

MARINE SPATIAL PLANNING PILOT

SCENARIO 3: MARINE PROTECTED AREAS *(Final)*

MSPP Consortium, November 2005

1. INTRODUCTION

The purpose of this scenario is to use information within the Irish Sea Regional Plan to identify a possible Marine Protected Area (MPA) network in the plan area that minimises conflict with other current and future use-related activities using the software Marxan.

This note provides a summary of how the assessment was carried out and the main results. Further details of the methodology and some of the technical requirements associated with running Marxan software are provided in Appendix 1.

2. POLICY AND TARGETS FOR A MARINE PROTECTED AREA NETWORK

While the UK is committed to establishing a representative network of MPAs by 2010/2012, there is currently no clear target in terms of required area of coverage or the range of habitats and features that such a network might include. For the purposes of this scenario, it has been assumed that a network will be established covering approximately 20-30% of the sea bed and which takes account of the following features:

- Important bird areas
- Fish nursery grounds
- Seabird colonies
- Sounds
- Sea lochs
- Estuaries
- Shallow and deep water mud basins
- Sediment wave mega-ripple fields
- Sand gravel banks
- Reefs (aphotic and photic)
- Low and high bed stress coarse sediment plains
- Sea mounds
- Fine sediment plains
- Deep water channels
- Coastal sediment
- Annex 1 Gas seeps
- Annex 1 Sandbanks
- Annex 1 Reefs

One option in developing a network might be to automatically include all national and internationally designated sites within the network. This has the advantage of administrative simplicity. However, for the purposes of this scenario we have chosen not to automatically lock in existing designated sites, but to seek to identify a potential 'least cost to other users' network throughout the plan area.

3. MINIMISING IMPACTS TO OTHER USES

The Joint Nature Conservation Committee has previously conducted a study of regional scale networks to protect biodiversity within the Irish Sea (Lieberknecht et al., 2004). These were selected based on Marxan, a computer optimisation model (see Appendix 1) with the intention of protecting 30% of sea areas. The results showed that there is a great deal of flexibility in the management options available, as relatively few places are identified as irreplaceable in terms of biodiversity. This indicates that there are choices that can be made about the location of sites within the network. Such choices can be used to minimise the potential conflicts that might arise between the conservation objectives for individual MPAs and the economic and social objectives associated with other use-related activities.

A total of 39 different uses have been included in the analysis with the objective of avoiding inclusion of areas of multiple and high economic and social value within the possible MPA network (see Appendix 1). For this scenario an approach to “valuing” economic and social uses has been taken based on the number of different uses occurring in an area and a simple weighting system. It is recognised that more complex approaches could be adopted, based on the economic value of uses or the importance afforded to them by Government policy.

The scenario has taken account of locations for potential future use for tidal stream energy generation (Scenario 1) and aggregate extraction (Scenario 2).

4. POSSIBLE MPA NETWORK

Figure 1 presents a Marxan solution for areas considered suitable for the MPA network within the plan area. This is based on existing information on the distribution of nature conservation features and the location of human activities. The solution seeks to minimise potential conflict with other human uses. An indication of the extent to which it has managed to achieve this is illustrated in Figure 2, which superimposes intensity of other uses.

It is important to note that the Marxan solution does not completely avoid other uses – indeed that would not be possible, given the existing high level of other uses within the Irish Sea. Rather, it simply seeks to minimise potential effects on other uses. Like any decision support tool, it is possible to modify the weight given to particular uses to steer the selection of areas towards or away from these uses. It is recognised that the assumptions made concerning such rules are therefore likely to be contentious. Nevertheless Marxan does provide the potential to explore a large number of different options for establishing MPA networks which could inform the decision making process.

Any final network established is likely to represent a compromise between scientific requirements, economic and social considerations for individual sectors and administrative simplicity. For example, it would be desirable for the boundaries of MPAs to be drawn using simple and clear lines to facilitate management and enforcement. The currently drawn network (Figure 1) would therefore ideally be refined into a smaller number of simple polygons.

