Two cargo vessels and a military vessel were also observed anchoring in Ballycotton Bay, approximately 1.4nm to the south west of the proposed eastern landfall. This was the nearest anchoring to the route within the study area.

Vessels (mainly cargo) were observed anchoring in Youghal Bay, with the nearest anchored vessel 4nm to the north-east of the proposed eastern landfall.

Two vessels anchored further offshore, a tanker 4.8nm to the west of the route, and a dredger, 5.9nm to the east. The tanker anchored at this point on two separate occasions in April 2014.

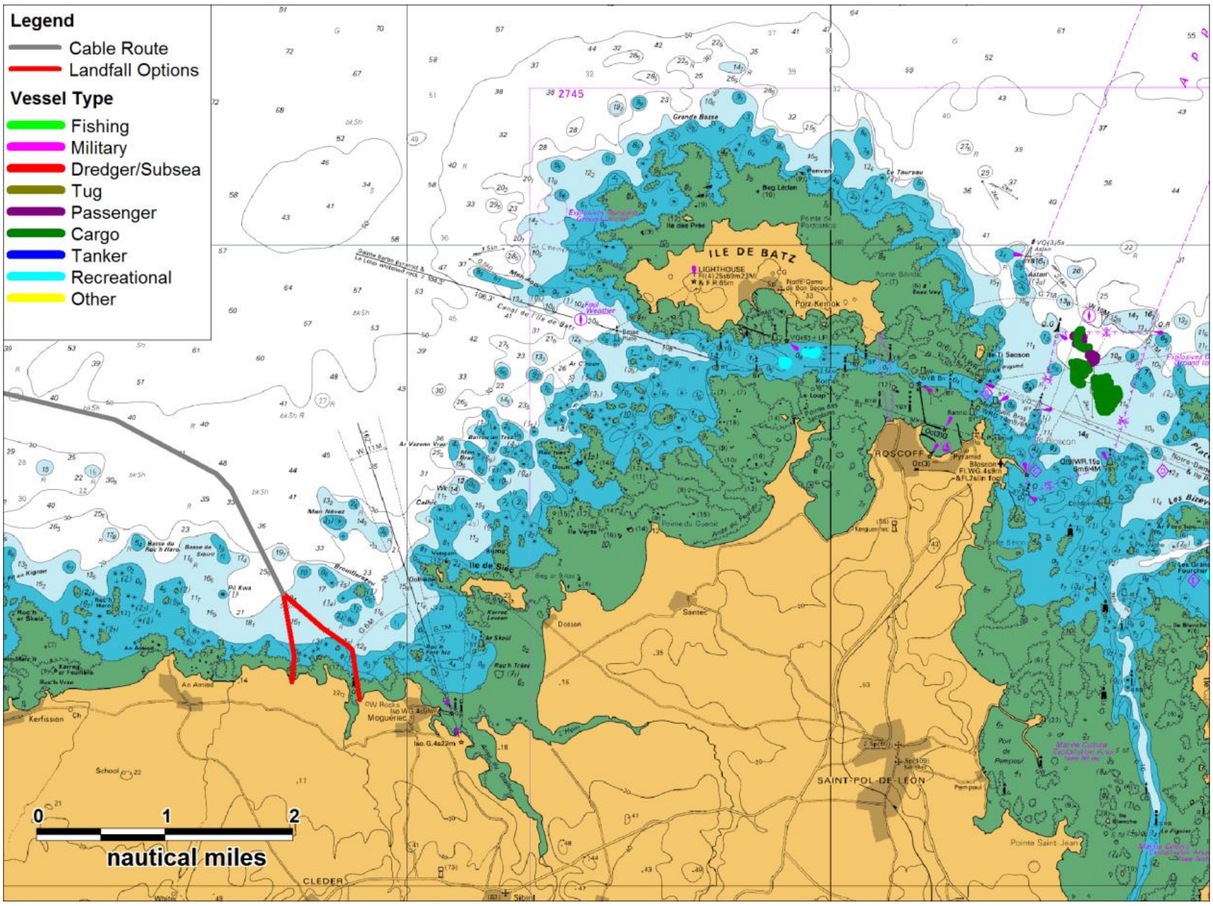

Figure 6.3 AIS Anchoring – French Waters

Recreational vessels were observed anchoring south of the Ile de Batz, approximately 4nm to the north east of the landfalls. The majority of anchoring in the study area within French waters occurred to the east of Roscoff from cargo and passenger vessels. It is noted that these vessels pose minimal risk to the route as the route is protected from these vessels by the land.

6.3 Anchor Penetration

The penetration depth of an anchor depends on the size of the anchor and the seabed type. The size of the anchor generally depends on the size of the vessel. A relationship between vessel DWT and anchor size is provided in based on anchor size requirements from the International Association of Classification Societies (IACS). This relationship is presented in Figure 6.4.

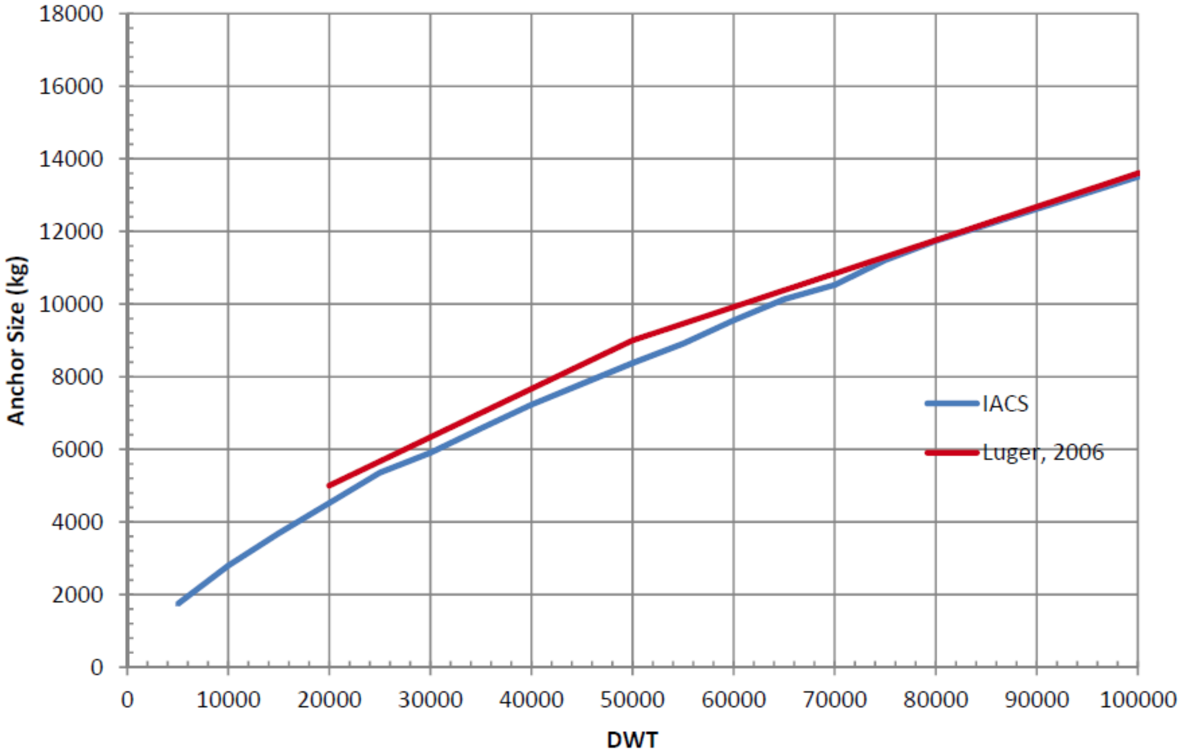

Figure 6.4 Carbon Trust Relationship between DWT and Anchor Size

From this figure, it can be seen that the IACS relationship compares well with anchor sizing proposed by Luger (Ref iv).

Using information from the manufacturers, the anchor mass can then be used to estimate the fluke length of the anchor, which is closely related to the penetration depth. Figure 6.5 shows a typical anchor design (Ref v).

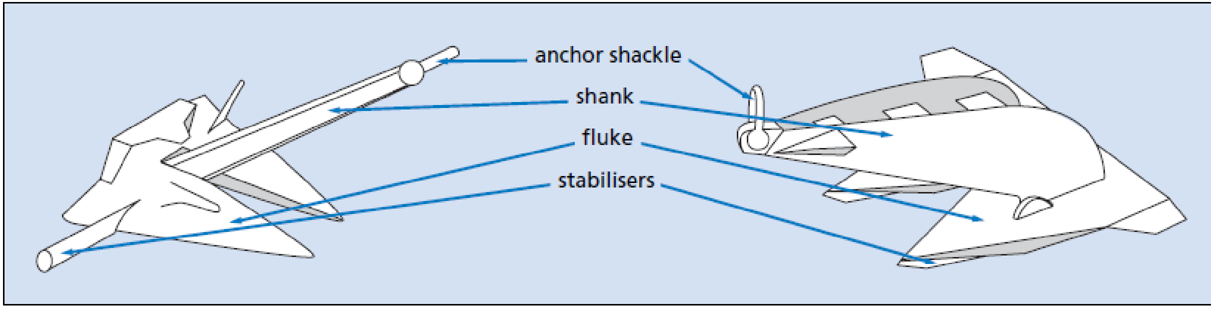

Figure 6.5 Typical Anchor Design

Table 6.1 shows a relationship between vessel DWT, anchor mass and the fluke length for various anchor types. This is based on the Luger relationship and the Vryhof anchor manual (Ref. v).

Vessel DWT	Anchor Mass (kg)	Fluke Length (m)		
		Vryhof	Danforth	Hall
1,500	2,400	2.1	1.7	1.4
5,000	3,000	2.2	1.9	1.5
15,000	4,500	2.6	2.1	1.7
40,000	7,800	3.1	2.5	2.0
200,000	16,500	3.9	3.1	2.6
400,000	26,000	4.5	3.6	3.0

Table 6.1 Vessel DWT, Anchor Mass and Fluke Length

The anchor penetration depth depends on the fluke length, the fluke angle and the seabed type. Typical fluke tip penetration depths for an average fluke angle of 32° are presented in Table 6.2.

Vessel DWT	Average Fluke Tip Penetration (m)
1,500	0.7 – 1.1
5,000	0.8 – 1.2
15,000	0.9 – 1.4
40,000	1.1 – 1.6
200,000	1.4 – 2.1
400,000	1.6 – 2.4

Table 6.2 Average Fluke Tip Penetration

It is assumed that this gives the typical penetration depths for anchors in a 'medium' seabed type, e.g. medium dense sand. These are likely to be smaller for harder sediments and larger for softer sediments.

In particular, for softer seabed types, the fluke angle may increase to a maximum of 50° (Ref v) and the anchor shank may embed into the seabed, giving a larger penetration depth. As discussed in Ref vi work by the US Naval Civil Engineering Laboratory indicates that in sands and stiff clays, the fluke tip penetration is limited to 1 fluke length, while in soft silts and clays, anchor penetration is between 3 and 5 fluke lengths. However, based on recent trials carried out in the German Bight, it is considered that the suggested penetration depth of 3 to 5 fluke lengths for soft clay is potentially excessive.

7. Fishing Analysis

7.1 Introduction

This section analyses the fishing activity within the study area. Certain types of fishing gear are operated close to or on the seabed, and therefore have the potential to interact with subsea equipment. This can cause damage to both subsea cables and to the fishing gear. In more serious cases, snagged gear can also cause a vessel to capsize as it attempts to free its gear.

The fishing vessels tracks recorded within the AIS data presented in Section 5 were extracted and analysed. As previously discussed in Section 3, the 2015 and majority of the 2014 AIS survey data covers all fishing vessels 15m length and over, with the remaining 2014 AIS data (April and May 2014) covering vessels 18m length and over. A proportion of smaller vessels may carry AIS voluntarily but they are not obliged to broadcast.

An additional analysis of Vessel Monitoring Service (VMS) satellite fishing data has been presented in Appendix B (Ref vii).

7.2 Fishing Vessel Positions

The fishing vessel tracks from the AIS data (see Section 5) are presented in Figure 7.1. The vessel identity information broadcast on AIS (e.g. name and CallSign) was used to research further details, including gear type, using public domain data, including EU fleets.

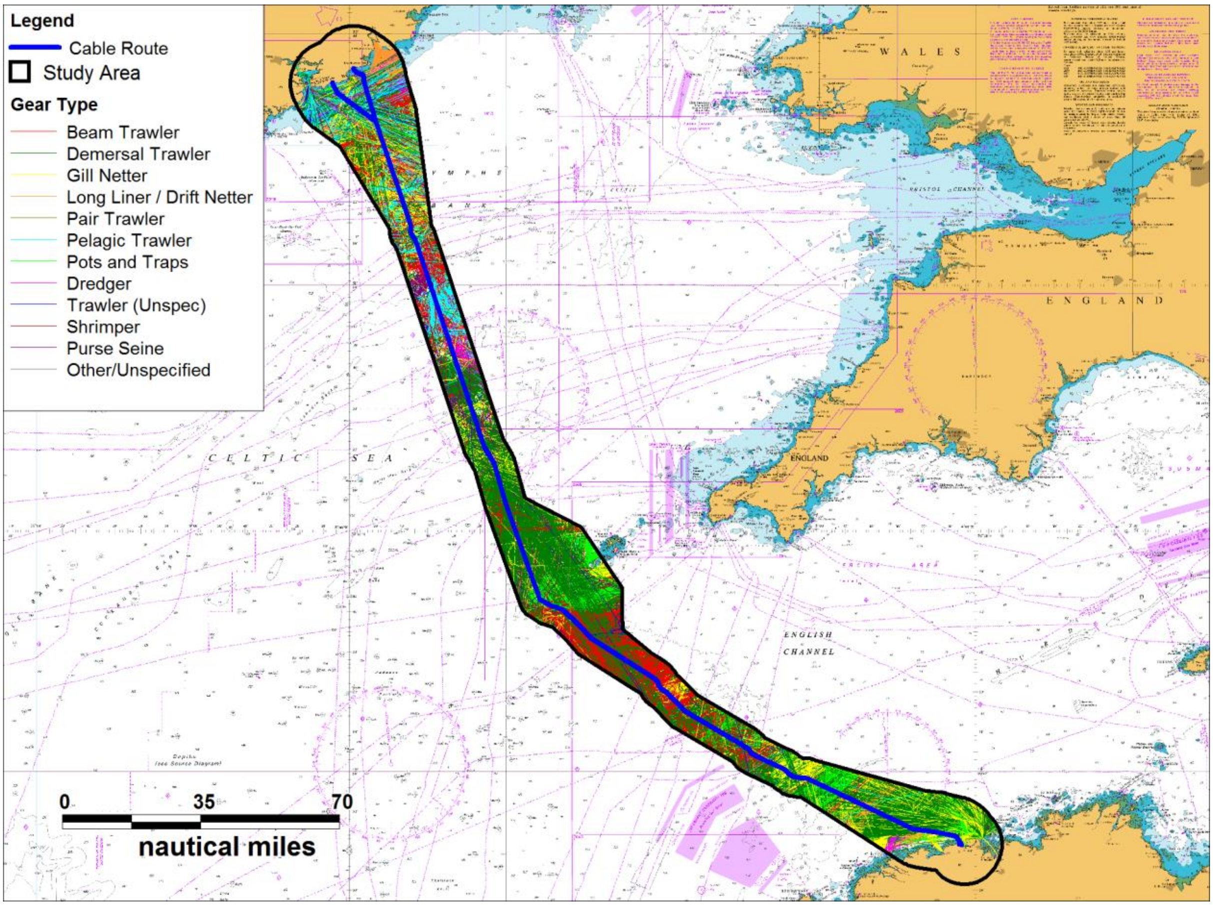

Figure 7.1 AIS Fishing Vessel Tracks (12 Months, 2014/2015)

It can be seen that during the 12 months of AIS data (6 months 2014 and 6 months 2015), there were a significant number of fishing vessels with various gear types tracked within the study area.

7.3 Vessel Numbers

The monthly fishing vessel counts (based on unique vessels per day) are presented in Figure 7.2. It is noted that October 2014 and April 2015 were not covered in the study period.

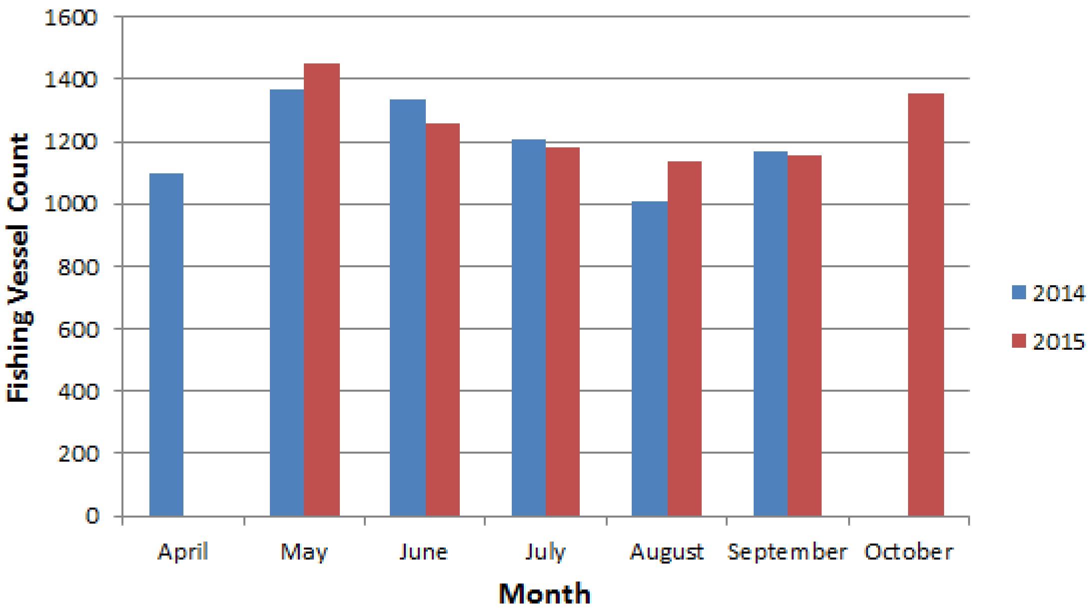

Figure 7.2 Monthly Fishing Vessel Count, 12 Months AIS Data (2014/2015)

An average of 40 unique fishing vessels were recorded per day within the study area. The busiest day was the 3rd October 2015, when 76 fishing vessels were recorded within the study area.

It can be seen that, in both 2014 and 2015, August was the quietest month for fishing vessels and May was the busiest month. As mentioned in Section 5.8, auxiliary data analysed in Appendix A (Ref i) showed fishing activity to be lower in winter than in summer, in UK and French waters, however it is noted that an increase in fishing vessel activity was observed in Irish waters during winter. This has been accounted for in the fishing risk assessment in Section 0.

7.4 Fishing Activity

Some of the vessels in the study area appeared to be steaming on passage rather than actively fishing. Speeds of vessels actively fishing depends on a number of factors, including vessel size, gear type, fishing method, target species, etc. In general, any vessel above 6 knots is likely to be steaming on passage between ports and/or fishing grounds. Fishing vessels travelling below 6 knots could also be steaming (dependent on vessel size and location) but could be actively fishing. To be conservative, it was assumed that all fishing vessels travelling at less than 6 knots were actively fishing. Based on this, the tracks of fishing vessels actively fishing within the study area are presented in Figure 7.3.

