South West of England Regional Development Agency

Wave Hub
Appendix L to the Environmental Statement

June 2006

Halcrow

South West *of* England
Regional Development Agency

Navigation Risk Assessment
Wave Hub Development

Prepared by:	Anatec UK Limited
Presented to:	Halcrow Group Limited
Date:	31 May 2006
Revision No.:	02
Ref.:	A1401-HA-RA-1

Anatec	**Cambridge Office**	**Aberdeen Office**
Address:	16 Ward Way, Witchford, Ely, Cambs, CB6 2JR, UK	57 Anderson Drive, Aberdeen, AB15 4UA, Scotland, UK
Tel:	01353 661200	01224 313355
Fax:	0709 2369326	0709 2367306
Email:	info@anatec.com	aberdeen@anatec.com

This study has been carried out by Anatec UK Ltd on behalf of Halcrow Group Ltd. The assessment represents Anatec's best judgment based on the information available at the time of preparation. Any use which a third party makes of this report is the responsibility of such third party. Anatec UK accepts no responsibility for damages suffered as a result of decisions made or actions taken in reliance on information contained in this report.

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Background

Anatec were commissioned by Halcrow Group Ltd (Halcrow) to perform a shipping and navigation assessment of the proposed Wave Hub located off Hayle in north Cornwall. This assessment informs the Environmental Impact Assessment (EIA) for the proposed Wave Hub.

This report presents an assessment of the potential impact of the proposed development on the routeing and safe navigation of vessels in the vicinity. The assessment is primarily based on the 28 days of vessel traffic survey data collected in the area in 2005 as well as consultation with stakeholders.

The report presents an analysis of the traffic data in the area, investigating existing route positions, traffic levels, timelines and encounter levels. A qualitative and quantitative assessment is presented on the likely potential impact on navigation associated with the proposed Wave Hub.

It should be noted that this assessment is based on the revised location of the proposed Wave Hub. The original proposed deployment area was relocated following consultation with navigation stakeholders (Trinity House, MCA, DfT and Chamber of Shipping) due to the fact that there was considered to be a greater potential for impact on navigation at the original deployment area due to its closer proximity to major shipping lanes compared with the revised (proposed) deployment area. A comparison of the original and revised site locations is presented in Appendix B.

A hazard identification exercise has been performed with project personnel and consultees for the project to document all the hazards that are likely to exist in relation to marine aspects of the development as well as to identify potential mitigation measures to be considered.

It should be noted that given that the Wave Energy Converter devices which will be used at the site are as yet unspecified, each device will require a device-specific risk assessment to be undertaken. This document includes a template for what should be included in such an assessment. Device-specific assessments will need to be submitted to the relevant stakeholders prior to consent (with respect to navigation issues) being given for a specific device to be installed and connected to the Wave Hub infrastructure.

1.2 Scope of work and methodology

The original scope of work was to undertake a fit-for-purpose navigational risk assessment in accordance with MGN 275 (M) (Aug 2004) (Ref. i). The study has also been carried out taking into account the Department of Trade and Industry (DTI) methodology written for windfarms (Ref.ii) which was in draft at the time of this study being commissioned.

An overview of the methodology applied in the assessment is presented below (Figure 1.1).

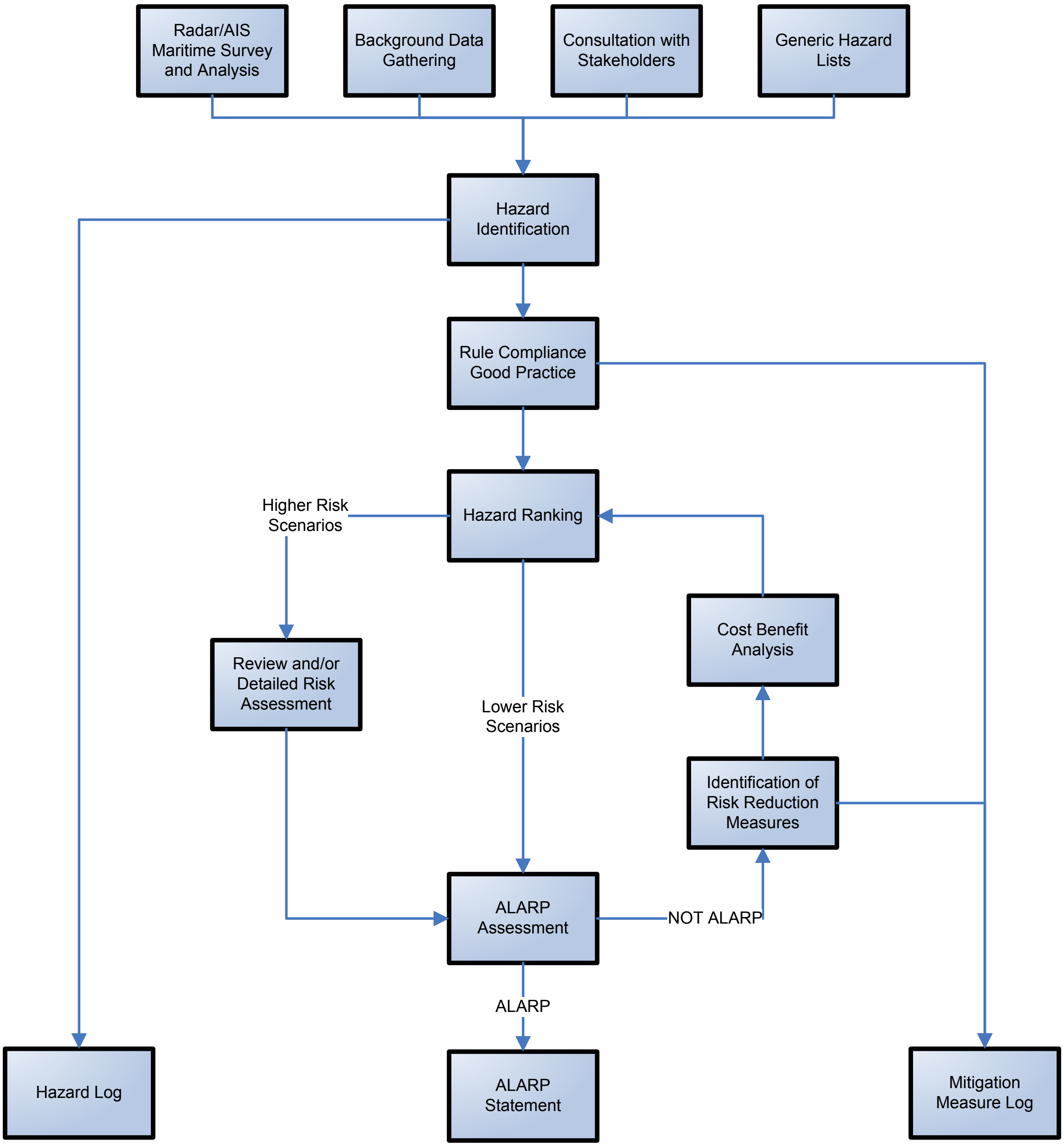


Figure 1.1 Overview of methodology for navigation risk assessment

More information on the regulations and guidance being addressed is presented in Section 2.

1.3 Abbreviations

The following abbreviations are used in this report:

AIS	-	Automatic Identification System
ALARP	-	As Low as Reasonably Practicable
ALB	-	All-weather Lifeboat
ATBA	-	Area To Be Avoided

AtoN	-	Aid to Navigation
CA	-	Cruising Association
CAA	-	Civil Aviation Authority
CBA	-	Cost Benefit Analysis
CPA	-	Closest Point of Approach
DEFRA	-	Department for Environment, Food and Rural Affairs
DfT	-	Department for Transport
DSC	-	Digital Selective Calling
DTI	-	Department of Trade and Industry
DWT	-	Dead Weight Tonnes
EIA	-	Environmental Impact Assessment
ETV	-	Emergency Towing Vessel
FN	-	Frequency-Number
FSA	-	Formal Safety Assessment
GPS	-	Global Positioning System
HF	-	High Frequency
HSE	-	Health and Safety Executive
HW	-	High Water
IALA	-	International Association of Marine Aids to Navigation and Lighthouses
ILB	-	Inshore Lifeboat
ICES	-	International Council for the Exploration of the Seas
IMO	-	International Maritime Organisation
km	-	Kilometre
LAT	-	Lowest Astronomical Tide
MAIB	-	Marine Accident Investigation Branch
MBS	-	Maritime Buoyage System
MCA	-	Maritime and Coastguard Agency
MGN	-	Marine Guidance Note
MHWS	-	Mean High Water Springs
MoD	-	Ministry of Defence
MRCC	-	Maritime Rescue Co-ordination Centre
MRSC	-	Maritime Rescue Sub-Centre
MW	-	Mega-Watt
NCI	-	National Coastwatch Institution
nm	-	Nautical Miles
OBO	-	Oil / Bulk / Ore
OREI	-	Offshore Renewable Energy Installations
PPE	-	Personal Protective Equipment
RAF	-	Royal Air Force
RCM	-	Risk Control Measure
RNLI	-	Royal National Lifeboat Institution
RYA	-	Royal Yachting Association
SAR	-	Search and Rescue
SFI	-	Sea Fisheries Inspectorate

SRR	-	Search and Rescue Region
THLS	-	Trinity House Lighthouse Service
TSS	-	Traffic Separation Scheme
UHF	-	Ultra High Frequency
UKCS	-	United Kingdom Continental Shelf
VHF	-	Very High Frequency
VMS	-	Vessel Monitoring Service

2. REGULATIONS AND GUIDANCE

2.1 MCA Marine Guidance Note 275

This guidance note (Ref. i) highlights issues that need to be taken into consideration when assessing the impact on navigational safety from offshore renewable energy developments proposed for United Kingdom internal waters, territorial sea or in a Renewable Energy Zone (when established) beyond the territorial sea.

Specific annexes address different issues such as:

- Annex 1: Site position, structures and safety zones
- Annex 2: Developments, navigation, collision avoidance and communications
- Annex 3: Safety and mitigation measures recommended for OREI during construction, operation and decommissioning
- Annex 4: Search and rescue matters

2.2 DTI methodology

This document (Ref. ii) has been produced by the DTI with the co-operation of the DfT as a Methodology for Assessing the Marine Navigational Safety Risks of Offshore Windfarms. It is noted that whilst this has been written for offshore windfarms, the same principles can be applied to wave energy developments. Its purpose is to be used as a template by Developers in preparing their navigation risk assessments, and for Government Departments to help in the assessment of these.

The Methodology is centred around risk controls and the feedback from risk controls into risk assessment. It requires a submission that shows that sufficient risk controls are, or will be, in place for the assessed risk to be judged as broadly acceptable or tolerable with further controls or actions.

The key features of the Marine Safety Navigational Risk Assessment Methodology are risk assessment (supported by appropriate techniques and tools), creating a hazard log, defining the risk controls (in a Risk Control Log) required to achieve a level of risk that is broadly acceptable (or tolerable with controls or actions), and preparing a submission that includes a Claim, based on a reasoned argument, for a positive consent decision.

Table 2.1 Key features of the DTI methodology (Ref. ii)

ID	Description
1	Define a scope and depth of the submission proportionate to the scale of the development and the magnitude of the risk
2	Estimate the "base case" level of risk
3	Estimate the "future case" level of risk
4	Create a hazard log
5	Define risk control and create a Risk Control Log
6	Predict "base case with windfarm*" level of risk
7	Predict "future case with windfarm*" level of risk
8	Submission

* As noted above, the DTI methodology is prepared for windfarm development but can be applied for the proposed Wave Hub development

2.3 Aids to Navigation

The Wave Hub deployment area will be marked according to IALA guidelines. The Corporation of Trinity House exercises control over the marking of Renewable Energy Installations in the waters of England and Wales. The Aids to Navigation (AtoN) required for the site during the different phases of construction, operation and decommissioning will be specified by Trinity House. The operator is also required to meet the availability, reliability and casualty response criteria laid out by Trinity House (Ref. iii).

3. DETAILS OF THE WAVE HUB DEVELOPMENT

3.1 Introduction

This section presents details of the Wave Hub deployment area. It is based on the revised location for the deployment which has been changed from the original proposed site to mitigate the potential impact on shipping whilst considering both the economic and technical feasibility, as well as other constraints (Ref. iv).

3.2 Wave Hub deployment area

The proposed Wave Hub deployment area is located approximately 9 nautical miles (nm) NNW off St. Ives Head in Cornwall. The total area of the deployment area is 8km^2 (4km x 2km). The corner coordinates of the deployment area are presented in Table 3.1.

Table 3.1 Co-ordinates of Wave Hub deployment area (WGS 84)

Corner	Latitude	Longitude
NW	50° 22’ 50” N	005° 37 ’46” W
NE	50° 22’ 59” N	005° 36 ’06” W
SE	50° 20’ 52” N	005° 35 ’34” W
SW	50° 20’ 42” N	005° 37 ’14” W

A chart overview of the site boundary is presented in Figure 3.1. The charted water depths in the area around the site ranges from approximately 40 to 55 metres LAT (43m to 53m within site).

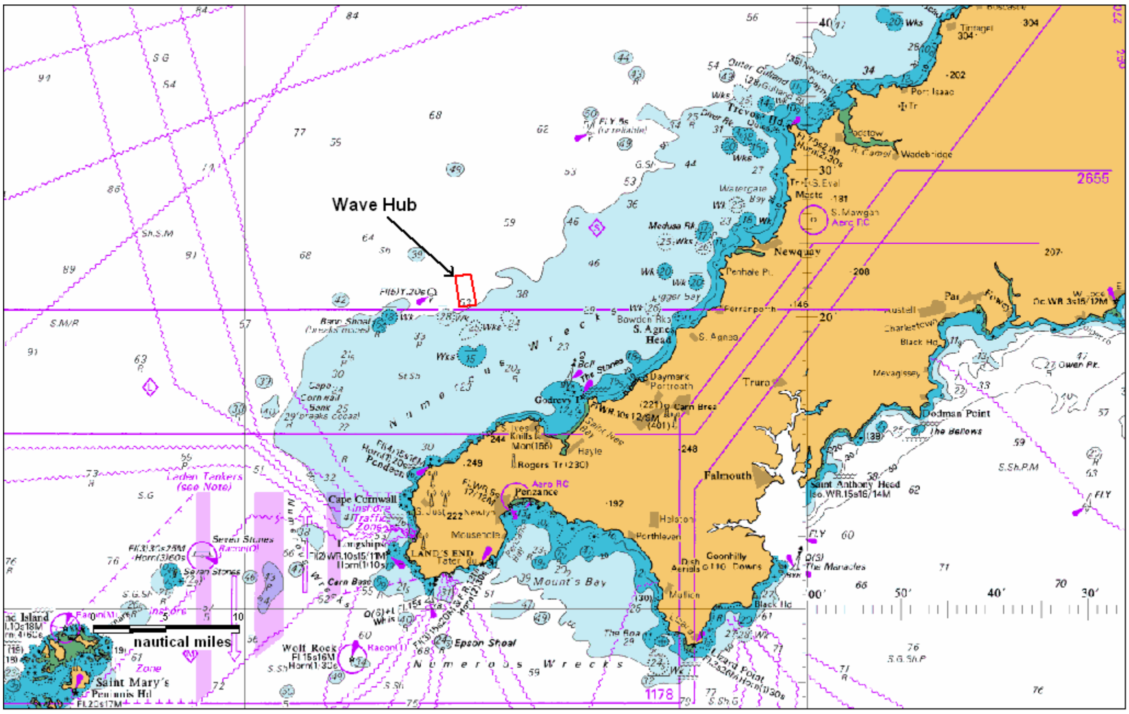


Figure 3.1 Chart overview of the Wave Hub deployment area

3.3 Comparison between revised (proposed) and original deployment area

The location of the proposed deployment area in relation to the originally proposed location is presented in Figure 3.2. The revised location has been proposed based on the initial consultation feedback from navigation stakeholders (MCA, Trinity House, DfT & Chamber of Shipping) on the potential impact associated with the original deployment area on commercial shipping navigation.

The centre of the revised deployment area is located approximately 4km to the ENE of the centre of the original site.

A more detailed comparison of the original and revised deployment areas is presented in Appendix B.

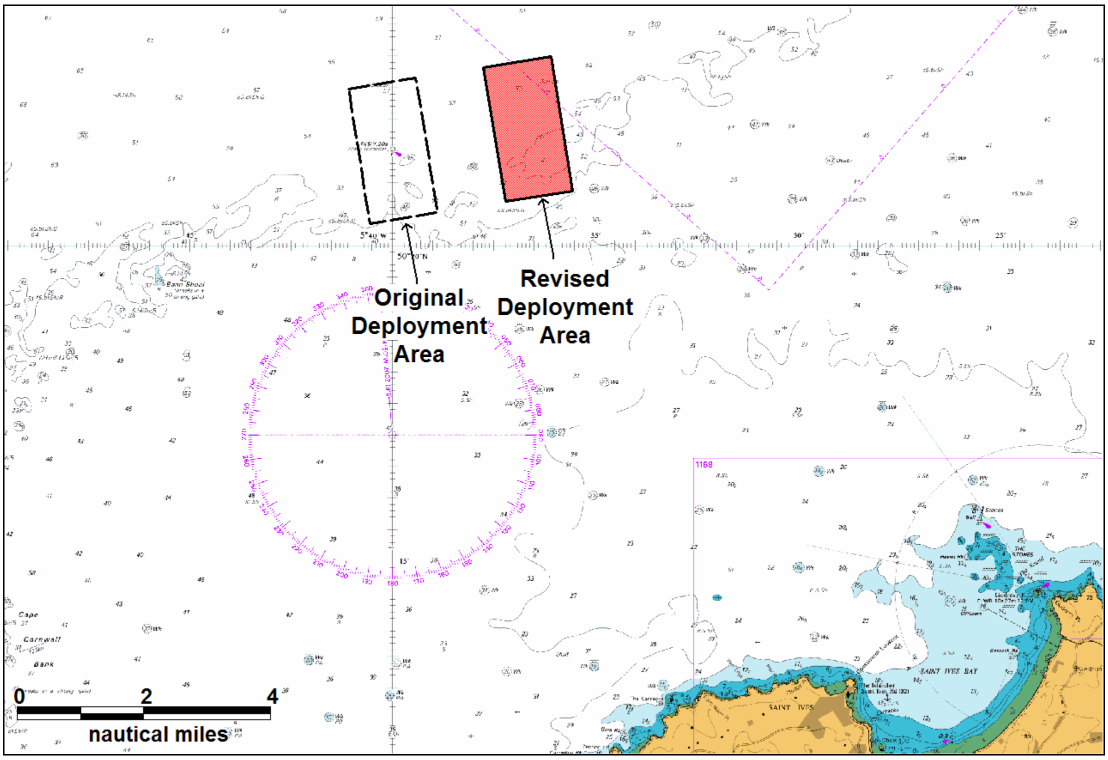


Figure 3.2 Original and revised (proposed) locations of the Wave Hub deployment area

3.4 Wave Energy Converter devices

The Wave Hub will have connection points for four arrays of Wave Energy Convertor (WEC) of devices, with the deployment of devices being phased. The devices to be used are yet to be confirmed. Potential devices include Ocean Power Delivery's PELAMIS ("sea snake") and Ocean Power Technologies' Autonomous Power Buoy, pictured in Figure 3.3.

The purpose of the Wave Hub development is to provide the infrastructure to allow different WEC devices to be tested (e.g. to determine their efficiency); therefore, there is likely to be a limited tenure with the possibility that devices may change over time.

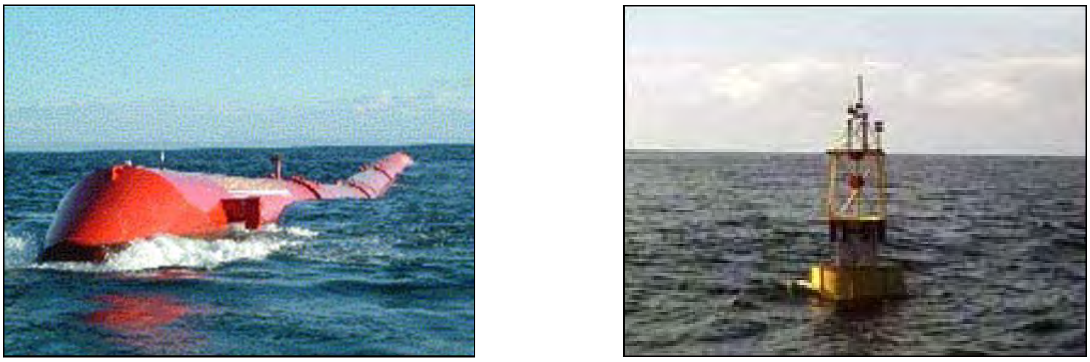


Figure 3.3 Pelamis (left) and Autonomous Power Buoy (right)

3.5 Cable route

The Wave Hub will be connected to the national grid at a substation located in Hayle. The cable corridor from the deployment area to the shore is shown in Figure 3.4.

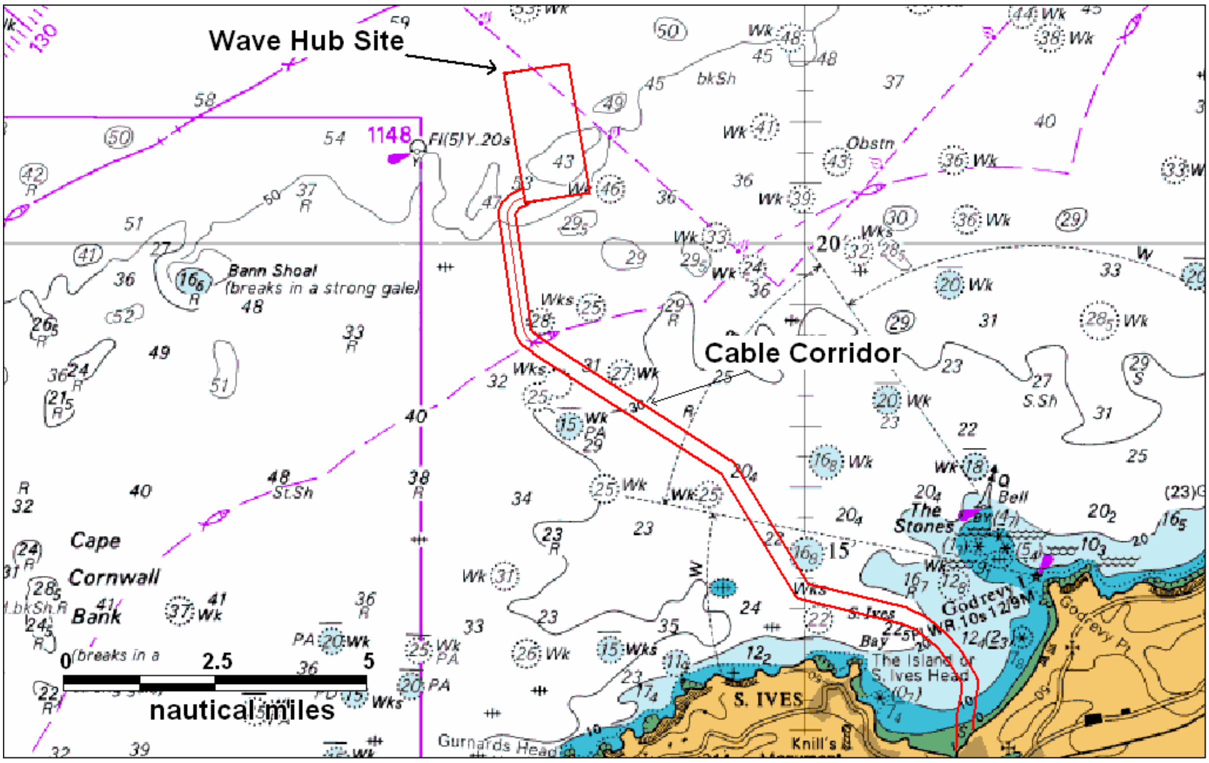


Figure 3.4 Proposed route of the cable from the deployment area to the shore

3.6 Marking, Area to be Avoided and safety zones

The proposals for marine navigational markings, Area to Be Avoided (ATBA) and safety zones around the Wave Hub deployment area are discussed in more detail in Sections 13 and 14 respectively.

3.7 Cumulative and in-combination effects

There are no other known projects planned in the vicinity of the Wave Hub deployment area. It is noted that there are plans to re-develop the harbour facilities at Hayle. This will mainly be to provide facilities for recreational craft and fishing vessels. It is not anticipated that there will be any in-combination and cumulative impacts associated with this development with respect to navigational impact.

4. CONSULTATION

4.1 Introduction

This section summarises the response of the various stakeholders consulted about the Wave Hub development. Consultation is divided into two stages; consultation held during the scoping phase of the project as well as consultation carried out during the assessment phase.

It should be noted that the scoping phase consultation commenced on the basis of the original deployment area. As a consequence of this consultation, the proposed deployment area was revised and the consultation undertaken during the subsequent assessment phase focussed on the revised site.

4.2 Consultations during the scoping phase

4.2.1 Background

The following navigation stakeholders were consulted during the scoping phase:

- Hayle Harbour Authority
- St. Ives Harbour
- HM Coastguard, MRCC Falmouth
- Trinity House
- Chamber of Shipping
- Maritime and Coastguard Agency (Including HM Coastguard, MRCC Falmouth)
- British Marine Aggregate Producers Association (BMAPA)
- Ministry of Defence
- Local fishermen
- Cornwall Sea Fisheries Committee
- Cornish Inshore Fishermen's Federation
- South Western Fish Producers' Organisation (SWFPO)
- Cornish Fish Producers' Organisation (CFPO)
- St. Ives Sailing Club
- RYA

4.2.2 Summary of responses

Table 4.1 summarises the main points made during the scoping phase consultation.

Table 4.1 Summary of main points made with respect to navigation during the scoping phase

Consultee	Main comments
Ministry of Defence	Development will not affect MoD surface and submarine interests. Close to Danger Area D001 which currently supports MoD search and rescue helicopter-training activities involving navigational procedures and surface retrieval activities.
Trinity House	Primary concern is the effect of this and similar developments on all types of marine navigation in the area. Also concerns over the impact the navigational marking (required to mitigate the potential risk caused by this development) may have. A navigational risk assessment should be carried out as part of the EIA (this will also need to consider seasonal traffic variations) Any marine navigational marking will need to meet the availability specified for such aids to navigation and once established will be included in Trinity House's inspection/audit regime. The EIA needs to address the eventual decommissioning of the Wave Hub at the end of its effective life. Any remains left on the site that have been identified as a danger to navigation could be a residual liability. It will be necessary to provide continued navigational marking by whatever means are appropriate at that time.
Hayle Harbour Authority	Vessels anchor in St Ives Bay when sheltering from south westerly and southerly winds. Cable burial below interaction levels would be advisable. Could be the order of 20 vessels anchoring at any one time. In the area beyond the 12nm limit, continental fishing trawlers and netting vessels are in abundance. Any hazard to shipping or safety exclusion area will need to be well published to ensure these vessels are aware of any offshore structures in this area.
MCA (including HM Coastguard)	The location of any offshore hub is likely to impact on deep water shipping activity, particularly northbound traffic from the Scilly Island Traffic Separation Scheme (TSS) heading northeast bound for the Bristol Channel. To reduce impact, if conditions were conducive, it would be preferable if any wave device exclusion area was aligned with the natural obstruction of the Bann Shoal. It is considered that coastal traffic (mainly pleasure craft) would not be severely hampered by exclusion areas as long as they were adequately marked.

Consultee	Main comments
	Advised to following the appropriate channels to look at the establishment of an Area to be Avoided (ATBA) as a measure around the site.
BMAPA	No interest in the immediate vicinity of the planned development. The nearest licence application is located further up the Bristol Channel. Aggregate dredgers do transit between the Bristol Channel and the south coast regions from time to time. Any assessment should take full account of not only established routes but also the transient coastal traffic engaged in short sea trade.
Fisheries	Within St Ives Bay, traps for spider crabs and lobsters are present throughout the year, but prevalent between February and May when the crabs migrate inshore. The larger beam trawlers can operate anywhere but tend to stay near the 12 mile international waters limit. Moving the site east (well into the military firing zone) optimises the opportunity to bury the cable as snagging was also a major concern to those present As well as St. Ives and Hayle, vessels from Padstow and Newlyn are also known to be active in this area.
RYA	Main concern related to navigational safety, marking, lighting, safety issues and the provision of information to recreational boaters (both local and those visiting the area from the UK and abroad).

4.3 Consultations during the assessment phase

4.3.1 Background

In addition to the consultation which was carried out during the scoping phase, further consultation took place following the completion of the maritime traffic survey for the site. This took place at different meetings and included representatives from the following organisations.

- Maritime and Coastguard Agency
- Department for Transport
- Trinity House Lighthouse Service
- Department of Trade and Industry
- RNLI
- Chamber of Shipping
- Hayle Harbour Authority

- RYA
- Cruising Association
- Fisheries representatives

4.3.2 Summary of responses:

A summary of the main points made during this phase of the consultation is presented in Table 4.2.

Table 4.2 Summary of main points made with respect to navigation during the assessment phase

Consultee	Main comments
Trinity House	During consultation on the original site Trinity House commented that the best mitigation would be to move the site further offshore (approximately 5nm to the North) away from the major shipping lanes. The revised Wave Hub deployment area is still located within sea lanes between Land's End and Bristol Channel. Concerns over encounters between SW bound traffic and vessels travelling North from Land's End TSS. Stated that both the original and revised sites present a significant danger to shipping and difficult to mark.
Department for Transport	Requested more clarity on selection of site compared to other sites given the proximity to existing shipping routes.
Chamber of Shipping	Comments supportive of Trinity House view above.
RNLI	No issues with the site. Wished to be kept informed of devices and information for access.
Hayle Harbour Authority	Commented that cable route could be exposed to anchor damage based on where vessels anchor in St. Ives Bay, especially given that the cable will not be buried in places. Consideration should be give to routeing the cable further to the East.
MCA	Concerned over consent being sought for all devices. Stated that MCA would require a device-specific risk assessment prior to accepting that any particular device could be consented to be deployed on site. Expressed concerns on the original site location based on the potential for encounters resulting in vessels with hazardous cargoes routeing closer to a hazard. Favoured the revised site relocated ENE. Stated that an ATBA was the measure they consider appropriate and proportionate to the risk associated with this development.
Fisheries	Commented that the site in its original location was fairly suitable in terms of the lower impact on fishing activity.
RYA and CA	Stated that most of the recreational traffic would be routeing much closer to the coast than where the site is located and that the site is

Consultee	Main comments
	not significant in terms of impact on recreational traffic. Noted the requirement for device-specific risk assessment.

4.4 Conclusions

Based on consultation, the original site was considered to be unacceptable by the main stakeholders based on its potential impact on commercial shipping. The revised site, whilst found to be more acceptable, is still not considered favourably by stakeholders Trinity House and the Chamber of Shipping.

5. EXISTING ENVIRONMENT

5.1 *Introduction*

This section presents general information on the existing environment in the area with respect to shipping and navigation.

5.2 *Local ports and harbours*

There are no merchant shipping ports near to the proposed Wave Hub deployment area. The closest ports are small recreational and fishing harbours located at St. Ives and Hayle. A chart showing local harbours relative to the Wave Hub deployment area is presented in Figure 5.1.

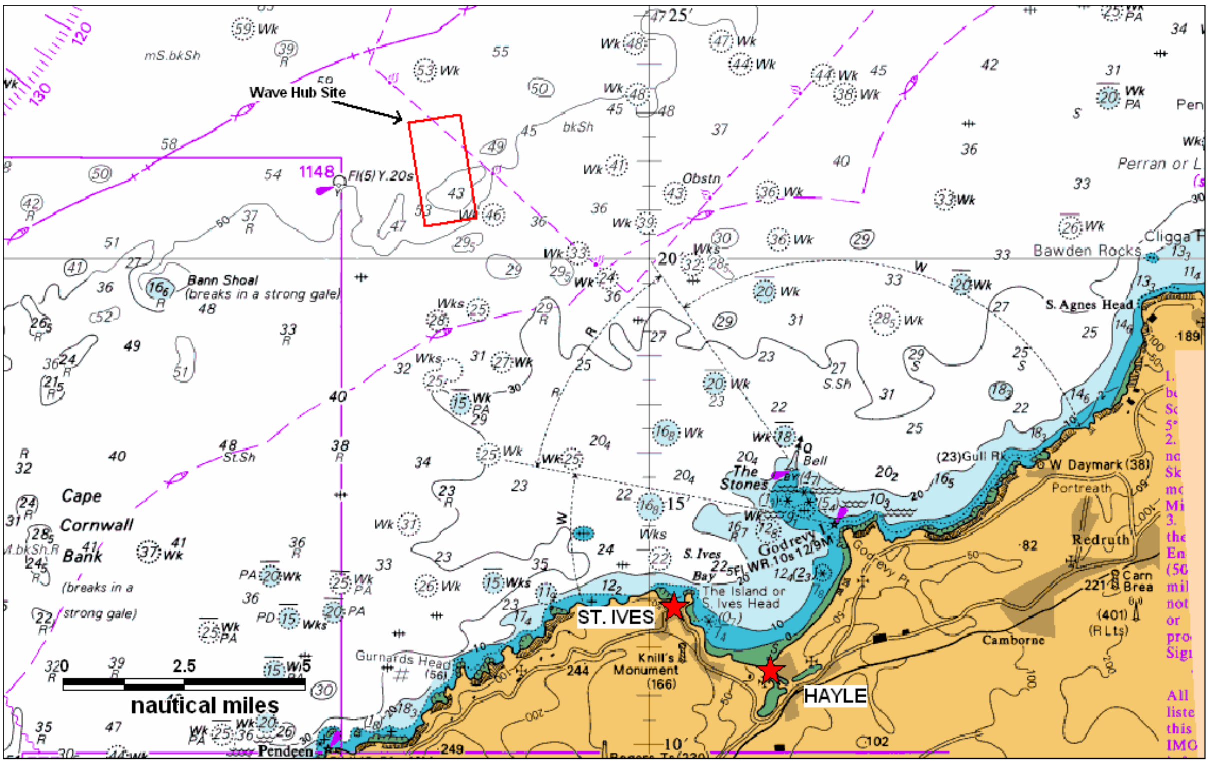


Figure 5.1 Harbours in the vicinity of the Wave Hub deployment area

More details on the harbours are provided below based on Admiralty Sailing Directions for the area (Ref. v). It is noted that vessels anchor in St. Ives Bay (best anchorage lies 5 cables ESE of St. Ives Head) in a depth of 16m.

5.3 *Routeing measures*

There is an IMO-adopted routeing measure in the form of the Traffic Separation Scheme (TSS) off Land's End, between Seven Stones and Longships, located in the order of 16nm SW of the Wave Hub deployment area. The location of the TSS relative to the Wave Hub is presented in Figure 5.2. The northbound lane of the TSS is nearest to the Wave Hub deployment area.

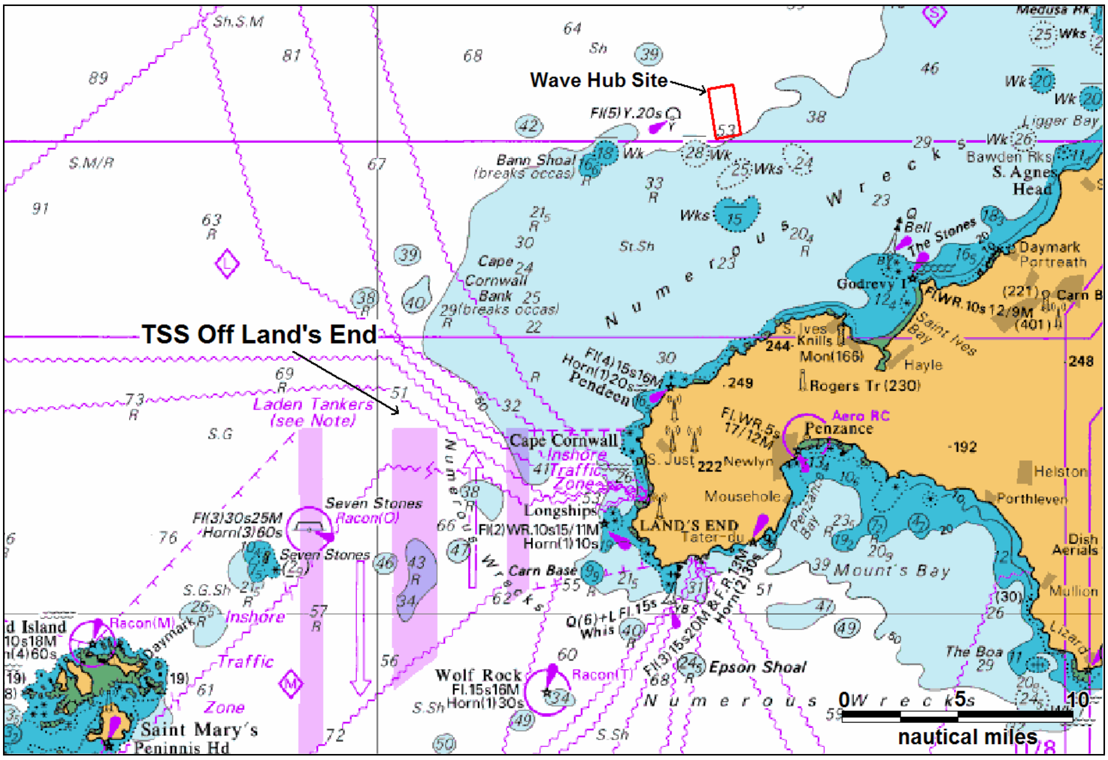


Figure 5.2 Location of TSS relative to the Wave Hub deployment area

5.4 Navigational aids

A plot of the principal buoys and landmarks in the vicinity of the Wave Hub deployment area is presented in Figure 5.3.

