INCISE2018

Sponsors:

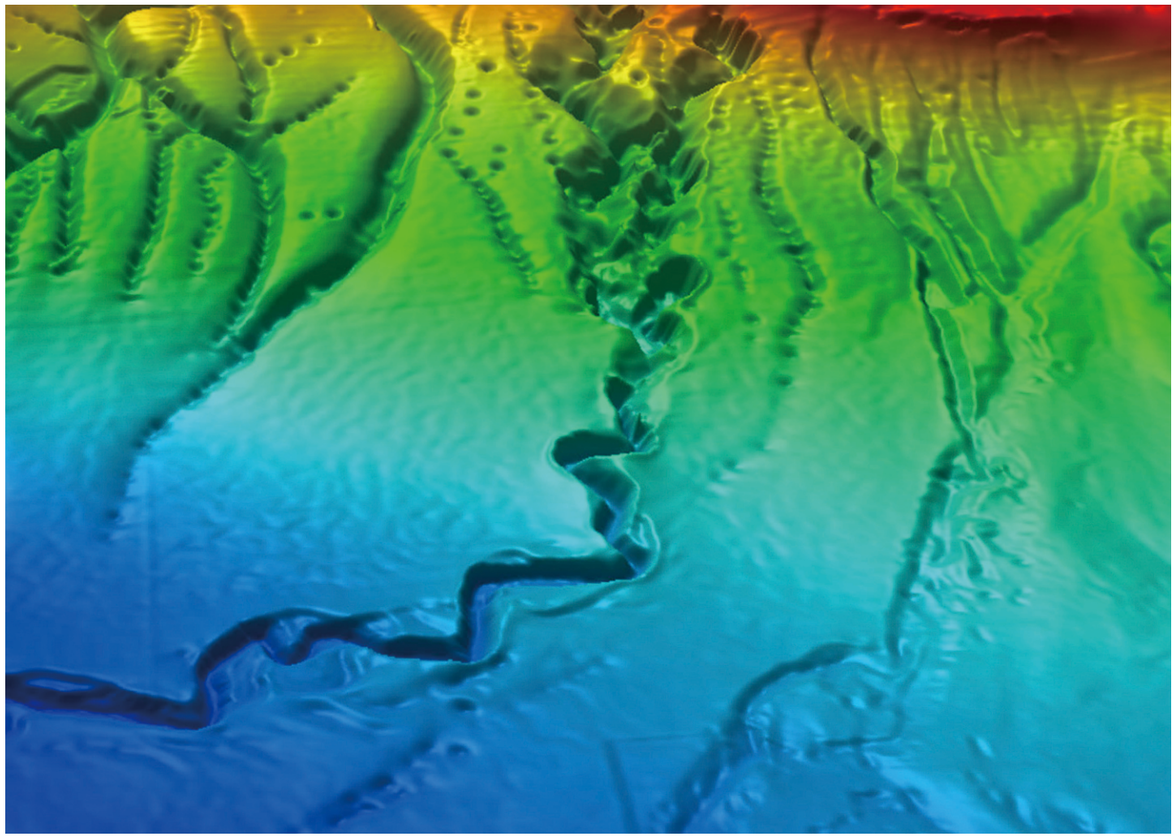
NORTEK

SUB OCEANTECH

4th International
Submarine Canyon Symposium

INCISE2018

5-7 November 2018 Shenzhen, CHINA



INCISE International Network for submarine Canyon Investigation and Scientific Exchange

SUSTech Southern University of Science and Technology

南科大海洋系 Institute of Oceanography at SUSTech

Front Cover: Differing submarine canyon morphologies offshore Equatorial Guinea.

Submarine canyon morphologies and their downslope evolution, shown by a time structure map of the modern Equatorial Guinean seafloor. The stark contrast between canyon morphologies results from differing sediment supply. In the south, high sediment supply forms steep slopes and shelf-indenting, sand-rich canyons with erosive morphologies and downslope submarine fans. The capture of sediment by these canyons starve the area to the north, where canyons are smooth, have aggradational morphologies, no shelf-edge indentation, mud-rich fill, and no downslope sediment accumulation. Inset map is a displays seafloor dip angle. See host Survey for publication details etc.

VSA Author: Zane Jobe; Date Created:2011-05-16

Contents

1. Introduction of INCISE ---- 2
2. Programme ---- 4
3. Opening Keynote ---- 8
4. Keynote Speakers ---- 10
5. Abstract ---- 12
   i.Session 1 ---- 12
   ii.Session 2 ---- 22
   iii.Session 3 ---- 29
   iv.Session 4 ---- 41
   v.Special Session ---- 48
6. Transportation Guide ---- 59
7. Weather and City Guide ---- 64
8. Field Trip(Optional) ---- 65
9. Mailing list ---- 67

Introduction of INCISE

INCISE, the International Network for Submarine Canyon Investigation and Scientific Exchange is an initiative that aims to bring together scientists working on all aspects of submarine canyon research, and to stimulate discussions across disciplines. The 1st, 2nd and 3rd editions were hosted in Brest, FRANCE, Edinburgh, SCOTLAND, and Victoria, CANADA (http://incise2016.oceannetworks.ca/home). The 4th symposium (INCISE2018) will take place in Shenzhen, Guangdong, CHINA, from 5th to 7th November 2018. The event is hosted by the Department of Ocean Science & Engineering, Southern University of Science and Technology (SUSTech).

Why study submarine canyons?

According to recent studies derived from high-resolution seafloor mapping, in the order of 10,000 submarine canyons exist worldwide. Fewer than one hundred canyons (only 1%) have been studied with some level of detail in terms of geology, physical oceanography, or habitat heterogeneity and biodiversity.

Submarine canyons are very important features along the world's continental and island margins. They create terrain habitat heterogeneity and provide important pathways for terrestrial sediments and carbon, detrital organic matter, pollutants and marine debris from the shelf to the deep sea. Canyons often concentrate organic matter enhancing overall ecosystem biomass and fisheries and acting as biodiversity hotspots. Canyons are also conduits for destructive gravity flows that caused devastating geohazards.

Recent advances in technology (e.g., ROVs, AUVs, gliders, etc.) allowed the expansion in the exploration of submarine canyons, revealing exuberant ecosystems with never-seen before life forms and entire habitats. However, while the scientific exploration on canyons advances, so does the human footprint into the deep sea, and on canyons in particular, with the increased worldwide demands for oil and gas, mineral deposits, and fisheries.

Therefore, the scientific community has the responsibility to prepare a comprehensive assessment of the role submarine canyons in generating and maintaining deep-sea biodiversity, ecosystem function and services; and in support of developing marine policies defining clear strategies for conservation.

Shenzhen in Autumn time

Shenzhen, whose nickname is PengCheng(city of roc), is one of the provincial cities of Guangdong province. It is west to the Daya and Dapeng Bays, farther east to the Pearl River Estuary and Lingdingyang, north to Hong Kong, and south of Dongguan and Huizhou.

Shenzhen is the first special economic zone of China, serving as a window for China's reform and openness. Now, Shenzhen has developed into an international city with great influence, creating the"Shenzhen Speed" which attracts worldwide attention. The autumn scenery of Shenzhen is very beautiful,attracting a large number of tourists from all over the world to visit it every year.

Local Organizing Committee (SUSTech)	Scientific Committee	INCISE Steering Committee
John Y. Chen	Susan Allen (UBC)	Veerle Huvene (NOC)
Chuanlun Zhang	Jaime Davies (UPL)	Jamie Davies (UPL)
Jingping Xu	Rob Hall (UEA)	Joshu Mountjoy (NIWA)
Qingsong Liu	Peter Harris (GRID-Arendal)	Rob Hall (UEA)
Xinxin Li	Veerle Huvenne (NOC)	Peter Harris (GRID-Arendal)
Zhiqiang Liu	Fabio De Leo (ONC)	Nathalie Valette-Silver (NOAA)
Dujiao Guo	Daniel Leduc (NIWA)	Aaron Micallef (University of Malta)
	James Liu (NSYSU)	Fabio De Leo (ONC)
	Pere Puig (ICM-CSIC)	
	Jingping Xu (SUSTech)	

Programme

Sunday, 4 NOVEMBER

Start time	Speaker	Title
14:00-17:00	Registration（**MAIN HALL**, 贵宾楼大堂）	
17:30	Ice breaker（**ZIYUN HALL**, 紫云阁）	

Monday, 5 NOVEMBER

Start time	Speaker	Title
8:00	Registration（**MAIN HALL**, 贵宾楼大堂）	
8:30	Welcome	
8:40	Overall Keynote: **Peter Harris**	Geo-reflections on the origin and evolution of submarine canyons
	Session 1- Canyon processes in the space-time continuum (formation, evolution, circulation) **Session Chair: Pere Puig**	
9:10	Keynote: Erika McPhee-Shaw	Low-mode internal tide energy loss at a canyon topographic “pinch point” leads to intense stratified mixing layers and a focused region of lateral flow between near-boundary and offshore waters
9:40	James Liu	Capturing hyperpycnal events in the benthic nepheloid layer of a submarine canyon in the wake of a typhoon
10:00	Ben Kneller	How do hyperpycnal flows travel so far down submarine canyons? entrainment, detrainment and salinification.
10:20	Yanwei Zhang	Different features of prolonged deep-sea turbidity currents triggered by individual typhoon and earthquake in the Gaoping Submarine Canyon
10:40	Coffee break	
11:10	Qiang Li	Numerical estimate of mixing rate due to internal tides generated by submarine canyons

Start time	Speaker	Title
11:30	Miwa Yokokawa	Morphology, sedimentary structures and grain size distribution of cyclic steps formed by surge-type turbidity currents in an experimental flume
11:50	Neil Mitchell	Bedrock erosion by sedimentary flows in submarine canyons
12:10	Ashiru Olusola Raheemat	Structural controls on Submarine channel evolution and Architecture, Offshore Western Niger Delta.
12:30	Zhongwei Zhao	Post-eruptive Submarine Terrace Development by Erosion of a Surtseyan Cone at Capelinhos, Faial Island, Azores
12:50	Lunch（**Cafeteria**, 自助餐厅）	
	Session 2 - New ways to study submarine canyons: integrated programs, new technologies and coordinated monitoring efforts **Session Chair : James Liu**	
14:00	Keynote: Matthieu Cartigny	How new deep-sea observations change turbidity current models
14:30	Charles Paull	Innovative monitoring reveals the anatomy of submarine canyon turbidity currents
14:50	Roberto Gwiazda	Going with the flow: Tracking turbidity currents along the seafloor with man-made motion-recording boulders.
15:10	Coffee break	
15:40	Peng Hu	Interactions between turbidity current and cyclic steps: a layer-averaged fully coupled numerical case study
16:00	Marta Arjona-Camas	Autonomous hydrographic profiling: a tool for assessing the nepheloid structure of trawled submarine canyons
16:20	Andy Wheeler	Mapping, Modelling and Monitoring Key Processes and Controls on Cold-water Coral Habitats in Submarine Canyons (MMMonKey_Pro)
16:40	Poster session	
18:30	Symposium dinner（**FENGHUANG HALL**, 凤凰阁）	

Tuesday, 6 NOVEMBER

Start time	Speaker	Title
	Session 3 - Patterns in submarine canyons: role of scale and heterogeneity **Session Chair : Fabio De Leo**	
9:00	Keynote: Furu Mienis	The unknown role of Whittard Canyon: Pathway or sink for organic carbon?
9:30	Sofia Ledin	The unknown role of submarine canyons – Linking habitat and faunal patterns to organic matter cycling in Whittard Canyon.
9:50	Tabitha Pearman	Internal tides and canyon wall faunal assemblages
10:10	Coffee break	
10:40	Sian Pledger	A Morphometric Analysis and Classification of Mediterranean Submarine Canyons
11:00	Zhi Huang	Geomorphic and habitat mapping of submarine canyons of the Australian continental margin
11:20	David Price	Scaling canyon ecology: multi-resolution consideration of biodiversity in Explorer Canyon.
11:40	Jaime Davies & Veerle Huvenne	Working Groups overview & topics for discussion
12:00	Lunch **(Cafeteria , 自助餐厅)**	
	Session 4 - Physical and anthropogenic disturbance in submarine canyons, conservation and marine policy **Session Chair : Veerle Huvenne**	
14:00	Keynote: Jaime Davies	Submarine canyon Marine Protected Areas: how effective are they?
14:30	Matra Guerra	Environmental drivers of the foraging distribution of sperm whales in the submarine canyon of Kaikōura, New Zealand
14:50	Pere Puig	ROV observations in intensively trawled submarine canyons of the Catalan margin (NW Mediterranean)
15:10	Veerle Huvenne	Litter in Whittard Canyon, NE Atlantic
15:30	Coffee break	
16:00	Discussion session	

Wednesday, 7 NOVEMBER

Start time	Speaker	Title
	Special Session - Canyons and trenches in South China Sea and West Pacific **Session Chair : Jingping Xu**	
9:00	Keynote: Chenglin Gong	Flow processes and sedimentation in unidirectionally migrating deep-water channels
9:30	Min Luo	Benthic carbon mineralization in hadal trenches: Insights from in-situ determination of benthic oxygen consumption
9:50	Yulong Zhao	In-situ observation of the subaqueous sand dunes at the upper slope of the northeast South China Sea
10:10	Xinxin Li	Contribution of net microbial carbon fixation to organic carbon cycling in Trench environment
10:30	Coffee break	
11:00	Ken Ikehara	Repeated deposition of thick muddy turbidites and mass-transport deposits in small basins along the Japan Trench floor
11:20	Naishuang BI	DSV-based observation in Taiwan submarine canyon in South China Sea by Chinese submersible Jiaolong
11:40	Menjun Li	Deciphering the sediment sources in Taiwan Canyon, northwestern South China Sea
12:00	Closing remarks \ INCISE coordination team	
12:20	Lunch **(Cafeteria , 自助餐厅)**	

Thursday, 8 NOVEMBER

Start time	Session
8:30-15:30	**Field Trip - Dapeng Peninsula National Geopark (OPTIONAL)**

Opening keynote

Geo-reflections on the origin and evolution of submarine canyons

Peter T. Harris
GRID-Arendal

The undisputed pioneer in submarine canyon research is Francis Parker Shephard (1897-1985), whose 1948 textbook “Submarine Geology” established the field now called “marine geology”. By as early as 1938 Shephard had compiled the first global database on submarine canyons – many books and papers followed. The first theories of how submarine canyons evolved called for erosion by rivers making a river valley that was later submerged by rising sea level. As more data became available it became clear that the largest canyons extended to depths of thousands of meters below sea level, demanding a mechanism other than river erosion to explain them. A paradigm shift resulted from the discovery of turbidity currents. The first evidence was the mysterious breakage in 1929 of submarine cables on the Grand Banks of Newfoundland by a current that must have flowed at a speed of ~20 m/sec. A paper by Heezen and Ewing (1952) on the topic started a field of research that continues to this day. The Grand Banks turbidity current was triggered by an earthquake and transported an estimated 150 cubic kilometers of sediment. Once geologists realized that earthquakes greater than magnitude seven occur more than once per month somewhere on the earth (a magnitude eight or greater occurs about once a year), it becomes apparent that slope failures and turbidity flows like the 1929 Grand Banks are probably a common occurrence in the global ocean over geologic timescales. A second paradigm shift resulted from sonar bathymetric mapping technology especially multibeam sonar. Detailed bathymetric maps of submarine canyons revealed that most (78%) incise only the continental slope and not the shelf. These “blind” canyons owe nothing of their origin to sediments mobilized from rivers or deposited on the shelf; rather, they are the product of retrograde slope failure. This observation has led to the development of an evolutionary model that calls for canyons to initiate on the slope. Blind canyons may capture smaller canyons as they develop and their growth up-slope may later result in incision of the shelf break, but this is not an essential part of their evolution. Contrasting with the slope-initiation model is one that calls for shelf-incising canyons to initiate at the shelf edge. In this model shelf-incising canyons start as small features that grow down-slope, broadening as they develop. There is a correlation between river sediment discharge and the frequency of occurrence of shelf-incising canyons. The greater the sediment load the more common shelf-incising canyons are. Furthermore, the largest canyons are shelf-incising canyons (twice the size of blind canyons, on average), and the largest canyons of all are found in the polar oceans, where glacial processes have delivered large volumes of sediment to continental margins over geologic timescales. Thus, there is a correlation between sediment load and canyon size as well as the occurrence of shelf-incising canyons. An intriguing difference exists between Arctic and Antarctic canyons that may be related to their glacial history. Arctic glaciation began in the late Pliocene and has been eroding the continents and delivering sediment to the slope for the last 2 million years. In contrast, the Antarctic glaciation began 40 million years ago and the continent is so deeply eroded that little sediment now reaches the shelf even during the Pleistocene glacial maxima. Whereas shelf incising canyons in the Arctic Ocean have the greatest mean length, greatest depth of incision and greatest average area, for blind canyons it is the Antarctic that has the greatest mean length, greatest depth of incision and greatest average area. Are blind canyons of the Antarctic margin the evolutionary products of shelf incising canyons that have been disconnected from terrigenous (glacial) sediment input? Submarine canyon research has attained maturity but still there are fundamental questions waiting to be answered by the next generation of marine geoscientists.

Keywords:
Submarine canyon, Evolution, Sediment load, Glaciation, Turbidite, Mass wasting

Peter Harris (GRID-Arendal)

Peter T. Harris is a dual citizen of USA and Australia and is a marine geoscientist with 30+ years experience working in marine science and management. Peter was educated at the University of Washington, Seattle (BSc) and University of Wales, Swansea (PhD). He has been the leader/co-leader of over 30 research voyages and conducted research on the Great Barrier Reef, the Fly River Delta in Papua New Guinea and on the geological record of Antarctic bottom water formation and ice sheet advance/retreat. Peter has a keen interest in submarine canyons and is a regular attendee of the INCISE meetings. He co-authored the first global synthesis of submarine canyons in 2011 and the first digital global seafloor geomorphic features map (GIS database) of the oceans in 2014. Since 2014 Peter has been the Managing Director of UNEP/GRID-Arendal, a foundation based in Norway established to assist developing countries with solving their environmental problems.

Keynote speakers

Erika McPhee-Shaw

(Western Washington University)

Erika McPhee-Shaw is a Professor at Western Washington University, Bellingham, WA USA. Previous academic positions include Professor at San Jose State University, Moss Landing Marine Laboratories, and Postdoctoral Research Associate at UC Santa Barbara, both in California, USA. Dr. McPhee-Shaw received a B.S. in Physics from Dartmouth College and a Ph.D. in Oceanography from the University of Washington. Her research focuses on the physics of internal waves interacting with continental slopes, shelves, and submarine canyons. Her particular interests are in how internal waves, and resulting stratified mixing and advection, transport sediment, heat, and nutrients, but she also studies a range of other topics in coastal circulation. McPhee-Shaw is a Leopold Leadership Fellow, has served on the nationwide board for the NOAA U.S. Integrated Ocean Observing System, and is co-chair of the 2019 Gordon Research Conference on Coastal Ocean Dynamics.

