Sands of Change: The Global Challenge of Sand Mining
International Conference
Wednesday 18th March 2026, Burlington House, Geological Society, London

Convenors

Tom Bide (BGS), Laurance Donnelly (IUGS-IFG & AHK International Ltd), Clive Mitchell (BGS), Duncan Pirrie (University of South Wales) & Alastair Ruffell (Queens University Belfast)

AM Programme

09:30-10.00	**Registration**
10:00-10.10	**Laurance Donnelly** Welcome and Introduction
Session 1	**Sand supply chains, governance, monitoring** **Chair: Tom Bide (British Geological Survey)**
10:10	**Pascal Peduzzi** (online) UNEP – Sand and sustainability an overview of UNEPs work on global sand governance.
10:30	**Sonu Kumar**, Yuen Kai Wan, Dung Duc Tran, Jingyu Wang, Adam D. Switzer & Edward Park (online) Deep Learning-Based Monitoring of Sand Mining and Illegal Extraction in the Mekong Delta
10:50	**Christopher Hackney** Monitoring in-channel sand mining in the Mekong with satellite imagery and deep learning
11:10	**Kai Wan Yuen**, Diganta Das, Dung, Duc Tran & Edward Park (online) Southeast Asia's dynamic sand trade and the need for better data
11:30-12.00	**Coffee Break**
Session 2	**Sand supply chains, governance, monitoring** **Chair: Clive Mitchell (British Geological Survey)**
12:00	**Mark Russell** Governance lessons from the UK
12:20	**Ian Selby** The value of sand – but how much do we really know ?
12:40	**Julia Stegemann** Sand, construction materials and the circular economy
13:00-14.00	**Lunch**

PM Programme

Session 3	Illegal Sand Mining Chair: Laurance Donnelly (IUGS-IFG and AHK International Ltd)
14:00	**Piers Larcombe** (online) Sedimentary processes relevant to sand mining: examples from sub-tropical and tropical coastal systems
14:20	**Bioantika, Juliana Segura-Salazar, Christian Antonio, Rob Fitzpatrick & Daniel Franks** Towards zero waste mining: Optimising ore-sand by-products in copper processing circuits
15:00	**Ping Yin** & Fei Gao (online) The forensic application of traceability technology in illegal marine sand mining crimes
15:20	**Alexander Finlay**, Lorenzo Sardisco, Tom Bide & Clive Mitchell Fingerprinting legal and illegally mined sand samples using lessons learnt from the oil and gas industry
15:40	**Francesca Alvisi** The disappearance of beaches: a local phenomenon or a global emergency?
16:00	**Carlos Gutiérrez Ayala**, Kylie Santos, Micahella Butardo, Faith Slansk, Julia Barbieri & Sophia Hayes (online) Forensic comparison of sands in Oahu, Hawaii using SuperSpectral Technology
16.20	Discussion and thanks (**Laurance Donnelly**)
16:30	**Close**

Event Description

Sand is one of the most important raw materials on the planet. After water, it is the second most utilised resource on Earth. Global demand for sand is driven by its use in construction (in particular in concrete) and wider industry (glass manufacture etc). Estimates suggest that global sand demand increased 23 times between 1900 and 2010, with a projected annual demand of 82 billion tonnes per annum by 2060. Human mass migration to cities has led to rapid, ongoing urban growth in many parts of the world fuelling an ever-increasing demand for sand. If not adequately managed, this demand can lead to extensive, unregulated and illegal sand mining. Illegal sand mining has been reported from 70 countries often largely involving artisanal and small-scale mining operations, but also larger scale criminality involving criminal cartels and associated conflict. Whilst on a local scale, illegal sand mining can provide employment and raw materials needed for development, unregulated mining has considerable cumulative negative environmental, social and economic impacts.

For many, sand is seen as a freely available, and easily extracted material. Yet, when sand is not adequately valued, supply can become inadequate to meet society's needs, causing price fluctuations and shortages in many countries, this is a supply system that is either breaking down or has effectively already broken down. Geoscience has a crucial role to play in the monitoring and management of sand supply. From understanding the location of deposits, the chemical and physical properties of sand, and how this relates to its end use, through to modelling the impacts of extraction and understanding how we can reduce our reliance on sand for a sustainable future.

