



Research Programme
- Short Calls, Final Report -

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Host Organisation name	Trinity College, Dublin
Project Title	Coastal platform geology, classification and roughness
Contract Number	2017-sc-040

Date: 15-Nov-2018

This report covers the period November 1st 2017 to October 31st 2018



2. (a) Project information:

Final project report (*max 2500 words, excluding figures and headings*):

- (i) Progress of objectives and scientific/engineering targets beyond the state of the art & methods used

Objective 1: Map the lithology of Irish coastal platforms

Platform morphology is a function of lithology, structure, tectonics, and weathering processes. Different minerals weather at different rates, influencing how the rock erodes and how weathering processes are physically expressed at different scales. In order to better understand the styles and rates of coastal erosion, the rock type of coastal platforms needs to be known. Here we present the geology of the coastal platforms of Ireland.

Methods: We used the Bedrock Geology (1:100,000) and Quaternary Geology data from the GSI. The Bedrock Geology consists of all lithostratigraphic categories of hard rock geology for Ireland (i.e., group, formation, member, bed(s), flow (s)), while the Quaternary Geology contains all till compositions and surface cover for Ireland. The utility of these datasets is that the Quaternary Geology shows explicitly where rock is exposed at the surface.

We joined the bedrock geology properties to the mapped platforms dataset of Bourke et al (2016) to identify the general rock type of the platform using a one-to-many spatial join, with the join method as 'nearest' and a 500 m search radius. Spatial Join, connects the attributes one feature to another based on the spatial relationship. The target features and the joined attributes from the join features were written to the output feature class. This tool was used specifically for the bedrock and Quaternary geology files to relate the feature attributes of rock type, i.e., "the closest polygon" of both bedrock and Quaternary to that of the mapped platform. These were used to determine the composition of the platform.

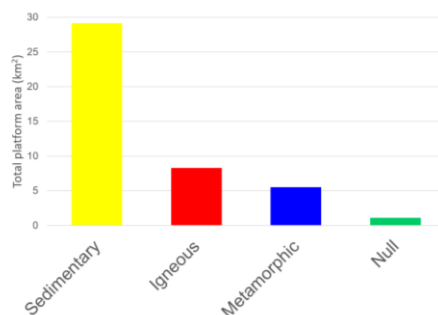


Figure 1. Total platform area (km²) per generalised bedrock geology type Source of lithology data: GSI Bedrock Geology 100k dataset.



Results: Platforms are formed on all principal lithologies, and most frequently formed on Sandstone facies along the southwest and west of Ireland (Fig. 1 and 2).

Discussion/Progress: Geology is important for understanding the platform erosion. Joints and discontinuities have been shown to influence mesoscale morphology and rates of platform erosion through removal of blocks (Naylor and Stephenson, 2010). Preferential weathering along weakness provide opportunities for channel formation and subsequent intrusion of seawater into the inner platform (Moura et al., 2011). It has been found that there is an increase in rock hardness/resistance with gradient and elevation of shore platforms (Hills, 1971; Trenhaile, 1987).

This work enhances the data delivery from the existing map of the coastal platforms location by assigning the rock lithology to individual platforms mapped. The next phase of investigation will involve the mapping of geological structures which are known to be a major influence on rates of rock breakdown.