Matthieu Cartigny

(Durham University)

Matthieu Cartigny started his career as an officer in the merchant navy (BSc at Maritime Institute “De Ruijter”). He sailed a wide variety of ships and crossed all the oceans, before starting his MSc in Mechanical Engineering at Delft University. During his MSc he specialised in Fluid Mechanics and Offshore Engineering. He then got his PhD degree in Geology/Geography at Utrecht University. His PhD focussed on experimental and numerical modelling of turbidity current dynamics. After a short post-doc, he started as a Staff Scientist at the National Oceanography Centre in the United Kingdom, where he developed and deployed instruments to directly measure turbidity currents on the ocean floor. In 2016 he started at Durham University, where he currently holds a Royal Society Dorothy Hodgkin Fellowship. During this 5-year fellowship he will use the latest ocean-floor data to develop a new approach to numerically model turbidity currents.

Furu Mienis

(Royal Netherlands Institute for Sea Research)

Dr. Furu Mienis works in the department of Ocean Systems at the NIOZ Royal Netherlands Institute for Sea Research. Her area of specialization is sedimentology and environmental analysis. Her research focuses on understanding processes occurring at the sediment-water interface following a multidisciplinary process-based approach with the main goal to ultimately define their influence on sediment transport and deep-sea ecological hotspots. During her PhD she studied near-bed environmental conditions influencing cold-water coral growth and therefor reef and mound development. Over the last years she also studies sedimentological and physical processes in canyons. Her work on submarine canyons along the European margin and east US margin aims to define if canyons are pathways or sinks for organic carbon and relates organic matter distributions to benthic and pelagic faunal activity and abundance. In parallel to her more fundamental research Furu Mienis works on the technical development of deep-sea landers, which resulted in several new observational and autonomous sampling tools.

Jaime Davies

(University of Plymouth)

Dr Jaime Davies is an associate research fellow at the University of Plymouth with over 10 years’ experience as a deep-sea benthic ecologist, acting as lead biologist on several research cruises. Working in the field of conservation, with an interest in the ecology and mapping of vulnerable species/habitats, providing data to government agencies to use for proposing/designating Marine Protected Areas in UK and French waters. With an interest in cold-water corals, Jaime works closely with coral taxonomists and has organised many international cold-water coral identification training workshops. She is a co-founder of the INCISE network, a working group leader of the INCISE conservation working group and editor of a special issue on submarine canyons.

Chenglin Gong

(China Petroleum University)

Chenglin Gong is Associate Professor at the College of Geosciences of the China University of Petroleum (Beijing), Associate Editors for AAPG Bulletin and Journal of Sedimentary Research. He obtained his Ph.D. degree in petroleum geosciences from the China University of Petroleum (Beijing) in 2014, and was a postdoctoral fellow working with Prof. Ronald J. Steel at the Jackson School of Geosciences of the University of Texas at Austin from 2014 to 2017. He has some 17 first authored papers, and 3 corresponding authored papers, and has received > 3 million yuan in external grants since 2014, while in China University of Petroleum (Beijing) and University of Texas at Austin. His research interests are on: (i) source-to-sink sediment partitioning in deep-water basins, (ii) sedimentology and stratigraphy of deep-water systems, and (iii) flow processes and sedimentation in deep-water channels.

Abstract

Session 1-Canyon processes in the space-time continuum (formation, evolution, circulation)

Low-mode internal tide energy loss at a canyon topographic “pinch point” leads to intense stratified mixing layers and a focused region of lateral flow between near-boundary and offshore waters

Erika McPhee-Shaw [1], Eric Kunze [2], James Girton [3], Jingping Xu [4], Amy Waterhouse [5]

[1] Department of Environmental Sciences, Western Washington University, USA
[2] NorthWest Research Associates, USA
[3] Applied Physics Laboratory.University of Washington, USA
[4] Department of Ocean Science and Engineering, Southern University of Science and Technology, CHINA
[5] Scripps Institution of Oceanography, USA

Energetic internal waves have long been recognized as a dominant dynamic feature in submarine canyons around the world. Here we discuss recent findings from studies over the past decade in canyons on the US west coast focused on understanding internal tide propagation and dissipation within canyons. Observational experiments from two canyons have shown dissipation to cause intense stratified mixing layers, and evidence of along-isopycnal exchange between boundary-layer and offshore waters. Monterey Canyon, Central California, USA, is characterized by low-mode semidiurnal internal wave energy from the outer ocean funneling into the outer canyon and propagating shoreward, causing intense tidal currents over the deep thalweg and stratified turbulent layers with elevated turbulent dissipation extending 200 to 600 meters above the seafloor. Wave energy is lost as propagation progresses up-canyon, and a bottleneck occurs where the canyon undergoes abrupt topographic change at a bend between about 1000 and 700-m depth, a site where topography steepens and two tributary canyon branches meet. 80% of incident low-mode internal wave energy flux is lost passing over this large-scale feature. Much of this energy loss goes to water column mixing. Yet the water column does not gain potential energy and instead appears to continuously re-stratify. One outcome of the re-stratification process is persistent exchange between near-boundary and offshore waters, and the formation of spatially persistent and recurrent intermediate nepheloid layers. Offshore exchange of mixed near-boundary waters was also found to affect the distribution of oxygen within the deep oxygen minimum zone offshore of the region of intense mixing. The Eel River Canyon, in northern California, is characterized by similar internal wave energetics, flux convergence, and intense stratified mixing layers extending hundreds of meters above the seafloor. Both canyons are important sinks for internal wave energy and the implications for canyon shape feeding back into abyssal mixing, internal tide energy loss, and boundary-interior exchange are discussed.

Keywords
Internal waves, Boundary layer, Turbulence, Sediment, Intermediate nepheloid layer

Capturing hyperpycnal events in the benthic nepheloid layer of a submarine canyon in the wake of a typhoon

James T. Liu, Ray T. Hsu

Department of Oceanography, National Sun Yat-sen University, Taiwan

In 2010 two moorings each configured with a CTD and an ADCP, one with an additional non-sequential sediment trap, were deployed in the head region of the Gaoping Submarine Canyon 3 days after the typhoon-induced peaks of the runoff and suspended sediment concentration (SSC) of the Gaoping River in southern Taiwan. Our data show a demarcation between tidal and hyperpycnal regimes in the temperature, salinity, and flow fields. The latter existed in the first 5 days out of the 18-day deployment, as defined by higher water density due to high SSC. Several lines of evidence indicate the presence of the tail end of a hyperpycnal turbidity current (HTC), including the retention of warm water near the canyon floor, high SSC, down-canyon directed residual flow and its vertical structure, and high terrestrial fraction (larger than 70%) of the organic particles carried by the flow. AMS δ14C dating results show that the river-sourced organic particles captured by the sediment trap were thousands of years old. The decreasing mass flux during the deployment is also an indication of a waning HTC. Our findings show that the vertical flow structure and the direction of the gravity-driven down-canyon HTC were retarded by the instantaneous up-canyon-directed tidal oscillations in the submarine canyon.

Keywords
Hyperpycnal Turbidity current, Tidal regime, Typhoon, Sediment trap, Terrestrial sediment

How do hyperpycnal flows travel so far down submarine canyons? entrainment, detrainment and salinification.

Ben Kneller [1], Yanwei Zhang, Liang Zhao, Zhifei Liu, Eckart Meiburg

[1.] School of Geosciences, University of Aberdeen; United Kingdom

Hyperpycnal flows occur where fluvial discharge to the ocean contains very high suspended sediment loads. They are common in areas affected by frequent typhoons, such as offshore Taiwan. Laboratory experiments and numerical models suggest that such flows should experience rapid buoyancy reversal and lofting due to sediment deposition. However, evidence from Gaoping Canyon shows that some such flows travel for hundreds of kilometres along the canyon and onto the floor of the Manila Trench, breaking telecommunications cables en route, and clearly maintaining their integrity as underflows. We suggest that several factors contribute to this long run-out. Hyperpycnal flows in submarine canyons are most likely auto-suspending rather than depositional, and thus do not experience buoyancy reversal. During down-canyon transit, three mechanisms may contribute to transformation of the flow into a normal turbidity current with saltwater interstitial fluid, thus increasing run-out. The first is simple entrainment of ambient fluid and its turbulent diffusion through the current, which also dilutes the sediment concentration field. The second is by double diffusion whereby salt diffuses from entrained enclaves of ambient fluid into the interstitial fluid. The third is by detrainment of fresh water as plumes from the top of the current, carrying fine sediment and heat.

Keywords
Hyperpycnal, Lofting, Entrainment, Detrainment, Diffusion

Different Features of Prolonged Deep-sea Turbidity Currents Triggered by Individual Typhoon and Earthquake in the Gaoping Submarine Canyon

Yanwei Zhang [1], Zhifei Liu, Yulong Zhao, Xiaodong Zhang

[1.] Tongji University, China

Submarine turbidity currents are argued to deliver more sediment along their long-runout propagation than other dynamic processes from shelf to deep sea. The in situ temporal and spatial features of turbidity currents are urgently required for a better quantitative constraints on sediment transport and deposition in the deep sea. Here, we document yearlong direct monitoring of turbidity currents in the middle reach at a water depth of 1265 m and the lower reach at 2425 m on the margin of the Gaoping Submarine Canyon off Taiwan, which has the wettest typhoons and active earthquakes. Both the two moorings (~35 km apart) were equipped with sediment traps and various sensors to collect particles consecutively with 18 days interval and to record velocity, sediment concentration, temperature and salinity with 20 min interval. Seven turbidity currents are identified consistently at these two reaches with enhanced sediment flux, which was recorded by a time-series sediment trap at 30 m above the seafloor. By combining the atmospheric measurements and earthquake data, four turbidity currents are triggered by the four powerful typhoons crossed Taiwan during typhoon season in boreal summer 2015, and one event is attributed to the ML 6.5 Kaohsiung earthquake in southern Taiwan in February 2016. The two types of turbidity currents associated with individual typhoon and earthquake show a sustained duration ranging from 9 to 41 days, far more prolonged than the longest documented deep-sea turbidity currents (~10 days) in other locations. The flow velocity observed on the margin (~0.2 m/s) is much weaker than that in the thalweg of the canyon (> 5.8 m/s) inferred from the break of cables. For the first time, our observation provides the variability of the timing and hydrographic properties of the turbidity currents triggered by individual mechanisms for better constraints on flow capacity and sediment redistribution.

Keywords
Pronlonged deep-sea turbidity; Typhoon; Earthquake; Gaoping Submarine Canyon; Mooring observation

Numerical estimate of mixing rate due to internal tides generated by submarine canyons

Qiang Li, Xianzhong Mao

Graduate School at Shenzhen, Tsinghua University, China

Interaction between barotropic tides and concave-shape canyons generates internal tides. Nonlinear interaction or shear instability during internal tide generation and propagation cause local diapycnal mixing, which is one of the key processes to control sediment transport and suspension in deep ocean. A linear model, based on normal-mode decomposition, reveals complex beam generation and interaction inside the canyon. Then, a fully-nonlinear regional ocean model is employed to validate the linear model result and estimate energy dissipation during internal tide generation by different tidal forcing. Constant viscosity coefficients are chosen. The relationship between internal tide generation and topography resolution is analyzed using numerical experiments. Dissipated energy contributes to local mixing, so the mixing rate can be obtained through the numerical model. Its sensitivity to the viscosity coefficients is also discussed through comparisons with other advanced turbulence closure schemes such as MY2.5, KL10, etc. Using the estimated mixing rate, through incorporating a sediment transport model, we can investigate the resuspension and transport of sediments due to internal tides inside the canyon.

Keywords
Internal waves, Tides, Canyons

Morphology, sedimentary structures and grain size distribution of cyclic steps formed by surge-typeturbidity currents in an experimental flume

Miwa Yokokawa [1], Kazunori Fujita [1], Isamu Mori [1], Roberto Fernandez [2], Matt Czapiga [2], John Berens [2], Jeffrey Kwang[2], Kensuke Naito[2] , Gary Parker[2], Norihiro Izumi [3], Hajime Naruse [4]

[1.]Osaka Institute of Technology; [2.] University of Illinois; [3.] Hokkaido University; [4.] Kyoto University

In the submarine canyon and the vicinity, continuous step-like morphology is often observed. Many of them are inferred to be formed by turbidity currents. In this study we investigate the morphology, sedimentary structures and grain size distribution of cyclic steps formed by surge-type turbidity currents in an experimental flume. Two kinds of plastic particles, whose grain-size distributions differ from each other, were used in this study to observe grain size distribution and sedimentary structures of the cyclic steps, with an eye to application to sediment waves in the modern sea floor and in the rock record. The experiment was conducted at the Hydrosystems Laboratory of University of Illinois, Urbana-Champaign (UIUC). In the experiment, a flume, which is 14.5 m long, 0.5 m deep and 0.1m wide was suspended in a larger tank, tilted at 2.5 degrees. Salt water (density: 1.17 g/cm3) and two kinds of plastic particles (specific gravity: 1.5, D50: 68 μm, 206 μm) were mixed at a weight ratio of 20:1:1 in the head tank, and then introduced into the flume as a slurry. In Case A, slurry filling the entire volume of the head tank, 58.7 L (5.87 L/cm), was supplied for single surge, which took 40 seconds to flow out. We repeated 40 such surges. In Case B, slurry filling half the volume of the head tank, 27.4 L (2.74 L/cm), was supplied for each surge, which took 10 seconds to flow out; we repeated 80 surges. The total amount of supplied sediment was about the same in both cases. The flow rate per unit time gradually decreased during a single surge. At the end of each series, 4 steps were formed in the two series. Those steps moved upstream during the series of pulse runs. The mean values of wave steepness of the resulting steps were 0.06 and 0.05. The sedimentary structures observed in the cyclic steps of these experiments were mainly laminae gently dipping toward the upstream side. These laminae were truncated at the downstream side of the step. Moreover, the grain size analysis of the cyclic steps showed that D50 of the surface sediments tended to decrease toward the downstream, with the tendency being more prominent as the total discharge of the surge increased. It was also found that the D50 on the downstream side is smaller than on the upstream side of each step. This distribution is inferred to be caused by a hydraulic jump at the upstream side of each step.

Keywords
Turbidity currents, Cyclic steps

Bedrock erosion by sedimentary flows in submarine canyons

Neil C. Mitchell

School of Earth, Atmospheric and Environmental Sciences, University of Manchester, UK

How indurated sediment and rock now outcropping in the walls of some submarine canyons were exhumed is unclear because the flows traversing them were muddy sedimentary flows so abrasion is unlikely to have been important in these cases. The answer may lie in the importance of quarrying or plucking; observations of rivers in extreme floods suggest that such erosion processes begin to operate effectively on jointed bedrock when reach-scale bed shear stress exceeds 100 Pa and become increasingly rapid beyond that stress level, with some floods producing >1000 Pa. Here, the sedimentary flow weights that would be needed to produce similar shear stresses are estimated for two canyons where observations from submersibles have revealed exposed bedrock: Monterey Canyon (California) and Hendrickson Canyon (New Jersey). Assuming that the dense portions of turbidity currents occupied Monterey Canyon to a height corresponding to a 100-m-high steep inner wall, the minimum flow-averaged excess density derived from the estimated flow weight is found to be only 5 kg m-3, whereas a 1000 Pa condition would suggest values 10 times larger. In contrast, muddy debrites and other mass transport deposits dominate the New Jersey slope and upper rise. The weight of debris flows occupying Hendrickson Canyon was computed using the stress constraints and converted to equivalent sediment thickness using upper slope in situ sediment deposit densities. These thicknesses were found to be 1-10 m, within the range of possible mobile sediment thicknesses suggested by relief of upper slope landslide embayments. The flow density (Monterey) and thicknesses (Hendrickson) are both modest, so bed shear stresses generated by sedimentary flows in continental slope canyons seem adequate to explain exhumation of bedrock by quarrying or plucking erosion mechanisms.

Keywords
Bedrock erosion, Submarine canyons, Submarine debris flows, Turbidity currents

Structural controls on Submarine channel evolution and Architecture, Offshore Western Niger Delta.

Ashiru Olusola Raheemat , Wu Shiguo

Laboratory of Geophysics and mineral resources, Institute of Deep Sea Science and Engineering, Chinese Academy of Sciences.

Axial channel deposits of low- high amplitude reflections were studied from 3D seismic profile from offshore Niger Delta. Four laterally offset channel forms were identified having U, V, and intermediate motifs. They are named BC1- BC4 respectively. BC3 channel was studied for the structural influence on channel form architecture. Four phases of channel evolution were recognized in BC3 H1, H2-H4. H4 has the highest sinuosity value of 1.9, H1 has the lowest sinuosity value of 1.06. 3 ridges with mud volcanoes (two actives, one dormant) were also identified and their influence on the evolution of BC3 showed a positive influence on the channel form architecture. Areas overlying ridge showed higher lateral offset and higher sinuosity than other parts. Seafloor gradient and channel thalweg profiles showed even distribution away from the ridges. Transform fault leading to a horst and graben structure as seen at UC11 horizon (about 1600 m/s, Upper Miocene) are locally responsible for avulsion of BC3, a development that influences BC3 evolution up till the Pliocene. Channel fill architecture for BC3 as compared with an adjacent channel (a different study) reveals close similarity with the exception of uneven inner levee growth, varying degree of inner levee amalgamation across the length of BC3. In addition, the thickness of the abandonment drape is nearly uniform in BC3 but thinly veils/ mimics channel fills in the adjacent channel. Localized growth fault is resultant of the mud diapirs. These faults influence channel gradient and channel thalweg profile. The presence of the mud diapir ridges influence localized channel floor gradient and invariably sinuosity. Other structures such as localized faulting have contributed to gradient changes along channel profile causing ponding in some parts and channel floor elevation in other areas. The mud volcanoes could have also contributed to the number of fines in the channel, increasing channel fill sediment and preserving leveed structures. This could have contributed to the abnormally thick channel abandonment drape as seen in BC3.

Keywords
Submarine channel, Avulsion, Mud diapir, Growth fault, Offshore, Niger Delta.

Post-eruptive Submarine Terrace Development by Erosion of a Surtseyan Cone at Capelinhos, Faial Island, Azores

Zhongwei Zhao [1], Neil C. Mitchell [1], Rui Quartau [2,3], Fernando Tempera [4,5], Lucy Bricheno [6]

[1.] School of Earth and Environmental Sciences, University of Manchester, UK;
[2.] Instituto Hidrográfico, Divisão de Geologia Marinha, Lisboa, Portugal;
[3.] Instituto Dom Luiz, Faculdade de Ciências da Universidade de Lisboa, Lisboa, Portugal
[4.] Centro do IMAR da Universidade dos Açores, MARE – Marine and Environmental Sciences Centre, Rua Prof. Dr. Frederico Machado, 4, 9901-862 Horta, Açores, Portugal;
[5.] IFREMER, Centre de Bretagne, DYNECO-LEBCO, CS 10070, 29280 Plouzané, France
[6.] National Oceanography Centre, UK.

