NAFC Marine Centre
University of the Highlands and Islands

The Scottish Government

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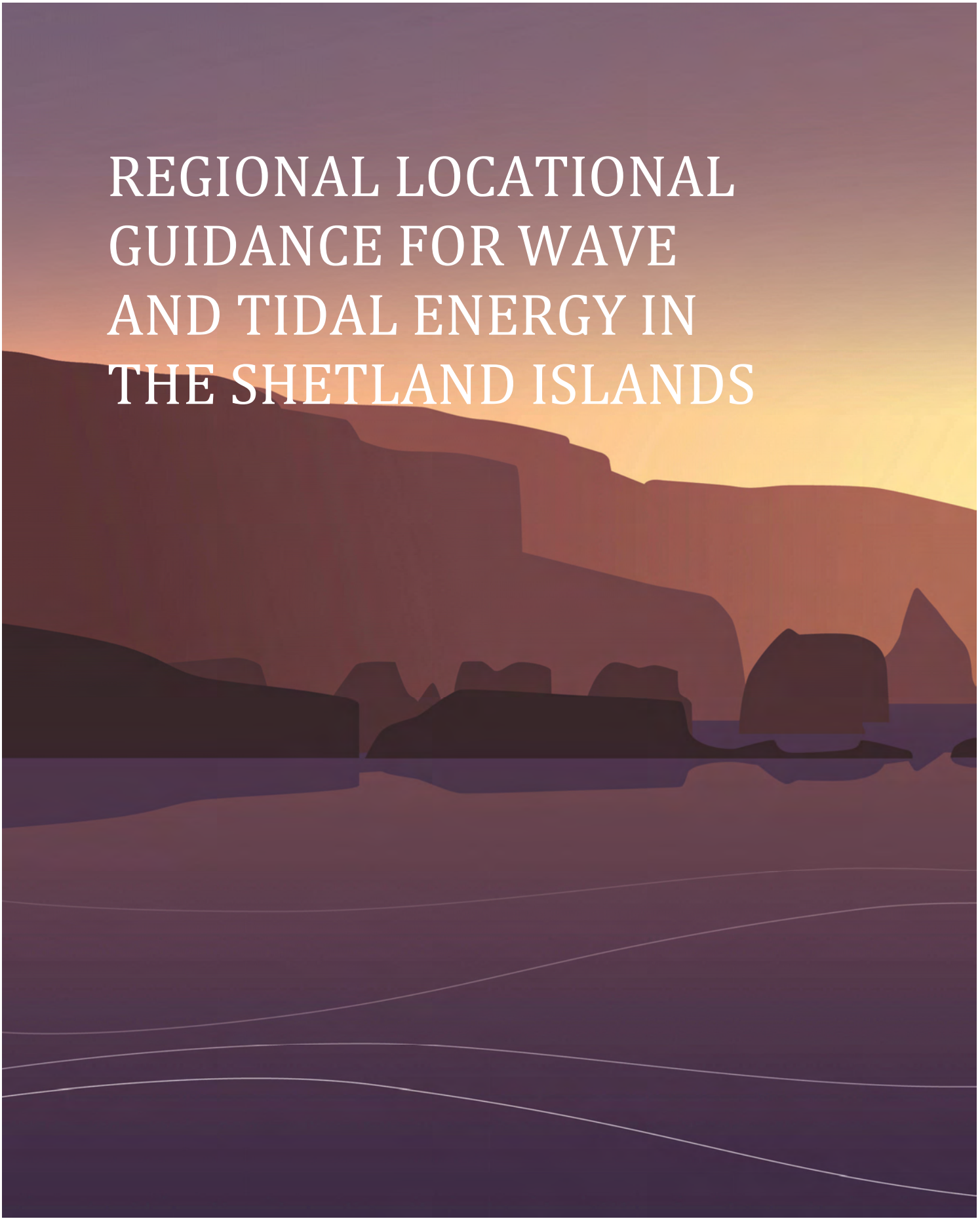
REGIONAL LOCATIONAL GUIDANCE FOR WAVE AND TIDAL ENERGY IN THE SHETLAND ISLANDS



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This document is available from our website at http://www.nafc.ac.uk/SSMEI.aspx
http://www.nafc.ac.uk/Shetland-Marine-Energy-Development.aspx

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1. Context

Over the last decade, the marine renewables industry has been subject to significant research and development investment, driven by increasing concerns over climate change and energy security. The Scottish Government has set a target of 30% of total energy demand being met by renewable sources by 2020, to be achieved by renewables satisfying 100% of electricity demand (31% by 2011), and 11% of heat demand (Scottish Government, 2011). It is anticipated that marine renewable energy sources (tidal and wave power) will play an important role in reaching these objectives. Whilst the development of a marine renewables industry is generally looked upon favourably, consideration must be given to potential environmental and social impacts, as well as conflicts with other users.

The Shetland Islands have been identified as having potential for both tidal and wave powered developments (Scottish Government, 2007; Natural Power, 2011). Figure 1 illustrates the tidal resource around Shetland, and Figure 2 illustrates the wave resource. The development of a large scale renewable industry in Shetland is currently limited by the absence of an interconnector to the UK national grid. However, it is anticipated that an interconnector will be in place by 2016/2017, and there is increasing interest in the development of the renewables industry in Shetland. Within Shetland, developers must gain both a Works Licence, issued by the Shetland Islands Council, and a Marine Licence, issued by Marine Scotland. One exploratory Works Licence has been granted by the Shetland Islands Council for a wave energy device, and a Works Licence and Marine Licence have been granted for a small scale, community owned tidal energy device.

It is anticipated that the number of licence applications for renewable devices around Shetland will increase in the future. To help guide the placement of renewable energy developments and associated cable landings, ArcGIS® has been used to map and integrate spatial data on resource opportunities and development constraints. This assessment incorporates environmental, social and economic considerations into the site selection process for marine renewable energy.

This guidance will form part of the 'The Marine Spatial Plan for the Shetland Islands' which has guided the siting of marine developments in Shetland since 2008 (NAFC, 2012). The Shetland Marine Spatial Plan (SMSP) contains spatial data on the marine and coastal environment and its uses, in addition to establishing an overarching policy framework. The spatial extent of the plan includes all territorial waters seaward of mean high water springs, out to 12 nautical miles, but also includes onshore habitats / ecological processes that are clearly affected by marine developments, such as cable landing sites.