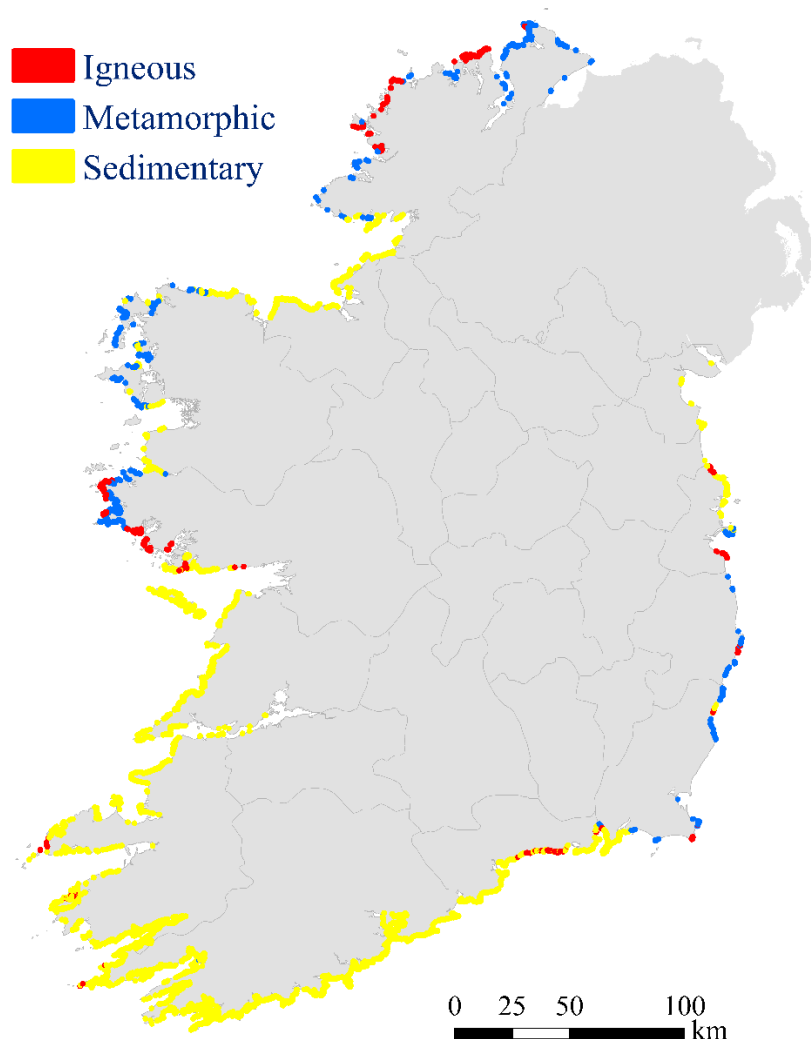


Figure 2: Map of the rock type of coastal platforms.



Objective 2: Assess the Bourke et al, 2016 classification of coastal rock platforms.

Methods: Rock coasts and platforms are broadly categorized as either Type A, Type B or plunging (Sunamura, 1992; Trenhaile, 1987). However, this classification does not capture the variable platform morphology observed on Ireland's coastline. Bourke et al (2016) have proposed a classification that was based on the pioneering work of McKenna et al. (1992) who characterised the Northern Irish platforms as chaotic erosional landforms composed of a highly irregular rock surfaces. The newly proposed classification operates at two scales. The **Platform-scale**, is analogous to existing platform classifications in spatial extent. The **sub-platform scale** extends the existing shore platform classification to include geomorphological features that occur on the platform surface.

The Bourke et al., (2016) classification was deployed at nine platform sites around the coast of Ireland: Donegal (3 platforms at Fanad); Clare (2 platform. At Lahinch and Clahane); Wexford (1 platform at Hook Head; Dublin (Skerries 2 platforms, Rush, 1 platform). Sites were photo-documented and visually surveyed. The classification logging form was populated at each site. A description of two of the nine sites is presented below.

Results:

Lahinch, Co. Clare: Washboard, Shale

The platform is shore-attached and backed by a rock cliff of varied elevation (Fig. 3). The platform dip is complex (ranging from seaward to sub horizontal). Platform surface features were dominated by a washboard morphology. The washboard surface features were transverse to shore and truncated in places, resulting in a stepped morphology (see Fig 4 a, b, e). In some areas the steps were complex, with two stepping directions evident.

Surface features include pits, pans, pools, channels and planar surfaces. Surface boulders were distributed but increased in frequency with distance from the high tide mark. The boulders ranged in size and roundness but majority were large sub-rounded to sub-angular boulders (see Fig 4 d).