5. CONCLUSIONS

- Marxan can be used to identify a possible MPA network that seeks to minimise potential conflicts with other uses;
- Marxan can be used to define a network that incorporates a range of different types of nature conservation interest features;
- Most of the areas identified for inclusion in the network are already subject to some level of existing use. The indicative network identified in this study is based on minimising conflicts with other uses, on the assumption that the greater the imputed use value, the greater the potential conflict with conservation objectives. However, it would be possible to redefine the penalty criteria on a different basis should that be appropriate;
- All Marxan solutions are subject to a large number of assumptions and decision makers need to be mindful of the implicit choices that are being made in developing particular solutions.

Figure 1. A Marxan solution for areas considered suitable for the MPA network with the MSPP study area. The solution minimises conflict with use-related activities.

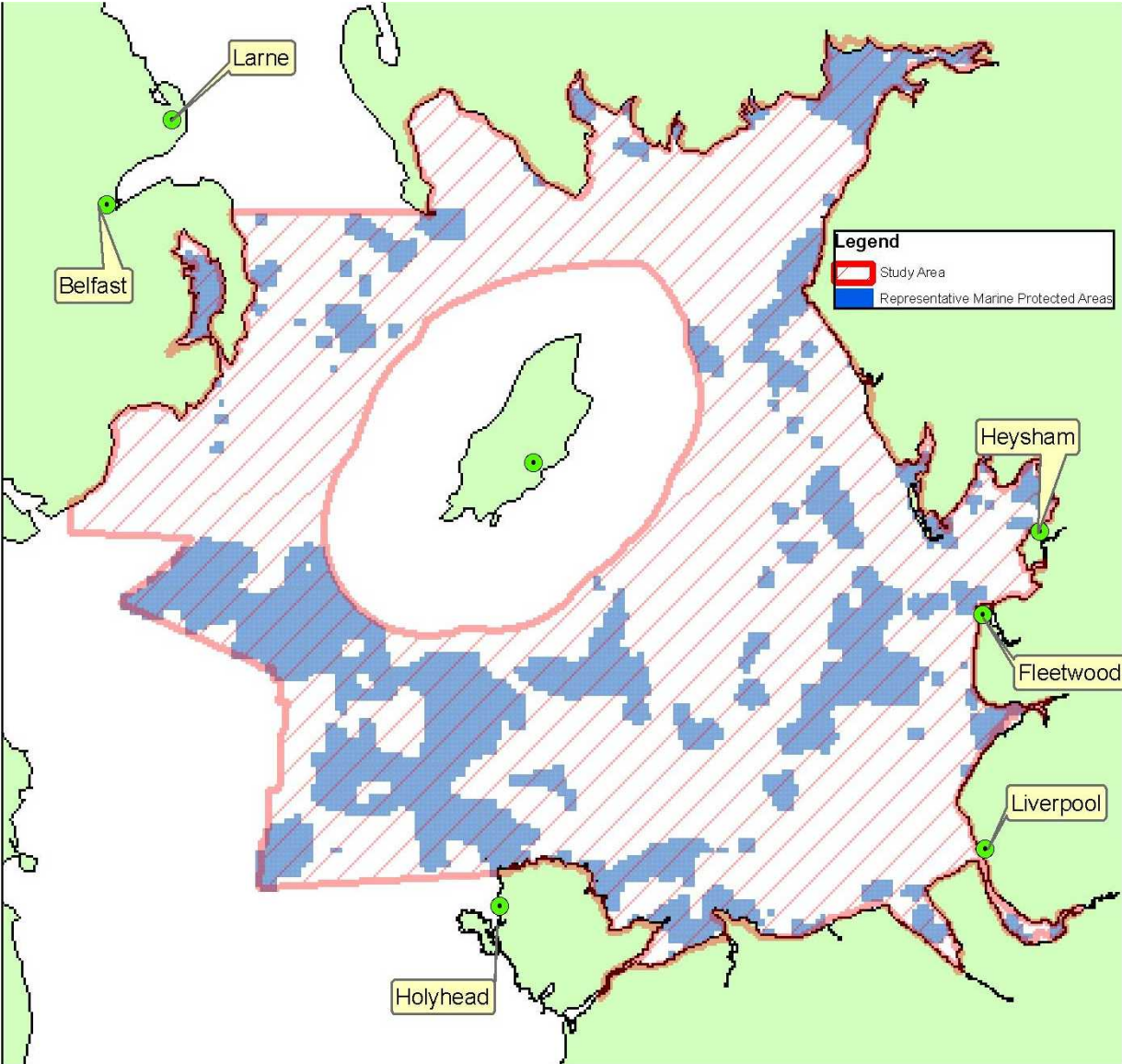
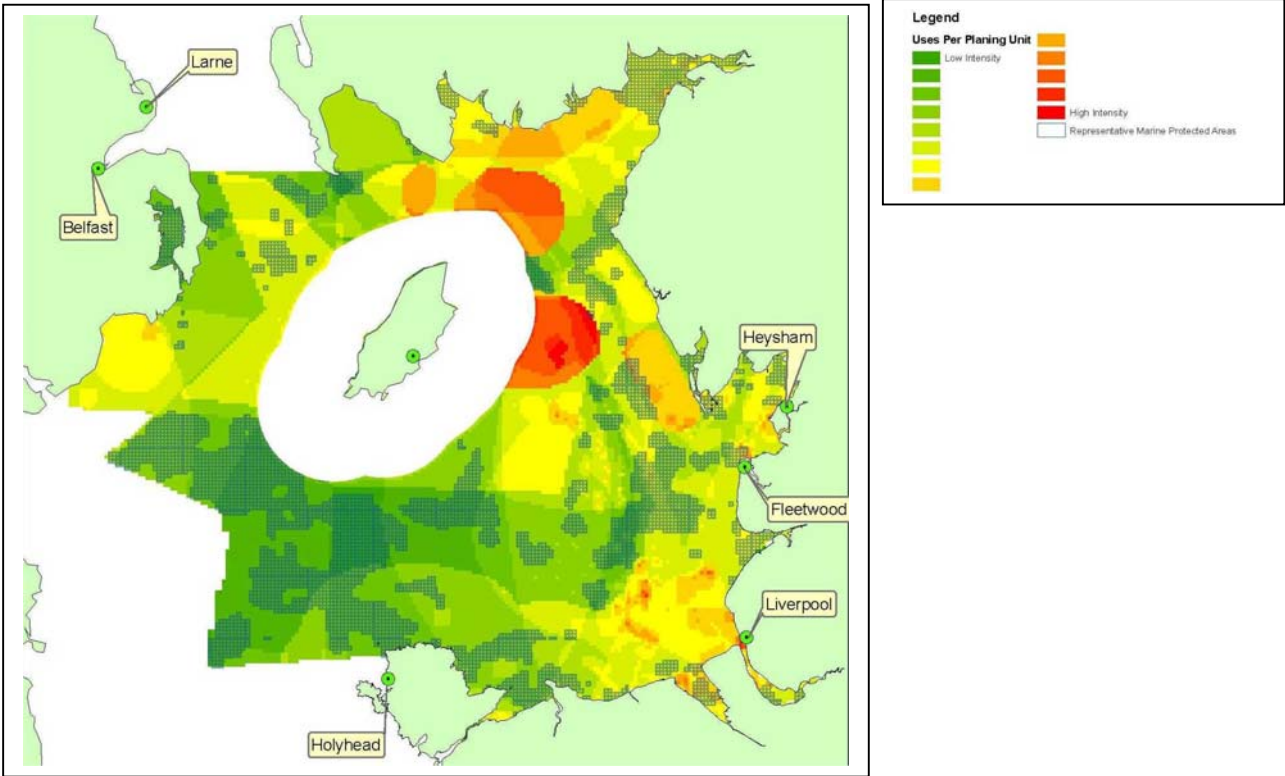


Figure 2. An example of minimising use-related conflict when designing a MPA network. Note that use intensity shows that the highest areas (shades towards red) have been avoided by the MPA network.



