

Geomorphology of Killary Harbour, Ireland: Potential Effects of Rocky Outcrops on Surrounding Sediments

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ABSTRACT
Killary Harbour, a fjard located on Ireland's western coast was mapped by the Marine Institute of Ireland and Geological Survey of Ireland as part of INFOMAR using the R/V *Celtic Voyager's* Kongsberg EM2040 multibeam sonar. The harbour's shallow water depth ranges from 5 to 45 m, allowing for high resolution data. Using CARIS HIPS 9.0 post-processing software, multibeam sonar bathymetry and backscatter intensity surfaces with 2 m resolution were created to analyze the harbour's geologic features and bottom hardness. This study focused on comparing different rocky outcrops that are surrounded by sediment to determine how the outcrops affect the area in this dynamic tidal environment. Similar channels in sediments near large rocky outcrops were compared and used to determine an association between the channeling around the rocky outcrops and the varying bottom hardness in the adjacent sediment areas.

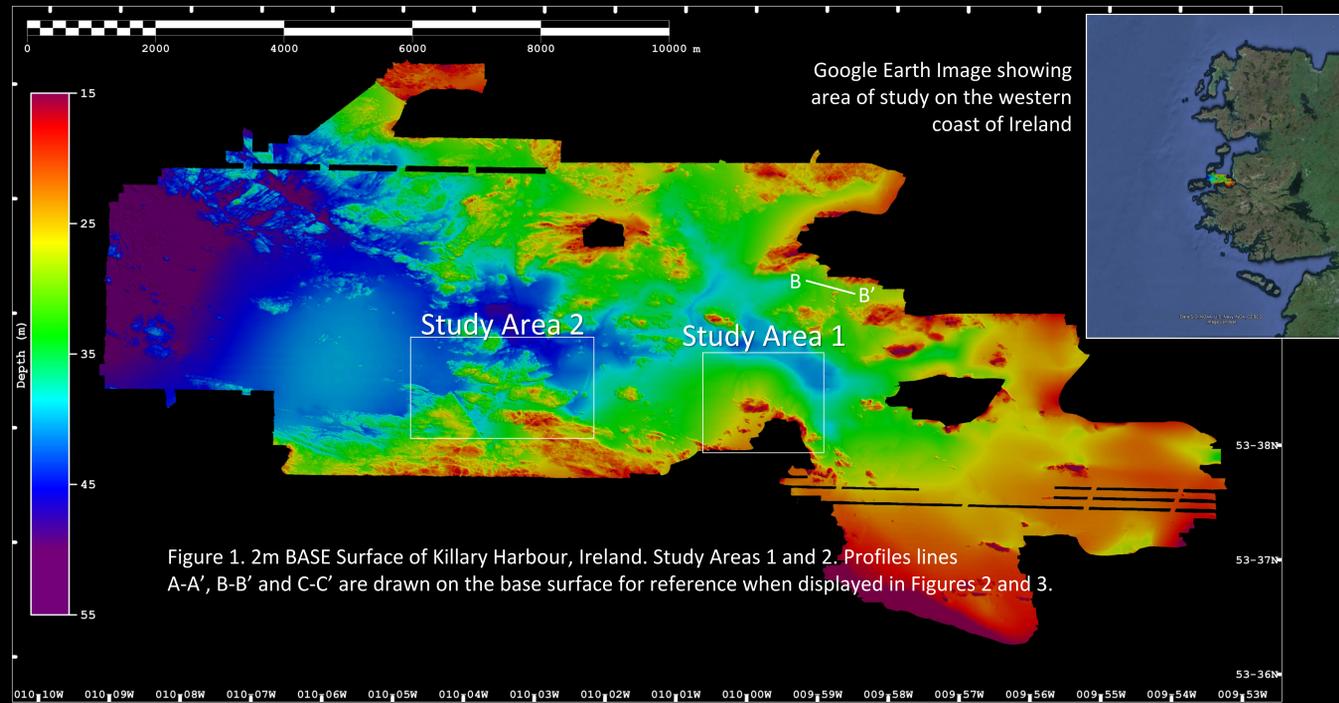


Figure 1. 2m BASE Surface of Killary Harbour, Ireland. Study Areas 1 and 2. Profiles lines A-A', B-B' and C-C' are drawn on the base surface for reference when displayed in Figures 2 and 3.

