THE CROWN ESTATE

Submarine cables and offshore renewable energy installations

PROXIMITY STUDY

RedPenguin

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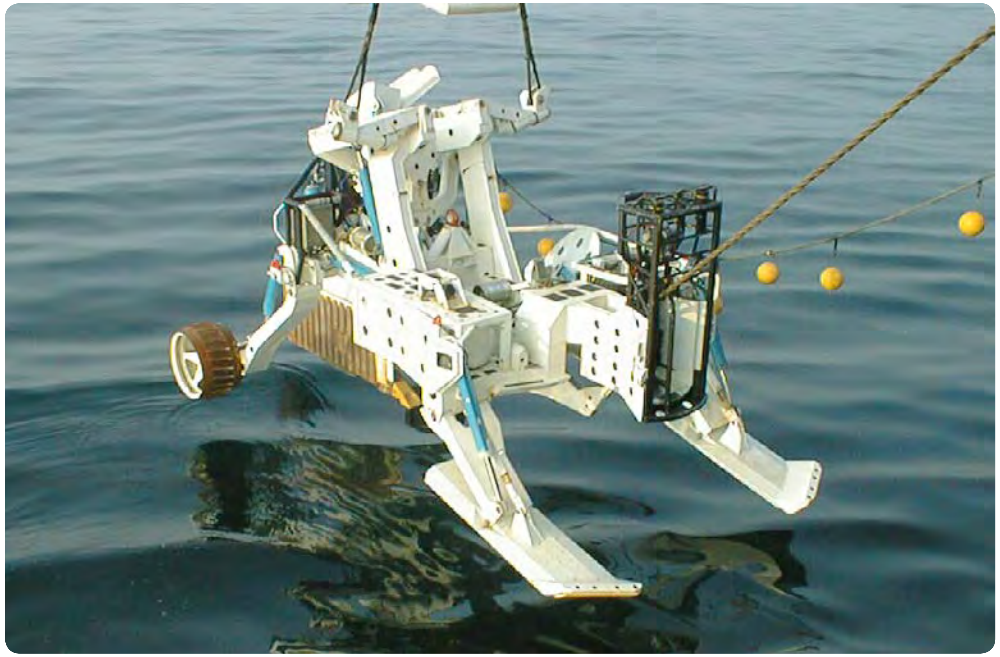

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Executive summary

The on-going development of wind farms within UK Renewable Energy Zone (REZ) waters has resulted in the need for cross industry endorsed guidelines on the proximity of submarine cables and wind farms. These guidelines will address installation and maintenance operations of wind farm structures, associated cables and other submarine cables, where such structures and submarine cables will occupy the same or neighbouring areas of seabed.

This study has been commissioned by The Crown Estate as the client on behalf of a group of industry stakeholders represented by Subsea Cables UK, Renewable UK and the Renewable Energy Association. A Steering Committee with members from The Crown Estate, Subsea Cables UK and Renewable UK has undertaken an iterative review process throughout the production of this report.

Whilst the focus of this document is on developments within UK REZ waters, other national administrations are invited to take note of its contents.

This report describes the findings of a desktop study conducted to provide an evidential basis upon which to draft these cross-industry guidelines. The report provides recommendations to de-conflict the installation and maintenance operations of the submarine cable and renewable energy industries where the activities or future requirements for maintenance for one may pose a risk for the other. The study has reviewed relevant legislation, reports and guidelines, made an assessment of any cross industry conflicts or constraints and from this an assessment of interactions was made and the associated risks identified.

Recommendations for the basic principles of submarine cable and renewable energy installation proximity guidelines are provided.

This study has focused on safe marine operations allowing for the most likely failure modes of vessels and equipment, using the right design, equipment, working methods and competent personnel and is provided as a reference tool to support the drafting and use of the proximity guidelines and as an assessment document for developers planning their operations. It is not intended as a guideline document in its own right.

The goals of future proximity guidelines are anticipated to be:

- Safe marine operations in accordance with legislation and industry best practice
- Minimising cable downtime in event of a fault
- Aim for risk assessed access for cable repairs for ease of repair-ability.

The application of these measures will:

- Protect wind farm and cable asset integrity
- Facilitate access to the wind farm site and export cable route for construction & maintenance
- Minimise changes to the optimum wind farm design (effect on revenue and capital costs)
- Minimise impact to the optimum routeing of cables
- Maximise the potential of consented areas for harnessing energy, and
- Minimise potential conflict between seabed users in congested coastal and offshore areas.

In terms of operational practice, we have assessed the proximity impacts between renewable energy installations and submarine cables in a range of water depths up to 200 metres (m), i.e. depths with foreseeable potential for OREI development in the next 10-20 years. A large part of the UK REZ has water depths in excess of 50m and it is likely that advances in foundation design and installation techniques will result in developments in these water depths in the future. Renewable energy developments in depths beyond 200m will require a re-appraisal of the issues assessed here and are therefore beyond the scope of this study.

The study identified that it is not appropriate to lay down specific separation distances between proximate situations, as the range of issues at any particular location are varied and particular to the site specific circumstances. The study consequently led to the recommendation that proximate situations are best dealt with through the mechanism of commercial agreement and sets out to provide examples of base case situations. The recommendation for a Proximity Agreement to manage proximate situations is based on the existing practice of proximity and crossing agreements within the industry.

The base case(s) developed in this report presents minima which may be considered when formulating the recommended Proximity Agreements, however the highly dynamic nature of the marine environment and the ordinary practice of seamen may make a reasonable deviation from these minima appropriate when drawing up guidelines to the industry, such that minimum distances are not considered the effective working distance until all circumstances of a particular case have been fully and properly assessed.

The arguments considered and the recommendations arising from the study are presented below immediately before the full report of the study, followed by Appendices, which contain much of the pertinent background information. .

As mentioned elsewhere in the report, the reader is cautioned to evaluate the currency of the information contained within this report and thus the relevant pertinence of the findings and recommendations over time.




Contents

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Glossary

Bathymetry: The measurement of water depth and the shape of seabed

Cable Crossing: A point at which a cable physically crosses another cable (or a pipeline). Such crossings normally being subject to an agreement protocol between the respective owners/operators

Catenary: The natural curve of a hanging cable, wire or rope

Dynamic Positioning (DP): a computer controlled system to automatically maintain a vessel's position and heading by using its own propellers and thrusters

Drift Off: The vessel drifts off position because of insufficient thruster capacity or because DP control system believes vessel to be keeping position

Drive Off: The vessel is driven off position by its own thrusters because the DP control system believes the vessel to be off position

Final Bight: The loop of cable laid to one side of the cable route at the location of a final joint in a submarine cable system or at the location of a fault repair

Grapnel: Generic term for a towed device of various designs used to locate, cut and recover a submarine cable

Interconnector: Generic term for a power cable linking two power distribution systems

Jetting: Marine cable burial techniques using a tracked, skid mounted or free swimming vehicle equipped with a water jet tool used to fluidise the seabed beneath a cable allowing it to sink into the seabed

Large Excursion: The vessel moves outside her footprint because of a disturbance to the DP control system

Ploughing: Marine cable burial techniques using a towed plough to bury a cable by mechanically displacing the soil

Repeater: Submarine housings in a telecommunication cable system which contain electronics and other equipment for the purposes of amplifying or equalising transmitted optical signals over great distances

Significant Wave Height (Hs): The average height of the one-third highest waves of a given wave group or sample

Tidal Energy Converter: A technical device or system designed to convert tidal stream energy to electrical energy

Trenching: Marine cable burial techniques using a tracked or skid mounted vehicle equipped with either a chain or wheel cutter to mechanically cut a trench in the seabed.

Wave Energy Converter: A technical device or system designed to convert wave energy to electrical energy

Abbreviations

AIS .... Automatic Identification System
ATBA .... Area to Be Avoided
BAS .... Burial Assessment Survey
BERR .... Department for Business, Enterprise and Regulatory Reform
CEFAS .... Centre for Environment Fisheries and Aquaculture Science
COWRIE ... Collaborative Offshore Wind Research into the Environment
CPA .... Coast Protection Act (1949)
DECC .... Department for Energy and Climate Change
DEFRA ...... Department for Environment, Food and Rural Affairs
DNV .... Det Norske Veritas
DP .... Dynamic Positioning
DSV .... Dive Support Vessel
DTI .... Department of Trade and Industry
EEZ .... Exclusive Economic Zone
EMS .... European Marine Site
EU .... European Union
FEPA .... Food and Environment Protection Act (1985)
FLR .... Fisheries Liaison Representative
GRT .... Gross Registered Tons
GW .... Gigawatt
HSE .... Health & Safety Executive
HVDC .... High Voltage Direct Current
IALA .... International Association of Lighthouse Authorities
IMO .... International Maritime Organisation
IPC .... Infrastructure Planning Commission
ISM .... International Safety Management (Code)
JNCC .... Joint Nature Conservation Committee
KIS-CA ...... Kingfisher Information Service – Cable awareness
KW .... Kilowatt
LWM .... Low Water Mark
MBR .... Minimum Bend Radius
MCA .... Maritime and Coastguard Agency
MCZ .... Marine Conservation Zone
MEHRA .... Marine Environmental High Risk Areas
MFE .... Mass Flow Excavator
MGN .... Marine Guidance Note
MHWS ..... Mean High Water Springs
MIN .... Marine Information Notice
MLWS ...... Mean Low Water Springs
MMO .... Marine Management Organisation
MSN .... Merchant Shipping Notice
MW .... Megawatt
NDPB .... Non-Departmental Public Body
NFFO .... National Federation of Fishermen's Organisations
NFFO .... Non-Fossil Fuel Obligation
NGO .... Non-Governmental Organisation
NRA .... Navigation Risk Assessment
NSIP .... Nationally Significant Infrastructure Project
OREI .... Offshore Renewable Energy Installations
REZ .... Renewable Energy Zone
ROV .... Remotely Operated Vehicle
RUK .... RenewablesUK
SEA .... Strategic Environmental Assessment
SFF .... Scottish Fisherman's Federation
STCW-95 .. Convention on Standards of Training Certification & Watch-keeping 1995
TEC .... Tidal Energy Converter
TMS .... Tether Management System
TSC .... Territorial Sea Committee
UK .... United Kingdom
UKOOA .... United Kingdom Offshore Operators Association (now Oil & Gas UK)
VTS .... Vessel Traffic Services
WAG .... Welsh Assembly Government
WEC .... Wave Energy Converter
WOAD ..... World Offshore Accident Database
WTG .... Wind Turbine Generator
WROV ...... Work-Class Remotely Operated Vehicle




Summary of principal arguments and recommendations

The principal arguments arising from the Proximity Study are:

1. **Creation of a Proximity Agreement protocol**
2. **Proper understanding of Minimum Distance of Approach.**

Proximity Agreements – General remarks

Such proximity agreements would be based on the well-established format and protocol of crossing agreements in common use in the industry which have for many years formed part of system installation design and practice.

It should be observed that with the creation of a Proximity Agreement, it is possible that crossing agreements may also be required as part of the same process. Depending on the circumstances of the case, such agreements may be included within an overall Proximity Agreement (if relevant) or dealt with as a separate item if outside the scope of the proximity document.

In either case the observance of agreed principles for cable proximity or crossing should be rigorously maintained.

Discussion on these agreements follows in the main body of the report.

Minimum Distance of Approach – General remarks

For Minimum Distance of Approach, the report offers base case examples for defining minimum approach distances of repair vessels to OREI and describes a control process that should be followed with regard to the DP rating of the vessel(s) involved.

It is to be noted that the discussion on minimum distances is viewed from a perspective of an absolute minimum to which suitable operational contingency may be added according to the prevailing circumstances and conditions.

Details of these examples (Minimum Distance of Approach) are contained in Appendix A.

Proximity Agreement – Detail

Overall strategy for developing a proximity agreement

After considering the evidence as presented in Section 2 and Appendix D of this study we are of the opinion that a simple set of limiting distances cannot be derived for all cable/wind farm proximity scenarios without recourse to a large number of caveats and exceptions. Our recommended approach is to use the principle of a bilateral proximity agreement for each specific scenario based on a standard template and base case guidelines. Such a proximity agreement would be based on the format and spirit of existing cable crossing and proximity agreements in common use throughout both industries.

We recommend that the following key elements be included in such a proximity agreement:

- Clauses to define the liabilities and rights of both parties
- The exclusion/inclusion of consequential losses
- Details of financial compensation arrangements for each party where applicable relating to base case arrangements
- Clearly defined limits of the area to which the Proximity Agreement applies
- Agreement on proximity limits informed by the Proximity Guidelines and then modified up or down by agreement depending on the method statements submitted and agreed
- Details of how the proximate work would be carried out – method statements provided by the party carrying out the work and accepted by the second party as suitable prior to work proceeding (it is not recommended that installation procedures be included in the body of the Agreement)
- Future maintenance requirements of both assets. This may include the method by which notification of operations by each party is given to the other
- Definition of the expiry of the Agreement (for example, at the decommissioning of one or other of the assets)
- Provision of representatives from one party to the other party's operations and their rights, obligations and limitation of their authority.

The process of using a proximity agreement and base case proximity distance tables as tools for drafting a site specific

Table 0-1 Recommended base case proximity limits for DP & self-propelled vessels

Scenario	Manual control proximity limit	DP 1 vessel proximity limit	DP 2 vessel proximity limit
	All distances measured from the closest extremity of the vessel to the OREI		
Conducting cable repair operations in the lee of a wind farm structure	200 metres (Control or propulsion failure resulting in a drift off scenario)	50 metres* (Control or propulsion failure resulting in a drift off scenario)	50 metres (Control or propulsion failure resulting in a drift off scenario)
Conducting cable repair operations on the weather side of a wind farm structure	500 metres (Control or propulsion failure resulting in a drift on and subsequent manual control correction)	200 metres* (Control or propulsion failure resulting in a drift on and subsequent manual control correction)	100 metres (Propulsion failure in DP 2 mode would require propulsion redundancy to correct drift on)

* Distances from closest point of approach of the vessel involved.

proximity agreement needs intelligent application and is not intended to be prescriptive.

An important factor in the overall strategy for developing proximity agreements will be safety management and competency, which is covered in the section below.

Safety management & competency

The station keeping performance capability of any vessel is a combination of design, maintenance standards and operational competence in the face of environmental and site specific conditions. We consider that close attention to safe operating practices, competency assurance and behavioural based safety to be equally as important as the technical reliability and performance of vessels and equipment when defining proximity limits. Statistical evidence and numerous reports and guidelines endorse this view.

Whilst the safe operation of vessels is legislated at international and national levels, there are a range of applicable safety standards depending on the size and/or power of a particular vessel with some vessels (particularly towed barges) which fall outside the more stringent requirements such as the International Safety Management (ISM) Code. We recommend that the principles of the ISM Code be applied to proximate vessel operations irrespective of vessel size, power or class.

The International Convention on Standards of Training, Certification and Watch-keeping for Seafarers (the STCW-95 Convention) has recently been amended (1st January 2012) to include training guidance for DP watch-keepers. This report recommends that this amendment and the existing Nautical Institute DP training scheme be acknowledged during the drafting of any proximity guidelines.

Operations within a Hazard Area (or Area of Enhanced Operational Awareness)

It is worth considering the safe working practices that have been developed in the oil and gas sector with respect to vessels approaching fixed and floating structures. Operational safety in these situations is largely managed by controls and procedures together with prescribed levels of personnel competency and good operating and maintenance practices. In all cases, these controls include contingency measures and factors of safety to provide for the recovery from all likely failure mode events for vessels and equipment.

Existing crossing and proximity agreement templates generally prescribe additional safety controls within a defined ‘hazardous area’ around a fixed or floating structure in order to manage the additional safety hazards present. A 250m ‘Notification Area’ around structures is often adopted where vessel entry would activate these additional requirements specified in the crossing or proximity agreement. We recommend that the definition of such a hazardous area be included within the proximity guidelines within which a heightened level of operational readiness and safety awareness be activated.

The role of the Master

In common with conventional maritime law and practice the Master has overall legal responsibility for the safety of his vessel, the personnel on board, and the protection of the environment, and we recommend that this is properly acknowledged in the development and spirit of the proximity guidelines.

It should be noted that the prerogative of the vessel master will play a significant part in the actual execution of the works that are defined within any proximity agreement and in all vessel operations discussed herein. As such this study actively encourages that due consultation with masters should form part of the preparation process.

In addition, we recommend that wherever possible, the relevant Masters and senior vessel officers are also involved in the planning of proximate marine operations.

Vessel operations – General comments.

Our detailed assessment identifies five key operations that dictate proximity limits, which are summarised below; namely:

- Dynamic positioning operations
- Use of ROVs and related subsea equipment
- Anchored vessel operations
- Grapnel operations
- Final bight laydown.

For each of these operations we recommend a risk based rather than prescriptive approach when determining proximity limits for a particular operation or location (recommended proximity limits would be subject to inclusion of any notification/hazard area mitigation measures deemed necessary by risk assessment).

DP operations

It is demonstrable that with increasing technical reliability of propulsion and control systems, the main causes of DP station keeping incidents are related to human error. While the DP class of a particular vessel remains relevant, we consider procedural regimes and behavioural safety to be of significant importance in developing proximity guidelines for DP and other self-propelled vessels.

While DP Class 1 vessels in common use, particularly in the telecommunications cable repair sector, are inherently less reliable in station keeping terms, we would assert that providing proper operating controls and procedures are followed then the use of DP Class 1 vessels should not translate into more station keeping incidents than for DP 2 vessels, providing such DP 1 vessels are operated more conservatively in terms of proximity distances.

Table 0-2 Recommended base case proximity limits for ROVs, ploughs and jetting legs

Subsea Tool	Self-propelled support vessel	Moored support vessel
Plough (towards a cable or subsea structure)	500m	100m
Plough (away from a cable or subsea structure)	100m	100m
Tracked mechanical ROV trencher	100m	100m
Tracked ROV Jetter	50m	50m
Jetting Leg (towards a cable or subsea structure)		100m
Jetting Leg (away from a cable or subsea structure)		100m

Table 0-3 Recommended base case anchor and anchor line proximity limits

Anchoring scenario	Self-propelled support vessel	Moored support vessel
Vessel & barge anchors (Routine anchoring)	500m	500m
Barge anchors (Pulling towards a cable or subsea structure)		250m
Barge anchors (Pulling towards a cable or subsea structure)		150m
Barge anchors (Pulling towards a cable or subsea structure)		100m
Barge anchors (Vertical separation between anchor line and cable or subsea structure)		10m

Table 0-4 Distances for grapnel operations

Water depth (metres)	Layback (metres)	Run on (metres)	Length of grapnel rope (metres)	Remarks
5	20	50	30	Grapnel rope length approximately 3 times the depth of water up to 200m depth of water. Depths of water greater than 200m are not considered here but a grapnel rope length in the order of (depth of water + 30%) would be appropriate
10	30	50	40	
20	40	50	50	
30	70	50	90	
40	100	50	120	
50	140	50	150	
100	240	50-60	250-300	
150	360-400	50-60	400-450	
200	500-550	50-60	600-650	

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In order to define base case proximity limits for DP cable repair vessels we have used our own operational experience and have consulted with vessel operators to derive Table 0-1 which includes 'Manual Control' vessels as a comparison.

The limits proposed in Table 0-1 assume that a particular vessel is designed, operated and manned in accordance with industry best practice, i.e. any deficiencies such as reduced manning or equipment downtime should be considered valid reasons for increasing such proximity limits.

ROVs & related subsea equipment

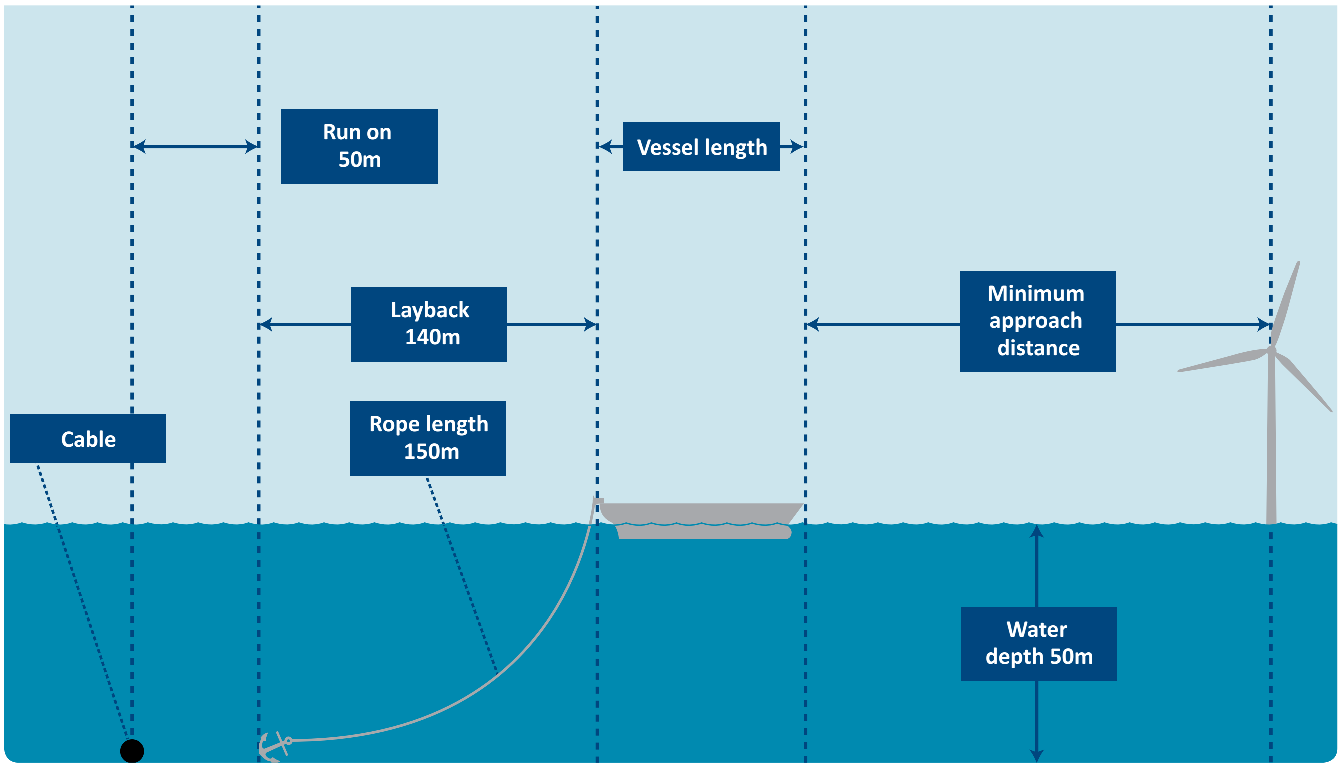
ROV intervention would in almost all cases be the preferred cable intervention method in water depths up to 200m, at least initially. Once initial ROV inspection has been completed then the options become more broad ranging, dictated by seabed type, depth of burial, environmental parameters, cable offset distance (in which case ROV is preferable), cable type etc. In the majority of cases it can be expected that cable fault repairs may be carried out using a combination of grapnel and ROV techniques. Table 0-2 summarises our recommended base case proximity limits.

Grapnel operations

As grapnel operations generally require more sea-room than ROV cable recovery methods, the use of grapnels is a key consideration for this study.

For depths of up to 200m, Table 0-4 is offered as a guideline set of base case operational distances for grapnel operations. It is acknowledged however that final proximity limits for a given repair scenario will be dependent on a large number of variables which combine to produce a unique set of requirements for each cable repair.

Figure 0-1: Minimum distance criteria for grapnel operations in 50m water depth



Trailed electrodes

The use of trailed electrodes remains a common and well-proven technique for fault finding in telecoms cable repair operations. For expediency it is common for the main repair vessel to carry out the work, but auxiliary vessels may also be employed if these are available and the operational conditions are suitable.

In either case the sea-room required for the vessel to safely and efficiently manoeuvre whilst trailing the electrode rig, must be properly considered within the cable versus OREI proximity argument.

Anchored operations

An anchored barge may be used for cable installation or repairs in proximity to a wind farm or conversely for wind farm work in proximity to an existing cable. The use of jack up barges for wind farm construction or cable repair activities can also involve the deployment of anchors to aid positioning prior to jacking operations.

While the deployment of anchors represents an additional constraint when planning proximity limits, the fact that anchors lines can span an existing subsea cable allows a degree of flexibility in the use of anchors in a congested seabed area.

While it is not possible to prescribe minimum proximity limits for anchors and wires that suit all situations, given proper controls, our assessment is that it should be possible to adopt base case limits as shown in Table 0-3.

Grapnel operations limits

As grapnel operations require more sea-room than ROV cable recovery methods, the use of grapnels is a key consideration for this study.

For depths of up to 200 metres, Table 0-4 is offered as a guideline set of base case operational distances for grapnel operations. It is acknowledged however that final proximity limits for a given repair scenario will be dependent on a large number of variables which combine to produce a unique set of requirements for each cable repair.

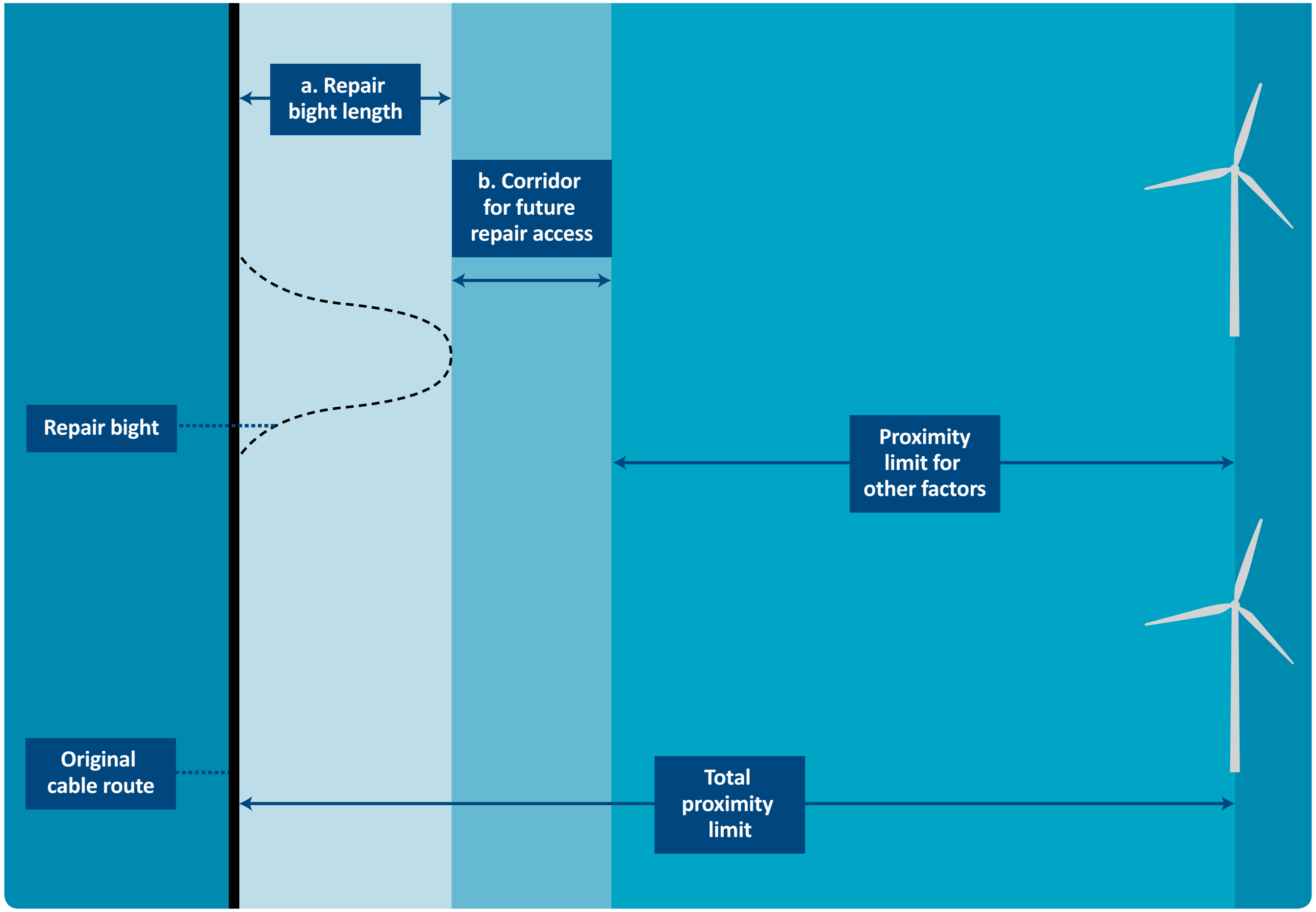
Taking the example illustrated in Figure 0-1, the minimum proximity distance between wind-farm structures and cable will need to take account the absolute minimum amount of the sea-room required for typical repair activities such as grappling thus: –

Run on e.g. 50m
Layback 140m
Vessel length 150m
Absolute minimum distance 340m

In addition to this distance the final overall proximity limit will then need to take into account:

- The sea-room required for manoeuvring of the vessel in preparation for the grappling operations as well as the grappling drive itself and,

Figure 0-2 Cable repair bight access requirements ('a' and 'b' defined in Table 0-5)



- Grappling distance (340m in this example), and the minimum approach distance for the vessel, which is a function of the relevant site-specific factors and the class of vessel in use.

This is discussed more fully in Appendix A.

Note 1: The distances shown in Fig 0-1 are to be considered as absolute minimum distances and are derived assuming the most optimum conditions and a most conservative grapnel layback.

In practice an allowance for differences in grappling rig arrangements, operational contingency (e.g. wind & tidal effects) and attention to the particular circumstances of the case should be made and added to the arguments expressed here. It is possible therefore that figures in excess of the examples shown may appear in other papers and publications on the subject.

Final bight laydown

The final laid down bight length (displacement from the original line) of a cable repair or final installed joint in a cable system is a function of:

- Water depth
- The physical characteristics of the cable
- Characteristics and constraints of the repair vessel layout
- Prevailing weather and tidal conditions at the time of the laydown operation.

Attention is drawn to the differences in bight deployment techniques between telecoms and power cables. Also the differences in preparation and laying out of cable ends for jointing are significant when comparing between telecoms and power systems. As such due recognition of each should be fully incorporated in all proximity planning.

It can be seen from Figure 0-2 that proximity limits between a cable and a wind farm structure needs to take rigorous account of the space required for a repair joint and in addition a further allowance for future cable repair access at or near the repair bight area.

Figure 0-3 above is provided to illustrate the terms water depth, freeboard, deck length and repair bight crown used in Table 0-5.

Table 0-5 provides our assessment of base case repair bight lengths (offset from original line) for a range of water depths up to 200m. An additional corridor providing for future cable repair access is also included for consideration, whilst *acknowledging that the probability of carrying out a subsequent cable repair at the crown of the repair bight is likely to be very low. The dimensions in table columns 'A' and 'B' equate to the 'A' and 'B' dimensions in Figure 0-2.*

It must be emphasised that this serves as an illustration of minimum distances and does not constitute a definitive case.

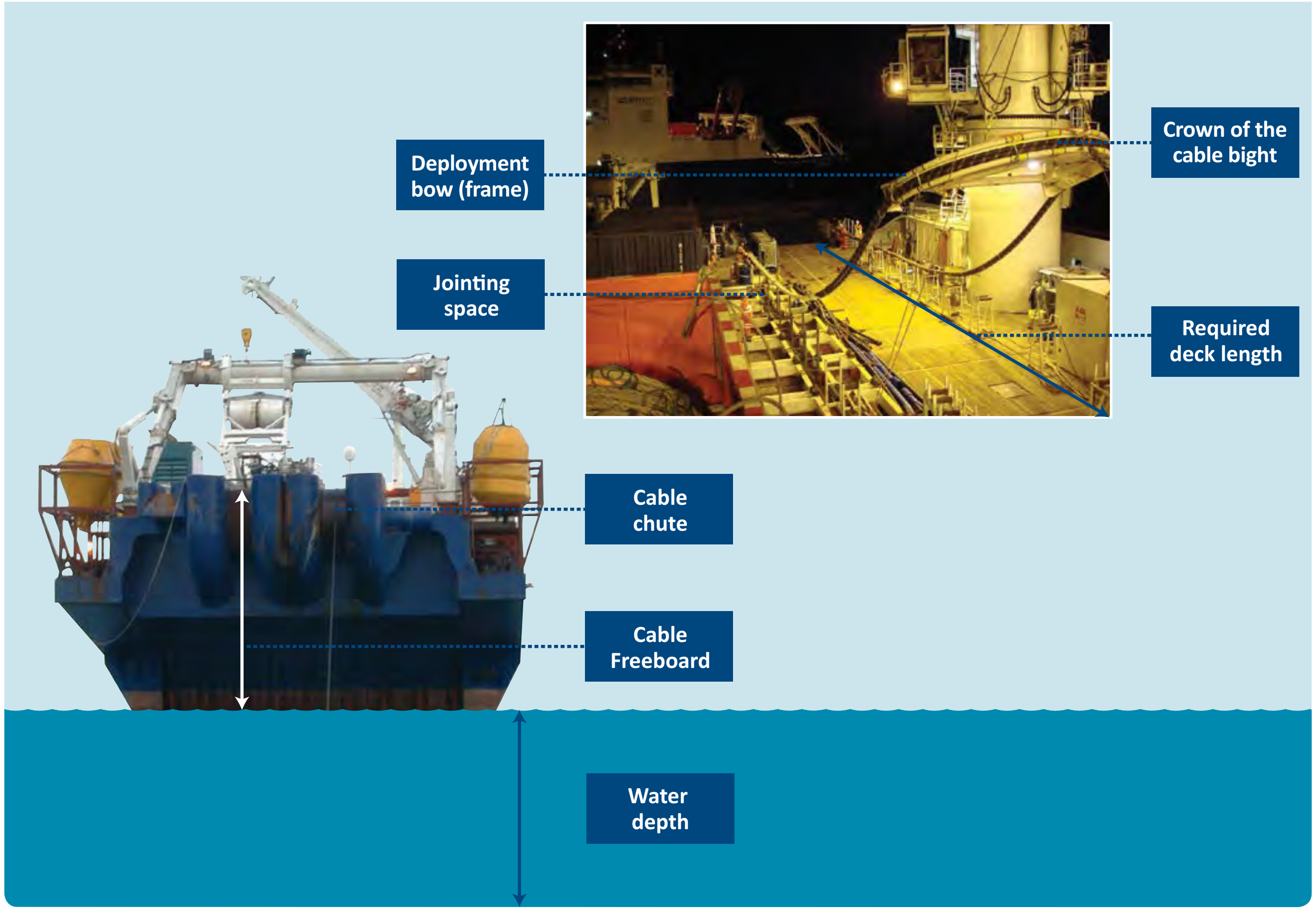
Additional considerations

There are a number of additional proximity considerations identified within this study summarised below:

Safety Zones – A mechanism providing dispensation to approach within the wind farm 500m/50m safety zone would in our assessment be mutually beneficial to both wind farm developer and cable owner.

Decommissioning – There is a general presumption in favour of disused installations (OREI structures and subsea cables) being removed from site unless the owner demonstrates that removal of a particular component is not viable or where removal may create a net detrimental environmental impact. This presumption of removal should be taken into account when planning proximity limits between two developments, particularly in congested seabed areas where installation removal would be required to create space for future/replacement developments. Due consideration should be given to the possibility of de-commissioned subsea cables or cable sections being left in situ as this may be favoured from an environmental impact.

Figure 0-3 Dimensions and terms relating to cable repair bights



Wave & tidal energy developments – Of the sites and areas identified to date with potential for development, many are in locations unsuitable for competing seabed developments due to the energetic nature of the environmental conditions. Our assessment is that in the medium term there are unlikely to be significant conflicts between submarine cables and wave/tidal energy developments. Where such conflicts do arise, the principles and base case limits proposed in this study should, in our opinion, be adopted.

Proximity limits process

From review of the base case proximity limits recommended for specific operations and equipment above, it is apparent that there is a fairly complex matrix of proximity scenarios. Our recommendation is that a the flow chart based on the proximity tables provided in Section 4 and above be used to identify the critical path activity or activities, that define the proximity limits for a given scenario. This flow chart

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Table 0-5 Cable repair bights – minimum dimensions

Water depth (metres)	Telecommunications cable repair bight displacement (metres)	Additional corridor width for future access to repair bight (metres)	Power cable repair bight displacement (metres)	Additional corridor width for future access to repair bight (metres)
	'a'	'b'	'a'	'b'
Minimum	Water depth + freeboard + repair bight crown + deck length[1]	50	Water depth + freeboard + repair bight crown + deck length	50
10-100	Water depth + freeboard + repair bight crown + deck length	100	Water depth + freeboard + repair bight crown + deck length	100
100-200	Water depth + freeboard + repair bight crown + deck length	200	Water depth + freeboard + repair bight crown + deck length	200

[1] Deck length base case (e.g. HVDC cable type) as follows:

Vessel freeboard.......................... = 5m (cable distance from waterline – cable chute)
Deck length.......................... = 45m (required on deck for handling, jointing etc)
Crown of cable bight................. = 5m
Total................................ = 55m

is also provided in Appendix A together with a worked example illustrating its use.

There are a number of operational decisions (some with commercial implications) that could be made to minimise proximity distances and these are discussed in detail elsewhere in this document, but in summary include:

- Use of DP control in conjunction with winch control of the grapnel set to minimise or eliminate the run on distance
- Carry out cable repairs only when environmental conditions present a drift off scenario allowing a vessel to approach closer to the wind farm structure
- Substitute the use of a DP Class 1 vessel with a DP Class 2 vessel for tasks in close proximity to structures
- Orientation of a vessel other than end on to the wind farm structure when carrying out proximate operations
- Conduct operations away from the immediate area of constraint with a potential consequence of requiring a greater length of inserted spare cable.

As we have stressed throughout this document this final base case proximity limit is just that – a base case proximity limit. A risk assessment of all site-specific factors has then to be conducted to arrive at the final figure for a given scenario, which may on occasion be greater than the base case.

Introduction

Background

The on-going development of wind farms within UK Renewable Energy Zone (REZ) waters has resulted in the need for cross industry-endorsed guidelines on the proximity of submarine cables and wind farms. These guidelines will address installation and maintenance operations of wind farm structures, associated cables and other submarine cables where such structures and submarine cables will occupy the same or neighbouring areas of seabed. The purpose of this report is to provide an evidence-based study and to provide a tool to support the drafting of the guidelines.

This report has been commissioned by The Crown Estate as the client on behalf of a group of industry stakeholders represented by Subsea Cables UK and Renewable UK. A Steering Committee with members from The Crown Estate, Subsea Cables UK and Renewable UK has undertaken an iterative review process throughout the production of this report.

Whilst the focus of this document is on developments within UK REZ waters, other national administrations are invited to take note of its contents.

