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THE SALTIRE PRIZE PROGRAMME

Further Scottish Leasing Round (Saltire Prize Projects) Scoping Study

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Marion Harrald and Ian Davies

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FURTHER SCOTTISH LEASING ROUND (SALTIRE PRIZE PROJECTS) SCOPING STUDY

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Preface

The Scottish Government announced the competition guidelines for the Saltire Prize on 23 March 2010. The Saltire prize of £10 million will be awarded to a company that achieves a minimum electrical output of 100 GWh over a continuous 2-year period using wave or tidal energy before 2017 from a site leased by The Crown Estate (TCE) in Scottish waters. Also announced in March were the results of The Crown Estate's first commercial leasing round for wave and tidal projects in the Pentland Firth and Orkney waters. Ten wave and tidal projects with a total project capacity of 1.2 GW have been awarded agreements for lease by TCE. These projects will be eligible to compete for the Saltire Prize.

In the spirit of encouraging rapid development of the wave and tidal energy, and to give opportunities for other projects to compete for the Saltire Prize, TCE and the Scottish Government (including Marine Scotland) are working in partnership to prepare plans for a further Scottish leasing round for wave and tidal projects. This leasing round is entirely separate and in addition to the first round of leasing in Pentland Firth and Orkney waters. A discussion paper on the proposed geographic areas to be leased, together with the executive summary of this scoping study, were published on 23 March 2010 and interested parties were invited to comment.

This is the full text of the scoping study, which Marine Scotland has published to give further details and invite further comment.

Executive Summary

Introduction

The purpose of the Saltire Prize is to stimulate innovation that will lead to delivery of commercial scale wave or tidal stream energy technology. Competitors for the Saltire Prize, of £10 million, must demonstrate commercially viable wave and/or tidal energy technology in Scottish waters that achieve a minimum electrical output of 100 Giga-Watt hours (GWh) over a continuous 2 year period, ending no later than 30 June 2017 (the Prize Competition Period).

An earlier study identified the Pentland Firth and Orkney Waters as a prime location for wave and tidal renewable energy development. The Crown Estate subsequently held a leasing round in this area, and on 16th March 2010 announced that companies had been awarded agreement for lease for 1200 MW of projects. This announcement opens up the possibility of further areas being made available for lease for wave and tidal energy projects and is primarily aimed at potential Saltire Prize competitors.

The Scottish Government and The Crown Estate have been working in partnership to identify these further areas. This document, by Marine Scotland (part of the Scottish Government), summarises how these proposed areas were identified, as the basis for inviting comments on the suitability and attractiveness of the areas for wave and tidal energy project development and achievement of the Saltire Prize.

Following discussion on the proposed areas, the Scottish Government and The Crown Estate intend to finalise areas for lease in a further Scottish leasing round for wave and tidal energy projects.

Selection of Areas for Future Development

In 2007 the Scottish Government published a Strategic Environmental Assessment (SEA) of the potential for coastal waters to the north and west of Scotland to support wave and tidal stream power generation industries. The report identified a very wide sea area with potential for wave power generation, and smaller areas, mainly in firths and sounds and around headlands, where tidal currents were sufficient to generate tidal power.

Preparation for the further Scottish leasing round requires more precise identification of potential areas to be offered for lease than is provided by the SEA. Account needs to be taken of the technical and commercial potential as well as a range of environmental sensitivities and existing marine activities within the potential areas. Therefore, the initial step in preparing for the further Scottish leasing round has been to identify a set of proposed areas. The selection took account of a number of characteristics, namely that potential areas of interest should:

1. Have the necessary natural resources of wave and/or tidal stream power;
2. Be identified as having commercial potential;
3. Avoid sensitive areas and have limited impacts on existing marine uses;
4. Have regard to the requirements of national security;
5. Have access to the necessary infrastructure, or be able to access new infrastructure provided within the Saltire Prize timescale.

The proposed areas will now be subjected to a short consultation with industry and other stakeholders before a final selection is made. The Scottish Government encourages industry and stakeholders to restrict comments to the proposed areas, but if there are any additional areas that they feel could accommodate development within the Saltire Prize requirements, they can bring these to the attention of Scottish Government. Due to the waters of the Pentland Firth and Orkney being the focus of an existing leasing round, they will not be included in this round.

Developers' Interest

In 2009 the Scottish Government and the Scottish Renewables Forum undertook a survey of industry to gain an understanding of development potential. The survey built upon the marine renewables SEA and developers were invited to identify broad areas that were of potential interest to them and to indicate the approximate timescale for developments. The outcome of the survey demonstrated widespread interest in commercial developments for both wave and tidal technologies. Responses from developers during the survey indicate that areas proposed for the further Scottish leasing round are likely to be attractive for development. However, the number and areas of interest are large and further refinement is necessary prior to the leasing round.

Environmental Sensitivities

It is Scottish Government policy that renewable developments have to be sustainable and that due regard is given to environmental sensitivities and conservation interests. The ambitious timescale of the Saltire Prize requires more stringent criteria to be applied than would usually be set in lease area selection. In this case, selection of the proposed areas has sought to avoid all environmentally sensitive areas (such as Natura sites) thus reducing the need for developers to carry out extensive time-intensive monitoring and assessment of potential areas for development purposes.

To select the proposed areas, Marine Scotland used The Crown Estate's Marine Resource System (MaRS) to develop a spatial representation of the relative strength of constraints applying to different areas of the sea. A wide range of constraints were taken into account. Some areas (termed exclusions) such as Natura sites and International Maritime Organisation (IMO) routes, and areas leased for future offshore wind farm developments were treated as being unavailable for the further Scottish wave and tidal leasing round, while others (termed restrictions) were treated as partial constraints.

Managing the Needs of Different Users of the Marine Environment

On the basis of the modelled constraints, Marine Scotland and The Crown Estate have developed a map of proposed areas for wave and tidal development in the further Scottish leasing round. This will form the basis for the preparation of more detailed locational guidance for potential developers (Figure 1). The boundaries of the areas are not precisely defined, as the suitability for development varies with the type of devices to be deployed. Feedback on the suitability of these areas for marine renewable development from developers, regulators, other interested parties and planning authorities is invited.

Infrastructure Required to Support Development

A significant element in the technical assessment of potential development areas is the assessment of the availability of the necessary supporting infrastructure. Scottish Enterprise and Highlands and Islands Enterprise have recently published a National Renewables Infrastructure Plan, which includes the need for ports and harbours with facilities for the manufacture, construction and maintenance of renewables devices, and capacity to accommodate specialised renewables vessels. Road access for maintenance and support vehicles is also an important issue for remote locations around Scotland.

Local grid connection points for all of the identified development areas (Figure 1) currently fall within the common geographic licence area of Scottish Hydro Electric Power Distribution (SHEPD) and Scottish Hydro Electric Transmission Ltd (SHETL). SHETL and SHEPD have advised that under current arrangements, and with existing assets, there is no immediately available transmission capacity for new power generation in any of the potential Saltire Prize leasing round development areas. The ability therefore to accommodate new generation will be contingent on reinforcements to the local terrestrial grid to reach back to the main transmission network, and in the meantime the scope for further deployment of innovative grid management technologies is under investigation. SHETL has already timetabled planned reinforcements to the grid in some of the potential Saltire Prize areas within the timescale of the Prize. To the extent that subsea grid cables are required to link offshore devices to the terrestrial grid, and if they are 132 kilovolts or higher, their provision will fall under the new Offshore Transmission Owner (OFTO) process which will be administered by the GB regulator Ofgem.

As this additional Saltire Prize leasing round is not limited to the areas identified in Figure 1, Scotland's other grid owner, Scottish Power Transmission Ltd, has advised that, “within its geographical area of responsibility (South East/West Scotland) developments can always be accommodated onto the network, although some developments may require incremental investment and time to establish the necessary infrastructure."

The Requirements of National Security

The modelling described above was able to take account of security of energy supply through applying protection to areas leased for oil and gas developments, pipelines, etc., and areas leased for future offshore wind power developments under The Crown Estate's Round 3 and current Scottish Territorial Waters round of offshore wind development. However, very large areas of coastal waters are used for military exercises, while other areas are routinely used for testing of munitions and other equipment. These activities will need to be taken into account when making the final selection of areas.

Next Steps

The timetable of the Saltire Prize is challenging, and all aspects of site selection, leasing, consenting, construction, deployment and maintenance will need to be carried out responsibly, efficiently and effectively. The competition guidelines (found at http://www.saltireprize.com) summarise the main steps in the timeline. In order to enable the leasing of suitable areas, Regional Locational Guidance will be developed and formally consulted on during the summer of 2010.

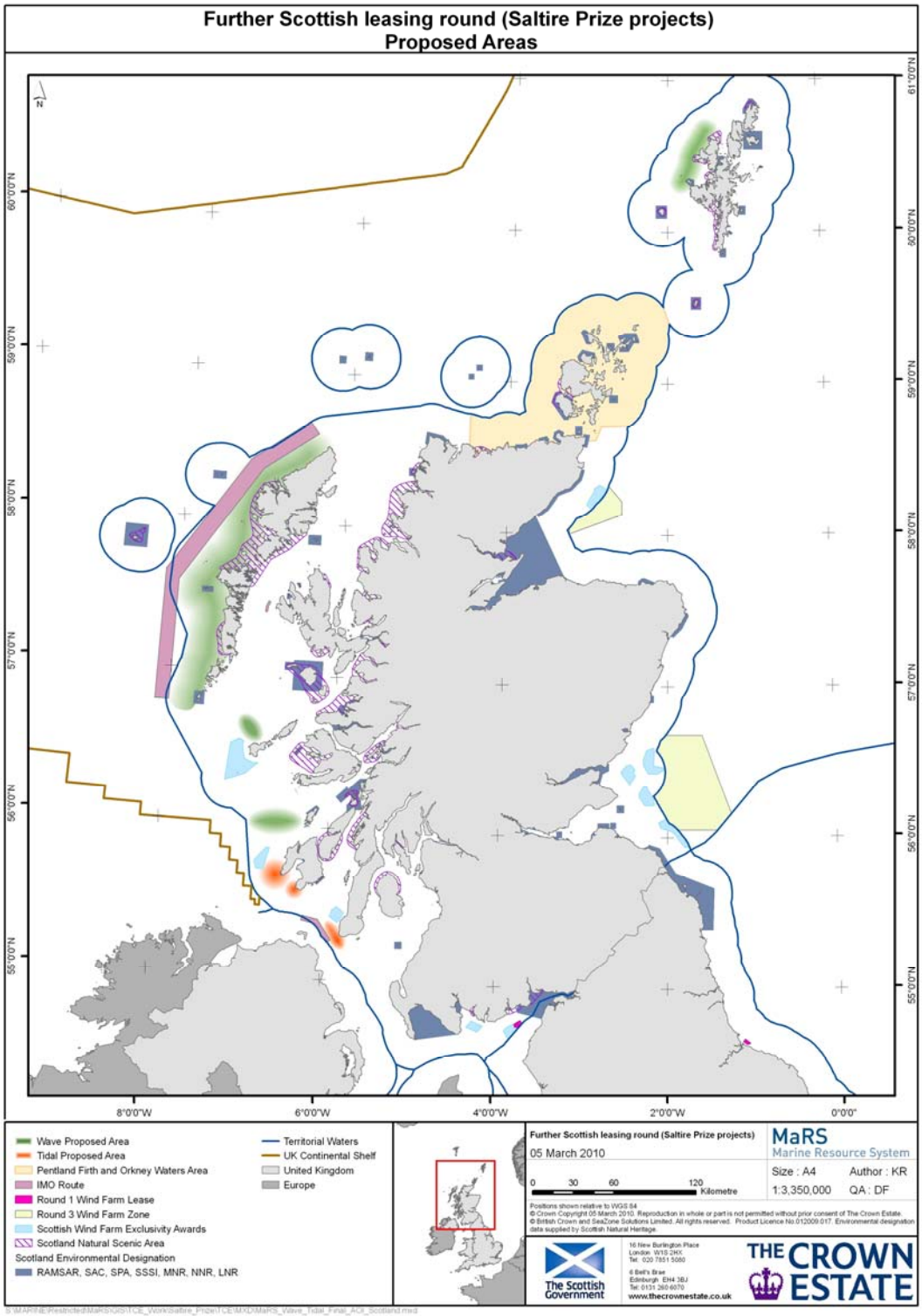

Figure 1: Map showing areas selected for further consideration for marine renewables development, including the west coast of Shetland, west coast of Lewis, north of Tiree and areas around the Mull of Kintyre.

1. Background

The purpose of the Saltire Prize is to stimulate innovation that will lead to delivery of commercial scale wave or tidal stream energy technology. Competitors for the Saltire Prize, of £10 million, must demonstrate commercially viable wave and/or tidal energy technology in a site leased by The Crown Estate (TCE) in Scottish waters that achieves a minimum electrical output of 100 Giga-Watt hours (GWh) over a continuous 2 year period, ending no later than 30th June 2017 (the end of the Grand Challenge Period). The winner of the Saltire Prize will be the competitor who, after achieving the minimum output of 100 GWh, is judged to be the best commercially deployable project, based on an assessment of the total amount of electrical output achieved. In addition, all competitors will have to demonstrate environmental sustainability and operational safety through continuous compliance with all relevant legislation and appropriate procedures, as set out in the Saltire Prize Guidelines (www.saltireprize.com) during the Saltire Prize Period.

The further Scottish leasing round is being developed by TCE in collaboration with the Scottish Government. The initial step is to identify areas of resource (wave and tidal stream) which avoid sensitive areas and limit impacts on existing marine users. This approach is specific to the further Scottish leasing round. More stringent criteria have been applied than would usually be set in lease area selection in response to the ambitious timescale of the Saltire Prize.

1. Interpretation

Based on the above brief, we have applied the following:

1) information on areas presenting significant wave and tidal energy resource should be identified;
2) areas of particular recognised sensitivity should be identified and excluded from a list of potential development areas for the further Scottish leasing round;
3) the existing pattern and intensity of use of the sea should be taken into account within potential development areas so as to limit the impact of the wave and tidal developments on existing users and the environment.

2. Approach

The identification of potentially suitable development areas was seen as an exercise in the application of marine spatial planning tools. In particular, the exercise required the accumulation of a large amount of spatial information relating to the availability of wave and tidal stream power resource, and on current activities/uses (such as the locations of Special Areas of Conservation - SACs, shipping routes and fishing activity) that may interact with the exploitation of the resource.

The primary source of information on the availability of wave and tidal resource was the Scottish Government Strategic Environmental Assessment (SEA) for Scottish Marine Renewables, published in 2007. The location of resource identified in the SEA is summarised in Figure 2. In this exercise we further refined those areas identified by the SEA.

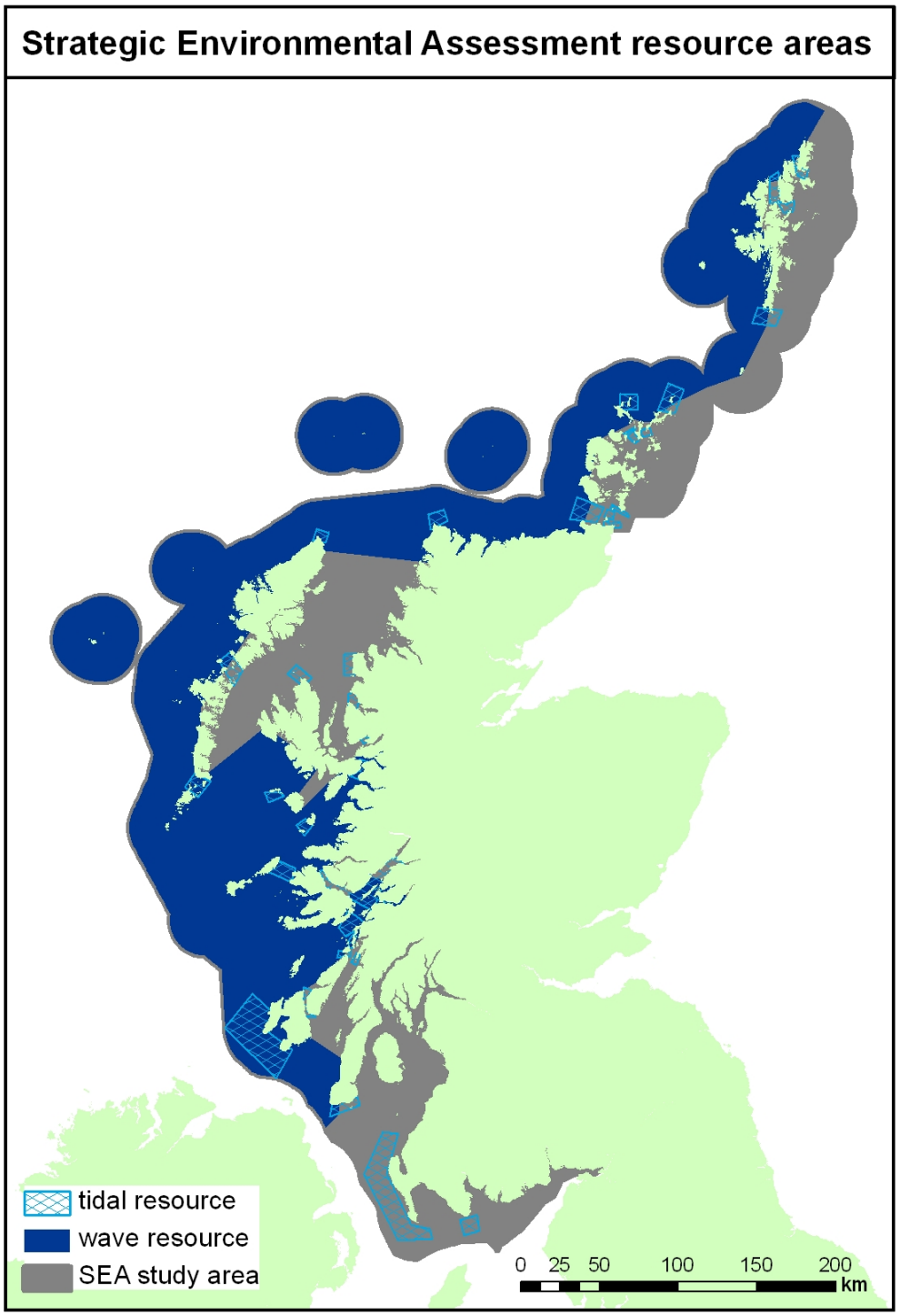

Figure 2: Areas of potential wave and tidal energy resource identified by the Scottish Government wet renewables Strategic Environmental Assessment in 2007.

Information on potential constraints was very diverse in character. In some cases, the information amounted to presence/absence of an activity (for example the locations of SACs). In other cases, the intensity of the activity was also important (for example the value of commercial fish landings). As well as being diverse, the volume of data was large. It was clear that data processing using Geographical Information System (GIS) software would be the most effective and efficient approach for the task.

Scottish Government (Marine Scotland - MS) has been in discussion with The Crown Estate (TCE) regarding sharing of geographically-based information to assist in meeting their various requirements for marine spatial planning. The main drivers for the Scottish Government are the provisions for marine spatial planning in the Marine (Scotland) Act (2010), and support for licensing, consenting and advisory work in various contexts. The main driver for TCE is the efficient and effective management of its marine estate (i.e. most of the seabed within the UK Exclusive Economic Zone). However, there is considerable similarity in the underlying data required by the two organisations. Differences in their objectives are reflected in the way the information is used.

In keeping with the partnership approach being used in the further Scottish leasing round, Marine Scotland - Science (MSS) staff worked with TCE staff in Autumn 2009 to undertake an initial identification of potential development areas that met the further Scottish leasing round requirement to “avoid sensitive areas and limit impacts on existing marine users”. This identification used the MaRS (Marine Resource System) GIS. MaRS has been developed by TCE as a decision support tool for marine spatial planning of activities such as aquaculture, carbon storage and offshore renewable energy. The tool uses TCE and third party GIS datasets to, firstly, identify potential areas for the technology in question and, secondly, to investigate the constraints on the proposed areas. The output is a series of maps of potential locations colour-coded by the level of constraint acting within that location.

In this exercise, MSS applied its own policies to the way data were used in MaRS. MaRS categorises data into a number of sectors (e.g. shipping, commercial fishing, recreation, environment, fish spawning and nursery grounds) reflecting the importance of different areas to a range of existing activities and the environment. Within each sector, some of the data layers were defined as exclusions to development while others are defined as restrictions. MSS was responsible for defining those areas in which development was not recommended (termed exclusions). MSS also controlled the weightings applied to the restriction data layers within each sector. The final stage of the modelling process was to combine the restriction data layers within each sector with those areas that had been excluded. MSS was able to alter the “character” of these combined models by adjusting the weightings of the restriction sectors relative to each other. For example, the commercial sectors (shipping, fishing, etc.) could be weighted more strongly than the environmental sectors (fish spawning grounds, seabird abundance, etc) or vice versa.

The MaRS outputs were examined to identify those locations that contained sufficient tidal/wave resource but exhibited a low level of constraint. It should be noted that although

we have tried to select areas of low constraint, there will still be some constraints in the selected areas and developers will still be required to follow usual procedures to obtain the necessary consents and licences.

3. Methods

4.1 Outline

Three types of models were produced on the path to the final MaRS model. These were:

a) Exclusion models: Sensitive areas (in the context of the further Scottish leasing round) were identified and were excluded from the areas potentially available for development.

b) Restriction models: Locations of other commercial activities or environmental sensitivities were mapped and used as constraints that reduced the suitability of areas for development. They were subsequently combined in a series of restriction models.

c) Normalised models: The process of normalising combines the exclusion model with each sector-based restriction model. It also rescales scores to make the ranges consistent between all models and thereby facilitates weighting between sectors.