Appendix 1: Additional Information on the Application of Marxan

Rationale for Using Marxan

The Marxan software was used to set targets across a wide range of different use-related activities to provide scientifically defensible solutions to the designation of an MPA network within the Irish Sea MSPP study area. Marxan has been designed to enable managers/planners who have a requirement to select areas for marine reserve status from a large number of potential sites within their jurisdiction. In the case of MSPP this is at a regional sea level. The software is able to capture various conservation criteria (biodiversity, habitats, cultural heritage etc) set by the user to identify optimal areas for inclusion in a marine reserve(s). The main advantage is that large volumes of information can be automatically processed so that an optimal solution can be derived from a wide range of different reserve scenarios given that it should not unnecessarily impact on use-related activities.

The alternative approach is for a manager/planner to establish a rule-of-thumb or simplification that reduces the search for solutions in a domain that are usually complex and poorly understood. This heuristic approach does not guarantee an optimal solution. Moreover, it is unlike algorithms (as used in Marxan), which are able to deal with any number of well defined 'targets' set to meet the conservation needs of a manager/planner by assigning well defined set of costs associated with the impact of meeting such targets. Although Marxan was not specifically developed to minimise use-related conflicts, it is possible to substitute the costs associated with impact of meeting conservation targets with costs associated with use-related activities.

Methodology

Marxan software is a decision support tool designed to identify potential areas as marine reserves that take account of user-defined conservation targets.

There are two aspects of Marxan that require user input. These include:

- The objective function, which gives a value for a collection of planning units as if that collection constituted a potential MPA;
- The optimisation of the objective function, which includes three possible sub-functions - iterative improvement, simulated annealing and greedy heuristic algorithm. For the preset study the simulated annealing function was used.

The objective function allows Marxan to calculate whether or not a particular change to a portfolio (any number of planning units selected based on the targets and cost set by the user and which are selected for when a solution run is operated) improves the overall effectiveness of the outcome. The objective function has two components, the measuring of the 'costs' for an MPA network and the 'penalty' for not meeting them when set against user defined conservation targets. The lower the penalty factor, given the other considerations within this objective function, the better the solution for an MPA network. The objective function is summarised in the following equation:

$$\sum_{\text{Planning units}} \text{Cost} + BLM \sum_{\text{Planning units}} \text{Boundary} + \sum_{\text{Con Value}} CFCP \times \text{Penalty} + \text{Cost Threshold Penalty} (t)$$

For this scenario, the cost of planning units has been substituted with costs relating to use related activities (see Table 1) and based on Figure A1. While Marxan was not originally designed with the capture of this information in mind, the approach does not violate the assumptions for running the optimization algorithm within the programme routine (*pers.coms* Ian Ball).