Channels on steep submarine slopes can often be linked with sources of sediment, though the volumes involved can be difficult to characterize. We here describe the erosion of the Surtseyan cone, where the history of coastline retreat is well known from historical and geophysical data. The Capelinhos volcano consists of a promontory formed in 1957/58 during a Surtseyan eruption that terminated with extensive lava forming new rocky coastal cliffs. Subsequent coastal and submarine erosion has reduced the area of the promontory and created a submarine terrace. This study uses historical information, photos and marine geophysical data collected around the promontory to characterize how the submarine terrace developed following the eruption. Historical coastline positions are supplemented with coastlines interpreted from 2004 and 2014 Google Earth images in order to work out coastline retreat rate and distance for lava- and tephra-dominated cliffs. Data from swath mapping sonars are used to characterise the submarine morphology of the resulting terrace. Photographs collected by SCUBA and ROV dives on the submarine terrace reveal a rugged surface now covered with boulders. The results reveal that coastal retreat rates decreased rapidly with time after the eruption approximately in an inverse power law relationship with the retreat distance. Model calculations suggest that wave attenuation over the developing terrace can only partly explain how rapidly the retreat rate declined. The varied resistance to erosion of gradually exposed cliff base materials with the protection from eroded materials owing to rapid wave erosion, constitutes a more likely explanation. Multibeam sonar data collected below the terrace reveals several chutes of ~10 m relief and each 100-200 m across. While we cannot be sure if the chutes were carved by sedimentary flows originating from the terrace or slope failure, they head at the change of gradient marking the terrace edge and were likely pathways for much of the eroded sediment.

Keywords
Submarine terrace, Coastal erosion, Wave attenuation, Sediment transport, Channelized movement

Morphology and sedimentation of Sakawa fan delta slope, Sagami Bay, Japan

Saiko Sugisaki, Taku Ajioka, Hajime Katayama, Ken Ikehara

Geological Survey of Japan, AIST, Japan

Poster

Izu Peninsula on the Philippine Plate has collided to Honshu island on the Amur and Okhotsk Plates from south, and the plate boundary of the Philippine Plate locates at both sides of the peninsula along the axes of Suruga (at west) and Sagami (at east) Bays. The collision has created uplift of young mountains, and has maintained large coarse sediment supply and large difference in water depth in the bays. Sakawa fan delta slope is a steep slope with its average gradient of 5–6˚ in the northwestern corner of Sagami Bay. We obtained a new swath bathymetry and backscatter data with surface sediment samples from 20 sites from the Sakawa fan delta slope and its surroundings. Numerous shallow channels were characteristics of the slope. Most of the origin of the channels locate offshore of modern river mouths, and the upper reaches of the channels incise the upper slope. Width of the channel is very narrow at the uppermost slope, but becomes wider in downslope direction. Slope gradient changes systematically from steep to gentle in downslope direction (upper slope: >15˚, middle slope: 5–10˚, lower slope: 2–5˚). The strongest backscatter intensity occurs at the middle slope, and the intensity becomes weaker in the lower slope. Relatively thick hemipelagic mud was collected from the middle slope, and some sand layers were obtained from the lower slope. However, the previous studies indicated the occurrence of thick gravelly sand at the middle slope. Some sand layers at the lower slope contained plant debris. Upward coarsening reverse grading and internal erosional surfaces in the sand layers suggest that at least some sand layers were flood origin. Density bottom currents with sands and gravels have confined in the incised channel at the upper slope. Coarse-grained sand and gravel deposits at the middle slope where the incised channels become unclear, but fine-sand and mud transports further downslope and deposits at the lower slope where the velocity of density currents are decreased. Repeated occurrence of flood-related density bottom currents through shallow channels had transported sand and gravels, and had formed sand layers at the lower slope.

Keywords
Fan delta slope, Morphology, Surface sediment, Flood deposit

Session 2 - New ways to study submarine canyons: integrated programs, new technologies and coordinated monitoring efforts

How new deep-sea observations change turbidity current models

Matthieu Cartigny

Department of Geography, Durham University, UK

The ocean floor comprises two thirds of our planet, and it hosts spectacular networks of channels and canyons formed by often powerful episodic sediment-laden flows, called turbidity currents. These submarine channels can extend for thousands of kilometres into the deep ocean, and are fed by submarine canyons that are as big as the Grand Canyon. The turbidity currents that created these channels remain poorly understood, as measurements of their velocities and sediment concentrations are only available in seven locations worldwide. This lack of observations reflects the relatively inaccessible and powerful nature of the flows, some of which powerful enough to drag 2,000 kg anchors for kilometres along the ocean floor. Fortunately, new technology now allow us to monitor turbidity currents in unprecedented detail. These new field observations are important as turbidity currents are of societal and economic relevance. These flows are the main supplier sediment, organic carbon and nutrients to much of the deep-sea, as turbidity currents rival rivers in their global capacity to transport sediment across our planet. These fluxes make turbidity currents an important part of the carbon cycle that affects long term climate change, and they sustain rare ecological communities on the deep sea bed. Turbidity currents pose a hazard to submarine infrastructure, and have forced pipeline operators to invest millions of dollars in re-routing pipelines. Furthermore, these flows create the largest sedimentary bodies on our planet (e.g. the Bengal submarine fan holding tens of million km3 of sediment), and these sedimentary body host a significant part of our oil and gas reservoirs. Here I will present observations of three turbidity current monitoring sides: submarine channels in Canadian fjords, Monterey Canyon and the Congo Canyon. The observations show that turbidity currents can substantially deviate from the textbook models. The dynamics of the turbidity currents are controlled by a fast-moving and dense frontal cell that set-up the more dilute cloud that is seen in most models. Additionally, the observations show a bifurcation in the behaviour of the flows, where a flow either develops as fast and dense or as slow and dilute. Furthermore, the flow observations are link to their sedimentary deposits. This direct link between flow dynamics and deposits can provide valuable insights into the dynamics of turbidity currents throughout geological times.

Keywords
Turbidity currents, Submarine canyon, Sediment transport, Seafloor monitoring

Innovative monitoring reveals the anatomy of submarine canyon turbidity currents

Charles K. Paull [1], Peter J. Talling [2], Katherine L. Maier [1], Daniel Parsons [3], Jingping Xu [4], David W. Caress [1], Roberto Gwiazda [1], Eve Lundsten [1], Krystle Anderson [1], James Barry [1], M. Chaffey [1], T. O'Reilly [1], K. Rosenberger [5], J. Gales [6], Brian Kieft [1], Mary McGann [7], Steven M. Simmons [3], Michael McCann [1], Esther J. Sumner [8], Michael A. Clare [8], Mathiew J. Cartigny [9], Monterey Coordinated Canyon Experiment Team

[1.] Monterey Bay Aquarium Research Institute, USA [2.] Departments of Geography and Earth Sciences, Durham University, UK [3] Energy and Environment Institute, University of Hull, UK [4.]Southern University of Science and Technology of China, China [5.]U.S. Geological Survey, Santa Cruz, USA [6.]University of Plymouth, UK [7.]U.S. Geological Survey, Menlo Park, USA [8.]National Oceanography Centre, University of Southampton Waterfront Campus, UK [9.]Departments of Geography and Earth Sciences, Durham University, UK

The recently completed Coordinated Canyon Experiment (CCE) was undertaken to provide detailed measurements of turbidity currents using multiple sensors and sediment traps deployed along the axis of Monterey Canyon, offshore California. The multi-institution study involving an array of moored instruments and repeated seafloor mapping surveys captured the passage of 15 flow events within the axis of Monterey Canyon and documented their impact on the canyon floor morphology over an 18-month period. Data from six moored downward looking acoustic Doppler current profilers (ADCP) show three of the flows ran for >50 km from less than 280 to over 1,860 m water depth (mwd). These flows had propagation velocities up to 7.2 m/sec, the fastest yet recorded by instruments. The canyon floor was mapped six times in the ranges 190-540 and 1500-1900 mwd with Autonomous Underwater Vehicles (AUV). The shallower surveys (190 to 540 mwd) revealed +3 m to –3 m bathymetric changes in the continuous crescent shaped bedforms that exist in a narrow band along the canyon axis and are attributed to flow events. Below 1500 mwd the bathymetric changes are much more-subtle. We demonstrate that flow events were driven by dense remobilized near-seabed sediment layers, which were capable of carrying heavy (800 kg) objects for several kilometers leaving them entombed in meters-thick sediment cover. The dense remobilized seafloor layer at the front of some flows spawned a dilute sediment cloud that lasted for many hours. The dense layers were generated by failure and remobilization of loosely-packed seabed within the canyon floor, and flows were not always initiated by an external trigger such as storms, floods, or earthquakes.

Keywords
Turbidity Currents, Monitoring, Seafloor mapping

Going with the flow: Tracking turbidity currents along the seafloor with man-made motion-recording boulders.

Roberto Gwiazda [1], Charles Paull [1], Brian Kieft [1], Dave Caress [1], Peter Talling [2], Krystle Anderson [1], Eve Lundsten [1], Matthieu Cartigny [2]

[1.] Monterey Bay Aquarium Research Institute, USA
[2.] Department of Earth Sciences and Geography, University of Durham, UK

During the course of 18 months the Coordinated Canyon Experiment (CCE) documented the passage of 15 sediment gravity flows along the axis of Monterey Canyon, offshore California, USA, utilizing a comprehensive array of moored sensors and instruments placed between 200m to 1,850m water depths (mwd). Boulder-like devices capable of recording their own motion were placed between 200- and 400- mwd to document the arrival, velocity and flow evolution of sediment density flows. These novel instruments called Benthic Event Detectors (BED) were housed inside spheres or cubes of 50 cm size made of metal, plastic and syntactic foam ballasted to a density of 2.1 gr/cc and half buried in the seafloor during deployment. One BED was also placed atop an 800 kg ~2m-tall metal tripod (density > 7 gr/cc). BEDS contain accelerometers along three orthogonal axes, a time recorder and a pressure sensor inside a pressure case rated to 500 mwd. Changes in orientation trigger data collection at a recording rate of 50 Hz until motion stops. Built-in acoustic beacons and modems allow for BEDs to be relocated and data to be downloaded, even when BEDs are buried in sediment to depths of >1 m. Over the course of the study twenty-four BED motions were recorded as a result of nine sediment density flows sweeping though the upper Canyon (<500 mwd). During a sediment gravity flow on the 24th of November 2016, round and square BEDs and the tripod-mounted BED all travelled at nearly the transit speed of the event, reaching 4 m/s. The simultaneous movement of 3 BEDS of different densities and shapes at nearly the same velocity at the front of the flow, and the simultaneous movement of 5 BEDs separated by a 3-km distance along the channel during this event, suggest the entire seabed along the canyon axis was in motion. This observation supports the proposition that sediment gravity flows consist of fast and dense near-bed layers of remobilized seafloor. The longest BED motion lasted half an hour and covered a distance of 4.5 Km. The detrended trajectory of this BED shows that the down-canyon movement of the BED includes multiple vertical deviation of ~ 1.7 m from the general down-canyon trajectory. In order to evaluate whether this variability reflects transport along crescent shaped bedforms the detrended BED trajectory is compared with the detrended bathymetry of the thalweg mapped with an autonomous underwater vehicle 2 weeks after the event. The detrended bathymetry shows vertical deviations of ~1.3 m. Significantly, the number of vertical deviations along the detrended BED record (n = 131) is close to the number of vertical deviation from the detrended bathymetry along the same distance (n =135). These observations are consistent with the BEDS riding within a basal layer that follows the crescent shaped bedforms morphology. The detailed record of BEDs motions during sediment gravity flows highlights the promise of this new tool for the study of marine sediment transport processes.

Keywords
Turbidity currents, Sediment density flows, Basal layer, Technology, Monitoring, Velocity

linteractions between turbidity current and cyclic steps: a layer-averaged fully coupled numerical case study

Peng HU [1], Yue LI [1], Chengling Gong [2]

[1.] Institute of Port, Coastal and Nearshore Engineering, Ocean College, Zhejiang University, China
[2.] College of Geosciences, China University of Petroleum (Beijing), China

Here a highly efficient layer-averaged fully coupled model is presented for submarine turbidity currents. Also included is a numerical case study of the interactions between turbidity currents dynamics and cyclic steps in Rio Muni Basin, Equatorial Guinea along West Africa. The present new model is based a previous model by Hu et al. (2012, Journal of Hydrology, 464-465, 41-53). New features include using triangular cells to represent the computational domain, considering non-uniform sediment transport, application of the recently developed local-time-stepping strategy (Hu et al. 2018, Journal of Hydraulic Engineering, under review) to improve computational efficiency. Before applying the model to cyclic steps in Rio Muni Basin, a theoretical analysis is performed with regards to erosion/deposition trends on the velocity-concentration plane. This helps revealing how and to what extent the velocity/concentration has to vary around a bed step, such that inter-change of the erosion/deposition trend could occur in response to an internal hydraulic jump, which is important for migration of cyclic steps. Afterwards, systematic numerical case studies are conducted with regards to turbidity current evolution over the Rio Muni Basin and their effects on bed erosion/deposition. Particular attention is paid to threshold conditions that may lead to the reported erosion/deposition patterns by Li and Gong (2018, Journal of Geophysical Research).

Keywords
Turbidity current, Cyclic step, Numerical modeling, Sediment transport

Autonomous hydrographic profiling: a tool for assessing the nepheloid structure of trawled submarine canyons

Marta Arjona-Camas [1], Pere Puig [1], Albert Palanques [1], Mikhail Emelianov [1], Ruth Durán [1], Martin White [2,3]

[1.] Institute of Marine Sciences (ICM-CSIC). Marine Geosciences Department, Barcelona, Spain;
[2.] Earth and Ocean Sciences, Ryan Institute - School of Natural Sciences, National University of Ireland, Galway ,Ireland,
[3.] Irish Centre for Research in Applied Geoscience (ICRAG), National University of Ireland, Galway, Ireland

Autonomous hydrographic profilers have been recently used to conduct continuous measurements of water column properties over large depth ranges at high temporal and vertical resolution. In the frame of the FORMED and the ABIDES Projects, the Aqualog profiling carrier, equipped with a CTD and a turbidimeter, was successfully tested in two submarine canyons (Foix and La Fonera) from the Catalan continental margin (NW Mediterranean), with the objective to study the temporal evolution of the nepheloid structure and to assess the contribution of trawling resuspension plumes. From April to June 2014, the mooring line was deployed in the Foix Canyon axis at 870 m depth, and the instruments were programmed to collect hydrographic profiles once per day from 800 to 200 m water depth. A similar mooring line was deployed in La Fonera Canyon axis at 929 m depth, from February to April 2017, increasing the profiling frequency, from 750 to 150 m water depth, twice a day. At this location, closed spaced CTD transects across the canyon were also conducted during three oceanographic cruises in June and October 2017, and in March 2018. Daily hydrographic profiles collected throughout both field studies illustrated a well-defined water turbidity structure consisting in intermediate nepheloid layers (INLs), developed mostly above the canyon rims, and near-bottom nepheloid layers (BNLs) confined within the canyon. Using fishing vessels' positioning from Vessel Monitoring System (VMS) and Automated Information System (AIS) data, the temporal and spatial distribution of the local trawling fleets over both canyons at the time of the deployments suggests that trawling is an important cause increasing turbidity in the water column. Nepheloid layers were absent when there was no fishing activity next to the mooring locations, whereas both INLs and BNLs were observed with trawling activity on the nearby fishing grounds. Nonetheless, natural processes also contribute to the advection and/or retention of resuspended particles, playing a major role in their transport along and across margin via nepheloid layers. These field experiments describe, for the first time, the temporal evolution of water column turbidity using an autonomous hydrographic profiler deployed within two trawled submarine canyons on the NW Mediterranean region. Although our data only provide a snapshot of a section of the water column, autonomous profiling observatories of the moored type have great potential in terms of marine environmental monitoring.

Keywords
Autonomous hydrographic profiler, Submarine canyon, Nepheloid structure, Bottom trawling, Resuspension, NW Mediterranean

Mapping, Modelling and Monitoring Key Processes and Controls on Cold-water Coral Habitats in Submarine Canyons (MMMonKey_Pro)

Andy J Wheeler, A. Lim, J. Appah, K. Harrison, O.J. O'Connor, L. O'Reilly

University College Cork / Irish Centre for Reseach in Applied Geoscience

Submarine canyons are dynamic environments that support diverse biological communities including fisheries. Recent work on the Irish Porcupine Bank Canyon (PBC), a natural laboratory isolated from terrigenous input, has revealed extensive speciose, high biomass cold-water coral (CWC) structural habitats. This "big science" project uses Irish state-of-the-art and new innovative marine exploration and analysis technologies to explore and monitor the PBC-CWC habitats and relate to ocean-climate environmental dynamics. The project will employ ROV-based multibeam bathymetry and novel 3D photogrammetric approaches for geostatistical analysis and habitat characterisation. Monitoring of canyon hydrodynamic and sedimentary processes, core and coral-morphotype analysis will reveal the process thresholds defining coral sub-habitats' limits, in space and time, and allow predictive CWC, and habitat sensitivity, models to assist marine spatial planning. By assessing the magnitude of existing anthropogenic impacts within the constraints of the sensitivity model, recommendations can be extrapolated from the data for sustainable, responsible intervention in these habitats for fisheries and hydrocarbon exploration. Likewise, process thresholds will reveal the potential impact-response from climate change facilitating knowledge-based recommendations for effective management. This project adds to Irish seabed mapping capacity, develops a critical mass to generate large consortia, building further capacity and relationships with industrial (hydrocarbon)/international partners.

Keywords
Habitat mapping, Sedimentology, Seabed imaging, Hydrodynamics, Submarine canyon, CT scanning

Nearly a decade of deep-sea monitoring in Barkley Canyon, NE Pacific, using the NEPTUNE cabled observatory.

