Atlas of the
Tidal Energy Resource
on the South East Coast of England

Prepared for the
South East England Development Agency (SEEDA)

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SEEDA Tidal Resource Atlas

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1. Foreword

1.1 Introduction

Marine and Technical Marketing Consultants (MTMC) was commissioned by the South East England Development Agency (SEEDA) to produce an atlas of the tidal resource around the coast of the SEEDA region, as an adjunct to a study (also conducted by MTMC) into the feasibility of establishing a Test and Evaluation Centre for marine energy generating devices on the Isle of Wight[1].

The purpose of this atlas is to identify those areas in the English Channel, Dover Straits and Thames Estuary where there is a significant resource of tidal energy, with potential to be harvested for the generation of clean, green electricity. This resource could contribute to the Region's renewable energy targets for 2020, if sufficient support is offered to encourage early deployment of tidal energy technologies.

Electricity generated from tidal stream energy in the near term will be of the order of tens of MW, which is at least an order of magnitude lower than conventional power stations. Therefore for best efficiency it should be delivered via the local distribution network for consumption by local coastal communities. For this reason, population density has been included on Chart 5 in the atlas.

There are substantial pressures on the marine environment, often resulting in competition for usage of the marine space. Developers of marine energy sites must consult widely with, and obtain agreement for the development from, other marine stakeholders before the necessary licenses will be granted. In recognition of this situation, a number of known constraints to exploitation of the tidal resource that currently exist in the waters around the SEEDA region are also presented in this atlas, although the list is by no means complete.

1.2 Tides and Tidal Streams[2]

As the earth rotates (carrying the oceans with it), the oceanic waters are attracted by the gravitational pull of the moon. The earth presents an ever-changing aspect to the moon and this causes the water to oscillate in a wave of very long length and period, and relatively low amplitude, across the surface of the earth. The oscillation manifests itself as the so-called diurnal tidal cycle with one full cycle lasting approximately 12½ hours.

The sun also exerts a gravitational pull on oceanic waters, but to a lesser extent than the moon, because it is further away. When the moon and sun are aligned (or in conjunction), the effect is to augment the tidal oscillation, giving rise to large tides known as spring tides, which occur one or two days after

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[1] "Feasibility Study: Solent Ocean Energy Centre. The case for establishing an evaluation and research centre for ocean energy technologies on the Isle of Wight" MTMC report prepared for the Isle of Wight Council, December 2006

[2] Michael Reeve-Fowkes: "The Yachtsman's Manual of Tides" Ch 1, Tidal Cause and Effect. Barnacle Marine Ltd, 1992

the full and new moon. Conversely, when the pull of the sun is at right angles to the pull of the moon, the tidal oscillation will be at a minimum. These periods are called neap tides and occur between the full and new moon. The interval between one spring tide and the next is about 14 days.

During spring tides, both the tidal range (the difference between the sea level at high and low water) and the strength of the tidal streams (the horizontal movement of water caused by the tides) will be at their maximum. The range and strength of tidal streams are much reduced at neap tides.

Since the tidal motion of water is oscillatory, the speed of a tidal stream continuously changes. It will build up from zero at slack water to a maximum value and then reduce back to zero at the next slack water. It then changes direction and repeats the process of increasing and decreasing speed until it reaches slack water again, some 12½ hours after the cycle began.

Both the tidal streams and the tidal range give rise to an inexhaustible source of energy that may be extracted to produce electricity with zero carbon dioxide emissions.

1.3 Area Covered

The remit of this work covers those areas of tidal water between the coastline of the SEEDA region seaward to the limit of the UK territorial waters.

The SEEDA region coastline extends from Christchurch, Dorset, eastwards along the south coast of England, through Hampshire, Sussex and Kent to Dover and then northwards to North Foreland. From this eastern extremity, the coastline runs westwards towards Sheerness and the river Medway, to the southern banks of the river Thames.

The Atlas therefore covers the English Channel (east of Christchurch), the Straits of Dover and the southern North Sea, up to the approximate midline of the Thames Estuary. In all cases, the seaward boundary is the limit of UK territorial waters.

In general, the scale of this project precludes the provision of information on local tidal variations in small creeks, estuaries and channels. This is particularly relevant for the channels around the sandbanks in the Thames Estuary, where a more detailed study may highlight localised, fast-flowing tidal streams. However more detailed tidal information for the Solent has been included in the Atlas, by drawing on the authors’ extensive knowledge of the waters around the Isle of Wight.

1.4 Information Sources

The maps and charts in this atlas have been compiled from information that is freely available in the public domain.

The tidal speed information originated from Admiralty Tidal Stream Atlases, which are published as navigational tools for the commercial shipping and leisure boat sectors[3]. These Admiralty Atlases provide spring and neap tidal velocities (speed and direction) at hourly intervals related to the time of high water at a selected standard port. Maximum speed values were manually extracted from the Admiralty publications and processed in order to produce Charts 1 and 2 (Peak flowrate for mean spring and neap tides respectively in the SEEDA region).

The times of maximum speed for east and west-going tidal flows in the English Channel (Charts 3 and 4 respectively) were also manually extracted from the Admiralty Tidal Stream Atlases.

The data presented in Chart 5 (Potential annual power generation for areas of significant tidal stream resource) gives the annual power that could be generated by a typical tidal stream turbine at locations of good tidal stream resource. The calculation of this data utilised mean annual power density values taken from the DTI Atlas of UK Marine Renewable Energy Resources[4] at locations around the SEEDA region. The power generation values are indicative, rather than definitive.

Chart 6 (Mean spring tidal range) was compiled from data on the Easytide website: http://easytide.ukho.gov.uk/EasyTide/. This site presents predictions of tidal curves (i.e the tidal height as a function of time) and mean spring tidal range for numerous ports around the UK coast.

Constraints to the deployment of tidal stream energy devices are shown in Chart 7 (Locations of physical and environmental constraints). More detailed information regarding such constraints is presented for the Straits of Dover (Chart 8) and the Solent and the Isle of Wight (Chart 9), where, in the opinion of the authors, the exploitation of tidal energy may be commercially viable.

