A review of practical deployment locations for European ocean energy projects

EVOLVE technical note: RADMApp modelling study

Produced by the EVOLVE Consortium

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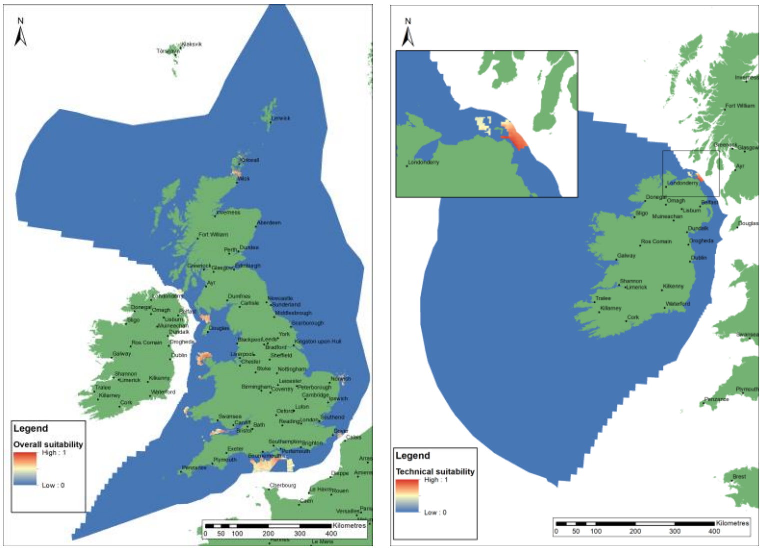
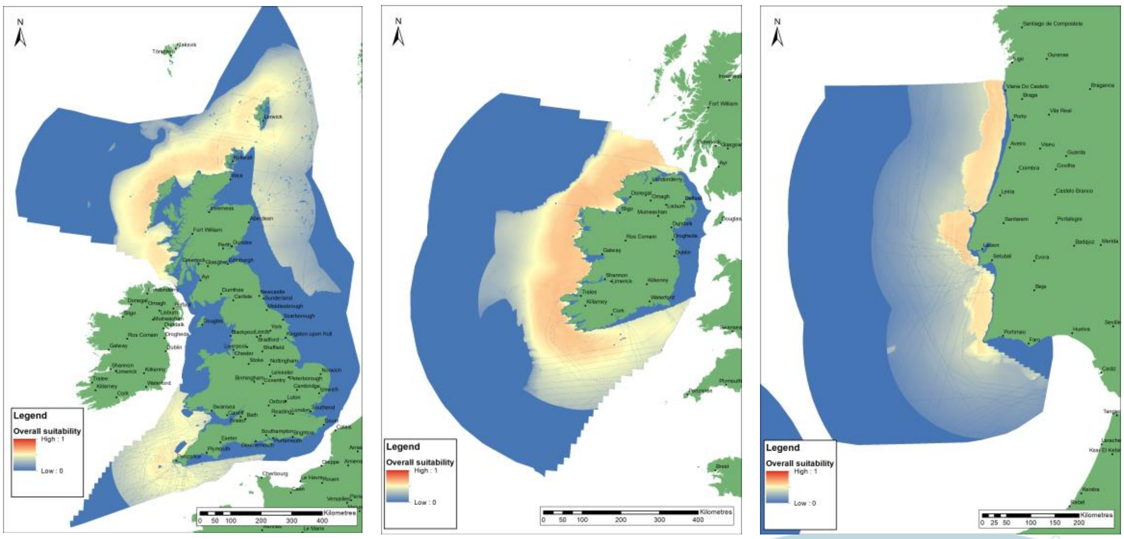
SUMMARY - POTENTIAL DEPLOYMENT LOCATIONS FOR EUROPEAN OCEAN ENERGY PROJECTS

In this technical note, Aquatera's RADMApp GIS modelling tool was used to identify suitable areas for the practical deployment of wave and tidal stream devices at each of the case study areas of Great Britain (GB), Ireland (IE) and Portugal (PT). Scoring criteria were applied over four layers: technical, cost, environmental, and other sea users. The results presented here are based on a multiplicative combination strategy of these layers to produce an overall suitability score.

For tidal stream energy devices, areas of suitability have been found to be focused at specific sites around the British Coastline and around Rathlin Island in Northern Ireland. **For tidal stream energy, Great Britain is expected to have a practical suitability up to 10.4GW and Ireland is expected to have up to 630 MW,** with Portugal not having a high enough tidal technical resource to be considered for this study.



For wave energy devices, results reveal that northern and western Scottish waters, southwest England and Wales, the west of Ireland, and around Lisbon and the northwest of Portugal have the highest suitability. **Overall, the results reveal practical suitability of 24.8 GW in Great Britain, 18.8 GW Ireland and 15.5 GW in Portugal for wave energy devices.**