This in person/virtual 1-day International Conference will be held at The Geological Society of London on Wednesday 18th March 2026 09.30-16.30, in association with the Geological Society of London Forensic Geoscience Group, International Union of Geological Sciences, Initiative on Forensic Geology and the British Geological Survey. This event is of interest to academics, practitioners, and those interested in the governance and mitigation of risks associated with illegal sand mining.

Abstracts

A personal perspective on international illegal sand mining and trading and the potential role of forensic geologists to mitigate the risks

Laurance Donnelly

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The illegal mining and trading of sand is a global problem that seems to have evaded the attention of geologist, police and law enforcement. Yet, this rapidly growing crime is reported to take place in over 70 countries, often controlled by organised crime and so called ‘sand mafias, with an estimated annual value of US$ 350 billion. Illegal sand mining can also have devasting environmental consequences, including flooding, coastal erosion, disruption to sediment deposition, marine habitat destruction and the undermining of engineered structures. Illegal sand mining was first brought to the attention of IUGS-IFG in 2022, during a workshop on illegal mining held in Brazil with the Brazilian Federal Police. IUGS-IFG subsequently brought this to the attention of international law enforcement agencies, with subsequent investigations, workshops and operations in Latin America, West Africa and Central Asia to better understand and mitigate the associated risks, and close down illegal sand mining. This one-day workshop ‘Sands of Change’ follows on from the above, and is the first of its kind in the UK to draw attention to illegal sand mining, its impacts, consequences, risks and how these may be mitigated using traditional geological techniques such as remote sensing, geophysics, mineralogy and geochemistry. Operational case examples are provided throughout to demonstrate the global threat of illegal sand mining and trading, and to emphasise the need for a multidisciplinary approach to detect, deter and disrupt the illegal sand industry.

Deep Learning-Based Monitoring of Sand Mining and Illegal Extraction in the Mekong Delta

Sonu Kumar[1,2], Yuen Kai Wan[1,2], Dung Duc Tran[1,2], Jingyu Wang[1], Adam D. Switzer[1,2,3] and Edward Park[1,2,3]

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Unmanaged sand extraction is driving severe geomorphic instability in river systems worldwide, despite sand's essential role in construction. The Vietnamese Mekong Delta (VMD) is among Southeast Asia's most intensively mined regions, yet reliable data on extraction rates and illegal activity remain scarce. To address this, we developed a remote sensing-based deep learning system to quantify sand mining and identify potential illegal extraction across the VMD. Using Sentinel-1 radar imagery, our YOLOv5 model detected sand-mining barges with 96.1% mean average precision. From 2015 to 2022, we mapped 256,647 boats, of which 17.4% were active extraction vessels. Converting boat density to incision-driven extraction estimates reveals that approximately 366 Mm^3 of sand was mined during this period, with annual volumes rising from 34.9 Mm^3 (2015) to 53.3 Mm^3 (2022). By integrating these detailed extraction maps with provincial licensing boundaries and legal quotas, we identify locations where activity consistently exceeded permitted thresholds. Independent analysis indicates 15-17 Mm^3/yr of sand was likely mined illegally, with persistent hotspots near Tan Chau, Cao Lanh, Long Xuyen, and Can Tho. These reaches correspond to some of the highest observed riverbed incision rates (up to 4-5 m/yr), consistent with prolonged over-extraction. While major uncertainties persist due to incomplete official records, our approach demonstrates that coupling AI-based detection with regulatory frameworks offers a critical pathway toward transparency and sustainable management of vulnerable deltas.

Monitoring in-channel sand mining in the Mekong with satellite imagery and deep learning

Christopher Hackney

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The global demand for sand has been rapidly increasing over the past few decades leading to unsustainable acceleration of sand abstraction from rivers and deltas. In parts of the Mekong basin, extraction far outstrips the sediment supply, resulting in a range of socio-environmental impacts including loss of land and damage to infrastructure and livelihoods from accelerated rates of bank erosion. Yet, basin wide assessments of extraction are limited given that the monitoring of riverine vessels is very difficult over large spatial areas. New approaches are, therefore, needed to help regulate the mining activity at the delta scale and fully understand it's biophysical impacts due to extraction. The emergence of nano-satellites, offering high spatiotemporal resolution imagery, combined with developments in computer vision created an unprecedented opportunity for tracking changes in anthropogenic activity at delta scale. Here, we trained the Faster R-CNN Resnet101 model to detect riverine vessels, achieving high detection accuracies (f-score = 0.84-0.85). We subsequently applied this model to available PlanetScope imagery over the period 2018-2021 across the entire Vietnamese Mekong Delta (VMD), and used the resultant detections to generate monthly and annual products mapping the riverine activity, termed the Human Waterway Footprint (HWF). We use the HWF to show, how waterborne activity has increased in the VMD (from approx. 2,200 active vessels in 2018 to 2,800 in 2021 - a 21% increase). We demonstrate how such monthly products can reveal substantial differences in traffic volume and in inter-annual trends of riverine activity at local and province level. Such monitoring offers great promise and can subsequently enable local and regional assessment of environmental impacts of anthropogenic activities on delta ecosystems around the globe.