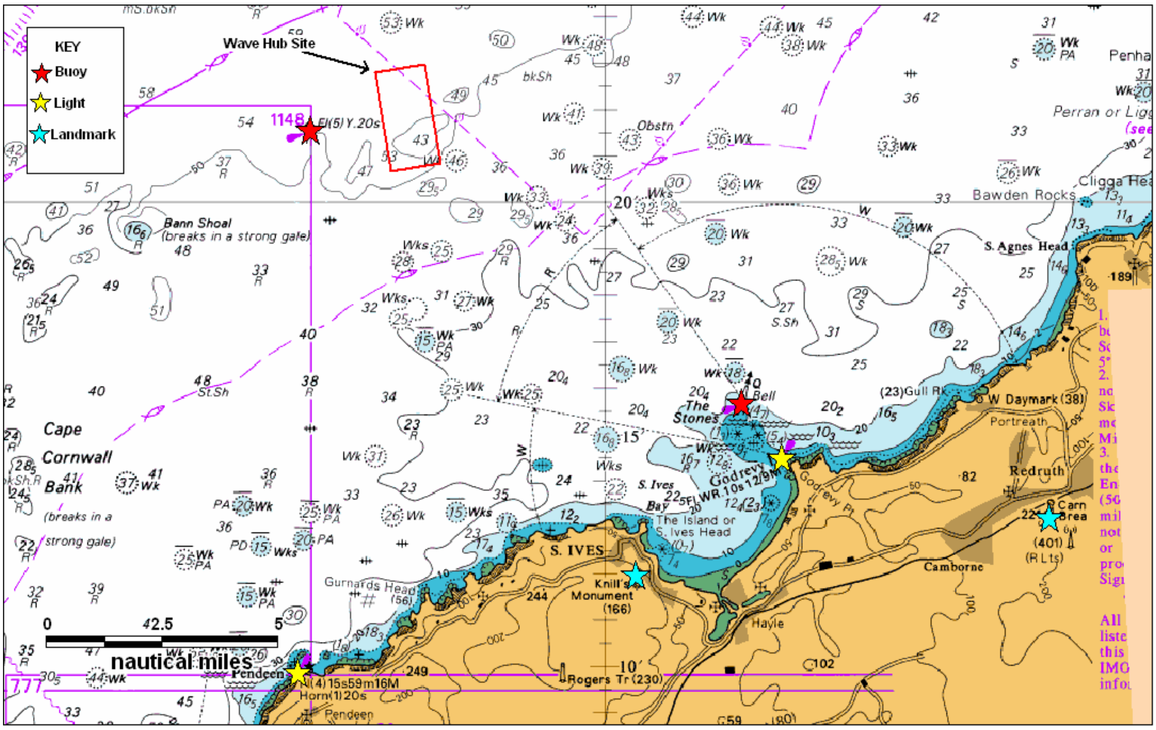


Figure 5.3 Navigational aids and landmarks in the vicinity of the Wave Hub deployment area

The principal landmarks are those listed in Admiralty Sailing Directions for the area (Ref. v). The buoy closest to the site is a wave rider buoy which is being used for measurements associated with the development.

5.5 Wrecks

The charted wrecks[1] in the area are shown in Figure 5.4. No vessels that are currently protected as ‘Controlled Sites’ or ‘Protected Sites’ under the ‘Protection of Military Remains Act’ (1986) are within the Wave Hub deployment area.

Any additional wrecks or wreck material identified will be reported to the receiver of wrecks in accordance with Section 236 of the Merchant Shipping Act 1995.

[1] There may be other wrecks or debris in the area that are not charted.

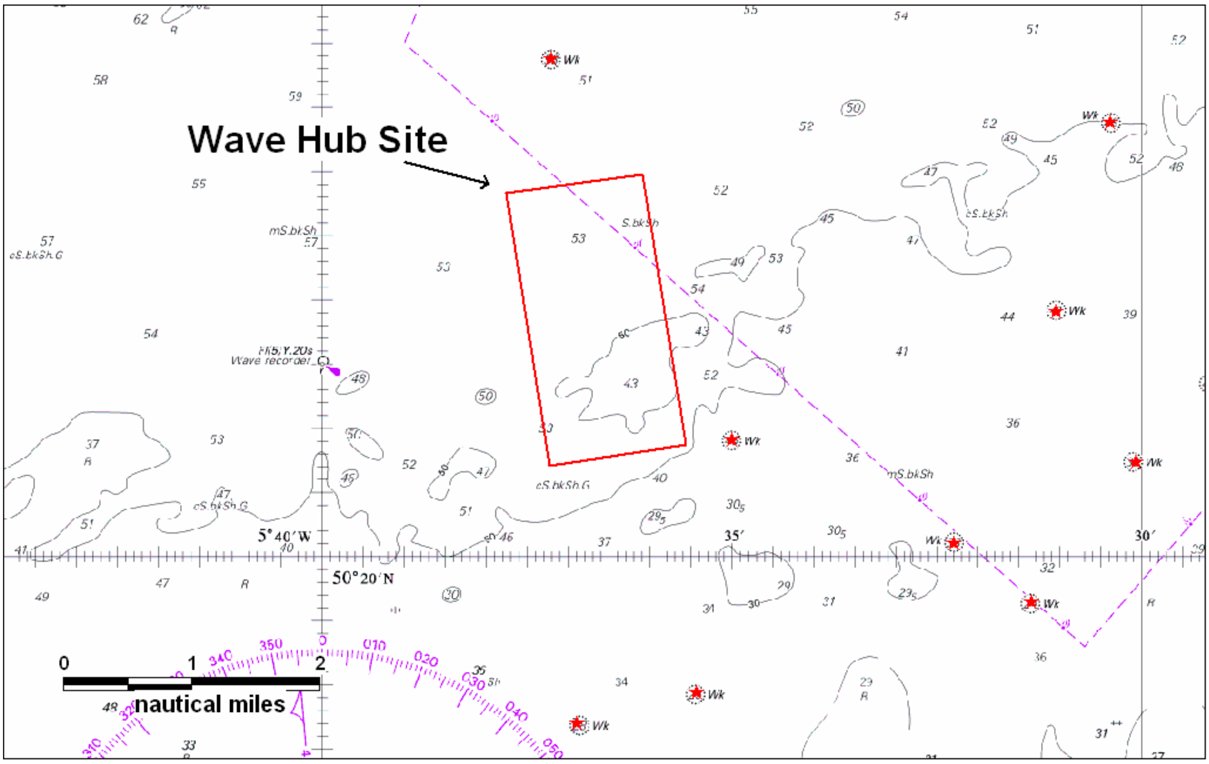


Figure 5.4 Charted Wrecks (based on Admiralty Chart 1149)

5.6 Oil and gas infrastructure

There are no licensed oil and gas blocks in the area.

5.7 Dredging activity

There is no dredging activity in the vicinity of the Wave Hub deployment area although dredgers transit the area on route to and from the Bristol Channel license areas.

5.8 Exercise areas

There are no charted submarine exercise areas in the vicinity of the Wave Hub deployment area.

The Trevose Head Firing Range Firing Practice Area (D001) intersects the NE corner of the revised Wave Hub Deployment Area. The developers are in discussions with the MoD about this (non-navigational) issue.

5.9 Metocean data

This section presents metocean statistics for the area of the Wave Hub deployment area which have been used as input to the generic risk assessment.

5.9.1 General overview

According to the Admiralty Sailing Directions (Ref. v), the Irish Sea region enjoys a mild maritime climate, although it can be very unsettled with periods of strong winds and rough seas. Gales can occur in any month but are most frequent in the winter months with winds reaching storm and hurricane strength on some occasions.

Rainfall is plentiful and frequent, and well distributed throughout the year with generally the driest months from March to June. It is frequently cloudy in all seasons with coasts obscured, at times, by low level cloud and driving rain.

Fog at sea is infrequent from November to May and is most common in June. Land fog is most frequent in the autumn and winter around dawn. Visibility is generally good, although, marginally less so in the area of the Irish Sea to the East of 4 West.

5.9.2 Wind

The wind data for the site has been obtained from the Met Office based on recordings from ships in the area between 1976 and 2005 (approx 11,400 recordings) (Ref. vi). The area from which the records were made is presented in Figure 5.5.

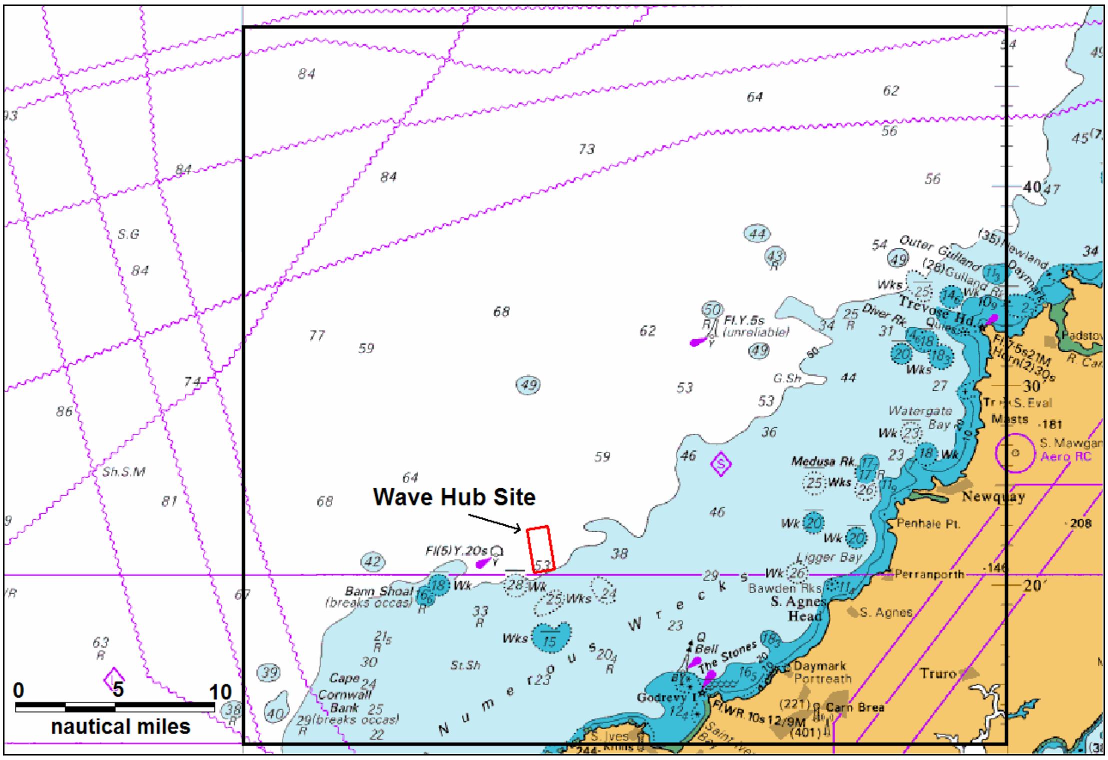


Figure 5.5 Ship observations area

The wind rose (direction v speed) is presented in Figure 5.6. It can be seen that the predominant wind direction is south-west.

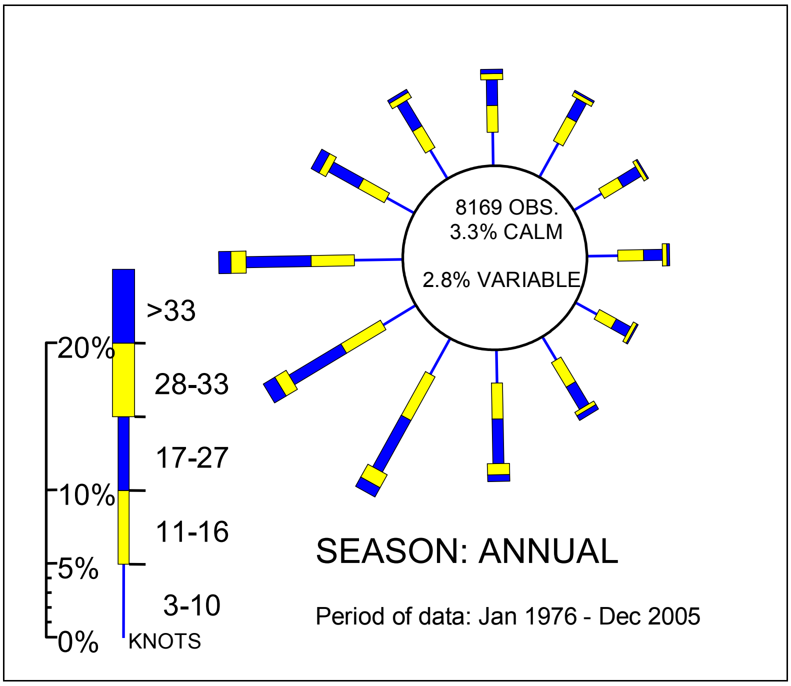


Figure 5.6 Average annual wind direction distribution

The wind speed exceedence curve is presented in Figure 5.7. The average wind speed is approximately 14 to 15 knots with approximately 6% frequency of winds in excess of 33 knots (Beaufort Force 8; gale force).

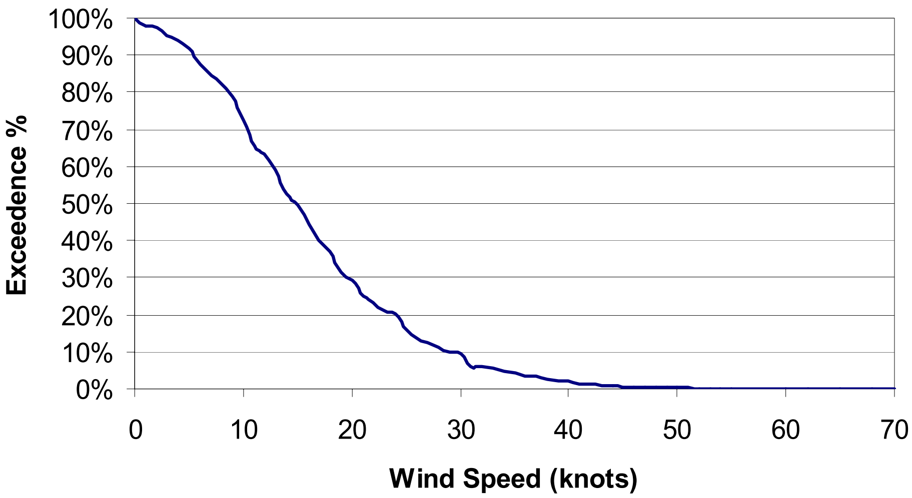


Figure 5.7 Average annual wind speed exceedence distribution

5.9.3 Visibility

Historically, visibility has been shown to have a major influence on the risk of ship collision. According to the Admiralty Sailing Directions (Ref. v), sea fog (visibility less than 1km) in the sea area West of England and Wales is most common with SW winds between April and

October and has a maximum frequency of between 2% and 5% of occasions in June. In January the frequency is generally less than 2% although to the East of 4 W it is between 5-10%.

The percentage frequency of occasions when the visibility is in excess of 5 miles is between 80-85% throughout the year, except for the area of the Irish Sea to the East of 4 W where the frequency falls to about 75% in mid-winter.

The average number of days with fog reported at coastal stations in West England and Wales, based on 18 years of observations from 1983 to 2000, is provided in Table 5.1.

Table 5.1 Fog reported by coastal stations

Station	Average days with fog per year
St. Mawgan	48
Bristol	11
Mumbles	30
Milford Haven	26
Aberporth	31
Valley	19
Rhyl	1
Crosby	13
Ronaldsway IOM	15
Walney Island	2
Point of Ayre IOM	8
St. Bees Head	15

It can be seen that St. Mawgan, the coastal station nearest to the Wave Hub site, has the highest frequency of fog, with an average of 48 days per year.

More detailed offshore visibility data has been obtained from the Met Office based on recordings from vessels in the area presented in Figure 5.5 (Ref. vii).

The average annual visibility exceedence curve presented in Figure 5.8.

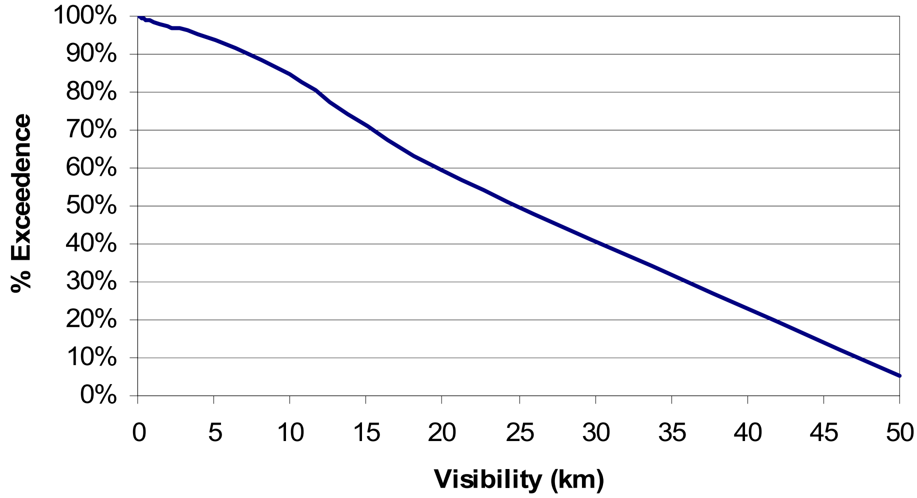


Figure 5.8 Visibility exceedence curve

The annual average probability of fog, defined as visibility less than 1 km, is estimated to be 1.6%. In terms of time of year, visibility tends to be poorest in February and March, as illustrated in Figure 5.9.

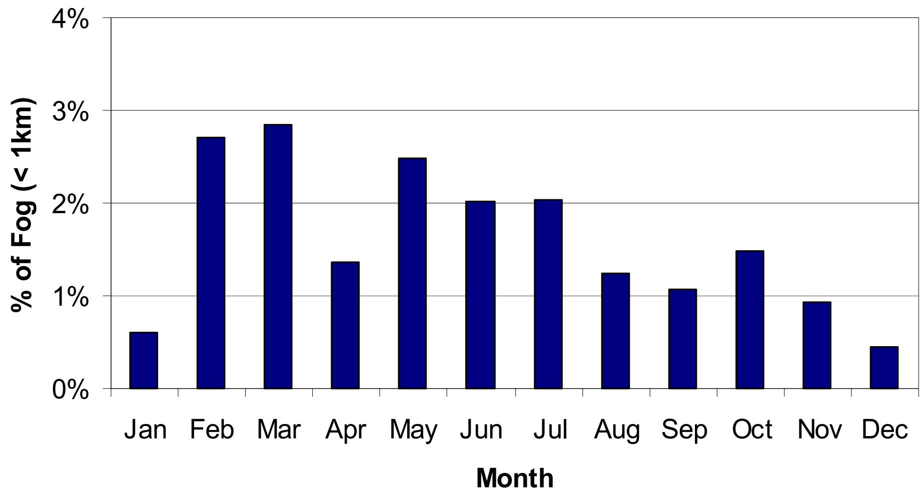


Figure 5.9 Monthly probability of visibility of less than 1km

5.9.4 Tide

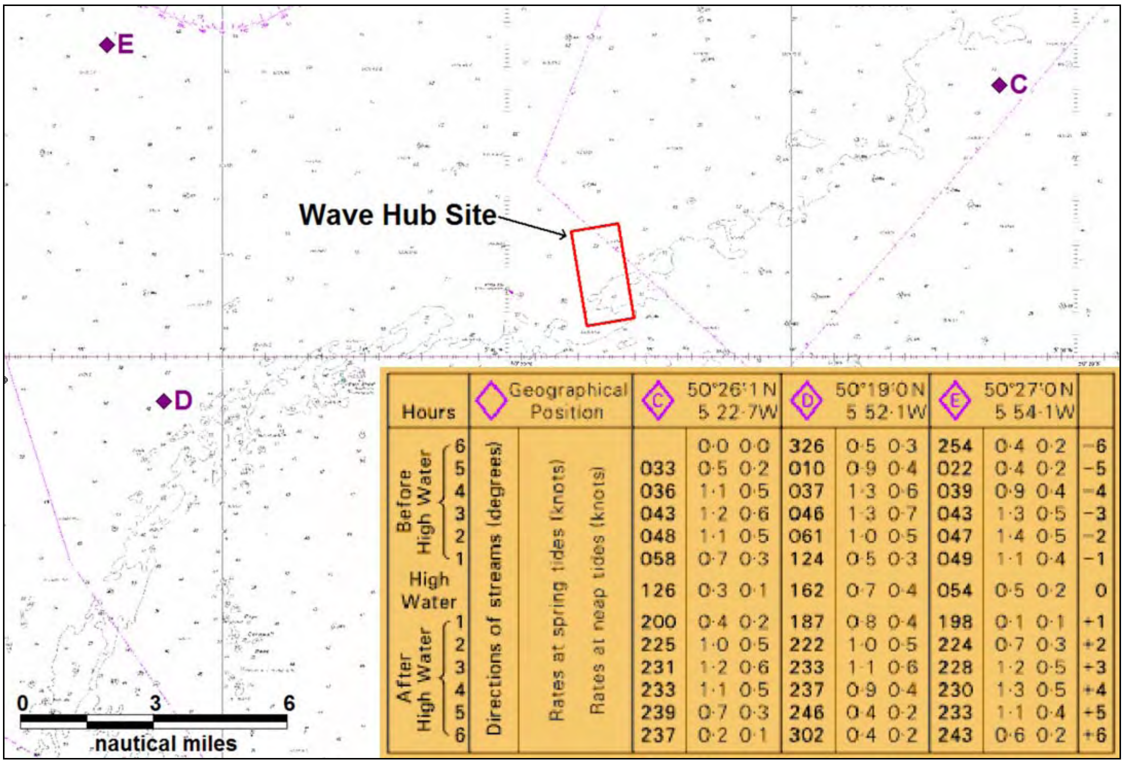
A description of the tidal streams in the general area between Cape Cornwall and Hartland Point is provided below (Ref. v):

The tidal streams run mainly parallel to the coast (NE/SW) at a spring rate of from 1 to 2 knots. They are stronger off Cape Cornwall and Hartland Point, and off salient points, but weaker in the bays between.

In Saint Ives Bay the NE stream is very weak; the SW-going stream though not strong, runs round the bay. The streams in both directions run fairly strong past Godrevy Island and across The Stones. Across The Sound they run ENE with the in-going tide and WSW with the out-going.

Admiralty Chart 1149 has three tidal diamonds within 12 miles of the Wave Hub area (Ref. viii), as shown in Figure 5.10.

At all three locations the flood tide runs in a NE direction whilst the ebb tide runs SW. The peak spring tidal rate is 1.3 knots and peak neap rate is 0.7 knots.



Hours	◇C 50°26'1N 5 22·7W Directions of streams (degrees)	Rates at spring tides (knots)	Rates at neap tides (knots)	◇D 50°19'0N 5 52·1W Directions of streams (degrees)	Rates at spring tides (knots)	Rates at neap tides (knots)	◇E 50°27'0N 5 54·1W Directions of streams (degrees)	Rates at spring tides (knots)	Rates at neap tides (knots)	
Before High Water 6		0·0	0·0	326	0·5	0·3	254	0·4	0·2	−6
5	033	0·5	0·2	010	0·9	0·4	022	0·4	0·2	−5
4	036	1·1	0·5	037	1·3	0·6	039	0·9	0·4	−4
3	043	1·2	0·6	046	1·3	0·7	043	1·3	0·5	−3
2	048	1·1	0·5	061	1·0	0·5	047	1·4	0·5	−2
1	058	0·7	0·3	124	0·5	0·3	049	1·1	0·4	−1
High Water	126	0·3	0·1	162	0·7	0·4	054	0·5	0·2	0
After High Water 1	200	0·4	0·2	187	0·8	0·4	198	0·1	0·1	+1
2	225	1·0	0·5	222	1·0	0·5	224	0·7	0·3	+2
3	231	1·2	0·6	233	1·1	0·6	228	1·2	0·5	+3
4	233	1·1	0·5	237	0·9	0·4	230	1·3	0·5	+4
5	239	0·7	0·3	246	0·4	0·2	233	1·1	0·4	+5
6	237	0·2	0·1	302	0·4	0·2	243	0·6	0·2	+6

Figure 5.10 Tidal stream data in the vicinity of the Wave Hub deployment area

6. MARITIME TRAFFIC SURVEY

6.1 Introduction

This section presents the results of the 28 day maritime traffic survey carried out in the vicinity of the Wave Hub deployment area using a combination of shore-based radar, AIS and visual observations. Full details of the survey analysis are presented in a separate report prepared by Anatec (Ref. ix). It should be noted that the analysis presented in the survey report refers to the original Wave Hub deployment area, whereas this section references the revised location. It is noted that based on the coverage area of the survey and the proximity of the two sites, then the survey is considered as being equally valid for both locations.

6.2 Survey details

The survey was carried out from the NCI St Ives over two 2-week surveys periods as follows:

- 20 May - 3 June 2005
- 29 July - 12 August 2005

The initial 2-week survey was carried out in generally low winds and dry conditions. The wind was predominantly from the SW and SE and reached a maximum of Force 7, averaging between 2 and 3. The survey commenced five days before spring tide.

The second 2-week period was carried out in generally fine weather with good visibility. The wind was predominantly from the W and NW and reached a maximum of Force 5, averaging between 2 and 3. The second survey commenced six days after spring tide.

With respect to seasonality, it should be noted that whilst the traffic survey has been carried out over the summer months, based on a review of port statistics no significant variation is expect in the commercial shipping movements in the area and the survey is considered representative. From a recreational vessel perspective, the survey is likely to be above the average given the weather conditions and time of year. For fishing, different activities are seasonal and seasonality factors have been considered for this through the use of surveillance data.

6.3 General review of area

The radar and AIS data have been combined due to the high incidence of radar tracks correlating with AIS tracks (including the vast majority of merchant ships). As the AIS receiver tended to track vessels over a greater range, and also provided more accurate information on position and ship characteristics, the AIS track has been used where the vessel was tracked by both systems. Vessels only tracked by radar (no AIS) have been added to the AIS data to create a single combined data set of all vessels.

In the analysis (below), the charts show all the tracks recorded during the survey but the analysis of daily vessels, type, speed and destination only considers vessels passing within 10nm of the Wave Hub deployment area.

Figure 6.1 presents the number of vessels per day (all types) recorded within 10nm of the Wave Hub deployment area during the survey.

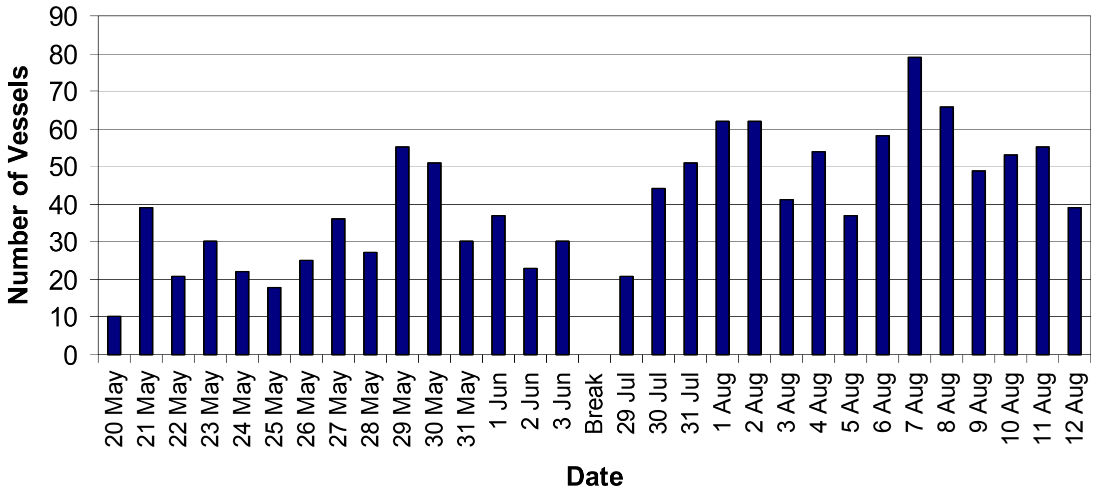


Figure 6.1 Number of vessels per day recorded during survey (all vessels)

The average number of tracks per day passing within 10nm of the Wave Hub deployment area was 44. The busiest day was 7 August when 79 unique tracks were recorded whilst the quietest day (excluding part days) was 25 May when 18 unique tracks were recorded.

Figure 6.2 presents a plot of the busiest day recorded during the survey.

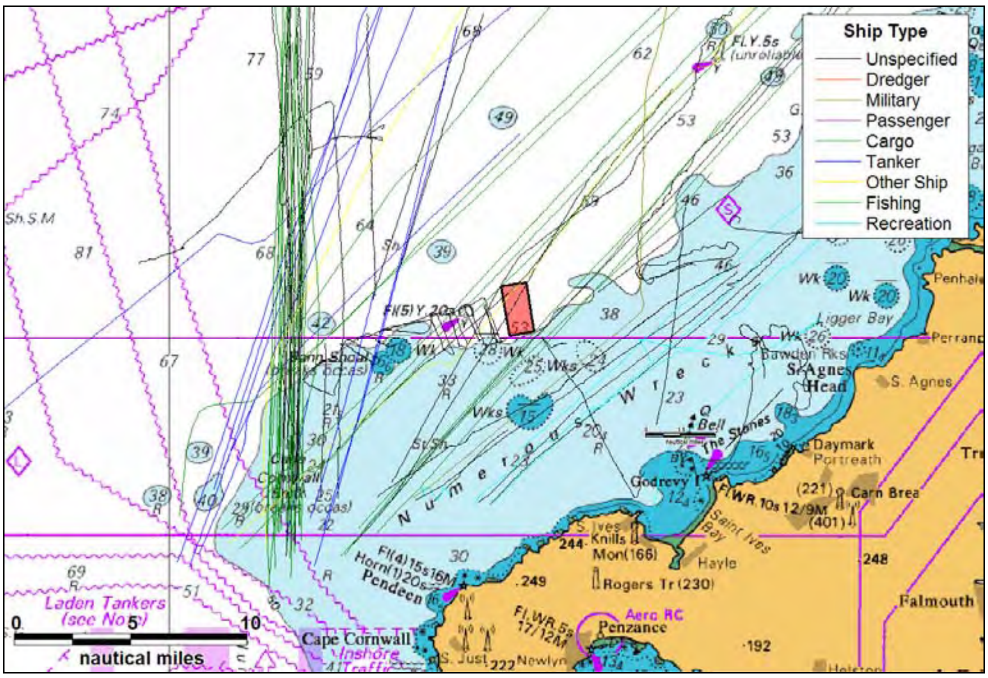


Figure 6.2 Vessel tracks for the busiest day recorded during the survey (7 August 2005)

Figure 6.3 presents the cumulative picture of shipping data over the full 28 days.

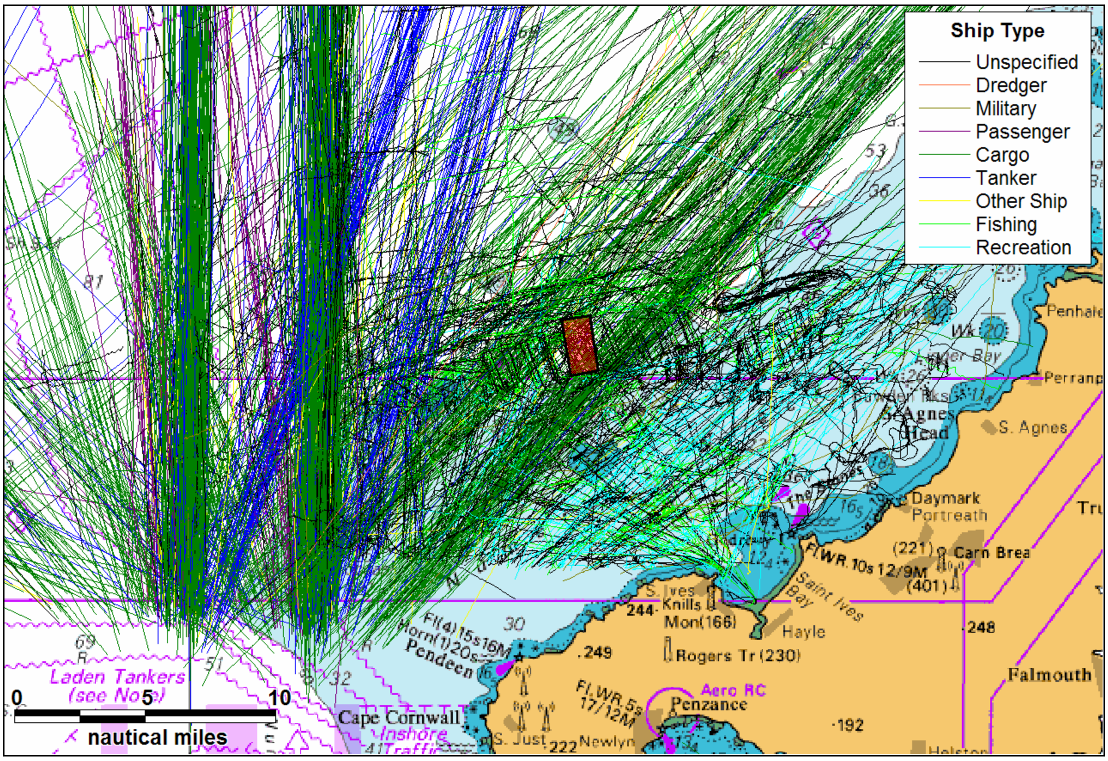


Figure 6.3 Overview of tracks recorded during survey (28 days)

Based on the AIS data and visual identification of radar tracks, an analysis of ship types identified within 10nm of the Wave Hub deployment area during the survey period is presented in Figure 6.4. It can be seen that the majority of tracks were made by cargo vessels (58%) and tankers (16%).

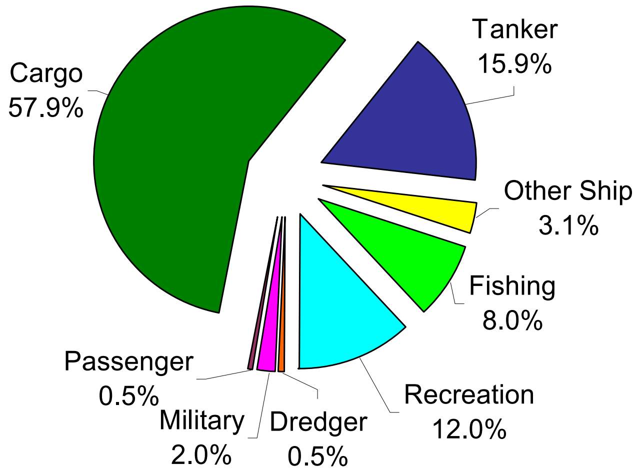


Figure 6.4 Vessel types identified within 10nm of the Wave Hub deployment area during the survey

Based on the information available from AIS, the tracks, colour-coded by draught (where known), are presented in Figure 6.5. This shows a wide range of draughts but the majority of vessels passing near the Wave Hub deployment area were of relatively shallow draught (below 7m). The largest draught vessel passing within 10nm was the bulk carrier *China Fortune* at 17.2 m.

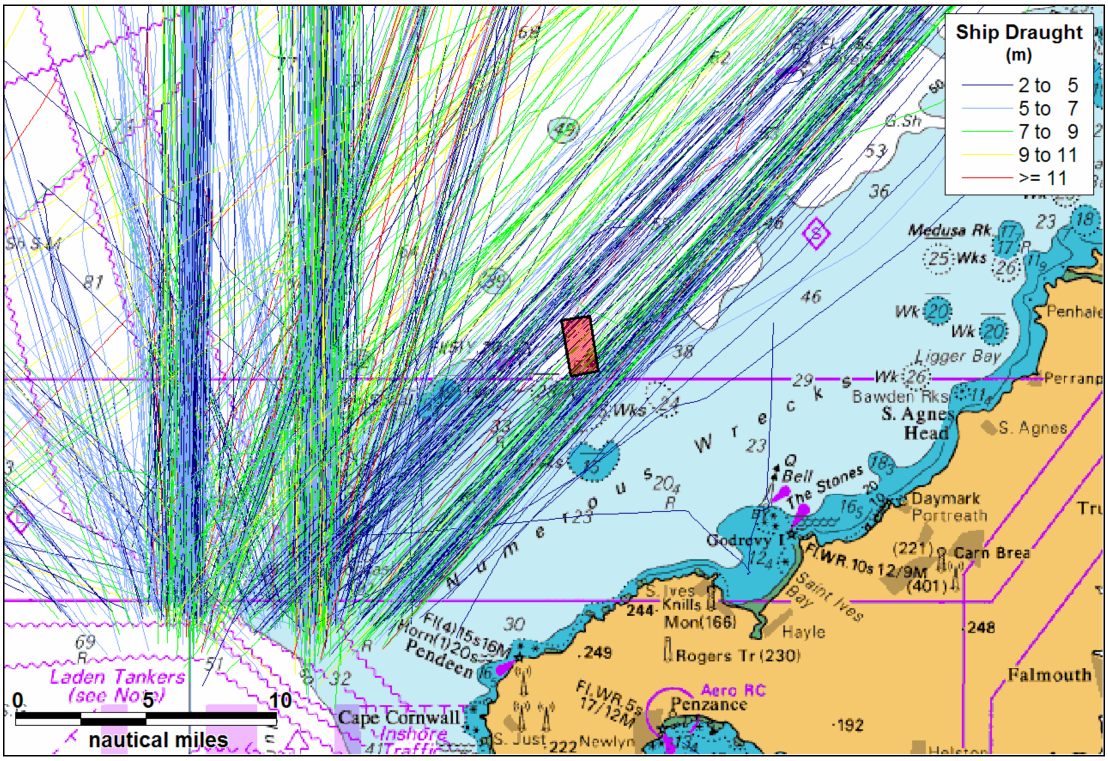


Figure 6.5 AIS tracks where ship draught was reported

Based on the AIS tracks within 10nm of the Wave Hub deployment area, the main ports that ships were destined for are presented in Figure 6.6.

