Interactive Session IV: Marine Case Studies

Marxan applied to Rottnest Island in Western Australia

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^ Workshop Disclaimer: all data used in this workshop must be considered to be fictitious. The scenarios are purely hypothetical, and have been developed specifically for demonstration purposes at this workshop. No input data or outcomes should be considered to represent any aspect of the real world or any actual marine NRM or Swan region situations. The project team wishes to thank the Rottnest Island Authority for permission to access their data for use in these hypothetical exercises.

Contents

1. Getting Started

Note : When we refer to path C:\Western_Australia in this document, substitute another path on your computer if you have the course data and applications installed on a drive other than C:\Western_Austalia. For example, if you have the course installed on C:\temp\Western_Australia2 then C:\Western_Australia should be replaced with C:\temp\Western_Australia2.

Disclaimer: There are many ways to run Marxan and look at its files. For the purpose of this class, we present just one method using our custom build MarZone interface software linked to ArcView3.

- Login to the computer.
- Navigate to folder **C:\temp\Western_Australia2**\ and where the course data and applications have been installed.
- This is where you will launch the applications for this Interactive Session.

2. Marxan Exercises

2.1 Scenario 1-Identify a system of marine sanctuary zones

Create a system of marine sanctuaries based on mapped marine habitat features and marine biodiversity surrogates, ignoring other users/uses

The goal is to identify a system of sanctuary zones that achieve a 15% target level of representation of each biodiversity feature while limiting the size (i.e. area) of sanctuary zones. Other uses/users are ignored (cost is based on area only).

* A conservation target of 15% requires biodiversity features to be represented in sanctuary zones at 15% of their occurrence/distribution.
* Examine the effect of different spatial constraints by modifying the BLM parameter which varies the importance placed on compact versus fragmented systems.
* Identify the best solution configured with:

BLM set at 0	(no requirement for compact systems)
BLM set at 0.1	(requirement for moderately compact systems)
BLM set at 1	(requirement for highly compact systems)
BLM set at 10	(requirement for highly compact systems)

* Instructions are outlined below.

Scenario 1

1. Open the ArcView project.

   Navigate to **C:\temp\Western_Australia2\MarZoneInterface.apr** by double clicking on **My Computer**, double click **C:** drive, double click **temp**, double click **Western_Australia2**, double click **Marzone Interface** (Apr File). 

2. Open the MarZone Interface program.

   Navigate to **C:\temp\Western_Australia2 \MarZoneInterface.exe** as above but double click **Marzone Interface** (exe File). 

3. Locate the command file for Scenario 1

   In the MarZone Interface program, set the **MarZone Database Path** for Scenario 1. To do this, browse to the location of Scenario 1's command file 'input.dat'. The file should be located in the directory:

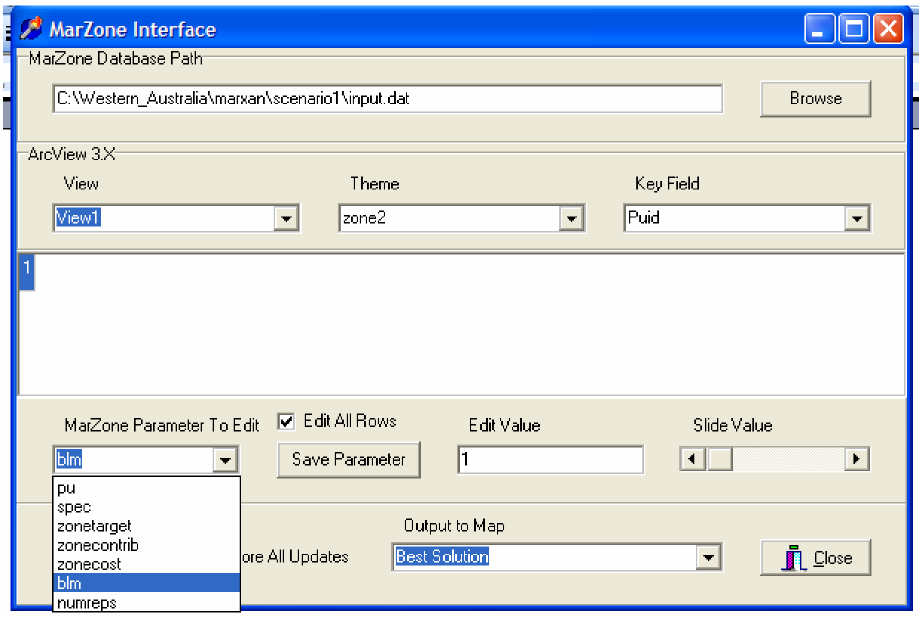
   C:\temp\Western_Australia2\marxan\scenario1\input.dat

4. Set the ArcView3 properties

   Click on the drop down list box under **View** and select View1. Click on the drop down list box under **Theme** and select zone2. Click on the drop down list box under **Key Field** and select Puid.

