

Shoreline Change Mapper

User's Guide

(August 13th, 2018)

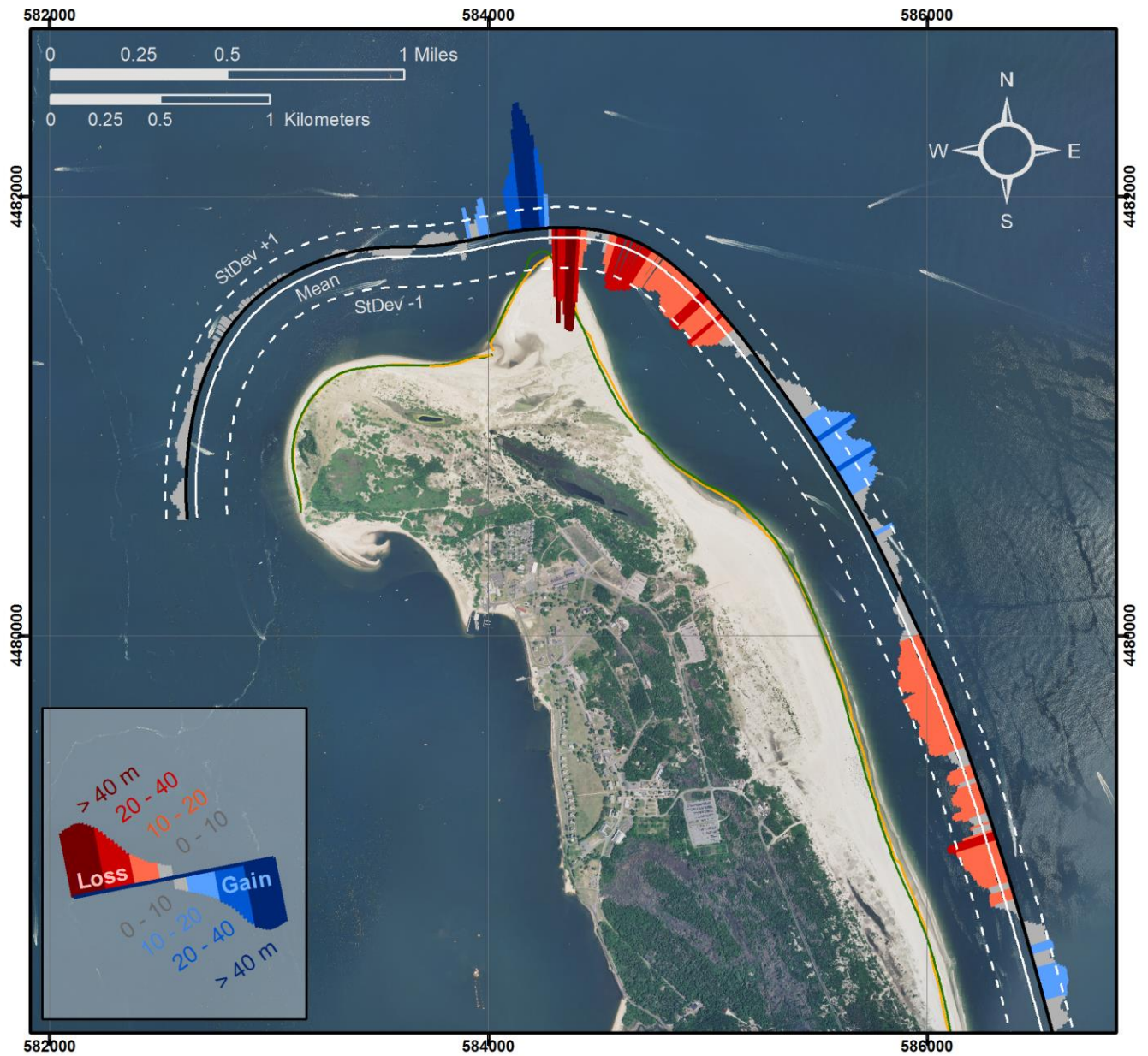


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ON THE COVER

Shoreline change vectors between Spring 2017 and Fall 2017 at Sandy Hook. The vectors were created using Shoreline Change Mapper. Red vectors indicate landward displacement of the shoreline, while blue vectors indicate seaward displacement. Gray vectors indicate displacement values within the range of uncertainty. These vectors are drawn from an offshore baseline in black.

Introduction

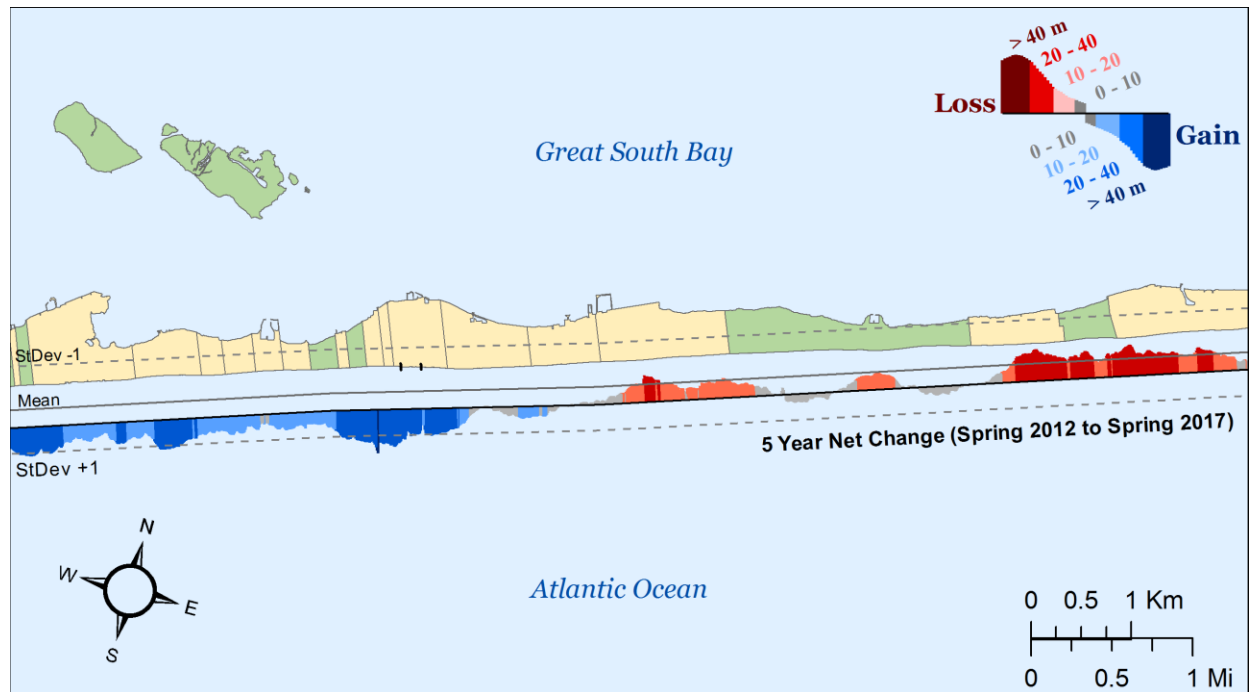


Figure 1. The 5 year net change in shoreline position for an area of Fire Island, generated with Shoreline Change Mapper (SCM). The shoreline change vectors indicate the magnitude of seaward (blue vectors) or landward (red vectors) displacement of the shoreline at the beach face between Spring of 2012 and Spring 2017.

The Shoreline Change Mapper (SCM) is a custom toolset developed for use in ArcGIS (10.2). The toolset incorporates GIS datasets created using USGS's Digital Shoreline Analysis System (DSAS) to show bar-graph-like diagrams of shoreline change (Figure 1).

SCM is a set of Python (a programming language) scripts called through a custom toolbox in ArcMap. The purpose of the Mapper is to automate a process that otherwise requires substantial time and an understanding of visual basic programming in ArcGIS to complete. The goal of the project is to simplify and standardize the protocol for generating these maps, while still allowing regional GIS managers to control aspects of the design.

SCM is distributed as a compressed folder that includes the Python scripts, a customized ArcMap document, and a sample dataset. The customized tools include basic documentation and 'Help' interfaces for new users. Installation and workflow instructions are included in this document.