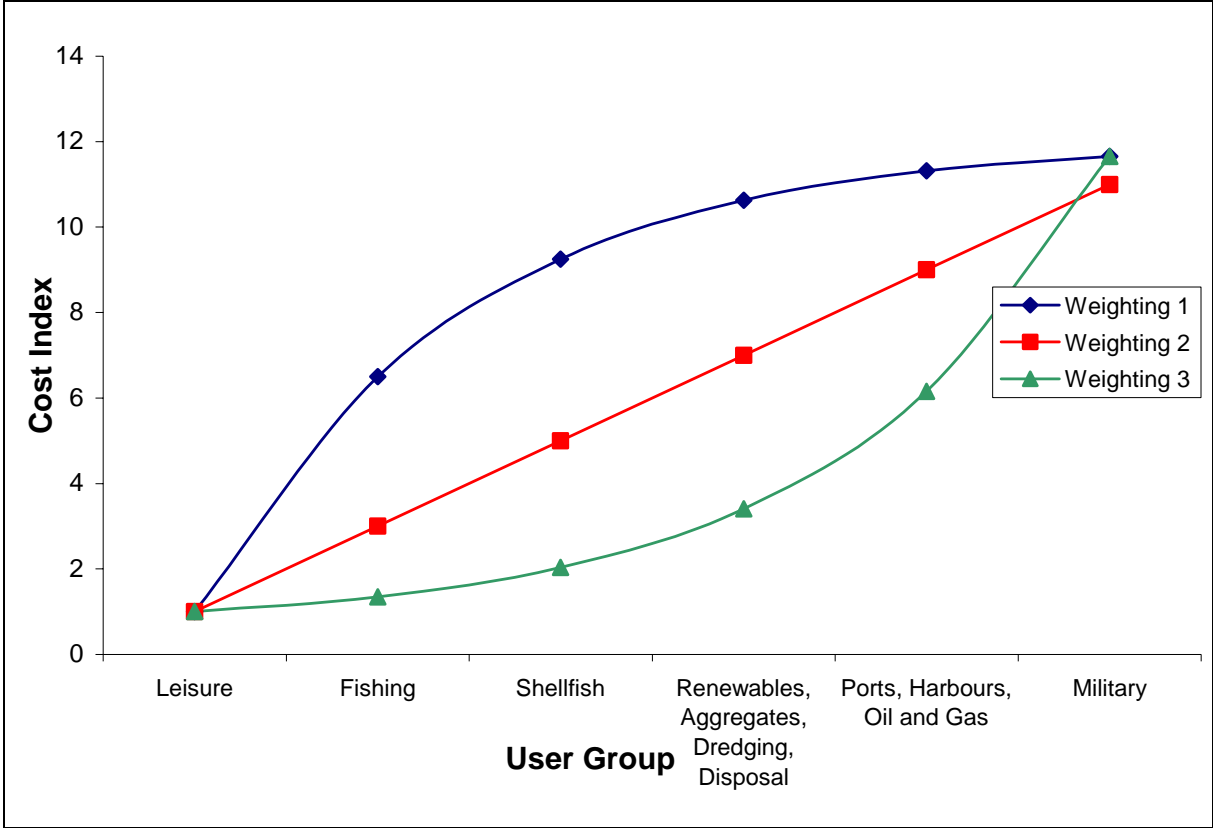


Figure A1: Illustrative cost functions that can be applied to human uses (weighting 1 was used in this scenario)

Table 1. List of use-related activities grouped into categories.

Use Type	Use Type Composition	Weighting 1	Weighting 2	Weighting 3	Weighting 4
Leisure	Recreational centres including marinas, sailing clubs and RYA centres	1	1	1	
Fishing	Bass fishing grounds	6.5	3	1.34375	
	Cod fishing grounds				
	Haddock fishing grounds				
	Herring fishing grounds				
	Nephrops fishing grounds				
	Plaice fishing grounds				
	Skate fishing grounds				
	Saithe fishing grounds				
	Sole fishing grounds				
	Turbot fishing grounds				
	Whiting fishing grounds				
	Currently restricted fishery				
	Inshore fishery				
	Experimental area				
	Restricted fishery				
	Restricted fishery				
	Herring fishery November till September				
	High intensity cod fishing grounds				
Shellfish	Shellfish harvesting areas	9.25	5	2.03125	
	Mariculture				
	Scallop fishery, October to June				
	Cockle and mussel fishery				
Renewable uses, aggregates, dredging and disposal	Active aggregate dredging areas	10.625	7	3.40625	
	Licensed aggregate dredging areas				
	Proposed aggregate extraction				
	Disposal sites				
	ABP and FEPA maintenance dredging				
	Round one windfarm cables				
	Offshore windfarms				
Ports, harbours, oil and gas	Ports	11.3125	9	6.15625	
	Harbour jurisdiction regions				
	Industrial docks, power stations and terminals for oil & gas				
	Sea surface infrastructure for oil and gas				
	Sea bed infrastructure for oil and gas				
	Hydrocarbon fields				
Military	MOD danger zones, PEXA zones & submarine exercise areas	11.65625	11	11.65625	

No weighting applied. All Planning units have a cost of 1.

The 'Boundary' is the length (of the boundary surrounding the MPAs. The constant Boundary Length Modifier (BLM) is the boundary length multiplier, which determines the importance given to the boundary length relative to the cost of the network. For example, if a value of 0 is given to the BLM then the boundary length is not included in the objective function.

