

Day Two

3. Interactive Session 2, Cockburn Sound Exercises

3.1 Scenario 1 - Identify Marine Reserve Systems for Cockburn Sound

The Cockburn Sound Environmental Management Plan (2005) presents the following recommendation

2.4.1-2 Natural and Cultural Heritage Uses

'...investigate the benefit and constraints of extending the Shoalwater Islands Marine Park to include the seagrass meadows of the western waters of the Sound'

Proceed to identify marine reserve systems for Cockburn Sound based on mapped marine habitat features, ignoring other uses/users.

- * In this scenario we have two types of zones
 - * Zone 1 – available
 - * Zone 2 - marine reserve
- * We require the marine reserve system to achieve a conservation target of 30%. This means conservation features must be represented at 30% of their occurrence/distribution
- * Identify reserve systems configured with varying BLM values
- * Review performance of the reserve systems
- * Familiarise with Cockburn Sound and its natural values
- * Instructions are outlined below.

Cockburn Sound Scenario 1



1. Open the Zonae Cogito Marxan User Interface

Navigate to D:\Broome\ZonaeCogito.exe by double clicking on **My Computer**, double click **D:** drive, double click **Broome**, double click **ZonaeCogito** (exe File).

2. Load Scenario 1.

In the Zonae Cogito main menu, select File/Open and choose CSscenario1.zcp

3. Edit the Conservation (spec) Target

In the **Marxan Parameter to Edit** drop box select the parameter '**SPEC**' and highlight **prop**. Enter the desired target (0.3) in the **Edit Value** box.

Remember to check the **Edit all box**.

The **spec** file contains information on the different conservation features and their conservation target. It includes the field 'name' which identifies the conservation features of interest. These are described in more detail in Table 1.1. below.

Table 1.1 Description of conservation features for the Cockburn Sound dataset

ID	Name	Description
1	CORAL	Coral features mapped by recreational divers
2	SG_MIXEDSP	Marine benthic habitat – mixed seagrass species
3	COBBLE	Marine benthic habitat - Cobble
4	DEPTHGT10M	Marine benthic habitat – Depth greater than 10m
5	FINE_SEDIM	Marine benthic habitat – Fine Sediment
6	SG_HALOPHI	Marine benthic habitat – seagrass, halophila spp
7	LIMESTONE	Marine benthic habitat – limestone reef
8	SG_REEF	Marine benthic habitat – seagrass and reef
9	SG_P_AUGUS	Marine benthic habitat – seagrass, Posidonia augustifolia
10	SG_PATCHYP	Marine benthic habitat – seagrass, patchy posidonia
11	PAVEMENT	Marine benthic habitat – pavement reef
12	SG_POSIDON	Marine benthic habitat – seagrass, Posidonia spp
13	SG_PS	Marine benthic habitat – seagrass, Posidonia sinuosa
14	VEGETATED	Marine benthic habitat – vegetated
15	WRACK	Marine benthic habitat – wrack
16	LP_COLONY	Little Penguin colony sites
17	LP_FORAGIN	Little Penguin foraging areas
18	PELICAN	Pelican roosting sites
19	CRESTED_TE	Crested Terns roosting sites
20	LITTLE_PIE	Little Pied Cormorants
21	FAIRY_TERN	Fairy Terns
22	SANDERLING	Sanderlings
23	GREY_PLOVE	Grey Plovers
25	ISO_0_10M	Depth gradient between 0 and 10m
26	ISO_10_20M	Depth gradient between 10m and 20m
27	ISO_20_50M	Depth gradient between 20 and 50m
29	PREV_HEATH	PreEuropean Vegetation – Heath communities
30	PREV_MOSAI	PreEuropean Vegetation – Mosaic vegetation
31	PREV_LOWFO	PreEuropean Lowform vegetation
32	WHALE_RIGH	Southern Right Whale distribution

4. Calibrate BLM Parameter

In the Marxan window click on the drop down box under **Marxan** and select **Calibrate**

This opens the **Calibrate Marzone Parameters** screen which provides you with options for calibration.

Set 1. **Choose Input to Calibrate** to BLM

Set 2. **Choose number of values** to 9

Set 3. **Choose range of values** and set **Minimum** to 0.01 and **Maximum** to 0.05

Next enter **Run Calibration**

5. Plot **Calibration Summary Report** results in *Zonae Cogito*

Navigate to the **Text Table** in the **Marxan** main menu. Select the **Graph table** to automatically graph the calibration results. Two fields are shown, set the **X axis field** to score and the **Y axis field** to boundary length. The score measures of the performance of the different reserve systems. See if you can identify the BLM value that achieves the best trade-off between score and boundary length. This is indicated as the point where you achieve good gains in compactness (small boundary length) yet minimal increases in reserve system score. At this point the BLM value achieves the desired result and is correctly calibrated. You may of course find that you desire more spatial compactness, depending on your management objectives (ie a single large reserve vs multiple reserves). In this case management may be willing to accept a higher score for more spatially compact reserve systems.

6. In the Marxan window click on the drop down box under **Marxan Parameter to Edit** and select the parameter '**BLM**' in **Edit Value** set the BLM to the calibrated value (0.025)
7. Now go to the **Output to Map** field in GIS and select **Best Solution**
8. Select **Run** to run Marxan. This should take 20-30 seconds, after which GIS will display the best solution for the defined problem as coloured planning units. You also have the option of viewing the alternative solutions. To view these in GIS, in the **Output to Map field** select the **Solution** number (from 1-10). GIS 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.
9. View Selection frequency

In addition, Marxan generates a selection frequency map that identifies the solution space for each defined problem. To view this, select the **Selection frequency reserved zone** in the GIS **Output to Map field**.

