WEDA Dredging Summit & Expo'18

Modeling the Transport and Fate of Sediments Released from Dredging Projects in the Coastal Waters of British Columbia, Canada

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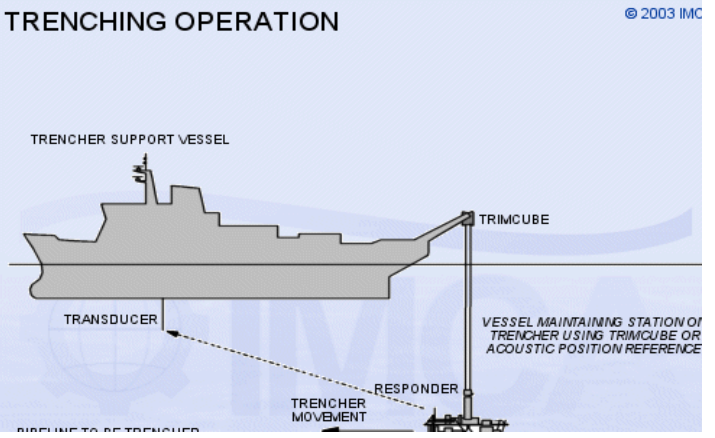
Outline

- Dredging Projects: Nature of Activities
- Addressing Environmental Requirements for Dredging Projects: Role of Numerical Models
- Physical Setting of British Columbia Coastal Waters
- Numerical Modeling Approaches and Methods
  - 3D Hydrodynamic Models
- Examples of Sediment Transport/Fate Numerical Models
- Summary

Dredging Projects: Nature of Activities

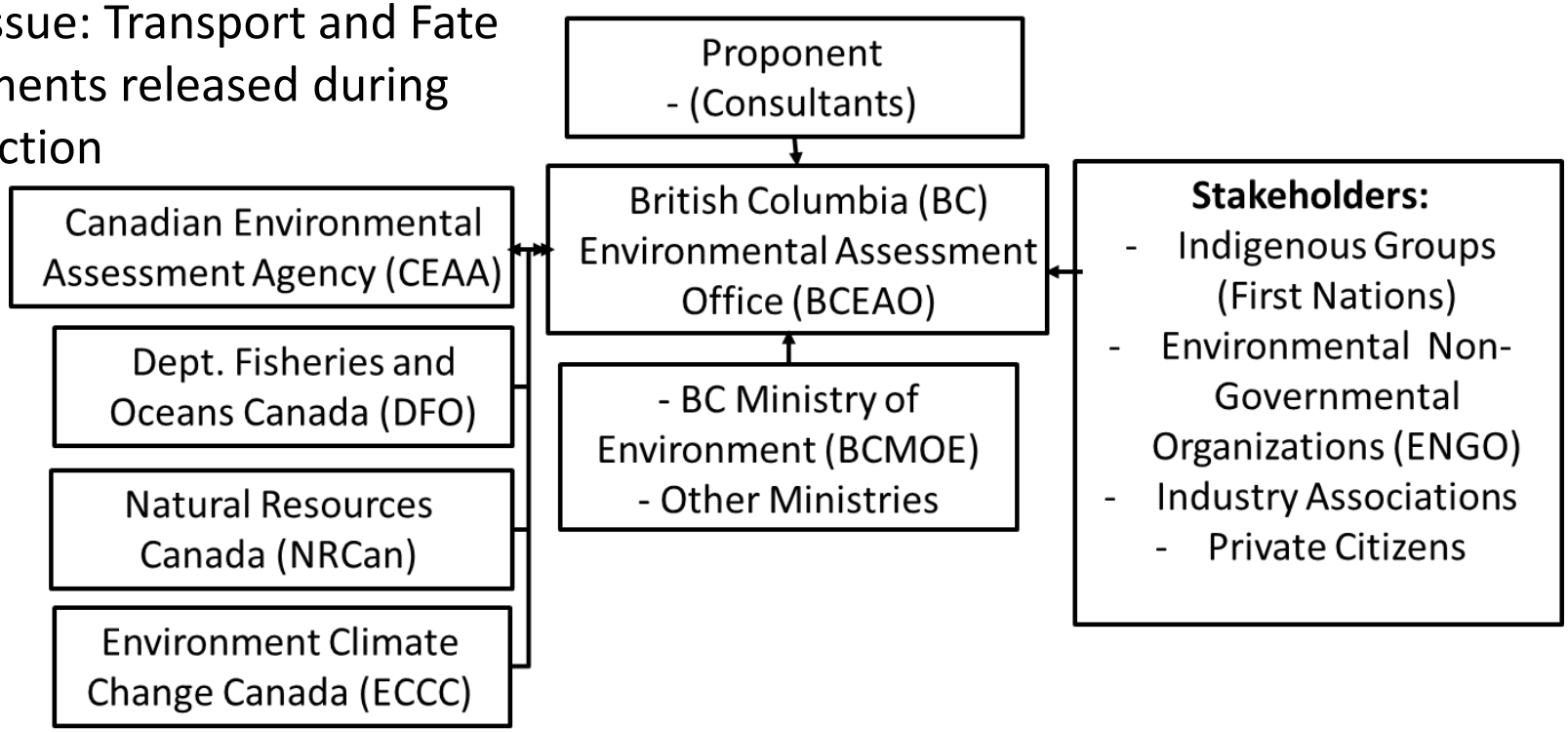
- Dredging for Ports and Harbor Expansion
- Trenching and Backfilling for:
  - Marine Pipelines
  - Underwater Cables