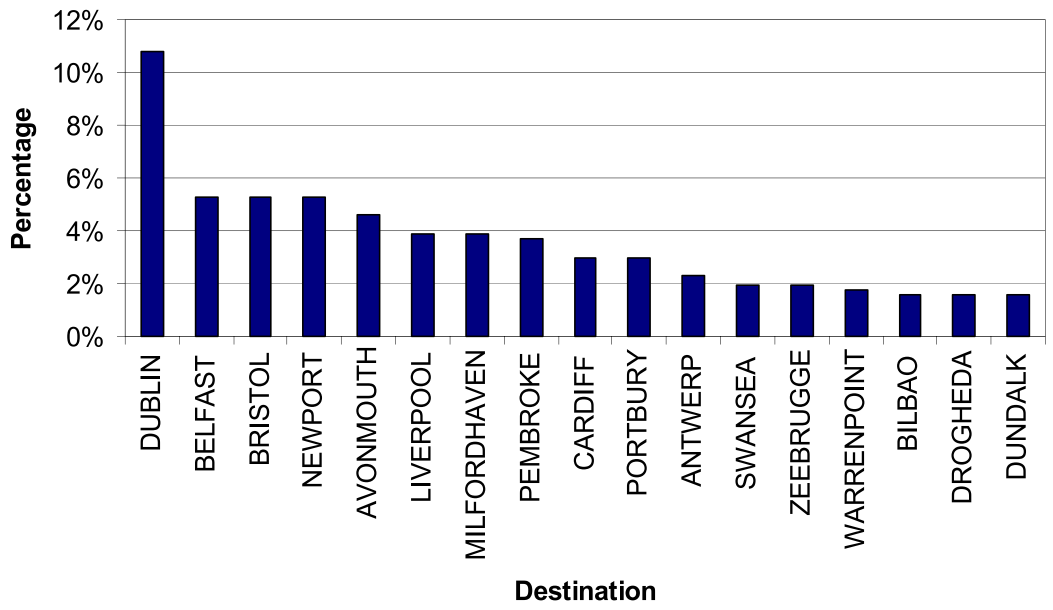


Figure 6.6 Destination ports of shipping identified in the survey within 10nm of the Wave Hub deployment area (AIS)

It can be seen that ships passing through the area are visiting a range of ports in the UK, Ireland and Continental Europe.

6.4 Site-specific review

A more detailed plot of the survey tracks relative to the Wave Hub deployment area is presented in Figure 6.7.

A total of 122 tracks were identified to pass within the Wave Hub deployment area boundary (an average of 4 to 5 vessels per day) during the 28 days survey. Excluding unspecified vessels, the vast majority were cargo vessels (86%), with a small proportion of tankers (4%), fishing vessels (6%) and recreational vessels (1%).

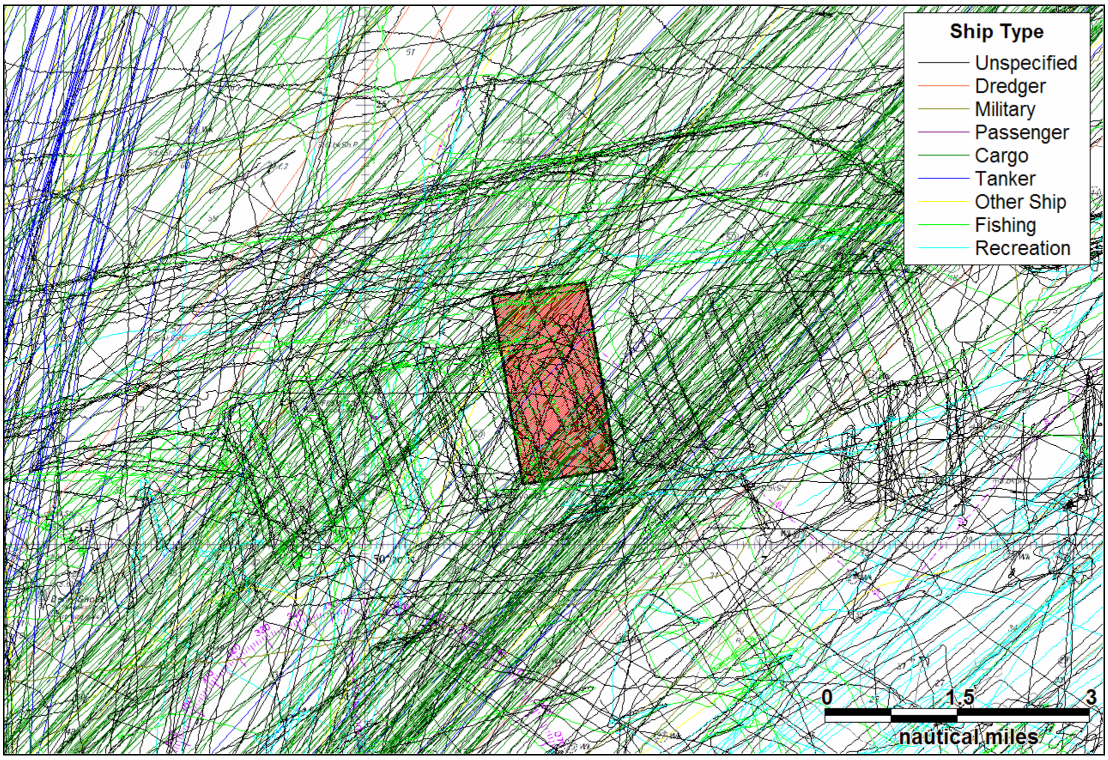


Figure 6.7 Detailed Chart of Tracks by Type passing in vicinity of Wave Hub

The majority of tracks intersecting the site were heading between the Bristol Channel (e.g., Bristol, Newport, Swansea) and the TSS off Land's End (ultimately bound for ports in Spain, France, Belgium, etc.).

7. COMMERCIAL SHIPPING NAVIGATION

7.1 Introduction

The maritime traffic survey identified that the majority of vessels in the area of the Wave Hub deployment area were commercial (merchant) vessels. This section reviews the commercial (merchant) shipping activity in the area of the deployment area in more detail and assesses the likely impact of the proposed development on commercial shipping navigation.

7.2 Routeing analysis

7.2.1 Current routes

From the survey, six main routes were identified passing in the vicinity of the proposed deployment area. The approximate route centrelines superimposed on the AIS survey tracks are presented in Figure 7.1.

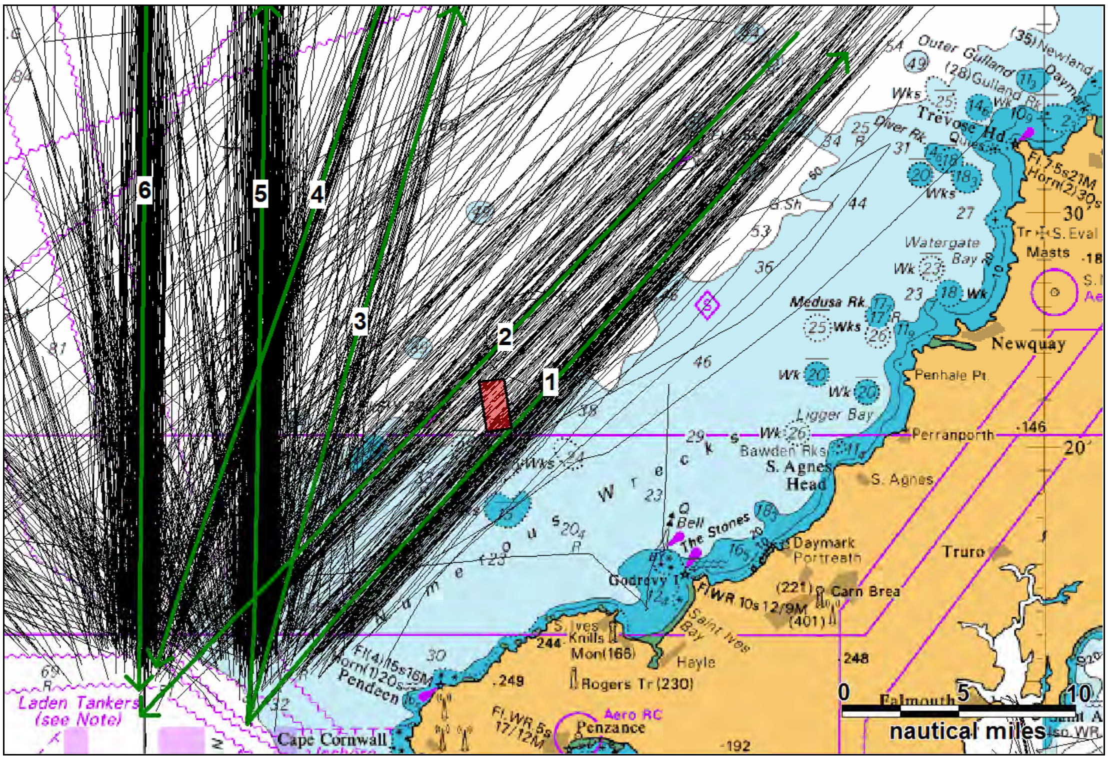


Figure 7.1 Main merchant shipping routes identified from survey data

The distribution of traffic on the six main routes has been analysed to identify the route mean positions and widths. The widths were defined based on the boundary within which 90% of the traffic passes on that route, as illustrated in Figure 7.2.

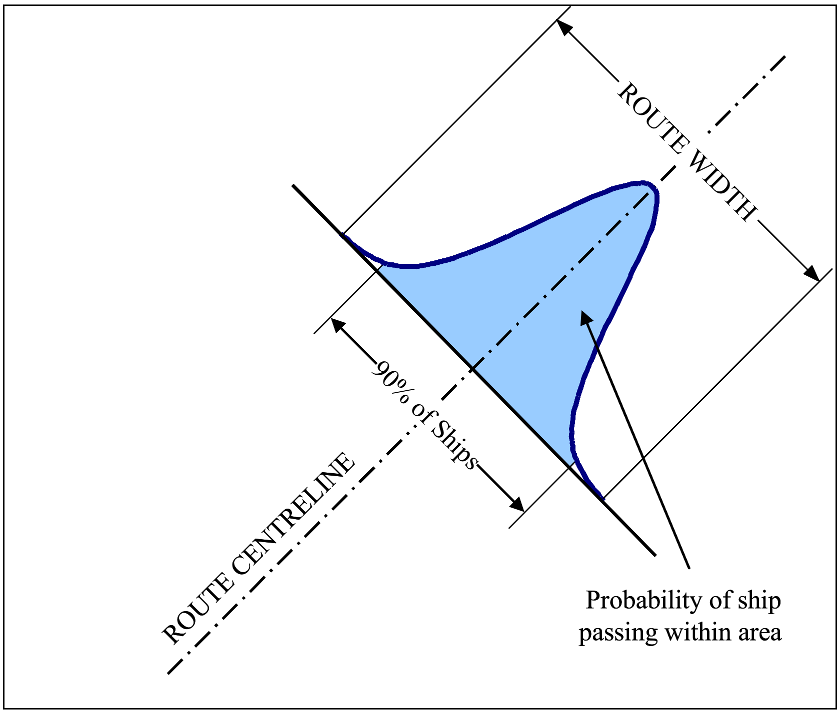


Figure 7.2 Illustration of lane width containing 90% of ships

The boundaries of the lanes encompassing 90% of the ships on the six routes overlaid on the AIS survey tracks is shown in Figure 7.3. This is based on the widths calculated at key reference locations along with route with manual adjustments between these points, where necessary, based on visual observation.

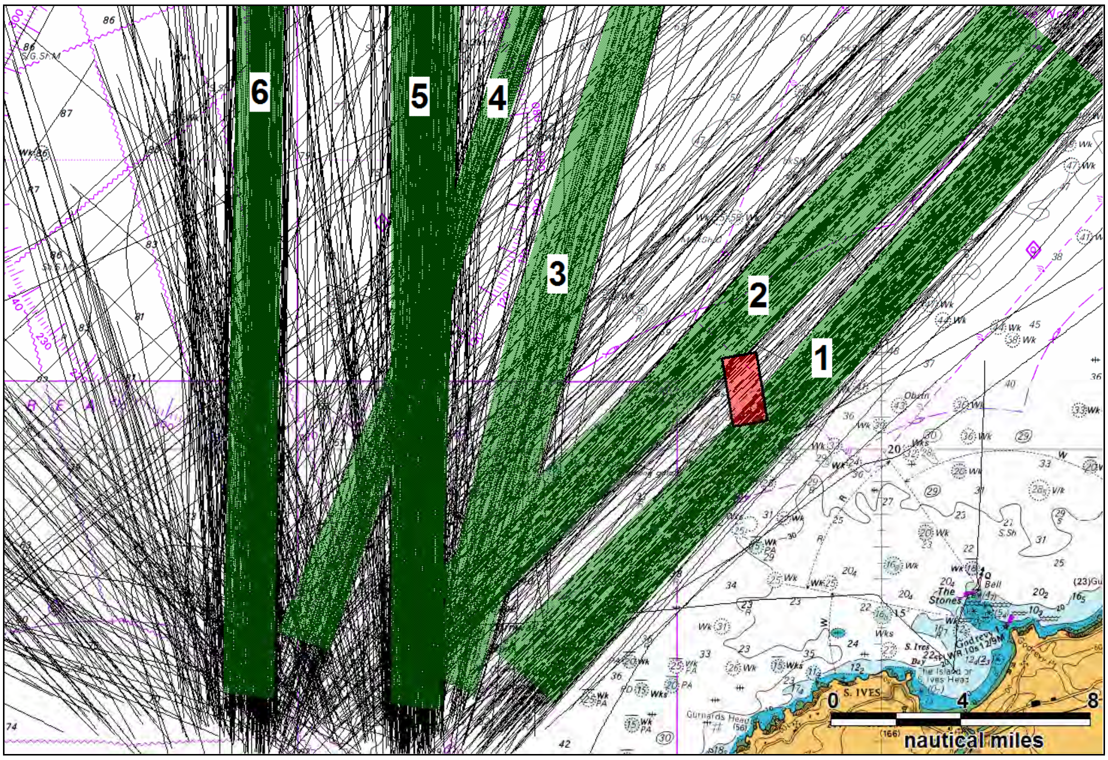


Figure 7.3 Boundaries of shipping lane width for the six main routes identified

Details on the six routes, including the Closest Point of Approach (CPA) and bearing of the mean positions from the nearest part of the Wave Hub deployment area boundary, and the average numbers of ships per day trafficking the routes, is provided in Table 7.1.

Table 7.1 Main routes passing the Wave Hub deployment area

Route	Description	CPA (nm)	Bearing ( )	Ships per day
1	TSS off Land's End to Bristol Channel	0.05	307	5
2	Bristol Channels to TSS off Land's Ends	0.5	316	5
3	TSS off Land's End to Milford Haven/Pembroke	5.6	290	2
4	Milford Haven/Pembroke to TSS off Land's End	9.1	290	2
5	TSS off Land's End to The Smalls TSS	9.4	272	10
6	The Smalls TSS to TSS off Land's End	14.3	271	10

All the route mean positions pass outside of the Wave Hub deployment area but it can be seen that Routes 1 and 2, heading between the Bristol Channel and the TSS off Land's End, pass very close to the Wave Hub deployment area and part of these shipping lanes (as defined by the approach illustrated in Figure 7.2) pass through the deployment area.

7.2.2 Re-routeing due to Wave Hub

From the above review it can be seen that the main impact of the Wave Hub will be on vessels routeing between the Bristol Channel and the TSS Off Lands End (Routes 1 and 2; see Figure 7.3).

As a consequence of the proposed Wave Hub, it is anticipated that these vessels navigating within Routes 1 and 2 will have to increase their clearance from the deployment area. The extent of this clearance and, therefore, passing distances from the deployment area will depend on the marking of the site and navigational advice issued by authorities, as well as the individual decisions of Masters on passing ships, which will vary based on type and size of ship, weather and tide conditions, sailing schedule, etc. From experience of analysing vessels passing other offshore developments in the North Sea and Irish Sea, it is anticipated that the average CPA of Routes 1 and 2 from the site will increase by the order of 1nm.

A plot of this anticipated effect on the centrelines of the main shipping lanes (Routes 1 and 2) is presented in Figure 7.4. The other main routes (No's 3 to 6) are not expected to be directly affected as they pass an average of over 5nm from the nearest part of the deployment area.

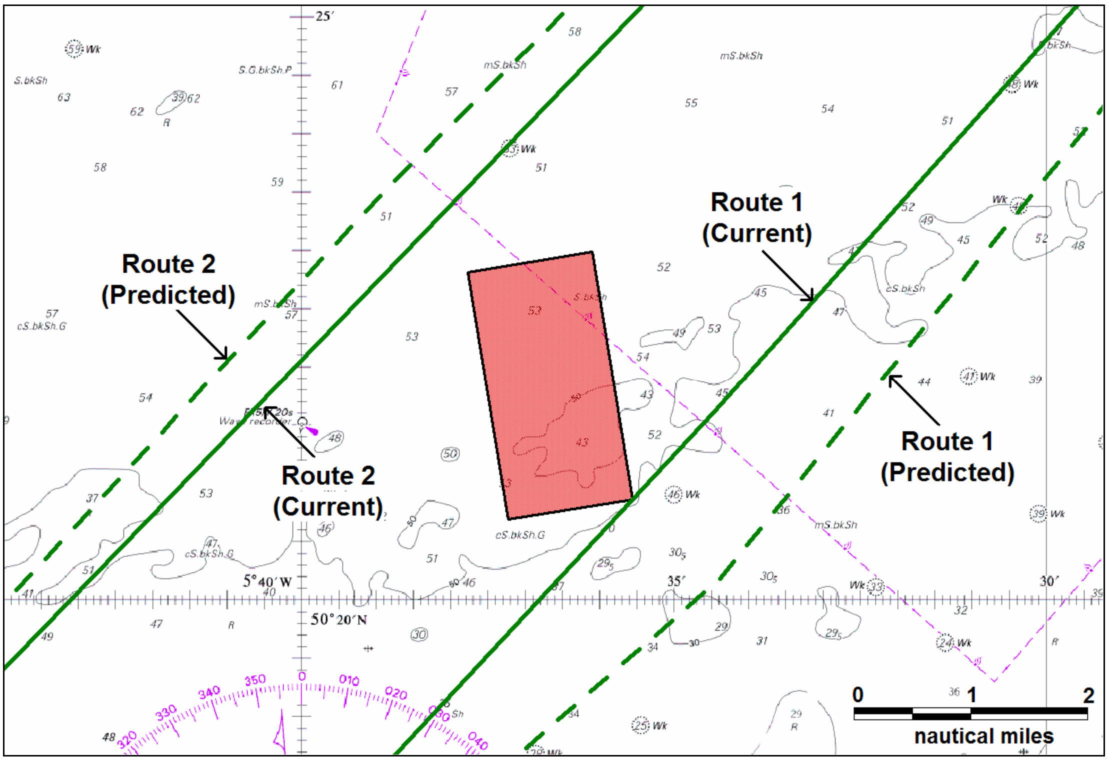


Figure 7.4 Anticipated Impact of Wave Hub deployment area on Routes 1 and 2

In terms of the additional sailing distances for commercial shipping, given the typical voyages of vessels on Route 1 and 2 (e.g. Bristol to Spain) and the relatively small displacement of the routes, there is not considered to be a significant commercial impact as a result of the Wave Hub deployment area being located at this site. The additional distance for Route 1 traffic is only approximately 0.2nm which based on an average speed of 10.4 knots equates to an extra voyage time of 1-2 minutes. For Route 2 the deviation will add less than one minute to the overall voyage time.

7.3 Timeline analysis to investigate traffic interaction

Further analysis was performed of vessels passing in the vicinity of the Wave Hub deployment area to assess the potential for interaction between traffic, in particular between northbound traffic to Milford Haven (Route 3) and SW-bound traffic out of the Bristol Channel heading for the TSS Off Land's End (Route 2). Potential interaction between these two lanes was highlighted as a concern during the consultation phase as the northbound vessels would be required by the Collision Regulations to give way, which could lead to these vessels moving to the east (i.e., altering course to starboard) towards the Wave Hub deployment area.

To investigate this, a "gate" was defined, as shown in Figure 7.5;if traffic on both these lanes passed through this gate at the same time, a give-way scenario could arise.

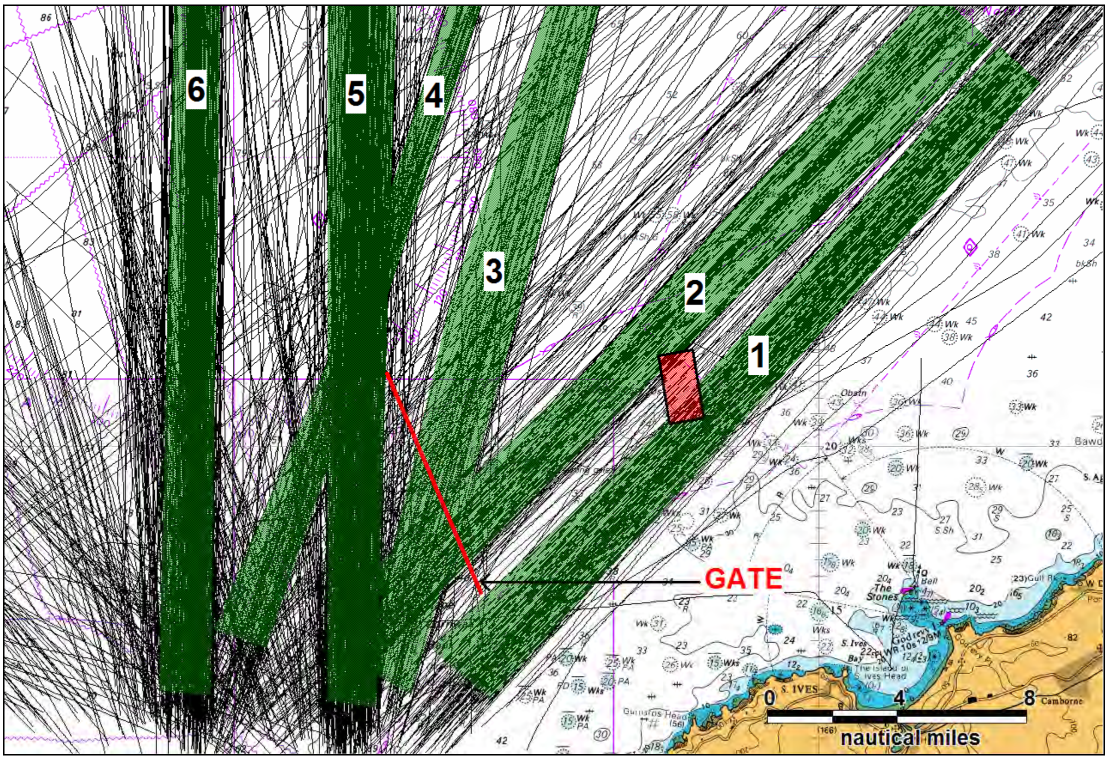


Figure 7.5 "Gate" used to analyse shipping interaction on Routes 2 and 3

Using the AIS data from the survey which covers the commercial ships of interest, a total of 197 ships passed through this gate over the 28 days, corresponding to an average of 7 per day. The overall daily distribution over the survey period is presented in Figure 7.6.

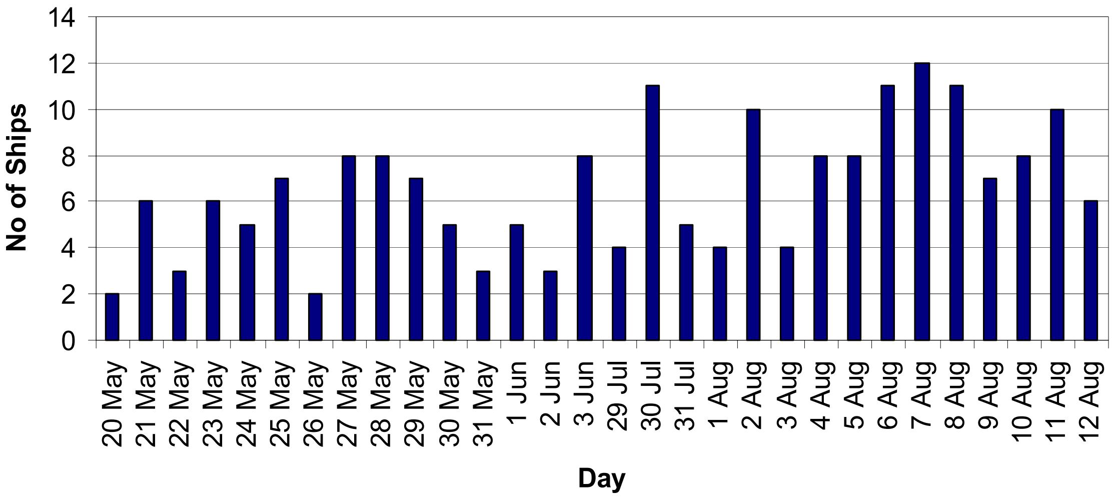


Figure 7.6 Number of ships per day passing through gate

Filtering vessels by course to isolate only vessels on Route 2 (approximately 210 to 235) and Route 3 (approximately 012 to 025), the daily distribution by route was as shown in Figure 7.7.

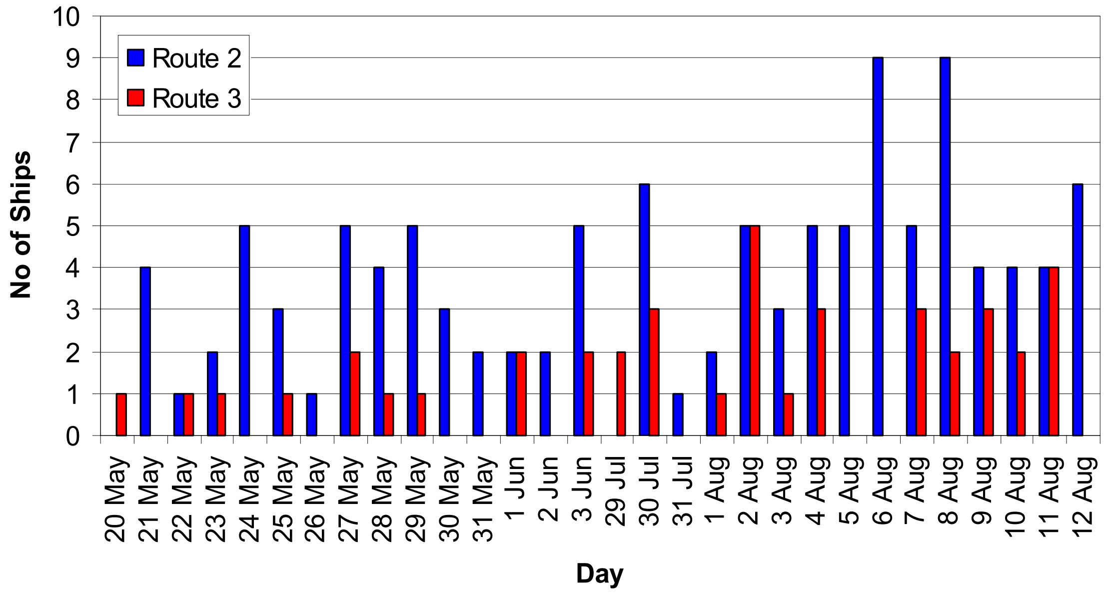


Figure 7.7 Number of ships per day on Routes 2 and 3 passing through gate

Figure 7.7 shows there were a number of days where several ships were using both routes, for example, 2 August when there were 5 ships on both Route 2 and Route 3. There were also days where only one of the routes was trafficked (e.g. 6 August when 9 ships passed on Route 2 but none on Route 3).

To assess the frequency of interaction of ships on Routes 2 and 3 it is also necessary to analyse the times that vessels were passing through the gate. The times that ships on Routes 2 and 3 intersected the gate over the entire 28 day survey are plotted below:

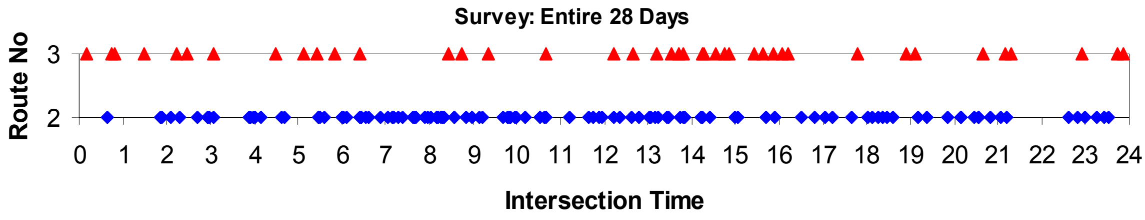


Figure 7.8 Times that ships on Routes 2 and 3 pass through the gate

Rounding the intersection time to the nearest hour, this information may be displayed as a histogram of hourly passages per route, as presented in Figure 7.9.

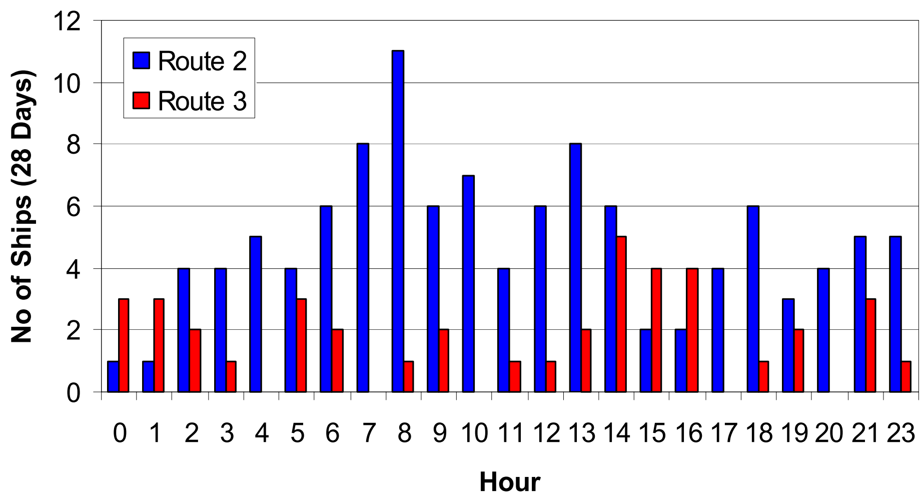


Figure 7.9 Histogram of hourly passages through gate by Routes 2 and 3

Figures 7.8 and 7.9 indicate that the traffic on both routes is fairly well dispersed over the 24-hour period, with the higher frequency of passages on Route 2 also clearly visible. However, the survey was scheduled to cover different tidal and seasonal conditions. To investigate whether is indeed well dispersed over time on a day-by-day basis, an analysis has been performed on five individual days when traffic was high on one or both routes.

The results per sample day are graphed in Figure 7.10.

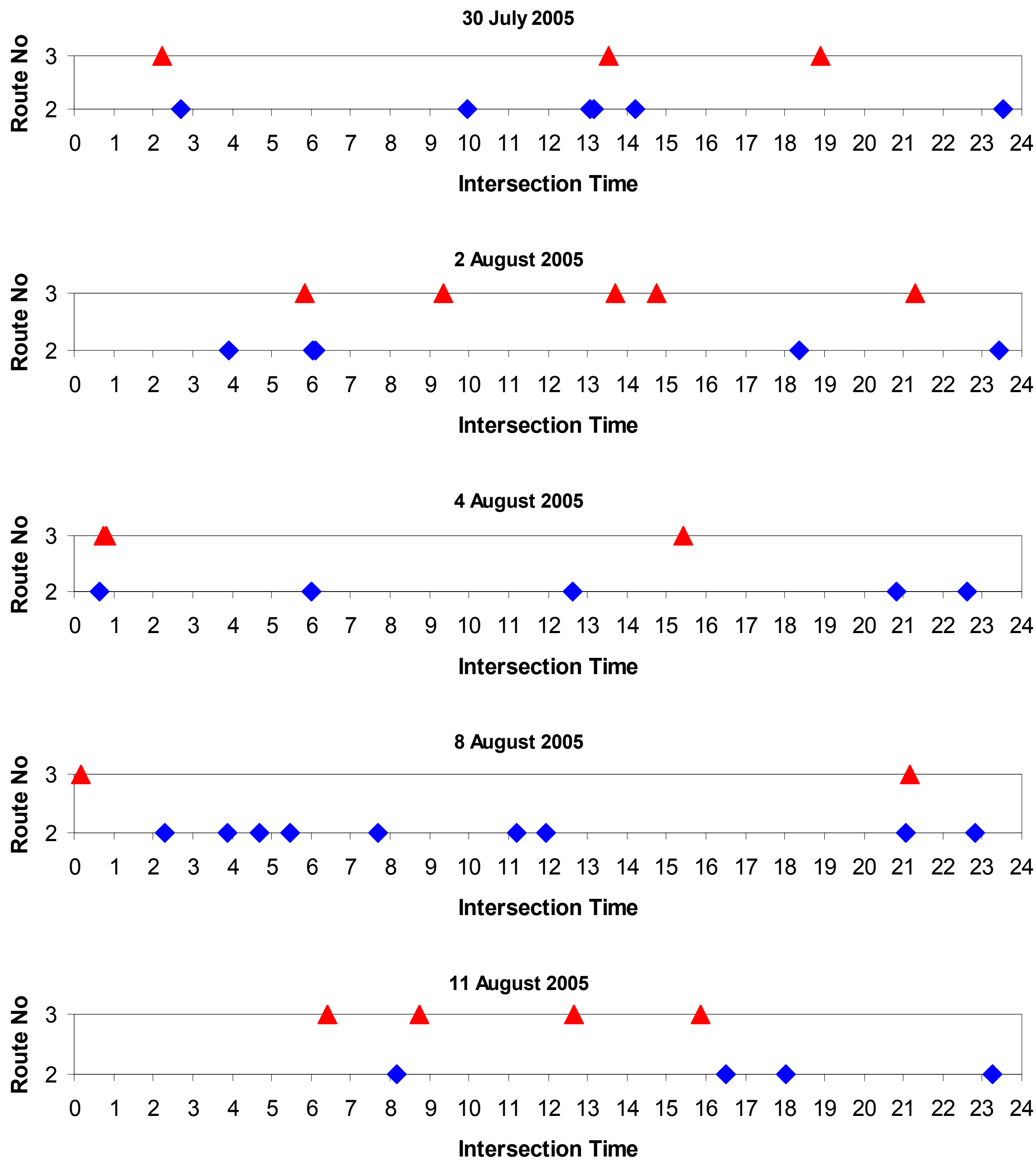


Figure 7.10 Sample daily time series of ships intersecting on Routes 2 and 3

The above daily graphs illustrate that the vessels tend to be dispersed throughout the day. Given this, and the relatively low volumes of shipping on the routes, in particular Route 3 to Milford Haven, this analysis indicates that there is no obvious threat of a Northbound vessel having to give-way to successive vessels heading SW and hence come into proximity of the Wave Hub deployment. It should be noted that this threat has been diminished by the relocation of the Wave Hub deployment area to the East (see Appendix B for more details).

The encounter analysis in Section 11.3.1 presents more information on interaction between all ships in the vicinity of the Wave Hub deployment area.

8. RECREATIONAL VESSEL ACTIVITY

8.1 Introduction

This section reviews recreational vessel activity at the Wave Hub deployment area based on information published by the RYA, consultation with the RYA and CA and radar tracking of recreational vessels during the 28 day maritime traffic survey.

8.2 RYA data

8.2.1 Introduction

Historically there has not been a database of recreational use of the UK's marine environment. As a response to the lack of information, the RYA, supported by the Cruising Association, started to identify recreational cruising routes, general sailing and racing areas. This work was based on extensive consultation and qualitative data collection from RYA and Cruising Association members, through the organisations' specialist and regional committees and through the RYA affiliated clubs. The consultation was also sent to berth holder associations and marinas. The results of this work were published in the document 'UK Coastal Atlas of Recreational Boating' (Ref. x). A summary of the data presented for the area around St Ives is presented below.

8.2.2 South West England recreational data

In the area around the Wave Hub deployment area there are relatively few marinas. The nearest recreational vessel facilities are at St. Ives and Hayle harbours. There are no general sailing areas or racing areas identified in the area from the atlas. Medium use recreational routes (defined as popular routes on which some recreational craft will be seen at most times during summer daylight hours) are identified inshore close to St Ives Head and offshore outside the 12nm limit. Both of these routes are well away from the Wave Hub deployment area. The following figure presents the data from the atlas.