10. Review Targets Met.

Marxan generates a **Summary Report** that compiles information on the performance of each run. To review the Summary Report, go to the main menu of Zonae Cogito, select **Marxan/ view output** and highlight **Summary Report** from the drop down menu.

An example is shown below. It reports on the performance of each individual run and includes information on a range of metrics used to assess each reserve system generated. Of interest for this exercise is the **Missing Values** column. **Examine your summary report** to see whether your conservation targets have been met.

Zonae Cogito
 File Edit Text Table Applications Convert Data Window Help

Marxan
 Marxan Dataset Path: C:\Broome\cockburn\marxan\scenario1\input.dat [Browse]

GIS
 Planning unit shapefile: C:\Broome\cockburn\pulyer\pulyer100.shp [v]
 Key Field: PUID [v]

0.004

C:\Broome\cockburn\marxan\scenario1\output\output_sum.csv
 rows 11 fields 10 data elements 110

"Run Number"	"Score"	"Cost"	"Planning Units"	available	reserved	"Boundary Length"	"Penalty"	"Shortfall"	"Missing Values"
1	58448.139815	3191.650000	10977	7663	3314	12279219.958968	-0.000000	0.000000	0
2	58492.214237	3200.580000	10977	7642	3335	12287029.830368	-0.000000	0.000000	0
3	58437.229905	3208.830000	10977	7626	3351	12272975.890168	0.008399	0.003000	1
4	58482.781365	3198.960000	10977	7657	3320	12285293.636568	-0.000000	0.000000	0
5	58544.986447	3199.810000	10977	7676	3301	12298925.609168	0.011206	0.004000	1
6	58459.424361	3206.450000	10977	7612	3365	12278421.299968	0.078511	0.024000	1
7	58481.695642	3199.660000	10977	7655	3322	12284879.362368	0.078511	0.024000	1
8	58519.116173	3199.900000	10977	7632	3345	12293156.660568	0.011200	0.004000	2
9	58461.761408	3202.510000	10977	7649	3328	12279631.779768	0.008399	0.003000	1
10	58477.743219	3196.670000	10977	7647	3330	12284598.568468	0.379661	0.024000	1

Marxan P... [BLM]

Run Save Run Load Run [Close]

3.2 Scenario 2 - Identify Marine Reserve Systems for Cockburn Sound that recognises proposed and existing marine parks

Investigate the proposal to extend the existing Shoalwater Island Marine Park and the proposed marine candidate area for waters of the Cockburn Sound as a basis for marine reserve systems design. Seagrass conservation features will be targeted for reservation consistent with the EMP recommendation below.

2.4.1-2 Natural and Cultural Heritage Uses

'.. investigate the benefit and constraints of extending the Shoalwater Islands Marine Park to include the seagrass meadows of the western waters of the Sound'

- * The goal is to configure marine reserve systems that achieve defined targets.
- * In this scenario, conservation targets are set at 30% for all seagrass features, other conservation features are set to 0.
- * The objective is to preferentially locate marine reserve systems adjacent to the Shoalwater Island Marine Park. We will investigate the use of free boundaries to formally incorporate this type of adjacency constraint.
- * The scenarios objective is to consider the proposal for the marine candidate area as part of the design for marine reserve systems in Cockburn Sound. This is achieved by using 'status' to define which planning units are available for selection.
 - * Planning units located in areas identified as the candidate marine conservation area are locked-in with a status of 2. Hence, the design of marine reserve systems must expand on these areas as the 'seed'.
- * Instructions are provided below.

Scenario 2

1. In the Zonae Cogito program, load Scenario 2. To do this, select File/open and choose CSscenario2.zcp
2. In the **Marxan Parameter to Edit** drop box select the parameter '**SPEC**' and highlight **prop**. Uncheck the **Edit all box**. In the **Edit Value** box check the that seagrass conservation features have a value of 0.3. These are listed below and are identified by the prefix **SG_**. For all other conservation features **Enter a target of 0** in the **Edit Value box**. This means that the objective is to achieve a target level of reservation of 30% for seagrass features only.

Table 2.1 Seagrass features targeted for reservation

Name	Description
SG_P_SINUO	Posidonia sinuosa
SG_MIXEDSP	Mixed species
SG_HALOPHI	Halophila species
SG_P_AUGUS	Posidonia augustifolia
SG_REEF	Seagrass and Reef
SG_PATCHYP	Patchy Posidonia
SG_POSIDON	Posidonia species

3. Note on the Boundary File

The boundary file is a table with the fields: 'id1' 'id2' and 'boundary'. The 'boundary' field indicates the cost between two neighbouring planning units. It is in this table that free boundaries (i.e. boundary = 0) are given to planning units located adjacent to the Shoalwater Island Marine Park. To view the boundary file choose **BOUND** in the **Marxan Parameter to Edit** dropdown menu.

