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Shore and cliff sensitivity to accelerating sea level rise

FCERM Research & Development Programme

Research report: Quick start guide

Date: January 2025

Version: SC120017/QSG

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Contents

1 Background

This quick start document is intended to guide new users through the accompanying spreadsheet tool (Environment Agency, 2025a). The tool helps estimate the effect of relative sea level rise on cliff toe recession at sites around the coast of England and Wales. More detail can be found in an accompanying technical report (Environment Agency, 2025b) and method report (Environment Agency, 2025c).

The tool, the method it represents, and the accompanying documentation are products of the project 'Cliff and shore erosion under accelerating sea level rise' (SC120017), which was commissioned by the Joint Defra/Environment Agency Flood and Coastal Erosion Risk Management (FCERM) Research and Development Programme. A project scoping stage was carried out by Royal Haskoning DHV and WSP. This was followed by the main project, carried out by WSP. It ran idealised mass simulations with the Soft Cliff And Platform (SCAPE) numerical modelling tool (Walkden and Hall, 2005), for 82 adjoining regions of the coastline of England and Wales.

The results were processed to estimate conservative indicators of cliff toe sensitivity to relative sea level rise (referred to cas 'conservative sensitivity indicators', but also known as 'recession sensitivity indicators' in accompanying reports). The results are designed to be more likely to overpredict future recession than to under predict it. Their application (using the spreadsheet tool) requires that the cliff toe has retreated historically and that this retreat has been estimated. In addition to representing the consequences of relative sea level rise, the indicators also account for a certain amount of wave growth, but represent no other influence on coastal cliff recession.

The approach presented is a new means of quantifying the effects of sea level rise on cliff recession and has been designed for use at sites with a limited or absent beach; such sites are not well supported by current methods. The method is incorporated into the 2025 update of the National Coastal Erosion Risk Map (NCERM).

Users should recognise that it will not be appropriate for all locations or decision-making contexts (see section 4) and that bespoke modelling can be expected to provide better results (SCAPE is freely available for this purpose, see Walkden (2019).

1.1 The tool

The spreadsheet tool (Environment Agency, 2025a) is published alongside this guide and can be downloaded from the project website.

1.1.1 Worksheets

The spreadsheet contains 12 worksheets. The first (white tab) is a 'read-me' page with background information. The following 2 worksheets 'tools' (blue tabs labelled 'baseline tool' and 'rebaseline tool') and these are used to make calculations (see Figure 1-1). The

remaining 9 tabs, coloured yellow, are ‘data’ worksheets (labelled ‘RCP’, followed by 2 digits and a percentage), which are explained in section 3.

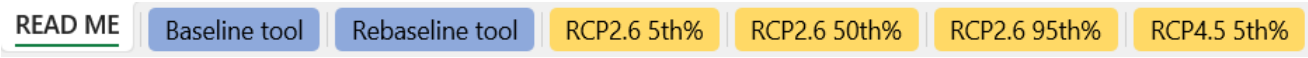


Figure 1-1: Screenshot of the first 7 tabs of the tool

These data worksheets contain columns of conservative sensitivity indicators for different regions and climatic conditions. Each row of these columns represents a year, from 1850 to 2130. An excerpt of the spreadsheet is shown in Figure 1-2. Data for regions considered to have high sensitivity are coloured red, to indicate that additional care is needed when using them (see section 4 for further information).