Southeast Asia's dynamic sand trade and the need for better data

Kai Wan Yuen[1], Diganta Das[2], Dung, Duc Tran[2,3] and Edward Park[1,2]

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Sand is a vital resource for modern structures but there is limited information on the scale of sand mining or what happens to the sand after it has been mined. Here, we focus on Southeast Asia (SEA) as rising affluence and population growth has turned the region into a global sand mining hotspot. We estimated the sand extraction budget in each Southeast Asian country and quantified the volume of sand that was exported and imported. In addition, the destinations in which the sand was exported to were detailed and we also clarified the origins of the imported sand. Our analysis revealed that locally mined sand was mostly consumed domestically, and sand was imported if supply was insufficient. In addition, the sand trade in SEA was also predominantly regional. Unfortunately, our understanding of the sand trade in SEA was hampered by limited and inconsistent data. For example, missing data meant that production and trade flows were unavailable for some years. The volume of sand traded between each country was also uncertain due to the mismatch of trade data. Additional information on the type of sand traded was also lacking. The reliability and credibility of existing data should be strengthened to improve material accounting.

Sedimentary processes relevant to sand mining: examples from sub-tropical and tropical coastal systems

Piers Larcombe

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Sedimentary processes and the nature of coastal physical systems are vital context to the issue of sand mining. This paper outlines some relevant controls of sand transport in coastal and estuarine systems, drawing on studies of various tropical and sub-tropical coastal, estuarine, and coastal-plain systems. The focus is on those systems with relatively active sediment transport pathways, including rivers, estuaries, tidal creeks, beaches, and the inner shelf, with associated comments on relevant sand transport along the shore and along the inner shelf.

