C-DOGS 2012

Conference of Dalhousie Oceanography Graduate Students

Friday March 23, 2012
8:30*am* - 5:00*pm*, University Hall
Dalhousie University, Halifax, Nova Scotia

Contents

Page

CLOSING REMARKS AND RETIRE TO 5th FLOOR LOUNGE
(Food and beverages provided) (16:30)

Dissolved hydrogen concentrations in the North and South Atlantic: a possible indicator of nitrogen fixation.

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It has been reported that nitrogen fixation is a source of hydrogen to near surface ocean waters suggesting that measurements of hydrogen supersaturation could be used as an indicator of nitrogen fixation. However, the limited number and sparse distribution of measurements of dissolved hydrogen and nitrogen fixation rates made together in the ocean have made this difficult to demonstrate. Using a new method of equilibrating seawater samples for hydrogen, measurements were made at 3.5 minute intervals along a 13,000km transect from the UK to Chile in 2010. Hydrogen concentrations are compared with chemical, physical and biological parameters, and evidence is provided to support nitrogen fixation as the source of observed supersaturations of hydrogen.

Insights Into Cold-Water Corals Recruitment Potential: Preliminary Results of a 4-year Field Experiment off the Continental Margin of the Gulf of Maine

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For marine benthic invertebrates, management strategies traditionally use the distribution of adult populations to determine ecologically significant areas. However, such an approach only partially reveals the vulnerability of an area if the recruitment potential (i.e. the presence of juveniles after a certain period of time) of these organisms has not been assessed. The Northeast Channel Coral Conservation Area was established in 2002 in the Gulf of Maine to protect the gorgonian octocorals *Primnoa resedaeformis*and *Paragorgia arborea*against destructive fishing practices. Such cold-water corals undergo a complex life cycle initiated with a pelagic phase (dispersing larvae), before settling into a benthic phase (adult colonies). To increase our understanding of cold-water coral (CWC) recruitment potential, we deployed arrays of settlement substrates at different depths and canyon locations in the Northeast Channel between 2006 and 2010. Preliminary results indicate that recruitment potential is species-specific in the area, as few recruits of *Paragorgia arborea*were recorded relative to the high abundance of *Primnoa resedaeformis*recruits. Furthermore, for the latter species, recruitment potential is similar across the canyon, and at both locations, the density of recruits on the array is much higher than the local density of adult colonies. From these preliminary results, we conclude that recruitment potential may be a limiting factor in determining the distribution of the adult colonies for some species of CWC (e.g. *Paragorgia arborea*), but not all species. Other factors such as *post*-recruitment processes or the availability of suitable habitat may be important as well.

Seasonal Variability of Total Suspended Matter in Minas Basin, The Bay of Fundy

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Minas Basin, at the eastern end of the Bay of Fundy in Nova Scotia, Canada, is a large macro-tidal estuary. Strong currents associated with the very large tidal water level range could potentially provide a source of renewable tidal energy, but are a fundamental part of the Bay of Fundy ecosystem. Significant extraction of tidal energy could lead to local and far field changes in the tidal regime and sediment dynamics. We present observations of total suspended matter (TSM) concentrations from ocean colour imagery (MERIS data) in Minas Basin from May 2008 to July 2011. Time series of TSM in 1 km^2 pixel boxes throughout the Basin were produced, and temporal autocorrelation analysis has been carried out with those time series. The analysis shows a strong semi-annual variability in TSM concentration in most parts of the Basin. Larger TSM is observed in mid-winter (Feb-Mar), and smaller TSM characterizes mid-summer (Jul-Aug). The strength of this signal varies throughout the Basin, with the largest variation occurring in the centre of Minas Basin, and the smallest variation occurring in Cobequid Bay. It is notable that the variation is smaller in Cobequid Bay but the TSM is the highest in this region. The maximum and mean TSM derived from both summer and winter MERIS data were compared to predictions using the Delft3D model, using different values of the critical bed shear stress for muds to approximate different biologically-controlled sediment cohesion in the different seasons. Comparison between the magnitude and spatial patterns of observed and simulated TSM will help to evaluate the appropriate sediment parameters in the model and understand the observed seasonal variability of sediments in suspension.