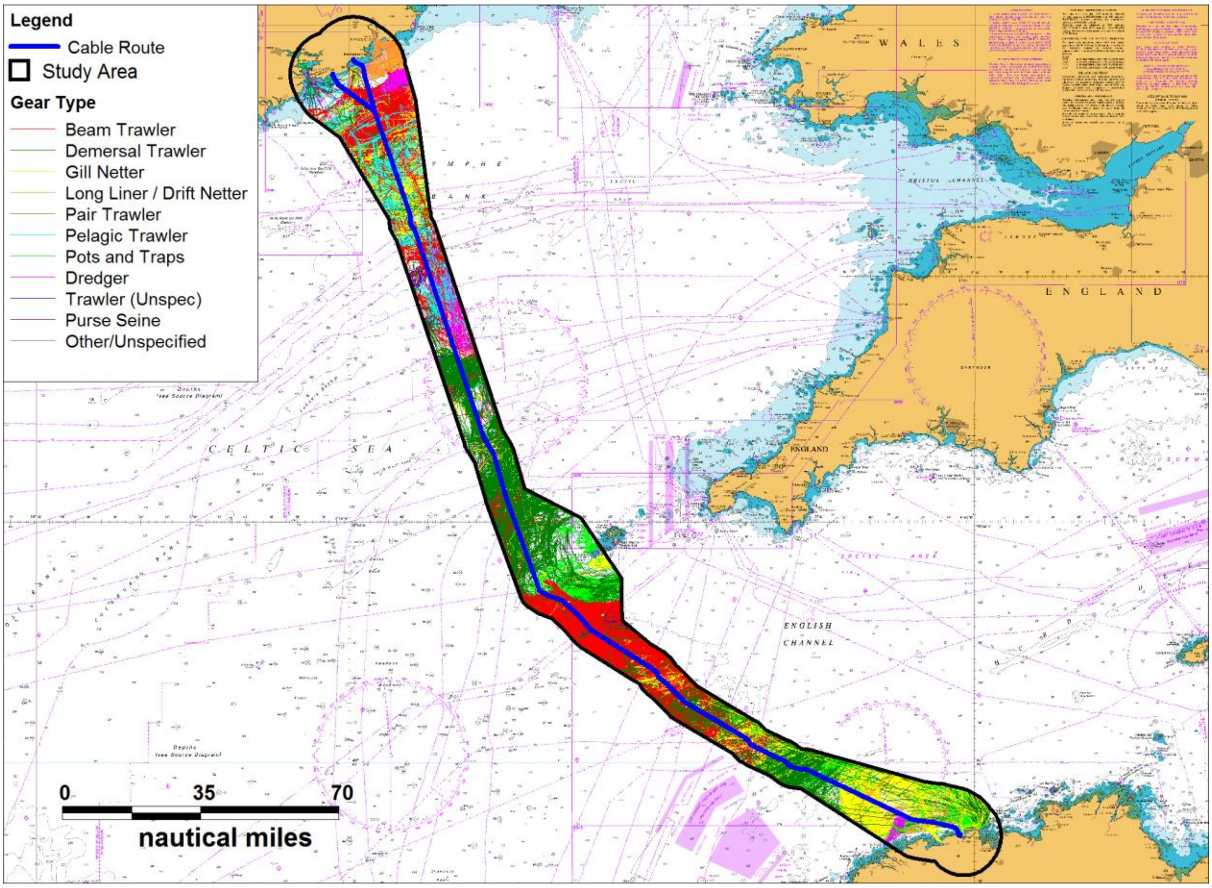

Figure 7.3 AIS Tracks less than 6 knots, 12 Months (2014/2015)

Detailed plots of the subset of fishing vessels with average speeds below 6 knots, in the Irish, UK, and French sectors, are presented in Figure 7.4, Figure 7.5, and Figure 7.6 respectively.

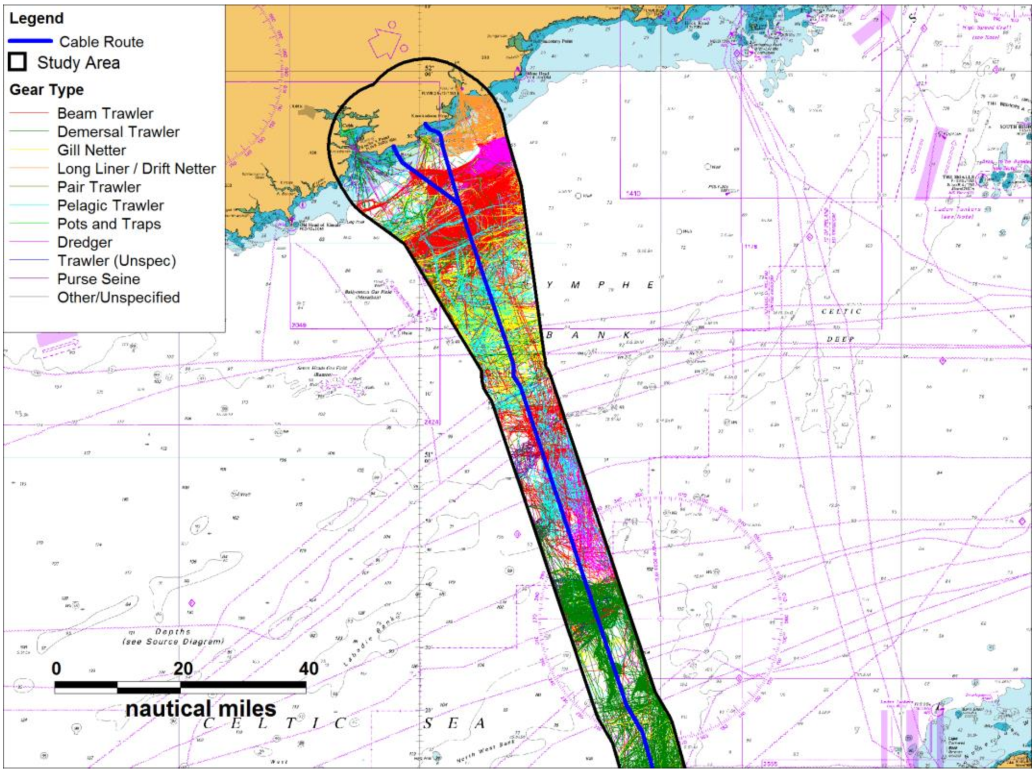

Figure 7.4 AIS Tracks less than 6 knots, 12 Months (2014/2015) – Ireland

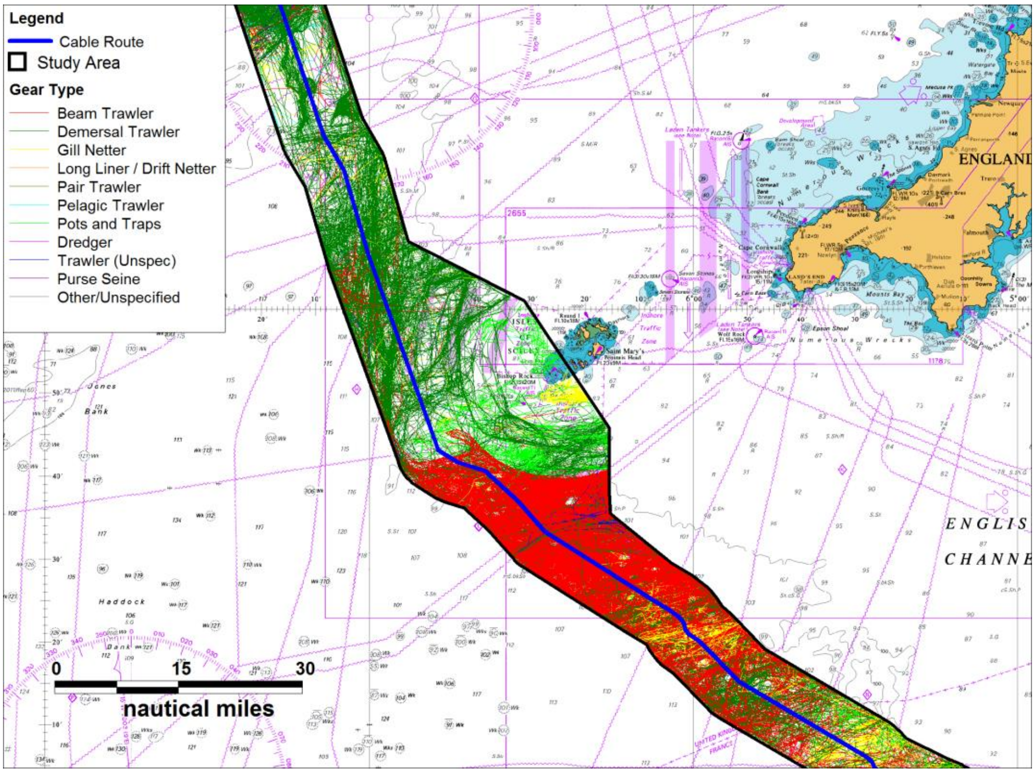

Figure 7.5 AIS Tracks less than 6 knots, 12 Months (2014/2015) – UK

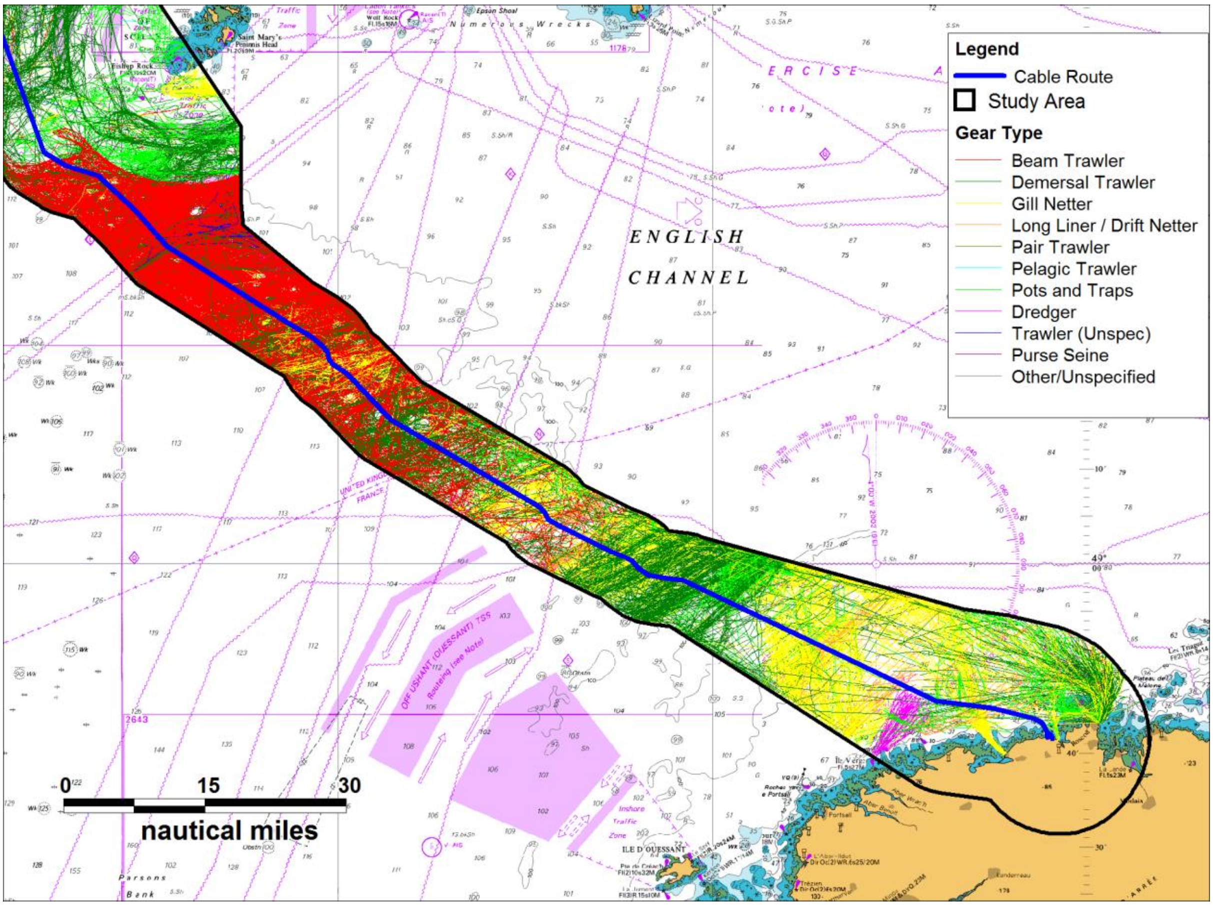

Figure 7.6 AIS Tracks less than 6 knots, 12 Months (2014/2015) – France

7.5 Gear Types

The gear type distribution for vessels actively fishing (i.e., < 6 knots) within the AIS data is presented in Figure 7.7. This is based on unique vessels per day in the study area.

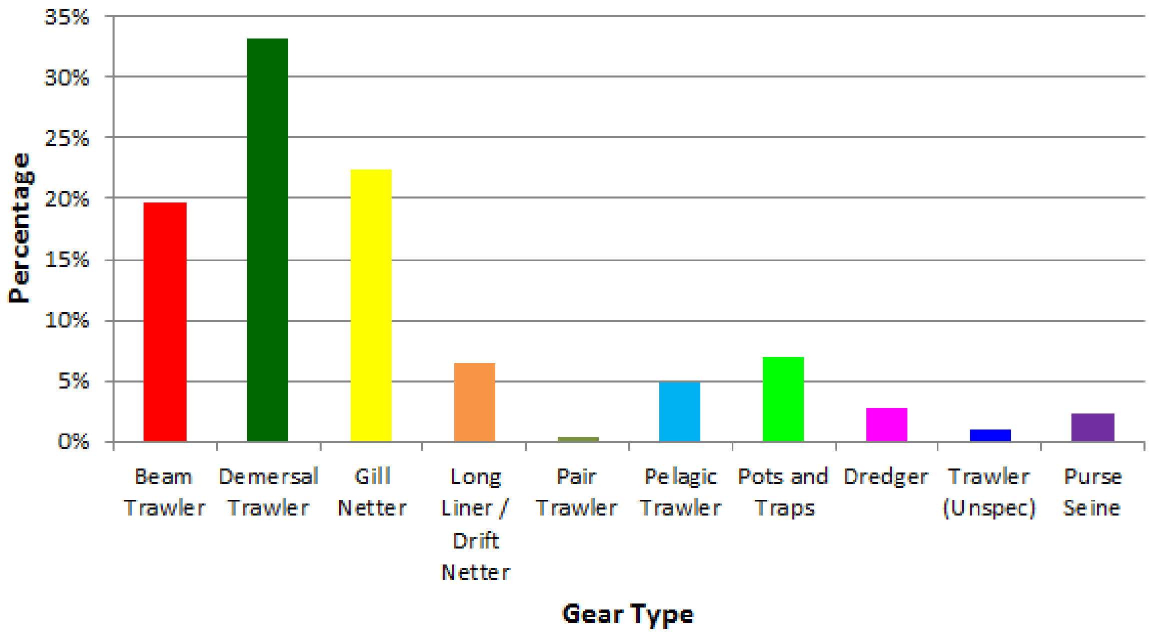

Figure 7.7 Gear Type Distribution, less than 6 knots, 12 Month AIS Data (2014/2015)

It can be seen that the majority of vessels assumed to be actively fishing within the study area were demersal (otter) trawlers (33%), followed by gill netters (22%) and beam trawlers (20%).

It is noted that beam trawlers and demersal trawlers both trawl along the seabed and could therefore interact with the route. Typical penetration depths of these gear types are presented in Section 7.10.

7.6 Vessel Sizes

Figure 7.8 presents the tracks of vessels actively fishing colour coded by vessel length.

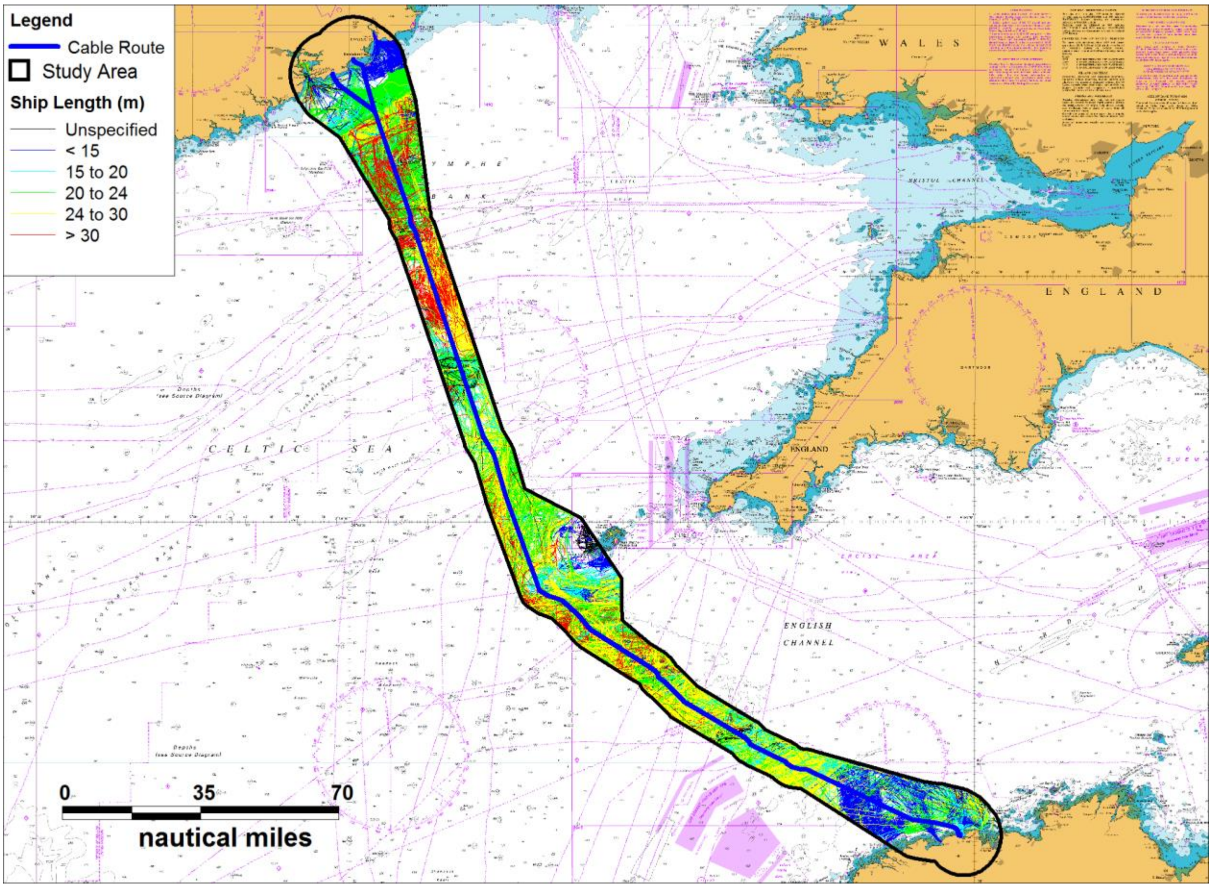

Figure 7.8 AIS less than 6 knots, by Length, 12 Months AIS Data (2014/2015)

It can be seen that the vast majority of vessels actively fishing had length of less than 30m. The distribution of vessels actively fishing by vessel length is presented in Figure 7.9. This is based on unique vessels per day.