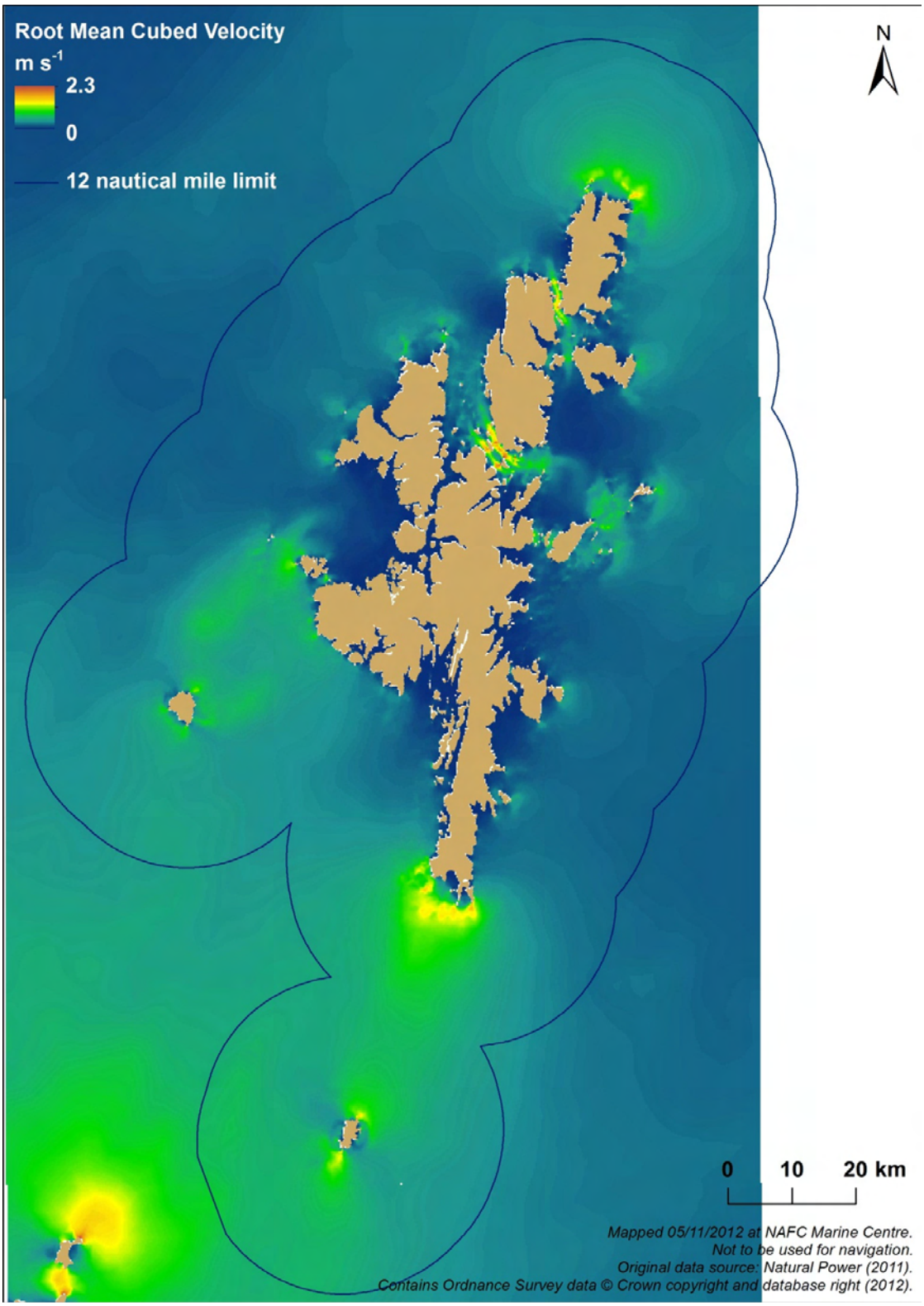

Figure 1. Tidal resource around the Shetland Islands.

Average tidal speeds (m s^{-1}) over the water column, calculated as a root mean cubed velocity. Original data source Natural Power (2011).

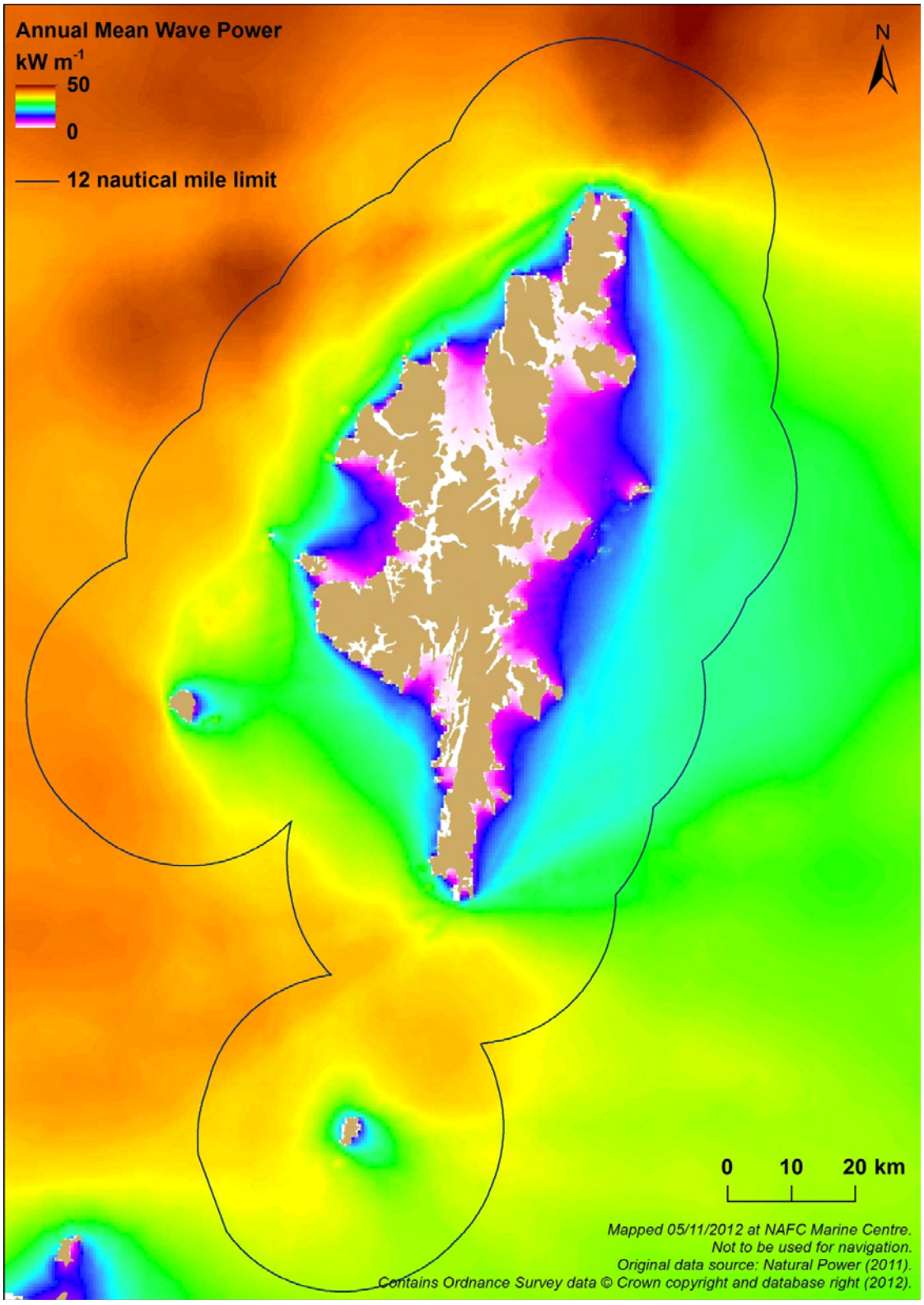

Figure 2. Wave resource around the Shetland Islands.
Average wave power (kW m^{-1}), calculated as an annual mean wave power. Original data source Natural Power (2011).

2. Approach

The SMSP has previously identified and mapped marine features and maritime activities in Shetland's waters. The spatial extents of these features and activities have been subject to local consultation, producing both local datasets and locally amended national datasets. A spatial model has been created showing potential areas of least resistance (lowest constraint) in the planning regime, reflecting a process of consultation on constraints with local advisors, planners, regulators, communities and developers. The model is designed as a decision support tool to assist in making more informed decisions about where developments are likely to be successful and where they are not. The maps presented do not illustrate clear boundaries between favourable and unfavourable areas for marine development, but represent the likelihood of finding suitable locations.

3. Model Structure

Constraints mapping within the model was based on information held within the SMSP. Local stakeholders (Appendix 1) were asked to provide a preliminary assessment of the level of constraint their activity or area of responsibility may cause to marine renewable developments in Shetland waters. A summary of the factors considered as potential constraints and their evaluation, provided by local stakeholders, is included in Tables 1–3. These factors were used to evaluate:

a. Constraints at sea

These are constraints relevant to device placement at sea. A range of economic, cultural, and environmental activities and features were provided by stakeholders as being constraints to device placement (Table 1). Additionally, within the marine renewables industry there is a common agreement to leave exploitation of areas where high wave and high tidal energy overlap to tidal device deployment. These areas are defined as where the maximum tidal speeds are over 1 m s^{-1}, and are marked in the model output.

b. Constraints at the coast

These are constraints relevant to cable landings. Coastal land within 200 metres of the shore was identified, in consultation with industry and local stakeholders, as the potential area where the cables, connecting the devices at sea to the electrical grid on land, would make landfall. Technical, physical and environmental constraints were considered as limiting factors to cable landings (Table 2). Islands without electrical grid, including Fair Isle and Foula, were excluded from the analysis.

A spatially varying level of constraint was generated from each mapped feature or activity, onto a fixed grid of 10 m by 10 m. The constraint levels due to each feature/activity were rescaled between 0 and 1, with 0 representing no constraint and 1 maximum constraint. The exception was Special Areas of Conservation (SACs) and Special Protected Areas (SPAs) which were defined with a constraint level of 2, ensuring they were always of medium constraint, as it was felt that this better reflected the legal protection afforded to them. The constraint levels were designated in one of two ways:

- Defined constraint level - where a feature has been given a set constraint value. For example, Nature Conservation designated areas have a set constraint level within their border, and no constraint outside their border. Defined constraint levels are also used to map activities where no use intensity data is available, such as for recreation.

- Varying constraint level - where an activity generates a continuous range of constraints, from high to low. Fuzzy logic was used to rescale the activity range from 0 (no activity occurring) to 1 (maximum activity occurring). This scoring method was used for activities which are spatially continuous but vary in intensity, such as varying levels of fishing activity. This type of constraint is also used to reflect distance from an important feature, for example the further the distance from a seabird colony, the lower the constraint.

