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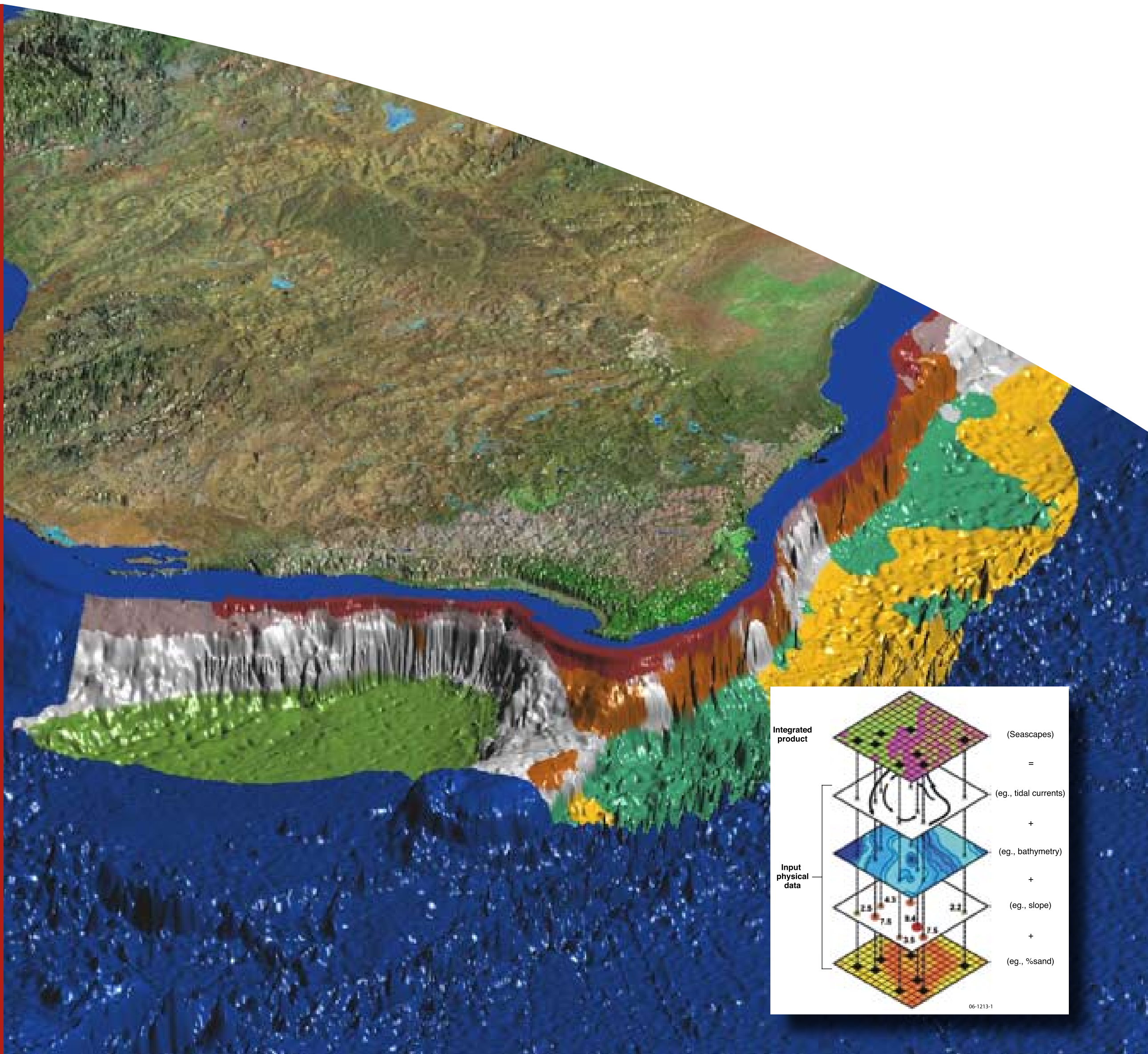
Seascapes of the Australian Margin and Adjacent Sea Floor - Keystroke Methodology

Hinde, A., Whiteway, T., Ruddick, R., and Heap, A.D.

Record
2007/10



S P A T I A L   I N F O R M A T I O N   F O R   T H E   N A T I O N

Geoscience Australia Record 2007/10

Seascapes of the Australian Margin and Adjacent Sea Floor

Keystroke Methodology

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Executive Summary

Geoscience Australia has undertaken a classification of biophysical datasets to create seabed habitat maps (termed 'seascapes') for the Australian margin and adjacent sea floor. Seascapes describe integrated, multiple layers of ecologically meaningful biophysical properties that spatially represents potential seabed habitats. Each area of a seascape corresponds to an area having similar physical properties and, by association, habitats and communities. The procedure adopted is inspired by the shelf classification applied in eastern Canada by Roff et al. (2003), who used physical properties (sediment type, physiography, bed roughness, wave and current regime) to define ecologically meaningful habitats on the Scotian Shelf. Geoscience Australia has used biophysical properties that have consistent and definable relationships with the benthic biota and are known in sufficient detail across Australia's entire marine region to create the seascapes. The seascapes are also an important source of knowledge for the Marine Protected Areas (MPA) planning process, providing information about areas for which biological data cannot be sourced.

The creation of seascapes is an ongoing, iterative process where both the input datasets and methodology are repeatedly revised and reviewed to improve the quality of the seascapes. The keystroke methodology detailed in this report represents the most recent methods used to create the seascapes. Main features include:

1. Use of ArcGIS 9.1™ for the creation and preparation of input variables, and the ERMapper™ package to further prepare input variables including logging and scaling the variables;
2. Use of the ISOclass (unsupervised classification) technique in ERMapper to analyse the data in an unbiased manner, allowing the statistics of the input variables to guide the delineation of class boundaries;
3. Choosing the optimal number of classes through the application of the Distance Ratio and the Calinkski-Harabasz pseudo F-statistic using purpose-built Visual Basic 6™ programs; and
4. Analysing the output dataset using Statistica 6.1™ to assess class means and correlation between input variables. The classes of the final classification are then named based on the relative compostion of the input variables and the dataset is described beside the geomorphology dataset.

The complete set of seascapes and validation of the methodology are contained in the accompanying Geoscience Australia Record 2007/11 entitled: *Seascapes of the Australian Margin and Adjacent Sea Floor: Methodology and Results* by Whiteway et al. (2007).

PART 1 – INTRODUCTION

This record contains the detailed keystroke methodology used to create seascapes for the Australian margin, with particular reference to the level 4 national marine bioregionalisation classifications (Department of the Environment and Heritage, 2005). This report is a compendium to Geoscience Australia Record 2007/11 by Whiteway et al. (2007) that details the methods and results of creating seascapes for the Australian margin and adjacent sea floor.

The methods used to create the seascapes are detailed in Part 2 – Example Classification and 'Keystroke' Sequence. This record has been written to ensure that future seascape classifications can be undertaken consistent with the initial classifications, and so that improvements to the methodology can be implemented.

The computer software packages ArcGIS 9.1™, ERMapper™, Visual Basic 6™, and Statistica 6.1™ were used. The Visual Basic programs have been compiled into Setup programs, with help files, which can be installed on a PC so knowledge of Visual Basic is not necessary to carry out further classifications, but knowledge of ArcGIS, ERMapper and Statistica is required.

1.1. AREAS CLASSIFIED

Initially areas chosen for trial classifications were rectangular. This avoided manipulating complex boundaries in the early trial classification stage. Four areas were defined: East, Gulf of Carpentaria, North West and South West. In later classification iterations, areas of interest were chosen based on the planning areas established by the Department of the Environment and Heritage (now Department of the Environment and Water Resources, DEW) including:

- South West Planning Area,
- Northern Planning Area,
- South East Planning Area,
- East Planning Area, and
- Great Barrier Reef.

1.2. INPUT DATA

Input data was collated from numerous organisations, including:

- % gravel (Geoscience Australia),
- % mud (Geoscience Australia),
- % sand (Geoscience Australia),
- % carbonate (Geoscience Australia),
- mean grain size (Geoscience Australia),
- bathymetry (Geoscience Australia),
- slope (Geoscience Australia),
- disturbance (Geoscience Australia),
- mean wave energy (Geoscience Australia),
- maximum tide speed (Geoscience Australia),
- geomorphology (Geoscience Australia),
- primary production (CSIRO), and
- sea floor temperature (CSIRO).

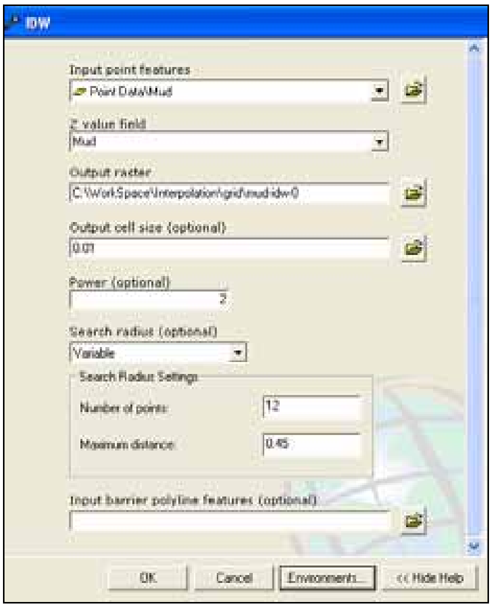


Figure 1.1. Inverse Distance Weighted (IDW) interpolation spatial analyst parameters.

Not all datasets were used for all areas (dependent on extent and relevance of each dataset to each area). Each dataset was aligned to the bathymetry grid and standardised to 0.01 decimal degree cell size and exported to ERMapper format. Highly skewed datasets (e.g., % gravel, % carbonate, % mud) were logged using a logarithmic transformation. All datasets were scaled to a range of 0 to 100 to ensure an equal weighting of the variables during the classification process.

The following provides a description of each input datasets lineage. Further metadata associated with each of the input grids are contained in Appendix A.

1.2.1. % Gravel, % Sand, % Mud, % Carbonate and Mean Grain Size

The following grids were created using ArcGIS Inverse Distance Weighted (IDW) methodology by Geoscience Australia (Fig. 1.1):

- % gravel,
- % sand,
- % mud,
- % carbonate, and
- mean grain size.

The IDW interpolation methodology assumes that the closer a cell is to the sample point, the more likely it is to be related to that point. Hence it is weighted to show that its value is also closer to the sample point to which it is closest. To undertake an IDW interpolation on the input sample points undertake the following steps:

1. Open appropriate point data in ArcGIS.
2. Set desired extents and coordinate system to Geographic WGS_84.
3. Interpolate using Spatial Analyst – Inverse Distance Weighting.

1.2.2. Effective Disturbance, Wave, Tide, and Current Disturbance

Effective Disturbance is a derived index from the combined effects of waves, tides and other ocean currents (Hemer, 2006). Wave data for 8 years (1997-2005) was generated by the Bureau of Meteorology from the global WAM wave model (Komen *et al*., 1994) and reported as 6 hourly mean and maximum predictions of significant wave height and mean wave period at 0.1° spatial resolution (Hemer, 2006). Tide data consisting of the major tidal constituents (M_2, S_2, K_1 and O_1) were derived from the linearised, shallow water tide model (Egbert *et al*., 1994). Altimetry data and tide gauge data from 16 primary and 41 secondary Australian ports were used as input. Seasonal wind and density-driven, near-bed ocean currents were estimated from the OCCAM ocean circulation model using years 8.0-12.0 (Webb *et al*., 1998). Full metadata for each of the effective disturbance, wave, tide and current datasets can be found in the Appendices and Whiteway *et al*. (2007). Full details of how the datasets were compiled are documented in Hemer (2006).

1.2.3. Bathymetry

The bathymetry dataset was compiled by Geoscience Australia from multi-beam and single beam data, Australian Hydrographic Service fair sheets, and the GEBCO bathymetry model to a grid cell size of 0.025 decimal degrees. For a full description of the bathymetry dataset refer to Webster and Petkovic (2005).

1.2.4. Slope

The ERMapper slope derivation process was used to create a slope grid from the Geoscience Australia bathymetry grid (re-sampled to a grid cell size of 0.01 decimal degrees). The ER Mapper slope derivation process calculates slope over a 3 x 3 cell neighbourhood. In this process the outside cells of the grid are lost due to the averaging process. If the outside cells are averaged they do not have the full 3 x 3 component and therefore the centre cell becomes null. To eliminate this problem, the slope derivation process was run on a much larger extent (and then clipped) to ensure that full coverage was maintained.

1. In order to derive the slope grid, the bathymetry grid is re-sampled to set the cell size from 0.25 decimal degrees (~250 m) to 0.01 decimal degrees (~1 km).
   Arc: w <set workspace location>
   Arc: GRID
   Grid: bath_resamp = resample(bathy, 0.01)
2. The Planning area boundaries were then buffered by 50 km (to ensure full coverage) using the ‘Analysis Tools’, ‘Proximity’, and ‘Buffer Tool’ applications. The buffered boundary dataset was then converted to a coverage in ArcInfo.
   Arc: SHAPEARC shapefile coverage
   Arc: BUILD coverage poly
3. The bathymetry grid was then clipped using ArcInfo to the buffered planning area boundary.
   Arc: GRID
   Grid: GRIDCLIP bath_resamp bathclp COVER clip_cover
4. The grid was exported to ERMapper *.ers format. Refer to Appendix B for full keystroke methodology for exporting ESRI grid to *.ers format.
5. The slope was calculated in degrees using the ‘*slope_degrees.ker*’ slope filter.

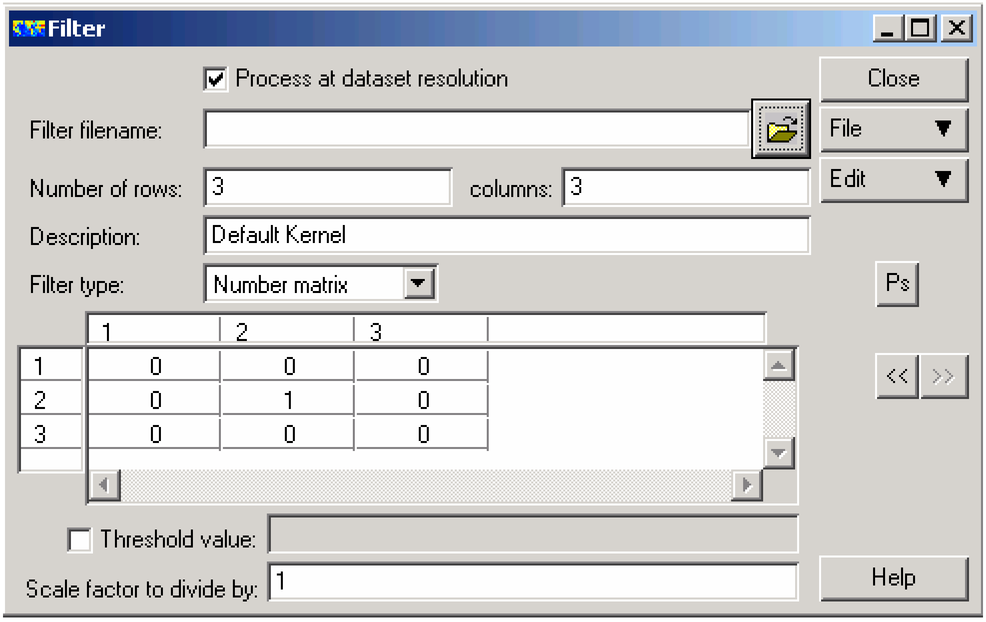


Figure 1.2. Parameters used to calculate the slope grid.

a. Open ERMapper and load the buffered, clipped DEM.
b. Click on the 'Edit Filter Kernel' button on the Algorithm window.
c. Select 'Process at dataset resolution'
d. Open the Filter Filename from *C:\ERMapper70\kernel\filters_DEM\slope_degrees.ker* (Fig. 1.2).
e. Select 'Close'
f. Export the file to a *.ers file (Appendix B) and load the new *.ers file into ArcMap to check spatial reference and alignment.

1.2.5. Primary Productivity

The primary productivity grid was derived by CSIRO from satellite data to a grid cell size of 0.01 decimal degrees (see DEH, 2005 for full details).

1.2.6. Sea Floor Temperature

The sea floor temperature grid was produced by CSIRO from interpolation of observations held in the CSIRO Atlas of Regional Seas (CARS) database to a grid cell size of 0.01 decimal degrees (see DEH, 2005 for full details).

1.3. CLASSIFICATION PROCESS

Classifications were run using ERMapper's unsupervised ISOclass classification technique. This technique allows the classes to be created based on the natural statistical patterns in the data. The primary objective to using this method is to ensure that the classes are created without user bias.

1.4. DETERMINING NUMBER OF CLASSES

Since ERMapper does not determine the optimum number of classes two methods external to ERMapper were employed to determine the optimal number of classes; the Distance Ratio and the Calinkski-Harabasz pseudo F-statistic.

1.4.1. Distance Ratio

Classifications were carried out for a number of classes, generally ranging from 5 to 15 or 20. For each of the classifications, the average of the mean distance of each class member to its class mean was calculated. This value gives an indication of how well the data conform with the classification. The smaller the value, the closer, on average, the individual class members are to their class means. In cases where there is a wide range in the number of members of each class, the average mean distance can be calculated by weighting each class by the number of members in the class.

The average mean distance is calculated with program 'ReadGridData', as follows:

$$\overline{D} = \frac{1}{n_c}\sum_{i=1}^{n_c}\overline{D_i} \qquad \text{(Eq. 1.1)}$$

where n_c is the number of classes and $\overline{D_i}$ is the mean distance of the members of class i to the centre of class i:

$$\overline{D_i} = \frac{1}{n_i}\sum_{j=1}^{n_i} d_{ij} \qquad \text{(Eq. 1.2)}$$

where n_i is the number of members (data points) in class i, and d_{ij} is the distance of the j'th member of class i to the centre of class i:

$$d_{ij} = \sqrt{\frac{1}{n_v}\sum_{k=1}^{n_v}\left(v_{ij}^k - \overline{v_i^k}\right)^2} \qquad \text{(Eq. 1.3)}$$

where v_{ij}^k is the value of the k'th variable of the j'th member of class i (note that k is not a power in this notation), n_v is the number of variables used in the classification (bathymetry, mud, gravel, etc.) - note the factor of $1/n_v$ distinguish this definition of distance from the normal Euclidean distance to one weighted by the number of dimensions, and $\overline{V_i^k}$ is the mean value of the k'th variable in class i:

$$\overline{v_i^k} = \frac{1}{n_i}\sum_{j=1}^{n_i} v_{ij}^k \qquad \text{(Eq. 1.4)}$$

The weighted average mean distance is given by:

$$\overline{W} = \sum_{i=1}^{n_c}\frac{n_i}{\sum n_i}\overline{D_i} = \frac{1}{n}\sum_{i=1}^{n_c}\sum_{j=1}^{n_i} d_{ij} \qquad \text{(Eq. 1.5)}$$

where n = n_i is the total number of data points in all classes.