Addressing Environmental Requirements for Dredging Projects: Role of Numerical Models

- Dredging Projects must Address Environmental Issues as part of the Regulatory Approval Process.
- Often the Greatest Challenge (*IADC and IAPH, 2011*[1])
- Major Issue: Transport and Fate of Sediments released during Construction

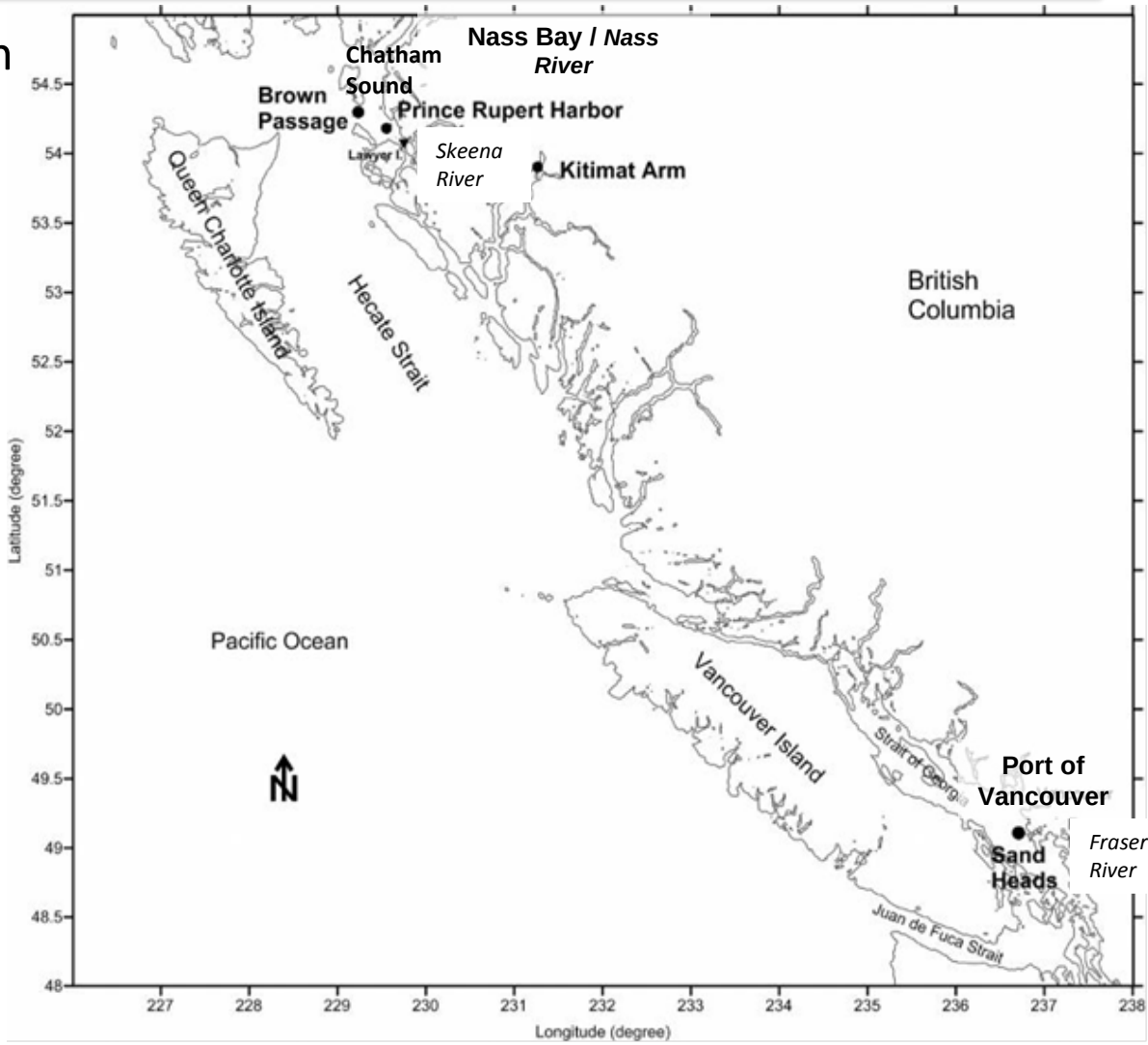
- Numerical Models Provide a Way to Quantify Effects on the Marine Environment.
- Examples of Models for Environmental Assessment in the Jurisdiction of British Columbia, Canada.