In 2009, the Scottish Government and Scottish Renewables Forum invited potential wave and tidal energy project developers to indicate areas of Scottish waters that were potentially of interest to them as development sites in the next 10 years (Figure 3). These were combined and converted into a single GIS layer that could be overlain onto the outputs of the normalised models. These areas were all within 30 miles of the coast, and therefore attention in the normalised models was concentrated on the area within 30 miles of the national baseline. This included the area covered by the wave and tidal power SEA, and is probably as large an area as is being seriously considered by developers at this time. Areas further from the coast are generally less attractive being in deeper water, more difficult to develop and requiring more costly linkages to the grid.

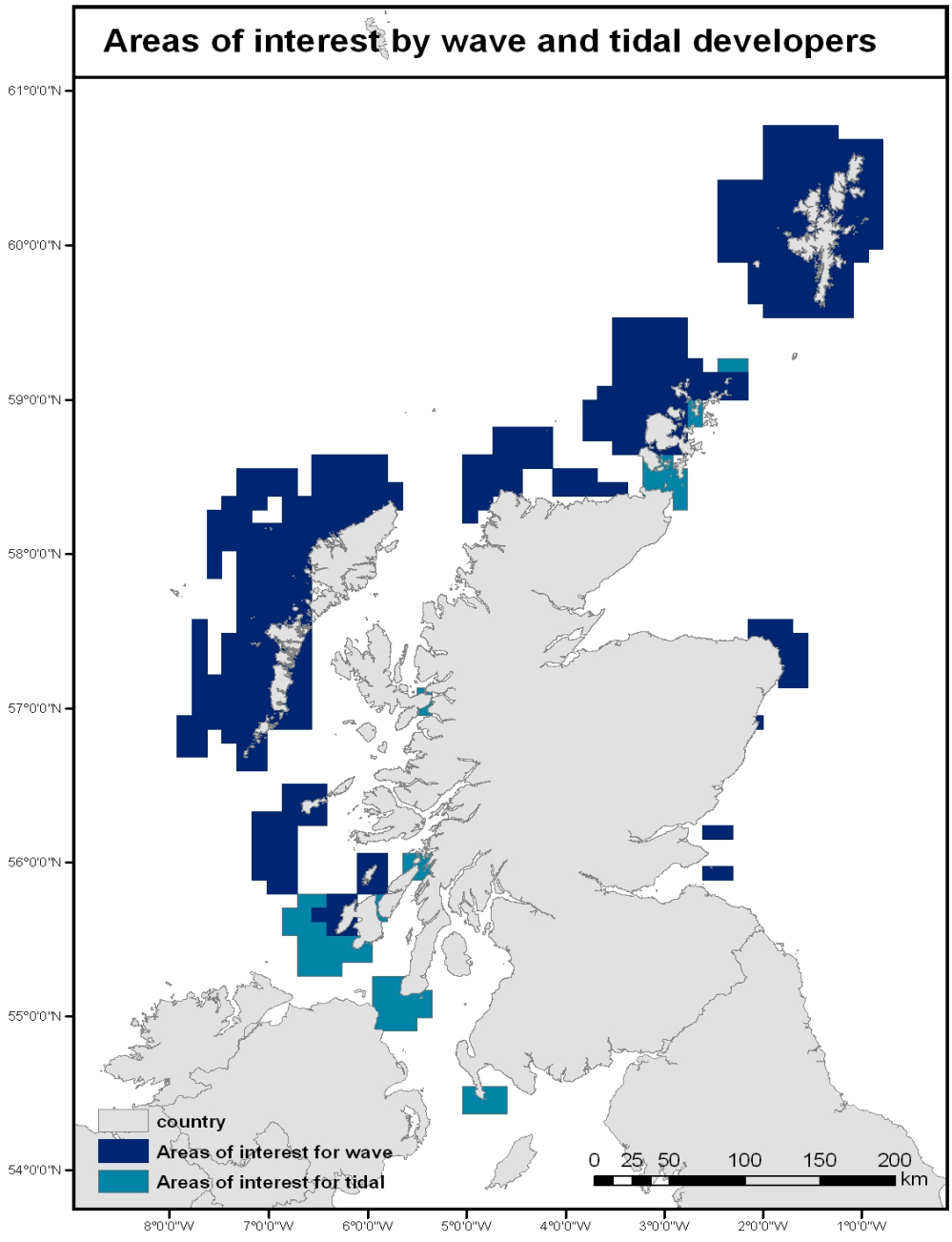

Figure 3: Areas of developer interest for wave and tidal stream energy generation.

The Crown Estate had also prepared a separate initial technical analysis of the suitability of areas for development, taking into account the availability of wave and tidal stream resource and other factors including water depth and distance from shore.

The MaRS tool was used to combine the output from the three models (exclusion, restriction and normalised), the technical feasibility assessment and the developer interest areas, in order to identify areas with greatest potential for inclusion in the further Scottish leasing round.

4.2 GIS Data Models

A wide range of data layers were available for the analysis and were imported into TCE MaRS GIS. Some information could not be captured in the time available for the exercise and the importance of this is discussed in section 6.

In general, the data layers (listed in Annex I) were taken as representing constraints on the suitability of areas for wave and tidal power leasing in the further Scottish leasing round. Some of the data are publically available, whereas others were used under appropriate licences held by TCE and/or MSS. Some had been generated by TCE or MSS in-house. The most up to date and comprehensive data were used where possible. However, as the data came from a range of sources, the quality and spatial resolution of the data does vary.

The data layers referred to different aspects of a wide range of current “uses” of the sea, including areas with various environmental designations, the value of commercial fisheries landings, areas used as shipping routes, etc. The data layers used as constraints are listed in Table 1. They were classified into 8 thematic categories or sectors, such as environment, commercial fishing, shipping etc. Some of the layers were used as exclusions (i.e. areas considered to be particularly sensitive), while others were used in restriction models, as described in 3 and 4.1 above.

TABLE 1

The data layers used in the exercise, classified into 8 sectors, and treated as either exclusions or restrictions to development.

Category number	Sector	Exclusion layers	Restriction layers	Buffer (m)
1	Environment	Special Areas of Conservation (SACs)		
		Special Protection Areas (SPAs)		
		Offshore SACs		
		SSSIs		
		RAMSAR sites		
		World Heritage Sites		
		National Scenic Areas (NSAs)		
		RSPB reserves		
			Seabirds at sea atlas	
			Cetacean atlas	
2	Shipping	International Maritime Organisation (IMO) routes		
			All shipping routes	
			Harbour administration areas	10
3	Fish spawning and nursery grounds		Fish spawning and nursery	
4	Commercial fishing		Catch value from COWRIE which combines Vessel Monitoring System (VMS) data and landings	
5	Cultural heritage	Protected wrecks		
		Other wrecks		100
		Schedule of Ancient Monuments (SAMS)		500
6	Commercial	Fish or shellfish farms pending		250
		Current fish or shellfish farms		250
		Dumps		
		Wave test leases		250
		Tidal test leases		250
		Wave leases		250
		Tidal leases		250
		Wind farms		250
		Round 3 Wind farms		250
		Oil and gas licenses		250
		Active wells		100
		Active pipelines		250
		Active cable		250
		Cables under construction		250
		Wind farm cables		250
		Interconnectors		250
7	Recreation		Marinas & sailing clubs	100
			Sailing areas	
			Racing routes	
			Cruising routes	100
			Bathing beaches	500
8	MOD	MOD munitions dumps		500

4.2.1 Exclusion Model

The exclusion model brings together those data layers which describe areas that are particularly sensitive and should be considered unavailable for leasing in the context of the further Scottish leasing round. The exclusion layers included areas with environmental designations (SACs, Special Protected Areas - SPAs, National Scenic Areas - NSAs, etc), and a range of current uses considered at this time to be incompatible with renewable energy development, such as protected wrecks, aquaculture leases, munitions dumps and some other commercial and cultural uses etc., as shown in Table 1.

We consider this to be a strong approach to the definition of exclusion areas, and to be in keeping with the brief for the task. However, it is possible that future experience may indicate that some forms of wave or tidal energy development may be compatible with the designations of some of these areas, as demonstrated by other offshore regulated activities. The strategy adopted interpreted these areas as sufficiently sensitive to exclude them from the further Scottish leasing round. A more detailed analysis than was possible in the available time-scale would be required to explore the details of any opportunity for development in these areas. For example, in the case of the Natura 2000 sites (SACs & SPAs), the level of evidence required to prove that there would be no significant effect on the qualifying features of the site may be difficult to accomplish within the time-frame of the Saltire Prize. Another example is NSAs, which were also excluded, since whether a wave or tidal array might conflict with the management plan of the NSA would be dependent on the size, shape and location of the array, all of which are as yet unknown.

Current and prospective leased areas for activities such as renewable energy developments (e.g. offshore wind farms), or aquaculture, were excluded and surrounded by a buffer of 250 m. The International Maritime Organisation (IMO) shipping routes (in particular the tanker route to the west of the Western Isles) were excluded due to heavy shipping activity. Wrecks were excluded and were given a buffer of 100 m due to the data being available as points and not the shape of the wreck/monument.

The final exclusion models are given in Figures 4 to 6.

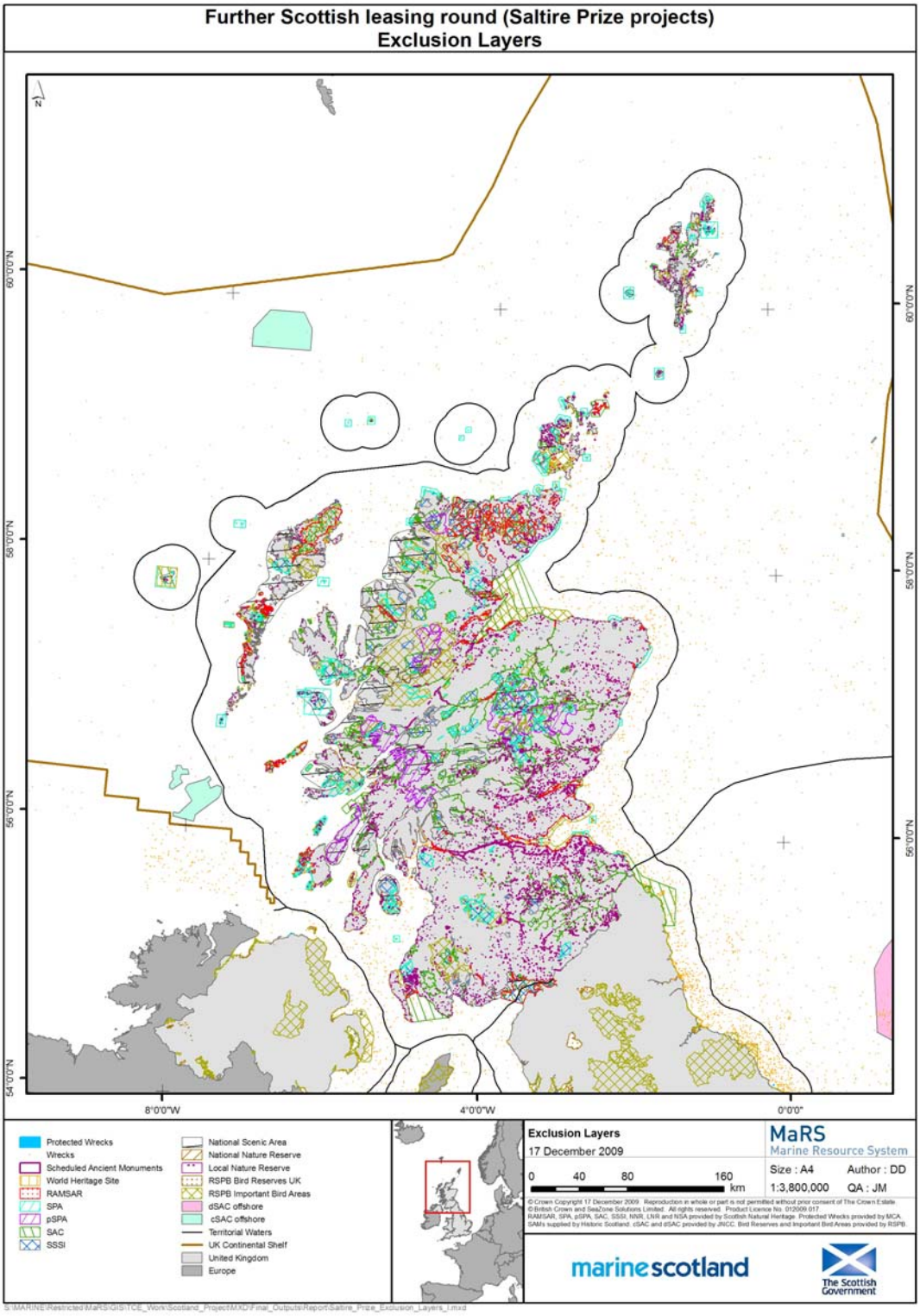

Figure 4: Environmental and cultural sites that were excluded from the full model and were not considered for this wave and tidal leasing round.

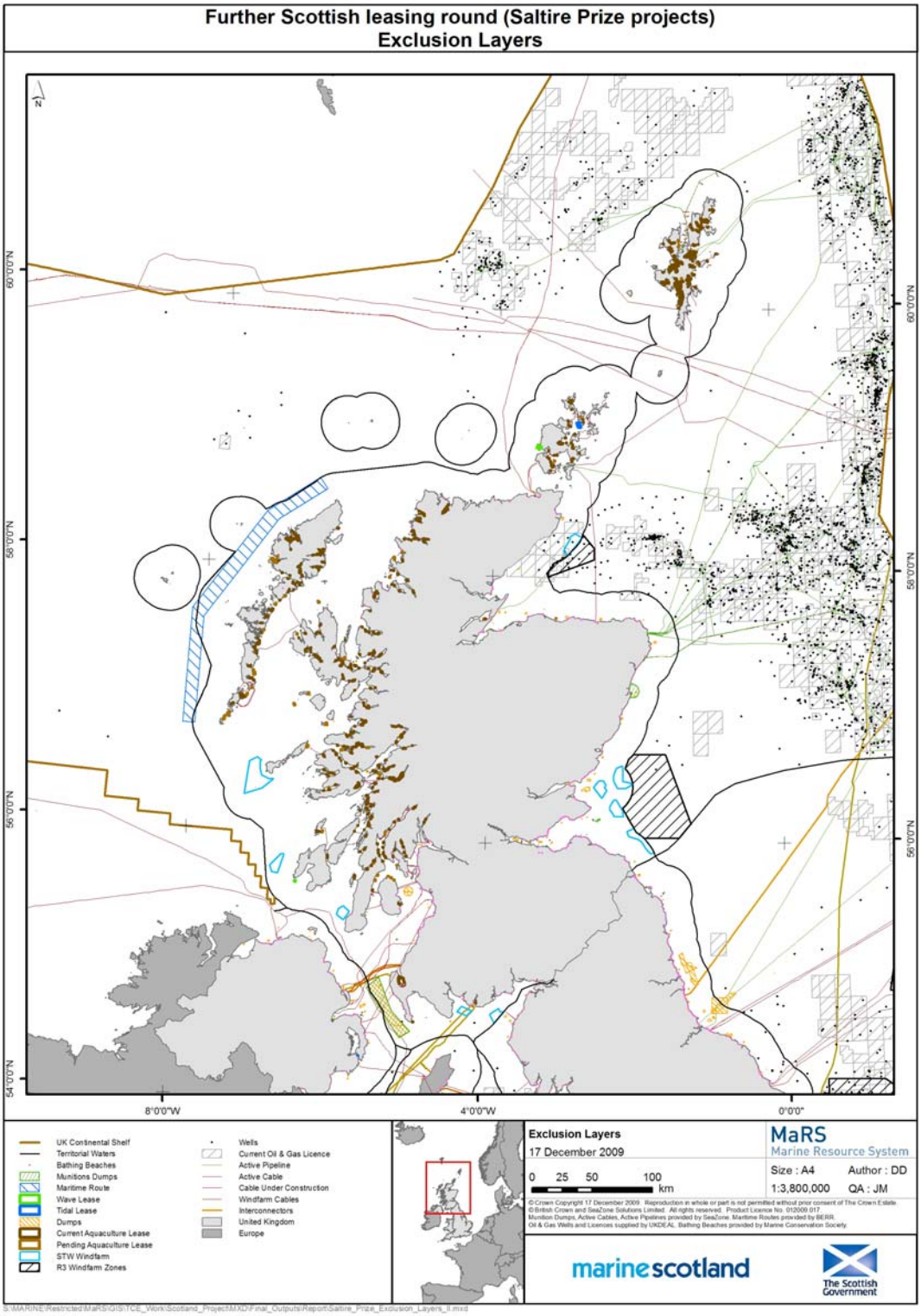

Figure 5: Military and commercial sites that were excluded from the full model and were not considered for this wave and tidal leasing round.

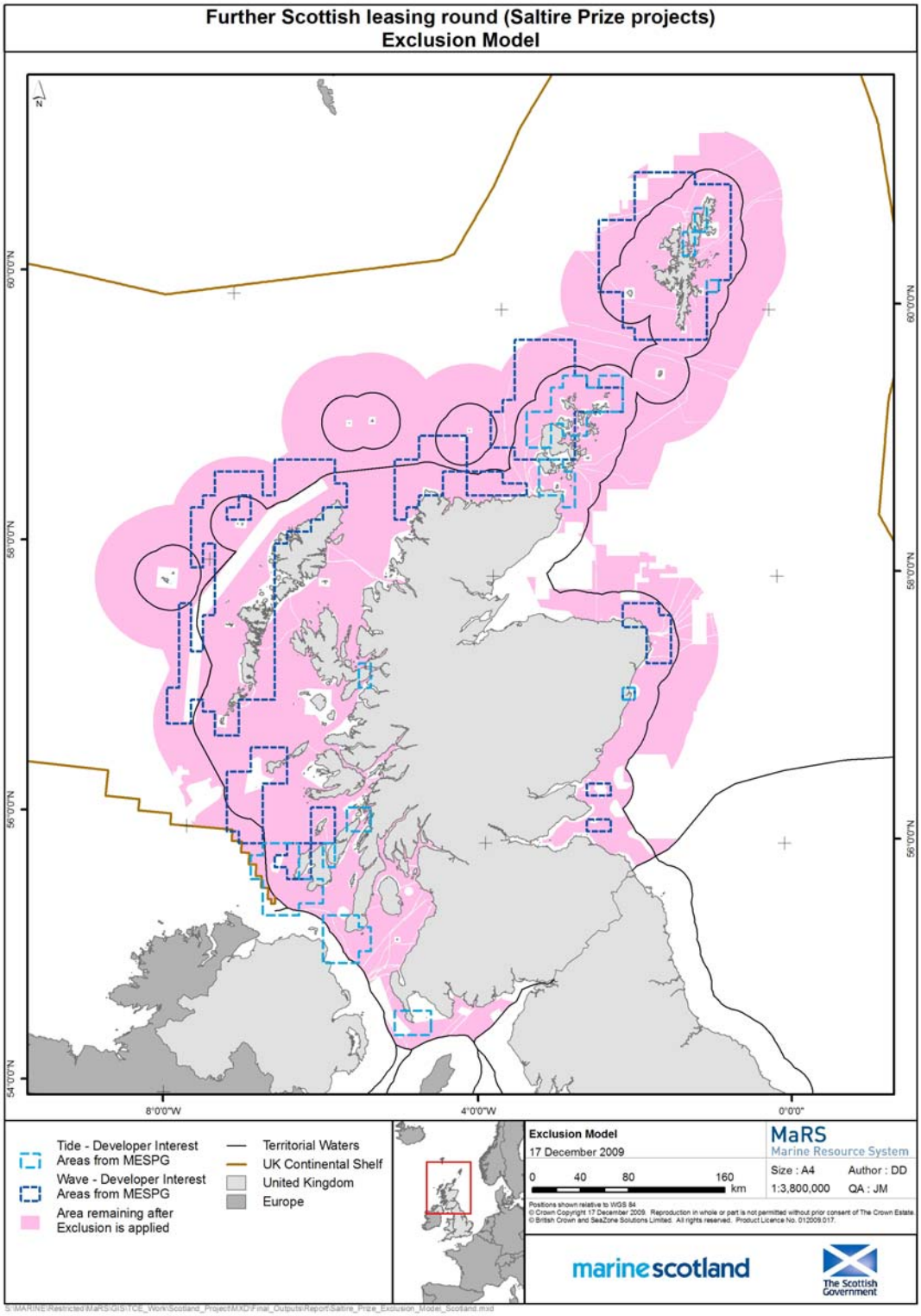

Figure 6: The output from the full exclusion model. Areas to be excluded are coloured white. Remaining areas, i.e. those considered potentially eligible for leasing, are coloured pink.

4.2.2 Restriction Models

The data layers used in the restriction models, i.e. treated as giving graduated degrees of constraint on development according to the nature and intensity of the activity, are listed in Table 1. The layers were categorised into a series of 5 sectors containing restriction layers (Table 1) and a separate restriction model was developed for each:

- environment
- recreation
- shipping
- commercial fishing
- fish spawning and nursery areas

Within each sectoral restriction model, data layers were weighted according to subjective judgements of the relative importance of each layer in relation to other layers within the sector. For example, the environment restriction model was comprised of datasets of cetaceans and seabirds at sea. It was decided that the cetaceans should receive a higher weighting (100) than seabirds (90) because all cetaceans in European waters are listed as European Protected Species under the EC Habitats Directive (1992) and are thus protected throughout their environment. However, most seabirds only receive protection while at their breeding site in those sites that have received SPA designation and SPAs have already been excluded. Details of the weighting of the layers within each restriction model are given in Annex II.