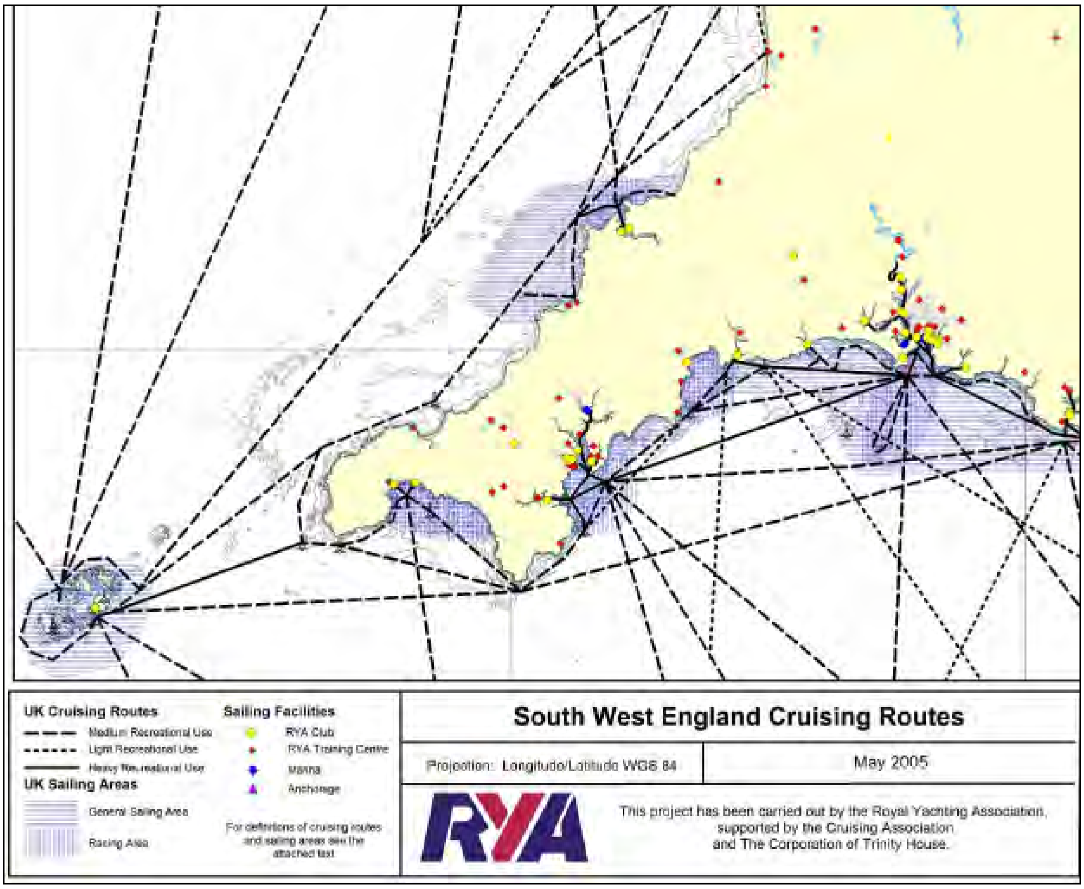


Figure 8.1 RYA recreational information for South West England

8.3 Survey data

The recreational vessel tracks identified during the maritime traffic survey from St. Ives are presented in Figure 8.2.

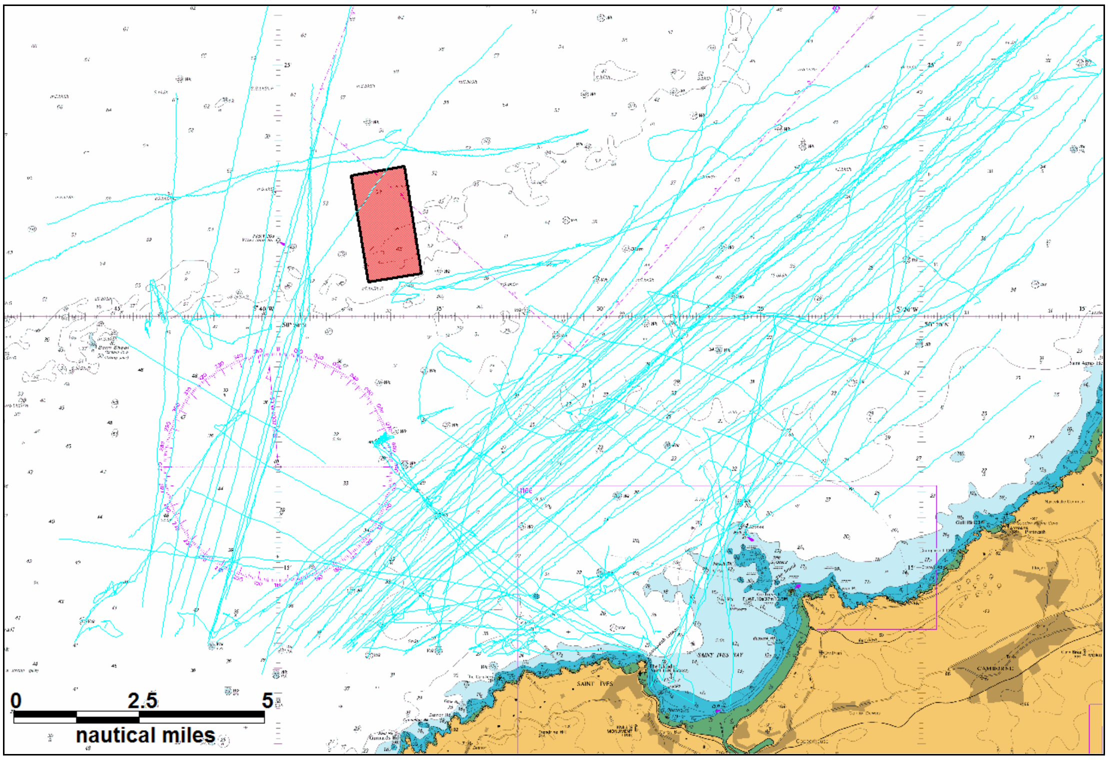


Figure 8.2 Recreational vessel survey tracks identified from the matitime traffic survey

There were 98 recreational vessels (including 70 yachts) tracked during the survey. Just one track (identified to be a yacht) passed through the Wave Hub deployment area and the majority of the other vessels passed between the Wave Hub deployment site and the coast.

A more detailed chart of the recreation vessel activity in proximity to the Wave Hub deployment area is presented in Figure 8.3.

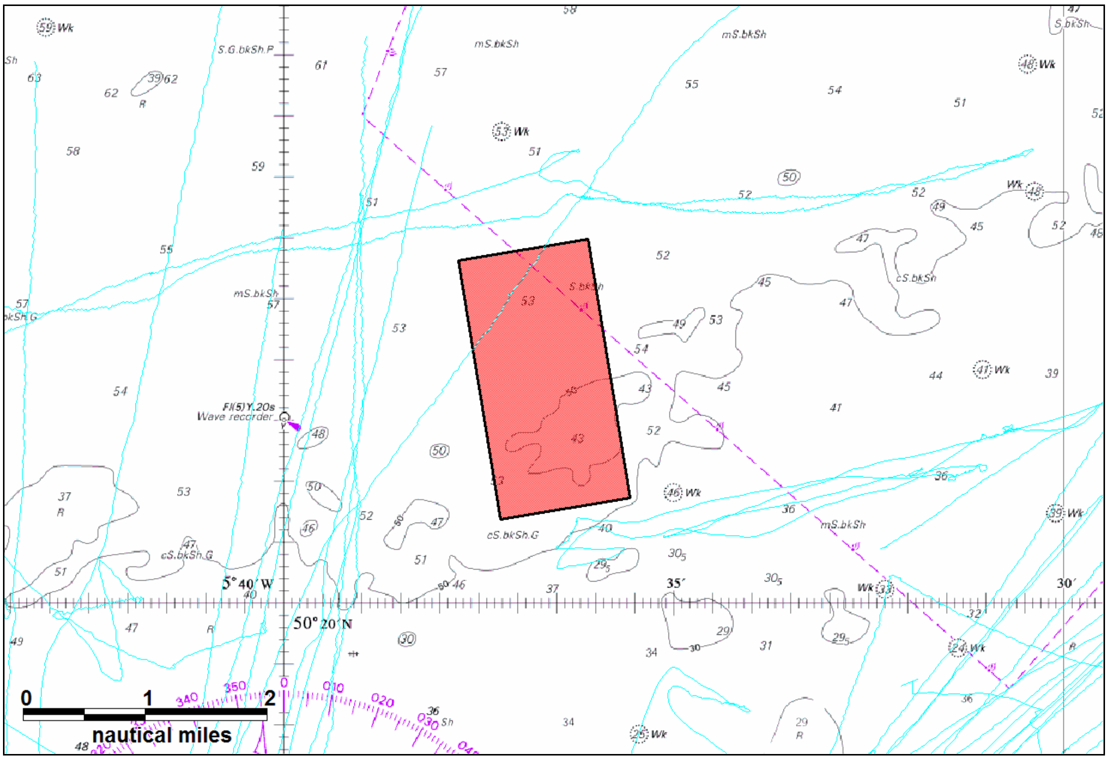


Figure 8.3 Recreational vessel survey tracks in proximity to Wave Hub deployment area

A photograph of one of the recreational craft observed during the survey is presented below.

Figure 8.4 Recreational vessel photographed during the survey

8.4 Consultation

Consultation with the RYA and CA (refer to Section 4), indicated that most of the recreational traffic would be routeing much closer to the coast than where the site is located and therefore the site would not have a significant impact on recreational traffic.

8.5 Potential impacts

Based on the preceding review, there is not considered to be the potential for a significant impact on recreational routes in the area. The main issue is for devices to be appropriately marked to aid their identification by recreational vessels as well as promulgation of information regarding the development to local users.

9. FISHING VESSEL ACTIVITY

9.1 Introduction

This section reviews the fishing vessel activity at the Wave Hub deployment area based on the 28 day maritime traffic survey and a detailed study of the commercial fishing activity in the vicinity (Ref. xi).

After reviewing these two data sources, further analysis is carried out of the surveillance data to assist in the navigation risk assessment. This is required as the fisheries study was primarily concerned with vessels actively fishing in the area whereas the navigation study considers all fishing vessel activity, including vessels on passage.

The proposed deployment area lies 8 to 11 miles from shore therefore it is between the UK 6 and 12 mile limits.

9.2 Survey tracks

A moderate level of fishing activity (65 vessels) was observed in the overall survey area although this was concentrated near-shore with just 5 fishing vessels passing through the proposed deployment area.

An overview of the fishing tracks is presented in Figure 9.1, with a more detailed chart presented in Figure 9.2.

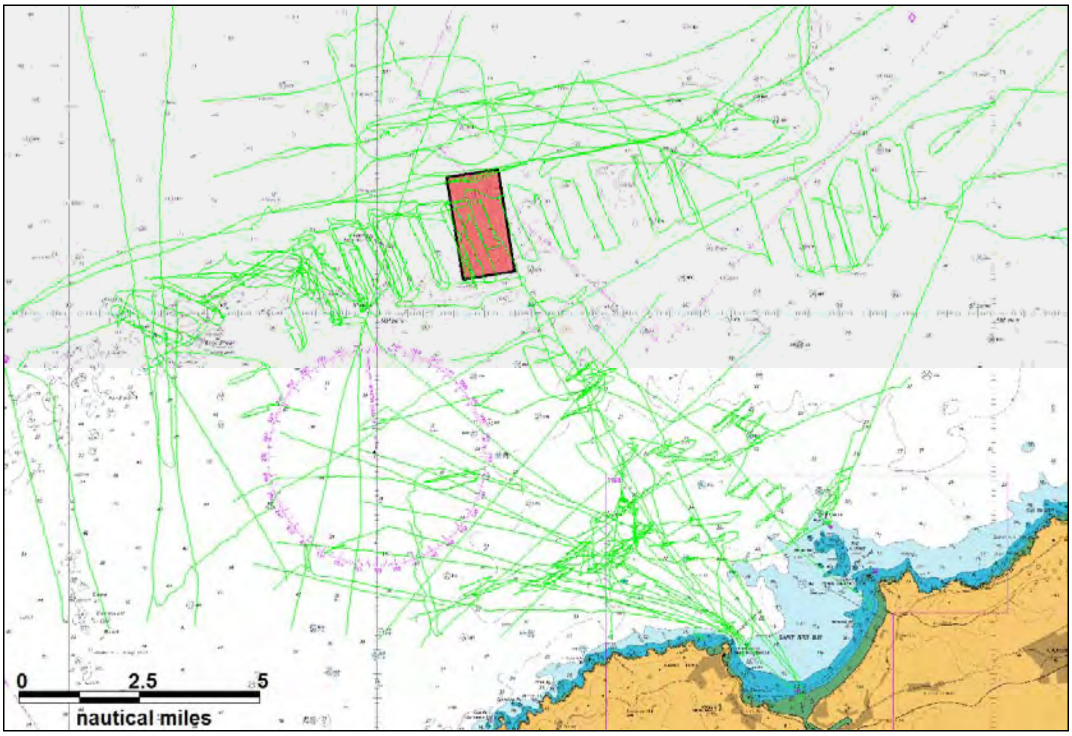


Figure 9.1 Overview chart of fishing vessels tracked during the survey

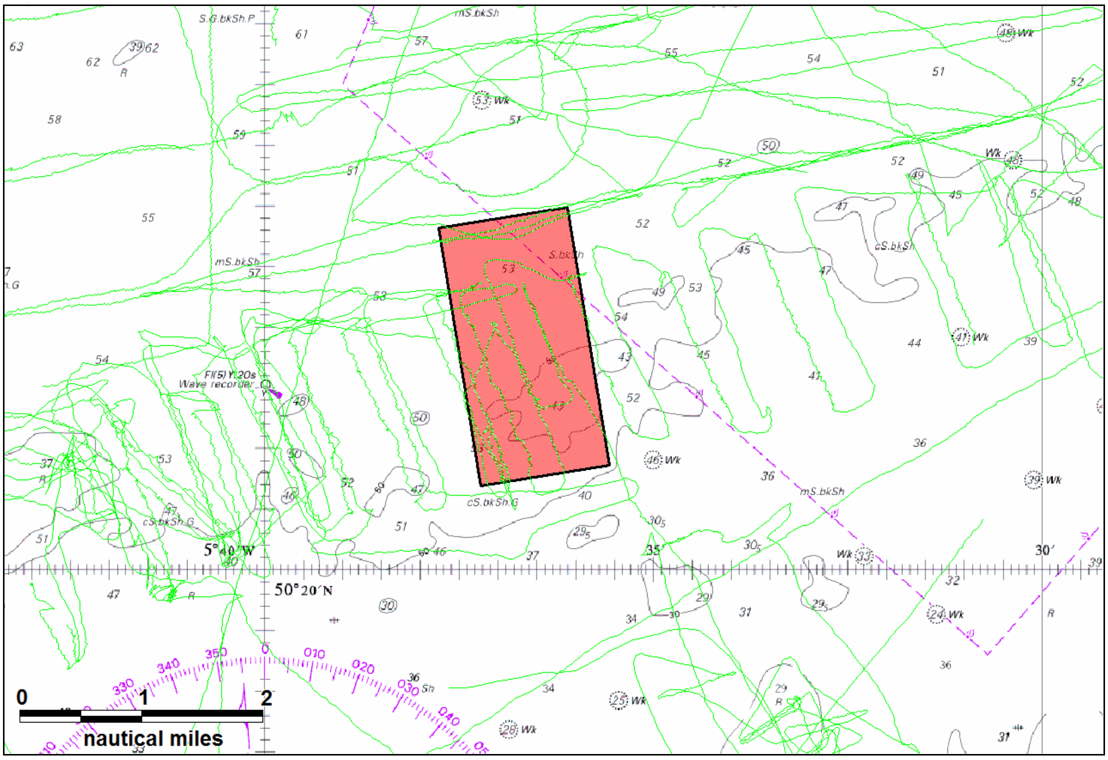


Figure 9.2 Fishing vessel survey tracks in proximity to the Wave Hub deployment area

An example of a fishing vessel observed during the survey is presented below.

Figure 9.3 French fishing vessel 'Nova Spira' photographed during survey

9.3 Commercial fisheries study

9.3.1 Introduction

A detailed study of the fishing activity in the vicinity of the Wave Hub deployment area has been undertaken by Emu Ltd (Ref. xi) as part of the EIA process for the proposed development. The study used a variety of data sources including:

- DEFRA fisheries surveillance data;
- Consultations with the local fishing industry;
- Site visits;
- Analysis of DEFRA landings data;
- Academic studies, previous fisheries reports, EIAs and other sources.

This section summarises some of the key findings of relevance to the navigation assessment. It is noted this study was focussed on the original deployment area but the findings are applicable to the revised site as the commercial fisheries study had a wide study area as it aims to describe commercial fisheries in the wider coastal waters around the deployment area.

9.3.2 Review of DEFRA surveillance data

Fisheries surveillance is undertaken by spotter aircraft and by fishery protection vessels and recorded by DEFRA within ICES statistical rectangles. The Wave Hub deployment area is within ICES Rectangle 29E4 Subsquare 1 (29E4/1) as shown in Figure 9.4.

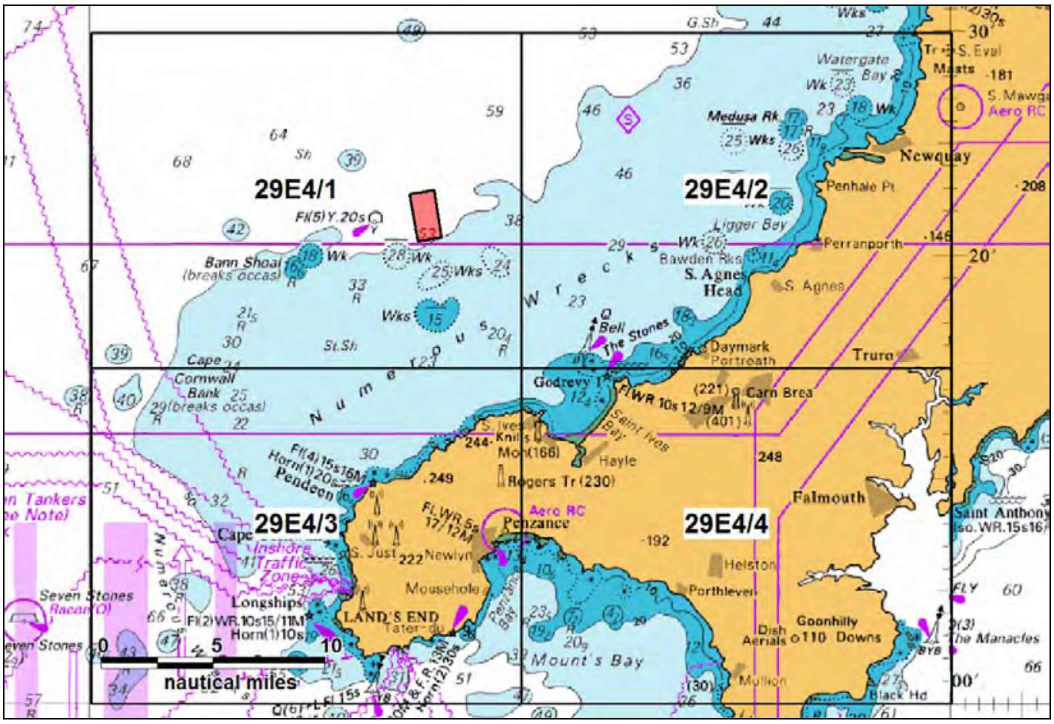


Figure 9.4 ICES rectangle and subsquare encompassing the deployment area

The following conclusions were made from a review of this data for the period 2000 to 2004:

- There is no significant trend in activity over the past 5 years;
- Fishing activity is highest in February and March during the sole fishery and lowest
- in November and December;
- U.K. vessels (47%) and French vessels (43%) account for the majority of sightings of active vessels;
- The great majority of French vessels are otter trawlers. Almost all of these fish outside the 12 mile limit;
- All the Belgian vessels are beam trawlers. Most sightings of these are outside the 12 mile limit;
- U.K. vessels use a number of different fishing methods in the area, including beam and otter trawling, potting and gill netting. Activity is spread across the whole of 29E4/1;
- Beam trawling activity is highest in February and March;
- Otter trawling activity is highest in January and February;
- Potting activity is highest in August and September;
- Gill netting activity is highest from June to October;
- Most of the otter trawling takes place outside of the 12 mile limit and will not be affected by the Wave Hub;
- Much of the beam trawling takes place outside of the 12 mile limit and will not be affected by the Wave Hub. However, some vessels are allowed to work inside the 12 mile limit and will be affected;
- Much of the potting takes place close to the Wave Hub and will be directly affected by any exclusion zone implemented as part of this development; and Gill netting will be little affected by the Wave Hub but will be impacted on by the site to shore cable route construction.

Further analysis of surveillance data relative to the revised site carried out for the navigation assessment is presented in Section 9.4.

9.3.3 Consultation with local fishing industry

Consultations were held with the fishing industry in and around Hayle and Newlyn during August 2005. Persons consulted included DEFRA officials, members of the Cornwall Sea Fisheries Committee, Cornwall Fish Producers Association, vessel owners and, most importantly, skippers of some of the vessels likely to be affected.

Based on this consultation exercise, the following key observations were made:

- Key species targeted in the wider study area include spider crab, edible (brown) crab, lobster, mackerel and sole;
- Lesser (but sometimes important) species include monkfish, bass, pollack, rays, plaice, cod, john dory, squid, turbot, herring and sprat;
- The fishery can be broadly divided into three main areas; (1) the inshore grounds, (2) the middle grounds and (3) the offshore fishery;

- Larger beam trawlers target the sole fishery in the offshore grounds between February and April each year;
- Potting for brown crab begins in earnest in May with the season lasting through until November. Some local vessels fish a lot of their gear in and around the proposed Wave Hub deployment area;
- The summer spider crab fishery is a key component of the local fishery; this species is targeted in the inshore and middle grounds by pots and nets;
- Lobster is also targeted by many vessels working the middle and offshore grounds;
- The other key fishery in this area is the summer mackerel hand-line fishery which has achieved Marine Stewardship Council accreditation as a sustainable fishery.

Based on discussions with local fishermen, it was estimated that there are approximately 85 inshore fishermen working in the immediate study area. This is a rough estimate and the actual number of fishermen who work in the study area may vary widely throughout the year.

More details on the make-up of the local fishing fleet by port is provided in the commercial fisheries study.

9.4 Site-Specific Fishing Vessel Analysis

For the purposes of the navigation assessment, this section estimates the fishing vessel density in the area of the Wave Hub deployment area using the latest 3-years of surveillance data presented in the commercial fisheries study (2002 to 2004), which covers vessels of all sizes and nationalities.

An overview of fishing vessel sightings colour-coded by nationality in ICES Rectangle 29E4 over the period 2002-04 is presented in Figure 9.5.

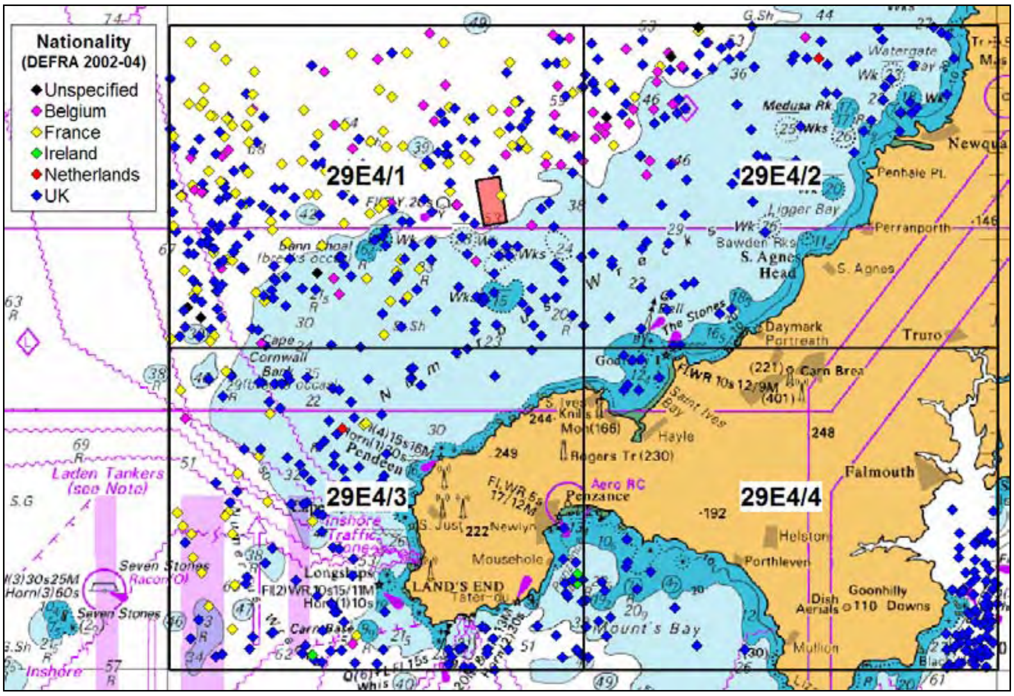


Figure 9.5 Fishing vessel sightings in ICES rectangle 29E4

More detailed plots of the fishing vessel sightings in Subsquare 29E4/1 encompassing the Wave Hub deployment area, colour-coded by nationality, activity and gear type, are presented in the following figures. These are based on a total of 221 patrols of Subsquare 29E4/1 between 2002 and 2004.

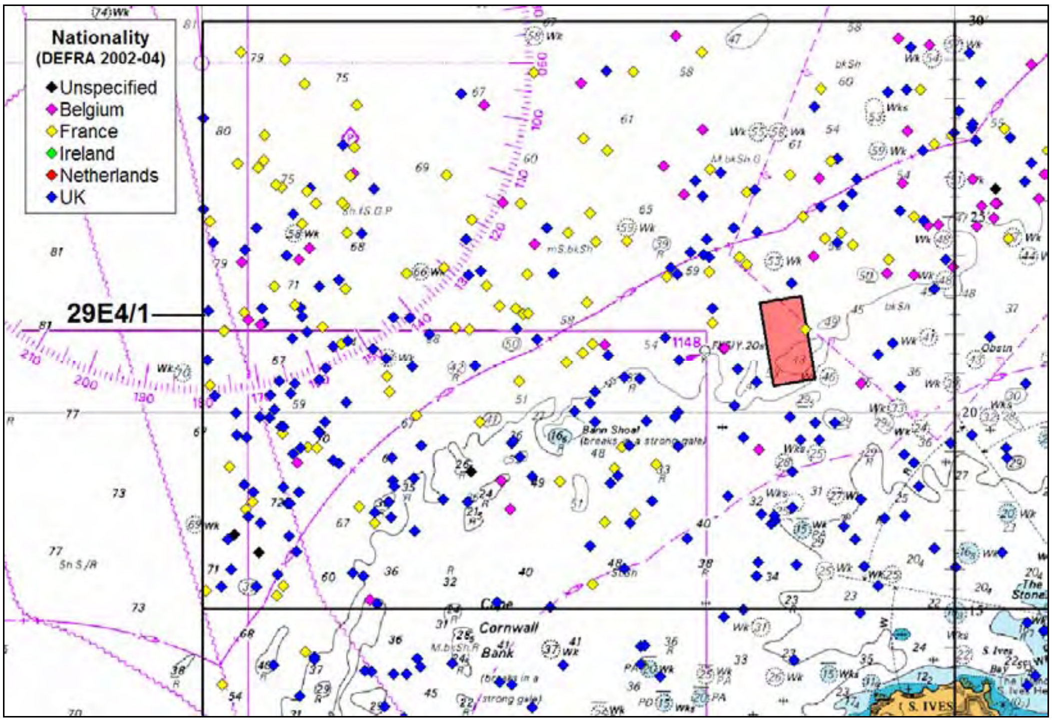


Figure 9.6 Fishing vessel sightings in the vicinity of the deployment area by nationality (2002-04)

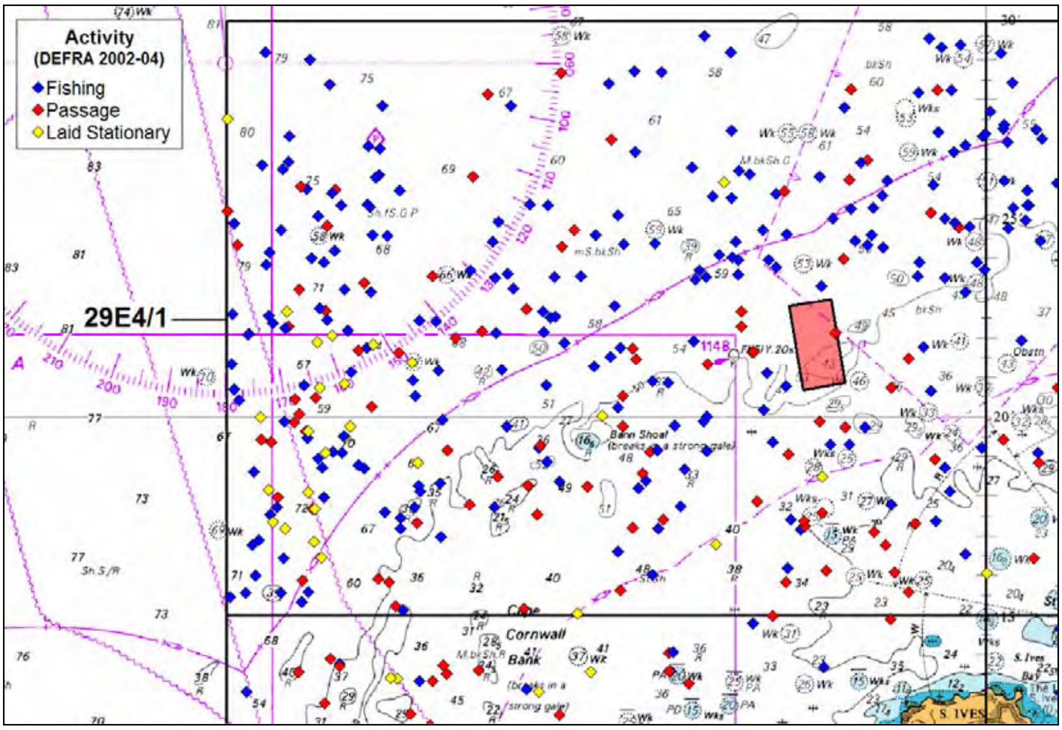


Figure 9.7 Fishing vessel sightings in the vicinity of the deployment area by activity (2002-04)

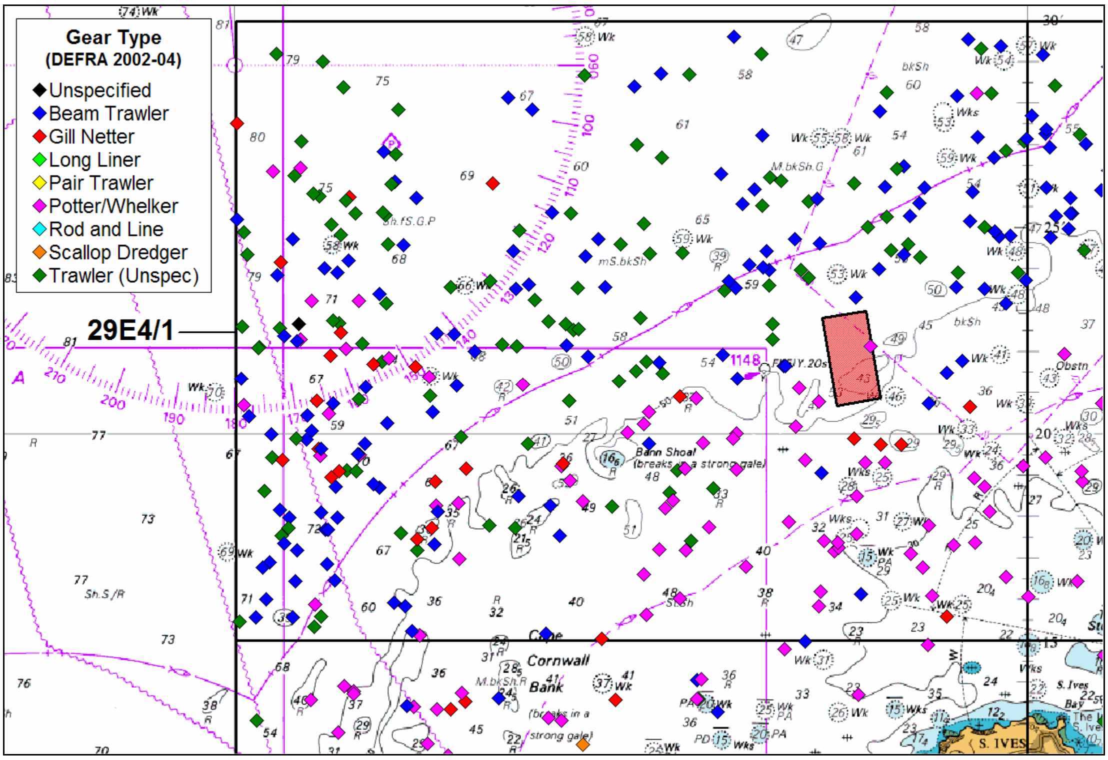


Figure 9.8 Fishing vessel sightings in the vicinity of the deployment area by gear type (2002-04)

From the above charts it can be seen that in Subsquare 29E4/1 as a whole, the main gear types sighted were beam trawlers (38%), unspecified trawlers (33%) and potters (21%).

The predominant vessel nationalities were UK (58%), French (31%) and Belgian (11%). In terms of activity, 65% of sightings were engaged in fishing, 27% were steaming (on passage) and 8% were laid stationary (vessels at anchor or pair vessels whose partner vessel is taking the catch whilst the other stands by).

A single fishing vessel was sighted within the Wave Hub perimeter. This was a French-registered potter recorded in November 2002 on passage through the area (not engaged in fishing).

The average number of fishing vessels sightings per patrol in ICES Subsquare 29E4/1 in each year is presented in Figure 9.9.

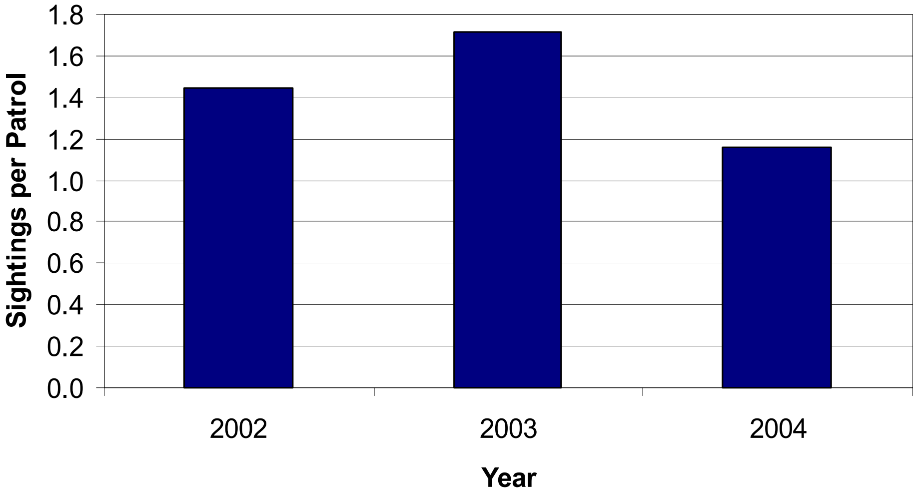


Figure 9.9 Annual sightings per patrol in Subsquare 29E4/1

The overall average was 1.4 fishing vessels within Subsquare 29E4/1 per surveillance patrol.

Based on this and the sea area of Subsquare 29E4/1 (985.7km^2 or 287.4nm^2), the average fishing vessel density within the Subsquare based on 3 years of surveillance patrols was 5 x 10^{-3} per nm^2.

It is recognised that the proposed Wave Hub deployment area only occupies a small area (8km^2 or 0.8%) of ICES Subsquare 29E4/1. Based on the geographical variation of sightings identified within the Subsquare, the overall fishing vessel density figure is considered to be reasonably representative of the fishing activity in proximity to the Wave Hub.

This estimate in used in the fishing vessel collision risk assessment presented in Section 11.4.3.

10. FORMAL SAFETY ASSESSMENT

10.1 Introduction

The IMO Formal Safety Assessment process (Ref. xii) as approved by the IMO in 2002 under SC/Circ.1023/MEPC/Circ392 has been applied within this study. This is a structured and systematic methodology based on risk analysis and cost benefit assessment (if applicable). There are five basic steps within this process:

1. Identification of hazards (a list of all relevant accident scenarios with potential causes and outcomes);
2. Assessment of risks (evaluation of risk factors);
3. Risk control options (devising regulatory measures to control and reduce the identified risks);
4. Cost benefit assessment (determining cost effectiveness of risk control measures); and
5. Recommendations for decision-making (information about the hazards, their associated risks and the cost effectiveness of alternative risk control measures).

Figure 10.1 is a flow diagram of the FSA methodology applied.

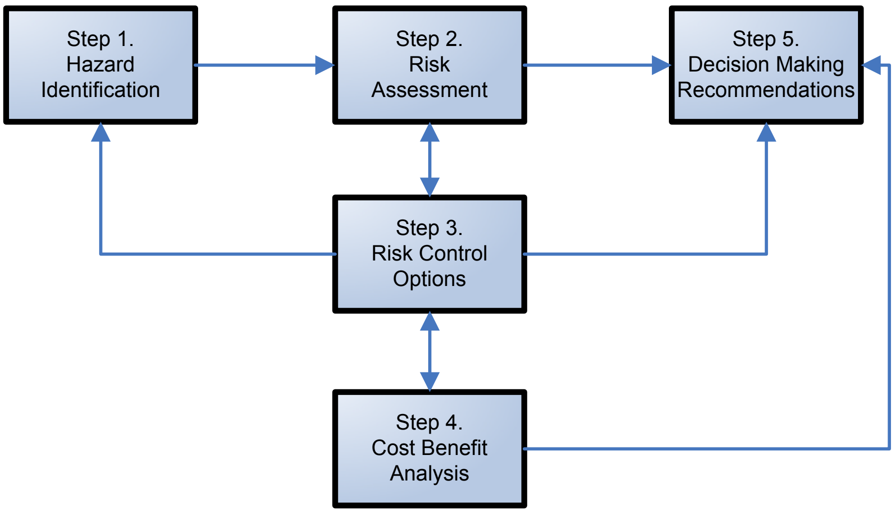


Figure 10.1 Overview of Formal Safety Assessment

As indicated within the IMO FSA guidelines and the DTI guidance on risk assessment methodology (Ref. ii) for offshore renewable projects, the depth of the assessment should be commensurate with the nature and significance of the problem. Within the assessment of proportionality consideration was given to both the scale of the development and the magnitude of the risks/navigational impact.

From review it was concluded that the Wave Hub development is a large scale development with the potential to impact navigational safety. As a result, the content and methods of the risk assessment were responsive to this and included the following:

- Comprehensive hazard log
- Risk Ranking
- Detailed and quantified Navigational Risk Assessment for selected hazards
- Preliminary search and rescue overview
- Preliminary emergency response overview
- Comprehensive risk control/mitigation measures log

It is noted that for this phase of the project the risk assessment is generic and not device-specific. It looks more at the site area as opposed to the individual devices, although issues which could relate to the different devices were discussed in the hazard identification process. Each individual device will be independently assessed prior to installation at the site (see discussion of requirements in Section 17).