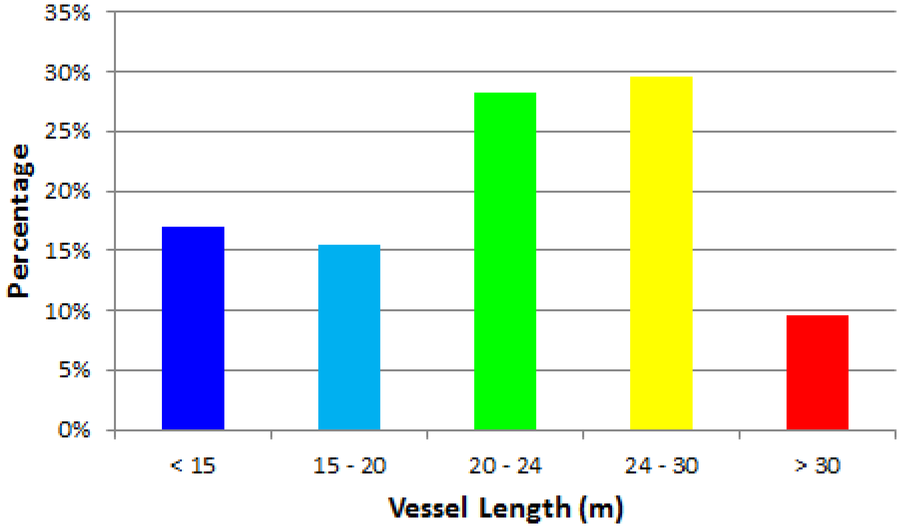

Figure 7.9 Fishing Vessel Length Distribution, less than 6 knots, AIS Data

Figure 7.10 presents the tracks of vessels actively fishing, colour-coded by gross tonnage.

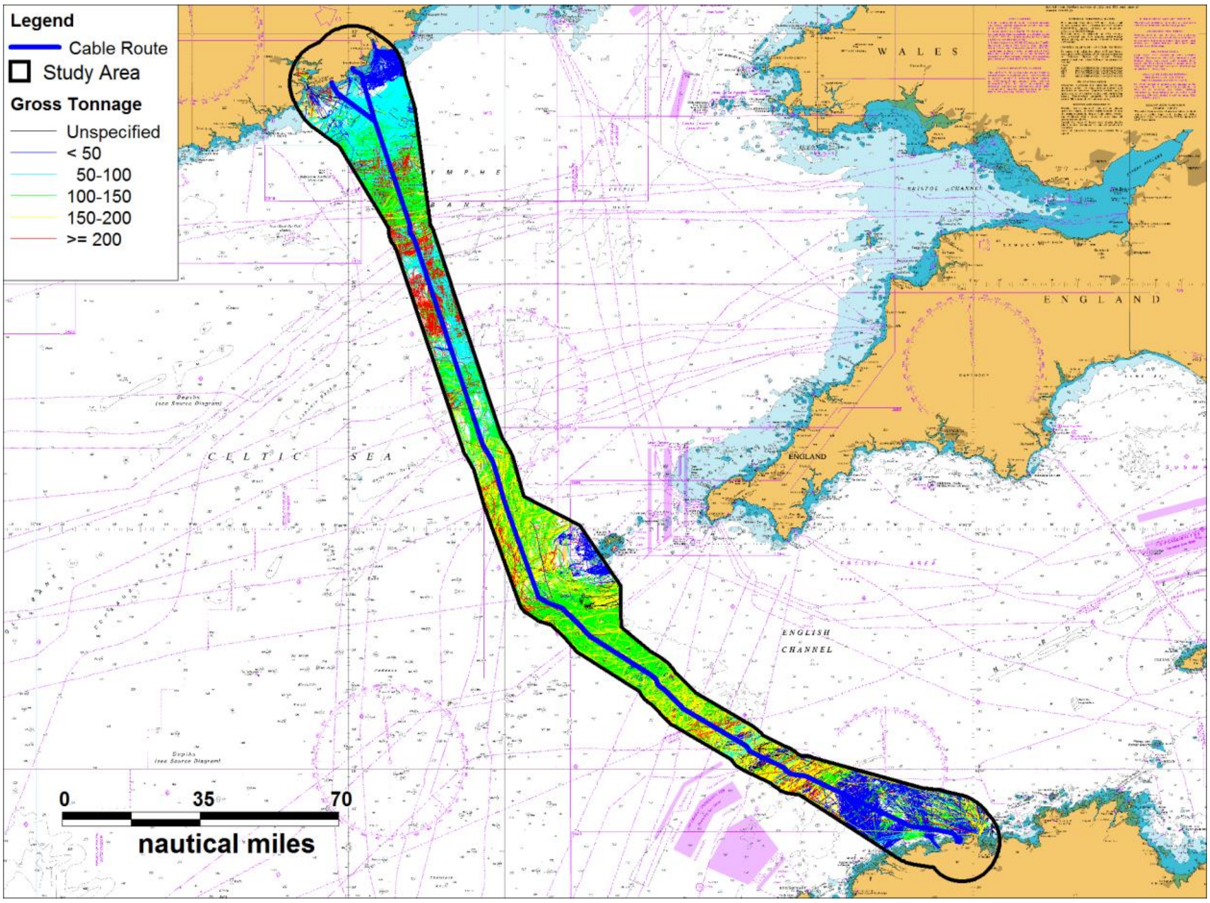

Figure 7.10 AIS less than 6 knots, by GT, 12 Months AIS Data (2014/2015)

The distribution of GT of the vessels at less than 6 knots is presented in Figure 7.11, excluding 1% unspecified.

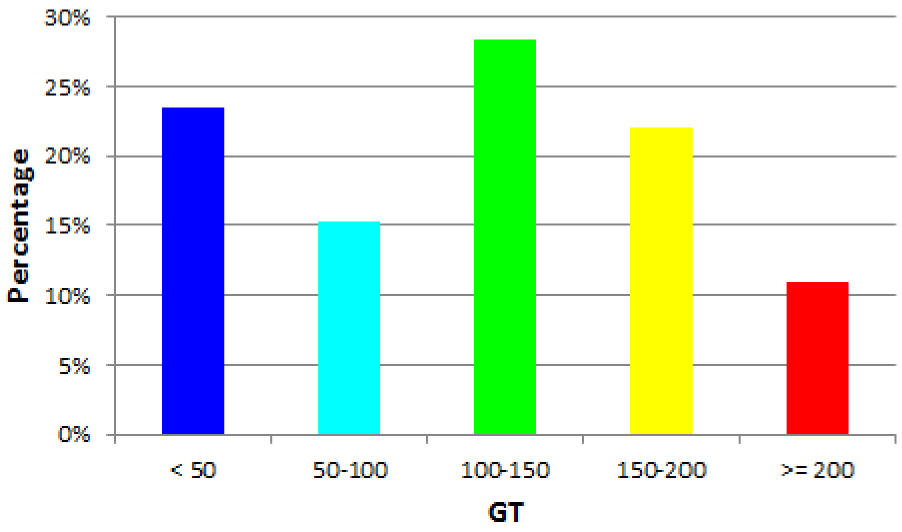

Figure 7.11 Fishing Vessel GT Distribution, less than 6 knots, AIS Data

7.7 Fishing Density

It was seen that the most significant gear types of vessels actively fishing in the study area were demersal (otter) trawlers, beam trawlers and gill netters. In order to identify sections of the proposed cable route where there was a significant amount of fishing activity, density maps for each of these gear types were created. These are presented in Figure 7.12, Figure 7.13 and Figure 7.14.

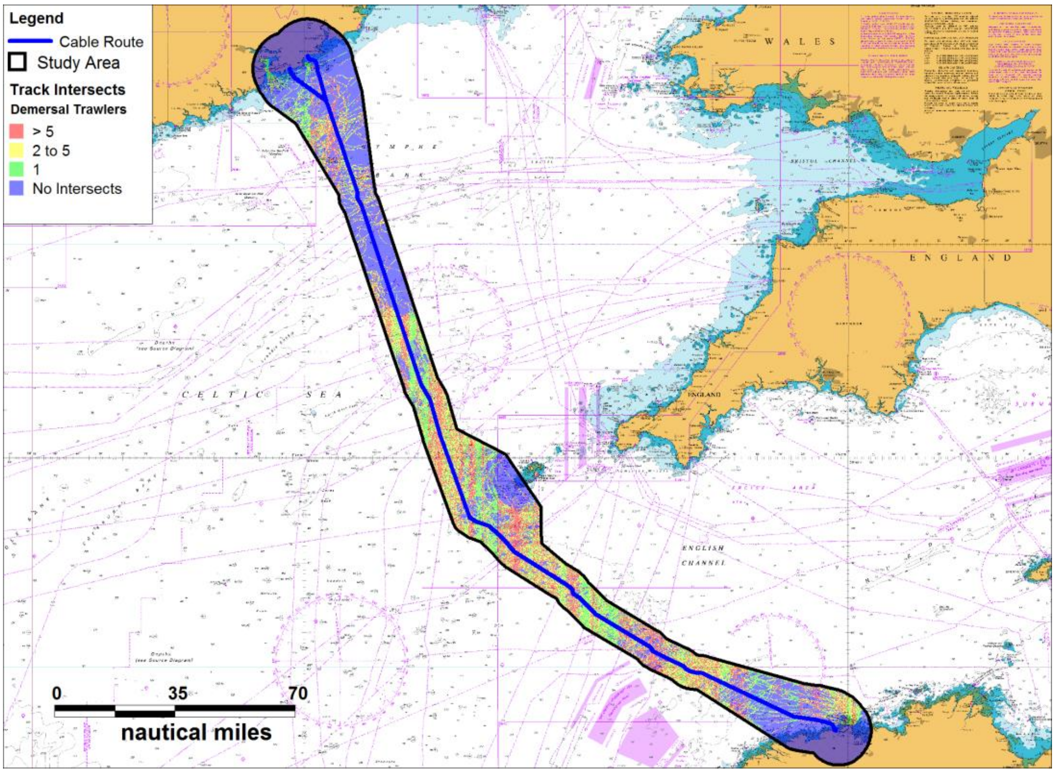

Figure 7.12 Demersal (Otter) Trawlers Actively Fishing, Density Plot

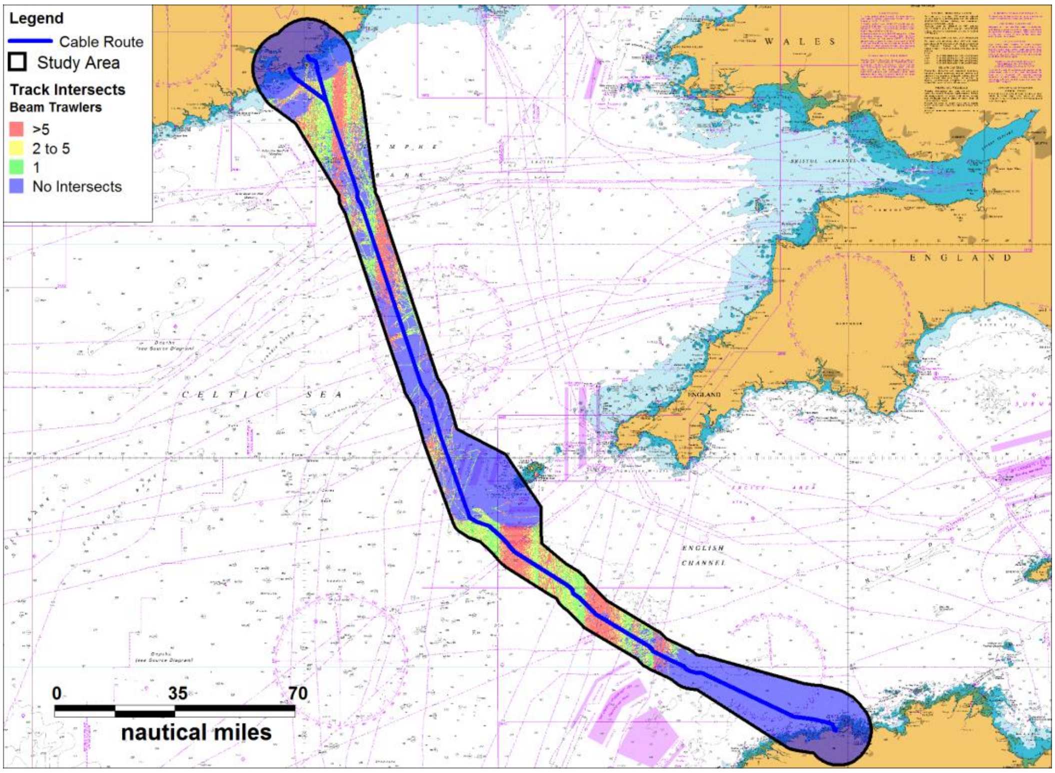

Figure 7.13 Beam Trawlers Actively Fishing, Density Plot

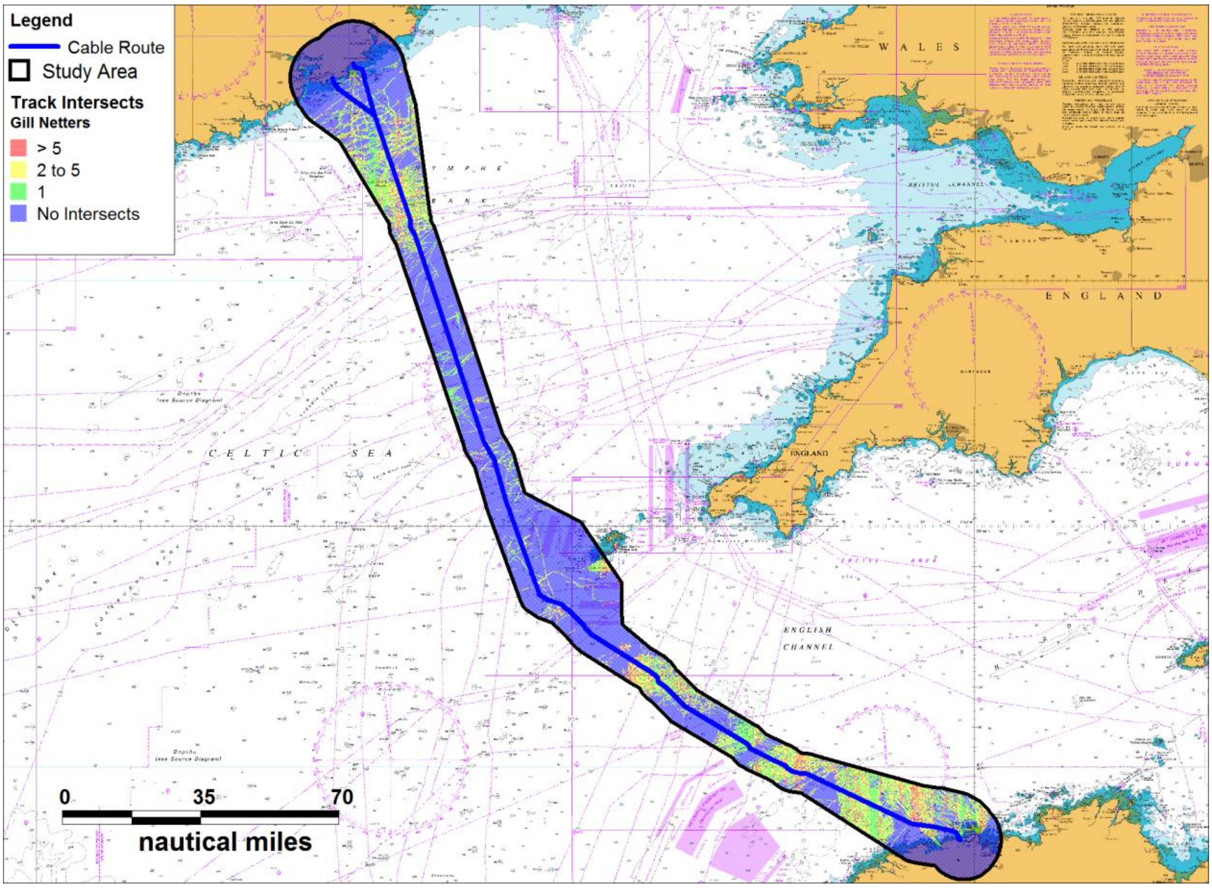

Figure 7.14 Gill Netters Actively Fishing, Density Plot

It can be seen that demersal trawlers were actively fishing within the study area along the majority of the route, while beam trawlers were mainly concentrated in the area off the coast of Ireland and to the SE of the Scilly Isles. The gill netters were seen to be actively fishing close to the Irish and French coasts. The density of gill netters was generally lower than the demersal otter and beam trawlers.

7.8 Fishing Crossing Frequency

This section assesses the frequency of crossings between fishing vessels and the proposed cable route, based on the 12 months of AIS data. A crossing is defined as a situation where a fishing vessel crosses a cable route based on consecutive points being either side of the cable route.

Anatec's Fishing Cable model was used to calculate the total number of crossings of the proposed cable route by fishing vessels.

The assessment focuses on vessels travelling at less than 6 knots, i.e. those that could potentially be actively fishing, since it is these vessels that are likely to interact with the cable.

The model calculates all crossings per KP of the cable route, i.e. if a vessel crosses a cable section multiple times, each crossing is counted within the results. Results are presented on an annual basis.

7.8.1 Fishing Crossing Results

The total number of crossings (by vessels travelling below 6 knots) for the main route was determined to be 8,062 per year, 222 of which were over the Ballinwilling landfall option. In addition, the Ballycroneen landfall option was calculated to have 399 crossings per year. The French landfall route options did not have any fishing-cable crossings.

In order to identify sections of the route considered to be high risk from fishing vessels, the distribution of the annual number of fishing-cable crossings per KP of cable is presented in Figure 7.15.

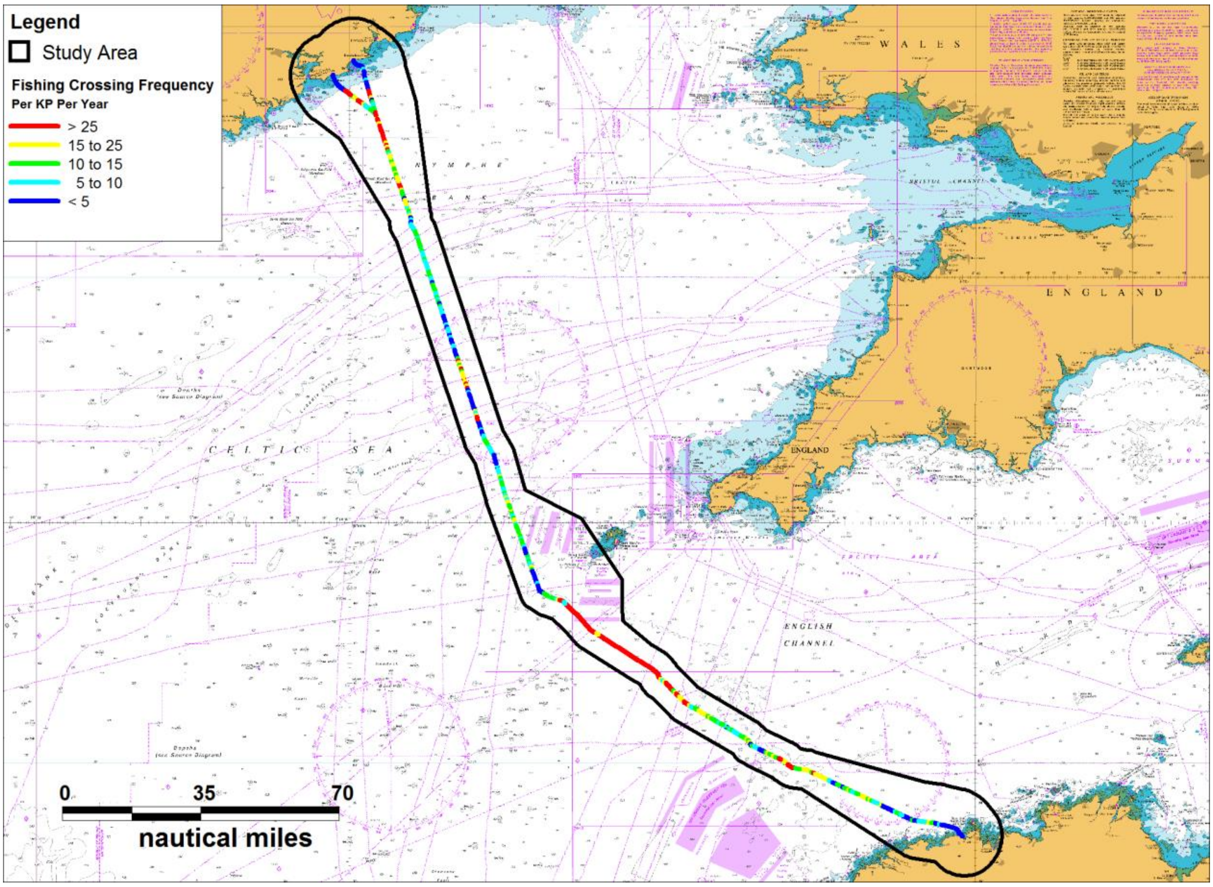

Figure 7.15 Annual Fishing Crossing Frequency Results per KP of Cable Route

It can be seen that the highest risk areas for fishing vessel crossings were the Irish landfall options, KP26 to KP44 on the main route (close to where the Ballycroneen landfall option branches off) and to the south of the Scilly Isles, between KP 265 and KP 343 on the main route.