5. Edit BLM Parameter

   In the MarZone Interface click on the drop down box under **MarZone Parameter to Edit** and select the parameter **'blm'** as shown below



6. Next, go to the **Edit Value** field and enter the required value. Enter 0 to start
7. Now go to the **Output to Map** field and select **Best Solution** as shown below
8. Select **Update** and when prompted to **save parameter** select **yes,** and then Marxan will run automatically. This should take 20-30 seconds, after which ArcView will display the best solution for the defined problem as yellow planning units.
9. As Marxan generates many good solutions, you also have the option of viewing the alternative solutions. To view these select the **Solution** number (from 1-10) in the MarZone Interface **Output to Map field.** ArcView will then automatically display the selected solution. **Hint,** after entering the **Output to Map** box, press the up and down arrow keys to quickly switch between different display modes.
10. Repeat steps 6 to 9 using alternative BLM values (e.g. (0.01, 0.1, 1, 10))

2.2 Scenario 2-Identify Systems Of Marine Sanctuaries At A Range Of Conservation Targets.

Create a system of marine sanctuaries based on mapped marine habitat features and marine biodiversity surrogates that meet a defined set of constraints. Familiarise with formulating different conservation targets. The relevant outputs will be irreplaceability maps

The goal is to create systems of sanctuary zones that achieve different target levels of representation while limiting the size (i.e. areal extent) of sanctuary zones. The cost objective is to minimise the areal extent of the sanctuary zones, (i.e. other uses/users are ignored)

- Examine the effect of different targets on the configuration of sanctuary zones by prescribing different target levels of representation of biodiversity features
- Identify the best solution configured with:

  target set at 15%

  target set at 30%

  target set at 50%
- Examine how a planning unit's irreplaceability value varies with the representation target
- Instructions are outlined below.