In order that the optimal BLM could be selected Marxan was run at a number of different BLMs. The cost and the representativeness of the output were then assessed (Figures A2 & A3). JNCC noted that there was little point having the BLM higher than the point at which the boundary length was not further reduced as the cost continued to rise with no gain in terms of the compactness of the reserve. Using this method the BLM should not be any higher than 0.01.

Marxan also produces a summary of the effectiveness of the reserve (Figure 3). Penalty is the penalty score for missing conservation features for the reserve system. Shortfall is the shortfall of all the conservation features, which haven't met their target. It is the sum, over all conservation features, of the targets that have not been met. Missing Values is the number of conservation features, which haven't met their target. As we are ultimately interested in producing a reserve that is both representative and comprehensive it seem logical that these factors should be used to determine the optimal BLM. The reserve had the lowest shortfall, penalty and number of missing values at a BLM of 0.05. It was therefore decided that for weighting one, the optimal BLM would be 0.05.

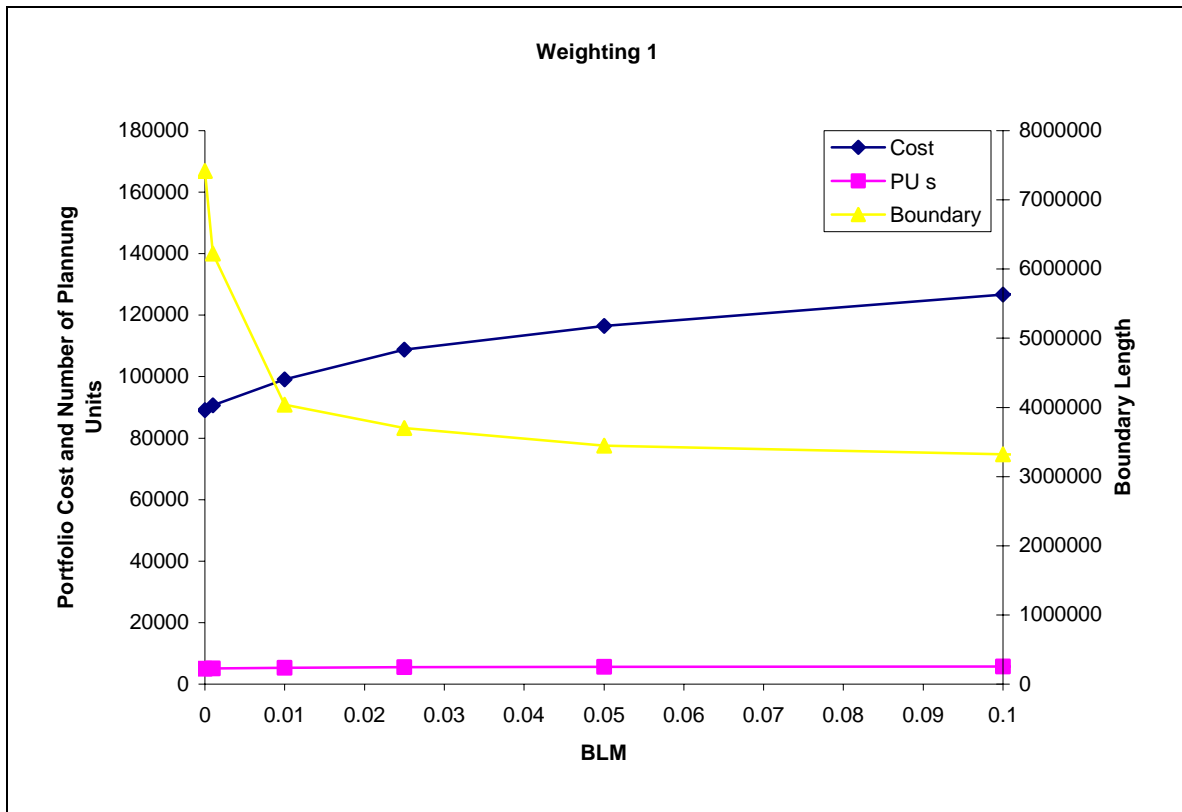


Figure A2: The effect of BLM upon cost and boundary length.

