frontiers | Frontiers in Marine Science

TYPE Editorial
PUBLISHED 09 November 2023
DOI 10.3389/fmars.2023.1304429

OPEN ACCESS

EDITED AND REVIEWED BY
Ana Hilário,
University of Aveiro, Portugal

*CORRESPONDENCE
Awantha Dissanayake
Awantha.Dissanayake@unigib.edu.gi

RECEIVED 29 September 2023
ACCEPTED 24 October 2023
PUBLISHED 09 November 2023

CITATION
Dissanayake A, Davies JS, Kiriakoulakis K and Huvenne VAI (2023) Editorial: Submarine canyons: human connections to the deep sea.
Front. Mar. Sci. 10:1304429.
doi: 10.3389/fmars.2023.1304429

Editorial: Submarine canyons: human connections to the deep sea

Awantha Dissanayake[1]*, Jaime Selina Davies[1,2], Kostas Kiriakoulakis[3] and Veerle Ann Ida Huvenne[4]

[1]School of Marine & Environmental Sciences, University of Gibraltar, Gibraltar, Gibraltar, [2]School of Biological and Marine Sciences, University of Plymouth, Plymouth, United Kingdom, [3]Liverpool John Moores University, Liverpool, United Kingdom, [4]Ocean BioGeosciences, National Oceanography Centre, Southampton, United Kingdom

KEYWORDS

submarine canyon, deep sea, marine litter, faunal assemblage, anthropogenic impact

Editorial on the Research Topic
Submarine canyons: human connections to the deep sea

Submarine canyons are described as conduits to the deep sea where the interplay between oceanographic, biological/ecological processes, and bathymetric and topographical features have consequences on the functioning and associated diversity of both pelagic and benthic communities. Impacts from human activities range from fishing, resource extraction, and as transport 'sinks'. The true human connection to these important features is often unknown, under-reported, and/or poorly understood. In order to better address the various challenges submarine canyons face, there is a need to strengthen our understanding of the types of anthropogenic pressures on and threats to submarine canyons and their associated communities.

This Research Topic, *Submarine Canyons: Human Connections to the Deep Sea*, presents three review papers and eight original research papers from 20 different countries (70 authors), and presents research that spans the field of submarine canyons and the wider deep-sea area, providing insight into the links between anthropogenic activities and canyons. Here, we summarize some of the highlights derived from the 11 articles published in this Research Topic.

Marine litter

Marine litter or debris (hereafter marine litter) is, by far, one of the most prevalent and pervasive contaminant inputs found in submarine canyons. Four articles in this Research Topic delve into the issue of marine litter from a geoscience and transportation perspective as well as short and longer-term ecological perspectives. Pierdomenico et al. evaluate from the published literature various sources and transport mechanisms responsible for marine litter deposition within canyons, concluding that impacts from fishing gear are found to

accumulate on canyon heads and walls, whereas general debris items, mainly plastic, are subject to hydrodynamical processes within canyons and are generally linked to proximity to coastal riverine inputs.

A case study from southern Spain reports litter hotspots related to canyon morphological features such as rocky outcrops. Most of the debris found was attributed to coastal origin e.g., from beaches and nearly regional agricultural practices as well as fishing gear (Cerrillo-Escoriza et al.). Two review articles take a more policy-based approach to understanding marine litter impacts in canyons. Hernandez et al. highlight the need for a standardized framework of reporting of marine litter due to varying worldwide practices in identifying, enumerating, and classifying such items and only through an implemented standardized approach to reporting can patterns in use and, thus, submarine canyon vulnerability be identified. To attain an understanding of the true ecological effects, Bruemmer et al. have created a comprehensive, standardized Marine Litter-Faunal Interactions framework to qualify the types of litter interactions observed with marine fauna. The framework is applicable for use in all aquatic research, not just in studying submarine canyons. The framework is intentionally broad, providing six main categories of interactions, two of which also occur with abiotic features such as entanglement, ingestion, smothering, habitat provision, adaptive behavior, and encountering. Among publications that have reported litter-fauna (L-F) interactions in canyons, the large majority occur in the Mediterranean Sea, and the most reported interaction is of corals becoming entangled in fishing gear.