The first step in the SCM workflow requires an ArcInfo license: the 'Pivot Table' tool is not available to ArcView or ArcEditor users. The remaining steps can be performed in ArcView, ArcEditor, or ArcInfo. Directions are included in Appendix A for users who need to perform this first step outside of ArcInfo using Microsoft Excel.

Installation

Below is a guide that illustrates how to add the SCM toolbox to the ArcMap document. The images were taken in ArcGIS 10.3 for Desktop with an Advanced License.

The Shoreline Change Mapper is distributed as a compressed (zipped) folder containing:

- ArcMap document (.mxd)
- Python scripts with the 'Shoreline' prefix (.py)
- Custom toolbox to hold the scripts (.tbx)
- Personal geodatabase with sample data (.mdb)
- Layer files for use in ArcMap (.lyr)

Extract / Unzip the Shoreline_Change_Mapper folder to a directory on your computer or network. The toolbox uses relative path names, so all of these files should be saved together in a single folder

1. **Open an ArcMap document and locate the 'ArcToolbox' window.** This window can be accessed either through a button on ArcMap's toolbar or under the "Geoprocessing" dropdown menu (Figure 2).

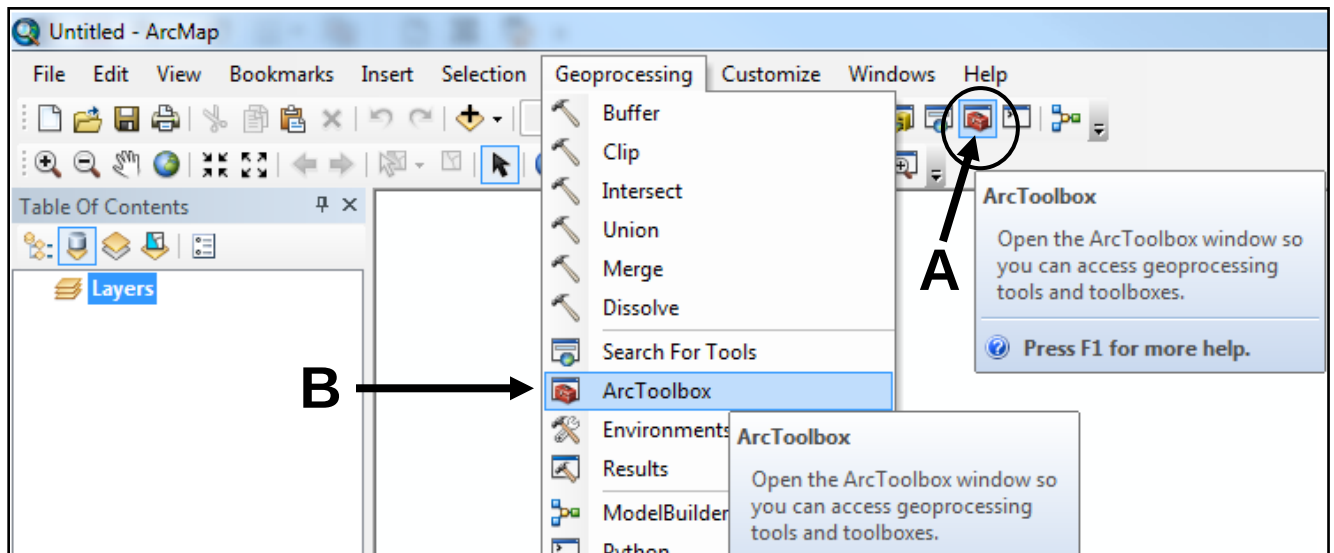


Figure 2. The two methods to open the ArcToolbox window: (A) the ArcToolbox button on the ArcMap toolbar; (B) the location of ArcToolbox on the Geoprocessing drop-down menu.

2. Add the SCM toolbox.

- a. Right click within the 'ArcToolbox' pane
- b. Select 'Add Toolbox' from the dropdown menu.
- c. Navigate to the folder where SCM was unzipped in Step 1
- d. Select 'Shoreline Change Mapper' with the ".tbx" extension.

3. **Confirm that the scripts are properly located in the toolbox.**

- a. Press the [+] button next to the SCM toolbox to expand its contents (Figure 3).
- b. Select the first tool, '1. Pivot Intersect Table,' right-click and select 'Properties' from the drop down menu.
- c. Under the 'Source' tab in the properties window, the 'Script File' should list the path to the same folder as the toolbox, to the corresponding python script. If this is not the case, click the folder icon next to the 'Script File' box. In the window that opens, select the corresponding python script with extension ".py".

Below are the tools and their corresponding scripts (Table 1). Note that the script name may include version numbers or dates.

Table 1. The three SCM tools and their corresponding scripts.

Tool	Script
1. Pivot Intersect Table	Shoreline_PivotTable.py
2. Draw Vectors	Shoreline_GenVectors.py
3. Mean & StDev Lines	Shoreline_GenStatsLine.py

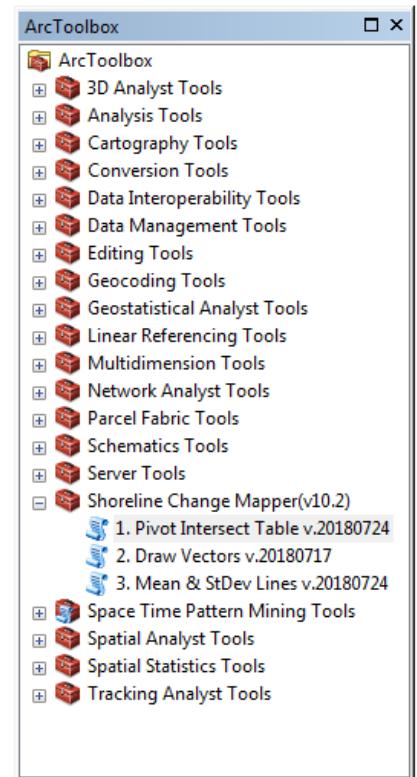


Figure 3. The expanded SCM Toolbox in the ArcToolbox window containing the three tools.

Using the Shoreline Change Mapper

Before you begin with the Shoreline Change Mapper, you should already have analyzed your data in DSAS (Version 4.0). The Mapper uses the 'intersect' table and 'transects' feature class generated by DSAS as inputs. The Mapper is designed to use the same geodatabase as DSAS—shapefiles will not work with the Shoreline Change Mapper. Also, the Mapper was designed around DSAS Version 4.0. Earlier versions may not work if the file structure (including field names) in the outputs does not match the Version 4.0 schema.

The Shoreline Change Mapper is a three-step process. The first tool in the process ('Pivot Table') only needs to be run one time for any given DSAS dataset. The next two steps ('Draw Vectors' and 'Mean & StDev Lines') will be run at least once for each pair of shorelines you wish to compare.

The tools can be accessed by double-clicking on the scripts in the toolbox. The following steps describe the workflow for the Shoreline Change Mapper.

1. Pivot Intersect Table

The first step 'reshapes' the DSAS intersect table to allow shoreline-to-shoreline comparisons by transect (Figure 4). This step uses the 'Pivot Table' tool which is only available for ArcInfo licenses. Microsoft Excel and many statistical packages like SAS include pivot capabilities: for directions on performing this step in Microsoft Excel, please see Appendix A.

