Utilizing Hydro-acoustics Data and GIS to:

Develop Hydro-acoustic Data for Fisheries

Create an Estimated Fish Population and Spatially Randomize in 3D the Estimated Population
Create a Depth Map for Water Volume Calculations
Create 3D Scenes of Hydro-acoustics Data

January 30, 2007

Will Stafford, GIS Consultant, Prince Albert, Saskatchewan
Ron Hlasny, Hydro-acoustics Specialist, Saskatchewan Environment, Prince Albert, Saskatchewan

Table of Contents

List of Figures

Appendix2 Figures

List of Tables

Background

Hydro-acoustics is a remote sensing tool used for aquatic assessment. It captures the return signal strength in decibels of air trapped in a fishes swim bladder. The return signal can be converted into fish length based on the relationship between signal strength and bladder size (i.e. Loves equation, Love ????). Each return is stored as a single record in a data table, also stored is the boats position via GPS (for us +- 3m using WAAS) and how deep the fish was and its offset from the central access of the sound cone (+- 0.1m).

Other required information is a high quality digital elevation model of the lake. Digital Elevation Data (DEM) can be captured from the bottom file of the hydro-acoustics run or you can create it using the Lowrance LCX-15MT fish finder/depth sounder. We discovered that by using the Lowrance unit we can go into shallower water and collect data faster up to 30km/hr. The Lowrance records X,Y and depth data which is and stored onto a digital media card. Since the boat can go into shallower water we normally increase the sampling density around reefs in order to capture the nuances of structure.

Data Processing

The following techniques assumes the user is reasonably familiar with ESRI's ArcMap 9.x software. Has the full version with the following extensions, ESRI's Spatial Analyst and 3D Analyst, Edit GeoTools 9.1 (http://www.ian-ko.com/), Hawth's Analysis Tools (http://www.spatialecology.com/htools/index.php) and GPSi (http://arcscripts.esri.com/details.asp?dbid=12749). In Saskatchewan our provincial projection standard is Universal Transverse Mercator (UTM) with a datum of North American Datum 1983 and a local correction called CSRS98.

Hydro-acoustics Data

The hydro-acoustic data is cleaned and analyzed by HTI's software EchoScape to produce a "fish table", that includes the following key fields; X (decimal degrees to10 decimal places), Y (decimal degrees to 10 decimal places), TSSignal strength,, depth to fish (metres to 2 decimal places).

We add the additional fields of Length(cm), Length(in) and Transect and Truedepth. Length values are based on Love's Equation of Length(cm) = 10log((TSSignal Strength + 64.071) / 19.1). Generally a –25 decibel return equates to 100cm fish.. Length in inches = Length(cm) / 2.54. Transect values are arbitrary and identify which transect the data comes from. Truedepth is the modified depth field to account for the depth of the sounder. We strive to place the sounder down 1m below surface for easy calculations, i.e. add 1m to fish depth.

When working with the hydro-acoustics data we have learned that the data can be either a .csv file, .dbf table or .mdb Access table. All of which can be accessed by ESRI ArcMap.

Creating a Spatially Referenced Hydro-acoustically Data Set

Once the hydro-acoustic data has been cleaned with respect to bottom and fish. The bottom values are saved out as the bottom file, while the tracked fish and/or user defined fish have been identified they can be exported out as the fish table.

The bottom file can be incorporated with the Lowrance data to improve bathymetric surface creation. As a check of data quality we overlay the two dataset and compare depth values from each data set where they intersect. If there is a significant difference between the two we ascertain who is correct and alter the incorrect one. This may seem a straight forward process but it requires though to determine who is correct, i.e. was it wavy day doing hydro or is the bottom really mucky both will effect the accuracy of the signal return and hence depth. From experience the differences can be 1-2 metres.

The completed fish table is imported into ArcMap 9x as a table then a spatial data set is created from the data points:

1) Add the hydro-acoustic data to ArcMap, .txt, .dbf, mdb.
2) Select Tools, AddXY to convert the data to a spatial data set (commonly called an Event theme/layer).
3) Use the Longitude for X and Latitude for Y, Set the projection information to a World Projection of Geographic with a datum of WGS84.
4) Right click on the Event layer and select Export to export the data to a shapefile format. On export the data will be saved with a projection of Geographic and datum of WGS84.
5) Use ArcMap Toolbox under Data Management, Projection and Transformation, Feature, Project to reproject the Geographic WGS84 data to a UTM Projection with a Datum of NAD83CSRS98 (in US just use NAD83).
6) Start a new session of ArcMap and add the projected UTM hydro-acoustic data.
7) Add the Hawth's Analysis toolbar. Select Analysis Tools, Table Tools, AddXY data to table, to add the X,Y position in UTM coordinates to the data table for each record. We will utilize those positional values further down.

Creating data suitable for Lake Digital Elevation Model Creation

Download the points from the Lowrance storage card, Appendix 1: Developing Lowrance DEM data files for Use in ArcMap or ArcView. We run a data conversion tool based in MicroSoft Access 2000 which converts data from Lowrance format to a csv format with a Geographic Projection and a WGS84 datum and depth(m). The second step is to use a custom MicroSoft Excel macros to do a data verification and to compile the data together from several boat transects into one data file.

Generally one uses the first excel macro to clean the data to remove fish echoes and other strange stuff and the second macro to compile the different data sets together to create one (potentially large) data set.

> Note, if you exceed 65,536 records you will have problems in Excel and have to append the exported data tables together in a text editor, not a big deal just another step. My favorite text editor is TextPad.
> Note, we normally work with one days data for compiling i.e. two boats collecting but make one data table out of both boats data for a particular day.
> Note: this limit is now removed in the new version of Microsoft Excel 2007 and rows can go to 1 million

1) Using ArcMap load each csv data table in, use:
2) Tools, AddXY to create a spatial file of each table.

3) Set the projection information of the Event theme to Geographic and WGS84 datum.
4) Export the Event theme to a new shapefile.

   Note, Once the lake is competed wrt to Lowrance transects this is where I normally append all of the data together. It saves having to reproject a lot of shapefiles.

In a new ArcMap session load in all of the depth point shapefiles. Appending can be done with the downloaded extensions or ArcMap toolbox and append them together to create one shapefile in Geographic coordinates with a WGS84 datum. Use Toolbox Data Management… to reproject the result from Geographic WGS84 to UTM NAD83 or your local projection.

Creating a Lake Digital Elevation Model

There are several software tools that will create DEM surfaces some are better than others. We used the Topogrid module in ArcMap/ArcInfo (http://support.esri.com/index.cfm?fa=knowledgebase.techarticles.articleShow&d=20779) because it was designed to create topographically correct elevation surfaces from points or contours based on the ANUDEM algorithm (http://cres.anu.edu.au/outputs/anudem.php). Another software built along the same lines is Surfer (http://www.goldensoftware.com/products/surfer/surfer.shtml).
The following instructions assumes you have the full version of ArcMap i.e. ArcMap/ArcInfo Workstation 9.x with grid module. If you do not then you need to use other software to create your dem. If you do have access to the full version of ArcMap / Workstation there is a tool/command line function called Topogrid at the ArcInfo Workstation command line or TopoRaster is a GUI with ArcMap 9.x. TopoRaster is a GUI/dialogue box inside ArcMap Toolbox or from the command line. This tool will allow the user to create a DEM of a lake in a cell or raster format. Please read the full documentation of Topogrid so you have an understanding of what it wants, format it wants the data in and what you will get out of it. For this operation you will need an accurate lake outline polygon and your shapefile of elevation points. It is also capable of working with breaklines if you have them for the lake or the land.

ArcInfo Workstation Command Line

If you are using the command line version in Workstation, you will need to convert your lake boundary data, elevation point data and breaklines from a shapefile format to a ESRI coverage data format.

   Note: When doing this conversion make sure that the conversion parameters wrt to precision is set to double double so that no precision issues arise. So check Tools, Options, Geoprocessing, Environments, set precision to double double.

In Toolbox click the search tab and search for shapearc (shapearc is the command/tool for data conversation between a shapefile and a coverage). Both the elevation shapefile and the lake surface polygon need to be converted. Once the lake surface is converted buffer it by 2 metres or so, and us this as the lake boundary coverage this seems to produce a better DEM at the edges.

Decide what cell size you want your lake DEM to be (we used 10m cells for Crean Lake), the command syntax is as follows and assumes the point dem data is called dempts with an attribute called elev holding depth values as negative numbers and the lake boundary polygon is called lakebnd;

```
topogrid lakedem_10 10
boundary lakebnd
datatype spot
point dempts elev
```

```
iterations 45
end
```

The process should start now but it may bomb out saying it does not have enough memory. To correct this read up on the GRIDALLOCSIZE variable, that variable needs to be set and the process restarted I apply it this way:

1) Click, Start, Run, Type in cmd hit enter
2) cd to data location i.e. c:\creanlake_dem
3) set GRIALLOCSIZE=200

Note: The above assigns 200megs of memory for Topogrid in this command window. You should set the value 50m above the error message value that appeared when it failed.

4) arc (starts ArcInfo Workstation)
5) Now re-due all of the commands from above

```
topogrid lakedem_10 10
boundary lakebnd
datatype spot
point dempts elev
iterations 45
end
```

The result lakedem_10 can be viewed as a grid in ArcMap.
You now need to create 1m or 2m contours:

1) Start ArcMap
2) Activate the Spatial Analyst extension and display the Spatial Analyst Toolbar.
3) Load the DEM surface
4) Click Spatial Analyst
5) Select Surface Analysis
6) Contour, set the dialogue values for 1m contours and click Okay.

This will create a polyline data set of 1m interpolated contours.

If you are using the GUI approach for Topogrid TopotoRaster the same options hold true including setting the GRIDALLOCSIZE variable (done by setting it in Control Panel, System Environment Variables).

Creating Contour Polygons from the Depth Contours

There is more than one way to accomplish this task. The approach we use is done using geodatabases feature datasets ability to convert polylines to polygons. There are other methods, one can convert the shapefile contours to coverage format and then select out by attributes the various contour lines and convert those to polygons. I have found that from an editing point of view (you will have to edit contours near the surface, i.e. 3m, 2m,1m, because they bleed out and do not form complete polygons), ArcMap is far easier to edit in than ArcInfo Workstation.

Using ArcMap 9X

Append the lake boundary file with the contour data set, to create a new shapefile.
Select all records without an elevation value (those should be the lake boundary arcs) give those an elev value of 0.

> Note, ArcMap can append shapefiles together but it does not add nodes at intersection points. We need those nodes at line intersections for this to work.

1) Click on the Edit GeoTools 9.1 button,
2) Select the Geoprocessing tab,
3) Merge Layers, Select a base layer,
4) Select the remaining layers to be merged specify the output name and location then run the tool,
5) To clean and add nodes at every intersection of the appended data click on the Edit GeoTools 9.1 button select Polyline tab then Clean Polyline.
6) Select the append data set
7) Run the tool.

It may take a few tries to get it correct. What you want is to have all of the contours enclosed by the lake boundary line with intersections where contours created from the DEMs cross the appended lake boundary lines. If overshoots exist they should not be a problem when creating the contour polygons.

Using ArcCatalog to create a Personal Geodatabase of Contours

Creating depth polygons requires creating a personal geodatabase.

1) Create a personal geodatabase, using ArcCatalog:
2) Navigate to where you want the geodatabase C:\temp\crean.
3) Right click on the right panel, New, Personal Geodatabase (called kallie from now on). Left Click on the kallie geodatabase then in the right panel create a Feature Dataset (called dog from now on) inside the new personal geodatabase kallie.
4) Set the projection information equal to the contour data set.
5) Use the Import button to import the projection information from the appended contour shapefile data set.

> Note: This will also set the spatial extent of the feature dataset this is a critical part because ArcMap is very fussy about projections and spatial extents in a geodatabase.

6) Right click on the geodatabases feature dataset dog and choose Import,
7) Import the appended shapefile dataset of contours and lake boundary file into the Geodatabase kallie Feature Dataset dog.

Now that the spatial extent and projection are set in the personal geodatabase kallie feature dataset dog we can now load the appended contours shapefile into ArcMap and use ArcMap to select out contour records to be used to create polygons.

Start a fresh ArcMap

1) Load in the appended contour shapefile data set (Don't use the appended dataset from the personal geodatabase kallie or you may get a database "Locked by another User" error.
2) Open the attribute table,

3) Click Options,
4) Click Select by Attributes,
5) Double click “contour” to add to bottom box then as an example type = -20
6) With those lines select right click the contour layer, select Export.
7) Change the export data type to read Personal Geodatabase,
8) Navigate to the created geodatabase kallie and into the feature dataset dog,
9) Name the output m20 (don’t use just a number since geodatabases do not like files named that way, so start with a character first, hence m20).

We are now ready to create the first depth polygon from the contour polylines.

1) Start ArcCatalog
2) Navigate to the personal geodatabase kallie,
3) Click on the feature dataset dog so it shows up as blue in the left hand panel of ArcCatalog now in the right panel,
4) Right click, New,
5) Select Polygon Feature Class from lines.

Note: The above steps do work but the order of how it is done is critical. As a rule I always navigate using the left panel in ArcCatalog and examine stuff using the right panel. It also saves seeing the error “Locked by another user”.

6) Modify the cluster tolerance to 1-2 metres so that snapping occurs correctly.

Note: You can leave this alone but since the contours are made from a 10*10m grid data a snapping tolerance of 2 metres is not going to mean much wrt precision of resulting contours polygonal area.

7) Continue the cycle until you have completed up to the –3m contour.

The remaining contours my not form properly i.e. –3m –2m –1m, because the contour lines may drift into shore. So you will have to manually select arc parts that form the lake boundary file elev = 0, or add new arcs to close up the polygon. Those arc segments will breach the gap between the –3m, -2m, -1m contours that have drifted into shore to create a complete polygons if its okay great if it fails go back to ArcMap and examine the selected arcs at a larger scale you will find that there are segments not highlighted because they were not –3m so you will have to manual select them as well. This is why we used Edit GeoTools earlier to create intersections between the 0 contour (lake boundary file) and any other contours i.e. –1, –2, –3 that may of bled into the shore.

Creating the Boat Tracks

We normally carry a second GPS with our start stop points and routes of our hydro-acoustic transects. Besides navigation, this GPS unit is used to hold our boat track data. The boats tracks are off loaded from the GPS directly into ArcMap using a GPSi extension then saved as a shapefile and the projection is defined via ArcCatalog as Geographic and a Datum of WGS84. This shapefile is then re-projected to UTM NAD83CSRS98 in our area, yours will be different. Once the lake is completed the daily tracks are merged together. One file continues the hydro-acoustic tracks the other contains the Lowrance boat tracks.

Adding and Calculating Fields to the Sampled Fish Data Table

Presently, our fish data table has a minimum of these fields, XUTM, YUTM, Depth(m) and Fish Length. You can carry the whole fish table but the fields above are required for the next steps. Add the following fields to the fish table in ArcMap;

Transect (can be string or number, we use string w1, w2…e1,e2)
Dclass (string d1-2, d2-3 etc, 5)
Basin (string, east, west, etc, 5)
Absdepth (number, long integer 5)

In ArcMap:

1) Right click the layer
2) Open Attribute table
3) Click Options to add new fields.
4) Provide the field Name and Type and string length or Precision

Now we need to populate the values of those fields, using ArcMap
Open the attribute table,
Graphically select all of the fish points location that are along transect 1,
Populate the transect field with "t1", select all of the fish records that are along transect t2 populate the transect field with "t2", etc.