Figure 3: Oblique aerial view of the Lahinch Platform (source Google Earth)

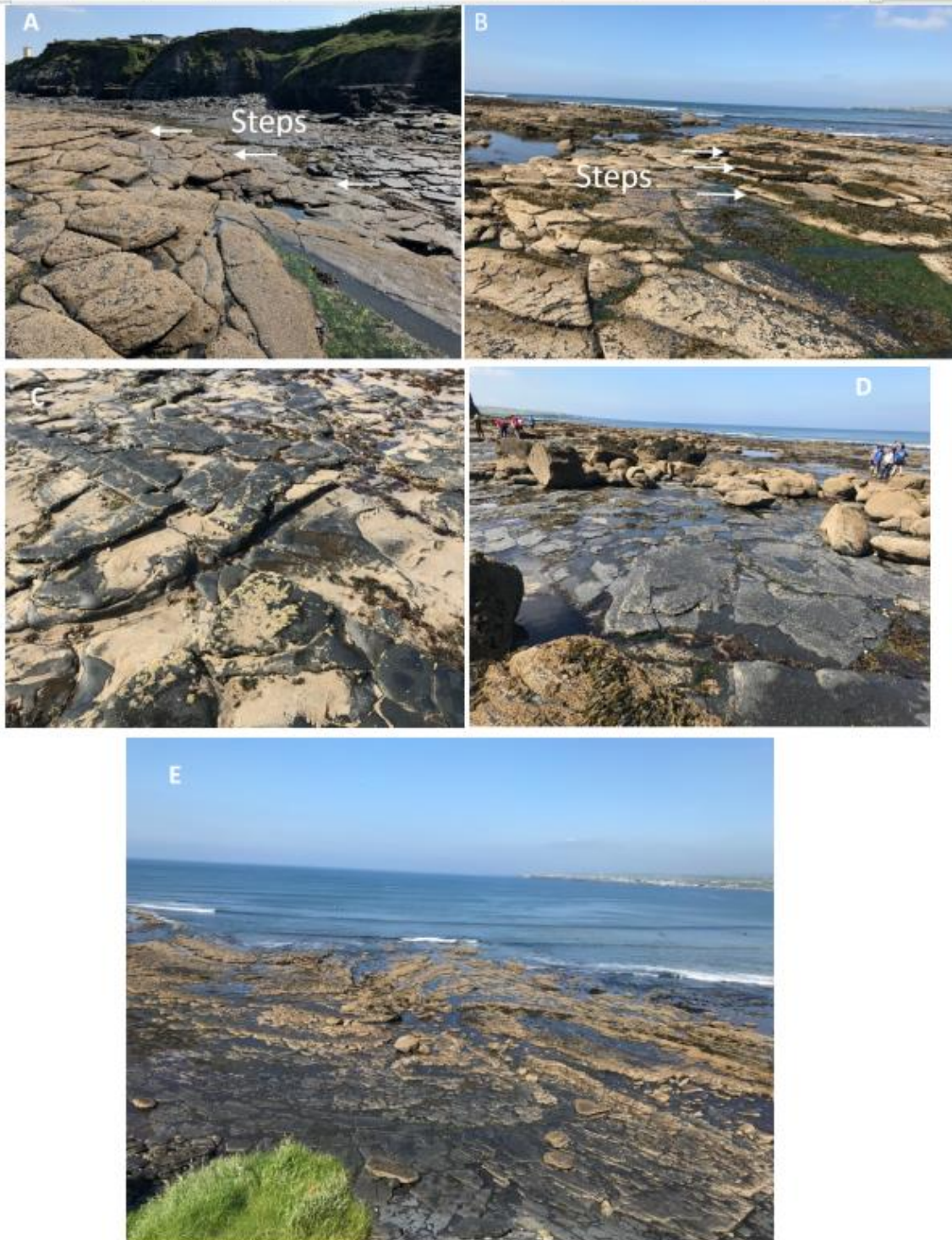


Figure 4: Field images from Lahinch coastal platform. A and B: truncated washboard features as steps; C: beach surface deposit; D: distributed boulders; E: aerial photo showing the washboard surface features.



Hook, Co. Wexford: Stepped, Washboard, Limestone (high abundance of fossils, such as crinoids, brachiopods, corals and bryozoans).