The Crown Estate, Subsea Cables UK & Renewable UK (RUK)

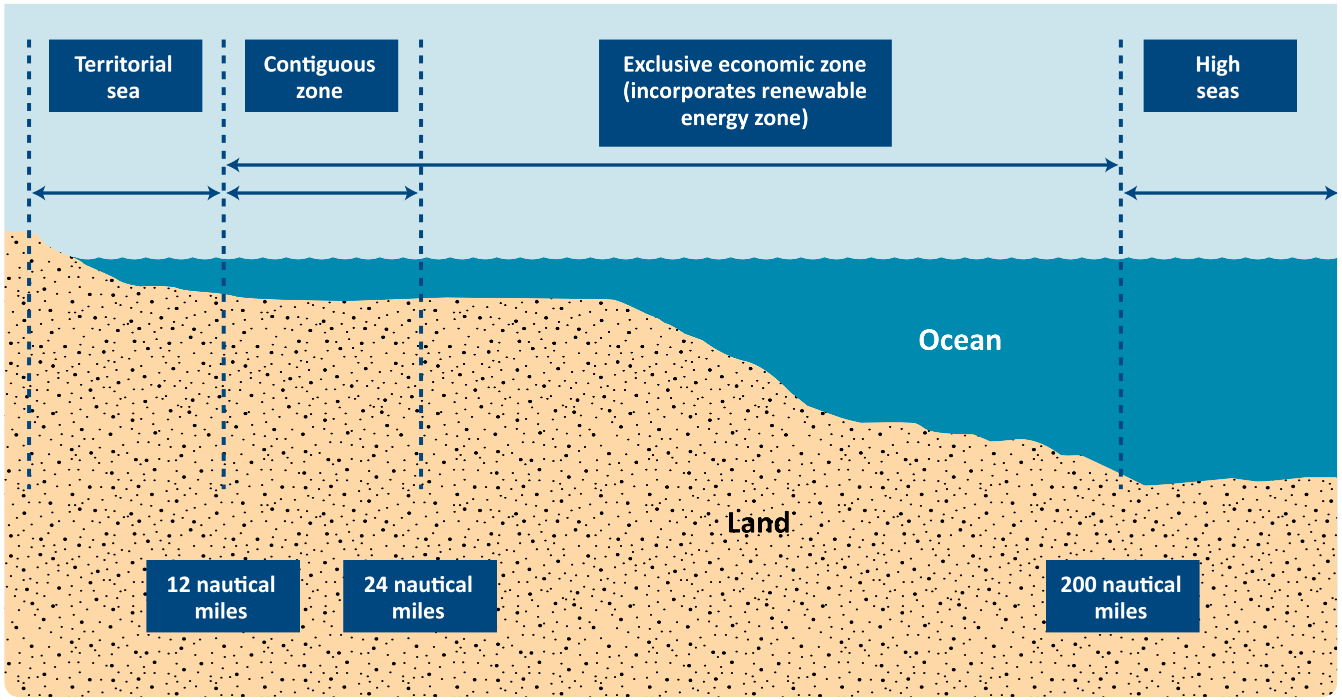
The Crown Estate manages on behalf of The Crown, approximately 50% of the foreshore, and tidal riverbeds together with most of the seabed out to the 12 nautical mile territorial limit and rights to renewable energy developments within the UK REZ. **http://www.thecrownestate.co.uk**

Subsea Cables UK (formerly the United Kingdom Cable Protection Committee – UKCPC) is a forum of national and international companies, which own, operate, or service submarine cables in UK and surrounding waters. The principal aim of Subsea Cables UK is the promotion of marine safety and safeguarding of submarine cables on the UK continental shelf from man-made and natural hazards. **http://www.subseacablesuk.org.uk**

Renewable UK (RUK) is the trade and professional body for the UK wind and marine (wave and tidal) renewable energy industries. Its primary aim is the promotion of wind, wave and tidal power in and around the UK on behalf of its members. **http://www.renewableuk.com**

The Renewable Energy Association (REA) is a UK renewable trade association that represents renewable

Figure 1-1 Inter-relationship between sea areas defined in UNCLOS



energy producers and promotes the use of all forms of renewable energy in the UK across power, heat, transport and renewable gas. It has 960 members, ranging from major multinationals to sole traders. The REA's Ocean Energy Group covers wave and tidal energy, focusing on the progress of device development to prove the capability and survivability of full-scale prototypes, and the transitional measures required to bring projects to commercial fruition:
http://www.r-e-a.net

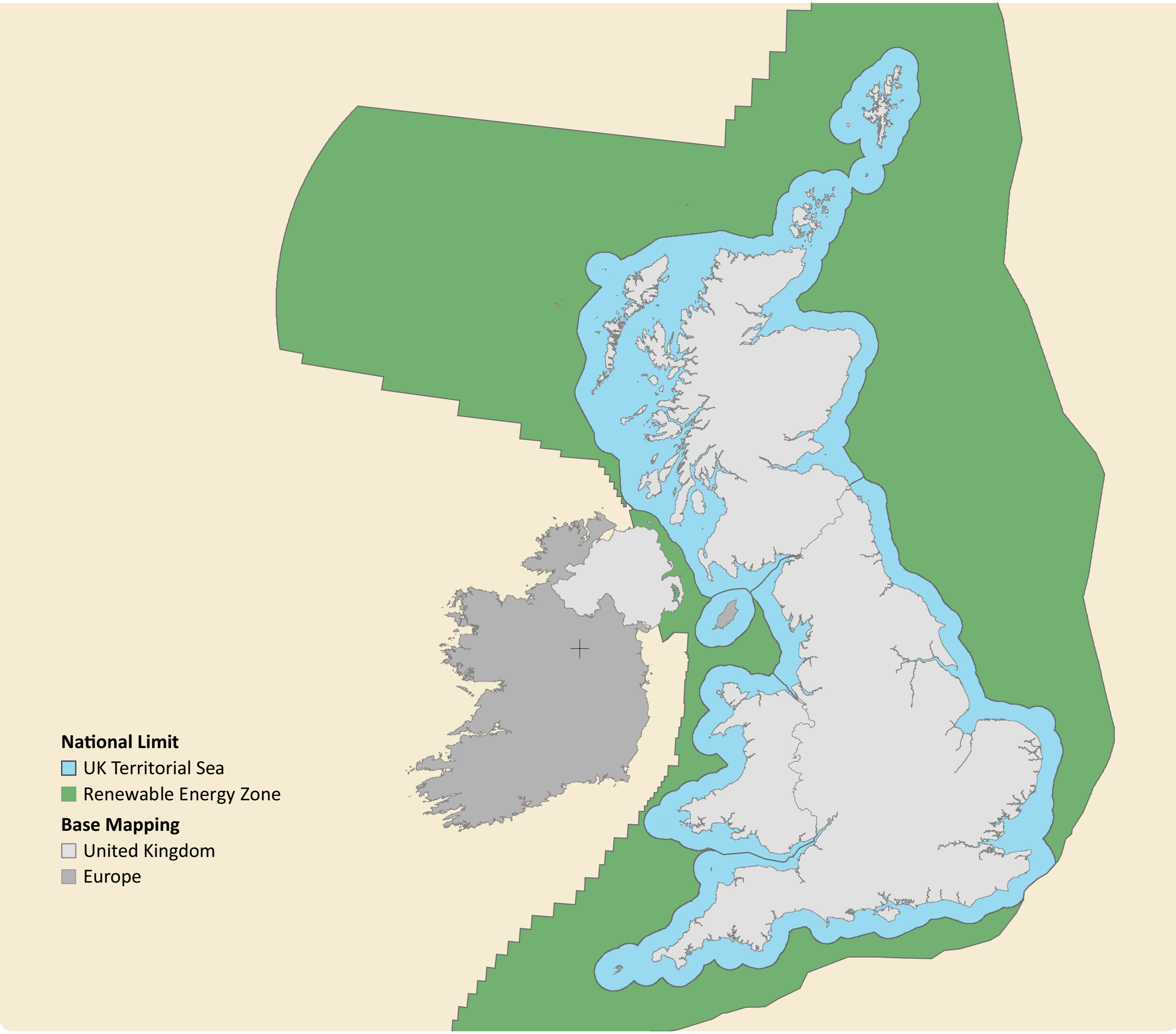
Red Penguin Associates

Red Penguin Associates Limited (Red Penguin) is a marine and cable engineering consultancy specialising in submarine cable operations and related matters, particularly the planning, engineering, installation and maintenance of telecommunications and power cables. Red Penguin is active in telecommunications and power transmission sectors and can demonstrate a successful track record in a range of projects for telecommunications carriers, grid interconnectors, offshore oil and gas projects and the offshore renewable energy industry.

Red Penguin's experience in these sectors and the wider marine environment, provides the depth of knowledge and capacity for an unrivalled source of experience of cable route design, engineering, installation, and the planning and execution of cable repairs and other maintenance operations for telecom's, HVDC and HVAC cables, preparation of crossing and proximity agreements, consents and permitting arrangements and review of associated studies.

Red Penguin is an independent member of Subsea Cables UK with representatives on the technical and marine sub committees and was awarded the contract to perform this study following an open tender process.

Figure 1-2 Extent of the UK Renewable Energy Zone



The background

Historical review

Submarine cables

The development of submarine cables started with the advent of radio telegraphy communications in the 1860's followed soon after, at the turn of the century, by relatively short power distribution cables in the form of inter-island and cross river or estuary power links. Overall the development of submarine cables in UK REZ waters can be considered in six distinct phases;

1. Telegraphy communications cables were first installed in the 1860s through to the mid-1950s
2. Co-axial telephony cables emerged in the 1950's and increased in total capacity through until the mid-1980s
3. Fibre optic digital cables have been installed from 1980s – present day with an exponential growth in capacity during that period
4. Power and umbilical cables servicing the UK offshore oil and gas industry established from 1970s – present day
5. Local submarine power cables providing short distance inter-island and cross-estuary links from early 1900s – present day
6. Modern energy generation and distribution comprising Renewables, Interconnectors and Offshore grid developments 1980s – present day.

Note: Cable systems are also in place for defence, maritime vigilance and scientific purposes but their extent is limited in comparison to the classes of cables described above.

The network of telecommunications cables grew to a considerable complexity; with the arrival of co-axial telephony and later fibre optic digital systems in the mid-1980's and the significant increase in submarine power cables more recently has greatly increased the cable density and distribution across the UK continental shelf. This is at a time when oil and gas development, aggregates extraction and offshore marine renewable energy projects (together with their respective service cables) have all shown significant development. The result today is ever increasing demands on the seabed space available.

Submarine power cables were first developed in the early 1900's and for a number of decades, power cable distribution was limited to relatively short applications such as river and estuary crossings and inter island links. It was not until the 1950's that the first serious plans were drawn up for a submarine interconnector link between France and UK, which was commissioned in 1961. Due to increasing capacity demands, this was replaced by a 2 GW link in 1986.

More recently in the last two decades, there has been a marked increase in the development of submarine power interconnectors between UK and neighbouring countries, and grid links, driven by the needs of the renewable energy sector and the desire for energy security at a national level. The development of interconnectors has occurred in tandem with the installation of the export and inter-array cables of the first offshore wind farms, the development of which is covered in more detail in Section 2.1.2.

Submarine cables connecting offshore oil and gas facilities have also increased significantly in numbers and technical complexity since the installation of the first oil and gas structures in the 1970s. Technological advances in subsea engineering and need to drive down operating costs has seen the development of remotely operated subsea structures and floating production facilities connected by umbilicals and jumpers supplying power, fibre optic communications, hydraulics and injection chemicals. There has also been a trend for powering offshore installations from onshore via submarine power cables. The latest development in the evolution of oil & gas related submarine cables is the use of submarine power cables to power offshore floating storage and production vessels (FPSOs) from the onshore grid.

Offshore wind power

The first developments in UK offshore wind power came about through the now discontinued Non Fossil Fuel Obligation (NFFO), leading to 17 lease applications being granted by The Crown Estate early in 2001 for small scale developments of 30 turbines or less. The first of these (North Hoyle) was commissioned in 2003 and the majority have now been built.

The second phase of development 'Round 2' was initiated by The Crown Estate and the DTI whereby new larger sites further offshore were identified in three zones (Liverpool Bay, Outer Thames Estuary and The Wash) and were offered to prospective developers through a competitive tender system. The first of these sites (Gunfleet Sands 2) was commissioned in 2010 and a further 6 sites have now been commissioned or are still under construction.

In May 2010 The Crown Estate gave approval for seven Round 1 and 2 sites to be extended creating an additional 2 GW of offshore wind capacity. These are 'the extension sites' which some in the industry call the Round 2.5 developments.

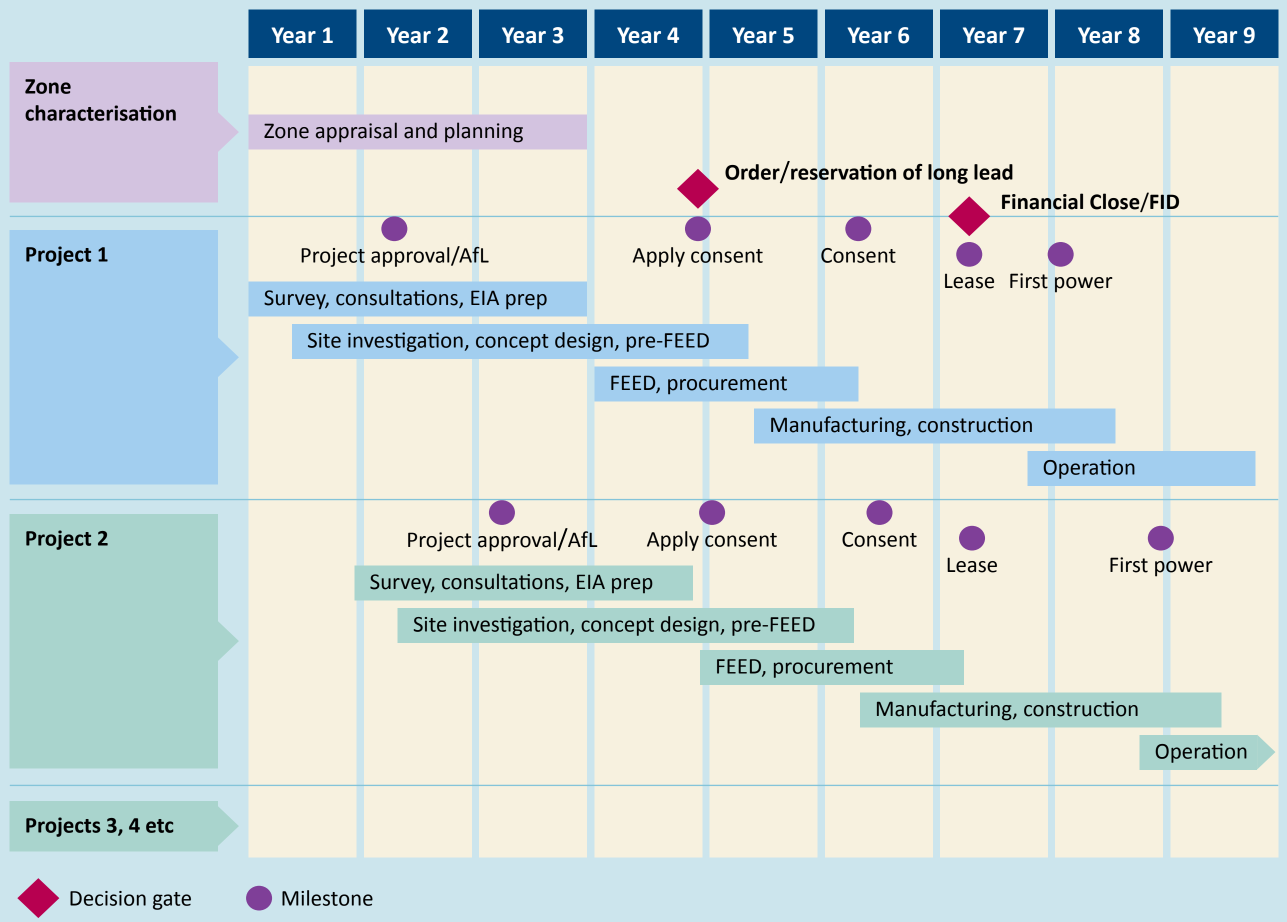
The 'Round 3' initiative was launched in June 2008 on a much larger scale than its predecessors. The UK Government is anticipating 18GW of offshore wind generating by 2020 and up to 40GW possible by 2030. The Crown Estate proposed 9 offshore zones following developer consultation and the Government SEA, within which a number of individual wind farms would be located. It ran a competitive tender process to award zones to consortia of potential developers, which concluded at the end of 2009 with the signing of Zone Development Agreements with successful bidders.

Round 3 differs from the previous rounds of offshore wind farm leasing in that developers (or development consortia) have been given rights over a larger area of seabed (a 'zone') within which they will search for areas to develop individual projects. When these areas have been identified, the developer must apply to The Crown Estate for an Agreement for Lease before commencing site development in earnest; following the granting of statutory consents for the project, the developer will then enter into a Lease with The Crown Estate, and can then commence construction of the project.

The development of projects will broadly follow the pattern illustrated in Figure 2-1; i.e. Zone characterisation > Identification and approval of a specific project within the Zone > signing of Agreement for Lease > EIA activities and applications for key project consent > financial investment decision > signing of a Lease > construction > operation.

Following the allocation of zones, individual planning applications still have to be sought by developers. These are unlikely to be completed before 2012 and the first Round 3 projects are not expected to begin generating electricity before 2015.

Figure 2-1 Lifecycle of Round 3 wind farm developments



Offshore wave & tidal power

To date, offshore wave and tidal power development has been limited to prototype testing and small-scale pilot or demonstrator projects. A number of larger commercial scale funding initiatives have been launched with the world's first commercial scale round of leasing for 11 sites in the Pentland Firth and Orkney waters carried out by The Crown Estate in 2010. These sites have a combined potential capacity of 1,600 MW and installation works are expected to start in 2014 and continue through to 2020.

The role of The Crown Estate

The Crown Estate owns virtually the entire seabed out to the 12 nautical mile territorial limit, including the rights to explore and utilise the natural resources of the UK continental shelf (excluding oil, gas and coal) and renewable energy within the UK REZ. The Crown also owns around just over half of the foreshore, in general the area between mean high and mean low water (spring tides in Scotland) and approximately half of the beds of estuaries and tidal rivers in the United Kingdom. Ownership control is subject to the rights of navigation and fisheries.

As managers of these assets on behalf of The Crown, The Crown Estate plays a vital role in the cables and pipelines business, offshore aggregate dredging and the development of offshore renewable energy.

The Crown Estate issues fee based leases, licences and consents for activities and developments on The Crown Estate land in accordance with the Crown Estate Act 1961, such as:

- Offshore renewable energy projects (wind, wave and tidal)
- Telecommunications and power cables
- Pipelines
- Marine minerals (aggregate dredging, sub-sea mining and disposal)
- Carbon capture and storage
- Natural gas storage
- Coastal developments (including ports, harbours, moorings, marinas, etc).

Figure 2-2 illustrates the extent and diversity of these activities and developments around the UK.

Under The Crown Estate Act 1961, The Crown Estate permission, in the form of a site lease/licence, is required for the placement of structures or cables on the seabed; this includes, power cables, telecommunications cables and offshore renewable energy installations including their ancillary cables (limited to within territorial waters for telecommunications and power cables).

The Energy Act 2004 vested rights to The Crown Estate to lease sites for the generation of renewable energy on the continental shelf within the limits of the UK REZ.

Historically The Crown Estate involvement has been limited to the administration of such site leases in the landowner role and for previous wind farm developments, selection through competition of parties to develop, construct, finance and operate the offshore projects.

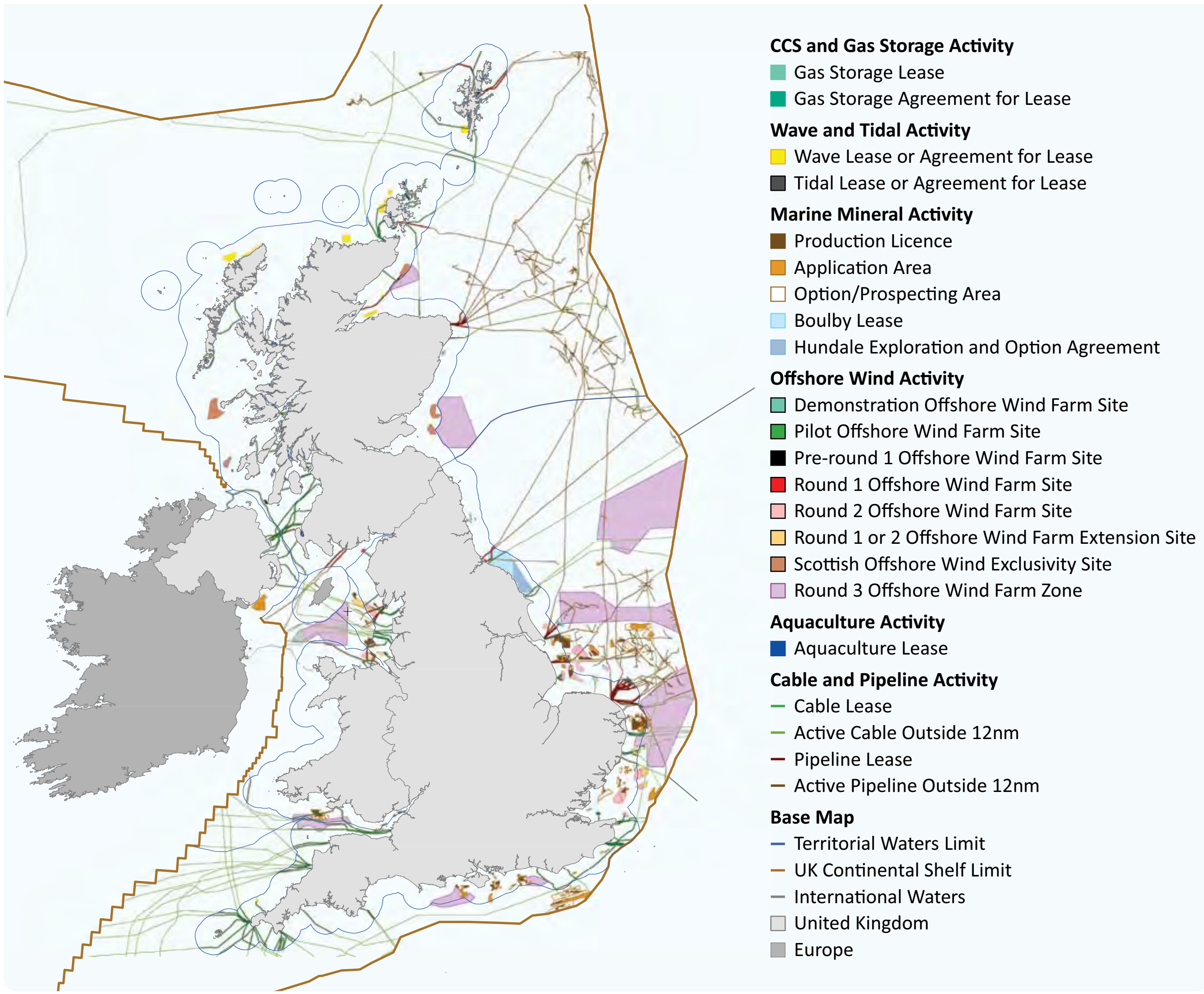
The Crown Estate role in Round 3 wind farms

In contrast to previous offshore wind leasing rounds, The Crown Estate's approach to (and role in) Round 3 is substantially different. This arises from the fact that Round 3 represents a significant increase in scale of offshore wind development in the UK, and requires a more targeted and programme-led approach than has been applied previously.

In addition to co-investment by The Crown Estate in the development phase of projects, and investment by The Crown Estate in a variety of strategic-level enabling actions to assist the industry, the key difference lies in the award of zones rather than specific sites for offshore wind development.

Round 3 comprises of nine development zones around the UK. Each zone has been awarded to a single zone developer (or a single consortium). The majority of zones will contain multiple offshore wind farm projects within the zone boundary; the zone developers are responsible for identification of project sites within the zones. The zone boundaries should therefore be viewed as 'areas of search' rather than large wind farms.

Figure 2-2 The Crown Estate offshore activity map



Note: areas marked in purple are Round 3 zones; i.e. areas of search, not individual wind farms.

The UK consents regime

There have been significant changes in the UK consenting regime for marine energy and submarine cable projects in recent years, particularly changes to the government bodies and departments responsible for administrating the regime. Key changes have been:

- Responsibility for Nationally Significant Infrastructure Projects (NSIPs) in England and Wales transferred from the Infrastructure Planning Commission (IPC) to the National Infrastructure Directorate within a reformed Planning Inspectorate
- Establishment of the Marine Management Organisation (MMO) with responsibilities for licensing, planning and enforcement under the Marine and Coastal Access Act 2009
- Rationalisation of the former FEPA and CPA consents into a single Marine Licence
- Responsibilities for marine licencing, planning and enforcement in Welsh and Scottish territorial waters managed by the respective devolved governments.

A detailed description of the UK marine consents regime is contained in Appendix C.

International legislation

UNCLOS 1982

The United Nations Convention on the Law of the Sea (UNCLOS) 1982 provides updated and increased protection to all submarine cables and pipelines (rather than only telecommunications cables as previously defined in the original 1885 Convention). The UNCLOS principles relating to submarine cables can be summarised as follows:

- Freedom to lay, maintain, and repair cables on and off the continental shelf
- Obligations on nations to impose criminal and civil penalties for intentional or negligent injury to cables
- Special status for ships laying and repairing cables (as defined in Rule 10 of the International Rules for the Prevention of Collisions at Sea and more generally in Article 79 of UNCLOS)
- Indemnification for vessels which sacrifice anchors or fishing gear to avoid damage to cables
- Obligations on owners with new cables that are laid over existing cables and pipelines to indemnify repair costs for any damage caused
- Universal access to national courts to enforce treaty obligations.

There are several Articles contained within UNCLOS which pertain to submarine cables, wind, wave and tidal energy developments on the UK continental shelf and REZ, but in particular:

Article 56 cites:

1. In the exclusive economic zone, the coastal state has:
   A. Sovereign rights for the purpose of exploring and exploiting, conserving and managing natural resources, whether living or non-living, of the waters superjacent to the seabed and of the seabed and its subsoil, and with regard to other activities for the economic exploitation and exploration of the zone, such as the production of energy from the water, currents and winds
   B. Jurisdiction as provided for in the relevant provisions of this Convention with regards to:
      i. The establishment and use of artificial islands, installations and structures
      ii. Marine scientific research
      iii. The protection and preservation of the marine environment
   C. Other rights and duties provided for in this Convention
2. In exercising its rights and performing its duties under this Convention in the exclusive economic zone, the coastal state shall have due regard to the rights and duties of other states and shall act in a manner compatible with the provisions of this Convention
3. The rights set out in this article with respect to the seabed and subsoil shall be exercised in accordance with Part VI.

Article 58 cites:

1. In the exclusive economic zone, all States whether coastal or land-locked, enjoy, subject to the relevant provisions of this Convention, the freedom referred to in Article 87 of navigation and over-flight and of the laying of submarine cables and pipelines, and other internationally lawful uses of the sea related to these freedoms, such as those associated with the operation of ships, aircraft and submarine cables and pipelines, and compatible with the other provisions of this Convention
2. Articles 88 to 115 and other pertinent rules of international law apply to the exclusive economic zone in so far as they are not incompatible with this part
3. In exercising their rights and performing their duties under this Convention in the exclusive economic zone, States shall have due regard to the rights and duties of the coastal state and shall comply with the laws and regulations adopted by the coastal state in accordance with the provisions of this Convention and other rules of international law in so far as they are not incompatible with this part.

Article 79 cites:

1. All States are entitled to lay submarine cables and pipelines on the continental shelf, in accordance with the provisions of this article
2. Subject to its right to take reasonable measures for the exploration of the continental shelf, the exploration of its natural resources and the prevention, reduction and control of pollution from pipelines, the coastal state may not impede the laying or maintenance of such cables or pipelines
3. The delineation of the course for the laying of such pipelines on the continental shelf is subject to the consent of the coastal state
4. Nothing in this part affects the right of the coastal state to establish conditions for cables and pipelines entering its territory or territorial sea, or its jurisdiction over cables and pipelines constructed or used in connection with its continental shelf or exploitation of its resources or the operations of artificial islands, installations and structures under its jurisdiction
5. When laying submarine cables or pipelines, states shall have due regard to cables or pipelines already in position. In particular, possibilities of repairing existing cables or pipelines shall not be prejudiced.

Compliance with UNCLOS and UK legislation

In the case of submarine cables, The Crown Estate's consent is required for all telecommunication cables and oil and gas pipelines that cross the seabed within 12 nautical miles of the UK coastline. This consent is recognition of The Crown Estate's proprietary interests. It is also highly desirable that The Crown Estate be informed of cables and pipelines transiting or seeking to transit waters that fall within the 200 nautical mile limit, as mineral rights, such as marine aggregates, gas and carbon capture & storage, or offshore wind-farm developments may be affected. This is to ensure that The Crown Estate is informed of all developments within the REZ and has a complete and full database of such activities.

The Crown Estate will only grant a lease or licence once all the necessary statutory consents have been obtained from government.

Offshore wind, wave and tidal energy developments are also legislated under UNCLOS, however the licensing authority of the State is the Secretary of State for the Department of Energy and Climate Change (DECC) (via IPC/NID) for developments in England and Wales, the Scottish Government in Scotland, the Welsh Government in Wales and the Department of Environment in Northern Ireland.

International regulations for preventing collisions at sea 1972

The current International Regulations for Preventing Collisions at Sea 1972 (COLREGS) have been amended a number of times with the amendments to Rule 10 – Traffic Separation Schemes being particularly relevant to this report. The 1981 amendment to Rule 10 allows a vessel engaged in cable operations a dispensation to manoeuvre as required by its work within a traffic separation scheme rather than follow the direction of traffic flow within such a scheme.

The parts of the COLREGS relevant to this study are discussed below:

- **Rule 3 – Generaldefinitions**

Rule 3 defines vessel types and categorises vessels engaged in surveying, underwater operations and submarine cable handling as a vessel restricted in her ability to manoeuvre. In addition vessels engaged in towing operations, which severely restricts the towing vessel and tow, fall into the same category.

Rule 3(g) states:
The term "vessel restricted in her ability to manoeuvre" means a vessel which from the nature of her work is restricted in her ability to manoeuvre as required by these Rules and is therefore unable to keep out of the way of another vessel. The term "vessels restricted in their ability to manoeuvre" shall include but not be limited to:

i. A vessel engaged in laying, servicing or picking up a navigation mark, submarine cable or pipeline
ii. A vessel engaged in dredging, surveying or underwater operations
vi. A vessel engaged in a towing operation such as severely restricts the towing vessel and her tow in their ability to deviate from their course.

- **Rule 10 – Traffic separation schemes**

Rule 10 provides for special status for a vessel engaged in cable operations within a traffic separation scheme and states:

A vessel restricted in her ability to manoeuvre when engaged in an operation for the laying, servicing or picking up of a submarine cable, within a traffic separation scheme, is exempted from complying with this Rule to the extent necessary to carry out the operation.

This gives a cable vessel priority to manoeuvre as required by its work within a traffic separation scheme. This is a significant dispensation within the COLREGS afforded to vessels engaged in cable operations.




- **Rule 18 – Responsibilities between vessels**

Rule 18 defines a basic 'hierarchy' of vessel types with a 'vessel restricted in her ability to manoeuvre' generally given priority over all vessels with some exceptions such as a 'vessel not under command' and states:

Except where rule 9, 10, and 13 otherwise require:

A. A power driven vessel underway shall keep out of the way of:
   i. A vessel not under command
   ii. A vessel restricted in her ability to manoeuvre
   iii. A vessel engaged in fishing
   iv. A sailing vessel.

B. A sailing vessel under way shall keep out of the way of:
   i. A vessel not under command
   ii. A vessel restricted in her ability to manoeuvre
   iii. A vessel engaged in fishing.

C. A vessel engaged in fishing when underway shall, so far as possible, keep out of the way of:
   i. A vessel not under command
   ii. A vessel restricted in her ability to manoeuvre.

D.
   i. Any vessel other than a vessel not under command or a vessel restricted in her ability to manoeuvre shall, if the circumstances of the case admit, avoid impeding the safe passage of a vessel constrained by her draft, exhibiting the signals in Rule 28
   ii. A vessel constrained by her draft shall navigate with particular caution having full regard to her special condition.

While this rule looks on first examination to be clear on the hierarchy of vessels, there are certain nuances such as the wording for fishing vessels –...shall so far as possible keep out of the way of...vessels restricted in their ability to manoeuvre.

- **Rule 27 – Vessels not under command or restricted in their ability to manoeuvre**

Rule 27 described the lights and shapes to be displayed by the majority of vessels engaged in cable operations and wind farm construction or maintenance work as follows:

B. A vessel restricted in her ability to manoeuvre, except a vessel engaged in mine-clearance operations, shall exhibit:
   i. Three all-round lights in a vertical line where they can be best seen. The highest and lowest of these lights shall be red and the middle light shall be white
   ii. Three shapes in a vertical line where they can best be seen. The highest and lowest of these shapes shall be balls and the middle one a diamond
   iii. When making way through the water, a masthead light or lights, sidelights and a sternlight, in addition to the lights prescribed in sub-paragraph (i)
   iv. When at anchor, in addition to the lights or shapes prescribed in sub-paragraphs (i) and (ii), the light, lights or shape prescribed in Rule 30.

C. A power-driven vessel engaged in a towing operation such as severely restricts the towing vessel and her tow in their ability to deviate from their course shall, in addition to the lights or shapes prescribed in Rule 24(a), exhibit the lights or shapes prescribed in sub-paragraphs (b) (i) and (ii) of this Rule

D. A vessel engaged in dredging or underwater operations, when restricted in her ability to manoeuvre, shall exhibit the lights and shapes prescribed in sub-paragraphs (B) (i), (ii) and (iii) of this Rule and shall in addition, when an obstruction exists, exhibit:
   i. Two all-round red lights or two balls in a vertical line to indicate the side on which the obstruction exists
   ii. Two all-round green lights or two diamonds in a vertical line to indicate the side on which another vessel may pass
   iii. When at anchor, the lights or shapes prescribed in this paragraph instead of the lights or shape prescribed in Rule 30.

E. Whenever the size of a vessel engaged in diving operations makes it impracticable to exhibit all lights and shapes prescribed in paragraph (D) of this Rule, the following shall be exhibited:
   i. Three all-round lights in a vertical line where they can be best seen. The highest and lowest of these lights shall be red and the middle light shall be white
   ii. A rigid replica of the code flag "A" not less than 1 metre in height. Measures shall be taken to ensure its all-round visibility.

- **Requirements for jack-up barges**

Jack-up barges are a special case and generally exhibit Rule 27 lights and shapes when working close inshore or within a port area.

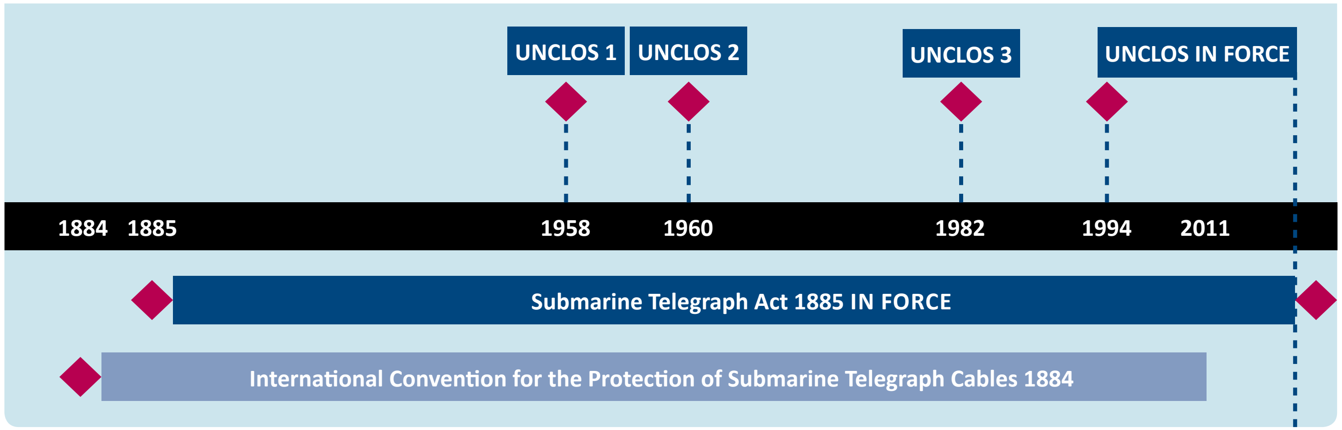
Where obstruction or danger to navigation is caused or is likely to result from installation of the jack-up on site; and where it is required under a consent granted under the provisions of the Coast Protection Act 1949 – Consent to Locate Offshore Installations – provision for marking off shore installations; a jack-up barge will be equipped with obstruction lights (white 360 degree Morse "U") displayed at each corner and with a fog signal in accordance with IALA Recommendation O-139.

Table 2-1 Summary of applicable UK legislation

UK Legislation[2]	Category	Relevance to Proximity Study
UK Territorial Sea Act 1987	Navigation Safety	Defines the extent of the UK Territorial Sea (12 nautical miles)
Petroleum Act 1998		Covers oil and gas installation 500m safety zones
The Electricity (Offshore Generating Stations) (Safety Zones) (Application Procedures and Control of Access) Regulations 2007		Legislation relevant to the provision of safety zones for OREIs
Merchant Shipping Acts		Covers all aspects of merchant shipping operations
Electricity Act 1989	Electrical Infrastructure	Legislation relevant to granting of licences for OREIs (Section 36 Consent)
Energy Act 2004		Legislation relevant to the provision of safety zones for OREIs
Energy Act 2008		Statutory decommissioning requirements Offshore transmission licencing
Crown Estate Act 1961	Marine planning & licensing	Provides legislative framework for The Crown Estate to deliver a return on assets
Planning Act 2008		Defines the role of the IPC
Localism Act 2011		Transfers the powers of the IPC to the National Infrastructure Directorate within a reformed Planning Inspectorate
Submarine Telegraph Act 1885	Telecommunications cables	Enacted the International Convention for the Protection of Submarine Telegraph Cables of 1884 providing legal protection for submarine telegraph cables
Telecommunications Act 1984		Updates previous legislation & sets out requirements for licensing – now consolidated in the Marine & Coastal Access Act 2009
Marine & Coastal Access Act 2009	Planning, licensing & environmental protection	Wide ranging marine and coastal protection legislation. Marine Licences issued and administered under this act.
The Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007 (as amended) (from 12 to 200 nautical miles)	Environmental protection	Wildlife conservation legislation applied in UK Territorial Seas
Conservation of Habitats and Species Regulations 2010		Wildlife conservation legislation applied from 12-200 miles offshore in UK
Conservation of Habitats and Species Regulations 2010		Wildlife conservation legislation applied in UK Territorial Seas
Water Resources Act 1991		Includes a requirement for an Environment Agency licence for cable landfall works to protect sea defences
Tort law	General UK Legislation (applicable within territorial waters)	Governs claims where a duty of care owed by/to the cable owner can be established (i.e. negligence causing cable damage)
Theft Act 1968		Governs the illegal misappropriation of cables within territorial water

[2] The list is not exhaustive and other legislation may be relevant to a particular circumstance and may, therefore, need to be taken into consideration in any given situation.