> Note, in Crean Lake we kept track of the fish by transect and basin so our transect values were w1, w2,… w7, e1,e2,… e8. Just encase there was a difference between basins.

Using ArcMap open the attribute table of fish and select by attributes where depth is >-1 and <= 0 populate Dclass as d0-d1, select by attributes where depth is between >-2 and <= -1 populate Dclass as d1-d2, etc to the bottom of the lake.

Sort the data table on transect ascending and select all of the west records and populate the Basin field with "west", switch the selection and populate the Basin field with "east", assuming only two basins. Ensure no records are selected and calculate the absdepth (accounts for the depth of the sounder unit as well, normally + 1m) field to depth * -1. This will make all depth values positive. It is the field we will use later to create a 3d shapefile.

Clipping Boat Tracks by Contour Depth Polygons

In order to calculate fish/m^2 we need to determine distance traveled over each depth. To accomplish this task we are going to clip the boat transects with each of the previously created depth polygons.
Start ArcMap.
Load the boat transects and some or all of the contour polygons i.e. m26, m27 etc.
Use ArcMap toolbox select Analysis Tools, Extract, Clip .
Input features equals the feature to clip i.e. boat tracks, Clip features equates to one of the depth polygons and output means output.
The output can be saved as a shapefile boattrackclippedm26.shp or possibly back into the personal geodatabase kallie at the root level not into the feature dataset dog, again because of "Locked by another user problem".
You want to add the clipped data back into ArcMap.

Open the attribute table of the clipped tracks and look for the length field, if it exists good, right click on that field and choose Statistics put the Sum of Length into a spreadsheet for that depth see the table 1.
If it is not there use Hawth's Analysis Tools, Table Tools to add the length field to the attribute table and proceed with the Statistics part. Continue until all the boat tracks have been clipped by all depth polygons and you have recorded the total length of tracks clipped by each depth polygon see table 1.

The next set of steps are data base manipulations and need to be done in both Excel and ArcMap. I have noticed problems when trying to create 3d shapefiles of fish from an existing 2d shapefile of fish. So I developed this work around to solve this problem.
Import the projected fish data table ???????.dbf into Excel.
Export the data table as a new dbf version 4 file with a new name, i.e. h_fishxy.dbf (8.3 filename limit applies to dbf 4 files). One can also save as a .csv file if one encounters problems with the dbf version 4 format dropping columns. I have experienced this, but only occasionally.
Start a new ArcMap session and turn on the 3D Analyst extension and 3D Analyst toolbar.
Load in the h_fishxy.dbf table and click Tools, AddXY Data, Use the XUTM and YUTM as the X,Y positions, set the projection information, i.e. UTM Zone13 NAD83CSRS98 in Saskatchewan, or import that information from the original 2d shapefile.
Click Okay and the data should appear in ArcMap's table of contents as an Event Layer.

We are now going to use 3d Analyst to create a 3d shapefile based on the absdepth field.
Click the 3D Analyst drop down, choose Convert, Features to 3D.
Input is the h_fishxy Events dataset,
Select input feature attribute to absdepth,
Output name and location is your choice. You should now have created a 3D shapefile of the hydro-acoustically sampled fish.

Creating a 3D Scene and Swim Through of Fish Data

Make sure ArcMap and ArcCatalog are closed.
Start ArcScene.
Load in the DEM grid data.
Right click on the layer and choose properties.
Click Base Height tab, Click Obtain heights for layer from surface.
Z unit conversion is set to a +10x (This value is the vertical exaggeration control, 10-15x works good for most projects I do on lake where depths are less then 30m, > 30m use 3-5x).
Click Okay and you should see the lake surface sink in the center.
Click Symbology and select a colour ramp you like (I like the green to blue with blue at the deepest part).
Click, Display and change Resample to Cubic Convolution (This gives the best i.e. smoothest shading of the surface).
Navigate around and have a look at your lake DEM.
Now add the 3D fish (Once loaded they should be sitting on the surface floating slightly over or level with the lakes DEM edge.
Right click the 3d fish layer, Properties, Base Height (If all is correct you should see "Layer features have Z Values. Use them for heights" clicked. If all is not correct then an error was made in creating the 3d shapefile, try again and consult Help docs on creating 3D shapefiles.

Adjust Z Unit Conversion to 10x to match the DEM exaggeration (watch the result). You should see the fish jump up and not down. Change the Z value to read –10x to put the fish in the lake.

> Note, The -10 is the trick ESRI never anticipated that a person would have – elevation values so if you try and use the true depth value for the fish i.e. –10.2 it will not work. So I came up with using the absolute depth value field for the 3d fish and then modify this variable to –10 or –20 exaggeration and viola the fish sink into the lake. ArcScene can deal with – grid values i.e. –10, -10.2 your DEM sank, but 3D shapefiles that uses a negative value field will fail to sink.

Click Symbology, Quantities, Graduated Symbols and the field Length to create proportional symbols based on Length.
Adjust he numbers and number of classes to make sense to you i.e. one class for us was Fish > 70cm. You have the ability to have 3D symbols represent different fish classes.
Right click on one of the symbol classes i.e. >70, select Properties, Click more Symbols and select 3D Basic, change Category to 3D Geometric Primitives and select a symbol i.e. red cube set size at 8 to 12 and close all of the windows to see the results. You can now swim around using the fly tools to view your data.
You also have the option of choosing a font symbol to present as 3D (ESRI Environmental fonts has fish). Ron Hlasny developed our fish symbols of Lake Trout, Lake Trout with LT as text in the body of the fish, Lake Whitefish, Cisco using Corel Draw. The Corel Draw vector graphic was exported to a True Type Font for each fish. Copy those new fonts to C:\WINDOWS\Fonts or use Start, Setting, Control Panel, Fonts, File, Install to install a new font, navigate to new font select and install.

> Note, to swim around your data requires a lot of horse power and a reasonable graphics card. If it switches to a wire frame display during the swim it is indicating that there is not enough horse power available. Only option is to switch to another machine. Our (SE) swim throughs are compiled on a dual 2.5 machine, 1.5 gig ram using a GForce video card with 128 or 256 megs of vram to give you some perspective. Compile time is usually several hours for a 5-8 minute movie.

To add extra enhancements to the 3D document load the following data set,
Polygon depth that represents the thermo-cline, modify Base Height to –10x or proper Z factor, set Use a constant value to i.e. –16m or the depth of polygon, Display, Transparency to 50 present, set the Symbol to light blue fill and out line to a bright colour so it stands out.
Lake surface polygon, modify Base Height to –10x or proper Z factor, set Use a constant value to i.e. 0 or depth of polygon Display Transparency to 50 present, set the symbol to light grey fill and out line to a bright colour so it stands out.
Boat transects, make same colour i.e. dashed black 1 pts wide no Base Height adjustment is require since they are at the surface.
Random fish (creating is detailed further down) can also be added using the same technique for creating the 3D data of hydro-acoustic fish. Load the random fish data set click Symbology, Quantities, Graduated Symbols and the field Length to create proportional symbols based on Length. Adjust the numbers and number of classes to make sense to you i.e. one class for us was Fish > 70cm. You have the ability to have 3D symbols represent different fish classes. Right click on one of the symbol classes i.e. >70, select Properties, Click more Symbols and select 3D Basic, change Category to 3D Geometric Primitives and select a symbol i.e. black cube set size at 8-12 and close all of the windows to see the results.

When dealing with so many 3D point locations 10-15,000 random fish the simpler the 3D symbol the better or the system becomes unresponsive and movies can't be made. One solution for this is to only load a few groups of Random Fish or keep 3D views so you only see a few Random Fish.

Adding Dissolved O2 and Temp Profiles

Dissolved O^2 and Temperature profiles can be added to ArcScene using this logic. The data table needs to have three positional columns plus the temperature and DO^2 values, i.e. UTMX, UTMY, Depth of Sample (remember absolute depth or it will not work), Dissolved O^2 or Temperature as your display value.

Load the table into ArcMap create the Event Layer then the 3D layer. Load into ArcScene and Base Height should be set (since it's a 3D shapefile) set Z exaggeration to -10x. Adjust the Symbol to 3D Geometric Primitives select Cylinders and adjust Symbology, Quantities, Graduated Colours and use the DO^2 field to set that. Change to an appropriate colour ramp, lastly adjust symbol size to get the cylinders to join top to bottom see figure 9.

Creating the Swim Through Movie

You can now start swimming through your data and recording various swims. Save multiple swim paths and pick one of them to create your movie. Use ArcScene help to guide you through this process, it is very straight forward. I have found that it is nice to have the table of contents showing so that viewers can see the legend and identify those values as the movie plays.

Creating the Population Estimate Table of Fish Based on the Hydro-acoustic Sample

To create a random population of fish we first need to know how many fish we estimate to be in the lake based on the hydro-acoustic sample. I used two approaches to achieve the same number estimate as a back check to my logic using area of polygons. Ron used volume estimates to get similar values. The following table Table 1: Crean Lakes Population Estimate based on area i.e. fish/m^2

A	B	C	D	E	F	G	H	I	J	K	L	M	N
Hydro Track	Sum Track Length (m)	Down Looker Cone Angle (degrees)	1/2 Cone Angle (degrees)	Depth (m)	Cone Width at Depth (m)	Area Sampled (m^2)	Depth Polyon Area (m^2)	Percent of Area Sampled	Sampled Number of Fish in Depth Class	Estimated Number of Fish in Depth Class % Based	Fish Density/m^2 Sampled	Estimated Number of Fish in Depth Class Density Based	Depth (m)
transect_clip2	52899	15	7.5	2	0.5	27857	104542301	0.026646766		0		0	2
transect_clip3	52899	15	7.5	3	0.8	41786	98508797	0.042418255	2	4715	0.00004786	4715	3
transect_clip4	52899	15	7.5	4	1.1	55714	92710739	0.060094747		0	0.00000000	0	4
transect_clip5	52899	15	7.5	5	1.3	69643	82664044	0.084248062	3	3561	0.00004308	3561	5
transect_clip6	52899	15	7.5	6	1.6	83571	82664044	0.101097674	3	2967	0.00003590	2967	6
transect_clip7	52834	15	7.5	7	1.8	97380	78167499	0.124578877	8	6422	0.00008215	6422	7
transect_clip8	52778	15	7.5	8	2.1	111174	73476898	0.151304276	8	5287	0.00007196	5287	8
transect_clip9	52626	15	7.5	9	2.4	124710	68665396	0.181620155	7	3854	0.00005613	3854	9
transect_clip10	52399	15	7.5	10	2.6	137969	63416176	0.217561503	13	5975	0.00009422	5975	10
transect_clip11	52182	15	7.5	11	2.9	151138	57292665	0.263799202	26	9856	0.00017203	9856	11
transect_clip12	51764	15	7.5	12	3.2	163557	51390366	0.318263225	20	6284	0.00012228	6284	12
transect_clip13	51257	15	7.5	13	3.4	175451	47546471	0.369009329	24	6504	0.00013679	6504	13
transect_clip14	50449	15	7.5	14	3.7	185969	44309716	0.419701701	22	5242	0.00011830	5242	14
transect_clip15	49583	15	7.5	15	3.9	195832	41449832	0.472454933	31	6561	0.00015830	6561	15
transect_clip16	48643	15	7.5	16	4.2	204927	38538605	0.531745028	72	13540	0.00035134	13540	16
transect_clip17	47726	15	7.5	17	4.5	213630	35595599	0.600159591	108	17995	0.00050555	17995	17
transect_clip18	46158	15	7.5	18	4.7	218765	32794511	0.66707924	237	35528	0.00108335	35528	18
transect_clip19	43946	15	7.5	19	5.0	219853	30001968	0.732794679	315	42986	0.00143278	42986	19
transect_clip20	40303	15	7.5	20	5.3	212240	26994102	0.78624443	383	48713	0.00180456	48713	20
transect_clip21	36289	15	7.5	21	5.5	200657	23722880	0.845835645	205	24236	0.00102165	24236	21
transect_clip22	32098	15	7.5	22	5.8	185934	20500109	0.906992245	89	9813	0.00047866	9813	22
transect_clip23	27895	15	7.5	23	6.1	168933	16404793	1.029775483	12	1165	0.00007103	1165	23
transect_clip24	20526	15	7.5	24	6.3	129710	11158890	1.162394876	1	86	0.00000771	86	24
transect_clip25	9359	15	7.5	25	6.6	61607	5168107	1.192057081	1	84	0.00001623	84	25
transect_clip26	5017	15	7.5	26	6.8	34346	2480724	1.384516226		0	0.00000000	0	26
transect_clip27	975	15	7.5	27	7.1	6932	6666668	0.103972537		0	0.00000000	0	27
								Total Estimated Population		261376			

The first field is the shapefile name of the clipped hydro tracks by depth polygon. Sum Track is the sum of the length of All tracks the cover a particular depth polygon, Cone Angle is the transducers cone angle 15^0, ½ Cone angle 7.5^0, Depth is water depth in metres, Cone Width at depth is how wide the cone is at a particular depth formula is =(TAN(D2*PI()/180)*E2)*2

Note, Excel quirk we need to convert to Radians first before Tan is executed.

Sampled Area is track length * cone width at depth, Depth Polygon Area is the total area of the polygon at depth (Read from the area column in the attribute table of each depth polygon), Percent of Area Sample between sampled area and Total Polygon Area (=(G2/H2)*100), Sampled Number of Fish in Depth classes comes from the hydro-acoustic data (we observed 12 fish between 11-12 meters), Estimated Number of Fish in Depth Class % Based (=(J3/(I3/100))), Fish Density/m^2 is Observed Fish / Sampled Area (=J3/G3), Estimated Fish Number of Fish in Depth Class Density Based (=L3*H3), Depth in metres.

Based on the fish density/m^2 at 1 meter intervals we can make a population estimate of 261,378 fish are present in Crean Lake during the summer of 2004. Now we need create a randomly allocated 261,376 fish shapefile and convert it to a 3D shapefile then incorporate that data into the ArcScene of Crean Lake.

Creating the Size Class Distribution for Random Fish Based on Hydro-acoustic Samples

The following is a convoluted process but it will give you a 3d shapefile of randomly allocated fish by depth and size class that can be placed in the lake. If reading know of a better or improved method please email me to discuss.

Load the Fish table with the following fields into Excel FishDepth, Length cm or in, Depth Classes by 1m increments.
Click Tools Addins and turn on the Analysis ToolPack
The following is an example data table

DEPTH_M	LENGTH_IN	LENGTH_CM	d_class
-10.69	7.97	20.25	d10-11
-10.20	9.87	25.06	d10-11
-10.89	9.60	24.38	d10-11
-10.38	2.55	6.49	d10-11
-10.64	3.21	8.16	d10-11
-10.17	2.75	6.97	d10-11
-10.03	2.08	5.29	d10-11
-10.38	3.03	7.69	d10-11
-10.91	2.69	6.84	d10-11
-10.53	2.57	6.52	d10-11
-10.88	2.43	6.18	d10-11
-10.48	2.14	5.43	d10-11
-10.39	2.06	5.23	d10-11
-11.06	10.02	25.46	d11-12
-11.61	7.34	18.65	d11-12
-11.39	7.29	18.52	d11-12
-11.95	5.93	15.06	d11-12

Table 2: Example required data fields

We are now going to create histograms of Each Depth Class by Length, which we will use to create the ramped up population.
Sort the data table by depth class descending or ascending it does not matter. What we are doing is grouping all of the sampled fish based on depth.

