Marine Geoscience Report 025

Galway Bay

Overview

Galway Bay is a broad, sheltered inlet on the west coast of Ireland, bordered by County Galway to the north and County Clare to the south. Its entrance is partially enclosed by the Aran Islands, which form a natural breakwater and divide the bay into a more protected inner bay and an open outer bay that faces the Atlantic Ocean. Ocean water enters the inner bay primarily through two deep channels that flank the Aran Islands, the North Sound and South Sound, although the primary inflow of Atlantic water into Galway Bay is through the South Sound, with outflow through the North Sound, creating an anticlockwise gyre (McCullagh, et al., 2020). Numerous smaller inlets and estuaries along the bay's coastline contribute to a varied circulation system and a range of sedimentary environments.

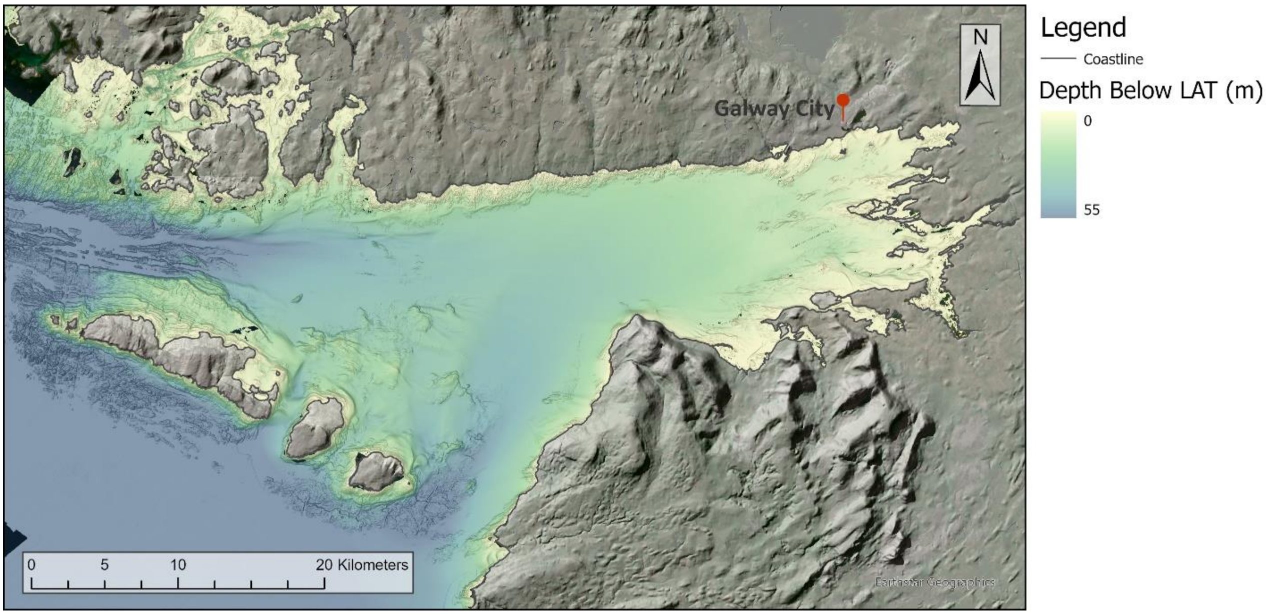

Figure 1: Bathymetry of Galway Bay. Depths are referenced to Lowest Astronomical Tide (LAT).

The bay's geology has been shaped by its bedrock structure and glacial history. It straddles a major geological boundary: ancient granites and metamorphic rocks dominate to the north, while Carboniferous limestone underlies the southern margin. These contrasting lithologies are separated by the east to west trending Galway Bay Fault, a structure that strongly influences both coastal topography and seafloor morphology. During the Last Glacial Maximum, an ice sheet covered the region, with a major ice stream flowing south-west through the area now occupied by the bay. As the ice retreated and global sea levels rose, the bay was gradually inundated, reshaping glacial landforms and depositing marine sediments. INFOMAR bathymetry data reveals a seabed marked by glacial features such as drumlins, scoured rock, and overdeepened channels, alongside more recent sedimentary structures including sandwaves and pockmarks. Together, these features make Galway Bay an important area for understanding how bedrock structure, glacial legacy and modern marine processes combine to shape the seabed.

Regional Geology

Galway Bay's underlying geology records a long history, spanning hundreds of millions of years. The bedrock framework reflects a series of tectonic and sedimentary events, from ancient mountain-building to tropical seas and glaciations. This geological structure strongly influences the shape of the bay, its seabed features, and the nature of its coastal habitats.

The oldest rocks in the region lie to the north and west of the bay, particularly in Connemara and around Galway City. These are mainly Ordovician to Silurian metasedimentary rocks, originally laid down as deep marine sediments between 440 and 420 Ma. During the Caledonian Orogeny (a continental collision and mountain building event that occurred between 470 and 400 Ma), these rocks were folded, uplifted, and metamorphosed (Pracht & Freely, 2004). Around the same time, large intrusions of molten granite were emplaced, forming major bodies such as the Galway Granite Batholith, a vast mass of coarse-grained crystalline rock. This is not a single body, but the product of the intrusion of several large granite plutons around 400 Ma. Emplaced at depth, the granites cooled slowly; the overlying rocks have since been eroded away (Parkes & Simms, 2009). Structurally, the northern region is characterised by intense faulting, predominantly trending south-west to north-east, the dominant structural grain imparted by the Caledonian Orogeny.

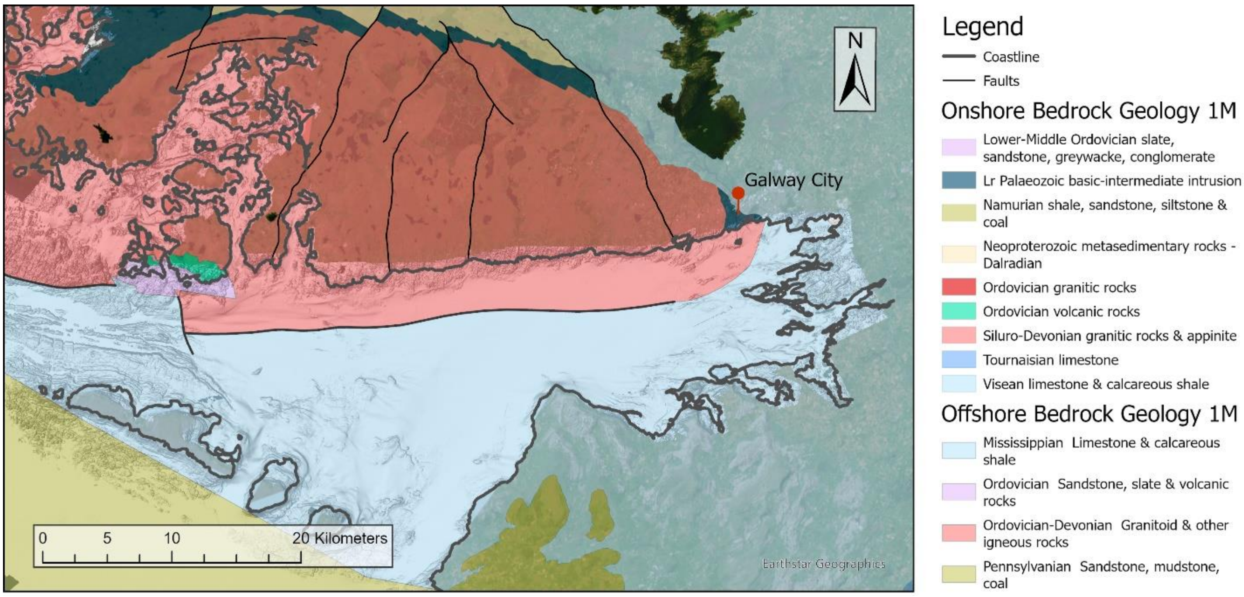

Figure 2: Geological map of Galway Bay.

To the south, the bedrock is dominated by Carboniferous limestone, deposited around 340 Ma when Ireland lay near the equator, submerged beneath a warm, shallow sea (Pracht & Freely, 2004). These fossil-rich limestones record abundant marine life and classic karst features, such as solutional pits and underground drainage systems (McNamara & Hennessy, 2010).

Towards the end of the Carboniferous, compressional forces associated with the Variscan Orogeny led to minor folding and the development of numerous east-west trending faults within the limestone belt (Pracht & Freely, 2004). The most significant structural feature of the region is the Galway Bay Fault, an east-west trending lineament that marks the boundary between the southern Carboniferous limestones and the northern granite/metasediment province. This fault exerts a strong control on the bay's morphology and has influenced the development of major features such as the North Sound.

Multibeam data have refined the location of the fault, as both limestone and granite are now clearly distinguishable across its contact, revealing a more accurate offshore trace than previously mapped.

