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Morlais
Menter Môn

Morlais Assessment of Interactive Boundaries

Applicant: Menter Môn Limited

Document Title: Morlais Assessment of Interactive Boundaries

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EXECUTIVE SUMMARY

This interactive boundary assessment has been undertaken by Marico Marine on behalf of Menter Môn in accordance with the methodology outlined within MGN 543, Annex 3: *'MCA Template for Assessing Distances between OREI Boundaries and Shipping Routes'*. This assessment supplements the analysis undertaken within the 2018 Navigation Risk Assessment and updates the results of the original Interactive Boundaries 01 assessment, following revisions to the Morlais Development Zone design.

The assessment has considered the northern interactive Morlais Development Zone boundary adjacent to the ferry route utilised by Irish Ferries and Stena Line and the eastern interactive boundary adjacent to the inshore route utilised primarily by small fishing, recreational and occasionally survey vessels.

The assessment has been undertaken utilising 28-days of combined summer and winter Automatic Identification System and RADAR data, which was analysed to establish the area occupied by 90% of the total shipping volume through each lane (the 90th percentile shipping routes) in accordance with the MGN 543 Annex 3 shipping route guidance template to determine the tolerability of the assessed boundaries.

By comparison to the Interactive Boundary 01 assessed layout for the northern route, which was assessed to be "intolerable" in line with the MGN 543 assessment criteria, the updated northern route layout represents a significant improvement which has been assessed to be "tolerable", owing to the achievement of a minimum worst-case separation of 0.55nm from the assessed boundary to the nearest shipping 90% traffic level, satisfying the 0.5nm assessment tolerability criteria.

The updated layout shows some improvement on the IB01 assessed design for the eastern route but remains "intolerable" in line with the MGN 543 tolerability assessment criteria, which requires a minimum 0.5nm separation between a 'turbine' boundary and the nearest 90% traffic level. Given that application of the Interactive Boundary template and guidance relates primarily to the assessment of commercial routeing, which is unrepresentative of the types of vessels utilising the inshore passage and given the proximity of the coastline to the east, opportunities for flexibility are limited and the eastern boundary is unable to satisfy the existing tolerability criteria. Precisely where an interactive boundary should lie requires flexible definition. It is suggested, that the appropriateness of the assessment criteria set out in MGN 543, Annex 3 for assessment of the eastern boundary should therefore be reviewed in discussion with the MCA.

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TABLE 1: ABBREVIATIONS

Abbreviation	Detail
AIS	Automatic Identification System
COLREGs	International Regulations for Preventing Collisions at Sea
IB	Interactive Boundary
IB01	Interactive Boundary Assessment 01
LOA	Length Over-All
m	Metre
MAIB	Marine Accident Investigation Branch
Marico Marine	Marine and Risk Consultants Ltd
MCA	Maritime and Coastguard Agency
MDZ	Morlais Development Zone
MGN	Marine Guidance Note
nm	Nautical Mile
NRA	Navigation Risk Assessment
NtM	Notice to Mariners
OREI	Offshore Renewable Energy Installation
RNLI	Royal National Lifeboat Institution
RYA	Royal Yachting Association
SOLAS	Safety Of Life At Sea
UKC	Under Keel Clearance
VTS	Vessel Traffic Study

1. INTRODUCTION

Marine and Risk Consultants Ltd. (Marico Marine) has been requested to undertake a second interactive boundaries assessment of the northern and eastern boundaries of the Morlais project in light of recent layout changes implemented following recommendations from the Navigation Risk Assessment (NRA) and the results of the Interactive Boundary Assessment 01 (IB01). The recommendations pertain to the northern MDZ boundary adjacent to the ferry route utilised by Irish Ferries and Stena Line and the eastern boundary adjacent to the inshore route utilised primarily by small fishing, recreational and occasionally survey vessels.

2. SCOPE

Since undertaking IB01, the layout of the Morlais Demonstration Zone was reviewed and updated in light of recommendations from the NRA and the findings of IB01 (**Annex A**) where both the northern and eastern assessment boundaries were assessed to be in intolerable given existing MCA MGN 543 IB assessment criteria (**Annex A**).

Two critical depths were determined to be of greatest importance by stakeholders within the NRA through consultation in order to ensure continued safe navigation through the Morlais Zone:

- A minimum 8m Under Keel Clearance (UKC) would be required to ensure continued safe navigation of vessels draught<3m through the Morlais Zone.
    - Along the eastern boundary where the risk of grounding of recreational vessels was scored as significant due to restriction of the inshore passage and proximity of the shore
- A minimum UKC of 20m would be required to ensure continued safe navigation of ferries and vessels draught >3m through the Morlais Zone.
    - Along the northern boundary where ferries intersect the two northern most sub-zones and the westernmost sub-zone of the Morlais Zone while utilising poor weather routing.

Layout revisions in light of the under-keel clearance recommendations discussed above are shown in **Figure 1**. The resultant minimum 8m and 20m UKC areas are designed to deconflict vessel / device interactions along the northern and eastern boundaries. As such, the boundaries between the minimum UKC defined areas and the remainder of the MDZ (marked in red) are taken to represent the ‘turbine boundaries’ for re-assessment in accordance with the MGN 543 Interactive Boundary assessment criteria.