Data regarding physical constraints were found from Admiralty Navigation Charts[5] and the authors' extensive knowledge of the waters in the Solent and around the Isle of Wight. Information about environmental constraints was found from the website of the Joint Nature Conservation Committee (JNCC): http://www.jncc.gov.uk/.

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[3] Admiralty Tidal Stream Atlases:
Dover Strait, NP233, 1995
Thames Estuary, NP249, 1985
English Channel, NP250, 1992
North Sea Southern Portion, NP251, 2005
The Solent and Adjacent Waters, NP337, 1993

[4] DTI Atlas of UK Marine Renewable Energy Resources, produced by ABPmer, the Met Office, Garrad Hassan and Proudman Oceanographic Laboratory, December 2004

[5] Admiralty Folios SC5600 and SC 5605

2. Maps and Charts

Chart 1 - Peak flowrate for mean spring tides

Key Points:

- The strongest tidal stream resource in the SEEDA region is 5 miles south of the Isle of Wight, in St Catherine's Race
- The good tidal stream resource south of the Isle of Wight extends across the English Channel (not shown on Chart 1) to the Cherbourg peninsula in northern France
- Localised areas of strong tidal stream resource occur in the Solent, for example in the Hurst Narrows, but exploitation is restricted, primarily because of potential conflicts with commercial shipping and leisure boat activities (see Chart 9)
- Exploitation of the good tidal stream resource in the Straits of Dover is likewise compromised, primarily by the constraints of congested commercial shipping routes (see Chart 8).

Chart 1: Peak flowrate for mean spring tides in the SEEDA region

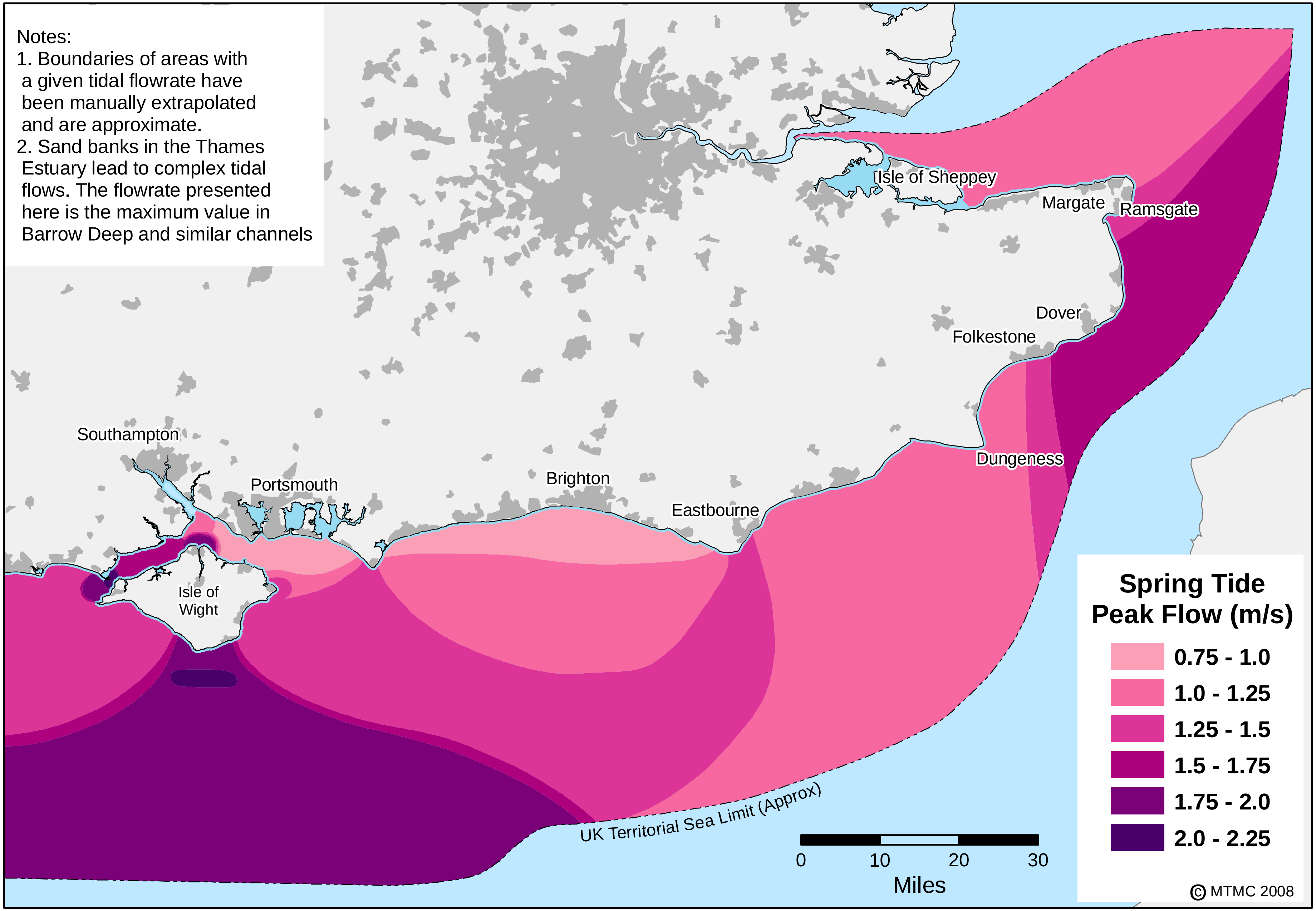


Chart 2 - Peak flowrate for mean neap tides

Key Points:

- The maximum tidal flowrate at neap tides is approximately 50% of the maximum flowrate at spring tides shown in Chart 1. As a rule of thumb, this relationship between spring and neap tide flowrates applies globally
- The locations of the best tidal stream resource for neap tides in the SEEDA region largely reflect the best locations at spring tides, as shown in Chart 1.