To convert the average and weighted average mean distances into dimensionless quantities, they can be divided by the overall average distance, $\overline{D_{tot}}$. The distance ratio is therefore given by

$$D_r = \frac{\overline{D}}{\overline{D_{tot}}} \quad \text{(Eq. 1.6)}$$

and the weighted distance ratio by:

$$W_r = \frac{\overline{W}}{\overline{D_{tot}}} \quad \text{(Eq. 1.7)}$$

Where:

$$\overline{D_{tot}} = \frac{1}{n}\sum_{i=1}^{n_c}\sum_{j=1}^{n_i}\sqrt{\frac{1}{n_v}\sum_{k=1}^{n_v}(V_{ij}^k - \overline{V^k})^2} \quad \text{(Eq. 1.8)}$$

Where:

$$\overline{V^k} = \frac{1}{n_c}\sum_{i=1}^{n_c}\frac{1}{n_i}\sum_{j=1}^{n_i}V_{ij}^k \quad \text{(Eq. 1.9)}$$

is the mean value of the k'th variable.

When the distance ratio is plotted against the number of classes, there is often a point where, after an initial decline, the curve flattens out, indicating that little will be gained by increasing the number of classes. This flattening point was generally used to determine the optimum number of classes. Where the number of data points in each class differed significantly, greater notice was taken of the weighted distance ratio.

1.4.2. Calinski-Harabasz pseudo F-statistic

An alternative method for determining the optimum number of classes is to find the maximum of the Calinkski-Harabasz pseudo F-statistic (F_{CH}) (Orpin & Kostylev, 2006) which is defined as:

$$F_{CH} = \frac{\left(\frac{R^2}{n_c - 1}\right)}{\left(\frac{1-R^2}{n - n_c}\right)} \quad \text{(Eq. 1.10)}$$

where n = n_i is the total number of data points in all classes, n_c is the number of classes, and

$$R^2 = \frac{SST - SSE}{SST} \quad \text{(Eq. 1.11)}$$

where SST is the total sum of squared distances to the overall mean (similar to the between-groups sum of squares):

$$SST = \sum_{i=1}^{n_c}\sum_{j=1}^{n_i}\sum_{k=1}^{n_v}\left(V_{ij}^k - \overline{V^k}\right)^2 \quad \text{(Eq. 1.12)}$$

and SSE is the sum of squared distances of the data points to their own class means (similar to the within group sum of squares):

$$SSE = \sum_{i=1}^{n_c}\sum_{j=1}^{n_i}\sum_{k=1}^{n_v}\left(V_{ij}^k - \overline{V_i^k}\right)^2 \quad \text{(Eq. 1.13)}$$

where n_i is the number of members (data points) in class i, n_v is the number of variables used in the classification (bathymetry, mud, gravel, etc.), v_{ij}^k is the value of the k'th variable of the j'th member of class i (note that k is not a power in this notation), $\overline{V^k}$ is the mean value of the k'th variable, and $\overline{V_i^k}$ is the mean over all observations of the k'th variable in class i. For computational purposes, F_{CH} is more conveniently written as:

$$F_{CH} = \left(\frac{SST}{SSE} - 1\right)\left(\frac{n - n_c}{n_c - 1}\right). \qquad \text{(Eq. 1.14)}$$

1.5. ANALYSING THE CLASSIFICATION

The classification obtained for the optimum number of classes was further analysed using Statistica, a descriptive name and indicative colour given to each of the classes, the results plotted in the form of a map of the classes as well as histograms and tables of the statistical analysis.

1.5.1. Basic Statistics and Histograms

Statistica was run to provide basic statistics of the input data (mean, standard deviation, minimum and maximum values, and correlation coefficients between the variables) and to display histograms of the data. Histograms for each variable, as well as histograms for each variable in each class were provided. The histograms were sometimes useful for naming the classes in that some distributions were bimodal or very spread out - qualities not apparent in the means.

1.5.2. Analysis of Variance

Statistica's one-way analysis of variance was useful in that it provides a plot of the means for each class and each variable making it easier to determine how the variables contributed to a particular class. For example, some classes tended to have a high or low mean value for a particular variable.

PART 2 – EXAMPLE CLASSIFICATION AND 'KEYSTROKE' SEQUENCE

This section provides in detail the methods employed to undertake the classification process. An example classification giving the individual commands or 'keystrokes' required at each stage is a large component of this document.

It is assumed that the user has sound knowledge of ArcGIS and ERMapper some experience with the statistical program Statistica.

2.1. PREPARING THE GRIDS FOR EXPORT

Prior to the export of data to ERMapper for analysis all input datasets were:

- Projected to GCS WGS84
- Clipped to the Area of Interest (AOI),
- Have a cell size of 0.01 decimal degrees,
- Aligned to the bathymetry grid (the cells of one grid line up with the cells of another grid),
- Have null values where islands occur, and
- Have null values where other grids have null values.

The following processes are undertaken using ArcINFO command line to ensure that all data is in this structure:

1. All analyses were undertaken on a cell size of 0.01 decimal degrees, and as such all grids need to be re-sampled to match the cell size and cell location of the bathymetry grid. The bathymetry grid is first re-sampled to set the cell size from 0.25 decimal degrees (~250 m) to 0.01 decimal degrees (~1 km).
   Arc: w <set workspace location>
   Arc: GRID
   Grid: bath_resamp = resample(bathy, 0.01)
2. Each other dataset is then re-sampled to match this grid (so that the cells line up and have the same cell size). The following series of commands sets the extent and cell parameters to the bathymetry grid and as such, when the grid is re-sampled its cell location and cell size will match the bathymetry grid.
   Grid: SETCELL bath_resamp
   Grid: SETWINDOW bath_resamp
   Grid: output_grid = resample(input_grid, 0.01)
3. The bathymetry grid is then clipped to match the area of interest. The area of interest is first converted to a coverage (that can be used in ArcINFO command line) and then the clip is undertaken. (Note: do not use the grid clipping tool in Arc toolbox because the cells are resampled instead of being clipped to the nearest cell.)
   Grid: q
   Arc: SHAPEARC shapefile coverage
   Arc: BUILD coverage poly
   Grid: GRIDCLIP bath_resamp bathclp COVER clip_cover
4. The clipped bathymetry grid still contains data covering islands that need to be removed prior to analysis. The island data is removed by setting all cells to null

where the bathymetry is greater then 0 (i.e. on land).
Grid: bathy_npa = setnull (bathclp >=1, bathclp)
Set cell values to null where the clipped bathymetry is >= 1, where the values are < 1 set values to bathymetry).

5. Subsequently, where a null value occurs in one grid, all values in other grids at the same cell must also be set to null.
    - In Spatial Analyst/Raster Calculator add all the datasets together to create a mask where all null values from all layers are displayed.
    - In spatial analyst/options set the analysis mask under the general tab to the new addition grid, in the extent box set the analysis extent to the new addition grid (and close the options box).
    - In the raster calculator (needs to be undertaken for each grid) double click on the grid and click evaluate.
    - The resultant grid will have null values at all locations where the other datasets had null values.

2.2. EXPORTING ESRI GRIDS TO ERMAPPER *.ERS FORMAT

The grids are now ready to be imported into ERMapper to be used in subsequent classification methodologies. Refer top Appendix B for full keystroke methodology for exporting ESRI grid to *.ers format.

2.3. CREATING THE ERMAPPER ALGORITHM

Prior to classification of the data, the variable datasets need to be loaded into a single ERMapper file.

6. Run ERMapper

7. Add all clipped variables to a new ERMapper window using the option ‘File’, ‘Add into Current Surface’.

8. Ensure that your algorithm window is open by clicking on the ‘Edit Algorithm’ button on the main ERMapper Toolbar.

9. Convert all variables to Red Green Blue (RGB) display from Pseudocolour by selecting ‘Surface’ and then ‘Red Green Blue’ in the ‘Color Mode’ dropdown list. Then progressively change each variable to red, green or blue alternatively as you move down the list (by right clicking on each layer and selecting the colour in the corresponding dropdown list).

10. Name all variables in the surface list to avoid confusion (Fig. 2.1).

11. View all files to ensure they line up and are displaying correctly and view the histogram for each of the variables by clicking on the ‘edit transformation limits’ button on the Algorithm window.

12. Save the file (with all variables turned on) as an algorithm file (Appendix C – Part 4.3.1).

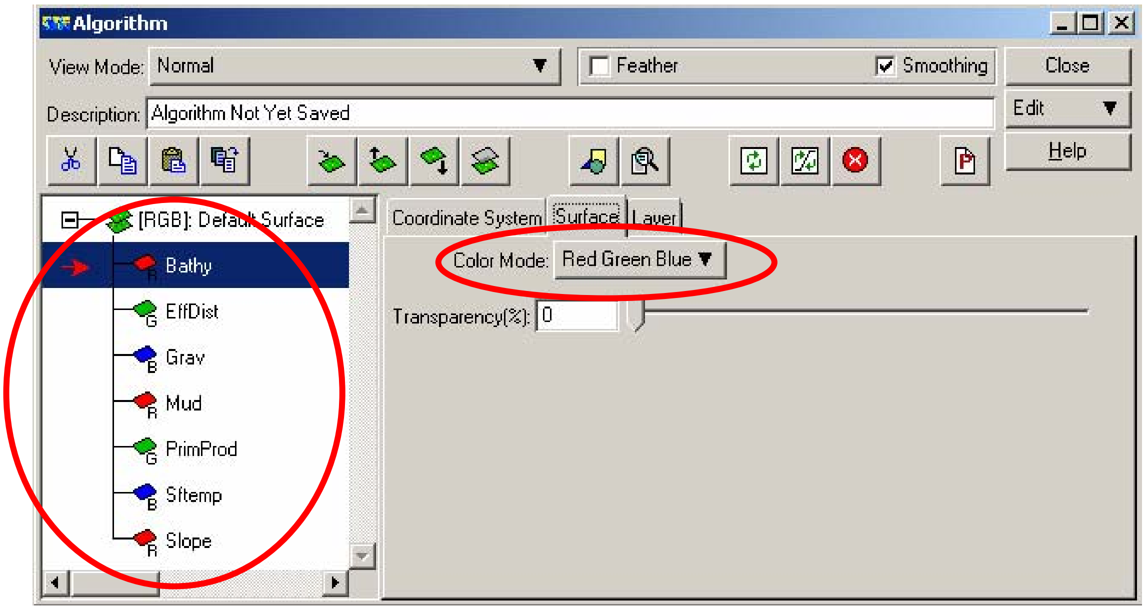


Figure 2.1. Setup of variables used to create the ERMapper surface algorithm.

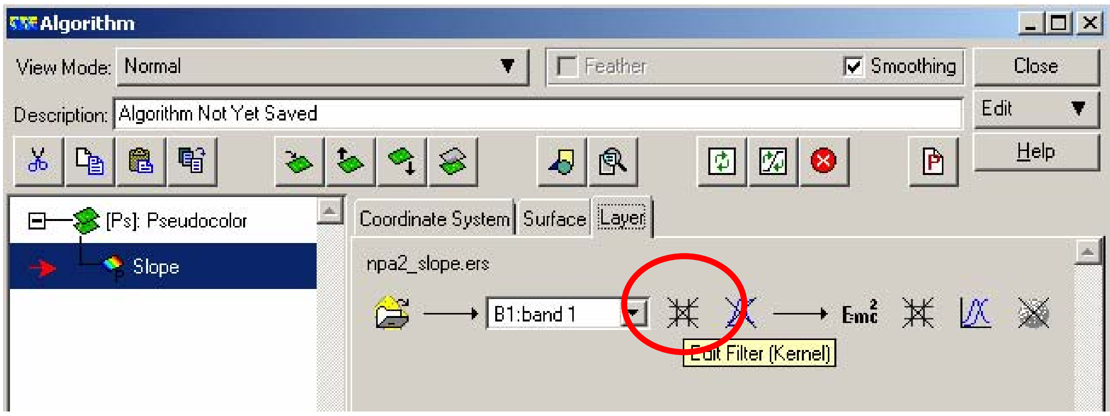


Figure 2.2. Edit Filter (Kernel) window selection button.

2.3.1. Filtering Slope

In some analyses the slope dataset has been filtered to limit the extreme variability inherent in the dataset. Without filtering the slope dataset, the final output classification variability is driven largely by the changes in slope. **NOTE: Only filter the slope if essential – the 21 by 21 filter will remove the outside 21 cells where there are not a full 21 cells to make up the analysis (i.e., cells around the edges of the grid are lost). ALTERNATIVELY: Clip a larger than extent area out of the ers slope data and filter this dataset, then setnull in ArcGIS and reimport to ERMapper.**

To filter the slope, open the slope variable in a new ERMapper session and open the algorithm window.

13. Click on the Edit Filter (Kernel) button on the Algorithm Window (Fig. 2.2).
14. In the Filter window that appears, apply a median filter by typing in the following filter parameters (Fig. 2.3):

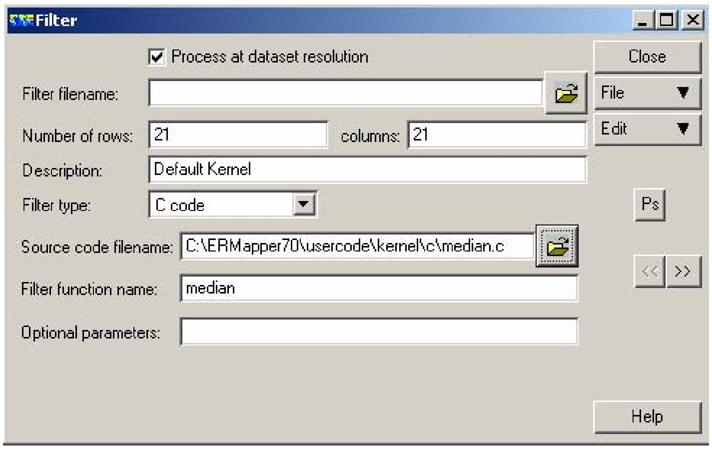


Figure 2.3. Slope filter parameters window.

- Filter Filename = (leave blank)
- Rows = 21
- Columns = 21
- Description = Median Filter
- Filter Type = c code
- Source = C:\ERMAPPER70\usercode\kernel\c\median.c

15. Click on the ‘Close’ button to apply the filter.

16. Export the filtered dataset as a new *.ers file (‘File’, ‘Save As…’) (Appendix B).

17. Add the new filtered slope dataset to the Gulf of Carpentaria algorithm by clicking on ‘File’, ‘Add into Current Surface’. Also remove the original slope layer from this algorithm.

18. Save the file as a new algorithm file with post-fix ‘filtered’ (Appendix C – part 4.3.1). (Saving new algorithm files will allow you to go back steps if the calculations fail at any point. The *.alg file does not store data in its make-up, so each algorithm is small.)

2.3.2. Logging Skewed Files

Some variables have a skewed distribution. Those variables that are skewed will not be represented in the data as effectively as those that are distributed normally. These files can be identified using the ‘edit transformation limits’ tool as shown below (Fig. 2.4).

Before continuing with the classification, skewed datasets need to be logged (mud, gravel and sand grids should not be logged because they total 100%). To log any positively skewed dataset, values of 0 need to be removed (as the log of zero is null). (NOTE: if there are no values of ‘0’ in the variable only undertake parts a, b, f and g).

19. To find out what to set the 0 values to:

    a. Log the variable by clicking on the ‘E=mc^2’ button on the algorithm window and in the main box under ‘Apply Changes’ (Fig. 2.5), set the formula to LOG(INPUT1) and click ‘Apply Changes’.

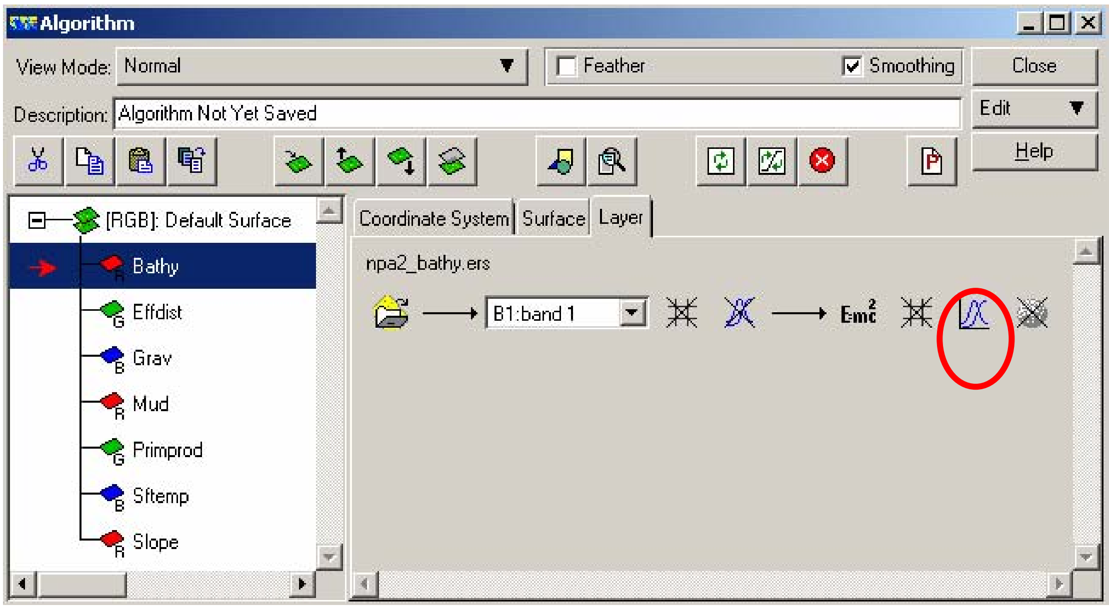


Figure 2.4. Edit Transform Limits selection button.