[1]*IADC (International Association of Dredging Companies and IAPH (International Association of Ports and Harbors) (2011). Dredging for Development. Eds. Nick Bray and Marsha Cohen, Sixth Edition, The Hague, Netherlands, 86 p.*

Physical Setting of British Columbia Coastal Waters

- Extends from NE Pacific Ocean continental margin in the east
  - water depths: up to 1800 m
  - inland seas and deep fjords extending into the mainland
- Highly energetic forcing:
  - seasonally large winds (fall and winter)
  - large tides – especially in the northern BC waters
  - major fresh water discharges, including the Fraser, Skeena and Nass Rivers
  - results in a high degree of density stratification of the water column.



3D Models Required: *Numerical models must represent the vertical variations in ocean currents and other water properties such as temperature, salinity and density*

Numerical Modeling Approach and Methods

Overview of modeling methods for addressing environmental assessment issues.

Release of Dredging Sediments:

- Represents the Initial Mixing / Dilution (IM/D) of Released Sediments
- Release Rate varies with Dredging Activity / Equipment Used
- Very Large Range: 0.2 – 10% (Dredging)
- Simplified When Model Grid Elements Match Initial Release Activity Volumes
- For Very High Resolution 3D Models (grid sizes of tens of meters), IM/D models may not be Required;
- IM/D models are Often Required for Other Activities, e.g. Disposal at Sea, Cutter Suction Dredge Pipe Discharges
  - Examples: STFATE and CDFATE (ADDAMS models)
- Representing Mitigative Measures: e.g. Sheet Piles and Silt Curtains

3D Hydrodynamic Model:

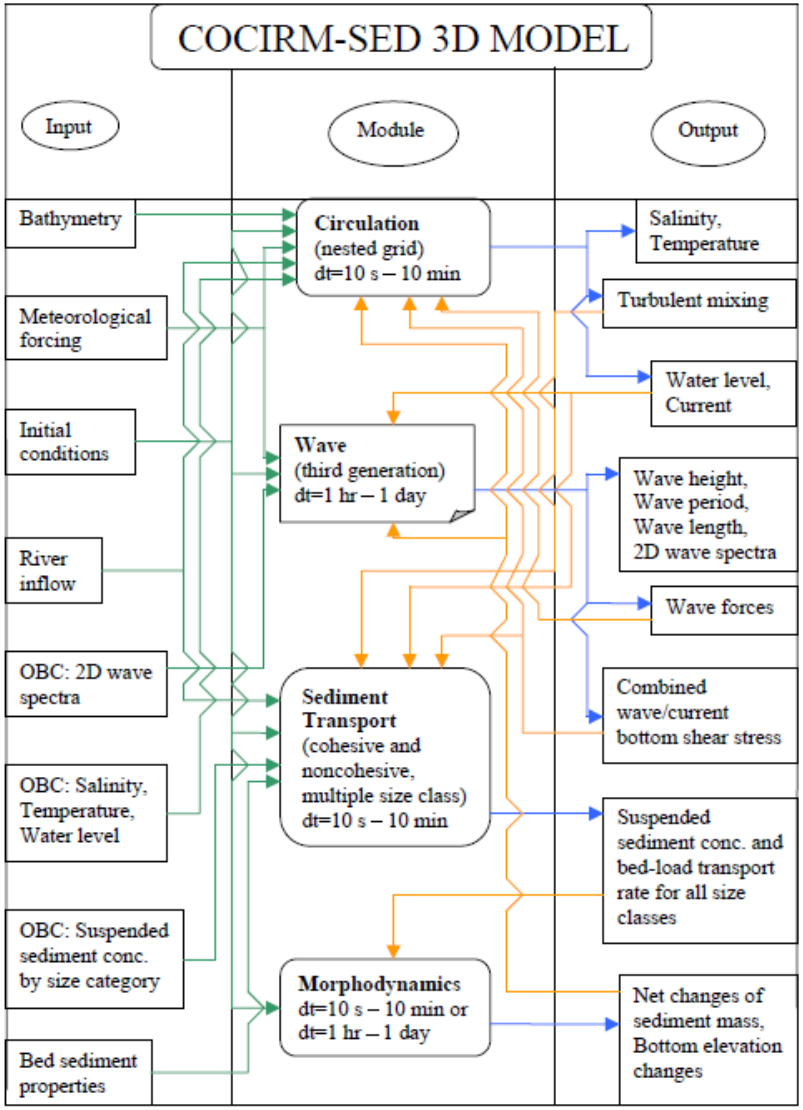
- Computes the 3D Circulation and Densities of Receiving Waters
- Examples to Follow

Model Outputs: for Env. Analyses

Sediment Transport Computational Module:

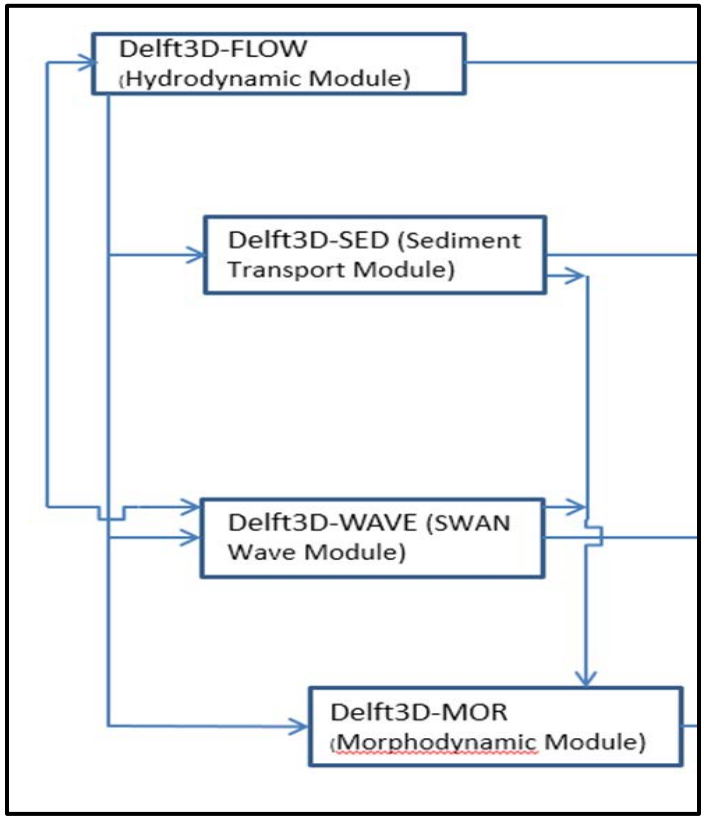
- requires input of percentage fraction for typically 4-8 sediment particle size categories
- Simulates by size category:
  - Settling Velocities
  - Suspended Sediment Concentrations
  - Deposition (area and thickness)

3D Hydrodynamic Models



Finite Difference Model: z- and sigma layers (10-30 vertical layers)
Horizontal Grid Size: 10 – few hundred meters

Schematic Diagrams of 3D Models



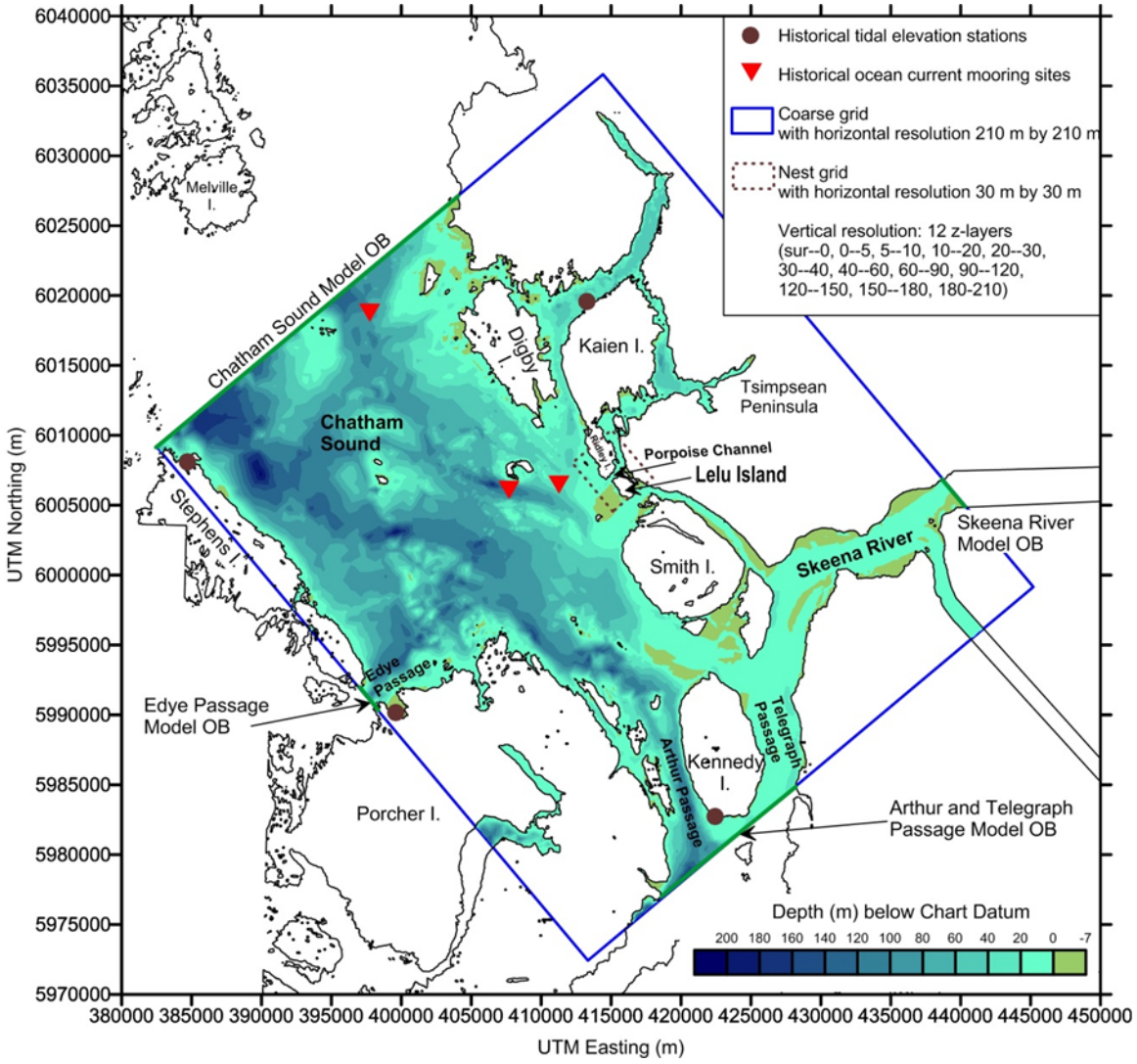
Supports Curvilinear and Spherical Coordinates; Horizontal Grid and Vertical Resolution similar to COCIRM