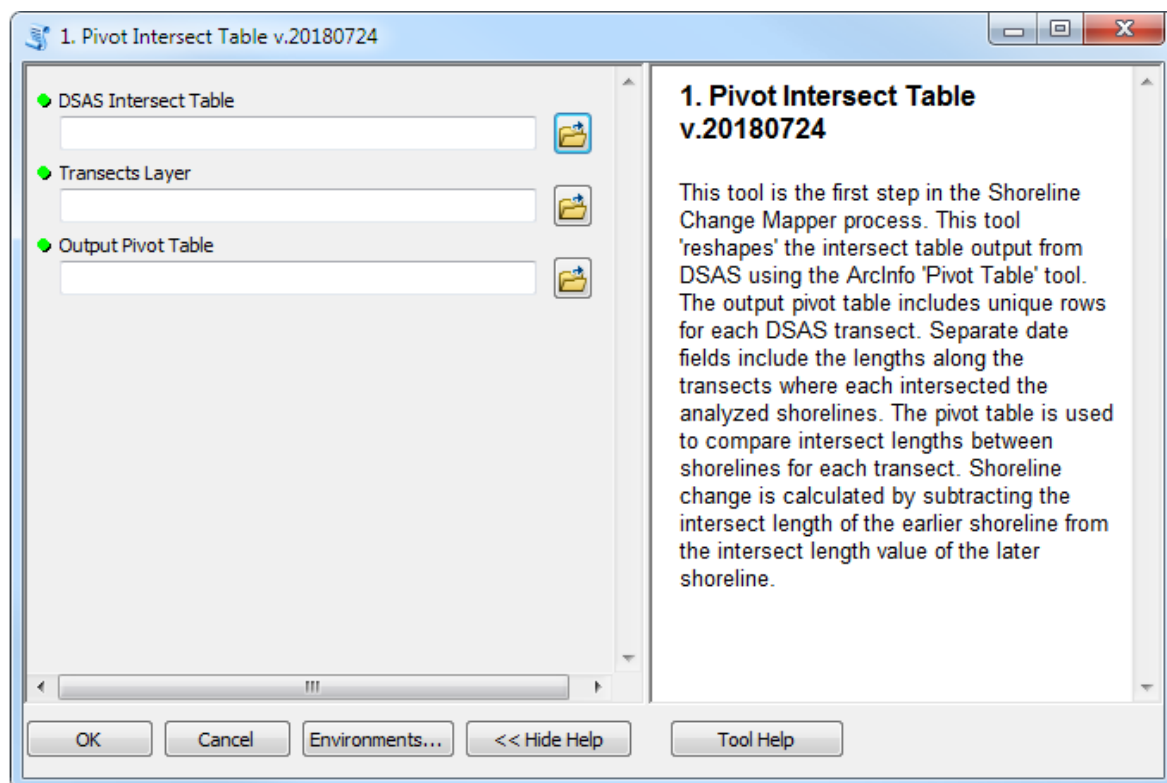


Figure 4. The 'Pivot Intersect Table' tool interface. The user inputs for Pivot Table include the DSAS Intersect Table, Transects Feature Layer, and Output Pivot Table path. Further details and instructions for each input appear in the message box to the right.

The ‘Pivot Intersect Table’ tool compresses the DSAS intersect table to create a single record for each transect (Figure 5). The different shoreline survey dates are represented in separate fields with the ‘Date_’ prefix. Each survey date field contains intersect values calculated by DSAS. These numbers represent the distance (in meters) along each transect from the baseline to the shoreline.

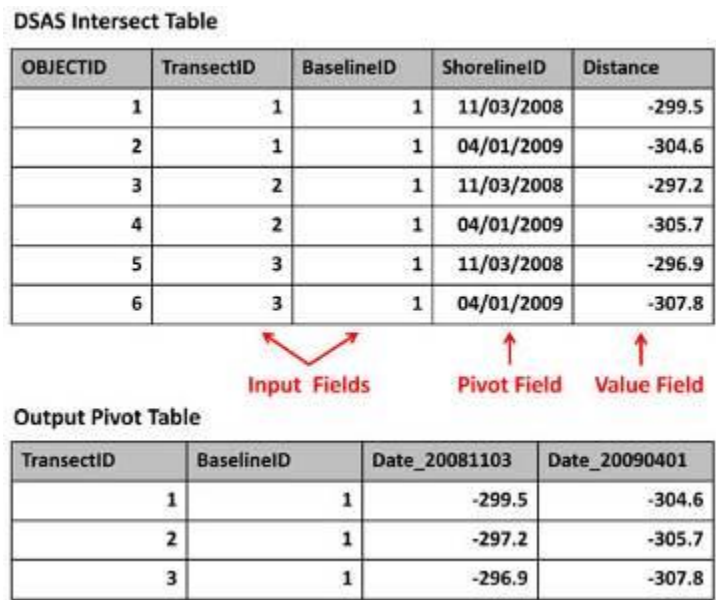


Figure 5. The Pivot Table function ‘reshapes’ the DSAS intersect table to create single records for each transect with separate fields for the survey dates. The ‘value field’ (Distance) is the distance between the shoreline and the baseline.

The output from the ‘Pivot Intersect Table’ tool is a table. The table should be saved inside the same geodatabase as the intersect table and other DSAS data.

2. Draw Vectors

The second step uses the pivot table created in the first step to draw shoreline change vectors whose length corresponds to the amount of change (positive or negative) between two compared shorelines (Figure 6).

This step requires the user to select an earlier and later shoreline to compare. Distance values calculated in DSAS for both shorelines are subtracted to find the amount of shoreline gain or retreat between the dates (the difference is saved to a field ('Dist_') in the 'Vectors' layer). The 'Draw Vectors' tool uses the change calculation to draw change lines at every transect corresponding to the amount of loss or gain between the shorelines at that transect. Gain over the period is shown by a vector seaward of the baseline; loss is shown by a vector landward of the baseline.

This step calculates the difference between two user-selected shorelines, and generates a new vector layer, each time it is run. The output vector layer includes attributes from the pivot table. For any transect where one or both of the shorelines under comparison are missing, the 'Dist_' field is set to '0.' Although a vector attribute record is included for '0' length transects (thereby maintaining a full attribute table in the vector output), its length is zero and there is no feature at this location. The 'Draw Vectors' user interface is shown in Figure 4.

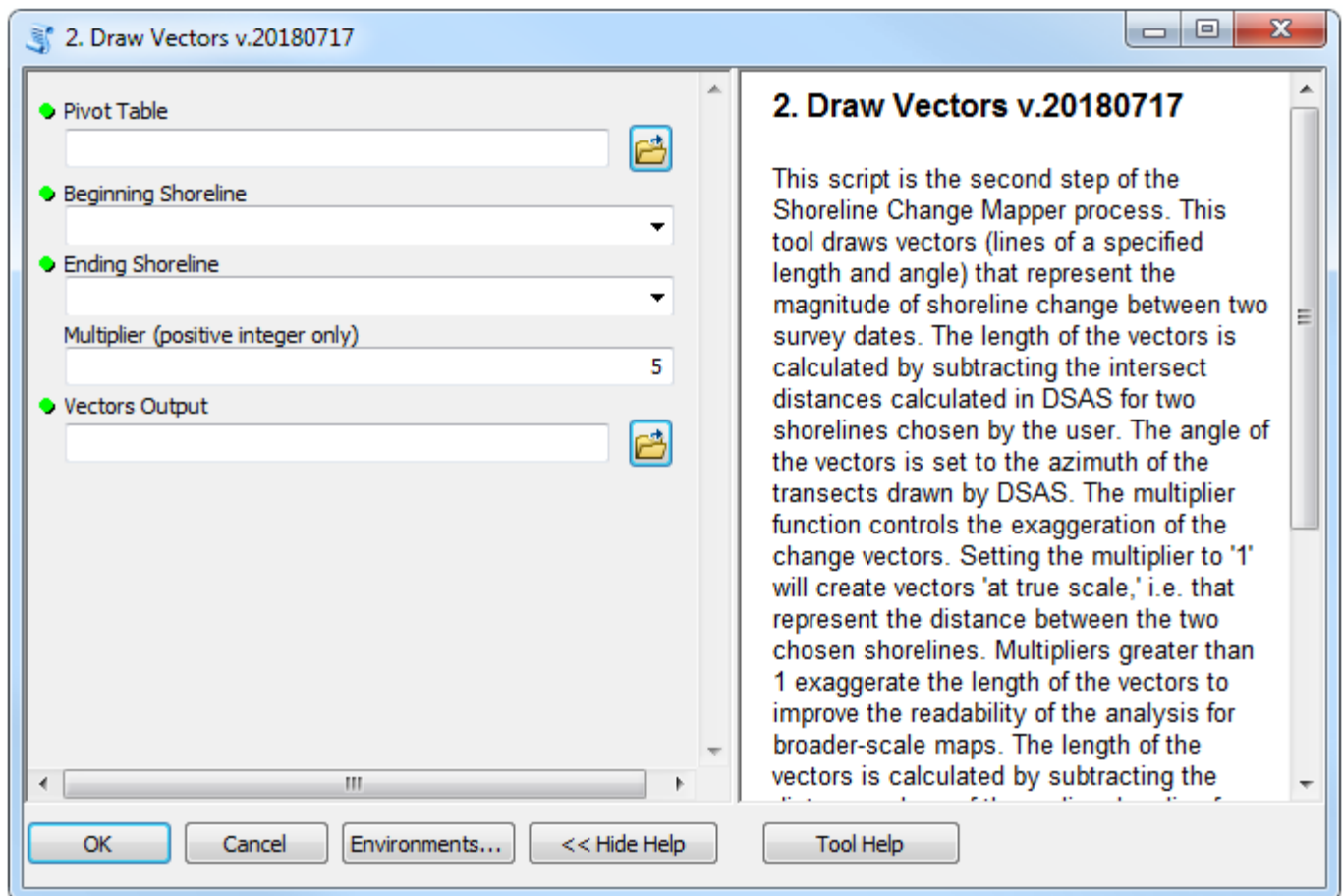


Figure 6. The 'Draw Vectors' Interface. The user inputs include a Pivot Table, Beginning and Ending Shoreline, Multiplier, and Vector Output for the resultant feature class. Further details and instructions for each input appear in the message box to the right.