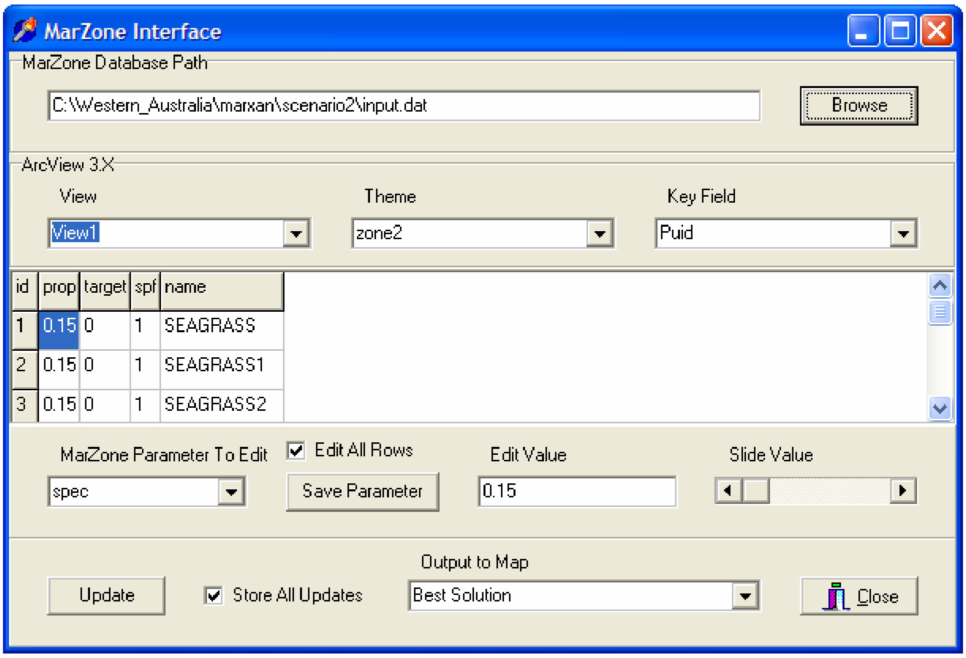
Scenario 2

1. In the MarZone Interface program, set the **MarZone Database Path** for Scenario 2. To do this, browse to the location of Scenario 2's command file 'input.dat' . The file should be located in the directory: **C:\temp\Western_Australia2\marxan\scenario2\input.dat**
2. **In the MarZone Parameter to Edit** drop box select the parameter **'spec'.** This brings up a table showing information about the biodiversity features. Features identified in the **spec** file are described in more detail in Table 2.1 below.

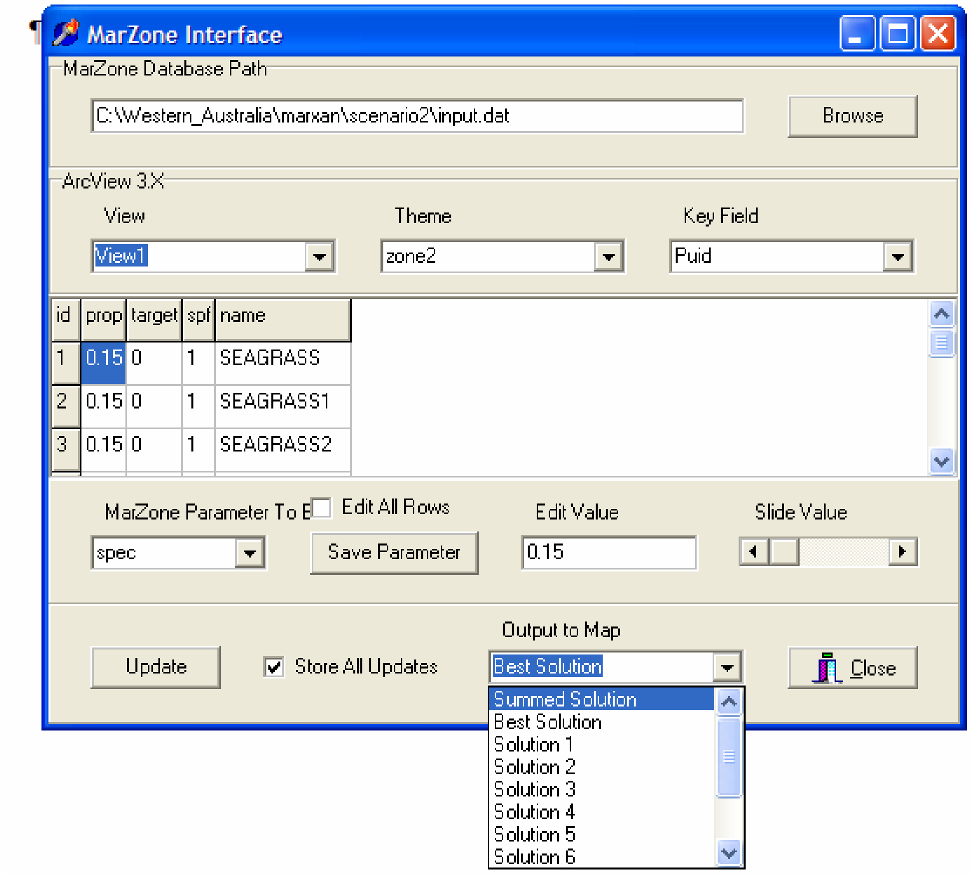
Table 2.1 Description of biodiversity features for the Rottnest Island dataset

