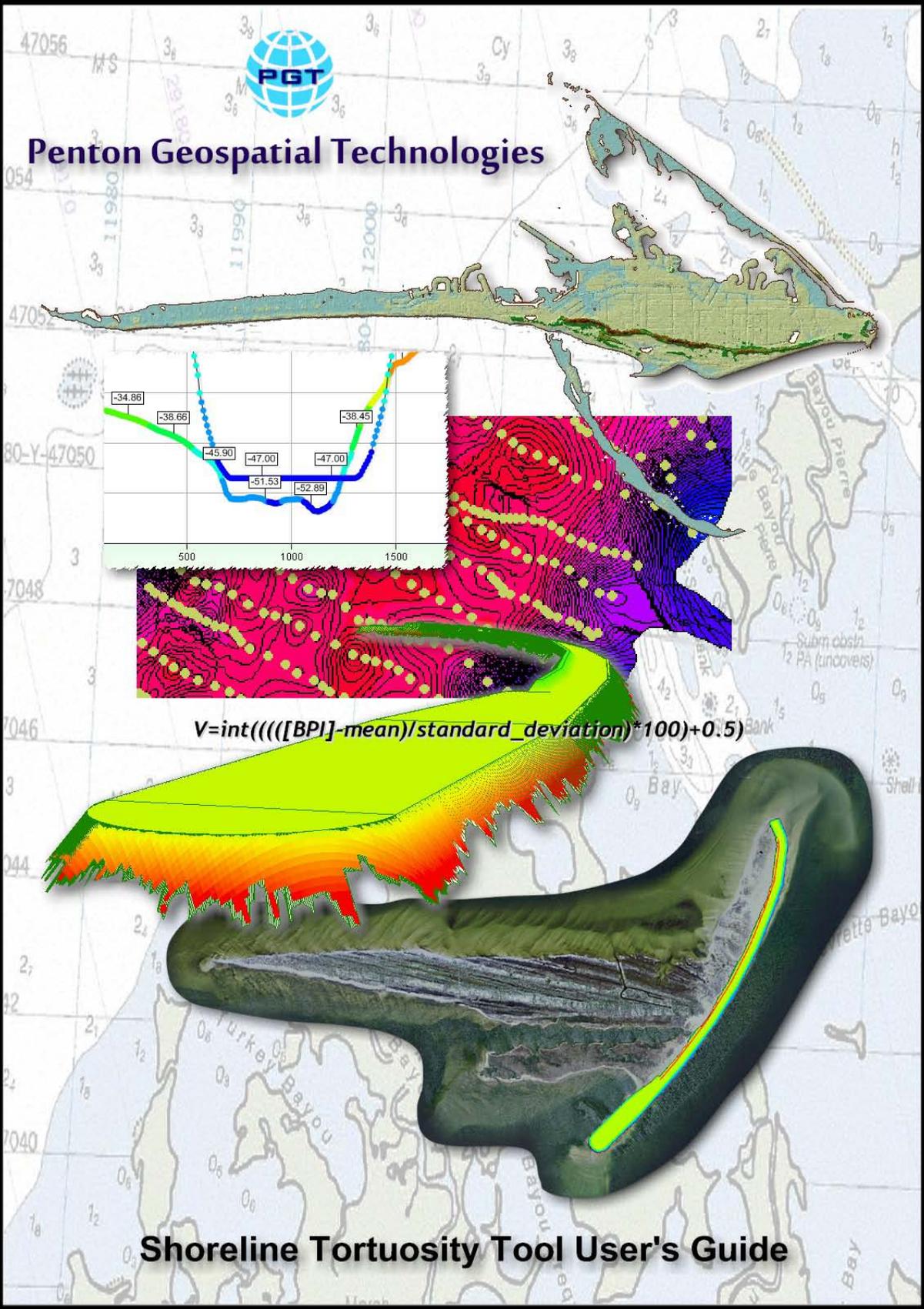




Penton Geospatial Technologies



$$V = \text{int}(\frac{[BPI] - \text{mean}}{\text{standard_deviation}} * 100) + 0.5$$

Shoreline Tortuosity Tool User's Guide

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1. Technical Requirements

This application runs with ArcGIS 10.0 with service pack 5 or newer. It was developed on Windows 7 using the 3.5 .NET framework and is a 32-bit application (dll). The tool analyzes polyline data and calculates the fractal dimension of the line. The use of linear routes, while being polyline data, is **NOT** recommended and in all probability will fail.