Copy the sorted data to a new worksheet delete all of the columns except, d_class and length cm or in. Move data around so it looks like the flowing table and add a Bin field that covers the complete size class distribution i.e. 2cm to 86cms.

d21-22	d22-23	d23-24	d24-25	d25-26	d26-27	Bin
85.92	73.24	38.25	7.35	5.50		2.00
68.99	61.69	35.46				4.00
66.46	59.48	33.37				6.00
61.49	55.16	32.24				8.00
60.94	49.27	28.31				10.00
60.42	48.93	26.27				12.00
58.49	47.57	15.14				14.00
57.22	47.54	12.94				16.00
57.13	45.49	6.53				18.00
54.99	44.59	6.43				20.00
54.96	42.65	6.04				22.00
54.96	42.60	4.99				24.00
54.69	42.39					26.00
54.68	41.84					28.00
54.08	41.80					30.00
53.61	41.13					32.00
51.86	40.59					34.00
51.60	40.20					36.00
51.47	39.02					38.00
51.26	38.74					40.00
50.98	38.10					42.00
50.31	37.76					44.00
50.25	37.49					46.00
49.95	37.17					48.00
49.37	36.86					50.00
49.35	36.68					52.00
49.12	35.72					54.00
49.12	35.12					56.00
48.69	34.12					58.00
47.77	33.79					60.00
47.25	33.11					62.00
46.67	32.67					64.00
46.37	31.86					66.00
46.12	31.25					68.00
45.64	30.47					70.00
45.46	30.43					72.00
45.35	30.21					74.00
45.32	30.17					76.00
45.19	29.91					78.00
44.54	29.44					80.00

44.11	29.13	82.00
43.81	28.37	84.00
43.73	27.97	86.00

Table 3: Subset of the Fish length by depth class worksheet.

I just cut and pasted each set of depth class data into a new a column and added a Bin column in 2cm size classes at the end.

We need to create a histogram of size classes for each depth class so that the proportions of size classes observed can be scaled up in the random population.
To create a histogram in Excel click Tool, Data Analysis, Histogram and Okay
For input range choose one depth class i.e. 23-24 and select all of the cells below it including the column title, bin range is the bin of size classes, click labels, select New Worksheet and call it the depth class i.e. d23-24 and select Chart Output, and lastly Okay. It should produce a similar result as seen in figure 1.

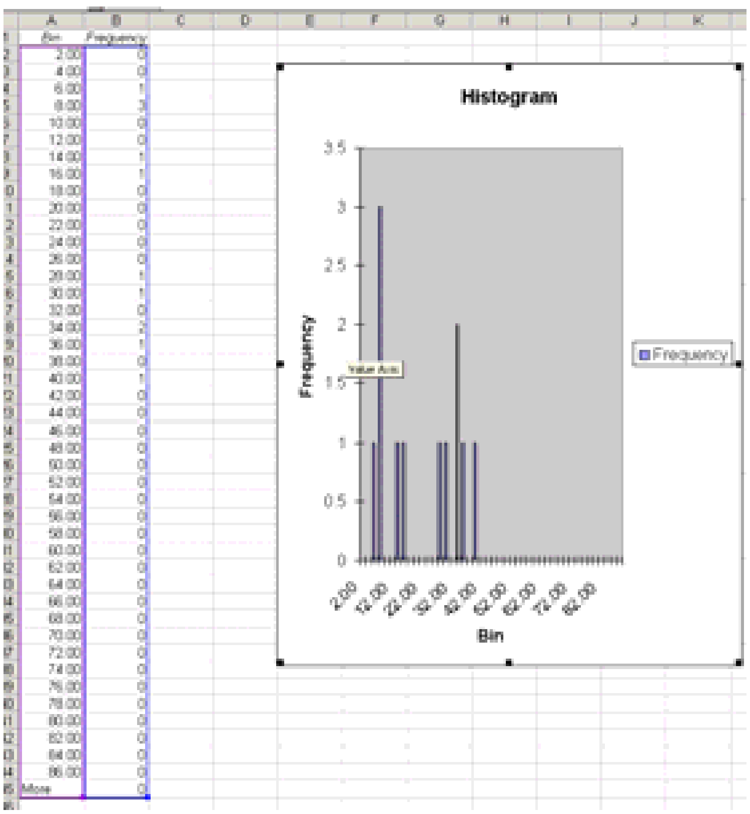

Figure 1: Histogram of 23-24m depth class.

Now in Cell C1 use this formula (=SUM(B3:B46) which is sum of the frequency values, in cell D1 put in the estimated population value calculated previously i.e. 1165 which is the estimated population for d23-24m class. Now we need to calculate the percent that each size class appears in the sample so in cell C3 place this formula (=(B3/C1).

> Note, this uses a locked cell reference C1 so the cell C1 is always referenced in the formula.

Copy this formula down to the bottom i.e. C46. In cell D3 we will estimate the number of fish by size class using the formula (=(C3)*D1), which is basically using the percentage observed and multiplying it by the estimated total number fish in the 23-24m depth class. The following figure 2 is a graphic of the completed worksheet.

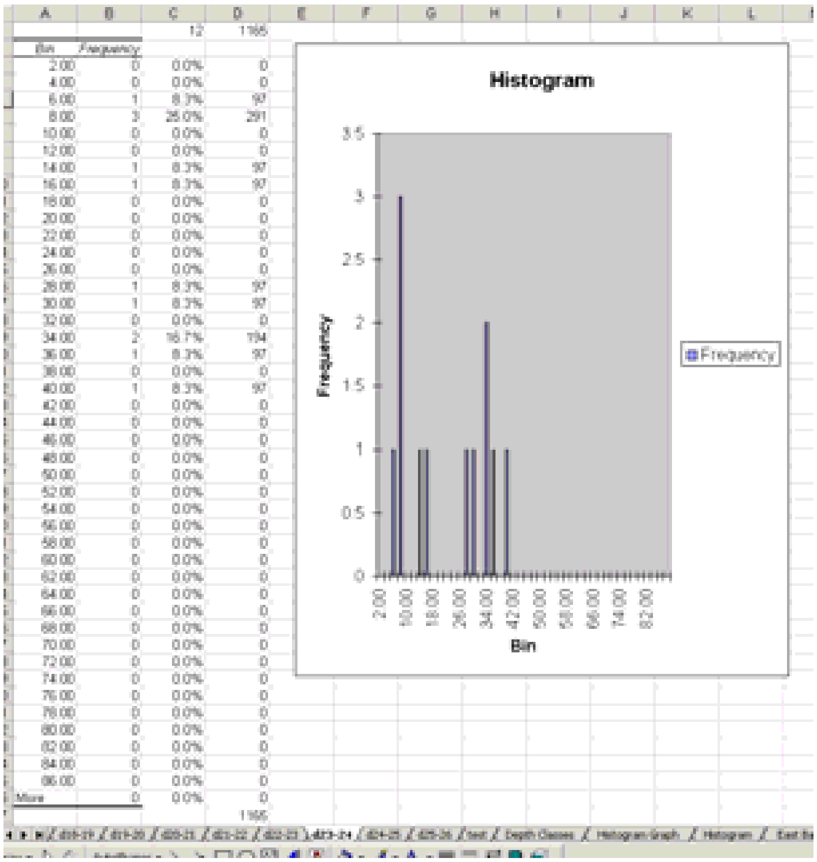

Figure 2: Calculating size class distribution for the 23-24m depth class.

We use the results in column D to define the size class proportions of the randomly allocated fish.

Creating Randomly Allocated Fish in the ArcMap

We create the random fish by using the Hawth's Analysis extension for ArcMap and the lake depth polygons.
Start ArcMap, and activate the Hawth's Analysis toolbar.
Load into ArcMap 3 to 5 of the depth lake polygons.
If more than one polygon exists in a depth zone like the example select the two largest polygons (highlighted blue) or all polygon of interest to you.
Click Analysis Tools, Generate Random Points.

> Note, if more than one polygon exists you will want to allocate a proportion of fish to each polygon. In the example two polygons are selected so we need to divide the total number of random fish 1165 by 2. Therefore 582 fish will be allocated to each selected polygon.

Click Polygon Layers, check Use Selected Only, click Generate this number points/polygon and select Polygon unique field (i.e. Fid) lastly, Output location and filename see figure 3. Click Okay and the program will generate those points see figure 4.
Click Analysis Tools, Table Tools, AddXY to Table to add the X,Y positions of each fish to the data table.

Figure 3: Hawth's Analysis Generate Random Points Dialogue.

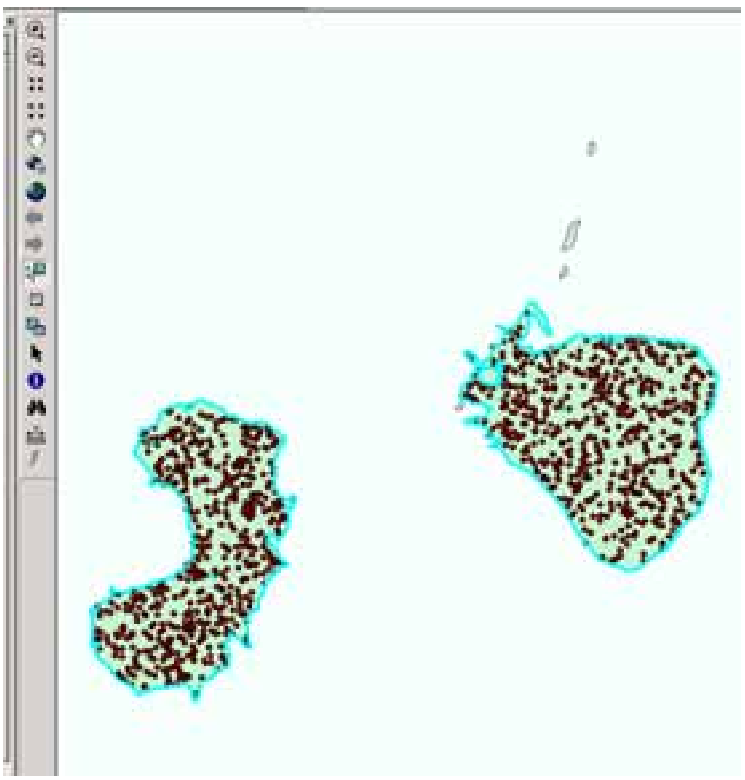

Figure 4: 582 Randomly allocated fish per polygon.

Open the attribute table of the random fish, and add four new fields to carry length values, a basin identifier, bottom depth value and depth class identifier. Options, Add Field, Name "lengthcm", Type is Long Integer, set precision 10 and scale 3, Okay to add the field. Options, Add Field, Name “basin”, Type is text 10 wide, Okay to add the field. Options, Add Field, Name “b_depth”, Type is long integer 6 set precision 10, Okay to add the field. Options, Add Field, Name “d_class”, Type is text 6 wide, Okay to add the field.

Select all of the points in the east basin and calculate the basin field to “east” and the b_depth equal to the bottom limit i.e. –24 switch the selection and calculate the basin field to “west” and the b_depth equal to the bottom limit i.e. –24

In the next set of steps we are going to use the estimated fish numbers per size class developed above using the histogram from the 23-23m depth class to assign sizes to each fish in each basin.
So from the spreadsheet histogram for d23-24 how many fish were in the 6cm size class (97). We will now select 97/2=48.5 48 records from the east basin and calculate the lenghtcm field to 6, scroll down to the west basin records and select 49 records and calculate lengthcm to 6 see figure 5.

> Note, if you notice as you select consecutive records they show up as random positions even though they are consecutive records.

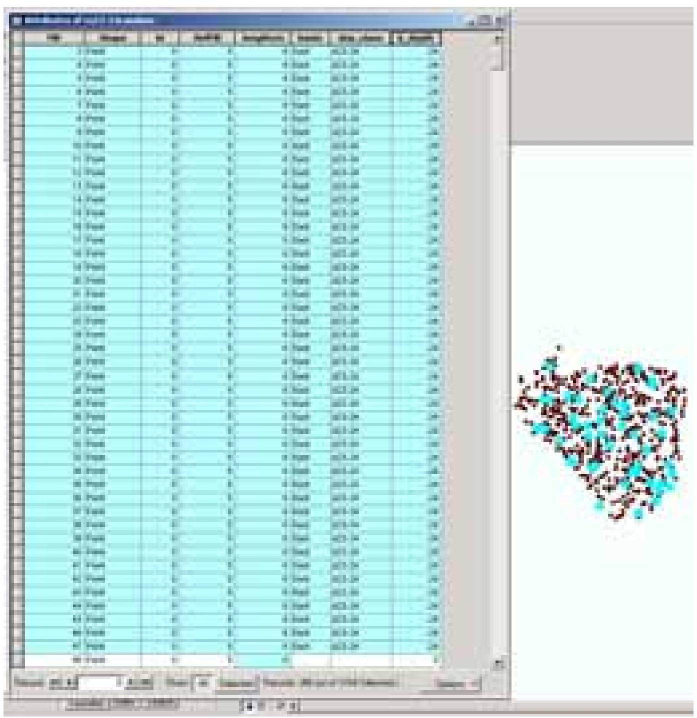

Figure 5: Size class 6, east basin, depth class 23-24.

This process was continued for all depth polygons i.e. -2 to -27 for Crean Lake. It was a time consuming and mindless process but well worth the result. You end up with a one shapefile for each depth class i.e. d23-24 of random fish in various size classes based on the hydro-acoustic data.

Once completed it’s a good idea to merge some of the shapefiles together. It will make the following process less time consuming. Remember that Excel has a 65,565 record limit and we have 261,376 fish records so when appending shapefile together keep below the 65000 record limit. Therefore, we can merge shapefiles -2 to -16 together, -17 stands alone, -18 and –19, then -20 to -27.

Start ArcMap, load in all of the random fish shapefiles, click Edit GeoTools 9.1 choose Geo-processing then Merge Layers. Select a base layer, select the layers to merge together and output file name finally, click Finish to merge the data see Figure 6.

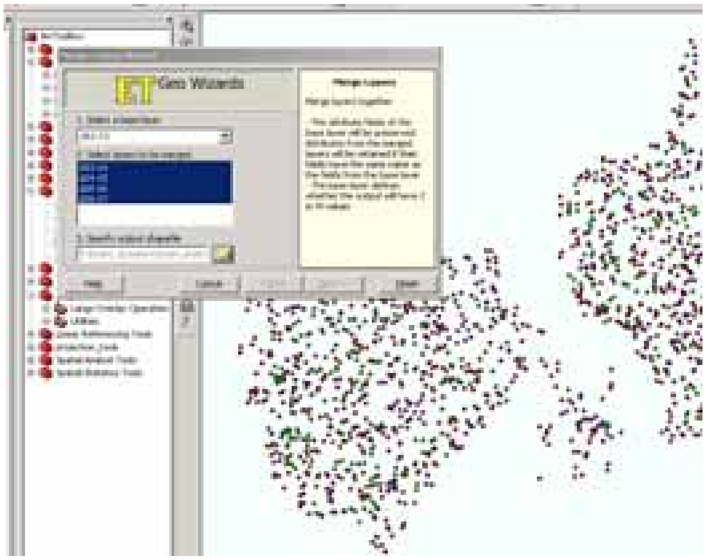

Figure 6: Merge of random fish shapefiles.