In each data layer, the intensity of the activity in each map cell (e.g. numbers of sightings of seabirds per cell, or number of ships per day per cell) was expressed numerically and visualised on the ArcMap GIS software used by MaRS. The “classify” function on ArcMap was used to create 10 classes based on the spread of the data. For all data layers, with the exception of commercial fishing, the function “natural breaks” was used. “Natural breaks” provides more class intervals where there is a higher density of values. This is often at the lower end of the dataset but could focus the interval around any part of the data that is dense. The commercial fishing data layer was classified using the “quantile” function, which is a more extreme version of natural breaks and was able to emphasise the value of the smaller fishing vessels.

These class intervals are then scored so that the sum of the total score is equal to the weight given to that data layer. The product of the weight and the score is calculated for each layer within a sector. The level of restriction on each cell is the sum of all the weights × scores of each layer. Because each layer within a sector has been weighted, the influence of an individual layer relative to others within the sector may vary.

4.2.3 Normalised Models

The purposes of the normalised models are two-fold;

a The normalised model runs the restriction model against the exclusion model within the same sector and excluded areas are discounted from the model. For example, the environment restriction model containing cetacean and seabird data was run against the environment exclusion model which comprised of designated areas. The restriction models that did not have exclusion models within the same sector, such as the commercial fishing restriction model, were normalised against all exclusions.

b The ranges, which were specific to each restriction model, were converted to values between 0 and 99 in order to make the models consistent with each other and to enable weighting between sectors in the subsequent full models.

The normalised models that were run for each sector (environment, recreation, shipping, commercial fishing and fish spawning and nursery areas) are given in Annex III and are illustrated in figures therein.

4.2.4 Full Models

A full model combines the exclusion models and all the normalised restriction models to produce a final output composed of 100 m^2 cells. Each normalised restriction model was weighted relative to each other and then scored. The intensity at any given location (in each 100 m^2 cell) is equal to the sum of the product of the weights and scores of all the normalised restriction models. The exclusions are eliminated altogether and locations with a highly weighted sector within them and/or a number of activities overlapping each other are expressed as being more constrained and less suitable for development at this time.

Since the influence (or importance) of a normalised restriction model for a sector is largely dependent on its weighting relative to other sectors, a number of scenarios were explored. In the initial scenario, all the sectors were weighted equally. One subsequent model weighted industrial activity as more important than environmental sectors (industry I). One model weighted environment as more important than industrial activity (environment). A final model, also with an industry bias, had a greater spread of weightings (i.e. there was a greater difference between the weight of the more highly ranked layer than the least, which increased the relative importance of industrial activities against other sectors).

TABLE 2

Relative influence (weights x scores) of each sector in each of four full model scenarios.

Sectors	Model name			
	Equal weighting	**Industry I**	**Industry II**	**Environment**
Shipping	100	200	300	100
Commercial fishing	100	200	300	100
Recreation	100	150	100	150
Fish spawning & nursery areas	100	100	200	200
Environment	100	100	200	200

5. Results and Interpretation

Four different model scenarios were used to investigate the consequences of the selection of different areas for development. The relative importance of industry versus environment/conservation interests were varied between the four models. One model emphasised minimisation of environmental interactions (Figures 7 - 10), two models emphasised minimisation of interactions with industrial activities (Figures 11 – 14, and 15 - 18) and one treated all sectors equally (Figures 19 - 22). In each of the figures the areas of interest, as expressed by wave and tidal project developers, are overlaid on each. Each cell is coloured by the level of constraints upon it, red depicting a high degree of constraint, and green low. Areas that have been excluded are shown in white.

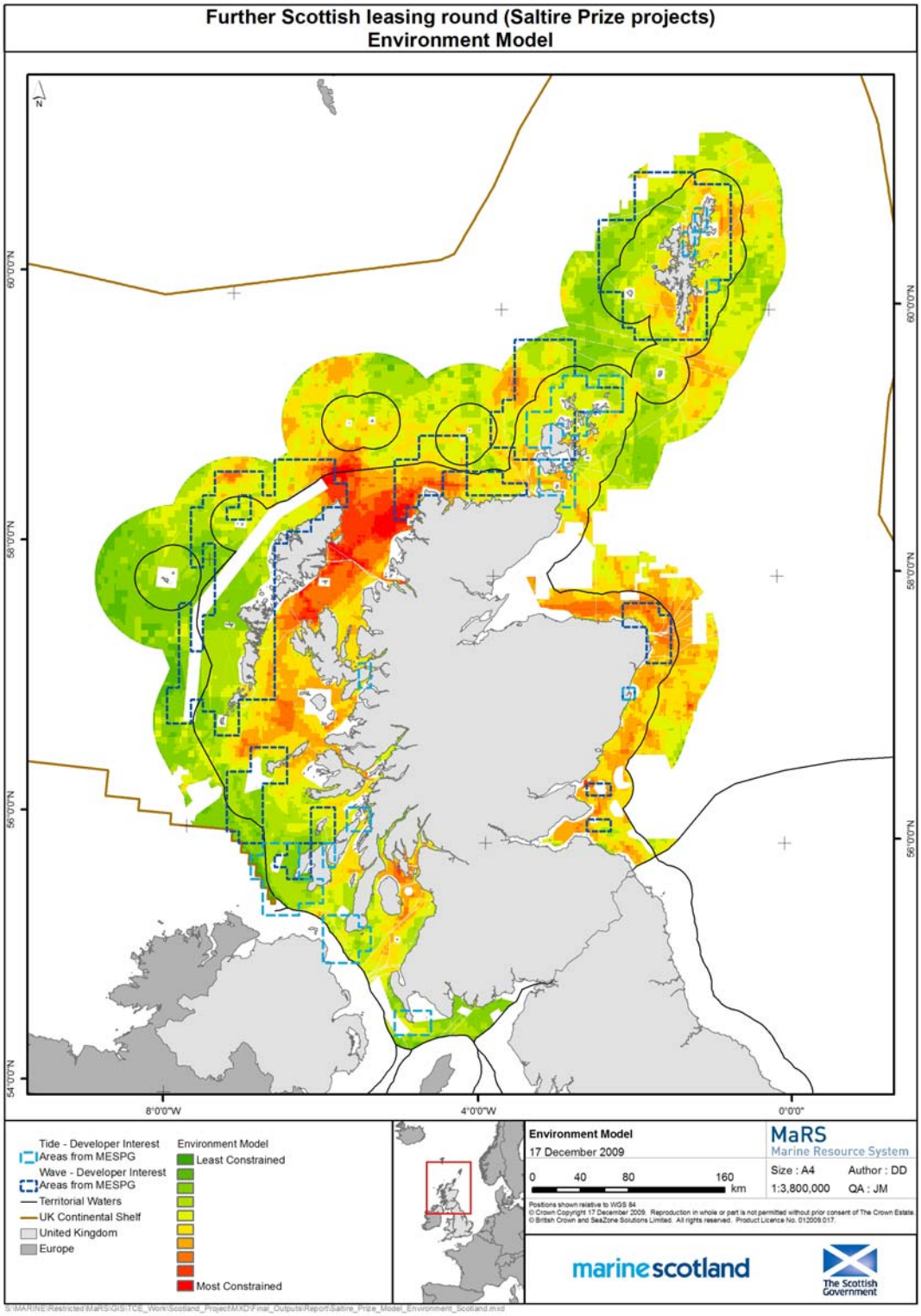

Figure 7: Full MaRS model for all of Scotland using the environment model weightings given in Table 2. Areas of developer interest for tidal stream and wave energy are overlain on the map and are outlined in turquoise and dark blue respectively. Cells coloured red exhibit the highest levels of constraint, green the least and exclusions white.

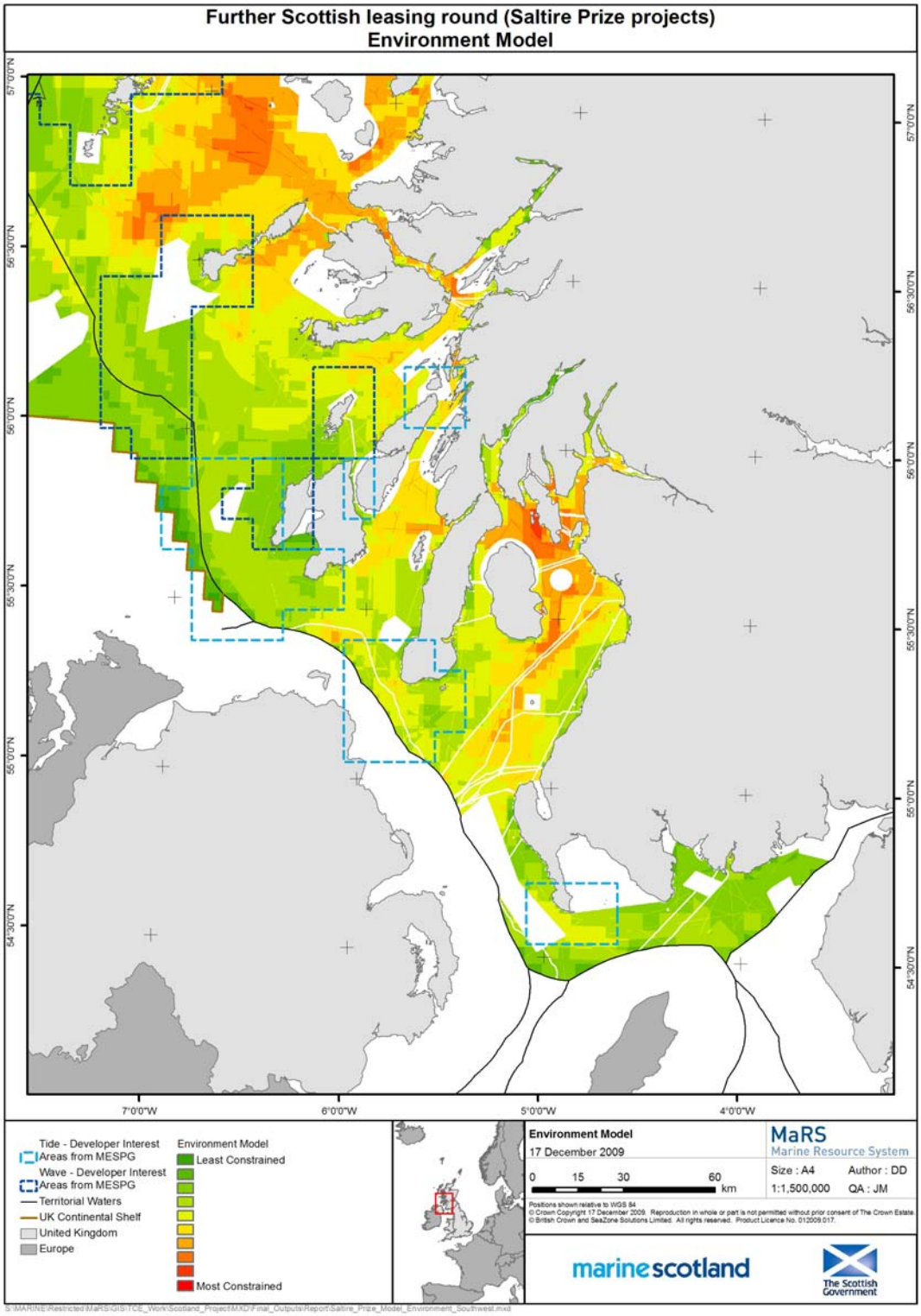

Figure 8: Full MaRS model for southwest Scotland using the environment model weightings given in Table 2. Areas of developer interest for tidal stream and wave energy are overlain on the map and are outlined in turquoise and dark blue respectively. Cells coloured red exhibit the highest levels of constraint, green the least and exclusions white.

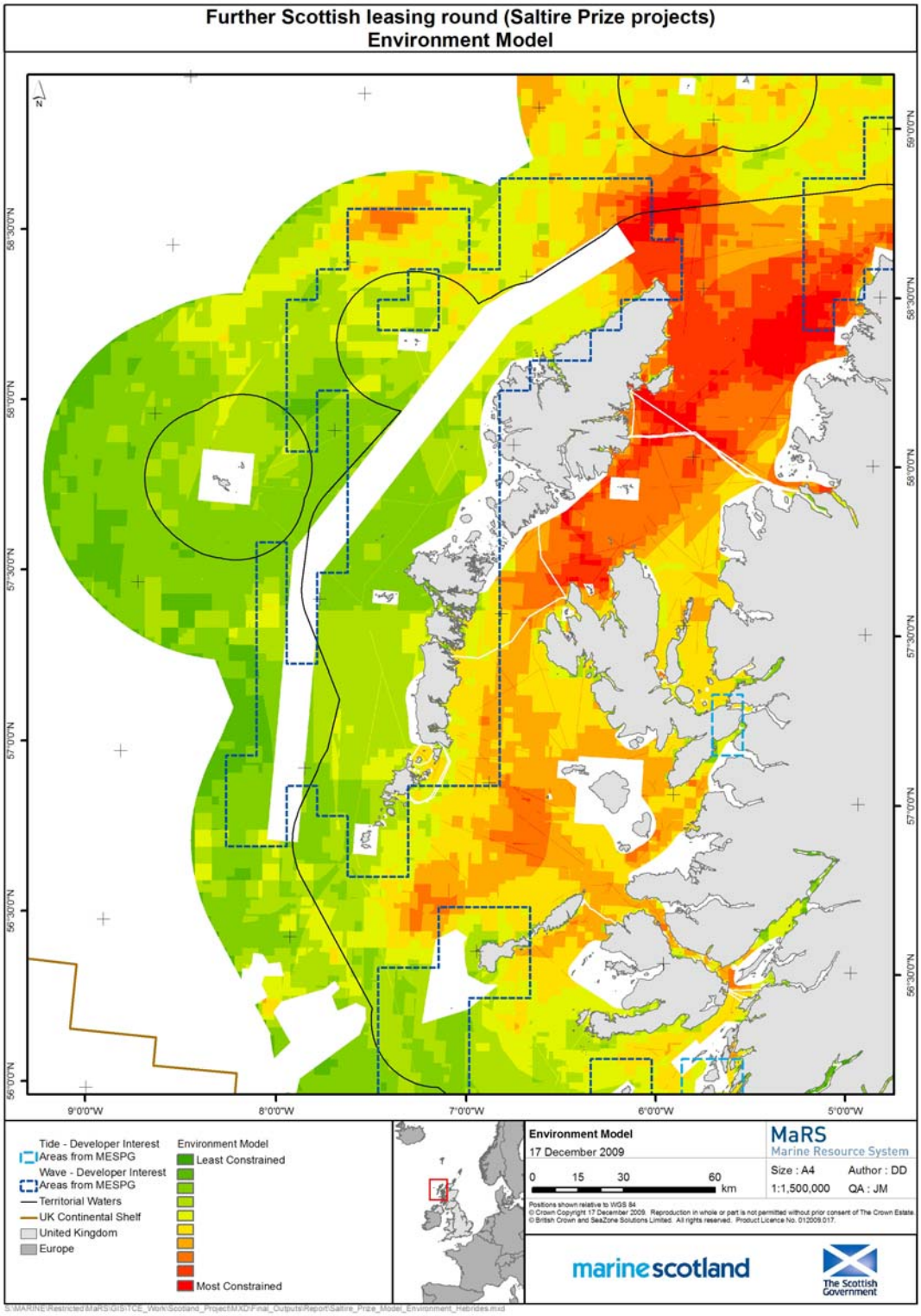

Figure 9: Full MaRS model for northwest Scotland using the environment model weightings given in Table 2. Areas of developer interest for tidal stream and wave energy are overlain on the map and are outlined in turquoise and dark blue respectively. Cells coloured red exhibit the highest levels of constraint, green the least and exclusions white.

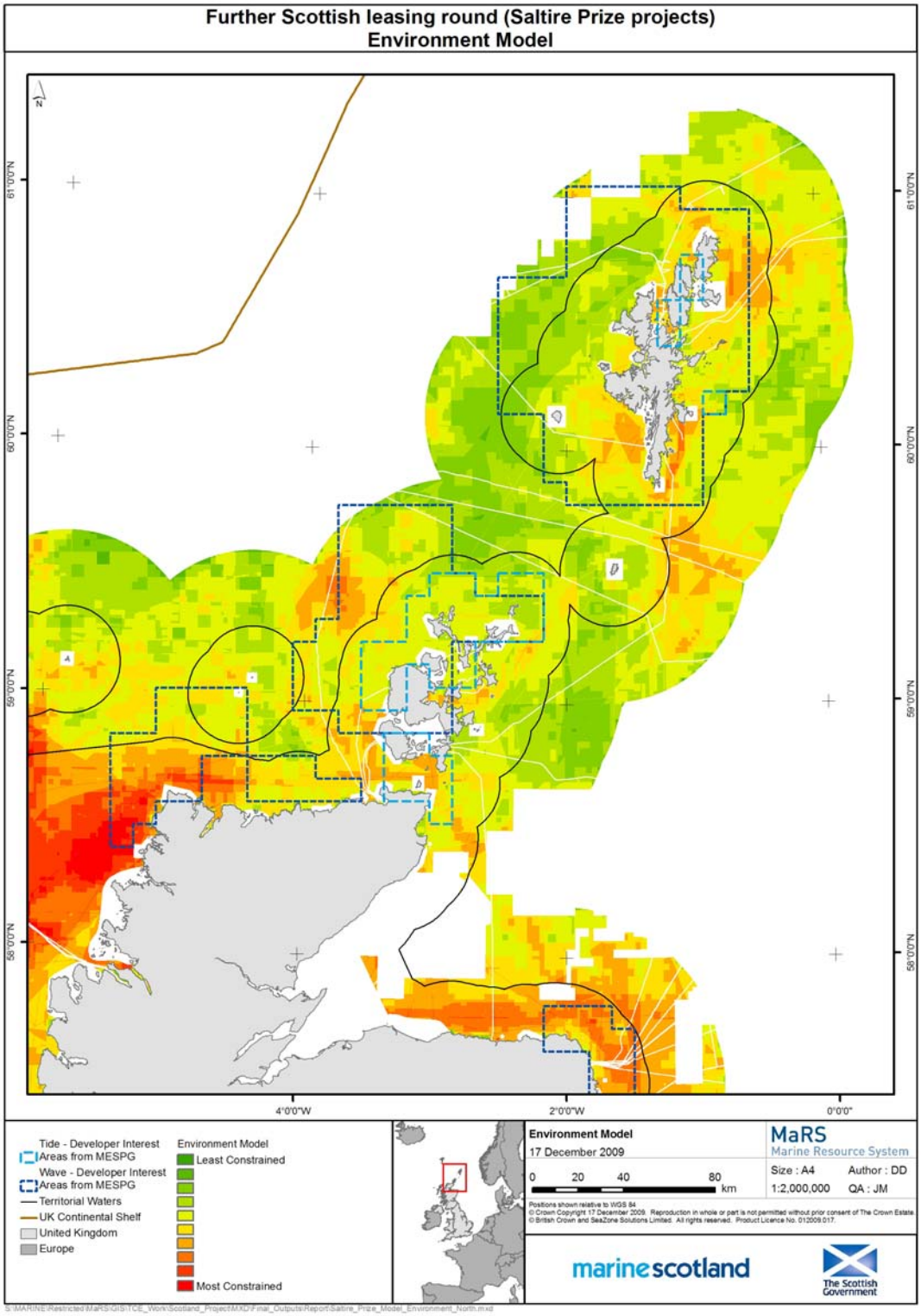

Figure 10: Full MaRS model for the north of Scotland using the environment model weightings given in Table 2. Areas of developer interest for tidal stream and wave energy are overlain on the map and are outlined in turquoise and dark blue respectively. Cells coloured red exhibit the highest levels of constraint, green the least and exclusions white.