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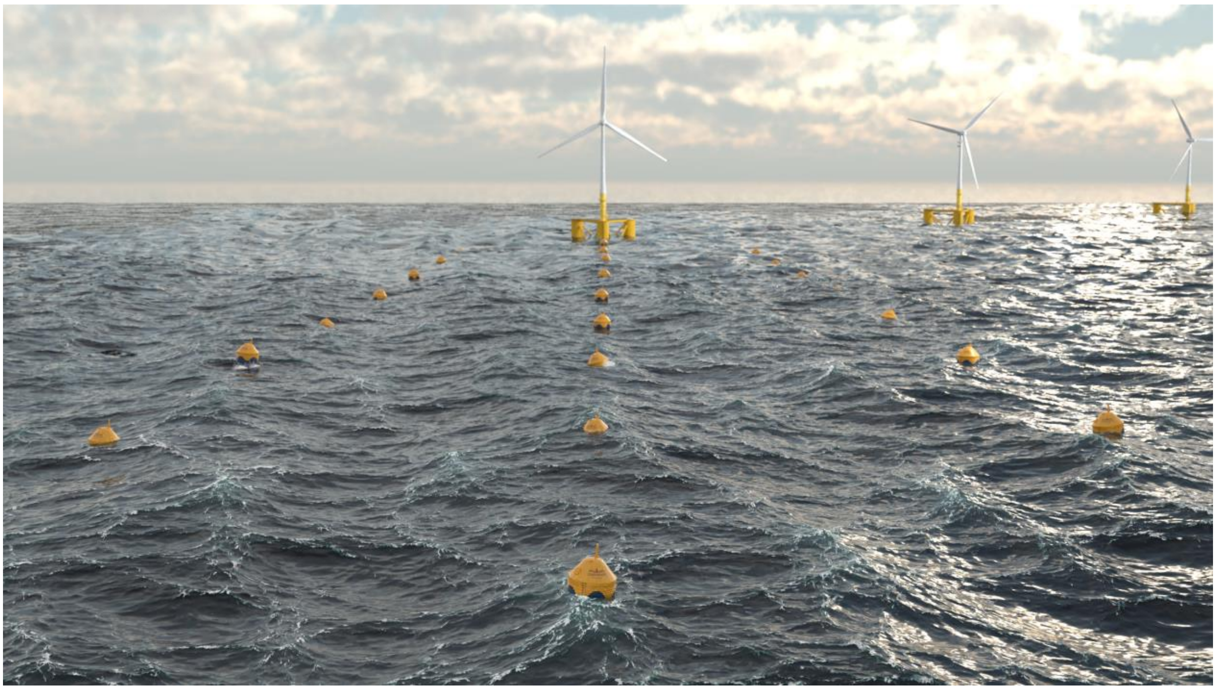

Simulated combined wind and wave farm (Image courtesy of CorPower Ocean AB)

1 INTRODUCTION

The EVOLVE project is funded through the OCEANERA-NET Cofund, with project partners from Scotland, Sweden and Portugal. The key objective of the EVOLVE project is to analyse the overall market value of including ocean energy in the European energy mix; ocean energy here being defined as tidal stream and wave energy. The project has focused on three European regions of interest: Great Britain (GB), Ireland (IE) and Portugal (PT).

Three key studies have been undertaken throughout the EVOLVE project, examining:

- The practical deployment potential for wave and tidal stream technologies in the EVOLVE regions of interest;
- The quantifiable system benefits (in terms of economics, carbon reduction and power system operation) of wave and tidal stream deployments in the EVOLVE regions of interest and;
- The potential role of wave and tidal stream within 100% renewable islanded systems, utilising the Orkney Islands, Scotland, as a case study.

This technical note summarises the first of these studies: a suitability analysis undertaken with the purpose of gaining an understanding of the potential future deployment locations for wave and tidal stream in the EVOLVE regions of interest. The expertise of the EVOLVE consortium is particularly well suited to this, as Aquatera have years of experience working in the marine renewable sector and conducting similar suitability assessments. The consortium also contains the expertise of an active wave technology developer (CorPower Ocean) and an active tidal stream technology developer (Orbital Marine Power). Figure 1 illustrates these wave and tidal technologies.

The work presented in this technical note has the following aims:

- Develop scoresheet inputs to RADMApp models representing three European regions (GB, IE, PT).
- Evaluate the future deployment potential for wave and tidal stream in each EVOLVE region, and the best locations in which these deployments could practically take place.

This analysis has been performed using Aquatera's in-house spatial mapping and data analysis tool known as 'RADMApp'. This raster-based spatial modelling framework aids the decision-making process for a variety of different scenarios through the provision of a universally comparable system for classifying suitability levels based on a range of criteria. This framework was exploited for the EVOLVE research to determine potential deployment locations for ocean energy devices for each of the case study areas including Great Britain, Ireland and Portugal. The results from this study are then used as inputs to the power system benefits studies, in which the hourly ocean energy availability profiles are based on the suitable deployment sites identified.

Figure 1. Ocean energy devices: CorPower Ocean's point-absorber WEC (left) and Orbital Marine Power's floating tidal device (right).

2 METHOD

A summary of the methodological framework for the suitability process is illustrated in Figure 2. The suitability for wave and tidal stream deployments has been analysed over three regional case studies, covering the electricity grids of Great Britain (GB), Ireland (IE), and Portugal (PT). It should be noted that the GB grid covers England, Wales, and Scotland; whilst the IE grid covers Northern Ireland and the Republic of Ireland (Éire).

Aquatera's RADMApp (Resource Analysis and Digital Mapping Application) package provides a GIS based framework for data analysis which is used as a powerful site selection tool. It is a raster-based GIS framework for data analysis which can be applied to many different scenarios. The tool helps to establish a robust framework by seeking to identify the key decision factors and providing a universal and comparable system for classifying the levels of suitability for each of these criteria. RADMApp has been used to determine the best deployment locations for ocean energy devices in the three selected EVOLVE regions of interest.

