MASTS Annual Science Meeting 2023

"Science, Sustainability and Society – valuing and protecting our marine systems"

Abstracts for MASTS Deep Sea Session

11.45-13.15 on Tuesday 5th December

Characterisation and Mapping of Cayman Islands Deep Reef Invertebrate and Fish Communities

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Area being submitted to (delete as appropriate): *1. General Science Session; ~~2. Multiple aquatic stressors; 3. Artificial Intelligence;~~ 4. Deep Sea; ~~5. Climate change; 6. eDNA or 7. Blue carbon~~*

Preferred presentation medium (delete as appropriate): (i) oral or (ii) e-poster format or (iii) ~~paper poster~~

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Are you a student? (Delete as appropriate): ~~Yes /~~ No.

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The Cayman Islands are the three peaks of a mid-Caribbean ridge immediately south of which lies the Cayman (or Bartlett) Trough, descending to a depth 7,686 metres. Most of the coast of the Cayman Islands is surrounded by well-developed fringing reef, where the coral communities remain in good condition compared to most of the Caribbean Region. The Islands have ~45% of the shoreline and 17.8% of the coastal shelf designated as Marine Protected Areas (MPAs), reflecting the economic importance of marine and coastal recreation and tourism to the islands. The coastal coral and fish communities have been well studied and monitored in the face of occasional coral bleaching events and most recently the arrival of Stony Coral Tissue Loss Disease (SCTLD). Among other work, the present authors have undertaken extensive assessment of the islands' shark and ray populations, using a combination of BRUVS (Baited Remote Underwater Video Stations), acoustic tagging, and citizen science monitoring (Ormond et al., 2017; Kohler et al., in press). However the islands' Marine Protected Areas only extend to 45m depth, and almost nothing is known of the distributions of flora and fauna at depths below that. Accordingly, we have recently initiated a survey of deep-water habitats and fish communities down to 1000m, with a view to mapping the distribution of deep-water biotopes and assisting the Cayman Islands Department of Environment in developing plans to manage this resource.

To achieve a first characterisation and broadscale distribution of benthic habitats and piscivorous fishes in reef areas down to ~1000m we have deployed a combination of drop-down drift video cameras and small sea-bed landers, both with bait bags attached to attract otherwise sparse predatory species. Our on-going surveys have revealed biotopes ranging from sponge and sea-whip dominated communities on steep slopes to gravelly-silty terraces occupied by worms and cnidarians. *Halimeda* spp. were the dominant macroalgae and surprisingly abundant to at least 100m. Among fishes, barracuda (*Sphyraena barracuda*) were the most common predator in the mesophotic zone, with bar jack (*Caranx lugubris*) and dogtooth tuna (*Gymnosarda unicolor*) also conspicuous in mid-water, and queen triggerfish (*Balistes vetula*) and the invasive lionfish (Pterois volitans) near the reef itself. At 100-300m the deep-water blackfin snapper (*Lutjanus buccanella*) became the most abundant predator, with video recordings also documenting the occurrence of grey reef and tiger sharks in locations where they are generally not seen nearer the surface. Videos also revealed the presence of a school of critically endangered scalloped hammerhead sharks (*Sphyrna lewini*). Lander recordings from depths up to 1000m documented the occurrence of species such as escolar (*Lepidocybium flavobrunneum*) and queen snapper (*Etelis oculatus*), and among sharks: the boa catshark (*Scyliorhinus boa*), the kitefin shark (*Dalatias licha*), and notably the first record for the Caribbean of the deep sea blurred lanternshark (*Etempoterus bigelowi*) (Gallagher et al. 2023). These findings are expected to support the implementation of Species/Habitat Action Plans for Cayman's deeper reef areas and the extension of existing MPAs and/or the designation of new ones to protect deep-sea habitats and resources.