Chart 2: Peak flowrate for mean neap tides in the SEEDA region

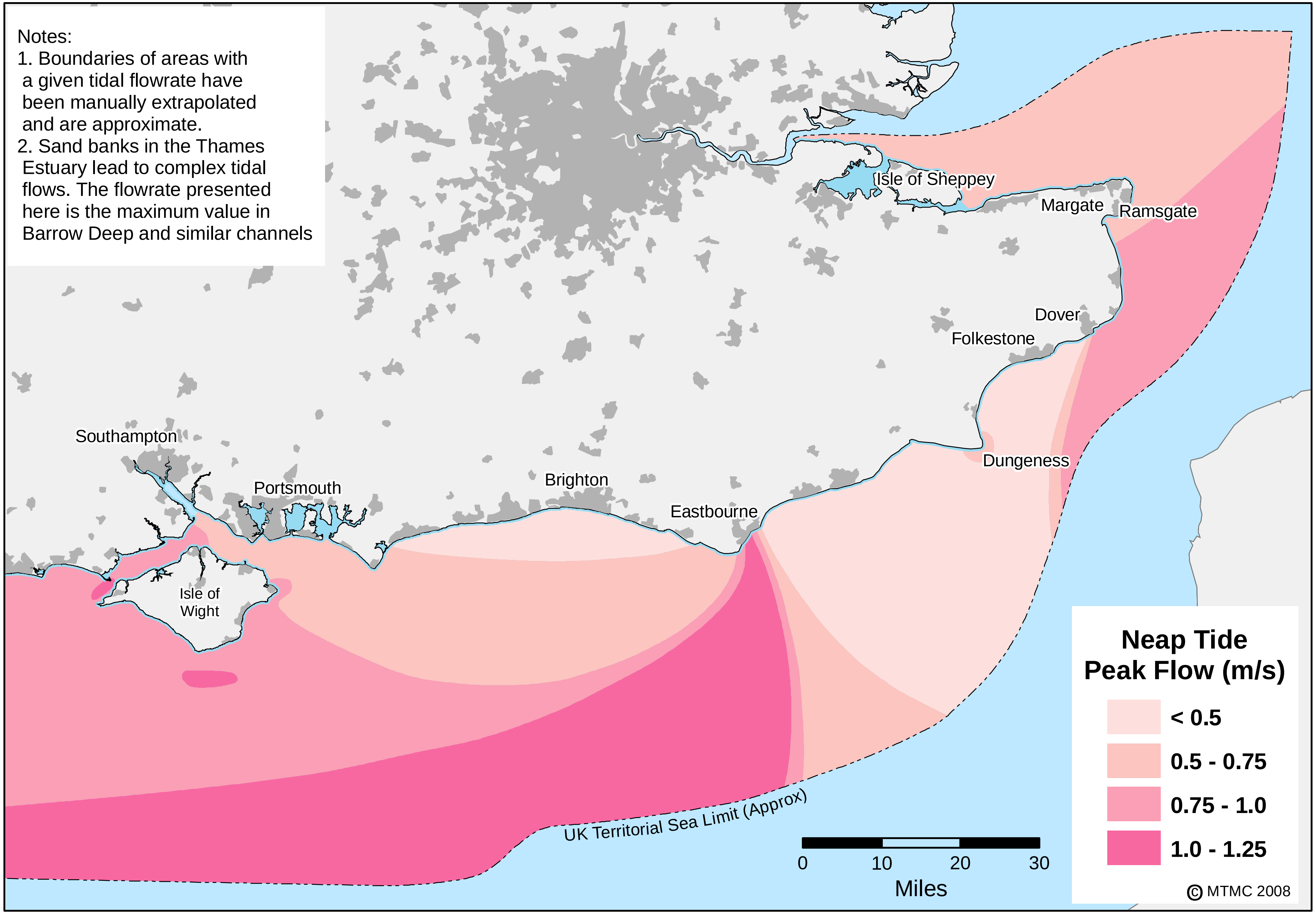


Chart 3 - Times of maximum tidal flowrate for eastward flow in the English Channel and southward flow in the Straits of Dover when high water at Dover is at 12.00pm (midday)

Key Points:

- The velocity of water in a tidal stream varies in a roughly sinusoidal manner from zero at slack water (the turn of the tide) to maximum rate some 2 – 4 hours later and reducing to zero again at the next slack water (approximately 6 ½ hours after the previous slack water).
- The amount of electricity that can be generated from a tidal stream resource is proportional to the cube of the tidal velocity (V^3)
- Hence tidal stream generators produce electricity intermittently, although (unlike wind turbines) the intermittency is entirely predictable from data freely available in nautical almanacs.
- The chart opposite illustrates the time lag for maximum tidal velocity at different locations in the English Channel, Straits of Dover and Thames Estuary, when the tidal stream is flowing east in the English Channel.
- As a consequence of this lag, the intermittency of electricity generation from the tidal stream resource of the SEEDA region could be smoothed by judicial selection of sites for energy extraction.
- For example, on the east-going tide in the middle of the English Channel and south of the Isle of Wight, the maximum tidal velocity occurs 2 hours later than in the Straits of Dover.

Chart 3: Times of maximum tidal flowrate for eastward flow in the English Channel and southward flow in the Straits of Dover when high water at Dover is at 12.00pm (midday)

