SCAPE

Scottish Coastal Archaeology and the Problem of Erosion

Coastal Zone Assessment Survey

Physical Prioritisation: Methodology

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Physical Prioritisation of the Scottish coastline for Coastal Zone Assessment Surveys: Methodology

Background

The SCAPE Trust is carrying out new Community Coastal Zone Assessment Survey (CCZAS) around the Scottish coastline. The purpose of a CCZAS is to record and update information regarding coastal archaeological and heritage sites, as well as to report on the nature of the physical coastline. The CoastArch project, funded by Historic Environment Scotland, is researching stretches of coastline which have not previously been systematically surveyed in the original coastal zone assessment surveys conducted in the 1990s and 2000s. The desk-based physical prioritisation of the coastline broadly identifies sections of coastline most vulnerable to coastal erosion and helps us to target fieldwork towards those areas where coastal heritage will be most at risk from coastal erosion.

Aim

To identify stretches of Scotland's coastline which modelling suggest are eroding now and/or in the near future, in order to target fieldwork conducted during new CCZASs to coastlines most vulnerable to coastal erosion.

Objectives

1) Combine two existing Scottish coastal models: (a) a model of coastal erosion susceptibility (the CESM, Fitton et al. 2016) and (b) a model of future rates of change and landward coastal retreat (Dynamic Coast Phase 2, shortened to DC2 within this report) to act as a basis on which to prioritise the coastline.
2) Identify stretches of coastline with moderate to high modelled rates of erosion to allow for further discussion with local authorities and refinement of walkover survey areas.

Underlying models used

Coastal Erosion Susceptibility Model (CESM)

The Scottish coastline has been assessed for its vulnerability to erosion by Fitton et al. (2016) with the creation of the Coastal Erosion Susceptibility Model (CESM). The model first combines physical characteristics of the coastline including ground and rock head elevation, wave exposure and proximity to the open coast, to create an Underlying Physical Susceptibility Model (UPSM) and then defence and accretion data was added to create the CESM. Each 50 m grid cell of the coastline was attributed a value of susceptibility from 1-100.

Dynamic Coast Phase 2 (DC2) – 2030 Rate of Change

Dynamic Coast Phase 2 (DC2) models coastal retreat of soft coastlines due to relative sea level rise (RSLR) (Hurst et al., 2021). Transects with 10 m spacing were constructed on the soft coastline of Scotland and the rate of change for each transect was calculated each decade until 2100, as well as the total projected erosion distance. We have utilised the 2030 Rate of Change [RATE_2030] data as it should most closely represent the rate of change occurring along the coastline today.

Methodology

1. A grid of cell size 0.5 km2 was created to cover the extent of the Scotland's coast.

2. Ranks were assigned to the CESM and DC2 model outputs (Table 1). The model attribute tables were interrogated using the Field Calculator to isolate each rank e.g. 0-40 values within the CESM, and these were exported as separate layers within the GIS.

3. Fields were added to the grid attribute table ('CESM_Rank', 'DC2_Rank' and 'Ranking'). The Select by Location tool was used to select grid cells which intersected with each CESM and DC2 ranked layer, in order from lowest to highest and the Field Calculator tool was used to assign the rank value to the selected records within the attribute table. The overall 'Ranking' field was calculated by using the Field Calculator to sum the 'CESM_rank' and the 'DC2_Rank' values.

4. The ranking matrix (Figure 1) assigns a colour code to each ranking outcome e.g. high and very high priority cells are red, low priority cells are dark green. A description of each priority grouping is provided in Table 2.

CESM	Ranking	DC2 Rate 2030* (m/yr)	Ranking
No Data	1	No Data	5
0-40 (Very Low - Low Susceptibility)	2	No change/Accretion (≥ 0)	10
40-60 (Moderate Susceptibility)	3	Low-Moderate Rate of Erosion (0 to -1.09)	15
60-80 (High Susceptibility)	4	High Rate of Erosion (-1.09 to -2.06)	20
80-100 (Very High Susceptibility)	5	Very High Rate of Erosion (< -2.06)	25

Table 1. CESM and DC2 ranking.