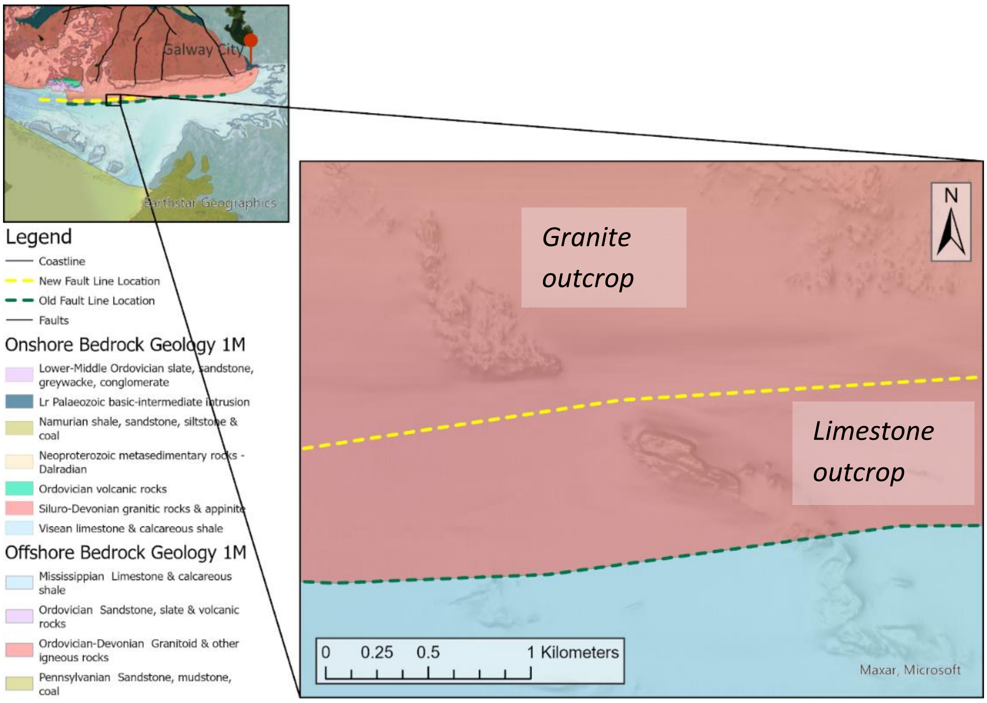

Figure 3: Old (green dashed line) and revised (yellow dashed line) location of the Galway Bay Fault.

Offshore, this lithological contrast is clearly reflected in seabed morphology. Granite typically appears as rugged pinnacles or ridges, while the limestone forms flatter terraces that may be pitted by karstic solution. The limestones either exhibit horizontal bedding or dip gently to the south, and show minor folding and faulting from Variscan tectonics, whereas the northern granites are heavily fractured, with north-east to south-west fault trends. The overall structural grain imparted by both Caledonian and Variscan events has helped define the orientation of many of the bay's channels and seafloor features.

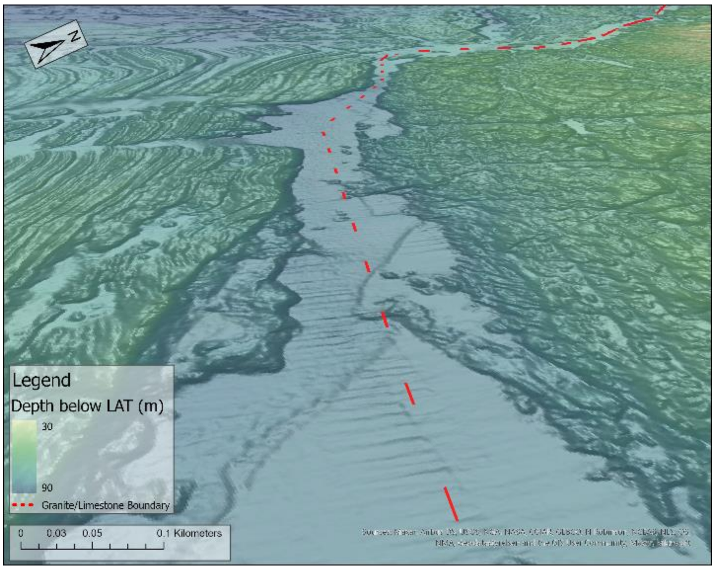

Figure 4: 3D image of the inferred contact between granite (to the right/north) and limestone (to the south).

Following the Variscan Orogeny, there is a significant gap in the geological record from the end of the Carboniferous until the onset of the Quaternary, around 2.59 Ma. This absence of preserved strata is largely attributed to prolonged uplift and subsequent erosion, which removed much of the sedimentary cover that may have accumulated during this interval (Pracht & Freely, 2004).

In the Quaternary period, repeated glaciations reshaped the landscape. During the Last Glacial Maximum (24,000 years ago), ice sheets advanced from the Irish Midlands and flowed south-west across what is now inner Galway Bay (McCullagh, et al., 2020). These glaciers sculpted the terrain, leaving behind glacial till, drumlins, and overdeepened channels. As the climate warmed, sea levels rose, and post-glacial marine flooding submerged the area.

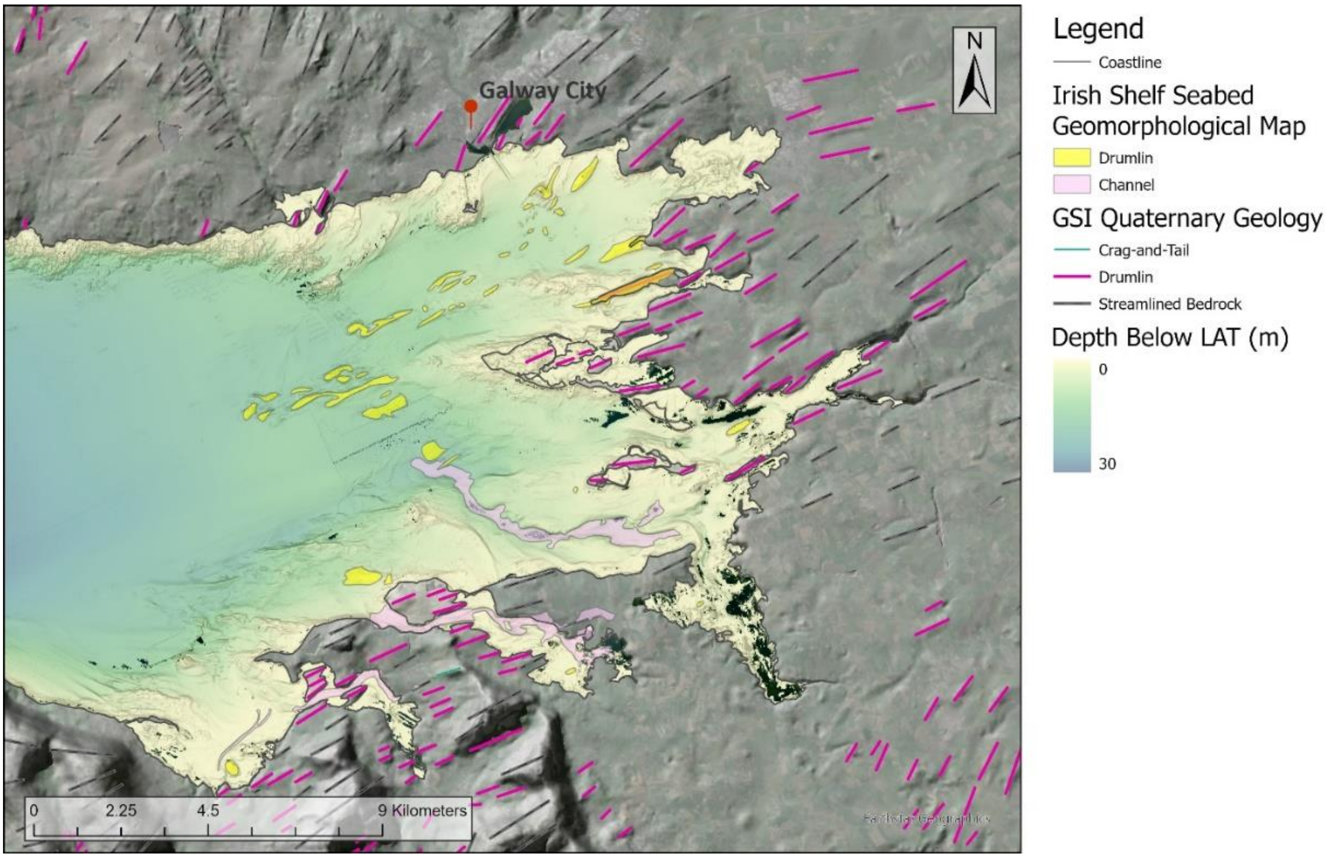

Figure 5: Map of glacial features onshore and offshore. Data from GSI Quaternary Mapping and the Irish Shelf Seabed Geomorphological Map (Arosio, et al., 2023).

Shallow seismic surveys can reveal the stratigraphic sequence beneath the bay: bedrock at the base, overlain by up to 10-14 m of glacial deposits (unit 3 in the image below), capped by marine sediments (unit 2, typically 2-15 m thick) deposited over the last 10,000 years, with a very thin sediment layer at the surface (unit 1) (Sheehan, 2024). In total, sediment thickness can exceed 20 m in some parts of the bay, though exposed bedrock and thin sediment veneers dominate areas near the outer bay and coasts.