1	RCP->	RCP 8.5	RCP 8.5	RCP 8.5	RCP 8.5	RCP 8.5	RCP 8.5	RCP 8.5	RCP 8.5	RCP 8.5
2	Percentile ->	95th Percentile	95th Percentile	95th Percentile	95th Percentile	95th Percentile	95th Percentile	95th Percentile	95th Percentile	95th Percentile
3	Sensitivity->	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
4	Year	Region 9	Region 12	Region 13	Region 14	Region 15	Region 16	Region 17	Region 18	Region 19
5	1850	-1.51	-1.56	-1.54	-1.55	-1.56	-1.56	-1.50	-1.51	-1.52
6	1851	-1.51	-1.55	-1.54	-1.54	-1.56	-1.55	-1.50	-1.50	-1.52
7	1852	-1.50	-1.54	-1.53	-1.53	-1.55	-1.55	-1.49	-1.50	-1.51
8	1853	-1.49	-1.54	-1.52	-1.53	-1.54	-1.54	-1.48	-1.49	-1.50
9	1854	-1.49	-1.53	-1.51	-1.52	-1.53	-1.53	-1.48	-1.48	-1.50
10	1855	-1.48	-1.52	-1.51	-1.51	-1.53	-1.52	-1.47	-1.48	-1.49
11	1856	-1.47	-1.51	-1.50	-1.50	-1.52	-1.51	-1.47	-1.47	-1.48
12	1857	-1.47	-1.51	-1.49	-1.49	-1.51	-1.51	-1.46	-1.46	-1.48
13	1858	-1.46	-1.50	-1.48	-1.49	-1.50	-1.50	-1.45	-1.46	-1.47
14	1859	-1.45	-1.49	-1.48	-1.48	-1.50	-1.49	-1.45	-1.45	-1.46
15	1860	-1.45	-1.48	-1.47	-1.47	-1.49	-1.48	-1.44	-1.45	-1.45
16	1861	-1.44	-1.47	-1.46	-1.47	-1.48	-1.48	-1.44	-1.44	-1.45
17	1862	-1.43	-1.47	-1.46	-1.46	-1.47	-1.47	-1.43	-1.43	-1.44
18	1863	-1.43	-1.46	-1.45	-1.45	-1.47	-1.46	-1.42	-1.43	-1.43
19	1864	-1.42	-1.45	-1.44	-1.44	-1.46	-1.46	-1.42	-1.42	-1.43
20	1865	-1.42	-1.44	-1.43	-1.44	-1.45	-1.45	-1.41	-1.42	-1.42
21	1866	-1.41	-1.44	-1.43	-1.43	-1.44	-1.44	-1.40	-1.41	-1.42
22	1867	-1.40	-1.43	-1.42	-1.42	-1.44	-1.43	-1.40	-1.40	-1.41
23	1868	-1.40	-1.42	-1.41	-1.41	-1.43	-1.43	-1.39	-1.40	-1.40
24	1869	-1.39	-1.41	-1.41	-1.41	-1.42	-1.42	-1.39	-1.39	-1.40
25	1870	-1.38	-1.41	-1.40	-1.40	-1.41	-1.41	-1.38	-1.38	-1.39
26	1871	-1.38	-1.40	-1.39	-1.39	-1.41	-1.40	-1.37	-1.38	-1.38

RCP2.6 50th% | RCP2.6 95th% | RCP4.5 5th% | RCP4.5 50th% | RCP4.5 95th% | RCP8.5 5th% | RCP8.5 50th% | RCP8.5 95th%

Figure 1-2: Screenshot from the spreadsheet tool presenting part of data worksheet 'RCP8.5 95th%

1.2 Conservative sensitivity indicators

The conservative sensitivity indicators (sometimes referred to as recession sensitivity indicators) are unitless and represent the cliff toe position normalised by (divided by) the total change in cliff toe position over a baseline period. The default baseline period is 1920 to 2020. The indicators are calculated relative to the cliff toe position in 2020. As a result, the indicators begin as negative values, pass through zero in 2020, and become positive after that.

To use the spreadsheet, the user must first identify the column in the ‘data’ tabs that is relevant to their site (following the guidance in section 3) and then copy the data to the correct place in one of the blue ‘tool’ worksheets.

2 The ‘tool’ worksheets

Of the 2 ‘tool’ worksheets (which have blue tabs), the one labelled ‘Baseline tool’ is the simplest.