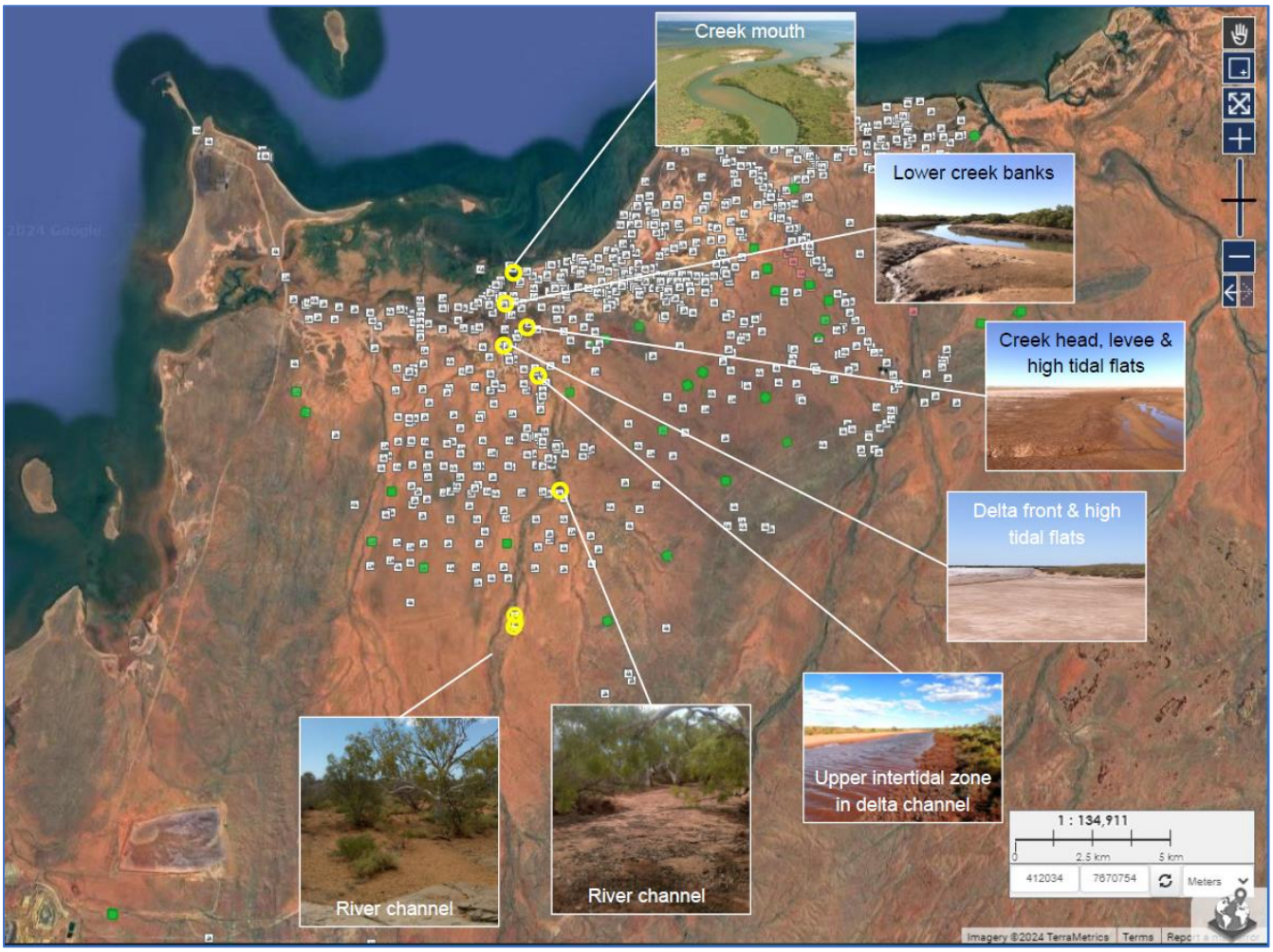

Figure 1. *Selected sedimentary environments of a river catchment and tidal creek systems on a wide coastal plain used to help assess sand transport pathways and system resilience (Larcombe, Eliot & Buchan, 2025, original photos from CMW Geosciences, 2022).*

In these tropical and sub-tropical environments, key factors include episodic weather events driven by tropical meteorological systems, and large seasonal variations in river flow and sand transport patterns. These interact in complex ways with other controls including (but not limited to) shelf bathymetry, shelf sediment availability, fluvial sediment delivery, coastal geology, waves, tidal range and coastal hypsometry, and storm surges.

The classic ternary diagram (Figure 2), originally drawn to represent estuaries, is helpful to illustrate the long-term results of geological processes resulting from a different mix of dominant drivers in different settings. However, it is unable to consider the relative role of episodic events compared to day-to-day processes in shaping sand transport near and at the coast.

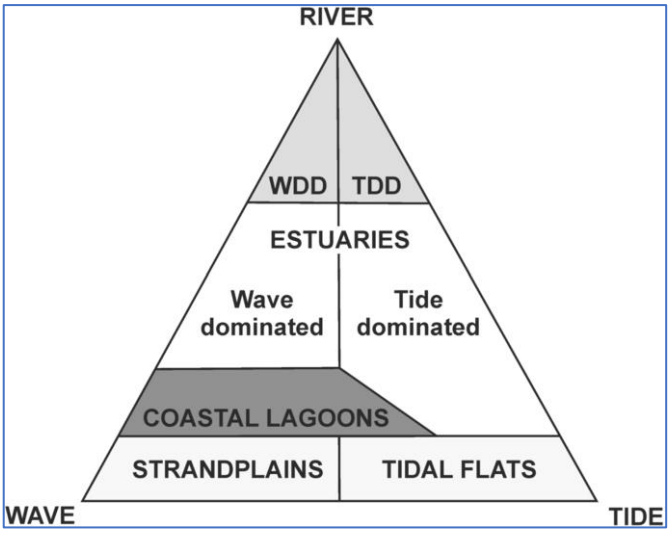

Figure 2. The ternary diagram of Dalrymple et al. (1992) and Boyd et al. (1992) which discriminates coastal environments using the relative 'dominance' of wave, tidal, and rivers (read terrigenous sediment supply). WDD = wave-dominated delta; TDD = tide-dominated delta.