Table 2.2 Example boundary length costs between neighbouring planning units

id1	id2	Boundary (metres)
1	1	108.911
1	2	55.4613
1	21	93.7316
2	2	103.78

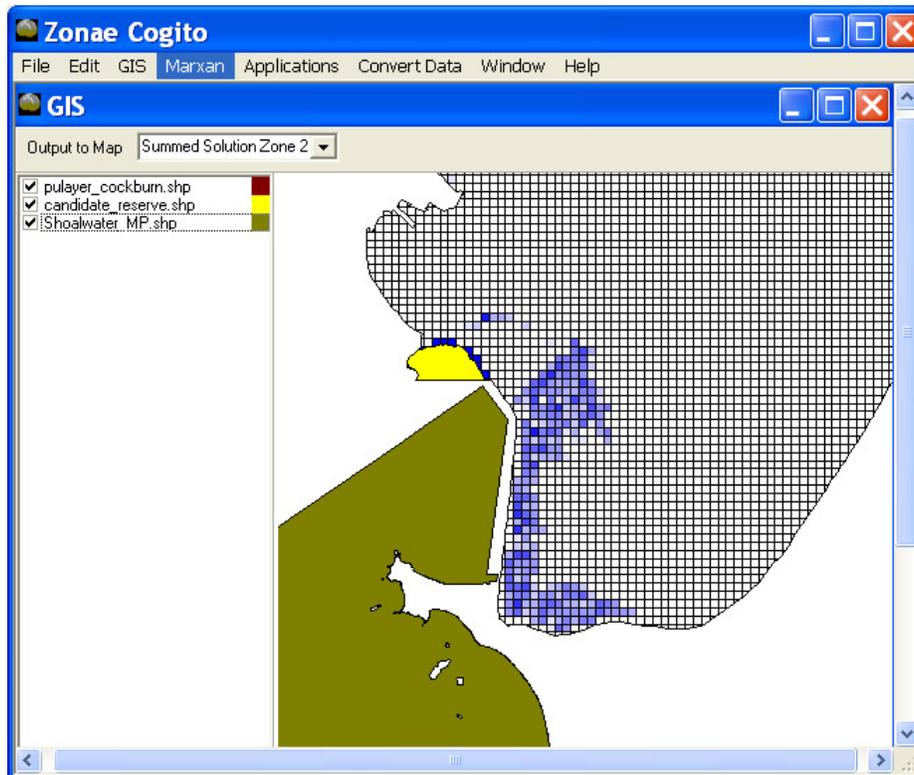
4. View Planning Unit status

In the **Marxan Parameter to Edit** drop box select the parameter '**PU**'. This brings up the table with the fields: 'cost' and 'status'. Scrolling down the status field you will find individual planning units are assigned a value of 0, or 2.

- a value of 0 means it is available for selection
- a value of 2 means it is locked-in to every solution
- a value of 3 (though not featured) means it is not available for selection (locked-out).

5. Select **Run** to run Marxan. In GIS examine the best solution and compare with alternative solutions and the **Selection frequency** identified in the **Output to Map** field. View contextual GIS layers.

- Go to **GIS** and tick the box adjacent to the theme you wish to highlight- the proposed (candidate) marine reserve or the Shoalwater Island Marine Park (planning units adjacent to this theme are allocated a free boundary)



-You should note that the Selection frequency map shows planning units adjacent to the Shoalwater Island Marine Park have a high selection frequency. This is due to the free boundary allocated to these planning units to preferentially expand the reserve system to areas adjacent to the Shoalwater island Marine Park.

-Similarly, planning units in the candidate marine protected area are reported as 100% irreplaceable, meaning that they are selected in every reserve system solution. This results from these planning units contained by the candidate marine reserve being allocated a status of 2.

6. Review Targets Met

Marxan generates a **Summary Report** that compiles information on the performance of each run. To review the Summary Report, go to the main menu of Zonae Cogito, select **Marxan/ view output** and highlight **Summary Report** from the drop down menu

7. If time allows, you can repeat step 2 and set conservation targets for additional conservation features to examine the sensitivity of marine reserve system design to the inclusion of conservation features and conservation feature targets. To do this, go to the **Marxan Parameter to Edit** drop box select the parameter '**SPEC**' and highlight **prop**. Uncheck the **Edit all box**. In the **Edit Value** box enter the desired target (e.g 0.3) for conservation features of interest. Select **Run** to run Marxan. In the GIS examine the best solution and compare with alternative solutions and the **Selection frequency** identified in the **Output to Map** field. Review the Targets Met by examining the **Summary Report** as outlined in step 6 above.

End Scenario

3.3 Scenario 3 - Identify Marine Reserve Systems that Recognise Objectives of Existing Management Areas

Configure marine reserve system in Cockburn Sound consistent with the Multiple-Use Planning strategy for Cockburn Sound and its Foreshores.

The Cockburn Sound EMP presents a Multiple Use Planning strategy for Cockburn Sound and its Foreshores as a basis for the long-term multiple use management of the region. This identifies the degree to which particular values are consistent with management objectives for areas across the Cockburn Sound as shown in Table 3.1 below.

Table 3.1 – Multiple-Use Planning for Cockburn Sound and its Foreshore

Management Area	Natural/Cultural ¹	Recreation	Commercial ²	Industrial ³	Defence
Garden Island	✓	✓	✓	✗	✓✓
Rockingham	✓	✓✓	✓✓	✗	n/a
Kwinana	✓	✓	✓	✓✓	n/a
Challenger Beach/Cliffs	✓✓ (cliffs)	✓✓ (beach)	✓✓ (beach)	?	n/a
Jervoise Bay	✓	✓	✓	✓✓	✓
Woodman Pt	✓✓	✓	✓	✓	n/a
Central Basin	✓	✓	✓	✓	✓

- ✓✓ *Priority use of a management area*
- ✓ *Use compatible with primary use and management area*
- ✗ *Use incompatible with management area*
- ? *Gap in knowledge*

- * The goal is to configure marine reserve systems taking into consideration the objectives of management areas identified in Table 3.1. Where possible, marine reserve systems should be located in areas where natural values are compatible with management area objectives. Table 3.1 indicates that preference should be given to the Challenger Beach/Cliffs and Woodman Point Management Areas.
- * These objectives have been interpreted into a cost matrix to reflect the compatibility between Natural/Cultural values and the Cockburn Sound Management Areas. The cost matrix is presented in Table 3.2 and applies a cost multiplier to planning units in accordance with the management area that they fall within.