The platform is shore-attached and backed by a quaternary deposit (Fig. 5). The platform dip is complex (ranging from seaward, landward and in some areas dipping perpendicular). Small microfolds observed along the face of the platform may indicate a much larger fold over the platform (See Figure 3). This fold may account for the complex dipping structure of the platform.



Figure 5: Aerial view of the three locations at Hook Head, Co. Wexford where the platforms were classified using the classification logging sheet. Source: Google Earth.

Platform surface features varied along a shore-parallel transect. Some meso steps can be seen in Figure 6A and B. Moving south along the platform, the step features develop into typical washboard features (Fig. 6D and 6E) with a micro scale washboard feature visible in Figure 7F. The washboard features may be truncated into steps. Surface features include pits, pans, pools and micro channels (Fig. 7). There were no surface deposits or boulders observed.



Figure 6: Field images of the platform's surface features. A & B: step features; C, D & E: washboard features; F: small scale washboard.

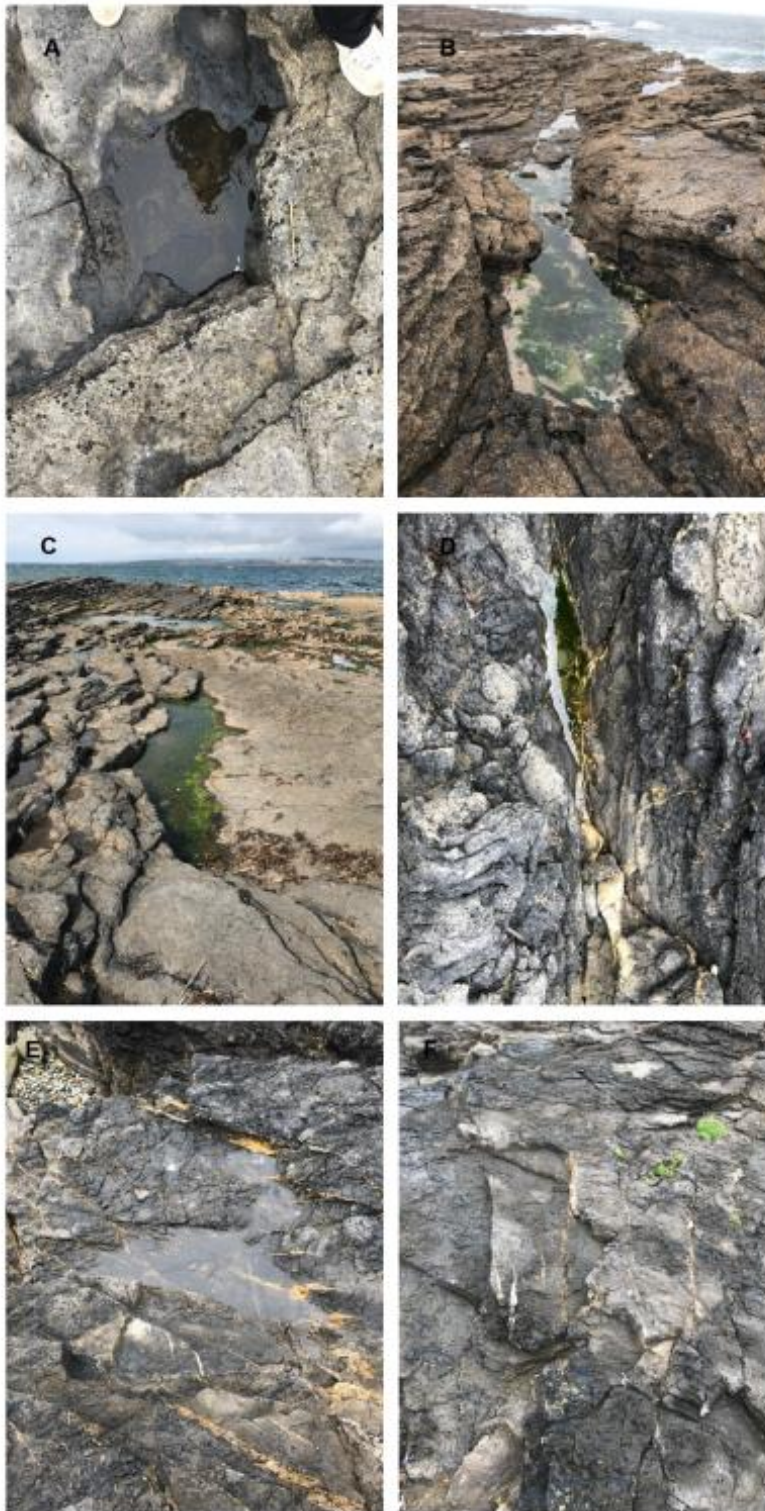


Figure 7: Field images of surface morphology. A: pit/pool; B: channel; C: pan; D: micro channel; E: pan; F: fractures



Discussion/Progress: We tested the newly proposed platform classification system proposed by Bourke et al., (2016) on a variety of platform types and lithologies. The classification system is a semi quantitative classification system that was devised using traditional geological mapping techniques (Barnes and Lisle, 2013) and supplemented by morphological descriptions of the different platform types observed. We found the classification to be robust for use in the field.

The system was applied to a larger range of platform types that was used in the development phase. As a consequence, we added additional categories: backing cliff type, descriptive terms for dip were removed and replaced with dip angle, scale options for steps and channels were included, a section for 'additional information' was added. In general, we found that the logging sheet was easy to follow, displayed the information in a succinct and clear way and enabled the generation of reports with ease. Future work will include further testing and the design of a digital platform for recording. The classification will contribute to a more comprehensive, quantitative and unified global classification of platform morphologies found in meso- and macro tidal environments.