7.8.2 Results per Gear Type

Figure 7.16 presents a plot of all fishing-cable crossings for vessels travelling at less than 6 knots, colour-coded by fishing vessel gear type.

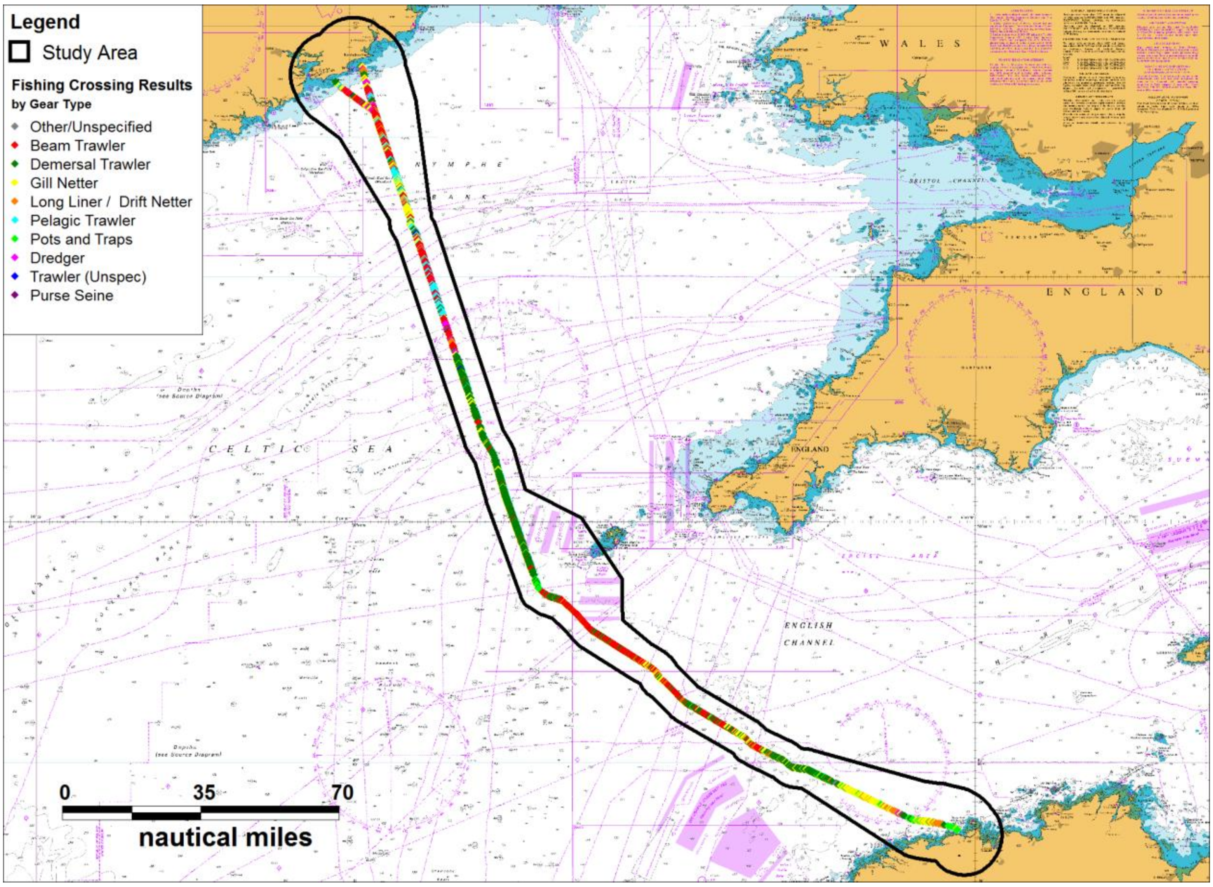

Figure 7.16 Annual Fishing Crossing Results by Gear Type

It can be seen that the majority of crossings were by beam trawlers, demersal trawlers and gill netters.

Table 7.1 and Table 7.2 present a breakdown of the annual number of crossings per gear type per 50km of the main route and for each of the Irish landfall options. There were no crossings of the French landfall options by vessels actively fishing. It is noted that, although there was activity from pair trawlers within the study area, none of these crossed the proposed routes.

Similarly for the ship crossings, the first 50km of the main route contains the Ballinwilling landfall option, although this is also presented separately in Table 7.2 for comparison with the Ballycroneen option.

Cable Route Section	Number of Fishing-Cable Crossings per Year										
	Beam Trawlers	Demersal Trawlers	Gill Netter	Long Liner / Drift Netter	Pelagic Trawler	Pots and Traps	Dredger	Trawler (Unspec)	Purse Seine	Other / Unspecified	Total
Main Route – KP 0-50	474	76	140	76	69	0	58	1	0	3	896
Main Route – KP 50-100	123	64	242	11	212	0	0	5	8	8	673
Main Route – KP 100-150	105	166	15	2	87	0	23	7	13	0	418
Main Route – KP 150-200	22	429	24	0	7	0	4	8	0	1	495
Main Route – KP 200-250	25	461	16	2	1	1	0	0	0	0	506
Main Route – KP 250-300	1603	269	9	0	0	29	0	9	2	0	1921
Main Route – KP 300-350	1083	381	213	0	0	0	1	0	0	0	1678
Main Route – KP 350-400	133	272	193	35	0	25	0	0	0	7	665

Cable Route Section	Number of Fishing-Cable Crossings per Year										
	Beam Trawlers	Demersal Trawlers	Gill Netter	Long Liner / Drift Netter	Pelagic Trawler	Pots and Traps	Dredger	Trawler (Unspec)	Purse Seine	Other / Unspecified	Total
Main Route – KP 400-450	0	250	276	29	0	86	0	0	0	7	648
Main Route – KP 450-488	0	11	67	35	0	40	9	0	0	0	162
Total	**3,568**	**2,379**	**1,195**	**189**	**376**	**181**	**95**	**30**	**23**	**26**	**8,062**

Table 7.1 Annual Fishing-Cable Crossings per 50km, Main Route, by Gear Type

Cable Route Section	Number of Fishing-Cable Crossings per Year										
	Beam Trawlers	Demersal Trawlers	Gill Netter	Long Liner / Drift Netter	Pelagic Trawler	Pots and Traps	Dredger	Trawler (Unspec)	Purse Seine	Other / Unspecified	Total
Ballinwilling Strand	117	13	23	17	6	0	45	1	0	0	222
Ballycroneen	303	19	31	10	15	0	19	1	1	0	399

Table 7.2 Annual Fishing-Cable Crossings, Irish Landfall Options, by Gear Type

It can be seen that 6,072 (75%) of the main route crossings, 342 (86%) of the Ballycroneen landfall option crossings and 176 (79%) of the Ballinwilling landfall option crossings were by demersal vessels (i.e. demersal trawlers, beam trawlers and dredgers), or by a vessel type that could include demersal vessels (i.e. trawlers or unspecified trawlers).

Within the fishing risk assessment in Section 0, the focus will be on demersal vessels actively fishing in the vicinity of the proposed cable routes.

7.9 Vessels Not Broadcasting on AIS

An analysis of fishing vessel crossings was also carried out using the 2009 VMS satellite data in Appendix B. This showed that the number of fishing vessels crossings agreed reasonably well with the AIS analysis, but there was a slightly higher number of crossings in the VMS data.

This could be due to the 5-6 year time difference between the two data sets, as it is possible that fishing locations and levels of activity have changed in this time, due to fluctuations in landings and changes in quota allocations, legislation, economic constraints and other restrictions.

However it has been observed that fishing vessels may temporarily stop broadcasting on AIS while fishing. An analysis in the North Sea investigated situations where fishing vessels had turned off AIS broadcasts while fishing. The analysis used radar survey recordings to compare the fishing vessels identified by radar with those recorded on AIS. It was estimated that, for the North Sea, approximately one third of fishing vessels were not broadcasting their position.

It is unclear whether this factor would be similar for the Celtic Interconnector study area, therefore it has not been applied in this case, but it should be noted that this could lead to under-reporting of fishing vessels in the AIS data.

It is further noted that AIS data only covers vessels greater than 15m in length and there may be some under-reporting of smaller vessels within the data. However, it is considered that, due to their size, these vessels are unlikely to cause significant damage to the proposed cable.

7.10 Fishing Gear Penetration Depths

The likelihood of damage to a buried subsea cable from fishing gear depends on the penetration depth of the equipment. This depends on the gear type and on the seabed type.

Fishing activity recorded in the study area included demersal (i.e. bottom), pelagic (midwater) and static gear types.

Demersal gear types include demersal trawlers, beam trawlers and dredgers. These vessels target both finfish and shellfish species found on or near the bottom of the sea. Demersal trawlers can be used in shallow or deep water, ranging from 25m to 1,000m (Ref viii). Beam trawlers and dredgers tend to be used in water depths up to 200m.

Pelagic gear types include pelagic trawlers and purse seines. These vessels are used principally in fishing for shoaling species, such as herring, mackerel, scad, blue whiting, sprats, etc. (Ref viii). These species may be found close to the surface, in midwater or close to the bottom and, as such, pelagic vessels may be used in a variety of water depths. Pelagic gear is not designed to interact with the seabed and any interaction may cause damage to the fishing gear. It is therefore assumed that the fishermen will ensure that the gear is operated correctly, maintaining a reasonable distance from the seabed, and, as such, pelagic gear is not expected to pose any risk to the cable.

Pair trawlers may be demersal or pelagic. Demersal pair trawlers are generally used in water depths under 200m. Pelagic pair trawlers may be used in a wide range of water depths, with larger trawlers searching for shoals far offshore, in deep water(Ref viii).

Static gear types, such as gill netters, pots and traps and long liners, are used to capture a variety of species, including finfish and shellfish. The gear may be anchored to the seabed to keep it stationary (subject to tides and currents) once in position. These gear types can be used in a wide range of water depths. Since it is assumed that fishermen will carefully choose the position of the fixed gear, taking into consideration the whereabouts of any seabed structures, and since the penetration depth of the anchors required to fix the gear to the seabed is only a few millimetres (Ref ix), these gear types are not considered to pose a risk to the proposed cable.

Of the fishing gear types active in the area, only beam trawlers, demersal trawlers, dredgers and any demersal pair trawlers are expected to interact with the route. Unspecified trawlers may be demersal or pelagic and have therefore been included within the demersal category for the fishing risk assessment in Section 0.

Table 7.3 presents researched penetration depths for vessels with different gear types and seabed types, from a number of sources. It is noted that there is a wide range of values indicated in the literature for fishing gear penetration depths. The values given in Table 7.3 are therefore indicative and subject to variations depending on the source, seabed type, vessel and gear size and other factors.

Gear Type	Penetration Depth	Reference	Substratum
Otter boards	100mm to 150mm	Arntz and Weber, 1970	Muddy fine sand
Otter boards	Up to 300mm	Jones, 1992	Soft mud
Otter trawl ticklers	Thin layer of top substrate	Bridger, 1970	Sand

Gear Type	Penetration Depth	Reference	Substratum
Beam trawls	80mm to 100mm	Margetts and Project Bridger, 1971	Muddy sand
Beam trawls	100mm to 200mm	Houghton et al., 1971	Sand
Beam trawls	0 to 27mm	Bridger, 1932	Mud
Beam trawls	Approximately 60mm	Bergman et al., 1990	Fine to medium hard sand
Beam trawls	200mm	Laane et al., 1990	Mud, sand
Beam trawls	40mm to 70mm	Laban and Lindeboom, 1991	Fine sand
Beam trawls	20mm to 300mm	Rauck, 1988	Mud, sand

Table 7.3 Penetration Depths of Fishing Gear Types

It can be seen that fishing gear tends to penetrate the seabed to only a few centimetres in most seabed types. The maximum penetration depth associated with fishing gear was seen to be 300mm.

8. Anchor Dragging Risk Assessment

8.1 Introduction

This section assesses the risk to the proposed Celtic Interconnector route from anchor dragging, that is, the probability that an anchored vessel loses its holding ground, and subsequently drags its anchor over the proposed cable route. The analysis in this section is based on the anchoring observed in the twelve months of AIS data, as presented in Section 5.

8.2 Methodology and Inputs

An overview of the Anchor Dragging model methodology, inputs, and outputs is presented in Figure 8.1.

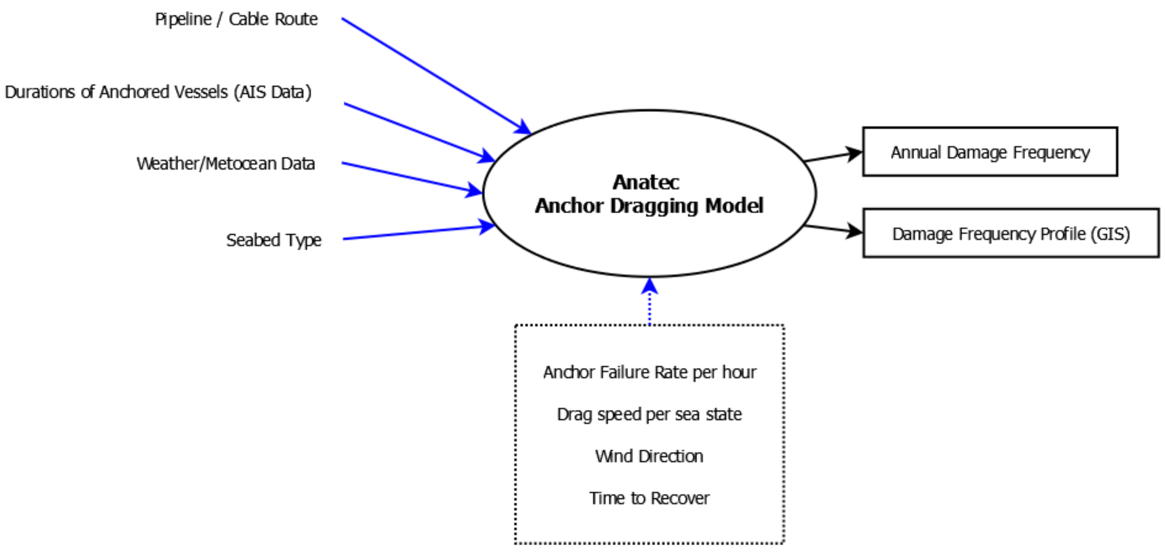

Figure 8.1 Anchor Dragging Model Methodology

The model takes as input a durations table, which consists of a grid containing durations of all vessels at anchor within the study area (presented in Section 6.2). The (hourly) probability that a vessel in a grid cell will drag anchor is given by the following formula:

$$\text{Probability of dragging anchor} = \frac{\text{Anchor Failure Rate}}{\text{Holding Factor}}$$

where the Anchor Failure Rate depends on the wind speed (calm, moderate or severe), and the Holding Factor depends on the sea bed type and mobility, e.g., sand, clay, gravel, etc.

The Anchor Failure Rate is defined as probability that an anchor is expected to lose its holding ground and subsequently drag per hour at anchor in a seabed of average holding ground (e.g. medium dense sand). The Holding Factor is a factor applied to each seabed type, defined by Anatec, which weights each type within the model according to their ability to hold an anchor (see Table 8.1).

The probability of dragging anchor is multiplied by the total accumulated hours that vessels are at anchor in each durations grid cell, for each vessel type and size, in order to get the frequency of dragged anchor events for each grid cell in the durations table.

The probability that a vessel drags anchor towards the cable depends on the direction of the cable from the vessel and the probability that the wind is in that direction.

Once the anchor starts to drag, it is likely that the vessel's crew will recognise this, either by changes in the vessel motion or from an alarm (if a watch zone has been set). The Master may be called and recovery action taken such as paying out more of the anchor chain, deploying the 2nd anchor and/or starting the vessel's engine(s) to allow the vessel to manoeuvre away from any danger. The probability that the action is not taken within the time it takes to reach the cable route is given by the following formula.

$$Probability\ of\ Not\ Recovering = exp\left(-\left(\frac{\text{Distance to Cable}}{\text{Drift Speed}}\right)/(\text{Time to Recover})\right)$$

The Drift Speed varies by wind speed (calm, moderate or severe), and is taken as follows:

- Calm = 1 knot
- Moderate = 1.5 knots
- Severe = 3 knots

The mean time to recover was taken as 15 minutes, based on marine experience and advice from master mariners.

The probability of not recovering is presented graphically in Figure 8.2 for each sea state.

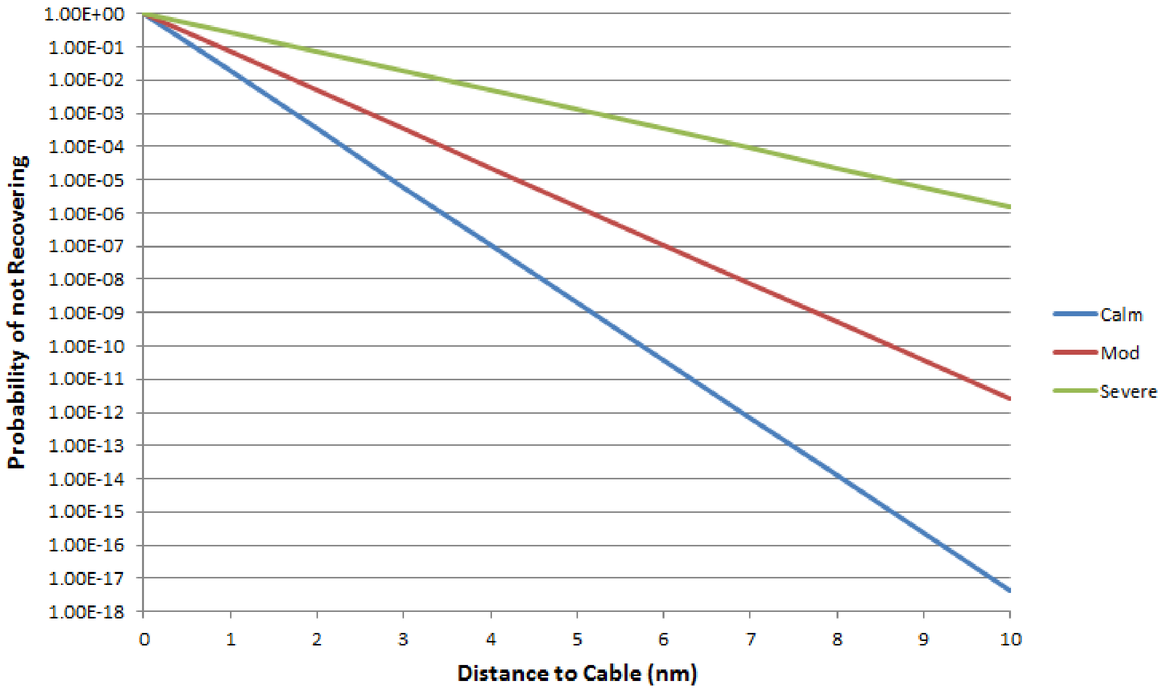

Figure 8.2 Probability of not Recovering

It can be seen that, if the vessel dragging anchor is 1nm from the cable, the probability that it does not recover before reaching the cable varies from 1 in 4 for severe sea states to 1 in 55 for calm seas. In contrast, at a distance of 10nm, the Probability of Not Recovering is approximately 1 in 600,000 for severe sea state, and becomes negligible for calm seas, i.e. there is a very high likelihood that the vessel can recover from a dragged anchor incident before it has drifted 10nm.