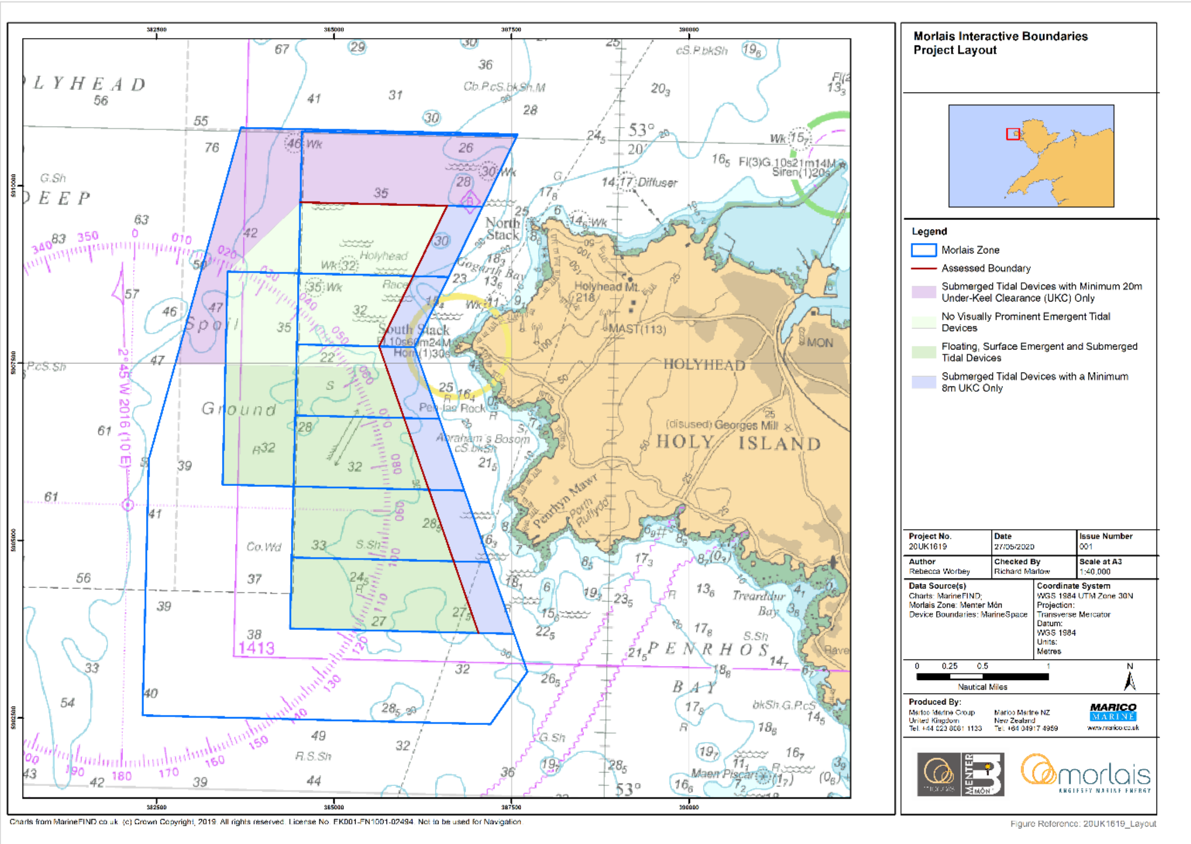


FIGURE 1: MORLAIS DEMONSTRATION ZONE (MDZ) LAYOUT

The objectives of this study are as follows:

- Review revised layout;
- Review the proximity of the updated layout assessed boundaries in relation to the 90th percentile route boundaries;
- Discuss results in relation to findings of IB01; and
- Make recommendations for next steps.

3. REFERENCE DOCUMENTS AND INPUT DATA

Documents referenced within this VTS are listed within **Table 2**.

TABLE 2: REFERENCE DOCUMENTS

Document Reference	**Description**
20UK1619_RN_MM_VTS-01	Interactive Boundary Assessment 01 (**Annex A**).
18UK1479_MorlaisNRA_Issue-03	Morlais Navigation Risk Assessment
Admiralty Sailing Directions NP37 – West Coast of England and Wales Pilot	Regional information on all aspects of navigation, including routeing and met-ocean conditions.

This assessment has been undertaken in accordance with the guidance outlined within **Table 3.** A full description of the guidance relating to MGN 543, Annex 3 is located within the IB01 assessment within **Annex A**.

TABLE 3: GUIDANCE DOCUMENTS

Policy / legislation	**Description**
MGN 543, Annex 3: MCA Template for assessing distances between OREI boundaries and shipping routes.	This MGN highlights issues to be considered when assessing the impact on navigational safety and emergency response, caused by OREI developments. Including traffic surveys, stakeholder consultation, structure layout, collision avoidance, impacts on communications/ radar/ positioning systems and hydrography.
COLREGs	International Regulations for Preventing Collisions at Sea.

4. ASSUMPTIONS

The following assumptions apply:

- For the purposes of this assessment the assessed boundaries (indicated in red within **Figure 1** are assumed to represent the ‘turbine boundary’ as stated within MGN 543. At this stage the specific device locations and device types to be installed are unknown.

- The Annex 3 template and guidance is related to the assessment of clearly defined shipping lanes utilised by commercial vessels as opposed to poorly defined routes typically utilised by smaller craft. It is, therefore, considered that the methodology is more suitable for application to the northern as opposed to the eastern route, where transit patterns are more erratic and the route is restricted on the eastern side by the Anglesey coastline.

- Aspects of the Annex 3 guidance are aimed specifically at assessing the interaction of shipping routes with wind farm boundaries. Factors for consideration or assessment that pertain to wind farms / turbines specifically have been omitted, for example, the potential for RADAR interference owing to proximity to wind turbines.

5. METHODOLOGY

The assessment was undertaken in accordance with the MGN 543, Annex 3 methodology outlined within (**Annex A**). This assessment updates the analysis undertaken within the 2018 Navigation Risk Assessment (**Annex A**).

For a detailed description of the methodology please see IB 01 (**Annex A**).

6. ANALYSIS

Vessel traffic analysis of AIS and RADAR data was undertaken as part of IB01 to determine 90th percentile boundaries, the methodology for which is detailed within **Annex A**.

Please note, ferry vessel tracks that appeared to be utilising the poor weather routes as opposed to operating along standard fair-weather route were removed from the analysis, as their inclusion would have served to skew the identification of the 90% boundary location. Also removed were any non-commercial vessels operating perpendicular to or not in adherence to the lane, such as fishing or recreational vessels.

6.1 NORTHERN ROUTE

The results of the 90th percentile analysis of the northern route are shown in **Figure 2**. The analysis demonstrates that, unlike the boundary assessed as part of IB01, the assessed boundary does not encroach on either the 90th percentile or 100 percent assessed shipping lane with a minimum 0.3nm of separation between the boundary and the nearest shipping route edge and 0,55nm between the assessed boundary and nearest 90th percentile route edge.

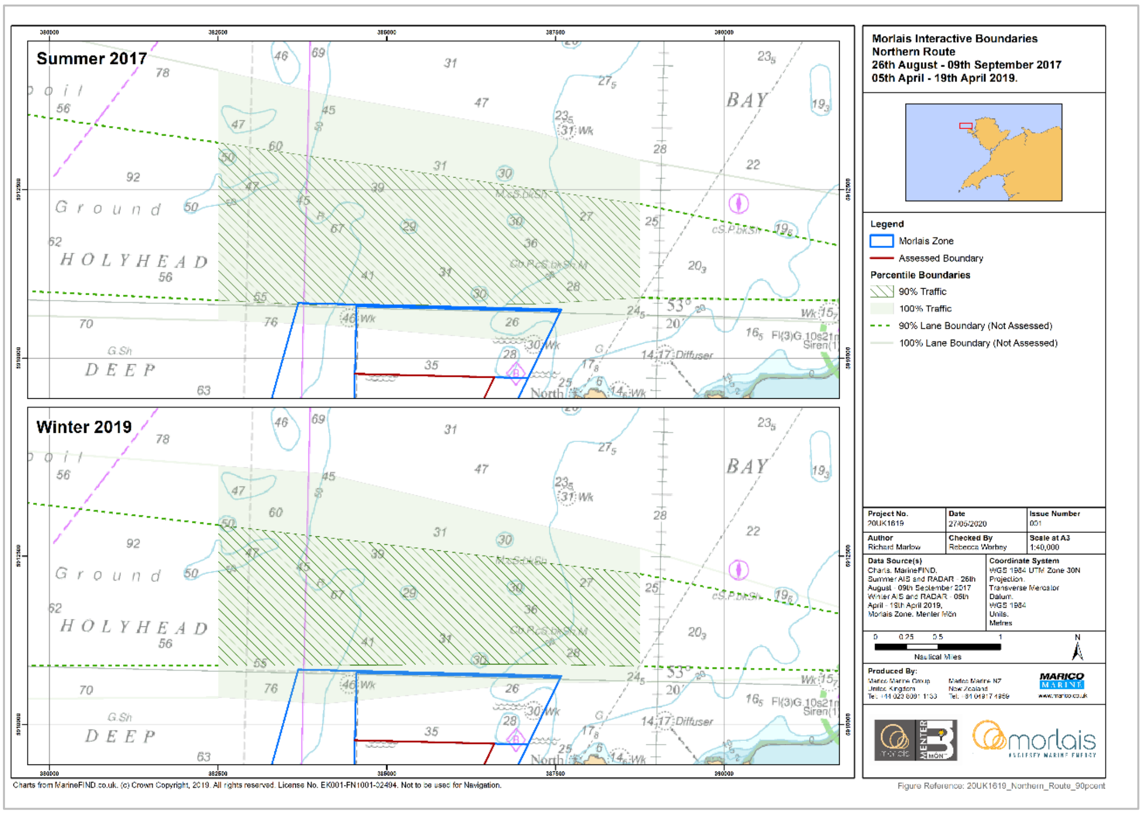


FIGURE 2: 90TH PERCENTILE SHIPPING BOUNDARIES – NORTHERN ROUTE

6.2 EASTERN ROUTE

The results of the 90% assessment for the eastern route is given in **Figure 3**.