Fabio Cabrera De Leo [1,2], Steve Mihály [1], Michael Morley [1], Jacopo Aguzzi [3], Craig Smith [4], Pere Puig [3], Laurenz Thomsen [5]

[1.] Ocean Networks Canada, University of Victoria, Canada;
[2.] Department of Biology, University of Victoria, Canada;
[3.] Institute of Marine Sciences (ICM-CSIC), Barcelona, Spain;
[4.] University of Hawaii at Manoa, Honolulu, USA;
[5.] Jacobs University, Bremen, Germany

Poster

Cabled observatories provide a permanent presence in the ocean, enabling discovery and tracking of previously unseen faunal behaviour and long-term changes in biodiversity and ecosystem function. Ocean Networks Canada operates large seafloor cabled observatory networks in the NE Pacific and in the Arctic. The seafloor network of 850+ km of backbone cables connects > 50 instrumented sites (>400 oceanographic instruments, >5,000 sensors), in habitats ranging from temperate coastal fjords and rocky reefs, ice-covered Arctic bays, to deep-sea canyons, cold seeps, abyssal plains and hydrothermal vents. Here we showcase nearly 10 years of deep-sea monitoring in Barkley Canyon, off the coast of British Columbia, and various research projects investigating a range of topics including benthic biodiversity and ecosystem function, bentho-pelagic coupling, fate of organic falls, sediment and organic matter transport and seasonal deep zooplankton ontogenetic migration. Approaching almost a decade since the NEPTUNE observatory came online in 2009, we were able to identify the main processes driving benthic biodiversity and ecosystem function, such as sea surface productivity and carbon flux, atmospheric and astronomic forcing, and the effects of the NE Pacific oxygen minimum zone. We also describe recently deployed and upcoming experiments designed to: 1) identify natural and anthropogenic sediment transport processes and its effects on the benthic biota; 2) to monitor seasonal and inter-annual fluctuations in abundance and size-structure of commercially exploited species (e.g., rockfish Sebastolobus alascanus and S. altivelis, blackcod Anoplopoma fimbria, tanner crab, Chionoecetes tanneri) using video imagery and passive and active acoustics.

Keywords
Barkley Canyon; NE Pacific; NEPTUNE cabled observatory; Benthic biodiversity; Ecosystem function

The unknown role of Whittard Canyon: Pathway or sink for organic carbon?

Furu Mienis, Sofia Ledin, Sabine Haalboom, Marc Lavaleye, Henko de Stigter, Hans van Haren, Gerard Duineveld

NIOZ, Royal Netherlands Institute for Sea Research and Utrecht University, The Netherlands

Submarine canyons provide effective connections between the productive shelf waters and the nutrient poor deep-sea, providing important lateral transport pathways for (organic) matter. During two cruises with the RV Pelagia in 2017/2018 these pathways were studied in the easternmost branch of the Whittard Canyon complex to determine which processes affect organic matter dispersal, remineralization and retention following a multidisciplinary approach. CTD transects were carried out to determine the presence of nepheloid layers in the canyon, while landers and moorings were deployed to study particle transport processes through time (days-year). Sediment samples were collected along the canyon axis and on the adjacent slopes to determine organic matter and sedimentation rates, while in situ and ex situ respiration experiments gave a first insight into remineralization processes. CTD transects showed the presence of nepheloid layers between 1200 and 2500 m water depth. Backscatter data collected with landers showed that the resuspension of material is related to internal waves that interact with the canyon topography. Over the year many large particle resuspension events were observed, which lasted from several days up to several weeks. Some events were linked to major storms, like Ophelia, while others are still to be identified. Particle transport during these events is mainly focused along the canyon axis. Clear differences in sediment composition and sedimentation rate were observed between the canyon and slope sediments and with depth. The head of the canyon is characterized by erosional processes and low organic matter contents, as are the slopes of the canyon. A depo center was found at around 2000 m water depth, showing high organic matter values and the presence of turbidites. The deepest part of the canyon is dominated by marine derived material, containing high, but aged organic matter. In situ respiration measurements showed a clear relation to the amount and freshness of organic matter. Highest rates were found near the depocenter, while lower rates were observed in the head of the canyon.

Keywords
Organic matter, Internal waves, Particle transport, Remineralization

The unknown role of submarine canyons – Linking habitat and faunal patterns to organic matter cycling in Whittard Canyon.

Sofia Ledin[1], Gerard Duineveld[1], Marc Lavaleye[1], Gert-Jan Reichart[1,2], Furu Mienis[1]

[1.] Department of ocean systems, NIOZ, The Royal Netherlands Institute of Sea Research and Utrecht University, Landsdiep 4, 1797 SZ 't Horntje, Texel
[2.] Department of Earth Sciences, Faculty of Geosciences, Utrecht University, PO Box 80125, 3508 TC Utrecht

Submarine canyons are regarded as major conduits for particle and organic matter (OM) transport from the continental shelf to the food deprived deep sea. The heterogeneous topography in canyon systems interacts with the hydrography, generating distinctive currents and numerous varieties of habitats. The Whittard Canyon system (Celtic Margin, NE Atlantic) was visited during cruises in 2017 and 2018 with R/V Pelagia. In this canyon complex hydrodynamics and related particle transport are mainly steered by internal tides. Habitat and macrofaunal distributions were mapped to study their link with the abiotic environment and OM availability. For this purpose, tethered video and image transects were made in the most eastern branch of Whittard Canyon. Intervals (10m per 50m) were analysed by applying distance and depth as factors, where all visible fauna, substrate variations and particle densities were noted. Habitat variation was furthermore linked to abiotic factors like temperature, salinity and oxygen, which were logged simultaneously, and sedimentary organic carbon content as derived from bottom samples. Preliminary results indicate a varied faunal assemblage along the canyon transects. Substrate changed rapidly in canyon transects both with distance and depth. Shallower depths of 250-500m with coarse substrate are characterised by crustaceans, while in soft sediment at depths near 1000m Pennatulacean, Porifera and Echinodermata are primarily observed. Octocorals were very abundant on hard substrate at depths below 1000m. The eastern and western canyon walls each displayed a different faunal assemblage. Lower abundance and species variation are observed on the western canyon wall in contrast to the eastern wall at comparable depths. Through linking habitat variation with faunal patterns, we can explore their potential use as proxies for OM availability and mineralization in canyon systems. In the near future we aim to utilize interdisciplinary methods to obtain a more comprehensive understanding of Whittard Canyons faunal and habitat variations, by integrating microbial data, eDNA and abiotic factors.

Keywords
Submarine canyons, Habitat heterogeneity, Faunal patterns, Organic Matter cycling, Whittard Canyon

Submarine canyons as centres of bioturbation activity and distinct ecosystem functioning

Craig M. Robertson[1], Demopoulos AWJ[2], Bourque JR[2], Mienis F[3], Duineveld GCA[3], Lavaleye MSS[3], Koivisto RK[1], Brooke SD[4], Ross SW[5], Rhode M[5], and Davies AJ[1]

[1.] Bangor University, School of Ocean Sciences, Bangor, UK
[2.] U.S.G.S. Wetland and Aquatic Research Centre, Gainesville, USA
[3.] NIOZ Royal Netherlands Institute for Sea Research and Utrecht University, Den Burg, the Netherlands
[4.] Florida State University, Coastal and Marine Lab, St. Teresa, USA
[5.] UNC-Wilmington, Center for Marine Science, USA

The deep-sea benthos occupies more than three quarters of the planet's surface, yet our knowledge of how benthic communities contribute to ecosystem processes is still in infancy. Submarine canyons are known as conduits of organic matter and sediments from shelf to abyssal plains and are often associated with distinct macrobenthic communities, enhanced diversity and standing stocks compared to neighbouring slope environments. However, whole community canyon system studies assessing how these communities function and contribute to important deep-sea sedimentary ecosystem processes are lacking. To investigate how environmental conditions within canyons can alter ecosystem function, this study examined the functional differences between two canyons and adjacent slopes macrofaunal communities in the Mid-Atlantic Bight region in the western north Atlantic. A total of 49 trait modalities across 10 biological traits were used and showed that higher functional richness was present within upper and middle canyon communities compared to slope communities across the studied depth gradient. Lower canyon communities (800-900 m) were less functionally rich, a feature attributed to substantial biomass contribution of opportunistic and dominant taxa that benefited from organically-enriched sediment in the canyons. Bioturbation potential was higher in the canyons than adjacent slope, especially within Baltimore Canyon, and was attributed to the high affinities for surface and subsurface sediment modifiers and sediment ingestion or filter-feeding bioturbators. The trait affinities within canyons showed propensity for sediment reworking to greater depths, suggesting that canyon communities may enhance nutrient fluxes and burial of accumulated organic matter. The findings confirm that enhanced macrofaunal community ecosystem function and higher bioturbation occurred within the canyons compared to the adjacent slopes and provides new insight into the distinct functional roles found within canyon and slope macrofauna.

Keywords
Macrofauna, Biological Traits, Ecosystem Function, Bioturbation, Disturbance

Internal tides and canyon wall faunal assemblages

Tabitha R R Pearman [1], Alex Callaway [2], Robert Hall [3], Anthony Jenson, Claudio Lo Iacono [4], Veerle Huvenne [4]

[1.] Ocean and Earth Science, University of Southampton, Southampton, UK
[2.] Centre for Environment, Fisheries and Aquaculture Science (Cefas), Lowestoft, UK
[3.] School of Environmental Sciences, University of East Anglia, Norwich, UK
[4.] National Oceanography Centre (NOC), UK

Submarine canyons are biodiversity hotspots in the deep sea with canyon walls supporting diverse faunal assemblages that exhibit high beta diversity. Wall assemblages can vary between and even within canyon branches. Understanding the processes that generate these spatial patterns is fundamental to effective management of canyon biodiversity. However, few ecological studies of canyon wall assemblages have been conducted and our understanding of the processes that generate these spatial patterns is limited. Canyons are recognised as sites of intensified hydrodynamic regimes, with internal tides linked to enhanced mixing and nepheloid layer production: two processes associated with increased faunal diversity and abundance. Recent species predictive mapping efforts for submarine canyons found model performance improved with the inclusion of physical oceanographic variables. Canyon faunal distributions respond to physical oceanographic (water mass characteristics and hydrodynamics) gradients. Internal tides also generate large local variations in water mass characteristics by their movement along the canyon. Internal tides with amplitudes up to 80 m have been observed for the M2 internal tide in Whittard Canyon, with internal waves generating daily 1°C temperature fluctuations and dissolved oxygen concentration changes of 12 µmol-1 on certain sections of the canyon walls. In this presentation we will explore if this variability in environmental conditions generated by the internal tide could be a contributing factor to spatial patterns in faunal distribution on canyon walls. We investigate this via an interdisciplinary study utilising biological, physical and oceanographic datasets to undertake high-resolution community analysis of wall assemblages within Whittard Canyon in relation to environmental variance experienced by canyon wall fauna.

Keywords
Fauna assemblages, Internal tide

A Morphometric Analysis and Classification of Mediterranean Submarine Canyons

Sian Pledger [1,2], Aaron Micallef [2]

[1.] AIS Environment Ltd
[2.] University of Malta

Submarine canyons are valleys that incise the continental shelf and slope. They play a crucial role in the transfer of sediment and water from the continental shelves to the deep oceans. Previous studies have shown that Mediterranean canyons are morphologically different from those elsewhere. The objective of this study is to investigate this phenomenon by carrying out a detailed morphometric analysis and classification of Mediterranean canyons. A geodatabase of the canyons was compiled from the literature, 203 canyons were mapped and their attributes were measured and calculated. The results show several correlations between the canyon attributes. Active margin canyons are smaller, shorter, smoother, straighter, shallower and steeper than passive margin canyons. Shelf breaching canyons are rougher, more meandering, wider and deeper than blind canyons. Hack's Law was successfully applied to the canyons, suggesting that as they grow they elongate. Spatial distribution of canyons, based on their attributes, is controlled by the proximity to terrestrial rivers or the characteristics of the incised continental margin. The classification of the Mediterranean canyons was investigated using two approaches: data-driven (cluster analysis) and knowledge-driven (ordination analysis). Principal component analysis suggested that area, head depth, axial gradient and rugosity are the most appropriate classifying attributes. The data-driven approach gave a five-cluster classification, but most of the canyons fell into one cluster. The differences between the clusters were considered to be an artefact of the method used to generate the clusters, rather than a consequence of morphological differences. The knowledge-driven approach provided no identifiable groups of canyons. It was concluded that a realistic and predictive classification system could not be devised for the Mediterranean canyons. This study provides a base for future geomorphological work on Mediterranean canyons, to improve understanding of their origin and evolution, and provides a methodological framework for replicating similar studies worldwide.

Keywords
Submarine Canyon; Geomorphology; Mediterranean; Classification

Geomorphic and habitat mapping of submarine canyons of the Australian continental margin

Zhi Huang [1], Thomas A. Schlacher [2], Scott Nichol [1], Rachel Nanson [1], Peter T. Harris [3], M Julian Caley [4], Alan Williams [5], Franziska Althaus [5], Rudy Kloser [5]

[1.] National Earth and Marine Observations Branch, Geoscience Australia, Australia
[2.] School of Science and Engineering, The University of the Sunshine Coast, Australia
[3.] GRID-Arendal, Norway
[4.] Queensland University of Technology, Australia
[5.] CSIRO Oceans and Atmosphere Flagship, Australia

Submarine canyons influence oceanographic processes, sediment transport, productivity and benthic biodiversity from the continental shelf to the slope and beyond. The relative influence of an individual canyon on these processes will, in part, be determined by its form, shape and position on the continental margin. Based on the latest bathymetry data for the Australian margin, we have mapped 753 submarine canyons and derived a large number of geomorphic metrics based on canyon form, shape and position. In this presentation we highlight key results, which show that these canyon metrics describe a wide variety of canyon form and physical complexity that is consistent with the geological evolution of the Australian margin and the local influence of geological and geomorphological processes. Thus, Australian submarine canyons cluster in the east, southeast, west and southwest where the margin is steepest and continental shelf is narrow. Subsequently, we used 22 environmental variables (including many of the geomorphic metrics) as surrogates to derive estimates of habitat potential for these submarine canyons. Our analysis shows that the high geomorphic and oceanographic diversity of Australian submarine canyons creates a multitude of potential habitat types, notably for benthic infaunal and epifaunal communities. Canyons with particularly high benthic habitat potential are located mainly offshore of the Great Barrier Reef and the New South Wales coast, on the eastern margin of Tasmania and Bass Strait, and on the southern Australian margin. Many of these canyons have complex bottom topography, are likely to have high primary and secondary production, and have less potential for sediment disturbance due to bottom current. Canyons that incise the shelf tend to score higher in habitat potential than those confined to the slope. This habitat potential is exemplified by Perth Canyon, a large shelf-incising canyon on the southwest Australian margin, which we present in this talk as a case study. High-resolution (20m) multibeam sonar data for the canyon reveals the geomorphic complexity characterised by escarpments, transverse ridges, large-scale mass movements and active bedform fields. This geodiversity and the interaction of the Perth Canyon with regional oceanographic currents (the Leeuwin Current and Undercurrent) provide highly diverse habitats for benthic fauna such as deep-sea corals and sponges and a variety of pelagic fauna including cetaceans (e.g., Australian pygmy blue whales, minke whales, sharks and tunas).

Keywords
Geomorphology, Habitat, Perth Canyon, mapping

Scaling canyon ecology: multi-resolution consideration of biodiversity in Explorer Canyon.

David Price [1,2], A. Callaway [3], K. Robert [4], C. Lo Iacono [2], R. Hall [5], V. Huvenne [2]

[1.] University of Southampton,UK
[2.] National Oceanography Centre, UK
[3.] Centre for Environment, Fisheries and Aquaculture Sciences (CEFAS), UK
[4.] Memorial University (MU), Canada
[5.] University of East Anglia (UAE), UK

Ecological research in deep-water environments has historically seen a trade-off between data resolution and data coverage. To achieve comprehensive, broad-scale coverage the resolution of data is necessarily low. Yet when examining key fine-scale features the data resolutions are comparatively, incredibly high, though over very small areas. This results in fine-scale relationships being extrapolated across broad-scale data although the implications of doing so are rarely considered due to the lack of an alternative approach. Recent implementation of multibeam echosounder (MBES) survey techniques from underwater robotic systems such as Remotely Operated Vehicles (ROVs) and Autonomous Underwater Vehicles (AUVs) has enabled acquisition of fine-scale information over broad-scale areas in deep water allowing the implication of resolution on biodiversity to be interrogated more effectively. In addition, novel imaging techniques such as Structure from Motion (SfM) can yield ecological studies an order of magnitude higher to centimetric resolution, a scale unobtainable through other methods. During the JC125 expedition, multi-scale MBES data in Explorer Canyon, NE Atlantic were collected. This work was funded by the ERC CODEMAP (Complex Deep-sea Environments: Mapping habitat heterogeneity As Proxy for biodiversity) project (Starting Grant no 258482) and the NERC MAREMAP programme. A combination of shipboard and AUV (Autosub 6000) acquired bathymetry was analysed to explore the role of terrain at different scales (metres to 10s of metres) in Explorer Canyon which is part of the wider Whittard Canyon complex. Using the ROV Isis, three video transects were collected to quantify biodiversity and community assemblages, and to ground-truth habitat occurrence. We explore the relationship further and investigate the role of very fine-scale, centimetric resolution terrain complexity derived from SfM, in the form of 40 reconstructed 3D 25 m transects. Fine-scale structural complexity strongly influenced community assemblage and biodiversity in tandem with, but not limited to cold-water coral reef occurrence. Comparing these scales give us greater insight into the canyon system from an ecological perspective. These data provide insight into how reliable broad-scale ecological assumptions are, with special reference to habitat mapping and species distribution modelling.

Keywords
Biodiversity Multi-scale mapping SfM

Quantifying the transfer of terrestrial organic matter into two contrasting New Zealand submarine canyon systems using bulk and compound-specific stable isotopes

Daniel Leduc[1], Max Gibbs, Andrew Swales, Andrew Kingston, Scott Nodder, Ashley Rowden, Fabio De Leo, Craig Smith, Joshu Mountjoy, Brittany Graham, Arne Pallentin

[1.] National Institute of Water & Atmospheric Research Ltd

Poster

The extent to which canyons can facilitate the transfer of land-derived organic matter to the deep sea depends on factors such as canyon geomorphology, their position relative to the coast, and proximity to sediment sources, such as rivers. We used bulk stable isotope and compound-specific isotope analyses to determine the sources of organic matter in sediments of two contrasting canyon systems on either side of the active plate boundary and associated uplifted mountain divide of the South Island off New Zealand: Kaikōura Canyon, a steep canyon close to the shore on the eastern seaboard, and Hokitika Canyon, a narrow and lower gradient canyon further from the coast on the western side of the island. In Kaikōura Canyon, high concentrations of land-derived organic matter were found in areas near the coast and down to 1000 m, but very little land-derived material was found further away from the coast (25 km) and deeper in the canyon, where marine-derived organic matter predominated. The nearshore areas with high input of land-derived organic matter were characterized by high biomass of benthic fauna. In contrast, sediment organic matter in Hokitika Canyon was comprised almost entirely of land-derived material, down to 2000 m and up to 200 km from the coast. Despite this relatively high input of organic matter from nearby rivers, the biomass of benthic fauna was low across the entire canyon, suggesting that land-derived organic material alone may be insufficient to support deep-sea benthic communities. The compound-specific stable isotope results indicate that some local rivers contribute more to canyon sediment organic matter than others, which may be related to river catchment sediment yields, the geomorphology of river mouths, their position relative to the canyon head, and local oceanographic hydrodynamics in the coastal zone and on the continental shelf. The significant differences in the local sources and quantity and quality of organic matter observed in the two contrasting canyon systems mirror the predominant sediment transport processes. The Kaikōura Canyon is driven largely by geologically significant episodes of canyon flushing, probably related to the cycle of large plate boundary earthquakes and local ground-shaking. In contrast, the Hokitika Canyon is more representative of a continually fed sediment system driven by a near-constant supply of material derived from a proximal, rapidly eroding and uplifting mountain range, the Southern Alps.