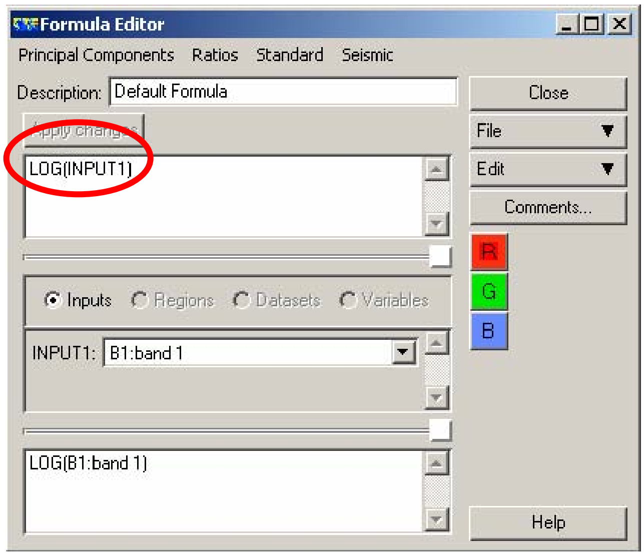


Figure 2.5. Formula editor window to apply log transformation to the data.

b. Now export the logged dataset as a new *.ers file with post-fix '_logged' (Appendix C – part 4.3.3).

c. The next step is to calculate the lowest logged value by calculating the statistics for the layer. Go to 'Process', 'Calculate Statistics' (set the dataset to the logged variable dataset, and set the sub sampling interval to 1), and click 'ok'. To view the statistics go to 'View', 'Statistics', 'Show Statistics'. Note the Minimum value in the statistics.

d. Close the statistics window and go back to the Algorithm window. Click on the 'E=mc2' button again and change the formula to:

- IF (INPUT1) <=0 THEN minloggedvalue ELSE LOG(INPUT1),
- For example: IF (INPUT1) <=0 THEN -6.202 ELSE LOG(INPUT1),

- Click 'Apply Changes'.

e. Close the formula editor window and export the new logged file (Appendix C – part 4.3.3). NOTE – overwrite the last exported version of this variable.

f. Remove the original (unlogged) variable from the ERMapper algorithm, and load the newly exported ers file in its place.

g. Check to ensure there are no null values in the middle of your dataset.

h. Apply this methodology to any other positively skewed datasets.

20. Save the final version of the algorithm (with all variables turned on and all newly logged variables added) the same name as the previous *.alg file with '_logged' as a postfix (to ensure you can back-step if required) (Appendix C – part 4.3.1).

2.4. SCALING THE VARIABLES

Scaling the variables is not a simple matter of using ERMapper to calculate the statistics of each variable (including minimum and maximum) and then re-scaling them accordingly. This is because ERMapper does not display the true minimum and maximum values in the histogram window. To get the actual minimum and maximum values, either calculate the statistics in ERMapper, or add the dataset to ArcMap and right click on the dataset in the data layers area. In the properties select 'source' and record the min and the max values. Either of these methods should give you the true values of the dataset It is always pertinent to use both methods and compare the results as a check.

If any variable does not have a range of 0 to 100 it must be scaled. This is done to individual layers of the multi-layered grid file, used for the classification, by modifying the algorithm file (or possibly to the relevant individual .ers files for the various variables and creating a new .alg file and saving it as a new multi-layered .ers file). **Note: % sand, gravel and mud datasets were not scaled in later analyses in order to preserve their actual values for naming using the Folk classification System (Folk, 1966).**

2.5. CREATING THE SCALED ERMAPPER ALGORITHM

The individual variables need to be scaled from 0 to 100 in order for each variable to have equal weighting in the analysis.

21. To identify the maximum and minimum for each variable:

    - Add the *.ers files for each variable to ArcMap.
    - Right click on the layer and select the 'properties' option.
    - Select the 'source' tab from the layer properties dialogue box, and note down the minimum and the maximum (Fig. 2.6).
    - If the variable does not range from 0 to 100, it will need to be scaled.

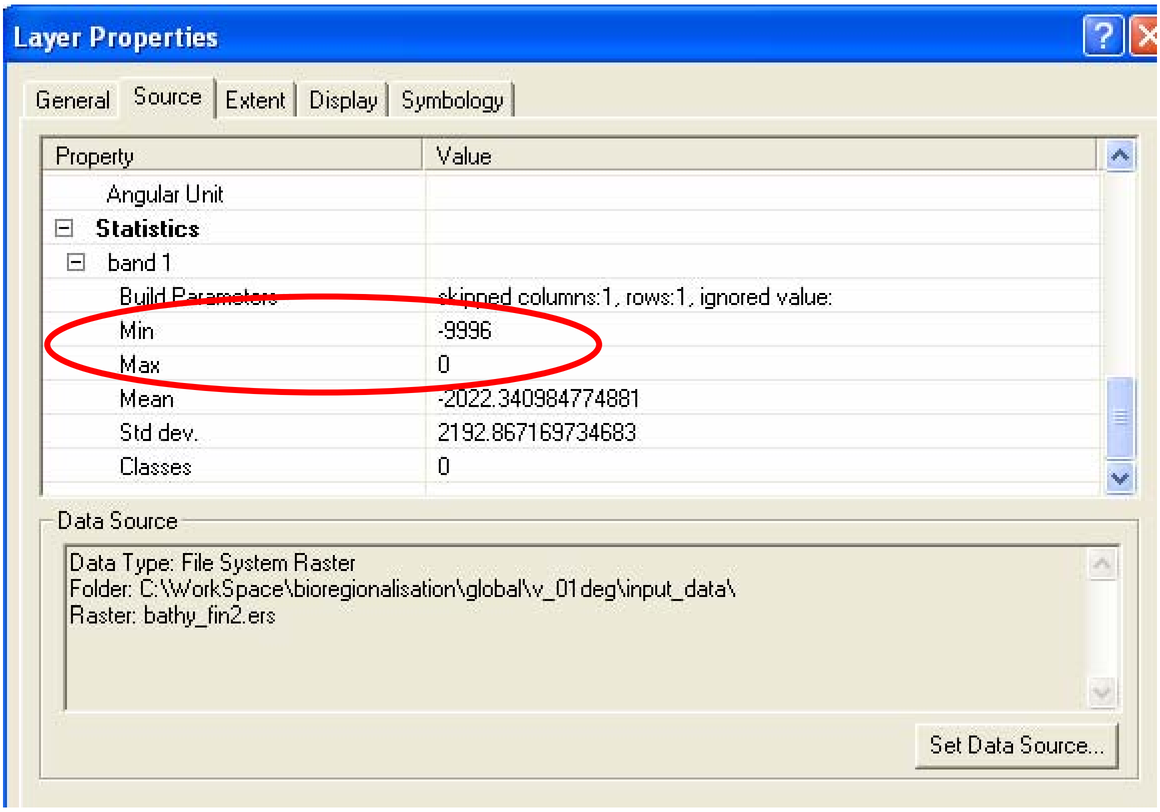


Figure 2.6. Minimum and Maximum values for the selected dataset in ArcMap Layer properties dialogue box.

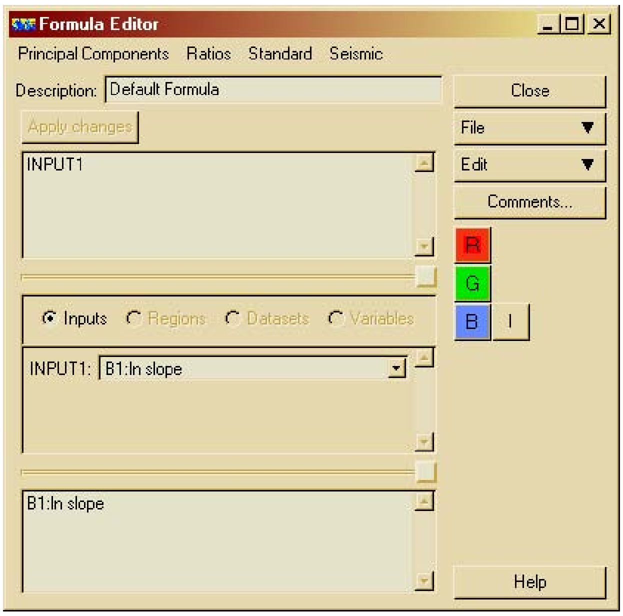


Figure 2.7. Formula editor window for entering user-defined transformation.

22. Scale each variable as required (i.e., variables that are not between 0 and 100), by:

- Click the 'Edit Algorithm' button on the 'Common Functions' toolbar, this brings up the 'Algorithm' window.
- Select a variable that needs scaling by clicking on it once.

- Click the 'Edit Formula' ('E=mc²') icon on the 'Edit Algorithm' window. This brings up the 'Formula Editor' window (Fig. 2.7).
- For example: to scale the logged slope layer select the 'ln slope' layer in the 'Edit Algorithm' window and enter the formula '(INPUT1 + 6.25) / (-0.7 + 6.25) * 100' in the formula box of the 'Formula Editor' window (under the 'Apply Changes' button) to replace 'INPUT1'. This applies a transformation to the ln slope data so that the range (-6.25 to -0.71) as displayed in step 33 is transformed into the range 0 to 100.
- Click the 'Apply Changes' button, which is now enabled.
- For example: to scale the Primary production layer select the 'primary prodn' layer in the 'Edit Algorithm' window and enter the formula '(INPUT1 - 89) / (1367 - 89) * 100' in the formula box of the 'Formula Editor' window. This transforms the range (89 to 1367) into the range 0 to 100.
- Click the 'Apply Changes' button, which is now enabled.
- For example: to scale the logged effective disturbance layer select the 'ln eff disturb' layer in the 'Edit Algorithm' window and enter the formula '(INPUT1 + 11.5) / (2.8 + 11.5) * 100' in the formula box of the 'Formula Editor' window. This transforms the range (-11.51 to 2.81) into the range 0 to 100.
- Click the 'Apply Changes' button, which is now enabled.
- Repeat this process for other files that need to be scaled.

23. Add the newly scaled variables to ArcGIS to ensure that all the variable values do range from 0 to 100.
24. Save all newly scaled files as individual *.ers files with the post-fix '_scaled' (Appendix C – Part 4.3.3).
25. Replace all initial input datasets in the algorithm with their newly scaled, exported *.ers files.
26. Save the algorithm with all scaled datasets (Appendix C – Part 4.3.1).

2.5.1. Preparing Input Variables for Analysis

27. Export each variable that appears in your final algorithm to an ASCII (txt) file using the 'Utilities', 'Export Raster', 'XYZ ASCII grid', 'Export' menu item.
    - First select your input dataset (ie) any of your final input variables (logged and scaled) for the 'Dataset to Export', then 'Enter'
    - For the export file name (in the 'Export Path/Device Name') enter the same name as your input file with file as *.txt, then click on 'OK' (Fig. 2.8).
    - Repeat this for all the other layers in the algorithm.

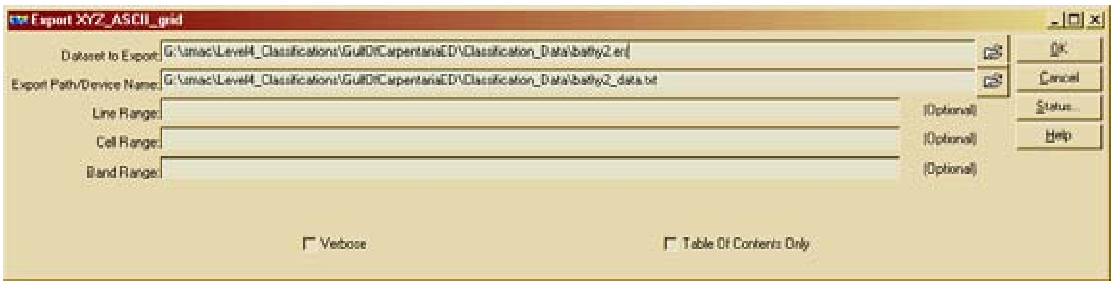


Figure 2.8. Parameters used when exporting data layers from ERMapper surface (ers) to ASCII (txt) format.

28. Save the algorithm ((with all layers on) as a new *.alg file (Appendix C – Part 4.3.1).

29. Save the final filtered, logged and scaled algorithm as a *.ers file for further analysis (Appendix C – Part 4.3.1).

2.6. RUNNING THE CLASSIFICATIONS

Now that the final filtered, logged and scaled *.ers file has been created, it is used to produce classifications for a number of classes. Most of the default ISOclass classification values were used, except that the desired percent unchanged was set to 100% and the maximum number of classes was manually set. In some cases, the classification process did not reach 100% convergence and had to be stopped manually, usually near 100% convergence. This problem was avoided if the 'Min distance between class means' parameter was made small enough. In some of the earlier classifications, the number of initial classes was increased to obtain 100% convergence.

The classifications need to be run from 3 to 15 classes. In order to run these either run them one at a time through ERMapper, or run the program ERMapperAutoClassifaction.exe to run them without manual intervention.

2.6.1. Option 1 – Manual Processing

30. Select the 'Process', 'Classification', 'ISOclass Unsupervised Classification...'
    - For 'Input Dataset' select the final filtered, logged and scaled *.ers file.
    - For 'Output Dataset' select the same path with uclassx.ers where x is the number of classes.
    - enter '3' for 'Maximum number of classes, and '100' for 'Desired percent unchanged' and click 'OK' to run the classification.

31. Repeat for 4, 5, 6, classes, and up to 15 classes, each time updating the file in 'Output Dataset' (‘*uclass4.ers*’, ‘*uclass5.ers*’, etc) and the value in 'Maximum number of classes'.

(Note: if a classification does not converge to 100% unchanged, it may be necessary to reduce the value of 'Min. distance between class means').

2.6.2. Option 2 – Automated Processing

32. Run the Visual Basic program '*ERMapperAutoClassifaction.exe*'. (This program can be installed using the 'setup.exe' program). Use the following parameters:

- Double click in the ‘Classification File’ to select your file (the final filtered, logged and scaled *.ers file).
- Select the output location by double clicking and add \uclass to the data – all output files will be called ‘uclassx’ where x is the number of classes specified.
- In the generate classifications box, enter the classifications (number of classes) you want undertaken (generally 3 to 15 inclusive)
- Set the minimum distance between classes to 1.

33. Before running the classifications automatically, close all ERMapper windows, then open a new ERMapper session.
34. Open the ISOclass classification tool in ‘Process’, ‘Classification’, ‘ISOclass Unsupervised Classification’. Tab through the controls in the window until the ‘OK’ button is highlighted.
35. Close the main ERMapper Window, leaving the Unsupervised Classification window open.
36. Return to the VB tool and click ‘Start Classifications’, leave the program to create unsupervised classifications automatically. Do not click on the ‘OK’ button when a classification finishes as the program uses this to indicate that it should start the next classification.

2.7. EXPORTING TO XYZ ASCII

All newly created classification files now need to be exported to ascii xyz format. To export these files either run them one at a time through ERMapper, or use the program ERMapperAutoExportAsciiXYZ.exe to run them without manual intervention.

2.7.1. Option 1 – Manual Processing

37. Use the 'Utilities', 'Export Raster', 'XYZ ASCII grid', 'Export' menu item to save each of the classification files (*uclass3.ers* etc) as ASCII XYZ files (called '*uclass3_data.txt*' etc).

2.7.2. Option 2 – Automated Processing

38. Run the Visual Basic program 'ERMapperAutoExportAsciiXYZ.exe'. (This program can be installed using the 'setup.exe' program. Use the following parameters:
    - Select the location of input files by entering a file location in the ‘Base .ers file name’ selection panel and add \uclass to the end of the file name – all files starting with uclass will be selected as inputs.
    - In the ‘Sequence number of files to be exported’ enter the classifications you want exported (3 to 15 generally).
39. Before running the classification, close all ERMapper windows, then open a new ERMapper session.

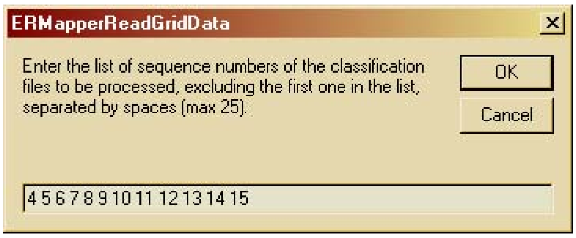


Figure 2.9. Window with list of files to be processed.

40. Open the 'Utilities', 'Export Raster', 'XYZ ASCII Grid', 'Grid' tool. Tab through the controls in the window until the 'OK' button is highlighted.

41. Close the main ERMapper Window, leaving the Export XYZ ASCII grid window open.

42. Return to the VB tool and click 'Start Exporting', leave the program to export the xyz files automatically. Do not click on the 'OK' button when an export finishes as the program uses this to indicate that it should start the next export.

2.8. DETERMINING THE OPTIMUM NUMBER OF CLASSES

To determine the optimum number of classes, plots of the distance ratio and Calinksi-Harabasz pseudo F-statistic are created using the ERMapperReadGridData program.

43. Run the Visual Basic program '*ERMapperReadGridData.exe*'.

44. Click 'Add' and open the file '*uclass3_data.txt*' created previously. Load each variable text file after that by clicking on the 'Add' button (note the order in which you load these files.

45. Select the 'Tools', 'Process all classifications' menu item and enter '4 5 6 7 8 9 10 11 12 13 14 15' in the dialog box that appears then click 'OK' (Fig. 2.9).

This will cause the program to first process all the classification files in the top list, after which it will use '*uclass4_data.txt*' etc up to '*uclass15_data.txt*'. It will automatically produce an excel work book with a work sheet displaying graphs of the distance ratio and C-H F-statistic (Fig. 2.10).

46. Enter the cell size into the grid size option in the lower left corner.

47. Repeat the process after restoring the first file in the top list to '*uclass3_data.txt*' (by double-clicking and opening the '*uclass3_data.txt*' file) and after clicking on the 'Weighted mean' check box. This will produce a plot of the *weighted* distance ratio as well as the F_{CH} -statistic. It may be more justified to use the weighted means than the unweighted means.

48. Combine the worksheets produced for both the weighted and unweighted distance ratios to produce a final excel spreadsheet called '*MeanDist_vs_NoClasses.xls*'.

The distance ratios indicate the goodness of fit for the classification. The smaller the value, the closer on average, the individual class members are to their class means. In cases where there is a wide range in the number of members of each class, the weighted distance ratio is more meaningful because it takes into account the size of each class.