The analysis demonstrates that, unlike the boundary assessed as part of IB01, the assessed boundary largely does not encroach the 90th percentile nearest boundary with the exception of the southern portion of the zone in summer where 0.02nm of the route overlaps the assessed boundary. With the exception of the most northern portion of the assessed boundary in winter all of the assessed boundary falls within the 100% traffic route.

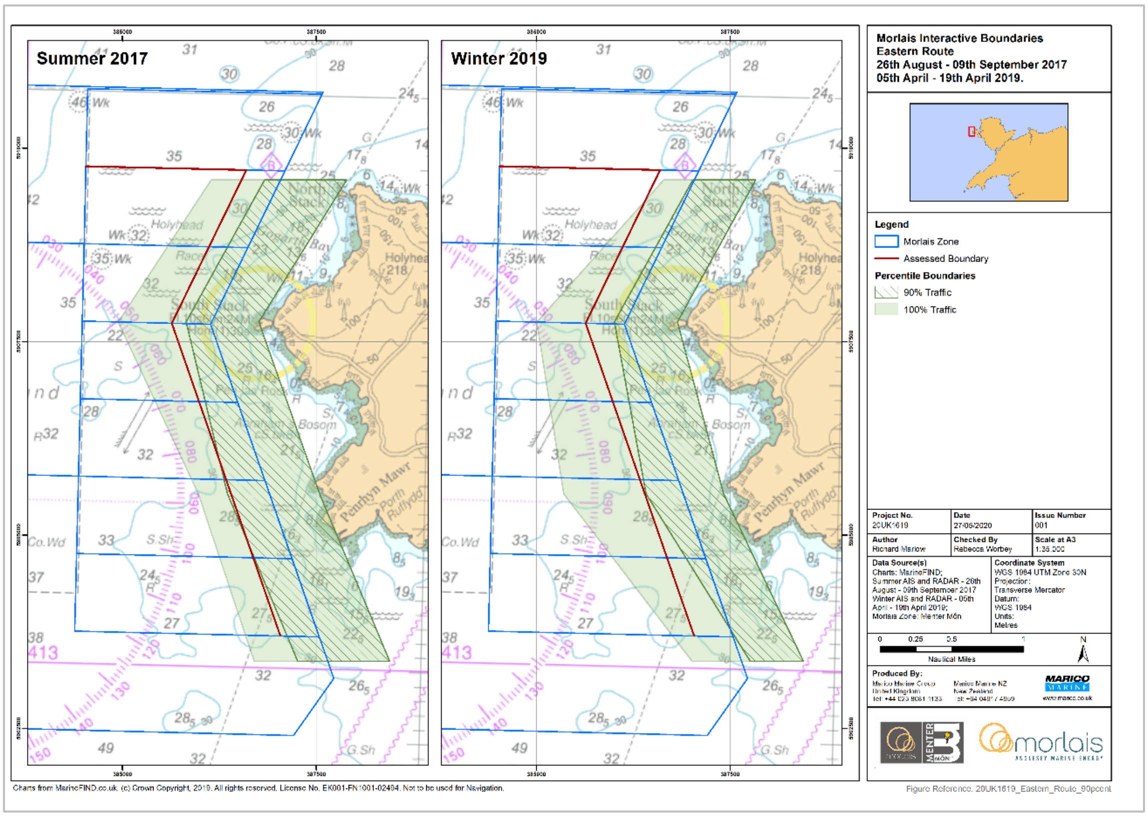


FIGURE 3: 90TH PERCENTILE SHIPPING BOUNDARIES – EASTERN ROUTE

Additional supporting analysis was undertaken within IB01 (**Annex A**) , including an assessment of the likelihood of mechanical failure, the impact of restricted sea room in the event of turning or anchoring and the ability for vessels to overtake maintaining a safe distance in accordance with best practice.

6.2.1 EASTERN ROUTE VESSEL DRAUGHTS

Analysis of vessel tracks used to determine percentile boundaries has been undertaken to identify the draught of vessels transiting the eastern route.

6.2.2 TRACKS DERIVED FROM AIS DATA

For the tracks derived from AIS data many were not transmitting their draught as part of the AIS static message.

For those vessels not transmitting their draught, each vessel was identified using their MMSI number and, using web-based vessel databases (such as MarineTraffic), their draught was assessed based on their characteristics.

30 were assessed as having a draught of <3m and three vessels were identified with a draught >3m (**Table 4**).

TABLE 4: EASTERN ROUTE VESSEL DRAUGHTS >3M

Vessel Name	Type	Season	Length (m)	Beam (m)	Draught (m)
PATRICIA	Buoy-Laying	Summer	86	14	4.5
FV HARMONI	Fishing	Summer	15	8	3.5
CORINTHIAN	Passenger	Summer	89	15	4.1

6.2.3 TRACKS DERIVED FROM RADAR DATA

For those tracks derived from radar/observation data alone, the on-site radar observers' visual records were accessed and their draught was assessed.

83 were assessed as having a draught of <3m and no vessels were identified with a draught >3m.

7. ANALYSIS

The results of the 90th percentile analysis, assessed in reference to the MGN 543 shipping route guidance template detailed within **Annex A** within are shown in **Table 5**.

Given the tolerability criteria specified within the MGN 543 assessment methodology, the northern interactive boundary is assessed to be tolerable and the eastern interactive boundary is assessed to be intolerable. A complete list of boundary measurements in accordance with the A-E assessment criteria as depicted within **Annex A** is given within **Annex B.**

TABLE 5: INTERACTIVE BOUNDARY ASSESSMENT RESULTS

Criteria			Result (m)		Result (nm)		Tolerability
			Summer	Winter	Summer	Winter	
Northern Route							
C	Turbine boundary to nearest shipping 90% traffic level		1,018.6	1,111.2	0.55	0.6	Tolerable
Eastern Route							
C	Turbine boundary to nearest shipping 90% traffic level	Worst Case	-37.04	14.816	-0.02	0.008	Intolerable
		South Stack	185.2	370.4	0.1	0.2	

8. DISCUSSION

The results of IB02 were reviewed against the findings of IB01 to identify improvements resulting from the layout revisions which are summarised below:

8.1. NORTHERN ROUTE

- The updated layout represents a significant improvement on the IB01 assessed design for the northern route and, as such, it has been assessed to be “tolerable” in line with the MGN 543 assessment criteria.
- As poor weather routeing has been omitted from the assessment (Section 6), it is recommended that the effect upon poor weather routing is reviewed in consultation with the ferry operators.

8.2. EASTERN ROUTE

- The updated layout shows some improvement on the IB01 assessed design for the eastern route but it remains “intolerable” in line with the MGN 543 0.5nm tolerability assessment criteria (Distance C, **Annex A**).
- The 0.5nm Distance C criteria set out in MGN 543, Annex 3, is not considered appropriate for assessment of the eastern boundary given the type of vessels utilising the inshore passage and the proximity of the coastline to the east as the eastern boundary cannot satisfy the existing tolerability criteria owing to the proximity of the shoreline.
- A review of the appropriateness of the use of the existing interactive boundary criteria in light of proximity to the shore and types of vessels using the inshore passage is recommended in discussion with the MCA.