Vectors are drawn at the angle of the corresponding transects generated in DSAS. The 'Angle' field is calculated in the first step. The 'Multiplier' function in the 'Draw Vectors' interface exaggerates the vertical component of the vectors to improve visibility for mapping (Figure 7). When the multiplier is set at 1, the vectors will be 'at-scale': the vector lengths represent the actual distance between the shorelines at the map scale. The default multiplier value is 5.

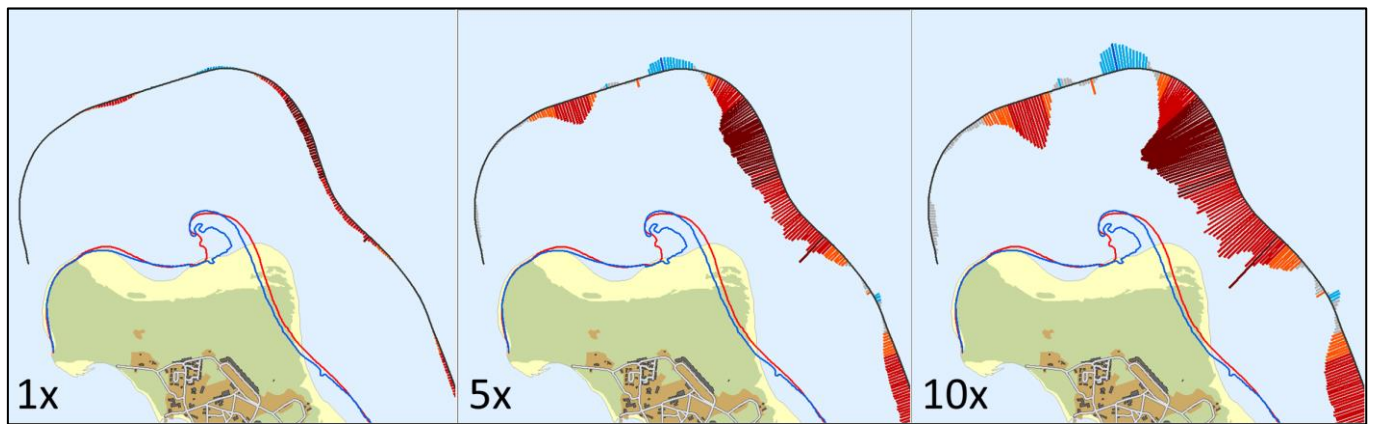


Figure 7. Vectors created using different multiplier values. The same multiplier is applied to the magnitude of shoreline displacement for all transects, and exaggerates the length of each vector.

3. Statistics Lines

The third step in the SCM workflow draws lines representing the Mean and Standard Deviations (± 1) of the vectors (Figure 8). These statistical measures are calculated for all transects where both shorelines are present, and separately by baseline section. So, if the baseline is divided into multiple segments, the mean and standard deviation of change along each segment will be calculated separately for transects originating along each segment.

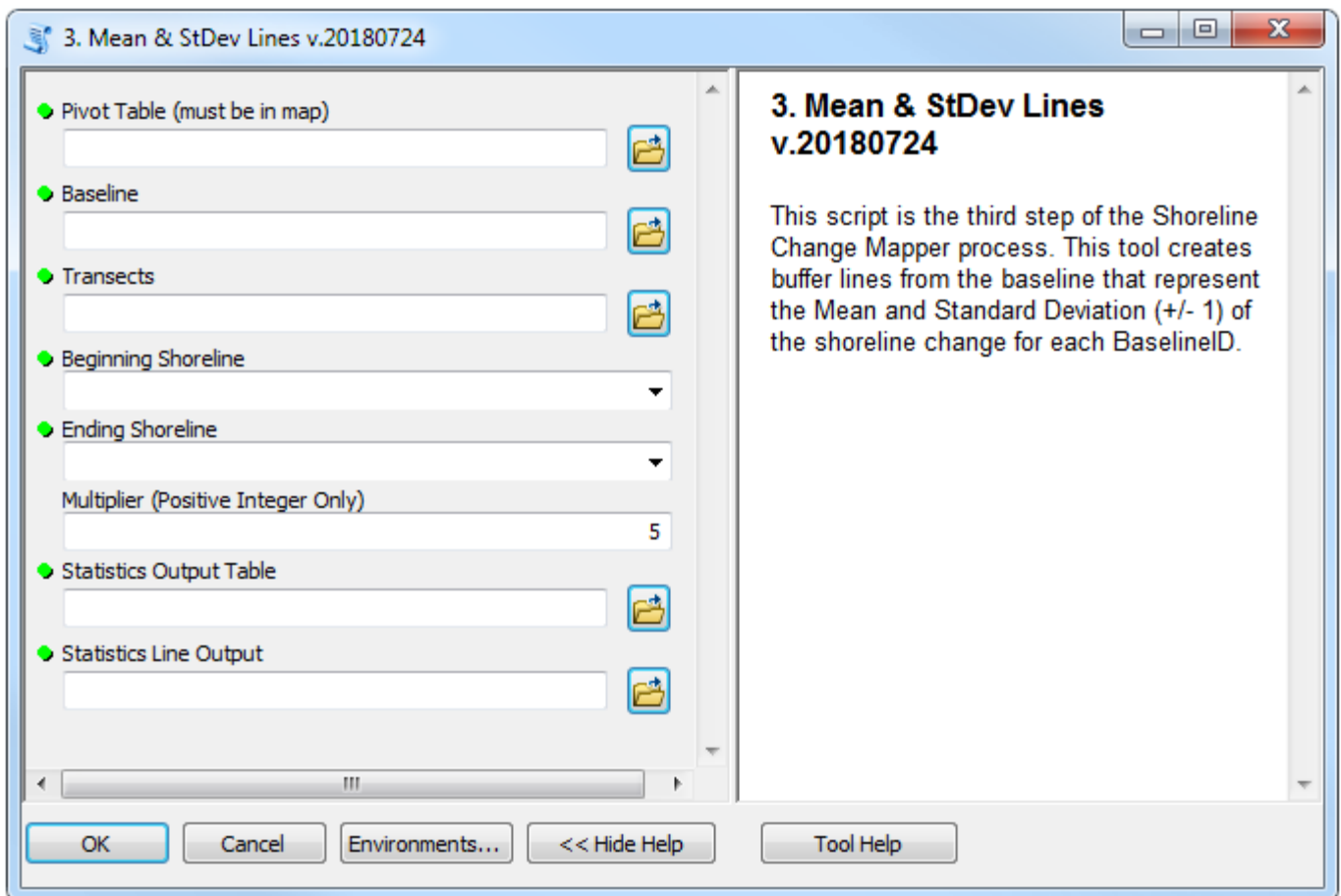


Figure 8. The 'Mean & StDev Lines' user interface. Inputs include a Pivot Table, Baseline and Transect Feature Layers, Beginning and Ending Shorelines, Multiplier, Statistics Output Table, and Statistics Line Output. Further details and instructions for each input appear in the message box to the right.

Because these statistical lines are designed to overlay on the vectors, the 'Statistics Lines' user interface includes a multiplier function that should be set to same integer value that was used in step 2 to draw the vectors.

The output lines will be added to the map view automatically. Symbology for the lines is set by the 'Statistics_Lines.lyr' layer file included in the SampleData folder

Appendix A: Performing the Pivot Function in Microsoft Excel

Because the first step of the Shoreline Change Mapper workflow requires an ArcInfo license, ArcView and ArcEditor users will need to perform the pivot function outside of ArcMap. The following instructions are for Microsoft Excel (2013 version).