10.2 Hazard identification workshop

Within this process the hazards associated with the Wave Hub development and possible generic devices were identified. This process was carried out in a workshop with project personnel and stakeholders using Anatec's Hazard Management software as well as supporting documentation. Table 10.1 presents a list of personnel who attended the Hazid workshop.

Table 10.1 Hazard workshop participants

Attendee	Position	Company
John Browne	Harbour Master	Hayle Harbour Authority
Peter Stothert	Project Director	Halcrow
Rod Hacker	Design Manager	Halcrow
Richard Luck	Planning Supervisor	Halcrow
Inma Andina-Pendas	Project Assistant Engineer	Halcrow
Thomas Cocking	St. Ives Coxswain	RNLI
Captain Roger Barker	Navigation Manager	Trinity House
Simon Cadman	Senior Officer	Cornwall Sea Fisheries Committee
Ali MacDonald	Senior Risk Analyst	Anatec
John Beattie	Senior Risk Analyst	Anatec

[Apologies for absence were received from Stephen Basset (St. Ives Harbour Master) and Alan Matthews (West Cornwall Sector Manager MCA).]

An overview of the development was presented by the project team as well as an overview of the traffic survey to aid in the discussion and the identification of hazards by the project team.

The following information was recorded at the workshop:

- Hazard category
- Area/location
- Hazard title and description
- Causes of hazard
- Most likely outcome/consequences
- Worst case outcome/consequences
- Proposed risk control (mitigation) measures
- Potential additional risk control measures

No risk ranking was undertaken at this stage as the devices are unknown. Risk ranking will take place within each device specific hazard identification and risk assessment (See Section 17).

10.3 Hazards identified and key findings

Table 10.2 presents a list of the hazards identified within the workshop. Further details on each of the hazards in terms of the causes as well as potential control measures can be found in Appendix A.

Table 10.2 List of hazards identified at the workshop

Hazard
Cargo vessel powered vessel collision with wave energy device (WEC)
Cargo vessel drifts into site and WEC devices
Cargo vessel collision with another vessel due to re-routeing as a result of the Wave Hub deployment area
Anchor fouling of site to shore cable
Fishing vessel gear interaction with site equipment when vessel is fishing
Fishing towed gear interaction with site equipment (subsea equipment or device within site)
Recreational vessel collides with structures
Submerged submarine collides with devices and associated equipment
Device drifts off station presenting a hazard to shipping
Loss of mooring line - device moving around still on location
Man overboard in site during maintenance operations
Attendant vessel collision with structures
Deliberate unauthorised boarding of structures
Debris drifts in to structures (jetsam and flotsam)
Construction/works vessel collision with passing vessel

Hazard
Dropped objects during installation/decommissioning

It is noted that the hazards identified are for the generic Wave Hub development and that this will require to be revisited and updated within each device's specific risk assessment (see Section 17).

The key issues identified in the workshop which require further consideration are listed below:

- For navigational markings, likely that a Racon may be required on one of the buoys marking the site. This would be given further consideration by Trinity House. AIS marking would also require to be considered.
- The cable route could be exposed to vessel anchor damage, based on where vessels anchor in St Ives Bay, particularly given that the cable will not be buried in some places. Comment was made that the consideration should be given to routeing the cable to the East as well as consideration given to protection of unburied cables by mattresses, etc.
- Some form of identification should be put on the cable (e.g. live cable) to warn mariners of the danger in event of it being picked up by an anchor.
- Noted that it is located outside but adjacent to a military exercise area and there are quite a number of military vessel activity movements in the area. MoD to be consulted with regard to markings for submarine activities if considered appropriate.
- One of the main hazards will be a device (or part of a device) drifting off station. Further consideration requires to be given to the monitoring of individual and multi component devices and how they will be tracked if they drift off station. Means of transmission would need to be independent of the cable. The monitoring, alarm and contingency plans for device recovery require to be developed in consultation with MCA for each device.
- Noted that a device adrift may not be easy to recover (e.g. to attach a tow line may need specialist equipment). Consideration should be given to this in device design.
- Consideration requires to be given to whether the devices should have radar reflectors and emergency lighting, should they drift and pose a hazard to shipping.
- It was noted that minimal intervention is planned for these devices; however, safety procedures will require to be developed for personnel carrying out any maintenance on devices. Such procedures should cater for Man overboard. The design of the devices should consider the potential entrapment of personnel within the structures. Procedures should specify if devices are shutdown during maintenance operations.
- Details of the devices and layouts etc should be provided to the RNLI in event of emergency response being required within the site.

- There may be a risk to devices from floating debris. Consideration should be given to this in the design of the devices.
- Local knowledge indicates marine growth (kelp) may be a problem. This will need to be considered in device design.
- Consideration should be given to putting warning notices on devices in case of persons planning to tie-up to or board devices. Wording also needs to be considered (e.g., 'Caution' rather than 'Danger'). Information will be promulgated to local sailing and water sport clubs.

10.4 Risk control measures

Based on the hazard identification workshop, the key measures which require to be considered in term of risk management and control of the Wave Hub development and associated devices are listed in the following tables. It is noted that some of the measures listed will apply to all phases of the operation.

Table 10.3 List of risk control measures (pre-installation)

Risk Control/Mitigation Measure
Consider relocation of site due to proximity to merchant shipping routes
Issue Notices to Mariners/NAVTEX
Issue guidance/information to Search & Rescue organisations (MCA/RNLI/Tug Companies)
Information to be marked on hydrographic charts
Consider siting of individual devices relative to shipping lanes and ease of identification
Promulgation of information to local users clubs
Planning of major construction operations relative to shipping activity in the area.
Design works packages to minimise numbers of vessels/durations of operations.

Table 10.4 List of risk control measures (construction phase)

Risk Control Measure
Issue Notices to Mariners/NAVTEX
Navigational Information Broadcasts
Navigational buoys installed in the area
AIS fitted on all workboats working within site.
Emergency response and shutdown procedures/plan
Site personnel trained in fire fighting, first aid and offshore survival
Personal Protective Equipment (PPE) for all personnel working in site.
Safety Management Systems for all vessels working in the site
Guard vessel during construction/decommissioning activities
Continuous watch by multi-channel VHF, including Digital Selective Calling (DSC)

Table 10.5 List of risk control measures (operational phase)

Risk Control Measure
Navigational (cardinal) buoys installed in the area
Racon (proposed measure)
Concrete mattresses to protect cable (To be considered)
ID on Cable "Live" to warn mariners (To be considered)
Navigation aids (radar reflector and/or light) on devices (To be considered)
AIS Transceiver
AIS fitted on all workboats working within site.
Emergency response and shutdown procedures/plan
Area to be Avoided/Safety Zones
Anchoring prohibited within site
Oil spill response plan developed for the site.
Planning of maintenance operations, adverse weather working policy and procedures
Cable Route Inspection
System condition monitoring of devices
Position monitoring of devices (GPS based)
Legal notice on devices (to be considered)
Devices shutdown during maintenance operations
Seasonal planning of operations (suitable weather windows)
Control monitoring & paging on call response

11. RISK ASSESSMENT OF WAVE HUB DEPLOYMENT AREA

11.1 Introduction

This section assesses in more detail some of the key (generic) risks associated with the Wave Hub deployment area in order to estimate the level of risk associated with the site.

The design and layout of devices within the sites has yet to be finalised and, therefore, the risk of direct collision has been assessed by assuming any infringement of the site boundary will lead to an impact. In reality, devices will only occupy a proportion of the site but this conservative approach provides an indication of the relative risks associated with the development. Further work is planned on a device-specific basis (see Section 17).

11.2 Risk assessment

The following scenarios were investigated in detail, quantitatively or qualitatively.

Baseline (without Wave Hub):

- Vessel-to-vessel collisions

With Wave Hub:

- Vessel-to-vessel collisions
- Ship-to-Wave Hub collisions (powered and drifting)
- Fishing Vessel-to-Wave Hub collisions
- Cable interaction

All the quantified risk assessments were carried out using Anatec's COLLRISK software which conforms to the DTI methodology as outlined in Annex D3 in the Guidance (Ref. ii). In line with this Anatec makes the declaration that the models used within this work have been validated and are appropriate for the intended use. As required the following have been considered and justified:

- Tuning of parameters
- Consistency checks
- Behavioural reasonableness
- Sensitivity analysis
- Comparison with the real world.

11.3 Baseline risks

11.3.1 Encounters

A prediction of current vessel-to-vessel encounters has been carried out by replaying at high-speed a fortnight of survey data. The following figure presents the predicted number of encounters per day occurring within 10nm of the originally proposed site, where an encounter has been defined as vessels passing within 1nm of each other. It is noted that the assessment area also covers the revised site location.

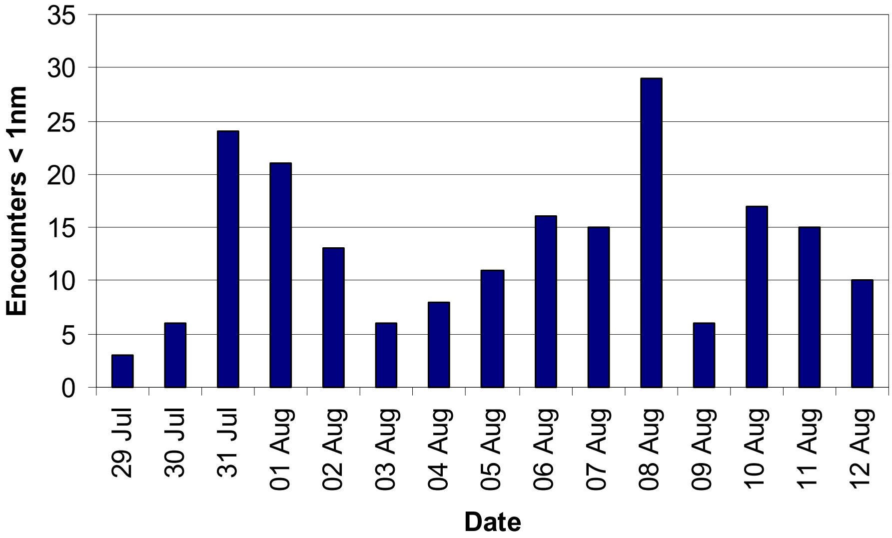


Figure 11.1 Predicted number of encounters (within 1nm) per day

The average number of predicted encounters was 14 per day, with the highest number (29 encounters) occurring on 8 August 2005.

The following figure presents the distribution of pairs of vessels involved in encounters (where both types were identified).

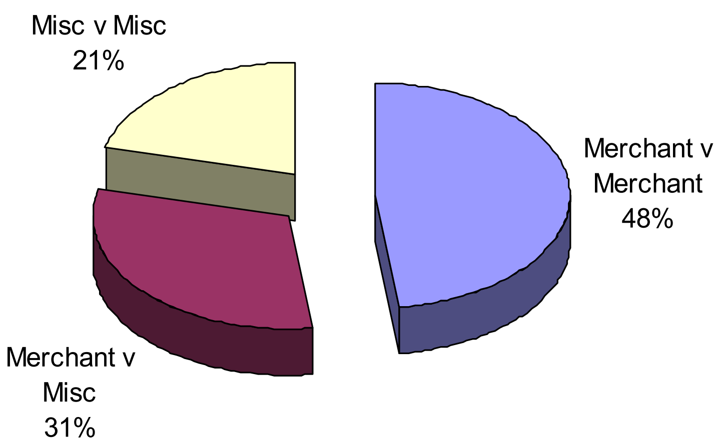


Figure 11.2 Pairs of vessels by type involved in encounters

It can be seen that just under half of all encounters are predicted to be between merchant vessels, with 31% involving merchant vessels passing close to miscellaneous vessels (i.e.

non-merchant vessels such as fishing and recreational craft) and the remainder involving pairs of miscellaneous vessels.

The locations of predicted encounters on the busiest day are presented in Figure 11.3. This shows the vessel tracks over the duration of the encounter (i.e. where two vessels are within one nautical mile of each other).

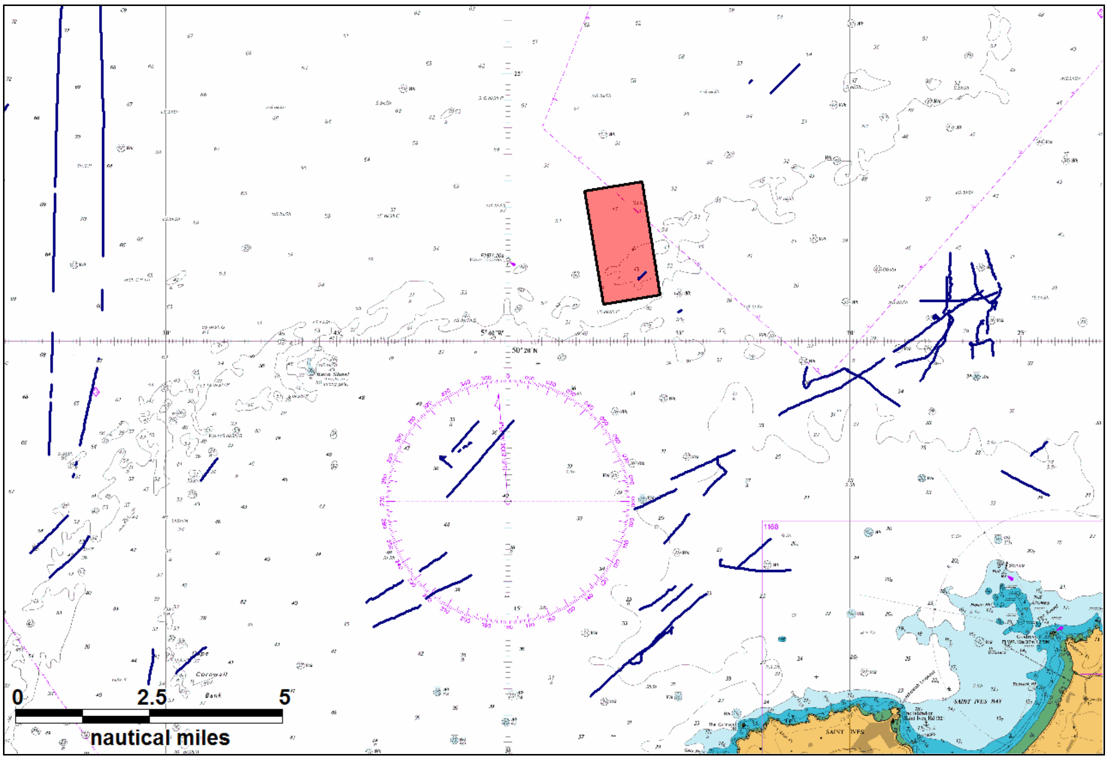


Figure 11.3 Overview of encounters on busiest day (8 August 2005)

The encounter tracks over the full period are presented in Figure 11.4. To assist interpretation of the results, the geographical distribution of encounters has been calculated using a grid of cells covering the area, as presented in Figure 11.5. This helps to illustrate where existing vessel activity is highest and, therefore, where offshore developments, such as the Wave Hub development, could potentially exacerbate congestion and hence increase the risk of encounters / collisions.

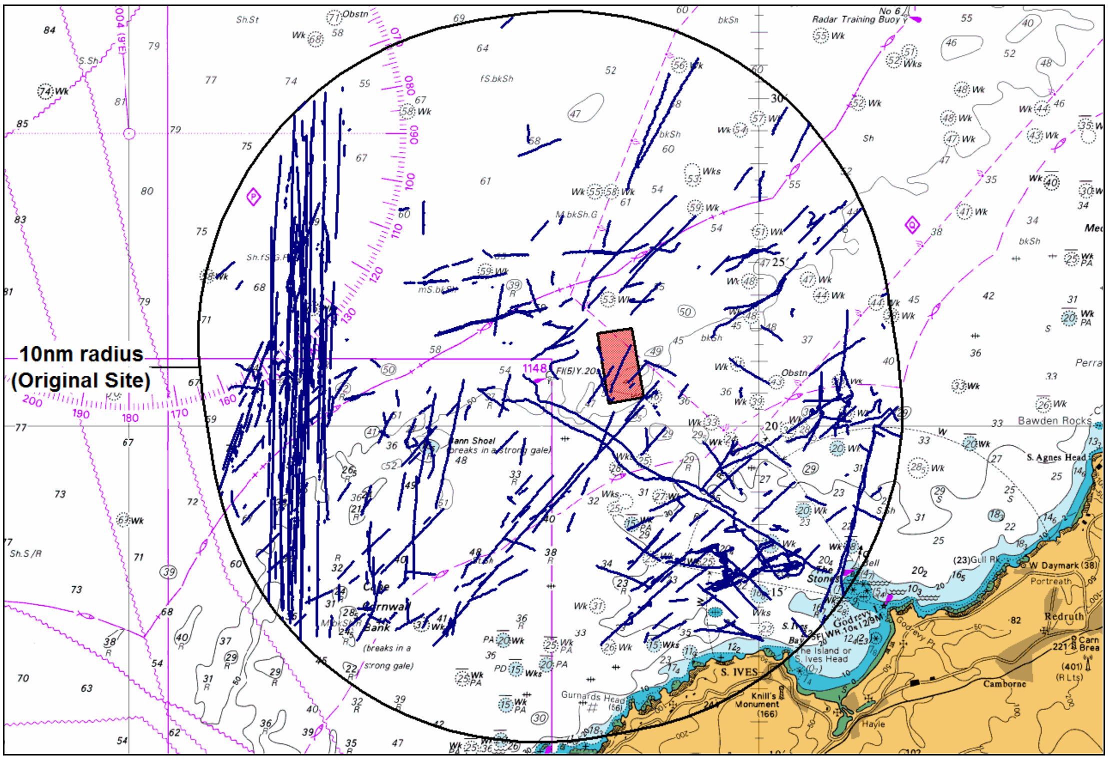


Figure 11.4 Distribution of encounter tracks

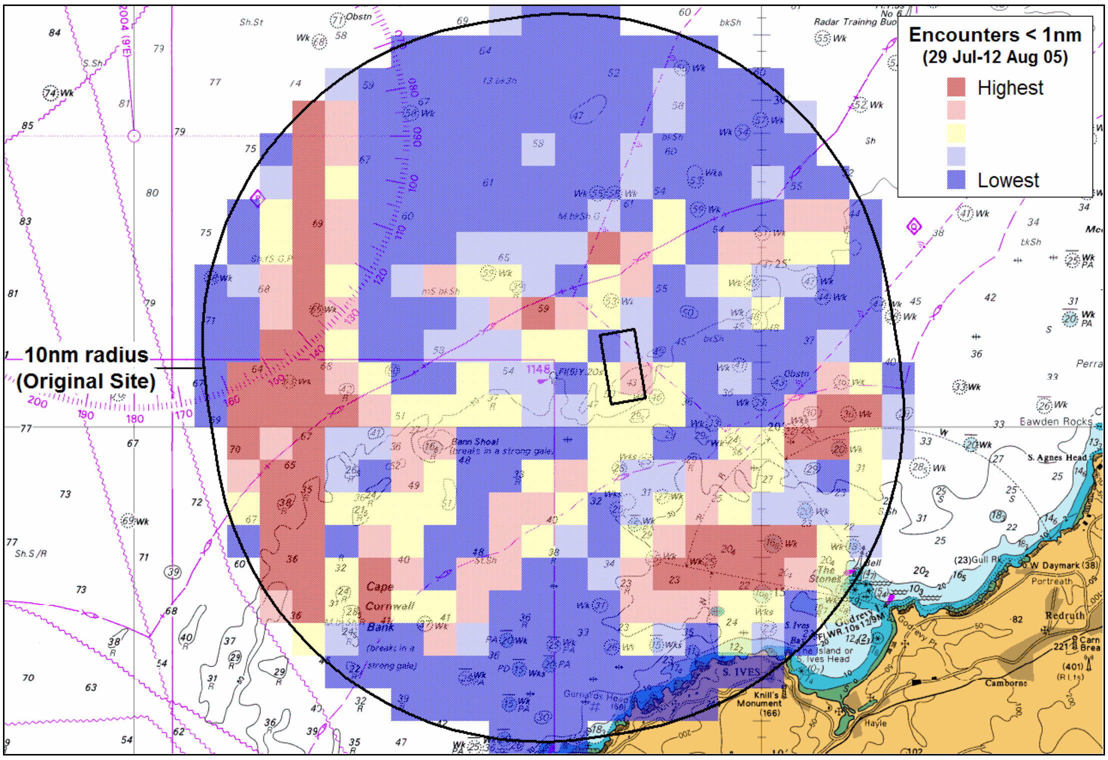


Figure 11.5 Density distribution of encounters

It can be seen that most encounters occurred well to the west of the proposed Wave Hub deployment area in the higher traffic density area between the TSS off Land's End and The Smalls TSS. There were also high density areas further inshore near St Ives, where non-merchant traffic is highest (fishing and recreation).

The density of encounters in the vicinity of the Wave Hub was low to moderate. Within the deployment area there were four encounters recorded over the period analysed, two involving cargo vessels and two others of unspecified types.

11.3.2 Vessel-to-vessel collisions

Based on the existing routeing and encounter levels in the area, Anatec's COLLRISK model has been run to estimate the existing vessel-to-vessel collision risks in the local area around the Wave Hub deployment area. The traffic details input to the model are based on the survey analysis.

Based on the modelling of the area, the baseline vessel-to-vessel collision risk level was estimated to be 0.013 per year (in the order of 1 major collision in 77 years[1]).

11.4 With Wave Hub risk

11.4.1 Vessel-to-vessel collisions – change in risk

The revised traffic pattern following the proposed Wave Hub development has been estimated based on the review of impact on navigation (see Section 7.2). The revised routeing picture is illustrated in Figure 11.6. This assumes effective mitigation in the form of information distribution about the developments to shipping through Notices to Mariners, updated charts, liaison with ports, etc.

[1] Note that the models have been calibrated against 'serious' casualty data. This requires the incident to be of a defined degree of seriousness in terms of loss of life, environmental damage and/or financial impact. Non-serious casualties are estimated to be in the order of 4 times more frequent than serious casualties. Anatec's models are calibrated against serious casualties as this minimises the probability of under-reporting and provides a benchmark level when comparing the frequency of accidents in different parts of the World.

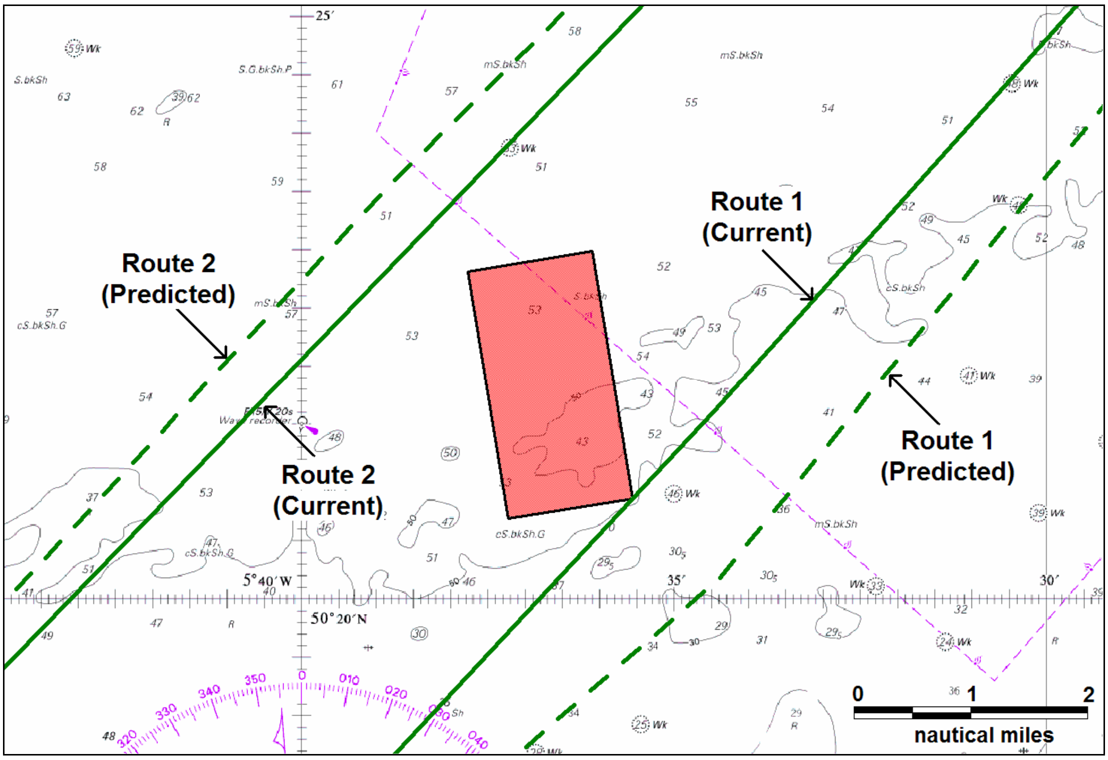


Figure 11.6 Revised routeing pattern (post-Wave Hub)

Based on vessel-to-vessel collision risk modelling of the revised traffic, the collision risk was estimated to reduce slightly to 0.011 per year (1 major collision in 94 years).

The slight decrease is mainly due to the anticipated separation of traffic on Routes 1 and 2 in the vicinity of the Wave Hub, which reduces the probability of head-on encounters / collisions between this traffic which is heading in opposite directions. This outweighs the impact of a slight increase in overtaking encounters / collisions due to narrowing of Routes 1 and 2.

11.4.2 Ship collision with devices

There are two main scenarios for passing ships colliding with offshore structures such as the proposed Wave Energy Converter devices.

- Powered Collision: Where the vessel is under power but errant
- Drifting Collision Where a ship on a passing route experiences propulsion failure and drifts under the influence of the prevailing conditions.

Each scenario is assessed below.

<u>Powered Ship Collision</u>

Based on the ship routeing identified for the area, and assuming effective mitigation in terms of making mariners aware of the site through Notices to Mariners, charts, lights and markings, etc., the frequency of an errant ship under power deviating from its route to the extent that it comes into proximity with the Wave Hub deployment area is considered to be low. The main risk of powered collision is from watch-keeper failure on the bridge of the ship.

Based on modelling the anticipated ship routeing pattern post-Wave Hub along with the overall deployment area of the Wave Hub and metocean data for the area, the risk of collision was estimated to be 5.6 x 10^{-3} per year (approximately 1 in 177 years).

This compares to the historical average of 5.3 x 10^{-4} per installation-year for offshore installations on the UKCS (1 in 1,900 years). The risk to the Wave Hub site is estimated to be an order of magnitude higher, which reflects both the traffic density passing nearby and the large exposed area of the Wave Hub used in the modelling. It is noted that in terms of collisions with specific devices, these will occupy only a proportion of the site area, therefore, the probability of collision on a device-specific basis is likely to be significantly lower.

Drifting Ship Collision

The risk of a ship losing power and drifting into a Wave Hub structure was assessed using Anatec's COLLRISK model. This model is based on the premise that propulsion on a vessel must fail before a vessel will drift. The model takes account of the type and size of the vessel, number of engines and average time to repair in different conditions.

The exposure times for a drifting scenario are based on the ship-hours spent in proximity to the Wave Hub deployment area (up to 10nm from perimeter). These have been estimated based on the traffic levels, speeds and revised routeing pattern. The exposure is divided by vessel type and size to ensure these factors, which based on analysis of historical accident data have been shown to influence accident rates, are taken into account within the modelling.

Using this information the overall rate of breakdown within the area surrounding the Wave Hub deployment area was estimated. The probability of a ship drifting towards the Wave Hub deployment area and the drift speed are dependent on the prevailing wind, wave and tide conditions at the time of the accident.

Based on local experience anything adrift around the Wave Hub site tends to drift with the prevailing tidal currents North East/South West and is slowly blown inshore by the onshore winds. This can be seen from the track of a buoy which went adrift from the Wave Hub site; when the buoy came loose it started drifting to the South West and then back and forth with the currents until it was recovered. The track of the buoy is presented in Figure 11.7.

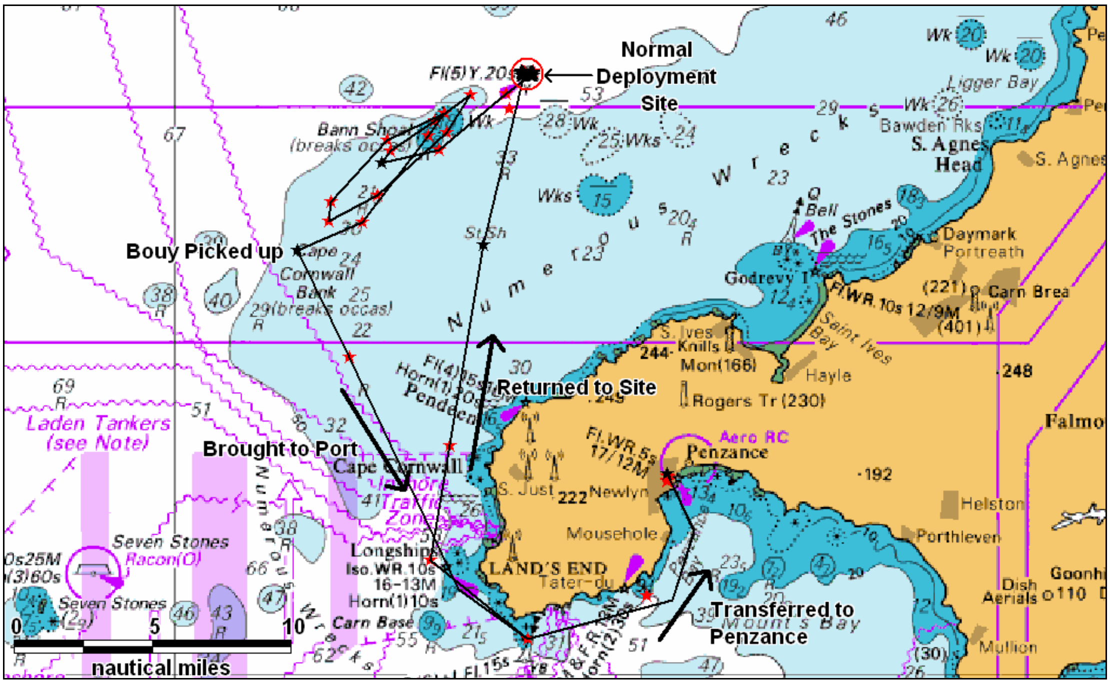


Figure 11.7 Waverider buoy drift pattern

For modelling of shipping drift scenarios, three drift conditions were simulated:

- Wind-dominated
- Peak Spring Flood Tide-dominated
- Peak Spring Ebb Tide-dominated

The worst-case result was generated based on wind-dominated drift. This is expected based on the anticipated traffic pattern (i.e. the closest ships are expected to pass to the NW and SE of the site) as whilst the predominant wind direction is SW it tends to more random whereas the tide generally run NE (flood) or SW (ebb). Therefore, the tide alone would not tend to take any vessels breaking down in the vicinity towards the Wave Hub deployment area.

The probability of vessel recovery from drift is estimated based on the speed of drift and hence the time available before reaching the site. Vessels that do not recover within this time are assumed to collide.

The annual drifting ship collision frequency with the Wave Hub generic area based on wind-dominated drift (worst-case) was estimated to be 2.7 x 10^{-4} per year corresponding to an average of one drifting ship collision per 3,700 years.

The relatively low risk estimate reflects the fact this is generally a low probability event. There have been no reported ‘passing’ drifting ship collisions with offshore oil and gas installation on the UKCS in over 6,000 operational-years. Whilst a large number of drifting ships have occurred each year in UK waters, the vessels have been recovered in time (e.g. anchored, restarted engines or taken in tow).

It is again noted that in terms of collisions with specific devices, these will occupy only a proportion of the site area; therefore, the probability of drifting ship collision on a device-specific basis is likely to be significantly lower.

11.4.3 Fishing vessel collision

The maritime traffic survey and commercial fisheries study (Ref. xi) have provided a detailed picture of the fishing activity in the area. However, the study also points out the inherent limitations in fisheries data and the unpredictability of external variables.

These limitations apply to modeling the collision risks associated with fishing vessels operating near the Wave Hub or steaming past the area. To provide an estimate of the risk, fisheries surveillance data has been used. Whilst surveillance sightings can only be considered a relative indicator of fishing activity, providing a series of snapshots of fishing activity within a defined area over time, it does provide a basis for calibrating a risk model of fishing vessel collisions in UK waters.

Anatec's COLLRISK fishing vessel risk model has been calibrated using surveillance data for the UK along with offshore installation operating experience in the UK (oil and gas) and the experience of collisions between fishing vessels and UKCS offshore installations (published by HSE).

The two main inputs to the model are the fishing vessel density for the area, based on the surveillance data, and the structure details (exposed target area for collision). In this generic study, the exposed target area is assumed to be the overall deployment area of the Wave Hub (i.e. 4km x 2km). This is obviously much larger than a normal offshore structure; therefore, the results should be viewed as indicating the frequency of fishing vessel incursions within the site as opposed to collisions.

Based on the findings of the commercial fisheries study, and acknowledging the uncertainties involved in future estimates, it is assumed the fishing vessel density in the area of the Wave Hub site will remain at the levels identified from the 2002 to 2004 surveillance data. From Section 9, the average fishing vessel density in the local area of the Wave Hub was estimated to be 5×10^{-3} per nm^2.

Using the fishing vessel density and exposed area (assumed to be the whole Wave Hub deployment area) as input to the model, the annual frequency of fishing vessel infringements was estimated to be 4 per year.

The design of the actual devices and their exposed area to collision should be used to estimate the probability of fishing vessel collision on a device-specific basis.

11.4.4 Recreational vessel collision

The main collision hazard from recreational vessels interacting with Wave Hub is a vessel colliding with a device either by becoming becalmed and drifting into the site or due to watchkeeping failure or navigational error and routeing through the site.

In good conditions, the Wave Hub site (e.g. devices, markings and/or navaids) should be visible, especially as most activity occurs during daylight hours. In this case vessels, if competently skippered, will be able to navigate safely to avoid the site. Even if a vessel were to get into difficulty, most should be able to keep clear of the devices or anchor or moor if necessary to avoid drifting closer to the devices whilst they fix the problem or call for assistance.

The main risk of collision is considered to be in bad weather, especially poor visibility, where a small craft could fail to see the devices and inadvertently end up closer than intended. The risk of small craft being in the area during bad weather is reduced by the fact that most craft are fitted with radio receivers and VHF so will be able to listen to regular broadcasts of the weather forecast by the BBC and hourly by the Coastguard. It is also standard practice for harbours, marinas and clubs to post weather forecasts on notice boards.

Given the ready availability of weather forecasts and growing use of GPS, the risk of a vessel being in proximity to the Wave Hub in bad weather is considered to be low but not negligible. In this scenario, a vessel unable to make way from the Wave Hub and unable to anchor due to water depth or adverse conditions, and therefore at risk of collision, may alert the Coastguard using VHF or flares.

To minimise the risk of collision in this worst-case scenario, mitigation in line with regulator guidance will be put in place. It will be ensured, consistent with the requirements of THLS, that the structures are marked in such a way as to enhance the prospect of visual observation by passing recreational craft even in adverse conditions.

THLS will consider the needs of small leisure craft by taking into account the likely traffic type and density when determining the correct level of marking for the works for the site. The site will also be fitted with foghorns to audibly warn vessels in periods of bad visibility, minimising the risk of encountering the structures with no warning.

The Operator will also ensure notification of the development to the recreational craft community is widespread and effective throughout all phases. Information will be promulgated to yacht clubs, marinas, harbour masters, etc.

These measures mean that whilst the collision risk cannot be completely eliminated it will be reduced to a level as low as reasonably practicable. In terms of consequences, most collisions with the devices should be relatively low speed and hence low energy.

11.5 Cable interaction – anchor and trawl

An armoured cable will be laid between the site and the sub-station at Hayle. It is planned for the cable to be buried up to 3m where sediment is available and conditions permit (i.e. where the seabed is not hard rock).

Any exposed cable and cable not buried to sufficient depth could be subject to anchor / trawl damage and/or pose a risk to fishing vessels which snag their gear on the cable.

In terms of anchoring, there is very little shelter along this coast and St. Ives Bay is one of few areas where vessels can shelter and anchor. Based on local consultation (see Section 4), it was stated that in bad weather up to 20 vessels could be anchoring in the area at any one time. Further consultations with Coastwatch at St. Ives stated that in recent years the maximum they have observed tends to be 3-4 and typically 1-2 merchant vessels with the occasional naval vessel or Trinity House tender. It is noted that no vessels were observed to anchor in the bay during the 4 weeks of traffic surveying (this is not surprising as the survey was carried out in summer months during good weather).

Figure 11.8 shows the position for anchoring as given in the Admiralty Sailing Directions for the area (Ref .v).