The constraint level maps for individual features and activities were then overlain and summed to create maps of total constraint, for both the coast (constraints applicable to cable landing sites) and at sea (constraints applicable to device placement). The constraint maps were added with equal weighting, without attributing priority to any factor. Exclusion buffers were then generated (Table 3), and overlain on the total constraints map as areas of maximum constraint. The use of exclusion buffers ensured these features were always of high constraint. The exclusion buffers were designated as:

- Exclusion buffers - where exclusion distances have been defined in the past, through, for example, legislative or precedence of past planning decisions. For example pipelines have an exclusion buffer of 230m either side based on local precedent.

4. Model Output

The model output was mapped, showing total constraint both at sea (Figure 3) and at the coast (Figure 4). Visual assessment of the model output confirmed the results were acceptable. The resilience of the model output was tested by doubling the constraint level of each of four factors (for both sea and coastal constraints), and comparing the results to the non-doubled model output (Appendix 2). The statistical distributions of total constraint levels within the model results were not significantly different between models. The percentage of model grid cells at low (total constraint level ≤ 1), medium ($1 <$ total constraint level < 4), and high (total constraint level ≥ 4) were also compared. The models were not found to dramatically alter, particularly at lower constraint levels (a maximum of 2.3% change in total area classed as low constraint). However, visual inspection of these test models showed they provided unrealistic results, seen particularly clearly with doubled constraints in Nature Conservation designated areas (Appendix 2, Figure A2.1), where large areas became excessively highly constrained, particularly within the SACs and SPAs which had already been assigned medium constraint . Therefore, the original, equal weighting model was found to be robust and realistic.

Table 1. Constraints at sea.
Data used to model constraints at sea. Data listed alphabetically.

Constraint	Data Source	Data available from	Constraint Type	Constraint Level	Constraint Consultee
Aquaculture (Fin Fish) Site	Shetland Islands Council	SMSP	Defined- 500 m buffer Varying- 500 m to 1000 m buffer	1 1 – 0	Representatives of Aquaculture Industry
Cetaceans	Shetland Amenity Trust	SMSP	Varying- 1000 m buffer	1 – 0	Shetland Biological Records Centre*
Important Habitats	JNCC	SMSP	Defined- extent	1	NA
Local Policy Development Restrictions	Shetland Islands Council; Lerwick Port Authority; Broonies Taing Pier Trust	SMSP	Defined- extent	1	NA
Nature Conservation Designated Areas	Scottish Natural Heritage; RSPB	SMSP; RSPB	Defined- SAC & SPA Defined- SSSI, RAMSAR, NNR & RSPB	2 1	NA
Otters	Shetland Biological Records Centre	SMSP	Varying- 6000 m buffer, to 10 m depth contour	1 – 0	Shetland Biological Records Centre*
Recreational Use & National Scenic Areas	NAFC SMSP; Scottish Government	SMSP; Scottish Government	Defined- extent	1	NA
Seabirds	Shetland Amenity Trust	SMSP	Varying- 1000 m buffer	1 – 0	Shetland Biological Records Centre*; Shetland Oil Terminal Advisory Group

*Part of Shetland Amenity Trust

Seals	Scottish Natural Heritage; Sea Mammal Research Unit; Scottish Government	SMSP	Defined- 500 m buffer Varying- 500 m to 1000 m buffer	1 1 – 0	Scottish Natural Heritage
Shellfish Fishing	Interviews with local fishermen; Shetland Shellfish Management Organisation	SMSP	Varying- economic contribution based	1 – 0	Shetland Shellfish Management Organisation
Waste-Water Discharge	Scottish Environment Protection Agency	SMSP	Varying- 100 m buffer	1 – 0	SEPA Environmental Quality Standards
White Fish Fishing	Marine Scotland	SMSP	Varying- intensity based	1 – 0	Shetland Fishermen's Association
Wrecks	Shetland Amenity Trust; RCAHMS; SeaZone Solutions Ltd.	Shetland Amenity Trust; RCAHMS; SeaZone Solutions Ltd.	Varying- 1000 m buffer	1 – 0	Shetland Regional Archaeologist*

*Part of Shetland Amenity Trust

Table 2. Constraints at the coast
Data used to model constraints at the coast. Data listed alphabetically.

Constraint	Data Source	Data available from	Constraint Type	Constraint Level	Constraint Consultee
Archaeology	Shetland Amenity Trust	Shetland Amenity Trust	Varying- 500 m buffer	1 – 0	Shetland Regional Archaeologist*
Coastal Morphology	SeaZone Solutions Ltd.	EDiNA Digimap®	Varying- steepness & height based	1 – 0	Representatives of Renewables Industry
Electrical Grid	National Grid	National Grid	Varying- distance based	1 – 0	Representatives of Renewables Industry
National Scenic Areas	Scottish Government	Scottish Government	Defined- extent	1	NA
Nature Conservation Designated Areas	Scottish Natural Heritage; RSPB	SMSP; RSPB	Defined- SAC & SPA Defined- SSSI, RAMSAR, NNR & RSPB	2 1	NA
Otters	Shetland Amenity Trust	SMSP	Varying- 6000 m buffer	1 – 0	Shetland Biological Records Centre*
Roads	Ordnance Survey	OS OpenData ™	Varying- distance based	1 – 0	Representatives of Renewables Industry
Seabirds (excluding gulls and fulmars)	JNCC	SMSP; JNCC	Varying- 1 km buffer	1 – 0	Shetland Biological Records Centre*; Shetland Oil Terminal Advisory Group
Seals	Scottish Natural Heritage; Sea Mammal Research Unit; Scottish Government	SMSP	Defined- 500 m buffer Varying- 500 m to 1000 m buffer	1 1 – 0	Scottish Natural Heritage

*Part of Shetland Amenity Trust

Table 3. Exclusion buffers
Data used to model exclusion buffers at sea. Data listed alphabetically.

Constraint	Data Source	Data available from	Constraint Type	Constraint Level	Constraint Consultee
Cables	KIS-CA; Shetland Islands Council	SMSP	Exclusion- 250 m buffer	High	Subsea Cables UK(2012) Guidelines
Dredge and Disposal Grounds	Lerwick Port Authority; Natural Capital; SeaZone Solutions Ltd.	SMSP	Exclusion- extent	High	Lerwick Port Authority; Shetland Islands Council
Aquaculture Sites	Shetland Islands Council	SMSP	Exclusion- extent	High	NA
Pipelines	Shetland Islands Council	SMSP	Exclusion- 230 m buffer	High	Shetland Islands Council
Priority Marine Features	Scottish Natural Heritage	SMSP	Exclusion- 50 m buffer	High	Scottish Natural Heritage
Protected Wrecks	Maritime and Coastguard Agency	SMSP	Exclusion- buffer defined by legislation	High	Legislation
Shipping Routes	Maritime and Coastguard Agency; Shetland Islands Council	SMSP	Exclusion- 250 m buffer	High	Maritime and Coastguard Agency