Preparatory Steps in ArcMap

1. **Re-calculate Azimuth Values** If you have altered any of the original DSAS-generated transects manually, you will need to re-run DSAS to recalculate transect intersects and the transect azimuths. To do this, open the attribute table for the transects layer. Use the Field Calculator on the “Azimuth” field and enter the following into the Python parser (Figure 9):

```
math.fmod(360+math.degrees(math.atan2(( !EndX!- !StartX!),(!EndY!- !StartY!))),360)
```

This should recalculate azimuth field to the correct value. This formula presumes that the StartX and StartY coordinates refer to the end of transect that is offshore (closer to the baseline), whereas the EndX and EndY coordinates refer to the end of the transect that is onshore.

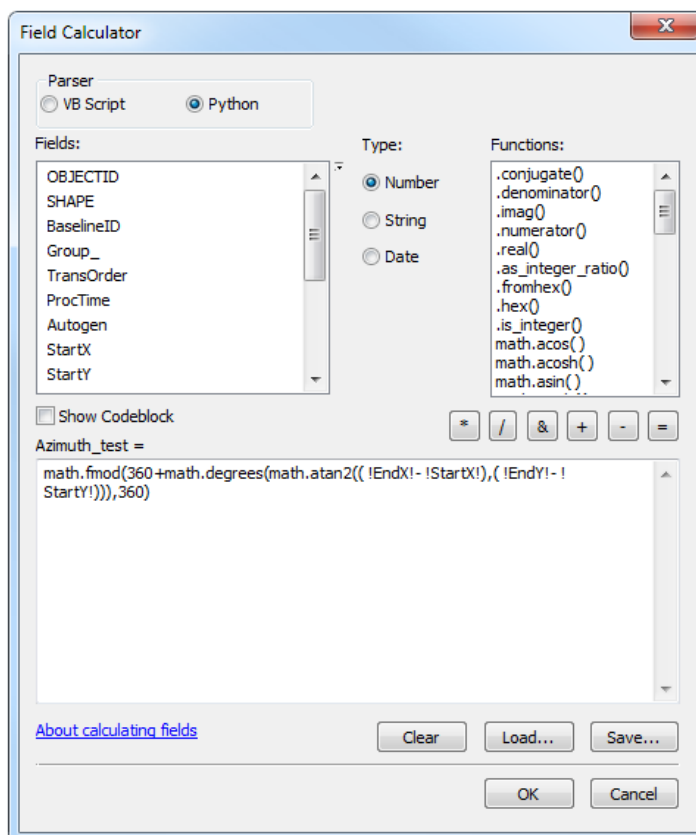


Figure 9. The code for azimuth recalculation, entered into the ArcMap field calculator. In the ‘Parser’ section, Python must be selected.

2. **Join the ‘Transect’ Attributes to the Intersect Table** Join the transect attribute table to the intersect table using the Transects IDs (Figure 10). Note that the “TransectId” field can sometimes be referred to as “TransOrder”.

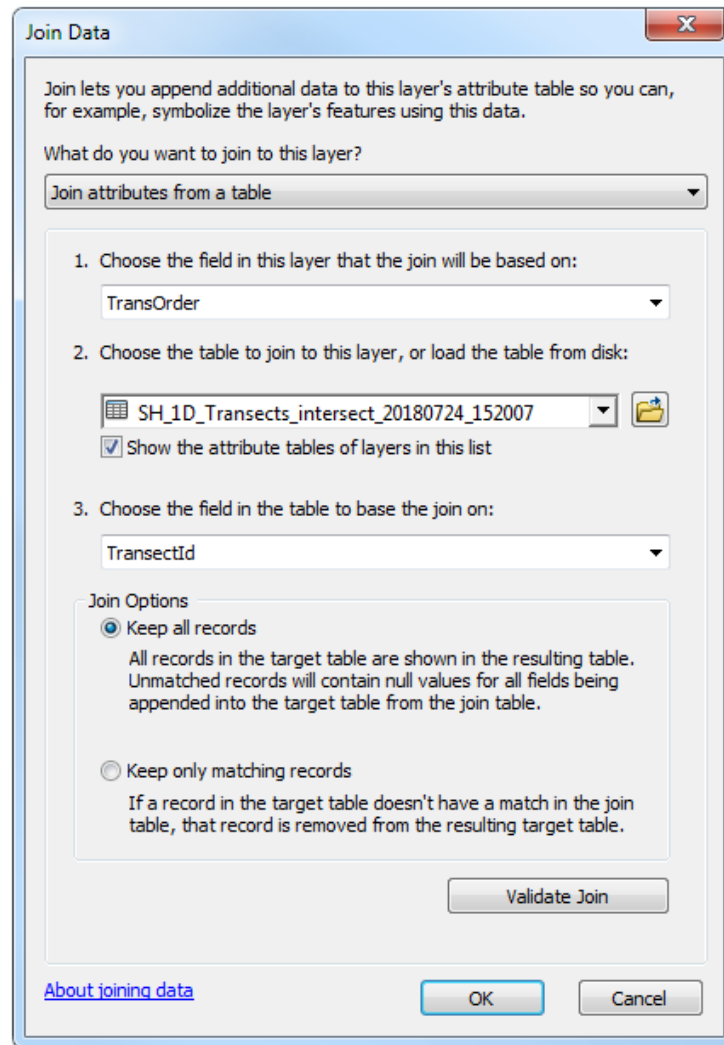


Figure 10. The "Join Data" dialog box. The join field ("TransOrder" in this example) links records in both the target layer and join layer (the intersect table).

3. **Export the Joined Tables to .DBF.** Open the joined intersect table and export it to a .dbf file (Figure 11). The exported table will contain the fields from both tables.