Objective 3: Quantify the roughness of coastal platforms classes

Methods:

Aerial survey: A Phantom 3 drone was used to acquire vertical air photos of seven platforms. The UAV was flown at a range of elevations along a way pointed flight path. The spacing of the parallel flight paths ensured that there was 70% overlap of images. Eleven Ground Control Points (GCP's) were surveyed in using a differential GPS (Trimble) and captured in the aerial image data. Surveys were planned to avoid long shadows, rainfall and high winds.

DEM generation: Once the survey was completed, the image data were exported, renamed and uploaded to Agisoft Photoscan. A workflow model for Agisoft is described in Verma and Bourke (2018). Digital elevation models were generated in Agisoft. The models were exported from AgiSoft at the lowest common pixel resolution for all models.

Surface Roughness: Surface roughness or rugosity is a measure of the structural complexity (i.e. topographic heterogeneity) of a land surface. To measure surface roughness we utilised a new method for measuring rugosity based on the arc-chord ratio (ACR) developed by Du Preez (2015). The ACR tool is available as an add-in tool for ArcMap in Benthic Terrain Modeller (Walbridge et al., 2018). The ACR approach is defined as the '*contoured area divided by the area of the surface orthogonally projected onto a plane of best fit (POBF)*' (Du Preez et al. 2015). The advantage of this approach is that it allows the calculation of rugosity for sloping terrains, such as shore platforms, using a 3 x 3 neighbourhood window. For the purposes of this study a 0.05 m per pixel resolution (0.15 m x 0.15 m neighbourhood window) was used. For further details on the procedure used to calculate rugosity using the ACR method the reader is referred to Du Preez et al. (2015).

Results:

Rugosity was calculated for 7 platform areas (Table 1). The values range between 1.177 (Skerries2) and 1.028 (Clahane). We find that **1.** The range of platforms rugosity values suggest that the



approach is robust to deploy and sensitive to detect the different surface morphologies at the scale of the topographic data. **2.** That the method is effective for deriving a quantitative value for the different classifications of coastal platforms. Further testing of the approach on a broader range of platform types is required before a recommendation for widespread application can be made.

Table 1. Output of the ACR calculator used to calculate rugosity of seven shore platforms on the Irish coast.