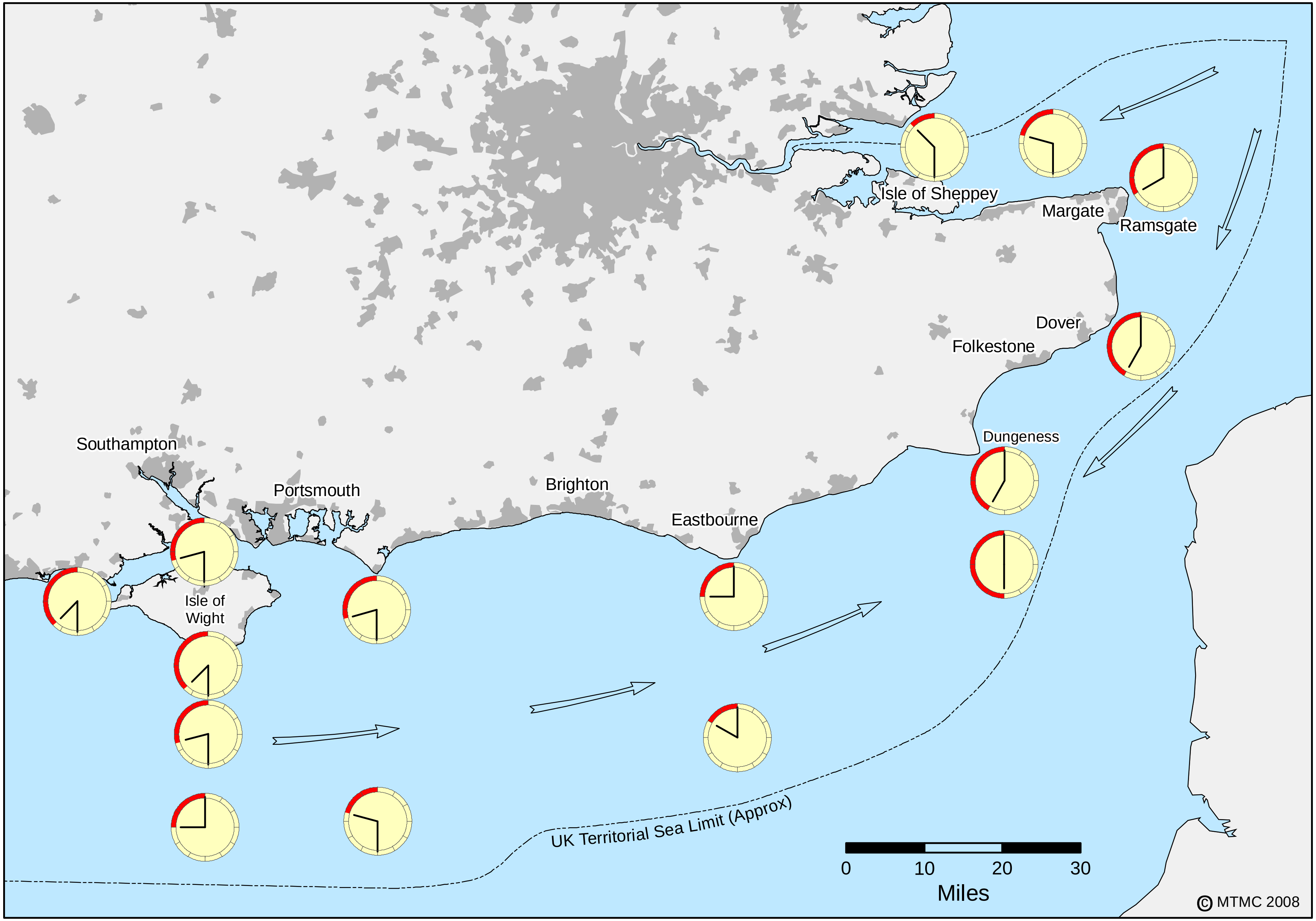


Chart 4 - Times of maximum tidal flowrate for westward flow in the English Channel and northward flow in the Straits of Dover when high water at Dover is at 12.00pm (midday)

Key Points:

- Please see key points for Chart 3 regarding the relationship between electricity generated and the velocity of water in a tidal stream
- The chart opposite illustrates the time lag for maximum tidal velocity at different locations in the English Channel, Straits of Dover and Thames Estuary, when the tidal stream is flowing west in the English Channel.
- As a consequence of this lag, the intermittency of electricity generation from the tidal stream resource of the SEEDA region could be smoothed by judicial selection of sites for energy extraction.
- For example, on the west-going tide in the middle of the English Channel and south of the Isle of Wight, the maximum tidal velocity occurs 3 hours later than in the Straits of Dover.

Chart 4: Times of maximum tidal flowrate for westward flow in the English Channel and northward flow in the Straits of Dover when high water at Dover is at 12.00pm (midday)