Table 3.2 – Cost matrix for Marine Reserve Design in Cockburn Sound

Management Area	Cost multiplier for Natural/Cultural values
Garden Island	50
Rockingham	50
Kwinana	100
Challenger Beach/Cliffs	1
Jervoise Bay	50
Woodman Pt	1
Central Basin	50

- A cost multiplier of 1 indicates strong compatibility between the marine reserve system values and the management area objectives
 - A cost multiplier of 50 indicates a degree of incompatibility between marine reserve system values and the management area objectives
 - A cost multiplier of 100 indicates strong incompatibility between the marine reserve system values and the management area objectives.
-
- * Conservation targets are set at 30% for seagrass features.
 - * Free boundaries are provided to planning units located adjacent to the Shoalwater Island Marine Park.
 - * Proposed/candidate marine parks are ignored.
 - * Familiarise with input file structures that incorporate cost weightings between management areas and natural values in the Cockburn Sound.
 - * Instructions are provided below.

Scenario 3

1. In the Zonae Cogito program, load Scenario 3. In the main menu select File/ open then choose CSscenario3.zcp.
2. In the **Marxan Parameter to Edit** drop box select the parameter '**SPEC**' and review the targets specified for the conservation features. Note that a proportional target (prop) of 0.3 is set for seagrass features only.
3. Next view the parameter **COSTS** and observe that each of the management areas are represented in this file with a costname. Now view the parameter **ZONECOSTS**. The zoneid field refers to zone 1 – available, and zone 2 – reserved. The costid field refers to the management areas and the multiplier captures the interaction between the zone objectives and that of the management areas. A low multiplier indicates compatibility between the management area and the zone objectives (hence a multiplier of 1 applies to all cost types in the general use zone, as a general use zone by definition permits the range of values identified across the different management areas). A high multiplier indicates that the management area and the zone have competing objectives. The higher cost serves as a deterrent to reserving planning units in management areas that are inconsistent with the conservation of natural/cultural values.
4. Select **Run** to run Marxan. In GIS examine the best solution and compare with alternative solutions and the **Selection frequency** 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. View contextual GIS layers.

Go to **GIS** and tick the box adjacent to the theme you wish to highlight as indicated below

To view the management areas, first click on **MA_Challenger** and **MA_Woodman_Point** -note that planning units in these management areas are the cheapest to allocate to the reserved zone (they have a low cost weighting).

Even though these management areas are the most compatible with the reserve zone, additional planning units are still required to meet conservation targets. Click on the **seagrass theme (CS_seagrass)**- you can see how this feature is distributed in other management areas, such as **MA_Garden_Island, and MA_Rockingham**. Although planning units in these management areas are more expensive to reserve, they must be included in the marine park if conservation feature targets are to be met.

To view the Shoalwater Island Marine Park, click on **Shoalwater_MarinePark**
Planning units adjacent to this theme are allocated a free boundary.

6. Repeat steps 2-5 and modify the cost matrix multiplier values shown in Table 3.2. See how changes to the cost multiplier for natural values across the different management areas alters the reserve system configuration. E.g. change 1 values to 100 and vice versa to see how sensitive Marxan is to these parameters. Review the Summary Report to see whether targets can be achieved under these settings.

End Scenario

4. Interactive Session 3, Cockburn Sound Exercise 2

4.1 Scenario 4 - Identify A System of Zones to Accommodate Aquaculture, Marine Reserves and Recreational Values

The Cockburn Sound EMP presents the following recommendation:

2.2.4-2 Incorporate the requirements of aquaculture (relatively deep water, good circulation, low levels of faecal bacteria, contaminants and toxic phytoplankton species, and sufficient phytoplankton for good mussel growth) into future planning for Cockburn Sound.

Aquaculture use refers to mussel farming in Cockburn Sound. Currently two mussel leases exist: Southern flats and Kwinana Grain Jetty. A third aquaculture lease for octopus farming occurs in the north west of Cockburn Sound

- * The goal is to identify a system of zones permitting a range of uses and explore the definition and weighting of costs for uses/values across these zones.
- * In this scenario we have identified three types of zones
 - * Zone 1 – general use
Objective is to accommodate recreational activities within general use zone at 80% of their current activity
 - * Zone 2 – marine park
Objective is to achieve 50% conservation targets for seagrass species
 - * Zone 3 – aquaculture
Objective is to expand on the existing aquaculture license areas to achieve a total area that is 250% of its current extent.
- * Planning units must be assigned to one of the three alternative zones. A different cost is associated with a planning unit being in any one of the different zones. A cost matrix represents the relationship between the zoning option and the management area objectives, defined previously in Scenario 3.

Table 4.1 – Cost matrix for Multiple-Use Planning in Cockburn Sound

Management Area	Recreation (general use)	Natural/Cultural (marine park)	Commercial (aquaculture)
Garden Island	5	5	10
Rockingham	1	5	1
Kwinana	5	10	5
Challenger Beach/Cliffs	1	1	1
Jervoise Bay	5	5	5
Woodman Pt	5	1	5
Central Basin	5	5	5

* Guided by the EMP, a cost matrix was devised to inform the selection of planning units into zones, as shown in Table 4.1.

* To ensure the zones are spatially compact and also spatially separated from each other a zone boundary cost file must be defined. This effectively sets the BLM (boundary length modifier) for interfaces between planning units of different zones. A zone boundary cost matrix represents the relationship between zones to calculate boundary length costs for our network of planning units. The following weightings apply to interfaces between planning units with a different zone.

Table 4.2 – Zone Boundary Cost Matrix for Spatially Compact zones

	Zone 1 - general use	Zone 2 - marine reserve	Zone 3 - aquaculture
Zone 1	0	1	1
Zone 2		0	0.8
Zone 3			0

Note on aquaculture requirement

* Aquaculture requirements are identified as relatively deep water (>10 metres depth) and excellent water quality. As no data on water quality was available, we limited aquaculture to areas in the High Protection Zone as a proxy for good water quality. A simple decision rule was devised to identify potential areas suited for aquaculture.