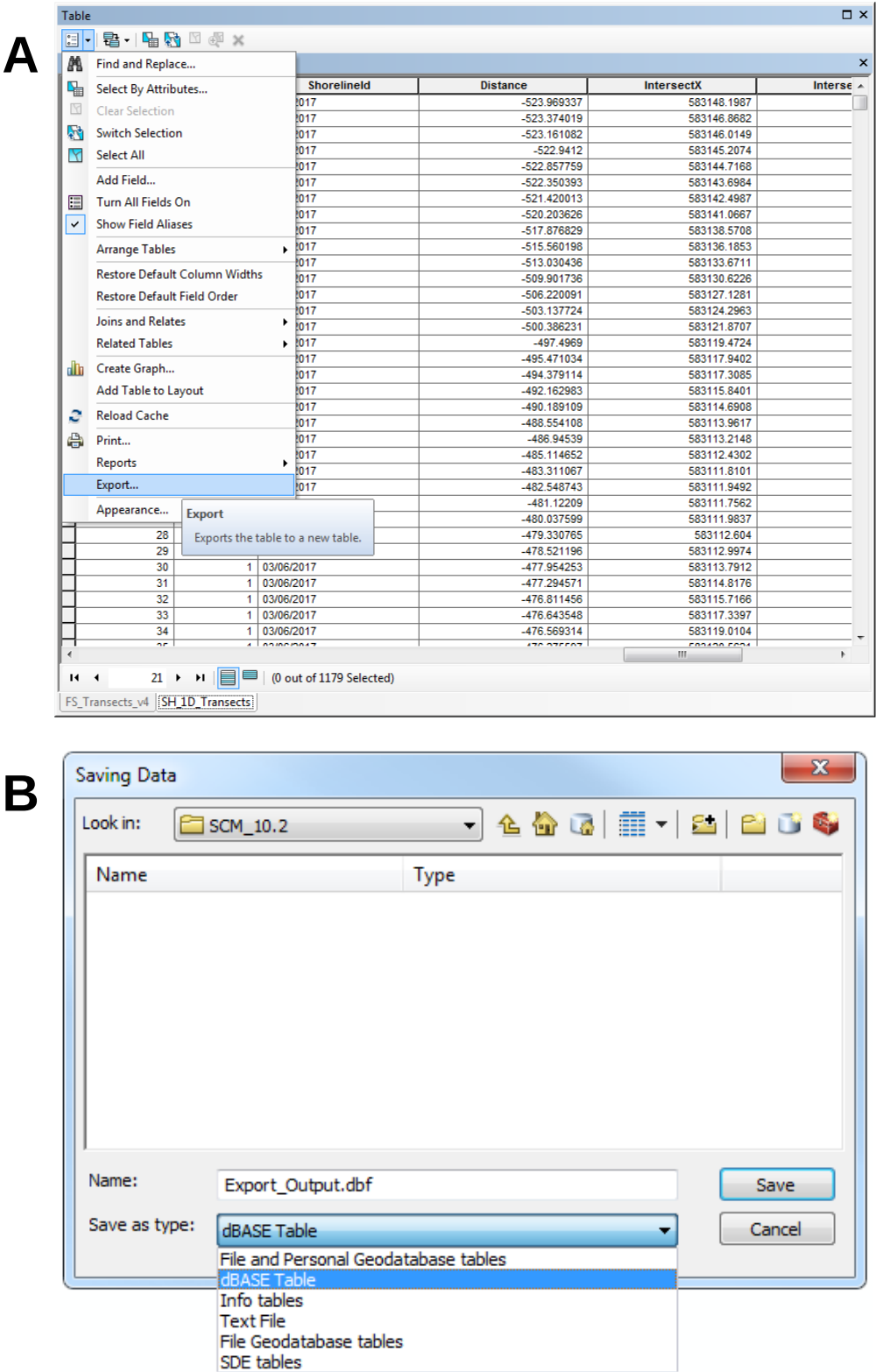


Figure 11. The process of exporting a “.dbf” file for the joined tables: (A) the location of ‘Export’ on the attribute table drop down menu; (B) where to select the desired format within the ‘Saving Data’ dialog box.

Pivot Table (Microsoft Office 2013)

1. **Open the .dbf table in Excel.** In the 'Open File' dialog box, if you don't see the .dbf table, select 'Files of Type:' >> 'All files (*.*)'
2. **Create an empty pivot table.** Select 'PivotTable' from the 'Insert' tab (Figure 12). By default, the 'Table/Range' is set to the entire table. Ensure that all records are included in the range. Choose 'OK' to send the pivot table to a new worksheet.

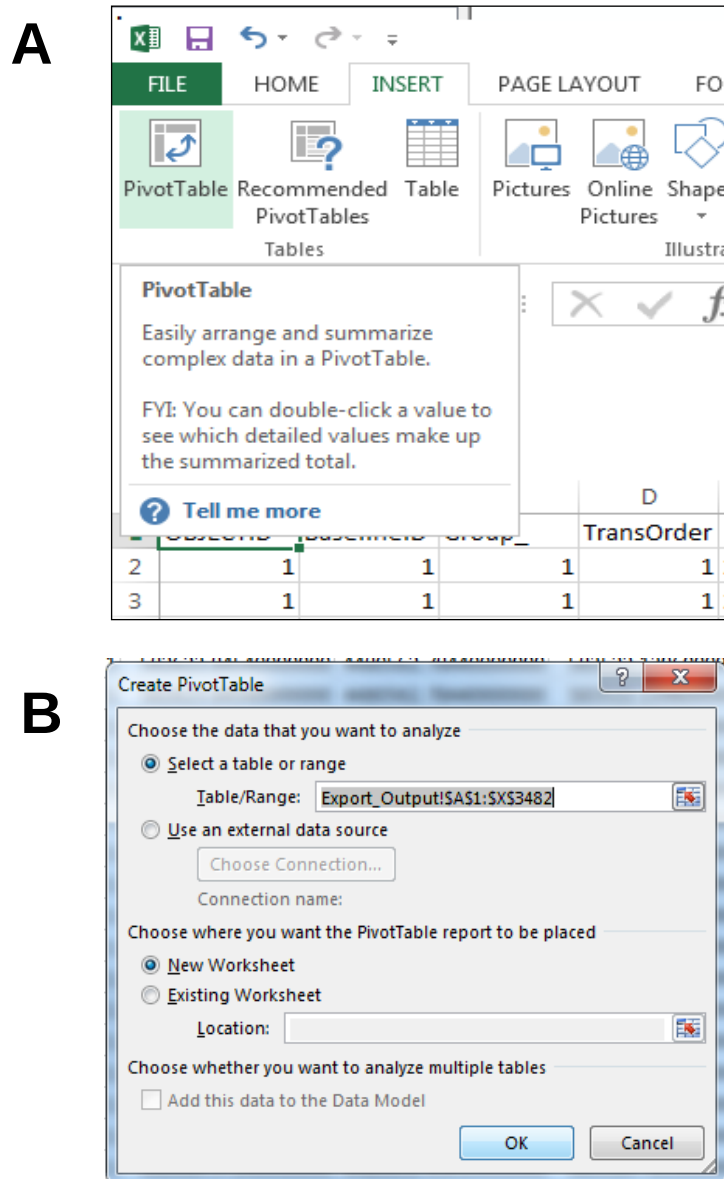


Figure 12. Steps to create a Pivot Table in Microsoft Excel: (A) the location of the 'Pivot Table' button in the 'Insert' tab; (B) the 'Create PivotTable' dialog box. The user input that indicates the range of records to be placed into the table is highlighted in gray.

3. **Begin populating the pivot table.** In the right-hand pane on the pivot table sheet...
 - a. Drag-and-drop the 'ShorelineId' field into 'Columns.'
 - b. Drag the 'Distance' field into 'Values.'
 - c. Drag the 'TransectId' field into 'Rows.'

The table should now contain individual records for each transect, listing the distance by the survey date (Figure 13).

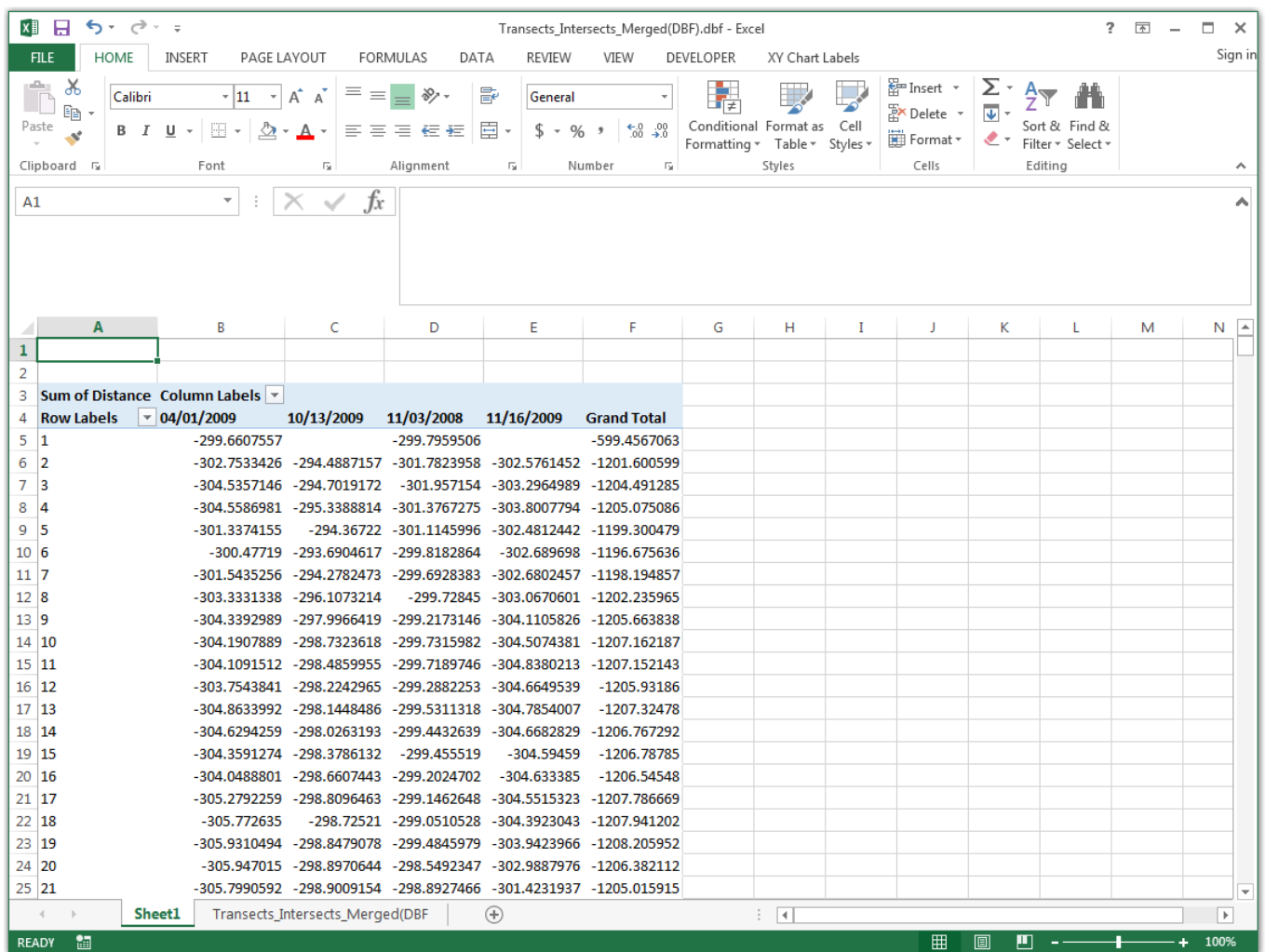
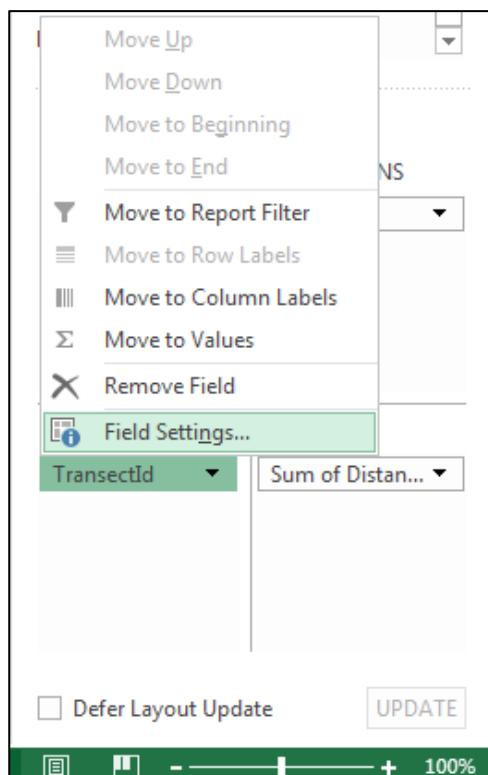