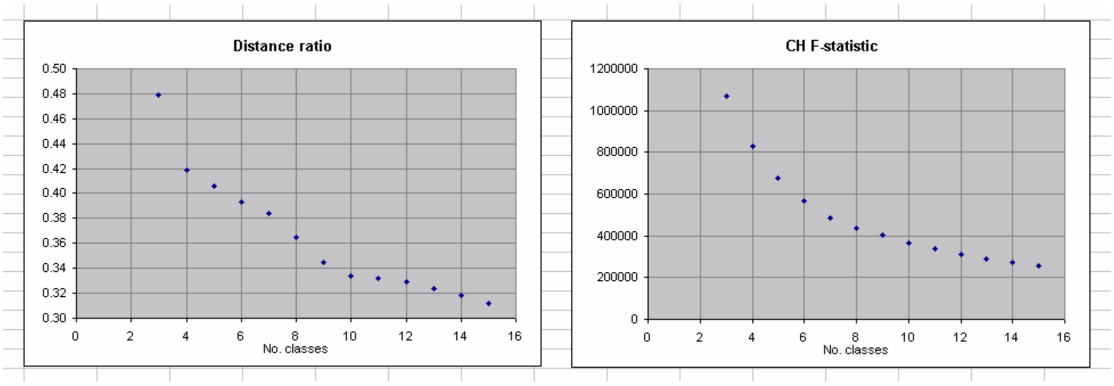


Figure 2.10. Graphs showing the distance and CH F-statistic results from the classification. The optimal number of classes is determined from local minima on the graphs or where the graphs flatten out.

For the purpose of determining the optimum number of classes, a plot of distance ratio and weighted distance ratio, versus number of classes was calculated for a range of classes, typically 5 to 15 classes (Fig. 2.10). These plots often have a local minimum indicating the optimum number of classes. In other cases, there is no local minimum but there is often a point where, after an initial decline, the curve flattens out, indicating that little will be gained by increasing the number of classes. Where the number of data points in each class differed a lot, greater notice was taken of the weighted distance ratio.

In the example above the distance ratio was used to decide on 10 classes for the classification as a local minimum occurs in the graph.

Alternatively the Calinski-Harabasz pseudo F-statistic (F_{CH}) can be used to determine the optimum number of classes. The optimum number of classes occurs where the F_{CH} statistic is at a local high. NOTE: Not all analyses will be conclusive; in some cases the optimal number of classes may still not be clear.

2.9. STATISTICAL ANALYSIS OF CLASSIFICATION

Once the number of classes has been chosen, the statistics for this class will be analysed. To create the statistics:

49. Replace the first file at the top of the list of files to be processed in ERMapperReadGridData with the text file for the number of classes you selected (ie uclassx.txt) and click on 'Process Files'.
50. Click on 'Save Data'. This creates a file called '*outputx.txt*', in the same directory, containing the classification and input data for the 5-class classification.
51. Quit ERMapperReadGridData.

The statistics are then analysed in Statistica:

52. Run Statistica and close any default windows that are open.
53. Select 'File', 'Open' to open the '*output5.txt*'. Import it as a spreadsheet, 'Import type' as 'Auto' using all default settings in the 'Open Text File' dialog.
54. Use 'File', 'Save As' to save the file as a '*.*sta*' file (in the same directory).
55. Ensure that the file has one blank variable at the start, and no other blank variables.

56. Use 'Tools', 'Macro', 'Macros', and click on 'Open' in the window that appears, to open the Statistica macro '*PrepareSeascapeData.svb*'.

57. Press 'F5' to run the macro. Close the macro window when finished. The macro will delete the first, unwanted, column and places the variable names in the column headers, and add a column at the end for the geomorphic classes with their names instead of numerical values. (It may be necessary to widen some of the columns in order to fully display the variable names.)

58. The variable names are contained in the file '*variable_names.txt*', which must be created manually.

59. To create the variables list type in the names of each variable in the order they were analysed (as per the list in Read Grid Data), and save the file as '*variable_names.txt*' NOTE: Make sure there are no spaces or carriage returns at the end of the list.

60. Before running the macro, personal preferences for graph displays can be chosen using 'Tools', 'Options' and going to the 'Graphs 1' and 'Graphs 2' tabs.

The following preferences were used for the classifications. On 'Graph 1' the 'Plot Markers' have been chosen as filled in symbols and the first 'Bar Areas' colour as a solid dark grey (RGB: 60, 60, 60) (Fig. 2.11 & 2.12). On 'Graph 2' the 'Graph document style' has been chosen as 'A4 Landscape Document Si...' (Fig. 2.13).

61. Use 'Tools', 'Macro', 'Macros', and click on 'Open' in the window that appears, to open the Statistica macro '*SeascapeCreateOutput.svb*'.

62. Click 'OK' to close the 'Options' window and press 'F5' to run the macro. Close the macro window when finished.

When finished, a workbook with four folders will be produced (Fig. 2.13). The contents of the folders are as follows:

- '*Basic Statistics*' - this follow contains a sub-folder with basic statistical quantities for all the input variables (minimum, maximum, mean and standard deviation) and a sub-folder with the correlations between each variable (note that statistically significant correlations are displayed in red);
- '*Total Histograms*' - this folder contains histogram plots of the distributions of each input variable (Fig. 2.13); '*Histograms for each class*' - this folder contains multiple histogram plots of the distributions of each input put variable for each class;
- '*Analysis of variance*' - this folder contains sub-folders with a plot of the class means for each input variable, and a sub-folder with the multivariate tests of significance for the analysis of variance (always highly significant because of the large number of data points). (Another option is calculate Fisher LSD tests of the significance of the differences between each pair of means for each variable. To calculate the Fisher LSD tests, click the 'More results' button on the 'ANOVA Results' window, click the 'Post-Hoc' tab, click the 'Dependant variables' tab and select all the variables, then click the 'Fisher LSD' button. Values in red indicate that the difference is statistically significant.)

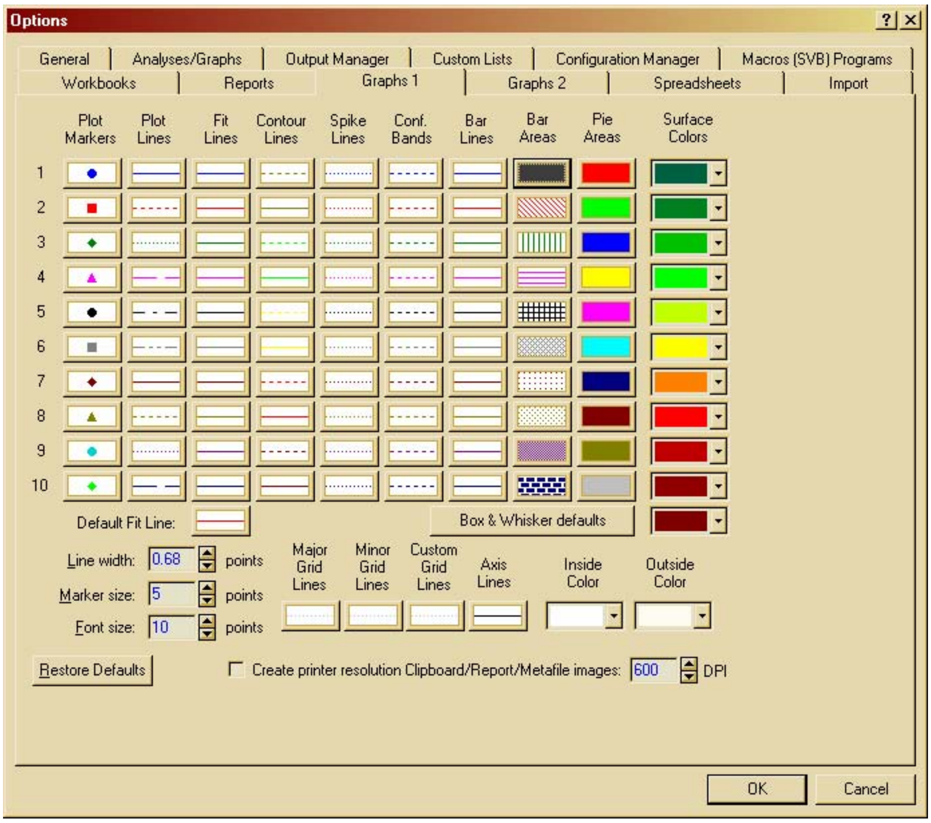


Figure 2.11. Graphing options for the final classes of the ISOclass classification.

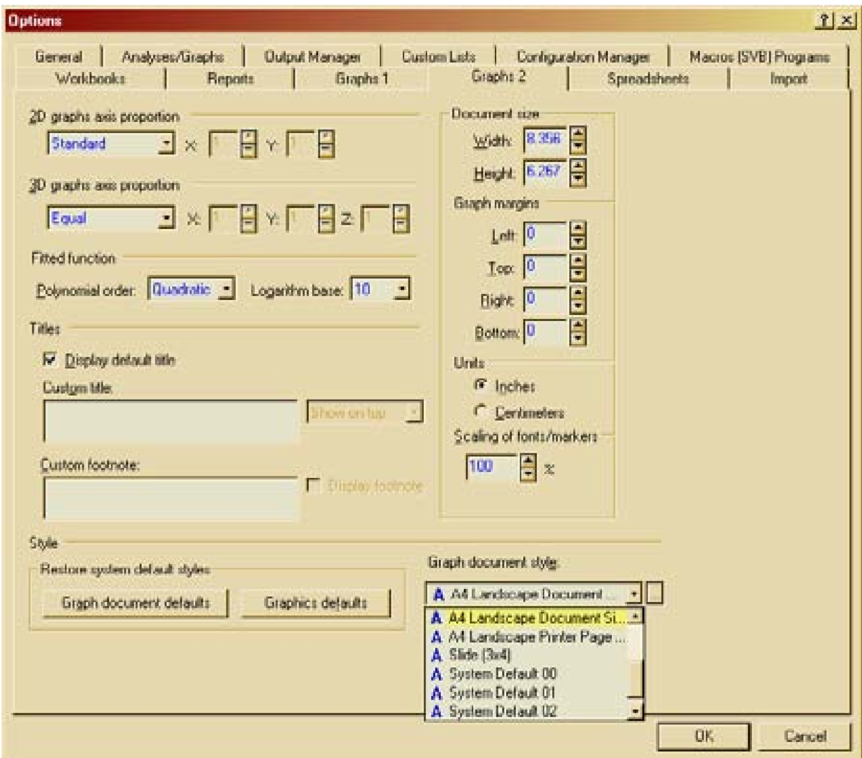
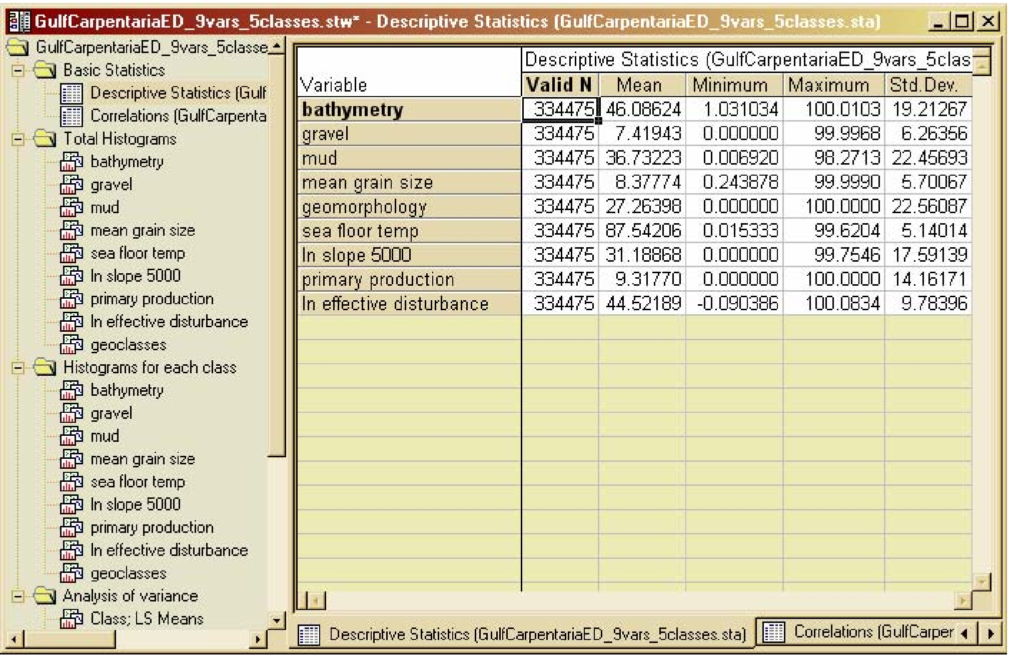


Figure 2.12. Printing options for the graphs produced from the final ISOclass classification.



Variable	Valid N	Mean	Minimum	Maximum	Std.Dev.
bathymetry	334475	46.08624	1.031034	100.0103	19.21267
gravel	334475	7.41943	0.000000	99.9968	6.26356
mud	334475	36.73223	0.006920	98.2713	22.45693
mean grain size	334475	8.37774	0.243878	99.9990	5.70067
geomorphology	334475	27.26398	0.000000	100.0000	22.56087
sea floor temp	334475	87.54206	0.015333	99.6204	5.14014
ln slope 5000	334475	31.18868	0.000000	99.7546	17.59139
primary production	334475	9.31770	0.000000	100.0000	14.16171
ln effective disturbance	334475	44.52189	-0.090386	100.0834	9.78396

Figure 2.13. Descriptive statistics calculated for each variable used in the ISOclass classification.

The Analysis of variance, class means plot, is manually fine-tuned as follows:

63. Click on the 'Class; LS Means' sub-folder in the 'Analysis of variance' folder to display the LS Means graph.

64. Right-click on the graph, and select the menu item 'Graph Data Editor...'

65. For each variable, in the displayed graph data spreadsheet, replace the values in the 'X' columns with the values 1, 2, 3, 4, 5, 6, 7, 8, 9, 10. Close the graph data window. The data points (LS means) should now all be vertically aligned.

66. Double-click on the third line of the title of the graph ('Effective hypothesis decomposition') and press <Delete>. Repeat for the next line ('Vertical bars denote 0.95 confidence intervals'). This removes unnecessary title lines thus increasing the space of the display. Double-click on the first line of the title, increase the font size to 12, and add the name of the classification to the text.

67. Save the workbook as a **.stw* file. The individual sub-folders are ready to be printed (landscape, A4).

2.10. NAMING THE CLASSES

Each class is given a name that reflects the variables that discriminate that class, as follows:

2.10.1. Initial Class Names

In initial classifications, the name consisted generally of a sediment type (mostly sand, mud or carbonate) qualified by a number of adjectives. The sediment type was determined by the predominant particle present using the analysis of variance means in a relative, rather than absolute, sense. Thus, those classes that had the highest average mud content, for example, were called ‘muds’ without regard for whether it was the correct geological term.

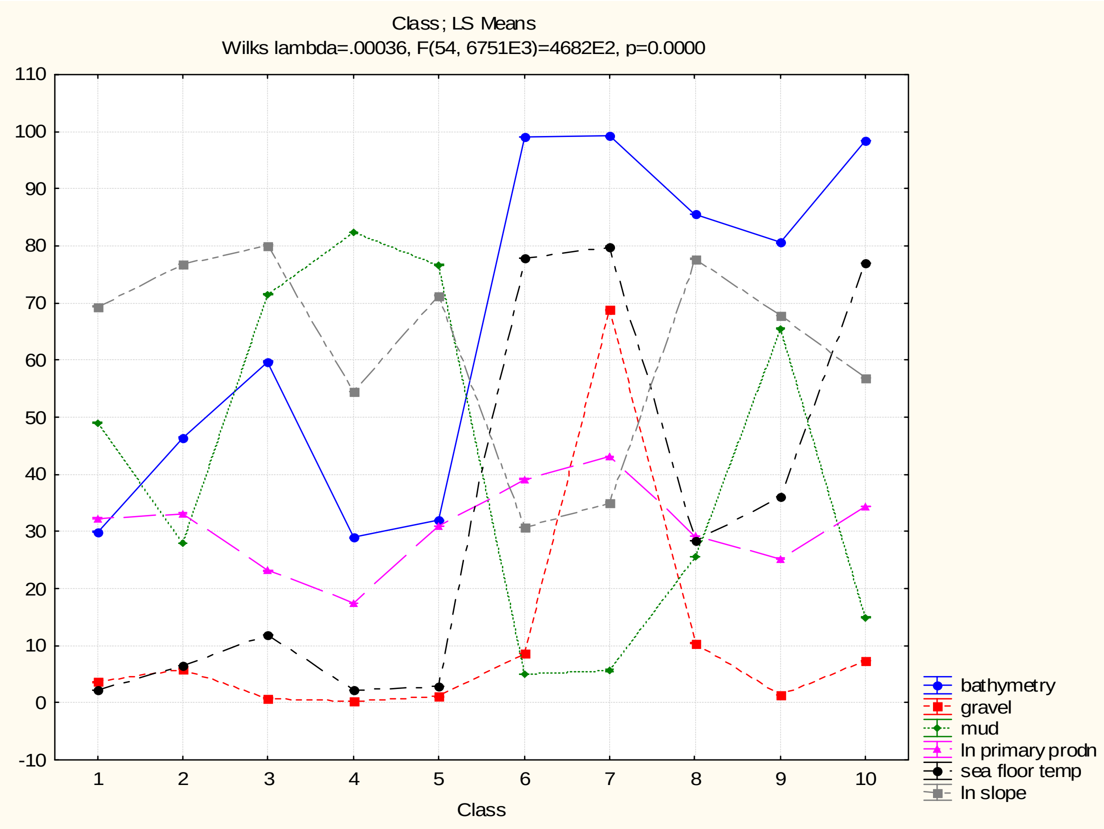


Figure 2.14. Graph of class means for each variable used in the ISOclass classification.

Adjectives were chosen from those means that had extreme values again relative to the values in each class. Thus 'deep' was used for those classes that had the highest mean values of bathymetry, while 'shallow' was used for those with the lowest, again in a relative sense. Occasionally, an adjective would be constructed from the variable name by appending a 'y' to indicate a high level of the variable but not an extreme value. For example, 'muddy' might be used to qualify a carbonate because that class had relatively high mud content.

Occasionally the histograms for each class would be referred to if the analysis of variance means did not provide enough information, even so, there were occasional classes that did not stand out in any particular variable and its name was thus less informative. In later classifications the naming convention was modified to more closely represent actual names.

Each class is named first for its sediment type based on the 3 types of sediment used in the classifications – sand gravel and mud.

- Where a class is dominated by one sediment type (for instance a single sediment type has greater than (about) 80%), the final sediment type is labelled for the dominant sediment (i.e., 10% mud, 5% gravel and 85% sand - the class would be called sand).

- If there are large proportions of 2 sediment types the name would be a combination of each of the sediment types. (i.e., 40% mud, 50% sand and 10% gravel – the class would be called muddy sand indicating that the sand is the dominant sediment type, but there is also a high proportion of mud).

- Finally a fairly equally mixed proportion of all 3 sediment types would be known as mixed sediment.

2.10.2. Final Class Names

In final classifications the sediment names were derived based on the Folk Classification System of 'textural terminology for gravel-bearing detrital sediments'. (Folk, 1966) In these classifications the other variables were named only if they showed an extreme. For instance, if the primary productivity was very high for one class in particular, the class name would include 'high productivity'. If the variable for a particular class was about average, then the name would not include any mention of the variable.