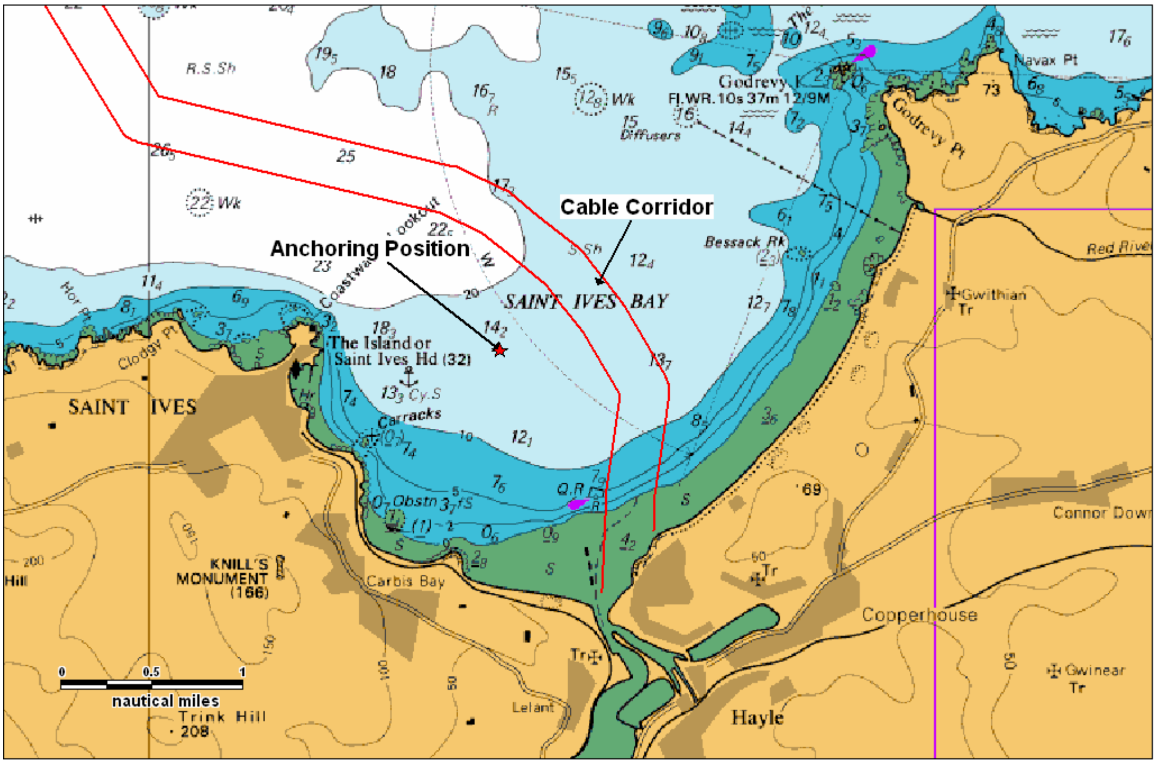


Figure 11.8 Anchoring position within St. Ives Bay relative to proposed corridor for the site to shore cable

It can be seen that the cable route is to the East of the anchor position given in the pilot book and marked on Admiralty Charts. However, this is not to say that vessels would not anchor further to the East. Therefore the cable route will be exposed to anchoring and dragged anchor risk and it is imperative that the cable is buried in the bay. If conditions are such that it is not possible to bury the cable, consideration should be given to protection by rock dump or mattresses.

In addition to anchoring, the risk of fishing gear snagging on cables also exists. At worst this could lead to the capsize of a vessel (e.g. if trawl doors were to be trapped under cable as a result of a span in the cable). To minimise the risk of spans, when the cable is laid on the seabed it will be surveyed and, where a span is identified, repositioned to keep spans to an absoluter minimum. In areas where it is not possible to bury the cable and trawling is known to take place then consideration should be given to protecting the cable with mattresses. During this post-installation inspection, if there are any spans in the cable then these will be rectified to keep spans to a minimum.

There will also be post-installation inspections and regular surveys carried out to ensure that the cable remains buried/protected and does not become exposed. It is envisaged that there will be two inspections in the first year following installation followed by annual surveys. Future survey plans will then be based on the findings of the initial surveys.

The "as-laid" position of the cable should also be shown on the Admiralty Charts and best-practice offshore cable installation liaison and notification procedures applied

11.6 Risk results summary

The baseline and post-Wave Hub levels of risk are summarised in Table 11.1 and Figure 11.9 (excluding fishing vessels which are discussed separately below.)

Table 11.1 Summary of results – generic Wave Hub risk assessment

Collision Scenario	Without Wave Hub	With Wave Hub	Change
Passing Powered	N/A	$5.6E^{-03}$	$5.6E^{-03}$
Passing Drifting	N/A	$2.7E^{-04}$	$2.7E^{-04}$
Vessel-to-Vessel	$1.3E^{-02}$	$1.1E^{-02}$	$-2.4E^{-03}$
Total	$1.3E^{-02}$	$1.7E^{-02}$	$3.5E^{-03}$

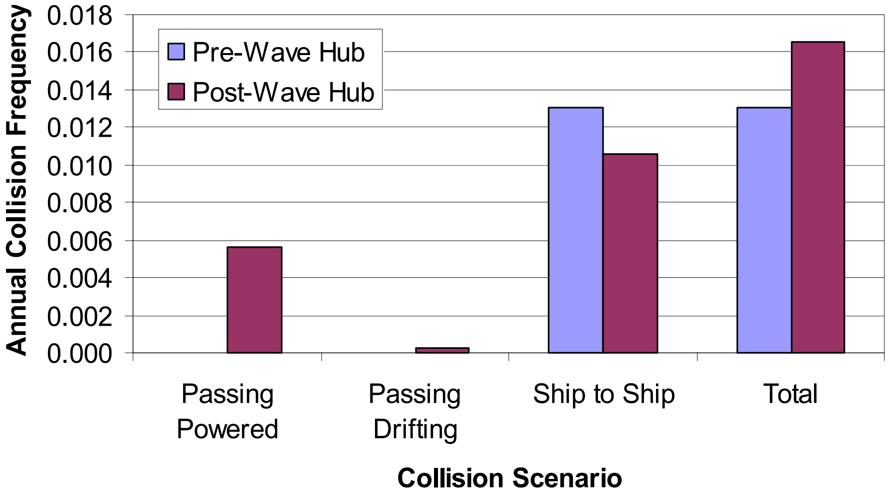


Figure 11.9 Summary of risk results

Therefore, the overall level of collision risk is estimated to increase by approximately 1 in 286 years due to the Wave Hub.

Due to the different modelling methodology, the fishing vessel results are not directly comparable with the above collision results; however, the assessment estimated there would be approximately 4 infringements of the Wave Hub deployment area per year by fishing vessels.

The design of the actual devices and their exposed area to collision should be used to estimate the collision frequency on a device-specific basis.

11.7 Consequences

The consequences of collision will vary depending upon the design of the device being impacted. This needs to be considered on a device-specific basis (see Section 17).

11.8 Future case level of risk

Based on the consultation meetings carried out during the project, no proposals were identified which are likely to significantly increase the levels of shipping activity in the immediate area of the Wave Hub, other than that associated with the Wave Hub development itself.

There are plans for expansion of Milford Haven, including an LNG terminal which is likely to increase commercial shipping to/from the port. However, the traffic survey indicated that this traffic passes a safe distance to the West of the Wave Hub.

There are also plans to re-develop the harbour facilities at Hayle. This will mainly be to provide facilities for recreational craft and fishing vessels. Any increase in recreational sailing is likely to take place inshore of the Wave Hub site, as is the case with the existing activity (see Section 8).

In terms of fishing, future changes are more difficult to predict as various external factors may have an influence but no trend indicating potential increasing activity in the future was evident from the commercial fisheries study.

12. POTENTIAL IMPACTS DURING CONSTRUCTION AND DECOMMISIONING

12.1 Introduction

This study has primarily focused on the operational and maintenance phase of the Wave Hub and generic issues as opposed to device-specific issues given that the characteristics of the devices are relatively unknown at this stage. However, it is recognised that there will be additional potential impacts during the construction and decommissioning phases of the project which have been considered in the Hazard Identification workshop carried out for the project (see Section 10.2). In general, whilst the same hazards apply as during operational and maintenance, there are additional hazards which are distinctly associated with these phases of the project and require different risk control measures.

12.2 Hazards during construction and decommissioning

Whilst the generic hazard log for the project has identified hazards which will be relevant in the construction and decommissioning phases of the project, the installation of different equipment and devices will each bring different hazards and potential control measures. It is noted that to a large extent the hazards will depend on the vessels and procedures which are to be used for these operations. This will not be known in detail until the devices, construction methods and vessels/contractors have been selected.

The construction work will be planned and managed using ALARP principles to ensure the safety of those involved and other maritime users in this area. This will include the selection of contractors and the working vessels to ensure they are competent/capable of undertaken the work required, and also following offshore industry guidance and best practices.

As the detail of the devices is not known at this stage, then a Hazard Identification workshop will require to be carried out for the construction phase which should cover both the Wave Hub itself as well as the different devices to be installed and the associated cables and moorings.

The presence of construction vessels within the area is likely to pose an additional navigational risk. There will also be a number of additional vessel movements to the operations bases in order to supply and re-crew the operations.

The objective of the workshops will be to identify all of the different activities which will be taking place and identify any potential hazards as well as appropriate mitigation measures and operating procedures relevant to the selected vessels and construction methods.

The suggested composition for the workshops is as follows:

- Project Team
- Contractor Representatives (barges, cable-laying, etc.)
- Local Harbour Representatives

- Coastguard (MCA)
- Fishing Representative
- Yachting Representative
- RNLI Representative

This process will build mutual understanding of the activities and operating constraints of the different parties involved and allow effective procedures to be developed. Separate workshops should be held for each phase of the project as well as for distinct activities.

It is noted the construction company appointed will have their own internal Health and Safety procedures that they will adhere to during the work, providing additional security. It is also good industry practice that experience and lessons learned from the construction of other offshore projects should be considered prior to Wave Hub being constructed. The same process should apply during the decommissioning phase of the project.

13. MARINE NAVIGATIONAL MARKING

13.1 Introduction

Throughout the project marine navigational marking will be provided in accordance with Trinity House requirements, which will comply with the IALA standards.

13.2 Construction and decommissioning

During the construction / decommissioning of an offshore wave energy device, working areas will be established and marked in accordance with the IALA Maritime Buoyage System (MBS). In addition to this, where advised by Trinity House additional temporary marking will be applied.

Notices to Mariners, Radio Navigational Warnings-NAVTEX and/or broadcast warnings will be promulgated in advance of and during construction / decommissioning of any the devices construction/decommissioning. Given the proximity of existing traffic to the site it is recommend that a guard vessel be utilised to monitor and warn traffic during the construction phase.

13.3 Marking of Wave Hub deployment area

It is likely that the deployment area itself will be marked. Based on the site layout, it is likely that 4 lighted cardinal buoys will be used to mark the four corners of the site. The buoys and their moorings will require to be designed to withstand the sea conditions in the area. It is likely that the buoys will require to be of a size equivalent to the standard Class 2 buoy used by Trinity House (about 2-3 metres in diameter with a focal plane of 4-5 metres). The lights on such buoys have a nominal range of 5 nautical miles.

In addition it is likely that a Racon and/or AIS Aids to Navigation units will be required. There may also be a requirement to have additional cardinal buoys. The detail of the markings will be provided by Trinity House. Whilst an AIS transceiver is proposed as a risk reduction measure, the necessary UK legislation to declare AIS as an aid to navigation has not been put in place, although this is currently being addressed.

13.4 Marking of individual structures

As the details of individual devices are as yet unknown, the markings of each individual device will need to be agreed with Trinity House. This will include requirements such as:

- Lighting
- Passive radar reflectors
- Retro reflecting material
- AIS
- Foghorn
- Painting of device above waterline

In order to avoid confusion from a proliferation of Aids to Navigation, full consideration will require to be given to the use of synchronised lighting, different light characters and varied light ranges.

13.5 Inspection, maintenance and contingency plans for aids to navigation

The Wave Hub operating company will require to ensure that they have a reliable inspection, maintenance and casualty response regime in place to ensure the required availability targets are met. Any aids to navigation required in connection with the deployment of the site and devices will be subject to the Trinity House inspection and audit regime in place at the time in a similar way to that applied to other locally provided aids to navigation and those exhibited at wind farms and other offshore installations.

The aids to navigation also need to meet the levels of availability that will need to be determined bearing in mind the location relative to shipping and relative importance, and the appropriate maintenance regime put in place accordingly. This will include having the necessary AtoN spares on hand and provision will be made at the design stage, where necessary, to ensure safe access for repair / replacement of aids.

14. AREA TO BE AVOIDED AND SAFETY ZONES

14.1 Introduction

There will be a number of devices, suspended cables and mooring lines within the Wave Hub deployment area. Some of the devices may be low freeboard floating structures with surface piercing and subsurface elements may extend laterally beyond the surface elements. The site could also include shared moorings and mid-water connections between units which may also carry electricity, control signals, hydraulics or pneumatics associated with the devices. Based on this it will not be desirable for vessels to navigate through the site.

In order to minimise risks to vessels navigating in the area and the devices, it is proposed that the area within which the devices are to be located be designated as an Area to be Avoided (ATBA). However, given that an ATBA is likely to require approval by the International Maritime Organisation and the time limits involved, it is proposed that safety zones of up to 500m will be applied for each individual device located within the site. The following sections discuss the different measures.

14.2 Area to be Avoided (ATBA)

An Area to be Avoided (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.

It is proposed to establish an ATBA at the Wave Hub deployment area. The measure, which has been considered by the MCA as being appropriate based on the shipping activities in the area, is being proposed for this site in order to evaluate effectiveness as a risk controlling measure to assure navigational safety.

The ATBA would essentially be the 4x2km area within which the devices will be located and marked with navigational buoys at the 4 corners together with additional markings and lighting as required by Trinity House.

Given the potential hazards of collision and entanglement of fishing gear with cables/mooring lines it is assumed that all fishing activity will be prohibited within the defined ATBA. The ATBA would be marked on all hydrographic charts covering the area. The effectiveness of the ATBA may be evaluated by periodic shipping surveys in the area.

14.3 Safety Zones

In any event Safety Zones will be required to be in place around each individual WEC. The Safety Zones take into account the potential for the lateral movement of WECs and associated infrastructure and can extend for up to 500m from the WEC.

Safety Zones will be established under the provisions of the Energy Act 2004 and define an area in which all vessels, other than authorised vessels, vessels seeking refuge in an emergency or emergency service vessels themselves, are not allowed to enter.

Given the potential hazards of collision and entanglement of fishing gear with cables/mooring lines it is assumed that all fishing activity will be prohibited within the defined Safety Zones.

During the construction (and decommissioning) phase of the development there will be a construction vessel and support craft in operation within and around the Wave Hub deployment area. To ensure the personnel carrying out these activities and those navigating in this sea area are not exposed to unnecessary risk, it is assumed that 500m Safety Zones will be established around all offshore structures and working vessels during these phases of the development. This will provide a means of regulating the rights of navigation so as to preserve the safety of those working in the site and those onboard other vessels that may be navigating in this area. These Safety Zones will apply to all vessel types not involved in the installation operations. The Safety Zones will be developed around the area under construction in consultation with the MCA.

During the construction and decommissioning phases, operational procedures will be implemented for radar and AIS monitoring of vessel activities within the working area, to detect Safety Zone infringements. Procedures will also be established to ensure that any infringements are formally reported in line with the regulatory requirements.

The existence of the Safety Zones will be published electronically and via Notices to Mariners

It is important for the Wave Hub deployment area and associated Safety Zones to be marked on hydrograhic charts together with an appropriate note to advise / caution vessels navigating in the area.

15. SAR RESPONSE

15.1 Introduction

To ensure SAR response issues are considered within this study an appraisal of the historical levels of accidents in the area has been conducted and the SAR resources available in the area assessed.

15.2 Maritime incidents

15.2.1 MAIB

All UK commercial vessels are required to report accidents to MAIB. Non-UK vessels do not have to report unless they are in a UK port or are in 12 mile territorial waters and carrying passengers to a UK port. There are no requirements for non-commercial recreational craft to report accidents to MAIB.

The locations[1] of accidents, injuries and hazardous incidents reported to MAIB within 10nm of the Wave Hub deployment between 1 January 1994 and 27 September 2005 are presented in Figure 15.1, colour-coded by incident type.

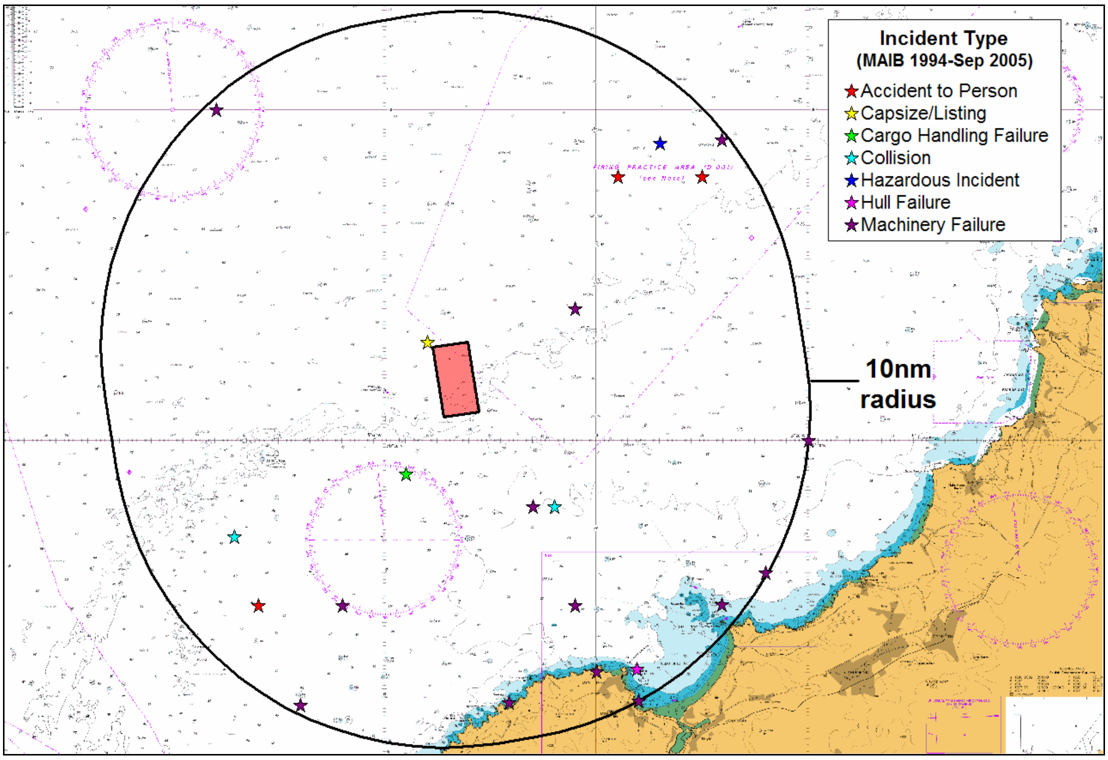


Figure 15.1 MAIB plot by incident type within 10nm of Wave Hub deployment area

[1] MAIB aim for 97% accuracy in reporting the locations of incidents.

A total of 23 incidents involving 26 vessels were reported in the area. The distributions by incident type, vessel type and year are presented below.

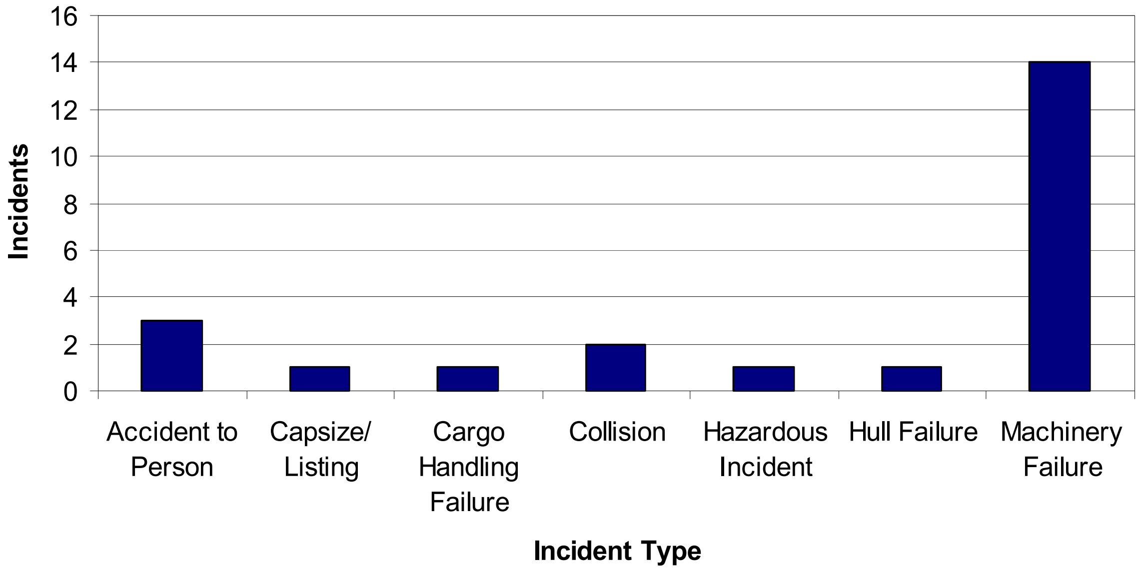


Figure 15.2 Incidents by Type within 10nm of the deployment area (MAIB 1994-Sep 2005)

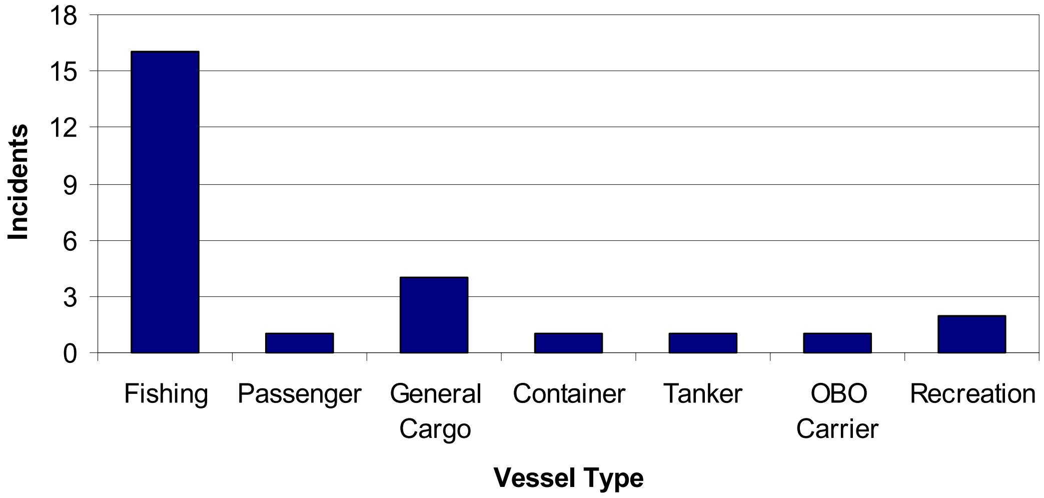


Figure 15.3 Incidents by vessel type within 10nm of the deployment areaSite (MAIB 1994-Sep 2005)

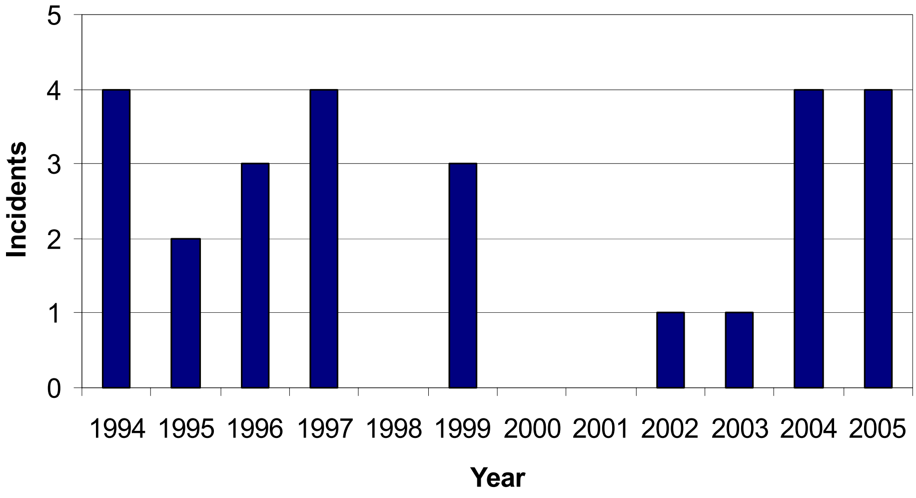


Figure 15.4 Incidents by year within 10nm of the deployment area (MAIB 1994-Sep 2005)

Therefore, the majority of incidents involved fishing vessels and the main cause was machinery failure.

No incidents occurred within the deployment area although there was an incident within 0.5nm of the north of the site in December 1994 involving a general cargo vessel. This single hold dry bulk carrier took up a list of about 4 degrees in heavy weather. The Master radioed the coastguard for support and put the vessel into a nearby port to correct the situation. It was found that a small quantity of loose water in the hold had caused the list.

No other incidents were recorded within 2 miles of the site boundary. Of the two collisions that occurred within 10 miles, one was between a fishing vessel and general cargo vessel with the cause reported as a lapse of attention by the lookout when steering into direct sunlight. The second was between a general cargo vessel and a container vessel (no cause reported). In both cases there was only negligible or minor damage to the vessels and no reports of injuries.

15.2.2 RNLI

Data on RNLI lifeboat responses in the SW area between 1996 and 2005 has been analysed. Figure 15.5 presents the geographical location of incidents. A total of 196 incidents were recorded within 10nm of the Wave Hub deployment area but it can be seen that the vast majority occurred on or near the coast, including a high proportion in St Ives Bay.

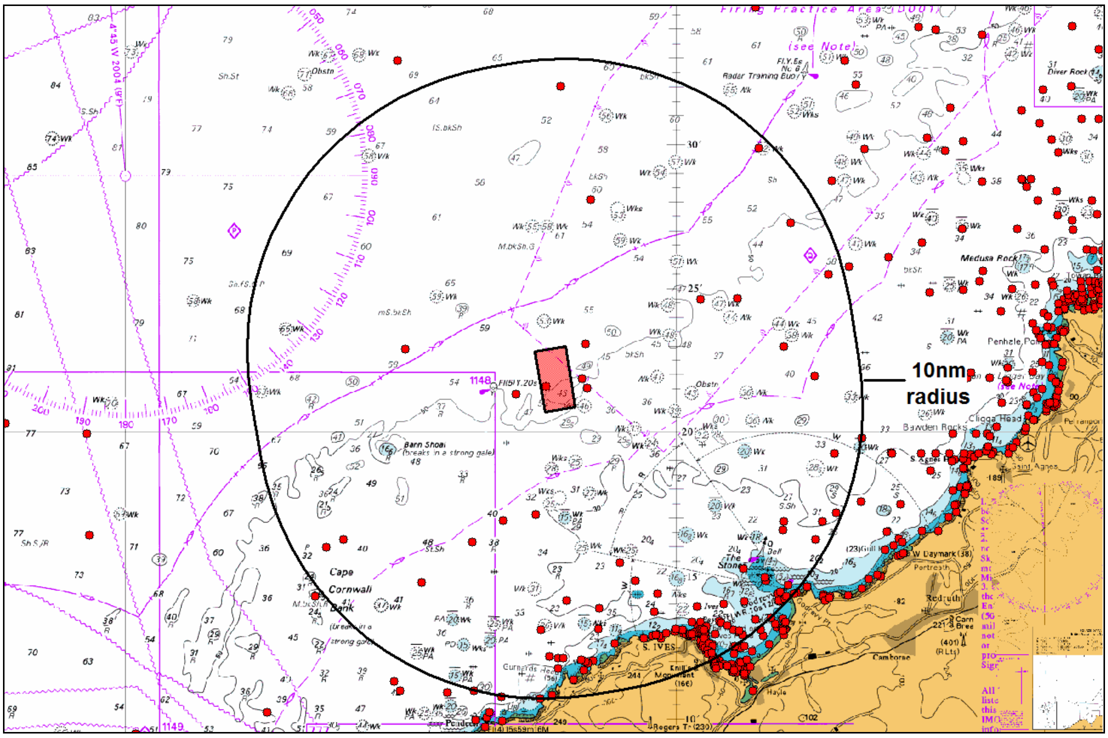


Figure 15.5 RNLI Launches 1996-2005 within 10nm of Wave Hub deployment area

The main types of casualties reported to have been involved in the incidents are plotted in Figure 15.6.

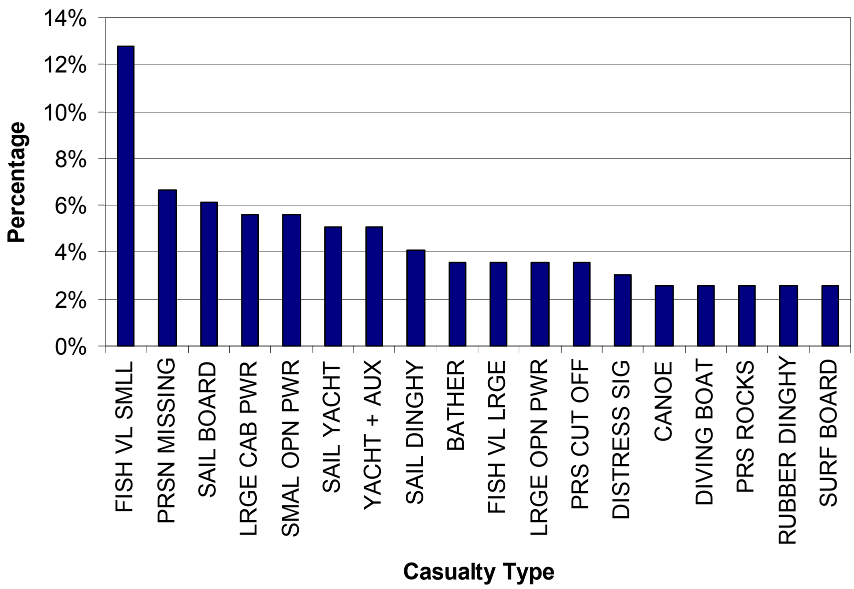


Figure 15.6 Casualty types based on RNLI information

The majority of incidents involved fishing vessels, recreational / pleasure craft and persons performing activities at the coast, e.g., bathing, swimming, climbing, etc.

In terms of the Wave Hub site, one incident was recorded within the proposed deployment area in June 2003 where the casualty was reported as a bather and the cause was drowning. An all-weather lifeboat (ALB) from St Ives responded to this incident.

Four other incidents occurred within 2 miles of the site perimeter as detailed below (responding lifeboat given in brackets):

- May 2000: Small fishing vessel suffered a machinery failure (ALB from St Ives).
- Feb 1999: Large fishing vessel suffered a machinery failure (ALB from St Ives).
- Sep 1998: Large cabin powered vessel suffered a machinery failure (ALB from Sennen Cove).
- Dec 2002: Small merchant vessel experienced a cargo shift (ALB from St Ives).

15.3 SAR Resources

15.3.1 SAR Helicopters

A review of the assets in the area of the Wave Hub deployment area indicated that the closest SAR helicopter base is located in Culdrose, operated by the RN, approximately 20nm to the SE of the deployment area (Note: there is also an RAF helicopter training facility at nearby St Mawgan). The Culdrose base has Sea King helicopters with a maximum endurance of 6 hours giving a radius of action of approximately 300nm which is well within the range of the site. One helicopter is available at 15 minutes readiness between 0800 and 2200 hours, with another available at 60 minutes readiness between 0800 hours and evening civil twilight (ECT). Between 2200 and 0800 hours, one helicopter is held at 45 minutes readiness.

All RAF/RN SAR helicopters are equipped for full day/night all weather operations over land and sea (some limitations exist with regard to freezing conditions, but in general terms the helicopters are all weather capable) and have a full night vision goggle (NVG) capability. Crews are well practised in NVG operations which is a major enhancement to search capability. In addition, all RAF SAR helicopter rear crew are medically trained, with the winchman trained up to paramedic standard.

Up to 18 persons can be carried, however this is dependent on weather conditions and the distance of the incident from the helicopter's operating base. All RAF SAR helicopters are equipped with VHF (Marine and Air Band), UHF, HF and Mountain Rescue radios. They are also capable of homing to all international distress frequencies.

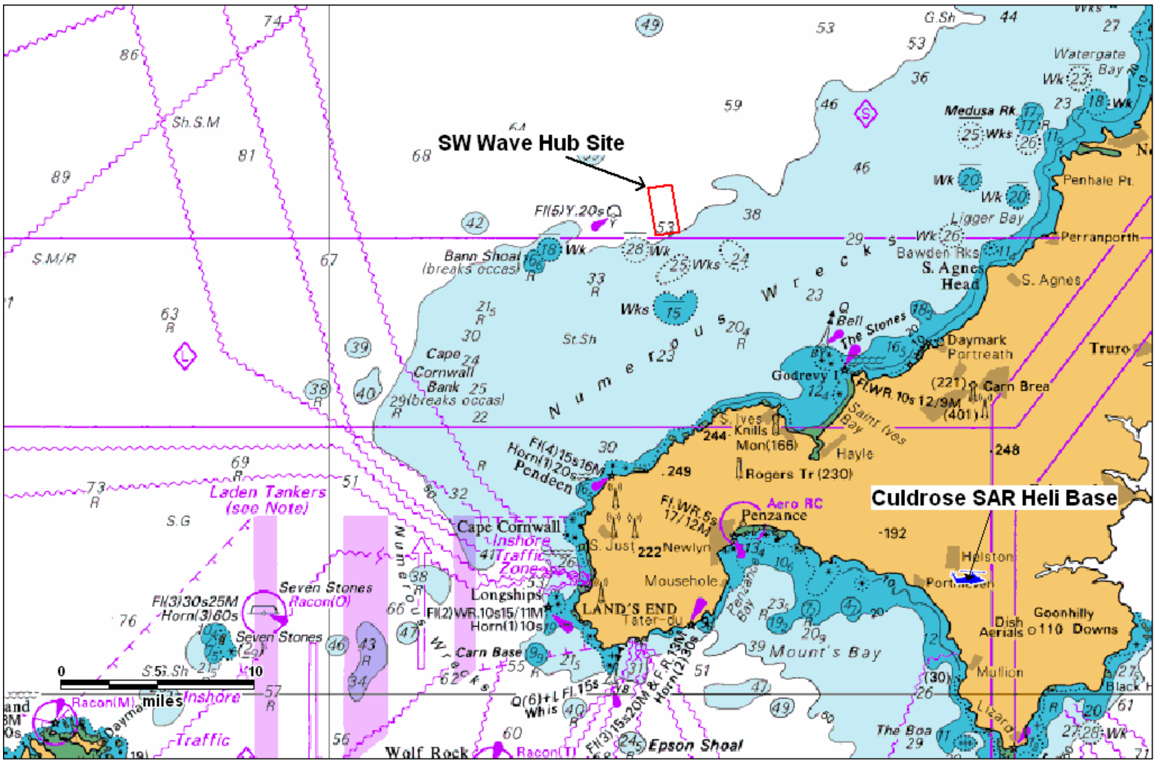


Figure 15.7 SAR helicopter base relative to Wave Hub deployment area

Based on the above information, the day-time response to the deployment area will be in the order of 25 minutes. At night time this will increase by 30 minutes to approximately 55 minutes due to the additional response time at the base. It is noted that these calculation are based on still air and will vary depending on the prevailing conditions.

15.3.2 RNLI Lifeboats

The Royal National Lifeboat Institution maintains a fleet of over 450 lifeboats of various types at stations round the coast of the UK and Ireland. The RNLI stations in the SW region are presented in Figure 15.8. The nearest stations to the Wave Hub site are:

- St. Ives
- St. Agnes
- Newquay
- Sennen Cove

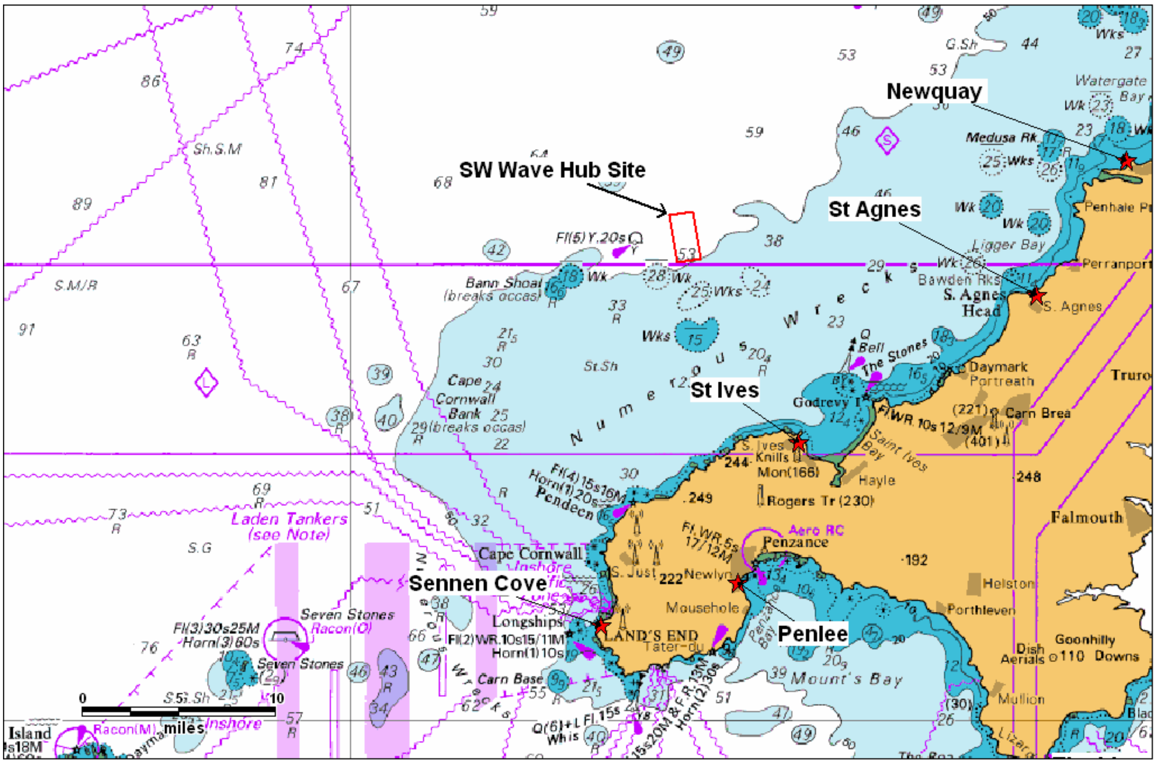


Figure 15.8 RNLI bases in SW area

At each of these stations crew and lifeboats are available on a 24-hour basis throughout the year. Table 15.1 provides a summary of the facilities at each of the nearby stations.