Episodic events such as tropical cyclones, storms and other ENSO-related events can have an immediate impact on sand transport pathways and rates, through river floods and changes in coastal geomorphology, such as barrier breaching. The intensity, frequency and timing of these events help dictate whether the changes are short-term or more permanent. All these factors combine to influence the resilience of different coastal systems to sand mining, at different physical scales and over various timescales.

Using public and proprietary information, this presentation will illustrate some of these factors using case studies from the wet and dry tropics from northern Australia. A variety of methods can help identify the active transport links within the sedimentary system, and help assess where, how fast and to what extent impacts might occur, and thus how systems may then respond to mitigation measures.

Figure 3. Fluvial sand outwash onto tidal flats (Larcombe, Eliot & Buchan, 2025, original photo from CMW Geosciences, 2022).

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Towards zero waste mining: Optimising ore-sand by-products in copper processing circuits

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An estimated 50 billion tonnes of sand and gravel are extracted globally each year. For natural sand, they are extracted from rivers and coasts, with environmental and social consequences particularly severe for communities in coastal regions. Simultaneously, the rising demand for critical metals to support the global energy transitions has driven a significant increase in mine waste. Between 2020 and 2050, global tailings generation is projected to reach 300 Gt. When poorly managed, mine tailings pose significant environmental and safety risks, contributing to more than 2,650 recorded deaths since 1915. Despite this, the mining industry continues to rely heavily on reactive waste strategies—repurposing and reuse—rather than preventing tailings at the source.

Ore-sand is a manufactured sand and a by-product of mineral processing, sourced from silicate-rich ore bodies and produced through dedicated processing circuits. It stems from the realisation that only a small fraction of the material extracted from a mine consists of target elements, while the vast majority are silicate minerals. These minerals, which constitute the main components of sand, are currently unutilised, yet might themselves be mined as fit-for-purpose by-products before they become tailings.

The forensic application of traceability technology in illegal marine sand mining crimes

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The total demand for sand used in construction, concrete, glass and chips is expected to exceed 50 billion tons globally in 2024, far surpassing the natural replenishment rate. According to the "2024 China Sand and Gravel Industry Operation Report", the total demand for aggregates in China was approximately 17.8 billion tons from 2015 to 2021, accounting for more than one-third of the global consumption. In recent years, affected by the downturn in the construction market, the total demand for sand across the country has continued to decline. The total market demand in 2024 is 13.7 billion tons.

According to the revised Mineral Resources Law of the People's Republic of China implemented on July 1, 2025, mineral resources including sand and gravel belong to the state. It is prohibited for any unit or individual to encroach on or damage mineral resources. Mining rights should be transferred through competitive means such as bidding, auction, and listing. Exceptions for individuals mining sand, gravel, and clay that can only be used as ordinary building materials for their own daily use. When mining mineral resources, effective measures shall be taken to avoid and reduce damage to the ecological systems and to prevent and control environmental pollution. The ecological restoration of mining areas should adhere to the combination of natural restoration and artificial restoration, and follow the principles of adapting to local conditions, scientific planning, systematic governance, and rational utilization.

Marine sand is a precious marine mineral resource and an important raw material for construction. With the development of urbanization and the decrease in the supply of sand and gravel resources on land, especially under the influence of strict environmental protection, marine sand has become an important supplement to sand and gravel resources, while the illegal exploitation of marine sand has gradually increased around the world, causing disruption to the legal development and utilization of marine mineral resources. Marine sand is an important part of the marine ecological environment, and illegal mining brings serious harm to this environment.

Modern marine geological survey, monitoring, experimental analysis and data processing technology have been widely used in the forensic identification of illegal marine sand mining. Sonar mapping can compare the changes of seabed landforms before and after sand mining in detail, and assess the seabed damages. Through the investigation of marine biodiversity, the influence of sand mining on the change of biological population has been detected. By means of mineral composition, particle size analysis, heavy mineral and element analysis and foraminifera analysis, the source information of marine sand can be traced. By combining the results of all physical and chemical analyses with ecological models, it is possible to fully assess the overall impact of illegal sand mining activities on marine ecosystems.

This report introduces the application cases of forensic geological in judicial protection of marine sand resources in China.