Decision Rule is water depth > 10m and in the High Protection Zone

* Instructions provided below.

Scenario 4

1. In the Zonae Cogito program, load Scenario 4. In the main menu, select File/open, then choose CScenario4.zcp.

2. In the **Marxan Parameter to Edit** drop box select the parameter **ZONES**

Review the three different zone types used to configure the Cockburn Sound multiple-use system.

Zone 1 = General Use

Zone 2 = Marine Park

Zone 3 = Aquaculture

3. In the **Marxan Parameter to Edit** drop box select the parameter **SPEC**

Review the features described in the spec file. These include a combination of conservation features, recreation features and other activity types (e.g. shipping routes). Note that the **prop** is set to 0, with no target defined for the spec features. For this scenario feature targets are defined in **ZONETARGET**

4. In the **Marxan Parameter to Edit** drop box select the parameter **ZONETARGET**

Review the zone targets prescribed for the different features. These features are described in the **spec** file and include a combination of conservation features, recreation features and other activity types (e.g. shipping routes). These targets are zone specific, meaning that contributions towards targets are only counted when they occur in particular zones e.g., contributions towards aquaculture targets are only measured from occurrences in the aquaculture zone.

5. In the **Marxan Parameter to Edit** drop box select the parameter **ZONEBOUNDCOST**.

Note that the zone boundary values shown in Table 4.2 (above) are tabulated into the **zoneboundcost** file format.

6. Select **Run** to run Marxan. In GIS examine the best solution and compare with alternative solutions and the **Selection frequency** identified in the **Output to Map** field. Select the **summary report** generated for the best solution and examine whether all targets have been met.

7. View contextual GIS layers. Go to **GIS** and tick the box adjacent to the theme you wish to highlight as indicated below

To view the management areas, click on **MA_Central_Basin**, **MA_Challenger**, **MA_Garden_Island**, **MA_Jervois_Bay**, **MA_Kwinana**, **MA_Rockingham**, and **MA_Woodman_Point**.

To view the areas where aquaculture site requirements are met, click on **aqua_poss_areas**

To view the areas where aquaculture currently occurs, click on

- **Existing_aquaculture**
- To view the distribution of seagrass across the planning region, click on **CS_seagrass**

8. Review the Summary Report. Select the **summary report** generated for the scenario and examine whether all targets have been met. You may wish to rerun the scenario with a higher penalty for missing values . To do this edit **spf** parameter below.
9. In the **Marxan Parameter to Edit** select the **SPEC** parameter and edit the spf field. This time, you may want to prioritise which feature targets are met. For example, to prioritise conservation feature targets, uncheck the Edit All Rows box. In the **spec** table, click on the spf value for the top conservation feature and while holding down, highlight the range of cells corresponding to the spf values for the conservation features (feature id 1 to 32), then enter a value of 100 in the edit value box. Run Marxan. Review the Summary Report to see if the higher spf value has improved on the number of missing values.

End Scenario

4.2 Scenario 5 - Identify A System of Zones to Accommodate Aquaculture, Marine Reserves and Recreational Values Whilst Recognising Existing Uses as Constraints

Identify a system of zones for Cockburn Sound which achieves the following objectives:

- expansion of the aquaculture industry, within specified constraints;
- protection of seagrass values, preferably through the extension of the Shoalwater Island Marine Park;
- maintain existing recreational uses.

In this scenario we configure a system of zones to implement a multiple use plan for aquaculture, conservation and recreation values as for Scenario 4. New to this scenario is the inclusion of constraints on where aquaculture areas are located. The Cockburn Sound EMP states that aquaculture is generally compatible with other uses, however in locating leases there is a need to consider navigation issues and the potential impact on benthic habitat.

- * The following values/uses are likely to constrain aquaculture due to their requirement for safe navigation
 - *Shipping_com (commercial shipping routes)*
 - *Shipping_naval (naval shipping routes)*
 - *Pleasure_Boating_Destinations_CockburnSound*
 - *WatercraftAreas_CSMC*
 - *TCYC_Course_Area_CockburnSound*
 - *RFBYC_SailingArea_CSMC*
- * To incorporate these navigational constraints for locating aquaculture the following decision rules will apply
 - Minimise impact of aquaculture on all shipping/boating activities
- * The following benthic habitat features are likely to constraint aquaculture
 - SG_P_SINUO SG_REEF
 - SG_MIXEDSP SG_P_AUGUS
 - SG_HALOPHI SG_PATCHYP
 - SG_P_AUGUS SG_POSIDON
- * To address these benthic habitat constraints on locating aquaculture the following decision rules will apply
 - Minimise impact of aquaculture on benthic habitat

Scenario 5

1. In the Zonae Cogito program, load Scenario 5. In the main menu, select File/open, then choose CSscenario5.zcp.

2. In the **Marxan Parameter to Edit** drop box select the parameter **ZONES**

Review the three different zone types used to configure the Cockburn Sound multiple-use system.

Zone 1 = General Use

Zone 2 = Marine Park

Zone 3 = Aquaculture

3. In the **Marxan Parameter to Edit** drop box select the parameter **SPEC**

Review the features described in the spec file. These include a combination of conservation features, recreation features and other activity types (eg. shipping routes). Note that the **prop** is set to 0, with no target defined for the spec features. For this scenario feature targets are defined in the **zonetarget** file

4. In the **Marxan Parameter to Edit** drop box select the parameter **ZONETARGET**.

Note that each zone has a unique set of features and feature targets. These reflect the different targets defined for varying features across each zone.

5. In the **Marxan Parameter to Edit** drop box select the parameter **ZONEBOUNDCOST**.

Note that each zone has a defined boundary cost with adjacent zones. These values are identified in a unique set of features and feature targets zone boundary values shown in Table 4.2 (above) are tabulated into the **zoneboundcost** file format.