Keywords
Stable isotopes, Compound-specific stable isotopes, Fatty acids, Terrestrial organic matter, Connectivity, Food web

Multiscale Mapping and Monitoring to Understand Habitat Drivers and Variability within the Porcupine Bank Canyon, NE Atlantic

Aaron Lim[1], Luis Conti[2], John Appah[1], Kim Harris[1], Luke O'Reilly[1], Andy Wheeler[1]

[1.] University College Cork
[2.] University Sao Paolo, Brazil

Poster

Submarine canyons are vast, steep-sided geomorphological features that cut through continental slopes globally. Channelling flow from the shelf to the deep sea, organic matter and sediment flux at these sites are common. As such, submarine canyons can host and sustain a range of benthic habitats. The Porcupine Bank Canyon, NE Atlantic, is a tectonically-initiated canyon, cut-off from direct terrigenous input. Ranging from -600 m to -3000 m water depth, the canyon hosts a range of cold water coral habitat types (reefs and mounds, coral gardens, isolated colonies and coral carbonate talus slopes). This study utilises multiscale mapping and monitoring to characterise these habitat types and determine drivers of variability and development. Spatial analyses of regional- (hull-mounted multibeam echosounders), local- (ROV-mounted multibeam echosounders) and fine-scale (3D photogrammetry and video) data show that these habitats types are distinctly different. In 2019, 8 benthic landers equipped with sediment traps and current meters will be deployed for a period of 3 months within each of these habitat types to understand the processes driving variability between habitat type. Further, analysis of sediment traps will allow to determine the influence of anthropogenic activity (microplastics, faecal pellets, sediment plumes) on deep water habitats. This poster presents the work completed to date on this project.

Keywords
Habitat mapping, Sediments, Cold water corals, Canyons, Monitoring

Temporal variability of cold water coral habitats from the Porcupine Bank Canyon NE Atlantic, using ROV-vibrocoring, CT-scanning and PSA: preliminary results.

Luke O'Reilly [1], Aaron Lim [1], Jürgen Titschack [2], OJ O'Connor [1], Kim Harris [1], John Appah [1], Andy Wheeler [1]

[1.] University College Cork
[2.] MARUM, Germany

Poster

Cold water corals (CWCs) are sessile suspension feeders and occur globally in deep sea settings. They trap current-suspended particles (food, nutrients and sediment) from their environment which becomes deposited in and around the coral framework resulting in the growth of topographic features called CWC mounds. As such, these coral mound features contain a record of paleoenvironmental change through time. Here, we present a project within the Mapping, Modelling and Monitoring Key Processes and Controls on Cold-water Coral Habitats in Submarine Canyons (MMMonkey_Pro; www.marinegeology.ucc.ie) research programme which focuses on the temporal development and paleoenvironmental history of CWC habitats in submarine canyons (reefs, gardens, mounds and coral-derived tallus slopes). This poster presentation shows work completed to date on this project which started in January, 2018. A number of ROV-mounted vibrocore samples have been retrieved from a range of CWC habitat types within the Porcupine Bank Canyon (PBC), NE Atlantic. These cores have been scanned using dual energy computed-tomography (CT) following, and further developing, a novel methodology (see Titschack et al., 2015; 2016). This has created comprehensive imagery of the internal architecture of the CWCs, as representative of reef development stages. The extrapolated data is processed using Amira software and coral core-specific algorithms (Titschack et al. 2015), to reveal variables such as matrix:coral ratio, coral fragmentation, coral fragment orientation and size. The cores have been further logged and subsampled for high-resolution laser granulometry and composition (CaCO3% and Organic%). In early 2019, coral pieces will be subjected to U/Th dating and benthic foraminiferal assemblages will be classified. This unique multidisciplinary ensemble approach will uncover the controls on mound cessation and development related to the dual energy, CT-identified reef development stages. For the first time, we aim to shed light on what controls the formation of different CWC habitats (gardens vs. mounds). Furthermore, analyses of these cores will be an essential component in understanding the key PBC processes and controls on habitat development in submarine canyons.

Keywords
Cold water corals, CT-scanning, Habitat development, Submarine canyons

Characterisation of Key Processes on Cold Water Coral Distribution in the Porcupine Bank Canyon, NE Atlantic

John Appah K.M [1], Luke O'Reilly [1,2], Kimberley Harris [1], Aaron Lim [1,2,3], Ruth Ramsay [1], Andy Wheeler [1,2,3]

[1.] School of Biological, Earth and Environmental Sciences, University College Cork (BEES,UCC), Ireland
[2.] Environmental Research Institute, University College Cork (ERI, UCC), Ireland
[3.] Irish Center for Research and Applied Geosciences, University College Cork (ICRAG, UCC), Ireland

Poster

Submarine canyons serve as channels where sediments, nutrients and organic matter from continental shelves are transported into the abyssal zone. The processes that occur within the canyon give rise to habitat heterogeneity which, in turn, support high biodiversity. The Porcupine Bank Canyon (PBC), located on the southwestern coast of Ireland, is cut off from direct river and shelf sediment inputs, making it an ideal model to investigate and understand the key control processes of the cold water coral habitats predominantly Lophelia pertusa and Madrepora oculata, through time and in space. A remotely operated vehicle (ROV) was used to collect HD video data of the seafloor to assess the different macrohabitats and megabenthic community structure existing within the canyon as well as anthropogenic fingerprints. Oceanographic variability were measured with Conductivity-Temperature-Depth (CTD) casts while particulate organic matter (POM) concentrations were analysed at different depths at different stations in the vicinity of the CWC. Our preliminary results show that the amount of POM did not vary with depth, suggesting that food availability may not be the major process affecting the distribution of the corals. Also, the video data revealed active, densely growing Lophelia pertusa corals at 600 - 800 m and small, sparsely growing corals at deeper parts of the canyon, and the presence of litter and fishing lines. CTD casts showed that corals occurring between depths of 600 - 1000 m were bathed with Eastern North Atlantic Water (ENAW). In addition, CTD casts showed a narrow variation in temperature, salinity and oxygen from 600 - 1200 m. Overall, habitat variability, carbon flux and oceanographic processes likely control benthic species distribution in the canyon.

Keywords
Cold water coral, Canyons, Habitat heterogeneity, Biodiversity

Organic matter and sediment characteristics in the Whittard Canyon, North East Atlantic: Preliminary results

Catherine Kershaw[1], Emma Smith[1], Annette Wilson[2], Martin White, Veerle Huvenne[3], Jason Kirby[1], Kostas Kiriakoulakis[1]

[1.] School of Natural Sciences and Psychology, Liverpool John Moores University, Liverpool, UK
[2.] Earth and Ocean Sciences, School of Natural Sciences, National University of Ireland, Galway, Ireland
[3.] National Oceanography Centre, Southampton, UK

Poster

The Whittard Canyon System (WCS; Celtic Sea, North East Atlantic) is a large (100 km across, 4500 m deep), dendritic system of smaller branches, the major ones are hereby labelled Western Middle, West/East Middle, Eastern Middle, Eastern and Far Eastern branches. WCS is situated in an area of high primary productivity away from terrestrial influence (~300 km from land) and characterised by complex hydrodynamic processes, supporting diverse ecosystems such as extensive cold-water coral (CWC) reefs and bivalve Acesta excavata beds. Sedimentological (grain size), morphological and geochemical (OC and N, δ13C and δ15N, lipids – not shown here) analyses are being carried out on a large number of POM samples (n=20) from the benthic boundary layer (BBL <15 m above bottom) and underlying short (< 20cm) sediment core samples (n=44). These were collected over a range of depths, from several branches, in spring and summer of 2014 to 2016. The aim was to assess the characteristics of material transport, carbon storage and deep-sea ecosystem functioning within the WCS, the latter particularly in relation to organic matter (OM) origin, transformations and nutritional quality. The sediments were dominated by silt and sand in most branches except the Far East branch where larger clay fractions were evident, suggesting varying and distinct hydrodynamic regimes within WCS. Preliminary OC results showed that most sediments are within typical deep sea values, i.e. 0.2%-0.6% OC of dry sediment. However, within the A. excavata rich area of the Western/East Middle branch at 681 m depth OC was measured as high as 2.7%. The reason for this exceptionally high value is unclear but it is worth noting that this area is known to be affected by thick nepheloid layers, possibly induced by trawling in the upper reaches of the canyon. BBL POM had typical deep sea OC and N concentrations at all sites sampled, ranging from 2.7 to 43.53 µg L-1 and 1.18 to 7.16 µg L-1, respectively. Molar C/N ratios of BBL POM ranged from 1.6 – 8.28, mostly showing a marine signal. The lower C/N values (<5) probably reflect inputs from (re)suspended inorganic nitrogen trapped in clay minerals. The marine signal of surficial sedimentary OM matter is also supported by the range of δ13C and δ15N values (-11.5‰ to 25.2‰ and 0.1‰ to 4.4‰ respectively measured from 30 core tops). However there seems to be a decoupling of BBL POM δ13C and δ15N isotope values from the underlying sediments, as the former have lower δ13C and higher δ15N values (-31.38‰ to -23.4‰ and 7.6‰ to 19.9‰) than the latter; the differences are significant (t-test; <0.05). The reason for this observation is unclear but could be related to nitrogen limitation and increased reworking of POM in the benthic boundary layer. Overall preliminary results emphasize the complexity of the WCS in terms of material transport and organic matter origin and transformations, highlighting a decoupling of sedimentary processes from (re)suspended overlying particles and possible influences of anthropogenic practices in certain parts of it.

Keywords Whittard canyon, Sediments, Organic matter, Carbon, Nitrogen

Session 4 - Physical and anthropogenic disturbance in submarine canyons, conservation and marine policy

Submarine canyon Marine Protected Areas: how effective are they?

Jaime Davies[1], Rowden A.[2], De Leo F.[3], MacMillan-Lawler M.[4], Howell K.L.[1], Harris P.[4]

[1.] University of Plymouth.UK
[2.] National Institute for Water and Atmospheric Research, New Zealand
[3.] Ocean Networks Canada, Canada
[4.] GRID-Arendal, Norway

With growing concerns over anthropogenic effects on the marine environment, Marine Protected Areas (MPAs) are an effective mechanism for providing conservation measures for species and habitats. Historically, conservation efforts have focused on implementing shallow-water MPAs, but currently more attention is being focused on vulnerable deep-sea habitats/features, including submarine canyons. Submarine canyons are complex geomorphological features which provide important resources and are highly vulnerable to anthropogenic effects. There are an estimated 9,507 canyons worldwide, of which only 1,291 are currently protected or partially protected by an MPA. To effectively conserve species and habitats within canyons, the functionality of the entire system is vital. We will examine three case studies of canyon systems (from New Zealand, UK and Canada) which have MPAs implemented, and compare the different approaches taken and discuss how effective they are.

Keywords
MPAs, Canyons, Conservation

Environmental drivers of the foraging distribution of sperm whales in the submarine canyon of Kaikōura, New Zealand

Marta Guerra, Tamlyn Somerford, Rob Smith, Steve Dawson, Liz Slooten, Will Rayment

University of Otago, New Zealand

The submarine canyon of Kaikōura is one of the most productive deep-sea habitats ever recorded and a year-round foraging ground for sperm whales. The number of whales feeding in the area, however, has declined over the last two decades. This trend could reflect a shift in distribution away from the canyon, potentially driven by ecological or oceanographic changes within the whales' habitat. It is therefore important to understand what environmental factors drive the distribution of sperm whales at Kaikōura. Species-habitat surveys were conducted over three years (2015-2017), and species-distribution models were used to relate the presence of foraging whales to habitat variables, including seafloor topography and water-column oceanographic data. The distribution of sperm whales was correlated with seafloor depth and slope characteristics, as well as with sub-surface chlorophyll maxima and thermal stratification in the water-column. Our results suggested that oceanographic processes play an indirect but important role in attracting prey to the canyon, shaping sperm whale habitat use. An exploratory analysis of climate indices and remotely-sensed SST data suggested inter-annual variability in the oceanographic regime off Kaikōura over the last 30 years, and a possible correlation with whale abundance. The results from this study contribute to our understanding of what habitat features make submarine canyons hotspots for sperm whales, and how climate fluctuations can affect the distribution of wide-ranging marine predators.

Keywords
Kaikoura Canyon, Sperm whales, Foraging distribution, Climate variability

ROV observations in intensively trawled submarine canyons of the Catalan margin (NW Mediterranean)

Pere Puig [1], Ruth Durán [1], Stefano Ambroso [1] Núria Callau [1], Claudio Lo Iacono [2], Fabio De Leo [3], Albert Palanques [1], Sarah Paradis [4], Marta Arjona-Camas [1], ABIDES Cruise Team

[1.] Institute of Marine Sciences (ICM-CSIC), Marine Geosciences Department, Spain;
[2.] National Oceanography Centre (NOC), United Kingdom
[3.] Ocean Networks Canada (ONC), University of Victoria, Canada
[4.] Autonomous University of Barcelona (UAB), Institute of Environmental Science and Technology, Spain

In the framework of the ABIDES (Assessment of Bottom-trawling Impacts in DEep-sea Sediments) Project, a focused remotely operated vehicle (ROV) cruise was conducted in September 2017 to target heavily impacted fishing grounds on the submarine canyons incising the Catalan margin (NW Mediterranean). Vessel monitoring system (VMS) data from March 2005 to September 2011 and Automated Information System (AIS) positioning information from April 2016 to April 2017 were analyzed to assess the spatial impact of trawling activities in this margin. Both sources of information indicate that trawling fleets on this region have been progressively specialized on a monospecific fishery targeting the blue and red deep-sea shrimp species (Aristeus antennatus), which is currently practiced at depths around 600-900 m. This bathymetric range has been experiencing a greater fishing effort than other continental slope regions, creating sharp boundaries between un-trawled and heavily trawled seafloor on numerous fishing grounds. ROV video transects were planned to cross this boundary, aiming to characterize the morphological and biological alteration induced by intensive trawling activities. Notorious morphological changes caused by the contact of the trawling gear over the seafloor were visualized and the seabed generally appeared as a ploughed field generated by the scarping of the otter boards during the successive fishing hauls of the trawling fleets. Push-cores were collected on un-trawled and trawled sites in order to characterize the changes on the surface sediment properties, whereas the analysis of the video footage has been used to evaluate the impact on the biodiversity of the benthic community.

Keywords
Bottom-trawling, Fishing grounds, Seafloor morphology, Benthic habitat

Litter in Whittard Canyon, NE Atlantic

Huvenne [1] V.A.I., Pearman [1,2] T.R.R., Price [1,2] D.M., Robert [3] K. and the CODEMAP2015 scientific party

[1.] National Oceanography Centre, Southampton, UK
[2.] University of Southampton, UK
[3.] Memorial University, Newfoundland, Canada

Following a number of high-profile documentaries and reports in the media, policy makers and the general public have become increasingly aware of the problem of litter in the marine environment. Early studies in Portuguese and Catalan canyons showed that submarine canyons, similar to their role of sediment transport pathways, can be very effective at trapping marine litter (Mordecai et al., 2011; Tubeau et al., 2015). Canyons were even reported to be the marine environment with the highest density of litter items (Pham et al., 2014). In addition, their common function as prime fishing grounds, albeit with locally rough seabed, often leads to an increased accumulation of lost and discarded fishing gear. However, current inventories of litter in canyons are still very patchy, and our understanding of how litter behaves and how it influences the benthic communities are still limited. During the CODEMAP2015 expedition on board the RRS James Cook, numerous items of litter and discarded fishing gear were observed during ROV video surveys in Whittard Canyon, NE Atlantic. This presentation will provide an inventory of the litter items found, their spatial distribution, and their classification according to the internationally set categories listed by OSPAR and the EU Marine Strategy Framework Directive. The observations provide an insight into litter 'behaviour' in terms of transport and accumulation in the canyon, and illustrates litter impact on benthic ecosystems both through the provision of hard substratum and the risk of ghost fishing. Our findings are compared with global marine litter inventories, and with canyon-specific studies. Whittard Canyon, in the Bay of Biscay, is located >200 nautical miles from land, but is heavily fished on its interfluves and canyon rims. This results in a marine litter composition that is strongly influenced by fishing activities. This research is based on data collected during the ERC Starting Grant project CODEMAP (Grant No 258482) and the NERC National Capability programme MAREMAP. The CODEMAP2015 expedition was also supported by the Joint Nature Conservation Committee. Mordecai G, Tyler P, Masson DG, Huvenne VAI (2011) Litter in submarine canyons off the west coast of Portugal. Deep Sea Research Part II 58:2489-2496 doi:doi:10.1016/j.dsr2.2011.08.009 Pham CK, Ramirez-Llodra E, Alt CHS, Amaro T, Bergman M, Canals M, Company JB, Davies J, Duineveld G, Galgani F, Howell KL, Huvenne VAI, Isidro E, Jones DOB, Lastras G, Morato T, Gomes-Pereira JN, Purser A, Stewart H, Tojera I, Tubau X, Van Rooij D, Tyler PA (2014) Marine litter distribution and density in European seas, from the shelves to deep basins. PLoS One 9(4):e95839 doi:doi:10.1371/journal.pone.0095839 Tubau X, Canals M, Lastras G, Rayo X, Rivera J, Amblas D (2015) Marine litter on the floor of deep submarine canyons of the Northwestern Mediterranean Sea: the role of hydrodynamic processes. Progress in Oceanography 134:379-403 doi:doi:10.1016/j.pocean.2015.03.013

Keywords
Litters, Whittard Canyon, CODEMAP2015

Potential dispersal and seascape connectedness of Lophelia pertusa in the Mediterranean Sea: the role of submarine canyons

Fábio L Matos [1], Joan B. Company [2], Marina R. Cunha [1]

[1.] Departamento de Biologia & CESAM, Universidade de Aveiro, Aveiro, PORTUGAL
[2.] Institut de Ciències del Mar (CSIC), Barcelona, SPAIN

Poster

Ecosystem connectivity determines the species distribution, the metapopulation dynamics and population resilience. It is a guiding principle in marine conservation planning, particularly for spatial prioritization and the design of networks of marine protected areas. Cold-water corals (CWC) are among the most vulnerable deep-sea ecosystems. In this work, we simulate transport of Lophelia pertusa larvae in the Mediterranean Sea, estimate their potential dispersal and the habitat availability, based on the suitability and spatial configuration of the seascape. The larval transport simulations were performed using a biophysical modelling tool built in a Lagrangian framework and accounted for inter-annual variability of Mediterranean Sea. Habitat availability was analysed using a graph-based approach taking into consideration the attributes of habitat areas. We concluded that connectivity among Mediterranean ecoregions was weak and that the intensification of climate-driven events (e.g., dense shelf water cascading) may worsen this scenario. The potential exchange of larvae between colonies within the same ecoregion was significant, favoring population resilience to local disturbances. The analyses of larval transport and habitat availability allowed identifying some of the areas characterized by the presence of canyons (e.g. Gulf of Lion, the Catalan and Apulian margins, and the Bari Canyon) as habitat areas playing an important role in the connectivity of Lophelia pertusa Mediterranean populations. However, these habitat areas are subjected to intense anthropogenic pressures, which, allied to the effects of climate change, may impose greater challenges to their conservation. We discuss the potential application of our results in designing future surveys targeting L. pertusa and as a framework for future empirical studies based on spatial explicit information with interest for the policy and management of Mediterranean seascape.