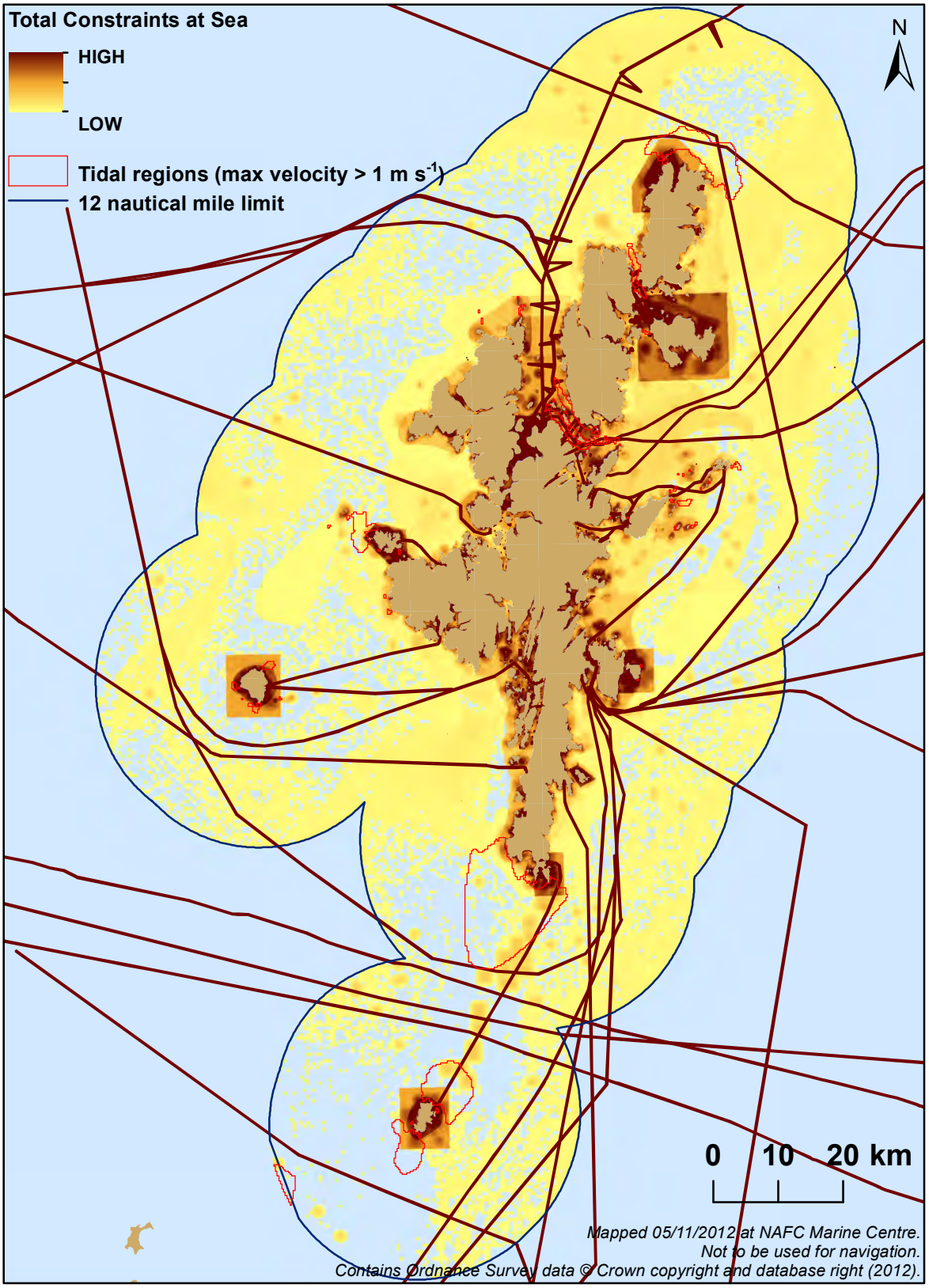

Figure 3. Total constraints at sea.
Marine constraints within the Shetland 12 nautical mile limit were mapped and summed in order to model total constraint levels. Developments will encounter increasing likelihood of conflicts at increasing levels of constraint.

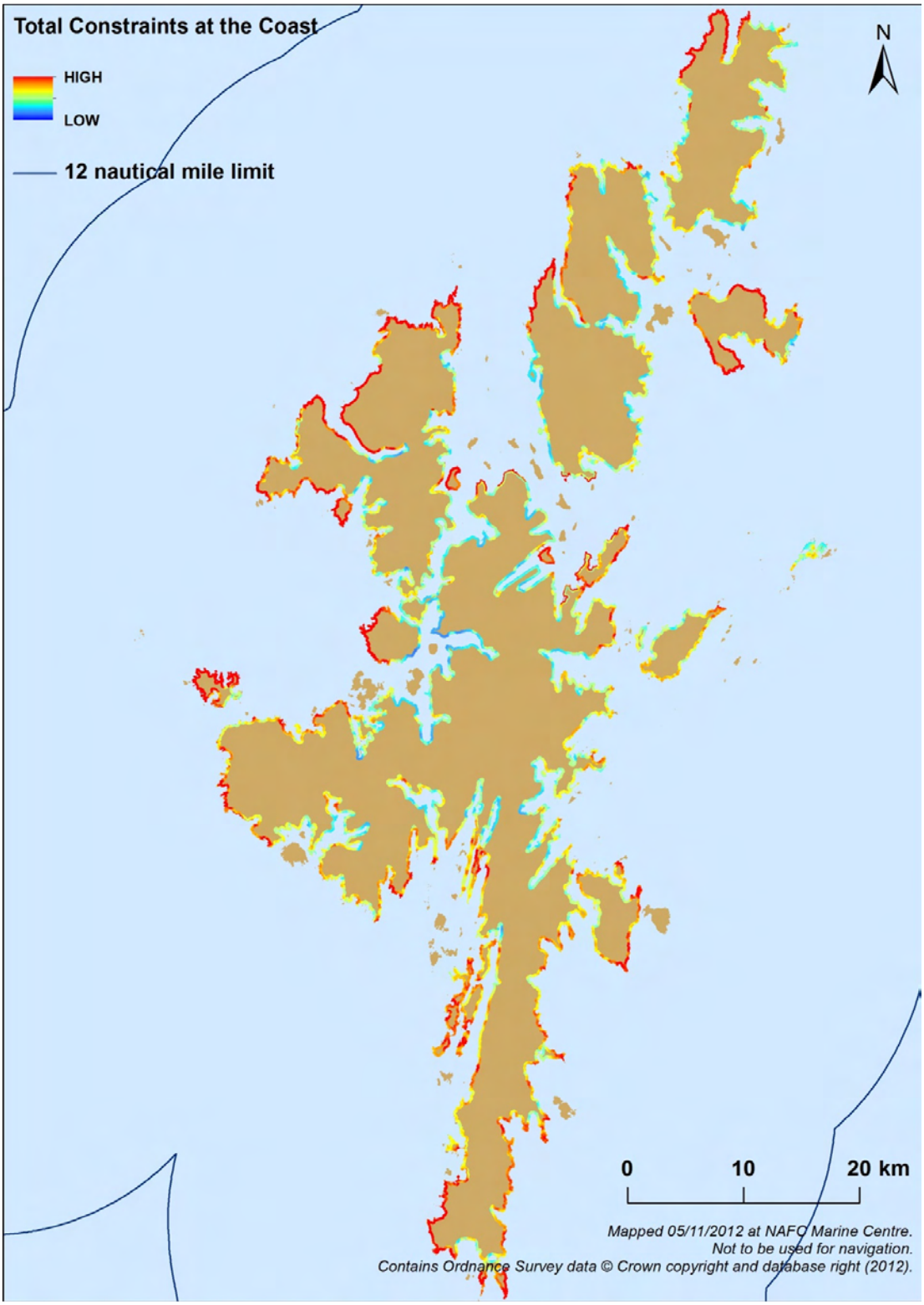

Figure 4. Total constraints at the coast.

Constraints within 200 m of the coast were mapped and summed in order to model total constraint levels. Developments will encounter increasing likelihood of conflicts at increasing levels of constraint.

5. Conclusions

The maps do not conclusively depict sites for marine renewable developments, but instead represent the likelihood of an area of being suitable. The outputs from the model will be integrated into the fourth edition of the Shetland Marine Spatial Plan through an additional marine renewables policy (NAFC, 2012). The policy is intended to guide developments towards areas of low constraint, and encourage the development of mitigation measures in areas of medium to high constraint. The findings of this assessment are part of an ongoing process, and will change as new information is captured. These regional locational guidelines (RLG) will be reviewed every 6 months, and revised as new or updated data becomes available.

6. Caveats

All maps should be interpreted taking into consideration:

1. Stakeholders assessing constraints did so without reference to specific wave or tidal projects. Assessments of environmental and socio-economic impacts are likely to vary with specific wave and tidal development schemes.

2. The model will be updated as new data becomes available. The most up to date output maps should be used (available from www.nafc.ac.uk).

3. The method of data collection and recording can influence the distribution of data on a map. For example, absence of data within an area of map may not represent no constraint, but may reflect data gaps generated by non-systematic surveys (as is the case with mobile species and archaeology datasets). It is advisable that consideration be given to whether an area with a low constraint value is truly an area with a low degree of constraint, or if the low constraint value is a consequence of small survey effort.

4. The presence of a high degree of constraint does not explicitly prohibit the development of marine renewables. Instead, it highlights that the area at sea or along the coast already is subject to several activities, or contains important marine features. Marine renewable developers are encouraged to consult with stakeholders to identify whether mitigation measures may permit developments in these areas.

5. There may be activities or marine features currently not considered within the layers of these models, which will need to be addressed in any marine renewables development proposal.

References

Natural Power (2011). Shetland Islands Wave and Tidal Resource. Published by Natural Power. (http://www.nafc.ac.uk/Shetland-Marine-Energy-Development.aspx)

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Scottish Government (2007). Scottish Marine Renewables: Strategic Environmental Assessment.