Figure 2-3 Timeline of key UK cables related legislation



UK legislation

Table 2-1 summarises the key UK legislation relevant to this study, and Figure 2-3 illustrates the timeline for UNCLOS and the Submarine Telegraph Act.

Legislation protecting submarine cable assets can be traced back to the International Convention for the Protection of Submarine Telegraph Cables of 1884 as enacted by the UK Submarine Telegraph Act also of 1885.

In summary, the key elements of the 1885 Act are:

- Anyone damaging a submarine telegraph cable, unlawfully, wilfully or negligently is liable for criminal and/or civil law sanctions
- All vessels shall keep 1 nautical mile clear from a vessel engaged in cable repairs, which also applies to the placement of fishing nets or gear
- All vessels shall keep ¼ nautical mile clear from cable marker buoys, which also applies to the placement of fishing nets or gear
- The Act allows for compensation to be claimed from a cable owner by a vessel owner for loss or damage to anchors, nets or fishing gear suffered in protecting a submarine cable.

The 1885 Telegraph Act continues to apply to submarine cables in UK waters and was most recently updated by the Merchant Shipping Act 1995. The most relevant clause to the present submarine cable situation is in Section 2 and states that "A person shall not unlawfully and wilfully, or by culpable negligence, break or injure any submarine cable [….] in such manner as might interrupt or obstruct in whole or in part telegraphic communication".

The UN Convention on the Law of the Sea (UNCLOS) subsequently enhanced the international regulation to include all submarine cables.

The Telegraph Act discriminates between types of submarine cable and does not expressly apply to power cables however UNCLOS does not discriminate between types of cable and would therefore apply to power cables. The legal discrepancy between the Telegraph Act on the one hand and UNCLOS on the other, is that the scope of UNCLOS includes power cables, but does not create any offence for deliberate damage to them, whereby the Telegraph Act makes it an offence to deliberately damage cables, but this offence does not extend to power cables. Power cables are therefore currently caught in a legal loophole between the two regimes. The ICPC has lobbied national governments on this problem.

Recent developments in technology have created a requirement for remote monitoring or control in relation to the projects for which power cables are installed. Power cables often have an integral fibre-optic package within their construction or are laid together with a fibre-optic cable bundled with, or alongside them, which, in either case, provides a data communications element to the power transmission cable system.

Third party stakeholders

An extensive range of stakeholder groups exists with interests in the UK REZ and it was beyond the scope and duration of the study to consider each in detail. The following list highlights those stakeholders with a particular interest or interaction with the proximity issues addressed by this study.

- Fisheries
- Aggregates extraction
- Oil & gas development
- Safety of navigation
- HM Forces/MOD
- Marine leisure interests
- Local & national government
- Environmental groups and bodies
- Coastal communities
- NGOs.

Offshore liaison roles

The Subsea Cables UK Offshore Liaison Guidelines state that: In addition to fisheries liaison requirements, Subsea Cables UK members should endeavour to:

- Liaise with other seabed users prior to, and during installation, and promote the presence of their subsequently installed submarine plant, in order that third parties are aware of members activities and installations; and
- Provide third parties/authorities/organisations with information regarding proposed or installed submarine plant when these third parties require approval for marine activities over, through or adjacent to members' submarine cables, associated seabed installations and other interests.

Early planning work in the design and engineering of cable routes and renewable energy developments will have identified key stakeholders and the need for good communication. Maintaining effective liaison with third parties is not only an essential part of good project management and safe practice but may also be a consent and legislative requirement (for example Fishery Liaison Officers). The necessity for effective liaison does not cease with the completion of construction/installation work but is an essential part of a responsible and efficient O&M strategy which can be achieved by the appointment of an Offshore Liaison role and which may include membership of active industry groups such as Subsea Cables UK and RenewablesUK.

Kingfisher information service – cable awareness

http://www.kisca.org.uk/

The use of the KIS-CA cable awareness charts and periodical bulletins also plays an important part in liaison between cable operators/contractors and fishing interests.

The two major seabed-exploiting industries, other than fishing, in northwestern European waters are oil and gas exploitation and the submarine telecommunication cable industry. In an attempt to reduce accidents, interaction has been established between fishermen and offshore operators to ensure that mutual understanding of respective industries is established.

Over the past decade there has been a significant increase in the number of submarine cables being installed. Although the dangers to fishing are understood, it should also be noted that fishing gear can cause severe damage to submarine cables – resulting not only in expensive repairs but also disrupted communications and lost revenue.

Prior to the creation of the KISCA project, only limited success had been achieved by some operators co-operating to improve general awareness of their activities. Therefore, to protect their individual interests, many companies published (and continue to publish) flyers, other ad-hoc material and also notices were published on the Kingfisher Fortnightly Bulletin to alert fishermen of their cable routes.

Kingfisher a department within the Sea Fish Industry Authority has undertaken the successful KIS-CA project aimed at improving safety to fishermen and protection of submarine cables. The project was initiated on 1st January 2000 with 50% funding from SubSea Cables UK and continues to be project managed by Subsea Cables UK.

The waters covered by the project are extensive – the North Sea, English Channel, Bristol Channel/Southwest Approaches, Irish Sea and West of Scotland – and therefore include cables between the coasts of Norway, Denmark, Germany, Netherlands, Belgium, France, Ireland and the UK.

Fishermen are able to receive information of cable routes and other physical details (for example repeaters and splices), together with emergency contact numbers and procedures in two formats:

1. Paper charts – The production and distribution, free of charge to fishermen, of annual updated cable awareness charts. These are divided into six areas around the UK and show in-service and recently out-of-service cables
2. Electronic format – The production and free distribution of this data in electronic format, compatible with the most common fishing plotter systems.

The data is also available for download over the Internet in both readable and chart plotter friendly formats. The final objective is the free distribution of the data, in the most useable form, to all relevant fishing vessels working in the waters covered.

Within the UK, both the Scottish Fishermen's Federation (SFF) and the National Federation of Fishermen's Organisations (NFFO) are assisting with the local distribution of charts and discs, with Kingfisher organising physical distribution to the rest of Europe, Internet distribution, and the issue of licenses to electronic charting companies.

Proximity & crossing agreements

While crossing agreements are not directly relevant to this study, review of the principles used, can provide a useful insight into how such a process could be applied to cable and wind farm proximity scenarios.

International Law provides only limited protection for the interests of the parties involved in a pipeline/power and telecommunications cable crossing and, where a crossing occurs within the legal jurisdiction of a State, the relevant legislation is also rarely sufficient. In addition, the recourse to any court following a conflict of interest is a lengthy and expensive matter. It is therefore recommended, in the interests of both parties, to negotiate an agreement to cover any pipeline/cable crossing. The contents of an agreement are a matter for the individual parties, but it is recommended that the following points be covered:

- Clauses to define the liabilities and rights of both parties
- The exclusion/inclusion of consequential losses. It is recommended that consequential losses shall be excluded
- Definition of a specific area in the vicinity of the crossing within which the Agreement will operate
- A general statement of the method of installation of the pipeline or cable as appropriate.

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It is not recommended that installation procedures be included in the body of the Agreement as they may require alteration prior to or during the operation. They may of course be included in the document as an appendix.

- Future maintenance of the pipeline and cable(s). This may include the method by which notification of operations by each party is given to the other
- Definition of the expiry of the Agreement – normally at the removal from service of either the pipeline or cable(s), whichever comes first
- Provision of representatives from one party to the other party's operations and their rights and limitation of their authority.

The early stages of the route engineering process will identify existing and planned cables that the new system will closely approach or cross. Early consultation should take place with the maintenance authorities of these other cables in order to reach an agreement on the position and manner of the crossing. In most cases the cable owners should be able to come to an accord without a formal crossing agreement, this being effected by a simple exchange of letters – an 'agreement to cross'. For a simple 'agreement to cross', the maintenance authority for the crossing cable should forward to the maintenance authority for the crossed cable the following information:

- An RPL showing the route of the cable for at least three times depth of water on both sides of the proposed crossing point (or +/– 50 metres in shallow water)

- Depth of water
- Angle of crossing
- Cable type
- Positions of any submarine plant
- Derivation of navigational data, including datums
- Type of seabed in area of crossing
- Burial information, if applicable, including the procedures to be followed by the Installer, when crossing the cable.

It may be helpful to include the above information in a chartlet of the crossing area, showing both cables and any other points of interest. Consideration should be given to supplying a copy of the RPL for the whole of the particular segment of the system involved as this may serve to highlight areas where the cables are in close proximity away from the crossing point.

The maintenance authority for the crossed cable should then review the information and respond on a timely basis to ensure that the crossing falls within the guidelines laid down by this procedure, or if that is not possible, that a compromise is reached which is acceptable to both parties.

ICPC Recommendation No. 2, Issue: 9A Issue Date: 26 January 2007 states that:
The need for both parties to provide the fullest possible information to each other as early as possible in the project timetable cannot be overstressed. Delay in forwarding the initial request will have a knock on effect, as will the failure to supply sufficient information for the other party to make an informed decision. Project timescales are becoming foreshortened and the fullest possible information, sent as early as possible, will help to ensure that crossing agreements can be concluded well in advance of the cable installation.

Repeaters
It is generally recommended that a clearance of three times the depth of water should be allowed between a crossing point and a repeater in the crossed system. This will ensure that the repeater can be recovered, without endangering the crossing cable, should the cable have been cut so close to the other end of the repeater that recovery from that end is not possible. However, with the use of modern navigational equipment and lay/repair practices, and if the particular circumstances and conditions permit, these distances could be reduced to twice the depth of water providing that the cable with the repeater was the upper of the two cables and such crossings do not exist on either side of the repeater. For general application these guidance values should be considered for both shallow and deeper waters.

Similarly, a clearance of three times depth of water should be allowed between the crossing point and a repeater in the crossing system. This will ensure that, in the event of a repair to the crossed cable, which results in that cable becoming the crossing cable, the repeater can be recovered should the cable have been cut close to the other end.

It should be noted that when repairs are carried out close to cable crossings, the planning process should ensure that the final splice is deployed well away from the crossing point, so that it does not compromise future repairs in the same area. It should also be noted that, whilst the clearance criteria of at least three times depth of water should be adequate in most circumstances, in very shallow water this might not be sufficient. For example, in 20m water depth grappling for the crossed cable only 60m from the crossing cable could result in that cable being disturbed – in this situation a clearance of a least 100m should be allowed.

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Submarine cables

Submarine cable distributions

Development of the cable networks

Further to the discussion of Section 2.1.1, the distribution of cables in United Kingdom waters has resulted from the combination of geographical location of the islands and the historical development of submarine cable technology.

Whilst the geographical location of the British Isles represents a significant factor in the development of the country as a trading nation, a leading role in the development and rapid expansion of the submarine telegraph cable networks during the latter half of the 19th century laid the foundation for a new era of international communication and commerce on a worldwide basis. As submarine cable telegraph technology emerged from around the 1860s – the completion of first transatlantic cable in 1866 representing one of the milestones of international co-operation and technological advancement. An international cable network grew steadily from those early times eventually to reach virtually every corner of the commercial world.

In addition to these, cable systems are also in place for defence, maritime vigilance and scientific purposes. Whilst the density and distribution of these networks does not approach that of the list above, they do also compete for available seabed space.

In summary therefore, we are faced with the need to accommodate those cable systems already in service as well as the exponential growth of new connections and networks that are being installed to serve new and essential communications and energy generation and distribution policies.

The current situation

As a result there is an increasing need to understand the current and future spatial demands for submarine cables in the UK REZ and their associated landfalls around the UK coast. Together with this understanding comes a responsibility to share knowledge and understanding of the varying ends to which the cables serve, the characteristics of the routes over which they have been laid and the importance that each one of them plays.

Whilst several European nations are successfully adopting this practice and have implemented legislation accordingly, the implementation of such a regime for the United Kingdom – as an island nation with a radial pattern cable network rather than a direct in and out corridor to a specific area (or areas) of coastline – has to date proven unsuitable. Whilst the use of dedicated corridors may be suitable for some portions of the UK telecom network, and is generally usable for export cables from wind farm developments, many other cables cannot conform due to their route orientation, particular purpose, seabed conditions, and surface navigational constraints. Nevertheless and with particular regard to future zonal wind farm developments where proposed locations are already identified, creation of such corridors (in conjunction with wind recovery corridors where possible) or cable areas are likely to be part of the proximity solution, providing the risks of third party damage to such concentrations of cables can be mitigated. The use of shallow waters away from established shipping lanes and areas of seafloor unsuitable for anchoring could be designated in this way.

Current cable distribution

The Thames Estuary and North Sea already have a high density of cables serving the industries discussed in this study and this density is growing significantly in line with general industry development. The complexity of the subsea network, together with an ever-increasing number of landing sites creates a distribution map that encompasses virtually all parts of the coastline of the United Kingdom.

Offshore wind-farm sites have produced relatively small but very dense areas of inter-array cables concentration within their in-field areas. The location of wind farms in waters generally unsuitable for use by other submarine asset owners and surface navigation does mitigate the pressures on available seabed space, but there are few alternatives other than a direct route when wind farm export cables are considered.

Probably the west coast of Ireland and the north & western coast of Scotland are the only coastal areas as yet unaffected by the growth of submarine infrastructure but here too the demands will come as the drive for deeper offshore wind, gas and hydrocarbon extraction extends into the REZ to the west of the British Isles.

The distribution of cables continues in a similar pattern down the western coast, with appreciable density and crossing patterns occurring in the Irish Sea, the Celtic Sea the Western Approaches. Wind farm developments are equally significant in the western seas as in the North Sea, with many already in operation, others under construction and more in the planning phase.

The English Channel is also an area densely populated by telecommunications cables linking to the Channel Islands, France, Spain and Portugal. In addition some trans-Atlantic/European systems routed through the English Channel serving other European countries from the main trunk line cable via spurs. The Folkestone – Sangatte HVDC array (4 cables) constitutes a major presence in the Dover Strait area, whilst in the southern North Sea a new HVDC interconnector (UK-NL) has recently added to the picture of dense seabed population. Other interconnectors are already in the planning stage, as are wider ranging European HVDC inter-connectivity initiatives and grid links. The relatively recent development of the offshore renewable energy industry and power interconnectors contrasts with that of telecommunications, built on many decades of advancement from the early days of telegraph technology. As both these industries move forward there will be an increasing need for cooperation and coordination, in order to make the best safe use of the available seabed within the UK REZ.

This naturally extends into the issue of what should constitute a safe distance of separation between cables and other subsea infrastructure and has created an urgent need for a review of the rules and accepted working practices, that to date have determined cable proximity. The need for a full understanding amongst the many parties, industrial bodies and national authorities is paramount.

Whilst this study is focused towards owners, operators, installers and maintainers of submarine cables and OREIs, appropriate and rigorous liaison with the fishing industry, marine archaeological interests and other seabed users is also required as each of these have to be accommodated in any industry discussions.

Cable types & characteristics

Generally cables of all purposes covered by this study will be of the armoured type with the inner cores protected by a series of steel armour wires arranged in helical arrangement. Lightweight or un-armoured telecommunications cables are used almost exclusively in the long deep ocean segments of international cable systems beyond the threat of fishing or other third party activities and are therefore not considered in this study.

In terms of physical characteristics of cables, there is a great variety in outside diameter and weight per metre – the key characteristics of interest to this study.

Cables in the energy sector frequently have an outside diameter of 200-300mm with a submerged weight of typically 50-60kgs per metre, whilst telecommunications cables are mostly of lighter construction, in the order of 30-50mm diameter with submerged weights of a few kilos per metre.

The minimum bend radii (MBR) of the two cable types are significantly different, as are the jointing and vessel requirements for repairs. In general a repair bight would typically require a working corridor of approximately 2 x depth of water to achieve a satisfactory laydown to the seabed, but this is not always strictly achievable as factors such as repair vessel layout, cable alignment on seabed, suitable bottom for deployment etc. will influence the final lay-down arrangement.

Power cables generally require more in way of preparation of cable ends before the final joint can be made. It is common for a working length of approximately 1.5 times depth of water to be arranged on either side to allow the repair vessel more manoeuvring flexibility during the extended jointing programme, which in many cases can extends to 5 days or more. By comparison, telecommunications joints rarely require more than 20 hours to complete.

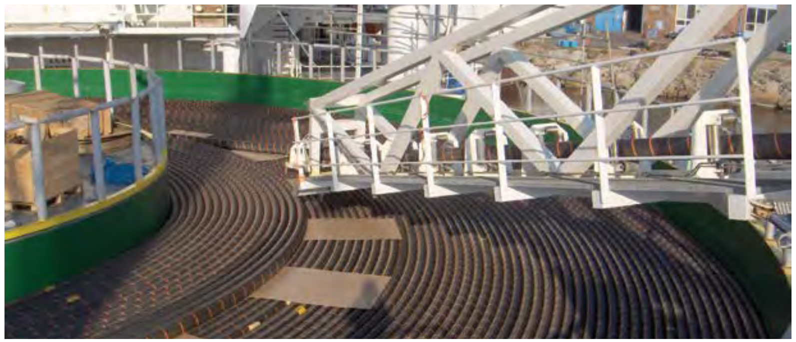
As a result more cable is usually required for a shallow water repair of a power cable than for a telecommunications cable. There may be exceptions to this, as very shallow waters will often require use of a barge rather than a seagoing vessel. In such a case it may be possible for a power cable repair to shorten the repair bight by suitable configuration of the jointing spread and attendant cable highways, given that the barge would normally remain in a fixed anchored position throughout the repair.

Cable Protection

In the modern era cable protection is achieved by burial into the seabed, wherever possible, with a wide range of sophisticated subsea cable burial tools available to cope with the diversity of soil types that exist.

Where burial is not achievable, due to unsuitable seabed material (e.g. bedrock, very heavy clay or boulders) or






where another cable or pipeline is already in place), a number of protective sleeves, ducting and jacket systems have been developed. These are applied to the cable at the surface and laid to the seabed as part of the laying process.

Additionally and where long sections of unsuitable seabed are encountered, rock placement is often the most time efficient and rugged form of protection. Whilst very efficient, rock placement is a costly exercise and is often subject to environmental permitting restrictions. Cable burial depth is a complex topic and often the subject of commercial debate. The use of a risk based approach to determining the optimum cable burial depth using a 'Burial Protection Index' has been widely adopted in recent times. This approach assesses the level of protection afforded by the site-specific soil conditions and the threat level posed by third party interactions such as fishing gear and ship's anchors .

Installation practices

Modern installation practices can be divided into three classes as follows:

A. Cables are surface laid by a cable-laying vessel, and burial is carried out in a post-lay mode using a separate vessel and trenching/jetting equipment spread.
B. Cables are laid and buried in a simultaneous operation with burial equipment being towed by the cable laying vessel or barge, in the case of a plough or burial sled, or operated from the laying vessel where a self-propelled ROV is utilised. Variations on the theme include the use of a jetting leg (also known as an injector) deployed from an anchored barge; this is a shallow water burial tool used for single and bundled cables with the capability to achieve deep burial in appropriate conditions, or post lay cable ploughing – a modification of the oil and gas sector's umbilical and pipeline ploughing methods. The latter techniques are however not widely used, as a number of significant difficulties may exist.
C. As for B above, with a separate vessel opening a pre-cut trench. The cable is then positioned into the trench on laying. This however is not a common method of operation, as considerable scope exists for difficulties in co-ordination of the two vessels working together in this way, for accurate positioning of the cable and for maintaining an open trench.

The most appropriate method will depend on a number of factors, not least that the cable is type approved for the method to be utilised.

Navigation & positioning.

The two technologies forming the backbone of today's offshore industry are the Global Positioning System (GPS) and Dynamic Positioning (DP).

DP can operate independently of GPS, but it is the timely development of both these technologies that has had a significant impact on the full range of specialised marine operations relevant to this study. While other positioning systems provide similar reliability and repeatability, GPS based systems provide the most common basis for position referencing on cable operations and are consequently referred to for the purposes of this Study.

For operations relating to cables and other subsea installations, the use of GPS and DP for navigation and positioning significantly enhances accuracy and repeatability in terms of knowing where the cable or asset actually is on the seabed and being able to return there time after time. Cables laid before the prevalence of GPS based systems may have positional errors and the older the cable the greater the allowance that should be made for positional error, subject of course to the presence of other aids to navigation.

Operation & maintenance practices

The telecommunications industry has, through volume of work, been responsible for providing a significant proportion of the knowledge on how to locate, recover, repair and generally handle submarine cables. This knowledge gained since the advent of submarine telecommunications forms the basis for the detailed procedures and method statements with which we are familiar today. Many of these 'lessons learned' translate into the modern era and remain relevant to modern subsea engineering projects including the development of offshore wind farms and other power cable related projects.

Cable repair bights

Advancing technology in cable repair equipment, vessel control and positioning accuracy has made significant contributions to the manner and efficiency of cable repair work but has not removed the need for cables to be brought to the surface to be worked upon. The re-deployment of the subsequent repair bight onto the seabed is an operation of key relevance to this study with the bight dimensions being one of the limiting factors for wind farm/cable proximity. Distances run by repair vessels and seabed space required for cable recovery by grappling where used is also a significant factor and this is discussed separately below.

In-line, laid-in or first splices/joints may on certain occasions need to be displaced and laid away from the original line of cable but in general their placement is not relevant to this study.

The length of a final bight laydown is a function of water depth and the length of cable required to complete the jointing work on deck. The length of cable will depend on:

- Vessel freeboard
- Height of cable deck
- Deck layout
- Location of the jointing facility.

Figure 2-4 Dimensions and terms relating to cable repair bights

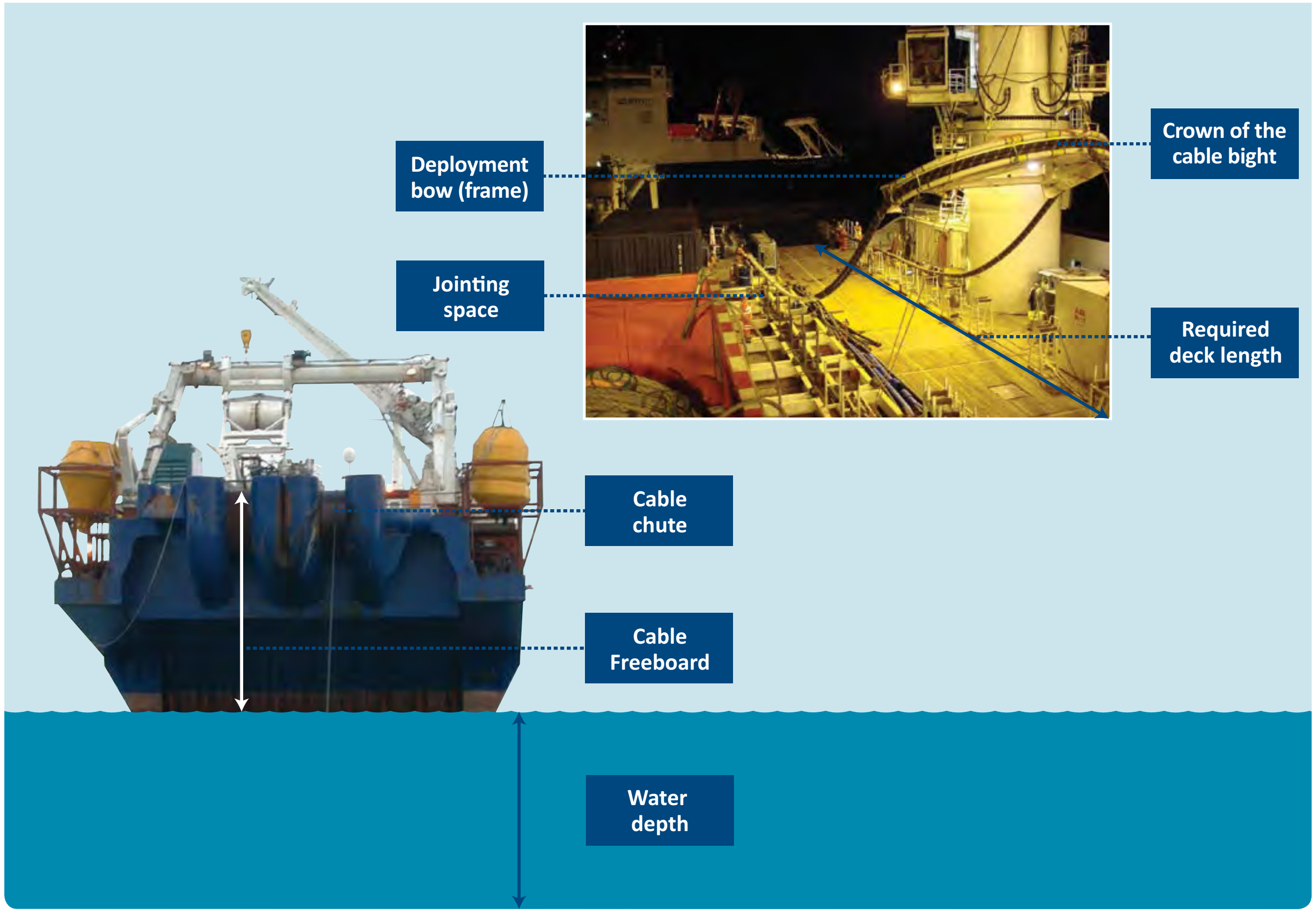


Figure 2.4 illustrates the terminology relating to final bight laydown.

Cable recovery – grappling & ROV

ROV intervention would in almost all cases be the preferred cable intervention method in water depths up to 200m, at least initially. Once initial ROV inspection has been completed then the options become more broad ranging, dictated by seabed type, depth of burial, environmental parameters, cable offset distance (in which case ROV is preferable), cable type etc.

To provide an illustration of how frequently ROV intervention is used, GMSL report that of 25 fault repairs carried out in all water depths in 2011, 25% have been conducted solely by means of ROV intervention. In the majority of cases it can be expected that fault repairs will be carried out using a combination of grapnel and ROV techniques in water depths of up to 200m.

The development and use of ROV's has been discussed earlier in this study, but in the case of cable repair operations their role is particularly significant, as modern cable systems are usually buried for protection and often beyond the reach of all but the most aggressive grappling equipment. The use of ROV intervention is useful, where there is insufficient room on the seabed at the repair location with respect to other seabed assets to safely deploy, tow and recover grappling equipment.

ROV mounted equipment is very often employed to locate or confirm the location of the cable fault in the first place, thus de-burial and cutting of the cable at the seabed is a logical extension to the use of the ROV.

To assist in the overall understanding it is worth reviewing the ground rules and techniques for conventional grappling:

i. The length of grappling rope paid out is dependent on the depth of water but it is important to note that the ratio of length against relative depth is a particularly significant factor. In shallow water and in normal circumstances the length of rope generally employed is in the order of three times the depth of water. By comparison for deeper water (> 200m approx.) the ratio decreases to the depth of water + approximately 30%
ii. Some distance will be required in order to stream the grapnel train and properly set the grapnels in motion across the seafloor
iii. More distance or run on is required to ensure that the grapnel set crosses the cable line and engages correctly.

It can be seen therefore that even in relatively shallow water, a good deal of sea room is required and more significantly, clear space at the seabed.

In view of this, the use of ROVs for cable location and recovery would seem a preferred option but there are many factors that prevent this or hamper the efficiency of the cable repair such as poor visibility and/or strong tidal currents. The sea state for launch and recovery of the vehicle will also have a bearing on selecting an ROV assisted programme. Thus, whilst ROVs constitute an invaluable tool in most repair operations, use of grappling for cutting and recovery of cables remains a potential method and its use is a key consideration for this study.

In terms of the efficiency of grappling as a technique, the use of Dynamic Positioning has significantly reduced the amount of sea-room required for the operation. For the purpose of this study we have made the assumption that all grapnel operations will be carried out under DP control.

To complement conventional grappling techniques, most of the designated telecoms cable repair vessels and most spot market mobilisations are equipped with ROVs and cable repair operations are normally planned around their optimum use. Not all cable maintenance vessels are large enough to carry a work class ROV and often commercial pressures do not allow the appointment of a separate ROV support vessel. ROV uses are varied and include cable and fault location, de-burial, cable cutting, attaching of gripping devices, removal of debris, wires & snagged fishing gear, general monitoring of the cables at the seabed during the repair, and post-repair inspection and remedial burial.

While ROVs and their associated tools are invaluable in cable repair operations there will continue to be many occasions where a combined approach is necessary or grappling techniques alone prove ultimately successful after everything else has failed.

Decomissioning & recovery of cables

There are some examples of de-commissioning and recovery of out of service (OOS) cables where significant lengths of old cable have been removed to accommodate new systems and conform with environmental requirements. This has been restricted mostly to coastal areas, where new cables seek landing sites in an already congested area or where older cables occupy the optimum seabed and are recovered to make way for new systems.

Recovery of old cables at those points where they cross a new cable system (or other seabed asset) is standard industry practice and forms a part of most installation projects.

Recovery of entire cable systems within a geographical area is achievable in practical terms but cable recycling or disposal in accordance with approved methods can be problematic.

Recovery of cable to a converted freighter for example, is a topic of frequent debate but whilst storage aboard the recovery vessel can be managed in the short term, the eventual disposal of perhaps hundreds of kilometres of cable with a minimum amount of viable materials for re-cycling presents considerable logistical and commercial difficulties. This is especially so for telecommunications fibre-optic cables, but equally applies to power cables where to date removal of heavy power cables for re-cycling purposes has not yet developed commercial sustainability.

New environmental awareness and environmental legislation will have considerable impact on cable decommissioning. The density of cable networks that are being created by the wind-farm industry, with many cables concentrated in areas often close to shore proving a particularly good illustration of the case. The decommissioning strategy for a given cable system will probably be a balance between minimising negative environmental impacts and releasing seabed space for future developments.

Future developments

The success of fibre-optic cable technology together, with the development of digital processing equipment, has enabled significant increases in operating capacity of submarine telecommunications cables. This has also reduced the need for installation of new cable systems, with major installation projects taking place far less frequently than previously. New systems are required however and already there are examples of first generation fibre-optic digital systems being retired from service.

New systems are in actual project phase, both in near continental as well as trans-oceanic applications ,meeting the seemingly incessant growth of the internet and the general expansion of communications corresponding to the current age.

The power cable industry is experiencing significant growth, with many new projects at installation phase at the time of writing and many more, in planning phase. This applies to offshore wind, HVDC interconnectors and potentially the proposed European super-grid (of which the interconnector market of today forms the first part).

Future developments in electro optical cabled science arrays and other data acquisitioning systems have been considered but due to the relatively small volume they may be assumed to be of little significance to the overall findings of this report. The presence of military and other government related cables and or submarine systems are expected to have the same constraints as other submarine cable types.

Offshore wind farms

Wind farm distributions

The current distribution of operational wind farms and wind farms in development is summarised in Appendix B.

Wind farm characteristics & layout

While the layout of each wind farm is unique, the design is determined by common factors including:

- Physical natural constraints
- Physical man made constraints
- Component design limitations
- Environmental considerations
- Metocean conditions
- Optimum use of the wind resource considering wake effects
- Economies of scale
- Inter array cabling economics and physical limitations.

Wake effects and turbine spacing

Downwind of a wind turbine the air is turbulent and of lower wind speed than ambient conditions. A turbine downwind of another receives this airflow and its performance and fatigue characteristics are therefore affected. This phenomenon is known as the wake effect. The wake effect and turbine fatigue loads are increased by reduced turbine spacing.

In the tables below it can be seen that there is a range in turbine spacing and no standard or typical spacing for a project. There is however a trend towards larger turbine spacing, as projects get bigger and wind turbine rotors get larger. This is not simply because there is more space to use. Developers naturally wish to maximise the capacity for a given area. Detailed analysis of wake modelling, cable costs and cable layout is needed to determine the optimum spacing and array layout design for a given project and turbine type. The wake effects are normally a stronger driver of economics than the increased costs of extra

Table 2-2 Examples of wind farm turbine spacing & density

Wind farm	Max MW	Turbine[4] spacing	Km2	MW/km2
Triton Knoll	1200	>700	207	5.8
Gwynt y Mor	750	>700	79	9.5
Gunfleet Sands I	108	890	10	10,8
Gunfleet Sands II	64	890	6	11.0
Walney	450	749-958	73	6.2
West of Duddon Sands	500	748-1064	67	7.5
Humber Gateway	300	919-1419	35	8.6
London Array	1000	>700	245	4.1
Sheringham Shoal	315	>700	35	9.0
Greater Gabbard	503	700-800	146	3.4
Race Bank	500	>630	74	6.7
Docking Shoal	500	>630	75	6.7
Thanet	300	800	35	8.6
Lincs	250	500	35	7.2
Dudgeon	300	>500	35	8.6
Westermost Rough	234	>500	35	5.3
			Average	**7.7**

[4] The turbine spacing provided in Tables 2.2-2.4 should be treated with caution due to a number of projects listed where the WTG model and size is yet to be confirmed by the developer and therefore the final design spacing may therefore be subject to change.

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Table 2-3 Turbine spacing & density for wind farms above 50km²

Wind farm	Max MW	Turbine spacing	Km2	MW/km2
Triton Knoll	1200	>700	207	5.8
Gwynt y Mor	750	>700	79	9.5
West of Duddon Sands	500	748-1064	67	7.5
London Array	1000	>700	245	4.1
Greater Gabbard	503	700-800	146	3.4
Race Bank	500	>630	74	6.7
Docking Shoal	500	> 630	75	6.7
			Average	**6.2**

Table 2-4 Turbine spacing & density for wind farms above 100 km²

Wind farm	Max MW	Turbine spacing	Km2	MW/km2
Triton Knoll	1200	>700	207	5.8
London Array	1000	>700	245	4.1
Greater Gabbard	503	700-800	146	3.4
			Average	**4.4**

sub-sea cabling that would be required to increase turbine spacing. Significant research and analysis work is being undertaken within the industry to improve the optimisation process of wind farm layout design and the associated lifetime costs.

Wind farm characteristics

Round one wind farms are generally located close to shore and linked directly to the grid via 33 KV export cables without the need for an offshore substation to step the voltage up to 132KV. For the larger Round 2 sites and beyond, the standard design has sub arrays of turbines linked via 33 KV array cables to one or more offshore substations. The offshore substation is normally located close to the centre of the offshore site to minimise array cable lengths. Each site will have one or more meteorological masts for the measurement of the wind speeds and the atmospheric conditions.

Figure 2-5 shows the planned layout of the Gwynt-y-Mor development off the North Wales coast with the sub arrays linked to two offshore sub stations, which are connected in turn to the grid via two export cables. The meteorological mast is located at the eastern extremity of the site.

The navigational aids of a wind farm, in accordance with IALA 0-139 guidelines, will be installed in two phases, with one set of navigational aids installed temporarily during construction and a permanent set installed for the operational phase. During construction there is normally a more extensive arrangement of navigation aids to warn mariners of partially completed and often unlit structures. Guard vessels are also often used during construction.

The philosophy followed for the installation of navigation aids is that 'Significant Peripheral Structures' and 'Intermediate Structures' will be highlighted to ensure that a group of structures is marked as a single entity – See Figure 2-6.

Currently and for future projects with relatively short export cable routes, 3 core AC cables will be used in either 33/132kV, or 33/220kV configurations, for the array and export cables respectively. As previously mentioned, longer export cable routes as required for a number of the Round 3 sites will require HVDC technology to minimise electrical losses. Cable protection is provided by burial over main cable sections and in the vicinity of foundation J or I tubes, a number of different cable protection solutions are used including mattressing and bespoke duct and clamped protection/bend stiffening arrangements.

Scour protection for foundations is either achieved by applying an allowance for global scour at the design stage or more often by installing measures such as graded rock protection.

One of two approaches for rock protection is usually followed:

- Static design – where rock is placed on the seabed surrounding the monopile shortly after the pile is installed. This is laid over a pre-installed filter layer of finer material, placed to prevent sand being lost from between the rocks of the main protection layer
- Dynamic design – where a scour pit is allowed to develop to its stable extent around the monopile with no scour protection) in place. The scour pit is then partly or wholly filled with wide graded rock.

Installation practices

Foundation installation practices

Foundations for turbines, met masts and offshore sub stations to date have been of the monopile design almost exclusively, although for future sites a number of alternatives more suitable for deeper water are being developed. The most obvious alternative is the piled jacket or tripod although there are a number of designs currently under consideration by developers including various gravity base designs. From an installation perspective each type of foundation required a broadly similar installation vessel i.e. either a jack-up barge or a floating heavy lift barge. In brief the installation techniques are as follows:

Monopiles – The monopiles are either transported to site by feeder barge or more often by the installation vessel. Pile upending is achieved followed by pile driving, drilling or a combination of both depending on soil conditions. Verticality tolerance is then achieved by installing a transition piece atop the pile using a grouted keyed bond. The majority of secondary steelwork such as boat landings, ladders and J tubes are pre-installed ashore. Often a scour protection filter layer is pre-laid at each pile location prior to piling.

Jackets & tripods – As for monopiles, jackets and tripods are shipped offshore either on transportation barges or on the installation vessel, together with the sets of pin piles

Figure 2-5 Indicative wind farm layouts

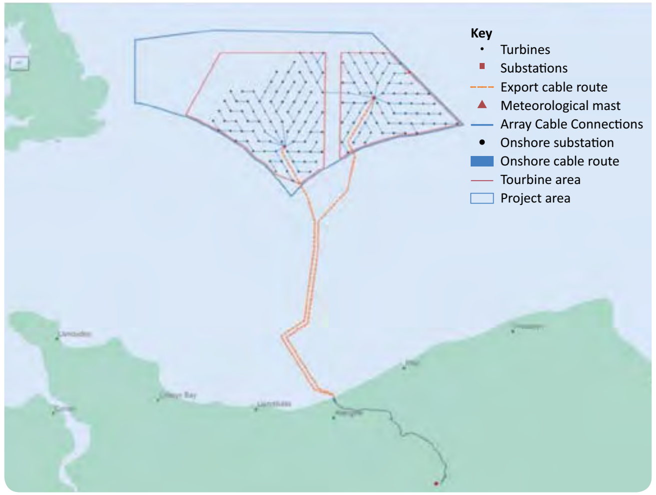
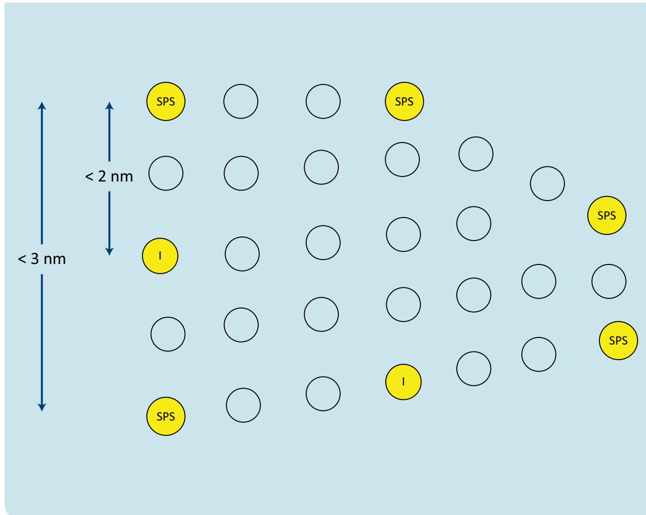


Figure 2-6 Typical wind farm layout with navigation aids at SPS and I structures



for securing the structure to the seabed via a grouted connection. Once the jacket is positioned on the seabed, the pin piles are either driven or drilled into position and a grouted connection made between piles and structure. Verticality is achieved by a number of methods including the use of hydraulic levelling tools and by vibro-piling.