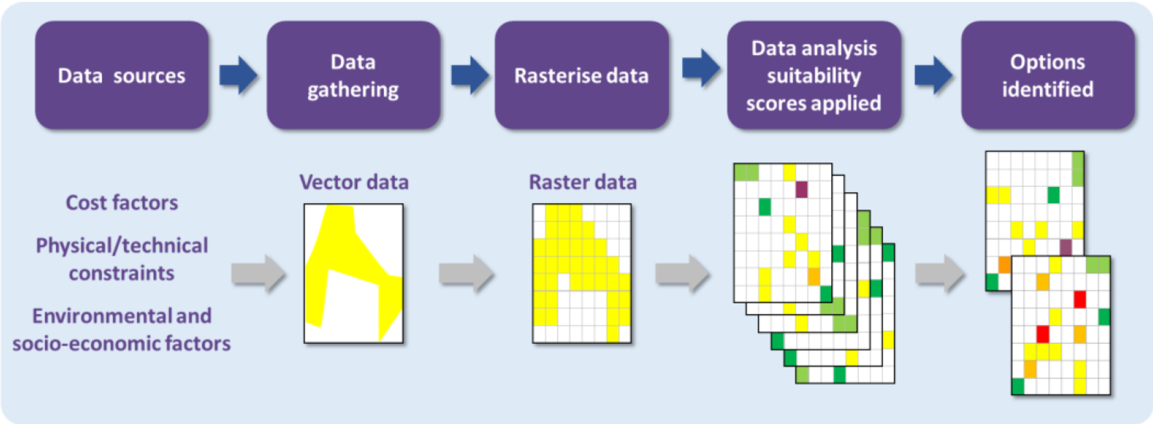

Figure 2. Suitability analysis methodological framework.

First, data sources were identified, and a comprehensive data catalogue was developed. The data were then classified into categories including 'cost', 'technical', 'environmental' and 'other sea users'. These factors were then used to determine the suitability of deploying each of the devices at each case study area. All data sets were rasterised and pre-processed to ensure they contained the same extent, resolution and referencing system enabling them to be compared, analysed, modelled, and combined. A 250m × 250m square grid cell resolution was used for this analysis. Based on the experience of the partners, each parameter was assigned a suitability score between 0 and 1, with scores of 1 representing areas of high suitability and scores closer to 0 representing areas of lower suitability. The completed scoresheets for this analysis can be found in the appendix. Values of 0 were assigned to parameters that were deemed an absolute constraint, to ensure they were removed from the results. The layers were then combined using a multiplicative combination strategy to provide an overall suitability score for each grid cell in the study area and for each device, illustrated in Figure 3. The results were then normalised to avoid extremely small values and to ensure the results were comparable between the different data layers. Maps were then generated to display the overall results of the suitability model.

As part of the technical parameters for wave, potential gross energy outputs were calculated for each 250 m^2 cell within the model. To achieve this, 5 years of hindcast wave data (e.g. [1]) at 3-hour intervals were compared with predicted energy outputs from the appropriate sea states in CorPower Ocean's power matrix. Comparing this to the potential 100% power output over a 5-year period provided a gross capacity factor for a wave device if it were to operate in a particular 250 m^2 cell. As the wave resource would be reduced in the shadow of devices at the wave front, it was determined that the maximum depth of a wave array that could feasibly deployed was 2 km. Therefore, based on the results of the overall suitability modelling, a device "front", 2 km in width was calculated for the areas of study.

For the tidal analysis, suitable sites were identified as described above, with a simple resource requirement of a minimum mean annual spring speed being achieved. For each of these potential sites, additional analysis was carried out determining the speed and volume of water travelling through each tidal channel, or stream. This provided an overall indication of the power available within each stream for each minute of a 14 day spring/neap tidal cycle. Power curves for the device in question were then used to determine how much energy could be technically extracted for each potential tidal stream location.

The key inputs and assumptions associated with this methodology can be summarised as:

- A 250 m resolution was determined suitable for the RADMApp model based on the overall size of the study area, the availability of data, and the processing requirements.
- Ocean energy devices considered:
    - **Wave:** CorPower Ocean (CPO) 400kW point-absorber Wave Energy Converter (WEC), shown in Figure 1 (left)
    - **Tidal:** Orbital Marine Power floating horizontal axis 2 MW device, also shown in Figure 1 (right)
- The parameters considered for each of the following categories:
    - **Technical:** Bathymetry, sediment depth, tidal stream speed, weather windows, survivability, gross potential capacity factor, seabed type.
    - **Cost:** Distance to land, distance to grid connection, distance to construction port, distance to maintenance port.
    - **Environmental:** Marine conservation areas, marine protected areas, Ramsar sites, Special Areas of Conservation (SAC), Special Protected Areas (SPA), visibility from coast, distance from areas designated for visual amenity e.g. Areas of Outstanding Natural Beauty (AONBs) or National Scenic Areas (NSAs).
    - **Other sea users:** Cables, pipelines, oil and gas infrastructure, existing renewable leases, shipping density, fishing efforts and military exercise areas.

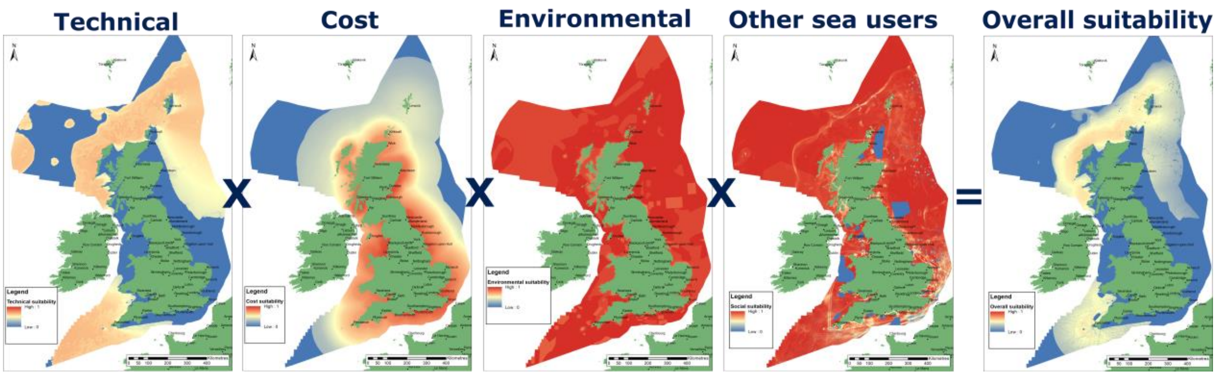

Figure 3. Illustration of combination of suitability maps to create overall suitability. Example maps from GB wave case study.