2.11. CLASS COLOURS

After naming each of the classes to reflect the relative amounts of the input variables displayed in the LS Means graph colours were assigned to each class and applied to the classification file as follows (Fig. 2.14).

The darkness (luminosity) of the colour was used approximately to indicate depth, dark colours for deeper classes, light colours for shallower classes. The colour (hue) was used to approximately indicate prominent variable values, generally as follows:

- yellow – sand;
- light brown – mud;
- green – carbonate;
- purple – wave; and
- orange – tide.

To select colours for each class, follow the steps below:

68. Run ERMapper and open the selected '*uclass5.ers*' ('File', 'Open').
69. Click the 'Edit Algorithm' button on the 'Common Functions' toolbar to bring up the 'Algorithm' window.
70. Right-click on the 'Psuedo' label in the left panel of the 'Algorithm' window and select 'Class Display'. The classification raster file is now displayed with a colour assigned to each class. The colours are initially shades of grey.
71. Select the 'Edit', 'Edit Class/Region Colour and Name...' menu item to bring up 'Edit Class/Region Details' window (Fig. 2.15).
72. Click on 'Set color...' for each class to set the colour for that class.
73. Click in the 'Name' edit boxes and edit the text to change the names of each class.
74. Click the 'Save' button to save the changes.
75. Close the 'Edit Class/Region Details' window.
76. Click the 'Refresh' button on the 'Standard' toolbar of ERMapper's main window. The new colours should now be displayed.
77. Select the 'File', 'Page Setup...' menu item and click on the 'Set Color ...' button and select pure white. This gets the display ready for printing. Close the 'Page Setup' window by clicking on the 'OK' button.

Figure 2.15. Edit Class/Region Details window used to assign colours and descriptors to classes.

78. Add the coastline of Australia by selecting the 'File', 'Add into Current Surface...' menu item and opening '*coast_1.erv*'.

79. Click on the 'Vector Layer' label in the left panel of the 'Algorithm' window.

80. Click on the 'color' icon in the 'Algorithm' window and select a dark colour for the coastline.

81. Use 'File', 'Print' to print the map of the classification. ('Fit page to output device' can be checked to get the maximum size that can fit onto the page.)

82. Quit ERMapper.

83. Run the Visual Basic program '*ERMapperReadClasses.vbp*' (Fig. 2.16). (This program can be installed using the '*setup.exe*'.)

84. Double-click in the 'File:' box and open the file '*uclassx.ers*' for your selected class number.

85. Double-click on each item in the 'Band descriptions:' list and enter abbreviations for each of the variables. Enter text for 'Description:' if desired. The window should now appear as follows.

86. Click the 'Read Classes' button to produce a display of the class colours and some basic statistics (Fig. 2.17).

87. Select the 'print' option and click the 'Read Classes' button to print the above display. (The page will not actually be printed until you quit out of the program.)

88. Select the 'Excel' option and click the 'Read Classes' button to create an Excel spreadsheet with the class colours and basic statistics in a spreadsheet format (Fig. 2.18). Save the workbook, and edit to produce a legend for the map of the classification.

89. Quit ERMapperReadClasses.

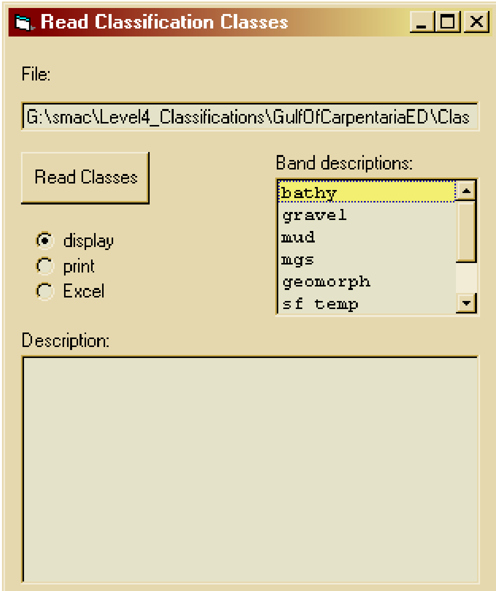
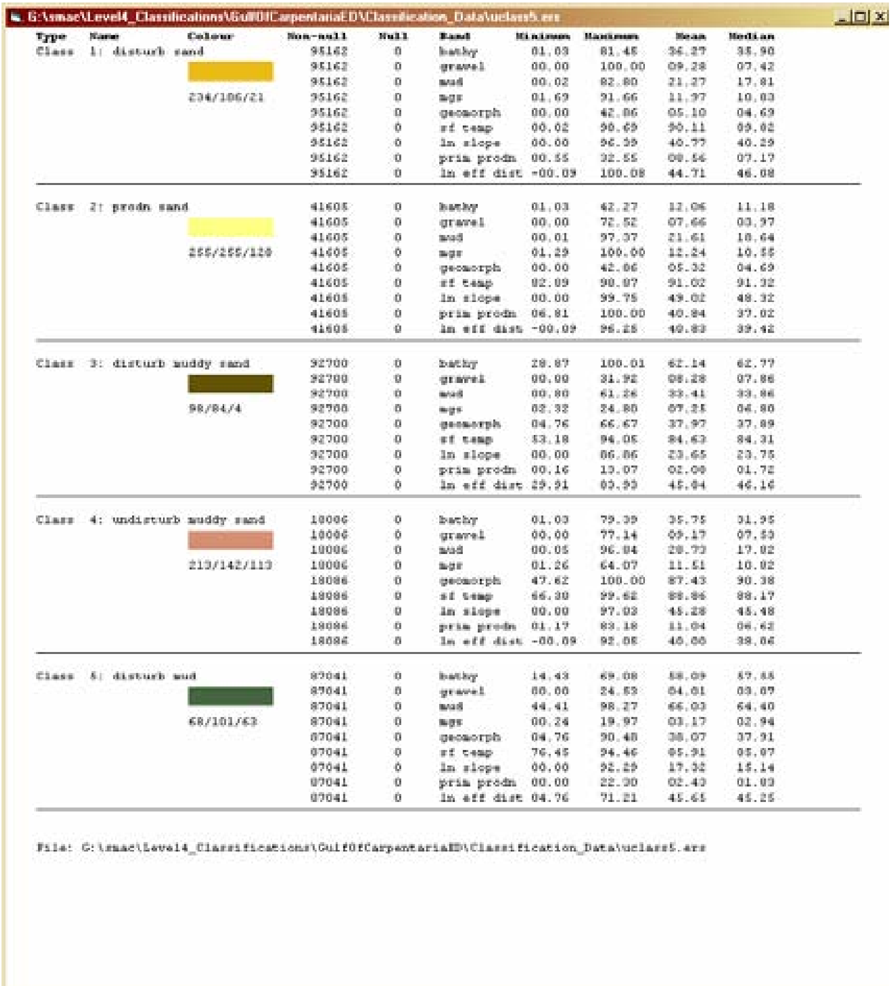


Figure 2.16. Band descriptions window to access statistics for each class in the final classification.



G:\smac\Level4_Classifications\GulfOfCarpentariaED\Classification_Data\uclass5.ers

Type	Name	Colour	Non-null	Null	Band	Minimum	Maximum	Mean	Median
Class	1: disturb sand		95162	0	bathy	01.03	81.45	36.27	35.90
			95162	0	gravel	00.00	100.00	09.28	07.42
			95162	0	mud	00.02	82.80	21.27	17.81
		234/186/21	95162	0	mgs	01.69	91.66	11.97	10.03
			95162	0	geomorph	00.00	42.06	05.10	04.69
			95162	0	sf temp	00.02	90.69	90.11	89.82
			95162	0	ln slope	00.00	96.39	40.77	40.29
			95162	0	prim prodn	00.55	32.55	08.56	07.17
			95162	0	ln eff dist	-00.09	100.08	44.71	46.08
Class	2: prodn sand		41605	0	bathy	01.03	42.27	12.06	11.18
			41605	0	gravel	00.00	72.52	07.66	03.97
			41605	0	mud	00.01	97.37	21.61	18.64
		255/255/128	41605	0	mgs	01.29	100.00	12.24	10.55
			41605	0	geomorph	00.00	42.06	05.32	04.69
			41605	0	sf temp	82.09	98.07	91.02	91.32
			41605	0	ln slope	00.00	99.75	49.02	48.32
			41605	0	prim prodn	06.81	100.00	40.84	37.02
			41605	0	ln eff dist	-00.09	96.28	40.83	39.42
Class	3: disturb muddy sand		92700	0	bathy	28.87	100.01	62.14	62.77
			92700	0	gravel	00.00	31.92	08.28	07.86
			92700	0	mud	00.80	61.26	33.41	33.86
		98/84/4	92700	0	mgs	02.32	24.80	07.25	06.80
			92700	0	geomorph	04.76	66.67	37.97	37.89
			92700	0	sf temp	53.18	94.05	84.63	84.31
			92700	0	ln slope	00.00	86.86	23.65	23.75
			92700	0	prim prodn	00.16	13.07	02.00	01.72
			92700	0	ln eff dist	29.91	83.93	45.04	46.16
Class	4: undisturb muddy sand		10006	0	bathy	01.03	79.39	35.75	31.95
			10006	0	gravel	00.00	77.14	09.17	07.53
			10006	0	mud	00.05	96.84	20.73	17.82
		213/142/113	10006	0	mgs	01.26	64.07	11.51	10.02
			18086	0	geomorph	47.62	100.00	87.43	90.38
			18086	0	sf temp	66.30	99.62	88.86	88.17
			18086	0	ln slope	00.00	97.02	45.28	45.48
			18086	0	prim prodn	01.17	83.18	11.04	06.62
			18086	0	ln eff dist	-00.09	92.08	40.00	38.06
Class	5: disturb mud		87041	0	bathy	14.43	69.08	58.09	57.55
			87041	0	gravel	00.00	24.53	04.01	03.07
			87041	0	mud	44.41	98.27	66.03	64.40
		68/101/63	87041	0	mgs	00.24	19.97	03.17	02.94
			87041	0	geomorph	04.76	90.48	38.07	37.91
			87041	0	sf temp	76.45	94.46	85.91	85.07
			87041	0	ln slope	00.00	92.29	17.32	15.14
			87041	0	prim prodn	00.00	22.30	02.43	01.83
			87041	0	ln eff dist	04.76	71.21	45.61	45.25

File: G:\smac\Level4_Classifications\GulfOfCarpentariaED\Classification_Data\uclass5.ers

Figure 2.17. Final statistics associated with the unsupervised ISOclass classification for the Gulf of Carpentaria.

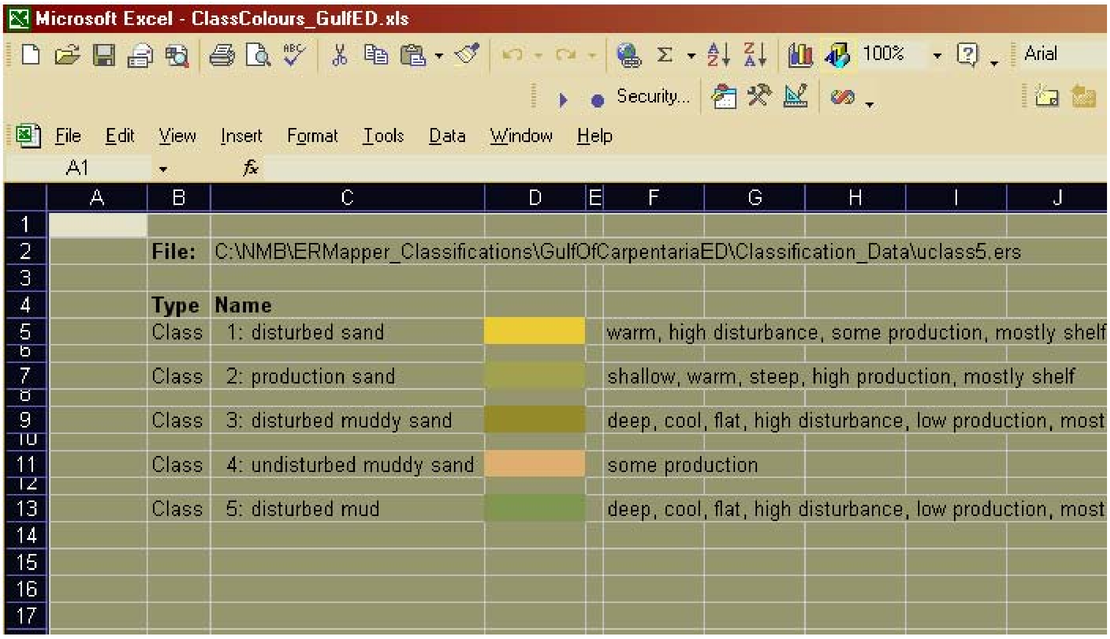


Figure 2.18. Legend options for Gulf of Carpentaria Unsupervised Classification.

2.12. CONVERSION FROM ERMAPPER TO ESRI GRID

90. The final classification file is exported to an ESRI grid to be mapped with other relevant data. To export the ERMapper file, follow the directions in Appendix D.

PART 3 – REFERENCES

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PART 4 – APPENDICES

4.1. APPENDIX A – METADATA FOR INPUT DATA

4.1.1. % Gravel

Dataset TITLE: Sedimentary Features (Gravel content) of the Australian Margin (Revised Geoscience Dataset).
Dataset AUTHORS: T. Whiteway, A. Hinde, V. Lucieer, A.D. Heap, R. Ruddick, P.T. Harris.
Dataset CUSTODIAN: Geoscience Australia.
Dataset JURISDICTION: Australia.
Description ABSTRACT: This dataset provides a visual representation of the gravel content of seabed sediments expressed as a percentage of total sediment (of a combination of mud, gravel and sand). The data on which this map is based were compiled from Geoscience Australia's marine samples database (MARS). The map coverage is Australia's Exclusive Economic Zone, excluding the offshore island territories, and the Australian Antarctic Territory. This dataset is a second revision of the sediment datasets for the South-west and Northern Planning Regions only.
Description SEARCH WORDS(S): GEOSCIENCES SEDIMENT MARINE mapping.
Description GEOGRAPHIC EXTENT POLYGON: Exclusive Economic Zone – AUS – Australia.
Description GEOGRAPHIC EXTENT BOUNDARIES: N_LAT: -8, S_LAT: -60, E_LONG: 172, W_LONG: 92.
Description GEOGRAPHIC EXTENT NAME(S): National.
Description NOMINAL SCALE: Scale: 1:5,500,000.
Dataset Currency BEGINNING DATE: 1Nov2006.
Dataset Currency ENDING DATE: Current.
Dataset Status PROGRESS: Complete.
Dataset Status MAINTENANCE AND UPDATE FREQUENCY: As required - When additional sediment data becomes available.
Access STORED DATA FORMAT: DIGITAL – GIS – ARC/MAP, DIGITAL – Images – JPEG, DIGITAL – Images – PDF.
Access AVAILABLE FORMAT TYPE(S): DIGITAL – GIS – ARC/MAP, DIGITAL – Images – JPEG, DIGITAL – Images – PDF.
Access ACCESS CONSTRAINT: DIGITAL - IMAGES – No access constraints, DIGITAL – GIS – Contact Data Custodian.
Data Quality LINEAGE: Marine sediment sample information within the Australian Maritime Jurisdiction was sourced by Geoscience Australia from Australian and International research groups, Government bodies, private corporate entities, and published/unpublished reports. This information was then used to populate a National Marine Samples Database (MARS). MARS is an Oracle database that has been developed by Geoscience Australia in line with ANZLIC data standards. The point data presented here is from seabed samples where grainsize has been measured or determined through scientific analysis, and was exported from MARS to ARC/GIS for the generation of maps.

Data Quality POSITIONAL ACCURACY: Positional accuracy of individual points varies depending on the source data. Some data is form old records, external records and the methods used to ascertain position accuracy is unknown. Due to the scale of the map and quality of the source, the accuracy is assumed to be within 5 km.
Data Quality ATTRIBUTE ACCURACY: No attribute for data quality exists at this stage. All the attribute data has been entered by Geoscience Australia staff from a range of reports. The accuracy depends on human error or that of the report.
Data Quality LOGICAL CONSISTENCY: All vector data has been visually checked for extraneous points and value added data. In some circumstances individual datasets were identified as inconsistent within the grid and either left out of the final grid or were corrected. Regional data sets were then compiled as a single national coverage. Tests were also carried out on the data for completeness, correct spatial representation, attribute accuracy, and logical consistency and correctness.
Data Quality COMPLETENESS: All vector data and details are complete and verified.
Contact Information CONTACT ORGANISATION: Geoscience Australia.
Contact Information CONTACT POSITION: MARS Database Administrator.
Contact Information MAIL ADDRESS 1: GPO Box 378.
Contact Information SUBURB OR PLACE OR LOCALITY: Canberra City.
Contact Information STATE: ACT.
Contact Information COUNTRY: Australia.
Contact Information POSTCODE: 2601.
Contact Information TELEPHONE: +61 2 6249-9111.
Contact Information FACSIMILE: +61 2 6249-9999.
Contact Information ELECTRONIC MAIL ADDRESS: Sales@ga.gov.au.
Metadata Date METADATA DATE: 19Jan2007.
COORDINATE SYSTEM DESCRIPTION: Projection GEOGRAPHIC: Datum WGS84; Units DD.
ADDITIONAL METADATA: None.

4.1.2. % Sand

Dataset TITLE: Sedimentary Features (Sand content) of the Australian Margin (Revised Geoscience Dataset).
Dataset AUTHORS: T. Whiteway, A. Hinde, V. Lucieer, A.D. Heap, R. Ruddick, P.T. Harris.
Dataset CUSTODIAN: Geoscience Australia.
Dataset JURISDICTION: Australia.
Description ABSTRACT: This dataset provides a visual representation of the sand content of seabed sediments expressed as a percentage of total sediment (of a combination of mud, gravel and sand). The data on which this map is based were compiled from Geoscience Australia's marine samples database (MARS). The map coverage is Australia's Exclusive Economic Zone, excluding the offshore island territories, and the Australian Antarctic Territory. This dataset is a second revision of the sediment datasets for the South-west and Northern Planning Regions only.
Description SEARCH WORDS(S): GEOSCIENCES SEDIMENT MARINE mapping.
Description GEOGRAPHIC EXTENT POLYGON: Exclusive Economic Zone – AUS – Australia.