The model determines the frequency of anchor drag over the cable by multiplying the probability of dragging anchor with the probability that the anchor drags towards the cable, followed by the probability that the vessel does not recover in time.

The frequency that a vessel in a grid cell drags anchor onto a section of cable is therefore calculated by:

$$\begin{aligned} &\mathit{Anchor\ Drag\ Frequency} \\ &\quad = \sum_{\mathit{grid\ cell}} \sum_{\mathit{vessel\ type}} \sum_{\mathit{vessel\ size}} (\mathit{Anchor\ Duration\ in\ grid\ cell} \\ &\quad \times \mathit{Probability\ of\ Anchor\ Drag\ per\ Hour} \\ &\quad \times \mathit{Probability\ of\ Wind\ in\ Direction\ of\ Cable\ Section} \\ &\quad \times \mathit{Probability\ of\ Not\ Recovering}) \end{aligned}$$

where

$$\text{Probability of Anchor Drag per Hour} = \sum_{sea\ state} \frac{\text{Anchor Failure Rate per sea state}}{\text{Holding Factor}} \times \text{Sea State Probability}$$

The model inputs are described below.

8.2.1 Durations Grid

The AIS tracks from anchored vessels (see Section 6) were used to determine the total number of hours that vessels spent at anchor within each 250m x 250m cell of a grid covering the study area, broken down by vessel type and size. A total of 5,119 hours were recorded during the twelve months, with the vast majority (91%) occurring in or near the outer Cork anchorage.

It is noted that the above total excludes cells in which land shields the anchored ships in the cell from the proposed cable route, should the vessel drag anchor. However, where there was only partial shielding, the cells have been included, which is conservative. It was confirmed this did not significantly affect the results.

Each grid cell with non-zero anchor durations was then assigned a Holding Factor based on the holding power of the seabed type of that cell. Seabed types were identified from the Pilot Books where possible, with Admiralty Charts used as a secondary source. Seabed types considered to have better holding ground were assigned greater Holding Factor.

The Holding Factors used are presented in Table 8.1. Holding Factors have been assigned by Anatec based on information from mariners and experience from previously undertaken anchoring assessments.

Seabed Type	Holding Factor
Mud	1.2
Sand and Mud	1.1
Sand	1
Mud and Gravel	1
Poor Sand	0.9
Gravel	0.9
Broken Shells	0.8
Rock	0.7

Table 8.1 Holding Factor

8.2.2 Weather and Vessel Characteristics

Anchor Failure Rate of ships has not been widely researched in general. It is known from experience to be a rare occurrence, and most common in storm conditions. The following describes the available information:

- Maritime and Coastguard Agency (MCA) commissioned research assigned an AFR of 6.5×10^{-5} per system hour for Inland Waterways and Coastal Waters (Ref. x).
- A report by a Canadian Naval Architect, Robert Allan Ltd (Ref. xi) considered the probability of vessels dragging anchor from various anchorages in British Columbia and assigned AFR values ranging from 0.01 (for smaller vessels) to 0.001 (for larger vessels with possibility of tug assistance). This is the rate that an anchor drags in severe weather per anchored event and each event was assumed to last a day. Hence the hourly AFR would be between 4.2×10^{-4} and 4.2×10^{-5}.
- The Marine Accident Investigation Branch (MAIB) (Ref xii) reported 20 accidents involving dragging anchor then grounding between 1992 and 2007. This corresponds to 1.3 events per year. If it is assumed that grounding only results in 1% of incidents, the AFR would range from approximately 5×10^{-5} to 1×10^{-4} per hour at anchor based on internal research by Anatec on the estimated duration of anchorings in the UK per year.

All sources are in reasonable agreement therefore the MCA value of 6.5×10^{-5} per hour was used in the model i.e. the model estimates that if a vessel was continuously anchored in the area for 2 years then it would drag anchor once during this time.

The failure rate was varied according to weather to make it more likely in severe conditions and less likely in calm conditions, which is aligned with marine experience. It was assumed that the Anchor Failure Rate would be an order of magnitude lower than the average value for calm sea state and an order of magnitude higher for severe sea state. The moderate sea state anchor failure rate was then weighted by sea state probability to ensure that the average anchor failure rate of 6.5×10^{-5} was maintained. Anatec's in-house metocean data was used to estimate the probability of calm, moderate and severe weather for the area. These probabilities varied along the proposed cable route. The average probabilities are provided in Table 8.2.

The anchor failure rates used within the model for each weather state are presented in Table 8.2.

Sea State	Sea State Probability	Anchor Failure Rate (Hourly)
Calm	0.15	6.5×10^{-6}
Moderate	0.80	3.1×10^{-5}
Severe	0.05	6.5×10^{-4}

Table 8.2 Weather States and Anchor Failure Rates

The Metocean data was also used to estimate the probabilities of wind direction.

8.3 Results

It was estimated that a vessel would drag anchor over the cable route once every 7,400 years, which corresponds to a frequency of 5.4×10^{-3} over the expected 40 year operational span of the proposed cable. It is noted that this includes the Ballinwilling Strand landfall option, but does not include a French landfall (see Section 2.1).

The anchor dragging frequencies estimated for each of the landfall options are presented in Table 8.3.

	Route	Frequency Per Year	Return Period
Ireland	Ballinwilling Strand	1.4×10^{-4}	7,400
	Ballycroneen	5.2×10^{-6}	193,100
France	Kerradenec	1.5×10^{-8}	67,187,300
	Port Neuf	1.2×10^{-8}	85,766,200

Table 8.3 Annual Anchor Dragging Frequency - Landfalls

The Ballinwilling Strand was estimated to experience an anchor dragging incident once every 7,400 years, which corresponds to a frequency of 5.4×10^{-3} over the expected 40 year operational span of the proposed cable. It is noted that the risk to this landfall corresponds to 99% of the total main route risk. An anchor dragging incident was estimated to occur over the Ballycroneen Irish landfall option once every 193,100 years, which corresponded to a frequency of 2.1×10^{-4} over the expected 40 year operational lifespan of the proposed cable.

The anchor dragging return period for the Kerradenec landfall option was estimated to be 67,000,000 years. The Port Neuf return period was 86,000,000 years. This corresponds to frequencies of 6.0×10^{-7} and 4.7×10^{-7}, respectively, over the expected 40 year operational lifetime of the proposed cable.

The vast majority of the anchor dragging risk was to the Irish landfall options. As no significant anchoring was recorded in areas that could reach the cable outwith Irish waters, the anchor dragging risk to the cable is very low in French and UK waters.

The results for the Irish landfalls are presented graphically in Figure 8.3. The tracks from anchored vessels have been included in the figure for reference.

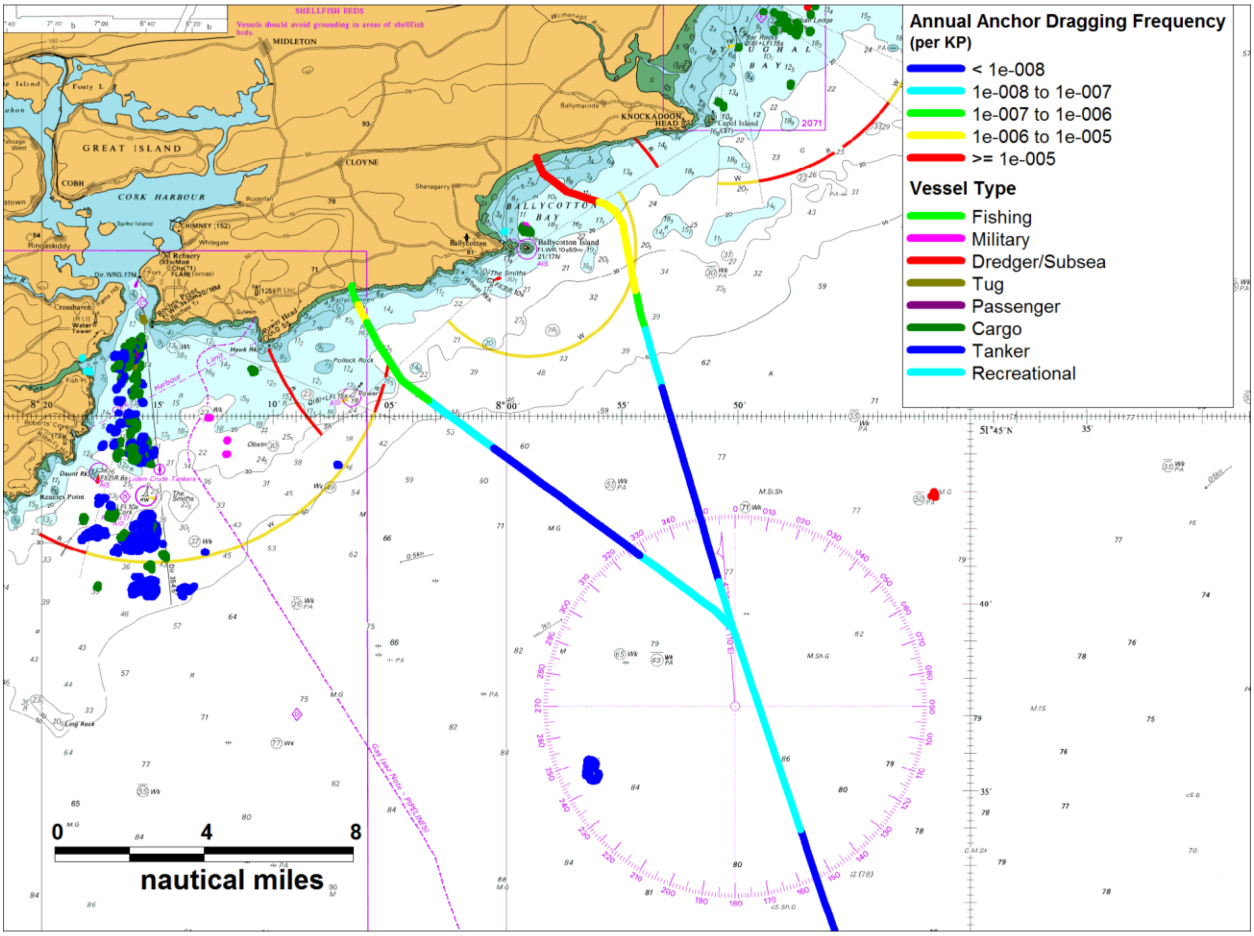

Figure 8.3 Annual Anchor Dragging – Irish Landfalls

The highest risk area was KP 1 to 4 of the main route, resulting from the vessels anchored in Ballycotton Bay (vessels less than 5,000 DWT). The vessels anchored east of the Cork outer anchorage were the most significant contributors to the Ballycroneen landfall option risk, particularly the cargo vessel and tanker anchored shown in Figure 8.3. It was noted that the vessels anchoring in or south of the anchorage (including cargo vessels and tankers greater than 40,000 DWT) contributed to a lesser extent.

Approximately 51% of the anchor dragging risk was from vessels less than 1,500 DWT, and 48% from vessels between 1,500 and 5,000 DWT. This was largely due to the anchoring in Ballycotton Bay. The annual anchor dragging risk for the main route split by 50km sections is presented in Table 8.4 divided by vessel size. The results for the landfall options split by size are presented in Table 8.5. Where the total return period of a section was less than once every billion years the risk has been labelled as negligible. The size categories are presented in Table 5.2.

Main Route Section	Anchor Dragging Risk					
	Size 1	**Size 2**	**Size 3**	**Size 4**	**Size 5**	**Size 6**
KP 0-50	6.92E-05	6.54E-05	1.38E-09	Negligible	Negligible	6.17E-07
KP 50-100	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
KP 100-150	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
KP 150-200	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
KP 200-250	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
KP 250-300	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
KP 300-350	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
KP 350-400	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
KP 400-450	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
KP 450-487	8.07E-08	4.46E-08	Negligible	Negligible	Negligible	Negligible
Total	6.93E-05	6.54E-05	1.38E-09	Negligible	Negligible	6.17E-07

Table 8.4 Annual Anchor Dragging Frequency by Size – Main Route

Landfalls	Anchor Dragging Risk					
	Size 1	**Size 2**	**Size 3**	**Size 4**	**Size 5**	**Size 6**
Ballinwilling Strand	6.92E-05	6.54E-05	1.38E-09	Negligible	Negligible	4.97E-08
Ballycroneen	1.10E-07	3.39E-07	3.94E-06	4.13E-07	1.23E-07	2.50E-07
Port Neuf	1.17E-08	Negligible	Negligible	Negligible	Negligible	Negligible
Kerradenec	1.49E-08	Negligible	Negligible	Negligible	Negligible	Negligible

Table 8.5 Annual Anchor Dragging Frequency by Size - Landfalls

9. Emergency Anchoring Risk Assessment

9.1 Introduction

This section investigates the potential risk to the proposed cable from vessels anchoring in an emergency.

Anatec's Emergency Anchoring model estimates the probability that a vessel sailing over a cable route suffers engine failure and subsequently drops anchor onto the cable. Calculations are performed within a Geographical Information System (GIS) with relevant shipping and operational data (e.g. vessel durations, water depth, distance to shore) as input. The emergency anchoring analysis has been based on the twelve months of AIS data presented in Section 5.

9.2 Methodology and Inputs

The Emergency Anchoring model combines the durations of vessels travelling near the cable route with the probability that a vessel suffers engine failure and the probability that the vessel drops anchor in an emergency (based on water depth and distance from the shore) to calculate the frequency of anchor drop due to emergency anchoring.

An overview of the emergency anchoring methodology, inputs and outputs is presented in Figure 9.1.

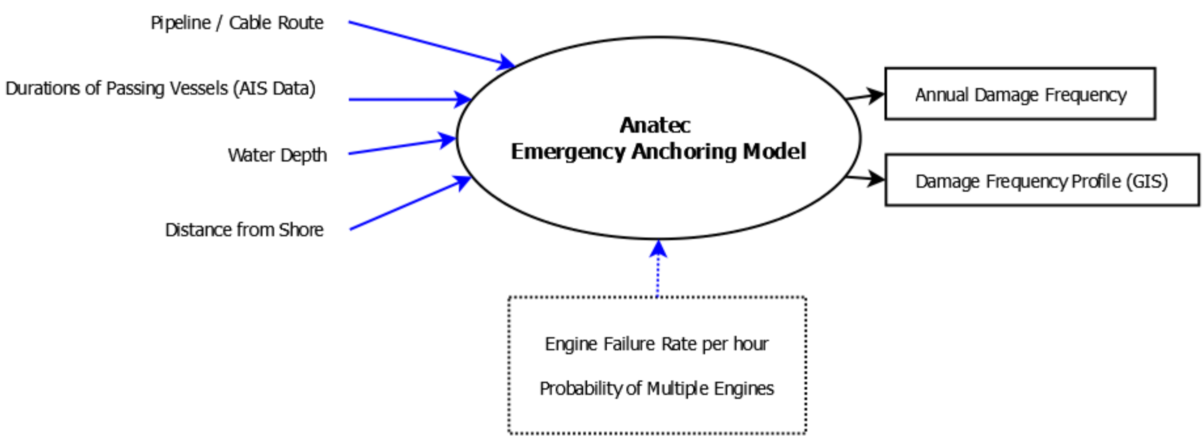

Figure 9.1 Emergency Anchoring Methodology

The formula for calculating the emergency anchoring probability is provided below:

$$Emergency\ Anchoring\ Frequency = \sum_{grid\ cell} \left(Water\ Depth\ Factor \times Distance\ Factor \times \sum_{vessel\ type} \sum_{vessel\ size} (Durations\ in\ grid\ cell \times Engine\ Failure\ Rate \times Twin\ engine\ probability) \right)$$

The input tables used by the Emergency Anchoring Model are described below.

9.2.1 Exposure Grid

Vessels that passed within 100m of the proposed cable route were considered to have the potential to cause damage to the cable by anchoring in an emergency. The 100m buffer is chosen to account for the possibility that:

- There may be slight inaccuracies in the vessel's Global Positioning System (GPS)
- The location of the anchor on the vessel may be some distance from the location of the GPS
- Following anchor drop, the anchor may drag a short distance before settling into the seabed

It is noted that, in some cases, a dropped anchor from a vessel transmitting its location outside the 100m buffer may still interact with the cable (e.g. if the distance between the GPS and anchor drop location is longer than 100m or if the anchor drags farther than 100m and towards the cable).

However, in the majority of cases, the 100m buffer is considered to be conservative, as it assumes that all vessels dropping an anchor within 100m could interact with the cable whereas, in reality, the location of the anchor drop could be far from the cable or the anchor could drag away from the cable before settling. Furthermore, the approximate diameter of the proposed cable is 300mm, indicating that the seabed area covered by the cable is 0.15% of the total area of the 100m buffer. In addition, information on dimensions for various anchor types (Ref v) shows that the maximum length of the largest anchors (65,000 kg) was approximately 10m, with the majority of anchor dimensions significantly smaller than this. This suggests that an anchor dropped within the 100m buffer is more likely to impact an area of seabed that does not contain the cable than the cable itself.

The AIS data were used to populate a 250m x 250m grid encompassing the proposed route, plus 100m buffer, with vessel durations by type and size. The grid was then cropped to the 100m buffer. This is illustrated in Figure 9.2, which shows an example of the 250m x 250m cells used prior to, and post cropping. When the grid cell is cropped to the buffer, the durations are factored according to the proportion of area of the cropped cell compared to the area of the full 250m by 250m cell.