3 RESULTS

3.1 SUITABILITY MAP LAYERS

Before detailing the regional results, it is interesting to examine a few general results found for the different suitability layers for wave and tidal stream devices:

- The areas of highest **technical suitability** vary by technology. Those for tidal stream resource are focused on a mixture of inter-island channels and prominent headlands with fast currents. For wave resource, they are located in exposed waters to the west of each region within the Atlantic ocean.
- Areas of highest **cost suitability** for ocean energy deployments are those closer to the coastline, as they are dependent on the costs associated with cabling, and proximity to existing markets and ports.
- In terms of **environmental suitability,** sites designated for environmental protection do not necessarily prohibit the possibility of ocean energy device installation. The scoring is weighted towards non-designated areas, but does not exclude the possibility of deployments within any environmentally protected area.
- Finally, there are several areas within each region largely constrained for development due to **other sea users**, such as military exercise areas, cables, pipelines and shipping lanes.

3.2 GREAT BRITAIN

Figure 4 and Figure 5 show the overall suitability maps for tidal stream and wave, respectively, in Great Britain. The four suitability layer maps for wave energy are also included in Figure 3 in the previous section. It can be seen that the areas of highest suitability for tidal stream developments are focused around several specific points on the British coastline and Orkney Islands. The areas of highest suitability for wave deployments are located in western and northern Scottish waters and towards the southwest of England and Wales. In terms of specific areas of interest, the areas of greatest practical deployment potential for tidal stream are in the north of Scotland, around the Pentland Firth, and the areas of greatest practical deployment potential for wave are located west of the Outer Hebrides, shown in Table 1.

Overall, the model estimates GB to have a total suitability for 24.8 GW of wave energy and up to 10.4 GW of tidal energy.

Figure 4. Overall suitability map for tidal stream in Great Britain, with regions of highest resource labelled.

Figure 5. Overall suitability map for wave in Great Britain, with regions of highest resource labelled.

Table 1. Wave energy practical deployment capacity for Great Britain.

Area	Installed Capacity	Gross annual output
West of Shetland	2.6 GW	13.5 TWh
West of Orkney	4.1 GW	16.6 TWh
Lewis and Cape Wrath	5.4 GW	25.5 TWh
Outer Hebrides	5.3 GW	25.0 TWh
Southern Inner Hebrides	2.6 GW	9.5 TWh
Cornwall	2.7 GW	8.0 TWh
Scilly Isles	2.1 GW	8.6 TWh
Total	**24.8 GW**	**106.7 TWh**

Table 2. Tidal stream's practical deployment capacity for Great Britain.

Area	Installed Capacity (10% tech.limit)	Installed capacity (20% tech. limit)	Gross annual output (10% tech. limit)	Gross annual output (20% tech. limit)
Shetland	82 MW	164 MW	0.2 TWh	0.4 TWh
Pentland Firth	3,098 MW	6,196 MW	11.3 TWh	22.6 TWh
Orkney Islands	294 MW	588 MW	0.7 TWh	1.4 TWh
Southern Inner Hebrides	345 MW	690 MW	0.7 TWh	1.4 TWh
Kintyre Peninsula	232 MW	464 MW	0.1 TWh	0.2 TWh
Mull of Galloway	119 MW	238 MW	0.1 TWh	0.2 TWh
Anglesey & North Wales	94 MW	188 MW	0.2 TWh	0.4 TWh
Bristol Channel	165 MW	330 MW	0.1 TWh	0.2 TWh
South of England	796 MW	1,592 MW	0.7 TWh	1.4 TWh
Total	**5.2 GW**	**10.4 GW**	**14.1 TWh**	**28.2 TWh**

Additional sensitivity analysis has also been undertaken for both wave and tidal suitability, to explore the impact on the results of considering a different type of wave energy converter (attenuator, rather than point absorber), different sizes of tidal stream rotors, and a different type of tidal stream device (bottom-mounted smaller kW-scale device, rather than floating large MW-scale device). The results of this sensitivity for GB can be summarised as:

- The attenuator WEC analysis showed areas of highest suitability towards the north and northwest of Scotland. Levels of suitability are much lower for the available attenuator device data (Pelamis) device compared to the CPO device, primarily because it extracts less energy at less energetic sea states.
- It was found that the potential energy that can be extracted from the tidal sites would increase with increased rotor diameters. However, the number of suitable areas decrease as water depth restricts the areas where the larger rotor tidal devices can be installed.
- A smaller-scale tidal stream device could potentially exploit more sites than a larger-scale device, as it is impacted less by spatial constraints. Further work utilising cost data from a specific device would be needed to explore which of these additional sites could be economically feasible, however.