Figure 13. The Pivot Table after dragging 'ShorelineId', 'Distance', and 'TransectId' into their corresponding categories within the 'PivotTable Fields' window. Each date has its own column indicating distance from the baseline.

4. Click on the drop-down arrow on the 'TransectId' label located under the 'Rows' category. Select 'Field Settings' from the drop down menu. In the 'Field Settings' dialog box, set 'Subtotals' to 'None' and click 'OK' (Figure 14).

A



B

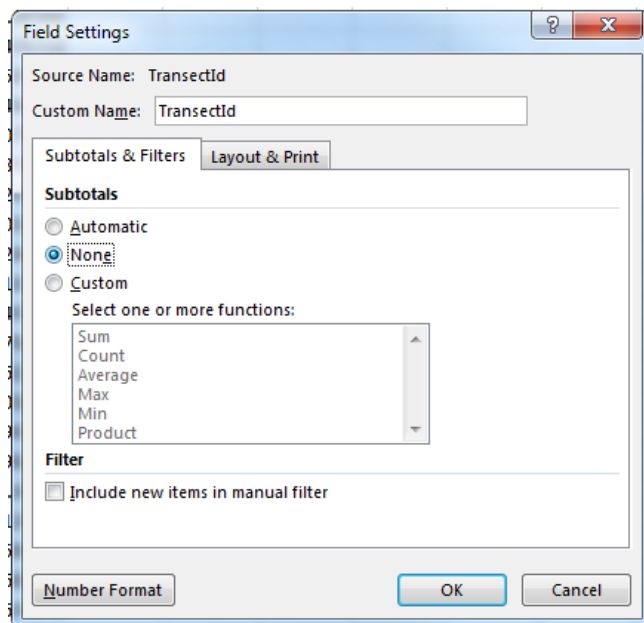


Figure 14. The process of accessing the 'Field Settings' dialog box: (A) the location of the 'Field Settings' selection in the drop-down arrow for 'TransectId'; (B) the location of the 'None' option under the 'Subtotals' section of the 'Field Settings' dialog box.

- Drag the **'Baseline', 'StartX', 'StartY', 'End X', 'EndY', and 'Azimuth'** fields to **'Rows'** (Figure 15). For each field, change the **'Subtotals'** to **'None'**, as with **'TransectId'** in Step 4.

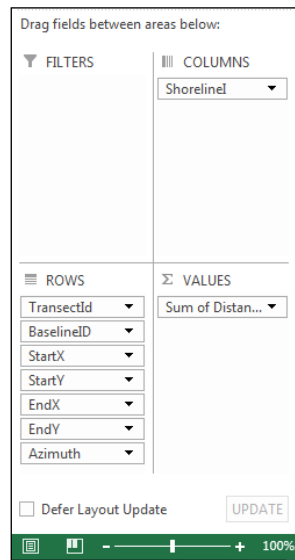


Figure 15. The fully populated 'Rows' category in the 'PivotTable Fields' window.

- On the **'Design'** tab, choose **'Report Layout'** and select **'Show in Tabular Form'** (Figure 16).

Figure 16 shows a screenshot of an Excel spreadsheet with a PivotTable in Tabular Form. The PivotTable is located in the range E1:K26. The columns are: TransectId, Baseline, StartX, StartY, EndX, EndY, Azimuth, and three dates (04/01/2009, 10/13/2009, 11/03/2009). The rows represent individual transects, with the first row being the header row. The data is as follows:

TransectId	Baseline	StartX	StartY	EndX	EndY	Azimuth	04/01/2009	10/13/2009	11/03/2009
1	1	582855.6300000000	4480512.1900000000	583539.5600000000	4480661.3300000000	77.69808392120	-299.6607557	-299	-299
2	1	582852.3100000000	4480531.9100000000	583536.0800000000	4480681.7700000000	77.63777829670	-302.7533426	-294.4887157	-301
3	1	582849.2600000000	4480551.6700000000	583533.1000000000	4480701.2300000000	77.66396548360	-304.5357146	-294.7019172	-301
4	1	582845.4900000000	4480571.3100000000	583529.5500000000	4480719.8400000000	77.75014270280	-304.5586981	-295.3388814	-301
5	1	582840.8400000000	4480590.7600000000	583525.2400000000	4480737.7300000000	77.88096202070	-301.3374155	-294.36722	-301
6	1	582835.9700000000	4480610.1600000000	583521.4200000000	4480752.1400000000	78.29763876300	-300.47719	-293.6904617	-299
7	1	582831.2200000000	4480629.5900000000	583517.4500000000	4480767.7400000000	78.61774331940	-301.5435256	-294.2782473	-299
8	1	582826.7000000000	4480649.0700000000	583513.4000000000	4480784.9300000000	78.80936449150	-303.3331338	-296.1073214	-2
9	1	582822.4500000000	4480668.6200000000	583509.6300000000	4480801.9900000000	79.01599501160	-304.3392989	-297.9966419	-299
10	1	582818.4500000000	4480688.2100000000	583506.6700000000	4480816.0600000000	79.47614524350	-304.1907889	-298.7323618	-299
11	1	582814.6900000000	4480707.8500000000	583504.7000000000	4480825.6600000000	80.31120665340	-304.1091512	-298.4859955	-299
12	1	582811.1900000000	4480727.5500000000	583503.2400000000	4480832.7800000000	81.35402392240	-303.7543841	-298.2242965	-299
13	1	582808.0100000000	4480747.2900000000	583501.9900000000	4480838.9100000000	82.47935943540	-304.8633992	-298.1448486	-299
14	1	582805.2200000000	4480767.1000000000	583500.9100000000	4480844.6600000000	83.63811808600	-304.6294259	-298.0263193	-299
15	1	582802.9300000000	4480786.9600000000	583500.0700000000	4480850.1500000000	84.82079499310	-304.3591274	-298.3786132	-299
16	1	582801.2600000000	4480806.8900000000	583499.5900000000	4480855.1800000000	86.04412260270	-304.0488801	-298.6607443	-299
17	1	582800.2200000000	4480826.8600000000	583499.4700000000	4480859.3600000000	87.33950887590	-305.2792259	-298.8096463	-299
18	1	582799.7400000000	4480846.8600000000	583499.5700000000	4480862.3900000000	88.72880922060	-305.772635	-298.72521	-299
19	1	582799.7100000000	4480866.8600000000	583499.7100000000	4480864.4900000000	90.19363209450	-305.9310494	-298.8479078	-299
20	1	582800.0600000000	4480886.8500000000	583499.7500000000	4480866.2600000000	91.68586024590	-305.947015	-298.8970644	-298
21	1	582800.7600000000	4480906.8400000000	583499.7000000000	4480868.2800000000	93.15811392450	-305.7990592	-298.9009154	-298
22	1	582801.8800000000	4480926.8100000000	583499.6500000000	4480870.9500000000	94.57737778580	-305.9964937	-298.7685166	-298

Figure 16. The Pivot Table in Tabular Form. Each transect is represented by an individual row, and their values for each field are indicated in separate columns.