Adding the Random Depth Value to Fish

At this point we need to randomize the fish wrt depth. In the data table we have a field called b_depth which contains the bottom depth of each depth class i.e. for d23-24 b_depth = -24. We use that field and value to randomly allocate those fish in the 23-24 depth class between -23 and -24 metres.
Use Excel to Open one of the merged shapefile .dbf file.
Save the data set as random_fish20_27.xls
Add a new column title to called rfish_d (Random Fish Depth) and it gets the formula (=RAND()*(ABS(F2)+-23)-24).
RAND() is Excel random number function used with values for a upper and lower bound. It produces a random number between two other number, i.e. -23 to -24. Copy this formula down to cover all of the d23-24 records see figure 7.
Since this spreadsheet contains Random Fish between –20 and –27 you have to repeat the above for each of the depth classes i.e. d20-21, d21-22, … d26-27 and modify the values in the formula to reflect the different top and bottom depth values per depth class. Save the spread sheet. Now repeat the process for the remaining appended shapefiles.

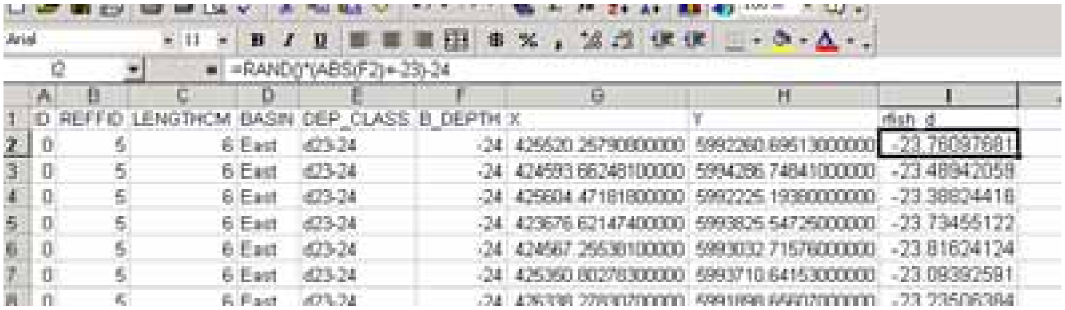

Figure 7: Calculate random depths between two values.

We have now completed the random fish data tables. It contains the correct number of randomly allocated fish by depth class, size class and position in X,Y,Z based on the hydro-acoustic sample data.

The last process is to bring in the random fish data tables into ArcMap, create event layers for each of them, append them all together, then create a 2d shapefile based on XUTM, YUTM then a 3d shapefile based on rfish_d using 3D Analyst.
Open the random fish data table with Excel, select Cell A1 and export the table to a CSV (MSDOS) text format, it is one of Excels export options. Close Excel, this avoids data locks between ArcMap and Excel.
Start ArcMap, and active the 3D Analyst Extension.
Load in each of the exported data tables from Excel, select Tools AddXY data and select XUTM as the X field, YUTM as the Y field and set the projection by importing the projection information from the original contours data (it should have a projection associated with it). Do the above for all of the imported data tables.
Use Edit GeoTools 9.1 to append the Event layers together into one very large point shapefile containing all 261,376 random fish.

The new appended shapefile should be added to ArcMap. Open the attribute table, click Options and add a New field call abs_depth, that is float with a precision of 10 and scale of 3. Calculate this new field to rfish_d * -1 to make all of the depth values positive.

Click 3D Analyst, Convert, Features to 3D, click Input feature attribute and select abs_depth, define the output location and name and Okay to convert the 2D shapefile to a 3D shapefile see figure 8.

Figure 8: Convert points from 2D to 3D.

Utilizing the Random Fish in ArcScene

The previously create 3D shapefile of random fish X,Y,Z can now be loaded into ArcScene. Remember to change the Z exaggeration value under Base Height tab to –10 to sink the fish into the lake. You can also symbolize the random fish by size classes since that was the whole point of this exercise to create a Random Fish population by size class in X,Y,Z directions. The final result can be scene in figure 9 and associated movie files.

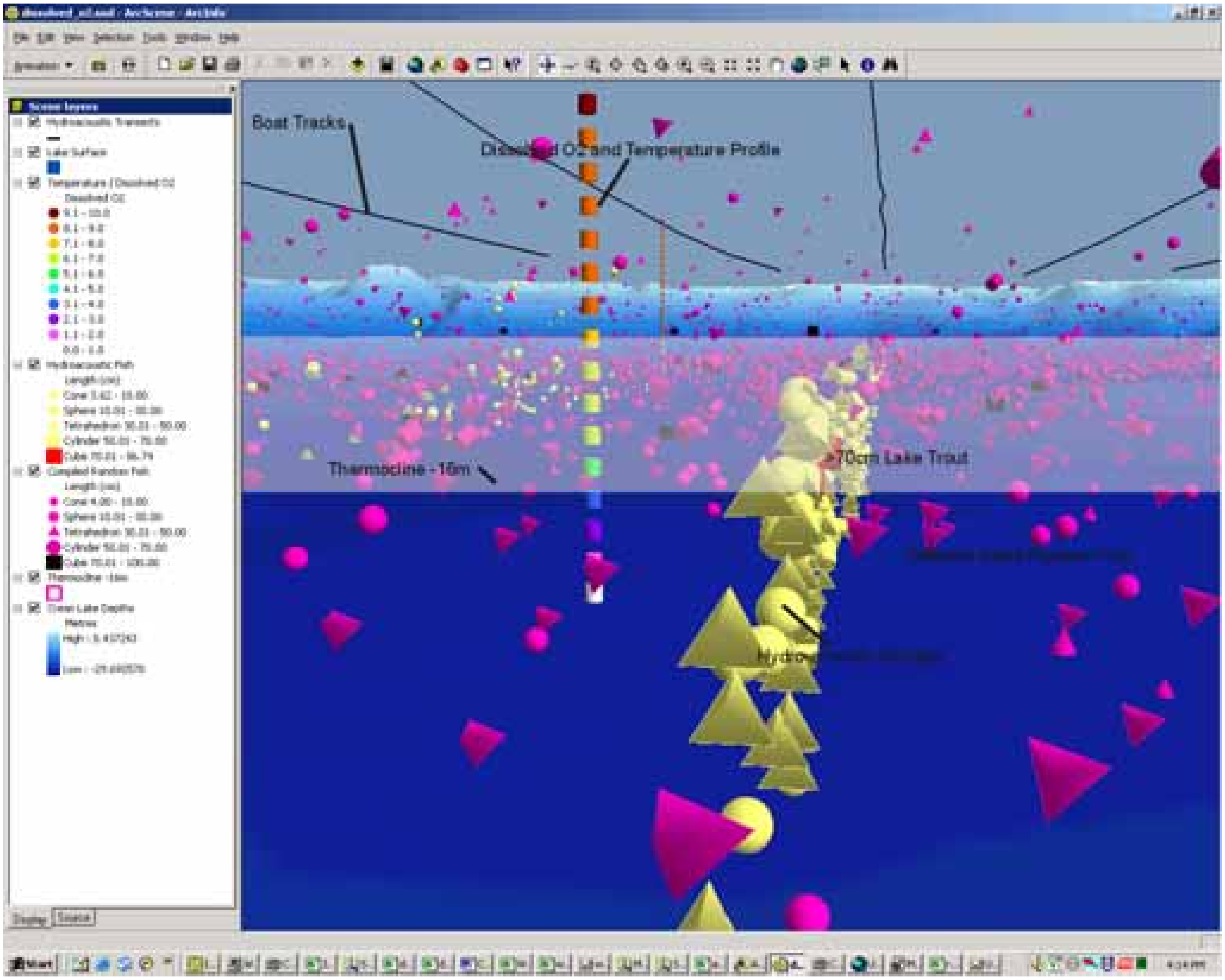

Figure 9: Random fish by size class, hydro-acoustic boat tracks, hydro-acoustic sample, Crean Lake DEM, -16m Thermo-cline and Lake Surface.

Creating Continuous Surfaces so Images can be Draped over the Land

Creating the continuous elevation surface to act as a base height source

The following describes a technique for creating a surface to drape images over. Part 2 covers the image creation that is draped of part1 surface but the lake area is clear / hollow / nodata so that lake depths and 3d fish are visible figure 10.

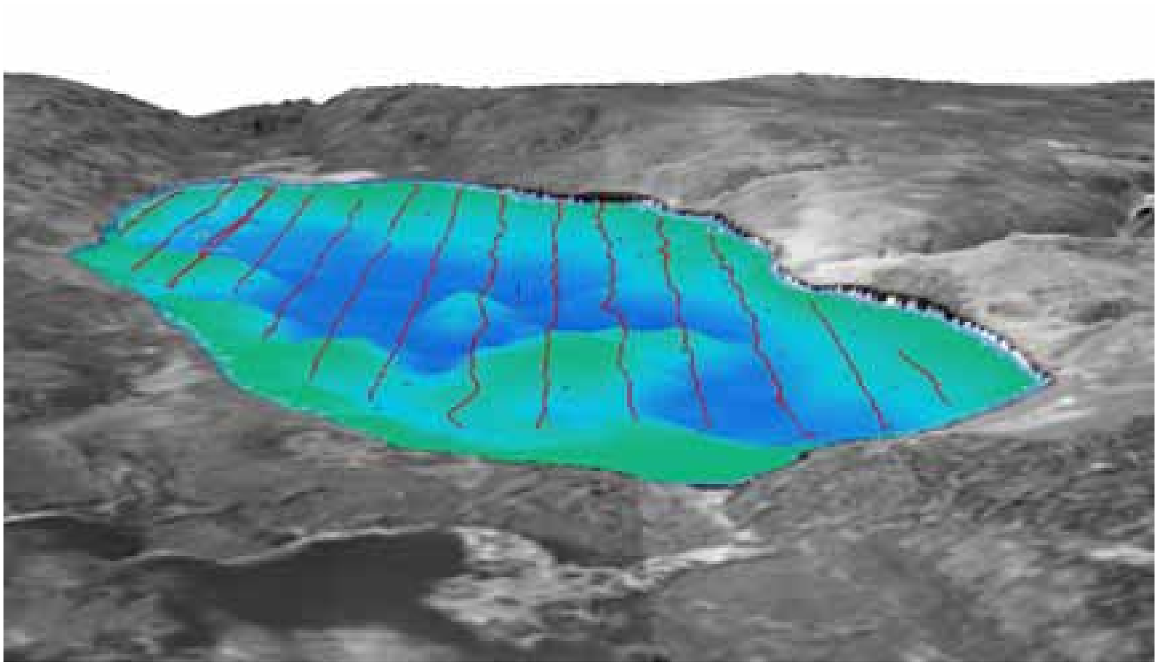

Figure 10: Ortho images draped of Wassegam Lake, Prince Albert National Park, 2006 5x vertical exaggeration.

To accomplish the following you will need these tools, ESRI ArcMap, ArcScene and Spatial Analyst or other tools like Surfer, Manifold GIS to create the raster dems. You can also use tins but I have not documented that process here.

The first step in this process is to create merge dem of the lake and a dem of the surrounding area. Previously you created a good dem (10m) cells for the lake and 30m or 75m dem for the land surrounding the lake. Normally I use ortho photo dem points to create the land dem (20m) figure 26, but if that does not exists Shuttle Radar Data (SRTM) works well at 75m, figure 27. For this process to work efficiently it is best to set your lake dem to true elevation values based on the lake surface elevation. This can be obtained from recorded surface elevations, SRTM data or gauging station data. So just add the true elevation value to starting X,Y point data before creating the lake dem or raster calculate it post lake dem creation. The following points outline the process to create a merged lake dem and surface dem.

Using ESRI Spatial Analyst you need to make the cells under the lake area equal to 0 or nodata for the SRTM or land dem. To do this task load the surface dem and the lake surface polygon and set the lake surface polygon to the analysis mask, figure 11.

Note, the figures are grouped together further down to make the process how to easier to understand since a picture is worth a thousand words.

Now do a raster calculation to make the cells under the lake polygon 0 by multiply the land dem by 0, figure 12.

It creates a new Calculation as a result with the lake cells = 0, figure 13.

For the next step to work properly you need to remove the analysis mask, otherwise you will just do the next raster calculation on the same area under the lake, not very helpful. Select Spatial Analyst, Option, Mask and reset to none.
Merge that data from 3 with the original land dem using raster calculator type merge([Calculation],[lake_land10m]), figure 14.

Now that the lake has a elevation value of 0 and all other cells are true elevation you can reclass the 0 values to nodata and make a hole for you lake dem.

Choose Spatial Analyst, Reclass to open the reclassification dialogue. Select the result from 4) in this case Calculation 2. Choose “Classifiy” and move the left most bar to the left close to the 0, to give you a class that can be set to nodata, figure 15. Lastly, delete the other classes figure 16 so they are not modified during the reclass process and then execute the reclass.

You now have a land dem ready to merge with your lake dem to create a continuous surface from the land to shore and down into the lake.

Remember to remove the analysis mask set, set the cell size to minimum of inputs, set analysis extent to the land dem so that processes occurs for the full data set.

Load in the lake dem and use the raster calculator to merge the two data sets together using Raster calculator, figure 17, merge([true_lake_dem10m], [Reclass of Calculation2]). Order matters, you want the land dem to be the last dataset see ArcMap help on merge for more information. Click Evaluate to create the new land lake surface, figure 18.
Verify that the surface is correct by changing the colour scheme, if correct save out the new data set to a permanent raster layer in a known location for use as a base height for image draping.

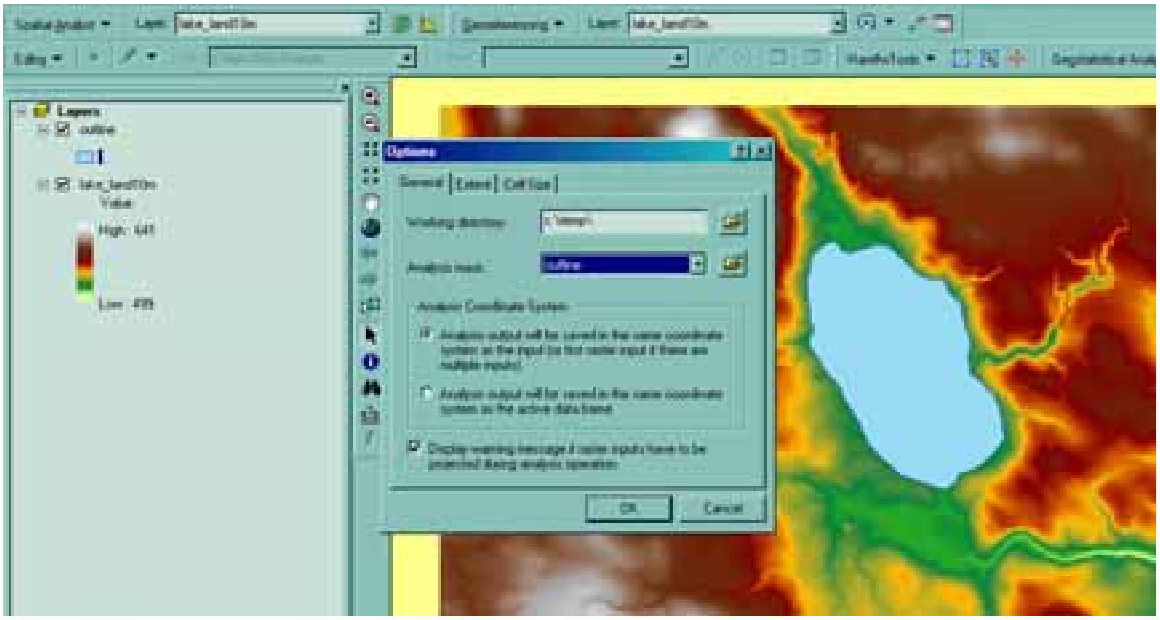

Figure 11: Analysis mask set to outline or the lake surface of the lake dem.