Spatial Structure of Flow over Orbital-scale Ripples

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Reliable measurements of velocity profiles within the oscillatory bottom boundary layer over a rippled bed are scarce. The vertical and horizontal structure of the phase-averaged flow over equilibrium orbital-scale sand ripples is investigated. These ripples were created using the RippleKart set-up described in *Hay et al.*[2011]. Vertical velocity profiles at turbulence-resolving scales near the bed were obtained using a wide-band coherent Doppler profiler (MFDop). Phase-averaged horizontal and vertical flow results are compared to those obtained from simplistic potential flow and boundary layer theories.

Three-dimensional Circulation near the Sable Gully of Nova Scotia

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The Sable Gully is a broad deep underwater canyon located on the edge of Scotian Shelf to the east of Sable Island. Being the home of many marine species including the endangered Northern Bottlenose whale, the Gully was designated as a Marine Protected Area (MPA) in 2004. Better understanding of physical environmental condition in this MPA is needed for sustainable ecosystem management. Due to the complex topography and highly varying circulation over the Gully, detailed three-dimensional numerical simulations have not been made for this area. In this study, a multi-nested model is used to simulate the three-dimensional circulation in the Gully. The model is driven by tide, wind and surface heat fluxes. The model results are validated by comparing against year-round current observations from four moorings deployed in the Gully from April 2006 to July 2007. The model results show a shelfbreak jet flows from northeast to southwest throughout the year. The circulation in the Gully has a complex vertical structure and varies from season to season. A persistent northward flow occurs in the deep layer of the Gully, indicating the cross shelf transport of deep ocean water onto the shelf.

Tracking fish behaviour with accelerometer tags: the effect of sampling frequency

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Accelerometer tags are used to remotely observe marine animals and to identify and quantify behavioral states and rates such as resting, swimming and migrating, and to estimate activity and energy budgets. Most studies use low frequency ($\leq$ 32Hz) accelerometer sampling due to battery and data-archive constraints. In this study we assessed the effect of sampling frequency (aliasing) on event detection rate (D_R) using the great sculpin (*Myoxocephalus polyacanthocephalus*). Feeding and escape events and spontaneous movements were triggered, observed and recorded using 100Hz accelerometer sampling and high-speed video among 7 different great sculpin. We demonstrate that multiple parameters in the time and probability domain can statistically differentiate among events. Identification rate for feeding and escape events decreased by 50% when sampling at $\leq$ 10Hz. Our analyses demonstrate additional problems associated with aliasing and how activity and energy-budget estimates can be compromised and misinterpreted. We recommend that high-frequency accelerometer sampling be used in similar (field) studies. If battery storage is limited, we also recommend archiving the events via an onboard algorithm that determines the highest likelihood and subsequent archiving of the various event-classes of interest.

Downscaling Ocean Conditions: Can we take advantage of the non-linear coupling between length scales?

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Large and small structures in the ocean are coupled through the non-linear terms of the governing equations of motion. Recently, Henshaw et al. (2003) provided evidence that small scale features can be reconstructed from the large scales due to the non-linear coupling between them. This implies that the interaction between the different length scales can be exploited for downscaling purposes. We propose a new method, based on nudging in specific wavebands and frequencies, to downscale ocean conditions. To test this method, several twin experiments are conducted using an idealized ocean model (quasigeostrophic model). Based on encouraging results, we discuss the implementation of this method in a realistic ocean model of the north-west Atlantic Ocean.

