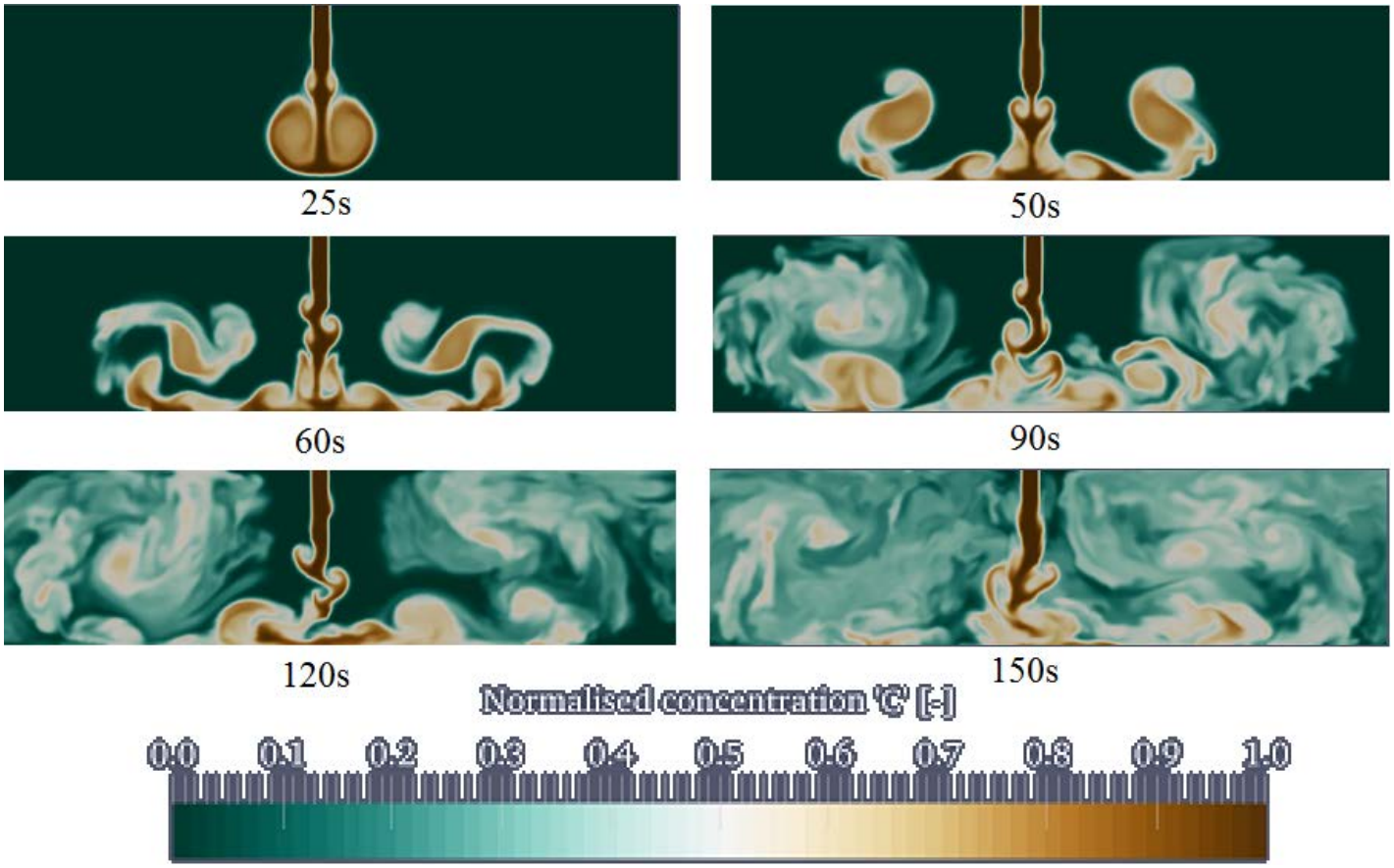




After measurements of Maurel and solliec (2001)