Ormond, R., Gore, M., Bladon, A., Dubock, O., Kohler, J., Millar, C. (2017) Protecting Cayman Island Sharks: Monitoring, Movement and Motive. In Proceedings of the

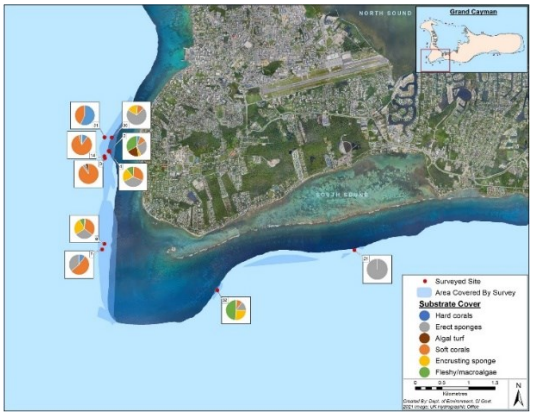
69th Gulf and Caribbean Fisheries Institute, Grand Cayman, Cayman Islands, 7–11 November 2016.
Gallagher, A.J., Shipley, O.N., De Silva, C., Kohler, J.K., Fernandes, T.F., Austin, T., Ormond, R.F. and Gore, M.A., 2023. First records of the blurred lantern shark *Etmopterus bigelowi* from the Cayman Islands, Western Atlantic. Frontiers in Marine Science, 10, p.1165207.

Johanna Kohler, Mauvis Gore, Rupert Ormond, Bradley Johnson and Timothy Austin (in press). First estimates of population size and home range of Caribbean reef and nurse sharks using photo-identification and BRUVS. Frontiers in Marine Science.

Tweet: (280 characters) Plus one image

Cayman Island MPAs cover ~45% of the coast but only extend to 45m depth. We are deploying baited drop-down videocams and landers to map the distribution of biotopes to a depth of 1000m. Sponges and sea-whips dominated the reef wall while fish include threatened and scarce sharks.

Figure: Example of deep-water substrate data generated by the project



How Shifts in Pelagic Food Falls May Directly Impact Abyssal Scavenging Dynamics

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Area being submitted to: *4. Deep Sea*

Preferred presentation medium (delete as appropriate): (i) oral

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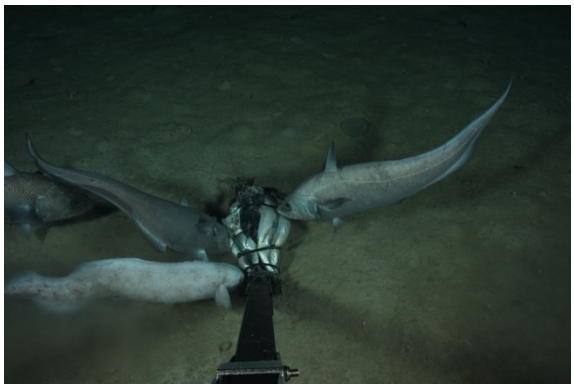
Twitter abstract

Pelagic food falls shift with climate change. How are abyssal scavengers impacted? We found faster scavenging and an altered community at squid compared to fish bait through camera lander deployments. Expected higher future squid stocks may disadvantage slower swimming scavengers with higher chemosensory thresholds.



ABSTRACT

Human pressures are changing upper ocean ecosystems, like the observed shift from fish to squid in overfished, poorly oxygenated systems. Carrion forms an important contribution to abyssal food input, but it is unclear how shifts in food fall types impact scavenger communities. We performed replicated baited camera lander deployments in the Cabo Verde Abyssal Basin using fish (*Scomber scombrus*) or squid (*Doryteuthis gahi*) bait. The maximum abundance of scavengers at the fish bait was greater and occurred later into the deployment for the majority of morphospecies. However, removal rates of squid were up to ten-fold greater. Correspondingly, we found a significantly different community composition at the squid bait, favouring faster swimming organisms with lower chemosensory thresholds (*Coryphaenoides* spp., *Hymenopeneaus laevis*) compared to the fish bait,

where slower-moving organisms (*Barathrites iris*) were less disadvantaged and the longer residence time allowed the development of a more complex community and dense amphipod aggregations. The differences observed between fish and squid bait may indicate how future changes in upper ocean ecosystems can impact deep-sea scavengers and the wider benthic community.