9. CONCLUSION

- The updated layout represents a significant improvement on the IB01 assessed design for the northern route, which is assessed to be tolerable.
- While the assessment of the eastern route remains intolerable, it is suggested that the unsuitability of the methodology, in particular use of the prescribed 0.5nm Distance C, IB assessment criteria for application to the eastern boundary understates the improvements achieved through the implementation of this change.

10. RECOMMENDATIONS

- A review of existing interactive boundary criteria the appropriateness and opportunities for flexibility given both the proximity of the eastern boundary to the shore and the types of vessels using the inshore passage is recommended in discussion with the MCA.

- It is recommended that the 2018 NRA is updated when the final device specific layout has been agreed to quantify the change in impact on the navigation risk profile and resultant risk scores.

ANNEX A – INTERACTIVE BOUNDARY ASSESSMENT 01 (20UK1619_RN_MM_VTS_01)

EXECUTIVE SUMMARY

This interactive boundary assessment has been undertaken by Marico Marine on behalf of Menter Môn in accordance with the methodology outlined within MGN 543, Annex 3. This assessment supplements the analysis undertaken within the 2018 Navigation Risk Assessment.

The assessment has been undertaken utilising 28-days of combined summer and winter Automatic Identification System (AIS) data and RADAR data.

The assessment has considered the northern and eastern interactive MDZ project boundaries. The proposed northern MDZ boundary lies adjacent to the ferry route utilised by Irish Ferries and Stena Line. While the eastern boundary lies adjacent to the inshore route utilised primarily by small fishing, recreational and occasionally survey vessels.

The 90th percentile shipping routes were identified and assessed in accordance with the MGN 543 shipping route guidance template to determine their tolerability. Both interactive boundaries were assessed to be intolerable, given the criteria defined within the assessment template.

Additional supporting analysis was undertaken to establish the degree to which their assessment may be flexible, including an assessment of the likelihood of mechanical failure, impact of restricted sea room in the event of turning or anchoring and the ability for vessels to overtake maintaining a safe distance in accordance with best practice.

The assessment has determined that while there is potential for flexibility at the northern interactive boundary, opportunities for flexibility at the eastern are limited, given the restrictions imposed by the proximity of the shore and the location of the tidal race. It is therefore considered that while spatial flexibility is limited, device flexibility may be considered.

It should be noted, application of the Interactive Boundary template and guidance relates primarily to the assessment of commercial routeing. As such, the appropriateness of its application to the eastern route, utilised comparatively infrequently by smaller craft with typically erratic transit patterns, is debateable. Additional methods of assessment, including qualitative assessment of standard best practice from mariner and stakeholder feedback should, therefore, also be considered in the determination of the eastern interactive boundary. Precisely where a flexible boundary should lie requires flexible definition and agreement and advice should be sought from regulators based on the evidence provided to determine their appropriateness.

INTRODUCTION

OVERVIEW

Marine and Risk Consultants Ltd. (Marico Marine) has been asked to undertake an interactive boundaries assessment of the northern and eastern boundaries of the Morlais project, in accordance with the methodology outlined within MGN 543, Annex 3 (Table 4). This assessment supplements the analysis undertaken within the 2018 Navigation Risk Assessment (**Table 1**).

SCOPE

The objectives of this study are as follows:

- Analyse vessel movements in proximity of the northern and eastern boundary of the Morlais project by; size, type and frequency;
- Identify the location of the principal shipping routes within the vicinity of the assessed boundaries;
- Review the proximity of the assessed boundaries in relation to the 90th percentile route boundaries;
- Review frequency of incidents pertaining to mechanical failure that may lead to emergency stopping / anchoring event; and
- Discuss results in relation to factors for consideration when determining shipping corridor width.

REFERENCE DOCUMENTS AND INPUT DATA

Documents referenced within this VTS are listed within **Table 1**.

TABLE 1: REFERENCE DOCUMENTS

Document Reference	Description
18UK1479_MorlaisNRA_Issue-03	Morlais Navigation Risk Assessment
Admiralty Sailing Directions NP37 – West Coast of England and Wales Pilot	Regional information on all aspects of navigation, including routeing and met-ocean conditions.

GUIDANCE

This assessment has been undertaken in accordance with the guidance outlined within **Table 2.**

TABLE 2: REFERENCE DOCUMENTS

Policy / legislation	**Description**
MGN 543, Annex 3: MCA Template for assessing distances between OREI boundaries and shipping routes.	This MGN highlights issues to be considered when assessing the impact on navigational safety and emergency response, caused by OREI developments. Including traffic surveys, stakeholder consultation, structure layout, collision avoidance, impacts on communications/ radar/ positioning systems and hydrography.
COLREGs	International Regulations for Preventing Collisions at Sea.

ASSUMPTIONS

The following assumptions apply:

- It is noted that the MGN 543 methodology makes reference to vessel route positions in relation to the ‘turbine boundary’. At this stage the device boundary location and device types to be installed are unknown, and, as such, the Morlais development boundary has been taken to represent the device boundary. In the same vein, a final tidal device layout has not yet been approved, as such, factors for consideration or assessment pertaining to minimum device separation have been omitted.

- The Annex 3 template and guidance is related to the assessment of clearly defined shipping lanes utilised by commercial vessels as opposed to poorly defined routes typically utilised by smaller craft. It is, therefore, considered that the methodology is more suitable for application to the northern as opposed to the eastern route, where transit patterns are more erratic.

- Aspects of the Annex 3 guidance are aimed specifically at assessing the interaction of shipping routes with wind farm boundaries. Factors for consideration or assessment that pertain to wind farms / turbines specifically have been omitted, for example, the potential for RADAR interference owing to proximity to wind turbines.

PROJECT DETAILS

The Morlais Development Zone (MDZ) project aims to generate renewable energy from the strong tidal flows around Anglesey. The project is located to the west of Holy Island, Anglesey, (see **Figure 1**) 500m off South Stack and occupies a total area of 35 sq.km.