Simulations

Single phase simulations – Impinging slot jet



Simulations

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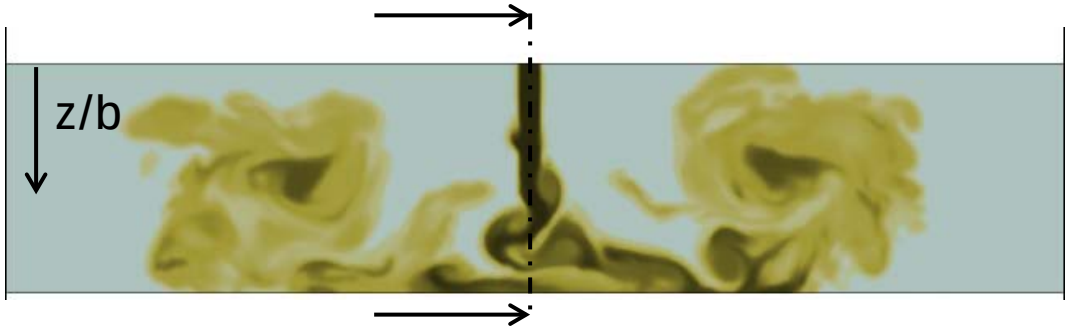
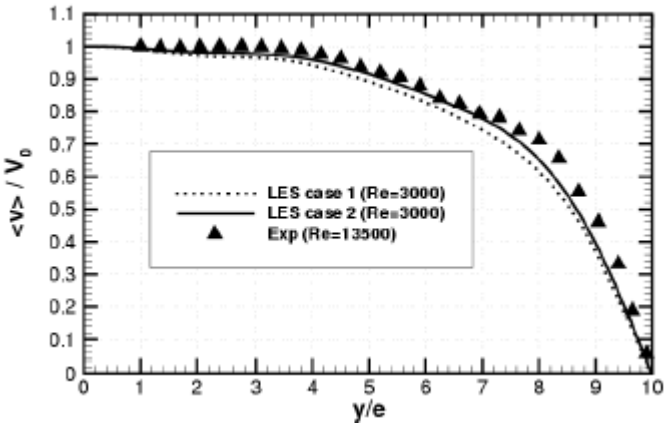
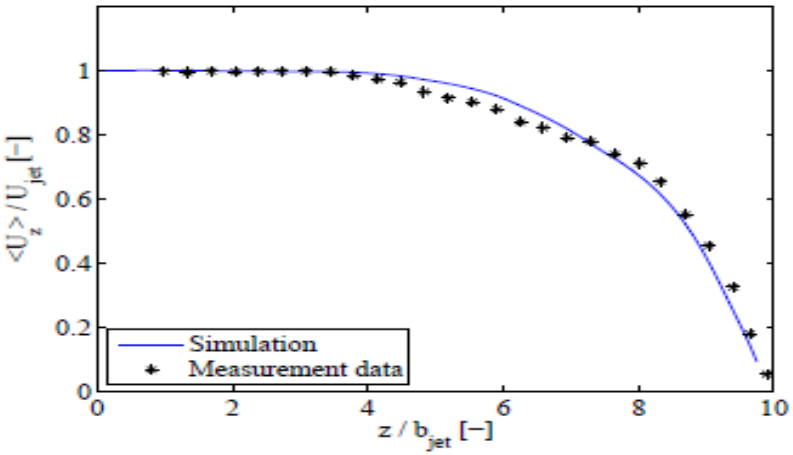


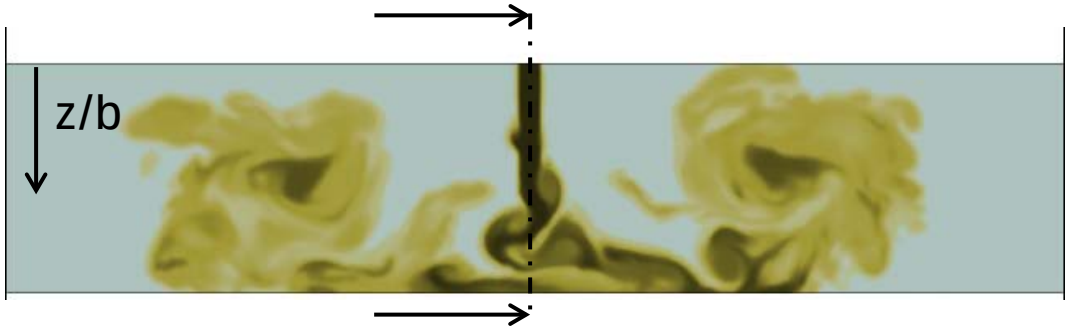


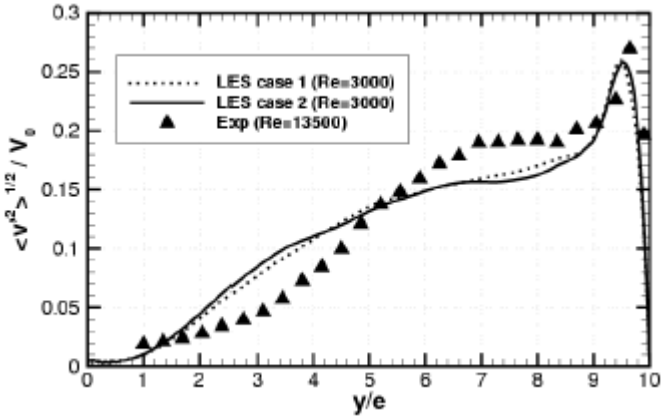


Beaubert and Viazoo (2001)