Name	Biodiversity feature	Description
SEAGRASS	seagrass	areas of high conservation
SEAGRASS1	seagrass type 1	areas of high conservation
SEAGRASS2	seagrass type 2	areas of high conservation
FISH1	tropical fish area 1	areas of high conservation
FISH2	tropical fish area 2	areas of high conservation
FISH3	tropical fish area 3	areas of high conservation
INVERT	marine invertebrates	areas of importance for
SHALLOW	0-5m depth	bathymetry
MEDIUM	5-10m depth	bathymetry
DEEP	10-15m depth	bathymetry
ABAS	active blowouts and sanddunes	coastal landforms
APUF	active partially unstable fordune	coastal landforms
BEACH	beach	coastal landforms
PUD	parabolic and undulating dunes	coastal landforms
PARDUNES	parabolic dunes	coastal landforms
RSF	relatively stable fordunes	coastal landforms
CORAL1	Coral area 1	coral distribution
CORAL2	Coral area 2	coral distribution
CORAL3	Coral area 3	coral distribution
INTERLEDGE	interidal ledge	intertidal ledge
ISLNDISLET	island and islets	island and islets
SEAGR_REEF	mixed seagrass and reef	mixed seagrass and reef
MOLLUSCS1	molluscs area 1	molluscs (zooanthids)
MOLLUSCS2	molluscs area 2	molluscs (zooanthids)
REEF	reef	reef
REEFAWASH	reef awash	reef awash
SAND	sand	sand
ECHINODERM	tropical echinoderms	tropical echinoderms

3. The fields 'id', 'prop', 'target', 'spf' and 'name' are shown. Select the **'prop'** field. This field is the proportion at which features must be represented if targets are to be met. A value of 0 means that no part of the biodiversity feature is required in sanctuary zones. A value of 1 means all of that biodiversity feature must be reserved to meet targets (i.e. 100%).



4. Select the **Edit All Rows** box, then in the **Edit Value** box input a value between 0 and 1 (for example, 0.15).
5. Select **Update** (Answer **Yes** to save prompt) and Marxan will run automatically. This should take 20-30 seconds, after which ArcView will display the best solution for the defined problem.
6. In addition, Marxan generates an irreplaceability map that identifies the solution space for each defined problem. To view irreplaceability select the **Summed Solution** in the MarZone Interface **Output to Map field** as shown below.



7. Repeat steps 3 to 8 using alternative (0.15, 0.3, 0.5) **prop** values

8. A summary table (Table 2.1) has been prepared for a similar dataset to illustrate reporting on the performance of reserve systems at different conservation targets. These tables can be generated using the Marxan output files and compiled in Excel.

Table 2.2 Summary table describing the performance of alternative reserve design scenarios (5-50% conservation targets) for an example dataset in South Australia (Stewart 2007)

Table 2. Summary data for seven alternative reserve-planning scenarios (5–50% conservation targets). [a]

Conservation target (%)	*Boundary length (km)*	*Reserve system area (km²)*	*Reserve system size*[b]	*Expected mean selection frequency*[c] *(p)*
5	2154	3763	169.9	0.054
10	3147	7170	316.5	0.101
15	4361	14010	460.4	0.148
20	3820	10539	610.2	0.196
30	5241	20752	898.1	0.288
40	5899	27575	1195.2	0.383
50	6457	34308	1487.3	0.477

[a] *The total number of planning units in the planning region is 3119.*
[b] *The reserve system size is reported as the mean number of planning units contained within the best reserve systems generated from 10 replicate runs performed at the different conservation targets.*
[c] *Expected mean selection frequencies are calculated based on the reserve system size.*

2.3 Scenario 3 -Identify Systems Of Marine Sanctuaries Using Different Numbers of Repeat Runs

Examine how the performance of marine reserve systems are affected by parameter setting in the number of 'repeat runs'.

* To understand the importance of the simulated annealing search routine in finding near optimal solutions for reserve design problems.

* How well we achieve our objectives is partly dependent on the ability of the algorithm to search the solution space. A small number of runs constrains the search of the solution space and can result in poor configurations of marine reserve systems. While a large number of runs allows the simulated annealing to search thoroughly for the near-optimal solution.

Scenario 3

1. In the MarZone Interface program, set the **MarZone Database Path** for Scenario 3. To do this, browse to the location of Scenario 3's command file 'input.dat' . The file should be located in the directory: **C:\temp\Western_Australia2\marxan\scenario3\input.dat**
2. **In the MarZone Parameter to Edit** drop box select the parameter **'repeat runs.** This displays the number of runs currently selected.
3. In the **Edit Value** box input a value for the number of repeat runs. For example, 5.

4. Select **Update (**Answer **Yes** to save prompt) and Marxan will run automatically. This should take 20-30 seconds, after which ArcView will display the best solution for the defined problem.
5. In addition, Marxan generates an irreplaceability map that identifies the solution space for each defined problem. To view irreplaceability select the **Summed Solution** in the MarZone Interface **Output to Map field** as shown below.
6. Once the scenario has run, press **Save** and enter a scenario name (for example **NUMREPS5** and press **Ok**.
7. Repeat steps 3 to 6 and using alternative (1, 5 and 20, 50) **repeat run** values.
8. Review the summary reports for scenarios configured with different repeat run values to examine the effect of this parameter on reserve system solutions.