Acknowledgements

We would like to express our sincere gratitude to the crew, UTM and scientific team aboard the RV *Sarmiento de Gamboa* for their on-board assistance as well as during the preparation of the iMirabilis2 expedition. The ship time has been provided by the Spanish Ministry of Science and Innovation. We would like to thank Rui Freitas, Manuel Biscoito, Monty Priede, Thomas Linley, Rosanna Milligan for expert input regarding the *Coryphaenoides* morphospecies, and Erik Simon-Lledó for help with morphospecies identification.

Deep-sea ecotoxicology. Baseline biomarker data for deep-sea fish

Mark G. J. Hartl[1], Acres, T-Jay[1], Lukas Bauman[1], Andrew K. Sweetman[2]

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Area being submitted to (delete as appropriate): *4. Deep sea*

Preferred presentation medium (delete as appropriate) oral

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Twitter abstract:

@M_Hartl presenting baseline ecotoxicological data for deep-sea fish, including an at sea Comet assay procedure using a custom-built gimble table to allow horizontal electrophoresis. #smartexccz #MASTSasm2023

Given the go ahead, deep-sea mining operations are likely to continue for decades on a substantial spatial scale and the resulting sediment plumes, likely extending beyond the licenced mining area could lead to the chronic exposure of deep-sea organisms to a mixture of metals, even mobile species, such as fish, that could conceivably display avoidance behaviour. The concentrations, often substantially below lethal doses, mean that individual mortality is too blunt a measure to allow assessment of "serious harm". The combined effect of multiple extreme physical drivers ("stressors") such as high hydrostatic pressure, low temperatures, and locally fluctuating pH in the deep-sea and the consequences for bioavailability mean that conclusions drawn from shallow water organisms about the toxicity of pollutant exposure are not necessarily applicable to deep-sea organisms. Commonly used cellular biomarkers of exposure in conventional ecotoxicology are oxidative stress markers (TBARS, SOD, GSH, CAT) and DNA damage (Comet assay). Whilst deep-sea fish are known to be exposed to metals true deep-sea ecotoxicological studies with fish are rare and to our knowledge, there is no published data or method optimizations for deep-sea fish. One of the reasons for this is the remoteness of many deep-sea locations.

The purpose of the present study, therefore, was to generate exotoxicological biomarker baseline data for deep-sea fish.
Coryphenoides armartus were collected during SMARTEX expedition 1 (Feb/March 2023) to the

Clarion Clipperton Zone (CCZ) in the Pacific Ocean using a baited trap deployed in 5,000 m depth for 24 hours after which they were transferred to a cold room for processing. Fish biometrics were taken, the gill tissue removed, shock frozen in liquid nitrogen and stored at -80°C for later oxidative stress marker assessment. Blood and gill tissue were removed and processed for the Comet assay. In order to reduce artefactual DNA damage form cryopreservation observed previously, two sets of samples were prepared: a cryopreservative (10% DMSO) was added to one set of samples and stored at -80°C; the second set was used to perform a Comet assay within hours of collection. A custom-built gimble table enabled horizontal electrophoresis at sea after which Comet assay slides were dried and stored at room temperature until further analsyis. Comet assay and oxidative stress markers were also assessed in freshly euthanised rainbow trout in order to evaluate potential artefacts from the collection and sampling procedure of deep-sea fish.

For the Comet assay the samples processed at sea had a significantly reduced level of DNA damage compared to the frozen samples. There was no significant difference between the deep-sea and rainbow trout samples. The oxidative stress values observed for deep-sea fish were not significantly different from those obtained from rainbow trout.

These results represent the first effort at establishing baseline ecotoxicological data for deep-sea fish, essential in understating and quantifying the impact of deep-sea mining.

Acknowledgements: This work was part of the UK Natural Environment Research Council Seabed Mining And Resilience To EXperimental impact (SMARTEX) project (Grant Reference NE/T003537/1).