Scottish Government (2011). 2020 Routemap for Renewable Energy in Scotland. (http://www.scotland.gov.uk/Publications/2011/08/04110353/0)

Subsea Cables UK (2012). Subsea Cables UK Guideline No 6: The Proximity of Offshore Renewable Energy Installations & Submarine Cable Infrastructure in UK Waters. http://www.ukcpc.org.uk/guidelines.asp

Appendix 1. Local Stakeholders and Consultees

Industry

Aquamarine Power (Megan Richardson)
Grieg Seafood Hjaltland UK Ltd. (Rachel Hope, John McEvoy)
Hammerfest Strøm (Inger Lise Mathisen)
Lerwick Port Authority (Captain Alexander Simpson)
Nova Innovation (Gary Connor, Simon Forrest)
Pelamis Wave Power (Laura Carse, Rosalind Hart)
Seafood Shetland (Ruth Henderson)
Shetland Shellfish Management Organisation (Jennifer Mouat)
SSE (Nathan Coote)
Vattenfall (Harvey Appelbe)
Voith Hydro Wavegen Ltd (David Langston)

Local and Central Government

Joint Nature Conservation Committee (Tim Dunn, Kerstin Kober)
Marine Scotland (Robert Watret)
Marine Scotland Licensing Operations Team (Gillian Graham)
Scottish Environment Protection Agency (Janet Davies)
Scottish Natural Heritage (Karen Hall)
Shetland Islands Council (Martin Holmes, Ryan Leask, John Rosie, John Williamson)

Heritage

Royal Society for the Protection of Birds (RSPB) (Pete Ellis)
Royal Yachting Association Scotland (Michael Gray, Graham Russell)
Sea Mammal Research Unit (Lindsay Wilson)
Shetland Amenity Trust (Paul Harvey, Val Turner)
Shetland Oil Terminal Environmental Advisory Group (Martin Heubeck)

Others

The Crown Estate (Alex Adrian)

Appendix 2. Testing Model Output

The model utilised the ArcGIS® ArcMap 10 Weighted Sum tool to overlay and sum the individual constraint maps, creating the 'total constraint' model output. Model output resilience was assessed through multiple model runs. In each model run the constraint level of one of four factors was doubled (i.e. given a weighting of 2), for both sea and coast models (Table A2.1). The model outputs were compared statistically (Table A2.1), and visually (Figures A2.1 – A2.8).

Table A2.1. Constraint factors doubled in testing model output resiliency	Total constraints at sea				Total constraints at the shore				
Factor doubled	Minimum	Maximum	Mean	Standard Deviation	Minimum	Maximum	Mean	Standard Deviation	Significantly different to equally weighted model?
Equal Weighting	0	8.493	0.390	0.890	0.526	7.753	2.757	1.111	- / -
Nature Conservation Designated Areas	0	10.493	0.462	1.166	0.526	9.753	2.962	1.539	No / No
Recreation & National Scenic Areas	0	9.222	0.416	0.975	0.526	8.753	2.945	1.304	No / No
White Fish Fishing	0	9.006	0.457	0.896	-	-	-	-	No / -
Shellfish Fishing	0	9.479	0.448	0.986	-	-	-	-	No / -
Archaeology	-	-	-	-	0.526	8.668	3.234	1.280	- / No
Electrical Grid	-	-	-	-	0.558	8.266	2.894	1.192	- / No

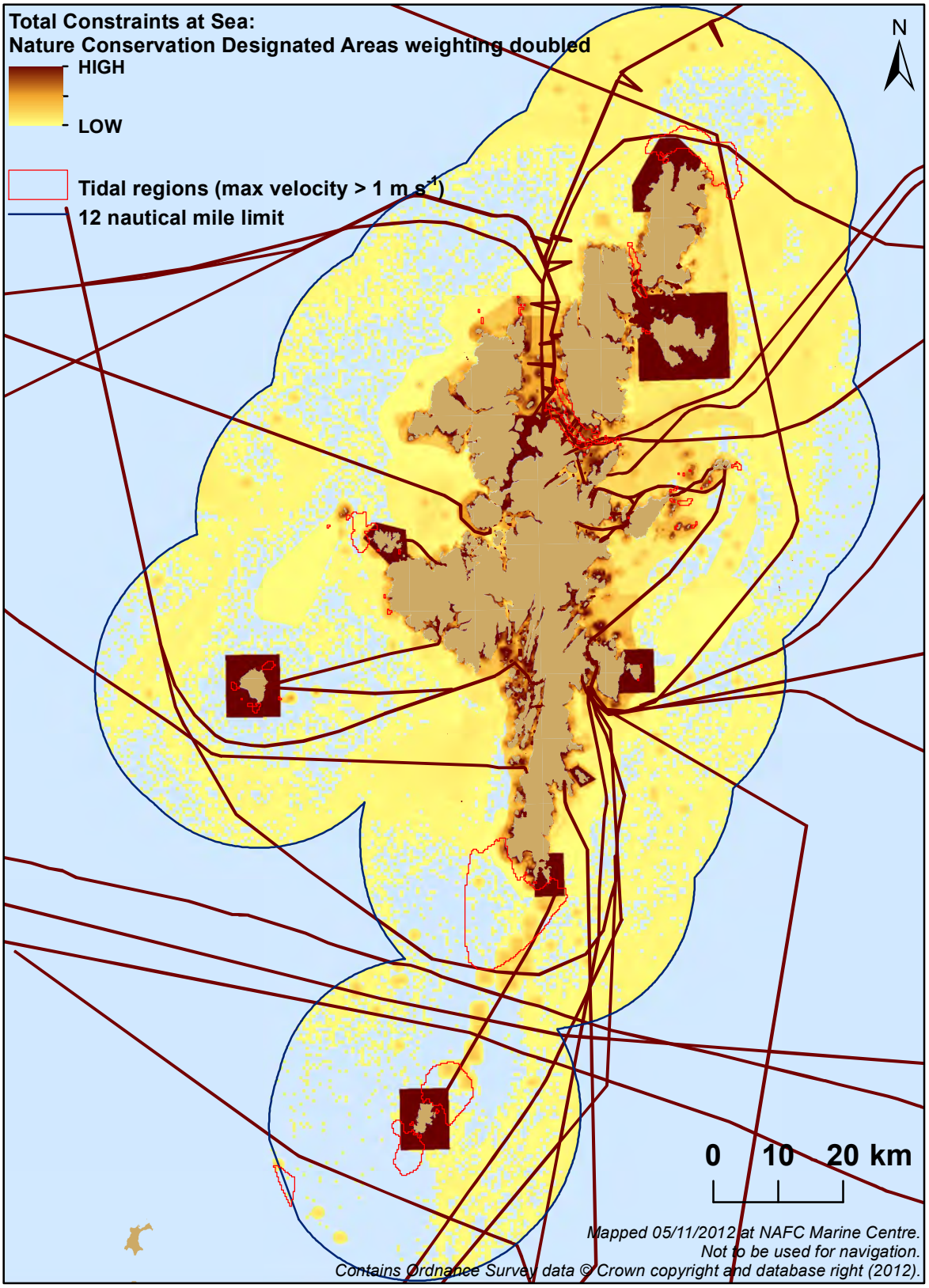

Figure A2.1. Total constraints at sea: Nature Conservation Designated Areas weighting doubled.