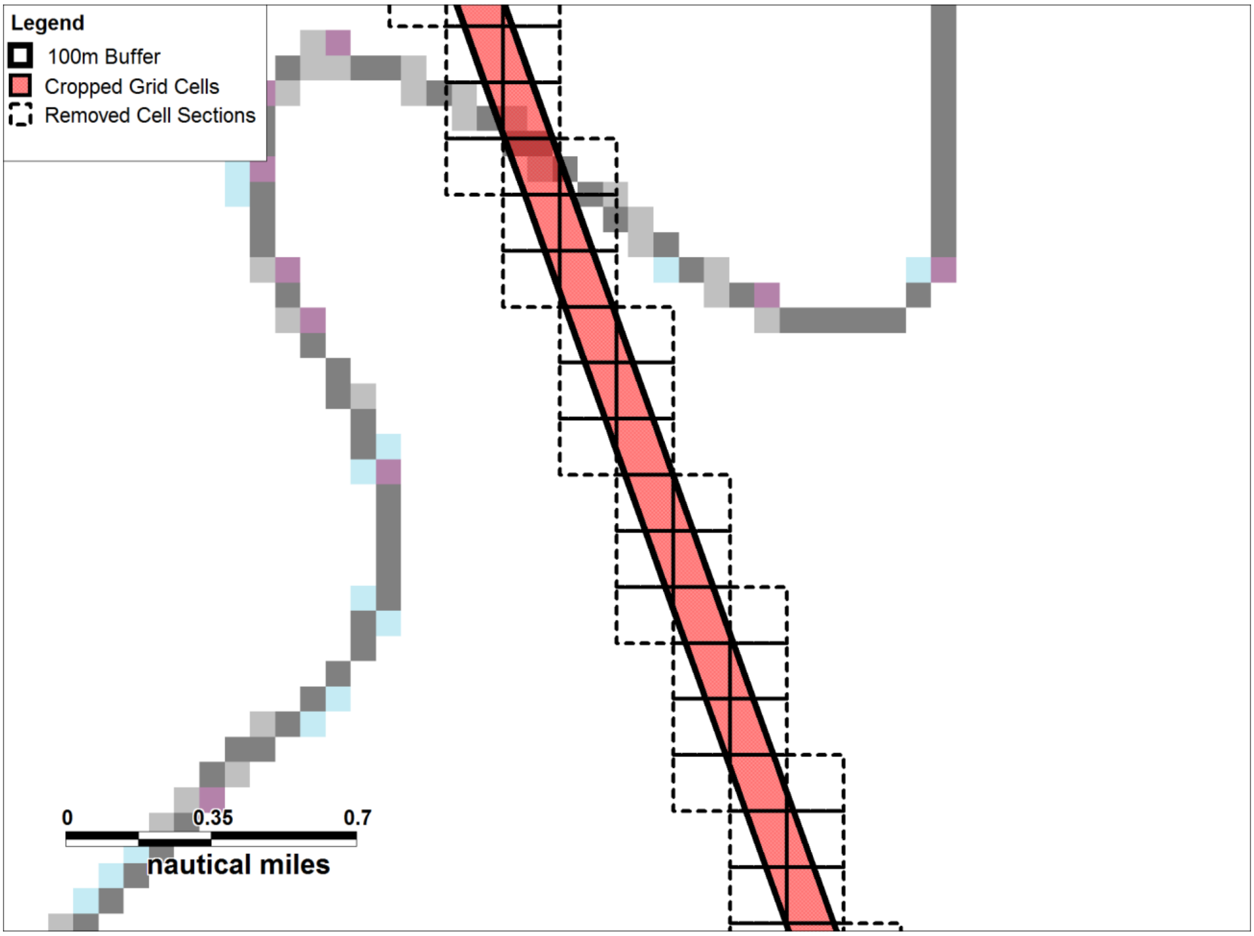

Figure 9.2 Cropped Grid Illustration

The total durations of vessels within 100m of the proposed cable route during the twelve month study period was estimated to be 1,432 hours.

The durations were multiplied with the probability of engine failure per hour, taking into account the proportion of vessels with single and multiple engines, determined according to the AIS data.

9.2.2 Engine Failure Rate

The engine breakdown probability is assumed to be 2×10^{-5} per hour. This generic failure rate is commonly cited in literature, including maritime risk studies performed on behalf of the UK Government (Ref. xiii) and US Government (Ref. xiv). The source(s) of the figure is unknown but as shipping is an international industry with standards developed and regulated through the IMO, it is assumed to be applicable to the shipping within the study area. To add further sensitivity, the failure rate has been combined with the likelihood that a vessel has more than one engine, based on vessel type and size, to give the probability that a vessel breaks down. The number of engines was assessed using vessel details for traffic travelling within 100m of the proposed cable route, identified in the AIS data.

The frequency of emergency anchoring was then estimated by combining this information with the probability that the vessel drops anchor, based on the vessel type and size and the water depth and distance from the shore. This takes into account that, on drifting, the Master will normally take some time (unless there is an immediate hazard such as risk of grounding) to assess the situation, including the location of any subsea structures identified on charts, and will only drop anchor if unavoidable or if unaware of the presence of a cable.

9.2.3 Water Depth

The probability that a vessel drops its anchor depends on the water depth, with the likelihood of dropping anchor in deeper waters lower than in shallower waters due to limitations on the length of anchor chain. The probability that a vessel anchors in a particular water depth, depending on vessel size, is given in Table 9.1.

DWT	Water Depth Factor			
	< 20m	20 – 50m	50 – 100m	> 100m
0 – 1,500	1	0.5	0.1	0.01
1,500 – 5,000	1	0.6	0.25	0.05
5,000 – 15,000	1	0.75	0.4	0.1
15,000 – 40,000	1	0.9	0.5	0.25
40,000 – 60,000	1	1	0.67	0.33

Table 9.1 Water Depth Factors

9.2.4 Distance from Shore

A vessel is more likely to drop anchor in an emergency if it is closer to shore, to prevent damage from grounding. The probability of anchoring for each distance range is given in Table 9.2.

Distance from Shore	Distance Factor
0 – 2 nm	0.5
2 – 5 nm	0.25
5 – 10 nm	0.1
> 10 nm	0.05

Table 9.2 Distance Factor

9.3 Results

It was estimated that a vessel would drop anchor in an emergency over the main route (inclusive of Ballinwilling landfall) once every 3,600 years. Over an estimated 40 year operational life of the proposed cable, this corresponds to a frequency of 1.1 x 10^{-2}. The emergency anchoring risk was greater than that from anchor dragging.

The results of the Emergency Anchoring analysis for the landfall options are presented in Table 9.3.

Country	Route	Frequency Per Year	Return Period
Ireland	Ballinwilling Strand	4.6 x 10^{-5}	21,700
	Ballycroneen	6.7 x 10^{-5}	14,900
France	Kerradenec	1.6 x 10^{-6}	646,100
	Port Neuf	3.5 x 10^{-7}	2,872,800

Table 9.3 Annual Emergency Anchoring Results Summary - Landfalls

The Ballycroneen landfall option emergency anchoring return period was approximately 15,000 years. Over the 40 year life of the proposed cable, this corresponds to a frequency of 2.7 x 10^{-3}. The emergency anchoring return period of the Ballinwilling Strand landfall option was estimated to be 22,000 years, corresponding to a frequency of 1.8 x 10^{-3} over the 40 year operational life.

The Kerradenec and Port Neuf French landfall options had return periods of approximately 650,000 and 2,900,000 respectively, corresponding to frequencies of 6.2 x 10^{-5} and 1.4 x 10^{-5} over the lifespan of the proposed cable.

An overview of the results is presented in Figure 9.3.

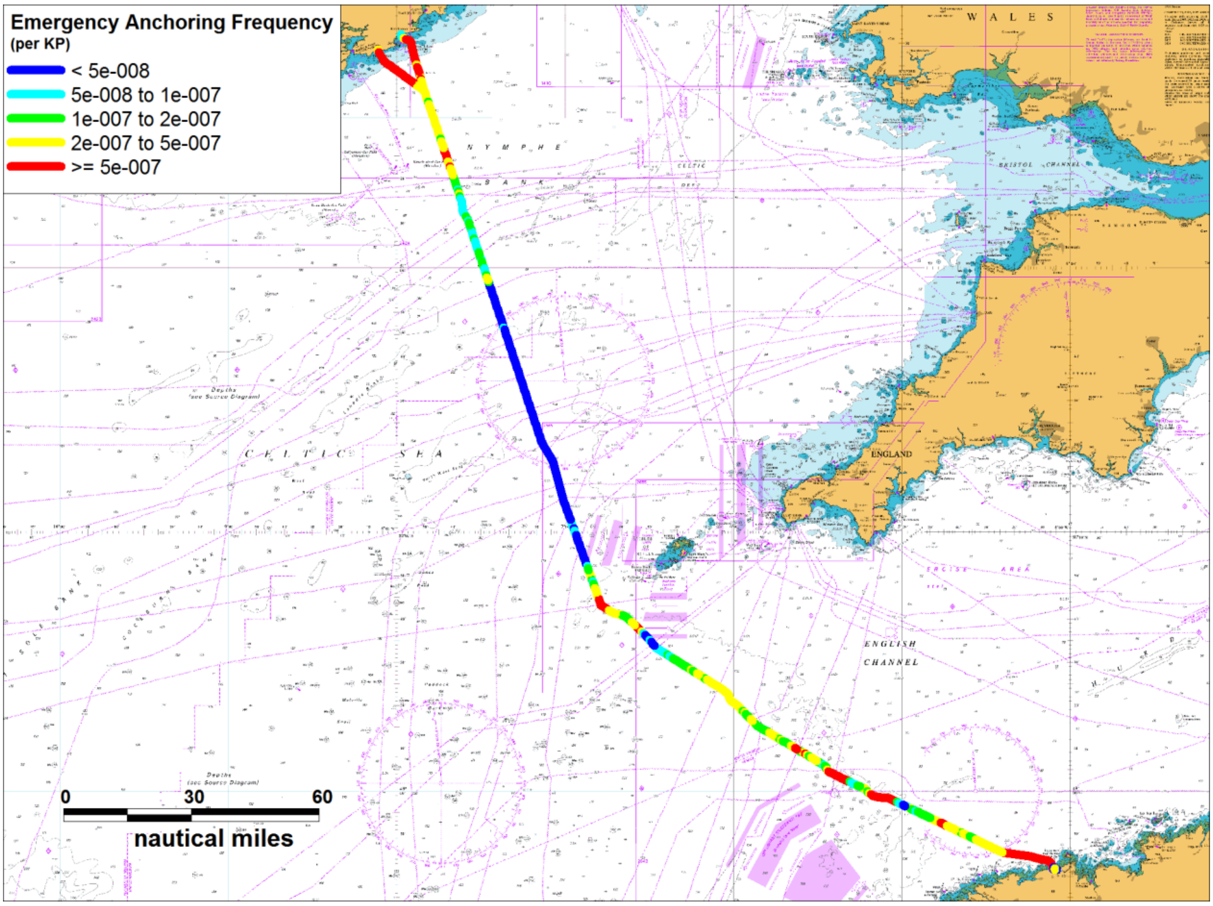

Figure 9.3 Annual Emergency Anchoring Frequency – General Overview

The following significant areas of emergency anchoring risk were identified:

- Irish Landfalls, due to the high vessel durations from coastal traffic routes combined with the proximity to danger (Irish coast) and, to a lesser extent, water depths;
- Intersection of the proposed cable with commercial traffic associated with Cork, between KPs 52 and 57, largely due to high vessel durations;
- Intersection of the proposed cable with northbound traffic and westbound traffic southwest of the Isles of Scilly, KPs 252 and 259, largely due to vessel durations;
- Entrance of the Eastbound lane of the Southern Isles of Scilly TSS, KPs 273 to 276 due to high commercial vessel durations;
- Both westbound (KPs 379 to 388) and eastbound (KPs 400 to 411) routes associated with the English Channel TSS due to the high commercial vessel durations;
- KP462 onwards, due to vessel durations, proximity to danger (French coast), and shallower water depths.

The emergency anchoring risk by size for per 50km of the main route is summarised in Table 9.4, and the result by size for each landfall option are presented in Table 9.5. KP0-50 is inclusive of the Ballinwilling Strand landfall option. The size categories used are presented in Table 5.2.

Main Route Section	Emergency Anchoring Risk					
	Size 1	Size 2	Size 3	Size 4	Size 5	Size 6
KP 0-50	3.44E-05	6.80E-06	7.18E-06	1.32E-06	1.50E-06	7.18E-07
KP 50-100	4.24E-06	1.55E-06	3.18E-06	1.18E-06	9.18E-07	3.87E-07
KP 100-150	8.91E-07	8.65E-08	1.22E-07	1.46E-07	5.87E-07	7.07E-08
KP 150-200	3.23E-07	4.53E-08	3.65E-08	8.26E-08	1.83E-07	2.39E-07
KP 200-250	5.51E-07	5.42E-07	6.08E-07	7.81E-07	6.36E-07	7.79E-07
KP 250-300	1.31E-06	1.08E-06	1.97E-06	6.08E-06	9.12E-06	2.85E-06
KP 300-350	8.48E-07	7.02E-07	1.40E-06	3.28E-06	4.53E-06	1.31E-06
KP 350-400	1.01E-06	2.53E-06	6.58E-06	1.08E-05	1.22E-05	7.28E-06
KP 400-450	6.47E-06	4.03E-06	7.17E-06	1.06E-05	1.18E-05	7.63E-06
KP 450-487	8.13E-05	9.08E-07	3.88E-07	Negligible	1.33E-07	Negligible
Total	**1.31E-04**	**1.83E-05**	**2.86E-05**	**3.42E-05**	**4.17E-05**	**2.13E-05**

Table 9.4 Annual Emergency Anchoring Frequency by Size – Main Route

Landfalls	Emergency Anchoring Risk					
	Size 1	Size 2	Size 3	Size 4	Size 5	Size 6
Ballinwilling Strand	3.12E-05	5.38E-06	6.88E-06	1.09E-06	1.02E-06	4.89E-07
Ballycroneen	4.08E-05	9.89E-06	1.11E-05	2.46E-06	2.05E-06	8.09E-07
Port Neuf	3.48E-07	Negligible	Negligible	Negligible	Negligible	Negligible
Kerradenec	1.55E-06	Negligible	Negligible	Negligible	Negligible	Negligible

Table 9.5 Annual Emergency Anchoring Frequency by Size - Landfalls

Overall, approximately half the emergency anchoring risk was from vessels less than 1,500 DWT. A total of 23% of the risk was from vessels larger than 40,000 DWT.

10. Foundering Risk Assessment

10.1 Introduction

A foundering event occurs when a vessel fails structurally and sinks. This type of incident has the potential to damage a subsea cable if a vessel sinks over its route. The Foundering feature of Anatec's COLLRISK model was run to assess the risk of a vessel foundering along the proposed cable route. This section uses the twelve months of AIS presented in Section 5 to assess the risk to the proposed cable from foundering.

10.2 Methodology and Inputs

The model uses the durations of vessels by type and size, and the probability of severe weather conditions to estimate the likelihood that a vessel will founder over the proposed cable route.

Anatec's Foundering model has been calibrated based on historical shipping accident data in the UK and Western Europe (49 - 62 North, 12 West - 4 East) over the 10-year period 1989 to 1998 (inclusive) as recorded in the Lloyd's Register Casualty Database. (Ref xiii). Incidents that occurred to vessels at sea have been included, whilst incidents that occurred within harbours, canals, rivers and lakes have been excluded.

The data was used to estimate the probability that vessels of differing type and size categories would founder in different weather states. The results of this analysis were then used to weight the model accordingly for each vessel type and size.

The Foundering model uses as input the grid of vessel durations along the proposed cable route by vessel type and size that was used in the emergency anchoring model, and weather data for the area, detailing the probability of different weather states. The output is a grid where each cell contains the frequency that a vessel will founder within its boundary.

As with emergency anchoring, (Section 9), vessel durations covered a 100m buffer of the proposed cable route. Total annual vessel durations within the 100m buffer of the entire proposed cable route were 1,432 hours.

10.3 Results

It was estimated that a vessel would founder over the main route (including Ballinwilling Strand Irish landfall) once every 400 years. Over the 40 year lifespan of the proposed cable this resulted in a frequency of 0.1.

The foundering risk was observed to be higher than that of anchor dragging and emergency anchoring. This is largely due to the proportion of small vessels sailing near the cable, which historically present a higher risk of foundering, especially in heavy seas. Small vessels, in particular fishing vessels, also contributed higher vessel durations than large vessels, which tended to steam quickly through the study area. In addition, the water depths along the majority of the proposed cable route are fairly high, indicating that vessels (particularly small vessels) are less likely to anchor in an emergency, which reduces this risk.

The results of the foundering analysis for each landfall option are presented in Table 10.1.

Country	Route	Frequency Per Year	Return Period
Ireland	Ballinwilling Strand	8.0×10^{-5}	12,600
	Ballycroneen	1.3×10^{-4}	7,800
France	Kerradenec	4.4×10^{-7}	2,279,300
	Port Neuf	9.5×10^{-8}	10,570,200

Table 10.1 Annual Foundering Results - Landfalls

The Ballycroneen landfall foundering frequency was estimated to be once every 7,800 years. This corresponds to a frequency of 5.2×10^{-3} over the lifespan of the proposed cable. A foundering incident was estimated to occur once every 12,600 years over the Ballinwilling Strand landfall option, which corresponds to a frequency of 3.2×10^{-3} over the proposed cable operational life.

The Kerradenec and Port Neuf French landfall options had return periods of approximately 2,300,000 and 10,600,000 years respectively, corresponding to frequencies of 1.8×10^{-5} and 3.8×10^{-6} over the lifespan of the proposed cable.

An overview of the foundering results is presented in Figure 10.1.

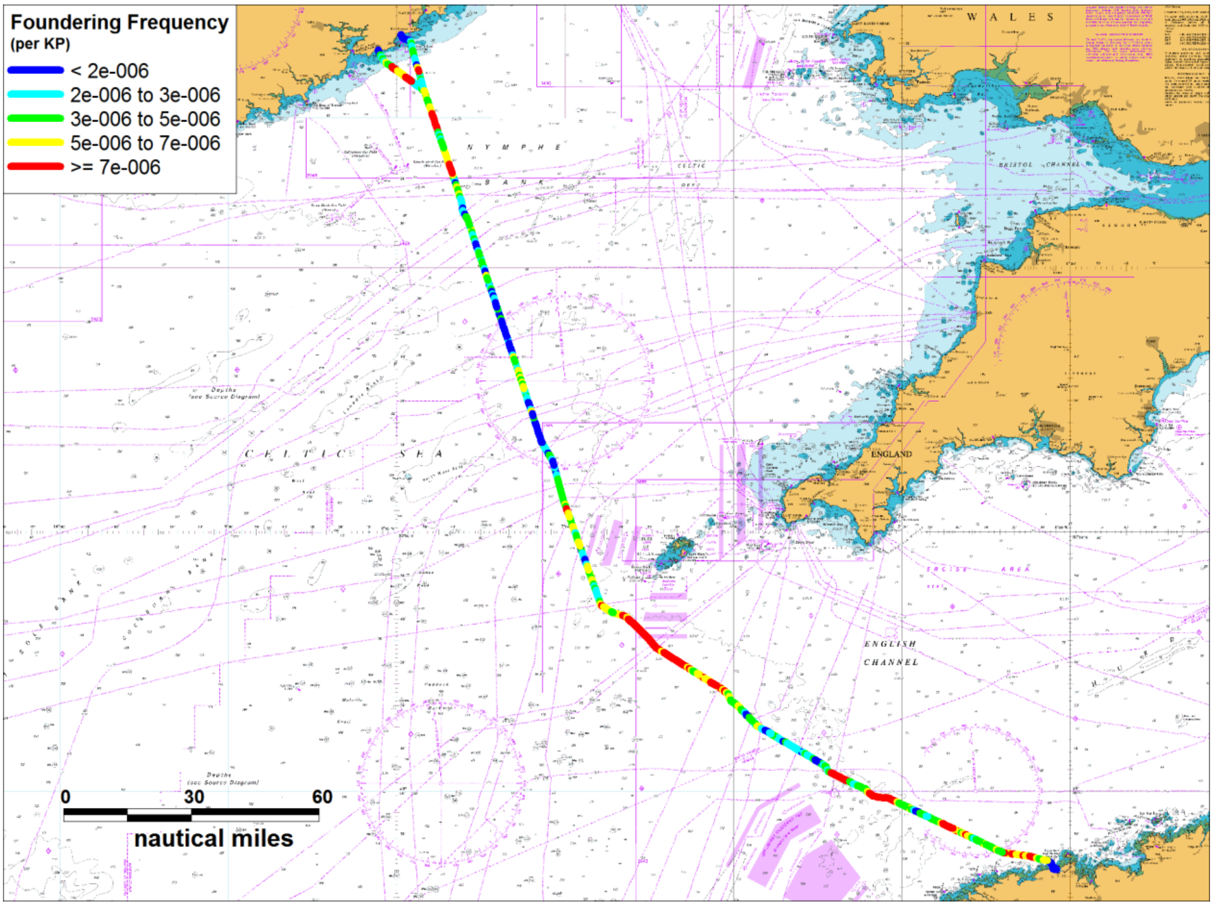

Figure 10.1 Foundering Frequency – General Overview

A summary of the foundering risk by size for the main route is presented in Table 10.2. The results for each landfall option are presented split by size in Table 10.3. Size categories are presented in Table 5.2.

