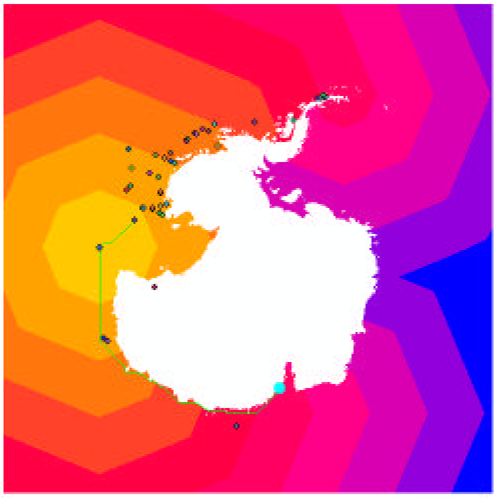
Measuring the Shortest Non-Linear Distances Between Marine Animal Locations Within an Ocean Mask



These instructions will enable you to create the paths and calculate the distances between marine locations without going over/through land. Using ESRI ArcGIS 8.x software with the **Spatial Analyst** extension, you perform the following:

- Create an analysis mask (this method uses the **XTools** extension)
- Add the XY data and save as a shapefile
- Run the distance, cost-weighted, and shortest path functions

ORIGINAL DATA

Samples.dbf	A dBase file of the marine locations (in GCS_WGS_1984) with an integer field called "ID" to uniquely identify each point location
Antarctica.shp	A shapefile of the Antarctic landmass (in South_Pole_Azimuthal_Equidistant – Central Meridian = -90 and Latitude of Origin = -90)

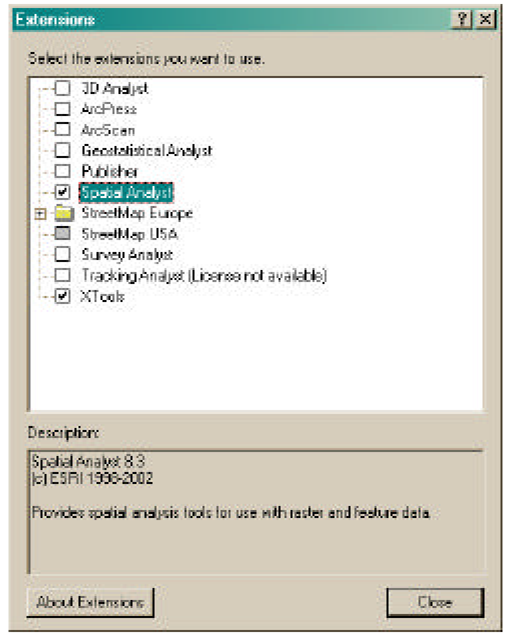
CREATED DATA

SamplePts.shp	A shapefile of reprojected Samples.dbf locations
Ocean.shp	An arbitrarily drawn rectangle to represent ocean
South_Ocean.shp	A shapefile of the reverse to Antarctica.shp; i.e. a polygon of the surrounding waters with "holes" where the land exists
South_Ocean2	A raster grid of ocean surface to represent the cost
CostDistance and CostDirection	Raster grids resulting from cost-weighted function; used as input into shortest path function
Path1to.shp	A shapefile of the path between points created from shortest path function

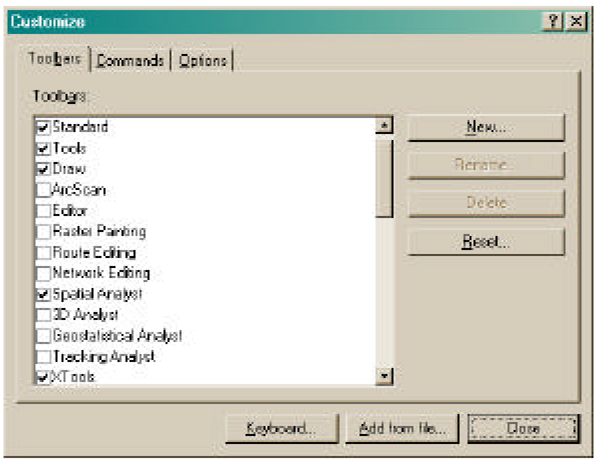
ArcMap Instructions

1. Open ArcMap using a new empty map

Enable extensions and display toolbars:



2. Choose TOOLS → EXTENSIONS
3. Click a check beside **Spatial Analyst** and **XTools** to enable the extensions
4. CLOSE the dialog window
5. Choose TOOLS → CUSTOMIZE
6. In the TOOLBARS tab, click a check beside **Spatial Analyst** and **XTools** to view the toolbars



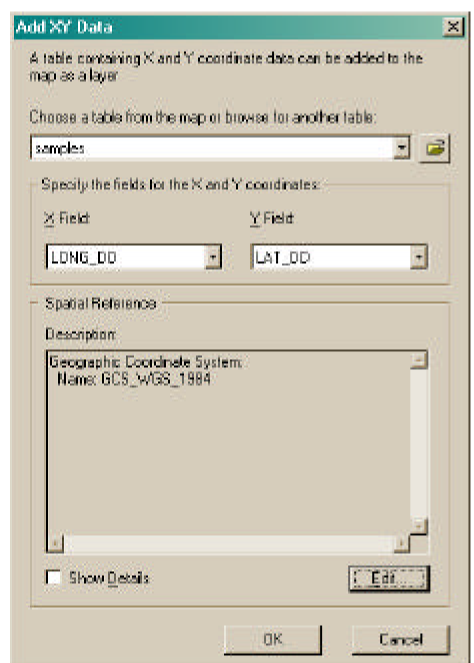
7. CLOSE the dialog window

Add the XY data and create the ocean mask:

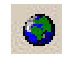
8. Click the ADD DATA button and navigate to find the **Antarctica.shp** shapefile and add it to the map document

This not only adds the main landmass layer but also assigns the coordinate system to the data frame. Now when the XY data is added and defined in its coordinate system, ArcMap can reproject on the fly so that the points are in the same coordinate space as the Antarctica polygon.

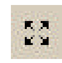
9. Choose TOOLS → ADD XY DATA
10. Click the BROWSE button and navigate to find the **Samples.dbf** table and add it
11. Click the EDIT button to set the appropriate coordinate system (e.g. GCS_WGS_1984 for data collected in decimal degrees latitude/longitude)



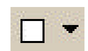
Export the event layer into a permanently projected shapefile.

12. In the table of contents, right click on the **samples Events** layer and choose DATA → EXPORT DATA
13. Choose to export “All features” and “Use the same Coordinate System as the data frame”
14. Navigate to the desired directory and specify **SamplePts.shp** as the output name
15. Click SAVE
16. Click YES to add the new data
17. Click on the ZOOM TO FULL EXTENT button 

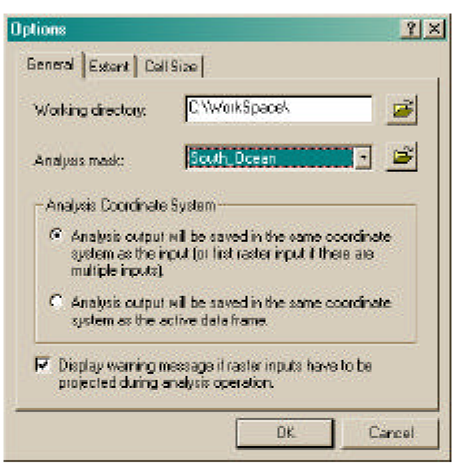
Just to provide a little extra moving room when calculating shortest paths around the landmass, zoom out a little more than the data extent.

18. Click on the FIXED ZOOM OUT button 

Create a simple “ocean” polygon to surround the landmass. The most efficient way to do this is using the handy tools in the XTools extension: Convert Graphics to Shape and Erase Features.