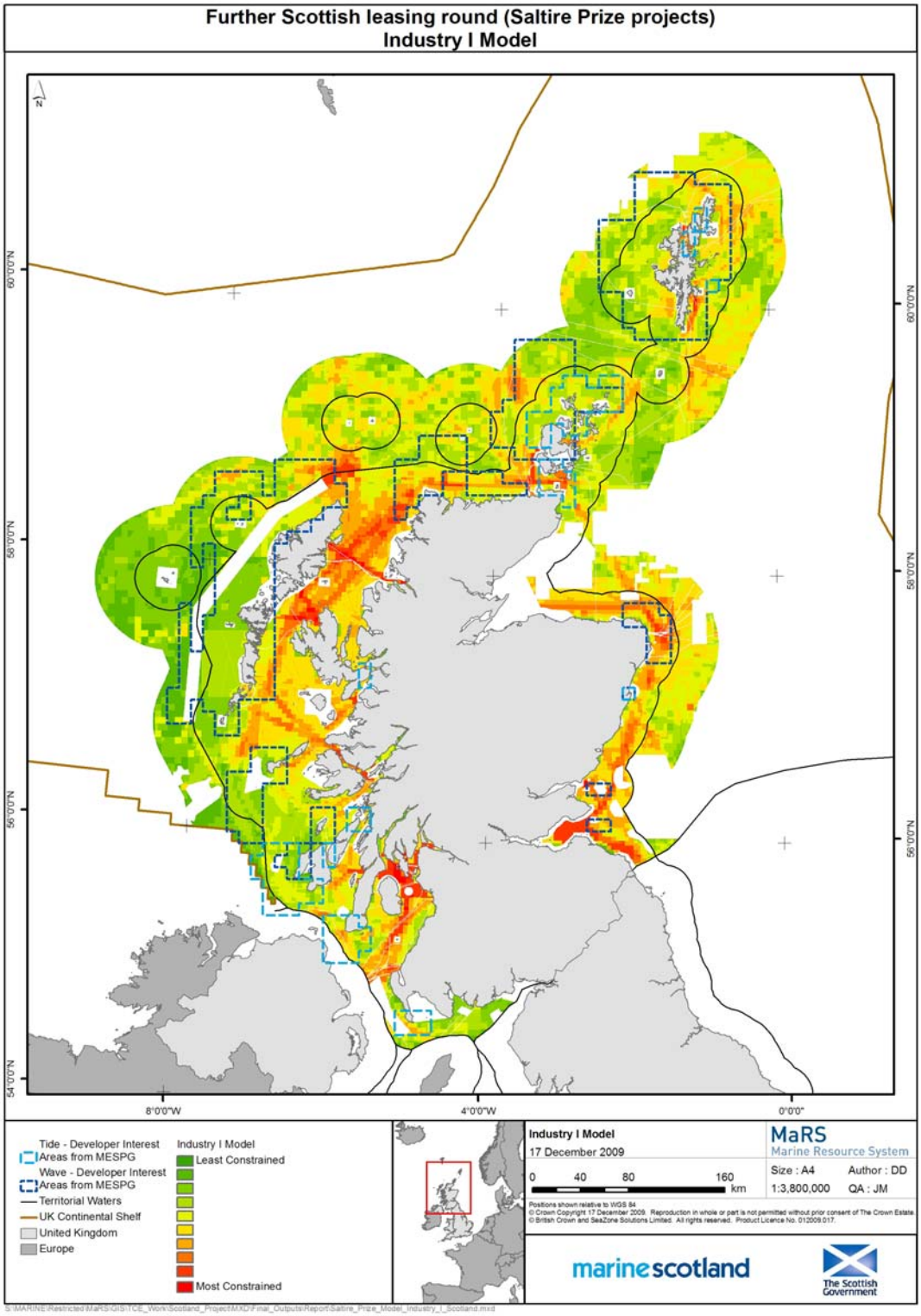

Figure 11: Full MaRS model for all of Scotland using the industry I model weightings given in Table 2. Areas of developer interest for tidal stream and wave energy are overlain on the map and are outlined in turquoise and dark blue respectively. Cells coloured red exhibit the highest levels of constraint, green the least and exclusions white.

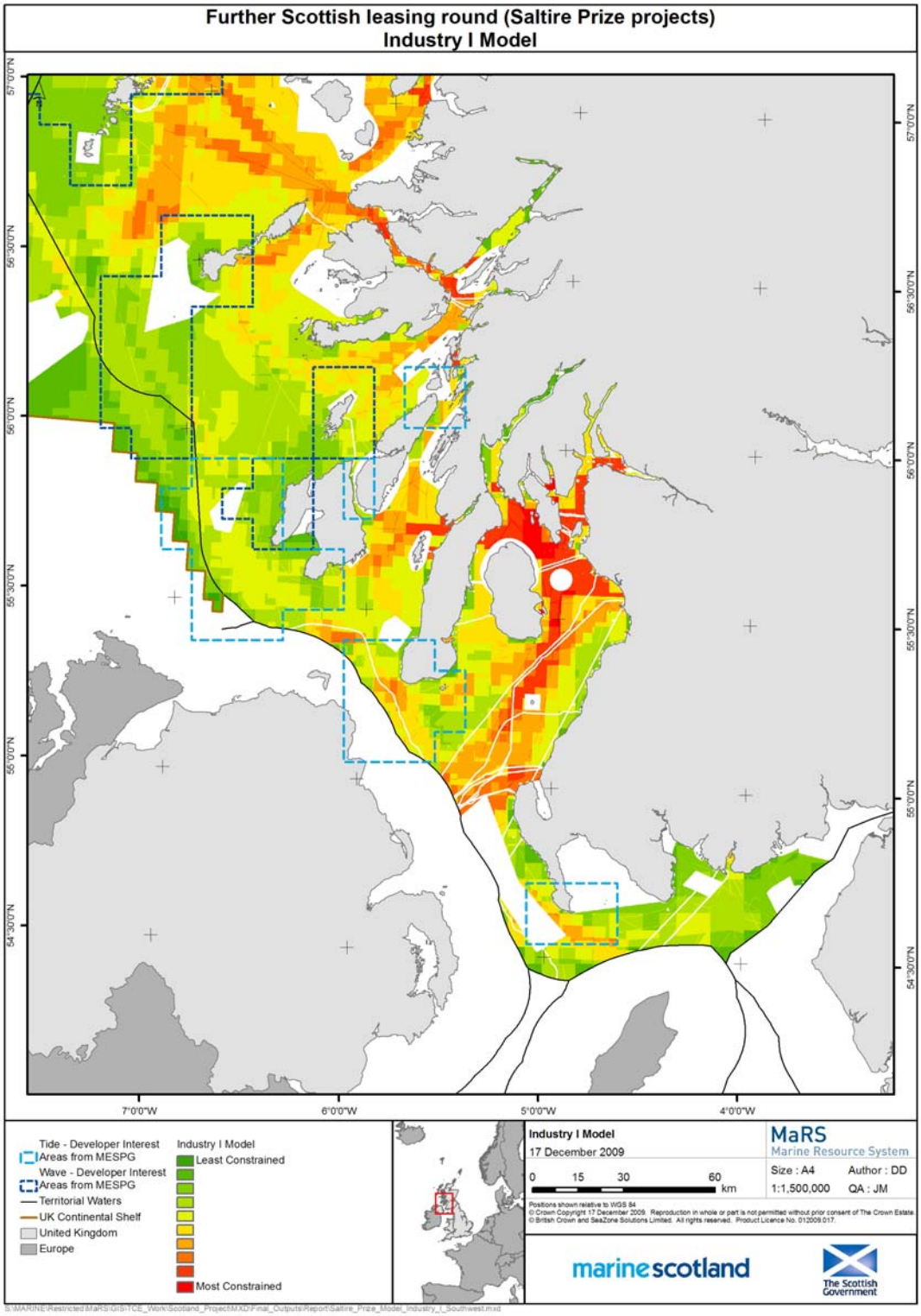

Figure 12: Full MaRS model for southwest Scotland using the industry I model weightings given in Table 2. Areas of developer interest for tidal stream and wave are overlain on the map and are outlined in turquoise and dark blue respectively. Cells coloured red exhibit the highest levels of constraint, green the least and exclusions white.

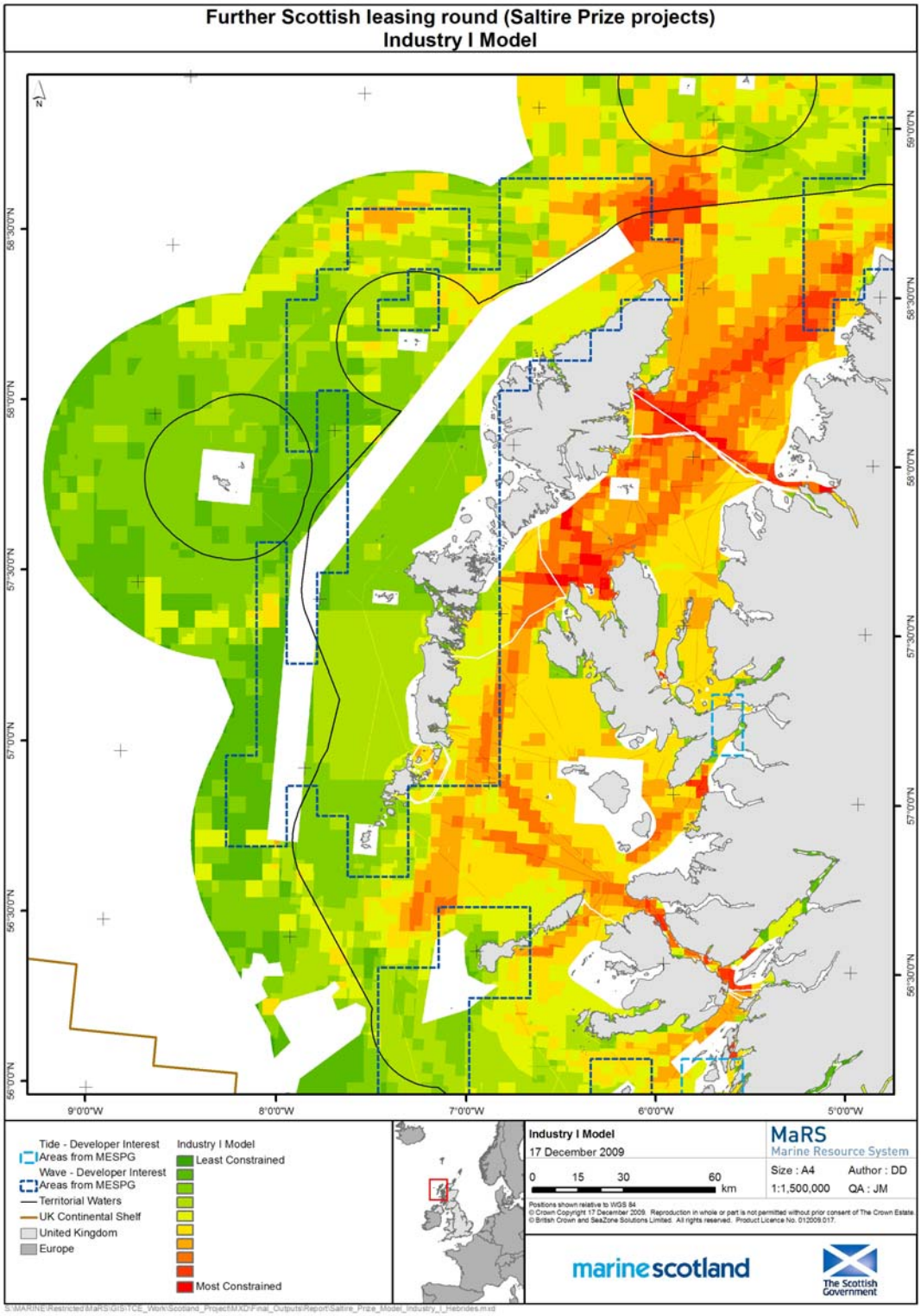

Figure 13: Full MaRS model for northwest Scotland using the industry I model weightings given in Table 2. Areas of developer interest for tidal stream and wave are overlain on the map and are outlined in turquoise and dark blue respectively. Cells coloured red exhibit the highest levels of constraint, green the least and exclusions white.

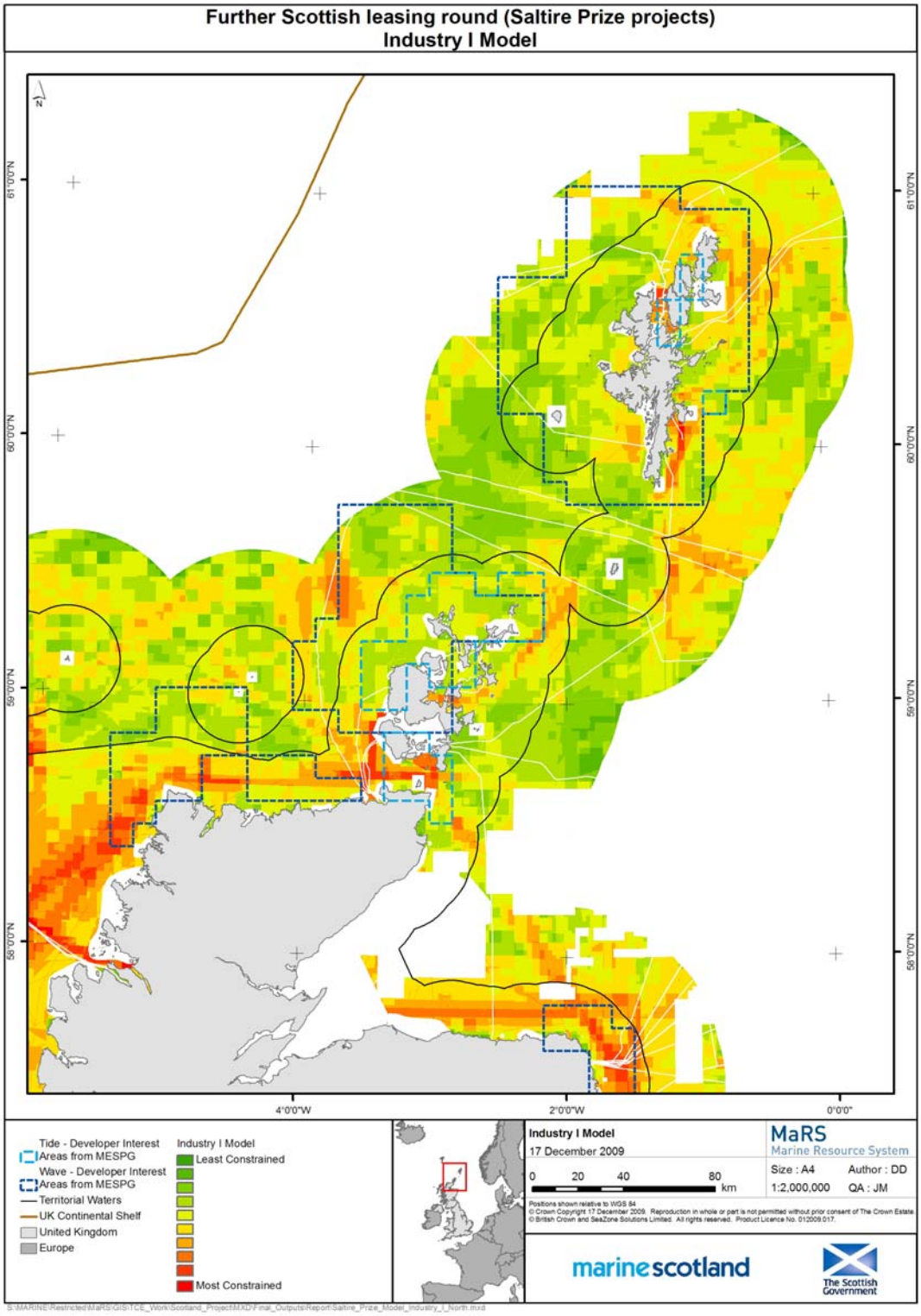

Figure 14: Full MaRS model for the north of Scotland using the industry I model weightings given in Table 2. Areas of developer interest for tidal stream and wave are overlain on the map and are outlined in turquoise and dark blue respectively. Cells coloured red exhibit the highest levels of constraint, green the least and exclusions white.

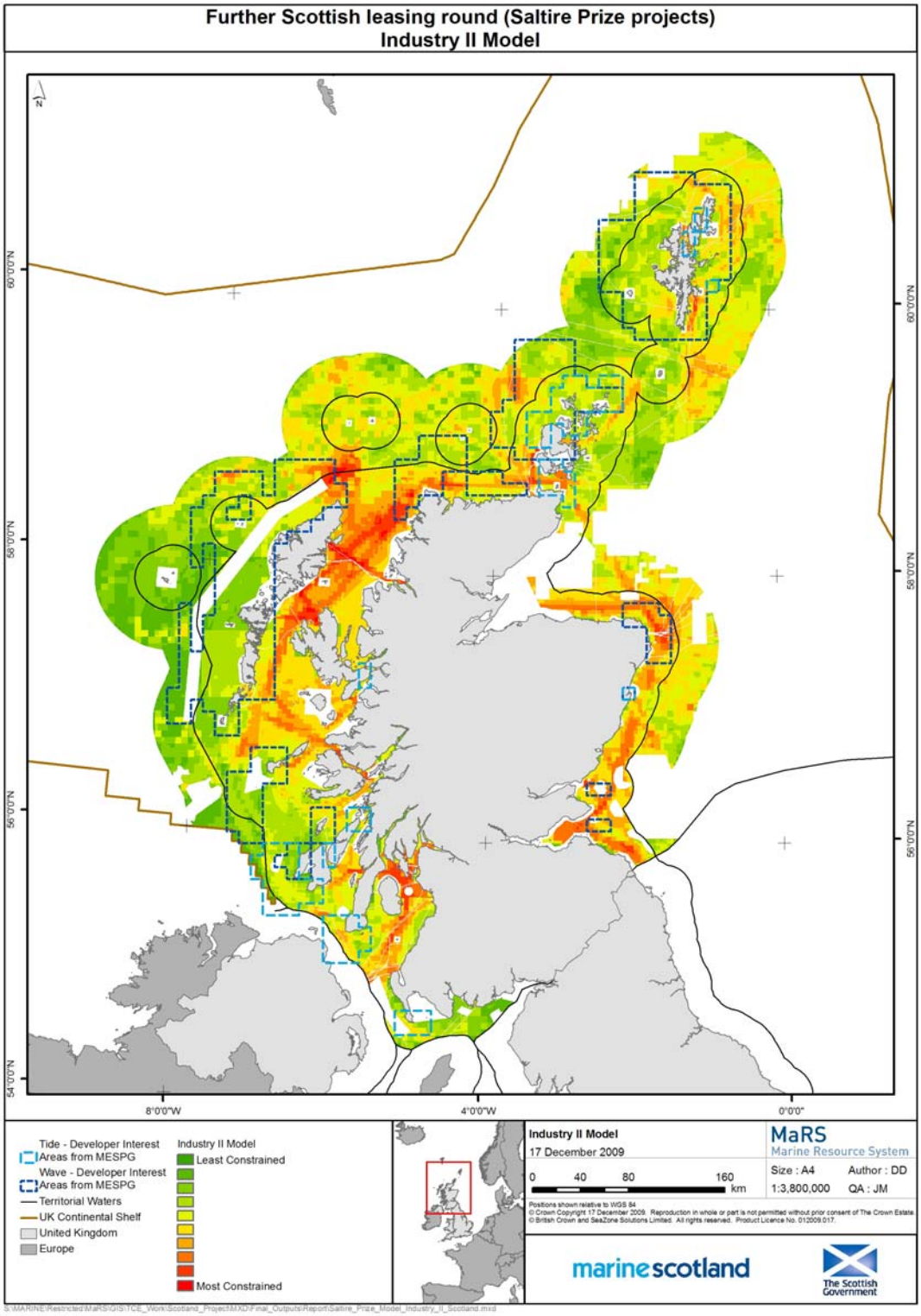

Figure 15: Full MaRS model for the whole of Scotland using the industry II model weightings given in Table 2. Areas of developer interest for tidal stream and wave are overlain on the map and are outlined in turquoise and dark blue respectively. Cells coloured red exhibit the highest levels of constraint, green the least and exclusions white.

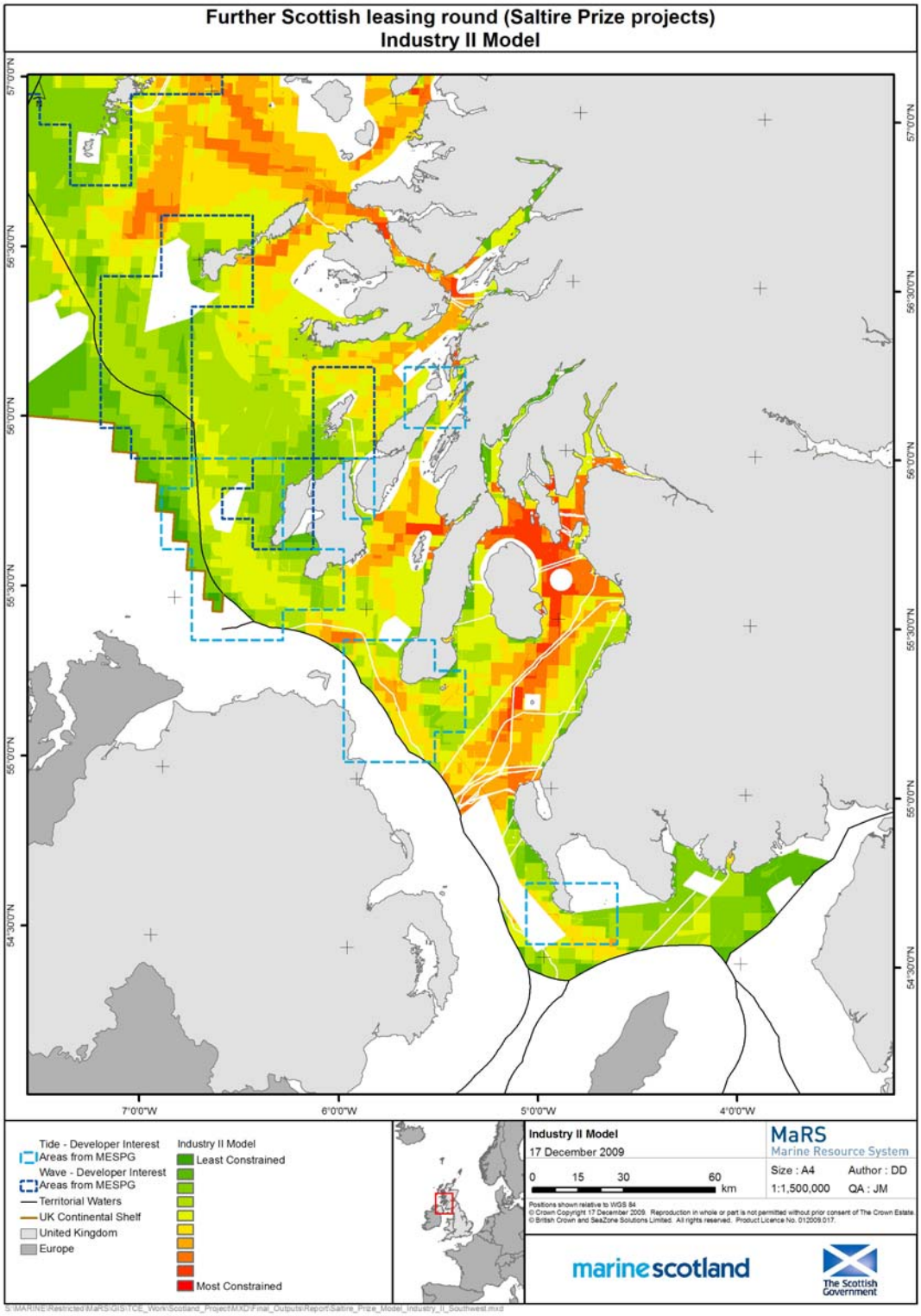

Figure 16: Full MaRS model for southwest Scotland using the industry II model weightings given in Table 2. Areas of developer interest for tidal stream and wave are overlain on the map and are outlined in turquoise and dark blue respectively. Cells coloured red exhibit the highest levels of constraint, green the least and exclusions white.