FVCOM 3D Hydrodynamic and Sediment Model (under development)

Sediment Transport Numerical Models - Examples

Geographical Area	Dredging Activity	Grid size (and vertical layers) Model	Literature Reference
Roberts Bank, Strait of Georgia	Vancouver Island Transmission Reinforcement (VITR) Project: trenching of large underwater electrical cables in shallow water.	10 m nested grid within 50 m (13 layers), COCIRM-SED	Jiang et al. (2008)
Kitimat Harbor	Dredging of marine berths at proposed oil export marine terminal for the Northern Gateway Project	20 m nested within 100 m (20 layers), COCIRM-SED	Fissel et al. (2006)
Prince Rupert Harbor	Dredging in Harbor, Disposal at Sea	100 m (22 layers), COCIRM-SED	Jiang and Fissel (2011)
Brown Passage	Disposal at Sea of marine dredgates from Dredging in Prince Rupert Harbor	100 m (22 layers), COCIRM-SED	Jiang and Fissel (2012); Lin et al (2016)
Porpoise Channel near Prince Rupert	**Dredging of Materials Offloading Facility (MOF) for the Pacific North West LNG Project**	**30 m nested within 210 m (12 layers), COCIRM-SED**	**Lin and Fissel (2013)**
Casey Cove near Prince Rupert	**Dredging of marine berths and the Materials Offloading Facility (MOF) for the Nexen Aurora LNG Project**	**30 m nested within 210 m (13 layers) , COCIRM-SED**	**Scoon et al. (2016)**
Kitimat Harbor	Dredging of LNG marine terminal for the LNG Canada Project	20 m nested within 100 m (20 layers), COCIRM-SED	BC EAO (2015)
Nass Bay and Iceberg Bay; Nasoga Gulf	Trenching and backfilling of marine gas pipeline	10 m in vicinity of pipeline, otherwise 35 m (10 layers), Delft3D-SED	BC OGC (2017)

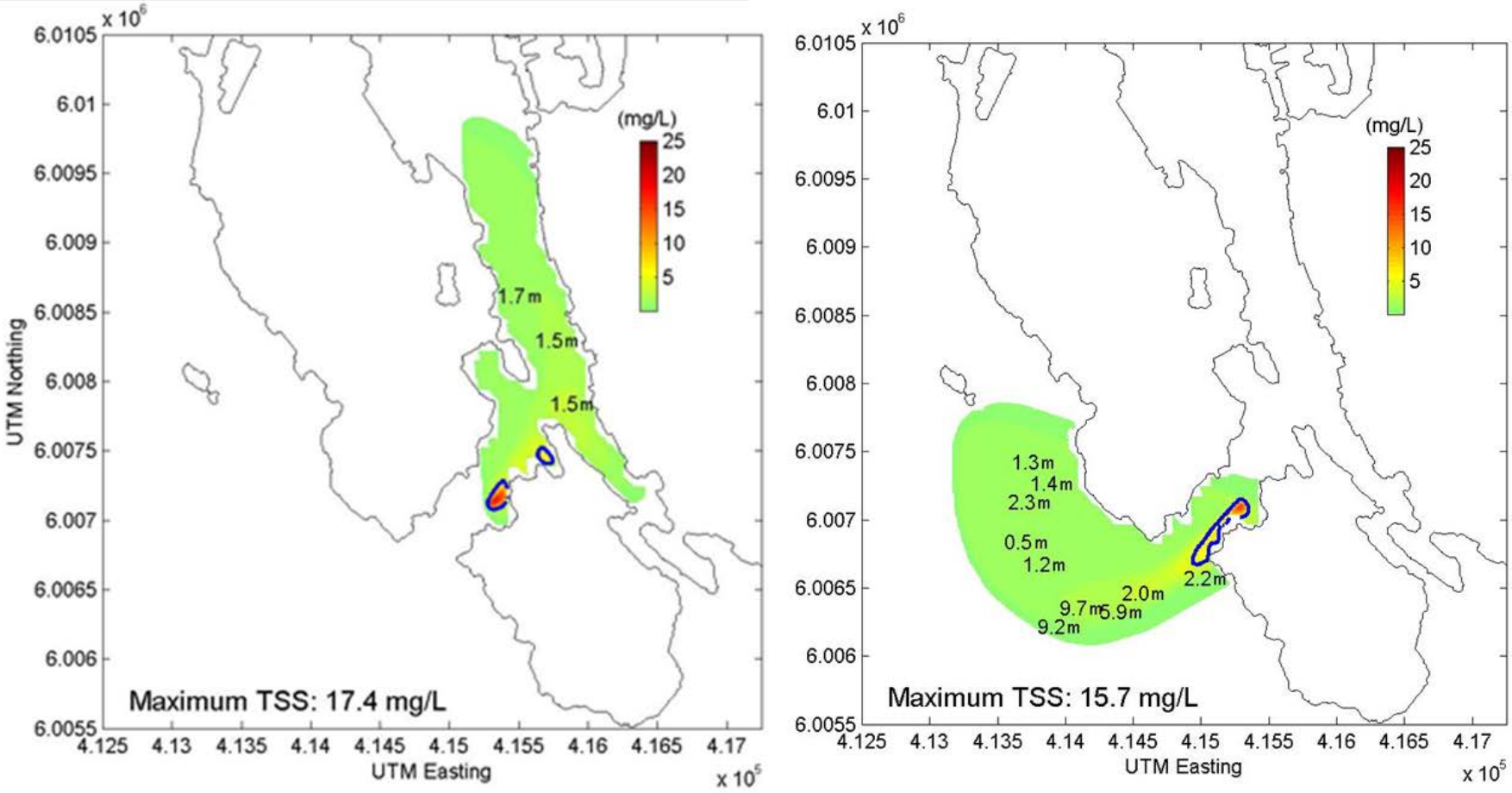
Examples of Sediment Transport/Fate Numerical Models: Chatham Sound – Porpoise Channel