Formation and release of sediment-laden ice blocks in Minas Basin

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Sediment-laden ice forms and accumulates in winter on the banks of tidal channels in Minas Basin, changing channel morphology. Gently sloping muddy banks become vertically-edged ice shelves composed of interlayered sediment and ice. Sediment-laden ice blocks are released from the ice shelves, typically during spring tides or during warm weather. The blocks become more dense by a fractional increase in sediment content due to melting, which preferentially releases water, and due to plucking of the seabed. A fraction of the blocks become neutrally or negatively buoyant. Slightly negatively buoyant ice blocks set adrift by currents may transit the Minas Basin and impact tidal energy generators. The fraction of sediment-laden ice blocks with negative buoyancy and the quantity of ice formed based on changes in channel morphology can be used to quantify the threat sediment-laden ice blocks pose to turbines.

Larval distributions and mortality: past and present research experiences

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The dispersal and survival of early life history stages has long been recognized as critical to the abundance and distribution of benthic marine organisms. I herein present past research on larval crab distributions and my plans for future research on invertebrate larval mortality at Dalhousie University. I described horizontal distributions of Dungeness crab (*Metacarcinus magister*) larvae to determine larval source locations and to infer underlying dispersal processes in the Strait of Georgia, BC, where *M. magister*is an important contributor to the commercial fishing industry and accounts for approximately 50% of larval crab assemblage abundance. The samples were obtained from an array of plankton tows collected in late April 2009 and 2010 that spanned the strait. I found that, in both years, early zoeal stages were highest in abundance in the south and central regions of the strait's eastern margin. Later stages were more widely distributed, but consistently low in abundance along the strait's western margin. Results suggest that the majority of larvae were released along the eastern margin of the south and central strait between February and early March, and that there is strong potential for northerly longitudinal transport from release locations. At present, my work at Dalhousie is focused on quantifying mortality rates of invertebrate larvae from field samples and determining the vulnerability of different larval forms to predation under a laboratory setting.

Uncertainty in the Dead Zone

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Numerical ocean models are becoming increasingly important tools for ocean research and prediction. It is therefore crucial to quantify uncertainty in the predictions of ocean models and gain an understanding of how uncertainty in the model inputs translates into uncertainty in the outputs. Using a statistical emulator technique, we perform an uncertainty analysis for a 3-dimensional, physical-biological ocean model of the Texas-Louisiana shelf in the Northern Gulf of Mexico. The model simulates the major processes involved in the formation of the dead zone, a recurring hypoxic area in summer that develops near the Mississippi delta. We assess how estimates of the dead zone's extent are affected by uncertainty in various inputs such as the river discharge, wind forcing, physical parameters, biological parameters, and biological initial and boundary conditions. We show that uncertainty in different inputs has distinct effects on model output which vary in magnitude, time and space.

Pulsations of High-Speed Flow: A Hazard for In-Stream Tidal Turbines?

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The development of small-scale tidal power is progressing in the three passages of Digby Neck as a result of the collaborative effort between Fundy Tidal Inc., Acadia University and Dalhousie University. The installation of the first in-stream turbine is planned for 2014 and resource assessments of Digby Gut, Petit Passage and Grand Passage are currently underway.

High resolution bathymetric data has been collected for each channel and flow measurements are presently being acquired using arrays of acoustic Doppler current profilers (ADCPs). Previous measurements and numerical simulations suggest that pulses of high speed flow pass through the centre of the channels, which could place significant stress on in-stream turbines. Using the ADCP data, in parallel with numerical simulations, we will attempt to determine whether the pulsations are a manifestation of resonant oscillations or a consequence of eddies shed from bathymetric features.