3.3 IRELAND

Figure 6 shows the overall suitability map for tidal stream for Ireland. The key area with suitability for tidal stream in Irish waters is around Rathlin Island off the northern coast of Northern Ireland, this is largely due to the technical suitability of the resource. Two smaller sites have also been identified for the Republic of Ireland, at Wicklow Head and Mizen Head. Other potential sites may be in sea loughs or in river systems, but these have not been included in the analysis due to the scale of the modelling. There are other potential tidal stream sites located off the southwest of the Irish coastline, but the exposure afforded by the large waves of the Atlantic ruled these out. Overall, the model estimates Ireland to have a practical suitability of up to 630 MW of tidal energy, shown in Table 3.

Figure 7 shows the overall suitability map for wave energy for Ireland. Due to the exposure to the Atlantic Ocean, areas towards the west coast of Ireland present highest suitability for wave energy deployments. Areas surrounding large cities such as Dublin, Cork and Belfast have lower suitability due to shipping lanes and port areas. Overall, the model estimates Ireland to have around 18.8 GW of wave energy, as shown in Table 4.

Table 3. Potential tidal stream locations around Ireland.

Stream name	Location	Orbital O20 Installed capacity	Extractable annual energy
Rathlin Island	Northern Ireland	132 MW	207 GWh
Rathlin Sound	Northern Ireland	92 MW	190 GWh
Wicklow Head	East of Wicklow	271 MW	149 GWh
Mizen Head	SW Cork	135 MW	82 GWh
Total		**630 MW**	**628 GWh**

Table 4. Regional wave practical resource capacity for Ireland.

Area	Installed Capacity	Gross annual output
Donegal	5.1 GW	21.7 TWh
Mayo and Galway	7.3 GW	37.2 TWh
North Kerry	1.4 GW	5.9 TWh
West Kerry and Cork	5.1 GW	24.9 TWh
Total	**18.9 GW**	**89.7 TWh**

Figure 6. Overall suitability map for Ireland tidal stream, with regions of highest resource labelled.

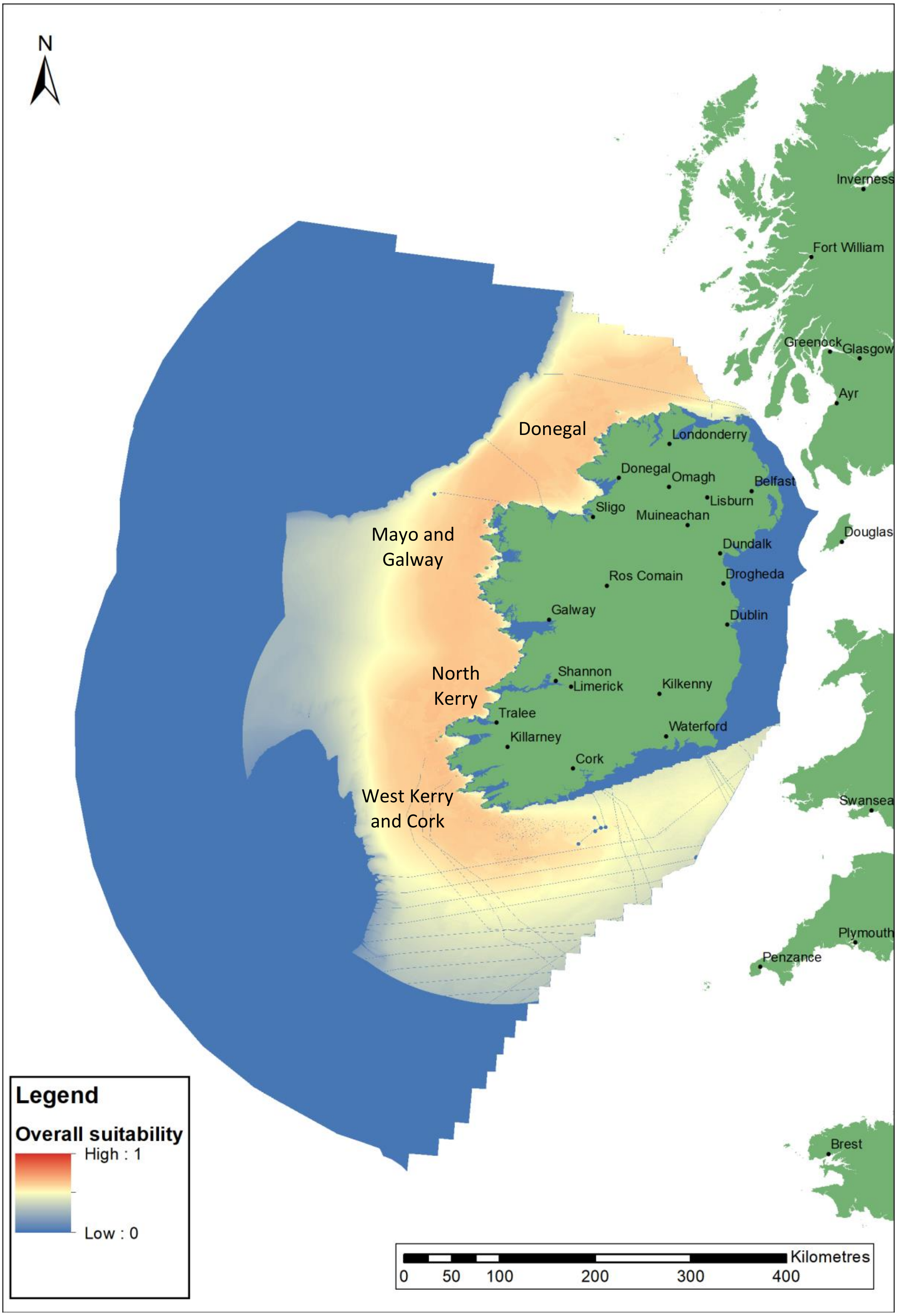

Figure 7. Overall suitability map for Ireland wave energy, with regions of highest resource labelled.