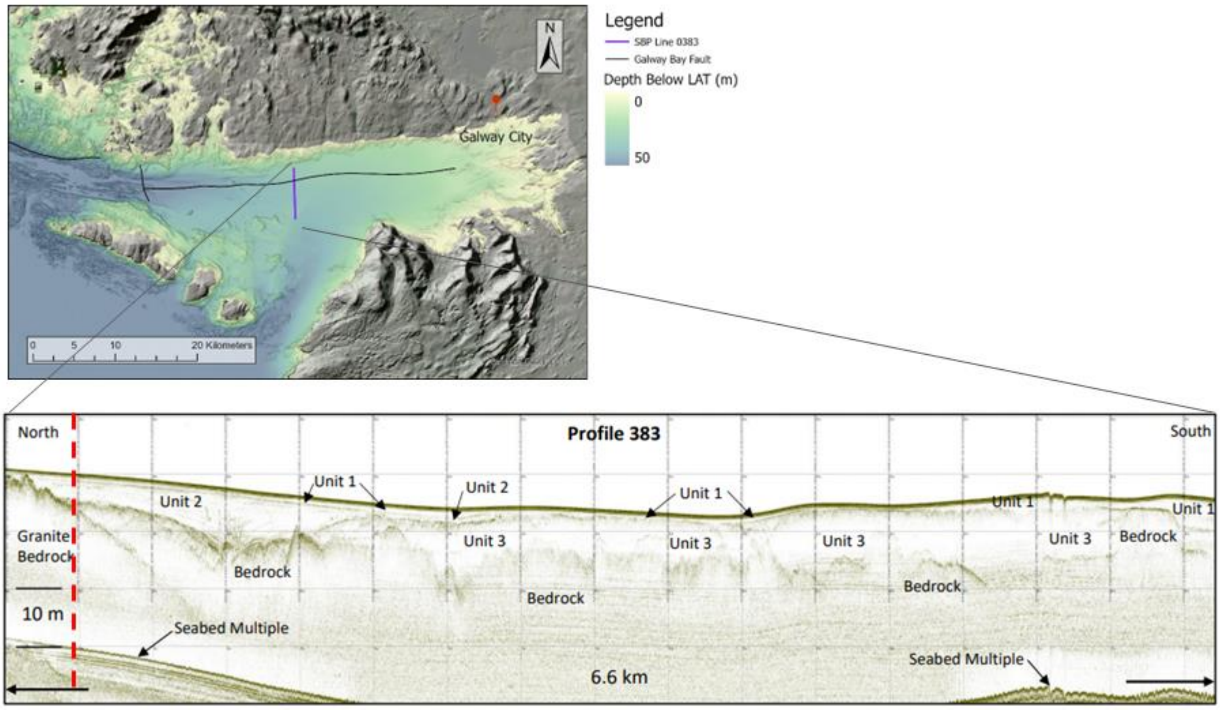

Figure 6: Sub-bottom profile of line 0383 from INFOMAR survey TC24_01 (Sheehan, 2024), with the approximate location of the fault indicated by the red dashed line.

Biodiversity

Galway Bay supports a wide diversity of marine habitats and species, much of which is underpinned by its geological and geomorphological foundation. The inner bay is designated as both a Special Area of Conservation (SAC) and a Special Protection Area (SPA), reflecting its environmental significance. Key habitats include seagrass beds, muddy estuarine flats, rocky reefs, and shallow sandbanks (National Parks & Wildlife Service, 2015). These environments support a range of marine life, including shellfish, fish nurseries, wading birds, and marine mammals such as bottlenose dolphins and seals (National Parks & Wildlife Service, 2019).

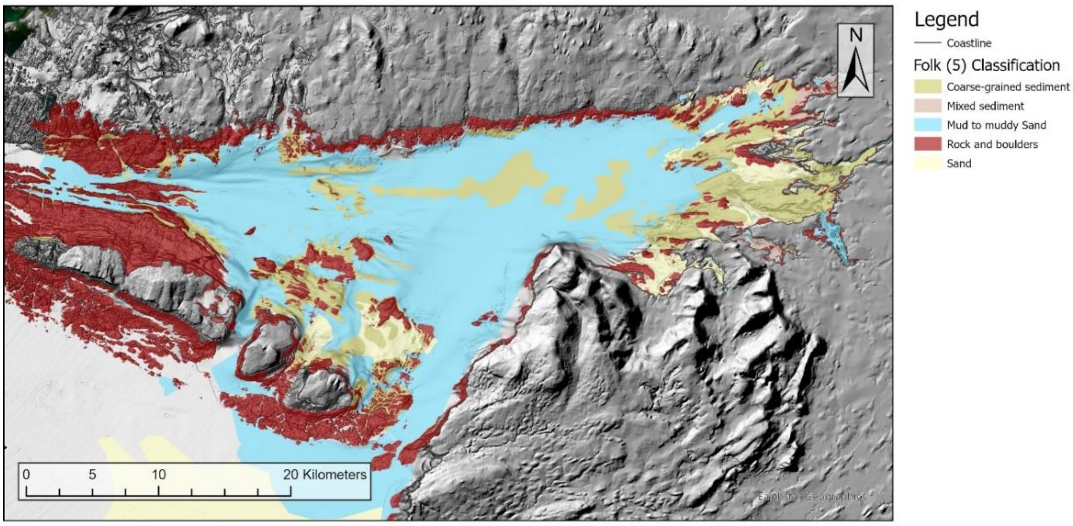

Figure 7: Sediment classification map of Galway Bay, showing the various substrate compositions, compiled from acoustic data and seabed sampling.

This biodiversity is closely linked to the bay's geological variety. The mixture of bedrock outcrops, glacial features, and sediment types creates a patchwork of ecological niches. Rocky reefs provide anchor points for kelp and other algae, while soft mud and sand flats are home to burrowing creatures and filter feeders (National Parks & Wildlife Service, 2019). Maërl and seagrass beds help to stabilise seabed sediments by trapping and binding fine material, reducing resuspension and helping to limit localised erosion. Strong-flowing tidal channels bring in nutrients and oxygen, helping to sustain the productivity of the system.

Modern acoustic survey techniques, such as multibeam bathymetry and backscatter mapping, allow scientists to identify and classify different seabed habitats. Bathymetric maps highlight features like reefs and channels, while backscatter data, recording the strength of returned sound signals, helps to distinguish between sediment types. Darker colours indicate a harder seabed or coarser material, while lighter colours indicate a softer sediment. This information is critical for marine habitat monitoring, environmental protection, and sustainable management of the bay's resources (INFOMAR, n.d.).

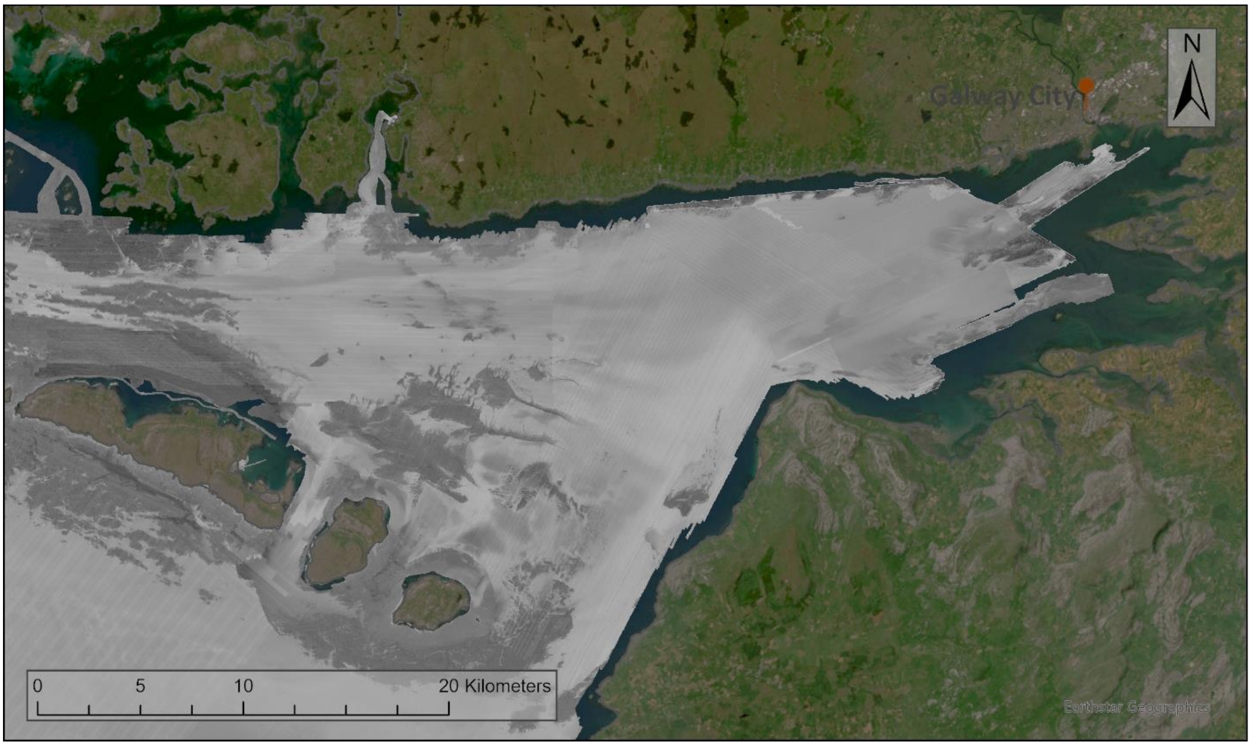

Figure 8: Backscatter map of Galway Bay, with the darker areas indicating harder seabed and the lighter colours indicating softer sediment.