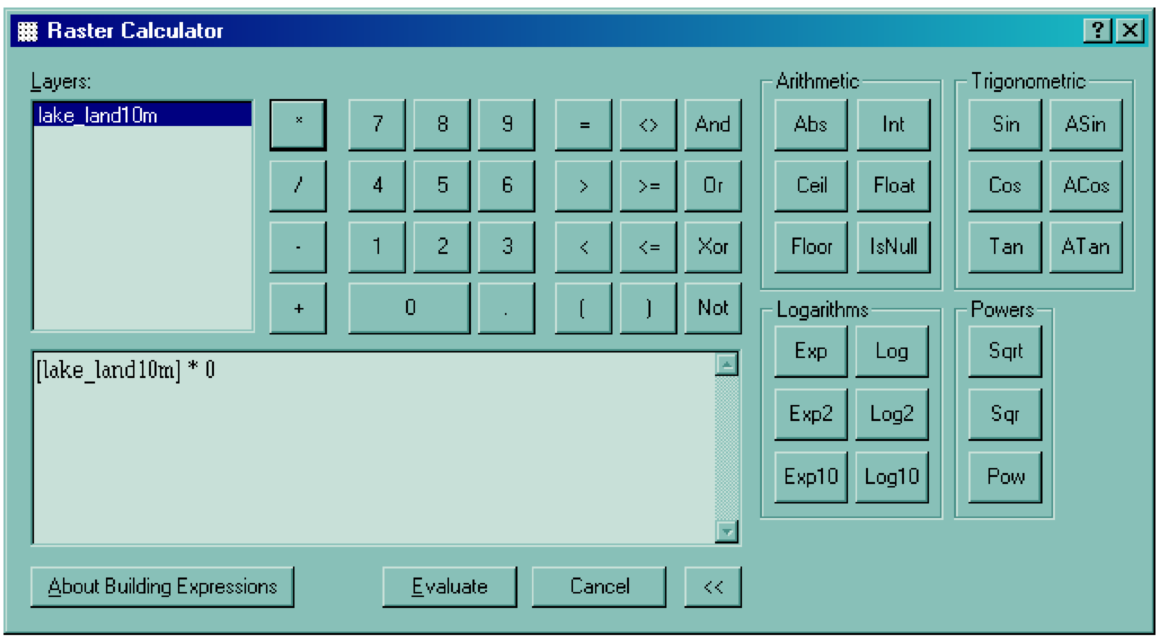

Figure 12: Raster calculation to make under lake cell = 0.

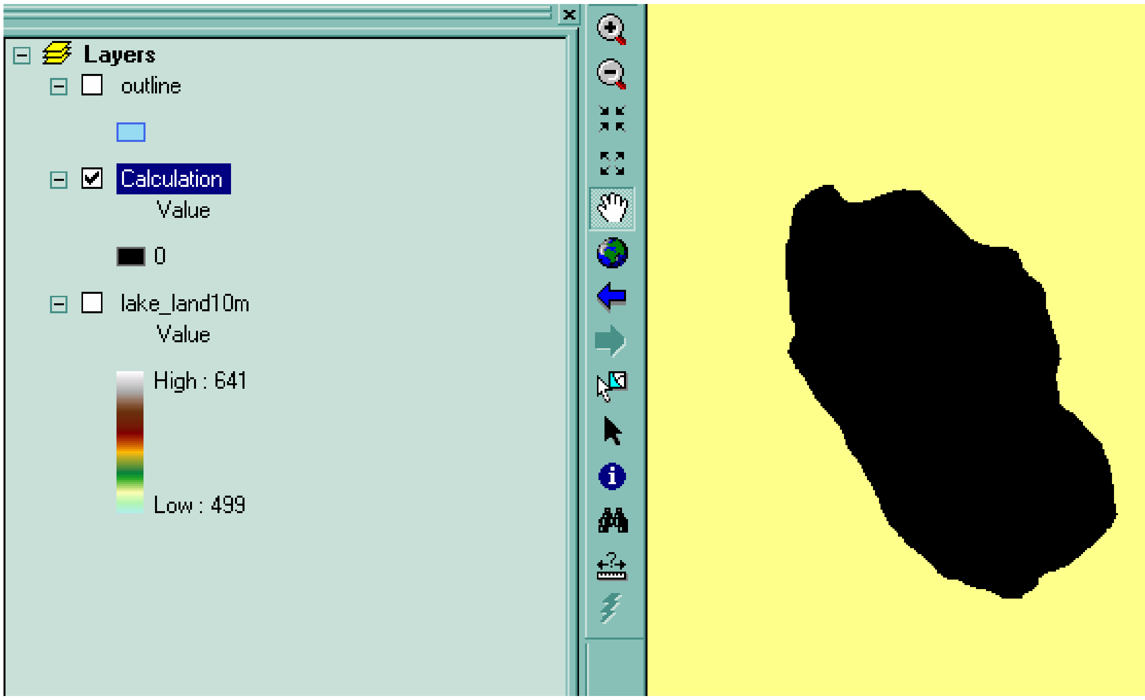

Figure 13: Calculation result cells under lake = 0.

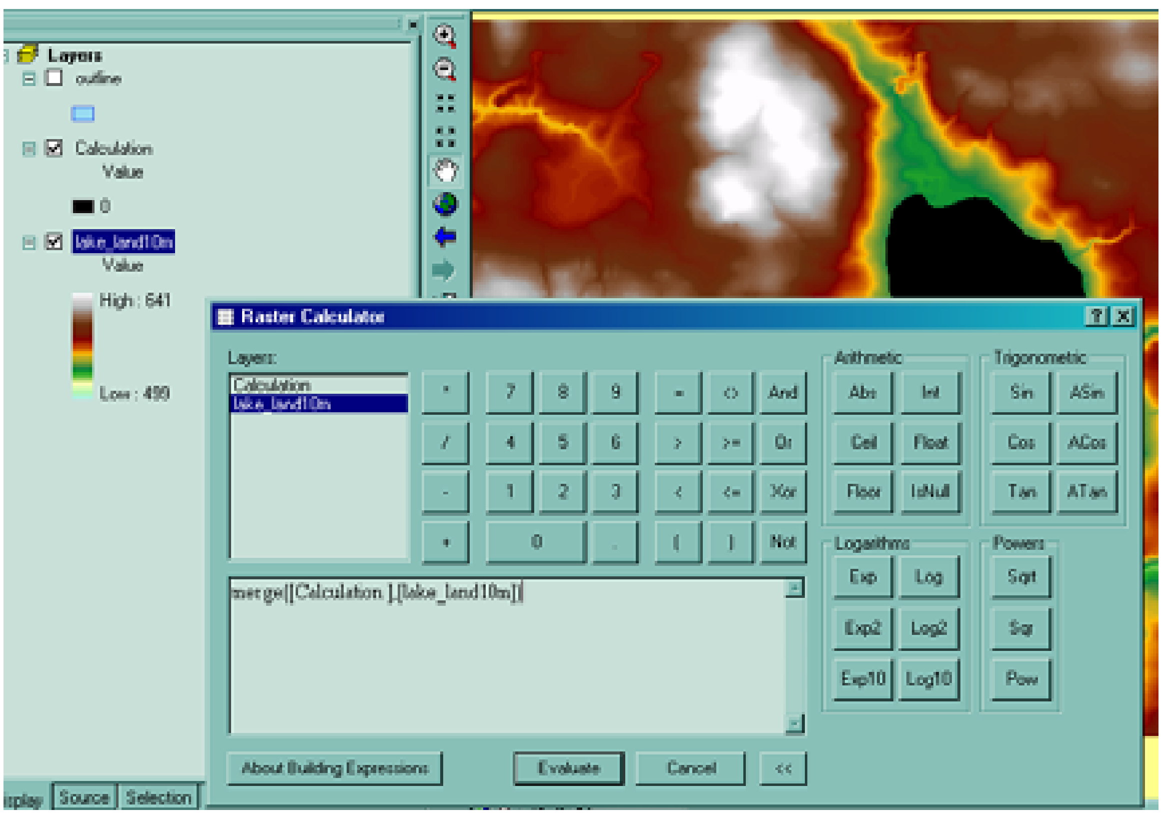

Figure 14: Merge land dem with 0 lake cells.

Figure 15: Adding a record to reclass ",s to nodata, using classify.

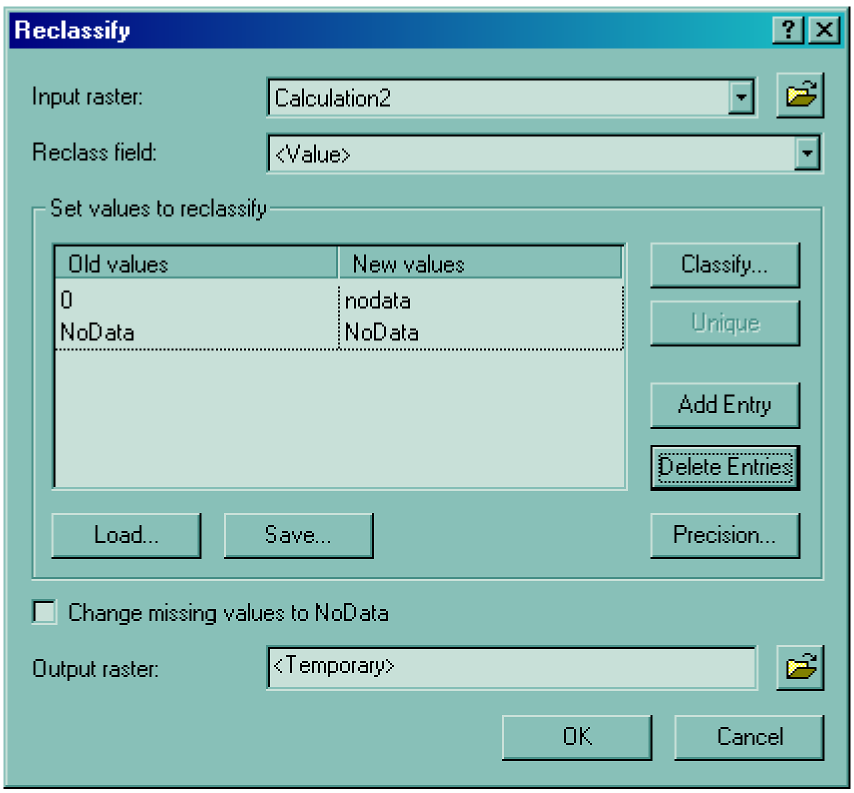

Figure 16: Deleting other classes so they are not reclassified.

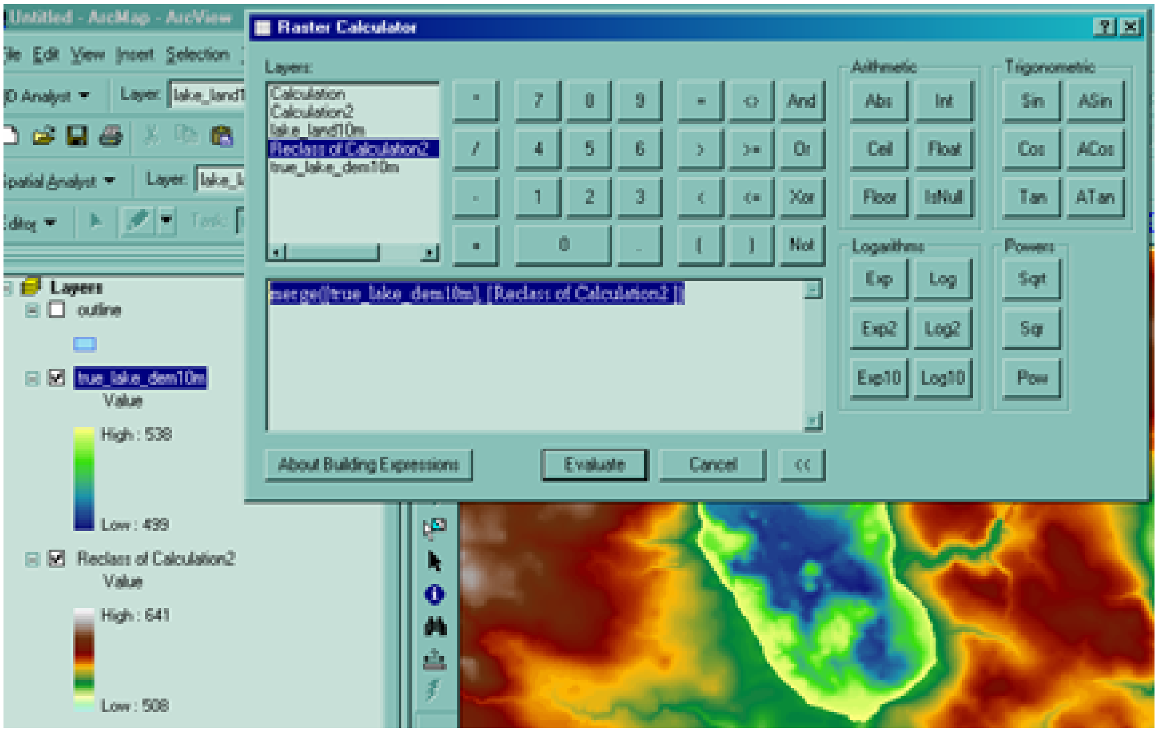

Figure 17: Merge land and lake dems together to create the final surface.

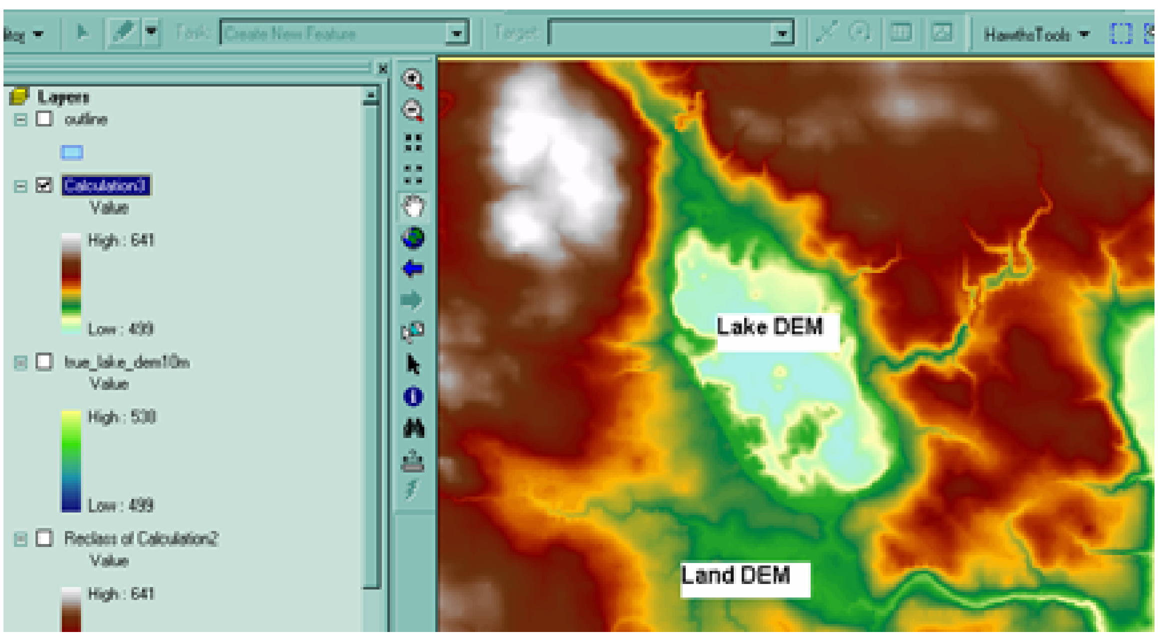

Figure 18: Lake and Land dem's merged with some edge at lake shore.