Gravity bases – Gravity bases are by necessity large heavy structures (in order to deal with sliding and overturning forces). The design can vary, but skirts are often used to increase friction. Due to their size and weight, gravity base foundations are normally installed using large capacity heavy lift crane barges. Achieving verticality can be problematic and depending on site conditions, seabed preparation can be required to ensure the final structure is aligned within the required tolerances.

Hybrid solutions – While still under development there are a number of new designs that have yet to be proven commercially including:

- Suction pile or can foundations
- Self-installing jack up foundations
- Floating tension leg foundations
- Pile assisted gravity bases.

Whichever foundation design is selected with the exception of floating tension leg foundations which have yet to be proven commercially, the installed foundation footprint is broadly similar from a cable proximity perspective – the greatest impact on cable proximity is the installation and maintenance vessel type and its station keeping mode (an anchored floating barge having the largest impact and a DP vessel the smallest). It should also be noted that an anchored barge may be used for power cable repairs and therefore also needs to be considered as an impact on proximity limits. See Section 2.13 for further details on vessel types.

Cable installation practices

Generally cable burial requirements for wind farm cables are no different than for other subsea power cable projects, with burial protection to depths of 1-2m typical for the inshore Round 1 sites where fishing and inshore commercial traffic represent the main threats. Burial depths for protection should be a function of the assessed threat to long-term cable integrity and the seabed properties, which would normally be considered during route selection, and survey phases of a project.

Round 1 and 2 projects have utilised multi point moored barges, DP 2 vessels and hybrid DP 2 vessels equipped with anchor spreads for the installation of inter-array and export cables. With the increase in project size and distance offshore, it is likely that DP cable installation vessels will become the preferred or necessary cable installation platform over conventional anchored lay barges, although landing point and route selection may dictate barge operations in shoal waters. Barge operations further offshore may be limited by safety considerations; not least the requirements of load line exemptions, and generally present a more weather sensitive solution.

Cable installation methods adopted to date have included simultaneous lay and burial, using a range of subsea trenching and burial equipment, including conventional towed ploughs, jetting ploughs, and vertical injector tools, deployed from both barges and DP vessels. Post lay burial using jetting or mechanical trenching tools depending on the soil properties, is generally carried out from a DP 2 support vessel, although anchored barges may be used for this purpose, particularly in shallow water near-shore areas.

As projects move further offshore the requirement for HVDC export systems will become prevalent. Plough burial of HVDC cables, particularly when bundled, is understood to be largely unacceptable to most cable suppliers as it presents a risk of latent defect to the cable, but improved design of subsea equipment and/or type approved cable, may make the technique feasible and more acceptable in the future.

The sites being developed in the next decade will have increased water depths but this is not expected to impact on current cable burial methods, as depths will generally be less than 60m.

Topsides installation practices

The topside structure of a wind turbine consists of tower, nacelle, rotor and blades, each of which is installed separately in sequence and generally by a jack up installation barge. A complete structure has been installed by a floating heavy lift barge in a single operation as a demonstrator project and this may be adopted for commercial sites in the future. The logistical arrangements do vary, but with the larger sites further offshore in the future, the preferred model is likely to be for a large installation jack-up or floating heavy lift barge to load-out a series of components for 4-6 locations and then install the components, before returning to base for the next load-out. Piling and grouting can either be performed by the main installation vessel or by a smaller dedicated spread. The latest sophisticated jack-up barges suitable for the deeper water locations are generally self-propelled and equipped with DP systems. Similarly there are large heavy lift barges on the market with DP station keeping, although the majority depend on multi point mooring systems for positioning.

The dimensions and weight of offshore sub-station structures are generally beyond the capabilities of jack up barges and therefore the preferred installation method is by using an anchored floating heavy lift barge. As mentioned above, there are floating heavy lift barges on the market equipped with DP systems.

Offshore sub-stations

Offshore sub stations designs to date have comprised a complete topside module installed onto a piled jacket or mono-pile foundation. The offshore installation is normally carried out using a floating heavy lift crane barge, with transportation of the foundation and topsides also carried out by the installation barge or by using a dedicated transportation barge. A self-installing jack-up design is also feasible although to date untried in the renewable energy sector.

Operation & maintenance practices

Currently operation and maintenance (O&M) of the fixed wind farm structures (wind turbine generators, met masts and offshore substations) is carried out from an onshore support base using small fast craft to ferry technicians to and from shore on a daily shift basis. Seasonal planned maintenance requiring more extensive support facilities offshore are normally carried out by small jack-up intervention vessels with crane capacity and outreach necessary for lifts to and from the nacelle. This O&M model is only suitable for sites close inshore in relatively sheltered waters.

Figure 2-7 Jack-up barge

As the larger sites are developed in the coming decade, the O&M requirements will become more sophisticated with shore to site and in-field helicopter transport becoming commonplace for day-to-day O&M activities. The deeper waters of the larger Round 3 sites will require either larger jack-up intervention vessels for seasonal O&M campaigns and breakdown maintenance of larger components or DP support vessels with bespoke access systems between vessel and structure. In addition, 'Flotel' vessels providing onsite accommodation for extended periods and/or permanent living quarters offshore will become part of the O&M infrastructure offshore. Offshore substations with permanent living quarters and helideck are currently under development for installation in German waters in the next 2-3 years, and are likely to be adopted in UK waters for Round 3.

In addition to the O&M of the fixed wind farm structures, periodical inspection surveys of the inter array and export cables are carried out. From the results of such survey and condition monitoring, remedial cable protection work or cable repairs may result. For repair, replacement or other work on an inter array cable within an 'in service' wind farm, the limited sea-room and proximity of seabed obstructions would indicate a preference for a vessel using DP for station keeping rather than anchors.

For the repair of an inter array cable, the short cable lengths and restricted location within the wind farm array usually means cable replacement is the only viable remedy, rather than an omega jointed repair. For export cable repairs a conventional omega joint is the most likely option where cable damage or a fault occurs. See Sections 2.10 and 3 for details of omega jointing and joint dimensions in relation to water depth and cable type. The ability of generating owners and operators and of OFTOs to respond in the event of an unplanned fault will depend upon their O&M strategy and their repair preparedness plan, which may include a range of options from spot market arrangements to owned or contracted standby assets.

Decommissioning of wind farms

The decommissioning scheme, as set out in the Energy Acts of 2004 and amended in the Act of 2008, applies to territorial waters and to waters in the UK Renewable Energy Zone for England, Scotland, Wales and Northern Ireland, and covers wind, wave and tidal energy developments. It does not apply to the intertidal zone where Marine Licence conditions (formerly CPA & FEPA consent conditions) will specify the decommissioning requirements.

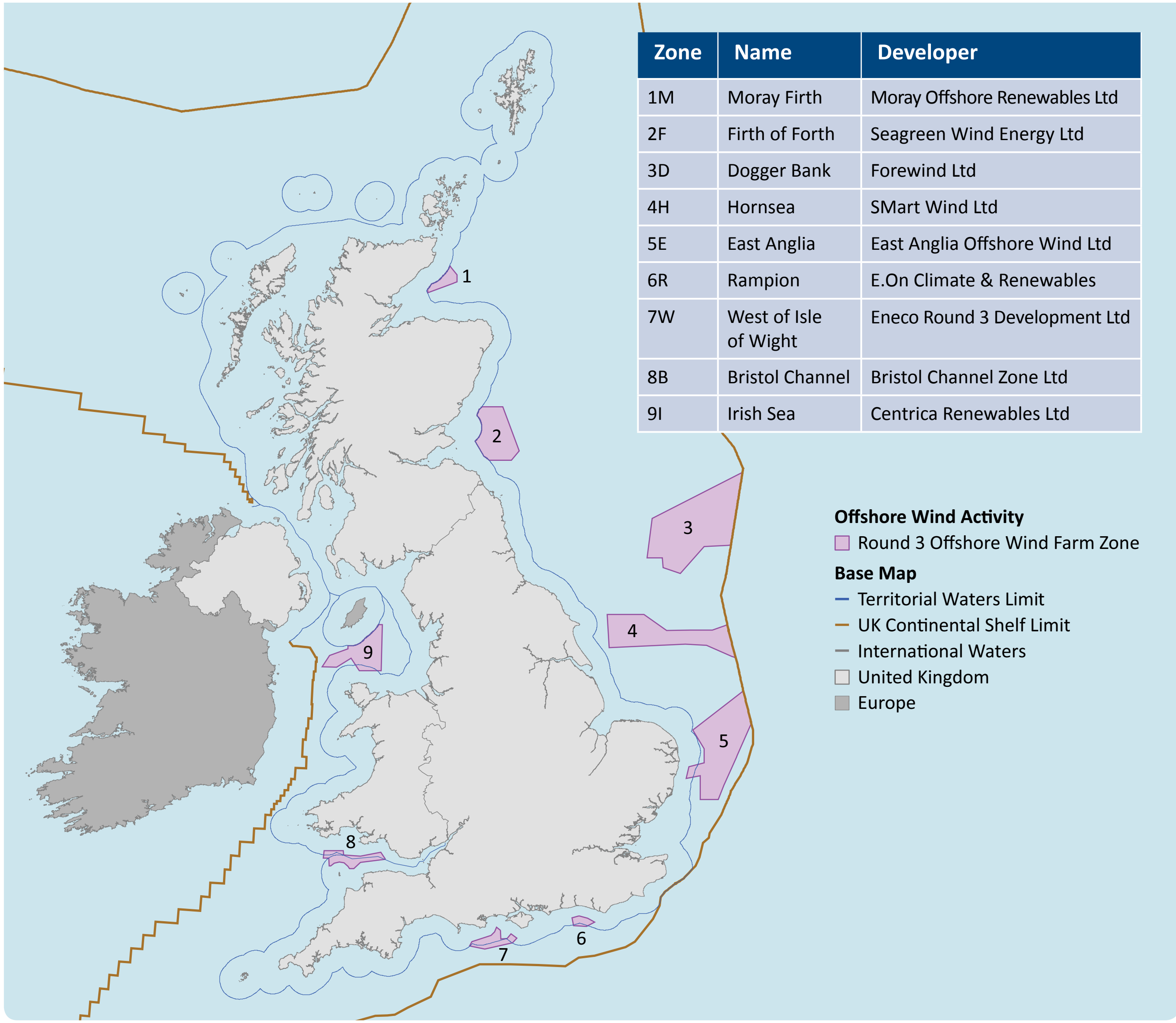
The latest decommissioning guidelines were published in January 2011 by the Government Department of Energy & Climate Change (DECC) titled Decommissioning of offshore renewable energy installations under the Energy Act 2004.

Whilst it should be noted that no UK offshore wind farm has yet been decommissioned, there is a general presumption in favour of disused installations being removed from site unless the owner demonstrates that removal of a particular component is not viable because:

- The component can serve a new use
- Extreme cost would be involved
- Unacceptable risks to personnel
- Unacceptable risks to the environment
- More than 4000t in air or located in >100m water depth.

This presumption in favour of removal has its origins in the United Nations Convention on the Law of the Sea (UNCLOS), 1982 in order to preserve safety of navigation.

Figure 2-8 Round 3 offshore wind farm zones



Zone	Name	Developer
1M	Moray Firth	Moray Offshore Renewables Ltd
2F	Firth of Forth	Seagreen Wind Energy Ltd
3D	Dogger Bank	Forewind Ltd
4H	Hornsea	SMart Wind Ltd
5E	East Anglia	East Anglia Offshore Wind Ltd
6R	Rampion	E.On Climate & Renewables
7W	West of Isle of Wight	Eneco Round 3 Development Ltd
8B	Bristol Channel	Bristol Channel Zone Ltd
9I	Irish Sea	Centrica Renewables Ltd

The Crown Estate does not impose any additional decommissioning requirements on developers – the terms and conditions of each lease agreement are aligned to the current legislation. For example, decommissioning programmes produced by developers in accordance with legislation are submitted to Government, who in turn will consult with The Crown Estate on the suitability of such programmes.

It is for each wind farm developer to present their decommissioning programme and for Government to review and accept it in its final agreed form. Nonetheless it is likely that in general, wind farm decommissioning will consist of removing the topsides and foundations of fixed structures to a prescribed depth below the surrounding seabed, leaving foundations in the seabed and any cables which are buried to a safe depth and scour protection materials where such materials may have a beneficial environmental effect. Full decommissioning has the additional benefit of releasing the previously occupied area of seabed for future development.

Future developments

The UK is heavily reliant on the development of offshore wind energy over the next decade in order to meet the national 2020 renewable energy targets and contribute towards the country's security strategy. UK currently has approximately 1.5GW of installed capacity. By comparison, the UK Government is anticipating 18GW of offshore wind generating by 2020 and up to 40GW possible by 2030. This is likely to equate to a further 10,000-15,000 km of export cables and over 5,000 km of array cables. The Round 3 zones are illustrated in Figure 2-8 and further details are contained in Section 2.5.8. Each of the zones will eventually comprise a number of individual wind farms in close proximity to each other with the size location and layout of these currently in planning and design. This type of multiple farm development is already underway in a number of, and is also the template for, the German offshore development programme in the North Sea.

Export cable lengths are set to increase in length per project as the larger offshore sites are developed in deeper water. This will require the utilisation of HVDC technology over the longer routes (in excess of 80 km). Consenting issues relating to EMF emissions affecting navigational safety and elasmobranchs may dictate that HVDC cables will be laid as a bundled pair, rather than separated on the seabed (this being depth related for navigational safety and location related for impacts on elasmobranchs). A number of HVDC interconnector cables have already been installed in this configuration (e.g. BritNed and currently being installed – EWIC and Cheju Do in Korea).

There is a trend for larger wind turbine generators with 3 to 3.6MW being the current benchmark. Over the next decade research and development will be aimed at increasing turbine size further to the 5-10MW range. The effect of larger turbines will be an increase in foundation size/footprint, turbine spacing and inter array cable lengths. The current turbine spacing of 500-700m is likely to increase to 1000m or more for larger turbine designs.

Developments in turbine foundation design for deeper water locations may include the use of tension leg or other anchored floating foundations, which would result in a larger footprint per turbine. The development of deep-water moored wind turbines is underway with a number of demonstrator projects currently in development. While the use of moored foundations for wind turbines on a commercial scale is likely to be some way off, their future presence and proximity to cable systems in the UK REZ will need to be included in future spatial planning.

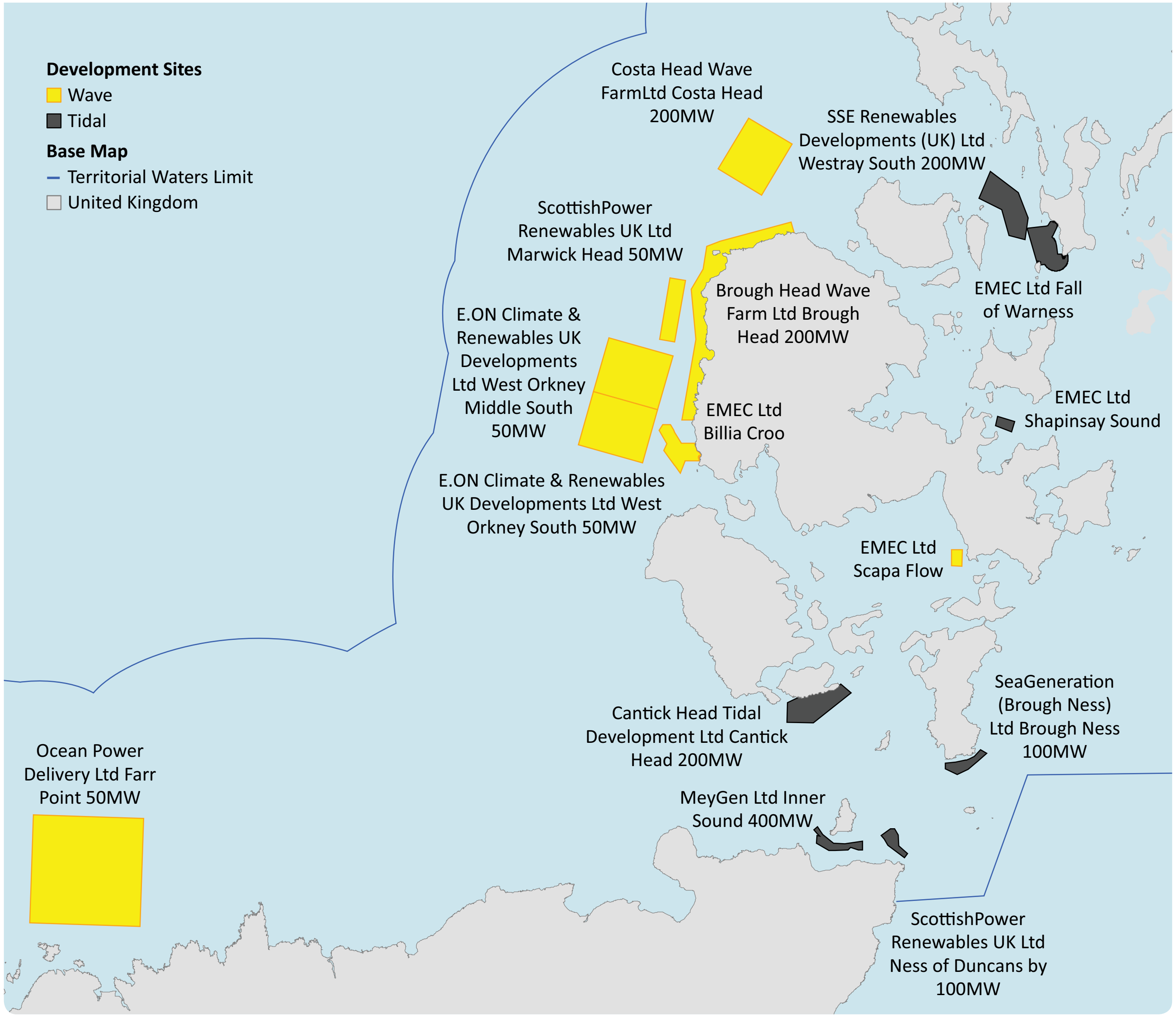
Wave & tidal energy projects

To date offshore wave and tidal power development has been limited to prototype testing and small-scale pilot or demonstrator projects. A number of larger commercial scale funding initiatives have been launched with the first commercial scale round of leasing carried out by The Crown Estate in 2010 for 11 sites in the Pentland Firth and Orkney waters. These sites have a combined potential capacity of 1,600 MW and installation works are expected to start in 2014 and continue through to 2020.

Commercial site name	Capacity (MW)	Owner(s) of tenant
Farr Point	50	Pelamis Wave Power Ltd
West Orkney South	50	E.ON Climate & Renewables UK Ltd
West Orkney Middle South	50	E.ON Climate & Renewables UK Ltd
Marwick Head	50	Scottish Power Renewables UK Ltd
Brough Head	200	Aquamarine Power Ltd & SSE Renewables Holdings (UK) Ltd
Costa Head	200	SSE Renewables Developments (UK) Ltd, Alstom UK Holdings Ltd
Westray South	200	SSE Renewables Developments (UK) Ltd
Cantick Head	200	SSE Renewables Developments (UK) Ltd & OpenHydro Site Development Ltd
Brough Ness	100	Marine Current Turbines Ltd
Neww of Duncansby	100	ScottishPower Renewables UK Ltd
Inner Sound	400	Atlantis Resources Corporation Pte Ltd, International Power Marine Developments Ltd, Morgan Stanley Capial Group Incorportated

* Tenant names are labelled on the map

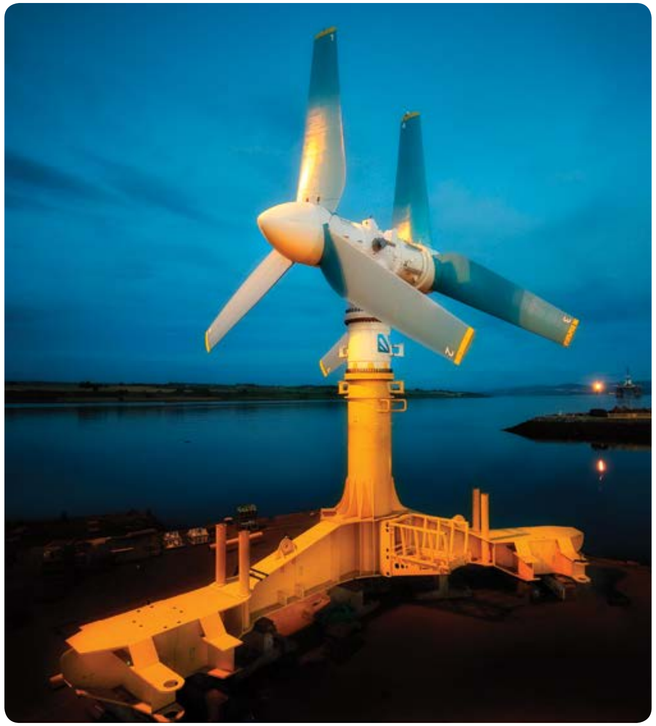
Figure 2-9 Wave & tidal energy sites planned for Pentland Firth & Orkney waters



Wave & tidal project distributions

The Pentland Firth and Orkney sites released by The Crown Estate have a combined potential capacity of 1,600MW and installation works are expected to start in 2014 and continue through to 2020, see Figure 2-9.

The Crown Estate launched offshore tidal stream (and wind) leasing rounds in December 2011 to select developers to take forward up to 800MW of projects in Northern Ireland waters. The potential tidal stream sites are located within the Rathlin Island and Torr Head Strategic Area – a single tidal stream area of up to 200MW capacity. Sites will be leased to developers for delivery of multiple projects and applications will be invited for projects of a range of sizes up to 100MW.



In addition to the development of commercial scale sites, there are also two existing test sites – EMEC in Orkney and Wave Hub in Cornwall. Site leases have also been granted for a number of 'demonstrator scale' projects. As the wave and tidal energy sector develops, it is likely that further sites (as yet unidentified) will be leased.

EMEC, Orkney

The European Marine Energy Centre (EMEC) is located in Orkney. They have 2 test sites, a wave site located outside Stromness on the mainland and a tidal test site located off the island of Eday. As the first centre of its kind to be created anywhere in the world, their role is to support the development of wave and tidal energy devices and to aid the evolution of the technology from the prototype stage into the commercial market place. **www.emec.org.uk**

The Scottish Government has set up the 'Saltire Prize' – a £10 million award to the team that can demonstrate in Scottish waters, a commercially viable wave or tidal stream energy technology that achieves the greatest volume of electrical output over the set minimum hurdle of 100GWh over a continuous 2 year period using only the power of the sea.

Wave Hub, Cornwall

The Wave Hub is a consented, grid-connected 20MW demonstration site for arrays of wave energy devices located 10 miles off the north coast in Cornwall. Completed in 2010, the project holds a 25 year lease of 8 km2 of seabed and has been designed for 4 x 5MW arrays of different devices. The system can be upgraded to generate 50MW in future. **www.wavehub.co.uk**

Installation practices & designs

Due to the wide variety of designs for wave energy converters (WECs) and tidal energy converters (TECs), the installation practices are similarly diverse. Disregarding those devices planned for installation in or close to the inter-tidal zone, all are either floating devices (surface or subsea) incorporating rigid or dynamic moorings or more commonly for TECs installed on the seabed. Due to the energetic environment in which these devices are installed, sophisticated mooring arrangements or subsea bases are required to resist the environmental forces. Similarly, the installation of array and export cables at typical wave and tidal energy sites can be problematic due to the high likelihood of encountering hard scoured seabed conditions.

To date, the installation of single demonstrator devices has generally utilised jack-up barges for drilling and grouting piled foundations and mooring piles, while moored barges and multi-purpose DP support vessels have been used for cable works and device deployment.

The 'footprint' of an installed device will also depend on the design and can vary from a relatively small gravity base foundation housing a tidal turbine to a large conventional anchor spread of several hundred metres in diameter. Also from a proximity perspective, devices may be installed on the seabed with sufficient vertical clearance for all surface navigation, installed at an intermediate depth in the water column or surface deployed, each of which needs to be considered separately when determining proximity limits.

Another factor peculiar to moored wave and tidal devices is their dynamic footprint which depends on their physical size and whether the mooring design allows them to 'weather vane' into the prevailing environmental forces.

Operation & maintenance practices

Wave and tidal devices may be maintained on site, but generally because of the extreme environmental conditions that predominate at such locations they are more likely to be

removed to a maintenance base for planned and breakdown maintenance. If a device is removed from site for maintenance, the mooring spread or gravity foundation may be left in situ or also removed temporarily. Devices maybe towed to and from site, or transported by vessel or dedicated maintenance barge depending on the design.

Decommissioning of wave & tidal projects

While falling under the same legislation, the decommissioning of wave and tidal power projects is not directly comparable to the process of decommissioning wind farms and their fixed structures (See section 2.10.5 and 2.11.5), given that wave and tidal devices vary greatly in design and operation and often include major components easily removed from site.

Future developments

There are currently a large number of wave and tidal energy devices at various stages of developments with only a small number having undertaken commercial prototype testing offshore. At the present time, the scale of wave and tidal energy development is difficult to predict, with significant technical hurdles still to be overcome and reliance on financial subsidies and incentives likely to be needed for some years to come to stimulate the sector.

Whichever technologies emerge as front-runners, the common development will be the deployment of arrays of devices rather than single units to take advantage of economies of scale.

The extent of wave and tidal energy resources in UK waters have been identified and mapped **(http://www.renewables-atlas.info/).** Of the sites and areas identified to date with potential for development, many are in locations unsuitable for competing seabed developments due to the energetic nature of the environmental conditions.

Vessels & position management systems

Introduction

Both the cables and renewable energy sectors require a wide variety of specialised vessels to complete the full range of activities associated with the two industries.

The cable installation and maintenance vessel designs have evolved over a long period with well-established operating practices. Market influence has also generated a number of cable installation vessels converted from vessels that were designed for other trades. These include Ro-Ro ferries, heavy lift vessels, offshore supply and construction vessels and barges. Traditionally cable installation and repair vessels have either been multi point anchored barges with or without self-propulsion suitable for relatively shallow water operations or self-propelled ‘manual control’ deep-water cable vessels. The advent of dynamic positioning in the 1980s has since been widely adopted as the station keeping mode of choice for cable installation and repair activities. A place remains within the industry for non-DP vessels particularly for landfall works, surveying and other specialised activities, where precise station keeping is not a priority.

The offshore renewable energy industry by comparison is very new, and requires a much wider variety of specialised vessel types for the multitude of tasks involved. Early wind farm developments ‘borrowed’ installation techniques and vessels from the inshore civil construction industry ideally suited to shallow sheltered water locations. These low tech vessels and barges proved adequate for small wind farm projects close inshore, but it soon became apparent that advances in efficiency would be required in order to develop larger sites further offshore. The rapid growth of the renewable energy market and competition from other marine sectors (cables and oil & gas) has led to a shortage of suitable installation and O&M vessels. The current trend is for dedicated wind farm installation vessels and a significant number of new builds are entering the market. Offshore renewable energy cable operations have to date been completed using either dedicated cable vessels from the cable sector or multi-purpose support vessels and barges from the oil and gas sector. Currently a number of oil and gas contractors with vessels normally engaged in that sector are entering the renewables cable market.

Jack up & spud leg barges

Spud leg barges are limited by leg length to shallow water operations and hold position by means of lowering one or more spud legs into the seabed. These barges are normally towed from A to B by a conventional tow tug or multicat type vessel. Sophisticated position monitoring equipment is not normally included in the vessel’s equipment, but is installed for project applications such as inshore cable trenching, where GPS-based systems are often used to monitor the trenching operation. Some spud leg barges are also fitted with multiple anchor systems and fall into the category described below.

Jack-up barges are regularly used in wind farm construction and maintenance. The latest purpose built jack-ups are self-propelled and equipped with DP Class II station keeping. Their footprint on station is therefore no larger than for an equivalent sized DP support vessel. Conventional towed or propulsion assisted jack-ups rely on a 4 point anchor spread for positioning and thus present a larger footprint during positioning and jacking.

Multi point moored barges

Multi point anchored barges, engaged in both wind farm operations and cable work, normally deploy a 4, 6 or 8 point mooring system with the scope of wire depending on the water depth and prevailing conditions, but generally in the order of 500-900m. Barges engaged in operations such as cable burial also deploy a single pulling anchor in the direction of travel. Such a pulling anchor is often deployed on a longer scope of 800-1200m. Such barges use high holding power anchors capable of deep seabed penetration. Anchors are deployed and recovered by one or more anchor handling tugs and a dedicated tow tug is normally also utilised. These barges may also be fitted with one or more spud legs and or manoeuvring thrusters.

For operations where positioning accuracy is critical, control and monitoring of barge and anchor positions is achieved with a dedicated DGPS survey package or barge management system. The provides a real time display of tug, barge, anchor and wire positions relative to seabed and surface obstructions and pre-programmed anchor drop locations. System accuracy is in the order of 1-2 metres but actual accuracy will be dependent on the skill of the personnel involved, particularly the tug skipper, using manual manoeuvring controls. Anchor drops normally achieve 10 metre accuracy in shallow waters of less than 100 metres, although final anchor position will depend on the seabed characteristics, anchor type and rig, among other factors. See section 3.2.1 for anchor/cable clearance distances.

Self propelled vessels – manual control

Self-propelled vessels with only manual positioning control include a wide variety of vessel types engaged in wind farm operations and to a lesser extent cable operations. The level of redundancy in the propulsion and control systems vary considerably, but in general vessels operating in close proximity to surface and subsea obstructions or carrying out position critical operations, are equipped with redundancy in both propulsion and propulsion control. By definition, manual control relies heavily on the competency of the operator, which includes ship handling skills, familiarisation with a particular vessel’s characteristics and knowledge of emergency response actions.

There are well established protocols in place for all vessels (including manually controlled) entering safety zones in the oil and gas sector and entering restricted port approaches, which are used to minimise the risks of loss of position control. These protocols focus on the use of checklists exchanged between parties, which typically confirm the following:

- Propulsion and steering systems including back-ups have been tested and are fully operational
- Communications between control stations have been tested and are functioning
- Communications frequencies, channels and protocols agreed
- Bridge & Engine-room manning levels and hours of rest requirements complied with
- Environmental conditions and forecast suitable
- Approach, manoeuvring restrictions and escape routes assessed and suitable
- Auto pilot disengaged
- Manoeuvring mode for the operation established and agreed
- Permission for entry obtained from the controlling authority and recorded.

Dynamically positioned vessels

The classes of dynamically positioned vessels are well known and in brief are as follows:

- DP Class 1 – Loss of position may occur in the event of a single fault
- DP Class 2 – Loss of position should not occur from a single fault of an active component or system such as generators, thruster, switchboards remote controlled valves etc. But may occur after failure of a static component such as cables, pipes, manual valves etc.
- DP Class 3 – Loss of position should not occur from any single failure including a completely burnt fire sub division or flooded watertight compartment.

DP Class 3 vessels designed with a focus on manned saturation diving and other position critical operations are generally not utilised for either wind farm or cable operations as their greater redundancy capabilities exceed minimum requirements of both sectors and in addition their high operating costs are reflected in their day rates.

DP vessels engaged in wind farm operations are generally Class 2 vessels due to the need for reliable station keeping in close proximity to fixed structures and other vessels. Cable vessels engaged in wind farm work are also generally DP Class 2 for the same reason – operations in proximity to fixed structures and other site obstructions.

As the essence of DP notation and the class awarded is a function of the redundancy afforded by the systems and design of the vessel, degradation of these systems may be entirely acceptable in an operational situation which may not impact on its ability to carry out a specific operation although it would preclude it from work which specifically required the standard required by the class notation.

DP cable vessels currently contracted for cable repairs in the UK REZ under long term maintenance agreements are generally older tonnage. Modern, higher specified vessels are often preferred for cable installation work. This means that in general cable maintenance vessels retained for cable repairs under long term maintenance agreements are generally DP Class 1 vessels or for commercial reasons DP Class 2 vessels operating to Class 1 requirements.

While competence of ship's Watchkeepers in general is legislated at an international level under the STCW-95 Convention, the specialism of DP operations is not regulated. The Nautical Institute DP training scheme is the industry standard for training and certification of DP operators and maintainers in UK.

The Nautical Institute has managed the scheme since its inception in the mid 1980s and in conjunction with industry has developed the certification criteria. It administers the certification of DPO's together with the accreditation of the training providers.

In order to ensure that the scheme continues to meet current Industry needs, the Dynamic Positioning Training Executive Group (DPTEG) was established to facilitate communication and input from a broad range of stakeholders.

The group is a pan Industry forum of training providers, trade organisations and professional associations who have a remit or interest in DP training.

Cable repair vessels

A comparison of DP related capabilities is provided below for Wave Sentinel (DP Class 1) and Edda Fjord (DP Class 2).

Table 2-5 DP capability comparison

Vessel	DP class	E.R.N.	Main engines	Bow thrusters	Stern thrusters	Length (M)	displacement (T)
Wave Sentinel	1	60.60.10	2 x 4500 KW	1 x 1350 KW 2 x 590 KW	2 x 1350 KW	138	4550
Edda Fjord	2	99.99.99	2 x 4500 KW	2 x 1200 KW 1 x 1500 KW	2 x 1000 KW	105	6600

While the ERN number developed by DNV is only one of a number of methods used to measure a vessel's station keeping ability it does provide a useful comparison between the two vessels illustrated.

The ERN designation xx.yy.zz illustrates the vessel's chance of remaining on location in a set of standard environmental conditions in three scenarios:

- xx is the percentage probability of holding position with all systems working
- yy is the percentage with the most ineffective thruster failing
- zz is the percentage chance if the most effective thruster fails.

The comparison above only considers the vessel's propulsion capabilities and excludes any allowance for propulsion inefficiencies and restoring forces necessary to correct a position excursion. The additional redundancy provided by the DP 2 classification of Edda Fjord further separates the two vessel's capabilities.

Other factors affecting the capabilities of repair vessels, include the installed cable handling equipment and storage systems. The cable highway, sheaves and turn radii should conform to the requirements of the cable being handled. Cable machinery should be compatible and cable storage arrangements suitable for the cable type. While most telecom repair vessels are able to handle all cable types in the telecommunications sector they may not be ready to accommodate power cable without modification. In deeper water operations the hydrodynamic properties of the vessel may be of concern with some cable types, although this was not considered an influencing factor within the scope of the Study.

Failure modes & effects

Failure modes of relevance to this study for the various vessel types are summarised in Table 2-6 below.

Table 2-6 Recommended base case anchor and anchor line proximity limits

Vessel Type	Failure Mode	Possible Causes
Spud leg barge	Loss of position from leg movement in soil	Soil conditions, tidal rise, operator error, operating outside environmental working limits
Spud leg barge/jack up barge	Contact with subsea structure/cable from positioning error	Operator error, survey system error, inaccuracy in position data for subsea structure/cable
Jack-up barge/floating barge	Loss of position from anchor drag	Anchor size type not suitable for soil conditions, unexpected/incorrectly interpreted soil conditions, insufficient scope of wire, poor anchor deployment technique, exceeding environmental limits
Jack-up barge/floating barge	Loss of position from anchor leg failure	Equipment failure from poor maintenance, exceeding environmental limits, exceeding safe working load, incorrect barge orientation relative to environmental forces, failure to appreciate and mitigate against worst case mooring leg failure
DP Vessels	Drive off	Incorrect DP command from operator or system, thruster failure to default setting, error in position or environment sensor input
DP Vessels	Drift off	Vessel blackout, position reference failure or fault, operator error, fire, computer fault, operator error
DP Vessels	Large excursion	Computer fault Sudden wave or other external force Operator error Wind sensor fault or input error Thruster control fault
Manually Controlled Vessels	Loss of positional control	Operator error External force not counteracted Propulsion or steering failure

There are numerous reports analysing collision statistics between vessels and fixed oil and gas structures, one of which 'Overview of collision detection in the UKCS' Prepared by AEA Technology plc for the UK Health and Safety Executive (HSE) 2006 highlights the following statistic:

[5] *The Ship/Platform Collision Incident Database (2001) contains details of 557 collision incidents recorded between 1975 and 2001. Of these, 549 (98.6%) were assessed as being collisions between an installation and an 'attendant vessel' and the remainder with a 'passing vessel'.*

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While this statistic cannot be applied directly to the proximity scenarios we are considering, it does highlight the risks associated with vessels manoeuvring in close proximity to fixed structures.

The UK HSE OTO Report 052 examines collision risk management in detail and highlights key root causes relevant to this study as:

- Lack of marine experience on the installation
- Poor communications between installation and vessel
- Insufficient understanding by management of the implications of selecting a vessel primarily on cost
- Insufficient manning on the vessel
- Reluctance by installation management to exclude vessels from the 500m safety zone
- Reluctance by Masters to call off operations in marginal conditions due to commercial pressure, threat of reprimand or professional pride
- Commercial pressures on vessel operator leading to crew fatigue, reduced crew training and increased likelihood of mechanical breakdown.

This report further highlights the need for operators to implement a collision risk management system that covers the following key elements:

- Hazard identification
- Risk assessment
- Preventative measures
- Control measures
- Mitigation measures
- Emergency response measures.

[5] *Ship/Platform Collision Incident Database (2001), Research report 053, JK Robson – MaTSU, 2003*

Subsea equipment

Introduction

Subsea equipment used during the installation and maintenance of wind farms and submarine cables vary enormously in their purpose, mode of operation and level of threat they pose to proximate assets.