Seabed Features

Galway Bay's seabed presents a variety of geological and geomorphological features, shaped by repeated glaciations and ongoing hydrodynamic processes. In the figure below, the 3D bathymetry places the bay's seabed morphology in its wider coastal setting, allowing the main offshore depth patterns to be viewed alongside the surrounding onshore geomorphology. This seabed relief is continually modified by tidal currents and wave action, which rework sediments and help maintain the bay's active suite of channels, sandbanks, and scour features.

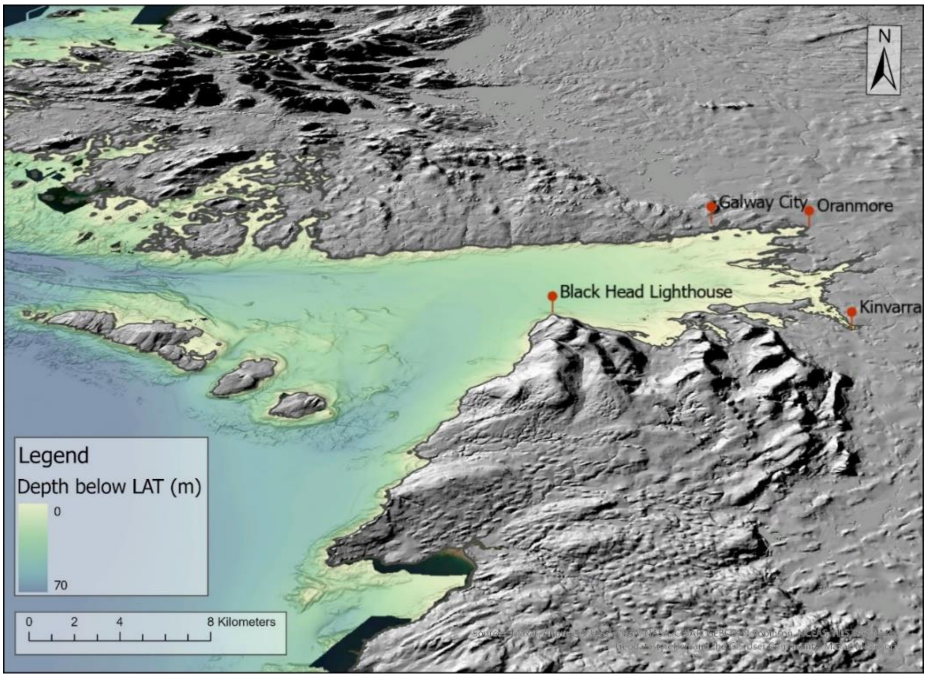

Figure 9: 3D image of Galway Bay, showing seabed relief in the context of the surrounding coastal (onshore) geomorphology.

Channels

Exchange with the Atlantic is focused through two outer gateways: the North Sound (between Connemara and the Aran Islands) and the South Sound (between the Aran Islands and the Burren coast). These openings towards the Atlantic support strong tidal currents and a residual circulation pattern, with the primary inflow of Atlantic water entering through the South Sound and outflow through the North Sound, creating an anticlockwise gyre within the bay (McCullagh, et al., 2020). Inside the bay, a web of shallow tidal channels branches across the inner flats. Together these pathways partition circulation patterns: the outer Sounds control ocean exchange and wave energy, while inner-bay meanders redistribute fine sediments across mudflats and saltmarsh.

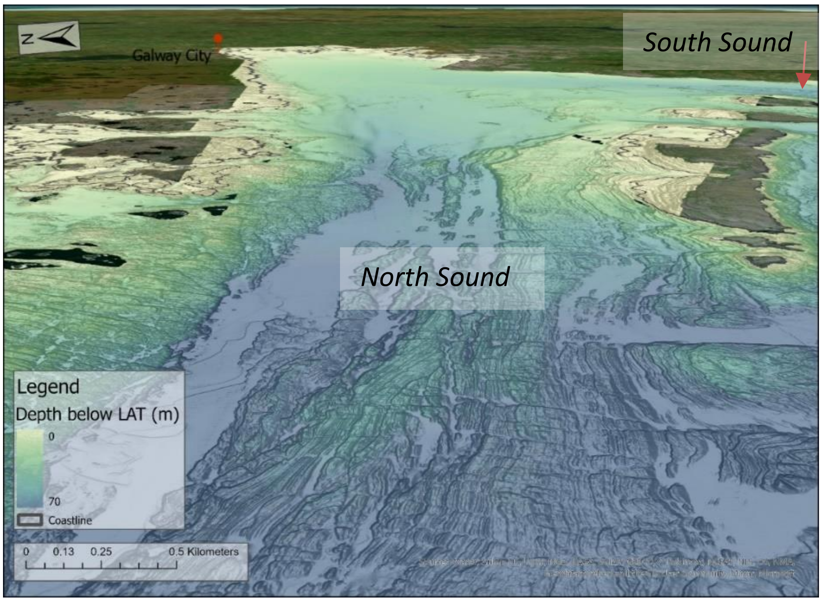

Figure 10: 3D bathymetry of the North Sound, between Inishmore and the mainland.

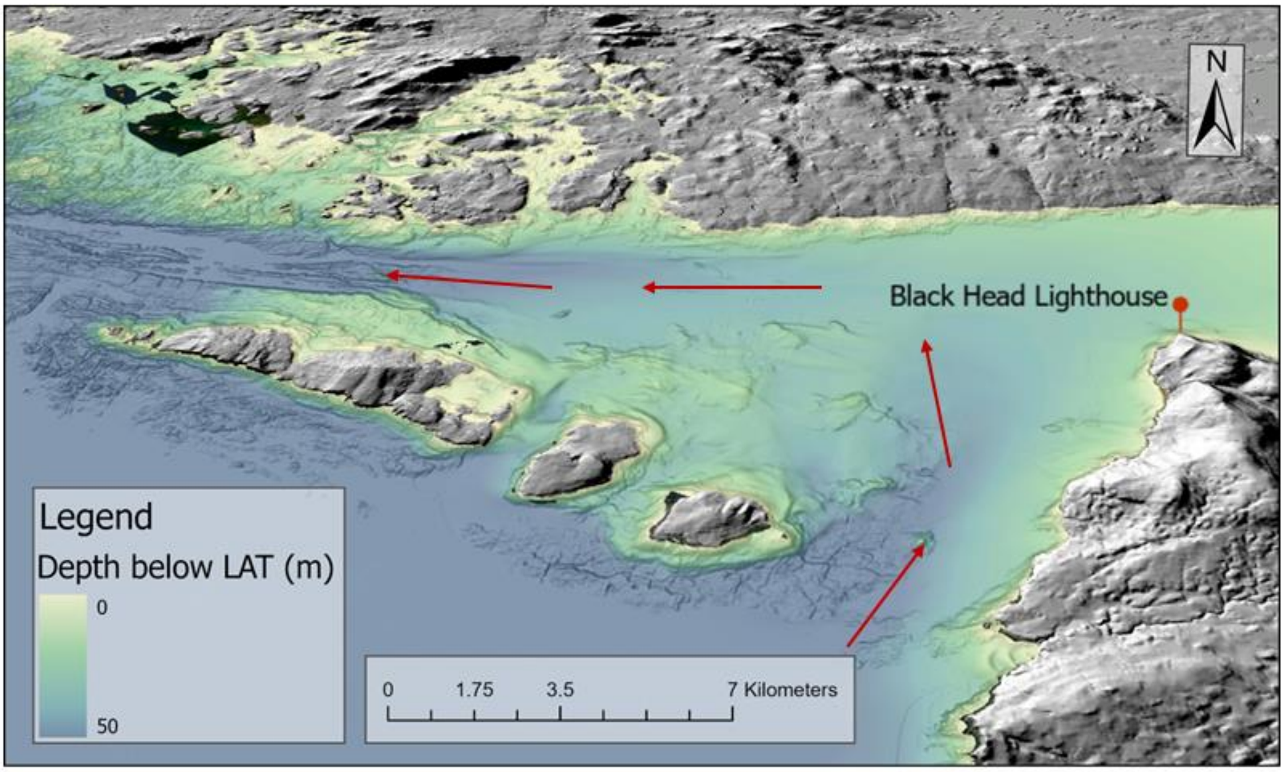

Figure 11: 3D bathymetry of the South Sound, between Inisheer and the mainland, with residual currents indicated by red arrows.