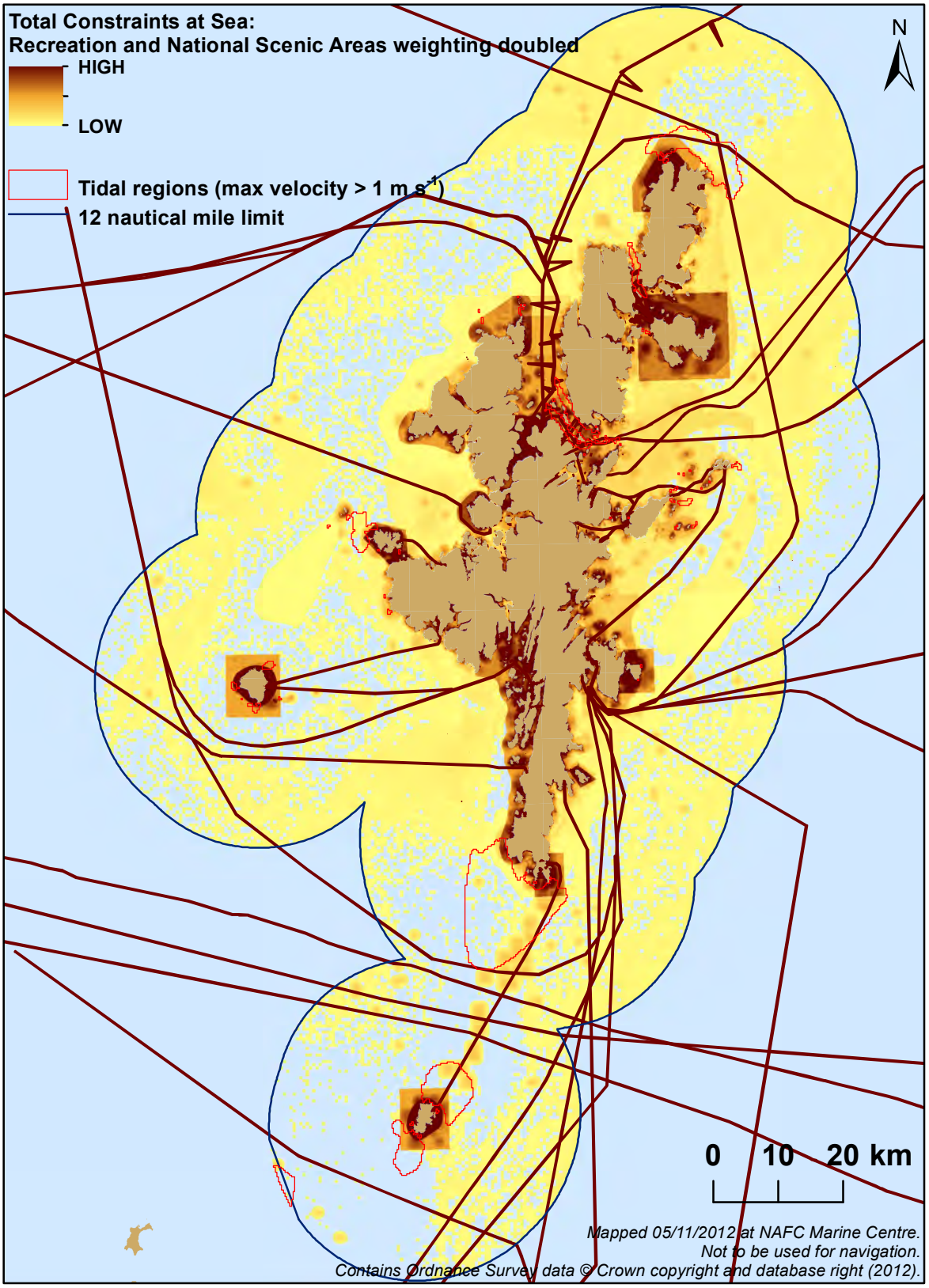

Figure A2.2. Total constraints at sea: Recreation and National Scenic Areas weighting doubled.

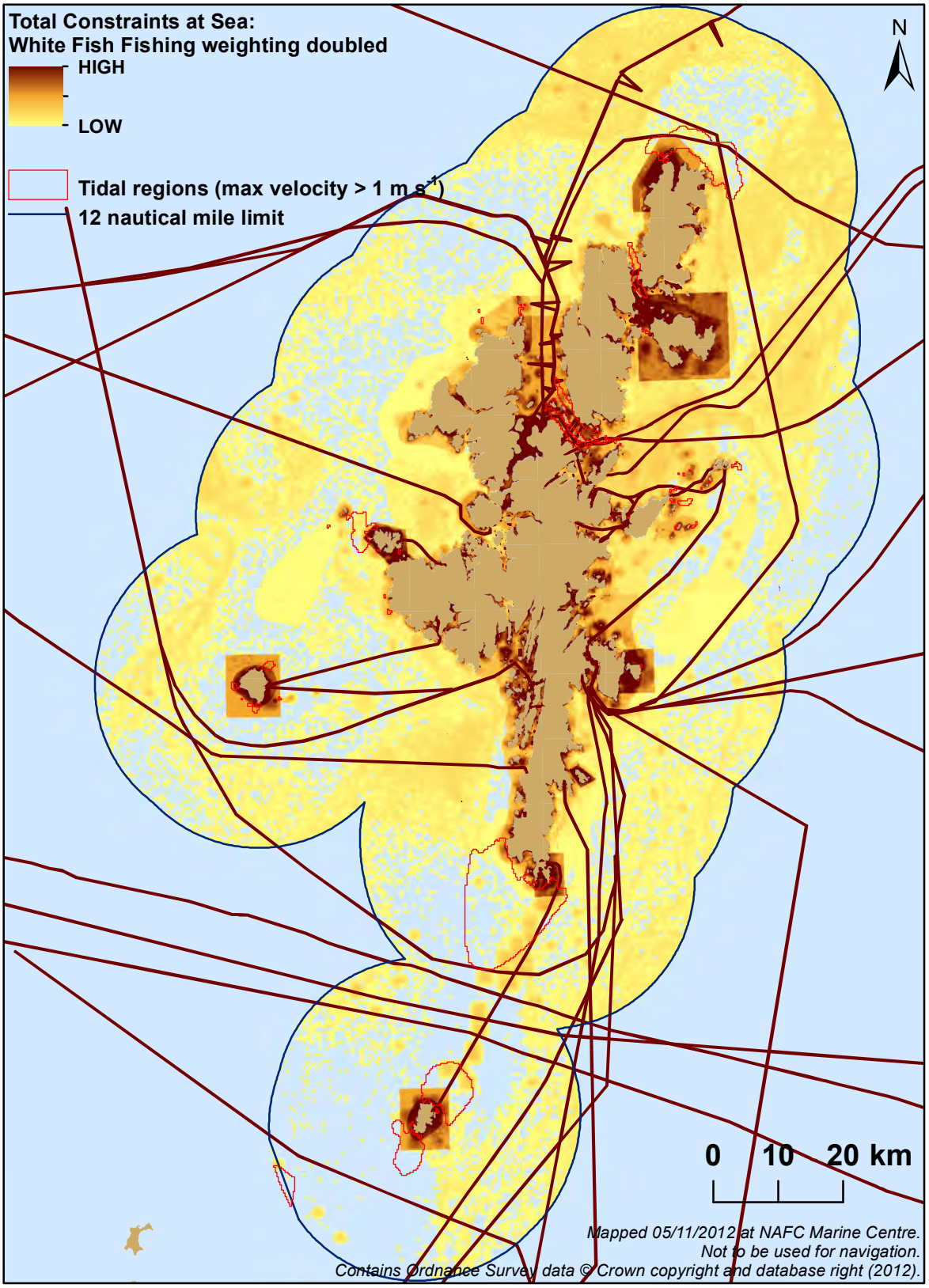

Figure A2.3. Total constraints at sea: White Fish Fishing weighting doubled.