Main Route Sections	Foundering Risk					
	Size 1	Size 2	Size 3	Size 4	Size 5	Size 6
KP 0-50	2.00E-04	1.31E-05	1.36E-06	2.06E-06	9.53E-07	7.63E-08
KP 50-100	1.96E-04	6.64E-06	4.79E-06	3.47E-06	8.57E-07	1.48E-07
KP 100-150	1.33E-04	2.09E-06	6.57E-07	3.49E-07	5.75E-07	7.33E-08
KP 150-200	1.50E-04	1.30E-06	1.93E-07	5.28E-07	3.94E-07	1.39E-07
KP 200-250	1.94E-04	1.04E-05	2.43E-06	4.34E-06	1.21E-06	4.18E-07
KP 250-300	4.81E-04	1.08E-05	5.42E-06	3.13E-05	1.66E-05	4.16E-06
KP 300-350	2.32E-04	1.12E-05	4.93E-06	1.21E-05	5.12E-06	1.50E-06
KP 350-400	1.38E-04	3.71E-05	2.06E-05	3.97E-05	1.67E-05	7.23E-06

Main Route Sections	Foundering Risk					
	Size 1	**Size 2**	**Size 3**	**Size 4**	**Size 5**	**Size 6**
KP 400-450	2.36E-04	3.98E-05	2.04E-05	3.90E-05	1.66E-05	8.10E-06
KP 450-487	1.80E-04	1.48E-06	1.75E-08	Negligible	4.17E-08	Negligible
Total	**2.14E-03**	**1.34E-04**	**6.08E-05**	**1.33E-04**	**5.90E-05**	**2.18E-05**

Table 10.2 Foundering Frequency by Size – Main Route

Landfalls	Foundering Risk					
	Size 1	**Size 2**	**Size 3**	**Size 4**	**Size 5**	**Size 6**
Ballinwilling Strand	7.25E-05	3.60E-06	1.09E-06	1.61E-06	6.31E-07	4.34E-08
Ballycroneen	1.20E-04	4.50E-06	1.25E-06	2.31E-06	7.44E-07	5.84E-08
Port Neuf	9.46E-08	Negligible	Negligible	Negligible	Negligible	Negligible
Kerradenec	4.39E-07	Negligible	Negligible	Negligible	Negligible	Negligible

Table 10.3 Foundering Frequency by Size – Landfalls

The majority of the foundering risk was from vessels less than 1,500 DWT, with an estimated frequency of 2.14 x 10^{-3} on the main route. This corresponds to approximately 84% of the total. It is noted that approximately three quarters of the total risk was from fishing vessels, as fishing vessel activity was significant within the study area (approximately one third of input durations), and small fishing vessels are assumed to be at a high risk of foundering within the model.

10.4 Sensitivity Analysis – Buffer Size

The foundering model methodology assumes that any vessel that founders within 100m of the proposed cable could cause damage to it. This is a conservative assumption for small vessels, but may not be conservative for very large vessels.

A sensitivity analysis on the buffer size was therefore carried out to investigate the effect of using varying buffer sizes per vessel size category.

10.4.1 Conservatism of 100m Buffer

Assuming that the orientation of a foundered vessel is random, the probability that a vessel of a certain length located at any point within a 100m buffer of the cable intersects the cable can be calculated. The table below shows the probabilities for varying vessel sizes. It is assumed that the centre-point of the vessel may be located at any point within the 100m buffer.

Vessel Length (m)	Probability that Vessel Intersect Cable
50	19%
100	38%
200	76%
300	89%
400	94%

Table 10.4 Probability that Vessel within 100m Buffer Intersects Cable

This shows that the probability that a small, foundered vessel positioned at a random point in the 100m buffer intersects the cable is small. In contrast, the probability that a very large vessel foundering at a random point in the 100m buffer intersects the cable is high.

The foundering methodology assumes that 100% of vessels with centre-points in the 100m buffer will intersect the cable. The table above shows that this is very conservative for small vessels (only 19% of 50m vessels would intersect the cable), but not necessarily conservative for very large vessels.

The use of the 100m buffer is conservative for all vessels less than 200m in length, since if the centre-point of such a vessel lies outside the 100m buffer, this vessel would not intersect the cable. If the centre-point lies within the 100m buffer, the probability of intersecting the cable is less than 100%. The average vessel length of unique vessels within 100m of the proposed Celtic Interconnector was 134m. Therefore, if the centre-point of an average vessel was located at a point outside the 100m buffer, it would not intersect the cable. The probability that a 134m vessel within the 100m buffer intersects the cable is 51%.

Note that if the end point (bow or stern) of the vessel is used in the analysis rather than the centre-point, the calculation would be different and vessels of 100-200m could intersect the cable from outside the 100m buffer. However the probability of intersecting at smaller distances would be less than that calculated using the centre-point, as the vessel could be orientated away from the cable rather than towards it. It is expected that the results would even out when integrated over all distances. The vessel centre-point approach is preferred as it is consistent with the grid durations' methodology used to generate the model inputs.

For vessels larger than 200m (24% of vessels in the study area), there is a chance that a vessel situated outside the 100m buffer might intersect the cable. This is (at least partly) counteracted by the probability that not all such vessels foundering inside the buffer distance will intersect the cable, as is currently assumed.

However, due to the inherent conservatism associated with the current approach for all vessels less than 200m length (76% of vessels in the study area), for example a conservatism factor of 51% for the average length vessel, and the fact that a significant proportion of vessels are much smaller (i.e. 62% of 100m vessels within the 100m buffer will not intersect the cable), combined with the fact that smaller vessels are more likely to be involved in a foundering incident, it is concluded overall that the current foundering methodology is conservative.

10.4.2 Varying Buffer Sizes

An analysis was carried out to investigate the effect on the foundering results of using a different buffer size per vessel size category. Table 10.5 presents the average, 90th percentile and maximum lengths for each size category used in the model. This is based on unique vessels within the study area per day.

Size Category	DWT Range	Length (m)		
		Average	90th Percentile	Maximum
1	0 – 1,500 DWT	21	33	163
2	1,500 – 5,000 DWT	97	125	238
3	5,000 – 15,000 DWT	138	185	348
4	15,000 – 40,000 DWT	180	210	360
5	40,000 – 100,000 DWT	233	294	336
6	> 100,000 DWT	308	367	400

Table 10.5 Vessel Lengths per Size Category

Note that the maximum length is much larger than the average and 90th percentile for the smallest size categories. This is due to passenger vessels (e.g. superyachts, cruise ships) that have a low DWT in comparison with the vessel length (compared to e.g. container ships).

Based on this information, the 90th percentile length was adopted as the new buffer size for each size category. In order to keep the calculations simple, without a need for re-running the model, it was assumed that the vessel durations are proportionate inside and outside the 100m buffer. The results per size category were therefore determined by factoring each size category by the 90th percentile length divided by 100m, e.g., 33/100 in the case of Size 1 vessels compared to 367/100 for Size 6. It can be seen that in all cases except Size 1, the factor will be higher than 1.

This approach is still conservative, as it assumes that all vessels within the new buffer will interact with the cable, whereas, based on Table 10.4 above, only a certain proportion of vessels inside the buffer will interact with the cable. In addition, 90% of vessels in each size category have no possibility of interacting with the cable from outside the buffer. In fact, based on the approach above, using the centre-point of the ship, only vessels that are at least twice the buffer size could interact with the cable from outside the buffer.

The results of the sensitivity analysis for the main route and for each landfall option are presented in Table 10.6. The original results are also provided for comparison.

Route	Sensitivity Analysis Results		Original Results	
	Frequency Per Year	Return Period	Frequency Per Year	Return Period
Main Route	1.5×10^{-3}	660	2.6×10^{-3}	400
Ballinwilling Strand	3.6×10^{-5}	27,900	8.0×10^{-5}	12,600
Ballycroneen	5.5×10^{-5}	18,300	1.3×10^{-4}	7,800
Kerradenec	1.5×10^{-7}	6,902,700	4.4×10^{-7}	2,279,300
Port Neuf	3.1×10^{-8}	32,032,800	9.5×10^{-8}	10,570,200

Table 10.6 Annual Foundering Results – Sensitivity Analysis

The total foundering frequency for the proposed main route was estimated to be one in 660 years using the sensitivity assessment approach.

It is noted that the effect of the sensitivity analysis was to reduce the overall foundering risk by 40%. This is due to the reduction in risk for vessels in the smallest size category, which contributed 84% of the original foundering risk.

For the sensitivity analysis, vessels in the smallest size category contribute 46% of the main route foundering risk.

10.5 Historical Foundering Incident Data

In order to validate the results of the foundering model, twenty years of Marine Accident Investigation Branch (MAIB) data (recorded between 1994 and 2013 inclusive) was analysed to assess recorded historical foundering incidents. This data generally covers all incidents in UK waters, and incidents outside UK waters involving a UK registered vessel.

In order to assess purely foundering incidents within the MAIB data, only incidents that were categorised as “Flooding/Foundering” by the MAIB and where the vessel was lost were considered. Such incidents identified to have occurred near the Celtic Interconnector are presented in Figure 10.2.

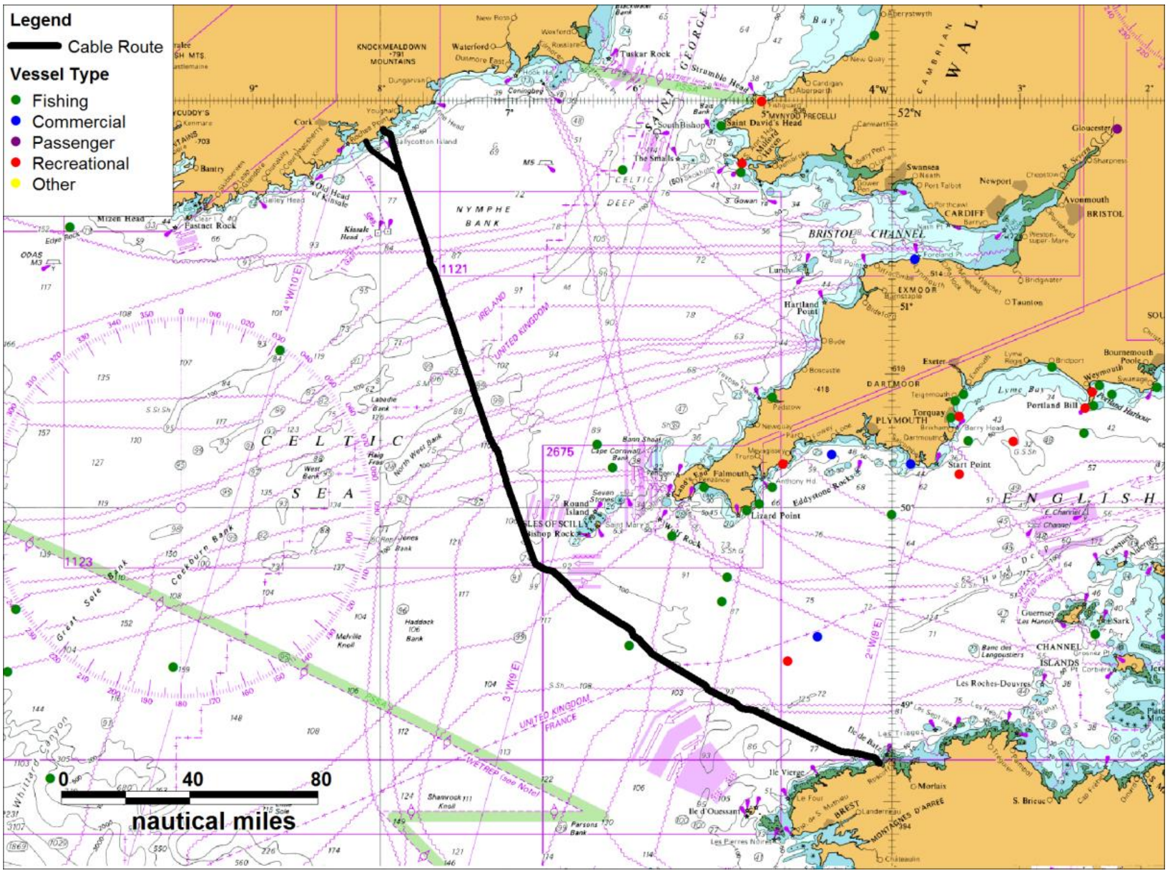

Figure 10.2 MAIB Foundering Incidents near Celtic Interconnector

During the twenty year study period, nine incidents of foundering were recorded within 50nm of the proposed cable route (seven fishing vessels, one recreational vessel, and one cargo vessel). The nearest foundering incident to the proposed cable occurred in September 2000 approximately 3nm from the route, in the south-west approaches to the English Channel. The vessel involved was a fishing vessel with a length of 23m, and a gross tonnage of 71. The synopsis given by MAIB was as follows:

> *Vessel was trawling for scallops when the bilge alarm sounded. The source of the flooding could not be identified. The seacocks in the engine room were closed, but this did not stop the flooding. The vessels bilge pumping could not contain the flooding, a coastguard helicopter put another pump on the vessel, but the flooding still increased, so the vessel was abandoned. She sank shortly after.*

Approximately 77% of all foundering incidents within the MAIB data involved fishing vessels during the studied 20 year period, which was in line with the original foundering modelling, which estimated that 75% of the total foundering risk was from fishing vessels.

Within the 20 year study period, the vast majority of vessel founderings were from vessels estimated to be less than 1,500 DWT. Again, this finding was in line with the original foundering modelling.

Overall, the foundering incidents within the MAIB data correlated well with the original foundering model assessment, as the data demonstrated that foundering incidents have occurred near the cable historically, and the majority of recorded incidents were from small fishing vessels.

11. Fishing Risk Assessment

11.1 Introduction

This section investigates the potential risk to the proposed cable routes by vessels fishing in the vicinity. The analysis is based on the fishing activity recorded in the 12 months of AIS data presented in Section 7.

The majority of the AIS data covers vessels of 15m length and over. The smaller vessels that are not covered, which are likely to be prevalent in coastal areas in particular, should not pose a threat to the proposed cable assuming standard protection measures are taken.

11.2 Methodology

The annual risk frequency associated with fishing vessels was assessed by calculating the number of hours per year that vessels were recorded to be actively fishing within the vicinity of the proposed cable. As a first approach, it was assumed that any vessel recorded actively fishing within 100m of the proposed route could potentially cause damage to the cable from gear components (e.g. trawl board, clump weight, etc.).

The assessment focuses on vessels travelling at less than 6 knots, i.e. those that could potentially be actively fishing, since it is these vessels that are likely to interact with the cable. It is noted that this is a conservative assumption, as it may include some vessels that are steaming through the area.

Since vessels that deploy their gear within the water column rather than along the seabed are not likely to pose any risk to the proposed cable, the assessment considers only vessels with demersal fishing gears (i.e. demersal trawlers, beam trawlers and dredgers), or a gear type that could include demersal vessels (i.e. pair trawlers or unspecified trawlers).

The fishing durations in the Irish sector (KP 0 to KP56) were factored by 1.08 to account for the fact that the Irish auxiliary data set indicated that fishing activity in winter was 16% higher than in summer, i.e. since the core data set covers spring, summer and autumn, but not winter, half of the durations are factored by 16%.

The factored durations were then divided by the total number of hours in a year to provide the annual frequency (in terms of vessel-years) that fishing vessels have the potential to interact with the proposed cable per KP and per gear type (demersal gears only).

11.3 Results

It was estimated that the annual frequency, in terms of vessel-years, of fishing vessels interacting with the main route was 3.77×10^{-2}. This equates to a demersal vessel actively fishing within 100m of the proposed cable for 330 hours, or approximately 2 weeks, every year. Over the 40 year lifespan of the proposed cable this gives a total frequency of approximately 1.5 vessel-years, i.e. a demersal vessel actively fishing within 100m of the proposed cable for an aggregate period of 1.5 years over the lifespan of the cable.

The results of the fishing risk assessment for each landfall option are presented in Table 11.1. It is noted that no demersal vessels were actively fishing within 100m of either of the proposed French landfall options.

Country	Route	Frequency Per Year	Vessel Hours Per Year
Ireland	Ballinwilling Strand	1.3×10^{-3}	11
	Ballycroneen	2.8×10^{-3}	24

Table 11.1 Annual Fishing Frequency Results - Landfalls

The Ballycroneen landfall frequency was estimated to be 2.8×10^{-3}. This corresponds to a frequency of 40 vessel-days over the lifespan of the cable. The frequency for the Ballinwilling Strand landfall option was estimated to be 1.3×10^{-3}, which corresponds to a frequency of 18 vessel-days over the proposed cable's operational life.

The risk to the Kerradenec and Port Neuf landfall options from fishing vessels was considered to be negligible.

An overview of the fishing frequency results per KP of cable is presented in Figure 11.1.