Description GEOGRAPHIC EXTENT BOUNDARIES: N_LAT: -8, S_LAT: -60, E_LONG: 172, W_LONG: 92.
Description GEOGRAPHIC EXTENT NAME(S): National.
Description NOMINAL SCALE: Scale 1:5,500,000.
Dataset Currency BEGINNING DATE: 1Nov2006.
Dataset Currency ENDING DATE: Current.
Dataset Status PROGRESS: Complete.
Dataset Status MAINTENANCE AND UPDATE FREQUENCY: As required - When additional sediment data becomes available.
Access STORED DATA FORMAT: DIGITAL – GIS – ARC/MAP, DIGITAL – Images – JPEG, DIGITAL – Images – PDF
Access AVAILABLE FORMAT TYPE(S): DIGITAL – GIS – ARC/MAP, DIGITAL – Images – JPEG, DIGITAL – Images – PDF.
Access ACCESS CONSTRAINT: DIGITAL - IMAGES – No access constraints, DIGITAL – GIS – Contact Data Custodian.
Data Quality LINEAGE: Marine sediment sample information within the Australian Maritime Jurisdiction was sourced by Geoscience Australia from Australian and International research groups, Government bodies, private corporate entities, and published/unpublished reports. This information was then used to populate a National Marine Sediments Database (MARS). MARS is an Oracle database that has been developed by Geoscience Australia in line with ANZLIC data standards. The point data presented here is from seabed samples where grainsize has been measured or determined through scientific analysis, and was exported from MARS to ARC/GIS for the generation of maps.
Data Quality POSITIONAL ACCURACY: Positional accuracy of individual points varies depending on the source data. Some data is form old records, external records and the methods used to ascertain position accuracy is unknown. Due to the scale of the map and quality of the source, the accuracy is assumed to be within 5 km.
Data Quality ATTRIBUTE ACCURACY: No attribute for data quality exists at this stage. All the attribute data has been entered by Geoscience Australia staff from a range of reports. The accuracy depends on human error or that of the report.
Data Quality LOGICAL CONSISTENCY: All vector data has been visually checked for extraneous points and value added data. In some circumstances individual datasets were identified as inconsistent within the grid and either left out of the final grid or were corrected. Regional data sets were then compiled as a single national coverage. Tests were also carried out on the data for completeness, correct spatial representation, attribute accuracy, and logical consistency and correctness.
Data Quality COMPLETENESS: All vector data and details are complete and verified.
Contact Information CONTACT ORGANISATION: Geoscience Australia.
Contact Information CONTACT POSITION: MARS Database Administrator.
Contact Information MAIL ADDRESS 1: GPO Box 378.
Contact Information SUBURB OR PLACE OR LOCALITY: Canberra City.
Contact Information STATE: ACT.
Contact Information COUNTRY: Australia.
Contact Information POSTCODE: 2601.
Contact Information TELEPHONE: +61 2 6249-9111.
Contact Information FACSIMILE: +61 2 6249-9999.
Contact Information ELECTRONIC MAIL ADDRESS: Sales@ga.gov.au.

Metadata Date METADATA DATE: 19Jan2007.
COORDINATE SYSTEM DESCRIPTION: Projection GEOGRAPHIC, Datum WGS84, Units DD.
ADDITIONAL METADATA: None.

4.1.3. % Mud

Dataset TITLE: Sedimentary Features (Mud content) of the Australian EEZ (Revised Geoscience Dataset).
Dataset AUTHORS: T. Whiteway, A. Hinde, V. Lucieer, A.D. Heap, R. Ruddick, P.T. Harris.
Dataset CUSTODIAN: Geoscience Australia.
Dataset JURISDICTION: Australia.
Description ABSTRACT: This dataset provides a visual representation of the mud content of seabed sediments expressed as a percentage of total sediment (of a combination of mud, gravel and sand). The data on which this map is based were compiled from Geoscience Australia's marine samples database (MARS). The map coverage is Australia's Exclusive Economic Zone, excluding the offshore island territories, and the Australian Antarctic Territory. This dataset is a second revision of the sediment datasets for the South-west and Northern Planning Regions only.
Description SEARCH WORDS(S): GEOSCIENCES SEDIMENT MARINE mapping.
Description GEOGRAPHIC EXTENT POLYGON: Exclusive Economic Zone – AUS – Australia.
Description GEOGRAPHIC EXTENT BOUNDARIES: N_LAT: -8, S_LAT: -60, E_LONG: 172, W_LONG: 92.
Description GEOGRAPHIC EXTENT NAME(S): National.
Description NOMINAL SCALE: Scale 1:5,500,000.
Dataset Currency BEGINNING DATE: 1Nov2006.
Dataset Currency ENDING DATE: Current.
Dataset Status PROGRESS: Complete.
Dataset Status MAINTENANCE AND UPDATE FREQUENCY: As required - When additional sediment data becomes available.
Access STORED DATA FORMAT: DIGITAL – GIS – ARC/MAP, DIGITAL – Images – JPEG, DIGITAL – Images – PDF.
Access AVAILABLE FORMAT TYPE(S): DIGITAL – GIS – ARC/MAP, DIGITAL – Images – JPEG, DIGITAL – Images – PDF.
Access ACCESS CONSTRAINT: DIGITAL - IMAGES – No access constraints, DIGITAL – GIS – Contact Data Custodian.
Data Quality LINEAGE: Marine sediment sample information within the Australian Maritime Jurisdiction was sourced by Geoscience Australia from Australian and International research groups, Government bodies, private corporate entities, and published/unpublished reports. This information was then used to populate a National Marine Samples Database (MARS). MARS is an Oracle database that has been developed by Geoscience Australia in line with ANZLIC data standards. The point data presented here is from seabed samples where grainsize has been measured or determined through scientific analysis, and was exported from MARS to ARC/GIS for the generation of maps.
Data Quality POSITIONAL ACCURACY: Positional accuracy of individual points varies depending on the source data. Some data is form old records, external records and the

methods used to ascertain position accuracy is unknown. Due to the scale of the map and quality of the source, the accuracy is assumed to be within 5 km.

Data Quality ATTRIBUTE ACCURACY: No attribute for data quality exists at this stage. All the attribute data has been entered by Geoscience Australia staff from a range of reports. The accuracy depends on human error or that of the report.

Data Quality LOGICAL CONSISTENCY: All vector data has been visually checked for extraneous points and value added data. In some circumstances individual datasets were identified as inconsistent within the grid and either left out of the final grid or were corrected. Regional data sets were then compiled as a single national coverage. Tests were also carried out on the data for completeness, correct spatial representation, attribute accuracy, and logical consistency and correctness.

Data Quality COMPLETENESS: All vector data and details are complete and verified.

Contact Information CONTACT ORGANISATION: Geoscience Australia.

Contact Information CONTACT POSITION: MARS Database Administrator.

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Contact Information ELECTRONIC MAIL ADDRESS: Sales@ga.gov.au.

Metadata Date METADATA DATE: 19Jan2007.

COORDINATE SYSTEM DESCRIPTION: Projection GEOGRAPHIC, Datum WGS84, Units DD.

ADDITIONAL METADATA: None.

4.1.4. % Carbonate

Dataset TITLE: Sedimentary Features (Carbonate content) of the Australian Margin (Revised Geoscience Dataset).

Dataset AUTHORS: T. Whiteway, A. Hinde, V. Lucieer, A.D. Heap, R. Ruddick, P.T. Harris.

Dataset CUSTODIAN: Geoscience Australia.

Dataset JURISDICTION: Australia.

Description ABSTRACT: This dataset provides a visual representation of the bulk carbonate content of seabed sediments expressed as a percentage of total sediment. The data on which this map is based were compiled from Geoscience Australia's marine samples database (MARS). The map coverage is Australia's Exclusive Economic Zone, excluding the offshore island territories, and the Australian Antarctic Territory. This dataset is a second revision of the sediment datasets for the South-west and Northern Planning Regions only.

Description SEARCH WORDS(S): GEOSCIENCES, SEDIMENT, MARINE mapping.

Description GEOGRAPHIC EXTENT POLYGON: Exclusive Economic Zone – AUS – Australia.

Description GEOGRAPHIC EXTENT BOUNDARIES: N_LAT: -8, S_LAT: -60, E_LONG: 172, W_LONG: 92.

Description GEOGRAPHIC EXTENT NAME(S): National.

Description NOMINAL SCALE: Scale: 1:5,500,000.

Dataset Currency BEGINNING DATE: 1Nov2006.
Dataset Currency ENDING DATE: Current.
Dataset Status PROGRESS: Complete.
Dataset Status MAINTENANCE AND UPDATE FREQUENCY: As required - When additional sediment data becomes available.
Access STORED DATA FORMAT: DIGITAL – GIS – ARC/MAP, DIGITAL – Images – JPEG, DIGITAL – Images – PDF.
Access AVAILABLE FORMAT TYPE(S): DIGITAL – GIS – ARC/MAP, DIGITAL – Images – JPEG, DIGITAL – Images – PDF.
Access ACCESS CONSTRAINT: DIGITAL - IMAGES – No access constraints, DIGITAL – GIS – Contact Data Custodian.
Data Quality LINEAGE: Marine sediment sample information within the Australian Maritime Jurisdiction was sourced by Geoscience Australia from Australian and International research groups, Government bodies, private corporate entities, and published/unpublished reports. This information was then used to populate a National Marine Samples Database (MARS). MARS is an Oracle database that has been developed by Geoscience Australia in line with ANZLIC data standards. The point data presented here is from seabed samples where grainsize has been measured or determined through scientific analysis, and was exported from MARS to ARC/GIS for the generation of maps.
Data Quality POSITIONAL ACCURACY: Positional accuracy of individual points varies depending on the source data. Some data is form old records, external records and the methods used to ascertain position accuracy is unknown. Due to the scale of the map and quality of the source, the accuracy is assumed to be within 5 km.
Data Quality ATTRIBUTE ACCURACY: No attribute for data quality exists at this stage. All the attribute data has been entered by Geoscience Australia staff from a range of reports. The accuracy depends on human error or that of the report.
Data Quality LOGICAL CONSISTENCY: All vector data has been visually checked for extraneous points and value added data. In some circumstances individual datasets were identified as inconsistent within the grid and either left out of the final grid or were corrected. Regional data sets were then compiled as a single national coverage. Tests were also carried out on the data for completeness, correct spatial representation, attribute accuracy, and logical consistency and correctness.
Data Quality COMPLETENESS: All vector data and details are complete and verified.
Contact Information CONTACT ORGANISATION: Geoscience Australia.
Contact Information CONTACT POSITION: MARS Database Administrator.
Contact Information MAIL ADDRESS 1: GPO Box 378.
Contact Information SUBURB OR PLACE OR LOCALITY: Canberra City.
Contact Information STATE: ACT.
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Contact Information FACSIMILE: +61 2 6249-9999.
Contact Information ELECTRONIC MAIL ADDRESS: Sales@ga.gov.au.
Metadata Date METADATA DATE: 19Jan2007.
COORDINATE SYSTEM DESCRIPTION: Projection GEOGRAPHIC: Datum WGS84; Units DD.
ADDITIONAL METADATA: None.

4.1.5. Mean Grain Size

Dataset TITLE: Sedimentary Features (Mean Grain Size) of the EEZ (National Geoscience Dataset).
Dataset AUTHORS: T. Whiteway, A. Hinde, V. Lucieer, A.D. Heap, R. Ruddick, P.T. Harris.
Dataset CUSTODIAN: Geoscience Australia.
Dataset JURISDICTION: Australia.
Description ABSTRACT: The map provides a visual representation of the mean grain size of sediments expressed in millimetres (mm). The data are represented by 13 categories of grain size, ranging from clay (0 - 0.002 mm) at the fine end of the mud range, through sand grain sizes, to pebbles (>4 mm) at the coarse end of the gravel range. The data on which this map is based were compiled from Geoscience Australia's sediment database (MARS) as part of the National Marine Sediment and Database and Seafloor Characteristics Project and a range of published and unpublished reports. The aim of the project was to identify and collate available sediment and seafloor data to assist with defining bioregions, particularly at finer scales on the continental shelf, where the majority of sediment sampling has taken place. The map coverage is Australia's Exclusive Economic Zone, excluding the offshore island territories, and the Australian Antarctic Territory.
Description SEARCH WORDS(S): GEOSCIENCES SEDIMENT MARINE mapping.
Description GEOGRAPHIC EXTENT POLYGON:AUSTRALIA INCLUDING EXTERNAL TERRITORIES – AUS – Australia.
Description GEOGRAPHIC EXTENT BOUNDARIES: N_LAT: -9, S_LAT: -55, E_LONG: 162, W_LONG: 108.
Description GEOGRAPHIC EXTENT NAME(S): National.
Description NOMINAL SCALE: Scale 1:5,500,000.
Dataset Currency BEGINNING DATE: 1JUL2004.
Dataset Currency ENDING DATE: Current.
Dataset Status PROGRESS: Complete.
Dataset Status MAINTENANCE AND UPDATE FREQUENCY: As required.
Access STORED DATA FORMAT: DIGITAL – GIS – ARC/MAP, DIGITAL – Images – JPEG, DIGITAL – Images – PDF.
Access AVAILABLE FORMAT TYPE(S): DIGITAL – GIS – ARC/MAP, DIGITAL – Images – JPEG, DIGITAL – Images – PDF.
Access ACCESS CONSTRAINT: DIGITAL - IMAGES – No access constraints, DIGITAL – GIS – Contact Data Custodian.
Data Quality LINEAGE: Marine sediment sample information within the Australian Maritime Jurisdiction was sourced by Geoscience Australia from Australian and International research groups, Government bodies, private corporate entities, and published/unpublished reports. This information was then used to populate a National Marine Sediments Database (MARS). MARS is an Oracle database that has been developed by Geoscience Australia in line with ANZLIC data standards. The mean grain size distribution presented here is calculated using the method of moments at those seabed sample locations where grain-size distribution has been measured or determined through scientific analysis. Output data was exported to ArcGIS for the generation of maps.
Data Quality POSITIONAL ACCURACY: Positional accuracy of individual points varies depending on the source data. Some data is from old records, external records and the

methods used to ascertain position accuracy is unknown. Due to the scale of the map, and quality of the source, the accuracy is assumed to be within 5 km.
Data Quality ATTRIBUTE ACCURACY: No attribute for data quality exists at this stage. All the attribute data has been entered by Geoscience Australia staff from a range of reports. The accuracy depends on human error or that of the report.
Data Quality LOGICAL CONSISTENCY: All vector data has been visually checked for extraneous points and value added data. In some circumstances individual datasets were identified as inconsistent within the grid and either left out of the final grid or were corrected. Regional data sets were then compiled as a single national coverage. Tests were also carried out on the data for completeness, correct spatial representation, attribute accuracy, and logical consistency and correctness.
Data Quality COMPLETENESS: All vector data and details are complete and verified.
Contact Information CONTACT ORGANISATION: Geoscience Australia.
Contact Information CONTACT POSITION: MARS Database Administrator.
Contact Information MAIL ADDRESS 1: GPO Box 378.
Contact Information SUBURB OR PLACE OR LOCALITY: Canberra City.
Contact Information STATE: ACT.
Contact Information COUNTRY: Australia.
Contact Information POSTCODE: 2601.
Contact Information TELEPHONE: +61 2 6249-9111.
Contact Information FACSIMILE: +61 2 6249-9999.
Contact Information ELECTRONIC MAIL ADDRESS: Sales@ga.gov.au.
Metadata Date METADATA DATE: 24Jun2004.
COORDINATE SYSTEM DESCRIPTION: Projection GEOGRAPHIC, Datum WGS84, Units DD.

4.1.6. Effective Disturbance

Dataset TITLE: Seabed exposure index.
Dataset AUTHORS: F. Saint-Cast, P.T. Harris, M.A. Hemer, R. Porter-Smith.
Dataset CUSTODIAN: Geoscience Australia.
Dataset JURISDICTION: Australia.
Description ABSTRACT: The seabed exposure index is a statistical representation of the sediment transport rate on the Australian continental shelf. The seabed exposure index is a model output from GEOMACS, also referred as GEOMAT v.2, which corresponds to the second improved version of Geological and Oceanographic Model of Australia's Territory (GEOMAT) developed at Geoscience Australia. The seabed exposure index was derived from the statistical distribution of the sediment transport rate, which reflected the strength and frequency of the combined wave-current bed shear stress. The bed shear stress was derived from a bottom boundary layer model, which integrated the combined action of tidal currents, oceanic currents, and gravity waves over a given sediment fraction.
Description SEARCH WORDS: GEOSCIENCES, SEDIMENT transport.
Description GEOGRAPHIC EXTENT POLYGON: Exclusive Economic Zone – AUS – AUSTRALIA.
Description GEOGRAPHIC EXTENT BOUNDARIES: N_LAT: -8, S_LAT: -45, E_LONG: 155, W_LONG: 110.
Description GEOGRAPHIC EXTENT NAME(S): National.

Description NOMINAL SCALE: Scale 1:5,500,000.
Dataset Currency BEGINNING DATE: 1 January 2004.
Dataset Currency ENDING DATE: Current.
Dataset Status PROGRESS: On going.
Dataset Status MAINTENANCE AND UPDATE FREQUENCY: As required.
Access STORED DATA FORMAT: DIGITAL – data – Netcdf / DIGITAL – images – jpeg
Access AVAILABLE FORMAT TYPE(S): DIGITAL – data – Netcdf / DIGITAL – images – jpeg
Access ACCESS CONSTRAINTS: DIGITAL – data – Netcdf: contact data custodian / DIGITAL – images – jpeg: no access constraints.
Data Quality LINEAGE: The Geological and Oceanographic Model of Australia's Territory (GEOMAT; Harris et al., 2000) developed at Geoscience Australia provides maps indicative of the Australian seabed exposure. GEOMAT v.1 proposed a classification of the Australian under water territory based on sediment mobility induced by distinct processes such as tidal currents and gravity waves (Porter-Smith et al., 2004). GEOMAT v.2 proposed an improved classification of the continental shelf area based on a seabed exposure index (Hemer, 2006). The seabed exposure index was derived from the statistical distribution of the sediment transport rate, which reflected the strength and frequency of the combined wave-current bed shear stress. The bed shear stress was derived from a bottom boundary layer model (SEDTRANS; Li and Amos, 2001), which integrated the combined action of tidal currents (Egbert et al., 1994), oceanic currents (OCCAM; Webb et al., 1998), and gravity waves (AUSWAM - Greenslade, 2001) over a given mean sediment fraction (MARS; Geoscience Australia, 2006).
Data Quality POSITIONAL ACCURACY: The seabed exposure index is estimated on a 0.1° grid resolution.
Data Quality ATTRIBUTE ACCURACY: No attribute accuracy is available at this time
Data Quality LOGICAL CONSISTENCY: All outputs and data have been visually checked for artefacts and spurious data. Tests conducted to ensure data are reliable and valid.
Data Quality COMPLETENESS: Complete.
Contact Information CONTACT ORGANISATION: Geoscience Australia (GA).
Contact Information CONTACT POSITION: Director, Sales and Distribution, CIMA.
Contact Information MAIL ADDRESS: GPO Box 378.
Contact Information LOCALITY: Canberra.
Contact Information STATE: ACT.
Contact Information COUNTRY: Australia.
Contact Information POSTCODE: 2601.
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Contact Information ELECTRONIC MAIL ADDRESS: Sales@ga.gov.au.
Metadata Date METADATA DATE: 31 January 2007.
Additional metadata: REFERENCES

Egbert, G.D., Bennett, A.F., and Foreman, M.G.G., 1994. TOPEX/POSEIDON tides estimated using a global inverse model. *Journal of Geophysical Research* **99**, 24821–24852.