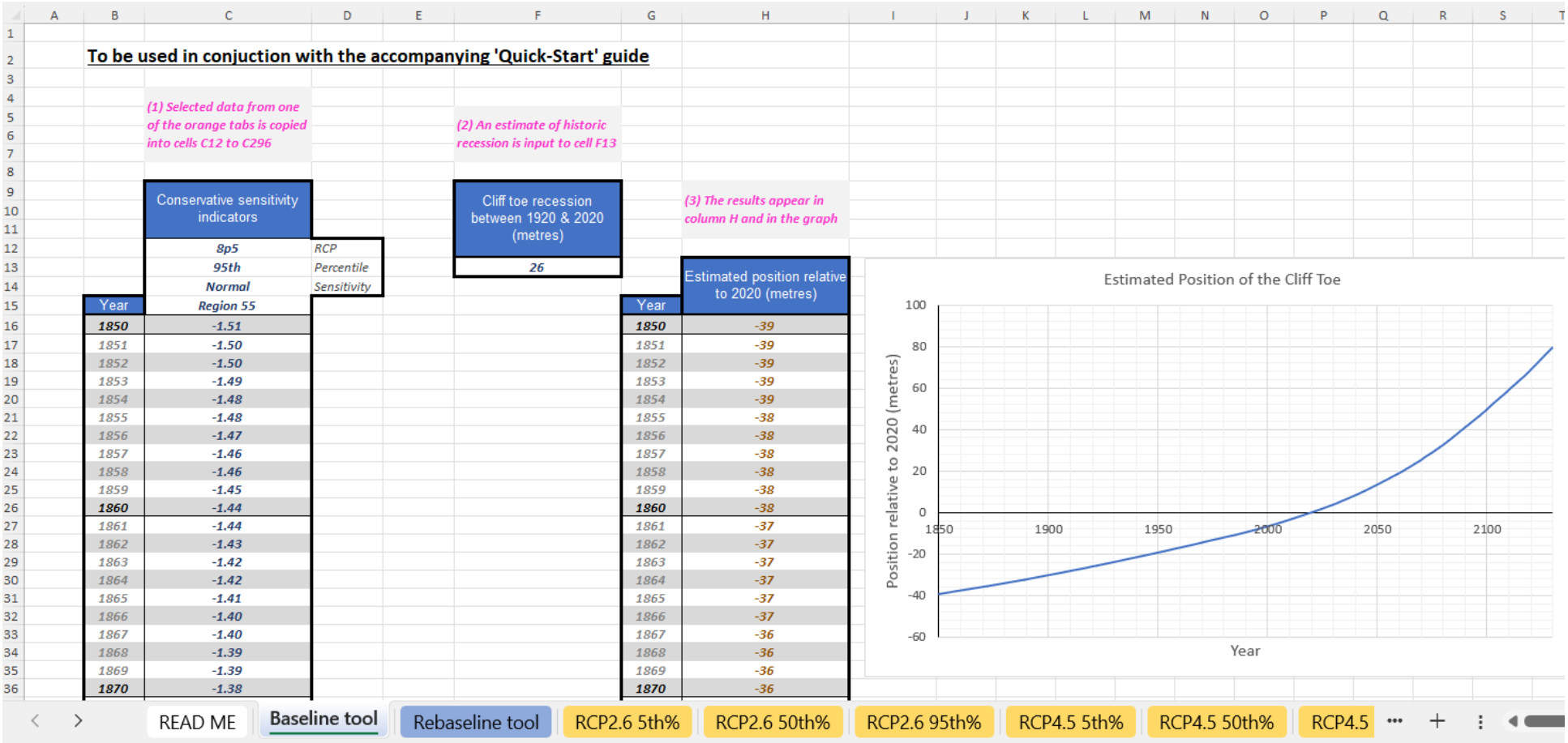
2.1 Baseline tool

This tool has been created assuming that the user can estimate the cliff toe retreat at their site between 1920 and 2020 (the default baseline period).

The ‘Baseline tool’ worksheet contains the following 4 elements, as illustrated in Figure 2-1:

- a table of conservative sensitivity indicators (in columns B and C)
- an estimate of cliff toe recession between 1920 and 2020 (in cell F13)
- a table of results (estimated position relative to 2020, in columns G and H)
- a graph of the results

Data to be input by the user are coloured in blue, and output data in brown.



Year	Conservative sensitivity indicators (Region 55)	Estimated position relative to 2020 (metres)
1850	-1.51	-39
1851	-1.50	-39
1852	-1.50	-39
1853	-1.49	-39
1854	-1.48	-39
1855	-1.48	-38
1856	-1.47	-38
1857	-1.46	-38
1858	-1.46	-38
1859	-1.45	-38
1860	-1.44	-38
1861	-1.44	-37
1862	-1.43	-37
1863	-1.42	-37
1864	-1.42	-37
1865	-1.41	-37
1866	-1.40	-37
1867	-1.40	-36
1868	-1.39	-36
1869	-1.39	-36
1870	-1.38	-36

Figure 2-1: Screenshot presenting elements of the 'Baseline tool' worksheet containing example input data, which is shown in blue.

The results in column H are equal to the conservative sensitivity indicators multiplied by the historical cliff toe recession distance (recorded in cell F13).