Dredging for new Marine Offloading Facility in Porpoise Channel:

- 30 m horizontal grid (nested) within 210 m grid (larger area)
- 12 z-layers

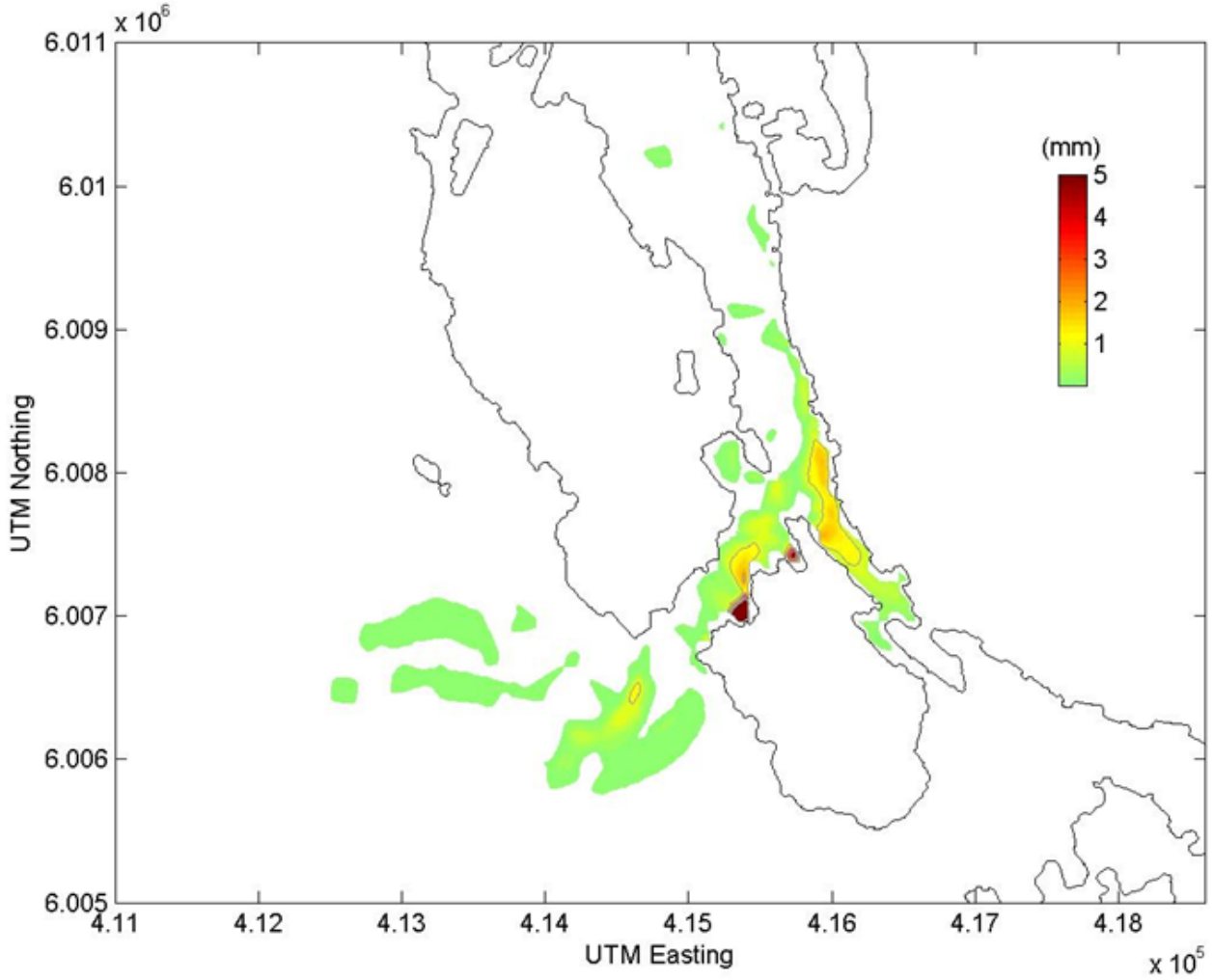
Examples: Chatham Sound-Porpoise Channel (Cont'd)