6. In the **Marxan Parameter to Edit** drop box select the parameter **ZONECOST**.

Note that this file identifies the cost multiplier that applies to different feature types across the different zone. Scroll down this file and note that cost weightings are now defined for an extended range of cost types. (Recall that in scenario 4 costs related to the management areas). These costs are identified in the **costs** file.

A general rule has been defined to relate different feature types to the system of zones, as shown below.

Table 5.1 – Cost matrix for Multiple-Use Planning in Cockburn Sound in Scenario 5

Type of Cost	Zone 1 General use	Zone 2 Marine reserve	Zone 3 Aquaculture
environmental	1	1	n/a
recreation	1	1	5
fisheries	1	10	1

other	1	10	10
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These cost multipliers have been defined to reflect the objective to spatially separate aquaculture from benthic marine habitat (seagrass) and recreational boating activities.

7. Select **Run** to run Marxan. In the GIS examine the best solution and compare with alternative solutions and the **Selection frequency** identified in the **Output to Map** field. Select the **summary report** generated for the best solution and examine whether all targets have been met.
8. View contextual GIS layers. Go to **the GIS** and tick the box adjacent to the theme you wish to highlight as shown below

To view the features that have requirements for safe navigation, click on

- *CS_shipping_routes*
- *Pleasure_Boating*
- *WatercraftAreas_CSMC*
- *Rec_sailing_areas*

And see to what extent aquaculture zones have avoided these areas

Uncheck the themes above and this time review the location of the marine park zones in the context of benthic seagrass distribution. To do this, click on

- *CS_seagrass*

End Scenario

4.3 Scenario 6 – Identify a Multiple Use Marine Plan for Cockburn Sound

Prepare a multiple use marine plan for Cockburn Sound considering the full suite of uses. Allow feature targets to be set separately for each zone.

In this scenario we extend on the complexity of previous zoning problems and examine options for a multiple use marine plan that configures a zoning scheme to accommodate the range of existing uses.

- * The defined zones are
 - * Zone 1 –general use
 - * Zone 2 –marine park
 - * Zone 3 – aquaculture
 - * Zone 4 –coastal recreational areas
 - * Zone 5 –port exclusion (port infrastructure)
 - * Zone 6 – industry
 - * Zone 7 –defense

- * Planning units must be assigned to one of the seven alternative zones in order for zone specific targets to be achieved.

- * Instructions are outlined below

Scenario 6

1. In the Zonae Cogito program, load Scenario 6. In the main menu, select File/ open, then choose CSscenario6.zcp.
2. In the **Marxan Parameter to Edit** drop box select the parameter **SPEC** and review the range of features occurring in the Cockburn Sound planning region.
3. In the **Marxan Parameter to Edit** drop box select the parameter **'ZONETARGET'** and review the zone specific feature targets. As you scroll through, note that
 - The general use zone (zone 1) has targets for recreational features set at 0.8 (80%) ,

- The marine park zone (zone 2) has targets of 30% for seagrass features
 - The aquaculture zone (zone 3) has targets for aquaculture set at 0.2 (20%)
 - The coastal recreational areas zone (zone 4) has targets for coastal recreational features (ie coastal heath vegetation, public jetties) set at 0.2 (20%), the exception being that 100% of swimming beaches are required.
 - The port exclusion zone (zone 5) has targets for commercial port activities ranging from 0.1 (10%) to 0.2 (20%)
 - The industry zone (zone 6) has targets for commercial boat harbours and industrial activities ranging from 0.2 (20%) to 1 (100%).
 - The defense zone (zone 7) requirements include 100% of naval shipping channels and boat ramps infrastructure.
4. Select **Run** to run Marxan. In the GIS examine the best solution and compare with alternative solutions. Examine the **Selection frequency** maps generated for each of the zones.
 5. Select the **summary report** generated for the best solution and examine whether all targets have been met.

A problem with this level of complexity and this many objectives is difficult to solve. Part of the problem may be that an informal management regime is likely to have different uses co-occurring in the same area (eg pleasure boating and snapper fishing), whereas a formal zoning scheme like that proposed here, requires these activities to be spatially separated into different zones. The result is that not all zone-specific feature targets can be met.

More accurate decision rules can be set to better resemble real world problems. The more time invested in accurately defining the planning problem, reviewing the features, targets and the interactions between them, the more confident you can be in the output.

5. Interactive Session 4, Cockburn Sound

5.1 Scenario 7 - Identify A Multiple Use Marine Plan for Cockburn Sound featuring multiple objectives for a range of uses, ranging from high level protection to exclusive types of use.

Identify a multiple-use system of zones for Cockburn Sound which aims to meet conservation, recreational activities, and recreational fishing targets whilst recognising existing uses as constraints. An additional objective is to give priority to meeting conservation targets over passive recreation and recreational fishing targets.

This zonation scheme (Table 5.1) seeks to satisfy multiple-use objectives by assigning planning units to one of 4 zones. Objectives were defined for feature targets by locking in existing uses (ports and infrastructure), and using zone-specific targets for conservation, passive recreational activities and recreational fishing. In this way, the proposed zones can better manage areas of multiple-use and minimise potential for conflict.

Table 5.1 Proposed Zonation Scheme for Cockburn Sound

Zone Name	Zone Objective
Zone 1 – General Use	Managed for passive recreational activities and general use (4 features each requiring 80% representation)
Zone 2 – Allocated (Existing Uses)	Managed for existing uses (12 features each requiring full representation)
Zone 3 – Recreational Fishing	Managed for recreational fishing (3 features each requiring representation target of 80%)
Zone 4 – Conservation	Managed for conservation (23 biodiversity features with targets varying)

- * Review the different zoning configurations under these constraints. Compare these solutions alongside the GIS layers for recreation, conservation and fishing.
- * Examine the Best Solution Feature reports to determine which targets are being met. Use the spf value to assign priority to particular features.
- * Instructions are provided below.