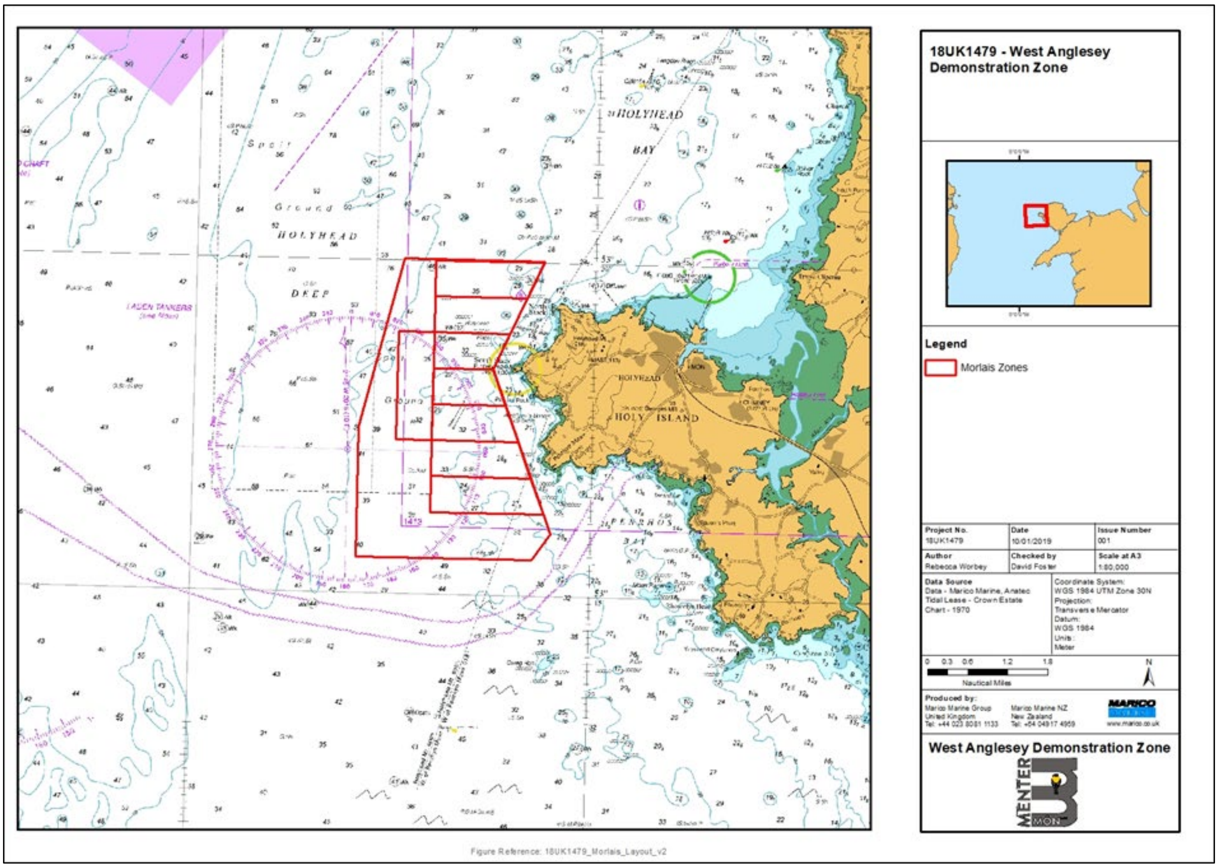


FIGURE 1: MORLAIS DEVELOPMENT ZONE

The proposed northern MDZ boundary lies adjacent to the ferry route utilised by Irish Ferries and Stena Line. While the eastern boundary lies adjacent to the inshore route utilised primarily by small fishing, recreational and occasionally survey vessels.

MET-OCEAN CONDITIONS

Generally, the region has a mild maritime climate with periods of strong winds and rough seas. Gales occur most frequently within the winter months. South-westerly gales are considered the most severe.

Waves greater than 5m are rare within the vicinity of the proposed Morlais Zone. The roughest seas are experienced with winds from between the south and north-west. 60% of seas over 2m are recorded within winter. The calmest seas occur within July. The predominant swell is from south and south-west, however, north swells increase within spring and summer.

The tidal stream is set N and S in the direction of the coast to the west of Anglesey and changes NNE SSW off the NW tip of Anglesey. The tide is strong around the promontories but is weaker within the bays. The NW coastal stream is joined by the N stream from Caernarfon Bay tending to set towards the land. The stream turns NNE around South Stack, whereas the SSW stream from North-Stack turns south across Caernarfon Bay and SE around South Stack.

A west-going eddy forms off the coast east of Penryhn Mawr during the SE going stream and there are eddies in Abraham’s Bosom and in Gogarth Bay during both streams and in both directions.

It is noted within the Admiralty Sailing Directions (ASD) that there is a rocky islet with dangerous tidal races to the west of South Stack (53˚18’.41N 4˚41’.98W) which lies close off the western extremity of Holy Island and is connected to it by means of a bridge.

INTRODUCTION

OVERVIEW

MGN 543, Annex 3 provides guidance on the approach to the assessment of interactive boundaries. The schematic represented in **Figure 2** provides a method for its assessment whereby 90th percentile traffic is identified to establish the 'nearest 90% traffic edge' as per distance C. This approach has been utilised in conjunction with the 'MGN 543, Annex 3 Shipping Route Guidance Template' outlined within **Figure 2**.

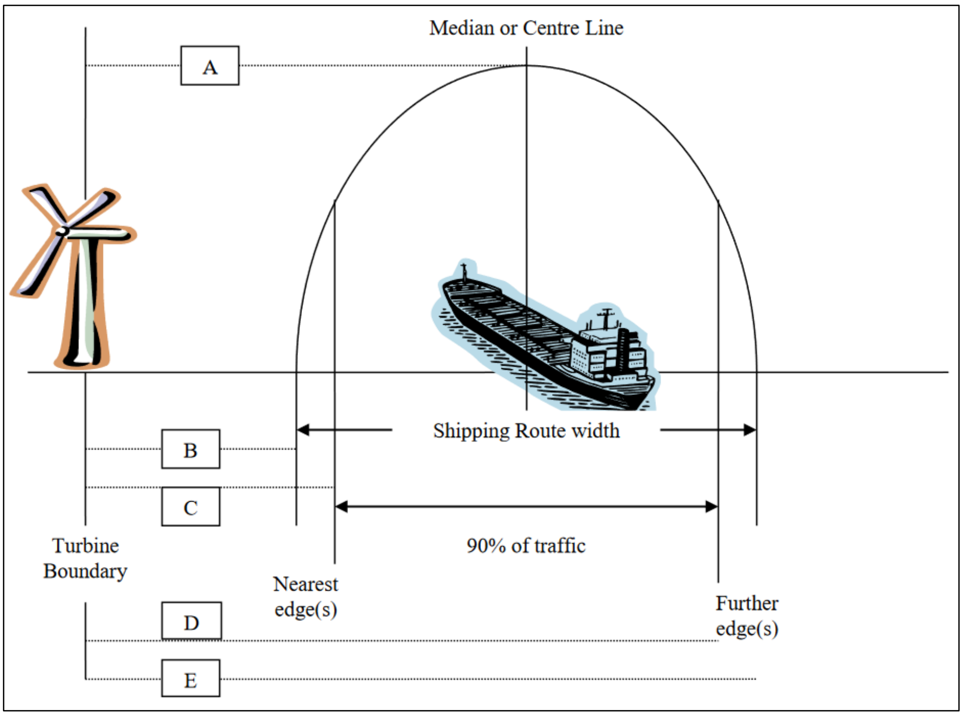


FIGURE 2: MORLAIS DEVELOPMENT ZONE

The 90th percentile routes will be determined by the analysis of vessel movements through the identified shipping routes adjacent to the northern and eastern boundary of the Morlais project. Details of the analytical processes for their delineation are given in **Section 4.**

The MGN 543 shipping route guidance template, shown within **Table 3**, to which the assumptions outlined within **Section 1.5** are applicable, will be applied to the resultant 90th percentile boundaries to determine a level of tolerability, whereby, if the distance of the nearest 90% turbine edge, as per distance C, is within <0.5nm from the turbine boundary, the interactive boundary is deemed intolerable.

Precisely where an interactive boundary should lie is not prescriptive and may require flexible definition and intelligent application on a case by case basis. Additional factors such as vessel manoeuvrability and met-ocean constraints are discussed in **Section 7** to further inform the level of risk and tolerability.

TABLE 3: SHIPPING ROUTE GUIDANCE TEMPLATE

Distance of Turbine Boundary From Shipping Route*		**Applicable Factors For Consideration**	**Tolerability**
nm	**m**		
< 0.5nm	<926m	N/A	Intolerable
0.5nm – 3.5nm	926m – 6,482m	Mariner's ship domain (vessel size and manoeuvrability). Compliance with COLREGs.	Tolerable if ALARP
>3.5nm	>6,482m	N/A	Broadly Acceptable

*(90% of traffic as per distance C, **Figure 2**).