Remotely operated vehicles (ROVs)

The smaller free swimming ROVs generally used for monitoring and simple manipulating tasks are general deployed from a vessel directly into the water without the use of a Tether Management System (TMS). They generally have limited thruster power, which limits their operating window in terms of tidal current strength. Larger more capable ROVs collectively known as 'Work Class' ROVs (WROV) are of primary interest to this study as their use in cable repair operations is a significant factor in determining proximity limits. WROVs are the mid-range in terms of size and are fitted out for multiple roles with the ability to be adapted for specific tasks in the industry they are servicing. A third group of ROVs are the much larger cable and pipe burial vehicles generally but not always dedicated to a single task such as cable trenching or jetting.

WROVs are generally available as standard equipment on cable repair vessels and can be adapted for use in surveys, cable detection and fault location, de-burial, burial, manipulating, cable cutting and recovery preparations and are normally mobilised with a dedicated launch and recovery system (LARS). Their operating limits are determined by:

- Underwater visibility
- Current strength (for free swimming vehicles)
- Seabed topography (for tracked and skidded vehicles)
- Soil conditions (for jetting/trenching ROVs)
- Water depth
- Sea state (for launch & recovery).

An example of a typical work class ROV capable of free swimming or tracked operations is the Atlas 2 which has the following general specification (all maximum values):

- Overall power............300 kW
- Jetting power..............250 kW
- Jetting speed...............510 m/hr
- Burial depth.................2 metres
- Weight in air................10.6 tonnes
- Tools.................................cable tracker, jetting tool, de-burial eductor, seabed profiler.

The third group of ROVs consists of dedicated trenching or jetting vehicles, which have much higher power ratings than the work class ROVs and consequently are more capable in terms of cable burial performance. These vehicles are generally tracked vehicles and due to their large size and weight are generally deployed from a sophisticated LARS.

Table 2-7 Comparison of i-Trencher and Excalibur

	I-trencher	Excalibur
Operator	Canyon Offshore	Global Marine Systems
Mode	Tracked mechanical chain trencher	Tracked jetting Tool
Weight in air	85 tonnes	23 tonnes
Power rating	1250 kW	900 kW
Trench depth	2 metres	3 metres
Burial speed	>500 m/hr	> 500 m/hr

Table 2-7 summarises the capabilities and characteristics of a mechanical trenching vehicle 'i-Trencher' and a jetting tool 'Excalibur', both typical of this group of vehicles.

For ROVs, the launching and recovery is often the most weather sensitive part of their deployment, and a number of factors combine to determine the weather limits for deployment and recovery including:

- Method of launching and recovery – some sophisticated LARS are designed to limit the motion of the vehicle between deck and water. Also the use of a TMS make recovery less weather sensitive than recovery directly from the sea surface
- The size and motion characteristics of the ROV support vessel is a significant factor, with many vessels equipped with motion damping features
- The height of the ROV deck from the sea and deployment position relative to the centre of gravity of the vessel both contribute towards defining the deployment limits.

Figure 2-10 i-Trencher chain trenching vehicle & LARS

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The use of a TMS rather than direct deployment has a number of benefits including the following:

- Less chance of fouling the ship's thrusters
- Reduction of drag forces on the umbilical at greater depths
- Protection of the ROV during launch and recovery through the splash zone
- Faster deployment to the working depth governed only by the speed of the winch, rather than the rate at which a free swimming ROV could dive using its vertical thruster(s)
- A safe haven at depth for the ROV between tasks.

Tracked ROVs during normal operations are relatively slow moving and their movement is easily controlled by a competent ROV pilot. However potential causes of failure modes that should be taken into account when planning proximity limits for ROV operations include:

- DP drive off or drift off resulting in dragging of the ROV across the seabed
- Poor underwater visibility and/or misinterpretation of sonar imagery
- Power failure resulting in a 'dead vehicle'

Figure 2.11 Excalibur jetting vehicle

- Operator error while manipulating ROV tools or driving of the vehicle
- Seabed slopes (more than 15o as a general rule) or uneven terrain can cause sudden movement of the vehicle
- Excursion limits in relation to depth of water and position of propulsion units.

Subject to risk assessment, tracked ROVs can be operated in close proximity to subsea structures and cables.

Jetting legs

Jetting legs or vertical injectors, as they are sometimes known are rigid legs normally deployed from an anchored barge and used for simultaneous lay and burial of cables into sands or clays capable of being fluidised.

As can be seen from figure 2-12, the jetting leg is normally suspended from the barge crane and held back by guide wires as the barge progresses along the lay track. The cable is deployed from a carousel or cable tank through the foot of the leg directly into the soil at the required depth.

Burial depth is controlled by means of raising or lowering the tool. Horizontal positioning is controlled by means of adjusting the barge anchors. Burial depths of 10m or more are possible in suitable soil conditions.

The use of jetting legs close to other cables and structures relies on the integrity of the barge anchor spread and competent use of the barge management system to ensure proximity limits are complied with. As the tool is physically connected to the barge, positioning accuracy of the barge is reflected directly as positioning accuracy of the burial tool.

Ploughs

Ploughs used for cable and pipeline burial can either be used as post lay burial tools or as simultaneous lay and burial tools. The key issue in determining proximity limits for ploughs involves the method of providing the pulling force through the seabed. The speed of a plough being pulled by a barge using an anchor spread is determined by the speed of the anchor winches and is easily controlled. A plough being pulled by a self-propelled vessel can speed up or slow down under constant tension depending on soil conditions and in extreme situations can speed up suddenly if low shear strength soils are unexpectedly encountered.

Mass flow excavators

Mass flow excavators (MFE's) could be used for cable de-burial. They operate either as a tracked vehicle or suspended above the work area and use high volume pumps to 'blow' non-cohesive soils from the target area. Their use is generally limited to deeper water (>10m) due to the minimum water head required for the pumps although smaller capacity MFE's can be operated in shallower depths (>5m). The advantage of MFE's lie in their high capacity and the fact that they use pumps to remove soil, thus minimising the possibility of cable damage, although the high turbidity created may give rise to ecological concerns.

Fall pipe operations

The fall pipe of a rock protection vessel is actually an integral part of the rock placement vessel, but does have the potential to interact with proximate subsea structures in the case of a DP failure or incident involving the control of the fall pipe.

Figure 2-13 illustrates the discharge end of a fall pipe laying a rock berm over a submarine cable or pipeline. The fall pipe position and rock berm application is controlled by the operator onboard the surface vessel monitoring remote cameras and position sensors on the fall pipe.

Figure 2-12 Schematic diagram showing the use of a jetting leg

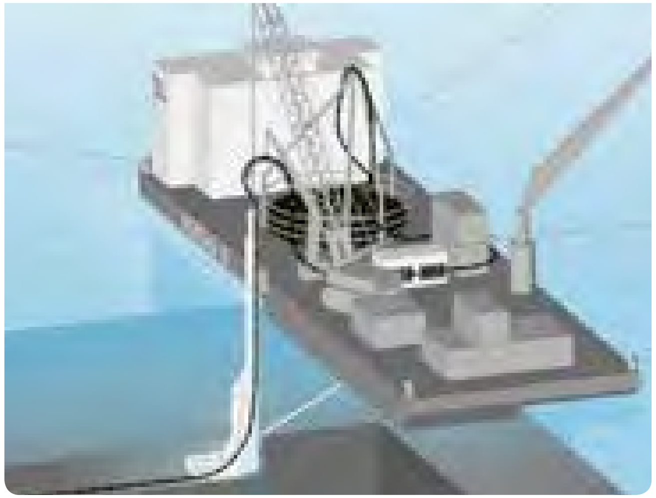
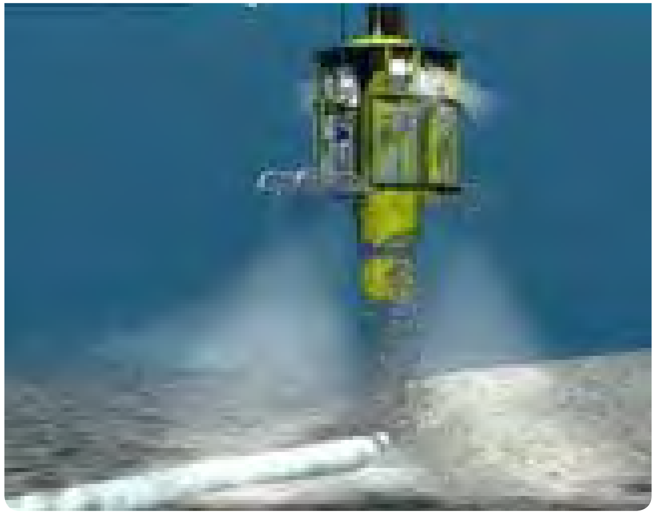


Figure 2-13 Fall-pipe application of a rock protection berm



International practices & lessons learned

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The high density of seabed developments in the UK REZ is mirrored in the waters of other northern European countries bordering the North Sea. Table 2.8 summarises the approach taken by each of the leading countries developing offshore renewable energy.

From our review of practices and policies adopted internationally, Germany emerges as the nation with broadly comparable proximity issues to the United Kingdom and the German approach is described in Section 2.15.1 in detail.

Germany

Marine developments in the German EEZ are managed in accordance with a spatial plan implemented by the Federal Government in 2009, following a wide-ranging consultation process. German government policy has provided offshore wind with priorities over other marine developments, unlike the UK model where equal priority is given to all seabed users. The spatial plan now in its early development phase, incorporates a number of measures relating to cables and offshore wind farms relevant to this study, which are summarised below. It should be borne in mind that some of the measures adopted in Germany are suited to their relatively short coastline and orientation of their German EEZ and are not necessarily suitable for consideration in UK waters. An example is the use of defined cable corridors, which for Germany are roughly perpendicular to the North Sea coast and are therefore aligned with the shortest routes between coastal landfalls and the offshore development areas. See Figure 2-14.

The Germany EEZ spatial plan includes the following key principles relevant to this study:

- Priority areas are nominated for key developments such as wind farms, shipping, and pipelines
- Submarine cables for the transport of power generated in the EEZ shall cross priority areas for shipping by the shortest route possible, not be laid parallel to areas designated for shipping
- Wherever possible, submarine cables should be laid in parallel using existing routes. Besides, submarine cables should be routed parallel to existing structures and facilities if possible
- Cable corridors in the transitional area to the territorial sea are allocated to submarine cables for the transport of power generated in the EEZ
- The grid operators are responsible for the laying and operation of cables from the wind farm offshore transformer station to shore
- Submarine cables should be bundled if possible. Bundling in the sense of parallel laying would also avoid excessive cutting across areas
- To reduce any risk of damage to existing pipelines and submarine cables and avoid impairing possibilities of repair, due consideration must be given to existing routes when selecting the routeing of new pipelines and submarine cables and an appropriate distance from them must be maintained. The appropriate distance has to be defined on a case-by-case basis, since it will be based on the specific on-site conditions
- Cable corridors are to cross TSS by the shortest route and at right angles
- Planning for a common European wind energy grid to connect offshore wind farms to the power grid, envisaged to be laid in the coastal waters, has not yet reached a mature stage and thus has been excluded from the Plan.

http://www.bsh.de/en/Marine_uses/Spatial_Planning_in_the_German_EEZ/index.jsp

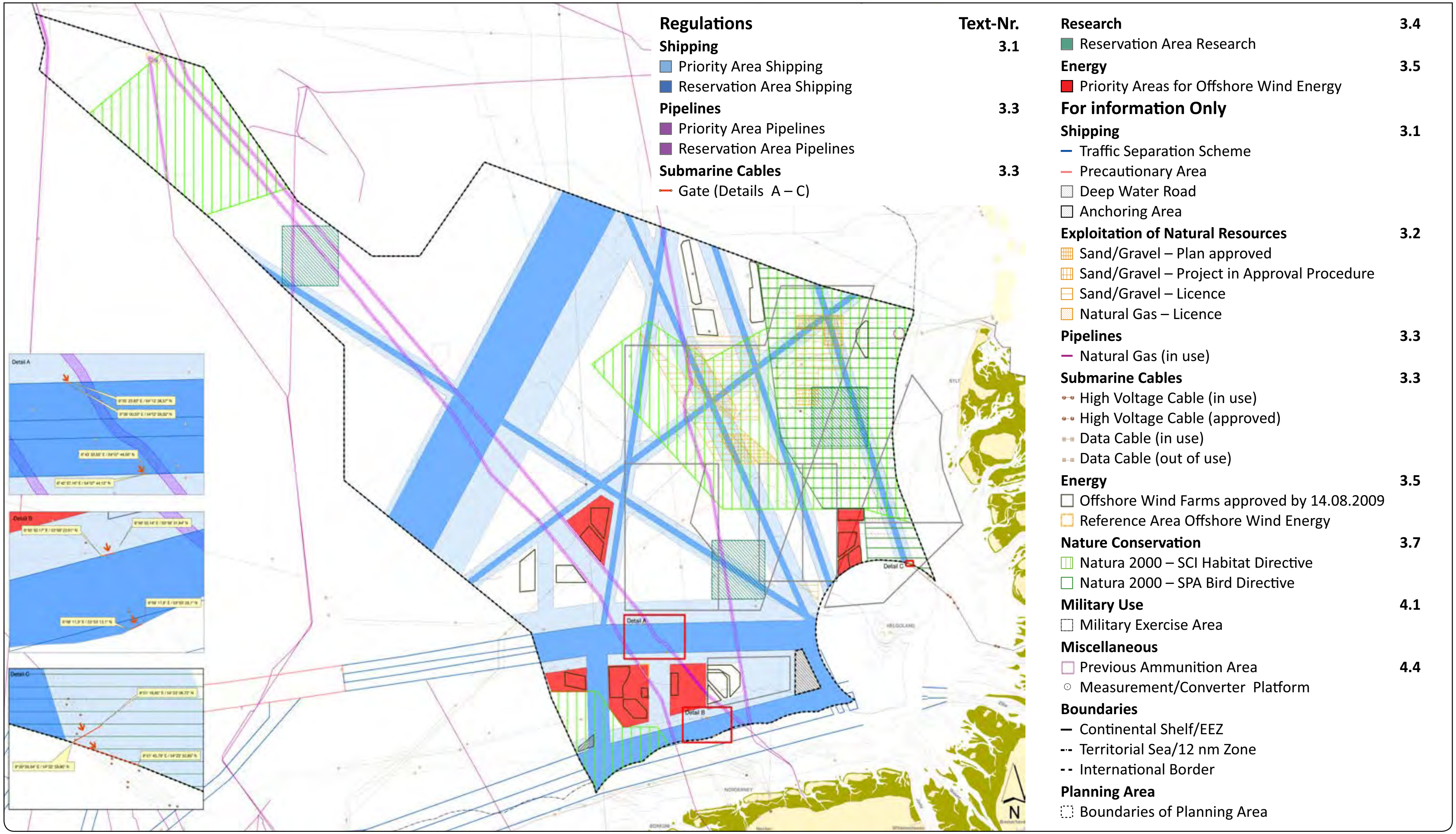
The Spatial Plan sets out base case rules for the separation distances between cables and essentially the base case separation is +/– 500m with a clear requirement for cable proximity to be dealt with on a case by case basis taking into account the various site specific factors in determining the final cable spacing.

Within a wind farm, the Transmission System operators have their own guidelines for separation of export cables from wind farm structures.

Table 2-8 International marine spatial planning summary

Country	OREI capacity installed & under construction 2011 (MW)	Comments on overall strategy for managing proximity issues
United Kingdom	2300	As per this report
Denmark	702	Danish legislation provides for an automatic 200m safety zone around cables and pipelines. There are no prescriptive requirements for wind farm structure safety zones – they may be applied on a case-by-case basis. There is currently no national marine spatial plan although initial work in this field is underway. This leaves wind farm and cable developers to agree proximity distances on a case-by-case basis (subject to the 200m safety zones legislation mentioned above). Danish waters are congested with natural and man-made features such as shallows, straits, islands, bridges and fish farms which forces seabed users to co-exist in close proximity. No priority is given to any particular seabed user group.
Germany	718	See Section 2.15.1
The Netherlands	247	The change in government policy earlier in 2011 away from subsidising offshore wind power will significantly cut the projected offshore wind capacity in The Netherlands. This will in turn reduce future seabed congestion and wind farm/subsea cable proximity conflicts.
Belgium	195	Belgium has the shortest North Sea coast of any of the NW European countries with an intensively used REZ seabed although offshore wind development is relatively modest. Belgium was one of the first NW European countries to develop a marine spatial plan, which has been implemented incrementally since 2003. **http://www.unesco-ioc-marinesp.be/uploads/documentenbank/b29ecdecdd3c1025c24b1f6473656633.pdf**
Sweden	163	Sweden has ambitious national targets for offshore wind power with the Swedish Energy Agency designating certain areas for offshore wind development. The Swedish government recognises the ever-increasing pressure on the seabed as a resource and a national marine spatial plan is being developed with delivery still some 4 years away.
Ireland	25	Although an island nation, the proximity constraints are significantly less than for UK waters, with only a relatively small number of offshore wind farms currently going through the consenting process.
USA	0	Currently only a handful of consented projects in planning with a large number either on hold or cancelled. No significant proximity difficulties likely for a significant time to come
Far East	0	Both China and South Korea have ambitious plans for offshore wind farm developments. Currently there are no significant parallels to draw with the proximity challenges being experienced in UK waters.

Figure 2-14 German EEZ spatial plan – North Sea coast



Risk assessment

The goals of future proximity guidelines are anticipated to be:

- Safe marine operations in accordance with legislation and industry best practice
- Minimise effects on cable downtime in event of a fault
- Aim for risk assessed access for cable repairs for ease of repair; by
  - Protection of wind farm and cable asset integrity
  - Facilitating access to the wind farm site and export cable route for construction & maintenance
  - Minimising changes to the optimum wind farm design (affecting revenue and capital costs)
  - Minimising impact to the optimum routeing of cables
  - Maximising the potential of consented areas for harnessing energy
- Avoiding potential conflict between seabed users in congested coastal and offshore areas.

For the purpose of this report we have assessed the proximity impacts between renewable energy installations and submarine cables in a range of water depths up to 200m, i.e. depths with foreseeable potential for OREI development in the next 10-20 years. The greater part of the UK REZ has water depths in excess of 50m and it is likely that advances in foundation design and installation techniques will result in developments in these water depths in the future. Renewable energy developments in depths beyond 200m will require a reappraisal of the issues assessed here and are therefore beyond the scope of this report.

During the course of the study the authors of this report became aware of at least one situation where a resolution between proximate parties has been achieved. While the details of the matter have not been made available to the authors for review it is understood that the circumstances were of a very specific nature and therefore not directly relevant to the more general nature of the Study and consequently have not been sought.

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Submarine cable operations assessment

Cable maintenance in proximity to a wind farm

While the majority of cable repairs can be considered to be localised and restricted in extent, there are instances where extensive damage has occurred as a result of third party aggression, particularly where the cable has been dragged out of location. It is inherent in the nature of unplanned cable faults that the circumstances of the case will often not be known until the cable ship arrives on site and starts to gather information which allows the experienced crew and engineers to build up a picture of events and the situation. Sometimes the full picture is not completely ascertained until all damaged cable has been recovered.

This study therefore had to consider the effect of a significantly aggressive fault over a more localised incident. An assessment of the full range of potential scenarios is beyond the scope of the study and experience has shown incidents where for instance, buried armoured telecommunications cable has been snagged and dragged over 1000m out of position in depths of water less than 50m, with the anchoring vessel repositioning to a designated anchorage area before releasing the snagged cable (having initially anchored outside the designated area). Such events, while they do occur, are the exception rather than the rule and consequently should not dictate the interpretations of the findings of this study for general recommendations. Repair methods for such events in proximate situations can be adapted to meet the requirements of the situation but it is recognised that the constraints imposed by the presence of structures and other assets may increase time to restoration than might otherwise be the case.

Cable crossing considerations

It should be noted that when repairs are carried out close to cable crossings, the planning process should ensure that the final splice is deployed well away from the crossing point, so that it does not compromise future repairs in the same area. It should also be noted that, whilst the clearance criteria of at least three times depth of water should be adequate in most circumstances, in very shallow water this might not be sufficient. For example, in 20m water depth grappling for the crossed cable only 60m from the crossing cable could result in that cable being disturbed – in this situation a clearance in the order of 100m could be more appropriate but the circumstances of the particular case should be fully considered.

It is recommended that a clearance of three times the depth of water should be allowed between a crossing point and a repeater in the crossed system. This will ensure that the repeater can be recovered, without endangering the crossing cable, should the cable have been cut so close to the other end of the repeater that recovery from that end is not possible. However, with the use of modern navigational equipment and lay/repair practices, these distances could be reduced to two times depth of water, providing that the cable with the repeater was the upper of the two cables and such crossings do not exist on either side of the repeater.

Similarly, a clearance of three times depth of water should be allowed between the crossing point and a repeater in the crossing system. This will ensure that, in the event of a repair to the crossed cable, which results in that cable becoming the crossing cable, the repeater can be recovered should the cable have been cut close to the other end.

Decommissioning considerations

There is a general presumption in favour of disused installations being removed from site, unless the owner demonstrates that removal of a particular component is not viable. While there is no equivalent legislation governing the decommissioning of telecommunications cables, The Crown Estate Guidelines also favours the presumption of removal in line with IMO guidelines for the decommissioning of offshore installations in general. This presumption of removal should be taken into account when planning proximity limits between two developments.

Cable fault detection

Cable fault detection in both telecommunications and power cables can be problematic, with detection success depending to a large degree upon the nature of the fault. Pulse reflection techniques such as OTDR & TDR have good track records in fault location but do have limitations, especially when large distances from shore are involved. Generally speaking unless there is a complete cable break within range of OTDR or TDR, some additional technology will be generally used for fault finding. In long range telecoms systems the detectability (or not) of repeaters greatly assists in the identification of the section in which the fault lies, but as separation of repeaters in modern systems is large, pin-pointing the fault will generally require intervention of the repair vessel after an initial cut and recover operation has been carried out. Even then the fault can be many kilometres away from the chosen cut-in position thus requiring additional work to complete the repair.

Trailing of electrodes is a well-established method which continues to see extensive use in the telecoms industry, while power cable fault location may require a combination of terminal based equipment and local sensing in the area of the anticipated fault. Such techniques may be singularly successful in pinpointing a fault to the required degree of accuracy, but often a combination of the long range and localised methods and ROV search is used to home in on a fault. The value of reviewing other, seemingly more generic, information including vessel activity and seabed conditions, can also help in pinpointing a fault.

Power cables can present visible signs of fault (such as an HV blow-out) where a search ROV may be able to visually detect signs of the fault or observe effects in the water, but is common for a combination of TDR, (and OTDR if a fibre element is present) ROV and electrodes to be used, the process for which – depending on the nature of the fault – may take some days to conclude satisfactorily.

Use of ROVS & related subsea equipment

ROV intervention would in almost all cases be the preferred cable intervention method in water depths up to 200m, at least initially. In the vast majority of shallow water repairs (up to 200m water depth) an ROV inspection would be used to locate the fault and suitable areas to either cut and attach a gripper or identify areas for grappling. Exceptions to this would almost certainly be dictated by weather or, in some cases, where electroding is required. Once initial ROV inspection has been completed then the options become more broad ranging, dictated by seabed type, depth of burial, environmental parameters, cable offset distance (in which case ROV is preferable), cable type etc.

ROV recovery may not be possible for a number of reasons including:

- Cable as laid position uncertainty
- Inability to put a tone on the cable for ROV detection
- Burial depth precludes detection
- Non availability of suitable ROV recovery spread
- Unsuitable environmental conditions – sea state, tidal currents, underwater visibility
- Unsuitable seabed topography.

The requirements for cable de-burial will depend on burial depth, soil conditions and cable specification/status. De-burial will normally be carried out using ROV techniques but de-trenching grapnels have been tried and the use of mass flow excavators could be feasible given sufficient water depth for their operation.

Tracked ROVs during normal operations are relatively slow moving and their movement is easily controlled by a competent ROV pilot. However potential failure modes that should be taken into account when planning proximity limits for ROV operations include:

- DP drive off or drift off resulting in dragging of the ROV across the seabed
- Poor underwater visibility and/or misinterpretation of sonar imagery
- Type of ROV tooling and potential for third party damage (a mechanical trenching tool in contact with a cable will cause damage while a jetting tool not necessarily so)
- Power failure resulting in a 'dead vehicle'
- Operator error while manipulating ROV tools or driving of the vehicle
- Seabed slopes (more than 15o as a general rule) or uneven terrain can cause sudden movement of the vehicle.

Subject to risk assessment, tracked ROVs can be operated in close proximity to subsea structures and cables. For example, providing the correct control measures are properly implemented, we would consider 5m to be a reasonable proximity limit for a tracked jetting ROV from the edge of a mattressed cable crossing.

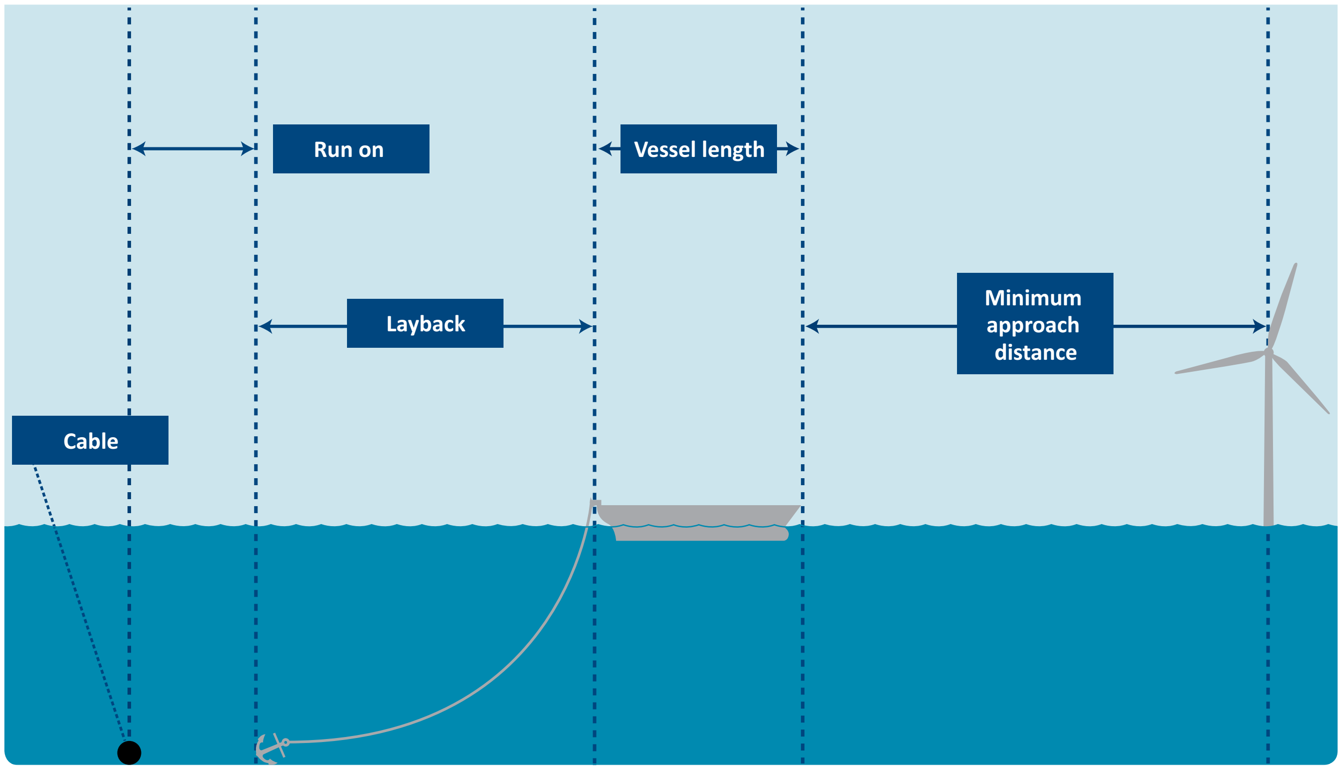
The use of jetting legs close to other cables and structures relies on the integrity of the barge anchor spread and competent use of the barge management system to ensure proximity limits are complied with. As the tool is physically connected to the barge, positioning accuracy of the barge is reflected directly as positioning accuracy of the burial tool.

The key issue in determining proximity limits for ploughs involves the method of providing the pulling force through the seabed. The speed of a plough being pulled by a barge using an anchor spread is determined by the speed of the anchor winches and is easily controlled. A plough being pulled by a self-propelled vessel can speed up or slow down

Table 3-1 Recommended base case proximity limits for ROVs and other subsea tools

Subsea tool	Self-propelled support vessel	Moored support vessel
Plough (towards a cable or subsea structure)	500m	100m
Plough (away from a cable or subsea structure)	100m	100m
Tracked mechanical ROV trencher	100m	100m
Tracked ROV Jetter	50m	50m
Jetting Leg (towards a cable or subsea structure)		100m
Jetting Leg (away from a cable or subsea structure)		100m

Figure 3-1 Grapnel operations – terminology



under constant tension, depending on soil conditions and in extreme situations can speed up suddenly if low shear strength soils are unexpectedly encountered.

The actual proximity limits for ROVs are likely to be based upon the following technical criteria:

- ROV type – free swimming or tracked
- Orientation of the cable to the wind farm structures
- Proximity of other seabed structures including wind farm cables
- Vessel length/beam and worst case orientation to the wind farm structures
- ROV tether management system (TMS) utilised or not
- Drift on or drift off position during cable recovery
- Failure modes of vessel and ROV
- Environmental conditions and DP capability of the vessel
- Water depth with respect to shallow water DP performance
- Cable characteristics with respects to weight, dimensions and MBR
- Cable burial depth and de-burial requirements
- Other site-specific issues such as seabed topography, presence of a crossing structure, concurrent wind farm operations etc.

Table 3-1 summarises our recommended base case proximity limits for ROVs, ploughs and jetting legs (all subject to case by case risk assessment).

Grapnel operations

In the event that ROV recovery is assessed as unsuitable (or attempted and found to be unsuccessful/unsuitable) then the next preferred method is likely to be grapnel recovery. Generally the use of grapnels will be a last resort option and their use is often complemented by ROV support.

Figure 3-1 illustrates the various terms associated with grapnel operations discussed in this section.

Run on

Run on is the term given to the distance a grapnel is allowed to travel past the cable route before recovery. The run on distance is water depth dependent and also depends on the nature of the cable fault. For a fault where little or no cable displacement has taken place and the as laid cable position is accurately known, a run on of approximately 50m in 50m water depth could be expected. This scenario contrasts with a fault involving significant cable displacement resulting from anchor or fishing gear contact, where the actual run on distance cannot be pre-calculated using empirical formulae.

Layback

The layback is the horizontal distance from the vessel to the deployed grapnel rig and again is a function of water depth. The layback distance is also dependent on correct rigging and grapnel techniques, and controlled slow vessel speed. It may be possible that increased length of heavy ground chain would allow a shorter layback, but the decrease in layback achieved may be offset by increased rigging and handling time making an appreciable difference to the overall time to restoration. Alternatively use of DP control in conjunction

Table 3-2 Base case grapnel operational distances[6]

Water depth (metres)	Layback (metres)	Run on (metres)	Length of grapnel rope (metres)	Remarks
5	20	50	30	Grapnel rope length approx 3 times the depth of water up to 200m depth of water. Depths of water greater than 200m are not considered here but a grapnel rope length in the order of (depth of water + 30%) would be appropriate
10	30	50	40	
20	40	50	50	
30	70	50	90	
40	100	50	120	
50	140	50	150	
100	240	50-60	250-300	
150	360-400	50-60	400-450	
200	500-550	60-60	600-650	

[6] The turbine spacing provided in Tables 2.2-2.4 should be treated with caution due to a number of projects listed where the WTG model and size is yet to be confirmed by the developer and therefore the final design spacing may therefore be subject to change.

with winch control of the grapnel set to minimise or eliminate the run on distance could be considered.

Repair vessel length/orientation
The ship's length is fixed and we have to assume that environmental conditions may dictate that the ship will approach the wind farm end on (i.e. worst case proximity scenario). Currently cable repair vessels generally fall into the 100m-150m range, but larger new build or converted vessels cannot be ruled out in the future. In an actual repair scenario, it may be possible for the vessel to approach and hold station in an orientation other than end on, thus potentially improving the minimum proximity distance, but this cannot be assumed. In addition it is accepted that bow or stern approached to fixed obstructions for some vessels is not prudent practice, depending on the failure modes of the vessel (the failure mode of some controllable pitch propellers is full pitch ahead or astern). A further consideration is that a vessel is capable of accelerating more quickly in the fore and aft direction than athwartships, which makes a 'beam to' set up less likely to result in a collision with the wind farm structure in the case of a 'drive on'.

For depths of up to 200m, Table 3-2 is offered as a guideline set of base case proximity limits for grapnel operations. It is acknowledged however that final proximity limits for a given repair scenario will be dependent on a large number of variables which combine to produce a unique set of requirements for each cable repair.

Minimum approach distance & wind farm safety zones
As reviewed in Section 2 wind farm safety zones can be implemented in accordance with the provisions of the Energy Act 2004 on a case-by-case basis by means of a Wind Farm Order applied for by the wind farm developer. Where such an order is in place, a 500m safety zone is applicable during construction and major maintenance,

reducing to 50m during normal operations. The actual provisions of a particular Wind Farm Order can vary from site to site, but in general, non-project related traffic is excluded from the safety zone or zones. The actual positions of safety zones within a site may change as construction or maintenance progresses.

The purpose of such safety zones is to provide an unhindered and safe site for the developer to carry out his business of constructing, maintaining and operating his offshore wind farm. Retracing the development steps of an offshore wind farm, the developer is required at the design and planning stage to take account of existing developments in proximity to the proposed site. At this early point there are significant benefits to the wind farm developer in liaison and agreement with the cable owner on how proximity limits can be minimised, i.e. benefits in increased site availability.

Operations within 500m/50m of an offshore renewable energy development if covered by a Wind Farm Order are likely to be restricted to those vessels directly engaged in wind farm work although the legislation is not prescriptive about this. However it is interesting to note that the equivalent legislation for the oil and gas sector (The Petroleum Act 1987) and the relevant Marine Safety Notice (MSN 1290) treats cable vessels as a special case (See Section 2.6.1).

It is noted that any 500m/50m safety zone is measured from the fixed or floating structure for which it is designated and not from the extremities of any anchor spread. This is likely to be more of an issue in the future as moored wind, wave and tidal energy converters are developed.

A mechanism providing dispensation to approach within the wind farm 500m/50m safety zone would in our assessment be mutually beneficial to both wind farm developer and cable owner – how could this be achieved? – The basis of the 'Wind Farm Orders' enacted under Energy Act 2004 allowing wind farm safety zones is 'The Geneva Convention' of the Continental Shelf. The wording of this excludes navigation within 500m unless the vessel is involved in wind farm activities. Rule 10 of COLREGS (see section 2.4.3) affords cable repair vessels special privileges, under general navigational circumstances and we are of the opinion that a similar status could be warranted in this situation, as is the case with oil and gas 500m safety zones. The basis for such an exemption could be the 'Submarine cables and offshore wind farm proximity guidelines' subject to application to the relevant authority.

In considering minimum approach distances, limitations in the vessel's commercial hire terms would need to be taken into account. Providing minimum approach distances were adopted, as revised industry guidelines, a simple amendment to contracts, charter parties and insurance policies should be possible stating that compliance with such guidelines would be followed.

In order to assess the minimum safe approach distance for any vessel and fixed structure there are a large number of variables to consider, from measurable technical performance criteria at one end of the scale, to the less tangible issues such as personnel competence and behaviour-based safety at the other. The station keeping performance capability of any vessel is a combination of design, maintenance standards, and operational competence in the face of environmental and site specific conditions.

Dynamically positioned vessels

The DP class of a particular vessel defines the level of redundancy built into the design of the propulsion and control systems that make up the component parts of the DP system. As previously discussed a DP 1 vessel can suffer a loss of

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position from a single fault event, while DP 2 vessels provide an increased level of redundancy against such events. This DP Class designation only covers redundancy, and a further measure of a vessel's capability is with respect to thruster power and hull profile – two vessels of identical propulsion capabilities but with different hull shape, superstructure and displacement will have very different station keeping performances. This applies equally to the opposite scenario, where two vessels with identical physical characteristics have different propulsion capabilities. In addition to these quantifiable measures of station keeping performance there are a number of procedural and behavioural related issues to consider including:

- Operator competency
- Maintenance procedures & standards
- Behavioural safety
- Standards of operating practices.

While not directly related, it is worth considering how the control mechanisms work in the oil and gas sector with respect to vessels approaching fixed and floating structures protected by a 500m safety zone. Such offshore support vessels routinely approach oil and gas structures to within 10m in manual control, DP 1 2 & 3 modes. The risk of collision in these situations is largely managed by controls and procedures together with certain levels of personnel competency and good operating and maintenance practices. We recognise the fact that cable repair vessels are of a certain specification (more often DP Class I) for commercial reasons and therefore are of the opinion that any solution to the proximity issue should be risk based rather than prescriptive, i.e. not based on station keeping specifications or DP class alone.

DP cable vessels currently contracted for cable repairs in the UK REZ under long term maintenance agreements are generally older tonnage. Modern, higher specified vessels are often preferred for cable installation work. This means that in general cable maintenance vessels retained for cable repairs under long term maintenance agreements are generally DP Class 1 vessels or for commercial reasons DP Class 2 vessels operating to Class 1 requirements.

Our view is that this state of affairs is unlikely to change in the next 5 years. While DP Class 1 vessels are inherently less reliable in station keeping terms, we would assert that providing proper operating controls and procedures are followed, then the use of DP Class 1 vessels should not translate into more station keeping incidents than for DP 2 vessels, providing such DP 1 vessels are operated more conservatively in terms of proximity distances.

As reviewed in Section 2, it is demonstrable that with increasing technical reliability of propulsion and control systems, the main cause of DP station keeping incidents are related to human error. While the DP class of a particular vessel remains relevant, we consider procedural regimes and behavioural-based safety to be of significant importance in developing proximity guidelines for DP vessels.

In order to define base case proximity limits for DP cable repair vessels we have used our own operational experience and have consulted with cable repair contractors to derive

Table 3-3 Base case proximity limits – DP cable repair vessels

Scenario	Manual control proximity limit	DP 1 vessel proximity limit	DP 2 vessel proximity limit
	All distances measured from the closest extremity of the vessel to the OREI		
Conducting cable repair operations in the lee of a wind farm structure	200 metres (Control or propulsion failure resulting in a drift off scenario)	100 metres (Control or propulsion failure resulting in a drift off scenario)	50 metres (Control or propulsion failure resulting in a drift off scenario)
Conducting cable repair operations on the weather side of a wind farm structure	500 metres (Control or propulsion failure resulting in a drift on and subsequent manual control correction	500 metres (Control or propulsion failure resulting in a drift on and subsequent manual control correction)	100 metres (Propulsion failure in DP 2 mode would require propulsion redundancy to correct drift on)

the following table of scenarios and limits and included 'Manual Control' vessels as a comparison:

The limits given in Table 3-3 are base case values. Actual site specific values will be wholly weather and tidal current dependent, and often the length of time required for a complete repair operation would require a vessel to hold station in variable tidal and weather conditions, which may dictate more conservative proximity limits. It should be remembered that year round cable access should be possible and so winter weather conditions do become a major factor in defining final proximity limits.