Multi-scale distribution and spatial variability of benthic invertebrate larvae

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Patchiness is a concept often referred to in plankton research but not often defined. Plankton "patches", or spatial heterogeneity, affects the detected patterns in the distribution of planktonic larvae, and the detection of "erroneous" data is often attributed to this patchiness. Additionally, plankton patchiness can affect the ultimate distribution of adults. This study was designed to quantify the spatial scale of variability in the distributions of benthic invertebrate larvae and relate this variability to that in physical and biological factors such as density, temperature, salinity, phytoplankton (fluorescence) and current velocity. Larvae were sampled continuously (one sample every $\sim$ 500 m) along two perpendicular 10 km transects with a 200 μm plankton ring net (0.75 m diameter) in St. George's Bay, NS. Density, temperature, salinity, fluorescence was measured with a CTD cast at each station and currents were quantified with an ADCP. Results indicate that gastropods, bivalves and, to a lesser extent, bryozoan larvae have very similar spatial distributions, but the distribution of decapod larvae does not follow the same pattern as the other groups. High abundances of gastropod and bivalve are associated with a "front" (sudden change in salinity and phytoplankton), while high abundances of bryozoans were associated with higher salinity and lower phytoplankton. Interestingly, analysis with variograms revealed that gastropod, bivalve and bryozoan larvae vary in abundance on very similar spatial scales ($\sim$ 4 km). These findings suggest that taxonomic groups that have functionally similar larvae (e.g. bivalves and gastropods) have similar dispersal properties (distribution and spatial variability) while the opposite is true functionally dissimilar larvae (e.g. bivalves and decapods).

Visualization of the Nova Scotia Current and tidal contribution to the circulation across the Halifax Line.

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Since 2008, three Acoustic Doppler Current Profilers (ADCPs) have been deployed along the Halifax Line to monitor the Nova Scotia Current continuously. Data collected from these ADCPs are used to provide a high-resolution visualization of the Nova Scotia Current and its variability, both spatially and temporally. A characterization of the Nova Scotia Current reveals a high variability at all frequencies. This talk will focus mainly on the role of tides in local circulation, as this is one of the major forcing mechanisms acting on the Nova Scotia Current. After identifying the principal tidal constituents using pressure sensors, the tidal signal is extracted from the measurements using a harmonic analysis (i.e. t_tide) and validated against independent tidal predictions from Webtide, a model-based prediction system. Tidal ellipses are plotted to investigate both the horizontal and vertical variability of the tidal constituents. Finally, the ratio of the tidal standard deviation to the total standard deviation (tidal and non-tidal) is used to quantify the contribution of tides to the local circulation over the inner part of the Halifax Line. A good understanding and characterization of the variability of the Nova Scotia Current across the Halifax Line is part of the Ocean Tracking Network objectives in an effort to relate oceanic circulation to migration patterns of marine fish and mammals.

Acoustic Detection of Sediment Laden Ice in Minas Passage

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The ocean is difficult to understand since it is difficult to measure. Fortunately, sound experiences relatively low attenuation in the ocean and can be used to transmit information. The backscatter of an acoustic signal from a known target can then be used to infer the properties of a remote structure. Acoustic backscatter models will be used to characterize the composition and inclusion structure of sediment laden ice blocks that threaten tidal power investments in Minas Passage. Ice blocks that have been collected from the Kennetcook River are used to characterize the structure of naturally occurring sediment laden ice. This data will be used to make realistic ice blocks for future scattering experiments. This research is part of a project conducted in partnership with Nova Scotia Power Incorporated that will quantify the hazard posed by negatively buoyant ice and provide the necessary foundation to drive mitigative action.

Can light attenuation estimates from electronic seal tags be used as phytoplankton proxies on the Scotian Shelf?

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We aim to test whether light measurements from electronic tags deployed on grey seals can be used to monitor spatial and temporal changes in phytoplankton biomass on the Scotian Shelf. Phytoplankton is a major contributor to vertical light attenuation, thus it may be possible to infer changes in phytoplankton biomass from changes in the light attenuation coefficient determined from seal tags. Between September and December of 2009 and 2010, 33 electronic tags were deployed on grey seals that measured pressure, temperature and light every 10 s. Individual grey seals performed 200-300 dives to the sea floor resulting in a similar number of light attenuation profiles. Pre-processing of light data obtained between local 10:00 h and 14:00 h revealed systematic differences in measured irradiance between the ascent and descent phase of the dives due to changes in the orientation of the light sensor, which was not designed for quantitative estimation of irradiance. Attenuation coefficients in the mixed layer were estimated from irradiance profiles obtained during the ascent phase. Measurements from the light sensors were intercalibrated and validated by deploying the tags on a sampling device with a full suite of bio-optical measurements and coincident with bottle sampling. These observations were also used to establish a proxy relationship between attenuation coefficients and phytoplankton biomass.