Keywords
Connectivity: Lophelia pertusa; Habitat availability; Biophysical modelling; Mediterranean Sea

Towards the Reduction of Trawl-Induced Sediment Resuspension and Seabed Impact through Self-Regulated Deep-Sea Fishery Management in la Fonera Canyon (NW Mediterranean)

Albert Palanques, Pere Puig, Marta Arjona-Camas

Institute of Marine Sciences (ICM-CSIC), Spain

Poster

Bottom trawling has been identified as the main human activity causing physical loss of -and damage to- the seafloor. Studies in the La Fonera Canyon have shown that the recurrent reworking of the deep seafloor by trawling gears creates periodic resuspension events, causes sediment removal from fishing grounds and ultimately smooths the seabed morphology over large spatial scales. Recently, there has been a tendency in the fishing sector to shift towards gears with less impact on the surface sediments. In this regard, the fishermen guild of the Palamós harbor initiated in 2013 a self-regulated project with the main goal to reduce the intensive erosion created by trawling gears on fishing grounds along La Fonera Canyon flanks. Six different types of otter boards were selected to monitor their impact on the sea floor. The fishing ground was closed to the fleet during the monitoring period and it was only visited by a single trawling vessel using different otter boards on consecutive days. Previously, a mooring line equipped with a downward looking ADCP and 3 turbidimeters was deployed on the northern flank of the submarine canyon at 980 m water depth, slightly deeper than the maximum trawling depth. Data was used to select the otter boards that performed better and resuspended less amount of sediment. The passage of the heavier otter boards that were in contact with the seafloor generated sharp increases in suspended sediment concentration (up to 900 mg/l at 5 m above seafloor) and the consequent intensification of the current speed closer to the seafloor that denoted the occurrence of sediment gravity flows. On the contrary, the hauls with the nets equipped with pelagic and light (< 500 kg) semi-pelagic and bottom otter boards did not produce any significant increase of the suspended sediment concentration and current speed, which indicated that even they could be in contact with the sea floor, did not cause any noticeable resuspension. These otter board models were selected to be used in all the trawling vessels working at these fishing grounds, and the complete change of trawling gear in the Palamós fleet was accomplished on September 2017.

Keywords
Submarine canyon, Trawling impact, Sediment resuspension, Otter boards

Anthropogenic disturbance on the NW Sicilian Canyons (western Mediterranean): trawling-induced impact and marine litters.

Claudio Lo Iacono [1], Pere Puig, Sarah Paradis, Antonio Pusceddu, Tommaso Russo, Pere Masqué, Pol Ramos Ibáñez, Andrea Gori, ISLAND Cruise Team

[1.] National Oceanography Centre, UK

Poster

Industrial bottom trawl fishery and marine litter are concerning environmental threats exerting a strong impact on deep-sea ecosystems, menacing the maintenance and preservation of renewable natural resources. One of the main goals of the EU Eurofleets-2 ISLAND (ExplorIng SiciLian CAnyoN Dynamics) expedition was to explore the role of bottom trawling in altering the natural sedimentary dynamics along the submarine canyons of the NW Sicilian Margin (western Mediterranean) and to quantify the marine litters within them. An holistic approach was adopted across a depth range of 150–800 m, spanning from the analysis of the seafloor complexity from Multi Beam (MB) bathymetry, the quantification of sedimentation rates and organic carbon content in surface sediments collected with a multi corer, the analysis of litters and benthic habitats from ROV videos. Remote sensing data and samples were collected based on the distribution of the trawling effort averaged from the Vessel Monitoring System (VMS) data analzyed over a period of 6 years (2009-2015). Submarine canyons with null, low and high fishing effort were explored and compared. Results showed a potential impact of trawling on the large-scale seascape heterogeneity, smoothing the morphology of small sediment-starved gullies on the regions undergoing the maximum effort. ROV videos showed differences in the habitat complexity between adjacent regions undergoing different trawling effort, with impacted areas having a strongly reduced biodiversity, with some exceptions for scavengers. Multi core analysis revealed that submarine canyons undergo enhanced sedimentation rates due to resuspension processes generated by the trawlers crossing their axes either the surrounding regions. Analysis of ROV videos show a strong qualitative difference in the amount of litters between trawled and untrawled canyons. Whereas trawled canyons show absence of litters on their grounds, untrawled canyons host a high amount of litters, which was widespread either organized in several small islands, 1 to 3 m wide. Canyons most probably function as a sink hole for marine debris transported with bottom currents up to the visited depth of 800 m. Plastic is the greatest contributor to seabed litter (40%), followed by large items such as tires, oil drums and metal sheets (20%) and fishing material (longlines and nets - 15%). These compelling evidences suggest that NW Sicilian canyons are largely subject to the effect of threatening human activities, with an evident impact at different spatial and temporal scales.

Keywords
Bottom trawling, Marine litters, Sedimentation rates, Seafloor complexity, NW Sicily, Southern Mediterranean

Special Session - Canyons and trenches in South China Sea and West Pacific

Flow processes and sedimentation in unidirectionally migrating deep-water channels

Chenglin Gong [1,2], Yingmin Wang [1,2], Ronald J. Steel [3], Michele Rebesco [4], Ehsan Ul Haq [1]

[1.] State Key Laboratory of Petroleum Resources and Prospecting (China University of Petroleum, Beijing), Beijing 102249, China
[2] College of Geosciences, China University of Petroleum (Beijing), Changping, Beijing, 102249, China
[3.] Department of Geological Sciences, Jackson School of Geosciences, The University of Texas, Austin, Texas78712, USA
[4.] Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS), Borgo Grotta Gigante 42/C, 34010 Sgonico, Trieste, Italy

A series of short and steep unidirectionally migrating deep-water channels, which are characterized by unidirectional channel-growth trajectories, asymmetrical channel cross-sections, and a lack of levees, are identified in the Pearl River Mouth and Lower Congo Basins, for the first time. Architecturally, unidirectionally migrating deep-water channels are composed of different channel-complex sets, within each of which reworked turbidites in the lower part grade upward into muddy debris-flow deposits and, finally, into shale drapes. Each of the channel-complex sets underwent three main stages of channel evolution: (1) early lowstand incision stage, during which intense turbidity flows mostly overwhelmed relatively weak bottom currents, resulting in basal erosional bounding surfaces and limited reworked turbidites; (2) the late lowstand lateral-migration and active-fill stage, during which the waned turbidity currents intensely interacted with bottom currents, resulting in substantial reworked turbidites and debris-flow deposits; and (3) the transgression abandonment stage, during which turbidity currents further waned, leading to extensive marine shales. Inspired by the two-layer model of a stratified lake forced by wind stress, we introduce the concept of Wedderburn number (W) to quantify how turbidity and contour currents interacted to determine sedimentation in unidirectionally migrating deep-water channels (Ucs). Bankfull turbidity flows in the studied UCs were computed to be supercritical [Froude number (Fr) of 1.11–1.38] and had velocities of 1.72–2.59 m/s. Contour currents with assumed constant velocities between 0.10 and 0.30 m/s flowing through their upper parts would result in pycnoclines between turbidity and contour currents, with amplitudes of up to 7.07 m. Such pycnoclines, in most cases, would produce Kelvin-Helmholtz (K-H) billows and bores that had velocities of 0.87–1.48 m/s and prograded toward the steep channel flanks by 4.0° to 19.2°. Their wavefronts with the strongest shocks and deepest oscillations would, therefore, occur preferentially along the steep flanks, thereby promoting erosion; on the other hand their wavetails with the weakest shocks and shallowest oscillations would occur preferentially along the gentle flanks, thereby promoting deposition. Such asymmetric intra-channel deposition, in turn, forced individual channels to consistently migrate toward the steep flanks, forming channels with unidirectional channel trajectories and asymmetrical channel cross-sections.

Keywords
Unidirectionally migrating deep-water channels, Flow processes, Wedderburn number, Kelvin-Helmholtz (K-H) billows and bores, Bottom current-controlled sedimentation

Benthic carbon mineralization in hadal trenches: Insights from in-situ determination of benthic oxygen consumption

Min Luo [1], Ronnie N. Glud, Binbin Pan, Frank Wenzhöfer, Yunping Xu, Gang Lin, Duofu Chen

[1.] Shanghai Ocean University

Hadal trenches have been proposed as depocenters of organic material and hotspots for organic matter mineralization. In this study, we for the first time quantified the total benthic O2 uptake in hadal trenches using in-situ chamber incubations. Three trenches in the tropical Pacific were targeted and exhibited relatively high diagenetic activity given the great water depths, i.e., the Mariana Trench (2.0×102 μmol O2 m-2 d-1, 10,853 m), the Mussau Trench (2.7±0.1×102 μmol O2 m-2 d-1, 7,011 m), and the New Britain Trench (6.0±0.1×102 μmol O2 m-2 d-1, 8,225 m). Combined with carbon isotopic compositions (δ13C) and radiocarbon contents (Δ14C) of sedimentary TOC and previously published in-situ O2 microprofiles from hadal settings, we suggest that hadal benthic carbon mineralization partly is governed by the surface production but also is linked to the distance from land which controls the amount of terrigenous organic material being transported to the trench bottom. 210Pbxs profiles and burial of carbonate (up to 50%) at the New Britain Trench bottom reflected the recent occurrence of mass-wasting events possibly induced by the earthquake, which was responsible for the transfer of pre-aged, terrigenous organic matter to the trench bottom. Therefore, we highlight that terrestrial organic matter can be of importance in sustaining benthic communities in some hadal settings and hypothesize that hadal trenches may host a distinct microbial community that is capable of feeding on the old, refractory terrigenous organic matter.

Keywords
Hadal trenches; Organic matter degradation; Sediment instability

In-situ observation of the subaqueous sand dunes at the upper slope of the northeast South China Sea

Yulong ZHAO, Zhifei LIU, Yanwei ZHANG, Pengfei MA

State Key Laboratory of Marine Geology, Tongji University, Shanghai 200092, China

Subaqueous sand dunes are significant sedimentary and geomorphological features of the upper northern South China Sea continental slope. Herein we present in-situ observation re-sults of these subaqueous sand dunes, performed during the “KK1803” NSFC open cruise in April to May 2018. The remoted operated vehicle (ROV) “ROPOS” of the Canadian Scientific Submersible Facility (CSSF) was adopted to deploy/recover tripods and sand-dune markers, and to obtain high-definition videos and photos. It is observed that sand dunes of different amplitudes and directions are developed. The first-order sand dunes have wave length of ~ 200-350 m and wave amplitude of 5-15 m, extending roughly parallel to the shelf break of the northern South China Sea. Overlapped on the crests of these large sand dunes, the second-order sand ridges, generally 0.5-2 m wide and 0.1-0.3 m high, are developed. These sand ridges are generally parallel to the large sand dunes, and 5-20 m apart from each other. Asymmetry sand ripples of smaller scales, usually with wave length of 10-20 cm and height of 1-2 cm, are found over-lapped on both the first- and second-order sand dunes. According to the results of the ADCP equipped on the tripod, sedimentary dynamics of the sand dunes are strongly linked to the high velocity and suspended sediment concentration in the benthic boundary layer, triggered by activities of the internal solitary waves during spring tides. Such internal solitary wave activities cause, in average, a ~10-cm movement of the second-order sand ridges in 22 days.

Keywords
Subaqueous sand dunes, Remoted operated vehicle (ROV), Internal solitary waves, In-situ observation

Contribution of net microbial carbon fixation to organic carbon cycling in Trench environment

Xinxin Li [1], Xin Zhao [1], Hongyue Dang [2], Chuanlun Zhang [1]

[1.] Department of Ocean Science and Engineering, Southern University of Science and Technology, Shenzhen, China
[2.] State Key Laboratory of Marine Environmental Science, Institute of Marine Microbes and Ecospheres, College of Ocean and Earth Sciences, Xiamen University, Xiamen, China

Carbon budget is one of the most important scientific questions in oceanography. Pelagic OC cycling in Trench is unique to study OC budget in complete ocean layers from epipelagic all the way to hadal pelagic environment. However, besides the occasional input of OC by geological activities such as mass wasting, landslides, earthquakes, the extraordinary high OC content in trench sediment mediated by microbes in overlying water columns are still poorly known. We propose to apply organic geochemical analysis such as elemental analysis, light spectrometry to study the composition and characteristics of POC/DOC in the pelagic realm of the trench; combining with measurement on microbial chemoautotrophic carbon fixation and respiration rate, we aim to first quantitatively analyze the carbon input from net microbial carbon fixation processes to trench sedimentary OC pool.

Keywords
Marine organic carbon cycling; Chemoautotrophic carbon fixation; Microbial respiration; Trench

Repeated deposition of thick muddy turbidites and mass-transport deposits in small basins along the Japan Trench floor

Ken Ikehara [1], Toshiya Kanamatsu [2], Kazuko Usami [3], Arata Kioka [4], Michael Strasser [4]

[1.] Geological Survey of Japan, AIST, Japan
[2] JAMSTEC, Japan
[3.] University of Tokyo, Japan
[4.] University of Innsbruck, Austria

Japan Trench is a plate boundary between the Pacific and Okhotsk Plates with its convergent rate of 8.0¬¬–8.6 cm/y. Horst-graben bathymetric relief on the obliquely subducting Pacific Plate makes a series of small basins along the trench floor. In each small basin, some thick acoustically transparent layers are found in the sub-bottom profiling records. Collected cores from the basins contained thick muddy turbidite beds. At the central Japan Trench where no apparent submarine canyon occurs in the lower slope, the thick muddy turbidites were correlated to onshore tsunami deposits on Sendai Plain, and considered as earthquake-induced turbidites. Differences of radiocarbon ages between hemipelagic and turbidite mud suggested the surface sediment remobilization by the huge earthquakes for the origin of turbidity currents. On the other hand, apparent submarine canyon is found at the northern and southern ends of the trench. At the southern end, the thickest muddy turbidite was obtained. Submarine canyon may play important role to transport the fine materials. A thick homogeneous mud (MTD) occurred at the northernmost basin. The MTD contained well-preserved calcareous benthic foraminifers which were lived in the outer shelf to the upper slope. There are several submarine landslide bodies in the upper slope of the Hidaka Trough. Submarine landslides in the upper slope may provide a significant amount of mud to the ultra-deep trench floor.

Keywords
Japan Trench, Homogeneous mud, Benthic foraminifer, Slope failure

DSV-based observation in Taiwan submarine canyon in South China Sea by Chinese submersible Jiaolong

Naishuang BI [1,2], Jingping XU [2,3], Yanyan ZHAO [1,2], Xuefa SHI [2,4], Mengjun LI [1]

[1.] Ocean University of China, Qingdao 266100, China
[2.] Qingdao National Laboratory for Marine Science and Technology, Qingdao 266100, China
[3] Southern University of Science and Technology, Shenzhen 518055, China
[4.] First Institute of Oceanography, SOA, Qingdao 266061, China

Submarine canyon systems in the northern South China Sea are a natural laboratory for studying turbidity currents and other gravity flow processes. With supports from the Qingdao National Laboratory for Marine Science and Technology, a DSV (Deep submersible vehicle)-based observation was carried out by the submersible Jiaolong in 2017, reaching a maximum water depth of 2980 meters in the Taiwan Submarine Canyon. Multibeam echo sounder and side-scan sonar on board the DSV were used to collect canyon morphologic data. In addition, high-definition photos and video footage near the canyon floor were acquired, and samples of sediment, seawater and organisms were also collected. This study shows that the morphologic changes along as well as across the canyon axis in the middle reaches of the Taiwan Canyon are very different from previous acoustic results based on shipboard multibeam observations. The microtopography of the canyon suggests historical occurrences of large turbidity currents in the middle reaches of the canyon. However, an exposed boulder on the canyon floor and live organisms attached to the surface of the boulder implies the absence of modern turbidity currents in the past hundreds of years.

Keywords
Taiwan Submarine Canyon; DSV Jiaolong; Turbidity currents

Deciphering the sediment sources in Taiwan Canyon, northwestern South China Sea

Mengjun Li [1], Naishuang Bi [1,2], Lisha Hu [1,2], Xuefa Shi [2,4], Jingping Xu [2,3]

[1.] Ocean University of China, Qingdao 266100, China
[2.] Qingdao National Laboratory for Marine Science and Technology, Qingdao 266100, China
[3.] Southern University of Science and Technology, Shenzhen 518055, China
[4.] First Institute of Oceanography, SOA, Qingdao 266061, China

During the Chinese DSV (Deep Submersible Vehicle) JiaoLong's Dive #140 in May 2017, several push cores were taken along as well as across the axis in the middle reach of Taiwan Canyon, northwestern South China Sea. Grain size analyses clearly showed a much coarser layer in the bottom 4 cm of the 15 cm-long push core taken immediately downstream the toe of a gigantic cyclic step. Delineation of benthic foraminifers showed a shallow water assemblage (Florilus scaphu、Elphidum advenum、Pseudorotalia Schroeteriana) in the coarser sediment section and a deep water assemblage in the upper part of the core. This is a strong evidence of downslope sediment transport by gravity flows along the Taiwan Canyon. Clay mineral and Rare Earth Element work suggest that the push core sediments are composed of major sources from Taiwan island and minor sources of Pear River and Luzon islands.