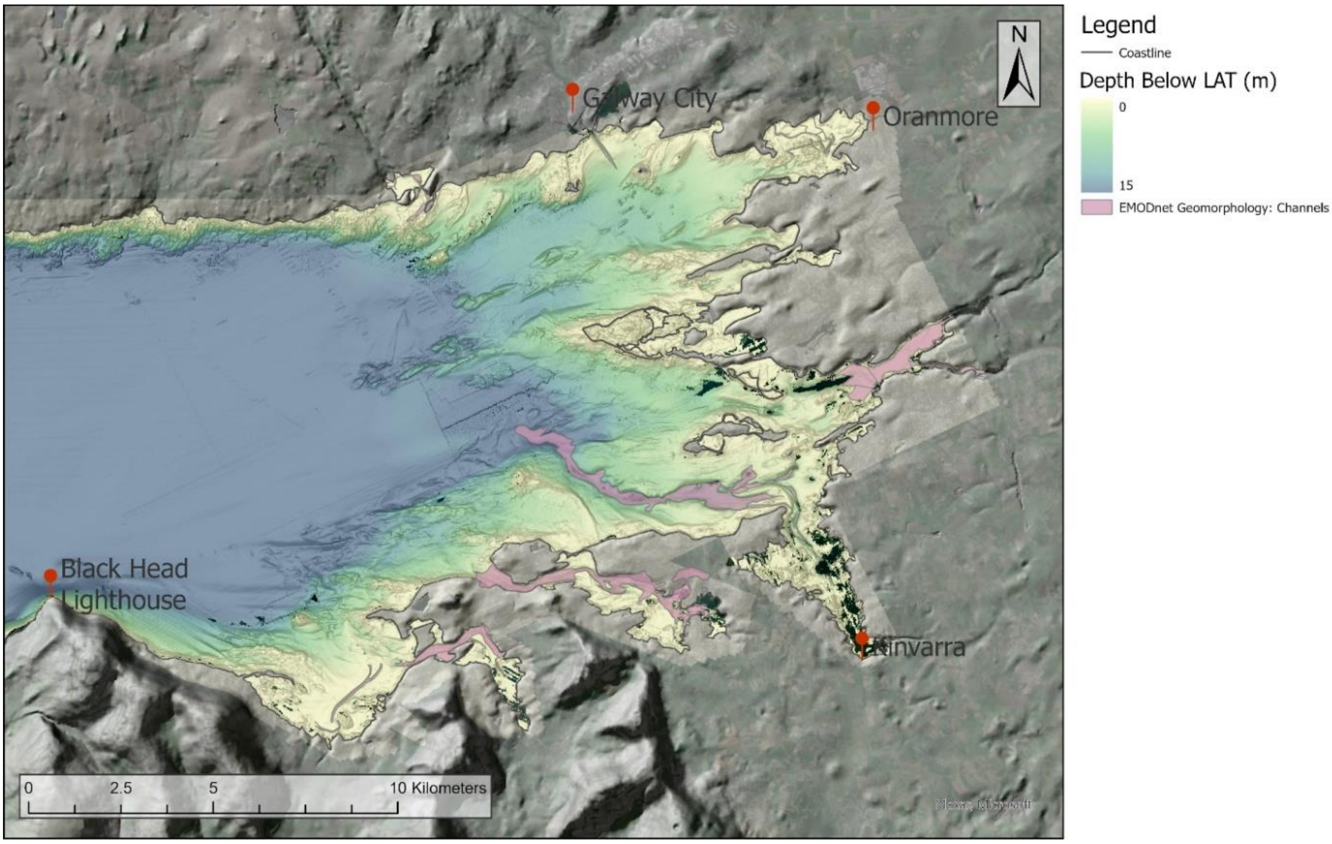

Figure 12: Overview of channels in the inner bay. Channel data from (McCullagh, et al., 2020).

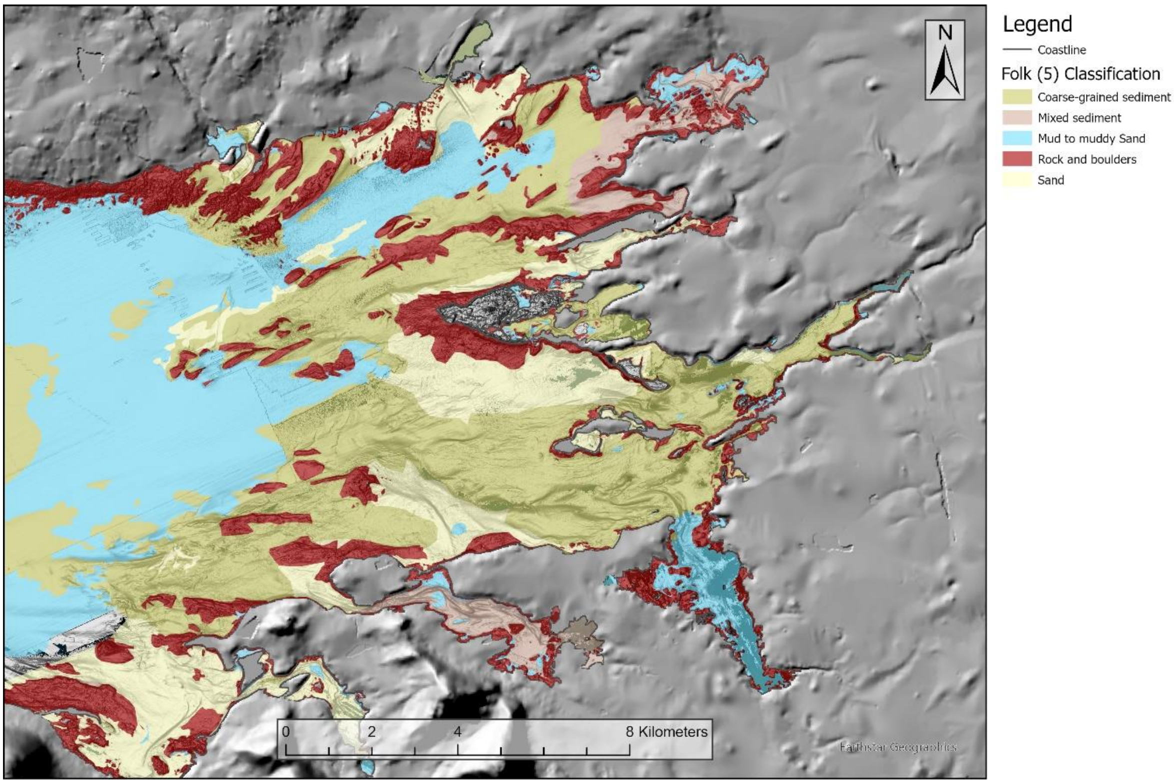

Figure 13: Sediment classification map of the inner bay.

Galway Bay Shipping Channel

One prominent dredged channel is the Galway Harbour shipping channel, dredged 3.5 m below the surrounding seabed to allow ships to navigate from Galway City to the deeper waters of the bay. This dredged channel follows roughly the old course of the Corrib outflow and is maintained by periodic dredging.

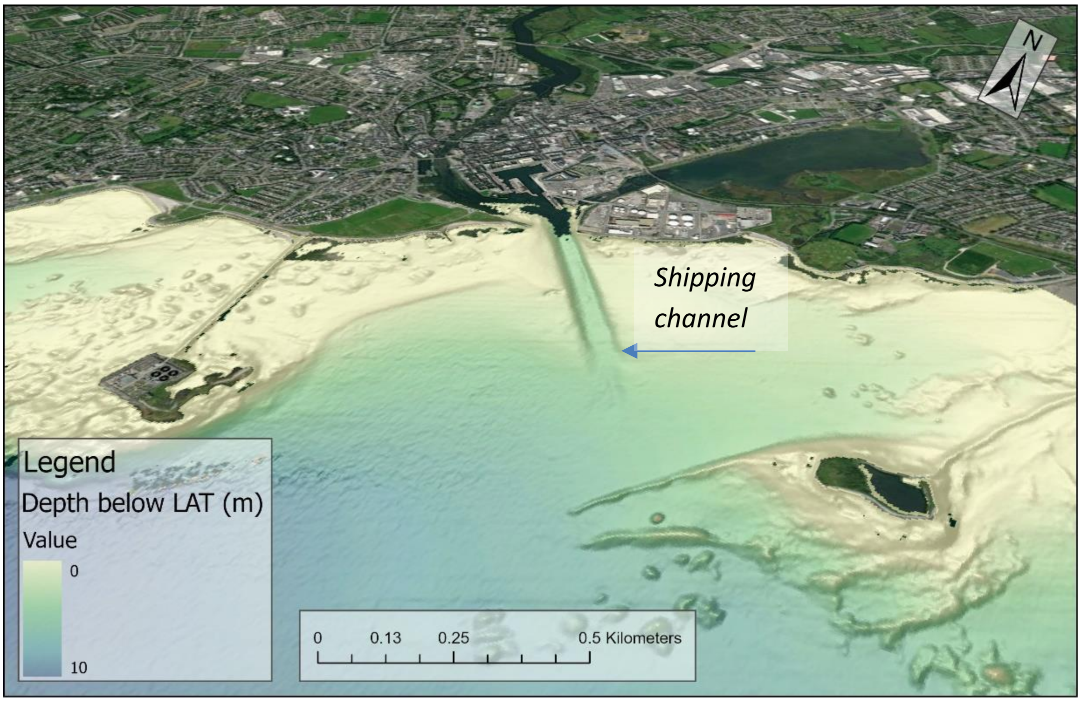

Figure 14: Bathymetry of Galway shipping channel.