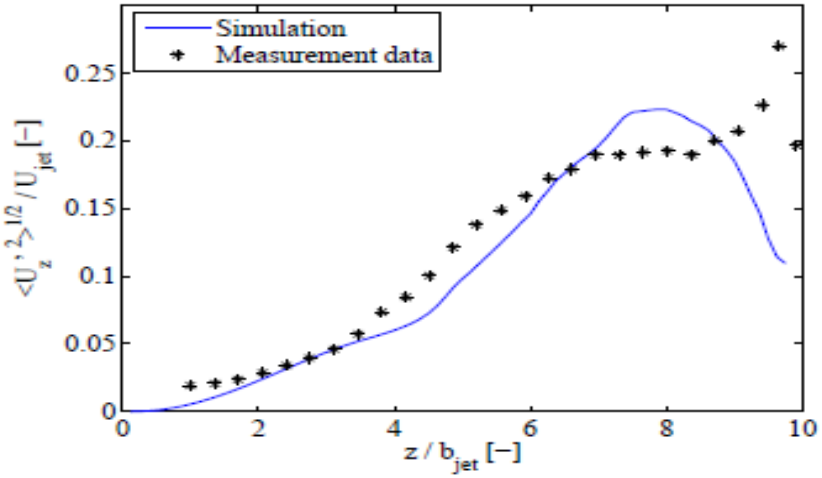
Simulations

Single phase simulations – Impinging slot jet





Beaubert and Viazoo (2001)



Preliminary results

- Chosen LES model (WALE) is validated within software OpenFOAM.
- Standard wall-functions will not work for impinging jets

Next step:

- Test the combination of the slurry and turbulence model.

Research overview

How to study the impact of offshore mining discharge plumes?

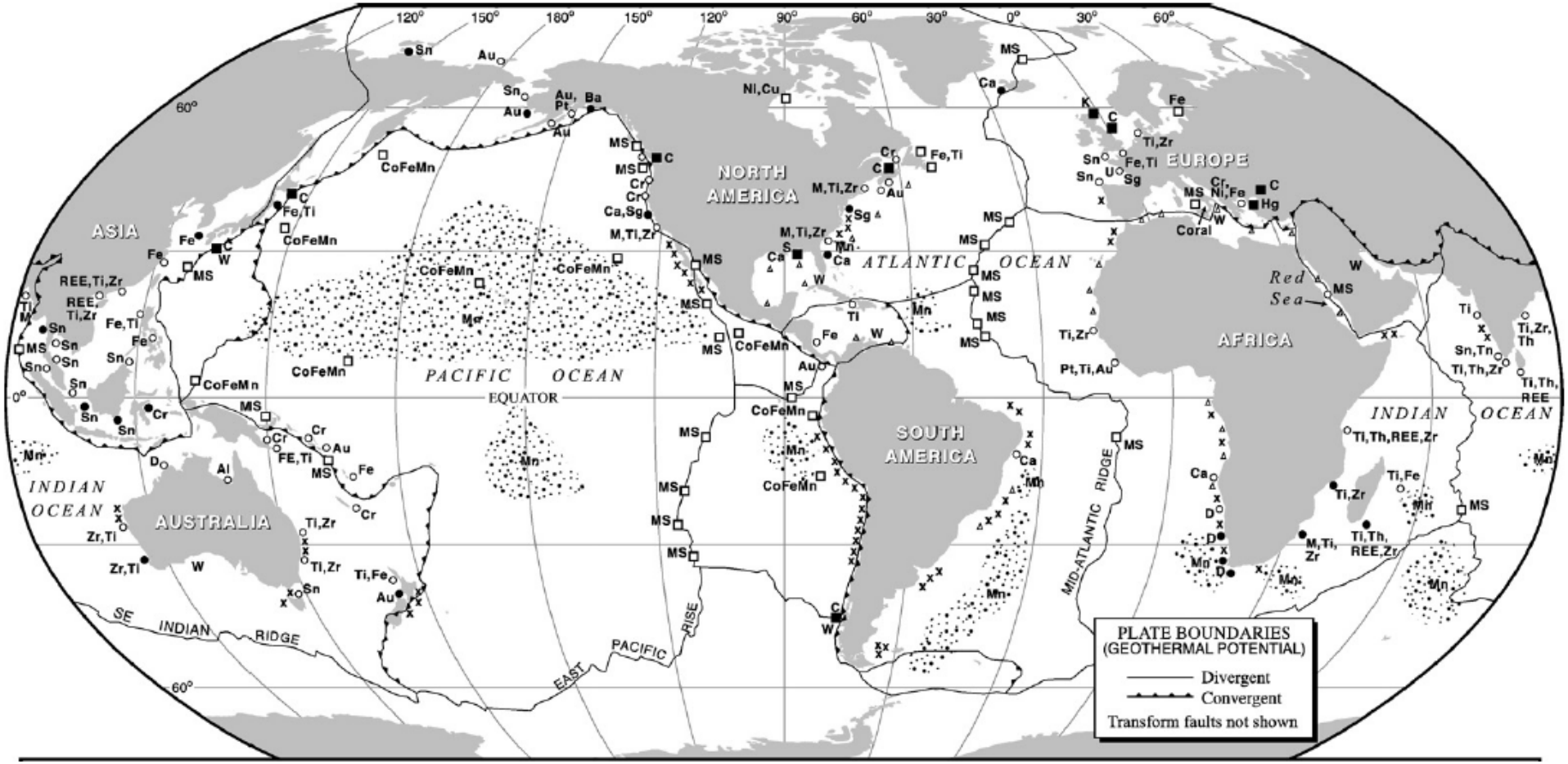
1. Capture the behavior in a numerical model
2. Validate the numerical model
3. Run various simulations
4. Construct advice for impact mitigation