This worksheet may be edited to represent a new site through the following steps:

(1) replace the contents of cells C12 to C296 with an appropriate column from one of the data worksheets (see section 3 for guidance on which to choose)

(2) estimate the 1920 to 2020 cliff toe recession of the new site and enter the value at cell F13

The data in column H (and in the graph) will then update to show new conservative estimates of the cliff toe position between 1850 and 2130, relative to the end of the baseline period (2020).

Historical recession is often difficult to establish with certainty, and so the user may wish to enter alternative estimates into cell F13 to explore the consequences.

Many users will prefer to use a baseline period other than 1920 to 2020, and the second blue tab, named ‘Rebaseline tool’ is designed to support this.

2.2 Rebaseline tool

The ‘Rebaseline’ worksheet has a similar layout to that of the ‘Baseline’ worksheet (see Figure 2-2). It supports the user in:

- defining a bespoke baseline period
- entering different estimates of historical change to, for example, recognise uncertainty

The new baseline period can begin no earlier than 1850.

The user must input the start and end year of the new baseline period, and their estimates of historical change. These are input to cells G12 to G13, and J13 to L13, respectively, as illustrated in Figure 2-2.

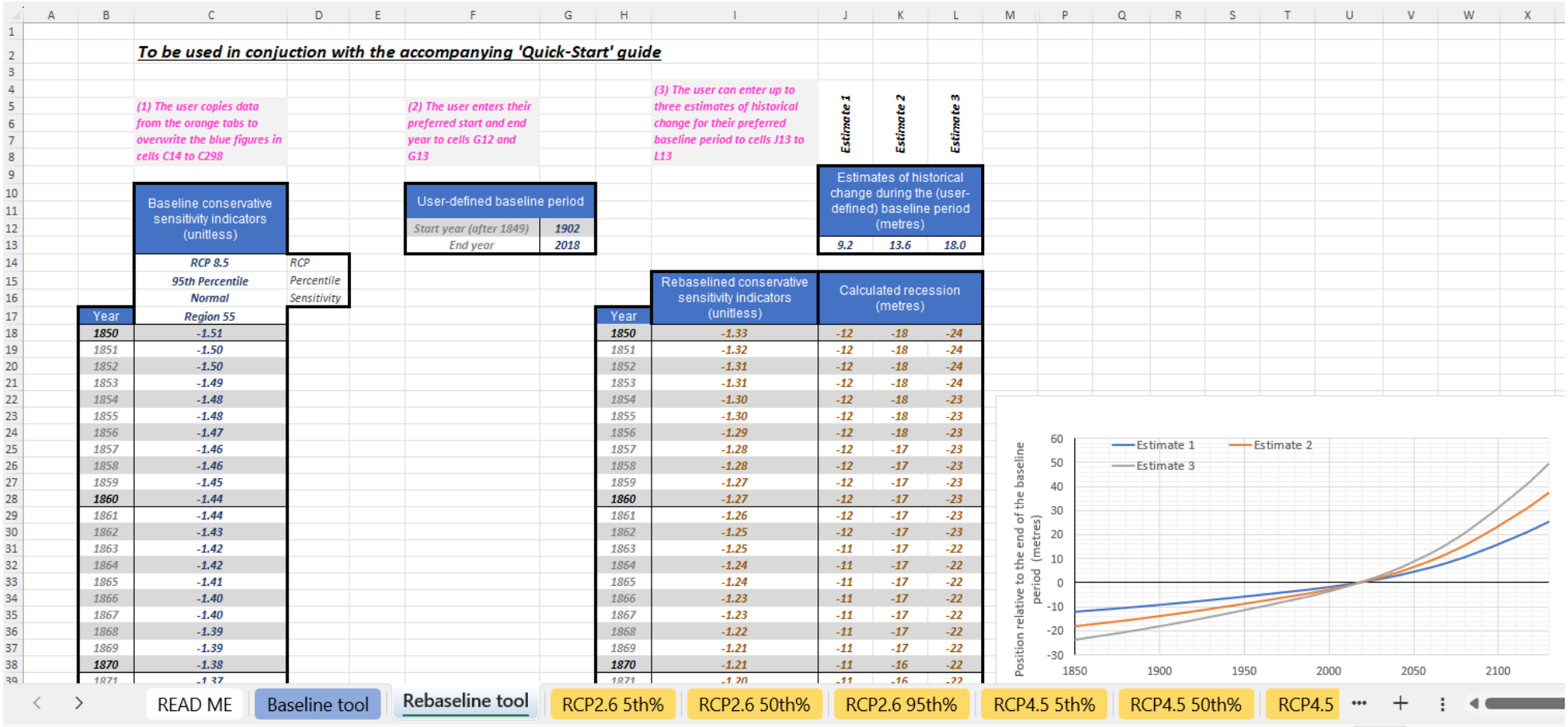


Figure 2-2: Screenshot showing the layout of the 'Rebaseline tool' worksheet, including example data