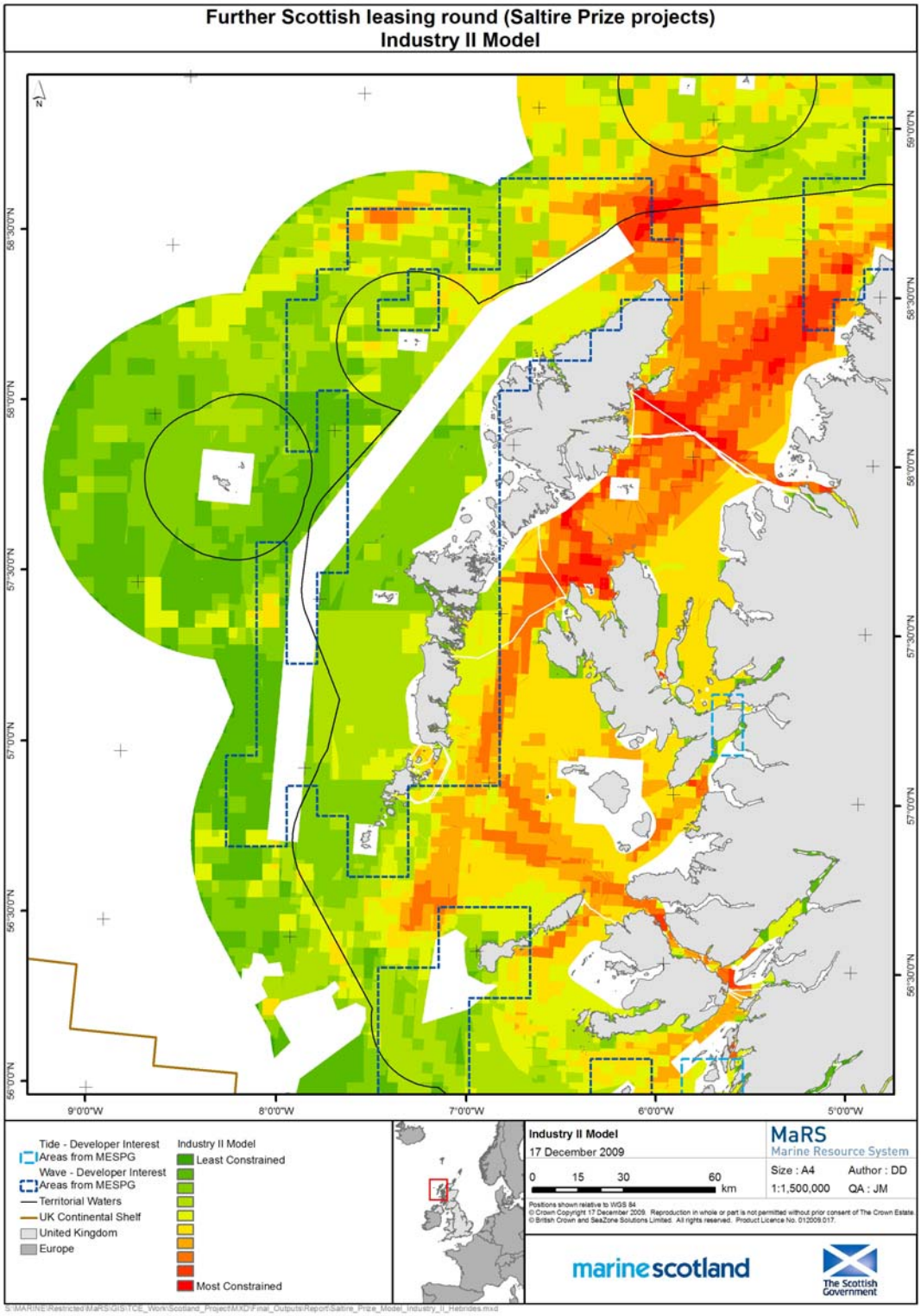

Figure 17: Full MaRS model for northwest Scotland using the industry II model weightings given in Table 2. Areas of developer interest for tidal stream and wave are overlain on the map and are outlined in turquoise and dark blue respectively. Cells coloured red exhibit the highest levels of constraint, green the least and exclusions white.

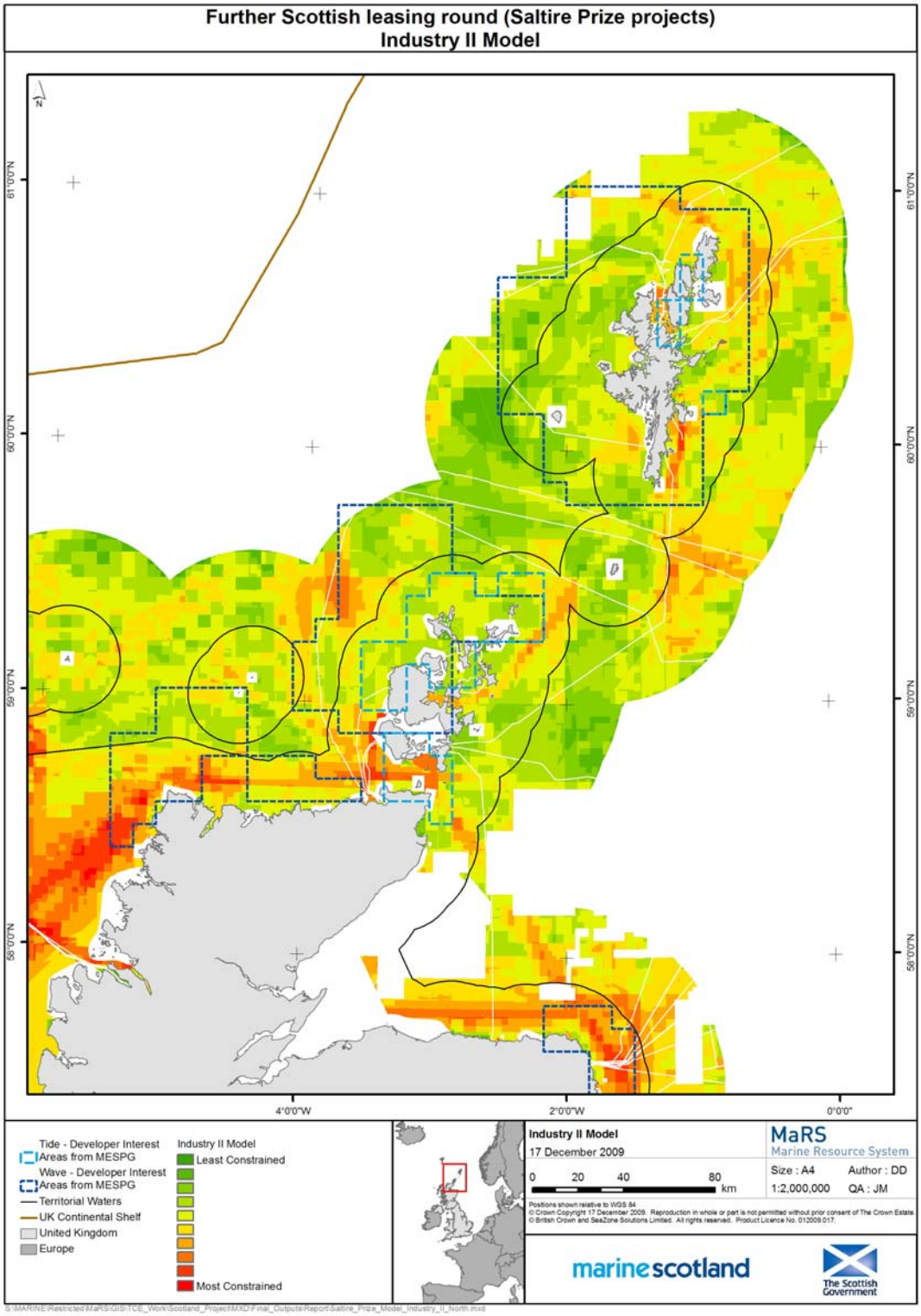

Figure 18: Full MaRS model for the north of Scotland using the industry II model weightings given in Table 2. Areas of developer interest for tidal stream and wave are overlain on the map and are outlined in turquoise and dark blue respectively. Cells coloured red exhibit the highest levels of constraint, green the least and exclusions white.

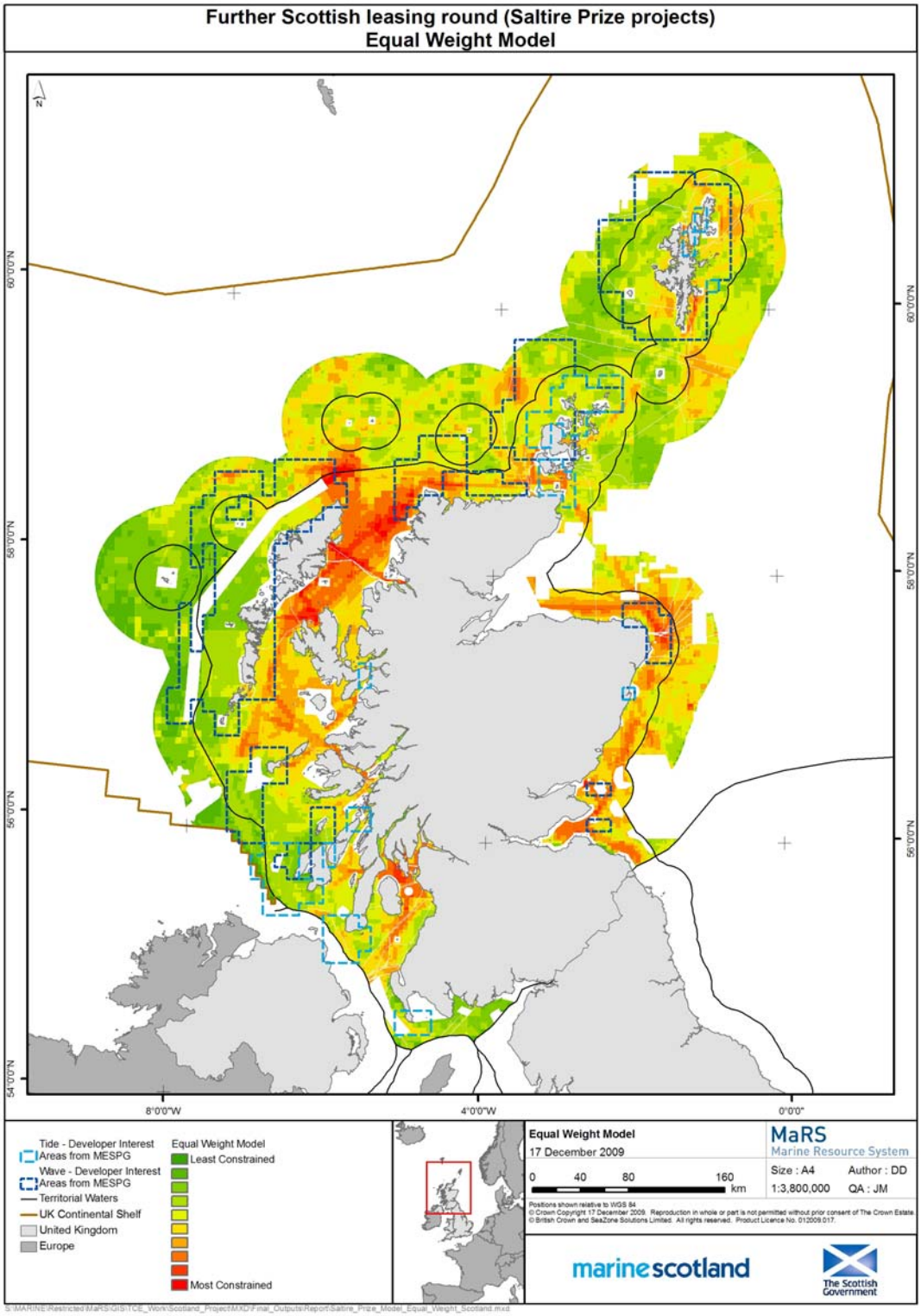

Figure 19: Full MaRS model for the whole of Scotland using the equal weighting model given in Table 2. Areas of developer interest for tidal stream and wave are overlain on the map and are outlined in turquoise and dark blue respectively. Cells coloured red exhibit the highest levels of constraint, green the least and exclusions white.

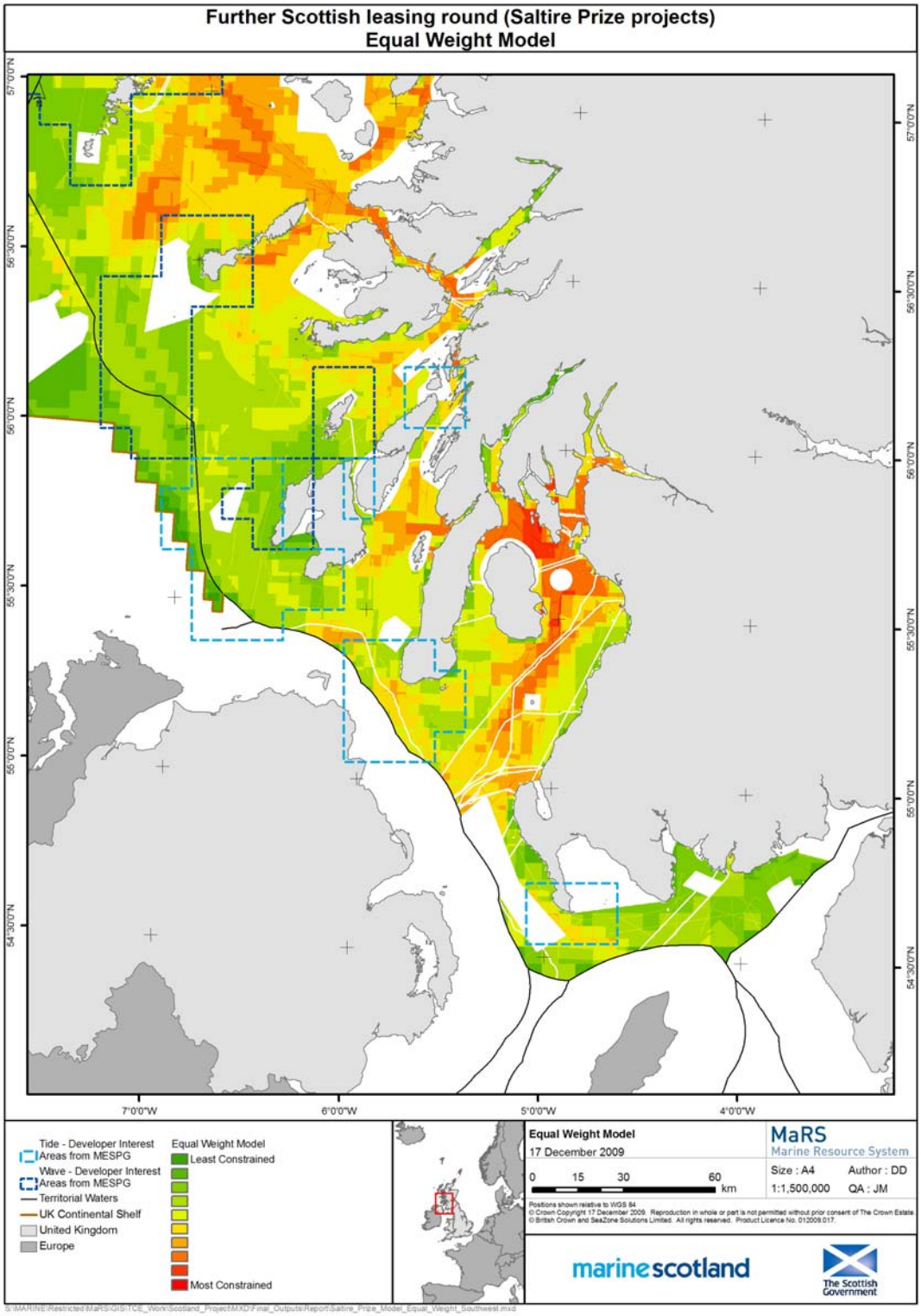

Figure 20: Full MaRS model for southwest Scotland using the equal weighting model given in Table 2. Areas of developer interest for tidal stream and wave are overlain on the map and are outlined in turquoise and dark blue respectively. Cells coloured red exhibit the highest levels of constraint, green the least and exclusions white.

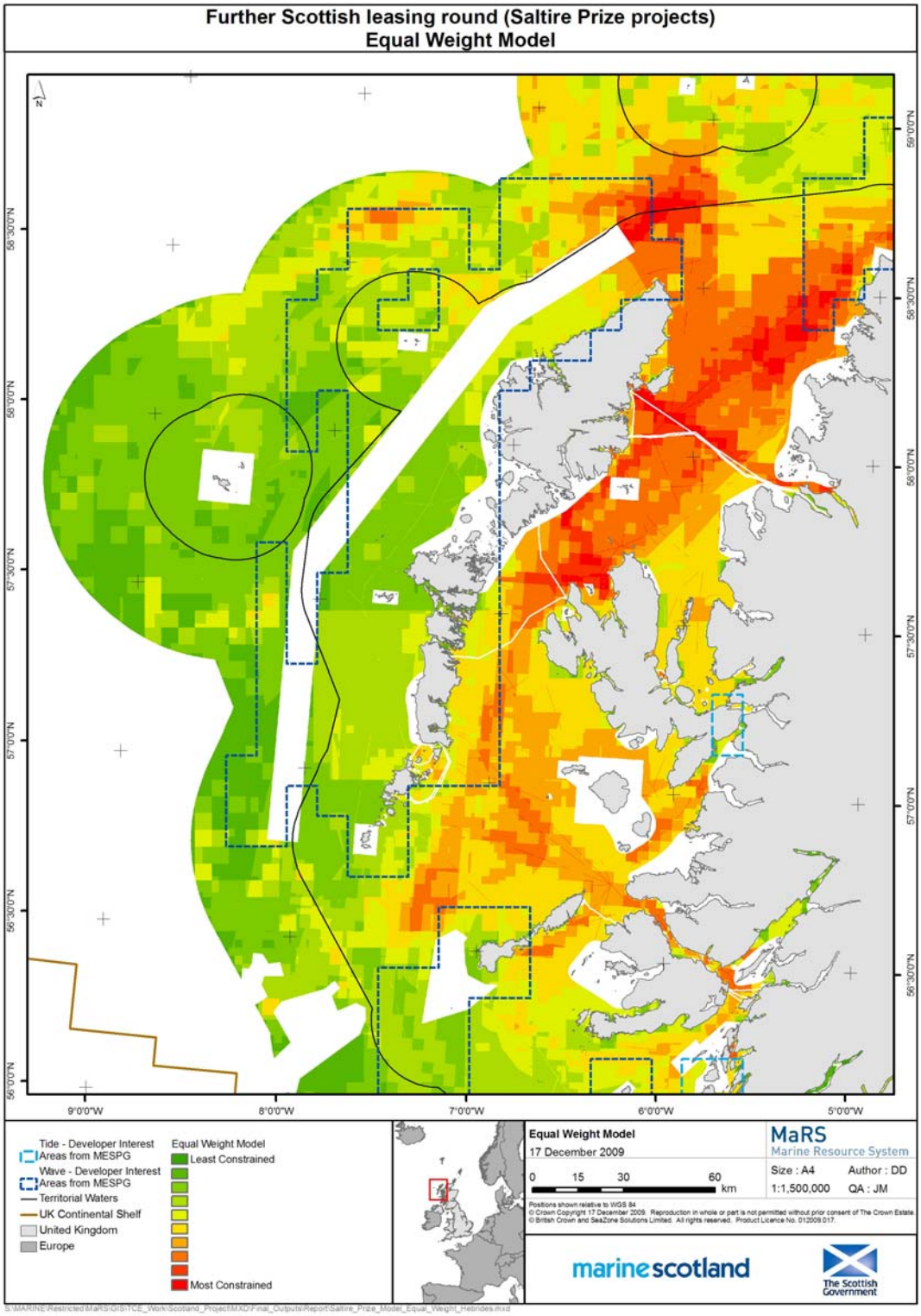

Figure 21: Full MaRS model for northwest Scotland using the equal weighting model given in Table 2. Areas of developer interest for tidal stream and wave are overlain on the map and are outlined in turquoise and dark blue respectively. Cells coloured red exhibit the highest levels of constraint, green the least and exclusions white.