In summary, for DP vessels operating in proximity to a third party asset, we recommend a risk based assessment rather than prescriptive approach when determining proximity limits for DP operations. Such an assessment should take into account not only the technical performance of the vessel and deployed equipment, ut also the range of procedural and behavioural-based safety factors outlined above.

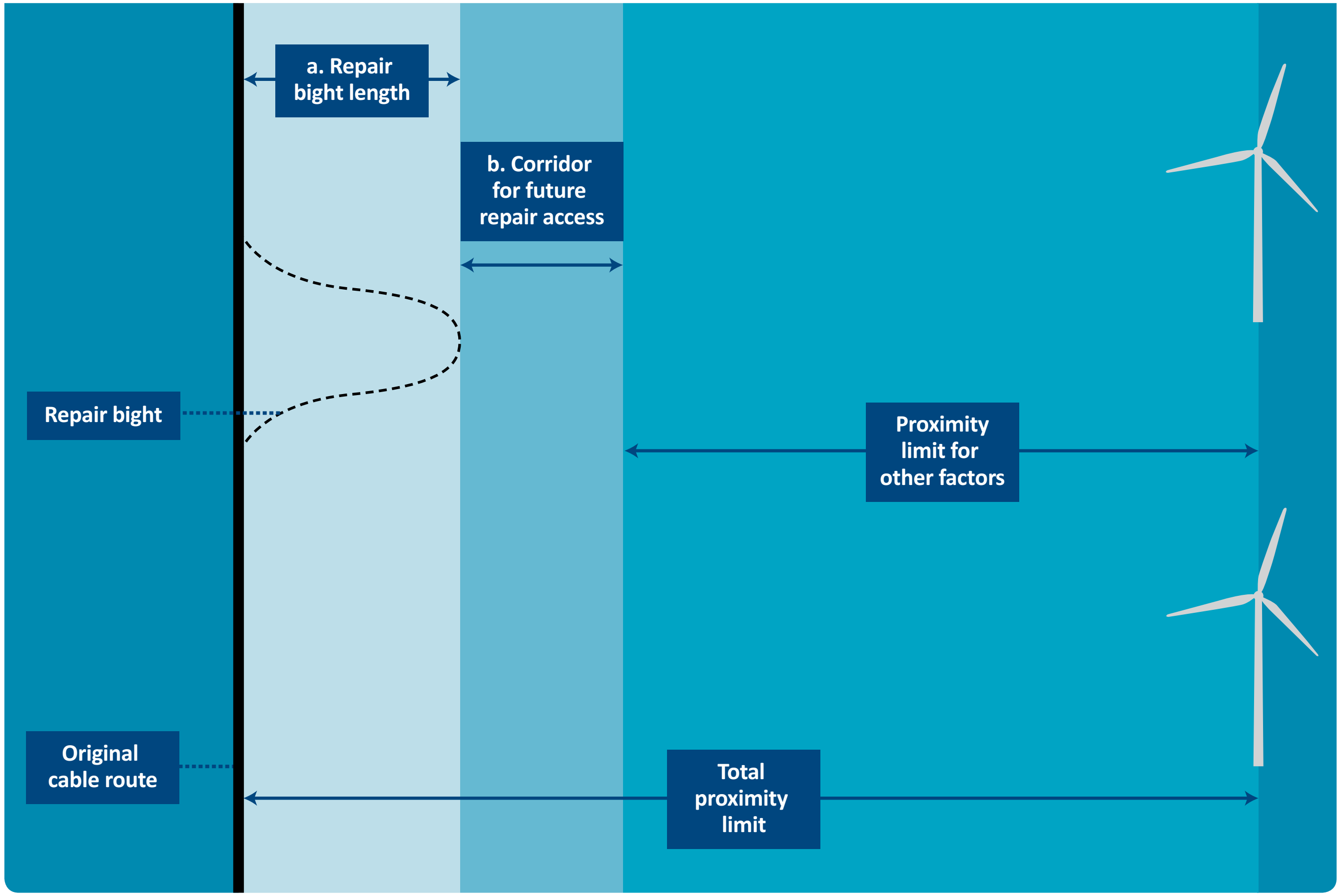
Final bight laydown

As discussed in Section 2.10.5, the final bight length of a cable repair or final installed joint in a cable system is a function of water depth, the physical characteristics of the cable, constraints of the repair vessel layout and prevailing weather conditions at the time of the laydown operation.

Weather conditions will dictate how a vessel will set up for a cable bight laydown and in conditions close to operational limits, it is likely that additional cable would be recovered in order to drive further off line, giving greater flexibility in ship's heading during the jointing and laydown operation.

It can be seen from Figure 3-2 that proximity limits between a cable and a wind farm structure needs to take rigorous account of the space required for a repair joint and in addition, a further allowance for future cable repair access at or near the repair bight area. For the purpose of this study we have assumed that a cable bundle (as found in bipole HVDC systems) will be repaired and re-laid as a single bight rather than separate bights laid either side of the original cable route.

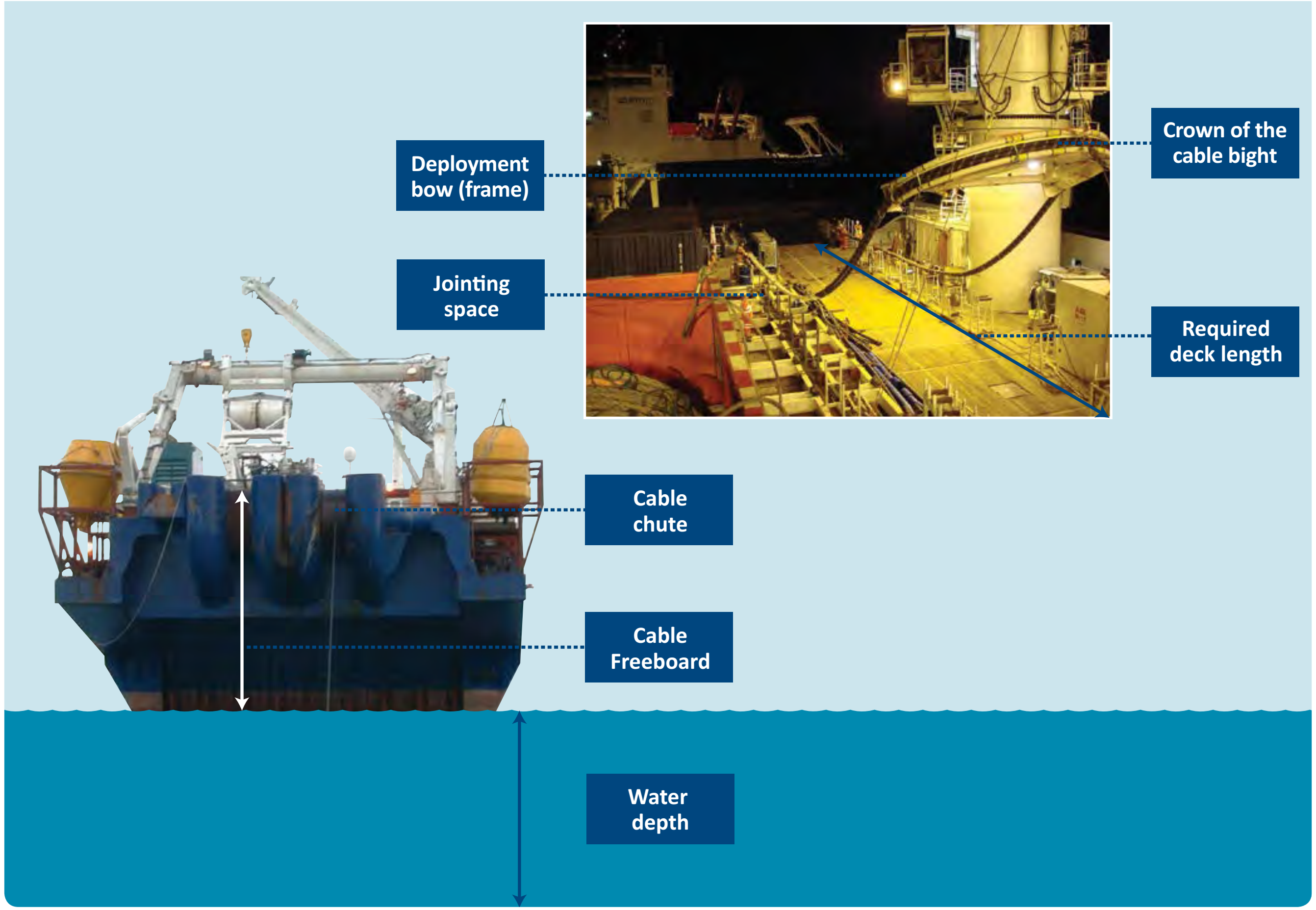
Figure 3-2 Cable repair bight access requirements ('a' and 'b' defined in Table 3-4)



Armoured power cables being stiffer than telecommunications cables will have a greater minimum bend radius, which in shallow waters will result in a greater final repair bight diameter. This is particularly so for HVDC MI cables, which in addition to greater MBR characteristics, also require specific arrangements of the cable ends for a final joint, which result in more cable being present

Freeboard (Distance from water surface to cable sheave/chute)	= 5m
Length of cable on deck for handling/stoppers/joint etc. (i.e. on each side & including cable to crown of bight)	= 45m
Crown of cable bight	= 5m
Thus distance from waterline to crown of bight	= 55m
Depth of water	= xxm
Seabed space required to lay down repair bight (minimum)	**= 55 + xx metres**

Figure 3-3 Dimensions and terms relating to cable repair bights



in the repair bight than would be the case in a telecommunications repair.

Telecommunications cable repairs are somewhat different from power cables as the jointing spaces are generally a good way forward of the stern sheaves or abaft the bow sheaves thus a much longer bight results.

Figure 3-3 above is provided to illustrate the terms water depth, freeboard, deck length and repair bight crown used in Table 3-4.

Table 3-4 provides our assessment of base case repair bight displacements for a range of water depths up to 200 metres. An additional corridor providing for future cable repair access is also included for consideration, whilst acknowledging that the probability of carrying out a subsequent cable repair at the crown of the repair bight is likely to be very low. The dimensions in table columns 'a' and 'b' equate to the 'a' and 'b' dimensions in Figure 3-3 above.

It must be emphasised that this is served as an illustration of minimum distances and does not constitute a definitive case. Extra distance will most likely be required to correctly set the cable catenary in a repair situation, but the variable nature of this renders it impractical to include in a table.

Note: The example shown below considers that of an HVDC (MI) type cable repair, as it is these cables that generally require the most specific arrangement of ends in order to carry out a final splice operation. Rigid joint casings of HVAC cables will also require special requirements. Repairs of telecommunications cables and power cables of lighter construction could result in reduced values.

The figures illustrated above could be greater depending on the conditions of control achievable at the time of deployment, state of tide, weather and conditions etc.

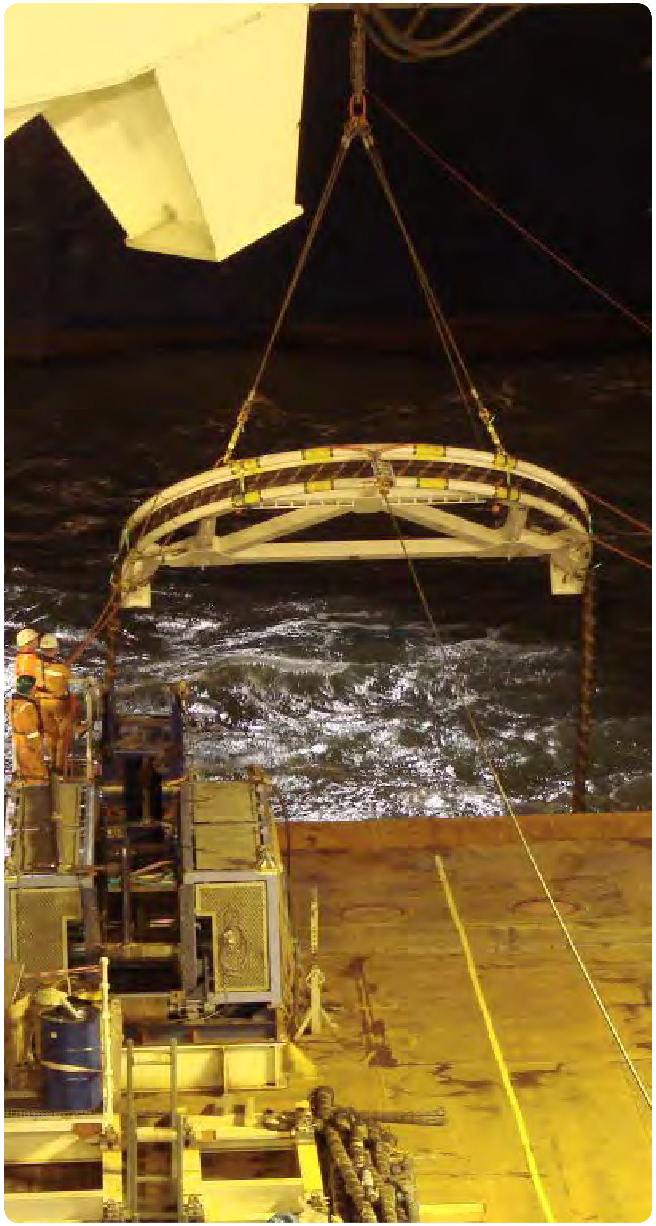
Table 3-4 Cable repair bights – minimum dimensions

Water depth (metres)	Telecommunications cable repair bight displacement (metres)	Additional corridor width for future access to repair bight (metres)	Power cable repair bight displacement (metres)	Additional corridor width for future access to repair bight (metres)
	'a'	'b'	'a'	'b'
Minimum	Water depth + freeboard + repair bight crown + deck length[1]	50	Water depth + freeboard + repair bight crown + deck length	50
10-100	Water depth + freeboard + repair bight crown + deck length	100	Water depth + freeboard + repair bight crown + deck length	100
100-200	Water depth + freeboard + repair bight crown + deck length	200	Water depth + freeboard + repair bight crown + deck length	200

Other variables affecting the sea-room required for cable repair joints are:

- Available cable deck length to jointing space – as issue predominantly for shallow water locations.
- The use of cable buoys and the additional requirement for sea room that may be required. It may be possible to reduce the swinging circle by rigging type – current trend is for all rope or lightweight wire moorings with some chain. Use of all chain buoy rigs has generally disappeared, but their low drift/small-swinging circle may be an issue to consider. Again as mentioned for grapnel operations, extra rigging time and recovery time may be in an issue when considered against overall time to restoration.
- The Human Factor: From the late 1990s market trends required significant cost cutting in telecommunications cable repair vessel operations globally. Crew numbers were dramatically reduced (in some cases by almost 50%) and modern operational techniques have been largely developed to accommodate reduced operational manning levels. Any changes to practices currently being employed and the use of equipment can be expected to impact on workload required of the repair crews. It is significant that in many repair vessel operations, particularly in the telecommunications sector, the ship's master and his crew are the cable operations team or play an integrated role in the operations and are fully engaged, if not having overall responsibility for, the repair engineering and on site project management.

Considering future developments in cable repair techniques, there appears to be little in view for either power or telecommunications cables that could significantly reduce cable bight dimensions and the resultant impact on proximity limits.



Wind farm operations assessment

Factors affecting proximity

Normally in The Crown Estate lease agreements for cables, a +/– 250m work restriction zone is prescribed whereby work by a third party (wind farm developer or operator) requires the cable operator's consent (not to be unreasonably withheld).

If the wind farm developer has applied for and obtained a 500m/50m safety zone around the site then that is also legally enforceable. It is noted that any 500m/50m safety zone is measured from the fixed or floating structure for which it is designated and not from the extremities of any anchor spread. This is likely to be more of an issue in the future as moored wind, wave and tidal energy converters are developed.

Anchored operations

From review of vessel types engaged in wind farm work the worst proximity scenarios would be for an anchored floating barge (or jack-up barge with anchors deployed during positioning). An anchored barge may be used for cable installation or repairs in proximity to a wind farm or conversely for wind farm work in proximity to an existing cable.

We acknowledge that anchor and anchor line proximity limits are another set of values that have to be set on a case by case basis and that adherence to a vertical proximity limit for anchor wires can be problematic to achieve and monitor particularly in the relatively shallow water depths we are examining here. The issue of vertical separation is probably best left to both parties to agree mitigation measures, such as mid water buoys or additional/temporary cable protection, rather than to propose a prescriptive separation distance.

In addition to agreeing anchor clearance limits, there are a number of control measures that can be adopted to ensure the safety of assets such as:

- Survey/barge management system minimum specifications
- Vessel minimum specifications such as lineout and wire tension monitoring, and winch specifications
- Agreed procedures following review of cable burial/protection
- Installation of additional cable protection prior to operation if deemed necessary
- Adoption of the principle of placing anchors crossing a cable as far from that cable as practically possible.
- The size, weight and design of the anchors and their suitability for the soil conditions on site
- Use of accurate site soils data
- Performance, capacity and condition of the anchor winch system
- Proper assessment of environmental conditions on site
- Correct selection of ultimate breaking loads of the weakest components in the anchor catenaries
- Selection of barge heading in relation to the prevailing environmental forces
- Contingency arrangements in the event of an anchor line failure
- Assessment of potential effects of an anchor drag
- Operator competency including crews of the anchor handling and tow tugs.

The RenewablesUK (BWEA) Guidelines for Jack-up Operations recommend anchor proximity limits of:

- 250m if laid over a cable or pipeline
- 150m if laid parallel
- 50m if laid on the safe side
- 5m vertical wire to cable clearance and less if proven no contact possible.

Table 3-5 Recommended base case anchor and anchor line proximity limits

Anchoring scenario	Self-propelled support vessel	Moored support vessel
Vessel & barge anchors (Routine anchoring)	500m	500m
Barge anchors (pulling towards a cable or subsea structure)		250m
Barge anchors (pulling parallel to a cable or subsea structure)		150m
Barge anchors (pulling away from a cable or subsea structure)		100m
Barge anchors (vertical separation between anchor line and cable or subsea structure)		10m
Barges & anchor handlers crossing within 50 metres of a subsea cable	Anchors either to be decked or double secured	

The Noble Denton Guidelines for Moorings 0032/ND recommend slightly more conservative values of 100m minimum horizontal anchor clearance and 300m if on the danger side. Vertical clearance of 25% of the water depth below 40m depth is recommended with 5m being the minimum.

The proximity limits contained in the current Subsea Cables UK Guideline 6 are 20m vertical clearances, 200m for anchors on the safe side and 400m on the danger side of a subsea structure.

While the deployment of anchors represents an additional constraint when planning proximity limits, the fact that anchor lines can span an existing subsea cable allows a degree of flexibility in the use of anchors in a congested seabed area.

While it is not possible to prescribe minimum proximity limits for anchors and wires that suit all situations, given proper controls, our assessment is that it should be possible to adopt base case limits as shown in Table 3-5 below:

Wind farm planning & design

Regional marine plans that will be developed by the MMO for England will guide developers about where they are likely to be able to carry out activities and may indicate the kind of conditions or restrictions that may be placed on what they do and how they do it. All operators and regulators in an area will be expected to work to the same plan, providing transparency and consistency in decision-making. While the MMO is required to deliver a series of 10 regional marine plans, these are not due for completion until 2021 and so are unlikely to help alleviate the wind farm/cable proximity issues significantly in the short term.

The Round 3 wind farm zonal appraisal and planning strategy advocated by The Crown Estate does encourage a number of principles that will assist in minimising wind farm/cable proximity conflicts, namely:

- Early and ongoing stakeholder engagement and project planning at zonal level rather than only at wind farm by wind farm level
- Use of protocols to consider zone cumulative and in-combination impacts
- Establishment of stakeholder relationships and development of an effective stakeholder engagement strategy for the Zone as a whole
- Development of a zone consenting strategy based on a thorough understanding of the Zone development opportunities and constraints.

The Crown Estate Round 3 Zone Appraisal & Planning document discusses key environmental & engineering constraints & states:

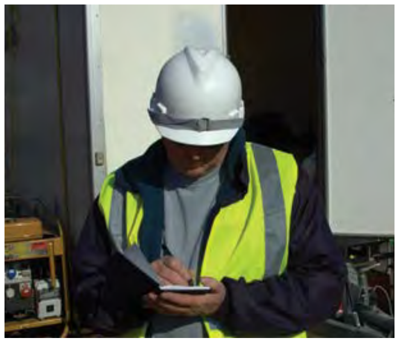
'In some cases, the spatial footprint of these constraints may be negotiated to accommodate development needs, but this would require further investigation and be assessed on a constraint-by-constraint basis with the relevant authorities and stakeholders'.

In the case of submarine cables there is a planning anomaly, whereby The Crown Estate's consent is only required for all cables that cross the seabed within 12 nautical miles of the UK coastline. This consent is recognition of The Crown Estate's proprietary interests. It is highly desirable that The Crown Estate be informed of cables transiting or seeking to transit waters that fall within the 200 nautical mile limit, as mineral rights, such as marine aggregates, or offshore wind-farm developments may be affected. This is to ensure that The Crown Estate is informed of all developments within the REZ and has a complete and full database of such activities.

From review of the range of material sources from this study, it is evident that there are further ways in which wind farm and cable proximity can be accommodated during the design stage such as:

- Orientation of rows of structures as parallel as possible to cable route to maximise manoeuvring space either side of a third party cable



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- Consideration of the working position of a cable vessel in relation to prevailing weather – holding position down weather of closest structure is preferable to both parties from a risk perspective
- Plan turbine spacing and locations to take into account cable repeater positions if applicable
- Close liaison with cable owner and following applicable proximity guidelines. If both wind farm and new third party cable are planned in proximity to each other, cooperation on design to allow either to construct first with minimum impact on the other
- Minimum requirements for wind farm developers included in lease agreements by The Crown Estate such as and the provision of 'as built' construction data and works notifications to proximate seabed users
- Pre-planned maintenance procedures agreed between both parties to minimise planning an approval periods between breakdown and restoration of cables and wind farm components
- Design new crossings as close to 90 degrees as possible for optimum access to both cables. (power cables crossing power cables have the additional issue of thermal effects where vertical separation and near 900 crossing angles minimises heating)
- Where multiple wind farms are planned in close proximity, such as for Round 3 zones, use of existing cable corridors as natural inter-farm boundaries where possible

Cable corridors & safe havens

It is evident that the use of cable routeing corridors in UK waters may not necessarily be a significant part of the solution to the proximity issue for the following reasons:

- The adoption of cable corridors is more suited to a coastline aligned in the same direction along its length to the adjacent waters, as is the case for Germany's North Sea coast. The unique geographical position of the UK as an island nation will limit the opportunities for concentrating cable routes into designated corridors
- The use of wind recovery corridors, for cable routeing would only be of use in a limited number of locations as they will generally be aligned at 900 to the prevailing winds (i.e. NW/SE)
- From a risk perspective, concentrating cables and navigational traffic into a densely populated corridor is not necessarily a good option for cable owners
- A typical wind recovery corridor with a width of 5 km would soon reach full capacity with cables spaces at typically 500 metres.

We would consider that the provision of safe havens or escape lanes within a wind farm array to be of limited benefit to vessels seeking an escape route in the event of deteriorating weather or a station-keeping incident. If the environmental conditions were such that a vessel could not operate safely with an array, then a safe haven of say twice the nominal turbine spacing would be of limited value – a vessel would by choice leave the array altogether. Similarly an escape lane would only offer safety in a drift off if orientated with the prevailing environmental conditions (often other bearings clear of wind farm structures would equally offer an escape route).

Future developments

The UK is heavily reliant on the development of offshore wind energy over the next decade in order to meet the national 2020 renewable energy targets (with commitments at EU level) and contribute towards the country's security strategy. UK currently has approximately 1.5 GW of installed capacity. By comparison, the UK Government is anticipating 18 GW of offshore wind generating by 2020 and up to 40 GW possible by 2030. This is likely to equate to a further 10,000-15,000 km of export cables and over 5,000 km of array cables. The sites being developed in the next decade will have increased water depths but this is not expected to impact on current cable burial methods, as depths will generally be less than 60 metres.

There is a trend for larger wind turbine generators with 3 to 3.6 MW being the current benchmark. Over the next decade research and development will be aimed at increasing turbine size further to the 5-10 MW range. The effect of larger turbines will be an increase in foundation size/footprint, turbine spacing and inter array cable lengths. The current turbine spacing of 500-700m is likely to increase to 1000m or more for larger turbine designs. The net effect on the issue of cable/wind farm proximity limits is likely to be a positive one with greater distances between turbines available for vessel and barge based operations.

Vessel operations assessment

The impact of the following vessel types on cable/wind farm proximity limits have been reviewed:

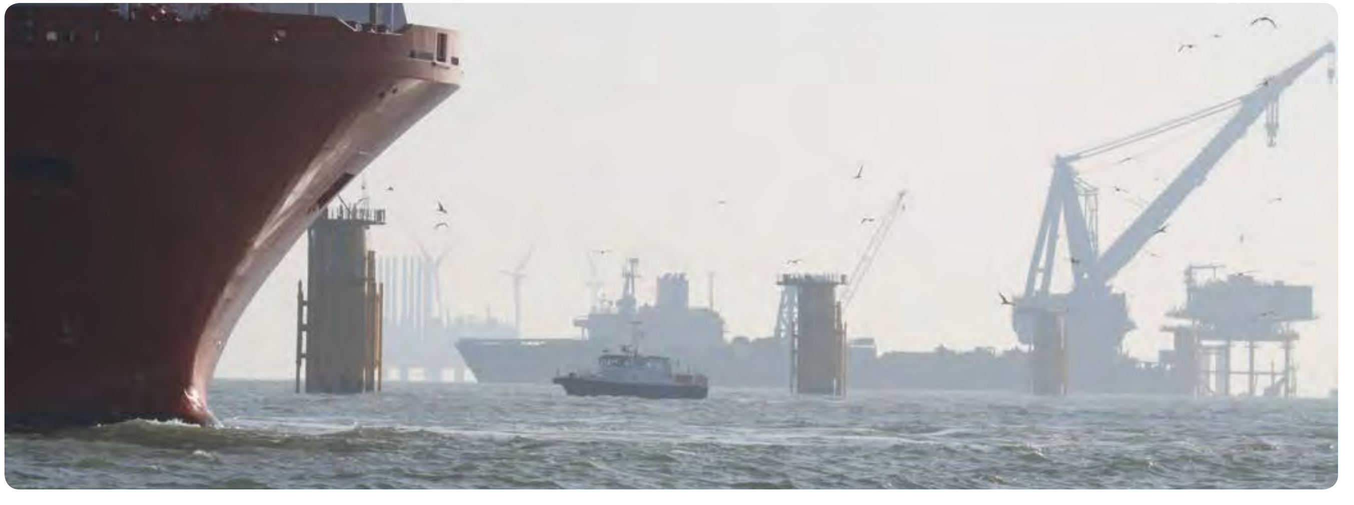
- DP cable operations vessels
- Jack up and floating barges with anchors deployed
- Other vessels routinely anchoring (dealt with by recommending a 500m safety zone for routine vessel anchoring).

DP vessels

DP vessels are assessed in Section 3.1 from a cable repair perspective and the discussion points presented there hold true for DP operations conducted during wind farm construction and maintenance operations.

Jack-up & floating barges

As identified in Section 2, jack-up barges use a variety of means for positioning prior to jacking operations. The use of multi-point anchor systems is the most onerous from a proximity perspective and this is assessed in Section 3.2.1 above.



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Financial factors assessment

It is evident from examination of the large number of variables affecting cable/wind farm proximity limits that any changes to the status quo will have a financial impact on one or other of the parties. With the realities of the commercial world it should be accepted that neither party can be expected to bear a financial penalty for the benefit of the other. We consider that any solution to the issue of proximity limits must include a mechanism for financial compensation to one or other of the parties where additional costs have to be born for the benefit of the other.

Financial issues – telecommunications cable operations

Telecommunications cables are required to operate at a very high level of availability in excess of 99.999%. Any delay to a telecommunications cable fault rectification due to wind farm proximity issues will have a significant lost revenue impact on a cable operator. Repair vessel mobilisation is normally within hours rather than days, once an approximate fault location has been determined.

Where a cable is laid through a wind farm, there is the potential for a 'cut and lay through' repair being required in the event of a cable fault within the bounds of the wind farm. In such a scenario, the cable owner will be required to hold longer lengths of spare cable to facilitate lay through repairs. Cut and lay-through repairs would often be preferred, having the benefit of potentially much higher weather working limits due to the limited time and nature of ship movements within the array, narrower operating corridors from the lack of excursions from the route, and shorter repair times and pre-planning when compared to a spot repair within the array.

Where the proximity of wind farm structures to cables are such that there is likely to be additional operational planning requirements and reduced weather window opportunities for cable repair, then these cable sections could be treated as 'non-standard' in cable repair contracts, as is the case with cables running within oil and gas 500m safety zones. In such cases repairs could be covered by a suspension or relaxing of contractual KPI's and limiting environmental criteria for repair.

The adoption of DP class 2 vessels as a minimum standard for telecommunications cable repairs in proximity to wind farms would be a significant cost and as previously discussed, the DP Class of a particular vessel is not a guarantee of a particular level of station keeping performance.

Financial issues – power cable operations

Power cable faults are also significant lost revenue events for the operators, but as vessels of opportunity are normally used for fault repairs and the cable handling requires specialist equipment to be mobilised on a case by case basis, there is likely to be sufficient time during the procurement and mobilisation for agreement by both parties on procedures and approvals.

The 'lay through' repair scenario as discussed in Section 3.4.1 is equally applicable to power cables, except that the

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cost per unit length of power cable is significantly greater than for telecommunications cable and power cable owners do not typically hold long lengths of spare in stock. Such cable lengths have a long lead-time and the supply of stock for 'lay through' repair could be relatively expensive.

Further additional costs could be associated with the capital and installation costs associated with route adjustments increasing cable length and the engineering of cable crossings.

Any proximity related issues affecting time to restoration will have a financial impact on the cable owner in an industry where low fault history and active and effective fault response are selling points for a particular cable system. Note: this is equally relevant for a wind farm export cable fault (covered in Section 3.4.3 below).

Financial issues – wind farm operators

Lost revenue from wind farm faults vary depending on the nature of the fault:

- Export cable fault – major or total loss of revenue depending on number of export cables from the site
- Array cable fault – loss of revenue from one turbine to one sub array of turbines – downtime therefore less critical than for export cable faults
- Turbine fault – loss of revenue from one turbine.

Removal or position adjustments of one or more turbines from an array at the design stage, to facilitate cable repair access or vessel safety, will have a detrimental effect on revenue for the lifetime of the project. There may be increased capital costs associated with array and export cable route adjustments.

Additional costs would also be associated with cable crossing engineering works and constructions delays attributable to proximity of third party cable assets.

Procedures & human elements

We consider that close attention to safe operating practices, competency assurance and behavioural safety to be equally important as technical reliability and performance of vessels and equipment when defining proximity limits. The MCA publication Marine Guidance Note 365 while focusing on shipping safety does endorse that view with the following words:

"The prime causal factor in nearly all shipping accidents can be attributed to human element issues occurring at some stage in the ship life cycle. Addressing technological failures alone will lead only to a limited improvement in safety. In order to make significant improvements in safety performance much greater attention must be paid to human element issues".

Consultation & liaison

A common theme is evident in various guidelines relating to offshore liaison published by Subsea Cables UK, ICPC, RenewablesUK, The Crown Estate and others, that advocate early and ongoing stakeholder engagement for all OREI and submarine cable development projects. A typical example is the following wording taken from the Subsea Cables UK Offshore Liaison Guidelines:

- Liaise with other seabed users prior to, and during, installation, and promote the presence of their subsequently installed submarine plant, in order that third parties are aware of members activities and installations; and
- Provide third parties/authorities/organisations with information regarding proposed or installed submarine plant when these third parties require approval for marine activities over, through or adjacent to members' submarine cables, associated seabed installations and other interests.

Wave & tidal energy developments

There are currently a large number of wave and tidal energy devices at various stages of developments, with only a small number having undertaken commercial prototype testing offshore. At the present time, the scale of wave and tidal energy development is difficult to predict, with significant technical hurdles still to be overcome and reliance on financial subsidies and incentives likely to be needed for some years to come to stimulate the sector.

Whichever technologies emerge as front-runners, the common development will be the deployment of arrays of devices, rather than single units, to take advantage of economies of scale.

Conclusions and recommendations

Process summary

The rapid development of OREIs and submarine cable projects within the UK Renewable Energy Zone (REZ) and projected growth for the future has resulted in the need for cross industry endorsed guidelines on the proximity of submarine cables and wind farms. These guidelines will need to address installation and maintenance operations of wind farm structures, associated cables and other submarine cables where such structures and submarine cables occupy the same area of seabed. The purpose of this report is to provide an evidence-based study to be used as a tool to support the drafting of the guidelines.

For the purpose of this report we have assessed the proximity impacts between renewable energy installations and submarine cables in a range of water depths up to 200m, i.e. depths with foreseeable potential for OREI development in the next 10-20 years. The greater part of the UK REZ has water depths in excess of 50m and it is likely that advances in foundation design and installation techniques will result in developments in these water depths in the future. Renewable energy developments in depths beyond 200m will require a reappraisal of the issues assessed here and are therefore beyond the scope of this report.

From this base data, we have made an assessment of interactions between submarine cables installations and renewable energy installations and the associated risks identified. From this assessment we have developed recommendations for the basic principles of submarine cable and renewable energy installation proximity guidelines as provided in this report.

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Conclusions

Recommended overall strategy

Overall strategy for developing a proximity agreement

After considering the large amount of evidence as presented in Section 2 and Appendix D of this study we are of the opinion that a simple set of limiting distances cannot be derived for all cable/wind farm proximity scenarios without recourse to a large number of caveats and exceptions. Our recommended approach is to use the principle of a bilateral proximity agreement for each specific scenario based on a standard template and base case guidelines. Such a proximity agreement would be based on the format and spirit of existing cable crossing and proximity agreements in common use throughout both industries. Such a proximity agreement would facilitate one of the underlying principles enshrined in UNCLOS; the obligation for due regard to the rights of others, that due regard being reciprocal, and that one should not impede the right of others to install, maintain and repair assets (Articles 58 and 79).

We recommend that the following key elements be included in such a proximity agreement:

- Clauses to define the liabilities and rights of both parties
- The exclusion/inclusion of consequential losses
- Details of financial compensation arrangements for each party where applicable relating to base case arrangements
- Clearly defined limits of the area to which the Proximity Agreement applies
- Agreement on proximity limits informed by the Proximity Guidelines and then modified up or down by agreement depending on the method statements submitted and agreed
- Details of how the proximate work would be carried out – method statements provided by the party carrying out the work and accepted by the second party as suitable prior to work proceeding (it is not recommended that installation procedures be included in the body of the Agreement)
- Future maintenance requirements of both assets. This may include the method by which notification of operations by each party is given to the other
- Definition of the expiry of the Agreement (for example, at the decommissioning of one or other of the assets)
- Provision of representatives from one party to the other party's operations and their rights, obligations and limitation of their authority.

The process of using a proximity agreement and base case proximity distance tables as tools for drafting a site specific proximity agreement needs intelligent application and is not intended to be prescriptive.

Safety management, competency and behavioural based safety

A systemic approach to the management of safety should aim to maintain risk within an acceptable range in an organisation's operations in a structured and preventative way. Through monitoring, assessment and evaluation the systemic approach is likely to ensure the effectiveness of systems and processes established for safety management. An organisation's safety management plan and operating policies should include evaluation and risk assessment of the component parts of a project.

The station keeping performance capability of any vessel is a combination of design, maintenance standards and operational competence in the face of environmental and site specific conditions. We consider that close attention to safe operating practices, competency assurance and behavioural based safety to be equally important as the technical reliability and performance of vessels and equipment when defining proximity limits.

Whilst the safe operation of vessels is legislated at international and national levels, there are a range of applicable safety standards depending on the size and/or power of a particular vessel with some vessels (particularly towed barges) falling outside the more stringent requirements such as the International Safety Management (ISM) Code. (The ISM Code is applicable to the majority of vessels of 500 GRT or more, and sets a common standard for safety management systems of those vessels). We recommend that the principles of the ISM Code be applied to proximate vessel operations irrespective of vessel size, power or class.

The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (the STCW-95 Convention) has recently been amended (1st January 2012) to include training guidance for DP watchkeepers. We recommend that this amendment and the existing Nautical Institute DP training scheme be acknowledged during the drafting of any proximity guidelines.

Operations within a Hazard Area
It is worth considering the safe working practices that have been developed in the oil and gas sector with respect to vessels approaching fixed and floating structures protected by a 500m safety zone. Such offshore support vessels routinely approach oil and gas structures to within 10m in manual control, DP 1, 2 & 3 modes. Operational safety in these situations is largely managed by controls and procedures together with prescribed levels of personnel competency and good operating and maintenance practices. In all cases, these controls include contingency measures and factors of safety to provide for the recovery from all likely failure mode events for vessels and equipment. A similar approach to navigational safety is adopted for vessels routinely entering and leaving congested port approaches, where the use of checklists, increased manning levels, technical redundancy and enhanced preparedness for failure modes are used to mitigate against the increased risk levels associated with operating in close proximity to navigational hazards.

Existing crossing and proximity agreement templates generally prescribe additional controls within a defined 'hazardous area' around a fixed or floating structure in order to manage the additional safety hazards present. A 250m 'Notification Area' around structures is often adopted, where vessel entry would activate these additional requirements specified in the crossing or proximity agreement.

We recommend that the definition of such a hazardous area be included within the proximity guidelines, within which a heightened level of operational readiness and safety awareness be activated.

The role of the Master
The ship's Master has overall legal responsibility for the safety of his vessel, the personnel onboard and the protection of the environment and we recommend that this is acknowledged in the development of the proximity guidelines. In addition, we recommend that wherever possible, the relevant Masters and senior officers are involved in the planning of proximate marine operations as they are often the persons with key experience and knowledge of their vessel's operating characteristics and limitations. This is particularly relevant for operations involving vessels manoeuvring in close proximity to surface and subsea obstructions, where operator competency is a key risk reduction measure.

Base case considerations
Note: The base case arguments offered are the property of this report and have been derived through professional experience and the considered opinion of the authorship team. As such they are not to be construed as legal instruments or as industry-accepted practice.

This section summarises our detailed assessment provided in Section 3 of the five key operations identified that dictate proximity limits; namely:

- Dynamic positioning operations
- Use of ROVs and related subsea equipment
- Anchored vessel operations
- Grapnel operations
- Final bight laydown.