BACKGROUND
Killary Harbour is located on the western coast of Ireland. It lies in a shallow fjard and has a very dynamic tidal environment causing dynamic geomorphology within the harbour. The depth of the harbour ranges from 5 to 45 m and has a semidiurnal meso-tidal range of 3.7 meters (Cooper, 2006). The majority of the rocks that comprise this area are Neoproterozoic to Lower Paleozoic meta-sedimentary rocks, Ordovician sandstone, slate & volcanic rocks, Silurian sandstone, siltstone, conglomerate (Bedrock Geology of Ireland). The purpose of this study is to determine the cause and effects of the channeling around the rock outcrops and if the bottom hardness and composition affects this channeling.

Study Area 1

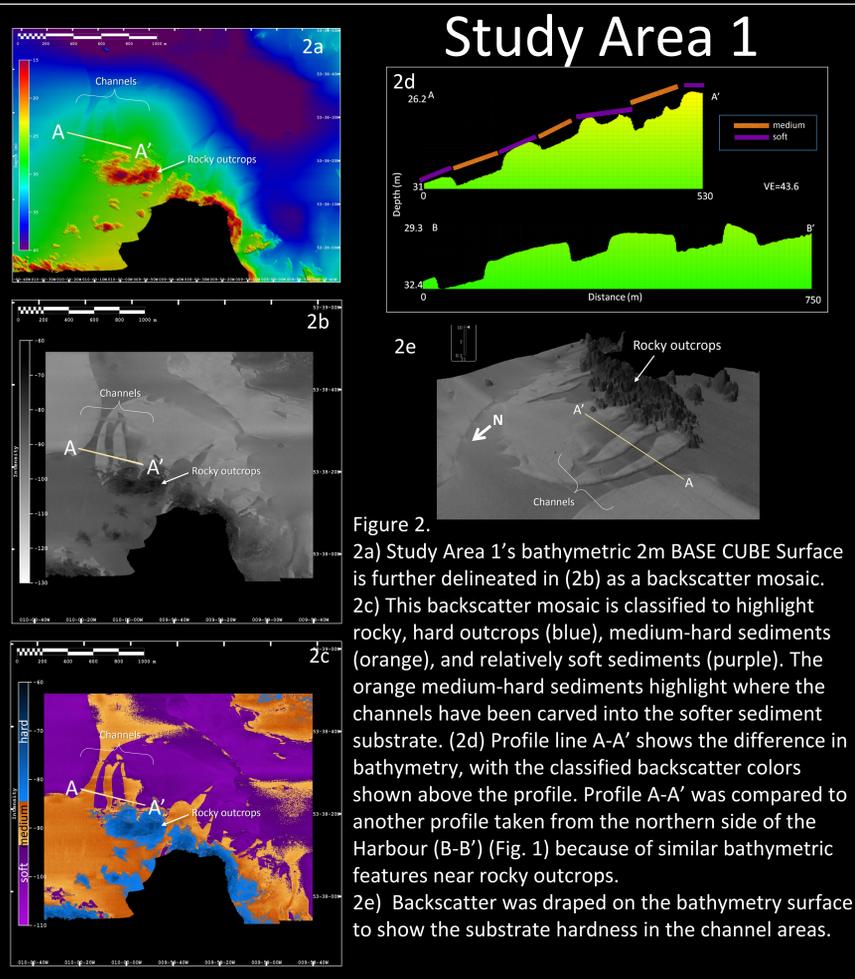


Figure 2.
2a) Study Area 1's bathymetric 2m CUBE BASE Surface is further delineated in (2b) as a backscatter mosaic. 2c) This backscatter mosaic is classified to highlight rocky, hard outcrops (blue), medium-hard sediments (orange), and relatively soft sediments (purple). The orange medium-hard sediments highlight where the channels have been carved into the softer sediment substrate. (2d) Profile line A-A' shows the difference in bathymetry, with the classified backscatter colors shown above the profile. Profile A-A' was compared to another profile taken from the northern side of the Harbour (B-B') (Fig. 1) because of similar bathymetric features near rocky outcrops. 2e) Backscatter was draped on the bathymetry surface to show the substrate hardness in the channel areas.