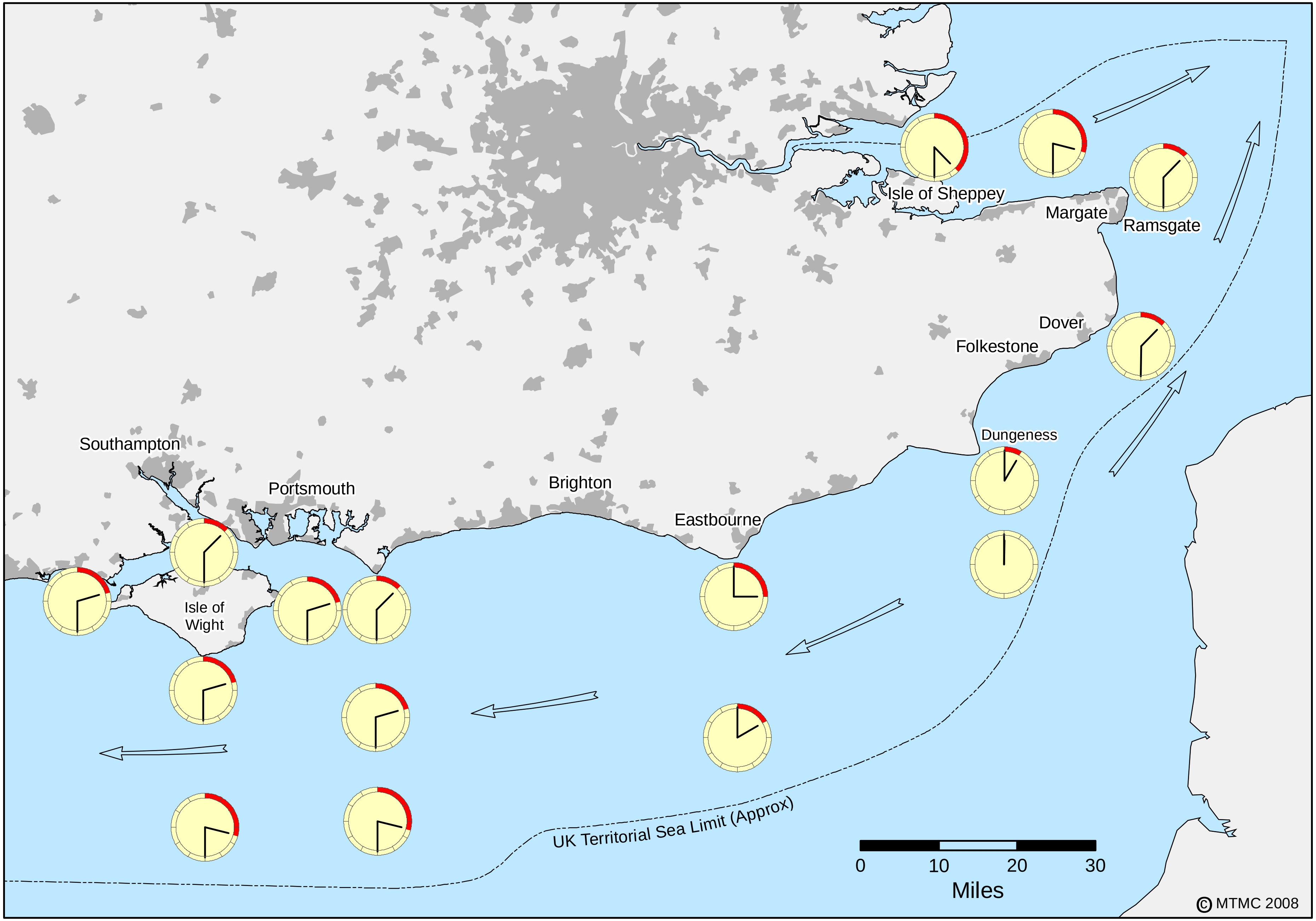


Chart 5 – Potential annual mean power generation for areas of significant tidal stream resource

Key Points:

- The data presented in the chart opposite gives an approximate value of the electrical power that a twin-rotor tidal turbine might deliver in one year
- A representative rotor diameter of 16 metres was used for the calculations
- The calculations make allowance for:
  - The Betz ratio (which governs the maximum power that can theoretically be extracted by an open rotor in a free-stream flow)
  - Mechanical efficiency
  - Electrical efficiency
- The data presented is indicative rather than definitive. It is suitable for initial estimates of potential electricity generation from tidal stream energy resources in the SEEDA region

Chart 5: Potential annual mean power generation for areas of significant tidal stream resource in the SEEDA region with population density

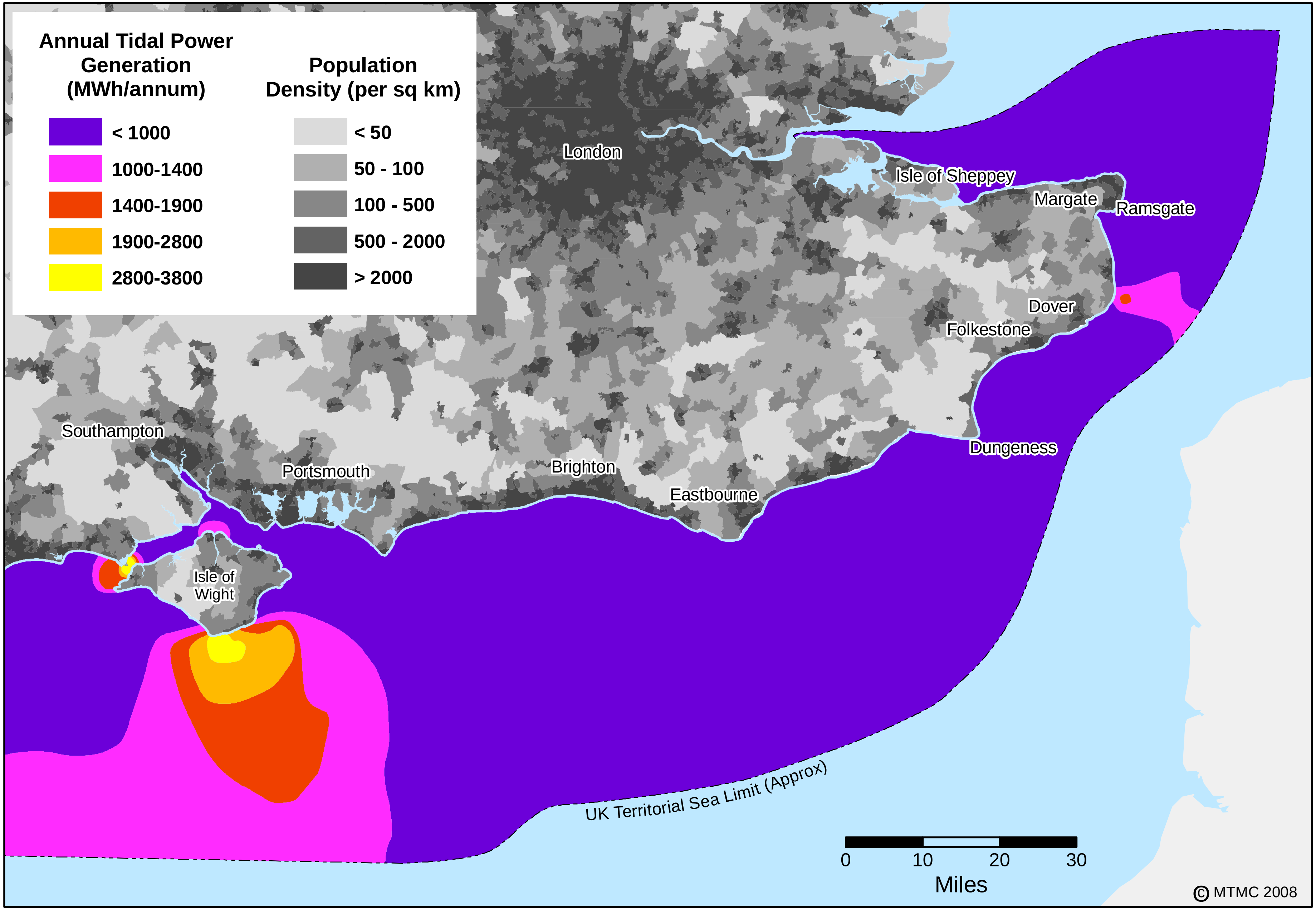


Chart 6 – Mean spring tidal range at coastal locations in the SEEDA region

Key Points:

- The tidal range shown opposite is the difference (in metres) between the sea level at mean high water springs and mean low water springs
- The tidal range increases as we move east along the south coast of England, owing to the constriction for tidal flow through the Straits of Dover
- A good tidal range resource occurs in certain locations, particularly between Eastbourne and Dungeness, where the tidal stream resource is too low for commercial exploitation
- Methods for exploitation of a high tidal range include barrages across estuaries and tidal lagoons. Other micro-scale methods of exploitation have been proposed, which would have a lower environmental impact.