Kinvarra Bay

Kinvarra Bay, in south-east Galway Bay, lies at the seaward end of the Gort–Kinvarra karst lowland and contains a range of submarine features, including shallow channels. The bay is notable for substantial submarine and intertidal groundwater discharge from major karst springs that emerge in the intertidal zone at Kinvarra and further offshore, forming three main spring groups along the shore (Drew, 2018).

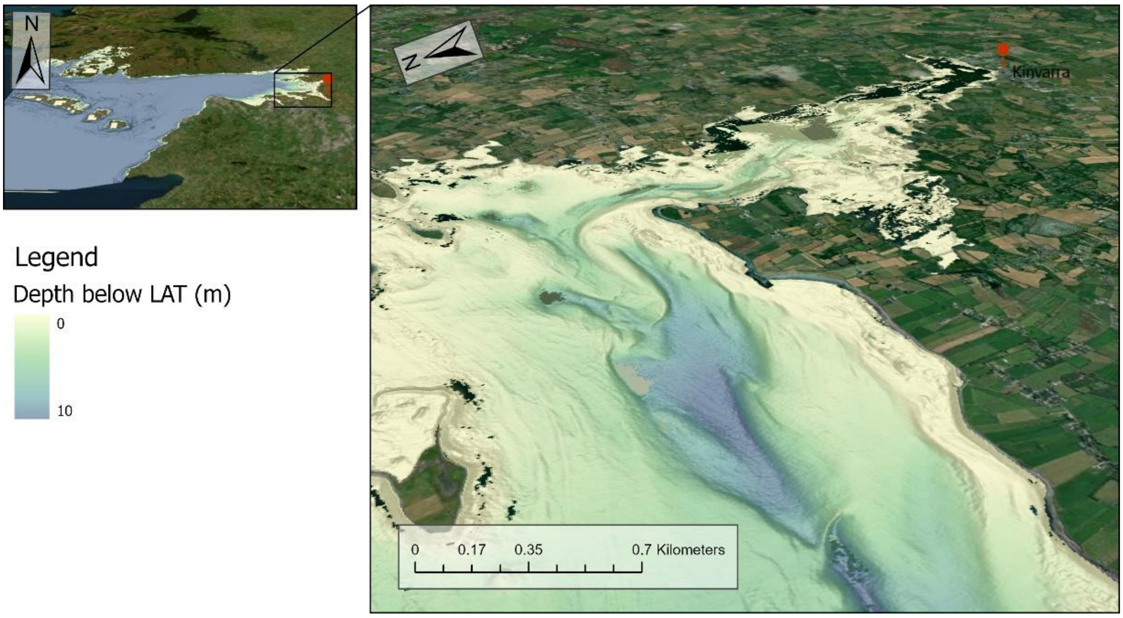

Figure 15: 3D bathymetry of Kinvarra channels.

These spring-fed conduits and tidal creeks form a diffuse channel system. Groundwater inflow modifies local salinity and sediment dynamics, encouraging the accumulation of fine sediments in the bay's quieter waters and the development of intertidal mudflats dissected by tidal creeks (Drew, 2018). This combination of mudflat, creek and gravel-dominated microhabitats supports a mosaic of communities, illustrating the close interaction between karst hydrogeology and coastal processes in shaping the local seabed (National Parks & Wildlife Service, 2019).

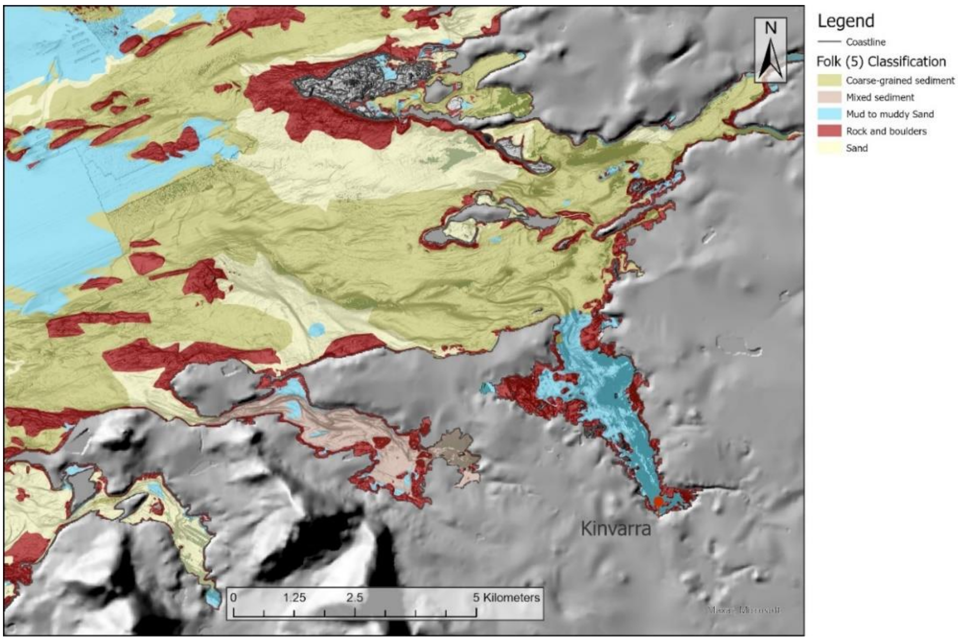

Figure 16: Sediment classification map of Kinvarra channels.

Oranmore Channels

The inner eastern bay around Oranmore is characterised by extensive tidal flats dissected by a network of shallow, sinuous, meandering channels. These shallow creeks carry both tidal flows and river discharge.

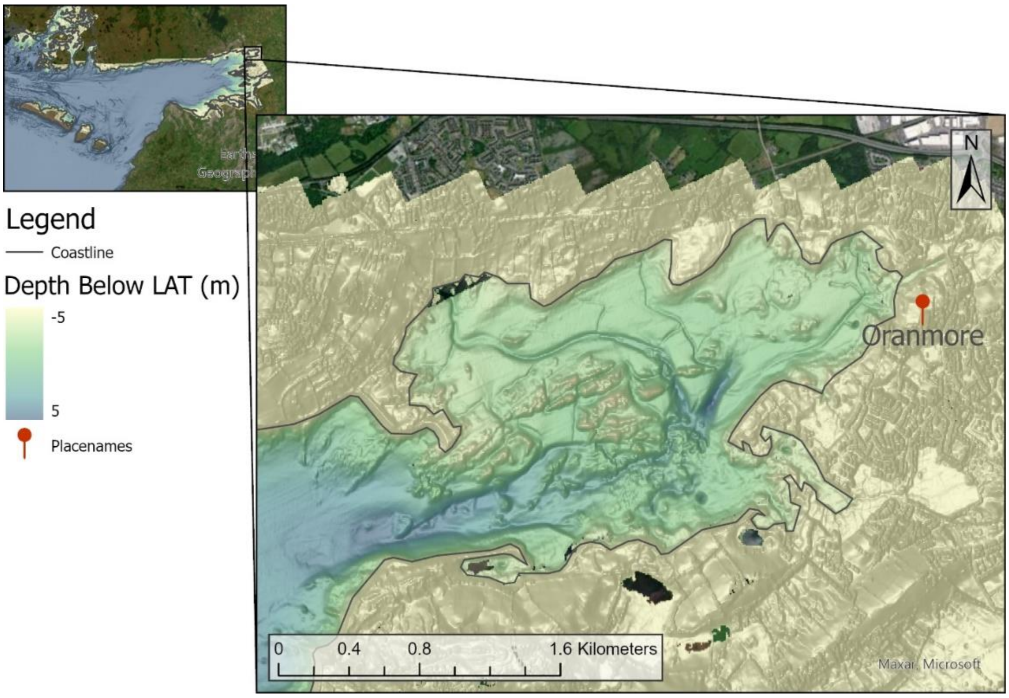

Figure 17: 3D bathymetry of Oranmore Channels.

Multibeam data show branching channels cut into soft sediments, bordered by mudflats and saltmarsh (National Parks & Wildlife Service, 2015). These channels maintain circulation, flush nutrients and detritus, and sustain salinity gradients that are important for lagoonal marsh habitats.