Platform ID	Surface Area (m ²)	Planar Area (m ²)	Slope (°)	Aspect (°)	Rugosity
Clahane	5700	5545	1	288	1.028
Fanad1	2600	2461	0.2	357	1.075
Fanad2	3677	3481	3	227	1.056
Fanad3	2441	2211	3	6	1.104
Skerries1	1391	1226	3	35	1.134
Skerries2	1259	1069	1.53	22	1.177
Wexford	4073	3874	6.5	284	1.051

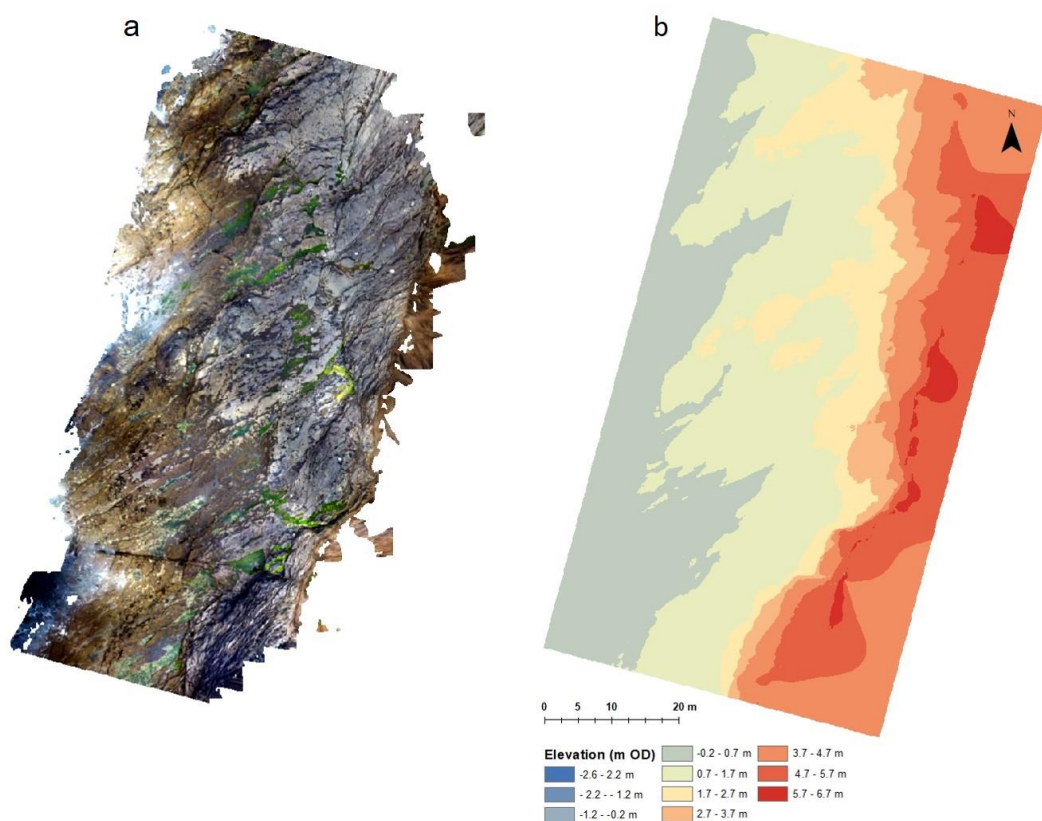


Figure 8: The orthophoto (a) and DEM (b) used to calculate the rugosity for the Wexford field site. Resolution is 0.05 m per pixel.



Discussion/Progress:

Recent climate change models predict an increase in the intensity of extreme storms and an increase in coastal storm surges. This will lead to an increase in wave height and intensity (Wang et al., 2008). There is therefore an urgent need to understand the role of shore platforms in natural coastal protection. Emerging evidence suggests that coastal rock platforms may provide an important role to slow rates of coastal retreat by attenuating wave energy and protecting the coastline cliffs from direct wave impact (Ogawa et al., 2015). Our work builds on a pilot study (funded by GSI short-call 2015) conducted in Co. Clare (Cullen and Bourke, 2018) which examined the role of platform roughness in attenuating wave energy (Bourke et al., 2016). They found a reduction in peak wave energy with increased roughness at the site. The data demonstrated that even small differences in platform roughness can significantly attenuate wave energy. The pilot data showed that platform elevation and morphology play an important role in determining the amount of wave energy that reaches the cliff.