Chart 6: Mean spring tidal range at coastal locations in the SEEDA region (in metres)

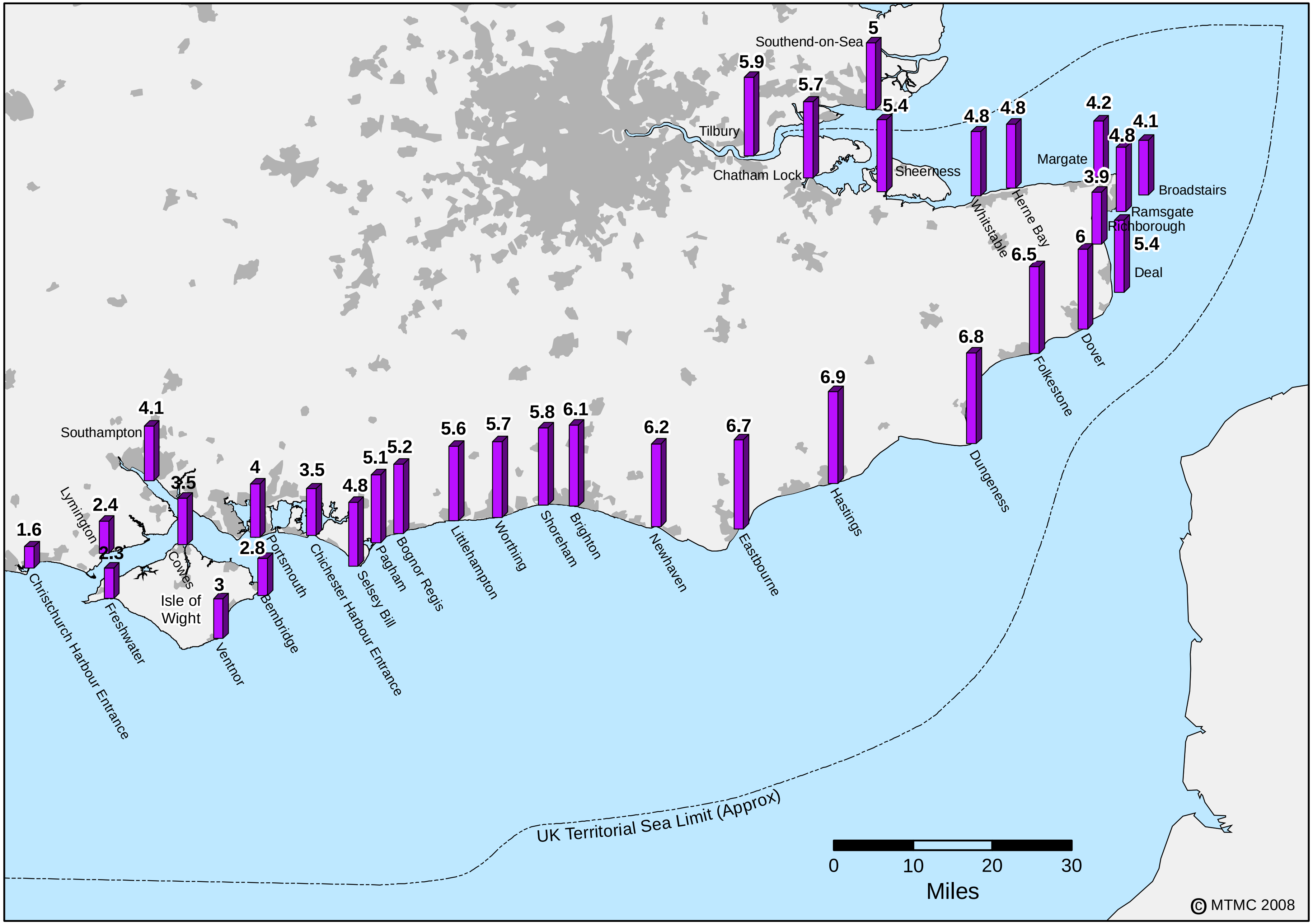


Chart 7 – Locations of physical and environmental constraints (overview)

Key Points:

- Marine renewable energy developments are subject to the conditions set out by necessary licences, such as the Food and Environmental Protection Act (FEPA) licence.
- The FEPA licence requires prior consultation with, and agreement to the development by, a number of statutory consultees and marine stakeholders
- The interests of these stakeholders will limit the areas in the SEEDA region where tidal stream energy developments will be permitted. Existing constraints include (but are not limited to):
    - Special Areas of Conservation (SACs), protected under EU legislation
    - Commercial shipping: congested shipping lanes, traffic separation schemes and designated shipping channels
    - Military activities: explosives dumping grounds and submarine exercise areas
    - Sites of protected historic wrecks
    - Subsea pipelines and cables
    - Leisure boat activities, e.g. Cowes Week Regatta and the Round the Island Race
- The insets on Chart 7 are expanded in Charts 8 and 9

Chart 7: Locations of physical and environmental constraints (overview)