RESULTS

- Study Area 1**
- Classified backscatter (Fig. 2c) shows that the outcrops are composed of the hardest substrate. The channels' bases are composed of medium-hard consolidated sediments and the shoaler sediments between each channel are comprised of unconsolidated sediments.
 - Profile lines (2d) A-A' in Study Area 1 and B-B' from the northern side of the harbour illustrate similar rocky outcrop features.
 - The channels in the profiles (2d) are cut with very similar shape and their locations are analogous, relative to their nearest rocky outcrop.
- Study Area 2**
- Two basins were observed to be relatively flat with consistent slope (3a).
 - Backscatter intensity (3b) and classified backscatter (3c) surfaces for these basins revealed very different bottom hardness ranging from hard rock to unconsolidated sediments.
 - These basins are surrounded by much shallower rocky outcrops.
 - The softer, less consolidated sediment substrates tend to make up the middle of the basin but the medium-hard sediments surround the edges of the basin and create linear paths at the edge reaching in to the middle of the basin.
 - Profile line C-C' and D-D' (3d) show that the basin's shoaler sediments are the softest (least consolidated) sediments and the troughs between these shoaler sediments are medium-hard sediments.

Study Area 2

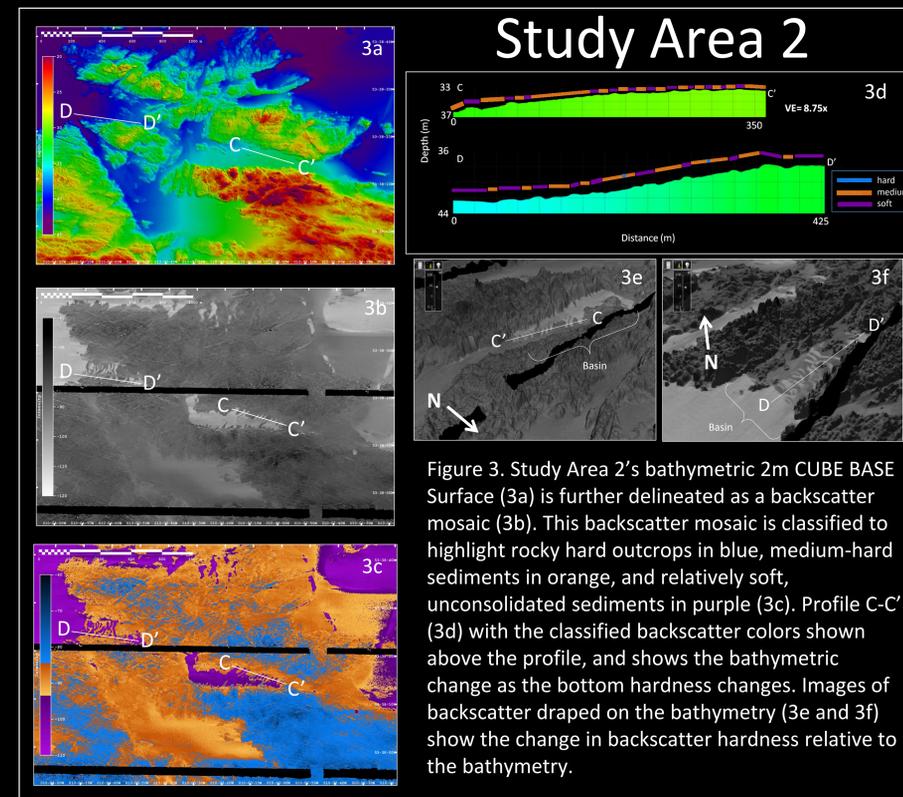


Figure 3. Study Area 2's bathymetric 2m CUBE BASE Surface (3a) is further delineated as a backscatter mosaic (3b). This backscatter mosaic is classified to highlight rocky hard outcrops in blue, medium-hard sediments in orange, and relatively soft, unconsolidated sediments in purple (3c). Profile C-C' (3d) with the classified backscatter colors shown above the profile, and shows the bathymetric change as the bottom hardness changes. Images of backscatter draped on the bathymetry (3e and 3f) show the change in backscatter hardness relative to the bathymetry.