Process to Drape Images over the Land but Not over Lake Areas
The next set of tasks will incorporate images i.e. ortho photos, air photos, landsat, ikonos imagery as a drape over the land surface to add a strong sense of realism to 3D models built using the lake and land dem surfaces. The following example details the technique using ortho photos. The process is the same of multi-band imagery but, you must do the process for each of the channels separately. So if you have a 3 band ikonos image you would do it three times, once for each of the channel, making sure you label intermediary layers with the band number so the finished product can be recombined correctly.

Again we need to use Spatial Analyst and now 3D Analyst to create the 3d view with the drape.

Load the imagery into ArcMap and if the data is several images it is best to merge/mosaic them together. Use merge if the tiles are side by side i.e. orthophotos, use mosaic if they overlap like air photos, figure 19.
Merge the two orthophotos's together, merge([se_1341601.tif],[se_1342601.tif]), figure 20.
Reclass the merged data values of "0" to 1 since there will be other 0 values over the image and we don't want to loose those values, however we need to "0"'s as a nodata value during display. It is the same approach used in 5 above.
Set analysis mask to lake surface (outline) polygon so cells under it will be calculated to "0"
Use the raster calculate to make the pixels under the lake = 0, [merge_orthos] * 0, figure 21.

Reset analysis mask to none and cell size = minimum of inputs or equal to image data and spatial extent to merge images so whole area gets processed during next step.

Now merge the two data set together, the lake 0 raster and the merged image, merge([Calculation],[merge_orthos]), figure 22.
Check the resulting layer that the cells under the lake can be set to clear and that no other cells go clear when that is set. Right click the new layer, Properties, choose Symbology select stretched on the left, then select a white to black colour ramp at right and finally check mark "Display Background Value" box and make sure that "0" is in the box to the right of it, figure 22.
If the result looks like figure 23 with the with lake portion of the dem showing through you are done. Save out the data set as a finished product.

With the new image data ready we can incorporate it into a 3D scene as a drape over the land lake dem. The following outlines that process. I assume the user has used 3D Analyst before and understands the term base heights and how to use them.

Start ArcScene and load in the land lake dem, the lake dem, and ortho photos or other imagery you have manipulated above to start.
Set the base heights of the land lake dem and lake dem to use their own values and set vertical exaggeration to 5 as a start, figure 24.
To drape the imagery right click the image layer, select base heights, set base height to land lake dem, set vertical exaggeration to 5, raster resolution to 20m and the click rendering and set "Quality Enhancement" to medium to high, figure 25.
The imagery is now draped over the land lake dem but does not cover the lake depths. Save your session of ArcScene as this ends the tutorial.

Figures 26, 27 depict all of the information that can be added to a 3d model such as 3d fish, 3d nets, 3d water quality locations, 2d boat tracks etc.

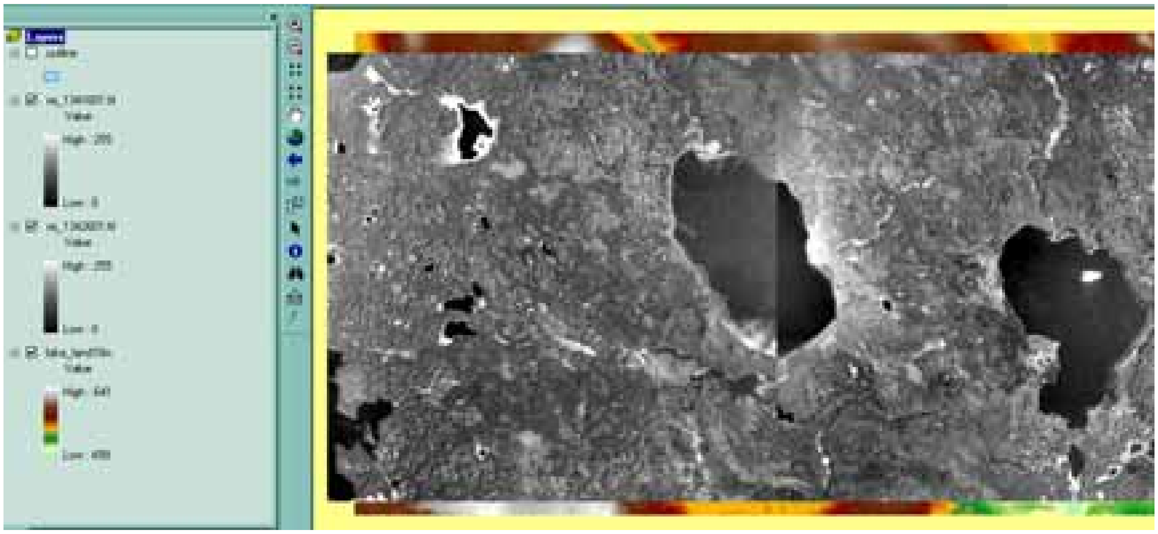

Figure 19: Starting data consists of two ortho photos, lake surface polygon (outline) and a land lake dem in back.

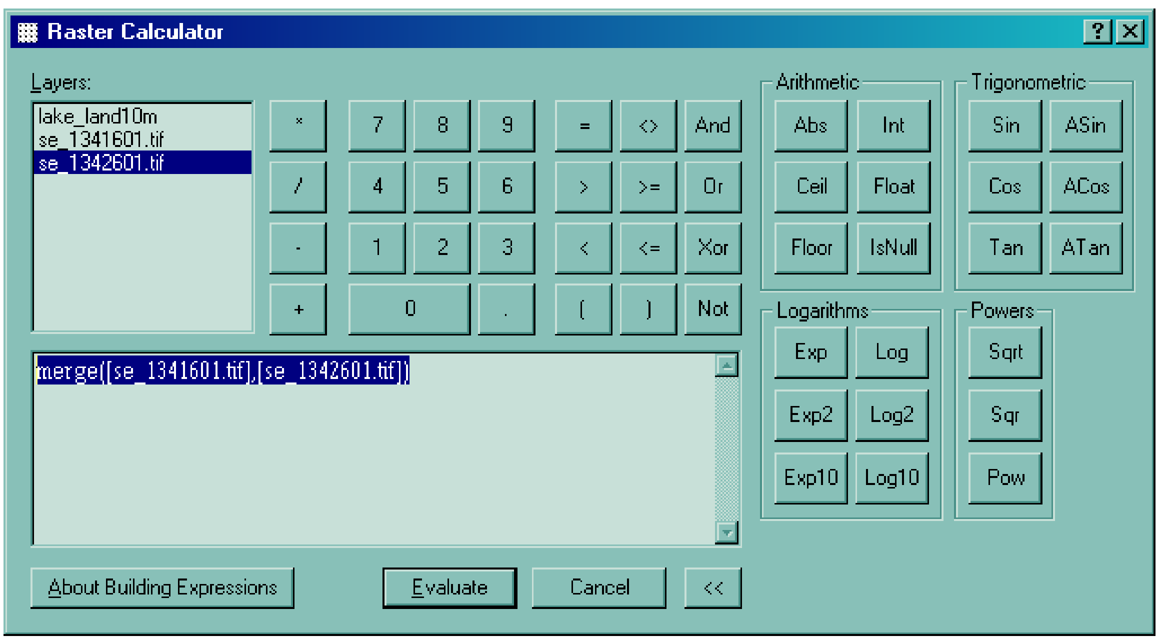

Figure 20: Merge two ortho photo together.

Figure 21: Lake cells calculated to 0.

Figure 21: Merge 0 lake cells with ortho images order matters images go last.

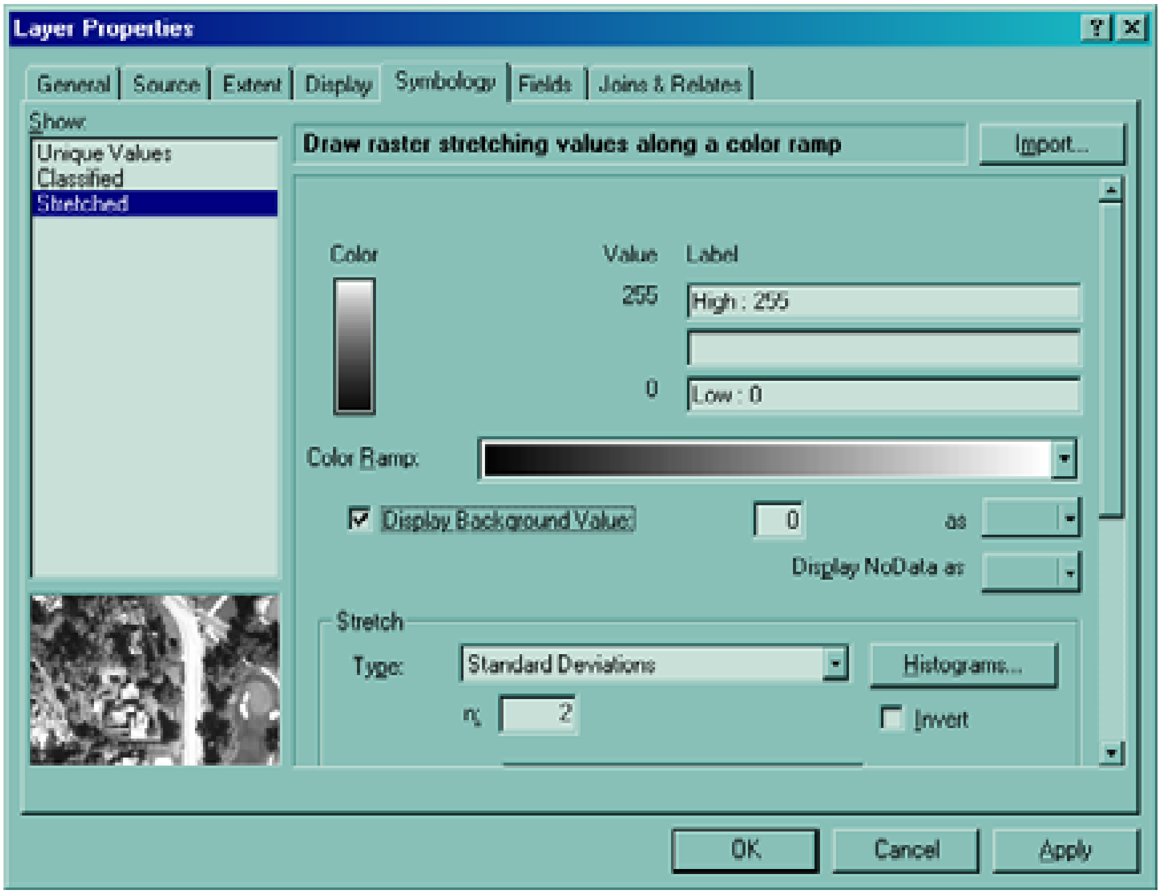

Figure 22: Setting “0” cells to clear / invisible.

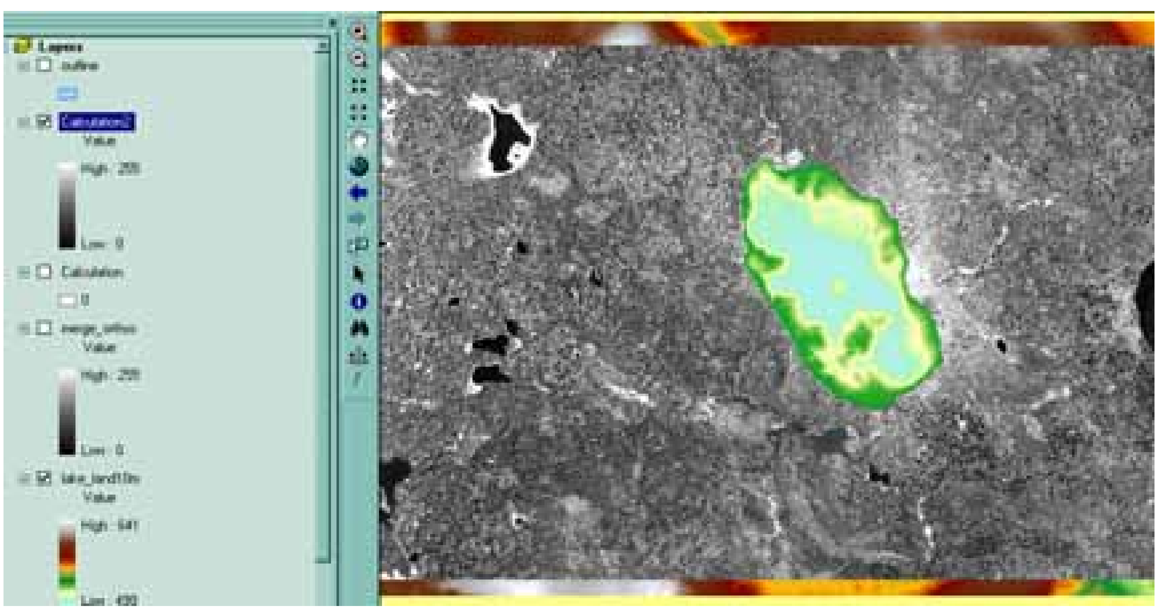

Figure 23: Correct result, “0” values go clear and lake dem underneath show through.

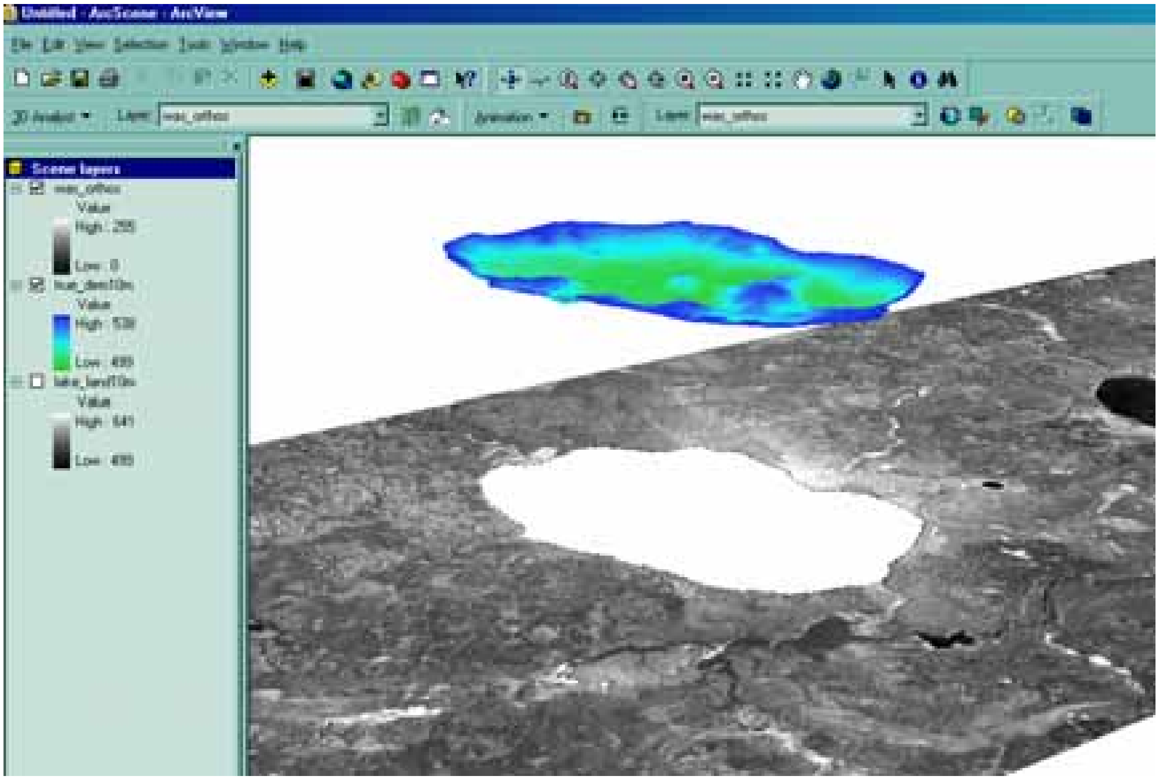

Figure 24: Lake dem base height set, vertical exaggeration set to 5, land lake dem not turned on but base height set and vertical exaggeration set at 5.