Table 15.1 Lifeboats held at nearby RNLI stations

Station	Lifeboats	ALB Spec	ILB Spec	Distance to Site Boundary
St Ives	ALB & ILB	12m Mersey	D	10nm
St Agnes	ILB	N/A	D	15nm
Sennen Cove	ALB & ILB	47 ft Tyne	D	18nm
Newquay	ILB (2)	N/A	B & D	20nm

The Mersey class lifeboat (St Ives) has a speed of 17 knots, range of 140nm and can operate in all-weather. All-weather lifeboats are fitted with the latest in navigation, location and communication equipment, including electronic chart plotter, VHF radio with direction finder, radar and global positioning systems (GPS).

The D class lifeboats are small and highly manoeuvrable, making it ideal for rescues close to shore in fair to moderate conditions. These inshore lifeboats have a speed of 25 knots, range of 3 hours at maximum speed and are equipped with VHF radio and GPS.

Response times vary but an average declared by RNLI is 14 minutes for all-weather lifeboats and 7 minutes for inshore lifeboats. This is the time from callout, i.e., first intimation from Coastguard to the lifeboat station to launch. This means the ALB at St. Ives could be on-scene within 50 minutes.

15.3.3 Coastguard stations

HM Coastguard is responsible for requesting and tasking SAR resources made available by other authorities and for co-ordinating the subsequent SAR operations (unless they fall within military jurisdiction).

The UK is organised into three Search and Rescue Regions (SRR), each under the authority of a Regional Inspector operating from a Maritime Rescue Co-ordination Centre (MRCC). Each SRR contains one or more Maritime Rescue Sub-Centre (MRSC), under the authority of a District Controller.

Each district is divided into sectors and within each sector there are Coastguard Rescue Teams (CRT) composed of Auxiliary Coastguards.

The proposed Wave Hub site lies within the Wales and West of England Search and Rescue Region, which has an MRCC based at Falmouth. The following Coastguard Rescue Teams (CRT) are located in the West Cornwall area:

- Penzance
- Lands End
- St Just
- St Ives
- Portreath
- St Agnes

The RNLI All Weather Lifeboats would be the Coastguard's first preference for any emergency at the Wave Hub site.

15.3.4 Salvage

MCA charters four Emergency Towing Vessels (ETVs) to provide emergency towing cover in winter months in the four areas adjudged to pose the highest risk of a marine accident: the Dover Strait, the Minches, the Western Approaches and the Fair Isle Channel. The Tug covering the Western Approaches is based at Falmouth and is most likely to be called upon should a tug be required at the Wave Hub site to aid in the recovery of a vessel or device.

15.4 SAR access to Wave Hub deployment area and SAR commitments

Access to the site in event of an emergency can be performed by helicopter or boat. A helicopter landing will not be possible, but access for winching of personnel should not be any different to that being performed on small vessels.

Given the proximity to St. Ives, most incidents are likely to be responded to by RNLI in the first instance. Access by lifeboats is not likely to be an issue and site layouts will be provided to RNLI and emergency exercises carried out. These will require to be reviewed for each specific device.

For a larger emergency vessel entering the site, such as the Falmouth ETV, there is likely to be more of an issue based on the numbers of mooring lines, suspended cables, etc., which could pose a hazard to the vessel. The coastguard and any tug operator who may provide a response within the site will require to know the layout and characteristics of devices and associated cables and lines. This liaison will be the responsibility of the Wave Hub Operating Company

In addition the Wave Hub Operating Company will require to:

- Assess the risks associated with the Wave Hub site in line with their Safety Management System (SMS) and use this assessment to form the basis for identifying scenarios to be considered within their emergency planning process.

- Endeavour to involve all appropriate parties in the forming of emergency response plans and operational procedures. This will include Wave Hub employees, appropriate contractors and external organisations such as:

    - MCA/HMCG
    - RNLI
    - MoD
    - Tug companies
    - Fire Brigade
    - Police

- Hold discussions with each party to ensure they have all the relevant details required to carry out the emergency response in an effective manner. All MRCC/MRSCs will be provided with a layout indicating the GPS position and details of equipment and characteristics.

- Ensure all those involved in emergency response within Wave Hub are trained and competent.

- Prepare a written PPE program for use by all Wave Hub employees working at the site and for those involved in emergency response.

- Conduct emergency response trials under realistic conditions to maintain competence and further improve the SMS using any knowledge gained.

- Test communication and shutdown procedures for the site twice per year.

- Maintain suitable records of emergency responses to be used to further improve systems within Wave Hub Operating Company and industry. The operator will require to be committed to sharing information with other companies within the renewable energy industry.

16. ADDITIONAL NAVIGATION ISSUES

16.1 Introduction

There are a number of additional navigational issues identified within MGN 275 (Ref. i) which require to be addressed by the developers. The following subsections cover additional navigation related issues which have not been covered elsewhere within this report. It should be noted that MGN 275 should be reviewed in the Device Specific Assessment for each individual device to be located within the site.

16.2 Visual navigation and collision avoidance

MGN 275 identifies the potential for visual navigation to be impaired by the location of offshore structures, based on vessels not being visible to each other (hidden behind structures) and navigational aids and/or landmarks not being visible to shipping. It is not envisaged based on relative sizes of the devices under consideration and the size of the area being considered that this will be a significant issue. This should be reviewed when devices are selected and the consideration given to this when positioning devices within the site.

16.3 Potential effects on waves and tidal currents

The impact of a proposed layout of devices under consideration within the Wave Hub deployment area will have on waves and tidal currents has been carried out within the Coastal Processes Study (Ref. xiii) that has been undertaken in support of the EIA.

The hydrodynamic modelling carried out shows that there will be a reduction in wave heights in the lee of the devices. The reduction in wave height will be up to 20% in the immediate vicinity of devices and gradually decreasing to around 5% near the shore based on single direction swell wave. There will also be changes in the flow speeds and current patterns around the devices in both the ebb and flood tides. Surface currents will change by between 0.2 and 0.5m/s within 12x12km. Currents in the area are currently around 0.5 to 1.0m/s and up to 1.6m/s for 50 year conditions.

Further information on this impact can be found in the Coastal Processes Study (Ref. xiii). Vessels operating in the vicinity of the devices will require to be made aware of the localised impacts.

16.4 Impacts of structures on wind masking/turbulence or sheer

Offshore structures have the potential to affect vessels under sail when passing through the site from effects such as wind shear, masking and turbulence. Given the limited number of structures and the fact that a number of them will have low freeboard as well as the fact that vessels will be passing outside the safety zones and/or ATBA, no impact is expected.

16.5 Sedimentation/scouring impacting navigable water depths

There exists the potential for structures in the tidal stream to produce siltation, deposition of sediment or scouring which could affect the navigable water depths in the area or adjacent to the area.

The Wave Hub site is located in relatively deep water remote from any sandbanks. The coastal processes study has shown that no impact on navigation will result from the potential effects of the Wave Hub development on the physical environment.

16.6 Structures and generators affecting sonar systems (fishing, industrial and military)

No evidence has been found to date with regard to existing offshore structures to suggest that they produce any kind of sonar interference which is detrimental to the fishing industry, or to military systems. No impact is anticipated for the Wave Hub development.

16.7 Electromagnetic interference on navigation equipment

It is noted that all equipment and cables will be rated and in compliance with design codes. In addition it is anticipated that any generated fields will be very weak and will have no impact on navigation or electronic equipment. No impact is anticipated for the Wave Hub development.

16.8 Impacts on communications and position fixing

The following summarises the potential impacts of the different communications and position fixing devices used in and around offshore sites. The following is based on the experience of personnel/vessels operating around Normally Unattended offshore oil and gas platforms as well as trials carried out by the MCA at the North Hoyle Offshore Windfarm in Liverpool Bay off North Wales (Ref. xiv).

16.8.1 VHF communications (including Digital Selective Calling)

Vessels operating around offshore platforms have not noted any noticeable effects on VHF (including voice and DSC communications). No significant impact is anticipated at the Wave Hub depoyment area.

16.8.2 Navtex

The Navtex system is used for the automatic broadcast of localised Maritime Safety Information (MSI). The system mainly operates in the Medium Frequency radio band just above and below the old 500 kHz Morse Distress frequency. No significant impact has been noted at offshore platforms and none are expected at the Wave Hub deployment area.

16.8.3 VHF direction finding

During the North Hoyle offshore windfarm trials, the VHF direction equipment carried in the lifeboats did not function correctly when very close to turbines (within about 50 metres). This is deemed to be a relatively small scale impact and not likely to be an issue at the Wave Hub deployment area.

16.8.4 Automatic Identification System (AIS)

In theory there could be interference when there is a structure located between the transmitting and receiving antennas (i.e., blocking line of sight). Given the limited number of structures, some of which will be very low in the water, no impact is perceived from the Wave Hub development.

16.8.5 Global Positioning System (GPS)

No problems with basic GPS reception or positional accuracy were reported during the trials at offshore wind farms. The Wave Hub development is a relatively small scale development compared to these sites with fewer structures and no significant impact is anticipated.

16.8.6 Loran C

Loran-C is a low frequency electronic position-fixing system using pulsed transmissions at 100 kHz. Based on the MCA North Hoyle study (Ref. xiv), although a position could not be obtained using Loran C in the windfarm area, the available signals were received without apparent degradation, therefore the Wave Hub development is not expected to have a significant impact.

16.8.7 Microwave links

There are no offshore microwave links in the area which could be impacted by the Wave Hub development.

16.9 Noise impact

16.9.1 Acoustic noise masking sound signals

The concern requiring to be addressed under MGN 275 is if acoustic noise from the machines could mask prescribed sound signals.

16.9.2 Noise impacting sonar

Once in operation it is not believed that the subsea acoustic noise generated by the Wave Hub devices (WECs) will have any significant impact on sonar systems. This will require to be confirmed for each individual device in the device specific assessment/review.

17. REQUIREMENT FOR DEVICE SPECIFIC RISK ASSESSMENT

17.1 Introduction

This assessment covers the generic issues associated with the Wave Hub development as opposed to looking at specific devices. Full details of the devices are not known and different devices will be installed at the site over the life of the field.

Based on this, each device will need to undergo a device-specific risk assessment in order for stakeholders to evaluate the devices prior to consent being granted for a specific device being located at the site. This section outlines the issues which require to be covered in each device specific assessment.

17.2 Risk Assessment – requirements

The following should be carried out for each device as part of a device specific risk assessment. It is noted that the shipping data and area issues have already been covered within this document.

Table 17.1 Wave Hub Device Specific Risk Assessment Requirements

Task	Guidelines
Hazard Identification & Risk Ranking	The generic site Hazard ID should form the basis for this and should be updated for each specific device with focus placed on device specific issues. The hazards should be listed together with causes, consequences and planned mitigation measures. The different hazards should also be ranked by frequency and consequence. Any potential, additional mitigation measures should be listed for each hazard. The outcome should be a demonstration that risks are ALARP for this device at the site.
Mooring Assessment	Each device will have different mooring requirements and an assessment should be carried out to determine the requirements as well as the possibility of the device losing its moorings and the consequences associated with this in terms of if the device will drift or sink, and if so at what speed and in which direction.
Collision Risk Associated with Device	Frequency and Consequences may vary depending on the size, type and numbers of devices.

Task	Guidelines
Navigational Markings for Device	Each device will have different characteristics and will require to be marked accordingly. The requirement for each device will need to be discussed with Trinity House who will advise on the markings. This will include as a minimum: • Lighting • Painting above waterline • Passive radar reflectors In order to avoid confusion from a proliferation of Aids to Navigation, full consideration should be given to the use of synchronised lighting, different light characters and varied light ranges.
Review of Emergency response & Contingency, Device Recovery Requirements	In the event of the device being lost on location (i.e., loss of moorings), a plan is required covering the following: • How the device will alarm (monitoring / emergency communications systems, back-up and operator response) • How the device (or sections of the device) will be tracked. • How the device or components will be recovered, the resources / equipment required to recover it and where it can be recovered to (i.e. a safe haven).
Cumulative Impacts (Interaction with other devices)	This should look at the potential interactions between the different devices and the location of the individual devices within the site.
Review of Health & Safety Management Systems	A Safety Management System (SMS) will require to be developed by the Wave Hub Operating Company for the site. The individual devices will require to be encompassed within this system (e.g., equipment safety monitoring for each device). It should be ensured that HSE systems meet the specified standards, e.g., OHSAS 18001 (Specification for Occupational Health & Safety Management Systems).

Task	Guidelines
Review against MGN 275 Guidelines	Each individual device should be reviewed against MGN 275.
Construction & Installation Hazard Review	A Hazid should be carried out to cover construction and installation for each individual device once the installation contractor has been selected. This should include the following parties: • Local RNLI • Local Fishing representatives • MCA • Trinity House • Construction contractor • Wave Hub Operating Company • Local recreational vessel representatives This should include a demonstration that risks are ALARP for this phase of work. In addition each supplier will require to provide an installation method statement and risk assessment for the installation contractor for his plant
Failure Modes & Effects Analysis (FMEA)	An FMEA should be performed during the design of the device. This provides a structured approach to the analysis of root cause (of failure), the estimation of severity of impact and the effectiveness of strategies for prevention.
Risk assessments for maintenance/inspection	Each device may have different requirements for inspection and maintenance and a risk assessment review should be carried out for each individual device looking at the procedures for these operations to be carried out. This will include issues such as device boarding procedures and operating limitations (weather operating criteria).
Decommissioning	(See Construction & Installation Hazard Review)

18. RESULTS, CONCLUSIONS AND RECOMMENDATIONS

18.1 Introduction

The following results, conclusions and recommendations are made based on the traffic survey, consultation and assessment work carried out within this project.

18.2 Results and conclusions

The results of the study are summarised as follows:

- Based on 1 month of traffic surveying carried out in the area, the average number of vessels passing within 10nm of the site was 44. The majority of these vessels are associated with vessels heading to/from the Off Land's End Traffic Separation Scheme (TSS).

- There was an average of 4-5 vessels per day passing through the proposed Wave Hub deployment area.

- The majority of tracks intersecting the site were heading between Bristol Channel (e.g. Bristol, Newport, Swansea) and the TSS off Land's End (ultimately to/from ports in SE England, Spain, France, Belgium, etc.). This traffic will have to re-route in order to achieve a safe clearance from the site.

- In terms of the additional sailing distances for commercial shipping, given the typical voyages of vessels on the routes affected (e.g. Bristol to Spain) and the relatively small displacement of the routes, there is not considered to be a significant commercial impact as a result of the Wave Hub development being located at this site.

- The risk of passing ship collision with the site (powered and drifting scenarios) has been estimated to be an average of 1 collision per 169 years. This is conservative as it assumes any ship entering the site will collide with a device.

- The existing ship to ship collision risk in the area has been estimated to be 1 in 77 years. With the Wave Hub development in place this has been revised to 1 in 94 years. This reduction in frequency is associated with the lower rate of head-on encounters likely to be experienced by vessels on the closest passing routes, as they will tend to navigate either side of the Wave Hub deployment area. This reduction outweighs the model prediction of an increase in overtaking vessel collisions.

- A separate commercial fisheries study has investigated the potential impact on fisheries in the area. From a navigational perspective, the maritime traffic survey and analysis of DEFRA surveillance data indicated the Wave Hub area is moderately fished. Based on the fishing vessel density for the ICES Subsquare encompassing the site, it was estimated that there would be in the order of 3-4 fishing vessel infringements of the site perimeter per year.

- Based on the traffic survey and consultation with stakeholders, recreational craft generally route inshore of the site, hence, there is not considered to be a significant impact on recreational routes in the area. The main issue is for devices to be appropriately marked to aid their identification by recreational vessels as well as promulgation of information about the development to local users.

- There is a risk of interaction between the cable to shore and anchors / fishing gear. This was highlighted at the Navigation Hazard Workshop carried out during the project and has been reviewed qualitatively in this study.

- There will be a risk of these devices losing their mooring and drifting off location and presenting a risk to shipping in the area. A device specific assessment will be required which should address issues such as moorings, markings, monitoring and emergency response.

- There is some uncertainty as to the risk of collision with some of these devices given their unique characteristics and the limited operating experience of such devices.

- A review of historical accidents and of SAR resources in the area has been carried out. Primary response to an incident in the site is likely to be from the RNLI at St. Ives. It is important that both they and other emergency services (e.g. HM Coastguard) understand the layout and workings of the site and are involved in emergency exercises for the site.

- The physical marking of both the site and individual devices will be critical in terms of mitigating the risk to shipping. Consideration will, require to be given to buoys, Racon, lighting, passive radar reflectors, painting of devices, retro reflecting material and AIS.

- The promulgation of information to local users and marking or Admiralty charts will also be critical.

- Based on the evaluation carried out (see Appendix B), the impact on navigation has been significantly reduced by the relocation of the site, both in terms of re-routeing and collision risk.

- On a project level the ALARP principles have been applied within the assessment by way of identification of hazards, ranking, risk assessment and identifying appropriate mitigation measures.

- The site positioning is ALARP with respect to shipping based on all other constraints identified i.e., when compared to the original site and other options being available. However, ALARP cannot be demonstrated fully until each device has been assessed and all the appropriate mitigation measures adopted.

18.3 Recommendations

The main recommendations made are as follows:

- Each device should undergo a separate device-specific risk assessment and review before being approved to go on location.

- A number of recommendations/mitigation measures were identified at the Hazard Identification workshop. A large number of these are device specific issues and should be considered for each device (e.g. device monitoring, tracking and recovery).

- Given that there will be different types of devices, including some with very low freeboard, suspended cables and mooring lines, the area within which devices are located should be avoided by shipping. MCA have proposed that an Area To Be Avoided (ATBA) be established around the site within which vessels are not permitted. In any event, safety zones of up to 500m should be applied for around each device.

- Given the proximity and levels of shipping passing the development, a vessel should be nominated to carry out traffic monitoring and guarding duties during the construction/installation and decommissioning phases of the project.

- The export cable will require to be buried within St. Ives Bay in order to minimise the risk of dragged anchor damage.

- Consideration should be given to the use of concrete mattresses to protect the cable in areas where it is not buried and trawling activities and or anchoring are known to take place.

18.4 Future monitoring

In terms of monitoring activities in relation to vessel navigation / risk:

- Monitoring will take place through the Wave Hub Operating Companies Safety Management System (SMS). The Safety Management System should include an incident/accident reporting system which will allow incidents and near misses to be recorded and reviewed to monitor the effectiveness of the risk control measures in place at the site. In addition to this, any information gleaned from near misses/accidents at other offshore wave/current device sites will be considered with respect to the control measures applied at the Wave Hub deployment area.

- Periodic shipping surveys should be carried out in the area to monitor the effectiveness of the ATBA and/or safety zones.

- The cable route will require to be surveyed following installation and periodically to identify any areas where the cable is exposed to shipping/fishing gear and identify any spans which may require to be rectified.

19. REFERENCES

i MCA Marine Guidance Note 275, Proposed Offshore Renewable Energy Installations (OREI), Guidance on Navigational Safety Issues.

ii Department of Trade & Industry, U.K. Government, Methodology for Assessing the Marine Navigational Safety Risks of Offshore Windfarms, Version Date : 7th September 2005.

iii Renewable Energy Installations Farms and Fields, Provision and Maintenance of Local Aids to Navigation by Trinity House Lighthouse Service; October 2005.

iv Wave Hub Development and Design Phase – Wave Hub Site Selection Clarification. Paper carried out by Halcrow on behalf of South West of England Regional Development Agency, March 2006.

v Admiralty Sailing Directions – West Coasts of England and Wales Pilot, NP 37, 15th Edition, 2002.

vi Met Office, Ship Observations in Area 50.2 to 50.8 North, 5 to 6 West, 1956 to 2005, Total of 11,420 Observations.

vii Met Office, Ship Observations in Area 50.2 to 50.8 North, 5 to 6 West, 1956 to 2005, Total of 11,420 Observations.

viii UKHO Admiralty Chart 1149, Pendeen to Trevose Head.

ix Maritime Traffic Survey (28 Days) Report – Wave Hub, Anatec UK Ltd, Report No: A1371-HA-TS-2, 26 August 2005.

x UK Coastal Atlas of Recreational Boating by RYA & CA; 2005.

xi Hayle Wave Hub, Commercial Fisheries Study, prepared for EMU Ltd by Martin Esseen; September 2005.

xii IMO, Guidelines for Formal Safety Assessment (FSA) for use in the IMO rule Making Process, 5th April 2002.

xiii Wave Hub Development Phase, Coastal Processes Study (Halcrow, 2006).

xiv Results of the EM Investigations and assessments of marine radar, communications and positioning systems undertaken at the North Hoyle Windfarm by QinetiQ and the Maritime & Coastguard Agency; 29 September 2004.

Wave Hub

Wave Hub Hazard Log

(Appendix A)

Prepared by:	Anatec UK Limited
Presented to:	Halcrow Group Limited
Date:	31 May 2006
Revision No.:	01
Ref.:	A1401-HAL-RA-1 App A

Anatec	**Main Office**	**Aberdeen Office**
Address:	16 Ward Way, Witchford, Ely, Cambs, CB6 2JR, UK	57 Anderson Drive, Aberdeen, AB15 4UA, Scotland, UK
Tel:	01353 661200	01224 313355
Fax:	0709 2369326	0709 2367306
Email:	info@anatec.com	aberdeen@anatec.com

HazardID Num	Phase	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Consequence	Worst Credible Consequence	Risk Reduction
A1401-1	Construction; Operation; Maintenance; Decommissioning	General Navigation Safety	Cargo vessel powered vessel collision with wave energy device (WEC)	Cargo vessel powered vessel collision with wave energy convertor (WEC) device	Watchkeeper failure; Poor visibility; Poor Operating Procedures; Personal Injury (slips, trips, falls, heart attack; Navigational error; Navigational Aid Failure; Lack of awareness; Human error;	Major damage to device, possible thgat device will be set adrift, damage to cable and sub-surface equipment. Damage to the hull of the vessel, fouled propellor. It is possible that the vessel could go through the site without making contact with a device.	Severe damage to WEC and vessel, compartment flooding of vessel, foundering of vessel, pollution and loss of life.	Navigational buoys installed in the area ; Locate site away from main shipping route; Issue Notices to Mariners/NAVTEX; Information to be marked on hydrographic charts; Individual lights and numbering on structures; Guard vessel during construction/decommissioning activities; AIS Transceiver;
A1401-2	Construction; Operation; Maintenance; Decommissioning	General Navigation Safety	Cargo vessel collision with another vessel due to re-routeing as a result of wave hub site	Cargo vessel collision with another vessel due to re-routeing as a result of wave hub site	Watchkeeper failure; Poor visibility; Navigational error; Location of wave hub site; Human error; communication failure; Bad weather;	Ship to ship collision, structural damage to vessels, potential pollution and loss of revenue for vessel operators	Vessel founders, loss of life , major pollution, kock on impact on local environment, loss of fisheries	Locate site away from main shipping route; Issue Notices to Mariners/NAVTEX; Information to be marked on hydrographic charts;
A1401-3	Construction; Operation; Maintenance; Decommissioning	General Navigation Safety	Anchor fouling of cable	Anchor fouling of cable	Uncharted obstruction on seabed; Lack of awareness; Human error; Exposed cable; Dragged anchor; Bad weather; Anchoring on cable; Anchoring in emergency;	Displacment of the cable (has some slack), ships in bay 5-6000 tonnes. Vessel may be able to clear itself and drop the anchor by picking it up. Resultant damage to the cable. Loss of revenue to ship as it canbot sail die to anchor damage.	Injury/fatality to person in the clearing processing (hauling anchor onto deck, clearing, dropping cable).	Promulgation of information to local users clubs; Issue Notices to Mariners/NAVTEX; Information to be marked on hydrographic charts; ID on Cable "Live" to warn mariners (To be considered); Concrete mattresses to protect cable (to be considered); Cables buried to safe depth; Cable Route Inspection; Anchoring prohibited within site;
A1401-4	PreInstallation; Construction; Operation; Maintenance; Decommissioning	General Navigation Safety	Fishing vessel gear interaction with site equipment when vessel is fishing	Fixed nets drifts or gear snags on devices (pots may move in rough weather although this in the main is an irritation and not a major risk).	Watchkeeper failure; Strong tides; Navigational error; Human error; Bad weather;	Loss of fishing gear, possible damage to cable.	Loss of vessel and life due to snagging.	Safety zones; Promulgation of information to local users clubs; No trawling or towed fishing activity within the site; Navigational buoys installed in the area ;
A1401-5	Construction; Operation; Maintenance; Decommissioning	General Navigation Safety	Fishing towed gear interaction with site equipment (subsea equipment or device within site)	Fishing towed gear interaction with site equipment (subsea equipment or device within site). Note the site is located on rocky ground so less trawling at the site.	Watchkeeper failure; Strong tides; Navigational error; Lack of awareness; Human error; Deliberate fishing close to equipment; Bad weather;	Loss and/or damage to gear.	Loss of vessel and life, damage to equipment/cables.	Safety zones; No trawling or towed fishing activity within the site; Navigational buoys installed in the area ; Issue Notices to Mariners/NAVTEX; Information to be marked on hydrographic charts;
A1401-6	Construction; Operation; Maintenance; Decommissioning	General Navigation Safety	Rectrational vessel collides with structures	Recreational vessel collides with structures ,(including vessels going out to visit site to a look at devices). Vessels could possibly tie up to devices.	Watchkeeper failure; Strong tides; Poor visibility; Navigational error; Navigational Aid Failure; Lack of awareness; Human error; Equipment failure; Bad weather;	Most likley consequences is minor damage to structure and vessel.	Loss of vessel and fatalities	Safety zones; Promulgation of information to local users clubs; Navigational Information Broadcasts; Navigational buoys installed in the area ; Navigational aids (lights and Foghorns) on selected turbines ; Issue Notices to Mariners/NAVTEX; Information to be marked on hydrographic charts; Guard vessel during construction/decommissioning activities;

A1401-7	Construction; Operation; Maintenance; Decommissioning	General Navigation Safety	Submerged submarine collides with devices and associayted equipment	Submarine collides with devices and associated equipment.	Watchkeeper failure; Strong tides; Navigational error; Navigational Aid Failure; Lack of awareness; Human error; Equipment failure; Bad weather;	most likey consequences damage to the equipment	Loss of submarine and fatalities.	Safety zones; Promulgation of information to local users clubs; Navigational Information Broadcasts; Navigational buoys installed in the area ; Navigational aids (lights and Foghorns) on selected turbines ; Located outwith military exercise area; Issue Notices to Mariners/NAVTEX;
A1401-8	Construction; Operation; Maintenance; Decommissioning	General Navigation Safety	Device drifts off station presenting a hazard to shipping	Device drifts off station presenting a hazard to shipping, drift towards shipping lane (note Traffic Separation Sheme TSS loacated to South West)	Structural failure; ship collision; Equipment failure; Dragged anchor; Bad weather;	Most likely consequence is that device drifts off station, recovered or grounds/sinks.	Worst case, vessel collides with device resulting in structural damage to vessel. Potential for pollution and/or loss of life.	System condition monitoring of devices; Provision for towing structures back to shore; position monitoring of deviecs (GPS based); Navigational Information Broadcasts; Navigation aids (radar reflector and ior light) on devices - To be considered; Issue Notices to Mariners/NAVTEX; Issue guidance/information to Search & Rescue organisations (MCA/RNLI/Tug Companies); Emergency response exercises; Emergency response and shutdown procedures/plan; Design certification (mooring system design etc); Control monitoring & paging on call response; Alarm system on wave hub;
A1401-9	Construction; Operation; Maintenance; Decommissioning	General Navigation Safety	Manoverboard in site during maintenace operations.	Man-overboard in site during routeine maintetnace opertions or during instalaltion/decommissioning operations. Limited visits to	Poor Operating Procedures; Personal Injury (slips, trips, falls, heart attack; Lack of awareness; Human error; communication failure; Bad weather;	Person in water with lifejacket and recovered by crew (injury)	Loss of life (fatality), person becomes trapped in device.	Site personnel trained in fire fighting, first aid and offshore survival; Rescue boat in the area; Planning of maintenance operations, adverse weather working policy and procedures; Personal Protective Equipment (PPE) for all personnel working in site.; Issue guidance/information to Search & Rescue organisations (MCA/RNLI/Tug Companies); Emergency response exercises; Devices shutdown during maintenance operations;
A1401-10	Construction; Operation; Maintenance; Decommissioning	General Navigation Safety	Attendant vessel collision with structures	Attendant vessel collides with structures	Watchkeeper failure; Strong tides; Poor Operating Procedures; Human error; Equipment failure; DP Failure; communication failure; Bad weather;	Minor damage to structures and vessel (low speed impact)	Loss of vessel, fatalities and pollution.	Safety Management Systems for all vessels working in the site ; Restrictions on types of vessels used at distance offshore for maintenace purposes.; Planning of maintenance operations, adverse weather working policy and procedures;
A1401-11	Construction; Operation; Maintenance; Decommissioning	General Navigation Safety	Deliberate unauthoirsed boarding of structures	Persons boarding devices and causing damage. Mooring to devices to fish etc.	Willfull intent;	Injury and economic costs (unlikley to damage the deviecs. Jetskiers etc). Long distance from shore means persons unlikley to go out this far.	Loss of life (fatality)	Safety zones; Promulgation of information to local users clubs; Legal notice on deviecs (to be considered);
A1401-12	Operation; Maintenance; Decommissioning	General Navigation Safety	Debris drifts in to structures (jetsam & flotsam)	Debris drifts in to structures	floating debris;	Minor damage to device	major damage to device	Consider design of devices;

A1401-13	Construction; Operation; Maintenance; Decommissioning	General Navigation Safety	Construction/works vessel collision with passing vessel	Construction vessel collision with passing vessel	Watchkeeper failure; Poor visibility; Navigational error; Navigational Aid Failure; Human error; Equipment failure; communication failure; Bad weather;	Damage to vessels, injury to personnel,	Loss of vessel, fatalities and pollution	Seasonal planning of operatiopns (suitable weather windows); Safety Management Systems for all vessels working in the site ; Rescue boat in the area; Promulgation of information to local users clubs; Navigational Information Broadcasts; Marine Coordinator on site; Issue Notices to Mariners/NAVTEX; Information to be marked on hydrographic charts; Guard vessel during construction/decommissioning activities; Design works packages to minimise numbers of vessels/durations of operations.; Continuous watch by multi-channel VHF, including Digital Selective Calling (DSC); Construction/works vessels marked according to collregs; AIS fitted on all workboats working within site.;
A1401-14	Construction; Decommissioning	General Navigation Safety	Dropped objects during installation/decommissioning	Major lifting operations and device or major component is dropped,	Wash from vessel; Structural failure; Strong tides; Poor Operating Procedures; Human error; Equipment failure; communication failure; Bad weather;	Loss of the device	Loss of vessel and fatalities.	Use certified/rated equipment; Safety Management Systems for all vessels working in the site ; Planning of maintenance operations, adverse weather working policy and procedures;
A1401-15	Construction; Operation; Maintenance; Decommissioning	General Navigation Safety	Cargo vessel drifts into site and WEC devices	Cargo vessel loses power and drifts towards site and collides with devices	Human error; Fire/Explosion; Equipment failure; Dragged anchor; Bad weather;	Vessel drifts and is repaired. Tug stands by.	Collision which resuklts in damaged device. Device breaks free which then breaks power cable. May pose a hazard to assisting vessel, worst case coud be holed compartment or propellor fouled. Could drag cable tight, damaging cable or surface device.Not an electrical hazards ansd protection circuits shutdown.	Navigational buoys installed in the area ; Information to be marked on hydrographic charts; Emergency response and shutdown procedures/plan; Alarm system on wave hub;
A1401-16	Operation	General Navigation Safety	Loss of mooring line - device moving around still on location	Loss of mooring line - device moving around still on location. Not total loss of the device from station.	Poor design; Equipment failure; Dragged anchor; Bad weather;	Device moves around resulting in minor damage to cables/mooring lines or other devices	Device moves around resulting in major damage to cables/mooring lines or other devices	Mooring analysis for individual devices; Inspection and maintenance procedures; Emergency response and shutdown procedures/plan;

Wave Hub
Site Comparison
(Appendix B)

Prepared by:	Anatec UK Limited
Presented to:	Halcrow Group Limited
Date:	31 May 2006
Revision No.:	01
Ref.:	A1401-HAL-RA-1 App B

Anatec	**Main Office**	**Aberdeen Office**
Address:	16 Ward Way, Witchford, Ely, Cambs, CB6 2JR, UK	57 Anderson Drive, Aberdeen, AB15 4UA, Scotland, UK
Tel:	01353 661200	01224 313355
Fax:	0709 2369326	0709 2367306
Email:	info@anatec.com	aberdeen@anatec.com

TABLE OF CONTENTS

1. Introduction

This Appendix presents a comparison of the original and revised Wave Hub sites in terms of navigational impact.

The revised site has been moved to the East to reduce the potential risk and obstruction to shipping as described in Section 2.

Section 3 presents analysis of the survey data collected over 28 days in 2005 relative to the two sites.

Section 4 compares the potential navigation impact presented by the alternative sites.

Section 5 compares the navigation risk based on modelling of the risk of collision presented by the sites.

Finally, Section 6 presents the conclusions from the work.

2. Site Overview

The original Wave Hub site was to be situated approximately 9nm to the northwest of St Ives and had an area of 4km x 2km, which included a proposed 500m Area To Be Avoided marked by corner buoys.

The centre of the revised site is located approximately 4km to the ENE of the original site centre and also has a deployment area of 4km x 2km.

Figure 1 shows the original and revised deployment areas. The revised site is provisionally planned to have special marks offset 200m from the corners of the deployment area and cardinal marks offset 500m from the edge of the deployment area to the North and South and 1km East and West (to be confirmed - not shown in figure).

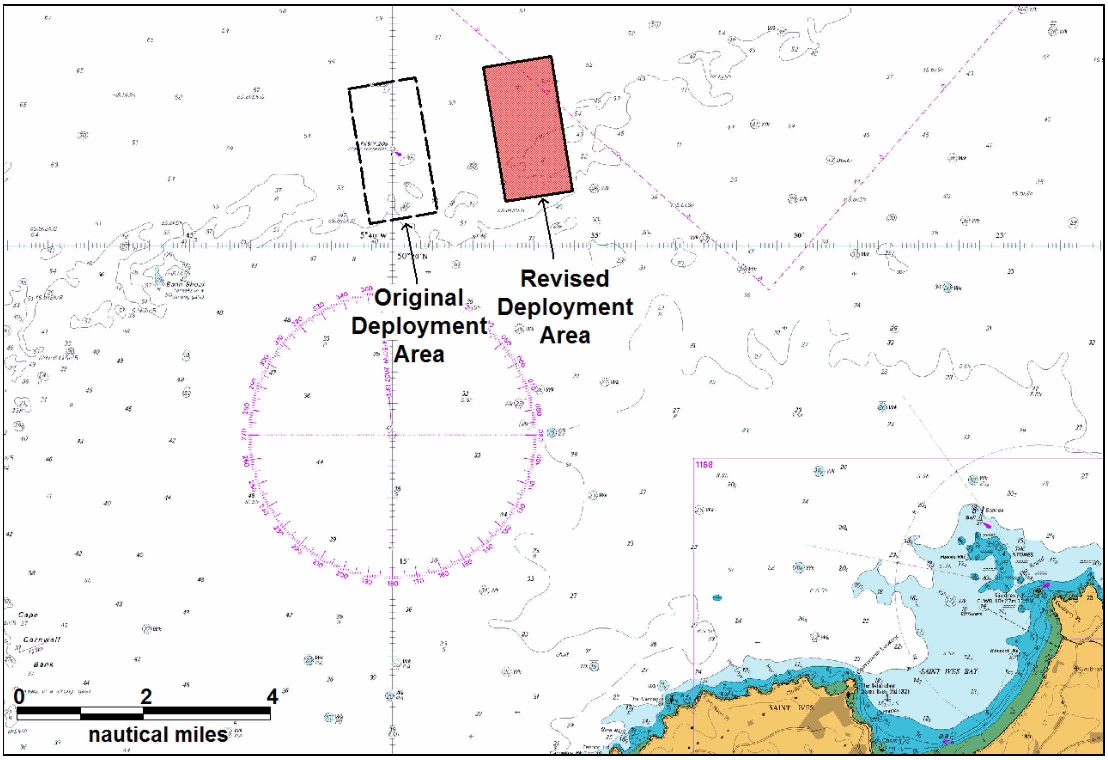


Figure 1 Original and Revised Wave HubSites off St Ives

3. Survey Data Analysis

3.1 Overview of Combined Tracks

As described in the main report, radar, AIS and visual observations were collected in two x 2-week surveys periods as follows:

- 20 May - 3 June 2005
- 29 July - 12 August 2005

The combined tracks coloured by type are presented in Figure 2 and Figure 3, overlaid on nautical charts showing the original and revised Wave Hub deployment areas.