DATA SOURCE

The principal data source in this assessment is provided from the Automatic Identification System. The assessment has been undertaken utilising 28-days of combined summer and winter Automatic Identification System and RADAR data as outlined within **Table 4.**

TABLE 4: SHIPPING ROUTE GUIDANCE TEMPLATE

Data Type	Season	Duration	Time Period
AIS	Summer	2 weeks	26th August - 09th September 2017
RADAR	Summer	2 weeks	26th August - 09th September 2017
AIS	Winter	2 weeks	05th April - 19th April 2019
RADAR	Winter	2 weeks	05th April - 19th April 2019

AUTOMATIC IDENTIFICATION SYSTEM DATA

In 2000, IMO adopted a new requirement as part of a revised Chapter V of Safety of Life at Sea (SOLAS) for ships to be fitted with the AIS. The system aims to improve a mariner's awareness of other vessels; augmenting radar, visual and sound as collision avoidance tools. AIS broadcasts key information about a vessel (such as its identity, position, type, speed and course etc.) at regular intervals through Very High Frequency (VHF) radio waves. AIS exists in two forms, Class A and Class B: the former is fitted in all vessels required to carry AIS under SOLAS; the latter on a voluntary basis by non-SOLAS vessels such as commercial fishing vessels less than 15m in length and recreational craft.

Regulation 19 of SOLAS Chapter V sets out the navigational equipment to be carried on board ships according to ship type, and AIS is required on:

- All ships of 300 and greater gross tonnage and engaged on international voyages
- Cargo ships of 500 and greater gross tonnage not engaged on international voyages
- All passenger ships irrespective of size.

In order to form a complete view of traffic operating within the eastern boundary inshore route where vessels have a propensity to be non-AIS carrying, RADAR data has additionally been assessed to overcome AIS data gaps.

SECONDARY DATA

The following secondary data sources have been utilised to supported the assessment of mechanical failure and inform the potential for emergency response.

- MAIB Incident Data.

VESSEL TRAFFIC ANALYSIS

Vessel traffic analysis to determine 90th percentile boundaries has been undertaken using the AIS and RADAR data from the vessel traffic surveys for the representative seasonal periods outlined in **Table 4** Vessel tracks identified operating within the northern and eastern routes were extracted and gate transects of appropriate length were constructed perpendicular to the routes and the associated MDZ boundary. Where the tracks intersected the gates, a transit was registered generating a frequency distribution from which 90th percentile boundaries could be determined.

NORTHERN ROUTE

The proposed northern MDZ boundary lies adjacent to the ferry route utilised by Irish Ferries and Stena Line. While the majority of passenger vessels transit clear of the northern zone boundary (**Figure 4**) , they occasionally pass within the northern two sub-zones and the western sub-zone, particularly during poor weather and met-ocean conditions when they are forced to adopt poor weather routeing to minimise the effects of rolling and cargo shift (**Figure 3**).

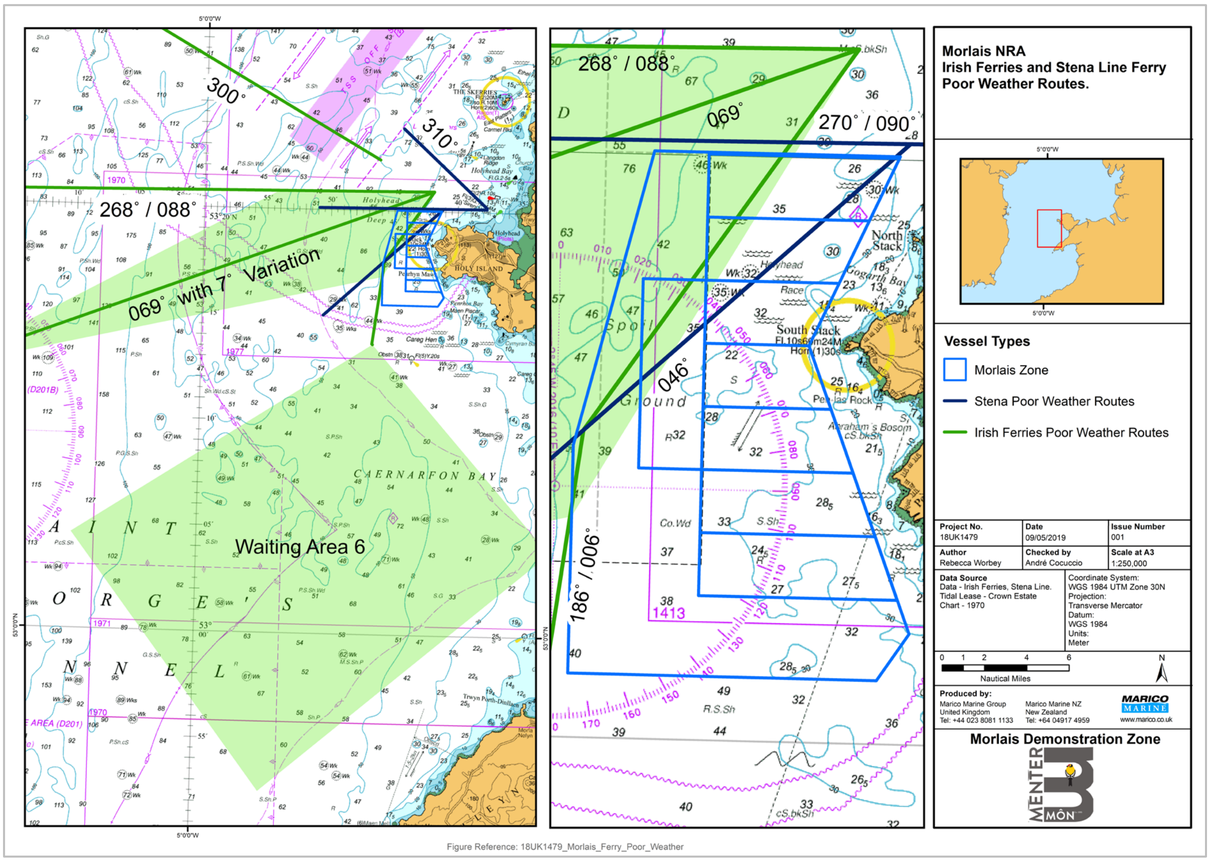


FIGURE 3: FERRY POOR WEATHER ROUTEING (SOURCE: NRA, 2018)

Vessel tracks that appeared to be utilising the poor weather routes as opposed to operating long standard fair-weather route were removed from the analysis, as their inclusion would have served to skew the identification of the 90% boundary location. Also removed were any non-commercial vessels operating perpendicular to or not in adherence to the lane, such as fishing or recreational vessels.

The assessed vessel tracks are shown in **Figure 4**. A total of 292 vessels transited the route during the assessed summer 2017 period and 234 during the assessed winter 2019 period equating to 21 vessels and 17 vessels a day respectively. Two gates of north/south direction were created perpendicular to the north of the site boundary and ferry route through which individual transits were generated. It is noted that in some cases, tracks were unique to a single gate as not all tracks transited both gates.