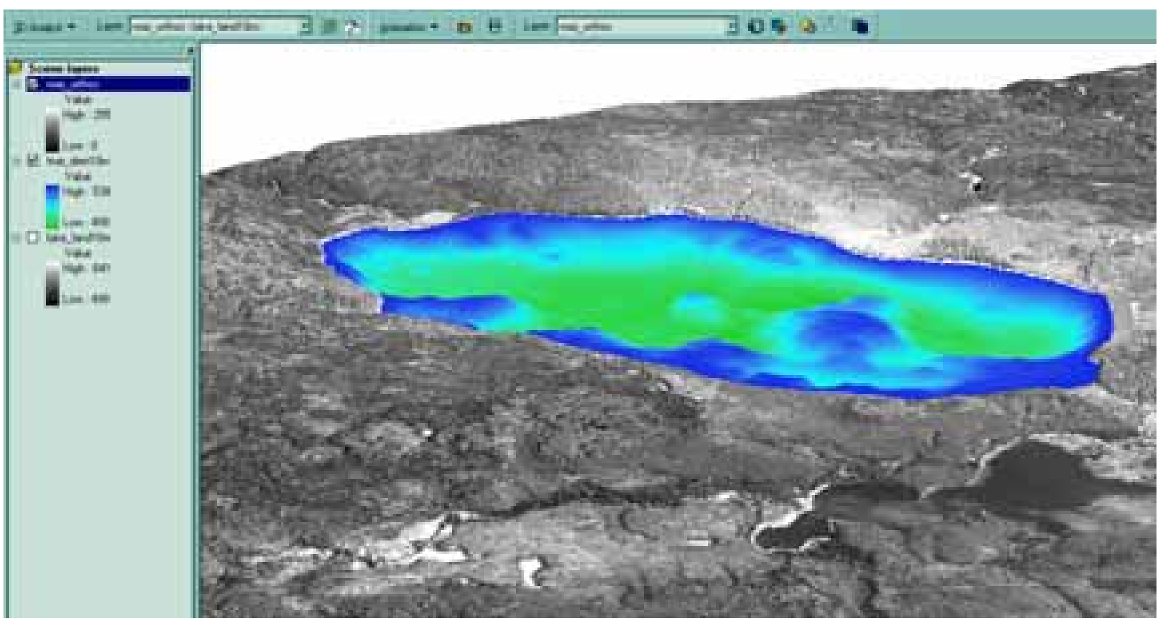

Figure 25: Wassegam Lake 2006, image data uses land lake dem for base heights and vertical exaggeration is set to 5, raster resolution is set to 2x cell size 20m, and rendering set to medium to high.

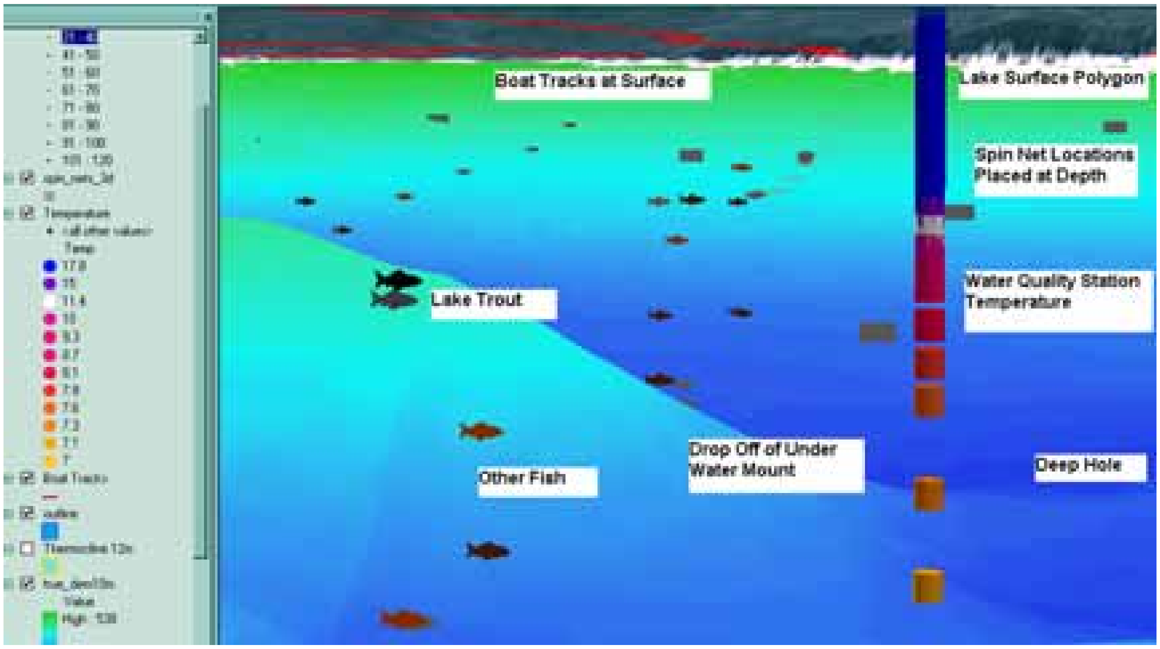

Figure 26: Wassegam Lake 2006 Hydro-acoustics survey at during day. Draped ortho photo image along shore with fish, nets, water quality and lake depth surface incorporated into ArcScene.

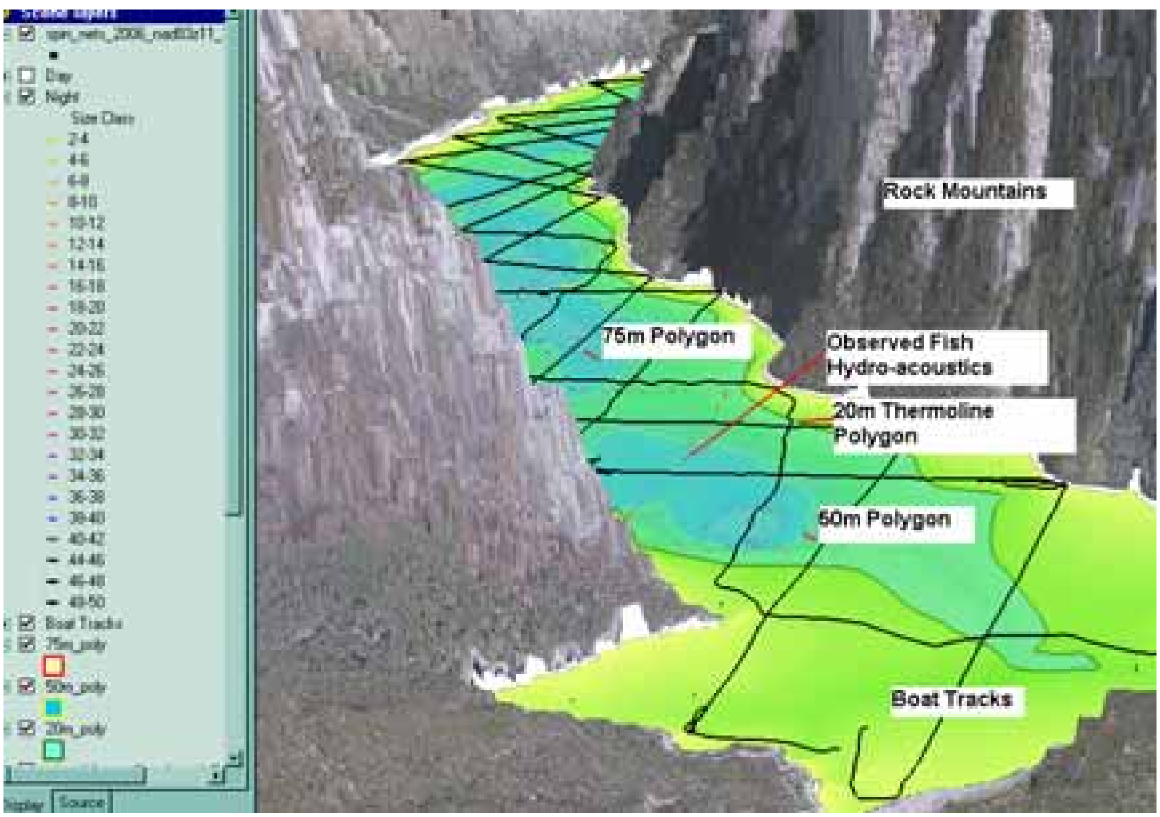

Figure 27: Lake Minnewanka, 2006 Hydro-acoustics survey at night. Draped 3 band ikonos 1 metre image over SRTM data with fish, nets, water quality and lake depth surface incorporated into ArcScene.

This completes the How To if you have any question don’t hesitate to call. I want you to find errors in my methods, approaches or logic ways so they can be improved upon and we will get a better product.

Contct Information:

Paper Compiled by: *Will Stafford and Ron Hlasny*

Will Stafford, GIS Specialist
G2S Pickin' Patch Inc.
Po Box 472
Prince Albert, Saskatchewan
S6V 5R8
Phone (306) 929 2091
stafford.will@sasktel.net

Ron Hlasny
Hydo-acoustics Specialist
Saskatchewan Environment
5th Floor, MacIntosh Mall
Box 3003
Prince Albert, Saskatchewan
S6V 6G1
Phone (306) 953 3242
ron.hlasny@gov.sk.ca

Appendix 1: Creating/Developing Lowrance Captured DEM data files for Use in ArcMap or ArcView

Part 1 Getting sonar data from Lowrance unit to PC
Remove the data chip from the Lowrance unit
Place data chip in Lowrance chip reader
Start a windows explorer session
Double click XXXXX to start the chip browser
Mark the file(s), then Edit, Copy in the browser software
Activate Windows Explorer and browse to c:\lake_name\slg_charts
Put first copied set into c:\lake_name\slg_charts (acts as backup area), Right click the Windows Explorer right panel and select paste to paste the files in

> Note, you have to wait for it to finish copying before you can paste it into c:\lake_name\slg_charts

Click View, Refresh to ensure files were copied
Repeat 5, but put data into c:\slg, once the files are copied again, in Windows Explorer click View, Refresh to verify that the data was copied properly.
Once you are sure the data was copied over you can delete the files off the data chip
Make the chip browser active select the files, Edit, Delete

> Note, there is NO UNDO once deleted they are gone and so is many hours of work, therefore make sure they were copied properly.

Part 2 Converting Sonar log files to text files
Open a Windows Explorer window and navigate to c:\slg
Rename one of the copied chart???.slg to temp.slg
Note, Remember the files original name i.e. chart09.slg
Double click the "shortcut to slg.mdb" in Windows Explorer or the one on the desktop
Click the SLG to txt button to perform the conversion
A new file called tmpdepth.txt is created to see the new file and rename it click View, Refresh in Windows Explorer and sort by modified (click the modified button, it only works in details view so set Windows Explorer to that view via View, Detail
To rename tmpdepth.txt to tmpdepth9.txt Method 1, select the file, then select File, Rename to rename the file or Method 2, select the file then left click the file again and you should be able to edit the file name from tmpdepth.txt to tmpdepth9.txt
Repeat 2 – 6 for all of the files in slg with the .slg extension
Copy all of the tmpdepth???.txt to c:\lowran_data\lowran_text

Part 3 Creating Excel spreadsheets for each tmpdepth???.txt files
In Windows Explorer navigate to c:\lowran_data
If the files txt_file_list.txt and/or xls_file_list.txt exists delete them
Navigate back to c:\slg and select then copy all of the tmpdepth???.txt files to c:\lowran_data\lowran_text directory
Now in Windows Explorer double click on file_list.bat to create a text file list of the tmpdepth???.txt files in c:\lowran_data\lowran_text
Double click the covert_lowran_data.xls file to open the spreadsheet
Yes you want to enable the macros if that message pops up

We now want to run a Macro that will convert the tmpdepth???.txt files to a spreadsheet format for bottom cleaning. In Excel click Tools, Macros, Macros, select Reformat_Lowran_data macro then click Run

This macro reformats the data and adds some extra columns to help with bottom editing.

Open the each of the processed spreadsheets and examine column G for any records that say “Possible Fish”. This is a location where there was an extremely rapid change in depth. Such as there was a bottom at –22m and a fish at 10m then back to bottom at –22m. It would Occur over for or five recorded in the data table i.e. 5 sonar pings. These location need to be examined to see if in fact they are a fish or just a fast depth change like going over a reef.

If fish are found modify the records to the correct bottom. I do this by copy depth values from adjacent records and pasting them over the fish records. Specially copy the –22m value over the three –10 fish value. You will notice that the “Possible Fish” error disappears because you have remove that rapid depth change.

Once edits are complete save this file out as a new spreadsheet with a new file name and I include the letter _cl to indicate that this file has been cleaned.

Once all of the cleaning is completed copy the clean spread sheets to .\lowran_compiled_soundings and then double click on the xls_file_list.bat. This will creates a text file .\xls_file_list.txt listing all of the .xls files in the directory .\lowran_compiled_soundings. The compile macro use that list to compile the data together.

Open the .\xls_file_list.txt file in text edit and just make sure that only _cl .xls are included in the list. If others are there delete them from list then save the file.

Double click convert_lowran_data.xls if it is not all ready open, Answer yes to enable macros and then run the second macro called Compile_Data_Point. This macro will compile those different spread sheets together and then save it out as a .csv file which can be imported into ArcMap or ArcView as a table.

Bug

Sometimes when the compile macro is run it will not compile all of the files together. Essentially it tries to paste in some copied data but fails to paste because it thinks it does not have enough room to insert the new records. I don’t at present know why this happens, I just know it happens at different times.

Work around is to record i.e. write down on paper which spreadsheet it got to. Switch to the compile spreadsheet and save it out as a .csv file called part1.csv. Close down Excel.

Open the .\xls_file_list.txt in a text edit (TextPad good editor) and remove all of the records above and not including the spreadsheet that you wrote down. Save the edits. Double click on click convert_lowran_data.xls and rerun the second macro. This normally fixes the problem. If the problem still exists with that particular spreadsheet just save it out as a separate .csv file., delete it from .\xls_file_list.txt and continue on.

Start ArcMap 9 or ArcView 3.2 and load in the .csv files as tables. ArcMap sees .csv natively, ArcView must be told to look for that extension type *.csv.

Create event themes from each of the data tables and save them out as separate shapefiles.

Load in all of the depth point shapefiles and a then append them together. In ArcMap I use Edit Geotools, In ArcView I use Xtools to append the shapefile together.

If you have ArcMap use ArcCatalog to define the projection as Geographic with a datum of WGS84.