Thank you for your attention!

Deep-sea mining

Known sites

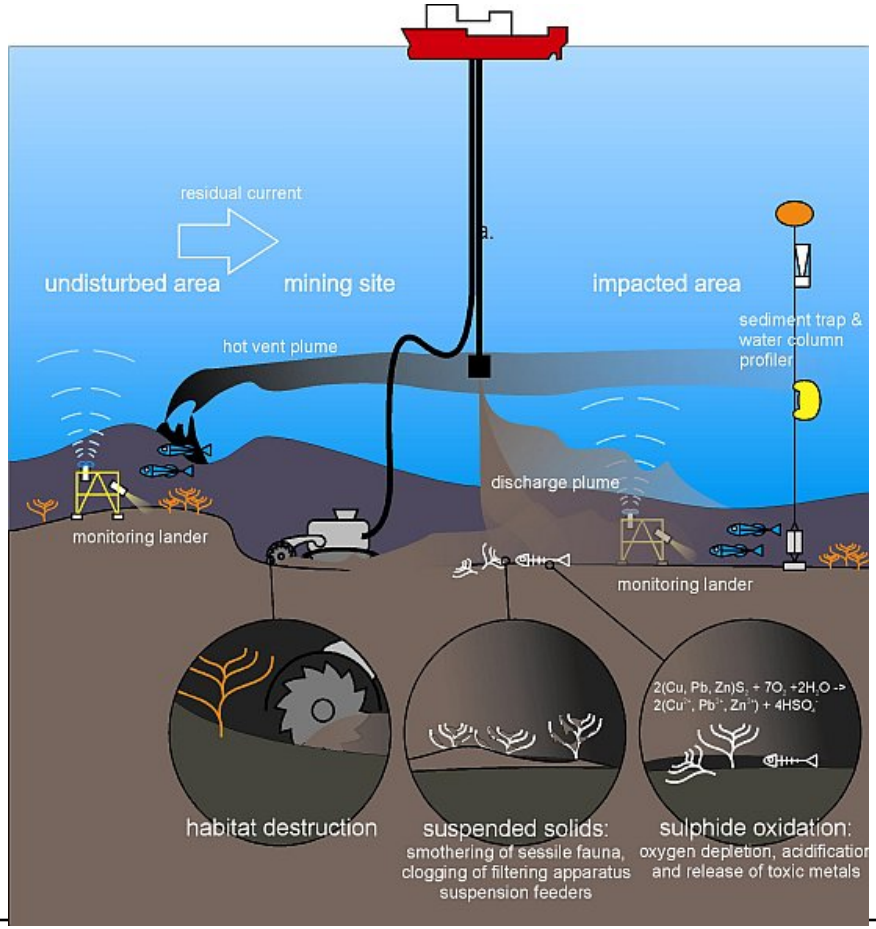
x = Phosphorites MS = Massive sulphides .·.·. = Polymetallic nodules



Source: P.A. Rhona, 2008.

TREASURE: 2014-2018

Towards Responsible ExtrAction of SUbmarine mineral REsources



WP 1 - NIOZ Inventory of the physiscal environment	WP 2 - TUD Tool to predict the dispersion of solids	WP 3 - NIOZ Assesment of the chemically reactive substances
WP 4 - NIOZ Inventory of the ecosystem and recovery potential	WP 5 - WUR Establish a framework for impact prediction	WP 6 - WUR Establishment of acceptence criteria
WP 7 - NIOZ Field testing of the developed approaches and toolbox in a mid-ocean ridge hydrothermal field		

General and practical approach to predict, monitor and mitigate the impact of deep-sea mining, which is succesfully tested in the field.