NORTHERN ROUTE – GATE ANALYSIS

The results of the gate analysis are given in **Figure 5,** which illustrates that during summer, a greater frequency of vessel transits were recorded. The density of transits is greatest through the eastern gate and disperses through the western gate as the ferry route widens, and vessels deviate onto an alternative course. The distribution of transits during the winter period is less well-defined with greater utilisation of poor weather routeing.

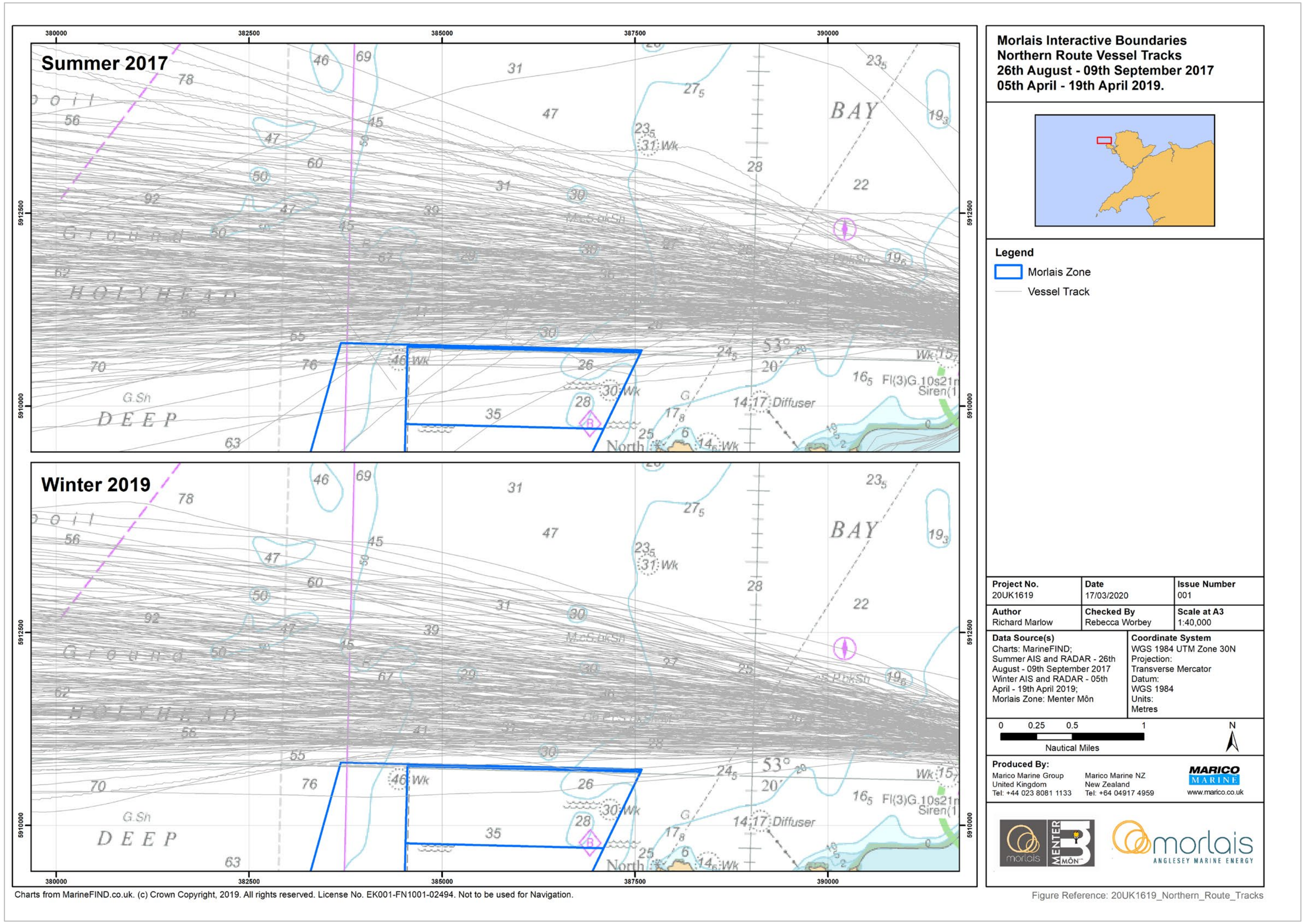


FIGURE 4: NORTHERN ROUTE TRACKS

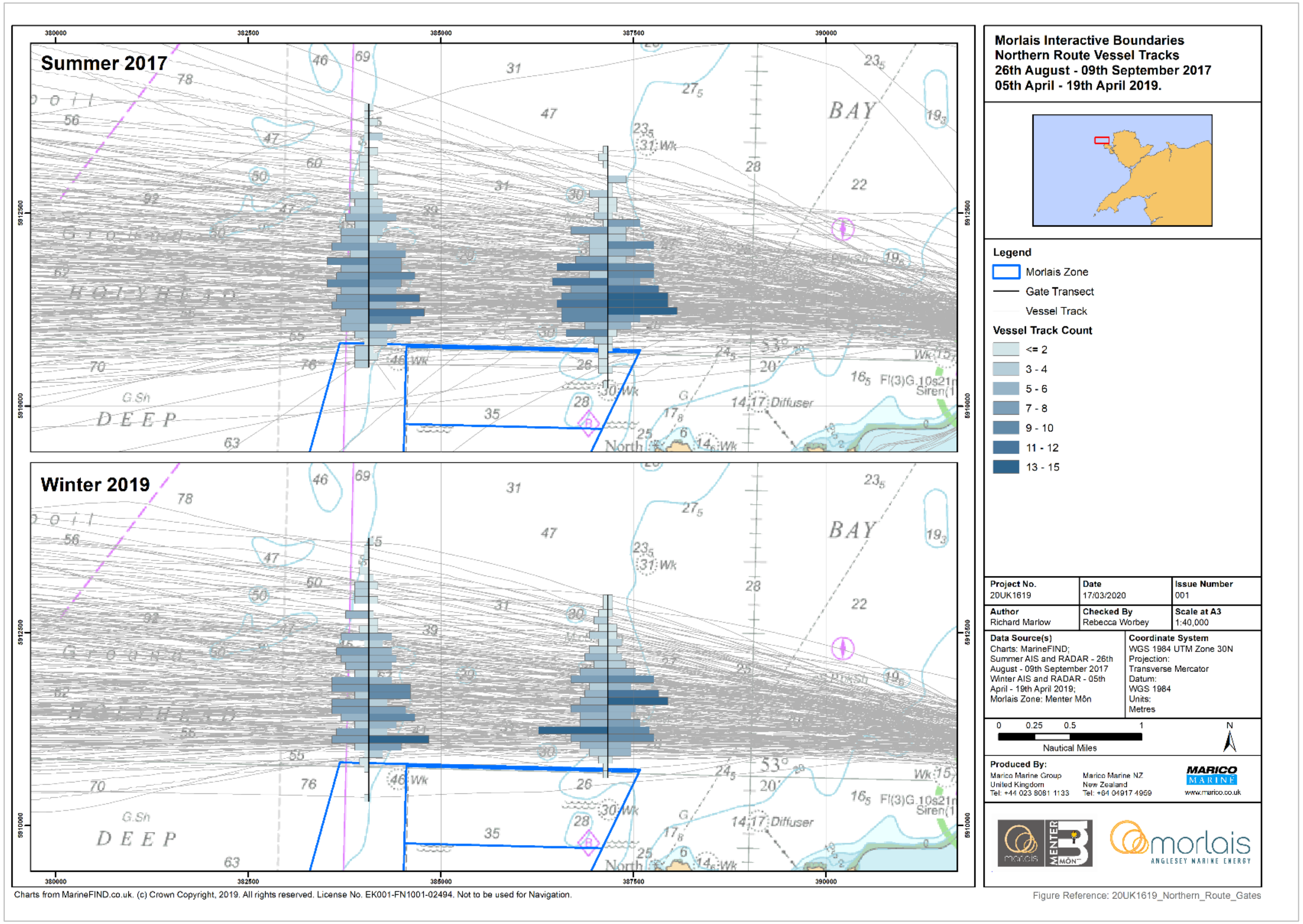


FIGURE 5: GATE ANALYSIS - NORTHERN ROUTE

Transits through the northern gates have been analysed according to type in **Figure 6**. The most common vessel type to transit the gates in both periods were passenger vessels, accounting for 76% of all transits during summer and 89% during winter. The high-speed passenger vessels, JONATHAN SWIFT and DUBLIN SWIFT, accounted for 20% of all transits during summer and 12% in winter respectively. Recreational and support vessels accounted for the remaining 4% in the summer. These vessel types were not present during the winter period.