Scenario 7

1. In the Zonae Cogito program, load Scenario 7. In the main menu, select File, open, then choose CSscenario7.zcp to begin.
2. In the **Marxan Parameter to Edit** drop box select the parameter **ZoneTarget** and review the zone-specific targets that have been formulated, consistent with Table 5.1 above. Note that the zone-specific targets for conservation features spec id 15-40 have been revised and require 100% representation for many of the conservation features.

The **specid** field has a number which corresponds to the features named in the spec table. To view these, select the parameter **spec** in the Marxan Parameter to Edit box.

3. In the **Marxan Parameter to Edit** drop box select the parameter **Costs** and review the 19 different cost features which have been identified. These capture the range of existing uses occurring in the Cockburn Sound region. The interactions between these cost features and the zones are captured in the parameter **zonecost**. A multiplier of 1 indicates compatibility between the cost feature (costid) and the zone type (zoneid). Here the cost weightings are defined to reflect the interactions between the conservation zone (zone 4) and the cost features. A high cost multiplier is used to see that conservation zones are allocated in planning units where cost feature's occurrences are negligible.
4. Select **Run** to run Marxan. In GIS examine the best solution and compare with alternative solutions and the **Selection frequency** 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 the performance of the best solution

In the Marxan window click on the drop down box under **Marxan** select **View Output**, then **Best Solution Features**. This opens the results for the best marxan run in the scenario. It reports on whether targets have been met for individual features. The key fields to review are :

- **Target Met conservation** this reports on whether zone-specific targets for conservation features were met. If a 'no' is reported then you should review the 'Target Conservation' and 'Amount Held Conservation' to determine whether the shortfall was significant or trivial. If it was significant then you may choose to increase the spf for that feature. A blank value indicates that no target was prescribed for that feature in that zone.

- **Target Met recfishing** this reports on whether zone-specific targets for recfishing were met. If a 'no' is reported then review the fields 'Target recfishing' and 'Amount Held recfishing' to see the shortfall in the target.

-**Target Met allocated** this reports on whether zone-specific targets for existing uses were met. If a 'no' is reported then review the fields 'Target allocated' and 'Amount Held allocated' to see the shortfall in the target.

-**Target Met general** reports on whether zone-specific targets for recreational features were met. If a 'no' is reported then review the fields 'Target general' and 'Amount Held general' to see the shortfall in the target.

6. In the **GIS**, highlight the shipwrecks, boating, sailing, water_training, jetski, and beach_swim themes to review the location of the recreational features. Highlight the GIS layer for Lock-Allocated.shp to see how conservation, recreational and recfishing feature targets must be met around the existing uses (shown here in the Lock-Allocated theme). Note potential conflicts between the existing uses and recreational uses.
7. Revise species penalty factor for recreational features in the general use zone with a shortfall

In the **Marxan Parameter to Edit** drop box select the parameter **SPEC** . To prioritise meeting recreational feature targets, scroll down the table to feature id 56-61, uncheck the **Edit All Rows** box and enter a new spf of 100 in the Edit Value box.

You may wish to revise the spf for conservation features, in which case repeat step 9 above for the conservation features 15-40 (excluding featureid 24 and 32) and increase the spf to 1000.

8. Select Run to run Marxan. In the GIS examine the best solution and compare with alternative solutions. Examine the **Selection frequency** maps generated for each of the zones. Select the **summary report** generated for the best solution and examine whether all targets have been met.
9. Review the performance of the best solution

In the Marxan window click on the drop down box under **Marxan** select **View Output**, then **Best Solution Features**. See if there has been an improvement in the targets met for recreation features in the general use zone (or targets met conservation).

End of Scenario

5.2 Scenario 8 – Examine the extent to which conservation objectives can be met when development proposals are introduced into Cockburn Sound.

Expand on the multiple-use planning framework for Cockburn Sound which aims to meet conservation, recreational activities, and recreational fishing targets whilst recognising existing uses as constraints. Consider how development proposals introduced to the region are likely to affect conservation objectives for the region.

- * Consider how locally significant biodiversity is potentially affected by development proposals (described below) :
 - Marina development at Port Rockingham ;
 - Marina development at Mangles Bay;
 - Port development - construction of an artificial island and access bridge ;
 - Development proposal - Aquaculture expansion area

- * The zonation scheme devised for Scenario 7 was expanded to provide for an additional zone – Development Proposals.

Table 5.2 Proposed Zonation Scheme for Cockburn Sound

Zone Name	Zone Objective
Zone 1 – General Use	Managed for recreational activities and general use (4 features each requiring 80% representation)
Zone 2 – Allocated	Managed for existing uses (12 features each requiring full representation)
Zone 3 – Conservation	Managed for conservation (23 biodiversity features with targets varying)
Zone 4 – Development	Development Proposals (requires full representation of development proposals).

Zone 5 – Recreational Fishing Managed for recreational fishing (3 features each requiring representation target of 80%)

- * Existing uses were locked-in to the Existing Uses zone (i.e. planning units with existing uses are not available to assign to other zones).

- * Examine the GIS layer for the development proposals

- * Compare the performance of the zoning plans (Scenario 7&8) to assess how the development proposals are impacting on the multiple objectives of the Sound.

- * Instructions are outlined below.

Scenario 8

1. In the Zonae Cogito program, load Scenario 8. In the main menu, select File, open, then choose CSscenario8.zcp to begin.