Sediments and transport

Paradis et al. evaluate the sediment transport and flux within the Palamós Canyon (NW Mediterranean) emanating from trawling activities during the trawling season (March – December) and seasonal closure (February). Using instrumented moorings deployed along the canyon axis and northern flank, it was found that fishing activities led to sediment flows at the canyon flank. Bottom trawling enhances the resuspension of degraded sediments and large particle fluxes within the canyon, the activity of which potentially affects canyon benthic communities. Tung et al. report on a case study on infaunal communities (meio- and macrofauna) within the Gaoping Submarine Canyon, Taiwan assessing the difference in biomass and body size, growth, metabolism, and size composition between canyon and adjacent continental slope. Larger individuals, both meio- and macrofauna, were observed within the slope than within the canyon. The dynamic nature of the canyon environment, with associated environmental conditions such as internal tides, bottom currents, and high sediment loading, are attributed to the lower community biomass, secondary production, and respiration rates.

Dobbs et al. assess how mobilization of sediments occurred across the Morro Bay continental slope (central California) from the Pleistocene to the present day. An integrated dataset encompassing multibeam bathymetry, sediment cores, radiocarbon samples, and isotope data was utilized. Results show that sediment deposition and clustering is predominantly due to lowstand sea-levels during the Last Glacial Maximum where canyons were directly connected to fluvial systems sequestered to the continental shelf. The implications for potential geohazards for offshore windfarm construction are discussed.

Faunal assemblages

Pearman et al. employ an interdisciplinary approach to evaluating faunal assemblages within the Whittard Canyon (North- East Atlantic). Using biological, hydrodynamic, and bathymetric datasets, a high- resolution analysis of the abiotic conditions within the biotic communities supports the hypothesis that spatial and temporal environmental heterogeneity from internal tides are an influencing factor of diversity on submarine canyon vertical walls. Brun et al. provide an insight into hydrodynamic processes with the Cassadaigne Canyon (Northwestern Mediterranean). As submarine canyons incise the continental shelf, they play a role in influencing hydrodynamic flows. Upwellings are induced by westerly/north-westerly winds in the region of speeds greater than 14 m s^{-1}. Current orientation near the canyon head and shelf is dependent on underlying topography, wind (speed and direction), and stratification. The mesoscale variability of the Northern Current, a feature of water circulation in the north-western Mediterranean Sea, can lead to its intrusion over the shelf and, in turn, to barotropic crosscurrents over the canyon. Turbidity currents were observed in this case study associated with upwellings, suggestive of its importance to shelf sedimentary processes in this area.

Filander et al. provide the first detailed description of species diversity and taxonomic description within and around the Cape Canyon, South Africa. This particular case study focused on two canyon and 13 non-canyon stations, evaluating biodiversity and hydrographic data to discern differences in species composition with substrate type and depth i.e. as predictors of distribution patterns. Thirteen species were found to be characteristic of canyon areas compared to three from non-canyon areas.

Bigham et al. report on the ecological recovery in a megafaunal community associated with the benthos within the Kaikōura Canyon following the 2016 earthquake (M_w 7.8). The megafauna community visible in seafloor imagery four years after the event appears to be resilient to the earthquake-triggered turbidity flow. Ecological productivity and thus recovery is now similar to the previous highly productive community present before the turbidity flow. Population growth models predict that the community could fully recover in a minimum of 4.5 years, though full recovery may take up to 12 years post- disturbance.

In summary, this Research Topic is of interest to the wider submarine canyon and deep-sea community and sheds light on the dynamic characteristics of canyons and the inextricable human connection to the deep sea.

Author contributions

AD: Writing – original draft, Writing – review & editing. JD: Writing – review & editing. KK: Writing – review & editing. VH: Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. VH was supported by the CLASS programme, funded by the Natural Environment Research Council, UK (Grant No NE/R015953/1).

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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