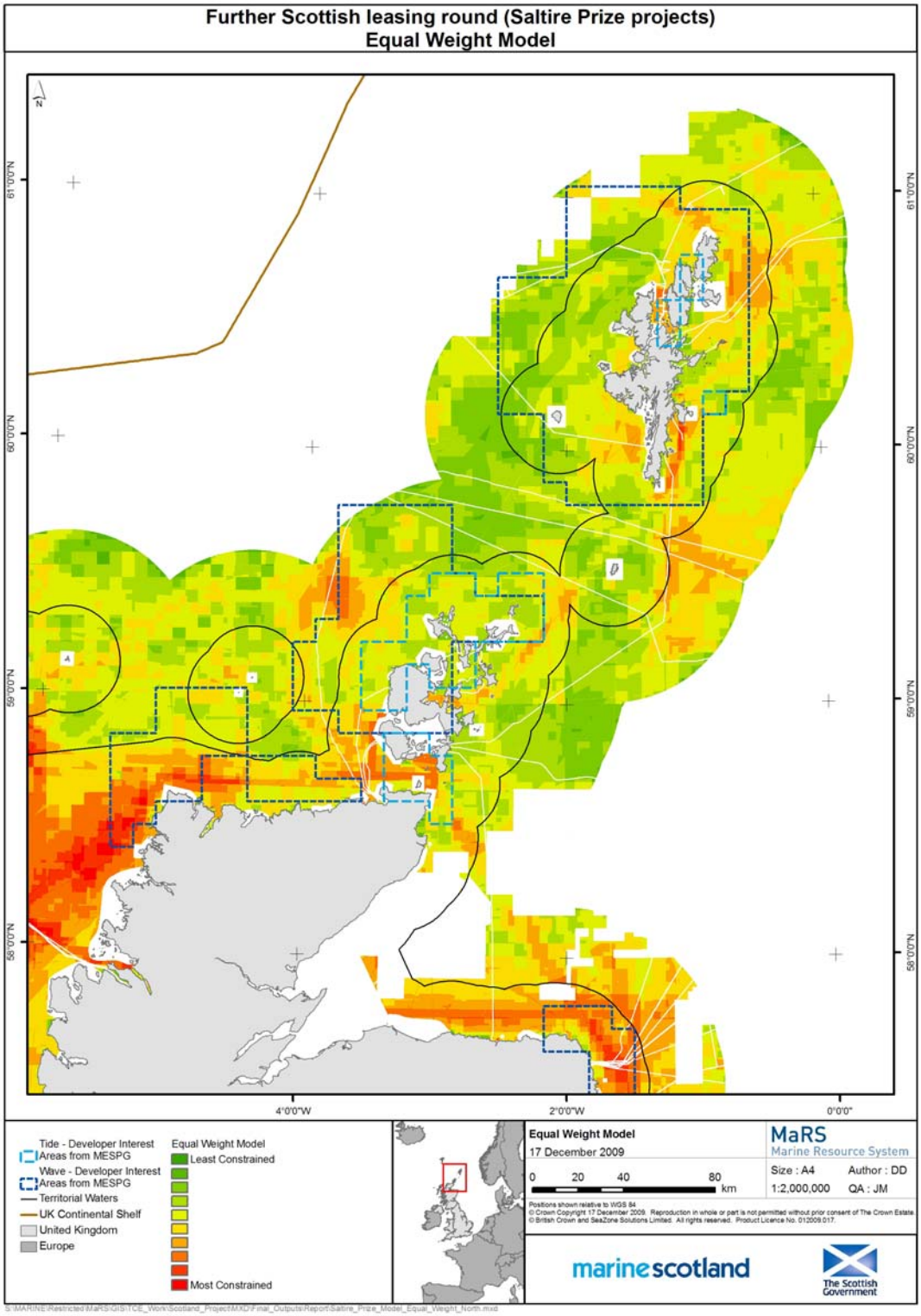

Figure 22: Full MaRS model for the north of Scotland using the equal weighting model given in Table 2. Areas of developer interest for tidal stream and wave are overlain on the map and are outlined in turquoise and dark blue respectively. Cells coloured red exhibit the highest levels of constraint, green the least and exclusions white.

6. Opportunities for Leasing for The Saltire Prize Programme

We have suggested 6 areas for consideration in the further Scottish leasing round, based primarily on outputs from the MaRS models but also using further information (admiralty charts, SeaZone and British Geological Survey) and upon consultation with stakeholders (Scottish and Southern Energy - SSE on the grid capacity and network availability, the Joint Nature Conservation Committee - JNCC on potential locations for future offshore SPAs and the Chamber of Shipping on shipping routes). The merits and constraints of the 6 areas presented in Figure 23 are discussed in the following paragraphs. A more detailed analysis of these areas selected for consideration under the further Scottish leasing round will follow in the regional locational guidance to be prepared.

Note that the first competitive leasing round in the Pentland Firth and Orkney waters was recently concluded and sites in these areas (Pentland Firth and Orkney Strategic Area labelled in Figure 23) have not been considered for the further Scottish leasing round.

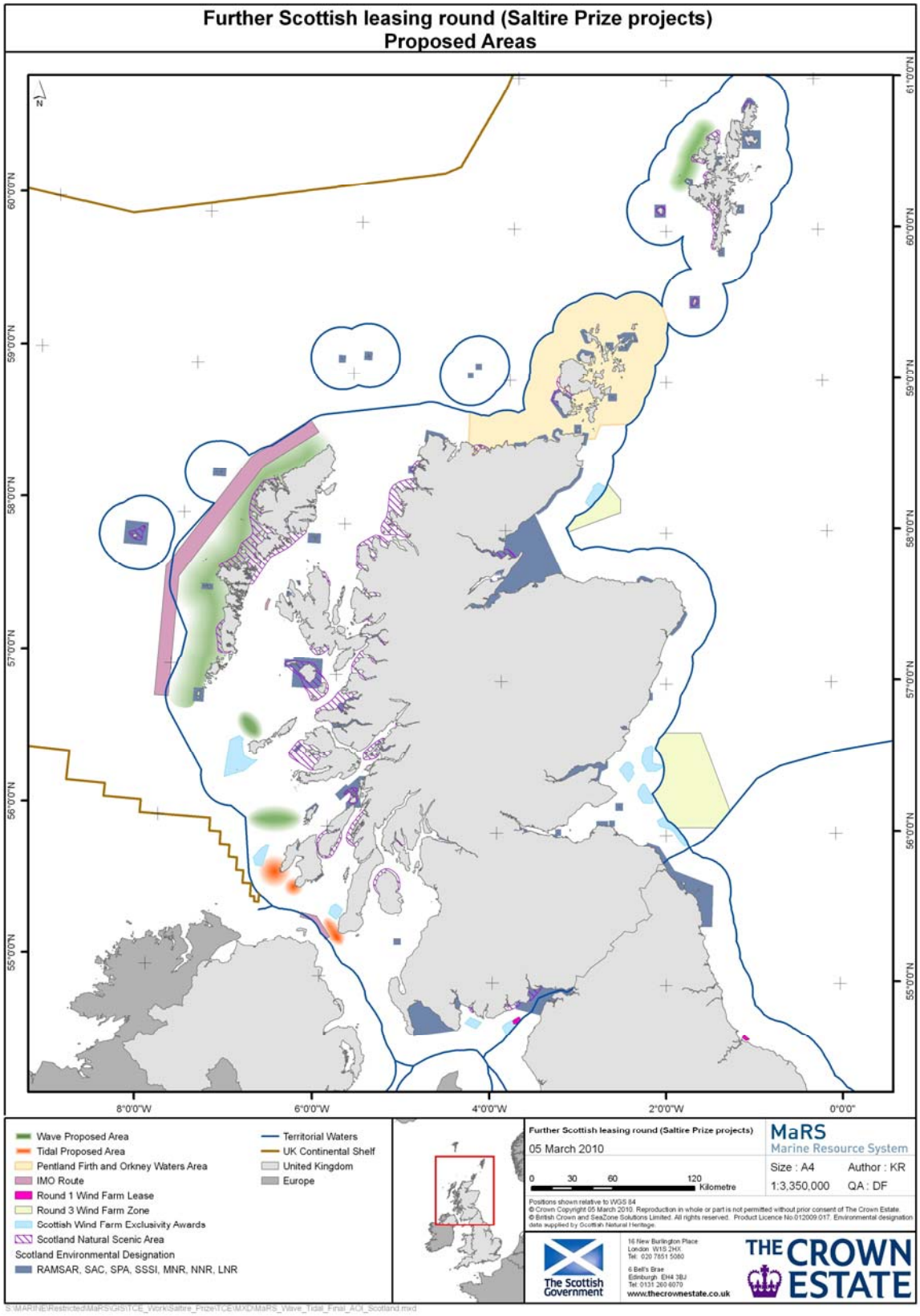

Figure 23: Sites suggested as opportunities for leasing of wave (green) and tidal stream (orange) energy generation for the further Scottish leasing round and some of the key constraints that have been taken into account in the selection process.

6.1 Opportunities for Tidal Stream Leases

Areas with potential for tidal stream power generation, and consequently of developer interest, are limited due to the requirement for powerful tidal currents associated with a low level of constraints. The area identified near Kyle of Lochalsh between Skye and the mainland (Kylerhea) was also excluded due to multiple existing uses of this site, such as shipping, aquaculture, designated areas and a military wreck. The area identified in the Sound of Islay was not considered further as there is active developer interest in the area. An area around the Mull of Galloway was also not considered due to concerns over heavy shipping in the narrow waters of the North Channel and use by the MOD.

The areas identified as having greatest potential for the further Scottish leasing round for tidal stream developments (Figure 23) are:

- Southwest of Islay
- West of the Mull of Kintyre

6.1.1 Southwest of Islay

The site proposed to the southwest of Islay contains a high level of tidal resource with estimated annual mean energy generation of up to 5.9 kW/m^2. The seabed is composed of gravel and sand and depths vary between approximately 40 and 100 m. This is a potentially challenging region however. The site experiences strong currents and the prevailing winds blow towards a dangerous coastline of exposed headlands. The region is also close to a busy shipping lane through the North Channel (see industry I and II models). The electrical transmission grid will require reinforcement before development can take place. Developers may also wish to consider proximity to ports and harbours, environmental concerns and other uses of this region.

Connection to the grid: SSE states that there is no existing capacity to accommodate new power generation. They propose establishment of two 132 kV subsea cable circuits between South Kintyre and Hunterston, establishment of a new 132 kV switching station at Crossaig Forest on Kintyre and rebuilding of the existing Crossaig to Carradale line with a double circuit 132 kV overhead line. Subject to consents the estimated completion date for this is 2013 and would generate 250 MW of incremental export capacity, although 100 MW of this is already committed.

Port and harbour access: Small ports such as Port Ellen and Port Askaig are relatively close by, but the larger ports in the Clyde are over 100 km away (by sea). However, a closer site at Campbeltown/Machrihanish has been identified as a possible location for the manufacture of wave/tidal devices (National Renewables Infrastructure Plan, Scottish Enterprise, 2009).

Environment: The region is close to an SAC designated for common seals, *Phoca vitulina,* and is under consideration as a future SPA. There are also habitats within the sites of

interest that are protected under the UK BAP, such as ‘tidal rapids’ and ‘sublittoral sands and gravels’.

Other uses: An area to the west of Islay has also been leased for offshore wind and may need to be avoided. According to data from SeaZone, this area is part of a wider area used by the MOD for submarine exercises and for military shipping. The MaRS models suggest that the area is not heavily fished.

6.1.2 West of the Mull of Kintyre

This area is characterised by high tidal flows and has an estimated annual mean power output of up to 3.4 kW/m^2. The seabed in this region takes the form of sandy gravel and muddy sand and the seabed drops off steeply from the shore to 100 m. However, similar to the site southwest of Islay, this site does have some constraints. It is adjacent to a busy shipping route and the electrical transmission grid will need reinforcement before it can accommodate additional power generation.

Connection to the grid: the grid requires reinforcement as for southwest Islay.

Ports and harbour: The site is less than 30 km from Campbeltown/Machrihanish, a potential site for wave and tidal development. Larger ports are between 55 and >100 km away in the Clyde.

Shipping: The proposed site is adjacent to an International Maritime Organisation (IMO) route marking a particularly narrow and high density shipping lane. The North Channel here is only 21 km wide and approximately half of this is occupied by the IMO route.

Environment: The area is not in the vicinity of any sites designated for conservation purposes. However, it does contain potential UK BAP habitats such as tidal rapids and sublittoral sand gravels.

Other uses: There is a proposal to develop offshore wind in the area immediately to the north of this site (Figure 23). The area has also been identified by the MOD as a submarine exercise area and for use by military ships. There are also a number of sailing routes through the region marked by the RYA. Relatively low levels of commercial fishing occur here.

6.2 Opportunities for Wave Power Leases

A large area has been identified by developers as having sufficient wave resource to generate power, particularly on the Scottish west coast and in the northern Isles. The areas that are being considered for wave power developments (Figure 23) are:

- West of the Outer Hebrides
- North of Tiree
- West of Colonsay
- West of Shetland

The east coast area off Aberdeen was considered less favourable due to a number of exclusions (bathing beaches and munitions dumps, and the high level of constraint from shipping and commercial fishing, see industry I and II models) and a relatively high abundance of cetaceans and seabirds (see environment model).

6.2.1 West of the Outer Hebrides

This large area to the west of the Uists, Harris and Lewis has been identified as suitable for wave power generation. It is predicted that a maximum of 43.0 kW/m^2 (annual mean) of power could be generated within this area. The seabed off the coast of Harris and North and South Uist is exposed rock and the depth is between 30 and 50 m. Off the coast of Lewis it takes the form of gravelly sand and sandy gravel at depths of between 30 and 70 m. The main concerns in this area are the lack of infrastructure in terms of proximity to ports and harbours, connection to the grid and exposure to the Atlantic weather. An area off Gallan Head on Lewis has been identified as being of particular environmental concern in the event of a shipping accident resulting in pollution. There are also concerns regarding use of the southerly part of this site by the military and over environmental interests.

Connection to the grid: The single connection from Lewis via Skye to Fort Augustus on the Scottish mainland is already at full capacity. Subject to consents, Scottish Hydro Electric Transmission Limited (SHETL) plans reinforcement of a 450 MW HVDC circuit between Gravir on Lewis and Beauly west of Inverness by 2012-13. 152 MW of this capacity will be allocated to already consented renewable energy generation. There is potential for wave/tidal development to connect into the 298 MW of spare capacity. However, if all other existing proposals gain consent, then only 18 MW of capacity will remain. There is potential to install a second 450 MW connection, but this is subject to approval by Ofgem (regulator of electricity and gas markets). Additionally, as the planned reinforcements are connecting to the east coast of Lewis, local reinforcements would be required in order to link developments on the west coast.

Ports and harbours: There are harbours on the west coast of the Outer Hebrides but these are relatively small. The nearest larger port is Stornoway, which has also been identified as a potential location for wave and tidal development by Scottish Enterprise.

Shipping: This proposed site does not experience a high level of shipping traffic. However, it backs on to a deepwater IMO route, which is used by large vessels avoiding passage through the Minches.

Environment: There are two SPAs for seabirds to the west of the Uists; Mingulay & Bernaray and the Monach Isles. To the east of the southern tip of the proposed site lies the Mingulay reef complex, which may acquire SAC status due to its deep water coral habitats. The area to the west of the Uists and Harris is also under consideration by the JNCC as an offshore SPA. Further north, off the west coast of Lewis, the Loch Roag lagoons are designated as an SAC and are considered to be one of the best examples of a lagoon system in the UK. The Flannan Isles SPA and St Kilda SPA/SAC/World Heritage Site are located to the west of the IMO route. Both of these sites support large numbers of breeding seabirds. The terrestrial SPAs may also require consideration, due to the red and black throated divers which fly offshore outwith the breeding season. The area surrounding the Sound of Harris may require appraisal due to the South Lewis, Harris and North Uist NSA. There is also a high abundance of cetaceans offshore from the Butt of Lewis.

Other uses: The southern sector of the site (as far north as North Uist) has been identified as being used by the MOD for firing, miscellaneous fleet exercises, submarine exercises and pilotless target aircraft practice. The MaRS model suggests that there is relatively little shipping within this site. The area is marked by the RYA as a route skirting the Outer Hebrides but outwith the IMO route.

6.2.2 North of Tiree

This area is predicted to generate a mean annual power output of up to 27.9 kW/m^2. The seabed is composed of sandy gravel and the depth in this area is relatively shallow (<50 m) out to 10 km from the shore. The main challenges in this area are that the network and capacity of the grid are likely insufficient.

Grid connection: Currently, after connection of wave devices to the existing network, small developments (<10 MW) could be accommodated. This falls short of the implied project capacity to compete the Saltire Prize of 20 MW or more. There is a plan for construction of a 132 kV wood pole overhead line circuit between Nant and Dalmally in north Argyll, which would accommodate 180 MW of export capacity. The timescale of this is >6 years, however, and would miss the target of generating power for 2 years by 2017.

Ports and harbours: This is a remote site and access to large ports is limited. Oban is >100 km away and the Clyde >250 km away.

Environment: Tiree harbours a number of SACs and SPAs along its northern coast. The SPA of Sleibhtean agus Cladach Thiriodh (Tiree Wetlands and Coast) may require appraisal for the wetland birds and geese it supports. The JNCC is also considering the site as a

future offshore SPA. The data on spawning and nursery areas for fish suggest this is a relatively sensitive area for certain species.

Other uses: A wind farm site has been proposed off the southwest of Tiree neighbouring the suggested site, thus there may be potential to share resources in terms of transmission. There is little shipping in this region but there is a high level of commercial fishing off the southwest of Tiree. The MOD also uses this area for submarine exercises and military shipping. The coast of Tiree is a popular area for surfing and the industry provides an important contribution to the island's economy. There is also one sailing route that passes through the eastern sector of the site.

6.2.3 West of Colonsay

The annual mean wave power in the site west of Colonsay reaches an estimated 24.6 kW/m^2. The seabed is relatively shallow close to shore (10 – 30 m) and levels out to a depth of 50 m beyond. It is composed of variants of gravelly sand to pure sand. The grid will require reinforcement before connection to it can take place.

Connection to the grid: as for southwest Islay and the Mull of Kintyre.

Access to ports and harbours: The port of Colonsay is only 13.5 km away. Access to larger ports such as Oban and Campbeltown are between 65 and 130 km away.

Shipping: This area experiences a low level of shipping traffic with the exception of the westerly boundary which is on the edge of the shipping route towards the Outer Hebrides. Perhaps a greater concern is that this area is close to the north Islay coast, which has been identified as a high risk area for environmental damage by shipping accidents.

Environment: There are no designated areas with marine interests on the north shore of Colonsay.

Other uses: The area is due north of a proposed wind farm site off the west coast of Islay. It is identified by the MOD as a submarine exercise area and for military shipping. The area has several RYA sailing routes passing through it. Other than these, it has few constraints in all model scenarios other than the equal weight model due to commercial fishing activity.

6.2.4 West of Shetland

This large area to the west of Shetland has been predicted to generate a mean annual power output of up to 31.8 kW/m^2. The site is composed predominantly of variants of sand and gravel in the south and gravelly sand in the north. The depth drops off steeply from the coast to between 50 and 100 m. In the southern section of this site, to the south of Papa Stour, the site is composed predominantly of sandy gravel and gravelly sand. The area is

relatively free from constraints. However, successful connection to the national grid, outwith Shetland, would require substantial upgrades to take place.

Connection to the grid: Connection of wave devices is contingent on local reinforcement of the existing Shetland 33 kV network. SHETL are also planning a 600 MW HVDC link to the Scottish mainland to accommodate power generated by Viking Energy wind farm.

Ports and harbours: There are a number of medium sized ports that may be able to accommodate the installation and servicing requirements of wave devices, such as Scalloway and Sullom Voe. The larger port of Lerwick is >65 nm away. Both Sullom Voe and Lerwick have been identified as a location where wave and tidal development could take place.

Shipping: This region does not experience a high level of shipping traffic other than at the northern boundary of the site. Shipping activity is actually limited due to an IMO restriction on vessels over 5000 tonnes carrying hazardous loads.

Environment: To the east of the site, the island of Papa Stour has been designated as an SPA for Arctic terns and ringed plover. It is also an SAC for its sea caves and reefs and is a SSSI. There are three NSAs on the west and northwest Mainland that overlook the site; Muckle Roe, Esha Ness and Fetherland. The site also overlaps with an area under consideration by the JNCC as a possible SPA for offshore bird aggregations. South of the site, the SPA on Foula and neighbouring waters harbours a vast seabird assemblage. Additionally, this area has been identified as being sensitive for many commercial fish and is an important nursery and spawning site for a number of species.

Other uses: There are cables and a submarine pipeline to the north of the proposed site between Orka Voe and oil and gas fields to the west of Shetland. The proposed site cuts into the western section of the RYA sailing area that has been marked all around the coast of Shetland. No military activity has been identified in this site.

7. Discussion

By using the MaRS GIS tool, we have been able to consider the degree of constraint in Scottish waters including those areas of potential interest to developers for wave and tidal stream energy generation. This report indicates sites for consideration for development that avoid sensitive areas and minimise conflict with other commercial users and the environment. We have identified 6 potential areas that could be utilised in the further Scottish leasing round, four suitable for wave energy and two for tidal.

The MaRS tool is efficient and effective in delivering sector-based marine spatial planning, but it is heavily reliant on the quality of the spatial information within it. Consultation with relevant stakeholders is helpful as a confirmatory “reality check” on the interpretations of the

outputs. The prior accumulation of information on the areas of interest to developers over the next 10 years or so does fill this requirement to a degree. The broad coincidence of areas of resource with low levels of constraint and areas identified by developers as of potential interest, gives us some confidence that the model outputs are a reasonable basis from which to move forward into additional stakeholder engagement leading towards a leasing round.