** Statistics were run on all DC2 RATE 2030 transect data. Positive values of change indicate accretion, negative values of change indicate erosion. The mean change is -0.12 m/yr with a standard deviation (SD) of 0.97. This data was used to rank the rates of erosion by severity. A low to moderate rate of erosion includes any erosion value within 1 SD of the mean. A high rate of erosion is any erosion value between 1 and 2 SD of the mean. A very high rate of erosion was calculated as any erosion value greater than 2 SD away from the mean.*

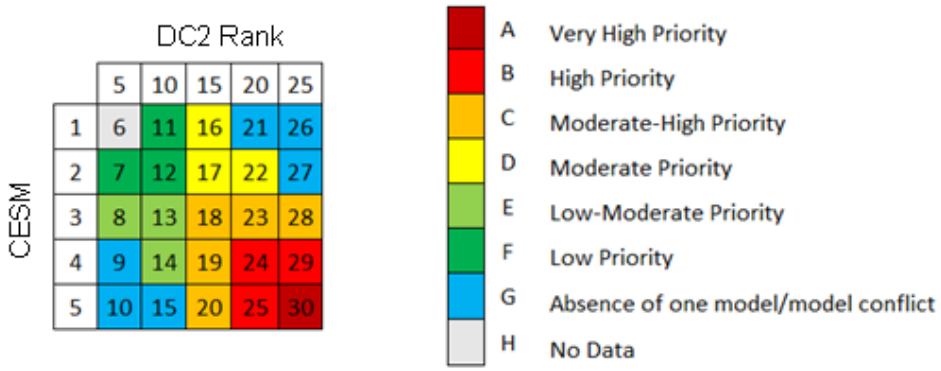

Figure 1. Ranking matrix for combined CESM and DC2 rank for each grid cell within the coastal survey area. Each colour grouping has been given a priority rating.

	Very High	Within the grid cell, there is coastline which has a very high susceptibility to erosion, and also contains DC2 transects which show a very high rate of erosion by 2030.
	High	Within the grid cell, there is coastline which has either a high or very high susceptibility to erosion and either a high or very high rate of erosion by 2030.
	Moderate-High	Within the grid cell, there is coastline which has at least a moderate susceptibility to erosion and it demonstrates a rate of erosion of any magnitude.
	Moderate	Within the grid cell the susceptibility to erosion is considered low, or there is no data, but there is a rate of erosion (ranking from low-high) by 2030 based on the DC2 model. In the CZAS, no grid cells returned a value of 22, meaning no grid cell had a high rate of erosion and a low susceptibility to erosion.
	Low-Moderate	Within the grid cell the susceptibility to erosion is moderate to high, but there is either a moderate susceptibility to erosion and no data from DC2, or there is moderate to high susceptibility to erosion but the DC2 model suggests the coastline is accreting. In this case the coastline may be dynamic but not thought to be at a high risk of erosion.
	Low	Within the grid cell the coastline is either not included in the susceptibility model and is accreting or showing no change, it is not included in the DC2 model but has a low susceptibility, or it has a low susceptibility and is accreting or showing no change. In these cases, the coastline is a low priority for coastal survey.
	Absence of one model/model conflict	The grid cells highlighted in blue hold conflicting information. Within the grid cell there is either a high or very high erosion rate and no data/low susceptibility to erosion, or there is no data, no change, or accreting data but high or very high susceptibility to erosion. In these cases, it is best to revert to the original models and consult other resources such as aerial photography to identify if the coastline is to be prioritised for survey.

Table 2. Details of each prioritisation

How we use the outputs

We use the outputs of the model in ArcGIS as a tool for planning fieldwork. Yellow, orange, and red cells contain coast which will experience erosion by 2030, with red cells having the highest vulnerability to or highest predicted rate of erosion according to the underlying models We target walkover surveys towards coasts which contain orange and red cells.

Following surveys, we compare the modelled erosion to our observations of the physical state of coasts and use the model in our analysis of future vulnerability of eroding heritage sites.

We have also used the modelled outputs to create an 'Erosion 2030' line on SCAPE's Sites at Risk map [https://scapetrust.org/sites-at-risk/] This line displays all coasts modelled to be eroding by 2030 without differentiating between relative vulnerability or rates of erosion.

Limitation of analysis

This analysis was carried out using a relatively low-resolution grid size of 0.5 km2 in order to clearly identify stretches of coastline which are, at least in part, modelled to be susceptible to erosion or which are projected to erode by 2030. This was done to help to more easily identify and plan walkover surveys which encompass the most vulnerable sections of coastline. Within a particular grid square, there may be a more complex story with both accretion and erosion occurring within the 0.5km2 area. For example, a high priority grid cell (red) should not be interpreted as suggesting that the entire 0.5km2 area being equally susceptible to coastal erosion, instead the grid cell contains within at least one transect of the coastline which is considered highly susceptible to coastal erosion. For more detailed resolution of coastal susceptibility of erosion (50m2) or to view individual modelled transects of erosion rates, please refer to the underlying models.

References

Fitton, J. M., Hansom, J. D. and Rennie, A. F. 2016. A national coastal erosion susceptibility model for Scotland. Ocean & Coastal Management, 132, 80-89.

Hurst, M. D., Muir, F. M. E., Rennie, A. F. and Hansom, J. D. 2021. Dynamic Coast: Future Coastal Erosion. CRW2017_08. Scotland's Centre of Expertise for Waters (CREW). Available online at: https://www.dynamiccoast.com/reports [Accessed 9 Feb 2023].