As with the previous example, the user must replace the contents of cells C14 to C298 with an appropriate column from the ‘orange’ worksheets (see section 3 for guidance on how to do this).

The tool calculates a new set of conservative sensitivity indicators adjusted to the user’s baseline period; these appear in column I, where they are shown in orange text.

Estimates of cliff toe position (the outputs of the tool) are also shown in orange, in the adjacent cells (columns J, K, and L). A graph is included to illustrate the projections.

3 Data worksheets

The 9 data worksheets have yellow tabs and contain many columns of conservative indicators of cliff toe sensitivity. The user is responsible for determining which is preferred, and for copying and pasting it into one of the tool worksheets.

The data worksheets are strongly tied to the United Kingdom Climate Projections (UKCP18, Met Office, 2018). The sea level rise provided by that study and its guidance on future changes in wave conditions (Palmer and others, 2018) were used in calculating the conservative indicators of cliff toe sensitivity.

3.1 Data worksheet names

Each of the 9 data worksheets represents one of three 'percentiles' (5^{th}, 50^{th} and 95^{th}) for one of three 'RCP' scenarios (2.6, 4.5 and 8.5), as shown in the tab names (Figure 3-1).

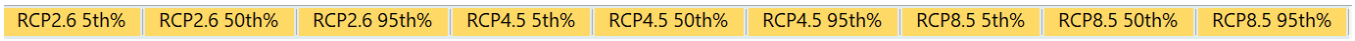


Figure 3-1: screenshot of the data tab names

'RCP' stands for Representative Concentration Pathway, which roughly corresponds to the severity of the future global climate. RCP8.5 represents a world with more global warming than is represented by RCP2.6.

The use of 'percentiles' acknowledges that significant uncertainty exists within each RCP, such that the 95^{th} percentile represents an outcome with more sea level rise than the 5^{th} percentile.

The user should consult best practice guidance on climate change when deciding which data tab is appropriate for their task.

3.2 Column selection

Once the appropriate data tab has been identified, the user must then choose a single column to copy and paste into the selected tool worksheet. Each column represents one of 82 regions, which are shown and numbered in Figure 3-2. The user must, therefore, select the region where their site is located to identify the appropriate data column.