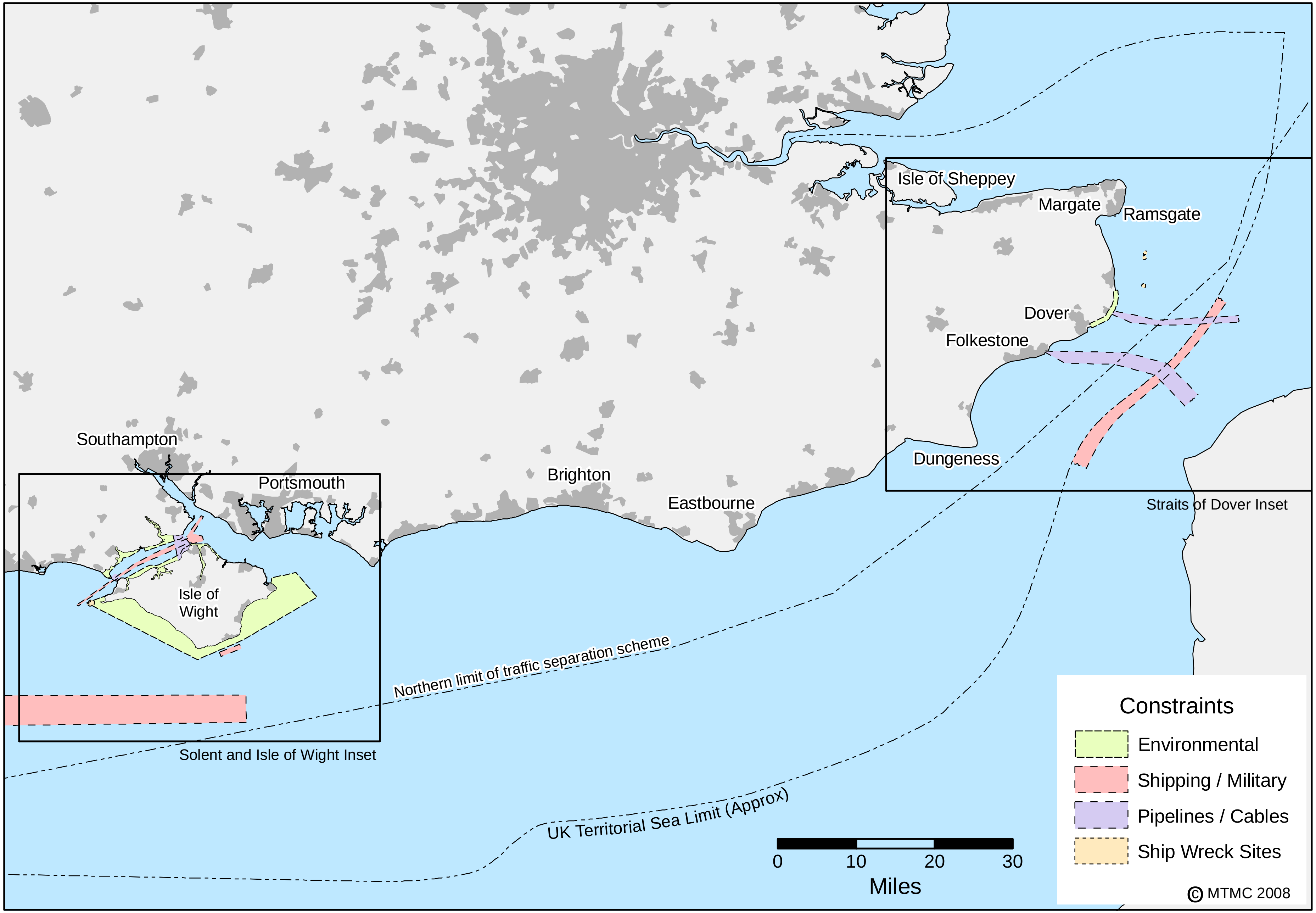


Chart 8 – Locations of physical and environmental constraints in the Straits of Dover

Key constraints on tidal stream energy development

- Congested shipping routes with traffic separation scheme
- Subsea power cables
- Protected historic wrecks on the Goodwin Sands
- Dover to Kingsdown Cliffs Special Area of Conservation (SAC) – chalk cliff exposure

Chart 8: Locations of physical and environmental constraints in the Straits of Dover

