SupergenORE Final Report – 2022-11-03

FF2020-1095: Cable scour from fluid-seabed interactions in regions of mobile sedimentary bedforms

Martin Austin, Katrien Van Landeghem, Ben Lincoln, Richard Whitehouse, Amelia Couldrey

Project appointments

The project Postdoctoral Research Associate Dr Christopher Unsworth was appointed to the role starting 01 April 2021 and ending 31 May 2022. Four months of this time is at 0.5 FTE.

Due to project budget savings with cruise facilitation during COVID, we were able to extend Unsworth's contract until the end of August 2022 at 1.0 FTE.

Field Data Collection

Observational data were collected during three sea-going cruises.

Cruise 1: 19 – 21 July 2020

Cruise 2: 17 – 23 September 2020

Cruise 3: 13 – 17 July 2021

The seabed lander was redeployed at the Constable Bank site with modifications to the acoustic sediment backscatter system and underwater cameras to enhance data collection based on experience from Cruise 2.

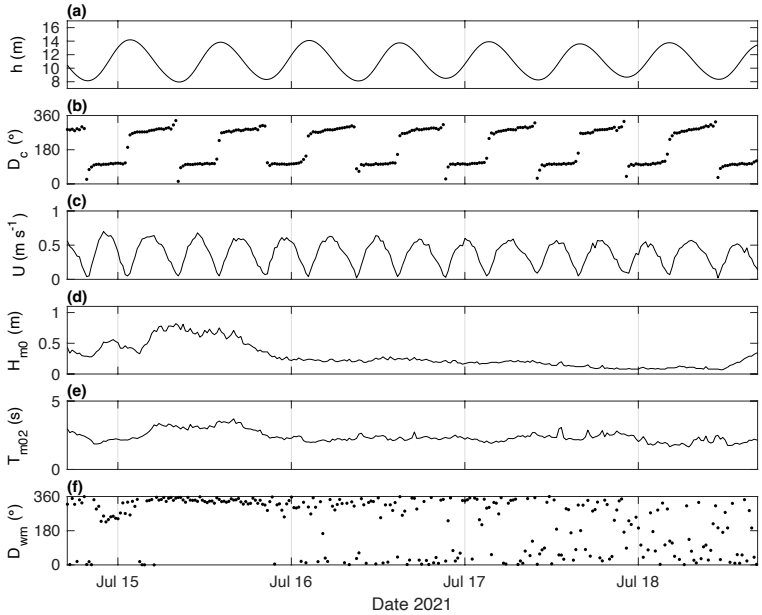

Figure 1 – Cruise 3 hydrodynamic forcing at seabed lander. (From top) water depth, mean tidal current direction, mean tidal current speed, significant wave height, mean wave period and mean wave direction.

Key findings

- Flood and ebb benthic boundary layer structures differ, consistent with the core hypothesis of the proposal that a significant wake develops due to the presence of infrastructure emplaced on the seabed.
- Mean velocity profiles display a consistent variation in the velocity gradient (Fig. 2a).
- Variations in vertical distribution of fluid stress are strongly influenced by the cable in the turbulent regime (Fig. 2c).
- Hydrodynamic conditions at the time of cable deployment exceeded theoretical threshold for the onset of scour. However, scour fails to develop and instead the system shifts to a regime of cable self-burial (Fig. 3).
- Despite bed shear stresses being above critical sediment entrainment thresholds for the majority of all observational periods, sediment suspension and seabed changes were generally low. This suggests the importance of other factors such as biological cohesion in determining scour formation in sandy seabeds. This observation is the focus of the currently in progress paper.