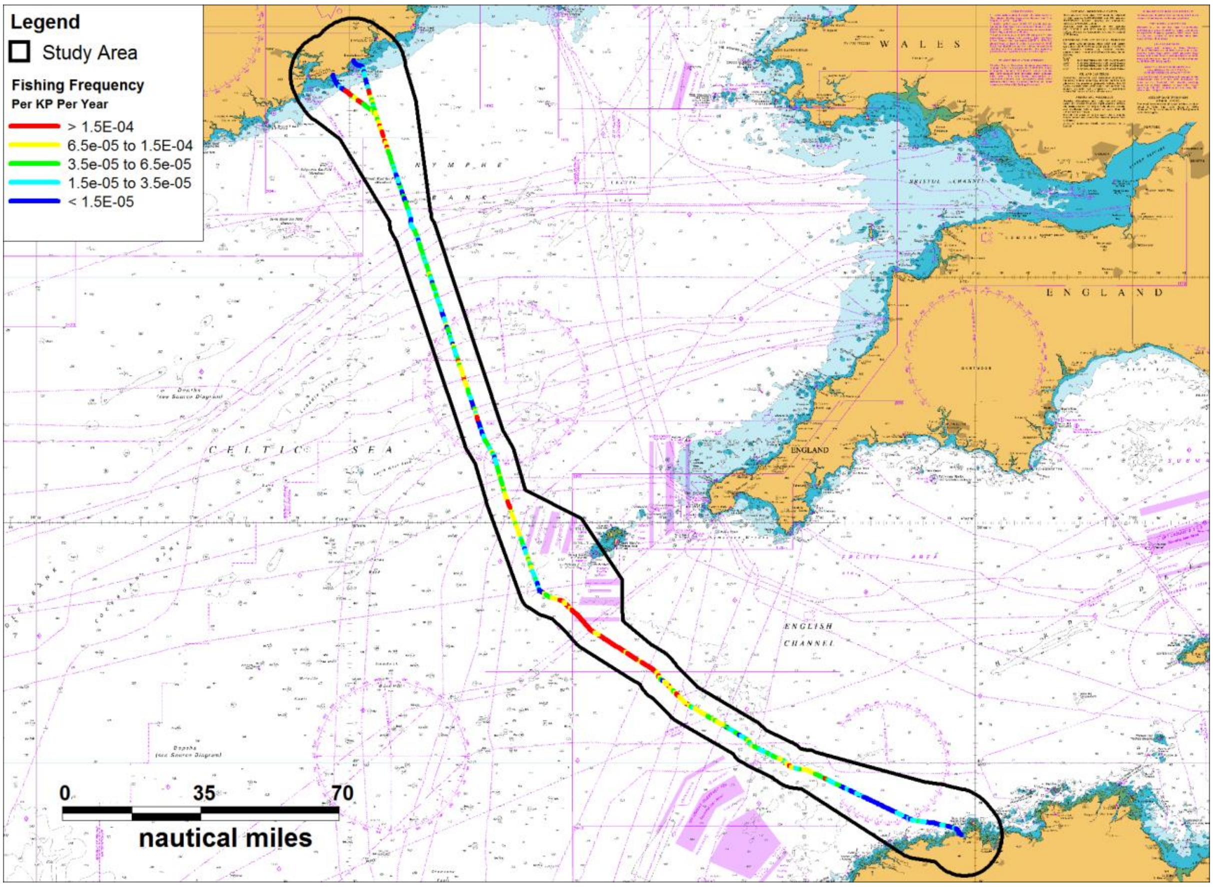

Figure 11.1 Annual Fishing Frequency Results – General Overview

It can be seen that the highest risk areas for fishing vessel crossings were the Irish landfall options, from KP27 to KP40 on the main route (close to where the Ballycroneen landfall option branches off) and to the south of the Scilly Isles, between KP 265 and KP 343 on the main route.

A summary of the fishing frequency results by gear type per 50km of the main route is presented in Table 11.2. The results for the Irish landfall options are presented in Table 11.3.

Cable Route Section	Fishing Frequency				
	Beam Trawlers	Demersal Trawlers	Pair Trawlers	Dredgers	Unspecified Trawlers
Main Route – KP 0-50	2.61E-03	8.53E-04	2.61E-05	3.08E-04	1.36E-05
Main Route – KP 50-100	1.02E-03	5.89E-04	Negligible	Negligible	3.01E-05
Main Route – KP 100-150	8.87E-04	9.03E-04	Negligible	2.27E-04	4.23E-05
Main Route – KP 150-200	1.06E-04	2.60E-03	Negligible	1.62E-05	6.55E-05
Main Route – KP 200-250	1.74E-04	3.64E-03	Negligible	Negligible	Negligible

Cable Route Section	Fishing Frequency				
	Beam Trawlers	Demersal Trawlers	Pair Trawlers	Dredgers	Unspecified Trawlers
Main Route – KP 250-300	9.10E-03	1.99E-03	Negligible	Negligible	5.52E-05
Main Route – KP 300-350	5.14E-03	2.36E-03	Negligible	3.66E-05	Negligible
Main Route – KP 350-400	9.03E-04	1.69E-03	Negligible	1.35E-05	Negligible
Main Route – KP 400-450	Negligible	1.78E-03	Negligible	Negligible	Negligible
Main Route – KP 450-487	Negligible	4.54E-04	Negligible	6.17E-05	Negligible
Total	**1.99E-02**	**1.69E-02**	**2.61E-05**	**6.63E-04**	**2.07E-04**

Table 11.2 Fishing Frequency by Gear Type – Main Route

Landfalls	Fishing Frequency				
	Beam Trawlers	Demersal Trawlers	Pair Trawlers	Dredgers	Unspecified Trawlers
Ballinwilling Strand	7.16E-04	3.01E-04	7.48E-06	2.26E-04	1.41E-05
Ballycroneen	2.20E-03	4.19E-04	6.31E-06	1.04E-04	2.72E-05

Table 11.3 Fishing Frequency by Gear Type – Landfalls

For the main route and both of the Irish landfall options, beam trawlers contributed approximately 50% of the risk frequency. Demersal trawlers also contributed a significant proportion of the risk from fishing vessels.

Figure 11.2 presents the breakdown of the fishing risk frequency by gross tonnage, for the main route and the Ballinwilling and Ballycroneen landfall options.

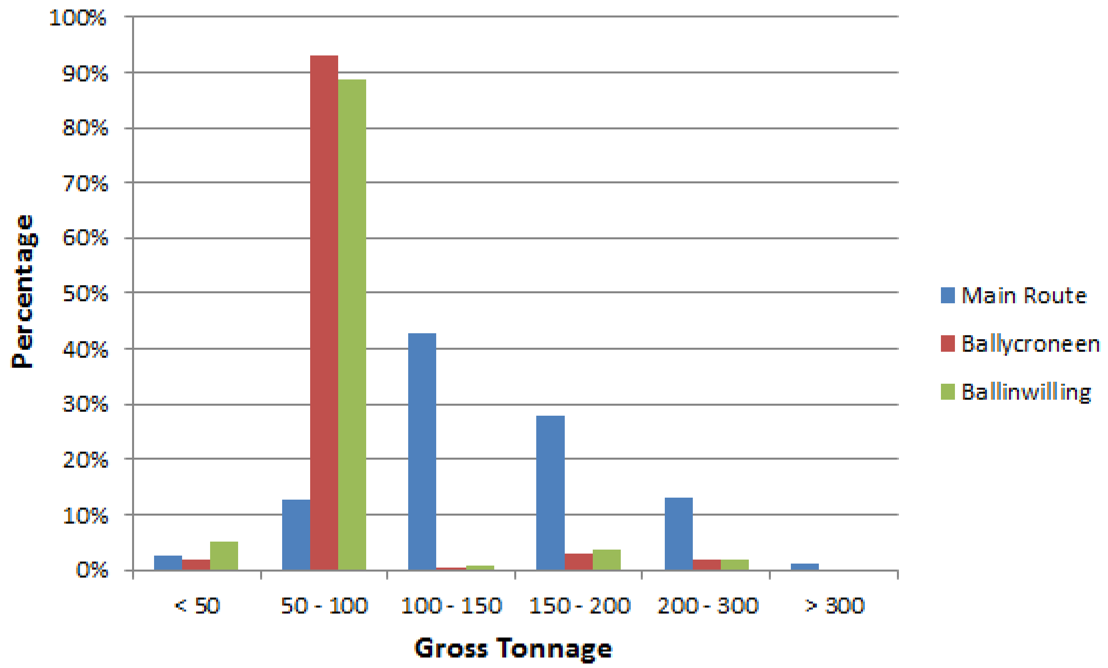

Figure 11.2 Gross Tonnage Distribution, Demersal Vessel Crossings

For the main route, the majority of demersal vessel crossings by vessels considered to be actively fishing across the proposed cable route (71%) had gross tonnage between 100 and 200 GT. For the Ballycroneen and Ballinwilling landfall options, the majority of crossings (93% and 89% respectively) had gross tonnage between 50 and 100 GT.

Figure 11.3 presents the breakdown of the fishing risk frequency by engine power, for the main route and the Ballinwilling and Ballycroneen landfall options.

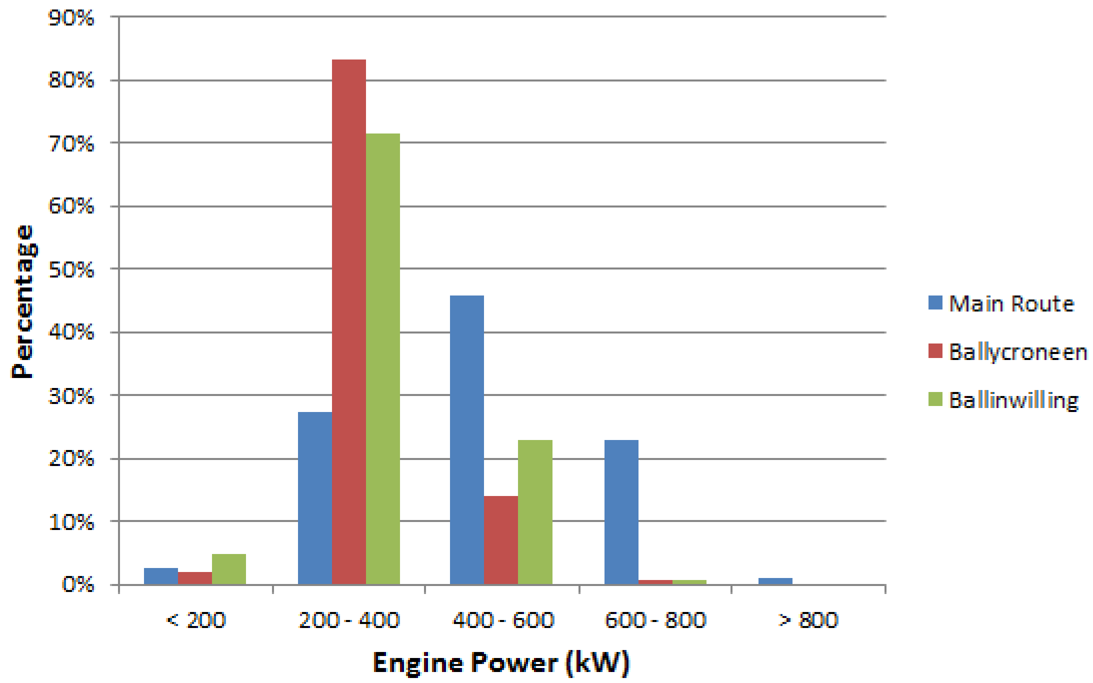

Figure 11.3 Engine Power Distribution, Demersal Vessel Crossings

It can be seen that, for the main route, the vast majority of demersal vessel crossings by vessels considered to be actively fishing across the proposed cable route (96%) had engine power between 200 and 800 kW, while for the Ballycroneen landfall option, the vast majority of crossings (83%) had engine power between 200 and 400kW. The vast majority (94%) of the Ballinwilling crossings had engine power between 200 and 600kW.

12. Summary

A Cable Risk Assessment was undertaken for the proposed Celtic Interconnector route and landfall options. Six months of 2014 AIS data and six months of 2015 AIS data was used to perform a shipping analysis, and to assess the risk to the proposed cable route from anchors, foundering vessels, and fishing vessels. A review of the navigation features in the area was also included.

12.1 Shipping Analysis

An average of 243 unique vessels per day were recorded within the study area during the 12 months. Approximately half of all traffic was comprised of cargo vessels, with a further 18% being tankers. Fishing vessels accounted for 17% of the total.

The average vessel length recorded during the 12 months was 131m, and the average draught was 7.7m (excluding 19% unspecified). The AIS data showed that the larger vessels tended to remain on routes associated with the Isles of Scilly and Channel Traffic Separation Schemes, unless they were on approach to ports within the study area.

The majority of vessels determined to be at anchor within the study area were located in the outer Cork anchorage. Vessels also anchored in Ballycotton Bay, with the closest being a fishing vessel anchored 0.8nm from the proposed Western cable landfall. The majority of anchoring within French waters occurred from vessels waiting outside Roscoff. No anchoring was recorded within in UK EEZ waters.

12.2 Fishing Analysis

An average of 40 unique fishing vessels per day were recorded within the study area during the 12 months.

A speed analysis was used to provide an indication of the areas of active fishing activity within the study area. The majority of vessels actively fishing within the study area were demersal trawlers, gill netters and beam trawlers.

An analysis of fishing vessels crossing the proposed cable route showed that the total number of crossings (by vessels travelling below 6 knots) for the main route was determined to be 8,062 per year, 222 of which were over the Ballinwilling landfall option. In addition, the Ballycroneen landfall option was calculated to have 399 crossings per year. The French landfall route options did not have any fishing-cable crossings.

75% of the main route crossings, 86% of the Ballycroneen landfall option crossings and 79% of the Ballinwilling landfall option crossings were by demersal vessels (i.e. demersal trawlers, beam trawlers and dredgers), or by a vessel type that could include demersal vessels (i.e. trawlers or unspecified trawlers).

It is noted that AIS data only covers vessels greater than 15m in length and there may be some under-reporting of smaller vessels within the data. However, it is considered that, due to their size, these vessels are unlikely to cause significant damage to the proposed cable.

It is further noted that fishing vessels may turn off their AIS broadcasts while fishing, leading to under-reporting of fishing activity in the AIS data.

A comparison with auxiliary AIS data sets (Appendix A) and VMS satellite data from 2009 (Appendix B) indicated that the core AIS data set provided a good representation of the fishing activity. However, the fishing activity in the Irish sector was shown to be higher in winter than in summer and the inputs to the fishing risk assessment were therefore factored accordingly.

12.3 Risk Modelling

12.3.1 Anchor Dragging

It was estimated that a vessel would drag anchor over the main route once every 7,400 years. Over the expected 40 year life of the proposed cable, this corresponds to a frequency of 5.4 x 10^{-3}.

The Ballinwilling Strand was estimated to experience an anchor dragging incident once every 7,400 years, which corresponds to a frequency of 5.4 x 10^{-3} over the expected 40 year operational span of the proposed cable. A vessel was estimated to drag anchor over the Ballycroneen landfall option once every 193,100 years, corresponding to a frequency of 2.1 x 10^{-4} over the expected 40 year life of the proposed cable. The vast majority of the risk associated with anchor dragging was to the Irish landfalls.

The Kerradenec and Port Neuf landfall options had return periods of 67,187,300 and 85,766,200 years respectively, corresponding to frequencies of 6.0 x 10^{-7} and 4.7 x 10^{-7}.

Approximately 99% of the risk to the cable was from vessels of less than 5,000 DWT.

12.3.2 Emergency Anchoring

It was estimated that a vessel would drop its anchor in an emergency over the main route once every 3,600 years. Over the 40 year life of the proposed cable, this corresponds to a frequency of 1.1 x 10^{-2}.

It was estimated that a vessel would drop its anchor in an emergency over the Ballycroneen landfall option once every 14,900 years. Over the 40 year life of the proposed cable, this corresponds to a frequency of 2.7 x 10^{-3}. The emergency anchoring return period of the Ballinwilling Strand landfall option was estimated to be 22,000 years, corresponding to a frequency of 1.8 x 10^{-3} over the 40 year operational life.

The Kerradenec and Port Neuf French landfall options had return periods of approximately 650,000 and 2,900,000 respectively, corresponding to frequencies of 6.2 x 10^{-5} and 1.4 x 10^{-5} over the lifespan of the proposed cable.

Approximately half the emergency anchoring risk was from vessels less than 1,500 DWT, and 23% from vessels greater than 40,000 DWT.

12.3.3 Foundering

It was estimated that a vessel would founder over the proposed cable route once every 400 years. Over the 40 year lifespan of the cable this resulted in a frequency of 1.0 x 10^{-1}.

The foundering return period of the Ballycroneen landfall option was estimated to be 7,800 years. This corresponds to a frequency of 5.2 x 10^{-3} over the lifespan of the proposed cable. A foundering incident was estimated to occur once every 12,600 years over the Ballinwilling Strand landfall option, which corresponds to a frequency of 3.2 x 10^{-3} over the proposed cable operational life.

The Kerradenec and Port Neuf French landfall options had return periods of approximately 2,300,000 and 10,600,000 years respectively, corresponding to frequencies of 1.8 x 10^{-5} and 3.8 x 10^{-6} over the lifespan of the proposed cable.

Approximately 84% of the risk was from vessels less than 1,500 DWT. Overall, 75% of the foundering risk was from fishing vessels.

A sensitivity analysis to investigate the effect of using varying buffer sizes per vessel size category was undertaken. The total foundering risk for the main route reduced by 40%, corresponding to a return period of 660 years.

12.3.4 Comparison

The annual frequencies of anchor dragging, emergency anchoring, and foundering are presented for the main route and landfall options in Table 12.1 for comparison. The foundering results are based on the sensitivity analysis using the varying buffer sizes per vessel size category as these are considered more realistic.

Route	Anchor Dragging	Emergency Anchoring	Foundering	Total
Main Route	1.4 x 10^{-4}	2.8 x 10^{-4}	1.5x 10^{-3}	1.9 x 10^{-3}
Ballycroneen	5.2 x 10^{-6}	6.7 x 10^{-5}	5.5 x 10^{-5}	1.3 x 10^{-4}
Ballinwilling	1.4 x 10^{-4}	4.6 x 10^{-5}	3.6 x 10^{-5}	2.2 x 10^{-4}
Port Neuf	1.2 x 10^{-8}	3.5 x 10^{-7}	3.1 x 10^{-8}	3.9 x 10^{-7}
Kerradanec	1.5 x 10^{-8}	1.6 x 10^{-6}	1.5 x 10^{-7}	1.7 x 10^{-6}

Table 12.1 Risk Modelling Summary

It was estimated that a vessel anchor or a foundering vessel would interact with the main route once every 518 years.

For the Ballycroneen landfall option, this frequency was once every 8,000 years while the Ballinwilling landfall option was once every 5,000 years.

It was estimated that a vessel anchor or a foundering vessel would interact with the Kerradenec landfall option once every 600,000 years, falling to once every 2.6 million years for the Port Neuf landfall option.

The highest risk to the proposed Interconnector cable was from vessels foundering over it. This is due to the proportion of small vessels sailing near the cable, which historically present a higher risk of foundering. Small vessels, in particular fishing vessels, also contributed higher vessel durations than large vessels, which tended to steam quickly through the study area. In addition, the water depths along the majority of the proposed cable route are fairly high, indicating that vessels (particularly small vessels) are less likely to anchor in an emergency.

For the Ballinwilling landfall option, anchor dragging presented the highest risk, due to the location of vessels at anchor very close to the cable route. For the other landfall options, the emergency anchoring risk was highest due to the smaller water depths and distance to danger near the coast, meaning that vessels were more likely to anchor in an emergency over the landfall options than along the main route.

12.4 Fishing Risk Assessment

The annual risk frequency associated with fishing vessels was assessed by calculating the number of hours per year that demersal vessels were recorded to be actively fishing within the vicinity of the proposed cable route and dividing this by the total number of hours in a year.

It was estimated that the annual frequency, in terms of vessel-years, of fishing vessels actively fishing over the main route (plus 100m buffer) was 3.77×10^{-2}, or approximately two weeks per year. Over the 40 year lifespan of the proposed cable this equates to a fishing frequency of 1.5 vessel-years, i.e. a demersal vessel actively fishing within 100m of the proposed cable for 1.5 years over the lifespan of the cable.

The Ballycroneen landfall frequency was estimated to be 2.8×10^{-4}. This corresponds to a frequency of 40 fishing vessel-days over the lifespan of the proposed cable. The frequency for the Ballinwilling Strand landfall option was estimated to be 1.3×10^{-3}, which corresponds to a frequency of 18 fishing vessel-days over the operational life of the cable.

The risk to the Kerradenec and Port Neuf landfall options from fishing vessels was considered to be negligible.

Approximately 50% of the fishing risk frequency was from demersal otter trawlers, with beam trawlers also contributing a significant proportion of risk.

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