Unprecedented oxygen production at the manganese nodule-covered aphotic abyssal seafloor.

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Area being submitted to *4. Deep Sea*

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Sweetman et al. carried out a series of in-situ benthic incubations from a previously unexplored manganese nodule province in the eastern equatorial Pacific Ocean and found dark oxygen production (DOP) was 11-53 times greater than estimates of demand within the sediment based on *in-situ* oxygen micro-profiles. If possible, please include #MASTSasm2023. **@ProfAKSweetman**.

Deep-sea benthic organisms consume oxygen as part of a global balance between photosynthesis and respiration, but direct observations of oxygen consumption rates from the abyssal seafloor are scarce relative to its areal extent and the diversity of seafloor habitats. We carried out a series of in-situ benthic incubations from a previously unexplored manganese nodule province in the eastern equatorial Pacific Ocean and found more oxygen was being produced at the

abyssal seafloor than was being consumed. In 41 incubations of the seafloor, we found oxygen levels increased in 93% of our enclosed chambers, rising to more than 3-times background levels over 48 hours. Dark oxygen production (DOP) rates measured from the change in O_2 concentration between the initial and peak O_2 concentration was 11-53 times greater than estimates of demand within the sediment based on *in-situ* oxygen micro-profiles and DOP was detected at sites up to 4000 km apart. DOP occurred exclusively in the presence of manganese nodules and was unresponsive to experimental abiological treatments. It is presently unclear what the mechanism for the DOP is, which therefore necessitates further investigations, but if it occurs consistently across the seafloor, it could play an important role in biogeochemical cycles and ecosystem function in manganese nodule-bearing environments.

Extending stand-off distance for Underwater LIBS

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Area being submitted to (delete as appropriate): *4. Deep Sea*
Preferred presentation medium (delete as appropriate): (i) oral
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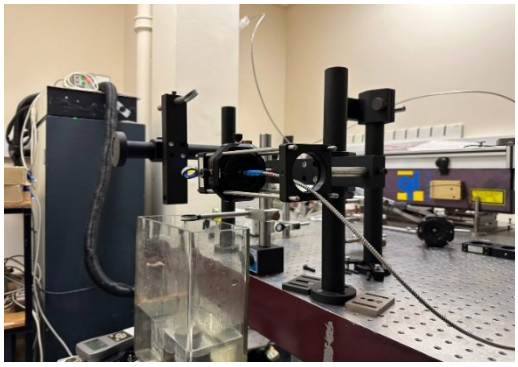
Are you a student? (Delete as appropriate): Yes

Fig.1: Photo of Experimental Setup for Tweeting

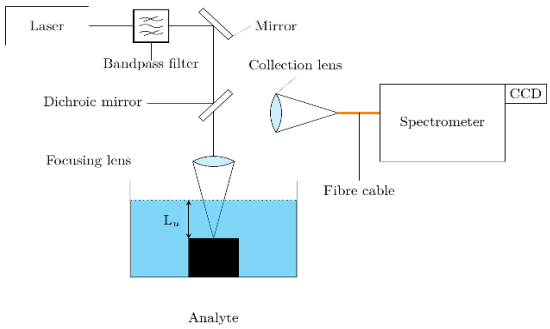


Tweetable abstract: Parameters affecting underwater LIBS were investigated with the aim of extending the stand-off distance between the LIBS instrument and the target. Single pulse Nd:YAG lasers at 1064 nm and 532 nm were used in this study. Analytes were calibrated solid metals immersed in water.

Laser Induced Breakdown Spectroscopy (LIBS) is a technique used to detect atomic constituents of materials by inducing plasma and studying its spectra [1]. In recent years, interest in underwater LIBS for in-situ subsea exploration has grown significantly [2], including for deep sea mineral mining[3]. Much research has been done on the effects of various conditions and properties, except on the distance in water between the plasma and the detector (underwater optical path L_u).

Fortes et al., investigated the influence of L_u using a double pulse setup [4]. For simplicity and practical underwater application of LIBS it is better to utilize single pulse approach. Figure 2 shows the schematic of the experimental setup that allowed the variation of the distance between the analyte material and detector.