2. Introduction

Determining the length of a country's coastline is not as simple as it seems at first. In fact, the answer depends on the length of the ruler you use for the measurements. A shorter ruler measures more of the sinuosity of bays and inlets than a larger one, so the estimated length continues to increase as the ruler length decreases. In fact, a coastline is an example of a fractal, and plotting the length of the ruler versus the measured length of the coastline on a log-log plot gives a straight line, the slope of which is the fractal dimension of the coastline (and will be a number between 1 and 2). Lewis Fry Richardson (1881-1953) first noted the regularity between the length of national boundaries and scale size. As it turns out, the relation between length estimate and length of scale is linear on a log-log plot.

$\log[L(s)] = (1-D)\log(s) + b$ where D is the Fractal Dimension

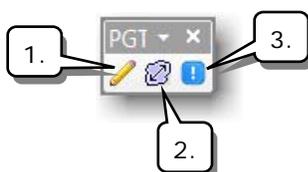
For Great Britain, $1 - D = -.24$, approximately. $D = 1 - (-.24) = 1.24$, a fractional value. The coastline of South Africa is very smooth, virtually an arc of a circle. The slope estimated above is very near zero. $D = 1 - 0 = 1$. This makes sense because the coastline is very nearly a regular Euclidean object, a line, which has dimensionality of one. In general, the 'rougher' the line, the steeper the slope, the larger the fractal dimension.



Figure 1 - Richardson Effect

3. Shoreline Tortuosity Toolbar

After installation look for the toolbar under the category name PGT-Shoreline-Tools.



1. Click this button to set a scratch working folder.
2. Click this button to open the tool dialog.
3. Click this button to open the application about box.

4. Shoreline Tortuosity Tool

The Shoreline Tortuosity Tool is a tool to calculate the fractal dimension, typically of a shoreline, and the sinuosity, a measure of the “curviness” of the shoreline. The tool does require a polyline layer that contains a single feature representing the shoreline geometry.

The layer must also be in a projected coordinate system with linear units of feet or meters. A new shape file is quickly and conveniently built on the fly if the original data is not in the correct form.

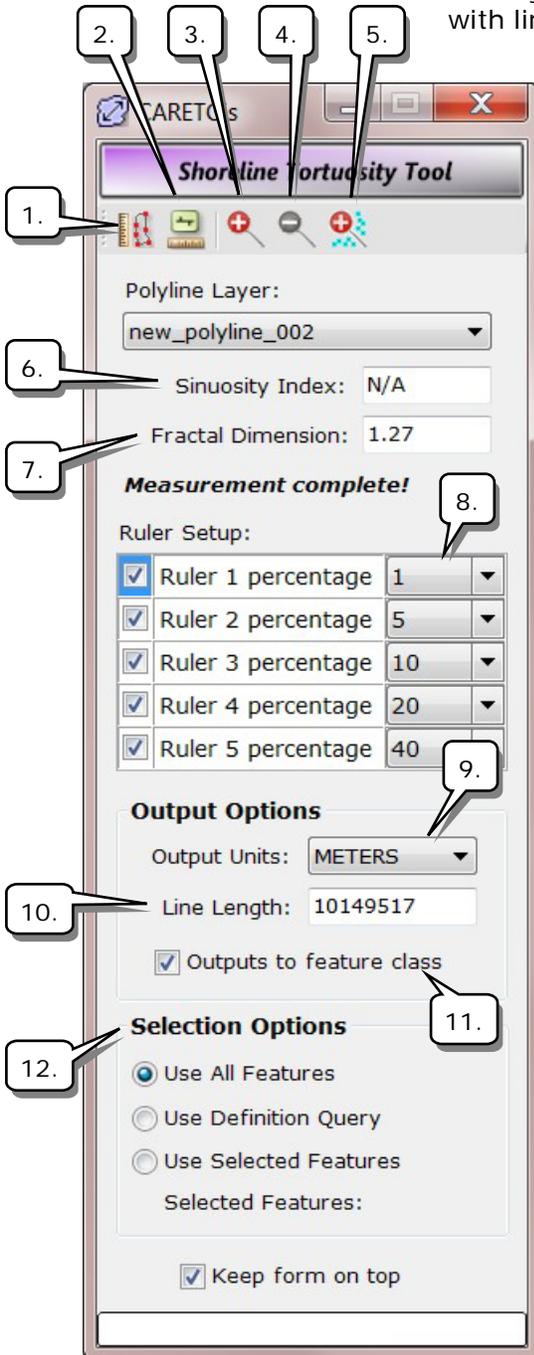


Figure 2 - Tool Dialog

1. Calculate Fractal Dimension: Once a polyline layer has been selected click this button to calculate the fractal dimension of the polyline. The polyline can be representative of a shoreline, river, or other boundaries. The tool requires a minimum of two checked “rulers” in order to run.