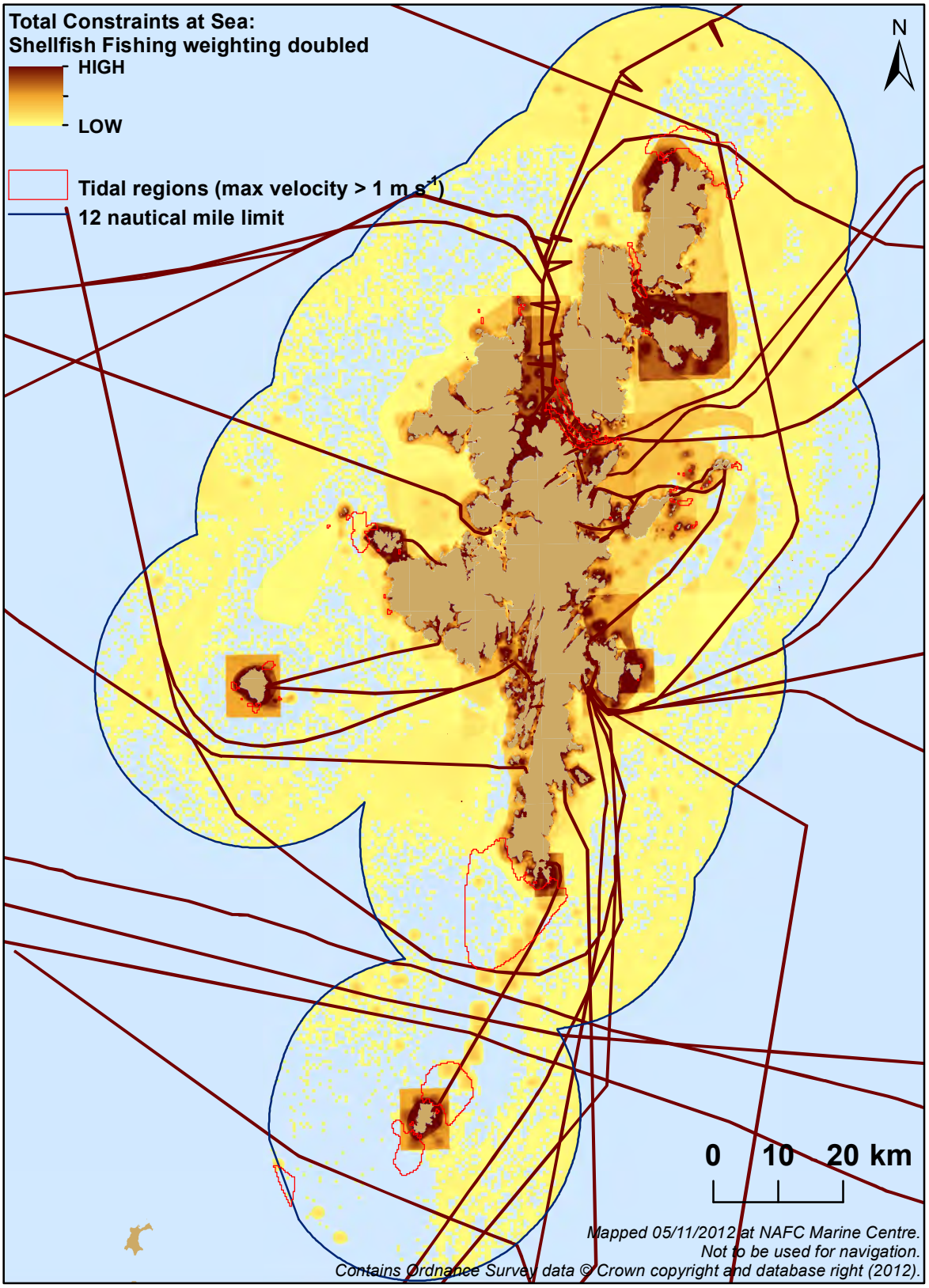

Figure A2.4. Total constraints at sea: Shellfish Fishing weighting doubled.

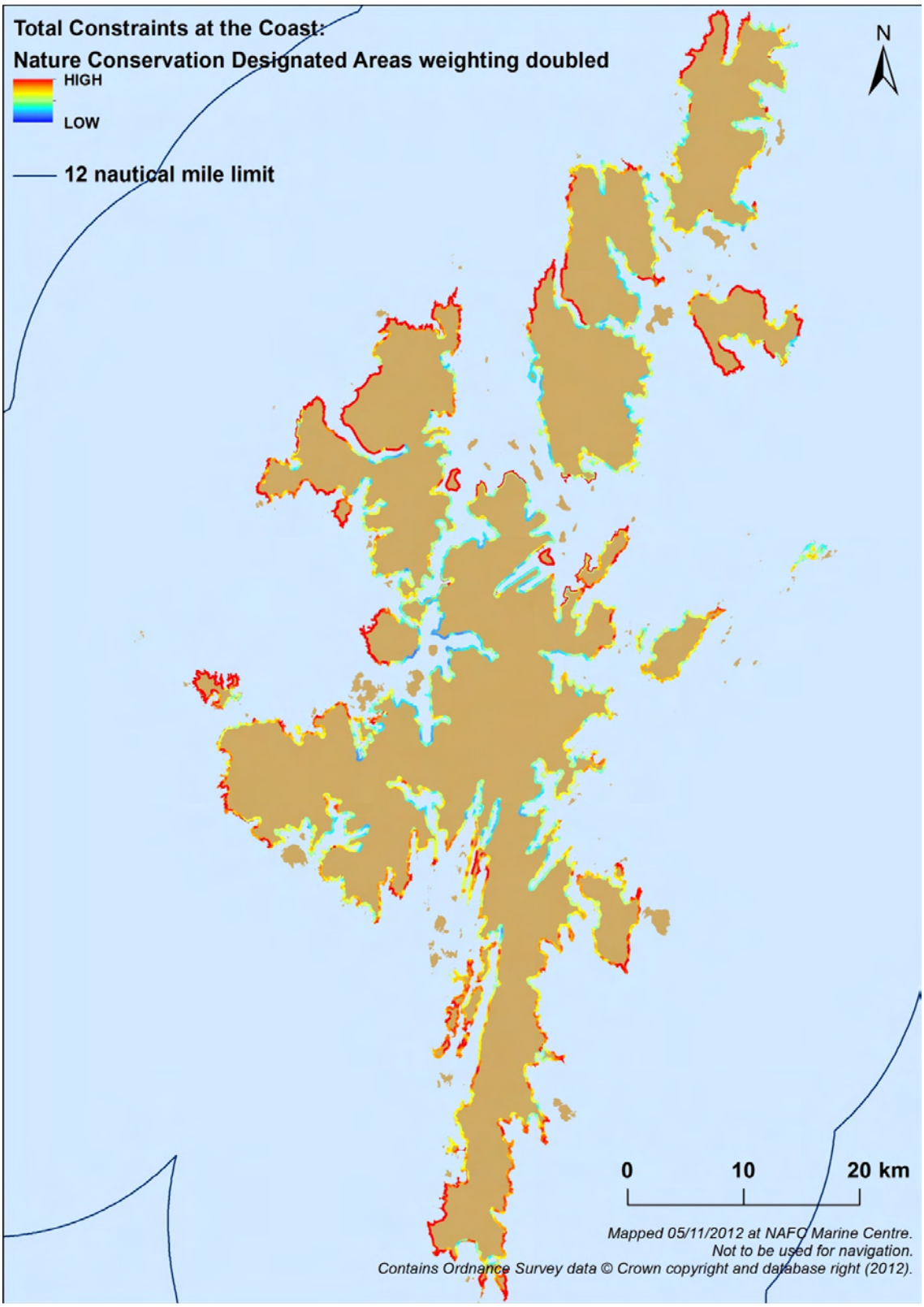

Figure A2.5. Total constraints at the coast: Nature Conservation designated areas weighting doubled.

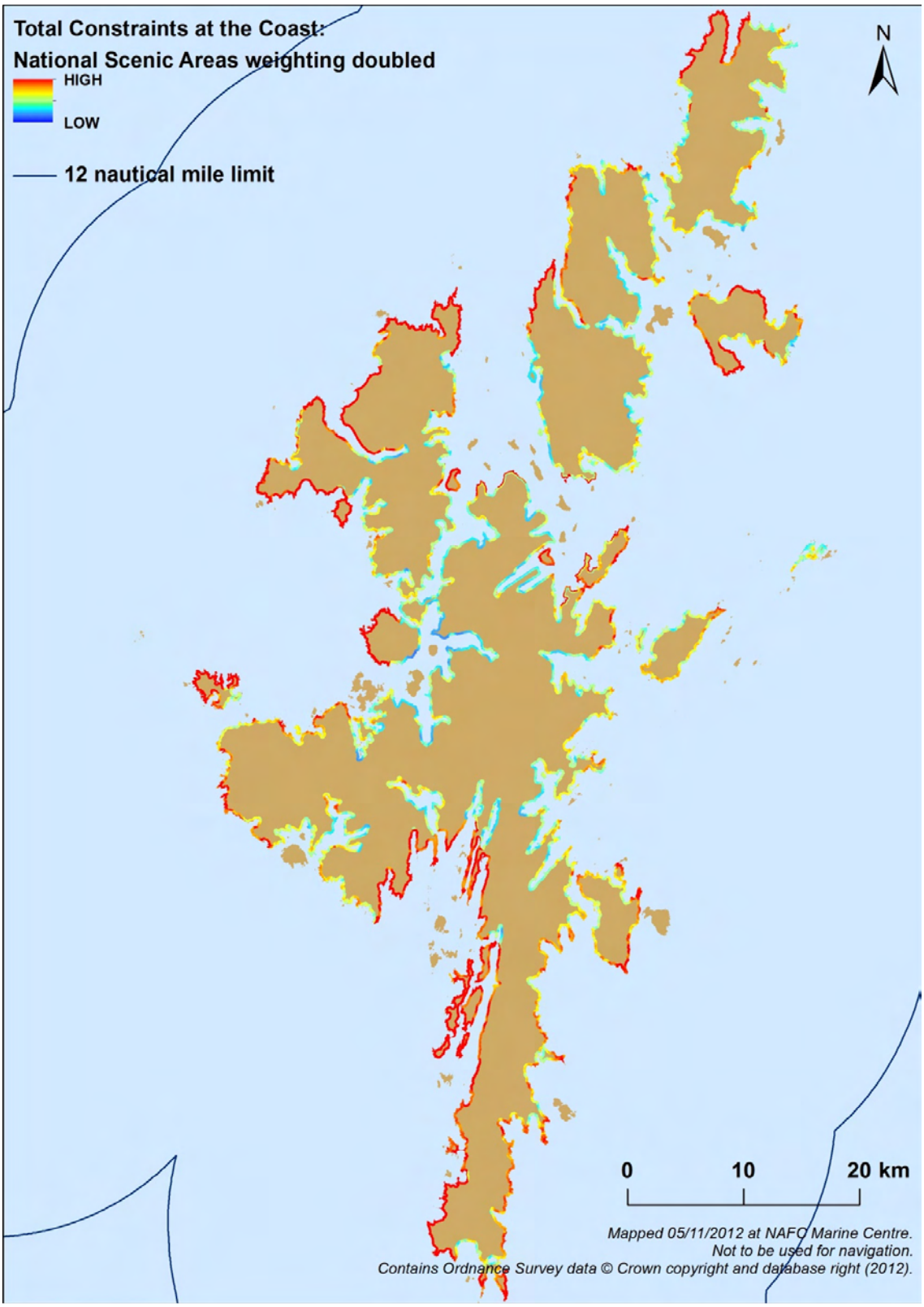

Figure A2.6. Total constraints at the coast: National Scenic Areas weighting doubled.