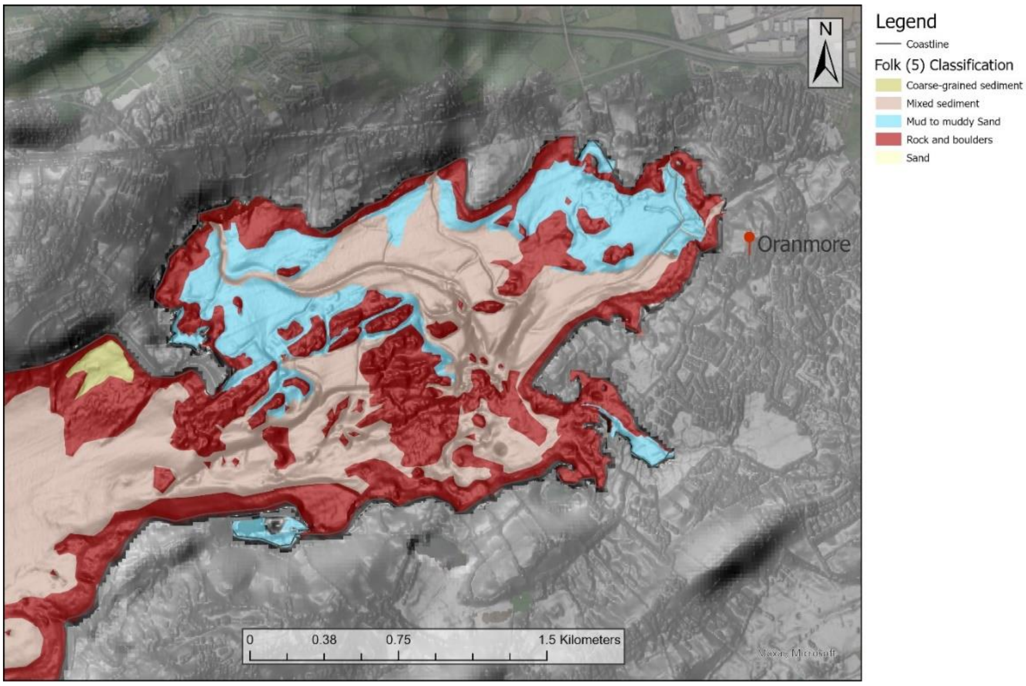

Figure 18: Sediment classification map of Oranmore channels.

Pockmarks

Scattered across parts of the bay floor are distinctive circular depressions known as pockmarks. These are small craters, typically 5 to 10 m in diameter and up to 1 m deep, formed by the escape of gas or pressurised groundwater from underlying sediments. Two notable fields have been identified: one west of Galway City, and another on the County Clare coast. The Clare coast group contains larger and more numerous features.

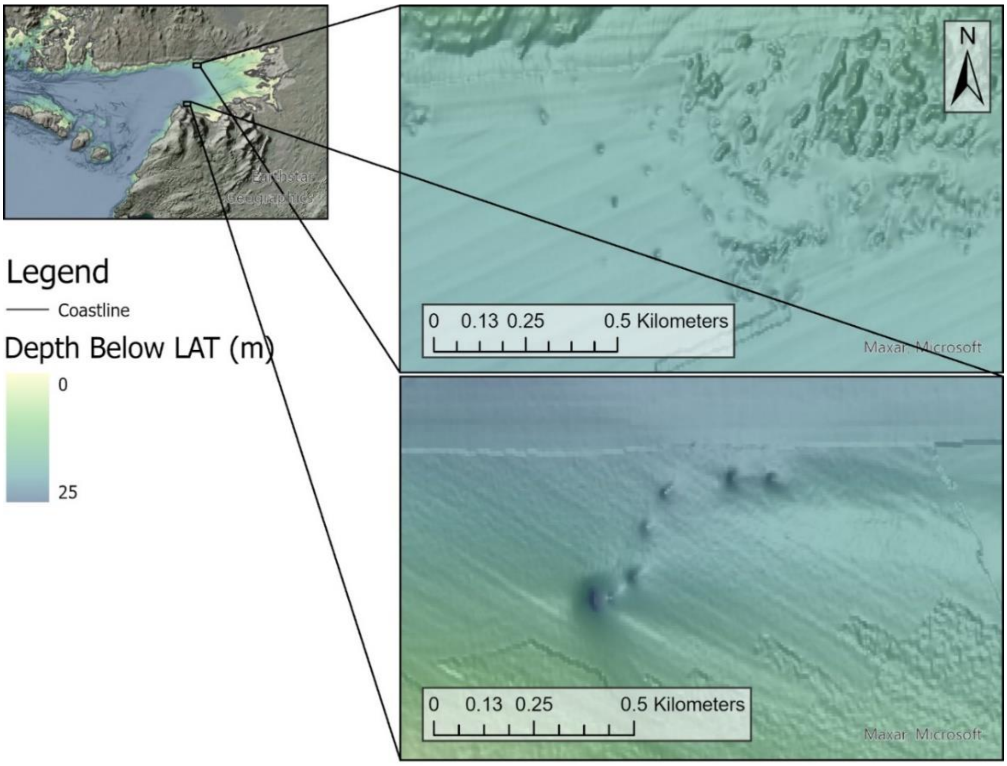

Figure 19: Bathymetric imagery of pockmarks.

These pockmarks occur mainly in fine muddy sediments and are key indicators of active or historic fluid-seepage processes, although the exact source of the gas or groundwater is still to be determined. McCullagh et al. (2020) report the presence of submarine groundwater drainage streams along the northern shores, which could contribute to pockmark formation.

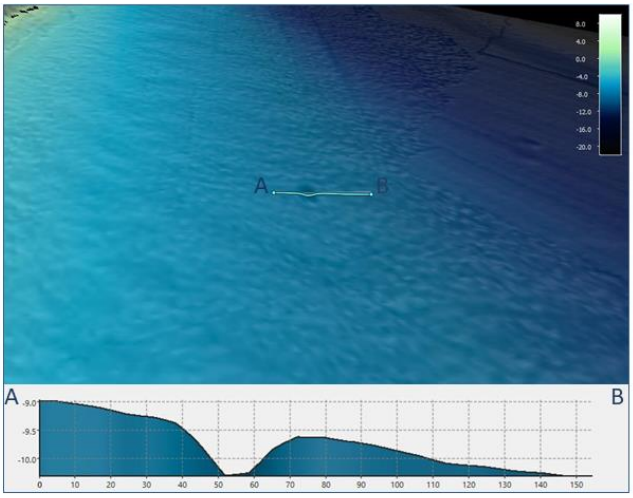

Figure 20: 3D profile of a pockmark.

Drumlins

Drumlins are elongated hills of glacial till formed beneath flowing ice. In Galway Bay, they occur near the shores of Connemara, across parts of the inner bay, and on submerged shoals in the outer bay. Many of the islands in the eastern bay are also interpreted as drowned drumlins, with the same oval shapes and aligned orientations seen on land. Their distribution indicates that the ice sheet once extended continuously across the area now occupied by Galway Bay (McCullagh, et al., 2020).

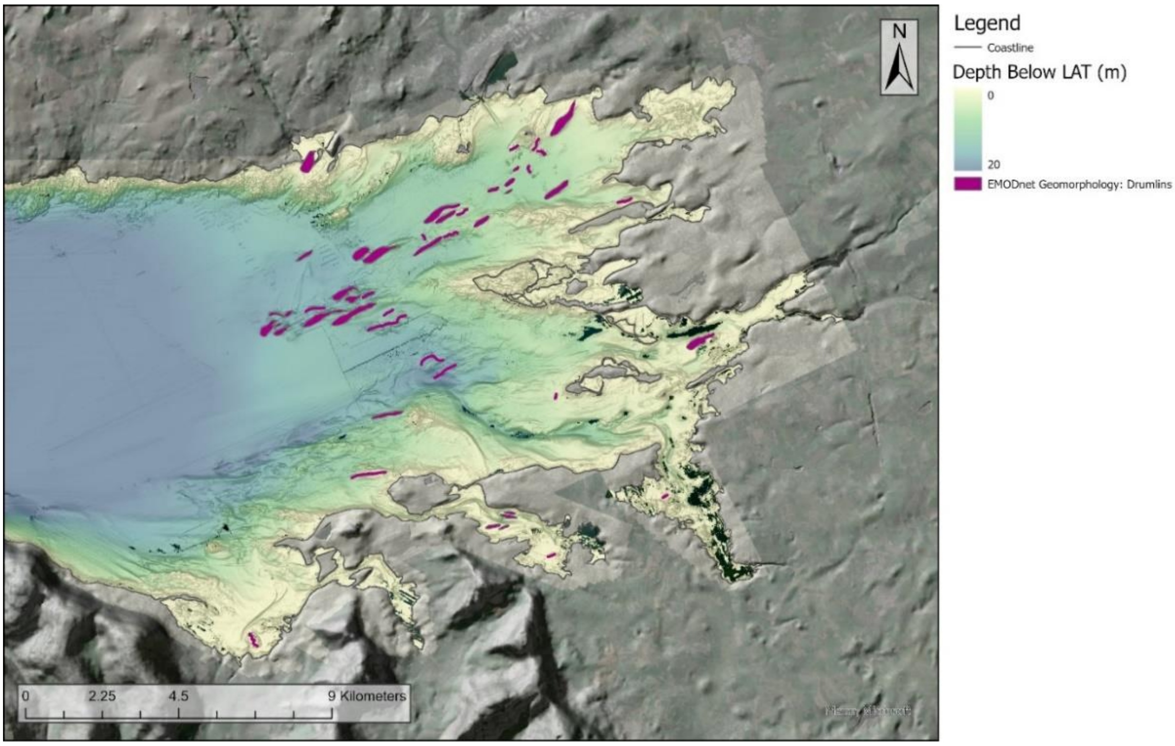

Figure 21: Bathymetry of drumlins in inner Galway Bay. Drumlin data from (McCullagh, et al., 2020).