2. Build Ruler Shape File Tool: Click this button to create a ruler shape file. The shape file output is a polyline shape file and is based upon the selected polyline layer and the rulers applied against the polyline layer.

3. Click this button to zoom in by 50%.

4. Click this button to zoom out by 50%.

5. Click this button to zoom to any selected features.

6. This index is the sinuosity of the polyline. If the polyline ends at the same point where it began this index is not calculated.

7. The calculated fractal dimension of the polyline is shown here and typically is between 1 and 2.

8. Ruler setup is done by checking each ruler as required and setting the percentage as required. The settings seen in the figure are the default settings. The actual ruler size is the percentage multiplied by the total polyline length. The fractal dimension is obtained by extracting the slope from an ordinary least squares regression of the number of ruler sizes used. It is recommended that all five rulers be used.

9. Select from this list the output units for the line length seen in the adjacent textbox.

10. This number represents the total length of the selected polyline.
11. Check this box to write the fractal dimension (and sinuosity if applicable) to the selected polyline layer attribute table.
12. As stated hereinbefore the application requires a polyline layer containing a single line that is representative of the shoreline to be processed. If the selected polyline layer contains multiple lines a new shape file will be built on the fly to be used in the calculation. What line features are included in the new shape file are based on the selection options used here.

4.1 Ruler Shape File

The output from clicking the build ruler shape file button is seen here. The figure shows a set of five rulers being applied to a section of coastline, with yellow being the largest ruler length (coarsest) and magenta being the smallest ruler length (finest). This is a graphical illustration of the Richardson Effect.



Figure 4 - Ruler Shapes

Table						
ruler_polyline_006						
FID	Shape	RULER	LENGTH	NUMRULERS	PERCENTAGE	
0	Polyline	1	6472612.887589	1240.57		1
1	Polyline	2	4379180.260797	167.866		5
2	Polyline	3	3621461.564758	69.4102		10
3	Polyline	4	2994295.551079	28.6949		20
4	Polyline	5	2338959.667841	11.2073		40

Figure 3 - Ruler Shape File Attributes

The data calculated in deriving the ruler shape file is seen here in the shape file attribute table.

4.2 Sinuosity Index

Where applicable a sinuosity index is also calculated at the same time. Sinuosity is a measure of how curvy a shoreline (or river) and is based on the ratio of the total curvy length of the polyline divided by the straight line length from the start point to the end point. Obviously if the line ends where it starts this value has no meaning.

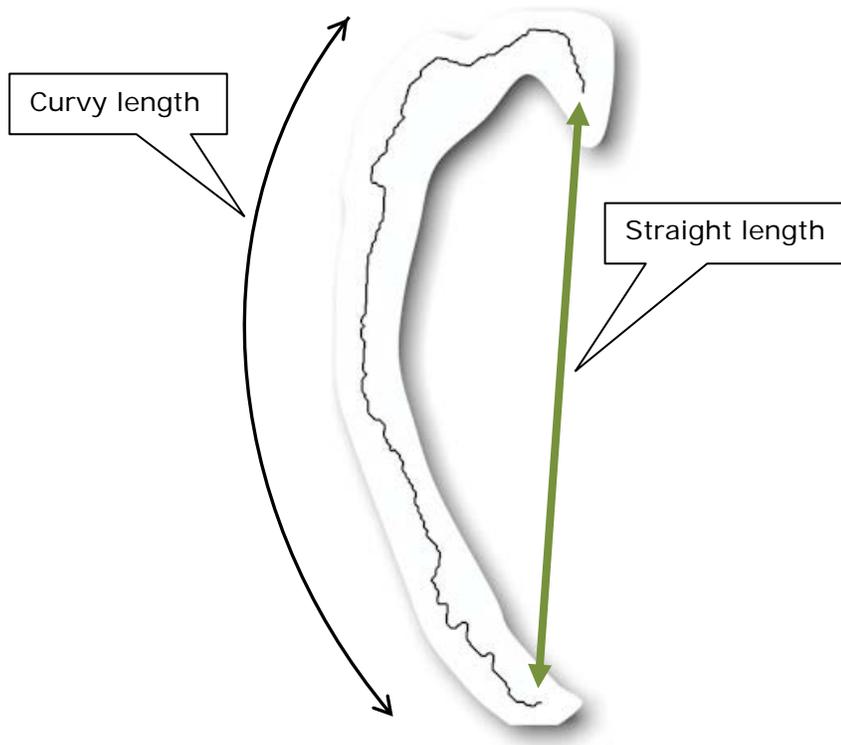


Figure 5 - Sinuosity