Keywords
Taiwan Canyon, Sediment sources, Forams

Insight Into the Pico- and Nano-Phytoplankton Communities in the Deepest Biosphere, the Mariana Trench

Yongyu Zhang [1], Ruoyu Guo [1], Yu Xin [2], Chuanlun Zhang [3], Jiwei Tian [2]

[1.] Qingdao Institute of Bioenergy and Bioprocess Technology, Chinese Academy of Sciences
[2.] Ocean University of China, China
[3.] Southern University of Science and Technology, China

Poster

As photoautotrophs, phytoplankton are generally present in the euphotic zone of the ocean, however, recently healthy phytoplankton cells were found to be also ubiquitous in the dark deep sea, i.e., at water depths between 2000 and 4000 m. The distributions of phytoplankton communities in much deeper waters, such as the hadal zone, are unclear. In this study, the vertical distribution of the pico- and nano-phytoplankton (PN) communities from the surface to 8320 m, including the epipelagic, mesopelagic, bathypelagic, and hadal zones, were investigated via both 18S and p23S rRNA gene analysis in the Challenger Deep of the Mariana Trench. The results showed that Dinoflagellata, Chrysophyceae, Haptophyta, Chlorophyta, Prochloraceae, Pseudanabaenaceae, Synechococcaceae, and Eustigmatophyceae, etc., were the predominant PN in the Mariana Trench. Redundancy analyses revealed that depth, followed by temperature, was the most important environmental factors correlated with vertical distribution of PN community. In the hadal zone, the PN community structure was considerably different from those in the shallower zones. Some PN communities, e.g., Eustigmatophyceae and Chrysophyceae, which have the heterotrophic characteristics, were sparse in shallower waters, while they were identified with high relative abundance (94.1% and 20.1%, respectively) at the depth of 8320 m. However, the dinoflagellates and Prochloraceae Prochlorococcus were detected throughout the entire water column. We proposed that vertical sinking, heterotrophic metabolism, and/or the transition to resting stage of phytoplankton might contribute to the presence of phytoplankton in the hadal zone. This study provided insight into the PN community in the Mariana Trench, implied the significance of phytoplankton in exporting organic matters from the euphotic to the hadal zone, and also hinted the possible existence of some undetermined energy metabolism (e.g., heterotrophy) of phytoplankton making themselves adapt and survive in the hadal environment.

Keywords
Phytoplankton, Diversity, Vertical distribution, Hadal trench

Comparison between the morphology of the axial channels of Kaoping and Monterey Submarine Canyons

Eve Lundsten[1], Anderson K., Paull C.K., Caress D.W., Thomas H., Gwiazda R., Liu C.S., Chen T.T.

[1.]Monterey Bay Aquarium Research Institute, Moss Landing, California 95039, USA

Poster

High-resolution multibeam bathymetric surveys of the floor and lowermost flanks of Kaoping Canyon (SW of Taiwan) and Monterey Canyon (off Central California) were collected with the Monterey Bay Aquarium Research Institute's mapping AUV (autonomous underwater vehicle). The resulting bathymetry (1 m horizontal resolution and 0.1 m vertical resolution) reveals the fine-scale morphology of both canyons at unprecedented levels of detail. Kaoping Canyon was surveyed in two depth ranges in May 2017, from 500 to 820 and 1310 to 1500 m depth along the axial channel. The axial channel of Monterey Canyon has been systematically mapped with the same AUV down to 2300 m and selected sections have been repeatedly surveyed between 2008 and 2016. In Monterey Canyon concave-up, crescent shaped bedforms (CSB) are the dominant seafloor morphology in the axial channel. The CSB are well defined, usually extend all the way across the channel and occur in a nearly continuous train along the canyon floor. In contrast, in Kaoping Canyon's axial channel there are some poorly defined CSB as well as other morphologies including pockmarks and large scale, complex, concave-down waveforms. We will show 1m resolution bathymetry that contrasts the differing morphologies in the axial channels of Kaoping and Monterey Canyons.

Keywords
Kaoping Canyon, Multibeam bathymetry, Monterey Canyon, Submarine canyon morphology

Morphology and seismic-stratigraphic charateristics of the Yitong Submarine Cayons in the northern continental slope of the South China Sea

Biwen Wang[1], Guangfa Zhong [1], Liaoliang Wang[2], Benduo Zhu[2], Yiqun Guo[2], Huodai Zhang[2]

[1.]State Key Laboratory of Marine Geology, Tongji University, China
[2.]Guangzhou Marine Geological Survey, China

Poster

High-resolution multibeam bathymetric data and multichannel seismic data were used to investigate the morphology and the seismic-stratigraphic characteristics of the Yitong submarine canyon group in the lower part of the northern continental slope, South China Sea. Multibeam bathymetric data indicate that the submarine canyon group contains 12 submarine canyons, with strikes varying eastward from NWW-SEE, NNW-SSE to N-S directions. In the intercanyon areas, many gullies can be identified. These submarine canyons are 6.1 to 53.3 km long and up to 2.3-11.4 km wide. Maximum incision depth of the canyon valleys ranges from 108 to 652 m, and average slope of the canyon thalwegs varies between 1.4 and 5.4°. Six seismic sequences were identified, with basal boundaries of the sequences being respectively identified as the base of Quaternary (~2.59 Ma), the base of Pliocene (~5.33 Ma) , the base of upper Miocene (~10 Ma), the base of middle Miocene (~15.97 Ma), the base of lower Miocene (~23.03 Ma),and the base of Paleogene (~66 Ma) by tying to well controls from ODP Leg 184 and IODP Expedition 349 in the nearby area. Based on seismic parameters like reflection configuration, amplitude and continuity, etc., five types of seismic facies were defined, which are progradational, wavy, chaotic, fill-type and stratified facies, respectively. The progradational seismic facies is developed in all sequences and spatially distributed in the upper slope upstream of the Yitong submarine cayons, and is interpreted as the shelf-edge to upper slope delta deposits. The wavy seismic facies consists of irregular wavy reflections of low amplitude and low continuity, and has been developed at the upper part of the intercanyon areas since the late Miocene. The facies is interpreted as sediment waves formed by sediment creeping or slumping. The chaotic facies occurs in the upper and middle portions of the intercanyon areas, and is interpreted as slides or slumps. The fill-type facies, distributed in the lower part of the canyons, is typified with a concave-upward surface and fill-typed reflections of variable amplitude, and is interpreted as canyon or channel filling. The stratified facies is featured by layered reflections of variable amplitude and moderate continuity. It is distributed in the lower part of the intercanyon areas since the early Miocene or occurs in the Paleogene sequence, and is interpreted as gravity flow deposits. The Yitong submarine canyons are slope-confined. We speculate that the canyons were initiated from submarine landslides. Retrogressive landsliding might make the canyons extending headward. This research was funded by the National Natural Science Foundation of China (grant numbers 41676029, 91528304, and 41876049).

Keywords
Morphology, Seismic stratigraphy, Slope-confined, Yitong Submarine Cayons, South China Sea

Turbidite sequences recorded in sediment cores from the Manila Trench, South China Sea (SCS)

Lisha Hu [1,2], Jingping Xu [2,3], Xiaohang Liu [1]

[1.] Ocean University of China, Qingdao 266100, China
[2.] Qingdao National Laboratory for Marine Science and Technology, Qingdao 266100, China
[3.] Southern University of Science and Technology, Shenzhen 518055, China

Poster

Turbidity currents are believed to be the most important transport mechanism of terrestrial sediments into deep SCS basins through the Manila Trench. As part of the NSFC-funded project, two gravity cores were taken from the upper reaches of the Manila Trench during the NSFC open cruise on R/V TKK, May - June, 2018. The sedimentation sequences are very different between the two cores: while core GEO14 (470 cm in length), collected in 3991 m water depth, is uniformity sandy-silts throughout the entire core, core GEO6 (122 cm in length) collected in 3747 m water depth, contains multiple cycles of sandy to silty sediments. There is a total of ~8 cycles with varying thickness, and some of which clearly show climbing bedding.

Grain size analysis of GEO6 core reveals that both turbidite and hemipelagic deposits were preserved in the core, and some of them also have signatures of tidal sedimentation sequences. Both coring sites were designed to be inside the thalweg of the Manila Trench, but had to be moved west, 200-400 m away from the trench channel for non-scientific reasons. At least 8 turbidite beds were recognized in the GEO6 core, occur on a variety of scales with average thickness of ~5 cm, while the downstream GEO14 core are with very weak turbidite signatures. We proposal that the turbidites in the GEO6 core were in fact the deposits of turbidity currents overspill the western levee of the Manila Trench turbidity channels. The preliminary result demonstrates that turbidity currents which were derived from the upstream of the Manila Trench, such as Gaoping Canyon, Taiwan Canyon groups, were transmitting to Manila Trench, at least to the site of GEO6 core and limited to deeper site of the GEO14 core.

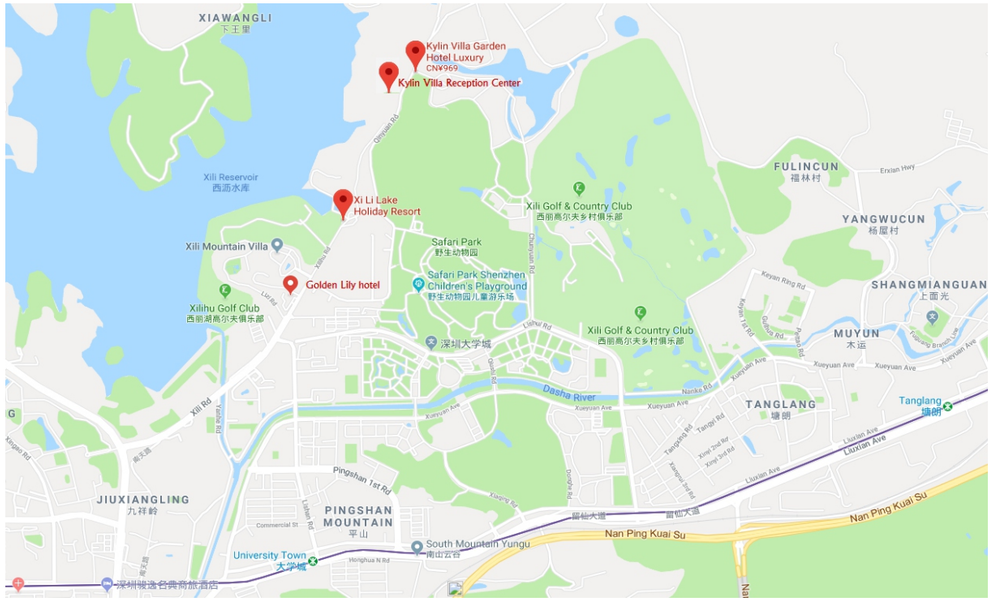
Keywords
Manila Trench, Turbidity current, South China Sea

Transportation Guide

Show the following Chinese address to the taxi driver to take you to the venue of INCISE2018:
深圳市南山区沁园路4599号深圳麒麟山庄贵宾楼

From Shenzhen Airport to Kylin Villa (麒麟山庄)

Shenzhen airport is about 27 kilometers from Kylin Villa.
Taxi: It takes you about 30 minutes to get there by taxi, about 80 Yuan.
Subway/Bus: It takes you about 1 hour 20 minutes, about 9 Yuan.
Airport Station(By Subway Line 11, Futian direction)→Qianhaiwan Station(Transfer to subway Line 5, Huangbeiling direction)→Xili Station(Exit C)→Xili Court2 (西丽法庭2) Bus Station(By bus M492 or 66, Wangjingkengcun(王京坑村方向) direction)→Reception of kylin villa(麒麟山庄接待处) Bus Station



■ From Hong Kong International Airport to Kylin Villa

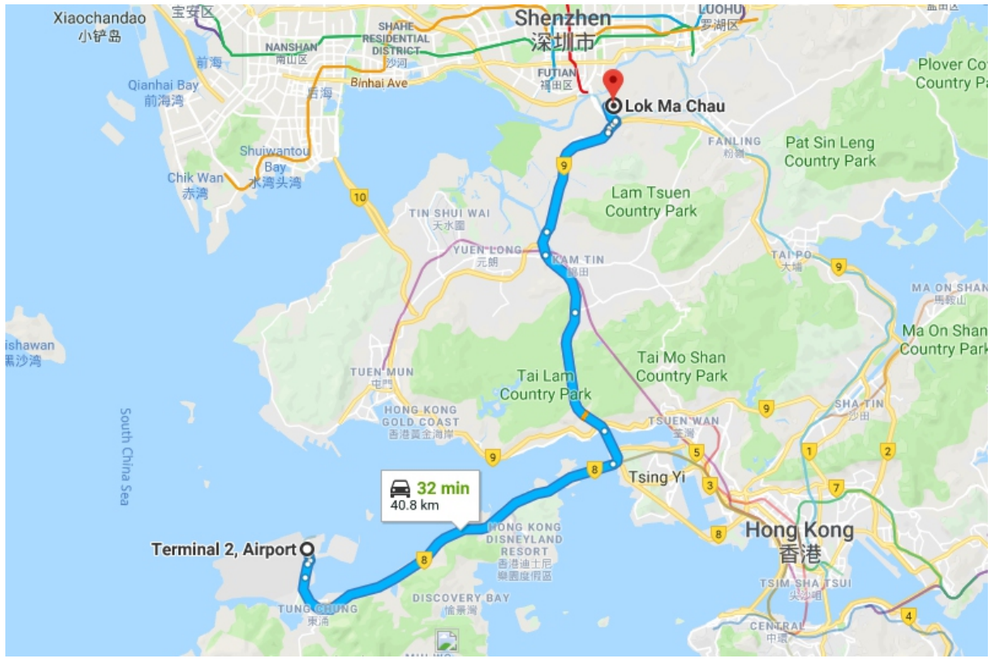
Hong Kong International Airport is about 62 kilometers from Kylin Villa.

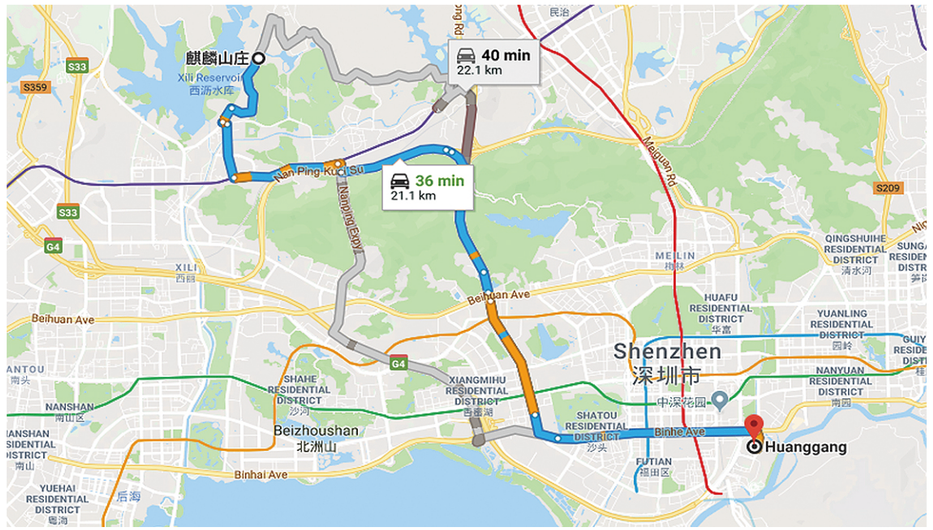
Path 1: If you leave from Hongkong Airport to Kylin Villa, the easiest way is asking a taxi to take you from Hongkong Airport to Huanggang Port. It costs you about 300 Hongkong dollars. After getting through the custom, call a taxi to take you from Huanggang Port to Kylin Villa. It costs you around 70 Yuan. It takes you 90 minutes totally.

Path 2: You can take the airport bus from airport to Huanggang Port. Then take subway(or take a taxi to venue directly) from Huanggang Port Station to Xili Lake Station. It costs you about 100 Yuan.

Path 3: Take the ferry from the SkyPier in Hong Kong International Airport to the Shekou Terminal in Shenzhen, then take a taxi to the kylin villa. It takes you 1 hour 20 minutes totally.

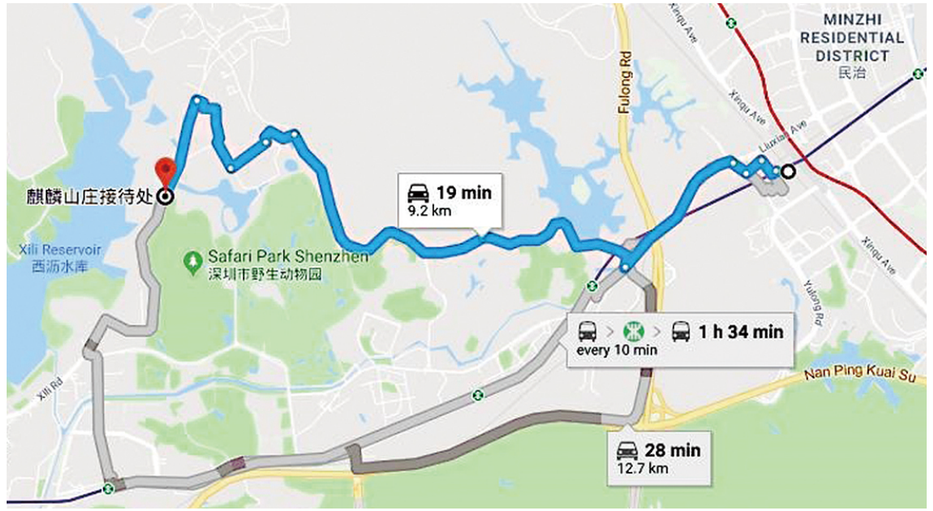
For more details and options from Hong Kong Airport to Shenzhen, please refer: http://www.hongkongshuttle.com/hong-kong-airport-to-shenzhen/