Greenslade, D.J.M. 2001. The Assimilation of ERS-2 Significant Wave Height Data in the Australian region. *Journal of Marine Systems* **28**, 141-160.

Harris, P. T., Smith, R., Anderson, O., Coleman, R., and Greenslade, D., 2000. *GEOMAT - modelling of continental shelf sediment mobility in support of Australia's regional marine* *planning process*. Australian Geological Survey Organisation Record 2000/41. Geoscience Australia, Canberra. 53pp.

Hemer, M.A., 2006. The magnitude and frequency of combined flow bed shear stress as a measure of exposure on the Australian continental shelf. *Continental Shelf Research* **26**, 1258–1280.

Li, M.Z., and Amos, C.L., 2001. SEDTRANS96: the upgraded and better calibrated sediment-transport model for continental shelves. *Computers and Geosciences* **27**, 619–645.

Porter-Smith, R., Harris, P.T., Anderson, O., Coleman, R., Greenslade, D.J.M., and Jenkins, C.J., 2004. Classification of the Australian continental shelf based on predicted sediment threshold exceedance from tidal currents and swell waves. *Marine Geology* **211**, 1-20.

Webb, D.J., Cuevas, B.A., and Coward, A.C., 1998. *The first main run of the OCCAM global ocean model*. Internal Report of James Rennell Division, Southampton Oceanography Centre, UK. 50pp. See also:http://www.noc.soton.ac.uk/JRD/OCCAM.

4.1.7. Bathymetry

Dataset TITLE: Australian bathymetry and Topography, June 2005.
Dataset AUTHOR(S): M.A. Webster and P. Petkovic.
Dataset CUSTODIAN: Geoscience Australia.
Dataset JURISDICTION: Australia.
Description ABSTRACT: Geoscience Australia and the National Oceans Office carried out a joint venture project to produce a consistent, high-quality 9 arc second (0.0025° or ~250 m at the equator) bathymetric data grid of those parts of the Australian water column jurisdiction lying between 92 E & 172 E and 8 S & 60 S. As well as the waters adjacent to the continent of Australia and Tasmania, the area selected also covers the area of water column jurisdiction surrounding Macquarie Island, and the Australian Territories of Norfolk Island, Christmas Island, and Cocos (Keeling) Islands. The area selected does not include Australia's marine jurisdiction off of the Territory of Heard and McDonald Islands and the Australian Antarctic Territory. This report provides a list of the datasets and procedures used to produce a grid of 9 arc second cell dimensions. The underlying data from which this grid is derived can only support this resolution in areas where direct bathymetric observations are sufficiently dense (e.g., where swath bathymetry data or digitised chart data exist). In areas where only track-line data exist, the grid resolution is high along-line but low perpendicular to lines. In areas where no sounding data are available, the grid is based on interpolated or indirectly observed bathymetry, and these data can only support a resolution of 2 arc minutes (2 nautical miles or ~3.7 km). The grid covers an area of approximately 41 million square kilometres. Its dimensions are 32,003 x 20,803 cells resulting in a file size slightly in excess of 1.3 Gb of 2-bytes integer numbers representing the bathymetric values. The grid synthesises approximately 1.7 billion observed data points. This grid is not suitable for use as an aid to navigation, or to replace any products produced by the Australian Hydrographic Service.
Description SEARCH WORD(S): MARINE, MARINE Coasts, OCEANOGRAPHY Physical.
Description GEOGRAPHIC EXTENT NAME(S): AUSTRALIA EXCLUDING EXTERNAL TERRITORIES, AUS AUSTRALIAN EEZ.
Description GEOGRAPHIC BOUNDING BOX: N_LAT: -8, S_LAT: -60, E_LONG: 172, W_LONG: 92.
Description GEOGRAPHIC EXTENT POLYGON(S): 92 -08, 92 -60, 172 -60, 172 -08, 92 -08.
Data Currency BEGINNING DATE: 20-APR-05.

Data Currency ENDING DATE: 28-JUL-05.
Dataset Status PROGRESS: Complete.
Dataset Status MAINTENANCE AND UPDATE FREQUENCY: Not Planned.
Access STORED FORMATS Digital/Non-Digital Description: DIGITAL ArcGIS-grid ArcInfo grid Geographic WGS84 WGS84, DIGITAL ascii ASCII text Geographic WGS84, DIGITAL ermapper ERMapper dataset file Geographic WGS84 WGS84, DIGITAL bil Band interleaved by line (BIL) image Geographic WGS84 WGS84,
Access AVAILABLE FORMATS Digital/Non-Digital Description: DIGITAL ArcGIS-grid ArcInfo grid Geographic WGS84 WGS84, DIGITAL ermapper ERMapper dataset file Geographic WGS84 WGS84, DIGITAL ascii ASCII text Geographic WGS84 WGS84.
Access CONSTRAINT: No restrictions
Data Quality LINEAGE: The data came from a variety of systems with differing data densities and levels of accuracy. In the geographic extents 34°N - 79°S, 90°E - 180°E, GA holds approximately 1,400 surveys that collected bathymetric data. For ship-track data the typical spacing of point data along track is 25-200 m, the two-dimensional spacing of points covered by swath surveys is of similar order. The coverage of ship-track surveys is widely variable, such that some points covered by grid lines are many tens of kilometres apart, whereas for swath bathymetry surveys, the areas of coverage are at relatively high density, but of very limited coverage. This product documents the procedures used to construct the bathymetric grid and their associated displays. The input data were derived from a number of sources, were of variable vintages and quality. A number of approaches were required to process, check and edit the data. The availability of data also varied considerably throughout the region, effectively restricting the maximum useful resolution of the grid in areas where no soundings exist, to that of the satellite predicted bathymetry that was used as infill. These data, together with predicted bathymetry from satellite altimetry, have been brought together into a single data and processing system to allow the routine creation of grids with a range of specifications, from which grids and images can be created.
Data Quality POSITIONAL ACCURACY: The grid incorporates data from surveys acquired since 1963. Modern surveys which used GPS have a positional accuracy of 5 - 30 m depending on several factors, while earlier surveys which used dead reckoning and Transit satellite fixes had positions accurate to 50-2,000 m depending upon the water depth and strength of currents. These surveys overlap in an irregular distribution. The grid cell size is 0.025 deg (close to 250 m), and it is estimated that 90% of cells give depths within 1 cell of their measured position. Nominal scale: 1:10,000,000 when imaged at 300 dpi.
Data Quality ATTRIBUTE ACCURACY: All data is in gridded format.
Data Quality LOGICAL CONSISTENCY: All the grids are checked at scale to verify that no data is incorrect, that there were no extraneous point segments, and that all values have the estimated correct bathymetric value.
Data Quality COMPLETENESS: This dataset is complete.
Contact Information CONTACT ORGANISATION: Geoscience Australia.
Contact Information CONTACT POSITION: Director, Sales and Distribution, CIMA.
Contact Information MAIL ADDRESS 1: GPO Box 378.
Contact Information SUBURB/PLACE/LOCALITY: Canberra.
Contact Information STATE/LOCALITY 2: ACT.
Contact Information COUNTRY: Australia.
Contact Information POSTCODE: 2601.
Contact Information TELEPHONE: +61 2 6249 9966.

Contact Information FACSIMILE: +61 2 6249 9960.
Contact Information ELECTRONIC MAIL ADDRESS: sales@ga.gov.au.
Metadata Date METADATA DATE: 20JUL2005.
Additional Metadata ADDITIONAL METADATA: GeoMET No. 8022, GeoCAT No. 63539.

4.1.8. Slope

Dataset TITLE: Australian Slope Grid, Aug 2006.
Dataset AUTHOR(S): T. Whiteway
Dataset CUSTODIAN: Geoscience Australia.
Dataset JURISDICTION: Australia.
Description ABSTRACT: The slope dataset has been created in ERMapper using the Geoscience Australia 250 m bathymetry grid. The bathymetry grid was compiled by a joint venture of Geoscience Australia and the National Oceans Office producing a consistent, high-quality 9 arc second (0.0025° or ~250m at the equator) bathymetric data grid of those parts of the Australian water column jurisdiction lying between 92E & 172E and 8S & 60S. As well as the waters adjacent to the continent of Australia and Tasmania, the area selected also covers the area of water column jurisdiction surrounding Macquarie Island, and the Australian Territories of Norfolk Island, Christmas Island, and Cocos (Keeling) Islands. The area selected does not include Australia's marine jurisdiction off of the Territory of Heard and McDonald Islands and the Australian Antarctic Territory. This report provides a list of the datasets and procedures used to produce a grid of 9 arc second cell dimensions. The underlying data from which this grid is derived can only support this resolution in areas where direct bathymetric observations are sufficiently dense (e.g., where swath bathymetry data or digitised chart data exist). In areas where only track-line data exist, the grid resolution is high along-line but low perpendicular to lines. In areas where no sounding data are available, the grid is based on interpolated or indirectly observed bathymetry, and these data can only support a resolution of 2 arc minutes (2 nautical miles or ~3.7 km). The grid covers an area of approximately 41 million square kilometres. Its dimensions are 32003 x 20803 cells resulting in a file size slightly in excess of 1.3 Gb of 2-bytes integer numbers representing the bathymetric values. The grid synthesises approximately 1.7 billion observed data points. This grid is not suitable for use as an aid to navigation, or to replace any products produced by the Australian Hydrographic Service. The slope grid was created using 21 by 21 slope filter for the Australian bathymetry grid.
Description SEARCH WORD(S): MARINE, MARINE Coasts, OCEANOGRAPHY Physical.
Description GEOGRAPHIC EXTENT NAME(S): AUSTRALIA EXCLUDING EXTERNAL TERRITORIES: AUS AUSTRALIAN EEZ: AUSTRALIAN EEZ.
Description GEOGRAPHIC BOUNDING BOX: N_LAT: -8 S_LAT: -60 E_LONG: 172 W_LONG: 92.
Description GEOGRAPHIC EXTENT POLYGON(S): 92 -08, 92 -60, 172 -60, 172 -08, 92 -08.
Data Currency BEGINNING DATE: 20-APR-05.
Data Currency ENDING DATE: 01-08-06.
Dataset Status PROGRESS: Complete.
Dataset Status MAINTENANCE AND UPDATE FREQUENCY: Not Planned.
Access STORED FORMATS Digital/Non-Digital Description: DIGITAL ArcGIS-grid ArcInfo grid Geographic WGS84 WGS84, DIGITAL ascii ASCII text Geographic WGS84

WGS84, DIGITAL ermapper ERMapper dataset file Geographic WGS84 WGS84, DIGITAL bil Band interleaved by line (BIL) image Geographic WGS84 WGS84.

Access AVAILABLE FORMATS Digital/Non-Digital Description: DIGITAL ArcGIS-grid ArcInfo grid Geographic WGS84 WGS84, DIGITAL ermapper ERMapper dataset file Geographic WGS84 WGS84, DIGITAL ascii ASCII text Geographic WGS84 WGS84.

Access ACCESS CONSTRAINT: No restrictions.

Data Quality LINEAGE: The input bathymetry data came from a variety of systems with differing data densities and levels of accuracy. In the geographic extents 34°N - 79°S, 90°E - 180°E, GA holds approximately 1400 surveys that collected bathymetric data. For ship-track data the typical spacing of point data along track is 25-200 m, the two-dimensional spacing of points covered by swath surveys is of similar order. The coverage of ship-track surveys is widely variable, such that some points covered by grid lines are many tens of kilometres apart, whereas for swath bathymetry surveys, the areas of coverage are at relatively high density, but of very limited coverage. This product documents the procedures used to construct the bathymetric grid and their associated displays. The input data were derived from a number of sources, were of variable vintages and quality. A number of approaches were required to process, check and edit the data. The availability of data also varied considerably throughout the region, effectively restricting the maximum useful resolution of the grid in areas where no soundings exist, to that of the satellite predicted bathymetry that was used as infill. These data, together with predicted bathymetry from satellite altimetry, have been brought together into a single data and processing system to allow the routine creation of grids with a range of specifications, from which grids and images can be created. The slope grid has been created from the analysis of the bathymetry grid to create a slope grid for the Australian EEZ using ERMapper's slope analysis process.

Data Quality POSITIONAL ACCURACY: The grid incorporates data from surveys acquired since 1963. Modern surveys which used GPS have a positional accuracy of 5 - 30 m depending on several factors, while earlier surveys which used dead reckoning and Transit satellite fixes had positions accurate to 50-2000 m depending upon the water depth and strength of currents. These surveys overlap in an irregular distribution. The grid cell size is 0.025 deg (close to 250 m), and it is estimated that 90% of cells give depths within 1 cell of their measured position. Nominal scale: 1:10,000,000 when imaged at 300 dpi The final slope data will have accuracy much lower than the oridinal input grid, due to the averaging process used by ERMapper's slope analysis process. The final grid cell size remains at 0.025deg.

Data Quality ATTRIBUTE ACCURACY: All data is in gridded format.

Data Quality LOGICAL CONSISTENCY: All the grids are checked at scale to verify that no data is incorrect, that there were no extraneous point segments, and that all values have the estimated correct bathymetric value.

Data Quality COMPLETENESS: This dataset is complete.

Contact Information CONTACT ORGANISATION: Geoscience Australia.

Contact Information CONTACT POSITION: Director, Sales and Distribution, CIMA.

Contact Information MAIL ADDRESS 1: GPO Box 378.

Contact Information SUBURB/PLACE/LOCALITY: Canberra.

Contact Information STATE/LOCALITY 2: ACT.

Contact Information COUNTRY: Australia.

Contact Information POSTCODE: 2601.

Contact Information TELEPHONE: +61 2 6249 9966.

Contact Information FACSIMILE: +61 2 6249 9960.
Contact Information ELECTRONIC MAIL ADDRESS: sales@ga.gov.au.
Metadata Date METADATA DATE: 20JUL2005.
Additional Metadata ADDITIONAL METADATA: GeoMET No. 8022, GeoCAT No. 63539.

4.1.9. Primary Productivity

Dataset SOURCE: CSIRO
Dataset TITLE: Primary Productivity in Australian waters by season
Dataset ANZLIC IDENTIFIER: ANZCW1205001050.
Dataset TYPE: GIS Data Layer.
Dataset CUSTODIAN: CSIRO Division of Marine Research - Hobart (CMR).
Dataset JURISDICTION: Australia.
Dataset ORIGINATOR ORGANISATIONS: CSIRO Division of Marine Research - Hobart (CMR).
Description ABSTRACT: Primary productivity point data from Australian waters that has been mapped using MapInfo. Data collected from oceanographic surveys conducted between 1959 and 1964 onboard the vessels "Gascoyne" and "Diamantina". Primary Production integrated to 100m grams Carbon per square metre per day. These Mapinfo layers have been produced by CSIRO for the National Oceans Office, as part of an ongoing commitment to natural resource planning and management through the 'National Marine Bioregionalisation' project.
Description ATTRIBUTES: Primary Production integrated to 100 m, grams Carbon per square metre per day. Contains ESRI layers relating to the map title, AUSLIG standard coastline, Jurisdictional boundaries, town and city locations, Primary Production.
Description LIMITATIONS: Variations in onscreen colour representation or printed reproduction may affect perception of the contained data.
Description DOCUMENTATION LINKS: Neptune Record: 'Mapset: Primary Productivity in northern Australian waters by northern season'. Neptune Record: 'Mapset: Primary Productivity in southern Australian waters by southern season'. Neptune Record: 'Primary Production around Australia 1959-1965'.
Description DATA LINKS: PrimProd.ID (2.83 KB), PrimProd.IND (14 KB), PrimProd.MAP (20 KB), PrimProd.TAB (454 bytes), PrimProd.xls (150 KB).
Description LOCATION KEYWORDS: Australia > Australian EEZ.
Description ANZLIC GEOGRAPHIC EXTENT NAMES (Category, [Jurisdiction], Name): Ocean and Sea Regions, [Australia], Australian EEZ.
Description GEOGRAPHIC EXTENT POLYGONS: 8.0 S, 93.0 E, 171.0 E, 47.5 S.
Description TAXONOMY KEYWORDS: EARTH SCIENCE > Biosphere > Microbiota > Chlorophyll.
Description GENERAL KEYWORDS: EARTH SCIENCE > Spectral/Engineering > Visible Wavelengths > Visible Imagery.
Description ANZLIC SEARCH WORDS: MARINE Biology, PHOTOGRAPHY AND IMAGERY Remote Sensing.
Data Currency BEGINNING DATE: Jul 2004.
Data Currency ENDING DATE: Jul 2004.
Dataset Status PROGRESS: Complete.

Dataset Status MAINTENANCE AND UPDATE FREQUENCY: As required.
Access STORED FORMATS Digital/Non-Digital Description: DIGITAL - GIS – Mapinfo, DIGITAL - Spreadsheets - MS Excel.
Access STORED DATA VOLUME: MapInfo: 37.2 KB, excel format: 150 KB.
Access AVAILABLE FORMATS: DIGITAL - GIS – Mapinfo, DIGITAL - Spreadsheets - MS Excel.
Access CONSTRAINT: No restrictions on acces to MapInfo layers.
Data Quality LINEAGE: The map layers and design layout were assembled using MapInfo by Franzis Althaus at CSIRO. Point data collected from historical data - published reports. Numeric spatial scale denominator: 250000.
Data Quality PROJECTION DETAILS: Projection GEOGRAPHIC Datum WGS84.
Data Quality POSITIONAL ACCURACY: The transcribed data have been plotted and checked for outliers or where data was obviously incorrect. These have been corrected where possible.
Data Quality ATTRIBUTE ACCURACY: See basedata record.
Data Quality LOGICAL CONSISTENCY: See basedata record.
Data Quality COMPLETENESS: Complete.
Contact Information CONTACT ORGANISATION: CSIRO Division of Marine Research.
Contact Information CONTACT POSITION: Donna Hayes.
Contact Information MAIL ADDRESS 1: GPO BOX 1538.
Contact Information SUBURB/PLACE/LOCALITY: Hobart.
Contact Information STATE/LOCALITY 2: TAS.
Contact Information COUNTRY: Australia.
Contact Information POSTCODE: 7001.
Contact Information TELEPHONE: +61 3 6232 5222.
Contact Information FACSIMILE: +61 3 6232 5000.
Contact Information ELECTRONIC MAIL ADDRESS: Donna.Hayes@csiro.au.
Additional Metadata ADDITIONAL METADATA: Marine Planning Region: Eastern-central Marine Region (ECMR), Kerguelen (Heard & MacDonald Is.) Marine Region, Lord Howe Marine Region, Macquarie Marine Region, South-east Marine Region (SEMR), South-west Marine Region (SWMR).