Fig.2: Schematic of Experimental Setup



In this research, we investigate how the variation of L_u influences the limit on the detection and data collection and analysis. Additionally, the experiments were carried out with different laser wavelengths (1064 nm and 532 nm) that can help us to understand how to select the various parameters that can minimize the limiting effects on the stand-off distance between the analyte and the LIBS instrument. In conclusion, this paper investigates use of a single pulse laser for increasing the L_u, as opposed to the common approach of using double pulses.

References

1. Cremers, D.A. and Radziemski, L.J. (2013) *Handbook of Laser Induced Breakdown Spectroscopy*. Chichester: Wiley.
2. De Giacomo, A. *et al.* (2007) 'From single pulse to double pulse NS-laser induced breakdown spectroscopy under water: Elemental analysis of aqueous solutions and submerged solid samples', *Spectrochimica Acta Part B: Atomic Spectroscopy*, 62(8), pp. 721–738. doi:10.1016/j.sab.2007.06.008.
3. Bhatt, C.R., Jain, J.C. and McIntyre, D.L. (2018) 'Investigating the CO2 pressure effect on underwater laser-induced plasma emission of EU and YB', *Spectrochimica Acta Part B: Atomic Spectroscopy*, 149, pp. 42–47. doi:10.1016/j.sab.2018.07.002.
4. Fortes, F.J. *et al.* (2015) 'A study of underwater stand-off laser-induced breakdown spectroscopy for chemical analysis of objects in the Deep Ocean', *Journal of Analytical Atomic Spectrometry*, 30(5), pp. 1050–1056. doi:10.1039/c4ja00489b.

Ship-to-shore training for active deep-sea capacity development

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Area being submitted to *4. Deep Sea*
Preferred presentation medium: (i) oral
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Tweet: At #MASTSasm2023 @KelseyBarnhill1 will present on how effective at-sea outreach and training includes co-developing training goals with onshore participants, using real-time engagement, and incorporating an onboard outreach liaison.

Abstract: Sailing on scientific expeditions as an early career researcher (ECR) offers the beneficial opportunity to gain field experience and training. However, the number of available berths to achieve the scientific goals of an expedition limits the number of onboard participants. Telepresence and remote learning can be utilized to increase the number of active participants, broadening the reach of capacity development. The 2021 iMirabilis2 expedition on board the Spanish Research Vessel Sarmiento de Gamboa used telepresence to virtually involve ECRs from several countries in deep-sea science. One year post-expedition, a survey of onshore participants was conducted to assess and quantify the effectiveness of the peer-to-peer ECR ship-to-shore scheme. During the expedition, live, interactive training via WhatsApp and Zoom was utilized by onshore ECRs more than traditional static, unidirectional methods of blog posts and pre-recorded videos. All respondents either agreed or strongly agreed that the scheme provided an inclusive and accessible platform to share deep-sea science. These results suggest similar schemes could be used to supplement shorter-duration at-sea-training, used prior to a seagoing experience to better prepare ECRs, or to allow members of the science community unable to join an expedition in person to actively participate remotely, increasing inclusivity.

Acknowledgements

The authors would like to thank Professor J.Murray Roberts, Christine Gaebel, Hannah Elise Barker, Helena Slater, the entire team at Unidad Technología Marina (UTM, CSIC), the team at Estrutura de Missão para a Extensão da Plataforma Continental (EMEPC), as well as the entire technical and scientific team and crew onboard the Spanish R/V Sarmiento de Gamboa (UTM-CSIC) for the iMirabilis2 Expedition. Thank you to the Spanish Ministry of Science and Innovation for providing ship time. A very special thanks to the onshore ECRs who participated in the scheme and provided survey responses.

References

Barnhill et al (2023), Ship-to-shore training for active deep-sea capacity development, ICES Journal of Marine Science, Volume 80, Issue 6, Pages 1619–1628, https://doi.org/10.1093/icesjms/fsad088