Model-derived SSC (mg/L above background, maximum value in the water column) at ebb flow (left panel, 21:00 January 12) and at flood flow (right panel, 21:00 January 12).

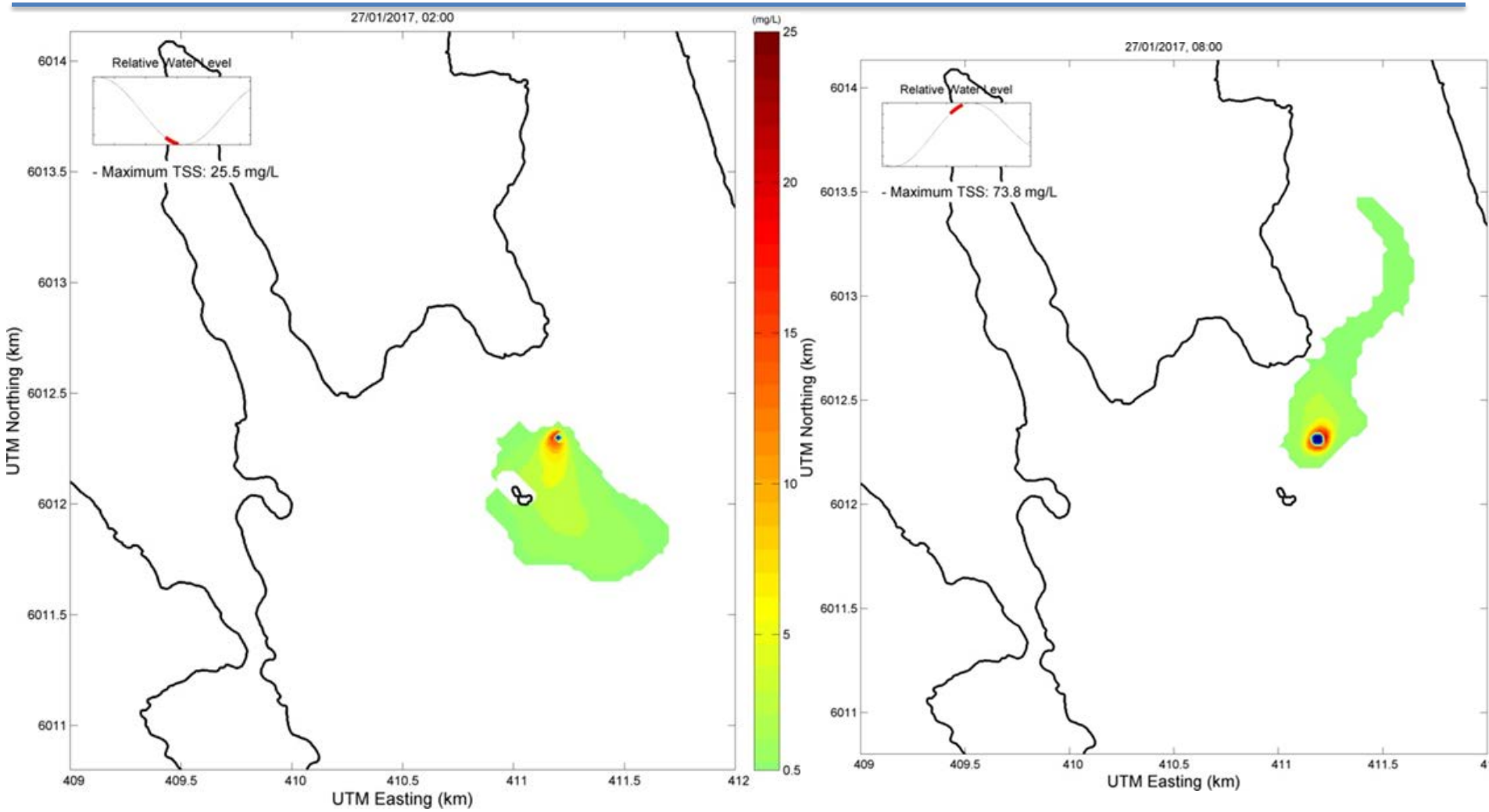
Numbers mark depths (above seabed) of maximum values in vertical column. Blue contours present the areas of SSC greater than 5 mg/L.