3.4 PORTUGAL

Figure 8 shows the overall suitability map for wave energy in Portuguese waters. It can be seen that the overall suitability for wave energy in Portugal is primarily close to the western coast, with hotspots located adjacent to the cities of Porto and Lisbon. Suitability then decreases with distance from coastline. Areas towards the south of Portugal present a much lower suitability due to the sheltering effect afforded by the Iberian Peninsula to the predominant direction of waves. In general, the capacity factors for wave energy in Portugal is more moderate, due to the overall smaller waves present compared to Britain and Ireland. In terms of other sea users it should also be noted that nearshore waters show some patterns of heavy vessel traffic and hotspots of fishing activity, particularly the west coast south of Porto and off the southern coast of the Algarve.

In total, the model estimates Portugal to have 15.5 GW of wave energy, shown in Table 5.

It should be noted that no results are shown for Portugal regarding tidal energy, as there is no significant resource available in Portuguese waters.

Table 5. Regional wave energy capacity for Portugal.

Area	Installed Capacity	Gross annual output
Viana do Castelo, Braga, and Porto	2.6 GW	9.2 TWh
Aveiro	1.6 GW	6.8 TWh
Coimbra and Leiria	2.9 GW	11.6 TWh
Peniche peninsula	0.6 GW	2.6 TWh
Lisboa	3.0 GW	11.5 TWh
Setúbal, Beja, and Faro	4.7 GW	15.6 TWh
Total	**15.4 GW**	**57.3 TWh**

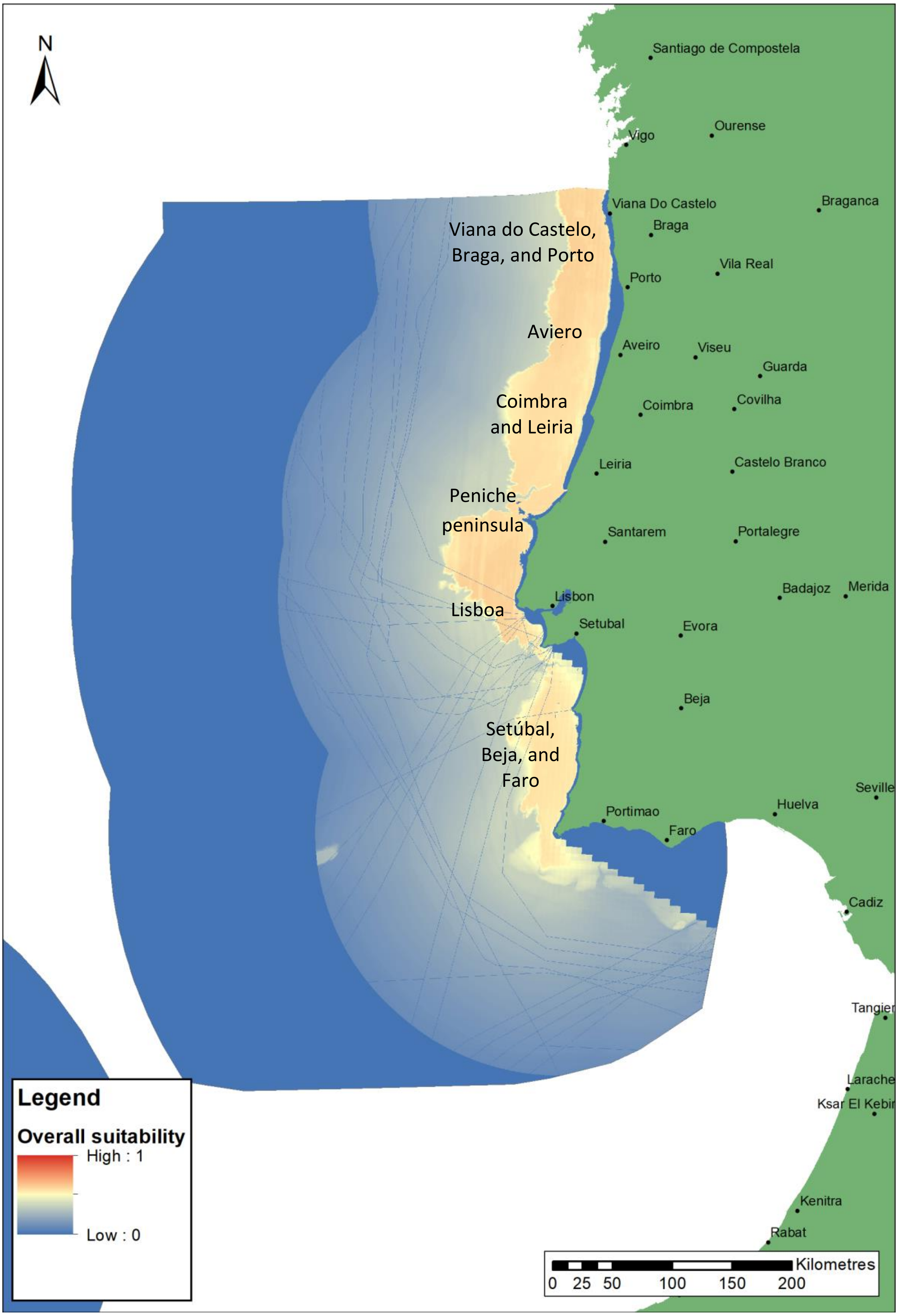

Figure 8. Overall suitability map for Portugal wave energy, with regions of highest resource labelled.

4 DISCUSSION

It is of interest to compare the findings from this study to those in previous research studies, for validation of the outputs. However, it should be noted that sometimes results can be difficult to compare between studies if the methodologies are not completely aligned, for example if they do not account for the same criteria when selecting suitable site locations.