19. Using the NEW SHAPE tool on the Drawing Toolbar, create a ***rectangle*** (default shape) that more than encompasses the landmass and sample locations 
20. Choose XTOOLS → FEATURE CONVERSIONS → CONVERT GRAPHICS TO SHAPE
21. Select “1 Graphic polygon” and click OK
22. Navigate to the desired directory, specify **Ocean.shp** as the output name, and click SAVE
23. DELETE the graphic 
24. Choose XTOOLS → LAYER OPERATIONS → ERASE FEATURES
25. Select **Ocean.shp** as the layer to erase features from
26. Select **Antarctica.shp** as the polygon layer used to erase features from the previous layer
27. Specify an output name; e.g. **South_Ocean.shp**
28. Click OK

You now have an ocean “mask” layer. This is very useful for forcing the analysis to take place in the water areas only!



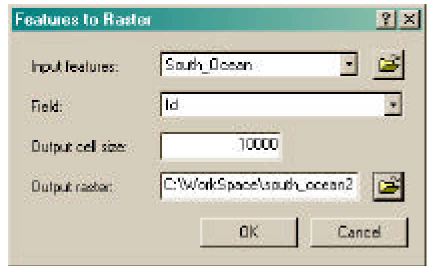
Very important! Set the Spatial Analyst analysis options:

29. Choose SPATIAL ANALYST → OPTIONS
30. In the GENERAL tab:
    - Set the Working directory
    - Select **South_Ocean.shp** as the Analysis Mask – *this indicates that only areas within this polygon layer will be processed*
31. In the EXTENT tab:
    - Select **South_Ocean.shp** as the Extent – *this indicates the output files will be within the same geographic limits*

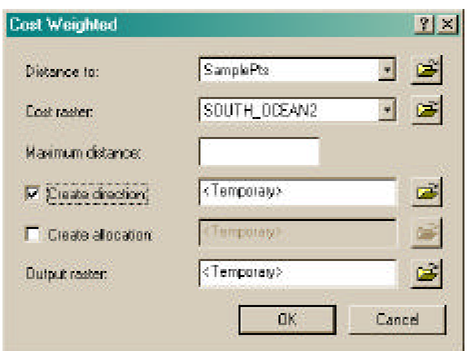
32. In the CELL SIZE tab:
    - Set the cell size to **10,000** – *the map units are in meters, so this indicates that output grids will have 10 km by 10 km sized cells*
33. Click OK

Create the cost surface:

This layer indicates the cost of moving across the surface. In this example, cell values indicate the friction involved in moving away from a particular point location. The ideal surface for this application is one in which all cell values are equal in value since the mask takes care of the travel space and the cost weighted functions take care of distance/direction.



34. Right click on **South_Ocean** and OPEN ATTRIBUTE TABLE
35. Calculate a value of one to use when converting to raster; i.e. **ID = 1**
36. Choose SPATIAL ANALYST → CONVERT → FEATURES TO RASTER
37. Select **South_Ocean** as the input layer
38. Select **ID** as the field to convert on
39. Specify and output name; e.g. **South_Ocean2**
40. Click OK



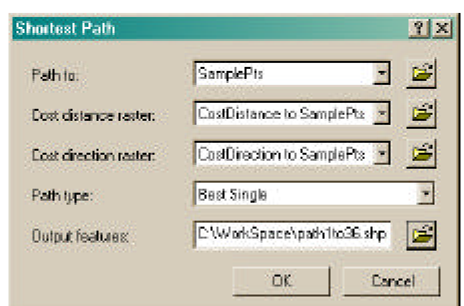
Create the cost weighted surface:

See the ArcGIS Desktop Help on "Finding the least-cost route for a road" and related topics for background info on these functions.