Evidence of dust deposition in a core of the Eastern Equatorial Pacific on glacial-interglacial timescale

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Phytoplankton growth in high nutrient low chlorophyll (HNLC) regions of the oceans, such as the Eastern Equatorial Pacific (EEP), is limited by low iron levels. Aeolian delivery of terrestrial dust is an important mechanism by which iron levels are increased in the ocean. In this study, disaggregated inorganic grain size (DIGS) distributions were obtained for layers of an EEP sediment core, covering the last 25 thousand years. Well-sorted peaks with diameters smaller than 10 m were interpreted as evidence for dust deposition. Our results suggest that the study location experienced dust deposition in the current interglacial period, but not during the most recent glaciation. These results, however, conflict with results from other dust proxies in the region, as well as with dust fluxes observed in ice core records, prompting for a reevaluation of our assumptions.

Critical Habitat of North Atlantic right whales

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Critical Habitat, the habitat required to complete the life history of a species, must legally be defined for endangered species under the Canadian Species at Risk Act. Yet this remains a major stumbling block for researchers studying the marine realm, and never before has a marine species had Critical Habitat defined. The culmination of this research project is a precedent setting event in Canadian conservation history, because the North Atlantic right whale will become the first species to have Critical Habitat defined and protected in Canadian waters. We undertook research in Roseway Basin on the western Scotian Shelf to measure the spatial distribution of abundance of right whale prey - diapausing Calanoid copepods - and the processes that aggregate prey in certain areas. Using this information we defined Critical Habitat for right whales in Roseway Basin, evaluated the provisional habitat boundaries, and made recommendations for their revision and the revision of conservation strategies currently in place in the area.

The effect physical variables have on copepod distribution in Bedford Basin

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The relationship between copepod distribution and turbulence is complicated and not fully understood. This presentation will focus on determining which physical factors in the water column affect the distribution of copepods in Bedford Basin. In particular, we ask whether turbulent dissipation rates affect the copepod distribution more than other physical factors such as density and temperature. We approach this question using data from a bio-physical profiler, which records co-incident measurements of both turbulent dissipation rates and plankton images, as well as CTD data.

Enhanced pore-water diffusive fluxes of 224-Ra and CO2 in Bedford Basin

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A field study in Bedford Basin reveals substantial vertical diffusive release of various chemical constituents from the sediment surface into the overlying water column in the weeks following a deep-water renewal event. Near bottom vertical gradients of 224-Radium isotopes yield vertical eddy diffusivities (KZ), which are applied to gradients of dissolved inorganic carbon (DIC) and dissolved oxygen (DO), resulting in estimates of benthic carbon and oxygen fluxes from basin sediments. These independent observations, along with time-series measurements of nutrients, yield fluxes with ratios comparable to Redfield values, suggesting benthic respiration as the source. Integrating our findings over the 29 day sampling period, the benthic return flux of DIC constitutes as much as 5% of the annual DIC uptake by primary production. Direct delivery of shallower waters, relatively enriched with particulate organic matter (POM), to deep basin sediments during the large deep-water renewal event may provide the mechanism required for this enhanced biological respiration and resulting benthic fluxes.

Leatherback snacks: work towards characterising the foraging behaviour of the world's largest turtle

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The leatherback turtle *Dermochelys coriacea*is a Species At Risk Act (SARA) endangered species that migrates seasonally into Canadian waters to forage on jellyfish. Foraging leatherbacks are notoriously difficult to study, with impediments to data collection including low overall turtle numbers and limited at-sea detection methods. By analysing data collected in the Cabot Straight between 2007-2011 using animal-mounted sensors - temperature-depth recorders (TDR), global positioning system (GPS), inertial sensors, and video camera - I aim to characterise the short-timescale (h) and small spatial scale (km) foraging behaviour of leatherbacks. My analyses demonstrate that silhouetting is not, as previously assumed, the primary mechanism of jellyfish detection.