2.4 Scenario 4- Identify A System Of Marine Sanctuaries Recognising Both Pre-Existing Sanctuaries And Absolutely Competing Use Requirement.

Create a system of marine sanctuaries that expand on the existing marine sanctuaries (located at Kingston Reef and Parker Point) without impacting existing recreational fishing grounds. Familiarise with planning unit status, the reporting of unmet targets and the different solutions generated.

* The goal is to create a system of sanctuary zones that achieve defined targets.

* While the cost objective is again to minimise the areal extent of the sanctuary zones, the selection of planning units can consider pre-existing uses/values by locking-in or locking-out planning units. This determines whether planning units are available for selection.

    * Planning units located in the areas identified as the 'Kingston Reef Sanctuary Zone' or the 'Parker Point Sanctuary Zone' are locked-in. Hence, the design of a system of sanctuary zones must expand on these areas as the 'seed'.

    * Planning units located in areas identified as recreational fishing grounds (defined here as recreational gamefishing, shorebased recreational fishing, or trolling) are locked-out, meaning they are not available for selection. Examine whether targets can be met without impacting on these areas.

* Review the different configurations of marine sanctuaries under these constraints. Compare these solutions alongside the GIS layers for shorebased recreational fishing, trolling and gamefishing.

* Examine summary reports to determine whether targets are being met. Does lowering the conservation targets enable targets to be met?

Scenario 4

1. In the MarZone Interface program, set the **MarZone Database Path** to browse to the input.dat file for Scenario 4, located in the the directory: **C:\temp\Western_Australia2\marxan\scenario4\input.dat**
2. In the **MarZone Parameter to Edit** drop box select the parameter '**pu'.** This brings up a table with the fields: 'cost' and 'status'. Scrolling down the **status** field you will find individual planning units are assigned a value of 0, 2 or 3.

   - A value of 0 means it is available for selection.

   - A value of 2 means it is locked-in to every system solution.

   - A value of 3 means it is not available for selection (locked-out).
3. Select **Update** to run MarZone. In ArcView examine the best solution and compare with alternative solutions identified in the **Output to Map** field.
4. View contextual layers.

   For planning units locked in (status 2) view the layers "Fisheries notice 301" and "Fisheries notice 332" which correspond to the Kingston reef and Parker point sanctuary zones.

   For planning units locked out (status 3) view the layers "Shoreline fishing", "Recfish trolling" and "Recfish game" which correspond to areas where recreational fishing occurs inside the marine park.
5. Select the **summary report.** Click on the **Report** menu and select **Summary** generated for the best solution and examine whether all targets have been met. Scroll right to the missing value field to examine whether all targets have been met (missing values). By locking out areas under fishing, the conservation target cannot be met.
6. Repeat steps 2-5, this time using a lower representation target (for example 0.1). To do this, in the MarZone Parameter To Edit drop box, select spec and highlight prop. Remember to check the Edit all box and enter a lower target, for example 0.1. and examine the **summary report** to see if targets are now being met.
7. Repeat steps 3-5, this time highlighting the status field to edit individual planning unit status. See if by making available some of the planning units that were previously locked-out you can meet all the targets.

2.5 Scenario 5- Identify Systems Of Marine Sanctuaries that Minimise 'Costs' to Existing Recreational Fishing Values/Uses.

Create a system of marine sanctuaries which minimises the cost to recreational fishing. Cost is a single aggregated cost.

* The goal is to create a system of sanctuary zones that achieve defined targets while minimising the cost to recreational fishing activities.

* In this scenario, a planning unit's cost is a measure of the extent to which recreational fishing activities are present. The higher the cost, the more valuable the planning unit is to fishing. As the objective is to minimise cost, cost measured in this way serves to minimise the impact that the system of sanctuary zones has upon recreational fishing.

* For the purposes of this workshop, recreational fishing activities are described as either shorebased fishing, gamefishing or trolling.

* The relevant output will be best solutions and irreplaceability maps. You may wish to compare systems identified here with those configured in Scenarios 1&2.