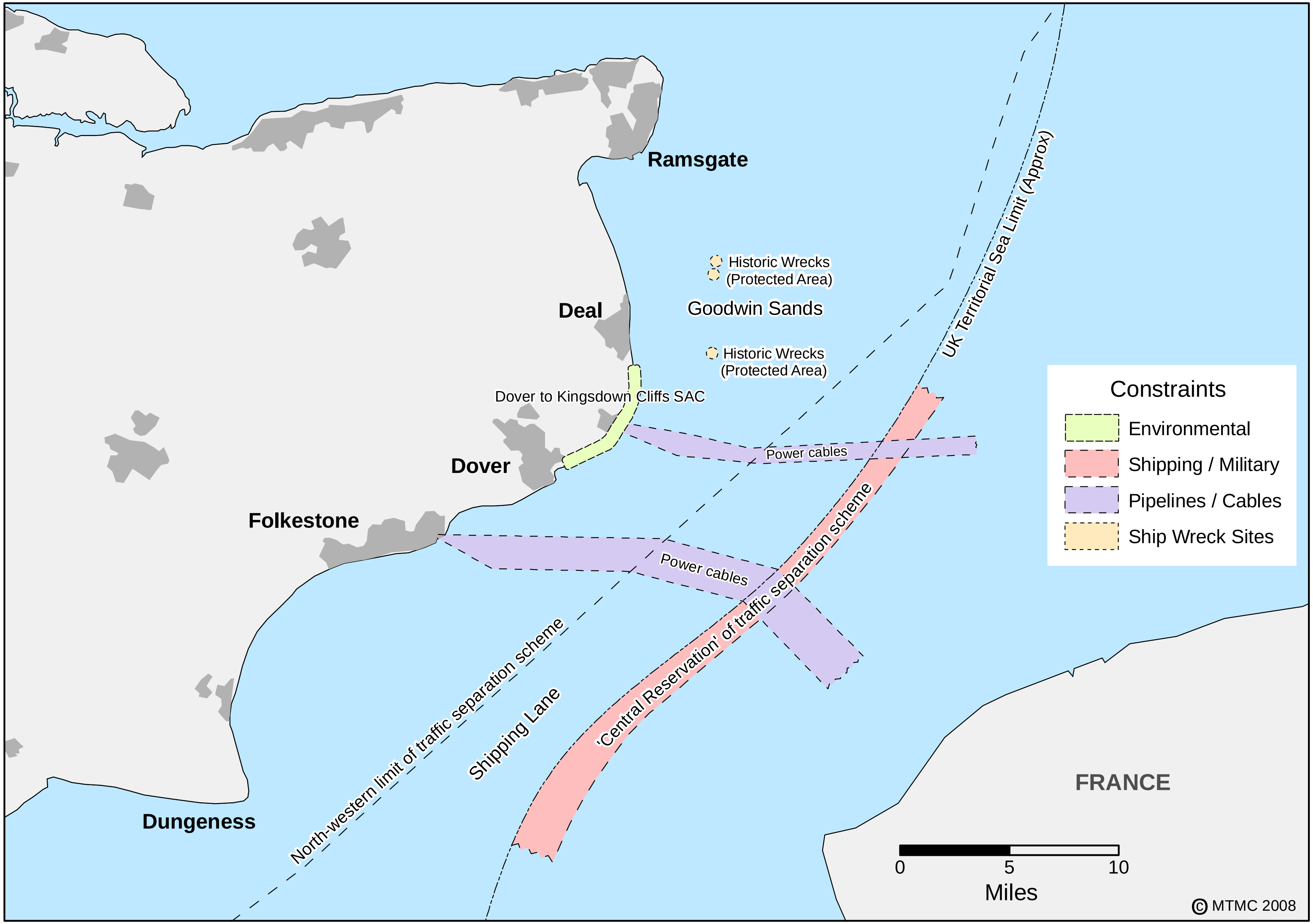


Chart 9 – Locations of physical and environmental constraints around the Solent and the Isle of Wight

Key constraints on tidal stream energy development

1. South of the Island

- Explosives dumping ground in St Catherine's Deep
- South Wight Maritime SAC – subtidal reefs
- Submarine exercise area (boundaries not marked on navigational charts)
- Offshore racing marks – occasional periods of high level activity for sailing boats

2. Central Solent

- Moving prohibited zone around underway vessels of greater length than 150 metres
- Submarine pipelines and cables

3. Western Solent

- Designated shipping channels
- Solent Maritime SAC – River Yar and Newtown Harbour estuaries and mudflats

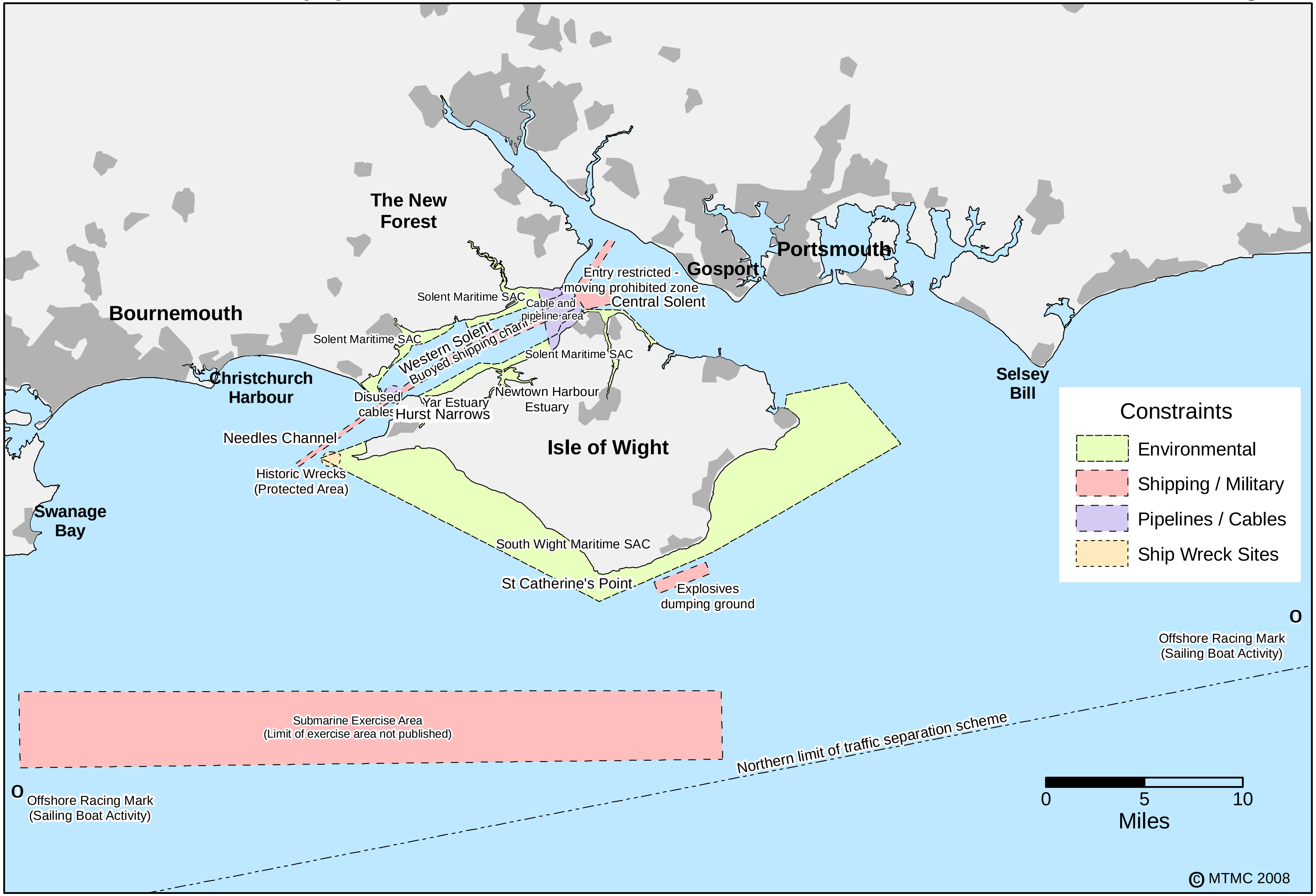
4. Hurst Narrows

- Designated shipping channel
- Numerous disused subsea cables

5. Needles Channel

- Designated shipping channel
- Protected historic wrecks at the Needles

Chart 9: Locations of physical and environmental constraints around the Solent and the Isle of Wight



3. Acknowledgements

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