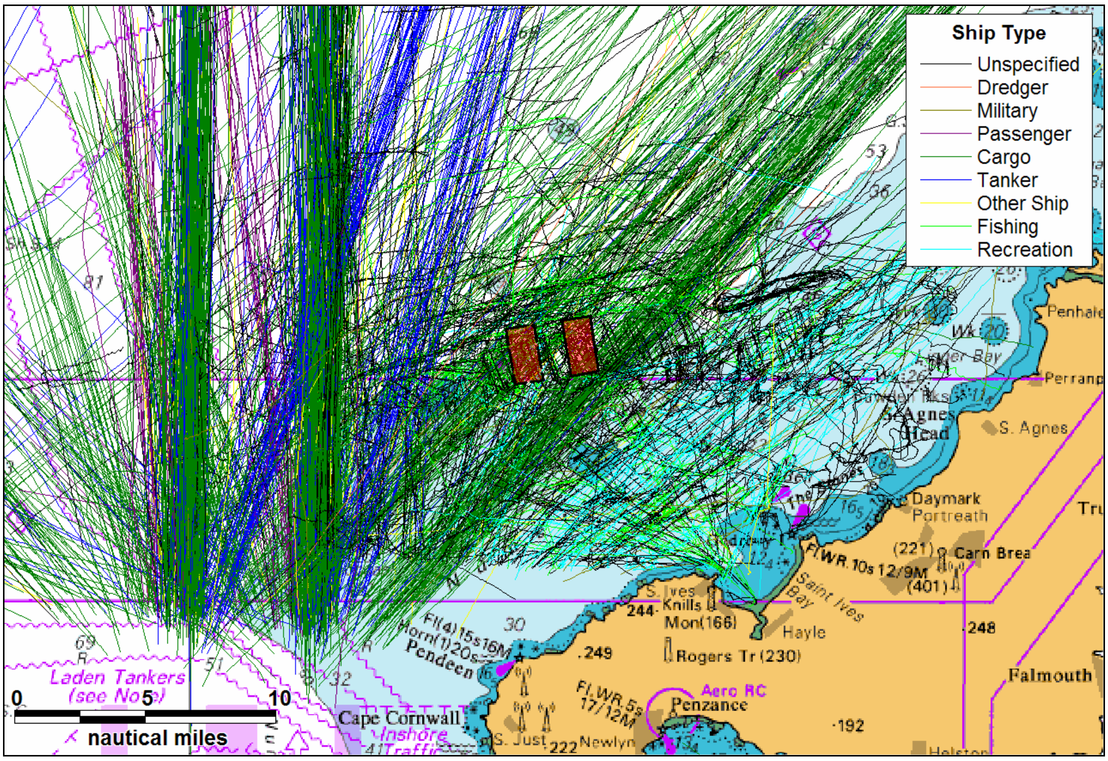


Figure 2 Overview of Tracks relative to Wave Hub Site

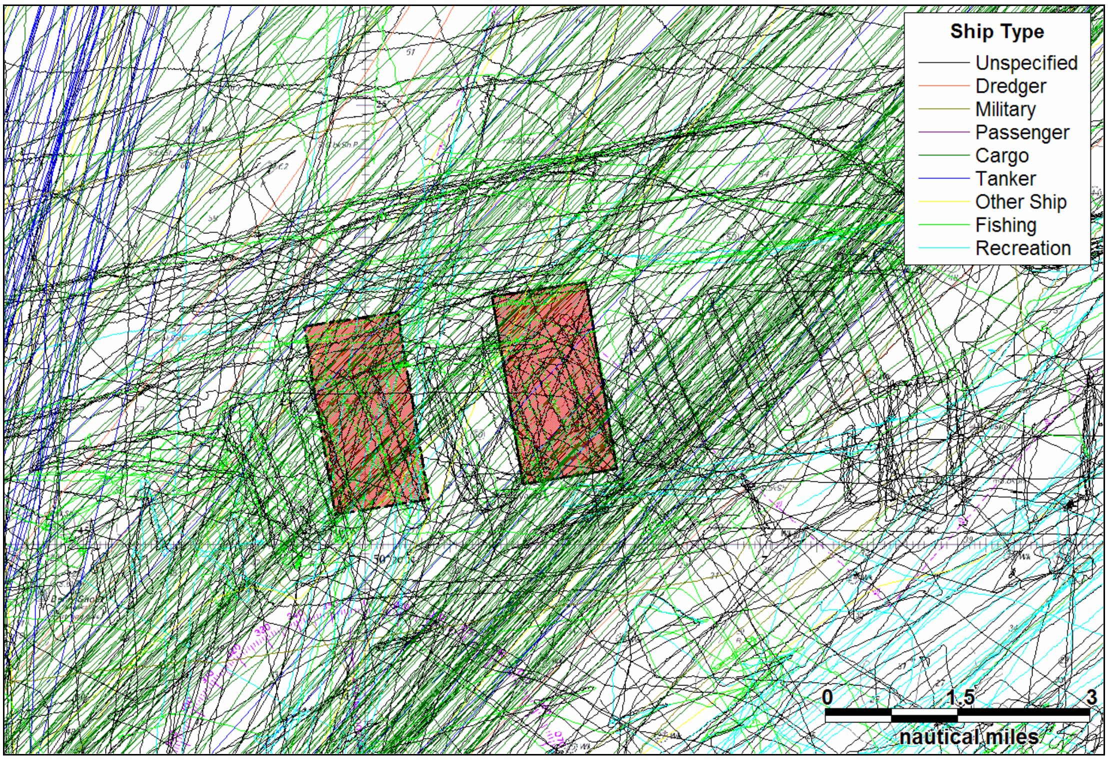


Figure 3 Detailed Overview of Tracks relative to Wave Hub Site

3.2 Intersecting Tracks

Details on the numbers of vessels by type intersecting each area are presented below.

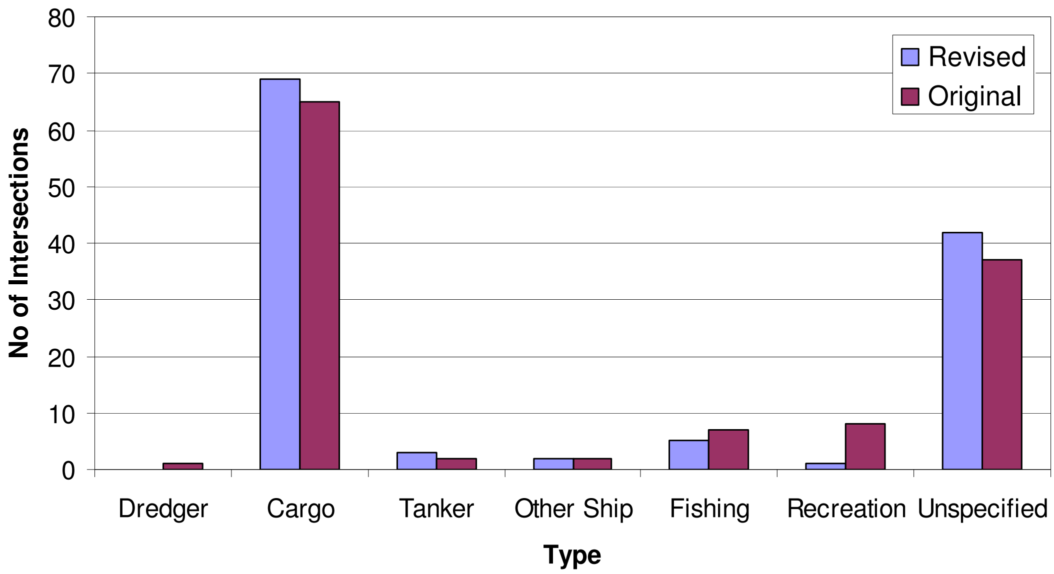


Figure 4 Intersecting Tracks by Type

A total of 122 survey tracks (average of 4 per day) passed through both the revised and original deployment areas.

For both areas, the majority of identified intersecting tracks were cargo vessels, with a small proportion of fishing vessels, tankers, recreational vessels and other ships. The original site had slightly more fishing and recreational vessels passing through it.

The merchant vessels passing through the original site were mainly routeing from the Bristol Channel (e.g., Bristol, Swansea and Bideford) towards the TSS off Land's End heading for ports in Spain, France, Belgium, etc. Vessels passing through the revised site were more equally distributed in terms of direction, with tracks heading both to and from the Bristol Channel.

3.3 Merchant Shipping Routes

3.3.1 Main Routes

The analysis above identified that the vast majority of vessels recorded during the survey period were commercial (merchant) vessels. The main routes superimposed on the AIS survey tracks are presented below:

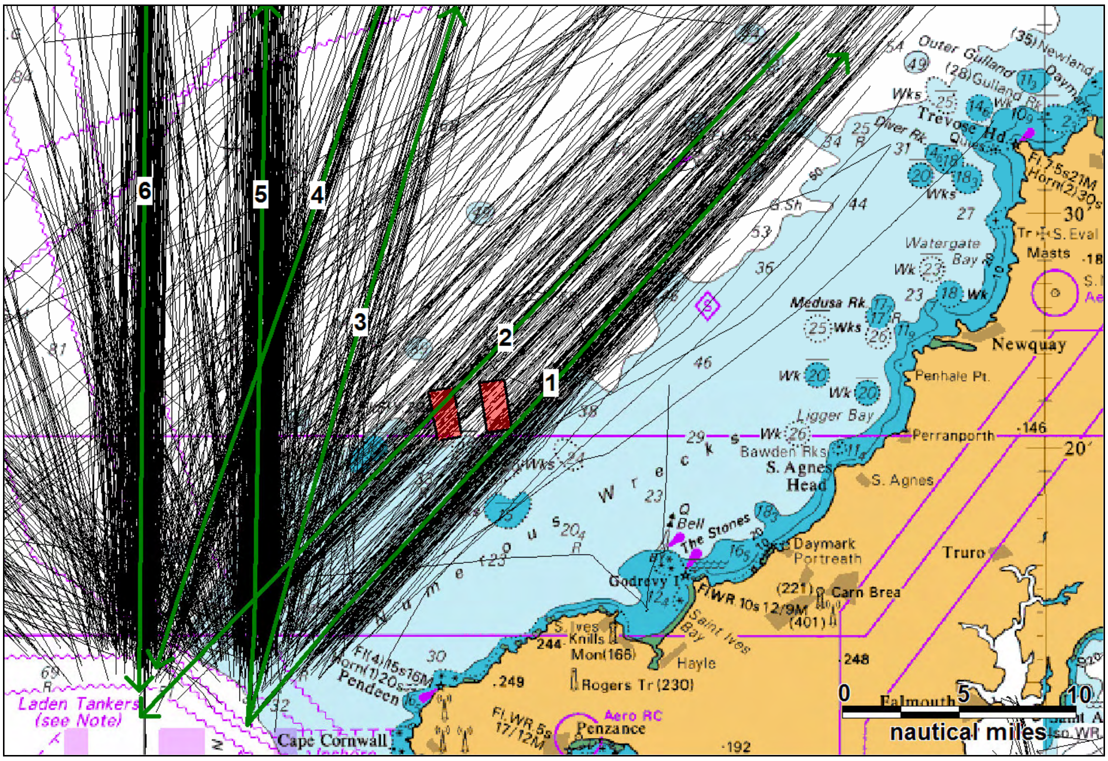


Figure 5 Main Merchant Routes identified from Survey Data

Summary information on each of the main routes is given in Table 1.

Table 1 Main Routes passing Wave HubSite

Route	Description	Average Ships per Day
1	TSS off Land's End to Bristol Channel	5
2	Bristol Channels to TSS off Land's Ends	5
3	TSS off Land's End to Milford Haven / Pembroke	2
4	Milford Haven / Pembroke to TSS off Land's End	2
5	TSS off Land's End to The Smalls TSS	10
6	The Smalls TSS to TSS off Land's End	10

It can be seen that Route No's 1 & 2 heading between the Bristol Channel and the TSS off Land's End, and each trafficked by an average of approximately 5 vessels per day, pass closest to the Wave Hub deployment area. The mean position of Route 2 passes through the original Wave Hub site whilst the mean position of Route 1 passes just outside the SE corner of the revised site.

The boundaries of the lanes encompassing 90% of the ships on the six routes overlaid on the AIS survey tracks are shown in Figure 6.

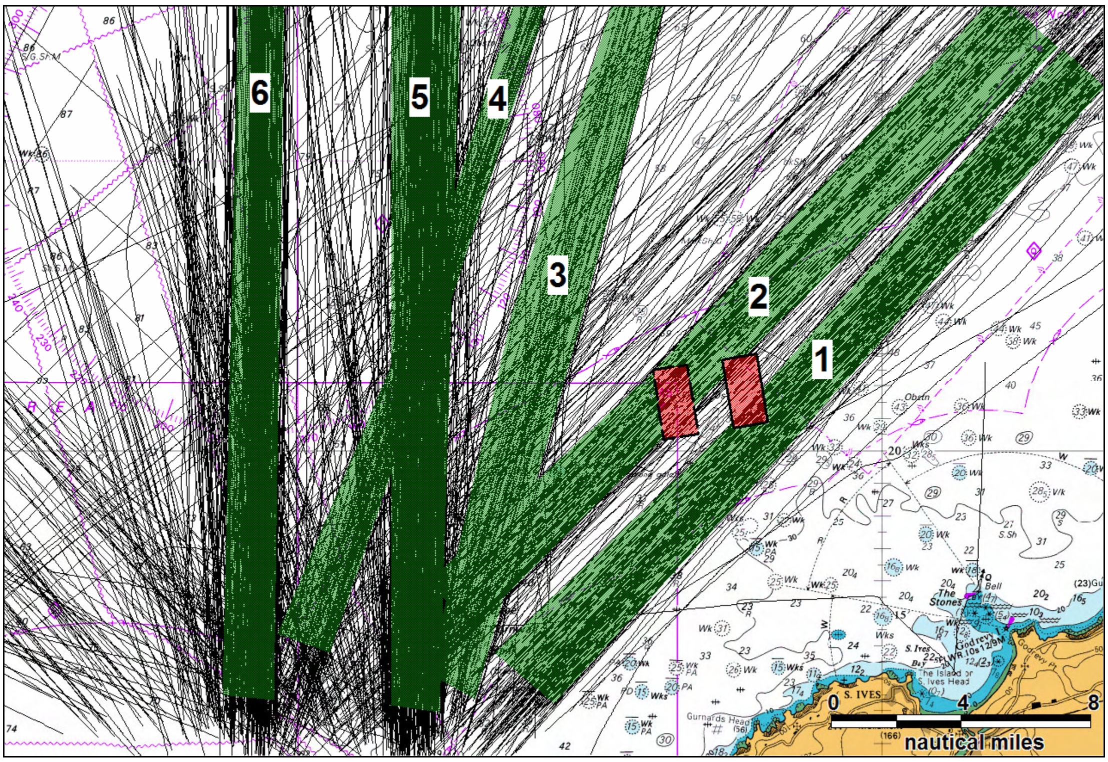


Figure 6 Lanes containing 90% of the Traffic on the Six Main Routes

Therefore, a large proportion of the traffic on Route 2 currently passes over the originally proposed Wave Hub site area. The fringes of Routes 1 and 2 pass over the revised site.

3.4 Non-Merchant Activity

3.4.1 Fishing

A chart of the fishing vessel tracks relative to the original and revised deployment areas is presented in Figure 7.

The main fishing activity observed in the survey was concentrated near-shore with just 7 fishing vessel tracks recorded passing through the original Wave Hub site and 5 tracks passing through the revised site. All the tracks were by trawlers.

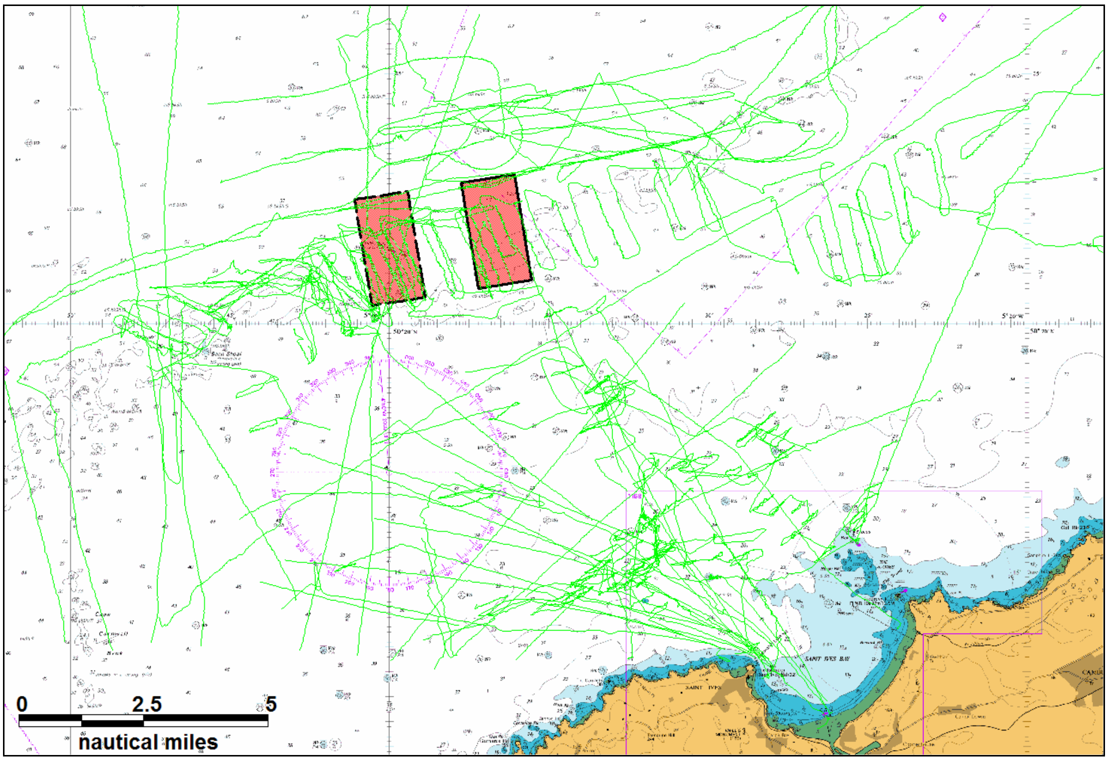


Figure 7 Fishing Vessels tracked during Survey

3.4.2 Recreation

The recreational vessels tracked during the survey are shown in Figure 8. The majority of the tracks passed between the Wave Hub site and the coast.

Eight recreational vessel tracks (7 yachts and one high-speed motor launch) passed through the original Wave Hub site compared to just one yacht through the revised site during the 28 days of surveying.

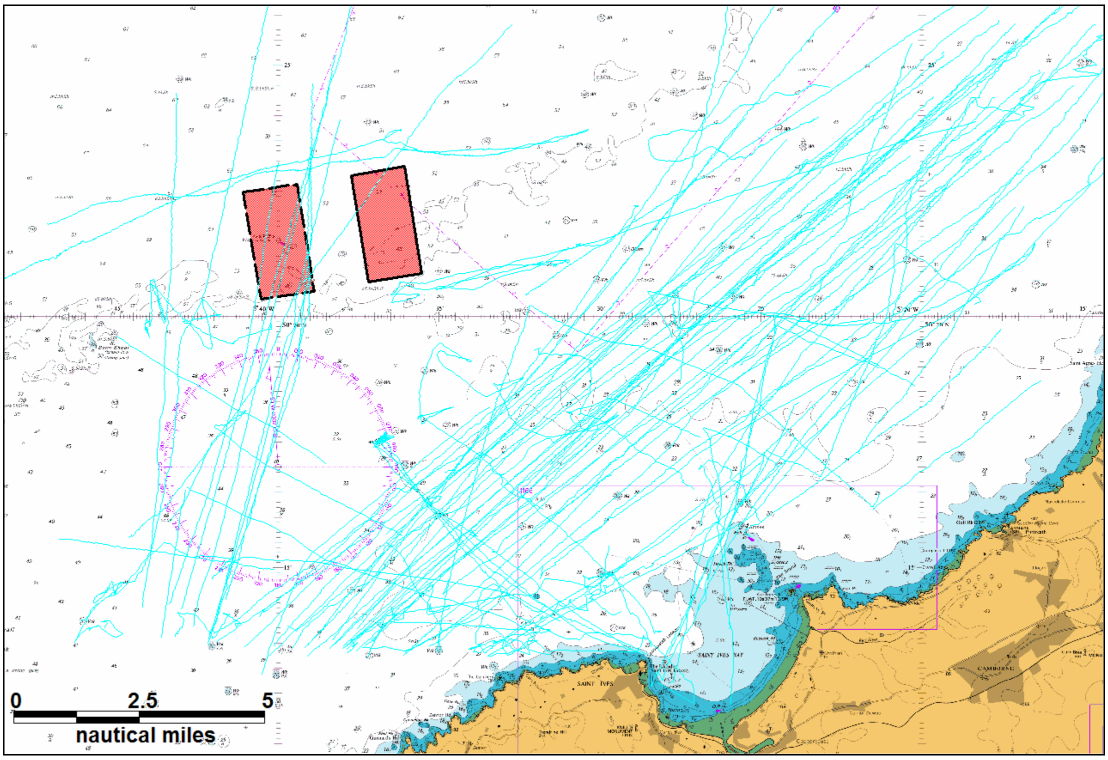


Figure 8 Recreational Vessels tracked during Survey

3.5 Encounters

An analysis has been conducted of the rate of encounters between vessels within 10nm of the original Wave Hub site based on the second survey fortnight. An encounter was defined as vessels passing within 1nm of each other. Based on the 10nm range applied, the analysis covers both the original and revised sites.

The results of the analysis, in the form of the encounter tracks and an encounters density grid, are presented below.

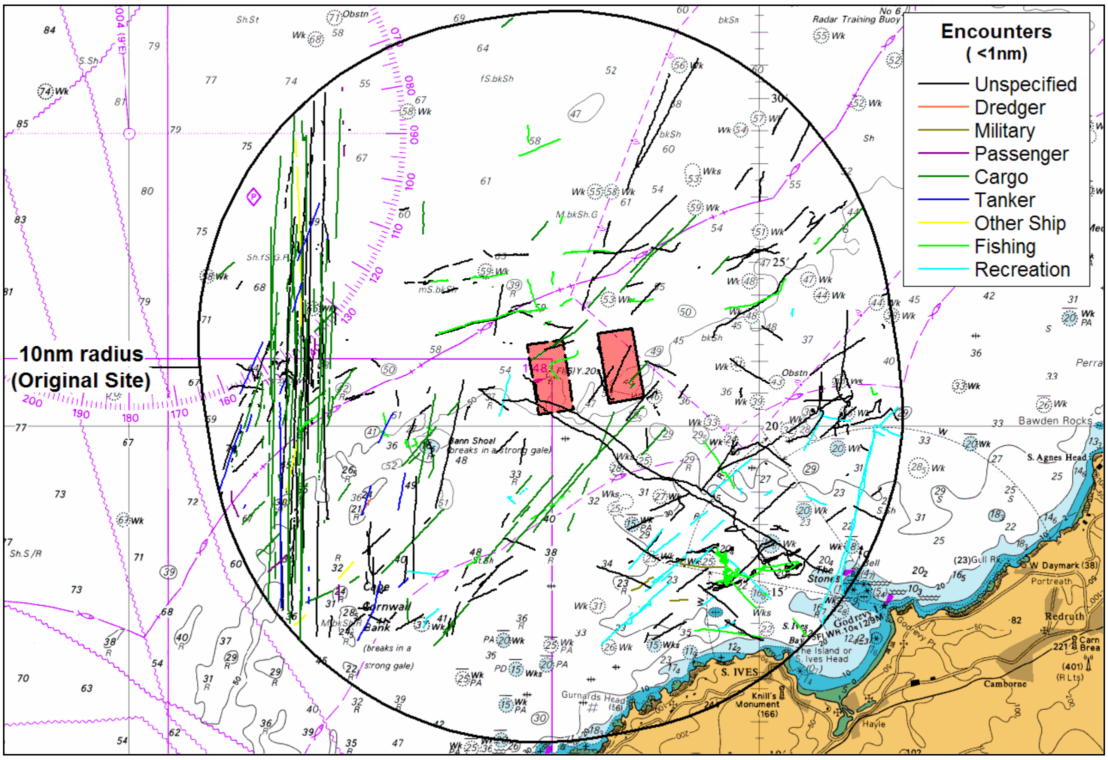


Figure 9 Encounter Tracks within 10nm of Wave Hub

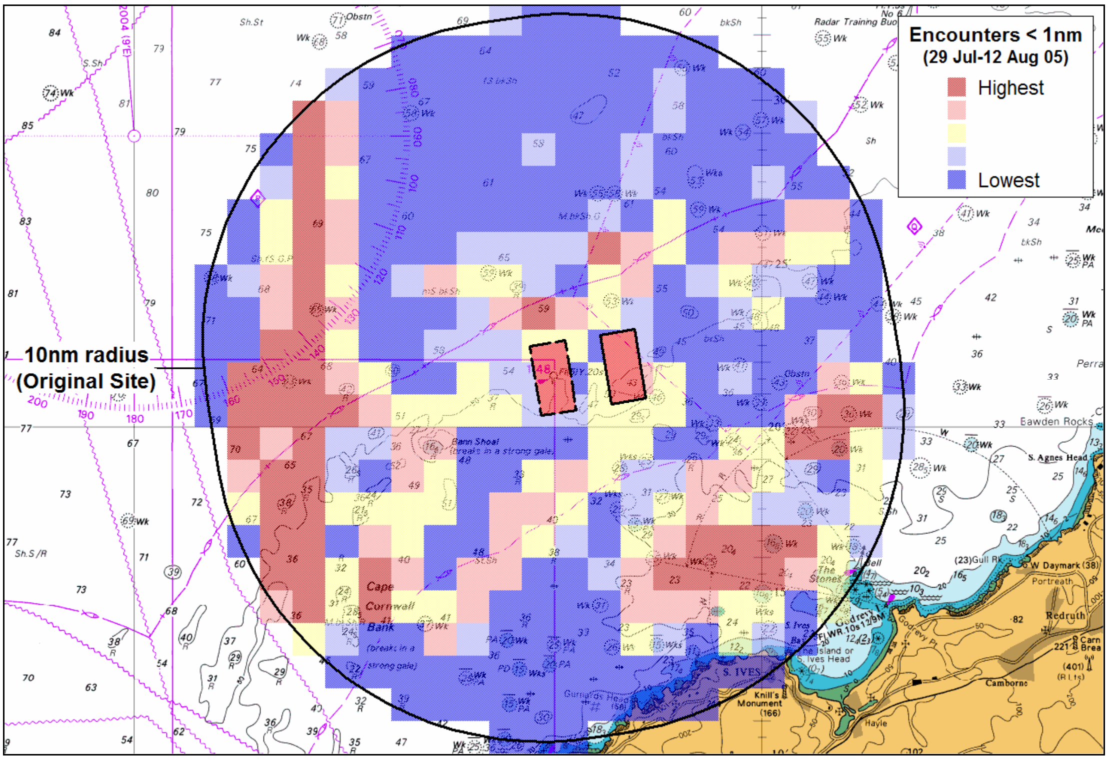


Figure 10 Encounter Density Grid within 10nm of Wave Hub

It can be seen that most encounters occurred to the west of the proposed Wave Hub sites in the higher traffic density area between the TSS off Land's End and The Smalls TSS.

The density of encounters in the vicinity of the Wave Hub sites was low to moderate in terms of relative rate of encounters in the local area. Within the original deployment area there were four encounters during the two-week period, with one involving a cargo vessel and a trawler and the others being unspecified types, most likely small fishing and recreational vessels. For the revised deployment area to the ENE, there were also 4 encounters, 2 involving cargo vessels and 2 others of unspecified types.

4. Impact on Navigation

In terms of merchant shipping, based on the analysis of route mean positions and lane boundaries it is considered that the original site would have a more significant impact on navigation than the revised site.

The original site would displace the traffic on Route 2 from Bristol Channel to the TSS Off Land's End, used by an average of 5 ships per day, with the majority of this traffic expected to move to the north of the site, as illustrated in Figure 11.

This will increase the voyage time/distance of vessels using this route. A proportion of the traffic on Route 2 may elect to pass south of the original site which would bring it into proximity of Route 1, which contains traffic heading in the opposite direction from the TSS to ports in the Bristol Channel.

The revised site is located between the centres of Route 1 & 2, therefore, whilst it will lead to some displacement of traffic on both routes, the extent of displacement will be smaller (less impact) and the main effect is likely to be to separate the two opposing flows of traffic, as shown in Figure 12.

The separation of the opposing flows of traffic on Routes 1 & 2 envisaged due to the Wave Hub is likely to reduce encounters between this traffic. This effect will be greater (beneficial effect) for the revised site based on the position of the site between the two opposing routes.

The displacement of Route 2 traffic anticipated due to the original Wave Hub site could also potentially impact vessels using Route 3 (mainly tankers to/from Milford Haven). For example, a northbound vessel on Route 3 heading for Milford Haven encountering a SW-bound vessel on Route 2 heading for the TSS Off Land's End would be required by the ColRegs to give way. The presence of the original Wave Hub site to the East of where the encounter takes place could complicate this manoeuvre which would normally involve altering course to starboard.

The lesser impact of the revised site on Route 2 and the fact the deployment area is a further 4km to the ENE (i.e., 4km further away from where the two lanes of traffic normally cross) means that there is less risk of interaction with "give-way" traffic on Route 3. (See Section 7.3 of the Main Report for a more detailed analysis.)

In terms of the potential displacement of fishing and recreational vessel activity onto commercial routes in the area, relatively little of this activity was observed around either of the proposed sites with the vast majority of activity being observed closer to shore. Therefore, the proposed movement of the site is considered broadly neutral in terms of navigational impact, although the survey did indicate slightly lower activity at the revised site.

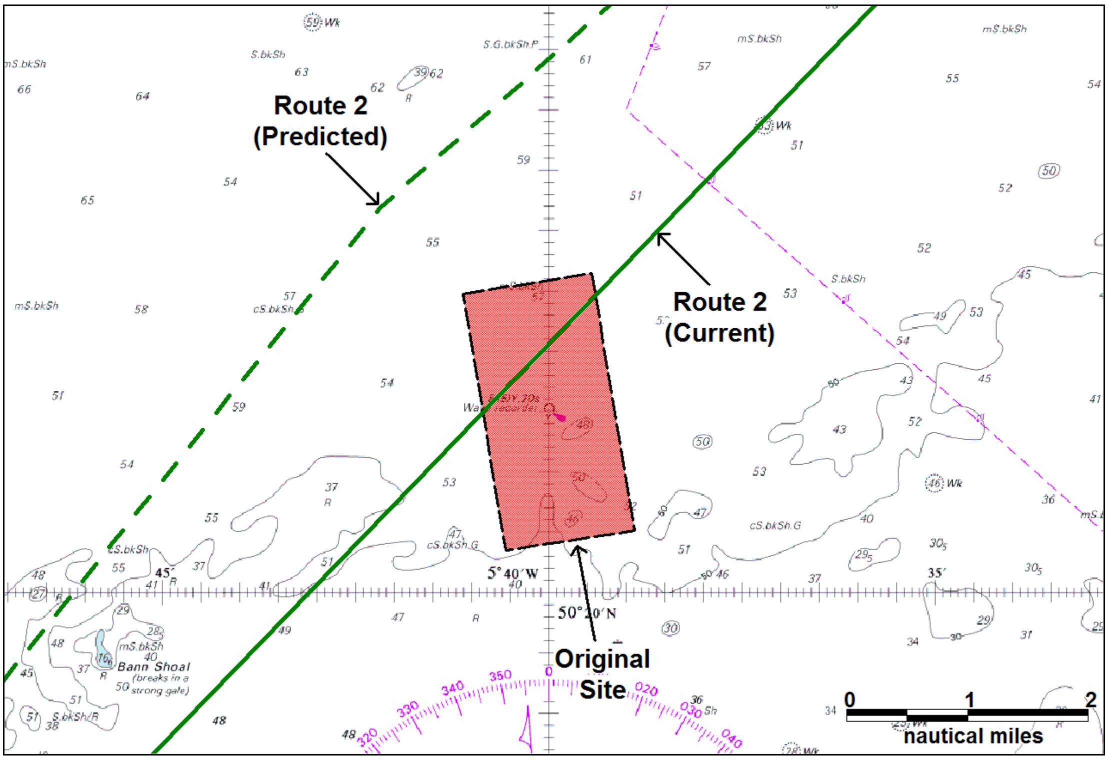


Figure 11 Anticipated Impact of Original Wave Hub Site on Route 2

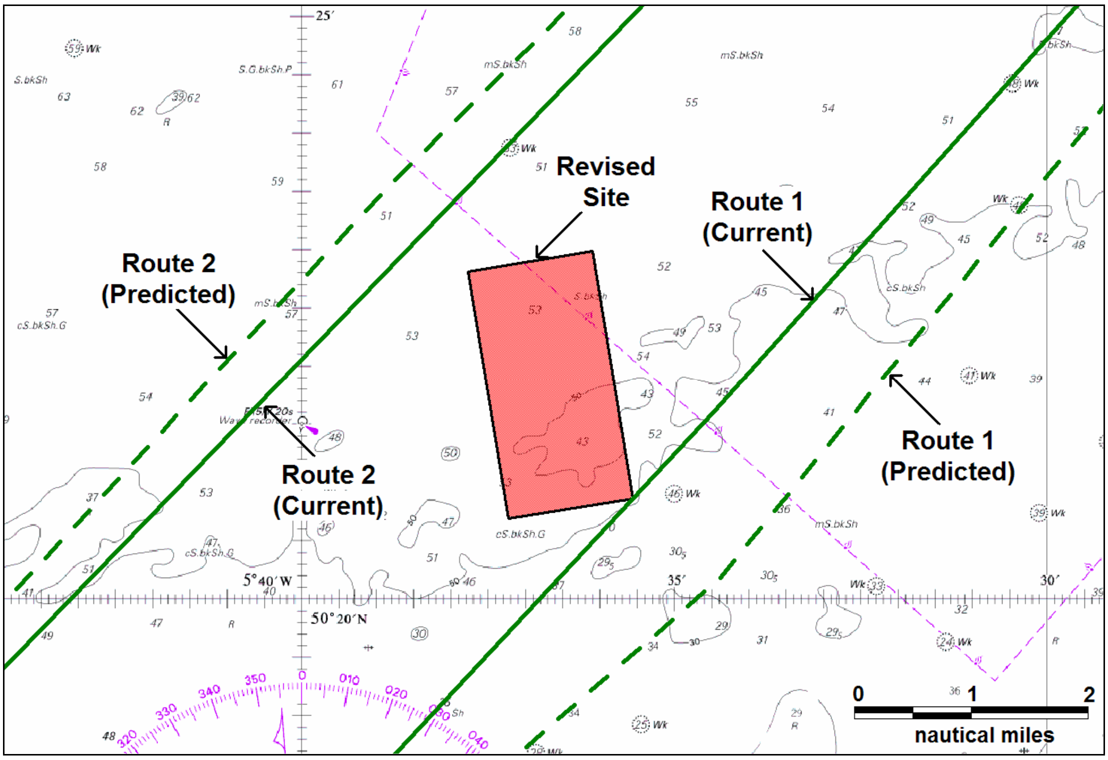


Figure 12 Anticipated Impact of Revised Wave Hub Site on Routes 1 & 2

5. Navigation Risk

This section quantifies the risks associated with the original site and compares the results with the risk assessment of the revised site (see Section 11 of Main Report for details on model methodology and inputs).

The results for the original and revised sites are presented in the following two tables and illustrated in Figure 13.

Table 2 Results Summary – Original Site

Collision Scenario	Without Wave Hub	With Wave Hub	Change
Passing Powered	N/A	7.8E-03	7.8E-03
Passing Drifting	N/A	2.3E-04	2.3E-04
Vessel-to-Vessel	1.3E-02	1.1E-02	-2.4E-03
Total	1.3E-02	1.9E-02	5.6E-03

Table 3 Results Summary– Revised Site

Collision Scenario	Without Wave Hub	With Wave Hub	Change
Passing Powered	N/A	5.6E-03	5.6E-03
Passing Drifting	N/A	2.7E-04	2.7E-04
Vessel-to-Vessel	1.3E-02	1.1E-02	-2.4E-03
Total	1.3E-02	1.7E-02	3.5E-03

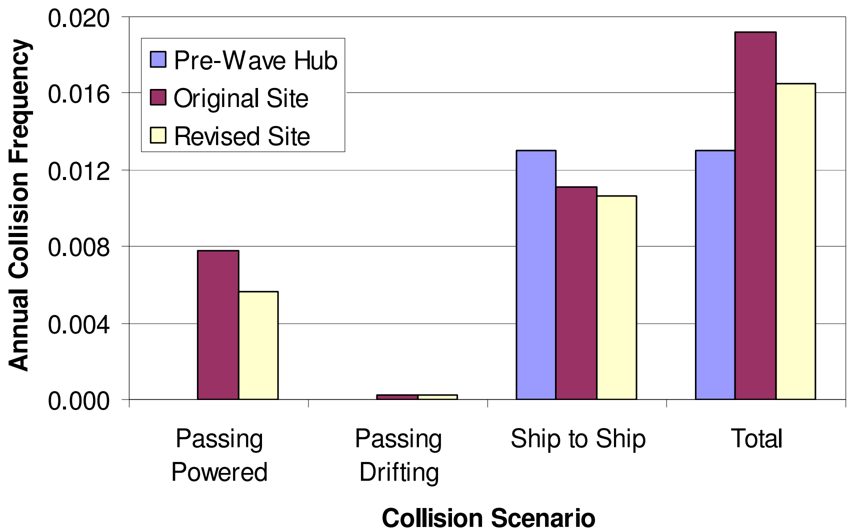


Figure 13 Comparison of Risk Results - Original and Revised Wave Hub Sites

Therefore, the risk of passing powered ship collision was estimated to be higher for the original site although there was a slight decrease in the less significant drifting vessel collision risk.

For both sites the risk of ship-to-ship collision was estimated to be lower post-Wave Hub due to the separation of the opposing flows of traffic on Routes 1 & 2. The risk reduction (beneficial effect) was assessed to be greater for the revised site.

Overall, the total collision risk is estimated to increase post-Wave Hub due to the newly introduced risk of collision with the devices, however, the increase is estimated to be significantly lower for the revised site compared to the originally proposed site (25% versus 47%, respectively).

For fishing and recreational vessel activity, the proposed movement of the site is considered broadly neutral in terms of navigational risk although the survey did indicate slightly lower activity at the revised site.

6. Conclusions

This appendix compared the navigation impact / risk associated with the original and revised Wave Hub sites.

The revised site, which has been moved 4km to the East of the originally proposed site (centre-to-centre), is considered to have a lower impact on navigation and lower risk of collision.