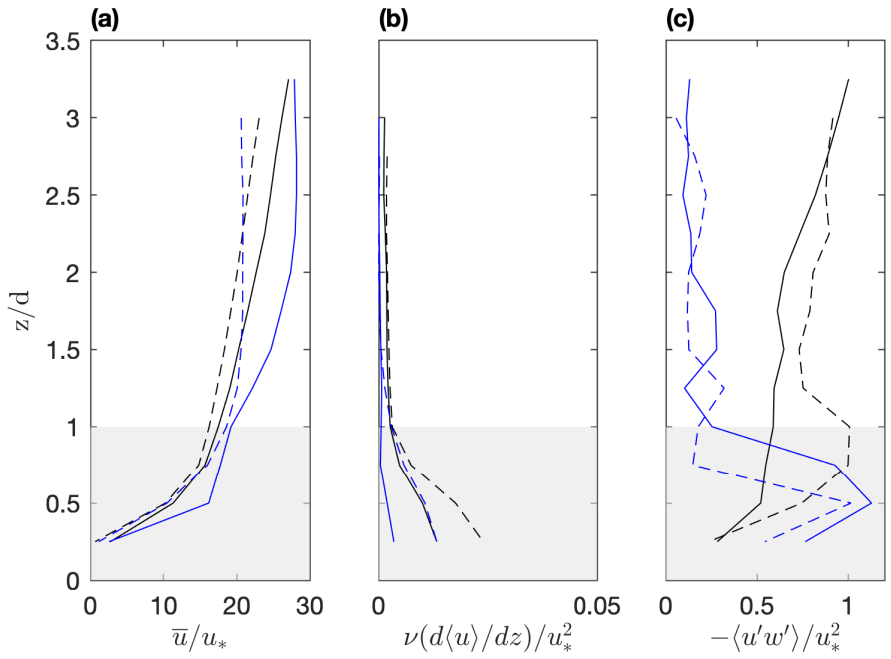

Figure 2 – Cable-modified (blue) and natural (black) stress profiles. Normalised (a) mean flow, (b) viscous stress and (c) turbulent stress. Vertical coordinate z is normalised by the cable diameter d.

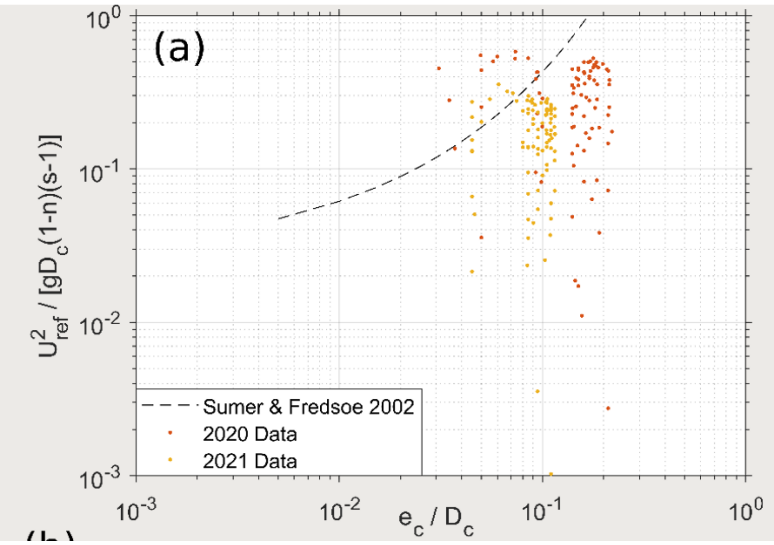

Figure 3 – Onset of scour under a rigid cable with Sumer & Fredsoe (2002) parameterisation.

Outputs

Unsworth, Austin, Van Landeghem, Couldrey & Whitehouse (submitted Nov 2022). Field measurements of cable self-burial in a sandy marine environment. Coastal Engineering.

Unsworth, Austin, Van Landeghem, Couldrey & Whitehouse (in progress). Parameterisation of wake-effected sediment suspension into a 2D model.

Couldrey, Whitehouse, Unsworth, Van Landeghem & Austin (to be submitted Jan 2023). Industry guidance on the use of benthic landers for monitoring sediment mobility. Technical Report No. ####.

Unsworth, Austin & Van Landeghem (2022). Using a natural laboratory to quantify sediment mobility in the turbulent wake of instrument frames and offshore infrastructure. EGU Conference, EGU22-8006

Van Landeghem, Unsworth, Austin & Waggitt (2022). Flow changes in the wake of a large sediment wave: helping to understand geological and ecological impacts of seabed infrastructure. EGU Conference, EGU22-6349.

Austin, Lincoln & Van Landeghem (2021). Non-equilibrium turbulence dissipation: wake affects in an energetic tidal boundary layer. Non-equilibrium Bedforms and Turbulence Workshop, British Society of Geomorphologists, May 2021.

Legacy

The project team have moved the work funded by the Supergen ORE grant forwards into the recently funded NERC ECOWind-Accelerate project valued at £2M and led by Van Landeghem, with Austin as Co-I, Unsworth as PDRF and HR Wallingford (Whitehouse and Couldrey) as project partners. This project takes many of the findings from the Supergen ORE work relating to wake interactions with seabed sediments and complex boundary layer dynamics forwards to provide industry-focused guidance on how future offshore windfarm developments will cause accelerated seabed changes resulting in dynamic feedback to ecosystems.

Co-I Lincoln has recently moved forwards onto a NERC Highlight Topic grant focusing on the effect of floating offshore wind infrastructure on turbulent mixing and biogeochemistry in stratified shelf sea environments.