7. Select all records, including the field headers (but not the ‘Grand Totals’ at the far right side, and at the bottom), and copy them (Figure 17).

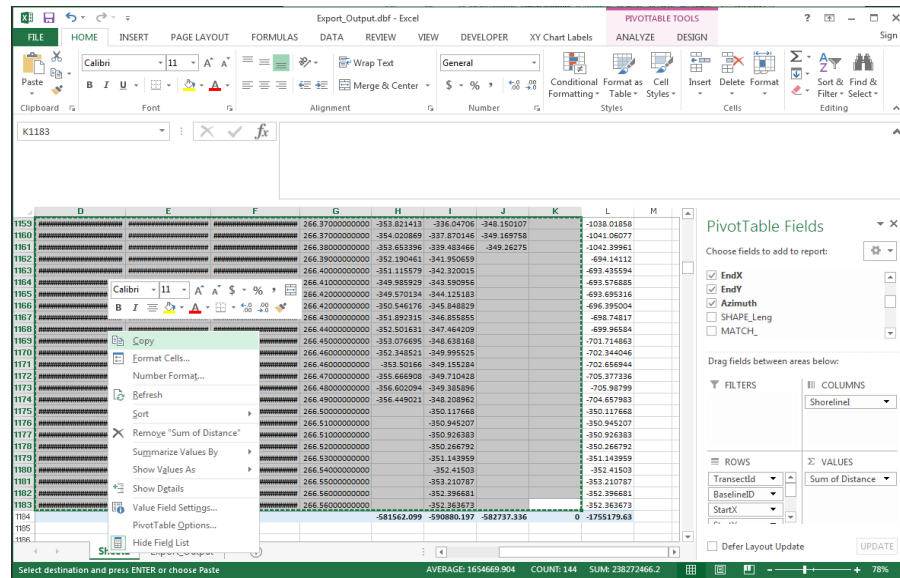


Figure 17. The selection of records that exclude the right-most ‘Grand Totals’ column and the bottom row. Insert a new worksheet. Right-click in cell A1 and click ‘Paste Special.’ In the ‘Paste Special’ dialogue box, choose ‘Values’ and press ‘OK’, resulting in a table without the ‘Grand Totals’ records (Figure 18).

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Sum of Distance															
2	TransectID	BaselineID	StartX	StartY	EndX	EndY	Azimuth	03/06/2017	04/12/201	10/23/201	(blank)					
3		0	1	587303.2	4472321	586404.8	4472268	266.57				0				
4				587303.8	4472312	586405.4	4472258	266.58				0				
5				587304.4	4472301	586406	4472248	266.59				0				
6				587304.9	4472293	586406.5	4472239	266.6				0				
7				587305.6	4472281	586407.2	4472228	266.61				0				
8				587306.2	4472272	586407.7	4472219	266.61				0				
9				587306.7	4472263	586408.3	4472210	266.62				0				
10				587307.3	4472252	586408.9	4472199	266.63				0				
11				587307.9	4472242	586409.5	4472190	266.64				0				
12				587308.5	4472232	586410.1	4472179	266.65				0				
13				587309.1	4472222	586410.6	4472170	266.65				0				
14				587309.6	4472213	586411.2	4472161	266.66				0				
15		1	1	582625.6	4480538	583523.3	4480602	85.88	-523.9693367	-526.051	-519.583					
16		2	1	582624.7	4480549	583522.6	4480611	86.08	-523.3740186	-528.016	-520.081					
17		3	1	582623.8	4480563	583522.1	4480618	86.47	-523.1610819	-528.994	-520.432					
18		4	1	582623	4480578	583521.7	4480625	86.97	-522.9412001	-528.638	-519.887					
19		5	1	582622.4	4480589	583521.5	4480631	87.36	-522.8577587	-527.601	-518.615					
20		6	1	582621.7	4480606	583521.1	4480639	87.97	-522.3503925	-525.12	-516.429					
21		7	1	582621.3	4480620	583520.9	4480645	88.39	-521.4200127	-522.96	-514.863					
22		8	1	582621	4480633	583520.8	4480651	88.83	-520.203626	-520.731	-513.099					

Figure 18. The values copied from the Pivot Table and pasted into a new sheet.

8. The dates in the field headers need to be changed before we can re-import this pivoted table into ArcGis. Remove the slashes and add “Date_” at the beginning of each field name (Figure 19).

I2

:

X

✓

fx

Date_20091013

	A	B	C	D	E	F	G	H	I	J	K
1	Sum of Distance							ShorelineI			
2	TransectI	BaselineI	StartX	StartY	EndX	EndY	Azimuth	Date_20090401	Date_2009101	11/3/2008	11/16/2009
3	1	1	582855.6	4480512	583539.6	4480661	77.69808	-299.6607557		-299.7959506	
4	2	1	582852.3	4480532	583536.1	4480682	77.63778	-302.7533426	-294.4887157	-301.7823958	-302.5761452
5	3	1	582849.3	4480552	583533.1	4480701	77.66397	-304.5357146	-294.7019172	-301.957154	-303.2964989
6	4	1	582845.5	4480571	583529.6	4480720	77.75014	-304.5586981	-295.3388814	-301.3767275	-303.8007794
7	5	1	582840.8	4480591	583525.2	4480738	77.88096	-301.3374155	-294.36722	-301.1145996	-302.4812442
8	6	1	582836	4480610	583521.4	4480752	78.29764	-300.47719	-293.6904617	-299.8182864	-302.689698
9	7	1	582831.2	4480630	583517.5	4480768	78.61774	-301.5435256	-294.2782473	-299.6928383	-302.6802457
10	8	1	582826.7	4480649	583513.4	4480785	78.80936	-303.3331338	-296.1073214	-299.72845	-303.0670601
11	9	1	582822.5	4480669	583509.6	4480802	79.016	-304.3392989	-297.9966419	-299.2173146	-304.1105826
12	10	1	582818.5	4480688	583506.7	4480816	79.47615	-304.1907889	-298.7323618	-299.7315982	-304.5074381
13	11	1	582814.7	4480708	583504.7	4480826	80.31121	-304.1091512	-298.4859955	-299.7189746	-304.8380213
14	12	1	582811.2	4480728	583503.2	4480833	81.35402	-303.7543841	-298.2242965	-299.2882253	-304.6649539
15	13	1	582808	4480747	583502	4480839	82.47936	-304.8633992	-298.1448486	-299.5311318	-304.7854007
16	14	1	582805.2	4480767	583500.9	4480845	83.63812	-304.6294259	-298.0263193	-299.4432639	-304.6682829
17	15	1	582802.9	4480787	583500.1	4480850	84.82079	-304.3591274	-298.3786132	-299.455519	-304.59459

Figure 19. Alterations made to the headers to prepare for input into the second step of SCM. The cells highlighted in yellow have the desired format, where the ShorelineI field is preceded by “Date_”. The cells highlighted in red have the original formatting before these edits were made.

9. Save this worksheet as a comma-delimited text file (.csv file type) and close Excel.
10. In ArcCatalog, navigate to your DSAS geodatabase. Right click the database and select ‘Import’ >> ‘Table (single).’ Select the .csv file and import to the geodatabase. You are now ready to begin Step 2 in the Shoreline Change Mapper, ‘2. Draw Vectors.’.