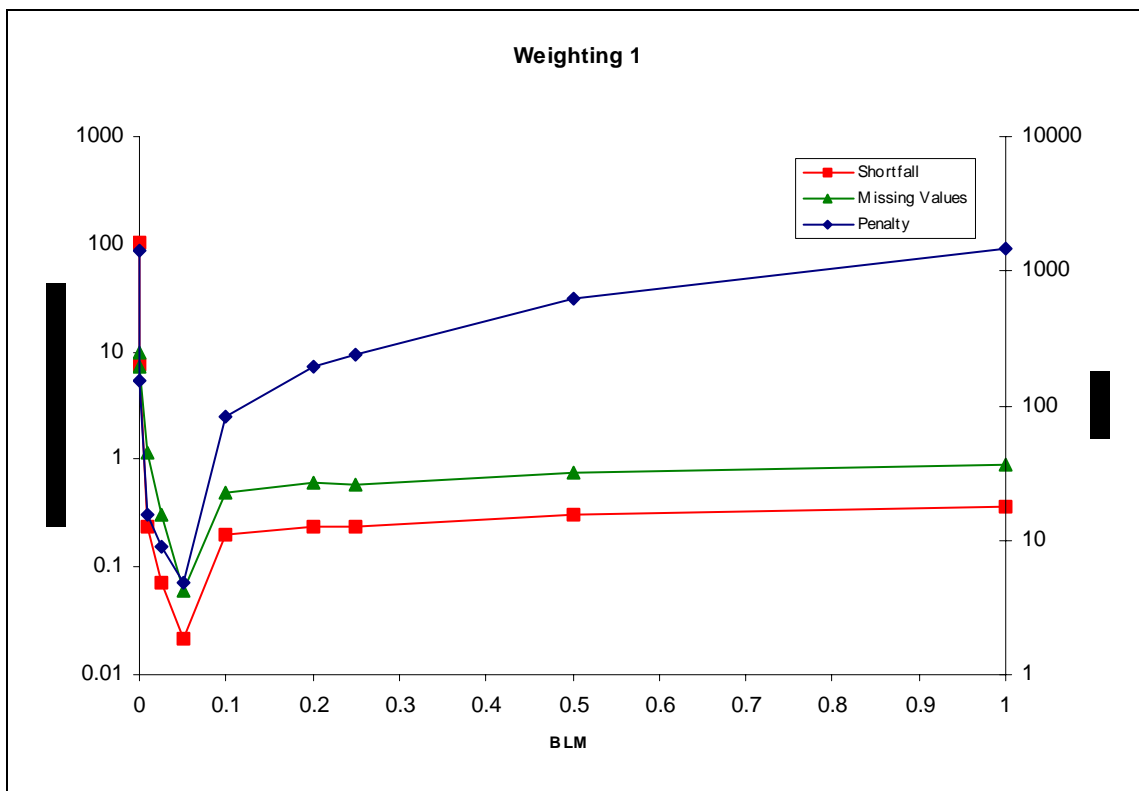


Figure A3: The change in the reserves representativeness and comprehensiveness of the reserve as a result of changes to the BLM.

The next term is a penalty given for not adequately representing a conservation feature, summed over all conservation features. CFPF stands for 'conservation feature penalty factor' and is a weighting factor for the conservation feature that determines the relative importance for adequately reserving that particular conservation feature.

The penalty term is a penalty associated with each underrepresented conservation feature. It is expressed in terms of cost and boundary length and is roughly the cost and additional modified boundary needed to adequately reserve a conservation feature that is not adequately represented in the current reserve system.

The cost threshold penalty is a penalty applied to the objective function if the target cost is exceeded. It is a function of the cost and possibly the boundary of the system and in some algorithms will change as the algorithm progresses (which is the 't' in the above formula). This penalty is also optional and can be excluded from the objective function.

The targets can include policy requirements and/or expert judgement. The software captures multiple features relating to conservation such as species, habitats, biodiversity etc that have been considered important by the user. It then allows the user to predefine a cost of a particular conservation feature depending on how important or valuable that feature is relative to target requirements. For this scenario the target values that were assigned using the relative conservation feature area are shown in Figure A4.