For each of these operations we recommend a risk based rather than prescriptive approach when determining proximity limits for a particular operation or location. (All proximity limits would be subject to inclusion of any notification/hazard area mitigation measures deemed necessary by risk assessment).

DP operations
As reviewed in Section 2, it is demonstrable that with increasing technical reliability of propulsion and control systems, the main cause of DP station keeping incidents are related to human error. While the DP class of a particular vessel remains relevant, we consider procedural regimes

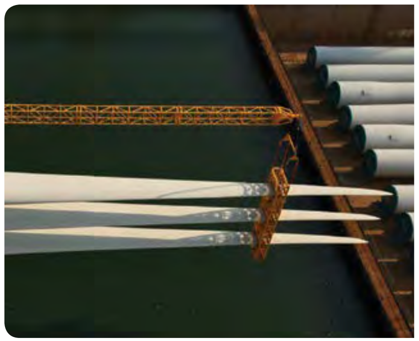


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Table 4-1 Recommended base case proximity limits for DP vessels.

Scenario	Manual control proximity limit	DP 1 vessel proximity limit	DP 2 vessel proximity limit
	All distances measured from the closest extremity of the vessel to the OREI		
Conducting cable repair operations in the lee of a wind farm structure	200 metres (Control or propulsion failure resulting in a drift off scenario)	100 metres (Control or propulsion failure resulting in a drift off scenario)	50 metres (Control or propulsion failure resulting in a drift off scenario)
Conducting cable repair operations on the weather side of a wind farm structure	500 metres (Control or propulsion failure resulting in a drift on and subsequent manual control correction	500 metres (Control or propulsion failure resulting in a drift on and subsequent manual control correction)	100 metres (Propulsion failure in DP 2 mode would require propulsion redundancy to correct drift on)

and behavioural safety to be of significant importance in developing proximity guidelines for DP and other self-propelled vessels.

Cable vessels currently contracted for cable repairs in the UK REZ under long term maintenance agreements are generally DP Class 1 vessels or for commercial reasons DP Class 2 vessels operating to Class 1 requirements.

Our view is that this state of affairs is unlikely to change in the next 5 years. While DP Class 1 vessels are inherently less reliable in station keeping terms, we would assert that providing proper operating controls and procedures are followed, then the use of DP Class 1 vessels should not translate into more station keeping incidents than for DP 2 vessels, providing such DP 1 vessels are operated more conservatively in terms of proximity distances.

In order to define base case proximity limits for DP cable repair vessels we have used our own operational experience and have consulted with cable repair contractors to derive Table 4-1 of scenarios and limits and included 'Manual Control' vessels as a comparison:

NB. The base case limits used in this table are property of this report and are based on the professional experience and considered opinion of the authorship team. As such the information is not be construed as a legal instrument or as industry accepted regulation.

The limits proposed in Table 4-1 assume that a particular vessel is designed, operated and manned in accordance with industry best practice, i.e. any deficiencies such as reduced manning or equipment downtime should be considered valid reasons for increasing such proximity limits.

In summary, for DP and self-propelled vessels operating in proximity to a third party asset, we recommend that the risk based assessment of proximity limits should take into account not only the technical performance of the vessel and site conditions, but a range of procedural and behavioural based safety factors detailed in Section 3.

ROVs & related subsea equipment
ROV intervention would in almost all cases be the preferred cable intervention method in water depths up to 200m, at least initially. Once initial ROV inspection has been completed then the options become more broad ranging, dictated by seabed type, depth of burial, environmental parameters, cable offset distance (in which case ROV is preferable), cable type etc. With respect to cable types, grappling is less likely to be employed for power cables.

Anchored operations
An anchored barge may be used for cable installation or repairs in proximity to a wind farm or conversely for wind farm work in proximity to an existing cable. The use of jack up barges for wind farm construction or cable repair activities can also involve the deployment of anchors to aid positioning prior to jacking operations.

We readily acknowledge that anchor and anchor line proximity limits are another set of values that have to be set on a case by case basis and that adherence to a vertical proximity limit for anchor wires can be problematic to achieve and monitor.

While the deployment of anchors represents an additional constraint when planning proximity limits, the fact that anchors lines can span an existing subsea cable allows a degree of flexibility in the use of anchors in a congested seabed area.

Grapnel operations limits
As grapnel operations require more sea-room than ROV cable recovery methods, the use of grapnels is a key consideration for this study.

For depths of up to 200m, Table 4-2 is offered as a guideline set of base case operational distances for grapnel operations. It is acknowledged however that

Table 4-2 Recommended base case grapnel operational distances

Water depth (metres)	Layback (metres)	Run on (metres)	Length of grapnel rope (metres)	Remarks
5	20	50	30	Grapnel rope length approx 3 times the depth of water up to 200m depth of water. Depths of water greater than 200m are not considered here but a grapnel rope length in the order of (depth of water + 30%) would be appropriate
10	30	50	40	
20	40	50	50	
30	70	50	90	
40	100	50	120	
50	140	50	150	
100	240	50-60	250-300	
150	360-400	50-60	400-450	
200	500-550	60-60	600-650	

final proximity limits for a given repair scenario will be dependent on a large number of variables which combine to produce a unique set of requirements for each cable repair.

Taking the example illustrated in Figure 4-1, the minimum proximity distance between windfarm structures and cable will need to take account of the sea-room required for grappling as follows:

Run on 50m
Layback 140m
Vessel length 150m
Total 340m

The final overall proximity limit will then take into account the sea-room required for grappling (340m in this case) and the minimum approach distance for the vessel which is a function of all site specific factors as described in Appendix A.

Final bight laydown

The final bight length of a cable repair or final installed joint in a cable system is a function of water depth, the physical characteristics of the cable, constraints of the repair vessel layout and prevailing weather conditions at the time of the laydown operation.

It can be seen from Figure 4-2 that proximity limits between a cable and a wind farm structure needs to take rigorous account of the space required for a repair joint and in addition a further allowance for future cable repair access at or near the repair bight area.

Figure 4-3 on page 79 is provided to illustrate the terms water depth, freeboard, deck length and repair bight crown used in Table 4-3.

Figure 4-1 Worked example – base case grapnel operational limits in 50 metres water depth

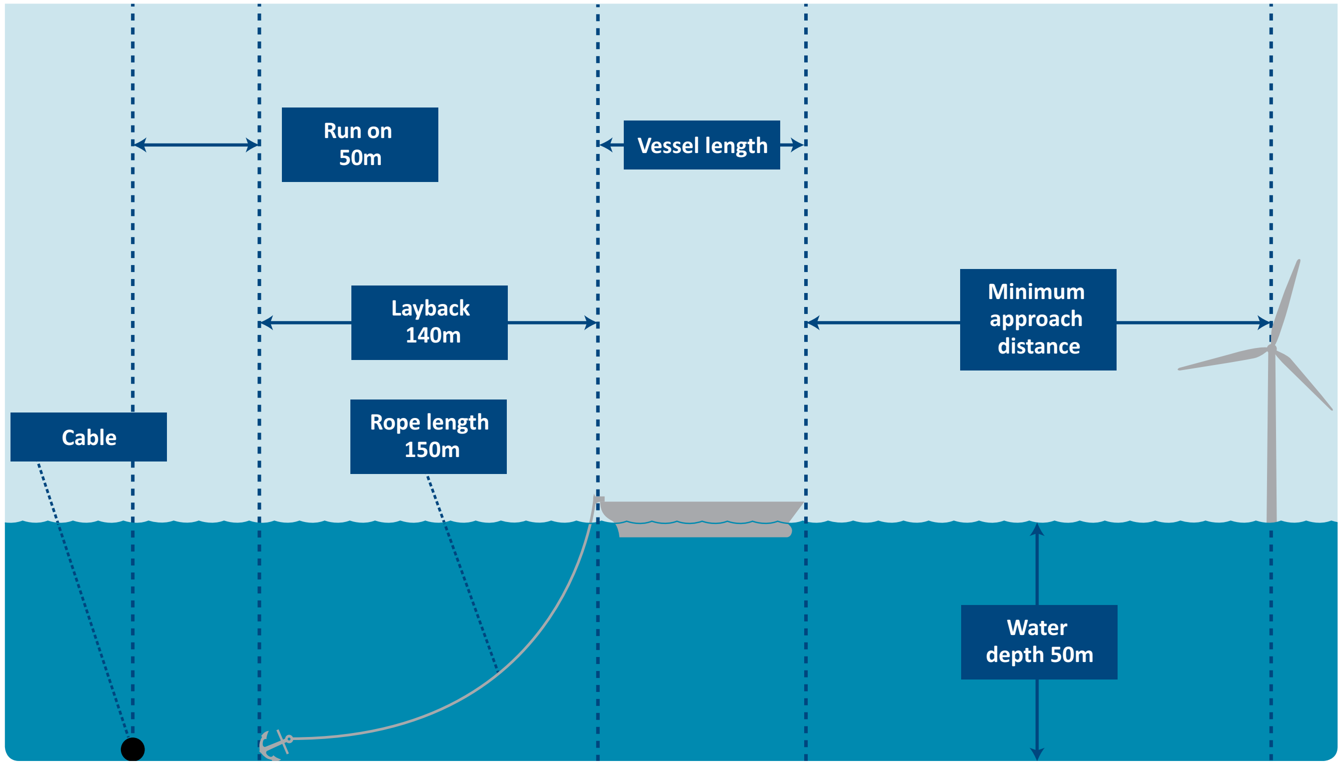


Figure 4-2 Final bight access requirements ('a' and 'b' defined in Table 4-3)

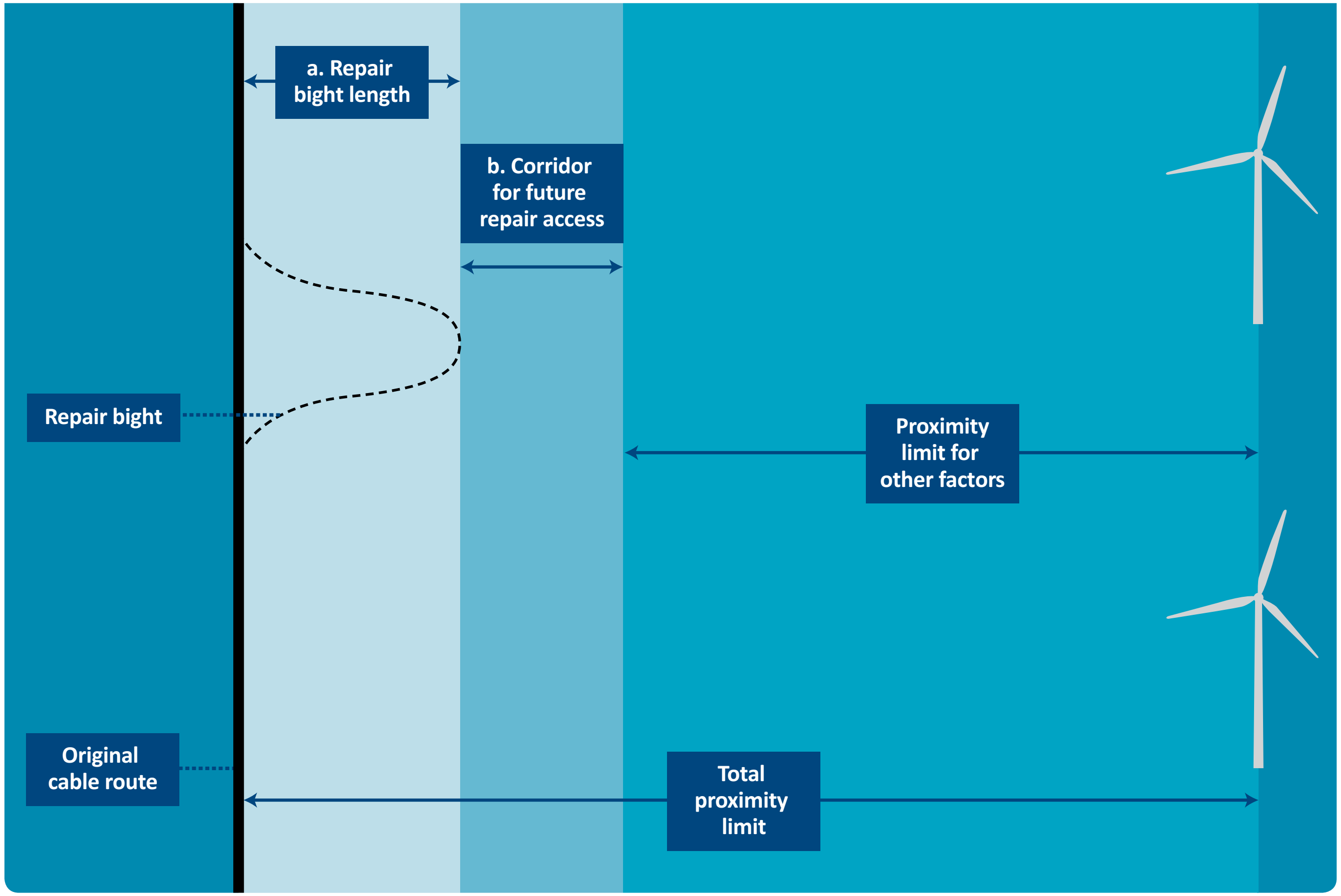
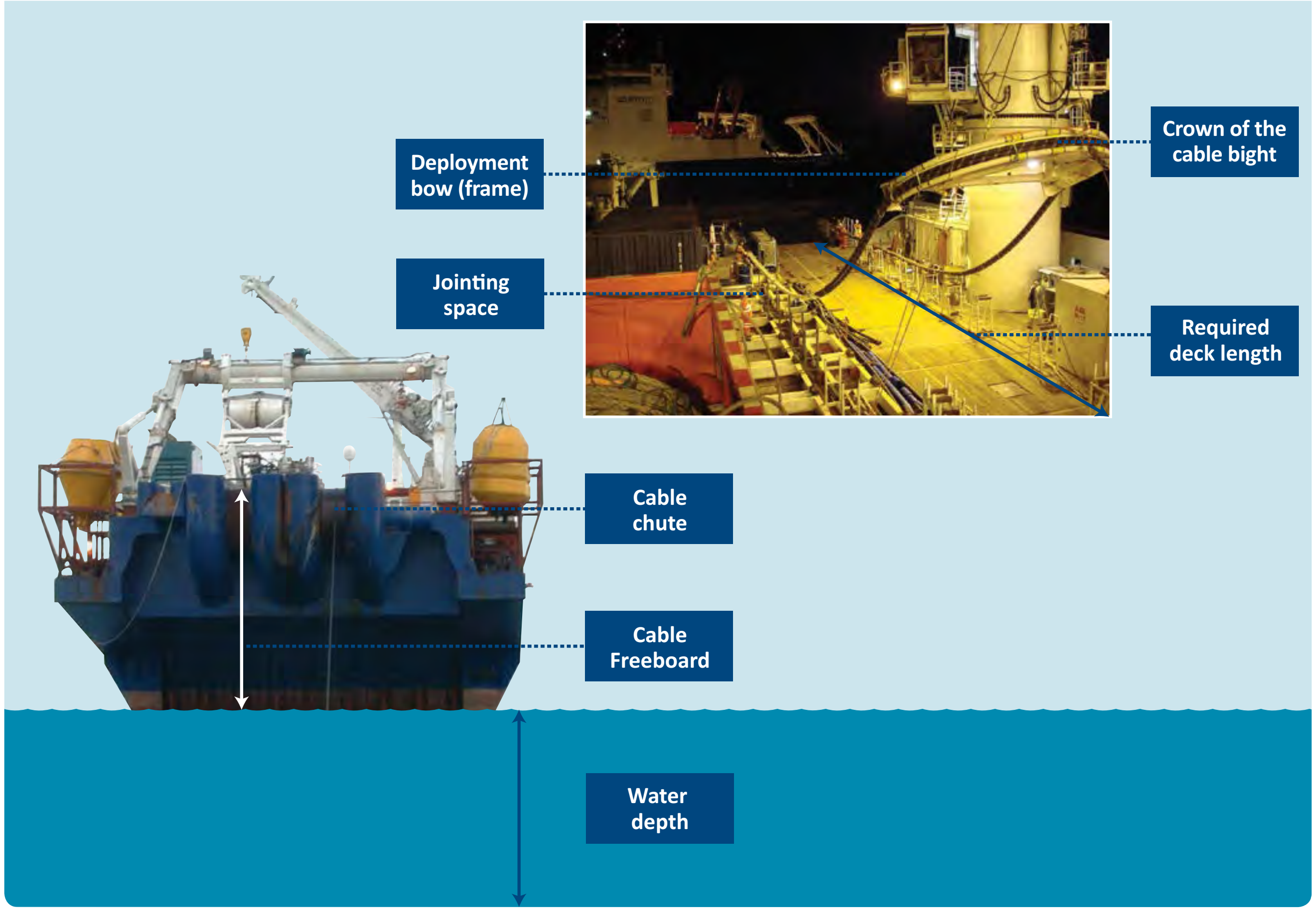


Table 4-3 provides our assessment of base case repair bight lengths for a range of water depths up to 200m. An additional corridor providing for future cable repair access is also included for consideration whilst acknowledging that the probability of carrying out a subsequent cable repair at the crown of the repair bight is likely to be very low. The dimensions in table columns 'a' and 'b' equate to the 'a' and 'b' dimensions in Figure 4-3.

It must be emphasised that this serves as an illustration of minimum distances and does not constitute a definitive case. Extra distance will most likely be required to correctly set the cable catenary in a repair situation

Figure 4-3 Dimensions and terms relating to cable repair bights



but the variable nature of this renders it impractical to include in a table.

Considering future developments in cable repair techniques, there appears to be little in view for either power or telecommunications cables that could significantly reduce cable bight dimensions and the resultant impact on proximity limits.

Additional Considerations

There are a number of additional proximity considerations identified in detail within this study summarised below:

Safety Zones – A mechanism providing dispensation to approach within the wind farm 500m/50m safety zone would be in our assessment mutually beneficial to both wind farm developer and cable owner.

Decommissioning – There is a general presumption in favour of disused installations (OREI structures and subsea cables) being removed from site unless the owner demonstrates that removal of a particular component is not viable or where removal may create a net detrimental environmental impact. This presumption of removal should be taken into account when planning proximity limits between two developments, particularly in congested seabed areas where installation removal would be required to create space for future/replacement developments. Due consideration should be given to the possibility of de-commissioned subsea cables or cable sections being left in situ as this may be favoured from an environmental impact perspective depending on the overall net environmental impacts for a particular asset.

Wave & Tidal Energy Developments – Of the sites and areas identified to date with potential for development, many are in locations unsuitable for competing seabed developments due to the energetic nature of the environmental conditions.

Our assessment is that in the medium term there is unlikely to be significant conflicts between submarine cables and wave/tidal energy developments. Where such conflicts do arise, the principles and base case limits proposed should, in our opinion, be adopted.

Proximity Limits Process

From review of the base case proximity limits recommended for specific operations and equipment it is apparent that there is a fairly complex matrix of proximity scenarios and site-specific factors to take into account. Our recommendation is that a flow chart based on the proximity tables provided above be used to identify the critical path activity or activities that define the proximity limits for a given scenario. This flow chart is provided in Appendix A together with a worked example illustrating its use.

There are a number of operational decisions (some with commercial implications) that can be made in to minimise proximity limits and these have been discussed earlier in this document, but in summary includes:

- Use of DP control in conjunction with winch control of the grapnel set to minimise or eliminate the run on distance[8]
- Carry out cable repairs only when environmental conditions present a drift off scenario allowing a vessel to approach closer to the wind farm structure[9]
- Substitute the use of a DP Class 1 vessel with a DP Class 2 vessel for tasks in close proximity to structures
- Orientation of a vessel other than end on to the wind farm structure when carrying out proximate operations[10]
- Conduct operations away from the immediate area of constraint with a potential consequence of requiring a greater length of inserted spare cable.

As we have stressed throughout this document, a final base case proximity limit is just that – **a base case proximity limit.** A risk assessment of all site-specific factors has then to be conducted to arrive at the final figure for a given scenario.

[7] Deck length base case (e.g. HVDC cable type) as follows:
Vessel freeboard .... = 5m (cable distance from waterline to cable chute)
Deck length .... = 45m (required on deck for handling, jointing etc)
Crown of cable bight .... = 5m
Total .... = 55m

[8] *Grappling for cables in confined space may require some departure from standard practice. In this regard techniques such as stopping the vessel at a pre-determined point and drawing the grapnel train forward by winch/cable gears could be considered but may affect the effectiveness of the grapnels.*

[9] *Limiting operations in this way may have significant commercial implications particularly where time to restoration is affected for telecommunications cables.*

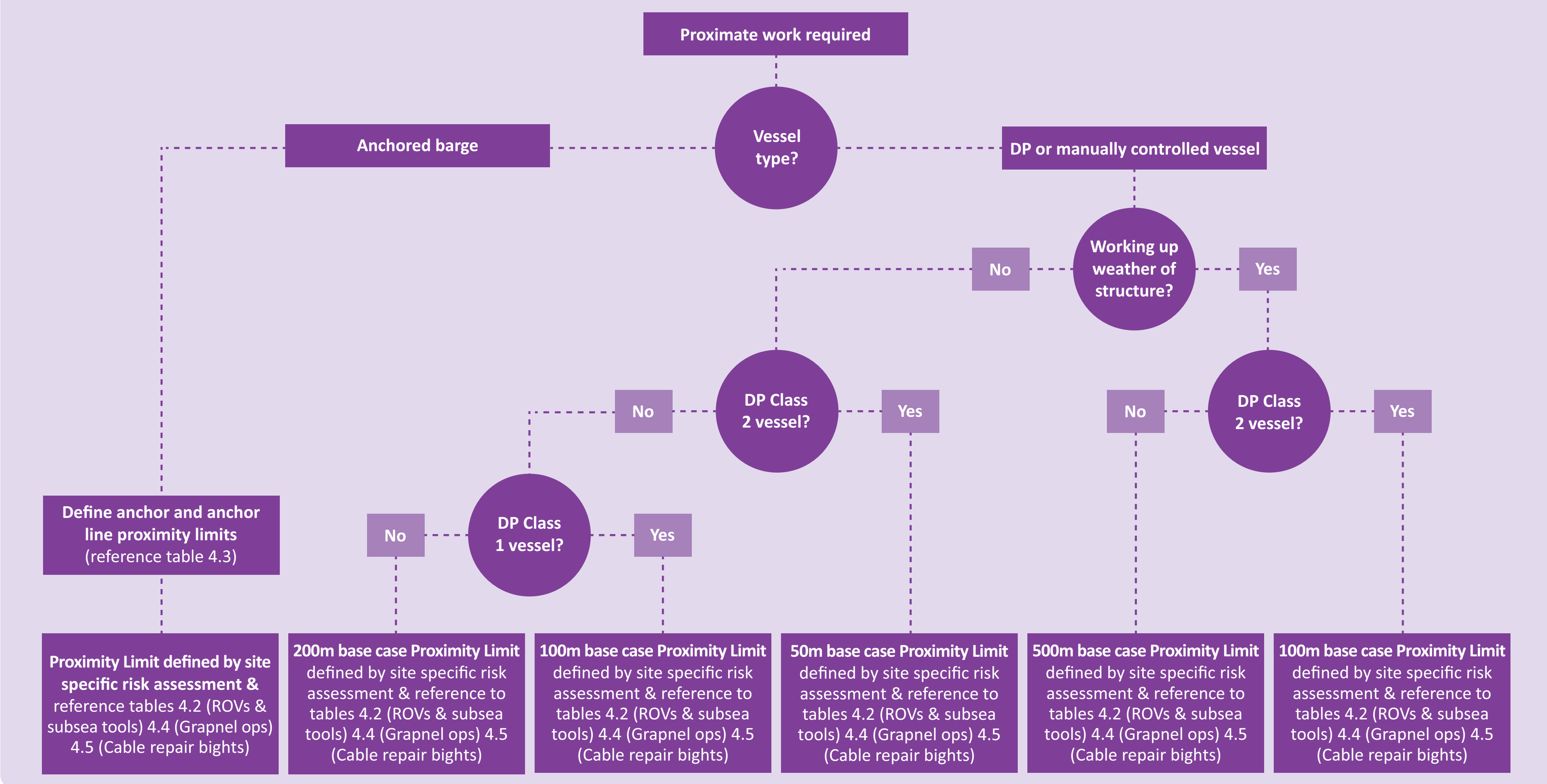
[10] *Proximity distances are measured from the closest extremity of the vessel.*

Table 3-4 Cable repair bights – minimum dimensions

Water depth (metres)	Telecommunications cable repair bight displacement (metres)	Additional corridor width for future access to repair bight (metres)	Power cable repair bight displacement (metres)	Additional corridor width for future access to repair bight (metres)
	'a'	'b'	'a'	'b'
Minimum	Water depth + freeboard + repair bight crown + deck length[7]	50	Water depth + freeboard + repair bight crown + deck length	50
10-100	Water depth + freeboard + repair bight crown + deck length	100	Water depth + freeboard + repair bight crown + deck length	100
100-200	Water depth + freeboard + repair bight crown + deck length	200	Water depth + freeboard + repair bight crown + deck length	200

Appendix A – Proximity flow chart and worked example

Figure A-1 Proximity limit assessment process



Worked examples

How much sea room is required to safely and efficiently conduct a cable repair?

Case 1

For a planned cable repair in 40m water depth adjacent to an existing offshore wind farm where cable repair work is to be performed by a DP Class 1 vessel.

Note: Further to reference earlier in the study it should be noted that the distances shown in the examples below (i.e. distance of minimum approach) are to be considered as absolute minimum and are derived assuming the most optimum condition and a conservative length of grapnel rig and run on across the cable line.

In practice an allowance for prudent operational contingency and due attention to the circumstances of the case should be made and added to the arguments expressed here.

It is likely therefore that figures in excess of the examples shown here may appear in other papers and publications on the subject.

From Figure A-1 – Proximity limit assessment process, it can be seen that the most onerous proximity limit is for the DP Class 1 repair vessel operating up weather of the wind farm structures and – due to operational circumstances – having to deploy a repair bight towards the structure.

Relevant tables & diagrams.

- Fig 3-1. Proximity Limit; assessment criteria
- Table 4-1. Recommended base case proximity limits for DP vessels

Figure 3-1 Proximity limit assessment criteria

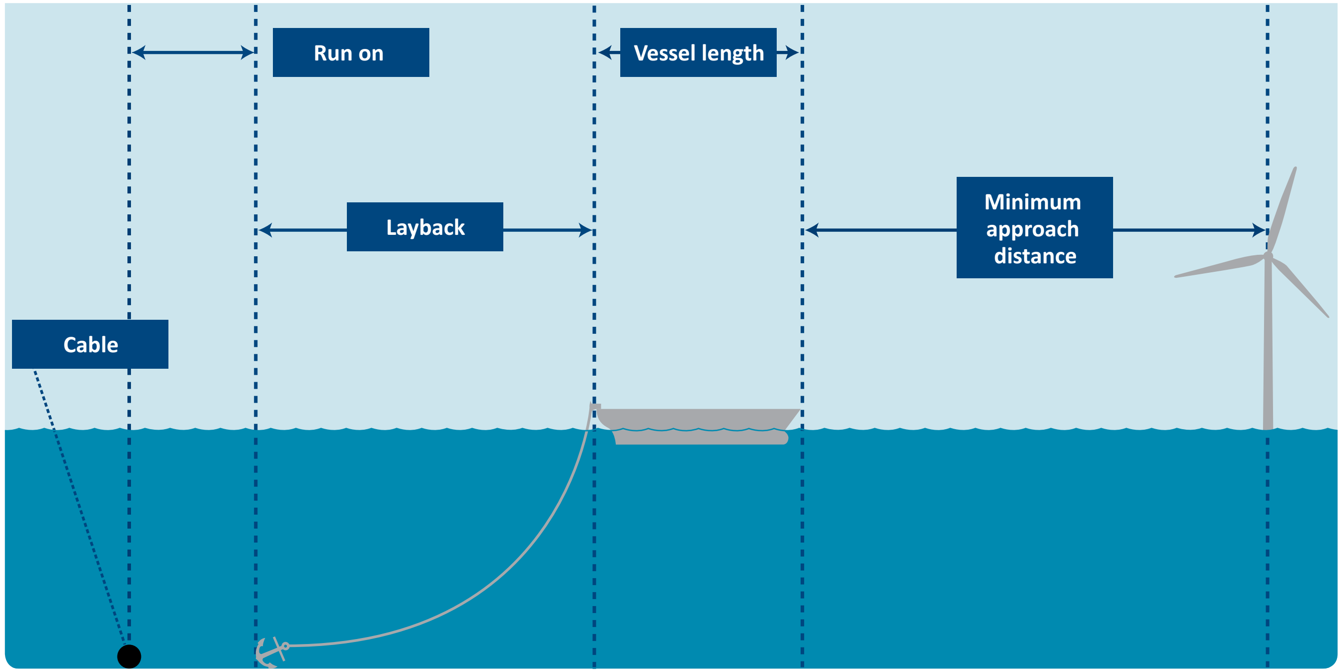


Table 4-2 Recommended base case proximity limits for DP vessels

Scenario	Manual control proximity limit	DP 1 vessel proximity limit	DP 2 vessel proximity limit
	All distances measured from the closest extremity of the vessel to the OREI		
Conducting cable repair operations in the lee of a wind farm structure	200 metres (Control or propulsion failure resulting in a drift off scenario)	100 metres (Control or propulsion failure resulting in a drift off scenario)	50 metres (Control or propulsion failure resulting in a drift off scenario)
Conducting cable repair operations on the weather side of a wind farm structure	500 metres (Control or propulsion failure resulting in a drift on and subsequent manual control correction	500 metres (Control or propulsion failure resulting in a drift on and subsequent manual control correction)	100 metres (Propulsion failure in DP 2 mode would require propulsion redundancy to correct drift on)

In practice an allowance for prudent operational contingency and due attention to the circumstances of the case should be made and added to the arguments expressed here.

This base case proximity limit is an illustration of (absolute) minimum distances that would apply in the case of a DP 1 type vessel. In the event of a DP 2 vessel being used this could be adjusted after full risk assessment of site and due consideration of the operational specific factors.

For example the arrangement of the grapnel rig may allow consideration for a reduction in proximity limits whilst strong adverse tidal currents may well require an increase in limits to be applied. The process of identifying the minimum base case proximity limits for a given scenario as described above, would operate alongside the designation of a 'hazardous' area within a proximity agreement as recommended within our report. Within such a hazardous area, a heightened level of operational readiness and safety awareness would be activated.

In all cases, the overall goal is a site-specific proximity limit that provides for safe operations allowing for all likely failure modes of vessels and equipment.

Minimum approach distances:

1. Grappling: –

A: Distance of Minimum Approach – DP Class 1 vessel (Table 4-1) .... = 500 metres
B: Length of vessel (assuming bow-on) .... = 150m
D: Layback of grappling train (min.) .... = 100m
E: Run-on (min.) .... = 30m

Minimum separation from structure: .... = 780m

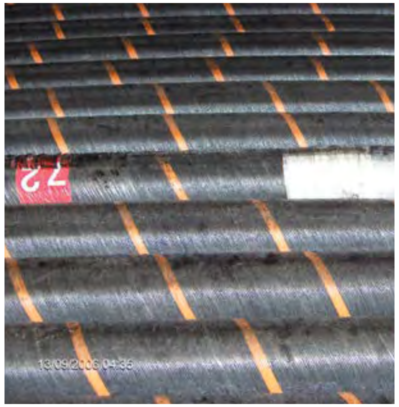
2. Cable lay-down (bight deployment): –

A: Distance of Minimum Approach – DP Class 1 vessel (Table 4-1) .... = 500 metres
B: Length of vessel (assuming bow-on) .... = 150m
C: Depth of water: .... = 40m
D: Cable freeboard .... = 15m
E: Deck cable length .... = 40m

Minimum separation from structure: .... = 745m

NB. These are absolute minimum values.



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Appendix B – UK REZ wind farms

Table B-1 Operational and consented wind farm developments

Wind farm	Location	Region	Turbines	Status
Barrow	Off Walney Island	North West	30	Operational
Burbo Bank	Off Liverpool	North West	25	Operational
Walney I	Off Walney Island	North West	51	Operational
Walney II	Off Walney Island	North West	51	In build
Ormonde	Off Walney Island	North West	30	In build
West of Duddon Sands	Off Walney Island	North West	108	Consented
Robin Rigg	Solway Firth	Scotland	60	Operational
Beatrice	Moray Firth	Scotland	2	Operational
Blyth Offshore	Blyth Harbour	North East	2	Operational
Teesside	Off Teesmouth	North East	27	In build
Gunfleet Sands I	Off Clacton-on-Sea	South East	30	Operational
Gunfleet Sands II	Off Clacton-On-Sea	South East	18	Operational
Kentish Flats	Off Whitstable	South East	30	Operational
Thanet	Off Margate	South East	100	Operational
London Array I	24km off Clacton-on-Sea	South East	175	In build
London Array II	Off Clacton-on-Sea	South East	100	Consented
North Hoyle	Off Prestatyn & Rhyl	North Wales	30	Operational
Rhyl Flats	Off Abergele	North Wales	25	Operational
Gwynt y Mor	Off North Wales	North Wales	160	Consented
Scroby Sands	Off Great Yarmouth	East of England	30	Operational
Lynn & Inner Dowsing	Off Skegness	East of England	54	Operational
Sheringham Shoal	Sheringham, Greater Wash	East of England	88	In build
Greater Gabbard	26km off Orford, Suffolk	East of England	140	In build
Lincs	8km off Skegness	East of England	75	In build
Humber Gateway	Off Humber Estuary	East of England	83	Consented
Westermost Rough	Off Humber Estuary	East of England	80	Consented

Table B-2 Operational & consented wind farm developments

Wind farm	Location	Region	Turbines	Status
Argyll Array	Isle of Tiree	Scotland	400	Site award
Beatrice	Moray Firth	Scotland	255	Site award
Inch Cape	Firth of Forth	Scotland	416	Site award
Islay	Off Isle of Islay	Scotland	189	Site award
Neart na Gaoithe	Firth of Forth	Scotland	125	Site award
Methil Offshore Wind Farm	Firth of Forth	Scotland	2	Planning
European Offshore Wind Deployment Centre Scotland	Off Aberdeen	Scotland	11	Submitted
Blyth Offshore Wind Demonstration site	Off Blyth	North East	20	Planning
Gunfleet Sands extension	Off Clacton-On-Sea	South East England	2	Submitted
Docking Shoal	North Norfolk coast	East of England	100	Submitted
Dudgeon	North Norfolk coast	East of England	168	Submitted
Race Bank	North Norfolk coast	East of England	88	Submitted
Triton Knoll	Off The Wash	East of England	330	Planning

Table B-3 Round 3 Zones

Round 3 Zone	Zone Capacity MW	Status
Moray Firth	1300	Zone awarded/early planning
Firth of Forth	3500	Zone awarded/early planning
Dogger Bank	9000	Zone awarded/early planning
Hornsea	4000	Zone awarded/early planning
East Anglia	7200	Zone awarded/early planning
Rampion	600	Zone awarded/early planning
Navitus Bay	900	Zone awarded/early planning
Bristol Channel	1500	Zone awarded/early planning
Irish Sea	4200	Zone awarded/early planning

Appendix C – UK consents regime

The UK marine consents regime

There have been significant changes in the UK consenting regime for marine energy and submarine cable projects in recent years, particularly changes to the government bodies and departments responsible for administrating the regime. Key changes have been:

- Responsibility for Nationally Significant Infrastructure Projects (NSIPs) in England and Wales transferred from the Infrastructure Planning Commission (IPC) to the National Infrastructure Directorate within a reformed Planning Inspectorate
- Establishment of the Marine Management Organisation (MMO) with responsibilities for licensing, planning and enforcement under the Marine and Coastal Access Act 2009

- Rationalisation of the former FEPA and CPA consents into a single Marine Licence
- Responsibilities for marine licencing, planning and enforcement in Welsh and Scottish territorial waters managed by the respective devolved governments.

Under the current legislative framework the permitting and licensing timescales are dependent upon the facility for which consent is sought. Generally, renewable energy sources have planning and approval windows of approximately 3 years while submarine cables in isolation have a planning window of approximately 1 year.

It is important to note that offshore renewables developers also require a marine licence from the MMO or Marine Scotland to undertake any extractive or depositional activity. Under the IPC system, the MMO provides a deemed marine licence, which requires maintenance throughout the life cycle of the relevant asset and MMO has, the powers to enforce and vary such deemed licences. For international cables passing through UK territorial waters, the MMO grants the relevant marine licence, but can include conditions concerning for example, cable burial and laying methods.

As well as being subject to an obligation a submarine land use licence from The Crown Estate, all cables require a Marine Licence from the MMO for the section within 12 nautical miles, but no Marine Licence is required for the section outside 12 nautical miles (except for OREI export cables). Cables alone also do not trigger the requirement for EIA, although they may be subject to assessment under the Habitats Regulations if they have the potential to affect a Natura2000 site.

A deposit, removal or dredging activity carried out for the purpose of executing emergency inspection or repair works only to a cable is exempt from requiring a marine licence, but does require approval from the MMO.

The planning process

The Infrastructure Planning Commission (IPC) was established through the Planning Act 2008 and is the body, which receives applications for Nationally Significant Infrastructure Projects (NSIPs) within England and Wales. (Note: The Localism Act 2011 provides for the abolition of the IPC with their powers being transferred to National Infrastructure Directorate and ultimately to the Secretary of State from April 2012). Offshore wind farms with a capacity of100MW or more qualify as NSIPs. In practice this means that all offshore wind projects in Round 3, and those above 100MW capacity, within the Round 1 and 2 Extension Round will have to make a consent application to the Secretary of State. The planning systems in Scotland and to a lesser extent Wales and Northern Ireland differ and are described in Sections 2.3.3 and 2.3.4.

The Planning Act 2008 and more recently The Localism Act 2011 made a number of important changes to the planning system in England and Wales. The most pertinent of these are:

- The granting by IPC/NID of a single Development Consent Order (DCO) which can include deemed permission for the majority of consents required for a project within a single consent (including a Marine Licence)
- The drafting of National Policy Statements (NPS) to confirm the need for various types of projects; this removes the burden on developers for detailed ‘statements of need’ and provides more certainty for them in developing their

project plans. The NPS for renewable energy clearly states that electricity generation from renewable sources of energy is an important element in the Government's development of a low-carbon economy
- Responsibility for planning decisions lies directly with the Secretary of State where NPS are in place. The Localism Act 2011 removes the IPC and replaces it with a National Infrastructure Directorate within a reformed Planning Inspectorate from April 2012. Final consent decisions are made by the Secretary of State
- The application process is very 'front loaded' in terms of the requirements placed on developers prior to submission of an application. The Planning Act places a duty on the developer to undertake consultation on the scheme, and a duty to take the views of consultees into account before deciding to submit an application. The published guidance on IPC pre-application consultation states that "There is a clear expectation that the views and impacts identified through the consultation can and should influence the final application. By addressing impediments and impacts before an application is submitted to the IPC, the examination process will be as fast and straightforward as possible"
- The amount of work done in advance of the application allows the determination of applications to be undertaken more swiftly, theoretically giving developers a shorter and more certain timeframe for obtaining a decision than under the previous consenting system.