Fingerprinting legal and illegally mined sand samples using lessons learnt from the oil and gas Industry

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Illegal extraction of sand, for construction and heavy minerals, is becoming a global problem due to the significant volumes involved. To combat this, supply chains need to be made transparent to enable traceability. This study investigates the potential for established analytical techniques from other industries to differentiate illegal and legal sand sources.

The chemostratigraphic interpretation of sand stone geochemical data to aid our understanding of oil and gas reservoirs has been undertaken in the oil & gas industry for more than 30 years. This Chemostratigraphic workflow has progressed from laboratory X-ray fluorescence analysis (XRF) to low part per million limit of detection Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES) and Inductively Coupled Plasma Mass Spectrometry (ICP-MS) means it is now possible to identify subtle compositional changes within quartz rich silica-sand horizons. Additional portable analytical tools such as new benchtop XRFs enable this analysis to be carried out at site, providing real time data to geologists to both identify key well depths (e.g. casing points) as well as geosteering well bores. Other mineralogical techniques such as X-ray diffraction (XRD) and Raman spectroscopy provide further information about the composition of sandstone units. Provenance tools such as automated Raman Heavy Mineral Analysis (HMA) and mineral geochronology (e.g. U-Pb zircon geochronology) further increase our knowledge of sand bodies through providing an understanding of the petrology and age of the sand bodies hinterland.

In this paper, we present a case study that demonstrates how, when integrated, these techniques can provide a thorough detailed understanding of a sand unit. We then will demonstrate a new proof of concept study where these techniques are applied to both a legal and illegally mined sand body from The Gambia and demonstrate:

- How sample preparation can affect geochemical data
- The pros and cons of onsite and laboratory elemental analysis
- How subtle elemental variations can differentiate sand samples
- What mineralogical analysis can tell us about a sand sample
- How mineralogical and geochronological provenance techniques can be utilised to understand subtle differences in sand samples as well as identify their likely hinterlands

This data will then be integrated to show the potential of utilising geochemical tools t to fingerprint and differentiate legal and illegally mined sand samples.

The disappearance of beaches: a local phenomenon or a global emergency?

Francesca Alvisi

National Research Council, Institute of Marine Sciences (CNR-ISMAR)

Sand has become a vital commodity for our modern economies. This material, which we often take for granted, is extracted worldwide at a rate that the tipping point has been already passed from an environmental, social and economic point of view (Rangel-Buitrago et al., 2023). This extraction, at a rate far more than the system's renewability (Beiser, 2018), is having a severe impact on rivers, deltas, coastal and marine ecosystems around the world, resulting in land loss, lowered water tables, decreased sediment supply, widespread habitat degradation and loss of biodiversity (UNEP, 2022). The absence of global aggregate extraction data makes environmental assessment very difficult and has contributed to the lack of awareness on this issue, which in turn results in a lack of action. There is in fact a large discrepancy between the extent of the problem and public awareness. As this is a highly topical issue (Pilkey et al., 2022), citizens should be directly involved through a Citizen Science approach in mapping and monitoring beaches along marine-coastal zones. We focused on this geomorphologic element by capturing its dual significance as a well-known, loved and frequented environment on the one hand, but a threatened, fragile interface, like other forms of the landscape, on the other. Beaches react very quickly to disturbances in sediment distribution and removal. Therefore, they can be used as efficient indicators of the combined results of sand mining both on land (rivers) and at sea.

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Forensic comparison of sands in Oahu, Hawaii using Superspectral technology

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This research aims to analyze the different types of sand found on eight beaches on the island of Oahu, Hawaii. The human eye can see a range of wavelengths from 400 to 700 nanometers. Below 400 nanometers, special UV light and filters are needed to observe the characteristics of different elements, in this case, sand. On the other hand, to observe wavelengths over 700 nanometers, IR technology and filters are necessary, which allow us to see the characteristics under this light. In this analysis, a regular SLR camera, an SLR IR camera, and the latest forensic technology for multispectral analysis called SuperSpectral from ForenScope were used to compare eight samples of different beaches on the island of Oahu. These sands were collected, dried, and weighed. For the analysis, the researcher used the same amount (100 ml) of sand. During this presentation, congress attendees will learn about the method, findings, and results of this forensic analysis, as well as how this sand database can assist in future criminal cases. Another key aspect that this research will demonstrate is the differences in findings among the regular camera, IR camera, and SuperSpectral technology.

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