4.1.10. Sea Floor Temperature

Dataset SOURCE: CSIRO.
Dataset TITLE: Sea Temperature in the Australian Region.
Dataset ANZLIC IDENTIFIER: ANZCW1205001044.
Dataset TYPE: GIS Data Layer.
Dataset CUSTODIAN: CSIRO Division of Marine Research - Hobart (CMR).
Dataset JURISDICTION: Australia.
Dataset ORIGINATOR ORGANISATIONS: CSIRO Division of Marine Research - Hobart (CMR).
Description ABSTRACT: ESRI grids showing sea temperature, linearly interpolated from CARS2000 mean and seasonal fields to 0.1 degree spaced grid, at depths of 0, 150, 500, 1000 and 2000 metres. The loess filter used to create CARS2000 resolves at each point a mean value and a sinusoid with 1 year period (and in some cases a 6 month period sinusoid - the "semi-annual cycle".) The provided "annual amplitude" is simply the magnitude of that

annual sinusoid. CARS is a set of seasonal maps of temperature, salinity, dissolved oxygen, nitrate, phosphate and silicate, generated using Loess mapping from all available oceanogrpahic data in the region. It covers the region 100-200E, 50-0S, on a 0.5 degree grid, and on 56 standard depth levels. Higher resolution versions are also available for the Australian continental shelf. The data was obtained from the World Ocean Atlas 98 and CSIRO Marine and NIWA archives. It was designed to improve on the Levitus WOA98 Atlas, in the Australian region.

Description ATTRIBUTES: grid space (X & Y grid spacing), ngridpts (number of grid points in Y & X directions), gr_origin (grid origin in lat-lon space), rotation (roation of grid about origin), corners (grid polygon corners in lat-lon space), map_details (mapping details), mean, annual_amplitude (amplitude of annual harmonics).

Description LIMITATIONS: CARS2000 is derived from ocean cast data, which is always measured above the seafloor. However, for properties which do not change rapidly near the seafloor, this would not lead to a significant error. All the limitations of CARS2000 also apply here.

Description DOCUMENTATION LINKS: CSIRO Atlas of Regional Seas (CARS2000), Marlin Record: 'CSIRO Atlas of Regional Seas (CARS)', Neptune Record: 'Mapset: Sea Temperature at Depth Annual Mean', Neptune Record: 'Sea Temperature at Depth in the Australian Region'.

Description DATA LINKS: CARS_Temp.zip (7.05 MB) arcinfo file, temp_amp.zip (4.86 MB) export file, temp_mean.zip (6.19 MB) export file.

Description LOCATION KEYWORDS: Australia.

Description ANZLIC GEOGRAPHIC EXTENT NAMES (Category, [Jurisdiction], Name): Australia, [Australia], Australia excluding external territories.

Description GEOGRAPHIC EXTENT POLYGONS: 0.0 N, 110.0 E, 160.0 E, 45.0 S.

Description GENERAL KEYWORDS: EARTH SCIENCE > Oceans > Ocean Temperature > Water Temperature.

Description ANZLIC SEARCH WORDS: OCEANOGRAPHY.

Data Currency BEGINNING DATE: 1900.

Data Currency ENDING DATE: 2000.

Dataset Status PROGRESS: Complete.

Dataset Status MAINTENANCE AND UPDATE FREQUENCY: Irregular.

Access STORED FORMATS Digitial/Non-Digital Description: DIGITAL - GIS - ARC/INFO, DIGITAL - GIS - ARC/EXPORT.

Access STORED DATA VOLUME: arcinfo: 7.05 MB, arcexport: 11 MB.

Access AVAILABLE FORMATS: DIGITAL - GIS - ARC/INFO, DIGITAL - GIS - ARC/EXPORT.

Access CONSTRAINT: No restrictions to access on grids.

Data Quality LINEAGe: Derived from CARS2000.

Data Quality PROJECTION DETAILS: Geographic.

Data Quality POSITIONAL ACCURACY: Errors may occur in location of cast data, which especially arises when data is passed from originator to accumulator organisations. For example, 1100 WOA94 casts were rejected prior to mapping due to being landward of the GEBCO coastline.

The grid spacing is much finer than the length scales of mapping/interpolation, so there is no issue with positional accuracy.

Data Quality ATTRIBUTE ACCURACY: Accuracy is less than that of the corresponding CARS2000 fields by a small but undefinable degree.

Data Quality LOGICAL CONSISTENCY REPORT: Points were generated by locally weighted filtering of measurements over a large domain, so there is a high degree of coherence and consistency between adjacent gridded values. [CARS200]"Mapping was optimised to accurately locate horizontal structure and mean values in mapped properties, and to reveal annual and semi-annual signals. Depth layers were only loosely related to adjacent layers, and spatial mapping scales varied between layers. The mapping methods therefore were NOT optimised to resolve vertical structure."

Data Quality COMPLETENESS: Complete.

Contact Information CONTACT ORGANISATION: CSIRO Division of Marine Research.

Contact Information CONTACT POSITION: Donna Hayes.

Contact Information MAIL ADDRESS 1: GPO Box 1538.

Contact Information SUBURB/PLACE/LOCALITY: Hobart.

Contact Information STATE/LOCALITY 2: TAS.

Contact Information COUNTRY: Australia.

Contact Information POSTCODE: 7001.

Contact Information TELEPHONE: +61 3 6232 5222.

Contact Information FACSIMILE: +61 3 6232 5000.

Contact Information ELECTRONIC MAIL ADDRESS: Donna.Hayes@csiro.au

Additional Metadata ADDITIONAL METADATA: Marine Planning Region: Eastern-central Marine Region (ECMR), Lord Howe Marine Region, Norfolk Marine Region, North-east Marine Region (NEMR), North-west Marine Region (NWMR), Northern Marine Region (NMR), South-east Marine Region (SEMR), South-west Marine Region (SWMR), Western-central Marine Region (WCMR).

Dunn, J.R., and Ridgway, K.R., 2002. Mapping ocean properties in regions of complex topography, Deep Sea Research Part I: Oceanographic Research, 49, 591-604.

Ridgway K.R., Dun, J.R., and Wilkin, J.L., 2002. Ocean interpolation by four-dimensional least squares - Application to the waters around Australia, Journal of Atmospheric & Oceanographic Technology, Vol 19, 1357-1375.

4.2. APPENDIX B – EXPORTING ESRI GRID TO ERMAPPER *.ERS FORMAT

The following points detail the process whereby an ESRI Grid can be exported to ERMapper *.ers format.

1. Open the input grid in ArcGIS and note the extents.
   Top: (Northing)
   Right: (Easting)
   Bottom:
   Left:
2. Using Arc Toolbox export each grid to an ASCII file.
3. Open the clipped grid in a text editor; note and remove the header,
   ncols (cells)
   nrows (lines)
   xllcorner

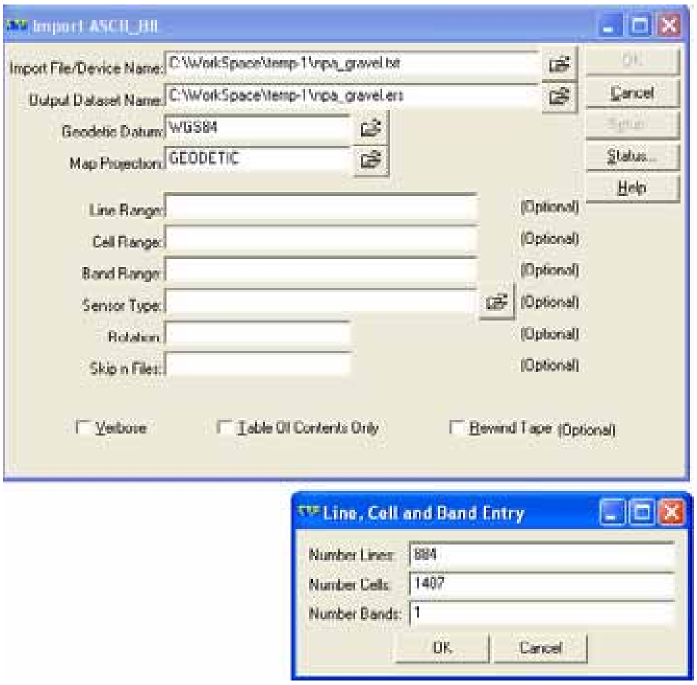

Figure 4.1. Window showing parameters for converting ESRI grid to ERMapper format.

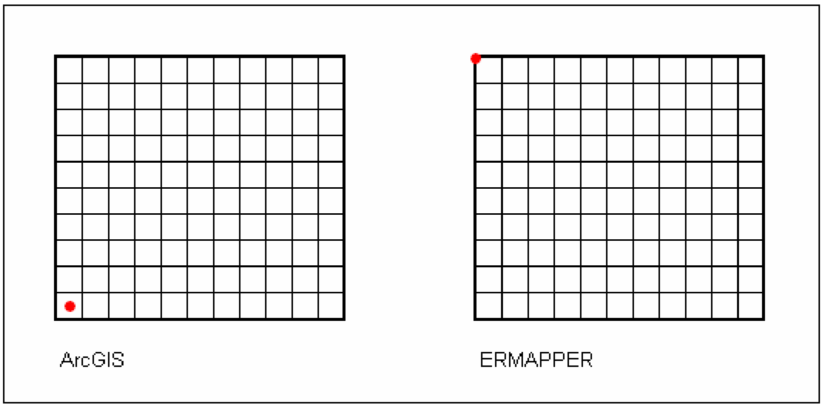

Figure 4.2. Diagram showing different referencing system of ArcGIS and ERMapper.

yllcorner
cellsize
NODATA_value.

4. Make sure there are no blank lines or spaces at the top of the file and save without the header.
5. Open a session of ERMapper and click on Utilities – Import ASCII and Binary Grids – ASCII Bil – Import.
6. When importing, set 'Geodetic Datum' to 'WGS84' and 'Map Projection' to 'Geodetic' (Fig. 4.1).
7. Enter the number of cells and lines (as obtained from the original header).

ArcGIS references grids differently to ERMapper. In ArcGIS the registration cell is the centre of the lower left cell and in ERMapper it is the top left corner of the upper left cell (Fig.

4.2). To adjust for this the .ers file needs to be edited. This can be done by modifying the *.ers file using a text editor (points 6 to 8 below).

8. Open the *.ers file in a text editor. The registration coordinates relate to the top left coordinate as noted above. Also a -0.5 offset needs to be applied in both directions (X and Y) to account for ERmapper using the top corner and ArcGIS using the centre.

```
DatasetHeader Begin
    Version         = "7.0"
    Name            = 'npa2_mud.ers'
    LastUpdated     = Thu Jul 27 04:32:44 GMT 2006
    SenseDate       = Thu Jul 27 03:43:59 GMT 2006
    DataSetType     = ERStorage
    DataType        = Raster
    ByteOrder       = LSBFirst
    CoordinateSpace Begin
        Datum           = 'WGS84'
        Projection      = 'GEODETIC'
        CoordinateType      = EN
        Rotation        = 0:0:0.0
    CoordinateSpace End
    RasterInfo Begin
        CellType        = IEEE4ByteReal
        NullCellValue       = -9999
        CellInfo Begin
            Xdimension  = 0.01
            Ydimension  = 0.01
        CellInfo End
        NrOfLines       = 884
        NrOfCellsPerLine    = 1487
        RegistrationCoord Begin
            Eastings        = as recorded above
            Northings       = as recorded above
        RegistrationCoord End
        RegistrationCellX   = -0.5
        RegistrationCellY   = -0.5
        NrOfBands       = 1
        BandId Begin
            Value   = 'band 1'
        BandId E
```

9. Save the modifications and close the *.ers file.
10. Undertake the same process for each newly imported *.ers file.

ALTERNATIVELY

Alternatively, the modifications can be made to the file using ERMapper's file editor. Follow steps 1 to 7 (above) and then:

a. In ERMapper select ‘File’ ‘Open’ and select the file you want to modify by clicking on it once, then select the 'Info…' button from the lower section of the panel (Fig. 4.3).

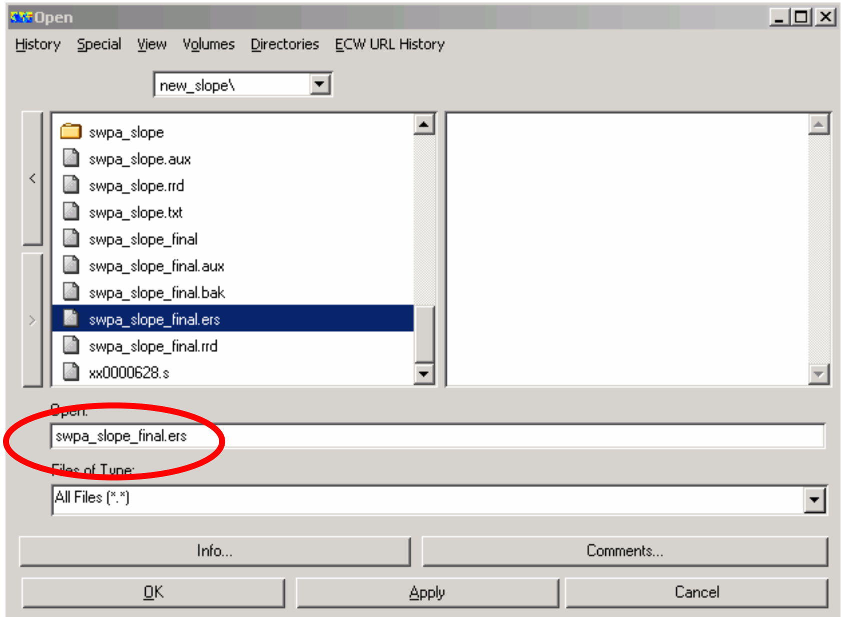

Figure 4.3. Window to make modifications using ERMapper’s file editor.

b. Then select 'Edit'

c. Then select 'Raster Info…' and ensure that the null cell value is -9999 and the cell type is IEEE4ByteReal.

d. Then select 'Registration Point…' and enter the value -0.5 for both 'Cell X' and 'Cell Y' (ie the middle of the first column of the grid cells) and 'Cell Y' should be the number of lines minus 0.5 (i.e. shift start location half a cell back and down so that it will line up with ArcGIS grid.)

e. Enter the ‘Eastings’ and ‘Northings’ values as recorded above from the original ArcGIS grid (Top = Northings and Right = Eastings).

f. Click 'OK' to close the dialog.

g. Select 'Cell Size' and enter '.01' for 'Xdimension' and 'Ydimension' and '1' for 'Zdimension'.

h. Finally close all dialogs by clicking their 'OK' buttons and save the changes when asked.

4.3. APPENDIX C – SAVING ERMAPPER FILES

When saving data in ER Mapper first select what type of file you need. If you are working on the individual datasets of a multi-layered grid, then save the data as a *.alg (ER Mapper algorithm file). This will preserve your input datasets and any input transformations. If you are ready to classify the data, the ER Mapper file needs to be presented as a single dataset. In this case save the dataset as a *.ers file. NOTE: This will not preserve your input file or transformation information. Finally, in some cases you may need to export an individual file from within a multi-layered grid. To do this follow instructions in part 4.3.3.

4.3.1. Multi-Layered Grids (*.alg files)

To save the file as a multi-layered .alg file (this will include any applied transforms) size the window to the required region to be saved and use the 'File', 'Save As' menu item selecting the 'ERMapper Raster Dataset (alg)' file type.

4.3.2. Single Layer Grids from multi-layered algorithms (*.ers files)

To save an algorithm as a single grid .ers file size the window to the required region to be saved and use the 'File', 'Save As' menu item selecting the 'ERMapper Raster Dataset (ers)' file type. The following information will need to be specified:

- Output Type: 'Multi Layer'
- Data Type: 'IEEE4ByteReal'
- Null Value: '-9999'

Ensure that you **do not** change the 'Pixel Width' and 'Pixel Height' if the program shows them as 0.0999999. If you modify these figures to 0.1, the grid will lose 1 cell width of data from around the outside edge.

4.3.3. Individual Grids (*.ers files)

To save an individual file as a single grid .ers file from within a multi-layered algorithm size the window to the required region to be saved. Turn off all layers you do not want to save by selecting them from the algorithm window and clicking the turn on/off button. Then go to the 'File', 'Save As' menu item selecting the 'ERMapper Raster Dataset (ers)' file type. The following information will need to be specified:

- Output Type: 'Multi Layer'
- Data Type: 'IEEE4ByteReal'
- Null Value: '-9999'

Ensure that you **do not** change the 'Pixel Width' and 'Pixel Height' if the program shows them as 0.0999999. If you modify these figures to 0.1, the grid will lose 1 cell width of data from around the outside edge.

4.4. APPENDIX D – EXPORTING ERMAPPER *.ERS TO ESRI GRID

The following points detail the process whereby an ERMapper *.ers file can be exported to an ESRI Grid.

1. Load the *.ers file into ArcMap and ensure that the layer lines up correctly with other local datasets.

2. Open the ‘Conversion Tools’ toolbox from ArcToolbox and open the ‘From Raster’ tool list. Select the ‘Raster to ASCII’ tool.

3. Select the *.ers file you want to export in the ‘Input Raster’ item, then name the file with a *.txt postfix and locate it in the same working directory. Select ‘OK’.

4. Open the ‘Conversion Tools’ toolbox from ArcToolbox and open the ‘To Raster’ tool list. Select the ‘ASCII to Raster’ tool.

5. Select the *.txt file you want to import in the ‘Input ASCII raster file’ item, then name the file and locate it in the same working directory. Select Integer if the grid has only whole numbers or float if the grid has decimal figures. Select ‘OK’.

6. Open the new grid in ArcMap and ensure that the new file lines up with the old *.ers file and other data.