It should be noted that as the results of the analysis are based on country-wide models at a 250 m resolution, it is not possible to provide a level of analysis to the same degree of certainty compared to a site-specific study where data is utilised at a sub-1 m resolution. The values presented here, should not, therefore, be taken as exact, or the locations of potential development prescriptive. The model also makes use of other third party modelled data. This is specifically relevant for the resource properties of wave and tidal regimes where modelled values will never be as accurate as remotely sensed recordings.

That said, the modelling process has endeavoured to be as transparent as possible, and the uncertainties outlined above would only mean suitable locations may not be in the exact locations presented, but would be in the immediate vicinity.

Carrying out such a study on countrywide basis has meant that certain aspects could not be incorporated into the model, such as the potential for river systems to add to tidal stream capacity, or detailed data on seabed "roughness" to determine if certain areas are in fact unsuitable for anchoring. The resolution also meant that in terms of the tidal stream model, certain streams would have been omitted due their narrow widths. Every diligence has been taken however, to revisit such sites and ensure that they have been included in the results. That said more focused analysis on specific geographical areas at a higher resolution with detailed analysis of tidal flow sites is likely to uncover additional potential resource.

Finally, it should be said that the results of the model are not intended as a recommendation for the exact locations where developments should take place. The model is meant as a comparative tool to show the pros and cons of all areas of the sea for development. Whilst in most cases, this is assessed qualitatively with respect to installation depths and required resource patterns, certain parameters are more subjective. Areas such as fishing grounds or environmental designations will have scored lower in this model, as it is our assumption that development could take place with less difficulty and disturbance elsewhere. However, there is no reason why a developer may not look to develop in such an area if he feels that the potential impacts can be suitably mitigated.

In general, the results presented in this study are comparable with the existing literature, but also can be used to fill some gaps, with the calculation of the practical deployment potential for each of the EVOLVE regions.

Specifically, the results from this study compare with the literature as:

- This study found that the practical potential deployment of wave energy in Great Britain could be up to 24.8 GW. These results are in close agreement with three studies: [2] (27 GW), [3] (26 GW) and [4] (23GW), although it is understood that these studies do not account for other sea users or environmental factors.
- This study found that the practical potential deployment of tidal stream in Great Britain could be up to 10.4 GW. These results are consistent with two studies: [19] (11.5GW) and [4] (15GW). The largest potential site locations around the Pentland Firth and Orkney islands are also well understood in the literature [5], [6].

- This study found that the practical potential deployment of wave energy in Ireland could be up to 18.8 GW (89.8 TWh). In 2005, the Sustainable Energy Authority of Ireland (SEAI) conducted a study and found that the theoretical wave energy potential in Ireland was around 525 TWh [7]. No results are available for the actual potential installed capacity which could be comparable to the Evolve results, as no other practical resource studies of wave energy in Ireland have been undertaken.
- This study found that the practical potential deployment of tidal stream in Ireland could be up to 630 MW. The viable resource has been calculated in the literature at 0.915 TWh/y [8], which approximately matches with the viable resource calculated for this study of 0.628 TWh/y.
- This study found that the practical potential deployment of wave energy in Portugal could be up to 15.5 GW, hotspots located adjacent to the cities of Porto and Lisbon. This result is coherent with two studies [9], [10] which show the highest potential for the Aguçadoura region between Viana do Castelo and Porto.

The spatial modelling carried out via RADMApp has identified a large potential for marine tidal energy development in North West Europe and as part of the wider studies helped determine the potential contribution of ocean energy in the future. As highlighted earlier in this section, there are improvements that could be made as part of future work that would look to refine the modelling carried out. Potential studies include, but are not limited to:

- higher resolution analysis of tidal streams in the main areas identified, taking account of morphological changes in the seabed to achieve a more accurate estimation of extractable tidal stream energy potential;
- further analysis of the wave shadow cast by devices, allowing a better understanding of the potential installed capacity and how it would vary with wave height and period variation;
- inclusion of river systems as a potential contributor to the tidal stream market;
- analysis of other ocean energy sources such as floating solar and tidal impoundment;
- extending the analysis to the whole of the European waters.

5 CONCLUSIONS

In this study, Aquatera's RADMApp modelling tool has been used to identify suitable areas for the practical deployment of wave and tidal energy devices at each of the EVOLVE project regions of interest (Great Britain, Ireland and Portugal).

For wave energy, the areas of highest suitability were found to be northern and western Scottish waters, southwest England and Wales, the west coast of Ireland, and around Lisbon and the northwest of Portugal. For tidal energy, areas of suitability are more focused on a mixture of inter-island channels and prominent headlands, particularly around the Orkney Islands and the Pentland Firth in Great Britain and around Rathlin Island in Northern Ireland.

Overall, the results for wave energy devices reveal a practical deployment potential of 24.8 GW in Great Britain, 18.8 GW Ireland and 15.5 GW in Portugal. For tidal energy, Great Britain is expected to have up to 10.4 GW and Ireland is expected to have up to 630 MW. The lack of tidal stream resource means that there are no areas identified in Portugal for tidal developments.

It has been shown that these results are in line with what previous studies have forecast, even though some methodological differences can make it difficult to make fair comparisons between studies. These results show a great potential for the three regions to further develop the possibilities of increasing the amount of wave and tidal energy into their respective energy mixes.

Finally, two further technical notes have been published by the EVOLVE project, showing the potential system benefits of deploying ocean energy at both a country-scale for the three EVOLVE regions of interest, and at an islanded microgrid level. These studies have found that increasing the proportion of wave and/or tidal stream within high-renewable future power systems results in a higher availability of renewable energy, and thus lower dispatch costs and carbon emissions.