* Examine summary reports to review the impact of the best solution on each of the recreational fishing activities identified above.

Scenario 5

1. In the MarZone Interface program, use the **MarZone Database Path** to browse to the input.dat file for Scenario 5, located in the directory: D:**Western_Australia2\marxan\scenario5\input.dat**
2. In the **MarZone Parameter to Edit** drop box select the parameter '**spec**' and highlight **prop.** Enter the desired target in the **Edit Value** box. Remember to check the **Edit all box.**
3. In the **MarZone Parameter to Edit** drop box select the parameter '**pu**' and observe that the table uses different costs to those used in previous scenarios. To calculate a planning unit's cost in Scenario 4, we measured the importance of the site for the three recreational fishing activities of interest to generate an aggregated cost of the expected impact on fishing. This approach to calculating cost is outlined in figure 5.1 and table 5.1 below.

Figure 5.1 – Calculating the cost of individual planning units *(Stewart et al. 2005)*

Devising a currency for reserve design

A site's cost (c_i) is the weighted sum its area (a_i) and recreational fishinig value (r_i). The variable, α controls the importance of area vs. fishing value

$$c_i = (1-\alpha)a_i + \alpha(a_i r_i)$$

Scenario 4 : $\alpha = 0$ (cost ≈ **AREA**)

Scenario 5 : $\alpha = 0.8$ (cost ≈ **AREA+CATCH**)

Planning unit i	Area (ha) a_i	Gamefishing	Shorebased	Trolling	Sum	Average value r_i	**Cost c_i**
1	1.0	0	0	0	0	0	**0.2**
2	1.0	0.5	0.5	0.5	1.5	0.5	**0.6**
3	1.0	1.0	0	0	1.0	0.3	**0.45**
4	1.0	1.0	1.0	1.0	3.0	1.0	**1.0**

Table 5.1 – Calculating planning unit cost for four sites of varying importance to fishing

4. Select **Update** to run Marzone. In ArcView examine the best solution and compare with alternative solutions and the **Summed Solution** identified in the **Output to Map** field. Select the **summary report** generated for the best solution and examine whether all targets have been met.
5. Review reports on the impact of the best solution to fishing activities.

Some general results from research findings are highlighted below.

Figure 5.1 – A South Australian example *(Stewart et al. 2005)*

Are economic and conservation objectives compatible?

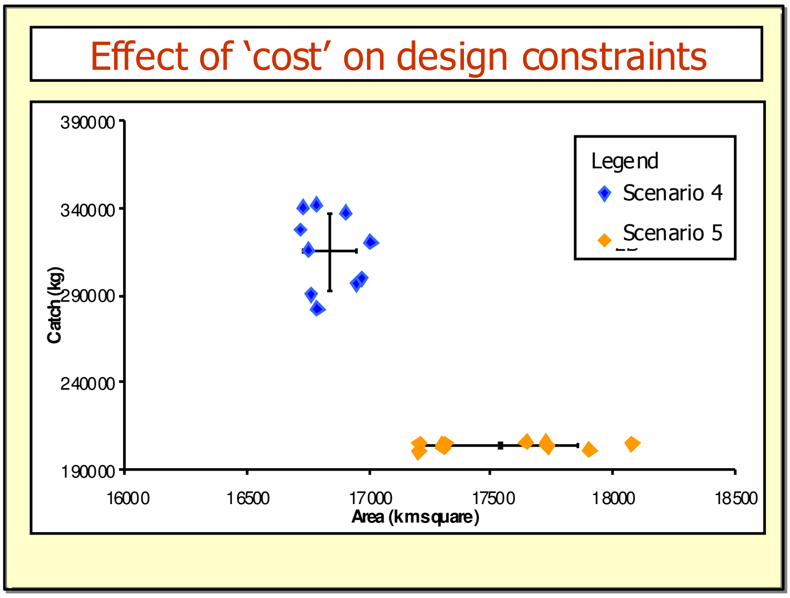
Start with some exploratory planning scenarios:

– Lock out all sites with catch rate **>0** kg/km^2
75 out of **102** biodiversity targets not met

– Lock out sites where catch rate **>100** kg/km^2 (high economic value sites)
6 out of **102** biodiversity targets not met

* Some high value sites are needed to achieve biodiversity targets

Fig 5.2 – An estimate of the available rock lobster catch outside the reserve system as a percentage of pre-reserve levels (i.e. total catch). Values in orange correspond to reserve systems configured with costs that include rock lobster catch, while those in blue do not. With a well defined problem and systematic planning, the size of the reserve system has no bearing on how much catch is displaced. *(Stewart et al. 2005)*



3. Marxan outputs and the GIS

3.1 Scenario (output_sen.dat)

The scenario file lists the input parameters that were used by Marxan to generate this set of output files. Browse to the folder **C:\temp\Western_Australia2\marxan\scenario1\output** and double click on the file output_sen.dat to load it into the text editor. You can see the parameters boundary length modifier, number of iterations and number of runs.