Although neither Subsea Cables UK nor its members fall within the list of statutory consultees to the IPC process (and therefore would not necessarily be contacted by the IPC automatically with details of schemes affecting them), it is recommended that their interests should be identified by developers as the Planning Act places a duty on developers to make a 'diligent inquiry' to identify all affected parties.

The role of the Marine Management Organisation (MMO)

The MMO is a new executive non-departmental public body (NDPB) established and given powers under the Marine and Coastal Access Act 2009. Its jurisdiction extends to English and Welsh waters.

The MMO plays a number of roles:
- Licensing – all depositional or extractive activity requires a marine licence from the MMO – this includes the sections of telecommunications and power cables within 12 nautical miles. Under the Planning Act process for offshore wind farms, the MMO grants a deemed Marine Licence
- Consultee – Under the IPC system the MMO is a key statutory consultee
- Marine planning – the MMO has implemented a program to deliver 10 regional marine plans across English waters be complete in 2021. The first two plan areas are East of England inshore and offshore
- Enforcement – The MMO is responsible for the enforcement of marine licences and has a range of statutory and non-statutory instruments at their disposal.

Marine planning

Marine planning is one of the major new functions of the Marine Management Organisation (MMO). The Marine Policy Statement, developed by the Department for Environment, Food and Rural Affairs in co-operation with other government departments, provides the strategic framework for all marine plans and guide decision-making in the marine area.

Marine plans that will be developed for England will guide developers about where they are likely to be able to carry out activities and may indicate the kind of conditions or restrictions that may be placed on what they do and how they do it. The East Inshore and East Offshore plans are currently underway.

All operators and regulators in an area will be expected to work to the same plan, providing transparency and consistency in decision-making.

Marine licensing

The MMO controls the environmental, navigational, human health and other impacts of construction, deposits and removals in the marine area. They give consent to activities under the new marine licensing system of the Marine and Coastal Access Act 2009, which started on 6 April 2011. The new licensing regime includes renewable energy projects, aggregate extraction and the laying of submarine cables. The MMO brief includes the following:

- Manage applications and enquiries
- Determine and grant licences
- Carry out inspections to ensure compliance with licences and licence conditions
- Vary, revoke, suspend and transfer licences
- Issue stop and emergency safety notices
- Identify and carry out or orders remediation works as necessary
- Issue compliance and remediation notices
- Issue (and review the issuing of) notices of intent or monetary penalties
- Maintain a register of licensing activities
- License offshore energy installations with a generating power of 100 MW or less and declare safety zones around those installations if applied for.

The MMO takes decisions in accordance with marine plans unless relevant considerations indicate otherwise. The organisation draws on the expertise of the Centre for Environment, Fisheries and Aquaculture Science (CEFAS), the Government's main source of marine science expertise. Advice is taken from a range of sources including Natural England, the Joint Nature Conservation Committee (JNCC) and the Maritime and Coastguard Agency.

The marine licensing system under the Marine and Coastal Access Act 2009 (MCAA) has been in force since 6 April 2011. This system consolidates and replaces some previous statutory controls, including:

- Licences under Part 2 of the Food and Environment Protection Act 1985
- Consents under section 34 of the Coast Protection Act 1949
- Consents under Paragraph 11 of Schedule 2 to the Telecommunications Act 1984.

The MMO is responsible for most marine licensing in English inshore and offshore waters and for Welsh and Northern Ireland offshore waters. The Secretary of State is the licensing authority for oil and gas-related activities and administers marine licences through the Department for Energy and Climate Change (DECC).

Marine nature conservation

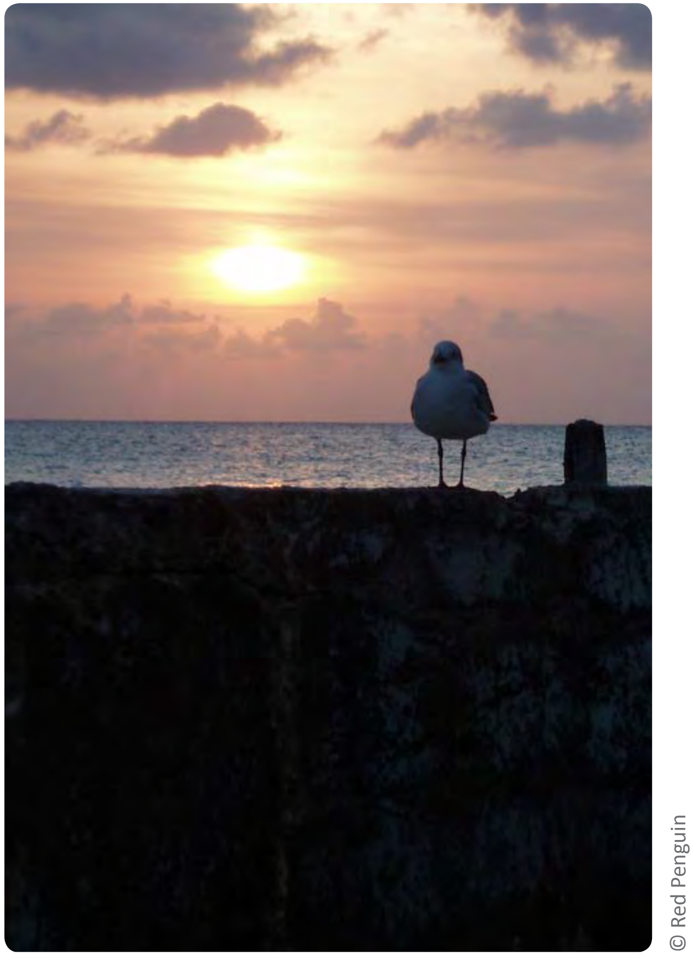
The MMO have powers under the Marine and Coastal Access Act 2009 to make byelaws for the protection of features of Marine Conservation Zones (MCZ) and European Marine Sites (EMS), and will consult stakeholders who could be affected by a proposed byelaw. Permits may be issued to allow certain levels of activity, which a byelaw would normally prohibit.

Devolved Governments

The Crown Estate remains the responsible authority for granting offshore leases within 12 nm of the coastline of Scotland and Wales.

For areas beyond the 12nm Territorial Sea and for the management of all other marine development permits (aside from the Crown Estate lease), The Marine and Coastal Access Act 2009 provides that the marine plan authorities for the UK devolved areas are as follows:

- For the English inshore region, the Secretary of State
- For the English offshore region, the Secretary of State
- For the Scottish offshore region, the Scottish Ministers
- For the Welsh inshore region, the Welsh Ministers
- For the Welsh offshore region, the Welsh Ministers
- For the Northern Ireland offshore region, the Department of the Environment in Northern Ireland.



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Scotland
The Scottish Government has helpfully included in Section 37 of the Marine (Scotland) Act 2010, an obligation for Scottish Ministers to grant any application made to them for a marine licence for laying of most types of submarine cables in the Scottish marine area, albeit with reasonable conditions that may be attached as set out in the Act (regarding for example, precaution, reporting obligations, removal).

Under Section 36 of the Electricity Act 1989 and the Electricity Act 1989 (Requirement of Consent for Offshore Generating Stations) (Scotland) Order 2002, consent (Section 36 Consent) is required from the Scottish Ministers to construct and operate an offshore generating station with a capacity of over 1 MW which is located in Scottish Territorial Waters or the UK REZ insofar as within the consenting jurisdiction of the Scottish Ministers.

The Scottish Government has acknowledged the planning challenges posed in the offshore area, including the laying of submarine cables, and is presently working on a National Marine Plan to address issues and streamline processes. The intention of the Scottish government is that eventually all marine licensing can be dealt with by a "one stop shop" system. Under the present regime where UK offshore leases are still administered by Crown Estates, the creation of such system may not be entirely possible.

Marine Scotland, an agency of the Scottish Government, determines Marine Licence applications in Scottish waters for both cables and offshore wind farms.

For offshore wind farms, Marine Scotland is also responsible for determining applications for generating licenses (under Section 36 of the Electricity Act 1989). Note: This is the role of the MMO for OREIs less than 100 MW in Scotland.

Wales
Wales is within the jurisdiction of the Marine and Coastal Access Act 2009 and its position on submarine cables therefore broadly mirrors that of England. Wales is currently working closely with DEFRA on the process of producing its marine plan.

From April 2011, the Marine Consents Unit of the Welsh Assembly Government (WAG) has been responsible for marine licensing under the MCAA within Welsh Territorial Seas. Licensing outside Welsh Territorial Seas is managed by the MMO.

Northern Ireland
In Northern Ireland, licensing within the Territorial Seas is managed by the Northern Ireland Department of Environment in conjunction with the Northern Ireland Environment Agency.

Isle of Man
The Territorial Seas (up to the 12 mile limit) was acquired by the Isle of Man Government from the United Kingdom through the UK Government and The Crown Estate in 1991. The Territorial Sea Committee (TSC) is a cross-governmental committee which was set up to manage the Isle of Man's interests following the purchase, replacing Crown Estates and other UK-based authorities.

Ownership of the Territorial Seas is vested in the Department of Infrastructure and managed by the Harbours Division. The TSC is chaired by the Director of Harbours and consists of officers from all Departments of Government. The task of the TSC includes management of the laying of cables and enquiries regarding an offshore wind farm. Any proposal to site a cable in Isle of Man waters is subject to Manx legislative requirements that include environmental assessments and a lease of easement from the Department of Transport (rather than from The Crown Estate in the case of the UK). The Island currently receives approximately £350,000 annually for cables (and pipelines, hydrocarbon exploration) passing through the area.

Applicable Manx legislation is the Submarine Cables Act 2003.

The Act codifies the process for obtaining approval for submarine cables in Manx waters and sets out the framework for the approval. This broadly mirrors the provisions generally included in The Crown Estate's licences. The main difference between The Crown Estate procedure and the Manx procedure as set out under the Act is that the Act is binding legislation, having legal effect for all persons, whereby The Crown Estate's licence regime is a private arrangement binding only on the parties to the agreement.

A further interesting point in the Act is its creation of a criminal offence for intentional/reckless damage of (any) cables. A detailed procedure is set out regarding the prosecution of offenders. As we have seen above (regarding UK), the situation regarding damage to cables in UK waters is unclear as to which sort of cables are covered.

The requirement for bi-lateral cable crossing indemnification is also briefly covered by the act for crossings within territorial waters.

The Manx regime for obtaining authorisation to lay a submarine cable is very clear, unambiguous and transparent. In view of the legislative backdrop, decision makers appear to be supported to make authoritative, democratic decisions regarding applications.

The Act is supported by a series of regulations:
- **The Submarine Cables (Application for Authorisation)**

Regulations 2004 clearly sets out the application procedure and gives information on the details required for the application.

- **The Submarine Cables (Authorised Persons) Regulations 2004** prescribes the powers and duties of authorised persons for the purpose of enforcing the Submarine Cables Act 2003 and regulations, overseeing works and other activities relating to submarine cables in territorial waters.
- The Submarine Cables (Fees) Regulations 2004 details the application and fees process. An application currently costs £18,000 payable to the Department of Transport, plus and inspection fee of £70/hour for any requisite safety inspections.
- The Submarine Cables (Safety) Regulations 2004 sets a safety exclusion zone of 250m around each cable and criminalises the act of breaching the safety zone requirements, without prior authorisation.

http://www.gov.im/transport/harbours/legislation.xml

Channel Islands
The legal regimes in Jersey and Guernsey differ, with Jersey being lead party in the area of submarine cables.

Jersey
Jersey's marine law is heavily influenced by either UK (UK Management Agreement) or France (Granville Bay Treaty).

Harbours (Protection of Cables in Territorial Waters) (Jersey) Regulations 2010
With regard to submarine cable matters, the French influence is dominant. The UK is silent on submarine cable matters in Jersey. Jersey has recently enacted the Harbours (Protection of Cables in Territorial Waters) (Jersey) Regulations 2010, which refers expressly to the cable connection with France.

The Regulation makes it an offence to carry out prohibited activities within 1000m either side of the electricity cable to France, but does not detail an application procedure for laying a submarine cable.

It is unclear which level of protection would be afforded to other similar (non-French) cables in Jersey waters.

Guernsey, Sark, Alderney
There is much less legislation in the other islands and there is no reference to the submarine cable regime applicable here.

The Jersey Fisheries and Marine Resources Panel make reference to a Marine Management Agreement with Guernsey being concluded and it appears that discussions on this topic are underway. Given the growing relevance of wind farms in the vicinity of the Islands and Jersey's recent attention to cables in its territorial waters, there is a possibility that such matter could be included in a New Jersey-Guernsey Management Agreement.

Appendix D – Guidelines reports and studies

Guidelines, reports & studies

This appendix records the relevant content from the various sources of reference material reviewed during the course of this study. Where applicable these references have been used to form our conclusions and recommendations contained within the body of the report.

The reference documents below are grouped by author/publishing body.

Marine & coastguard agency (mca)

http://www.dft.gov.uk/mca/mcga07-home/shipsandcargoes/mcga-shipsregsandguidance/marinenotices.htm

Merchant Shipping Notices (MSNs)

MSN 1221 (DP Vessels & Dangers to Divers operating from DP Vessels)

This document highlights the need for other vessels to give DP vessels engaged in diving, a wide berth particularly when operating close to fixed structures.

A recommendation is included that passing vessels should provide a ½ mile clearance if unable to reduce speed.

http://www.dft.gov.uk/mca/mcga-mnotice.htm?textobjid=9B674D9F5152A114

MSN 1290 (Offshore Installations – Observance of Safety Zones)

Whilst not directly relevant to this study as it focuses on safety zones around oil and gas installations and the Petroleum Act 1987, it does clearly state which vessels may enter a safety zone and under what circumstances. This is of interest to our study as cable vessels are specifically mentioned. MSN 1290 states:

Safety zones can only be entered under the following conditions:

(i) With the consent of the Secretary of State, or a person authorised by him
(ii) To lay, test, inspect, repair, alter, renew or remove a submarine cable or pipe-line
(iii) To provide services for an installation within the zone or to transport persons to or from it, or under authorisation of a government department to inspect it
(iv) For a general lighthouse authority vessel to perform duties relating to the safety of navigation
(v) To save life or property, owing to stress of weather or when in distress.

http://www.dft.gov.uk/mca/mcga-mnotice.htm?textobjid=3FA78A522EFAA2D5

Marine Guidance Notes (MGNs)

MGN 365 (Human Element Assessment Tool) introduces two human element assessment tools developed by the MCA and made freely available to industry as a measure designed to improve safety at sea. While the application is aimed at the shipping industry in general, some of the content is relevant to our examination of proximity issues and in particular the following statement made by the MCA:

"The prime causal factor in nearly all shipping accidents can be attributed to human element issues occurring at some stage in the ship life cycle. Addressing technological failures alone will lead only to a limited improvement in safety. In order to make significant improvements in safety performance much greater attention must be paid to human element issues".

http://www.dft.gov.uk/mca/mcga07-home/shipsandcargoes/mcga-shipsregsandguidance/marinenotices/mcga-mnotice.htm?textobjid=A0CF713D2499E59D

MGN 371 (OREIs – Navigational Practice, Safety and Emergency response)

Whilst the recommendations in this guidance note are intended primarily for OREI developers seeking consent for marine works there are a number of points relevant to this study:

Consent cannot be granted for an OREI, which is likely to interfere with the use of "recognised sea lanes essential to international navigation". This statement highlights the basic principle of innocent passage contained within UNCLOS.The Guidance Note sets out the minimum requirements for a Navigation Risk Assessment (NRA) to be carried out by the developer as part of the consenting process, which is to include an assessment of proximate developments and marine activities. It is noted that submarine cables are not specifically mentioned.

The document recommends that the effects of tidal streams and weather combining with the physical constraints of the wind farm are included in any NRA, together with any negative effects on communications, radar and positioning systems posed by the wind farm structures.

A recommended 22 metres minimum clearance between wind turbine blade tips and the mean high water springs (MHWS) sea level is specified with the qualification that this may be adjusted providing the clearance is suitable for the vessel types known to operate in the area.

The option for a wind farm developer to apply for a site to be designated 'An Area to Be Avoided' (ATBA) is highlighted. An ATBA is a routeing measure comprising an area within defined limits in which either navigation is particularly hazardous or it is exceptionally important to avoid casualties and which should be avoided by all ships or certain classes of ships.

Reference is made to SI 2007 No 1948 "The Electricity (Offshore Generating Stations) (Safety Zones) (Application Procedures and Control of Access) Regulations 2007 as the regulations governing the use of safety zones for OREIs.

Minimum recommended emergency arrangements for OREIs are included with the following points relating to emergency shutdown facilities of relevance to this study:

The OREI should be designed and constructed to satisfy the following requirements for emergency shutdown:

- All OREI generators and transmission systems should be equipped with control mechanisms that can be operated from the OREI Central Control Room or through a single contact point
- Throughout the design process for an OREI, appropriate assessments and methods for safe shutdown should be established. The OREI control mechanisms should allow the Control Room, single contact point Operator to fix and maintain the position of WTG blades, nacelles and other appropriate OREI moving parts

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- This same Operator must be able to immediately effect the control of offshore substations and export cables
- The Central Control Room, or mutually agreed single contact point, should be manned 24 hours a day.

Finally a recommended method for determining safe distances for passing traffic is provided with a template for assessing the various factors. While this template is intended for the interaction between a wind farm development and passing shipping, the approach is worth studying in the context of determining proximity limits for wind farms and submarine cables.

http://www.mcga.gov.uk/mca/mgn371.pdf

MGN 372 (OREIs – Guidance to mariners)

MGN 372 is aimed at mariners navigating in proximity to OREIs and offers guidance on safe navigational practices and provides detailed information on the characteristics of wind farms and the service vessels operating around them.

Navigational routeing factors are summarised as:

- Turbine spacing
- Effects on charted water depths
- Local effects on tidal streams
- Submarine cables and limitations on anchoring
- Potential for effects on communications and navigation systems
- Air draft limits in relation to rotor tip heights
- Wake effects from wind turbines (note potential for effects on DP wind sensors)
- Visibility of partially submerged wave energy converters (WECs) and tidal energy converters (TECs)
- Extend of WEC and TEC mooring spreads
- Existence of Safety Zones around structures.

http://www.mcga.gov.uk/mca/mgn372.pdf

Marine Information Notes (MINs)

MIN 357 (Guidance for Avoiding Dangerous Situations in Adverse Weather)

This Marine Information Notice contains useful guidance on the frequency of waves significantly larger than the significant wave height (Hs) used in weather forecasting and widely used to describe working limits for vessels and deployment of subsea equipment. MIN summarises technical research findings in practical terms as follows:

A vessel on a sheltered route might expect to encounter a wave of twice the significant height about once in 2½ hours. In exposed conditions, one might expect to encounter a wave of twice the significant height about once in 5½ hours. It must be understood, however, that this does not mean that an encounter with a significantly larger wave will be followed by a period of 2½ or 5½ hours' relative calm because this two thousandth wave may arrive at any time. There is also some evidence that a combination of two or more weather systems acting together may produce effects, which can either reduce or increase the height of significantly larger waves.

http://www.dft.gov.uk/mca/min357-2.pdf

MCA Report – North Hoyle Wind Farm Electromagnetic Effects

The Maritime & Coastguard Agency (MCA) and NPower Renewables published the results of trials undertaken to assess the impact of offshore wind farms on marine radar, communications and positioning systems. The trials took place at the North Hoyle wind farm off the coastline of North Wales.

In brief, the report concludes that there is minimal impact by offshore wind farms on:

- Communications systems (VHF radios and mobile phones)
- Automatic Identification System (AIS) of ships
- Reception of Global Positioning System (GPS) data by ships
- Magnetic compasses other than that that could be reasonably expected.

It also concludes that:

'The wind farm may be clearly and readily identified at distance by radar but that erroneous and spurious radar returns may be generated in closer proximity to the turbines – similar effects may be found on land-based marine radars'.

http://www.dft.gov.uk/mca/mcga-safety_information/nav-com/offshore-renewable_energy_installations/mcga_north_hoyle_wind farm_report.htm

UK Hydrographic Office (UKHO)
Annual Summary of Notices to Mariners

The Annual Summary of Notices to Mariners provides details and locations of a number of offshore features, which may affect surface navigation, and the planning of OREI and cable system installations including the following:

- Military Practice and Exercise Areas as detailed on the PEXA navigation chart series for UK waters
- Mine Laying & Countermeasure Exercise Areas
- Protected, Historic and Dangerous Wreck Sites
- Traffic Separation Schemes
- Marine Environmental High Risk Areas (MEHRAs).

http://www.ukho.gov.uk/productsandservices/martimesafety/pages/nmpublic.aspx

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Subsea cables UK
http://www.subseacablesuk.org.uk

Subsea Cables UK formerly the United Kingdom Cable Protection Committee (UKCPC), publishes guidelines (aligned to a similar series of recommendations published by the ICPC) for the attention of members and other seabed users.

Guidelines for Fishing Liaison #1
Guideline #1 provides recommendations for liaison between cable owners and fishermen, which could apply equally to wind farm developers and fishermen and covers:

- The appointment of Fisheries Liaison Representatives (FLRs)
- Recommended liaison practices and acknowledgement that fisheries liaison is often a consent condition for a project
- Recommendations for internal company protocols to ensure FLRs are able to promulgate up to date information on cable operations
- The use of FLRs offshore
- Assistance given to fishermen offshore
- Actions in the event of fishing gear fouling a cable
- Compensation arrangement in the event of lost or damaged gear
- Compensation arrangements in the event of static gear being moved to facilitate cable operations.

Guidelines for Offshore Liaison #4
This document provides guidance on offshore liaison in general and includes the following principles for cable owners seeking to protect their assets:

- Liaise with other seabed users prior to, and during installation, and promote the presence of their subsequently installed submarine plant
- Provide third parties/authorities/organisations with information regarding proposed or installed submarine plant when these third parties require approval for marine activities over, through or adjacent to members' submarine cables, associated seabed installations and other interests.

The principle of using a risk-based approach to proactive liaison is recommended i.e. by identifying the main risks to cable integrity in order to target liaison efforts before, during and after cable installation works.

Guidelines for Proximity of Wind Farm Developments & Submarine Cables #6
The current guideline #6 on proximity of wind farm developments and submarine cables is currently under review and this report is part of that review process.

Guidelines for Cable Decommissioning #8
This document recommends the following principles for cable decommissioning:

- Specific decommissioning requirements should be determined on a case by case basis in accordance with a decommissioning strategy
- Any cable parts left on the seabed after a cable is decommissioned always remain the property of, and liability of the cable owner. This obligation originated in the Submarine Telegraph Act of 1885
- Cables above the low water mark should generally be recovered
- Cables between the low water mark and 12 mile limit generally recover the cable if it is exposed, shallow buried or deemed a hazard to other seabed users (all subject to The Crown Estate licence conditions)
- Cables outside the 12 mile limit should generally be left but can be recovered if it is exposed, shallow buried or deemed a hazard to other seabed users (all subject to The Crown Estate licence conditions)
- Any decommissioning should be agreed with the regulatory and consenting authorities before commencing decommissioning work
- Disposal of recovered cable and treatment of cable ends should be in accordance with ICPC Recommendation 1
- When determining a decommissioning strategy, a risk assessment should be used to evaluate the risks to other seabed users if the redundant cable is left in situ
- A search on legislative requirements for decommissioning should be made when determining a decommissioning strategy
- One area where a cable owner will have an ongoing liability is to be responsible for the recovery of any cable section that is only left on the seabed because it is trapped under a crossing of another in-service cable or pipeline. In this instance, it is best industry practice for the owner to engage in a dialogue with the owner of the other product, and to agree a future recovery strategy. Liability remains with the original cable owner unless ownership is legally transferred.

Renewables UK (RUK)
http://www.renewableuk.com

Renewables UK Report – Offshore Wind – Staying on Track

This report provides a forecast for offshore wind farm development to 2015 and predicts a relatively steady build rate of 0.6 GW-1.0 GW per annum.

Renewables UK Report – Wave & Tidal Energy in UK – State of the Industry
This 2011 report provides a forecast for offshore wave and tidal development to 2020 and reports that as of March 2011, the UK had 3.4MW of installed marine energy capacity year). A total of 7.4MW of prototypes are in the advanced stages of planning and fabrication for deployment in 2011. Looking further ahead, a total of 11MW of marine energy projects have been awarded consents and an additional 23MW has entered the planning system. The report recognises that development potential in the next decade will depend heavily on the degree of financial assistance provided to developers but predicts 2.17GW of marine energy capacity is possible by 2020. It is expected that the Pentland Firth and Orkney Waters Round One sites annual development plan will peak in 2019.

Best Practice Guidelines – Consultation for Offshore Wind Developments
Whilst this set of guidelines was produced under Renewable UK's former name The British Wind Energy Association, the consultation principles remain valid today. It is interesting to note that this document from 2002 does not focus on consultation between wind farm developers and cable owners.

International Cable Protection Committee (ICPC)
http://www.iscpc.org/

The ICPC publishes recommendations for the attention of members and other seabed users. The preamble contained in each guideline summarises the scope and purpose of these documents very clearly as follows:

An International Cable Protection Committee Ltd ("ICPC") Recommendation ("Recommendation") implies a consensus of those substantially concerned with its scope and provisions. A Recommendation is intended as a guide zto aid cable owners and other seabed users in promoting the highest goals of reliability and safety in the submarine cable environment. The existence of a Recommendation does not in any respect preclude anyone, whether he has approved the Recommendation or not, from laying or repairing undersea cables or employing procedures to these ends which may be required by the ordinary practice of seamanship or by the special circumstances of each case, but which may not be conforming to the Recommendation.

Recommendation #1 – Recovery of Out of Service Cables
Recommendation #1 details guidance for operations involving out of service (OOS) and redundant cables with the following key points included:
- When clearing an OOS cable for a new cable installation, a 1000m clear corridor is recommended
- Where sections of OOS cables are left in situ, methods minimising impacts on other seabed users are recommended including the use of clump weights or cable ends
- The rights of ownership and liabilities remain unchanged when a cable is declared OOS.

Recommendation #3 Cable Crossing Criteria for Telecommunications & Power Cables
This ICPC Recommendation provides an overview of all the technical and commercial issues to be considered when planning and executing a cable crossing. While cable crossings are not directly relevant to this study, the issues summarised are worth reviewing in the context of wind farm/submarine cable proximity. In addition the recommended crossing agreement contents provide a basis for any bi-lateral agreement between marine asset owners planning work in close proximity. The recommended contents can be summarised as follows:

- Clauses to define the liabilities and rights of both parties
- The exclusion/inclusion of consequential losses
- Definition of a specific area in the vicinity of the crossing within which the Agreement will operate
- A general statement of the method of installation of the new asset. It is not recommended that installation procedures be included in the body of the Agreement as they may require alteration prior to or during the operation. They may of course be included in the document as an appendix
- Future maintenance of both assets. This may include the method by which notification of operations by each party is given to the other
- Definition of the expiry of the Agreement
- Provision of representatives from one party to the other party's operations and their rights and limitation of their authority.

Recommendation #7 Offshore Civil Engineering Works in Proximity to Live Cables
Recommendation #7 provides general guidance on practices to be adopted when civil engineering work is planned in proximity to an existing cable as summarised below:

- Liaison between both parties at the planning stage recommended to identify any issues that might impact on design or location of the new structure
- The position of the cable should be positively confirmed (by ROV if necessary)
- Key contacts and communications protocols should be established
- Timing and extent of site works to be notified to the cable party
- Arrangements for managing the commercial impacts resulting from such works are discussed including the use of a binding legal agreement between both parties
- Liaison during the works and the presence of a cable representative on site is recommended
- As built data for the new structure should be provided to the cable party on completion.

Recommendation #13 Proximity of Wind Farm Developments and Submarine Cables
Recommendation #13 is aligned to the Subsea Cables UK Guideline #6 which is currently under review and revision.

European Wind Energy Association (EWEA)
http://www.ewea.org/

Report – Offshore Electricity Grid Infrastructure in Europe
This report published in October 2011 details the findings of the Offshore Grid project – a techno-economic study funded by the EU to investigate how an offshore grid could be developed in the North and Baltic Seas.

The report recommends the connection of wind farm clusters to offshore hubs rather than the current practice of individual export cables to shore but recognises that there are significant political, financial and technical hurdles to overcome.

International marine contractors association (IMCA)
http://www.imca-int.com/

IMCA M103 (Rev 1, Dec 2007) – **Guidelines for the Design and Operation of DP Vessels**
IMCA M103 provides the industry standard guidelines for the design and operation of DP Vessels and covers operating principles, vessel types, communications, manning and operator competencies.

IMCA Report M181 – Analysis of Station Keeping Incident Data
IMCA Report M181 provides an analysis of DP station keeping incidents for the period 1994-2007 focusing on DP 2 and DP 3 vessels. Whilst the focus on DP operations in our proximity study is on DP 1 and DP 2 vessels, there are a number of conclusions that are relevant here, namely:

- The majority of DP incidents had more than one secondary cause and that the more serious incidents tended to have more secondary causes than the less serious incidents. These additional secondary causes were usually associated with human factors such that over 97% of incidents might have been reduced or eliminated by attention to these human factor related causes
- For thruster related incidents, a control failure of one thruster caused on average 17.5% of reported DP incidents. Most of these come from the pitch control of thrusters; none were found from speed control failures
- For operator error incidents the DPO triggered incidents dominate, as expected.

Figure D-1 summarises the trigger types and frequencies for DP incidents and highlights the following:

Figure D-1 IMCA Report M181 DP incident causes 1994-2005

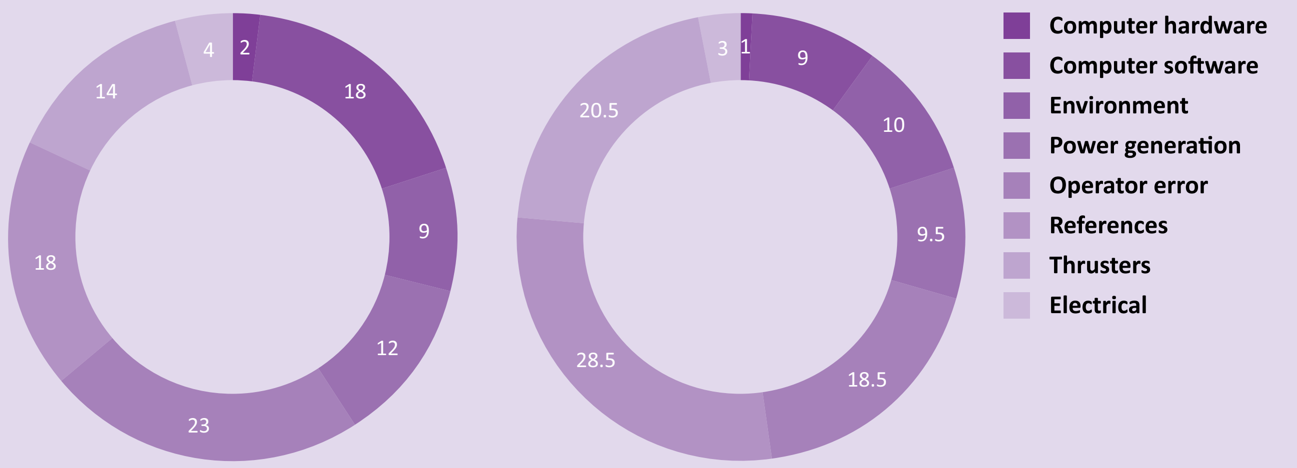

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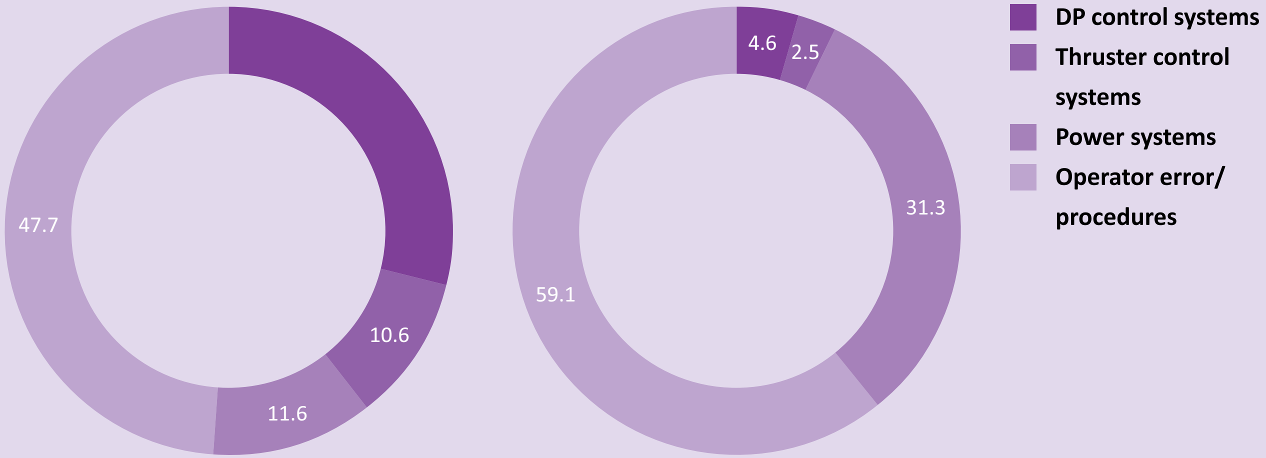
Figure D-1 IMCA Report M181 DP incident causes 1994-2005

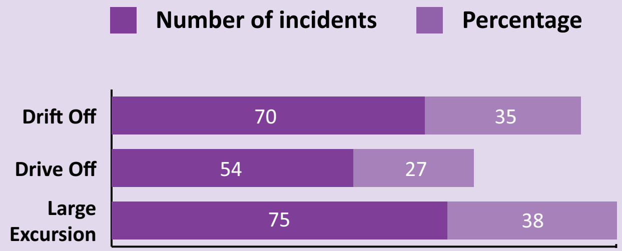


- Computer software failures are more likely to cause an incident than computer hardware
- Power generation and environmental failures caused roughly the same percentage of incidents
- Ratio of incidents was very similar for electrical failures and environmental failures
- References are more frequently the cause of less serious incidents because work is being carried out where a position loss is considered to be an acceptable risk (e.g. ROV work away from structures).

DPVOA REPORT 115 – Risk analysis of Collisions with Installations

Based on historical incident data (up to 1994) for DP vessels of class 2 & 3 operating in proximity to oil and gas installations, this report provides a detailed analysis of the incident types and causal categories.

Figure D-3 Distribution of DP incident types from DPVOA 115



While it should be born in mind that this report is from 1994, it is based on a relatively small number of incident reports and significant technical advances have be made since that time, Figure D-2 illustrates the significance of human error in DP station keeping incidents.

A further data set of interest to this study is the distribution of the three types of DP incidents as illustrated in Figure D-3 below which shows a reasonably even spread.

Department for Business Inovation & Skills (BIS)

Review of Cabling Techniques Applicable to the Offshore Wind Farm Industry

This report is focused on the environmental impacts of offshore wind farm cable operations but does provide some useful background information to this study with respect to;

- Power and telecommunications cable types and specifications
- Installation, maintenance and decommissioning techniques.

www.bis.gov.uk/files/file43527.pdf

The Crown Estate

http://www.thecrownestate.co.uk/

Round 3 Zone Appraisal & Planning

This guidance document published by The Crown Estate provides information on the Zone Appraisal and Planning (ZAP) process for Round 3 wind farm zones. One of the main objectives of the non-statutory ZAP approach is to encourage early and ongoing stakeholder engagement and project planning at zonal level rather than only at wind farm by wind farm level.

Whilst there is no formal requirement to undertake the ZAP process, and much of the Zone level learning will be incorporated directly into Project-level documentation, the common elements of work anticipated in Round 3 development strategies include the following relevant to this study:

- A GIS and data management strategy/policy
- An initiative to broadly characterise and obtain baseline information for the environmental aspects of the Zone (physical, biological, socio-economic)
- A method/protocol to adequately consider Zone cumulative and in-combination impacts
- A process that identifies integrates and balances the factors that influence wind farm development in a Zone to assist in Zone Planning
- A risk-based model to identify and define Projects to take forward into EIA for IPC consent
- Establishment of stakeholder relationships and development of an effective stakeholder engagement strategy for the Zone and subsequent Projects
- A Zone consenting strategy based on a thorough understanding of the Zone development opportunities and constraints.

The document discusses the key environmental and engineering constraints that influence development and identifies '*areas within the Zone in which offshore wind farm development may be less favourable (e.g. oil and gas platforms, pipeline routes*' as one and further states;

'In some cases, the spatial footprint of these constraints may be negotiated to accommodate development needs, but this would require further investigation and be assessed on a constraint-by-constraint basis with the relevant authorities and stakeholders'.

Key stakeholders are tabulated in the document for each impact area and one stakeholder is identified for cables – Subsea Cables UK (formerly UKCPC).

Report – Round 3 Offshore Wind Farm Connection Study

This investigation carried out by Senergy, Econnect and National Grid for The Crown Estate presents an indicative set of optimum offshore and onshore electricity transmission network reinforcements required for the connection of up to 25GW of the Round 3 wind farm zones (including indicative export cable routes from each zone).

Telecommunications Cables Decommissioning Guidelines

This guidance document states:

In the absence of a statutory regime for the decommissioning of submarine telecommunication cables the extent of infrastructure allowed to remain following the permanent cessation of use, is at the discretion of The Crown Estate, acting reasonably. The general principle is one of complete removal but we recognise that in certain circumstances this may not be appropriate. The Crown Estate expects all apparatus to be properly decommissioned and requires all proposed decommissioning works to comply with the relevant sections of recommended policy/guidelines for similar offshore developments and the conditions of seabed consents.

The document states that in the absence of a statutory regime, The Crown Estate will seek to apply the DECC and IMO guidelines for the decommissioning of offshore installations as applicable to submarine telecommunications cables.

Lease Agreement Templates

The Crown Estate has standard Lease Agreement templates for wind farm, telecommunications cable and power cable developments.

The three templates are currently under internal review and therefore not appended to this document. When available (via The Crown Estate's website) the templates should be referenced in conjunction with this study.

International association of lighthouse authorities

http://www.iala-aism.org/iala/index.php

Recommendation O-139 – Marking of Man-Made Offshore Structures

This document is for the guidance of stakeholders such as national administrations and lighthouse authorities as well as contractors and developers of the offshore structures.

Markings for offshore wind farms, tidal generators and wave energy generators are all included.

The recommendations apply to all structures that present an obstruction to navigation. Further details of markings for renewable energy structures are contained in Section 2.11.

The Crown Estate
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