Despite using the best available data that we could locate, there were a number of weaknesses with our models. We did not include access to the national grid and the capacity of the grid to accommodate additional energy sources from these developments in the MaRS analysis. Further consultation with SSE has indicated that reinforcement will be required locally and substantial investment will be necessary to link them to the national grid. SSE has given a timescale for this as between 2012 and 2016 or beyond given the necessary consents.

There were also weaknesses with the data that were included in the models in terms of accuracy and resolution. For example, the commercial fishing layer was derived using VMS and landings data from 2004 - 2007 and expressed as value of catch. Fishing patterns and the value vary spatially and temporally and although the value was averaged over 4 years, it may not be representative of current and future trends over the time-span of this leasing round. This dataset is also weak for vessels <15 metres which are not required to carry VMS and therefore the exact location of fishing activity cannot be recorded. Data for these smaller vessels only exists in the form of landings by species averaged across the area of an ICES statistical rectangle.

It has been acknowledged that the dataset on fish spawning and nursery grounds could now be re-developed to a higher spatial resolution, given the greater understanding of these species than when the original layer was made. It is also unclear to what extent wave and tidal devices are a constraint on these species as their effect on fish survival and behaviour is unknown. It is possible that foraging or spawning habitat may be lost or that the turbines could present a danger to certain species. Then again, a site set aside for an array of wave/tidal devices, in which other activities such as commercial fishing or shipping are excluded, might be analogous to a marine protected area and actually benefit certain species.

A number of constraints were not included in the model due to low resolution of data or none available and thus will need to be considered at a subsequent review stage. It was decided that two of the layers available for MOD activity (which represent practice and danger areas) would not be used because the information was insufficient to draw clear assessments on the actual use of areas of sea within the rather broad areas indicated by the data layers. For example, the danger areas were not used in the models because one of the areas given was exceptionally large, covering a large part of Scottish coastal waters. The exact location of MOD activity within that area, and its degree of incompatibility with wave and tidal

development, is being ascertained through on-going discussions with the MOD on the proposed areas.

Environmental interactions are of particular concern because there is little research into potential impacts of wave and tidal devices on species or habitats. Seals, for example, are protected under the EC Habitats Directive and their conservation requires designation of marine SACs. Despite excluding all SACs in the MaRS analysis, we did not include information on seal colonies or their migration routes. It will therefore still be necessary to consider interactions of wave/tidal devices with seals from protected colonies, even when the devices are located outwith the SAC boundaries.

Other than cetaceans and seabirds, the models did not include Biodiversity Action Plan (BAP) habitats or species, one of the most significant of which for placement of tidal stream devices is 'tidal rapids', defined as,

"... a broad range of high energy environments including deep tidal streams and tide-swept habitats... Wherever they occur, strong tidal streams result in characteristic marine communities rich in diversity, nourished by a constantly renewed food source brought in on each tide." (UK BAP)

Presence of some important species or habitats for conservation will be included in the locational guidance but effects of wave/tidal devices on such ecosystems require further research.

A list of other aspects of the marine environment and its current uses that could not be included in the MaRS assessment include:

- Grid, distance to suitable ports
- MOD danger & practice areas
- Regional high resolution energy resource
- Seabed type
- Geological features
- Shellfish waters
- Otters (EPS)
- Salmon (EPS)
- Tidal rapids and other BAP species/habitats
- Recreational fishing
- Surfing
- Diving
- Whale and bird watching

8. Conclusion

Using TCE MaRS, we have been able to incorporate spatial information on commercial and recreational users of Scottish seas with environmental constraints. We have suggested 6 areas on the Scottish west coast and in the northern Isles for further investigation as potential leasing sites for Saltire Prize projects, all with high levels of power resource and relatively low levels of constraints (Figure 23). The next stages in the Saltire Prize Programme include further consultations with the wave and tidal industry and with other marine/coastal stakeholders, a more detailed analysis of constraints such as seabed suitability and environmental interactions, and ensuring that suitable infrastructure is in place, or can be put in place, to service the potential development sites. Much of this information will be captured in the Regional Locational Guidance for the sites in question that will be produced in summer 2010.

ANNEX I

Description of the Data Layers used in the Identification of Potential Leasing Sites for the Further Scottish Leasing Round

Type of activity	Data layer	Description of the data layer
Recreation	**Royal Yachting Association Marinas 2008**	The dataset displays the location of the RYA Marinas. The dataset was first created in 2006. Marinas - most charted are commercial marinas. Most berth-holders will be permanently based at that marina but most also have a high proportion of visitor berths available for passing craft. Most have a full range of yachting facilities such as chandlers and repair shops and should be regarded as primary ports of origin and destination for recreational craft. More information can be found in the RYA Marina Guide. In the North and West of Scotland and the islands, marinas tend to be smaller with fewer berths and facilities but are nevertheless important ports of call and destinations.
	Royal Yachting Association Sailing Areas 2008	The dataset displays the location of the RYA Sailing Areas as of 2008. The dataset was first created in 2006. General Sailing Areas - areas in extensive use for general day-sailing by all types of recreational craft but particularly smaller craft such as small cruisers, day-boats, dinghies, sailboards and personal watercraft. Such craft will not normally be undertaking point-to-point passages but will be on out and return activities and may appear to be sailing in random directions as they take advantage of wind and tide to make progress.
	Royal Yachting Association Racing Areas 2008	The dataset displays the location of the RYA Racing Areas as of 2008. Racing Areas - areas in frequent use, particularly at week-ends and holiday periods, by large numbers of racing craft normally under sail but also power. Such areas are generally under the control of nearby sailing clubs and may contain temporary or permanent race course marking buoys. Detailed routes will normally only be determined on the day of the race although certain longer-distance races may have routes published in advance. In addition some racing may take place outside the areas indicated. Racing craft will obey the specialised racing rules between themselves but will follow the conventional Collision Regulations when other vessels are in conflict.
	Royal Yachting Association Cruising Routes 2008	The dataset displays the location of the RYA cruising routes throughout the UK waters. The dataset was first created in 2006.
	Bathing Beaches	A list of the British Bathing Beaches, as listed by the Good Beach Guide. This guide is compiled by the Marine Conservation Society.
Commercial	**Current Aquaculture Leases**	This dataset identifies the spatial boundaries of areas currently under lease for aquaculture purposes. Leases include both finfish and shellfish. This dataset was obtained from the TCE.

	Pending Aquaculture Leases	This dataset identifies the spatial boundaries of leases which are pending for aquaculture. Leases include both finfish and shellfish. This dataset was obtained from the TCE.
	Disposal Sites	The dataset shows the extent and location of dumping grounds in UK waters.
	Tidal Leases	The dataset shows the location of TCE tidal leases in UK waters.
	Wave Lease points in the United Kingdom	The dataset shows the location of TCE wave leases in UK waters.
	Scottish Wind Farm Exclusivity Awards	This dataset shows the location of Scottish wind farm lease applications submitted to The Crown Estate. It displays the applications for the Exclusivity Awards.
	Round 3 Wind Farm Zones (Iteration III)	These data represent potential development opportunities for future offshore wind farms. This version is iteration III of these data. This dataset displays TCE's present view of locations for potential zones for the development of offshore wind farms. The zones are subject to revision and do not in any way reflect the output of BERR's (Department for Business, Enterprise and Regulatory Reform) SEA.
	Current Licensed Areas for Hydrocarbon	This dataset contains current licence areas provided by BERR as a monthly export of their database.
	Offshore Wells in United Kingdom Waters	Dataset contains complete set of offshore UK well positions and descriptive attributes. The definitive source of well reference information is UK DEAL.
	Active Cable	The dataset shows the extent and location of all active cables throughout the United Kingdom Continental Shelf. Data has been combined by TCE from SeaZone and Kingfisher (2004) active cable data.
	Active Pipelines	This dataset contains active sub-sea pipelines and umbilicals related to the petroleum industry. It does not include telecommunication cables. The definitive data source are the individual owner companies of the infrastructure.
	Cable Under Construction	These data represent all cables currently under construction in UK waters.
	Wind Farm Cables	The dataset shows all cables supplying online wind farms in UK waters.
	Electricity and Gas Interconnectors	These data show interconnectors throughout UK waters. Interconnectors connect up sections of electricity cables or gas pipelines. These data include both current and proposed interconnectors.
MOD	**Munitions Dumps in United Kingdom Waters**	The layer shows military (MOD) storage facility for live ammunition and explosives in UK waters. The storage of live ammunition and explosives is inherently hazardous. There is the potential for accidents in unloading, packing and transfer; the threat of theft, misuse or sabotage; and, if neglected, the near-certainty that poorly stored explosives will degrade and become shock-sensitive over time.
Environment	**IA JNCC Cetacean**	This dataset created by TCE for Interaction Analysis is based on the JNCC cetacean data and shows the total annual density of cetaceans encountered in UK Waters
	IA JNCC Sea Birds	This dataset created by TCE for Interactive Analysis is based on the JNCC sea bird atlas data and shows the total annual density of birds encountered in UK Waters.

	Important Bird Areas in the United Kingdom	This dataset shows the location and extent of areas identified by the Royal Society for the Protection of Birds (RSPB) as "Important Bird Areas (IBAs)".
	National Nature Reserves (NNR) in Scotland	NNRs contain examples of some of the most important natural and semi-natural terrestrial and coastal ecosystems in Great Britain. Dataset downloaded from Scottish Natural Heritage Interactive (SNHI).
	Local Nature Reserves (LNRs) in Scotland	LNRs are established in a variety of locations with varied habitats and species. Dataset downloaded from SNHI.
	RAMSAR Sites in Scotland	The dataset shows the extent and location of RAMSAR site in Scotland. Ramsar sites comprise of globally important wetland areas. Dataset downloaded from SNHI.
	Sites of Special Scientific Interest (SSSI) in Scotland	The SSSI series has been developed over the last 50 years as a series of sites providing statutory protection for the best examples of the UK's flora, fauna, or geological or physiographical features. Dataset downloaded from SNHI.
	Possible Special Protection Areas (pSPA) in Scotland	This dataset includes proposed Special Protection Areas (SPAs) and proposed extensions to SPAs which are at the public consultation stage. These are identified with a status of 'pSPA' and may be subject to change when classified. Dataset downloaded from SNHI.
	Special Areas of Conservation (SAC) in Scotland	The dataset shows the location and extent of Special Area of Conservation (SACs) in Scotland. Dataset downloaded from SNI.
	Candidate Special Areas of Conservation (cSAC) in UK - Offshore and Outside 12nm	This dataset shows the location and extent of 2008 Candidate SACs. A candidate SAC (cSAC) is one that has been submitted to European Commission, but has not yet had formal approval from Europe. The data was provided by the JNCC.
	Draft Special Areas of Conservation (dSAC) - Offshore and Outside 12nm	This dataset shows the location and extent of Draft SACs. A draft SAC (dSAC) is a site that has been formally recommended to DEFRA by the JNCC. A site remains a dSAC until it has had Cabinet Committee approval to go out to formal public consultation. There are currently two draft SACs. The data was provided by the JNCC.
	Special Protection Areas (SPA) in Scotland	SPAs in Scotland are classified by Scottish Ministers. These are areas of the most important habitat for rare (listed on Annex I to the Directive) and regularly occurring migratory birds within the European Union. SPAs are classified under the EC Birds Directive and together with SACs, form the Natura 2000 network. Dataset downloaded from SNHI.
	Scotland National Scenic Areas	The dataset details all National Scenic Areas (NSAs) across Scotland. Downloaded from Scottish Government.
Shipping	**Shipping Density**	The dataset shows average annual shipping densities from Anatec. The data is a mixture of AIS (within 30 miles of the coast and for areas of heavy oil and gas interests) and modelled outputs from the Anatec model. This dataset shows the following shipping density data: 1.) estimated ships per year, ship type distribution (4 categories); 2.) ship size distribution (5 tonnage categories); and 3.) a rank score (1 lowest & 5 highest) based on total shipping density in UK waters.

	IMO Routing	The dataset shows the International Maritime Organisation (IMO) Routes in UK waters.
Commercial fishing	**Fish Value (Non-VMS and VMS) Combined for all Gear Classes**	This dataset shows the annual mean value of fishing activity within UK waters from 2004 to 2007. It is a combination of VMS and non-VMS gear classes. The value was derived from fishing effort data courtesy of processed VMS data for UK vessels and financial landing value per ICES rectangle. The processed VMS data was supplied by CEFAS and FRS for Scotland and financial landing value was supplied by the MFA.
Fish spawning and nursery grounds	**Fish Spawning Areas of Commercial Fish/Shellfish Species**	The dataset shows the extent of spawning areas of key commercial fish/shellfish species.
	Nursery Areas of Key Commercial Fish Species	The dataset shows the location and extent of nursery areas of key commercial fish species.
Cultural heritage	**Scheduled Ancient Monuments in Scotland**	This dataset shows the boundaries of all scheduled monuments in Scotland. A scheduled monument is a monument of national importance that Scottish Ministers have given protection under the Ancient Monuments and Archaeological Areas Act 1979. This dataset was downloaded from Historic Scotland.
	World Heritage Sites in Scotland	The dataset represents the location of the UNESCO World Heritage Sites (WHS) in Scotland. This dataset was obtained from SNHI.
	Wreck Points	The dataset is supplied by SeaZone and shows the extent and location of wreck points. A wreck is the ruined remains of a stranded or sunken vessel which has been rendered useless.
	Protected Wreck Point	The dataset shows the location and extent of exclusion zones as designated by the Maritime and Coastguard Agency (MCA) under the The Protection of Wrecks Act 1973 - section 1 and 2.
	Protected Wreck Exclusion Buffer	The dataset shows the location and extent of 3 exclusion zones as designated by Maritime and Coastguard Agency (MCA) under the The Protection of Wrecks Act 1973 - section 1 and 2. The 3 sites are represented by rectangles.
Resources	**Atlas of UK Marine Renewable Energy Resources (Tide)**	The dataset shows the distribution of flow, power and tidal range for the area of the UK Continental Shelf. For further information please refer to 2008 Renewable Atlas technical report available from http://www.renewables-atlas.info. Tidal data supplied by Proudman Oceanographic Laboratory (POL) on behalf of BERR for the Atlas of UK Marine Renewable Energy Resources project. This layer contains the primary tidal data attributes from the Atlas database for sigma levels closest to the depths of 50% of the surface.
	Atlas of UK Marine Renewable Energy Resources (Wave)	The dataset shows the distribution of significant wave heights and full wave field power for the UK Continental Shelf. All data was recorded between 2001 and 2008. For further information please refer to the 2008 Renewable Atlas technical report. Wave data supplied by the Met Office on behalf of BERR for the Atlas of UK Marine Renewable Energy Resources project. This layer contains the primary wave data attributes from the Atlas database.

	SeaZone Bathymetry Surface for UK Waters (180m) - extended	The dataset shows the gridded bathymetry for UK waters at a 180 m resolution. This dataset is an amalgamation of SeaZone bathymetry data and the world digital bathymetry "DBDB-V" by NASA.

ANNEX II

Weights and Scores used in Restriction Models

For each restriction model a table of the weights (relative influence of a layer) and scores (importance of a class within each layer) is given in Tables AII– 1 to 5.

TABLE AII-1

Weights and scores for each layer in environment restriction model.

Layer Name	Weighting	Rank		W*S
		Range	Score	
Cetaceans (observation per hour)	100	0 - 0.11	2	200
	100	0.11 - 0.31	4	400
	100	0.31 - 0.57	5	500
	100	0.57 - 0.89	7	700
	100	0.89 - 1.3	9	900
	100	1.3 - 1.83	11	1100
	100	1.83 - 2.55	13	1300
	100	2.55 - 3.84	15	1500
	100	3.84 - 5.7	16	1600
	100	5.7 - 8.83	18	1800
Birds (observations)	90	0 - 34.65	2	180
	90	34.65 - 92.95	3	270
	90	92.95 - 154.94	5	450
	90	154.94 - 227.34	7	630
	90	227.34 - 312.37	8	720
	90	312.37 - 429.37	10	900
	90	429.37 - 623.29	11	990
	90	623.29 - 964.22	13	1170
	90	964.22 - 1546.89	15	1350
	90	1546.89 - 3501.73	16	1440

TABLE AII-2

Weights and scores for each layer in shipping restriction model including shipping density (predicted ships per year) and harbour administration areas.

Shipping	Weighting	Rank		W*S
		Range	Score	
0 - 93	90	1 - 12	2	180
93 - 311	90	12 - 52	3	270
311 - 687	90	52 - 104	5	450
687 - 1278	90	104 - 208	7	630
1278 - 2174	90	208 - 300	8	720
2174 - 3304	90	300 - 365	10	900
3304 - 4606	90	365 - 500	11	990
4606 - 6612	90	500 - 730	13	1170
6612 - 11183	90	730 - 23599	15	1350
11183 - 23600	90	730 - 23599	16	1440
Harbour Admin Area	100	All Features	10	1000

TABLE AII-3

Weights and scores for each layer in fish spawning and nursery grounds restriction model.

Layer Name		Weighting	Score	W*S
Nursery	Mackerel	50	5	250
	Nephrops	50	5	250
	Norway pout	50	5	250
	Plaice	50	5	250
	Saithe	50	5	250
	Sandeel	50	5	250
	Sole	50	5	250
	Whiting	50	5	250
Spawning	Whiting	50	5	250
	Sprat	50	5	250
	Sole	50	5	250
	Sandeel	50	5	250
	Saithe	50	5	250
	Plaice	50	5	250
	Norway pout	50	5	250
	Nephrops	50	5	250
	Mackerel	50	5	250
	Lemon sole	50	5	250
	Herring	50	5	250
	Haddock	50	5	250
	Cod	50	5	250
	Blue whiting	50	5	250

TABLE AII-4

Weights and scores for each layer in commercial fishing restriction model.

Commercial fishing	Weighting	Rank		W*S
		Range	Score	
Fishing intensity (value, £)	100	0 - 1365.35	2	200
	100	1365.35 - 3598.75	4	400
	100	3598.75 - 5668.42	5	500
	100	5668.42 - 8711.87	7	700
	100	8711.87 - 12170.99	9	900
	100	12170.99 - 15149.65	11	1100
	100	15149.65 - 20862.75	13	1300
	100	20862.75 - 27955.84	15	1500
	100	27955.84 - 39482.73	16	1600
	100	39482.73 - 313859.7	18	1800

TABLE AII-5

Weights and scores for each layer in recreation restriction model.

Layer Name	Weighting	Rank Score	Buffer	W*S
Marinas, Clubs	50	5	100	250
Sailing Areas	50	5	0	250
Racing Areas	50	5	0	250
Cruising Routes	50	5	100	250

ANNEX III

NORMALISED MODELS

The normalised version (or the original restriction model where normalising was used) of the restriction models is given in Figures AIII – 1 to 6. The normalising process removes exclusions from each restriction model and re-classifies the scale of each restriction model so that they are consistent with each other.

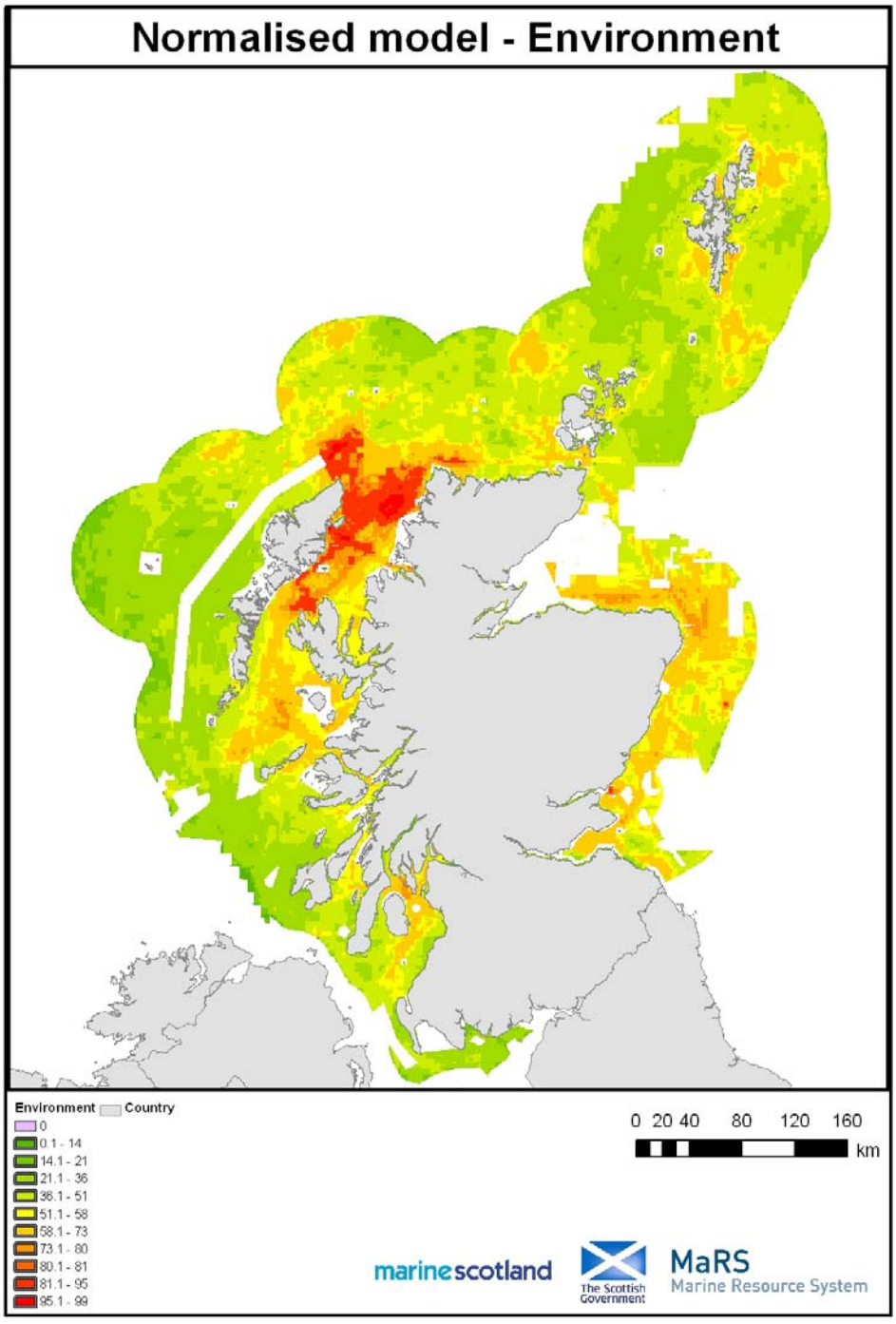

Figure AIII – 1 Normalised output from the environmental restriction model. Exclusions are given in white.