DISCUSSION

The geomorphology of Killary Harbour is very complex and dynamic due to the range of substrate types, based on their relative hardness and how these substrates are affected by the meso-tidal range of 3.7 meters (Cooper, 2006). The two areas examined in detail have very interesting bathymetry. When comparing channels from Study Area 1 (Fig. 2) to channeling on the opposite side of the harbour with similar composition, the channels' geomorphologies were visibly similar in height, width and length (Fig. 2c). Backscatter intensity shows that the bases of the channels are comprised of harder substrate than the shoaler parts between the channels. One likely explanation for this is that the area was once covered semi-uniformly with sediments. These channels were carved by tidal and other currents that bent around the rocky outcrops, removing unconsolidated sediments and compacting the channel base sediments. However, this does not explain the very boxy shape of the channels, since normal channels have a more "U" shaped base (Kuang, 2014).

Non-channelized basins in Study Area 2 (Fig. 3) were observed to have a similar relationship between bathymetry and bottom hardness when compared to the channels in Study Area 1. In the basin area, sediments were likely deposited due to lower current flow but then formed sand waves from current refracting around the large rocky outcrops. The basin is filled in with what looks like linear stripes of different sediment hardness reaching into the basin from the edges. The stripes in the backscatter images (Figs. 3b and 3c) appear to be forming small, wave-like features with different sediment types making up the crests and troughs. When further reviewed through the 2m CUBE BASE surface (Fig. 3a) and profiles C-C' and D-D' (Fig. 3d) the shoaler sediments are the least consolidated, and the troughs between these shoaler areas are made up of medium-hard substrates. With the protection from the surrounding outcrops a weaker current would create sand waves unlike the stronger current in area 1. The stronger current scours away the softer unconsolidated sediments revealing the med-hard consolidated substrate below due to less interference with large rocky outcrops.

METHODS

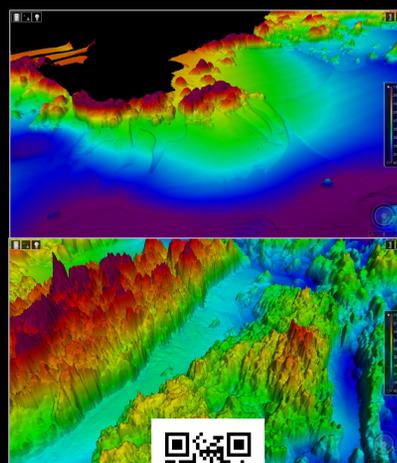
- Raw bathymetric and backscatter data were collected on a research cruise for INFOMAR, the Marine Institute of Ireland and the Geologic Survey of Ireland by lead scientist Kevin Sheehan on the R/V *Celtic Voyager* using a Kongsberg EM2040 multi-beam sonar in July and August of 2014.
- Post-processing was done using CARIS HIPS and SIPS 9.0 to produce a 2m resolution CUBE BASE surface and backscatter Intensity mosaics.
- Backscatter mosaics were classified to delineate relative bottom hardness.
- Profiles were created to compare channeling between opposite sides of the harbour.
- Two basins surrounded by outcrops of hard rock were observed to determine how the bottom hardness affected the bathymetry of the basin.

REFERENCES

- "Bedrock Geology of Ireland." Geologic Survey of Ireland. Geologic Survey of Northern Ireland. Map. 2014.
Cooper, J.A.G., 2006, Geomorphology of Irish estuaries: Inherited and dynamic controls. *Journal of Coastal Research*, v. 39, p. 176-180.
Crouse, L. & Sautter, L. (2016, Feb.) Bathymetric Terrain and Substrate Characterization in Killary Harbour, Ireland. Poster session presented for the College of Charleston BEAMS Research class, Charleston, SC.
Kuang, Z., Zhong, G., Wang, L., Guo, Y., 2014, Channel-related sediment waves on the eastern slope offshore Dongsha Islands, northern South China Sea. *Journal of the Asian Earth Science*, v. 79, p. 540-55.

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3D Fly-through of Killary Harbour