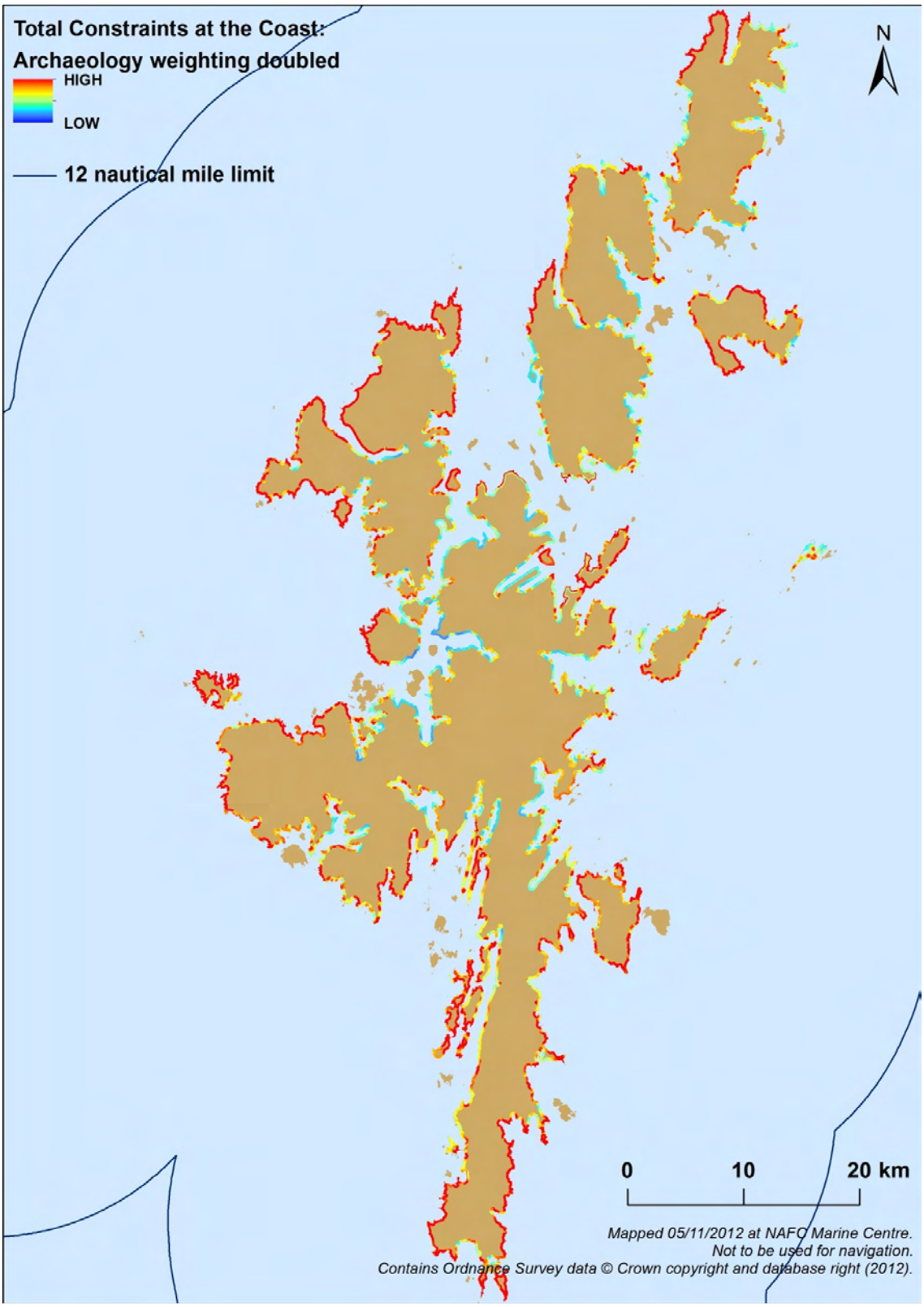

Figure A2.7. Total constraints at the coast: Archaeology weighting doubled.

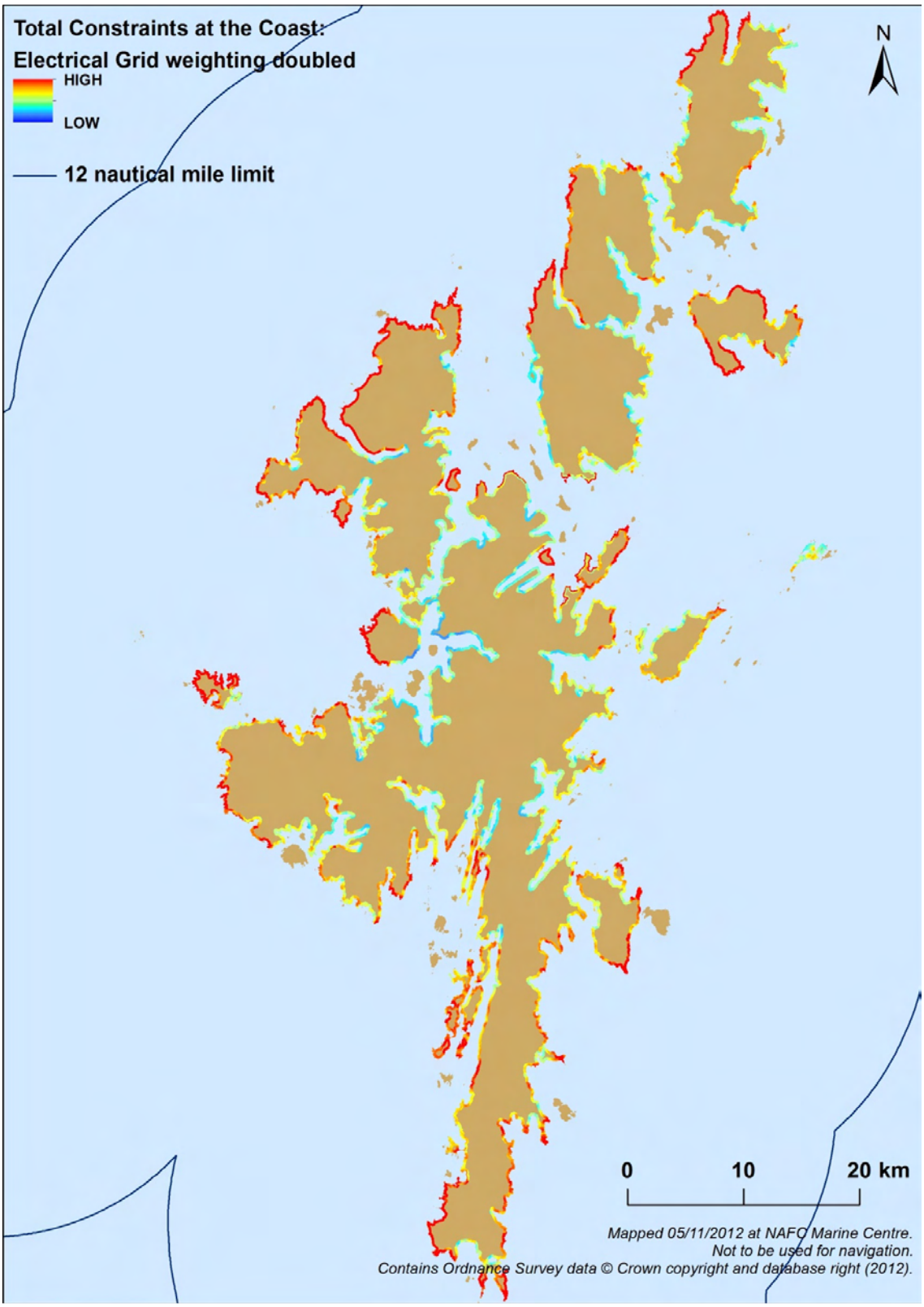

Figure A2.8. Total constraints at the coast: Electrical Grid weighting doubled.