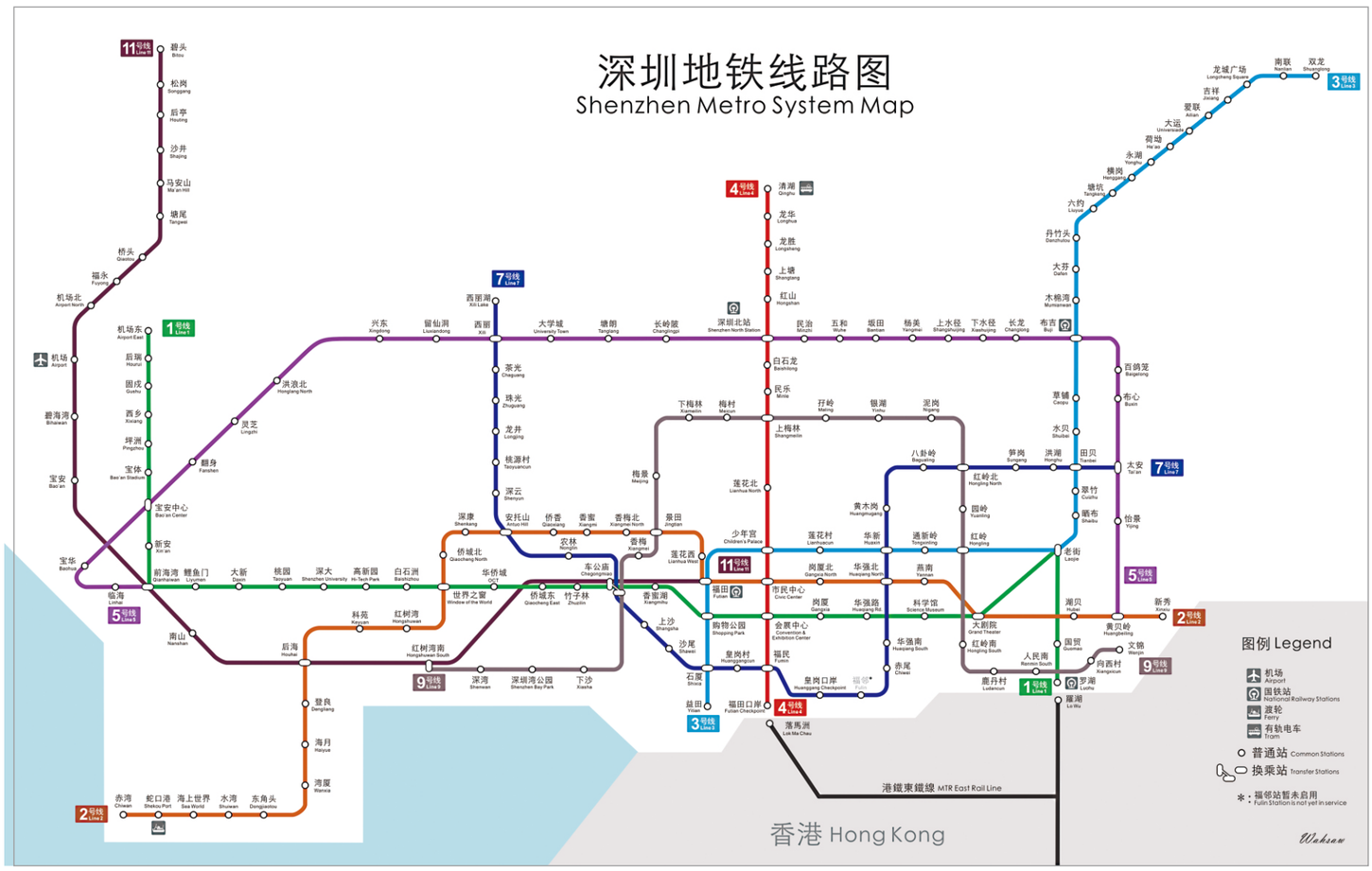


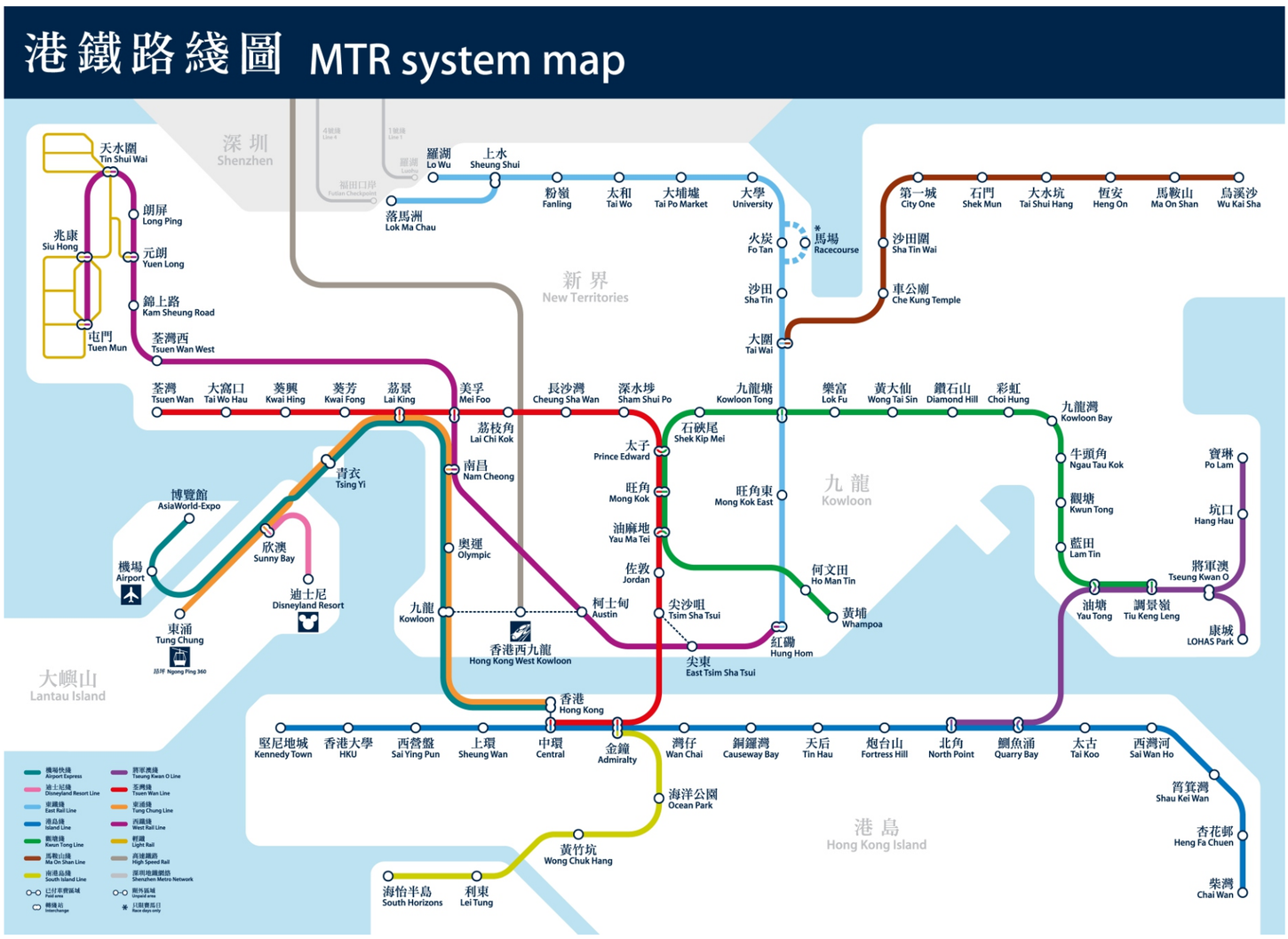


■ From Shenzhen North Railway Station to Kylin Villa

If you leave from Shenzhen North Railway Station, you can take subway from Shenzhen North Station to Xili Lake Station; or directly call a taxi to Kylin Villa from Shenzhen North Railway Station. Totally 10 KM. It takes you around 20 minutes.



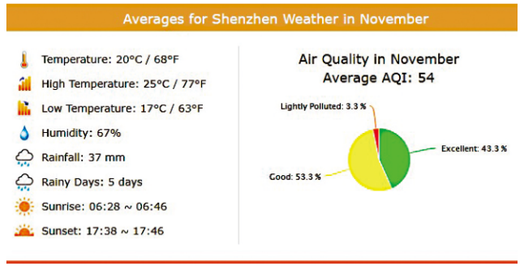

深圳地铁线路图
Shenzhen Metro System Map
香港 Hong Kong
港鐵東鐵線 MTR East Rail Line
图例 Legend
机场 Airport
国铁站 National Railway Stations
渡轮 Ferry
有轨电车 Tram
普通站 Common Stations
换乘站 Transfer Stations
*：福邻站暂未启用
* : Fulin Station is not yet in service


港鐵路綫圖 MTR system map
深 圳
Shenzhen
新 界
New Territories
九 龍
Kowloon
港 島
Hong Kong Island
大嶼山
Lantau Island
天水圍 Tin Shui Wai
朗屏 Long Ping
兆康 Siu Hong
元朗 Yuen Long
錦上路 Kam Sheung Road
屯門 Tuen Mun
荃灣西 Tsuen Wan West
荃灣 Tsuen Wan
大窩口 Tai Wo Hau
葵興 Kwai Hing
葵芳 Kwai Fong
荔景 Lai King
美孚 Mei Foo
荔枝角 Lai Chi Kok
長沙灣 Cheung Sha Wan
深水埗 Sham Shui Po
南昌 Nam Cheong
青衣 Tsing Yi
博覽館 AsiaWorld-Expo
機場 Airport
欣澳 Sunny Bay
迪士尼 Disneyland Resort
東涌 Tung Chung
奧運 Olympic
九龍 Kowloon
柯士甸 Austin
香港西九龍 Hong Kong West Kowloon
羅湖 Lo Wu
上水 Sheung Shui
落馬洲 Lok Ma Chau
粉嶺 Fanling
太和 Tai Wo
大埔墟 Tai Po Market
大學 University
火炭 Fo Tan
馬場 Racecourse
沙田 Sha Tin
大圍 Tai Wai
第一城 City One
石門 Shek Mun
大水坑 Tai Shui Hang
恒安 Heng On
馬鞍山 Ma On Shan
烏溪沙 Wu Kai Sha
沙田圍 Sha Tin Wai
車公廟 Che Kung Temple
九龍塘 Kowloon Tong
樂富 Lok Fu
黃大仙 Wong Tai Sin
鑽石山 Diamond Hill
彩虹 Choi Hung
九龍灣 Kowloon Bay
牛頭角 Ngau Tau Kok
觀塘 Kwun Tong
藍田 Lam Tin
寶琳 Po Lam
坑口 Hang Hau
將軍澳 Tseung Kwan O
油塘 Yau Tong
調景嶺 Tiu Keng Leng
康城 LOHAS Park
石硤尾 Shek Kip Mei
太子 Prince Edward
旺角 Mong Kok
旺角東 Mong Kok East
油麻地 Yau Ma Tei
佐敦 Jordan
何文田 Ho Man Tin
尖沙咀 Tsim Sha Tsui
黃埔 Whampoa
紅磡 Hung Hom
尖東 East Tsim Sha Tsui
香港 Hong Kong
堅尼地城 Kennedy Town
香港大學 HKU
西營盤 Sai Ying Pun
上環 Sheung Wan
中環 Central
金鐘 Admiralty
灣仔 Wan Chai
銅鑼灣 Causeway Bay
天后 Tin Hau
炮台山 Fortress Hill
北角 North Point
鰂魚涌 Quarry Bay
太古 Tai Koo
西灣河 Sai Wan Ho
筲箕灣 Shau Kei Wan
杏花邨 Heng Fa Chuen
柴灣 Chai Wan
海洋公園 Ocean Park
黃竹坑 Wong Chuk Hang
海怡半島 South Horizons
利東 Lei Tung

Weather and City Guide

Shenzhen Weather in November

Autumn significantly falls on Shenzhen in November, accompanied by cool and dry weather. The average temperature is about 25°C (77°F) in day and 17°C (63°F) at night, and the average total precipitation volume falls to about 37mm. In general, November is suitable for travelling in Shenzhen, especially for outdoor activities, because there are many sunny days and little rain.



Day	Description	Low/High
Sunday Nov. 4	Sunny	20℃ - 26℃
Monday Nov. 5	Sunny to Cloudy	21℃ - 27℃
Tuesday Nov. 6	Sunny to Cloudy	22℃ - 27℃
Wednesday Nov. 7	Sunny	21℃ - 28℃

What to Wear

It is recommended to wear shirts, long dresses, light T-shirts and other breathable clothes made of cotton and linen fabric in day. In November, temperature varies greatly from morning to evening, so travelers had better also bring some warm clothes, such as suits, lined dresses, wind coats, leisure suits, and light sweaters. Add or reduce clothes according to temperature changes. Wear a pair of comfortable shoes.

Things to Do

In autumn, the sky is clear and the air is fresh, it is time to go on a sightseeing tour in Shenzhen. Travelers can choose to go to Mangrove Natural Reserve, Shenzhen Safari Park, Lotus Hill Park to embrace the beautiful environment. If you want to know about the history and development of Shenzhen, the Shenzhen museum is worth visiting. If you're interested in shopping and the modern city, you can go downtown (Houhai or Shopping park).

Field Trip

Field Trip To Roc Geological Park And Roc Ancient City

Thursday, 8 NOVEMBER

Time	Description
08:30	Gathering at Kylin Villa
08:30-10:00	Departure to Roc Ancient City by bus
10:00-12:00	Sightseeing in Roc Ancient City
12:00-13:00	Lunch of farmhouse kiln chicken flavor in True Taste Farm
13:00-15:00	Sightseeing in Roc Geological Park
15:30	Gathering and departure back to Kylin Villa by bus

Roc Ancient City

Roc Ancient City was built in the 27th year of Hongwu Period in the Ming Dynasty (AD 1394) and covers an area of about 110,000 square meters. It is an important military fortress of coastal defense of southern China in the Ming and Qing Dynasties with a history of more than 600 years of resistance to foreign aggression. A number of outstanding national heroes such as Sijue Lai, Qilong Liu and Heizi Liu emerged from here. The reason why Shenzhen is also known as Roc City alternatively originates from it. Roc Ancient City is a key protection unit of cultural relics and a patriotic education base in Guangdong Province. In 1996, the Roc Ancient City Museum was established with the aim of better protection of cultural relics, historical research and tourism development.

Roc Ancient City is a very important place of interests with majestic ancient city gates, antique ancient dwellings, ancient streets, and

imposing mansions of ancient generals. Dapeng City is also the most well-preserved sea defense center of the Ming and Qing Dynasties in China which makes it an important subject of studying the military system of the Ming Dynasty. In the Qing Dynasty and the general of the city, Lai Jingjue won the first battle of the Opium War-Kowloon naval battle, which is the most glorious page in the history of Shenzhen and has an unique position in the modern history of China. Roc Ancient City also preserves a special folk culture which is an important part of the southern culture. All the characteristics of this city makes it "the living fossil" of researching the culture of ancient China.

Shenzhen Roc Peninsula National Geological Park

Shenzhen Roc Peninsula National Geological Park is located in the southeast of the Pearl River Delta, about 50km away from the city center and is the south-central part of Roc Peninsula in the east of Shenzhen. The area of protection of geological heritage in the park is 50.87 km2 and the coverage rate of forest is 98%. The Roc Peninsula in which the park is located is in the east of Daya Bay bordering Huizhou, west of Roc Bay, near South China Sea, and the shortest distance from Hongkong Ping Chau Island is only two nautical miles. On September 19, 2005, the Ministry of Land and Resources officially approved the establishment of the “Shenzhen Roc Peninsula National Geological Park”.

Tips: The whole trip is free of charge and accompanied by an English-speaking guide. Please contact organizing committee(incise2018@sustc.edu.cn) if you want to participate.

Mailing list

Name	Affiliation	Email
John Appah K.M	University College Cork, Ireland	john.appah@umail.ucc.ie
Marta Arjona-Camas	Institute of Marine Sciences (ICM-CSIC), Spain	marjona@icm.csic.es
Naishuang BI	Ocean University of China, China	binaishuang@ouc.edu.cn
Fabio Cabrera De Leo	Ocean Networks Canada, University of Victoria, Canada	fdeleo@uvic.ca
Matthieu Cartigny	Durham University, UK	matthieu.j.cartigny@durham.ac.uk
Marina R. Cunha	Universidade de Aveiro-CESAM, Portugal	marina.cunha@ua.pt
Jaime Davies	University of Plymouth, UK	jaime.davies@plymouth.ac.uk
Chenglin Gong	China University of Petroleum(Beijing), China	chenglingong@hotmail.com
Marta Guerra	University of Otago, New Zealand	marta.guerra@otago.ac.nz
Roberto Gwiazda	Monterey Bay Aquarium Research Institute, USA	rgwiazda@mbari.org
Peter T. Harris	GRID-Arendal, Norway	Peter.Harris@grida.no
Lisha Hu	Ocean University of China, China	hulisha2127@ouc.edu.cn
Peng HU	Zhejiang University, China	pengphu@zju.edu.cn
Zhi Huang	Geoscience Australia, Australia	Zhi.Huang@ga.gov.au
Veerle A.I. Huvenne	National Oceanography Centre,University of Southampton Waterfront Campus, UK	vaih@noc.ac.uk
Ken Ikehara	Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, Japan	k-ikehara@aist.go.jp
Kostas Kiriakoulakis	Liverpool John Moores University, UK	K.Kiriakoulakis@ljmu.ac.uk
Ben Kneller	University of Aberdeen, UK	b.kneller@abdn.ac.uk

Name	Affiliation	Email
Sofia Ledin	Royal Netherlands Institute for Sea Research, Netherlands	sofia.ledin@nioz.nl
Daniel Leduc	National Institute of Water & Atmospheric Research Ltd, New Zealand	Daniel.Leduc@niwa.co.nz
Mengjun Li	Ocean University of China, China	limj819@163.com
Qiang Li	Graduate School at Shenzhen, Tsinghua University, China	li.qiang@sz.tsinghua.edu.cn
Xinxin Li	Department of Ocean Science and Engineering, Southern University of Science and Technology, China	lixinxin@sustc.edu.cn
Aaron Lim	University College Cork, Ireland	aaron.lim@ucc.ie
James T. Liu	Department of Oceanography, National Sun Yat-sen University, Taiwan	james@mail.nsysu.edu.tw
Claudio Lo Iacono	National Oceanography Centre, UK	clo@noc.ac.uk
Eve Lundsten	Monterey Bay Aquarium Research Institute, USA	eve@mbari.org
Min Luo	Shanghai Ocean University, China	mluo@shou.edu.cn
Erika McPhee-Shaw	Western Washington University, USA	erika.mcphee-shaw@wwu.edu
Furu Mienis	NIOZ Royal Netherlands Institute for Sea Research, Netherlands	furu.mienis@nioz.nl
Neil C. Mitchell	The University of Manchester, UK	neil.mitchell@manchester.ac.uk
Luke O'Reilly	University College Cork, Ireland	luke.oreilly@ucc.ie
Albert Palanques	Institute of Marine Sciences (CSIC), Spain	albertp@icm.csic.es
Charles K. Paull	Monterey Bay Aquarium Research Institute, USA	paull@mbari.org
Tabitha R R Pearman	University of Southampton, National Oceanography Centre, UK	trrp1n15@soton.ac.uk
Sian Pledger	AIS Environment, Malta	pledger.sian@gmail.com
David Price	University of Southampton, National Oceanography Centre, UK	d.m.price@soton.ac.uk
Pere Puig	Institute of Marine Sciences (ICM-CSIC), Spain	ppuig@icm.csic.es
Ashiru Olusola Raheemat	Institute of Deep Sea Science and Engineering, Chinese Academy of Sciences, China	olusola@idsse.ac.cn
Craig M. Robertson	Bangor University, UK	craig.robertson@bangor.ac.uk
Saiko Sugisaki	Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, Japan	k-ikehara@aist.go.jp
Biwen Wang	Tongji University, China	bww@tongji.edu.cn
Andy J Wheeler	University College Cork, Ireland	a.wheeler@ucc.ie
Jingping Xu	Department of Ocean Science and Engineering, Southern University of Science and Technology, China	xujp@sustc.edu.cn
Miwa Yokokawa	Osaka Institute of Technology, Japan	miwa.yokokawa@oit.ac.jp
Yanwei Zhang	Tongji University, China	ywzhang@tongji.edu.cn
Yongyu Zhang	Qingdao Institute of Bioenergy and Bioprocess Technology, Chinese Academy of Sciences, China	zhangyy@qibebt.ac.cn
Yulong ZHAO	Tongji University, China	yeoloon@tongji.edu.cn
Zhongwei Zhao	University of Manchester, UK	zhongwei.zhao@manchester.ac.uk

INCISE2018 Organizing Committee Contact: incise2018@sustc.edu.cn