41. SELECT point **ID = 1**
42. Select **SamplePts** as the distance to layer
43. Select **South_Ocean2** as the cost raster
44. Click a check beside "Create direction"
45. Click OK

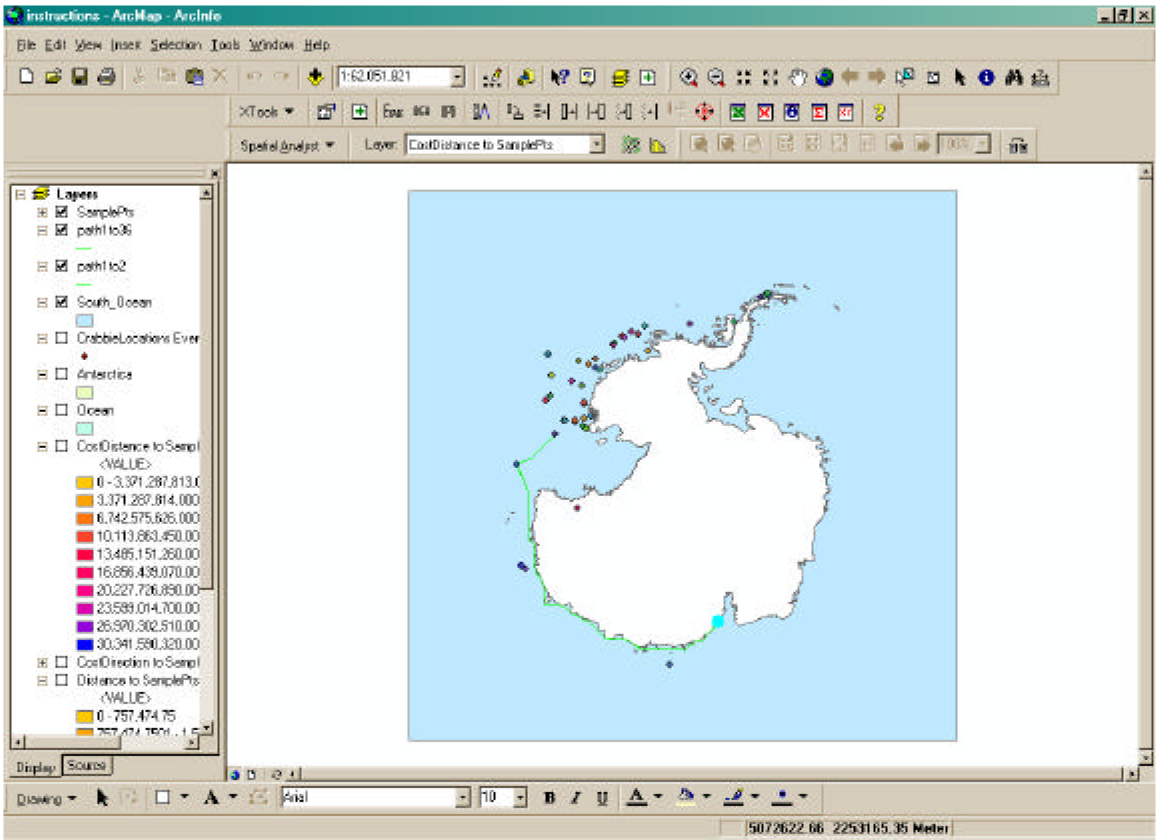
Create the shortest path feature:

46. Select **ID = 2** for the **SamplePts.shp** layer
47. Choose SPATIAL ANALYST → DISTANCE → SHORTEST PATH
48. Select the following:
    - Path to: **SamplePts**
    - Cost distance raster: **CostDistance to SamplePts**
    - Cost direction raster: **CostDirection to SamplePts**
    - Path type: **Best Single**
    - Output features: **path1to2.shp**
49. Click OK



The output shapefile indicates the shortest path between the first sample location and the selected one. Apply the XTools tool for calculating the length.

50. REPEAT for distance between **ID = 1** and all other sample locations
51. Then REPEAT from the beginning of "**Create a cost surface**" for **ID = 2** and all other locations, and then for **ID = 3**, and so on…



Cost Surface Variations:

Instead of using an equal cost value surface, you may opt to create a cost surface with one of the following characteristics:

- To force the path to be closer to the land then use a cost surface equal to [Distance to Antarctica]
- To force the path through the other points then use a cost surface equal to [Distance to SamplePts]
- Alternately, [Distance to SamplePts] X [Distance to Antarctica] will force the path through the points and close to the land