Interannual Variability of Circulation and Hydrography over the Eastern Canadian Continental Shelf

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A regional ocean-ice model of the Northwest Atlantic ocean is used to examine main physical processes affecting the interannual variability of circulation over the eastern Canadian continental shelf (ECS). The interannual variability in the model from the period 1988-2004 is examined based on a Complex Empirical Orthogonal Function (CEOF) analysis. The CEOF analysis of model results demonstrates that the interannual variability over the Labrador and northern Newfoundland shelves is affected significantly by the variability at high latitudes which propagates onto these shelves through the northern open boundary. Over the eastern Newfoundland shelf, the interannual variability is affected significantly by the non-linear interaction of the Labrador Current with the North Atlantic Current and by the variability propagating from the southern Labrador Shelf. Over the Slope water region off the Scotian shelf the interannual variability is affected significantly by anomalies advected by the Gulf Stream and by the non-linear dynamics taking place in the deep waters to the south of the Tail of the Grand Banks.

Signatures of wave-induced light field fluctuations in measured irradiance depth profiles

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Wave induced light field fluctuations are readily observed as fast variations of intensities in continuous irradiance depth profiles. These fluctuations are often treated as noise and filtered out in applied optics exercises. In this study, an effort is made to extract the signals pertinent to the light field fluctuations from irradiance depth profiles measured at 555 nm. The irradiance data are collected in oceanic and coastal waters by a specially designed optical profiling package equipped with a downwelling irradiance sensor and a high dynamic range radiance camera. Two signatures including the dominant frequency and the coefficient of variation of irradiance fluctuations along the water column are identified from the variance spectrum. The structures of the irradiance field in the vertical direction are examined. Both signatures are satisfactorily fitted to analytic models. Analyses of irradiance depth profiles have given consistent results with theoretical models and other independent measurements. Possible mechanisms contributing to the observed variations and their relationships with other parameters are discussed.

Geotechnical investigation of subaqueous sediment dynamics: A field work adventure

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Geotechnical parameters such as bearing capacity, shear strength or pore pressure have a high impact on the initiation of subaqueous sediment motion, seafloor stability as well as sediment mass movements that might trigger, e.g., tsunamis or coastline collapses. With the increasing industrial and recreational usage of coastal zones, the geotechnical investigation of subaqueous sediment dynamics gains in importance. However, geotechnical tests in the laboratory using sediment cores are easily disturbed by changes in sediment texture and consolidation during core retrieval, transport and storage. Standard in situ techniques are often big and heavy, and in consequence, not suitable for deployment in areas with difficult access (e.g., narrow canyons, close to offshore constructions, highly energetic areas). Here, we present results from two field campaigns utilizing the new small-scale dynamic penetrometer NIMROD for geotechnical investigations (1) of sediment dynamics in narrow canyons of the Rhone Delta in Lake Geneva, and (2) of scour processes at the foundations of offshore wind energy converters in the German Bight, North Sea. In the case of the former, the NIMROD was deployed from the MIR submersibles (operated by the Russian Academy of Sciences) targeting positions in the canyons, on the slope and along the Rhone plateau. The results show traces of recent sediment dynamics in terms of sediment stratification regarding the sediment strength and consolidation state supporting the hypothesis of underflow processes in the Rhone Delta. During the field campaign in the offshore windpark, NIMROD was deployed in the close vicinity of tripod as well as jacket foundations. Specific patterns of sediment strength depending on time, location with regard to position in the windpark and to the main current direction, foundation type and season were revealed potentially complementing on-going research on and development of scour models at offshore constructions. The presented campaigns highlight the importance of geotechnical investigations of subaqueous sediment dynamics, and the need for new geotechnical techniques suitable for deployments in difficult offshore conditions.