Examples: Chatham Sound-Porpoise Channel (Cont'd)



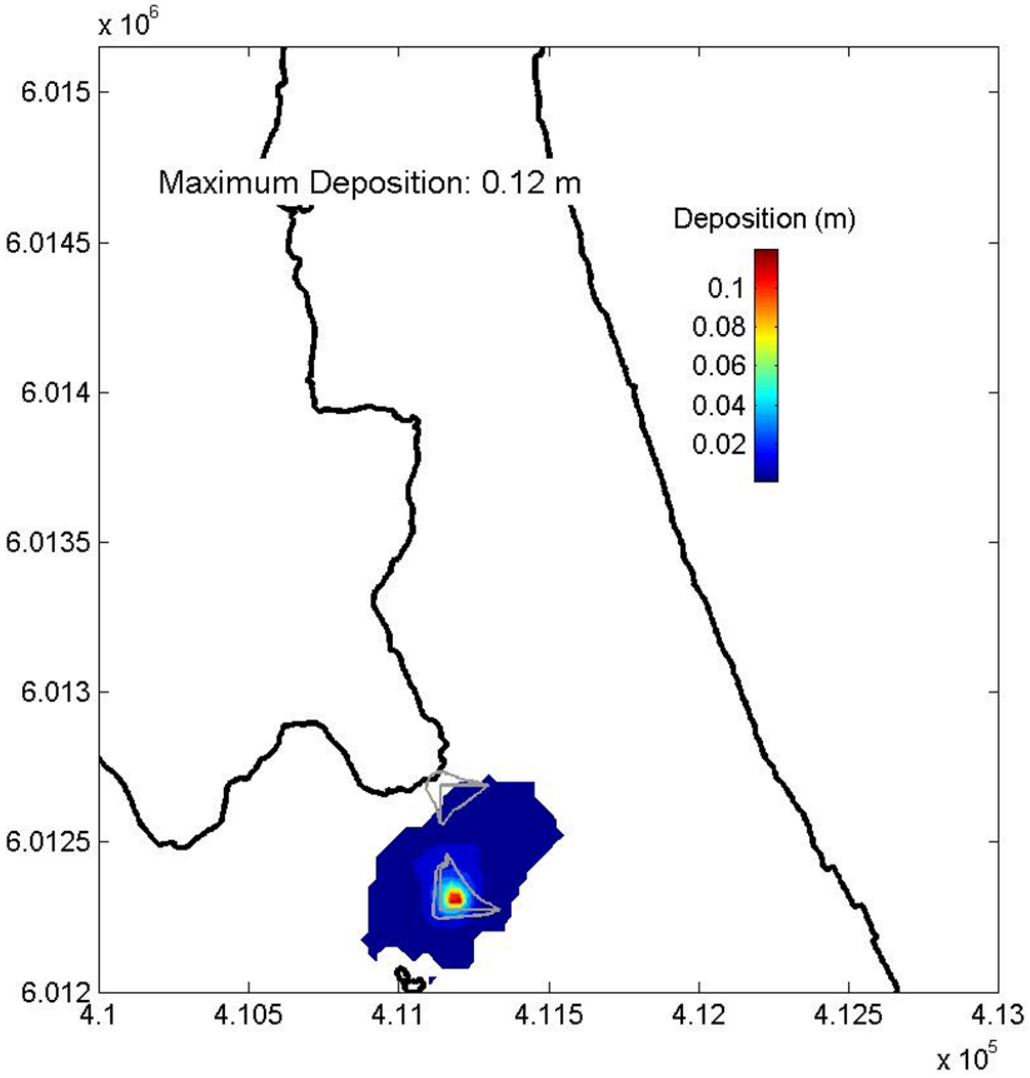
Model derived deposition onto the seabed in Porpoise Channel and the surrounding area after 30 days of dredging activity in January.

Examples: Entrance to Prince Rupert Harbor (Aurora LNG Project)



Model derived maximum SSC values in the water column on January 27 following an ebb tide (left panel) and following a flood tide (right panel)

Examples: Entrance to Prince Rupert Harbor (Cont'd)



Model derived deposition onto the seabed after 17 days of dredging activity at Berth B1S of the Aurora LNG project

Summary of Numerical Modeling of Dredging Activities

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- Integrated 3D Hydrodynamic Circulation Models Provide A Useful Method:
  - for determining suspended sediment concentrations and depositions resulting from dredging activities
  - Provides quantitative basis for use in Environmental Assessments
- Examples of Present Capabilities Presented for Dredging Projects in British Columbia Coastal Waters
  - Wide range of forcing conditions – winds, tides, etc
  - Diverse bathymetric, temperature and salinity fields (even ice)