Reproject the compiled depth points to UTM Zone???? and datum NAD83 or what ever your projection is. Geographic WGS84 can be projected to ever other common projection.

Appendix 2: Process Sonar Data from Lowrance LCX-15MT Using ArcView 3.X and ArcMap 9.X

The following takes the user through the conversion of Lowrance SLG files from the downloading of the data to the creation of a point shapefile that has locational X,Y and depth data.

We start with coping the slg data folder and contents to your C:\ drive.

Open the MMC browser, select the .slg file, then click on edit and copy, figure 1.

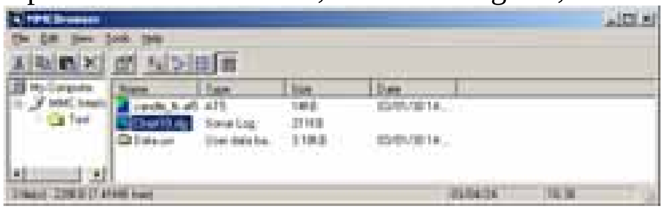

Figure 1: Copy data from MMC card.

Paste the file into the c:\slg folder, figure 2.

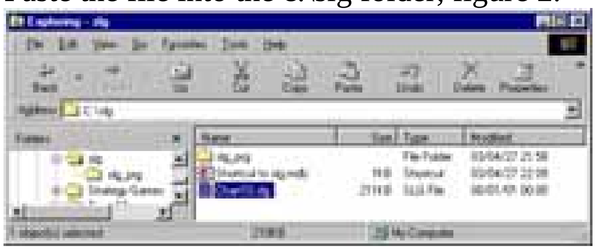

Figure 2: Paste data from MMC card to hard drive.

Rename the .slg file to temp.slg, figure 3, figure 4.

Figure 3: Renaming the file to temp.slg.

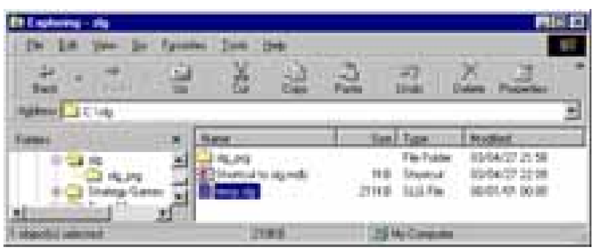

Figure 4: Renaming the file to temp.slg.

Open the slg.mdb with the shortcut in the C:\slg folder. You require Access2000 to run the program, figure 5.

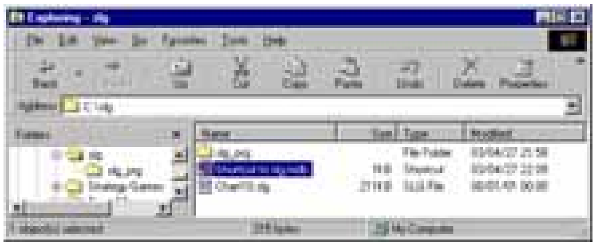

Figure 5: Starting the access database to process the files

Click on the SLG to TXT button to convert temp.slg to process the file, figure 6.

Figure 6: Processing the temp.slg file

Close the Sonar Conversion Program after file is converted. A new text file should be in c:\slg folder called tmpdepth.txt, figure 7.

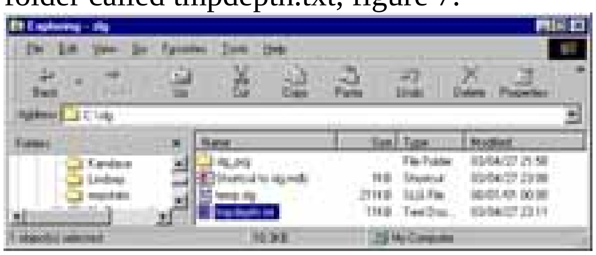

Figure 7: Converted file called tmpdepth.txt.

The raw slg file is now converted into a ascii format file that can be open in ArcView 3x or ArcMap and converted to a spatial data set of depth points. The first example is in ArcView 3x the second example will be in ArcMap

ArcView 3X Example
To process in ArcView 3x start ArcView application and click on the tables menu, figure 8.

Figure 8: Starting ArcView 3x and adding a ascii table.

ArcView automatically looks for .dbf files. You need to change the file type it looks for so click the types drop down and select *.txt for file type and add tmpdepth.txt, figure 9.

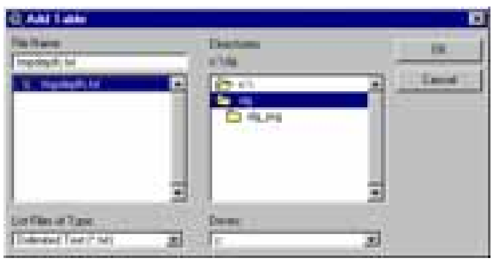

Figure 9: Adding tmpdepth.txt files to AcrView.

The tmpdepth.txt table should import and be displayed as in figure 10.

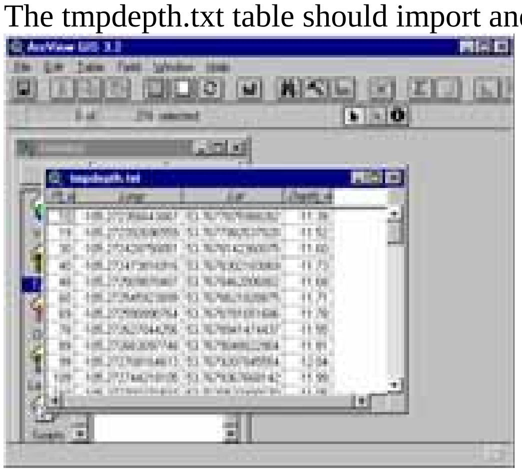

Figure 10: Table loaded and displayed.

Next close the table, open a new view and add an event theme. An event theme is theme that is created based on a tables attributes to create a spatial representation, figure 11.

Figure 11: Creating an Event Theme.

Generally you can accept the shown table and x, y fields as is because the program understands that Long = X and Lat = Y, figure 12. If this is not the case you need to select the correct field that represents the “X” data and the field that represents the “Y” data.

Figure 12: Defining spatial fields.

Lastly , click on the new theme to view it. It will / should be a line of points in Geographic projection and WGS1984 datum., figure 13.

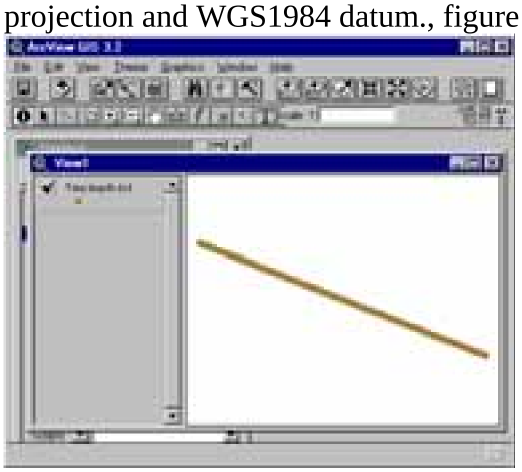

Figure 13: View of depth points collected from the Loran depth sounder.

This data is still just and event theme and needs to be converted to a regular shapefile for further processing. Access the Theme menu and convert the new theme to a shape file, figure 14.

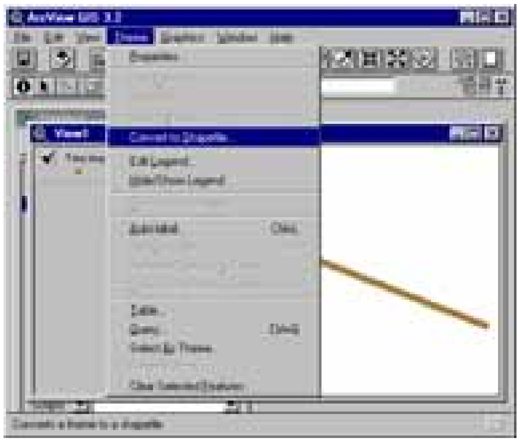

Figure 14: Converting to a shapefile.

The shape file you are creating will have a projection of Geographic with a datum of WGS1984. You may want to add 84 to the name to indicate this, since ArcView 3x does not automatically create a projection file like ArcMap does, figure 14.

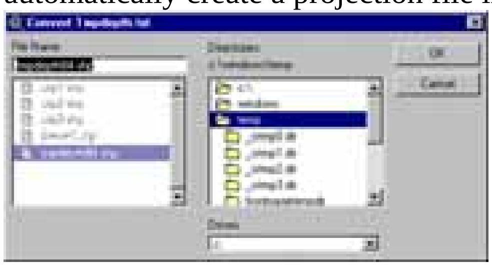

Figure 15: Giving the shapefile a name.

ArcView will ask if you want to add the new data layer, answer yes and then save the project, figure 16.

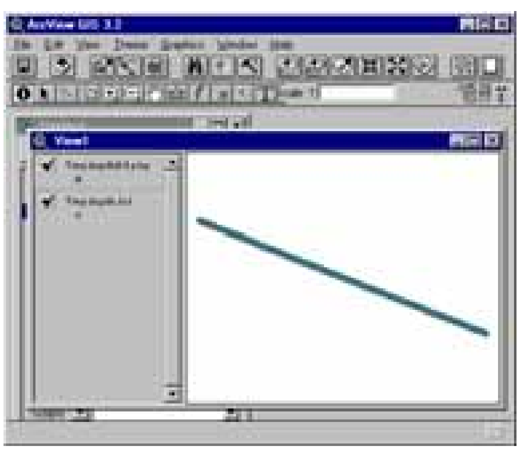

Figure 16: Adding completed data to view.

ArcMap Example
To load a txt file into ArcMap click the add data button and navigate to .txt file created above select it and click ok figure 17.

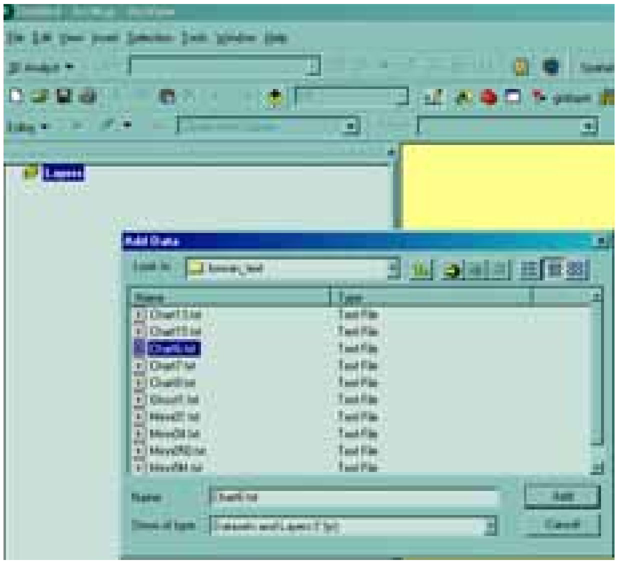

Figure 17: Adding a sgl text file to ArcMap

Wit the textfile load click Tools, AddXY data to bring up a dialogue to define which field has the X values and which has the Y values. Define the spatial reference click Edit in the spatial reference area, then select to select a projection, choose geographic coordinate system, World and lastly, WGS 1984.prj click Add then Okay to set the spatial reference, figure 18. and Okay to add the data.

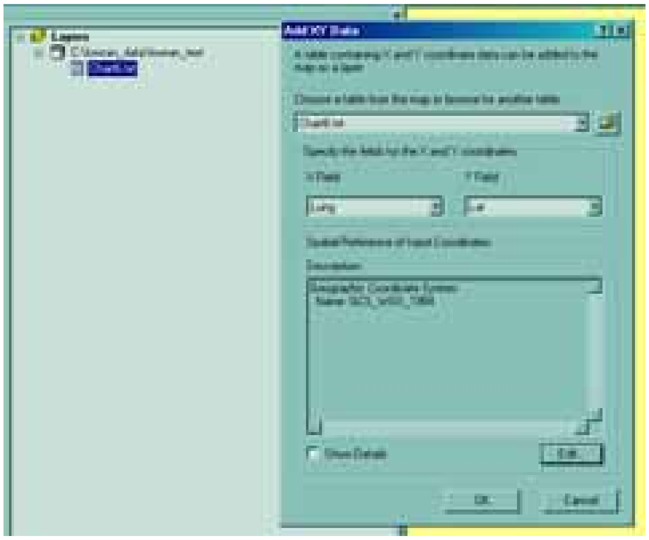

Figure 18: Defining X,Y fields and spatial reference.

The added data will now appear in the mapping area, figure 19.

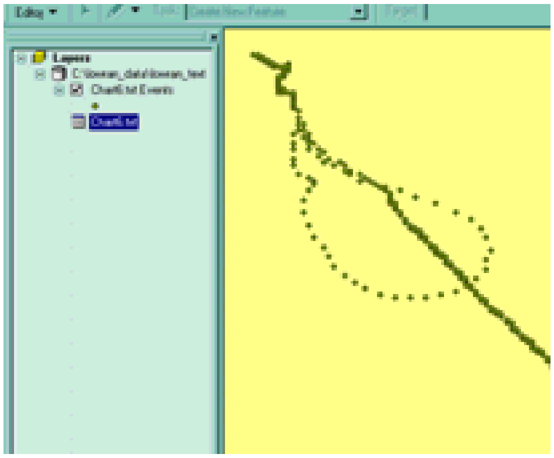

Figure 19: Depth points along the boat track.

As before we need to save / export this data out so that we create a stand alone shapefile. Right click the displayed spatial layer choose Data then Export, figure 20.

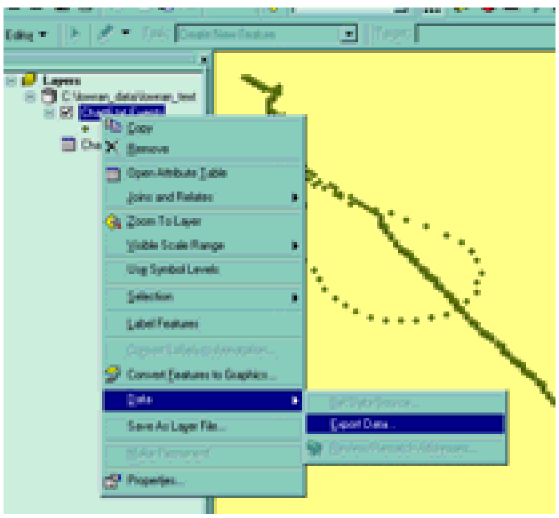

Figure 20: Creating a stand alone shapefile from the displayed XY data.

Change the path for the exported data and give it a name, then click Okay to export the data, figure 21.

Figure 21: Saving the data as a shapefile.

> Note: It s not necessary to add wgs84 or 84 to the file name since a projection file will be created when the data is export.

You can answer yes to add the data. Review the data to make sure it is in the correct location and it looks correct. If it is delete the slg table you added. Right click the table, click remove to remove the table and it spatial representation. Once completed you are left with your new shapefile.

The above examples cover the processing of one file. From experience we have learned that it is best to create a new slg file every transect or every hour or so. It reduces the potential for data loss or data corruption. Therefore, you are going to want to merge numerous shapefile together so that in the end you have just one shapefile to reproject.

> Note: It is also import to make backups of the data to an external drive or burn to a CD or DVD. My personal preference is to use those 2.5 inch external drives that are powered off two USB ports. It is portable and can be connected to another computer.

References

Love, R. H. 1977. Target strength of an individual fish at any aspect. Journal of the Acoustical Society of America 62:1397–1403.