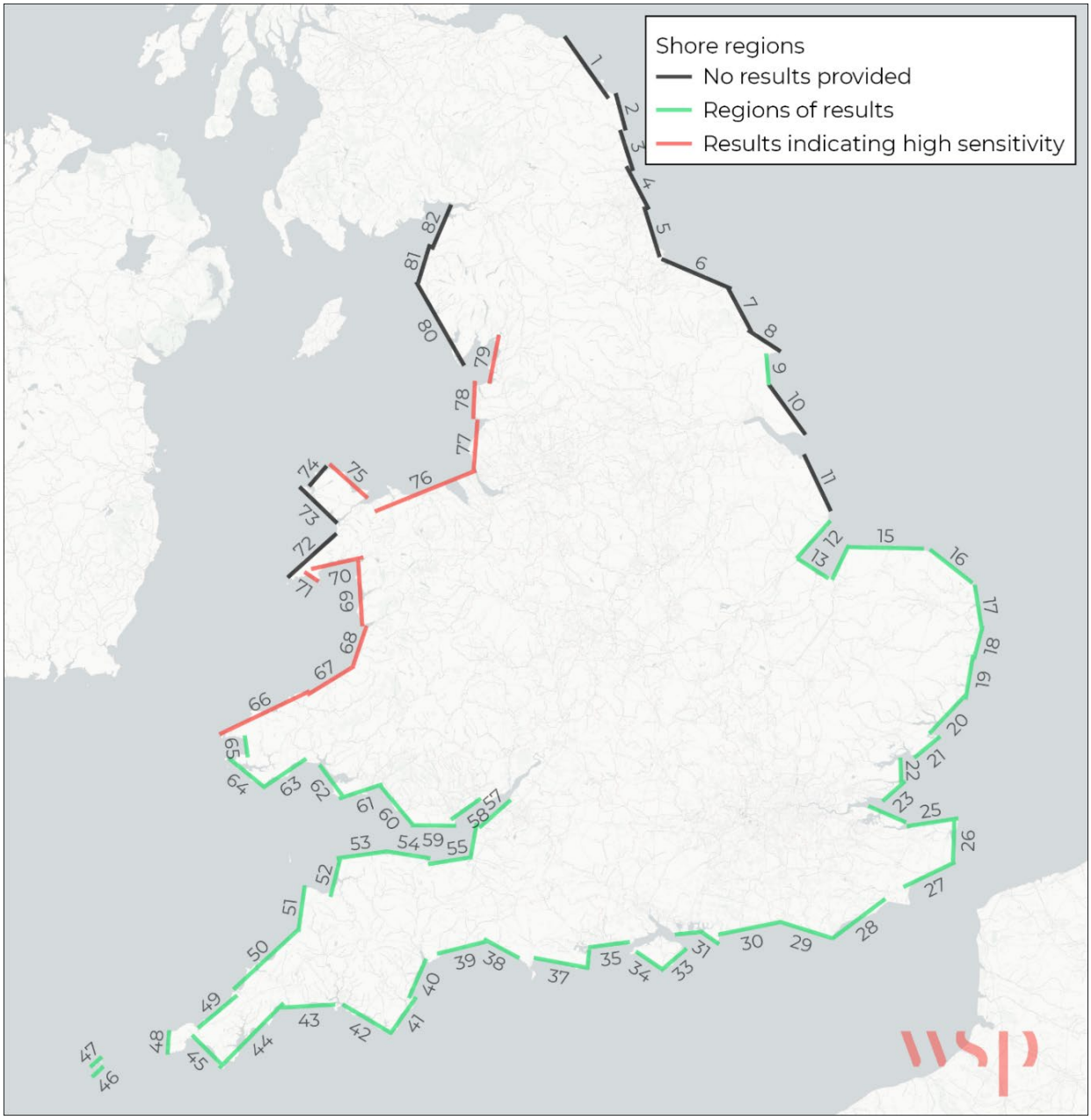


Figure 3-2: Map showing the model regions around the coast of England and Wales. Note that: (1) black lines indicate regions where results could not be calculated, (2) red lines show areas of particularly high sensitivity, and (3) regions 14, 24, 32, 36 and 56 are not labelled, but exist in (clockwise) sequence

In Figure 3-2 regions where results have not yet been calculated (represented with black lines) is due to overly conservative representation of Holocene sea levels. These regions are not represented in the data tabs.

The red lines show areas where results should be used with increased caution because they indicate particularly high sensitivity to sea level rise.

4 Further information

More detailed information on the project ‘Cliff and shore erosion under accelerating sea level rise’ (SC120017) and its outputs can be found in the accompanying technical report and method report (Environment Agency 2025b and 2025c).

4.1 Technical report

The technical report (Environment Agency, 2025b) includes, among other things:

- the research questions addressed by project SC120017 (in section 1.3)
- descriptions of the modelling and post-processing carried out to derive the conservative sensitivity indicators, including the assumptions and compromises made and the treatment of uncertainty
- how the study improves our conceptualisation of shore response to sea level rise (sections 2.2, 2.3 and 6)
- the representation of wave climate change (sections 3.5.2 and 6)
- the reason why results are not yet available for some regions of the north (section 5.3)
- a discussion of the high sensitivity found in some regions (sections 5.5 and 6)
- an overview of what the conservative sensitivity indicators reveal about spatial and temporal variations in sensitivity to relative sea level rise (section 5.6)

4.2 Method report

The method report (Environment Agency, 2025c) describes:

- the main concepts of the study (section 2)
- what the conservative sensitivity indicators account for (section 1)
- how they may be used to estimate cliff recession in appropriate settings (sections 3 and 4)
- the strengths and limitations of the new approach relative to existing methods (section 5)
- the treatment of uncertainty (section 5.1)
- guidance on the types of setting where the new method may be most valuable (sections 5.2 and 5.3)
- comments on the treatment of the areas of high sensitivity (section 5.4)

5 References

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