3.2 Log (output_log.dat)

The log file contains all the text that Marxan prints to the screen while it is executing. Summary information about files loaded, temperature and cooling rate for each run of simulated annealing, and objective function values for the start and end of the annealing run and iterative improvement run are included

Browse to the folder **C:\temp\Western_Australia2\marxan\scenario1\output** and double click on the file **output_log.dat** to load it into the text editor.

3.3 Summary (output_sum.csv)

The summary file lists information about each run such as the value of each term of the objective function and the number of missing features for the run.

Browse to the folder C:\temp\Western_Australia2\marxan\scenario1\output and double click on the file output_sum.csv to load it into excel. Select the entire table and auto fit it to view all the text. Close the file down and close excel down before continuing.

3.4 Best Solution (output_best.csv)

The best solution file lists all the planning units that were chosen in the best solution. The best solution is the solution that has the lowest overall value for the objective function.

Click on the **Output to Map** control then select **Best Solution**. The best solution will then be displayed in the ArcView map display.

Browse to the folder **C:\temp\Western_Australia2\marxan\scenario1\output** and double click on the file **output_best.csv** to load it into excel. Select the entire table and auto fit it to view all the text. Close the file down and close excel down before continuing.

3.5 Best Solution Missing Values (output_mvbest.csv)

The best solution missing values file lists all the species in the dataset and the level of representation they have achieved in the best solution. It also lists other information such as the area and occurrences of each species and whether the species has reached target or not.

Browse to the folder **C:\temp\Western_Australia2\marxan\scenario1\output** and double click on the file **output_mvbest.csv** to load it into excel. Select the entire table and auto fit it to view all the text. Close the file down and close excel down before continuing.

3.6 Solution N (output_r0000N.txt)

The solution file lists all the planning units that were chosen in the solution. N is the solution number. There will be one of these files for each solution generated.

Click on the **Output to Map** control then select **Solution 1**. Solution 1 will then be displayed in the ArcView map display. The other solutions generated will be displayed if their relevant solution number is clicked on in the **Output to Map** control. **Tip**: clicking the up and down buttons will cycle through all the solutions and display them in turn in the ArcView map display.

Browse to the folder **C:\temp\Western_Australia2\marxan\scenario1\output** and double click on the file **output_r00001.csv** to load solution 1 into excel. Select the entire table and auto fit it to view all the text. Close the file down and close excel down before continuing. The other solutions can be loaded into excel by loading their relevant solution file.

3.7 Solution N Missing Values (output_mv0000N.csv)

The solution missing values file lists all the species in the dataset and the level of representation they have achieved in a particular solution. It also lists other information such as the area and occurrences of each species and whether the species has reached target or not. N is the solution number. There will be one of these files for each solution generated.

Browse to the folder **C:\temp\Western_Australia2\marxan\scenario1\output** and double click on the file **output_mv00001.csv** to load the missing values file for solution 1 into excel. Select the entire table and auto fit it to view all the text. Close the file down and close excel down before continuing. The missing values tables for the other solutions can be loaded into excel by loading their relevant missing values file.

3.8 Summed Solution (output_ssoln.csv)

The summed solution file lists all the planning units in the dataset and their selection frequency. That is, the number of times they were chosen in one of the solutions.

Click on the **Output to Map** control then select **Summed Solution**. The summed solution will then be displayed in the ArcView map display. The planning units with a dark colour have a high selection frequency. The planning units with a lighter colour have a lower selection frequency.

Browse to the folder C**:\temp\Western_Australia2\marxan\scenario1\output** and double click on the file **output_ssoln.csv** to load the summed solution into excel. Select the entire table and auto fit it to view all the text. Close the file down and close excel down before continuing.

The End