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APPENDIX A WAVE AND TIDAL STREAM SCORESHEETS

A.1 TECHNICAL PARAMETERS

Category	Data Set	Subset	Wave CorPower	Tidal Orbital
Technical	Bathymetry (m)	> -5	0	0
		-5 to -10	0	0
		-10 to -20	0	0
		-20 to -35	0	0.8
		-35 to -40	1	1
		-40 to -50	1	1
		-50 to -75	1	0.8
		-75 to -100	1	0.6
		-100 to -150	1	0.4
		-150 to -200	1	0.2
		-200 to -300	1	0
		-300 to -400	1	0
		-400 to -500	1	0
		< -500	0.2	0
	Sediment Depth (m)	<5 (Sediment veneer)	1	1
		>5	1	0.8
	Tidal stream speed (m/s)	< 0.25	1	0
		0.25 to 0.5	1	0.2
		0.5 to 1	1	0.4
		1 to 1.5	1	0.6
		1.5 to 2	1	0.8
		2 to 2.5	1	1
		2.5 to 3	1	1
		3 to 3.5	1	1
		3.5 to 4	1	1
		4 to 4.5	1	1
		4.5 to 5	1	1
		5 to 5.5	1	1
		5.5 to 6	1	1
		> 6	1	1
	Number of good wave weather windows (A weather window is considered good if it lasts 6h and Hs is less than 2 m)	< 250	0	NA
		250 to 350	0.2	
		350 to 500	0.4	
		500 to 750	0.6	
		750 to 1000	0.8	
		> 1000	1	
	Mean Annual Wave Height (m) (survivability)	< 2	NA	1
		2 to 3		0.8
		3 to 4		0.5
		> 4		0
	Gross Potential Capacity Factor (Wave Devices)	0%	0	1
		20%	0.2	1
		60%	0.6	1
		80%	0.8	1
		100%	1	1
	Seabed type	Rock	1	1
		Gravel	0.8	0.8
		Sand	1	0.8
		Mud	1	0.8

A.2 COST PARAMETERS

Category	Data Set	Subset	Wave	Tidal
			CorPower	Orbital
Cost	Distance to land (km)	< 1	1	1
		1 to 5	1	0.9
		5 to 10	1	0.8
		10 to 20	1	0.7
		20 to 30	1	0.6
		30 to 40	1	0.5
		40 to 50	1	0.4
		50 to 100	0.9	0.3
		100 to 200	0.7	0.2
		> 200	0.1	0.1
	Distance to grid connection point (km)	< 1	1	1
		1 to 5	1	0.9
		5 to 10	1	0.8
		10 to 20	1	0.7
		20 to 30	1	0.6
		30 to 40	1	0.5
		40 to 50	1	0.4
		50 to 100	0.9	0.3
		100 to 200	0.7	0.2
		> 200	0.1	0.1
	Distance to Construction Port (km)	< 1	1	1
		1 to 5	1	0.9
		5 to 10	1	0.8
		10 to 20	1	0.7
		20 to 30	1	0.6
		30 to 40	1	0.5
		40 to 50	1	0.4
		50 to 100	1	0.3
		100 to 200	0.9	0.2
		> 200	0.8	0.1
	Distance to Maintenance Port (km)	< 1	1	1
		1 to 5	1	0.9
		5 to 10	1	0.8
		10 to 20	1	0.7
		20 to 30	1	0.6
		30 to 40	1	0.5
		40 to 50	1	0.4
		50 to 100	0.9	0.3
		100 to 200	0.7	0.2
		> 200	0.1	0.1

A.3 ENVIRONMENTAL PARAMETERS

Category	Data Set	Subset	Wave	Tidal
			CorPower	Orbital
Environmental	Marine Conservation Zone (MCZ)	Yes	0.8	0.4
		No	1	1
	Marine Protected Area (MPA)	Yes	0.8	0.4
		No	1	1
	Ramsar	Yes	1	1
		No	1	1
	Special Area of Conservation (SAC)	Yes	0.2	0.7
		No	1	1
	Special Protection Area (SPA)	Yes	0.7	0.7
		No	1	1
	Visibility from coast	Yes within 5km	0.9	0.6
		Yes within 10km	1	0.9
		Yes within 20km	1	1
		No	1	1
	Visibility from Areas of Outstanding Natural Beauty/NSA	Yes within 5km	0.7	0.6
		Yes within 10km	1	0.8
		Yes within 20km	1	1
		No	1	1

A.4 OTHER SEA USERS

Category	Data Set	Subset	Wave	Tidal
			CorPower	Orbital
Other Sea Users	Cables	Yes	0	0
		No	1	1
	Pipelines	Yes	0	0
		No	1	1
	Oil and Gas Infrastructure	Yes	0	0
		No	1	1
	Existing Renewable Leases	Yes	0	0
		No	1	1
	Shipping Density (vessels per day)	< 0.01	1	1
		0.01 to 0.1	0.8	1
		0.1 to 0.2	0.6	0.6
		0.2 to 0.5	0.4	0.4
		0.5 to 1	0.2	0.2
		1 to 5	0.1	0.1
		> 5	0	0
	Fishing Effort	Very Low	1	1
		Low	0.8	0.8
		Medium	0.6	0.6
		High	0.4	0.4
		Very High	0.2	0.2
	Military Exercise Area	Submarine	0.7	0.7
		Naval Manouevres	0.6	0.6
		Bombing and firing	0	0
		Low Flying	1	1