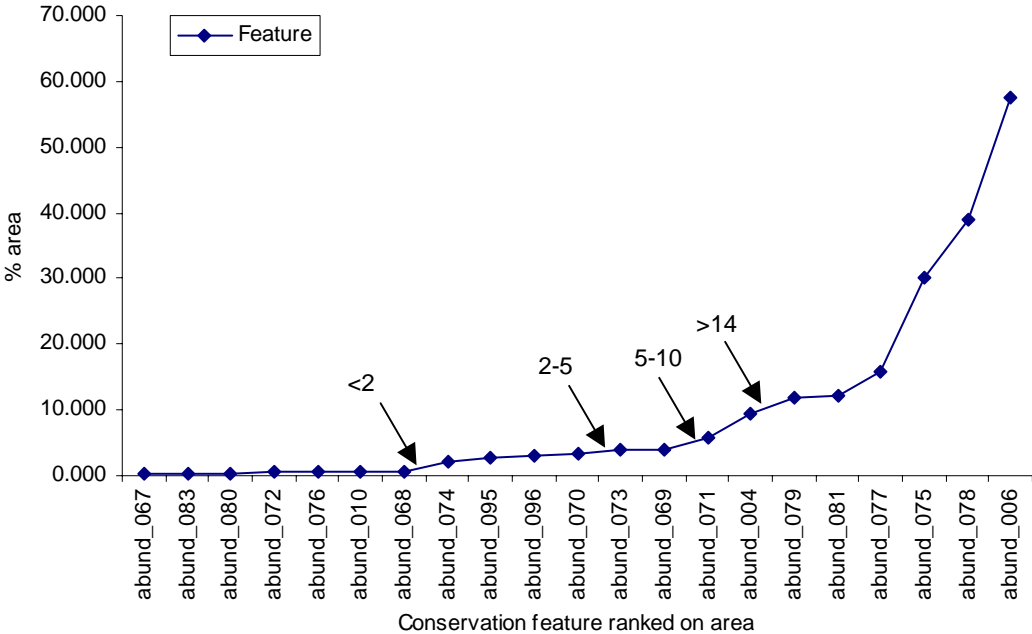


Figure A4. Criteria used to set nature conservation targets. Area denotes the number planning units (each unit 1 km²) within the study area (~25,000 units) and conservation feature names on the x-axis relate to those listed in Table 2.

Table 2. List of nature conservation features used in Marxan and corresponding identification number, which were used only as a tracking reference within Marxan. Note that features are in rank order.

Nature conservation feature	Tracking reference	Marxan target values
Sounds	adund_067	924.8
Annex 1 Gas seeps	adund_083	2863.6
Deep water channels	adund_80	83.4
Sand gravel banks	adund_072	46.8
Sea mounds	adund_076	110.4
Seabird colonies	adund_010	497
Sea lochs	adund_068	426
Reefs (photic)	adund_074	589.6
Annex 1 Sandbanks	adund_095	72
Annex 1 Reefs	adund_096	485
Shallow water mud basins	adund_070	253
Reefs (aphotic)	adund_073	1508
Estuaries	adund_069	79.2
Sediment wave mega-ripple fields	adund_071	791.4
Important bird areas	adund_004	1939.6
Deep water mud basins	adund_079	877.5
Coastal sediment	adund_081	52.8
High bed stress coarse sediment plains	adund_077	906
Low and high bed stress coarse sediment plains	adund_075	49.2
Fine sediment plains	adund_078	342.5
Fish nursery grounds	adund_006	367.5

While the best data available to the project team has been used, it is recognised that there are still deficiencies in our understanding of the distribution of nature conservation resources in the Irish Sea. Consideration has been given to the spatial representativeness of data the extent to which it was duplicated within another dataset.

References

Lieberknecht, L.M., Carwardine, J., Connor, D.W., Vincent, M.A., Atkins, S.M., and Lumb, C.M. (2004) The Irish Sea Pilot. Report on the identification of nationally important marine areas in the Irish Sea. JNCC, Peterborough.