2. In the **Marxan Parameter to Edit** drop box select the parameter **Zones** and note the inclusion of the development zone (zone 4).
3. Now review the parameter **SPEC** and scroll down the table to feature id 65-69 and observe the inclusion of the development proposals as features. Select the parameter **ZoneTarget** and scroll down the table to zone 4. You will see that the development proposal features (specid65-69) have a zone-specific target, requiring 100% of each in the development zone. Note also that targets were set for other types of uses (eg recreational fishing and general use), however the **SPEC** table shows that these are given a lower priority weighting than for the conservation objectives.
4. In the **Marxan Parameter to Edit** drop box select the parameter **Costs** and review the 19 different cost features which have been identified. These capture the range of existing uses occurring in the Cockburn Sound region. The interactions between these cost features and the zones are captured in the parameter **zonecost**. A multiplier of 1 indicates compatibility between the cost feature (costid) and the zone type (zoneid). Here the cost weightings are defined to reflect the interactions between the conservation zone (zone 4) and the cost features. A high cost multiplier is used to see that conservation zones are allocated in planning units where cost feature's occurrences are negligible.
5. Select **Run** to run Marxan. In GIS examine the best solution and compare with alternative solutions and the **Selection frequency** identified in the **Output to Map** field. Highlight the GIS layer for Lock-Development.shp and Lock-Allocated.shp to see how conservation, recreational and recfishing feature targets must be met around the existing uses and the proposed developments (shown here in the Lock-Allocated and lock-development themes).
6. Select the **summary report** generated for the best solution and examine whether all targets have been met.

7. Review the performance of the best solution

In the Marxan window click on the drop down box under **Marxan** select **View Output**, then **Best Solution Features**. This opens the results for the best marxan run in the scenario. Examine the performance of the zoning configuration for individual features. Note under the ‘Target Met development’ that all targets have been met. This is because planning units coinciding with the location of the Developments Proposals were locked in to the Development Zone and not available for allocation to any other zone.

8. Report on the impact of the Development Proposals on the conservation objectives of Cockburn Sound

Both Scenario 7 and Scenario 8 generate the **Best Solution Feature** reports, these show how well the two scenarios performed in meeting conservation objectives. Both scenarios failed to meet all conservation objectives, a result which is not surprising given the requirement for 100% targets for many biodiversity features, combined with the limited spatial options for achieving those targets within the framework of existing uses in the Sound.

We examined how many feature targets were met for each of the zones and compared how they performed in scenario 7 with how they performed in Scenario 8 when development proposals were introduced. This information is presented in Table 5.3 and illustrates an analysis of Marxan outputs that can serve to inform the trade-offs which arise when existing uses and development proposals are prioritised above conservation objectives.

The multiple-objective problem as defined here for Cockburn Sound means that biodiversity feature targets can only be achieved after the objectives for the existing uses and the development proposals are satisfied. In view of these results, the issue can be further explored in Marxan with Zones, using new definitions of the planning problem to achieve an explicit set of management outcomes that recognise the achievable objectives for biodiversity features in the context of existing and planned uses.

Table 5.3 The amount of biodiversity features held in the Conservation zone when existing uses are locked-in (Scenario 7), and development proposals together with existing uses are locked-in (Scenario 8). Unmet feature targets are reported in bold. Shaded cells indicate biodiversity features that are adversely affected by the development proposals.

FEATURE ID	FEATURE TARGET	SCENARIO 7	SCENARIO 8	CONSERVATION TRADE-OFF EFFECT FROM DEVELOPMENT PROPOSALS
BENTHIC HABITAT				
1. VEGETATED	30 %	33 %	45 %	
2. WRACK	30 %	53 %	67 %	
3. COBBLE	30 %	89 %	49 %	
4. PAVEMENT REEF	30 %	59 %	55 %	
5. FINE SEDIMENT	30 %	55 %	47%	
6. LIMESTONE REEF	30 %	82 %	82 %	
SEAGRASS MEADOWS				
7. MIXED SEAGRASS	100%	96 %	96 %	
8. AMPHIBOLIS & POSIDONIA SPP.	95 %	96 %	96 %	
9. HALOPHILA SPP.	100 %	95 %	47 %	48 %
10. PATCHY POSIDONIA	100 %	100 %	100 %	
11. POSIDONIA SPP.	100 %	98 %	96 %	2 %
12. P. SINUOSA & P. AUSTRALIS	100 %	37 %	30 %	7 %
13. P. SINUOSA	100 %	81 %	76 %	5 %
14. P. ANGUSTIFOLIA	100 %	98 %	98 %	
SHORELINE HABITAT				
15. SANDY BEACH	100 %	55 %	31 %	24 %
16. LIMESTONE CLIFF	100 %	3 %	3 %	
OTHER				
17. CORAL AREAS	75 %	75 %	75 %	
18. POTENTIAL CORAL AREAS	50%	83 %	75 %	
19. SNAPPER SPAWNING AREA	100%	90 %	88 %	2 %
20. LITTLE PENGUIN COLONY	100%	66 %	66 %	
21. LITTLE PENGUIN FORAGING AREA	90%	90 %	86 %	4 %
22. SEAL	100%	82 %	82 %	
23. DOLPHIN	100%	89 %	87 %	2 %

Appendix

A1. Demonstration Session, Marxan outputs and the GIS

A1.1 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

D:\rotnest\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**.

A1.2 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 **D:\rotnest\marxan\scenario1\output** and double click on the file **output_log.dat** to load it into the text editor.

A1.3 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 **D:\rotnest\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.

A1.4 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 GIS map display.

Browse to the folder **D:\rotnest\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.

A1.5 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 **D:\rotnest\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.

A1.6 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 GIS 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 GIS map display.

Browse to the folder **D:\rotnest\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.

A1.7 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 **D:\rotnest\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.

A1.8 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 GIS 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 **D:\rotnest\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.