Therefore, we can hypothesize that the presence and topography of a shore platform, in addition to variations in platform width, slope and lithology, will play an important role in attenuating wave energy delivered to the cliff. This will influence the spatial variations in rates of coastal retreat around Ireland. Understanding the differential capacity of shore platforms and rock coasts to buffer risks of erosion and flooding is paramount to improving Ireland's strategic coastal planning efforts.

We have proposed a method for the estimation of the roughness of coastal rock platforms. This is the first time that such a quantitative approach to coastal platforms has been undertaken. If we assume that the ability of shore platforms reduce the rate of coastal retreat through the attenuation of wave energy is differential, then our current knowledge of platforms of differing roughness represents a significant gap in our understanding of the response of Ireland's coast to sea level rise and increased storminess.

Therefore, the work presented here on developing a representative quantified roughness approach for specific platform classes will assist in determining how effective certain platform types are at wave energy attenuation or exacerbation across platforms with different morphologies. This will have important implications for predicting rates of coastal erosion in the future.

- (ii) Implementation (please include any issues with timelines, milestones, management etc. or deviations from the original implementation plan)

Hiring of the RA was postponed in favour of a 6 month full-time contract, rather than a 12 month half time contract. The project shifted to the warmer months where field work could be conducted more reliably.

Two Research Assistants were hired: Fay for fieldwork expertise and Donnelly-smith for model development. Both worked for 6 months.

- (iii) Outputs (please provide a short description and complete the table below)

- Map of shore platform distribution for the Republic of Ireland coastline with lithology and structure identified in GIS format.
- Training of two early career research staff in UAV, TSL, DTM production, field mapping.



- Final scientific report.
- Financial Report.
- Paper will be submitted in 2018 'A proposed classification of shore platform types' (Q1 Journal).

Poster presentations:

Bourke, M. C., N. Fay and R. Donnelly-Swift (2018). High resolution DTM and roughness estimates for Irish coastal platforms derived from UAV. National Geoscience Conference. Dublin.

Bourke, M. C., N. Fay and R. Donnelly-Swift (2018). High resolution DTM and roughness estimates for Irish coastal platforms derived from UAV. Irish Geomorphology Workshop. Coleraine, UK.

Task No.	Deliverable description	Planned delivery (as per proposal)	Date of delivery
1	Map of shore platform distribution for the Republic of Ireland coastline with lithology and structure identified in GIS format.	The shape files will be made available following publication in a peer review Open Access journal.	unknown
	Poster delivered at National geoscience conference		November 2018
	Poster delivered at Irish Geomorphology Group workshop		December 2018

Publications to date:

[Conference presentation] Bourke, M. C., N. Fay and R. Donnelly-Swift (2018). High resolution DTM and roughness estimates for Irish coastal platforms derived from UAV. *National Geoscience Conference*. Dublin.



4. Data/outputs submitted with final report *(please list the documents, presentations, datasets etc. submitted with this report)*

- a. Bourke, M. C., N. Fay and R. Donnelly-Swift (2018). High resolution DTM and roughness estimates for Irish coastal platforms derived from UAV. National Geoscience Conference. Dublin. PDF



SUPPLEMENTARY MATERIAL

(This section will be included in your published report unless otherwise instructed. If you have a published report, publication, etc. you may include it here).

Bourke, M. C., N. Fay and R. Donnelly-Swift (2018). High resolution DTM and roughness estimates for Irish coastal platforms derived from UAV. National Geoscience Conference. Dublin.

Bourke, M. C., N. Fay and R. Donnelly-Swift (2018). High resolution DTM and roughness estimates for Irish coastal platforms derived from UAV. Irish Geomorphology Workshop. Coleraine, UK.