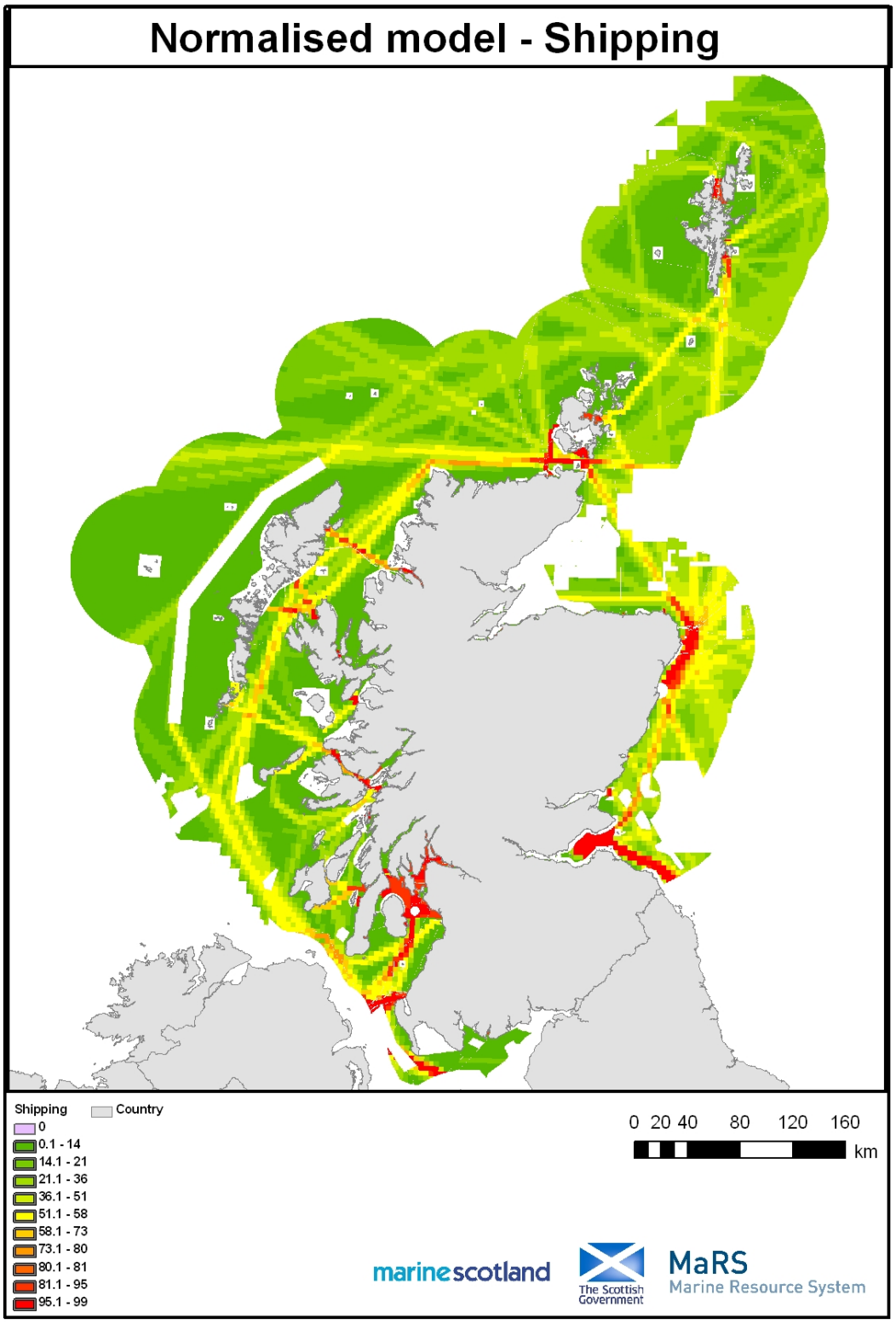

Figure AIII – 2 Normalised output from the shipping restriction model. Exclusions are given in white.

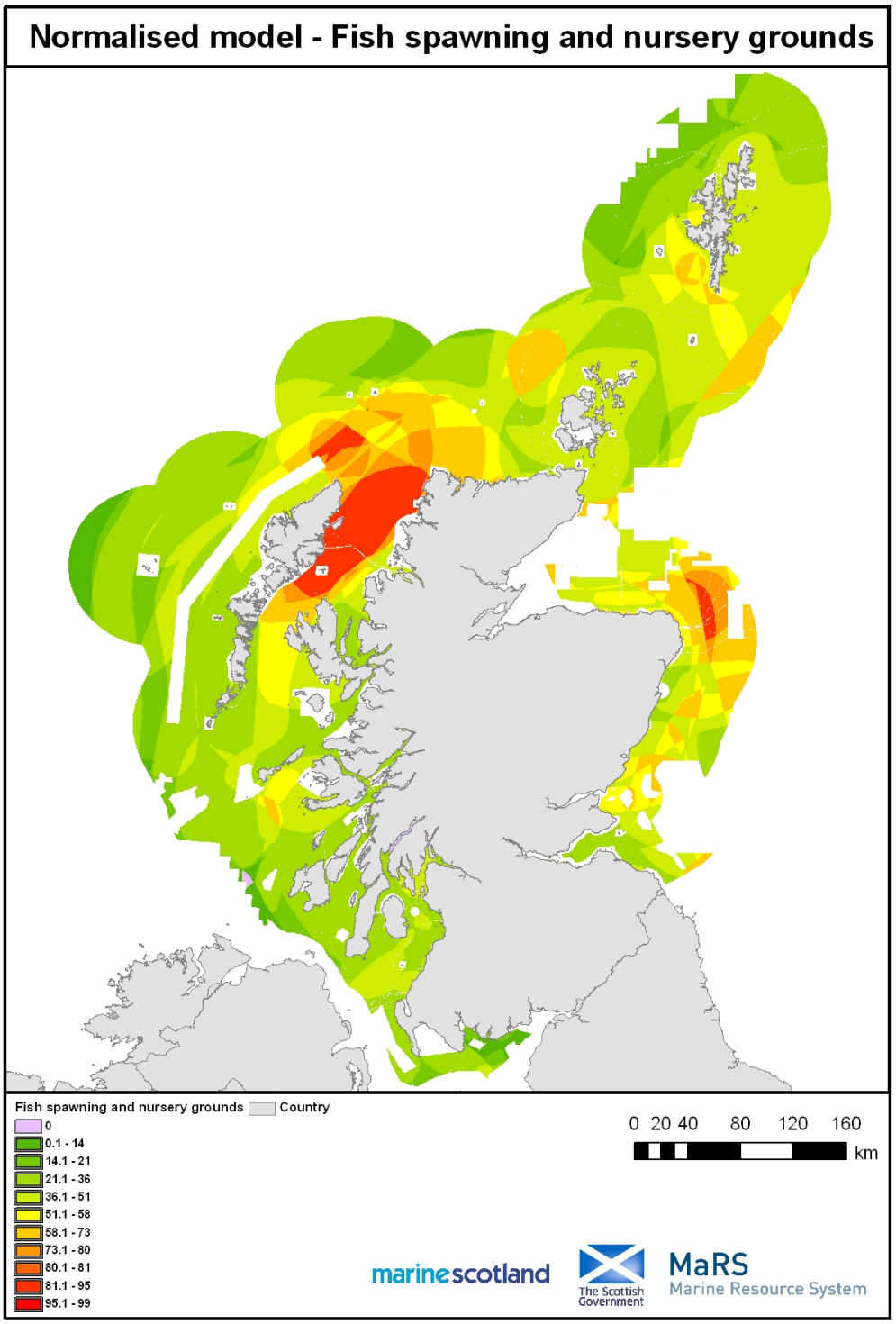

Figure AIII – 3 Normalised output from the fish spawning and nursery grounds restriction model. Exclusions are given in white.

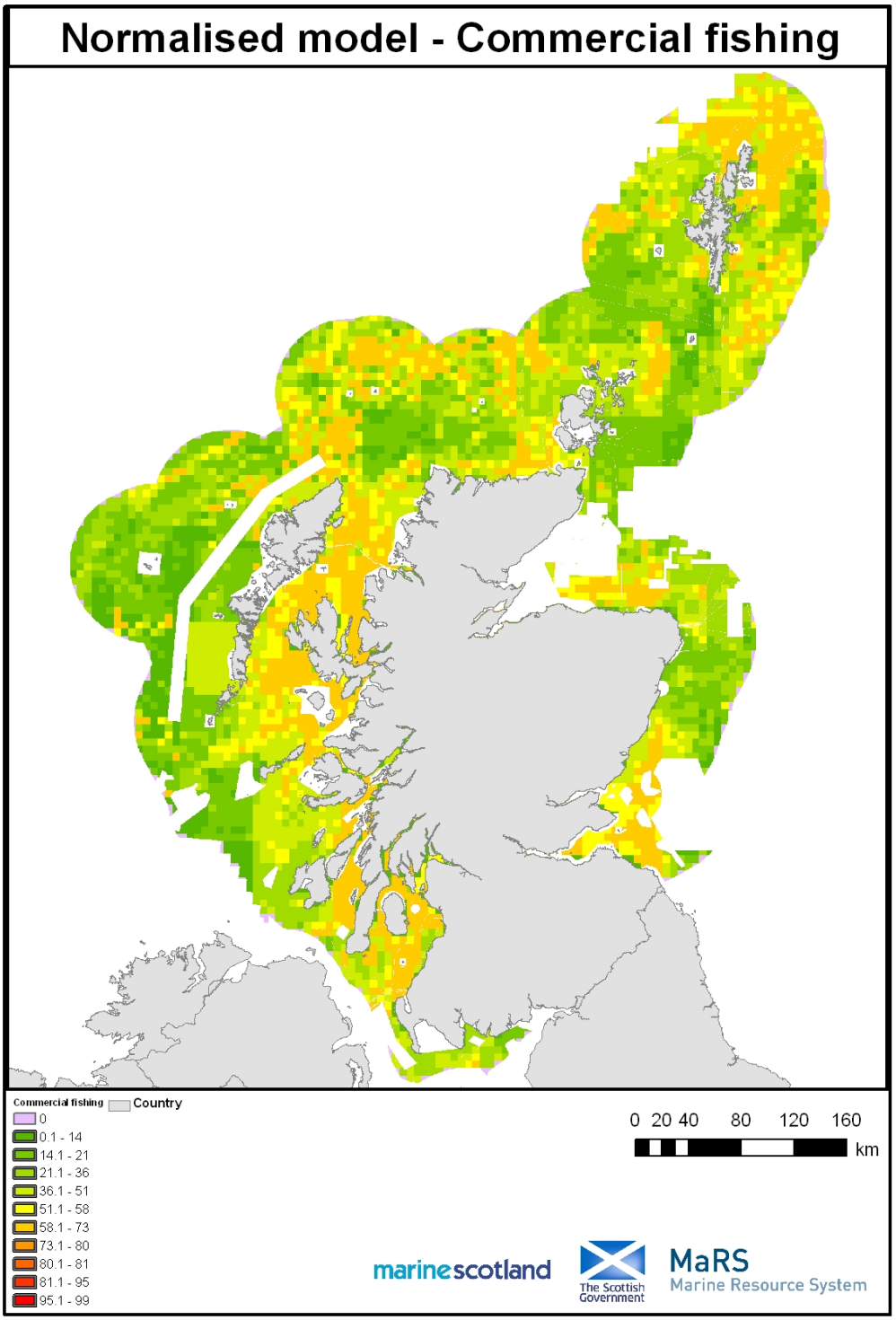

Figure AIII – 4 Normalised output of commercial fishing restriction model. Exclusions are given in white.

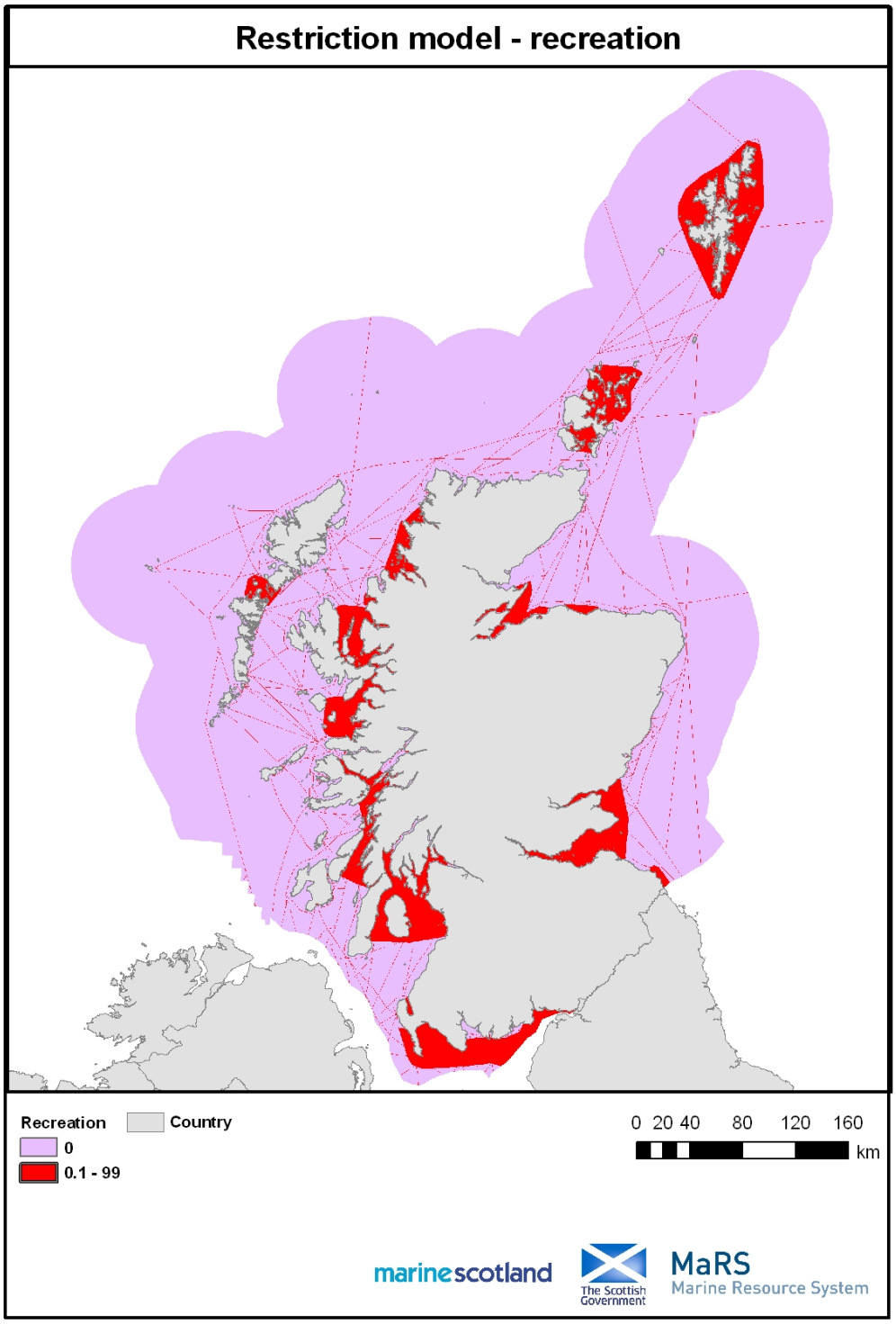

Figure AIII – 5 Raw output from the recreation restriction model. Note: this model was not normalised due to lack of classes within the layers

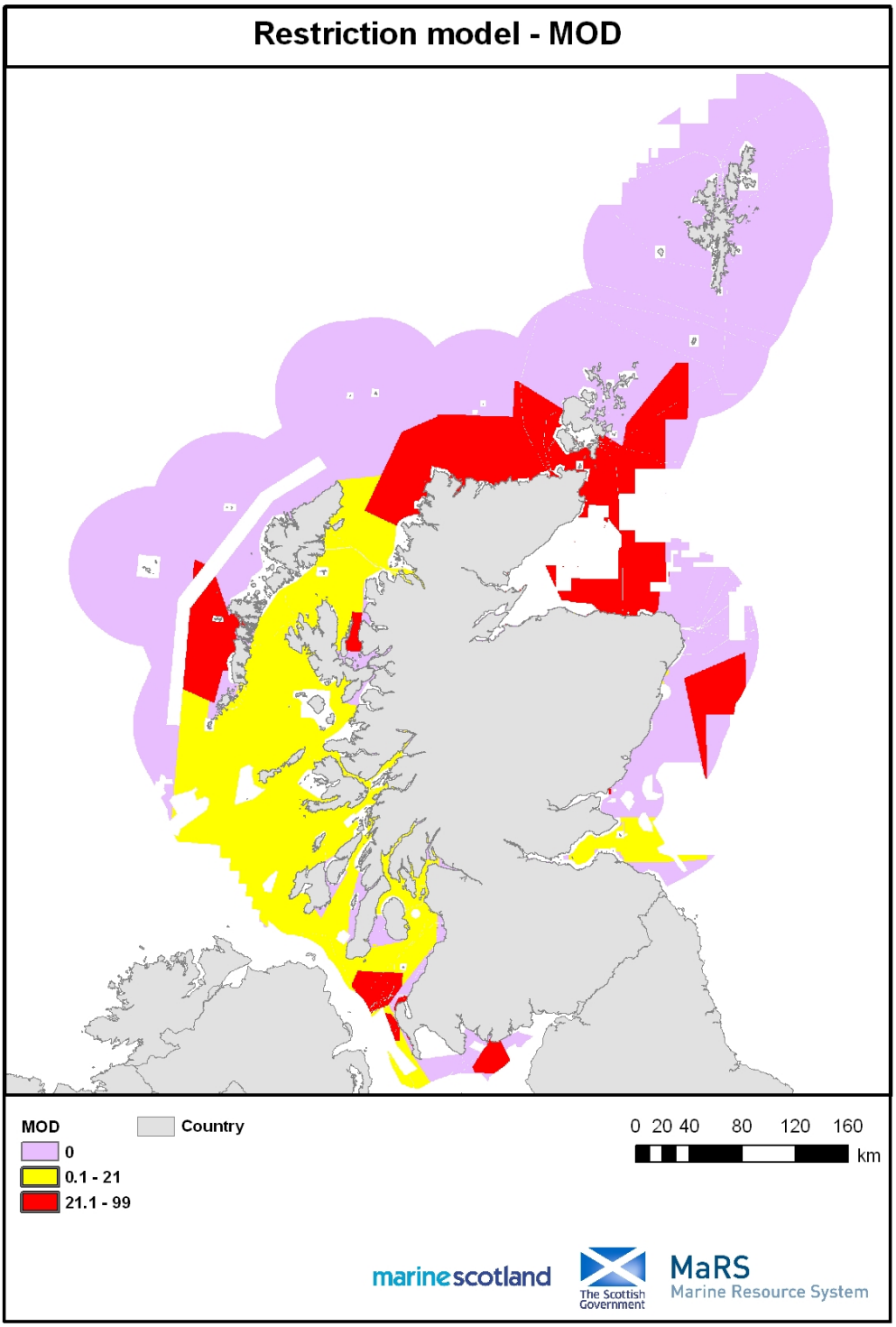

Figure AIII – 6 Raw output from the MOD restriction model. This model was not normalised and not included in the final models. Yellow areas are MOD practice areas, red are MOD danger areas and white areas are exclusions

ANNEX IV

Quality Assurance Check Record

Each model produced was checked by TCE and MSS for quality assurance.

TABLE AIV - 1

Quality assurance of each model produced and the weights and scores within them (labelled ‘y’ if checked).

Model Name	Type	Weight	Score
Environment	Restriction	y	y
Environment	Exclusion	y	y
Recreation	Restriction	y	y
Recreation	Exclusion	y	y
MOD	Restriction	y	y
MOD	Exclusion	y	y
Shipping	Restriction	y	y
Shipping	Exclusion	y	y
Fishing (commercial)	Restriction	y	y
Spawning and Nursery Grounds	Restriction	y	y
Heritage	Exclusion	y	y
Commercial	Exclusion	y	y
Technical - Wave	Exclusion	y	y
Technical - Tide	Exclusion	y	y
Scenario - Equal Weight	Restriction	y	y
Scenario - Environmental	Restriction	y	y
Scenario - Industry (I)	Restriction	y	y
Scenario - Industry (II)	Restriction	y	y
Saltire Prize Exclusion All Themes	Exclusion	y	y