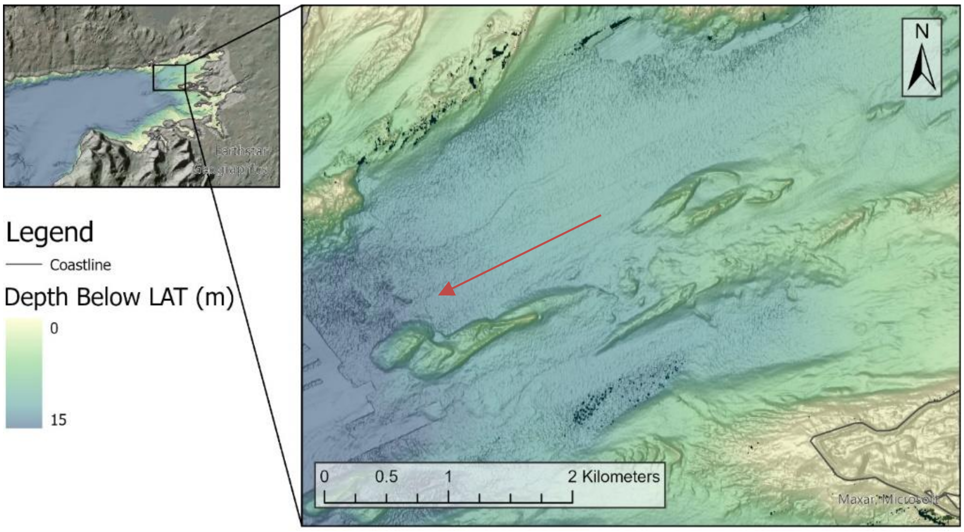

Figure 22: Detailed bathymetry of drumlins, with direction of ice flow indicated by arrow.

A typical drumlin is composed mainly of glacial till, an unsorted mixture of clay, silt, sand and stones. It is usually aligned parallel to ice flow, with a steeper stoss side facing the direction from which the ice advanced and a tapered lee side pointing downstream. The term derives from the Irish word *droimnín*, meaning “little ridge” (McCullagh, et al., 2020).

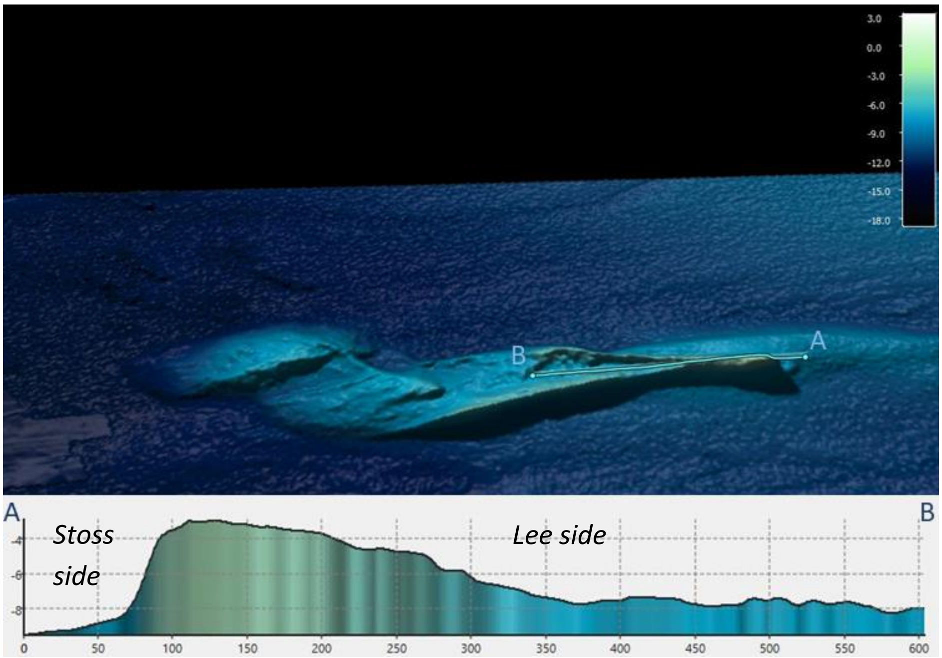

Figure 23: 3D profile of drumlin.

Submarine drumlins mapped in Galway Bay range from 60 m to several hundred metres wide and up to 1.5 km long, rising 10 to 20 m above the surrounding seabed. They generally align north-east to south-west, reflecting ice flow from the Irish Midlands towards the Atlantic. Backscatter imagery shows coarse surface textures, consistent with resistant glacial till and gravel. Their flanks are often swept free of fine sediment by tidal and wave currents, leaving elevated coarse-grained features that contrast with the surrounding flat or muddy seabed.

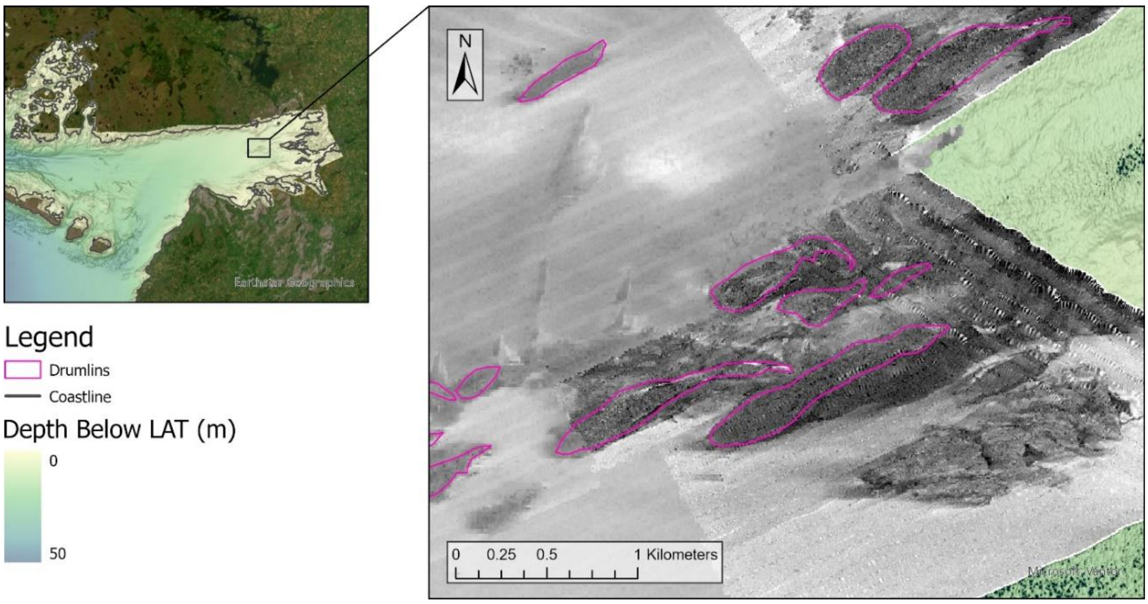

Figure 24: Backscatter imagery of drumlins, with drumlin polygons from (McCullagh, et al., 2020).

The preservation of these drumlins offshore provides important evidence for reconstructing former ice limits, ice-flow direction and retreat patterns. It also has practical relevance, as engineering works such as mooring foundations or cable trenching must account for their compact cores and limited sediment cover.

Conclusion

Galway Bay records the combined influence of bedrock geology, Quaternary glaciation, and ongoing coastal and shelf processes. The bay straddles a major lithological boundary, with granitic rocks to the north and Carboniferous limestone to the south. This contrast, together with the east-west trending Galway Bay Fault and associated fracture and fault networks, influences regional morphology and the configuration of major channels, including the North and South Sounds.

The Quaternary imprint is expressed through drumlins, scoured bedrock, and overdeepened channels, with shallow seismic data indicating glacial and post-glacial sediment packages that locally exceed 20 m thickness. Modern hydrodynamic processes continue to modify this inherited surface: tidal currents and wave action redistribute sediments, maintain tidal-channel networks in the inner bay, and influence patterns of sediment redistribution and seabed exposure, particularly in higher-energy areas.

Geodiversity underpins habitat variability across the bay by creating a spatial mosaic of substrate types and seabed forms. Rocky outcrops and reefs support macroalgal communities, while mud and sand flats support burrowing fauna and filter feeders; maërl and seagrass habitats contribute to sediment stabilisation by trapping fine material and reducing resuspension in suitable settings. Understanding the bay's seabed is essential for both conservation and development. Ongoing mapping and survey programmes, such as those by INFOMAR and GSI, support research, policy and public understanding of these submerged landscapes.

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