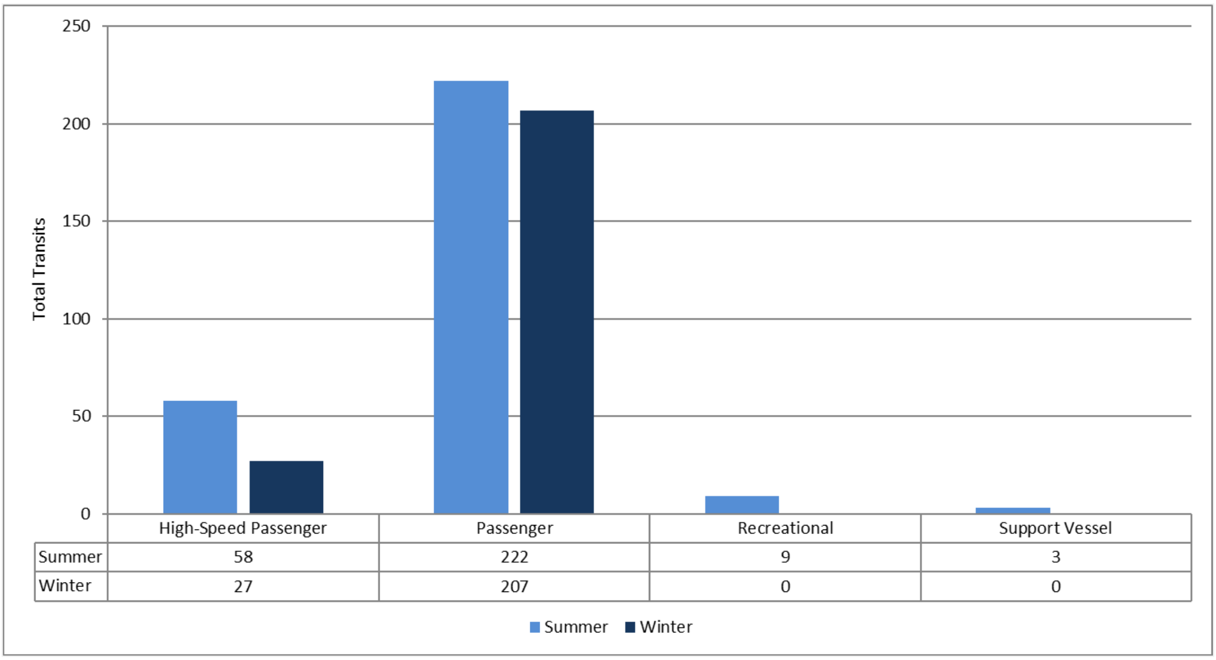


FIGURE 6: FREQUENCY OF TRANSITS BY VESSEL TYPE – NORTHERN ROUTE

Figure 7 demonstrates transits through the northern gate by LOA. The majority of vessels in both assessed periods were greater than 200m LOA reflecting the predominance of passenger vessels. 21% of the vessels during the summer period were a result of the presence of the High-Speed Passenger vessel JONATHAN SWIFT (LOA 87m) run by Irish Ferries. The remaining 4% of the summer vessels under 100m LOA were recreational, small passenger and support vessels. During the winter period, all identified vessels were greater than 100m LOA.

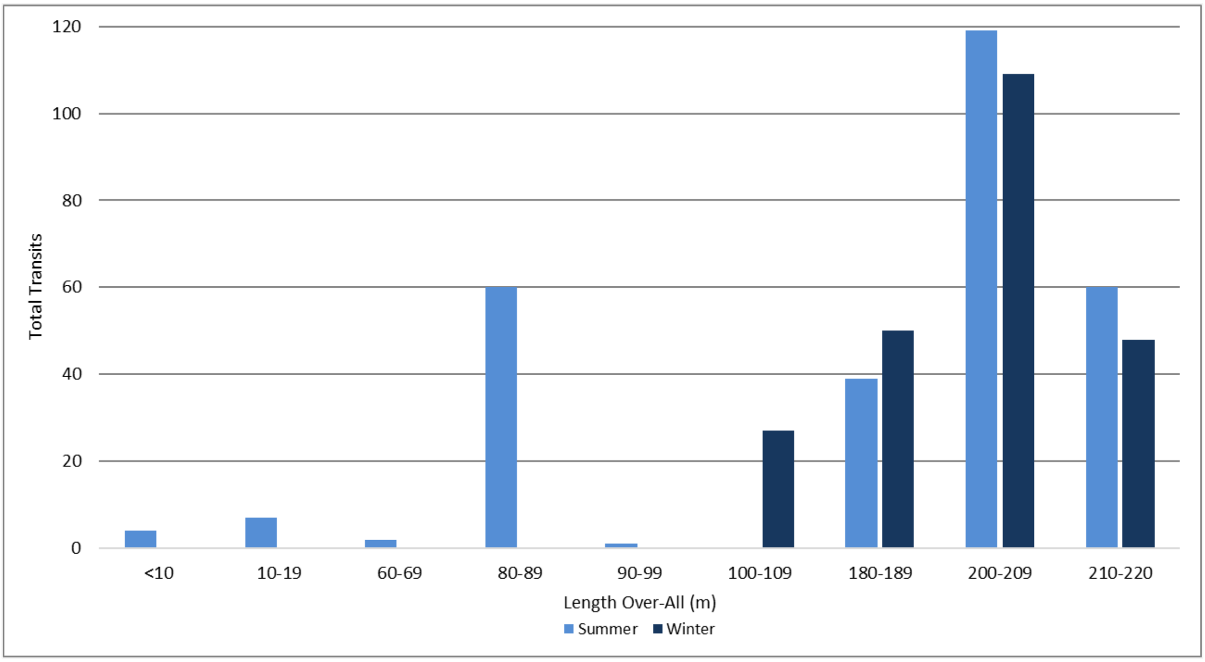


FIGURE 7: VESSEL TRANSITS BY LOA – NORTHERN ROUTE

NORTHERN ROUTE - 90% SHIPPING BOUNDARIES

The results of the 90% boundary assessment is shown in **Figure 8**. A polygon, representing the outer extent of the route (100% traffic) is shown for comparison. For the winter period, the results show that 90% of the vessel traffic transiting the ferry route is outside of the northern extent of the Morlais site boundary, however, during the summer period, the 90th percentile boundaries overlaps the northwest edge of the site boundary by up to 19m (See also **Table 5**).

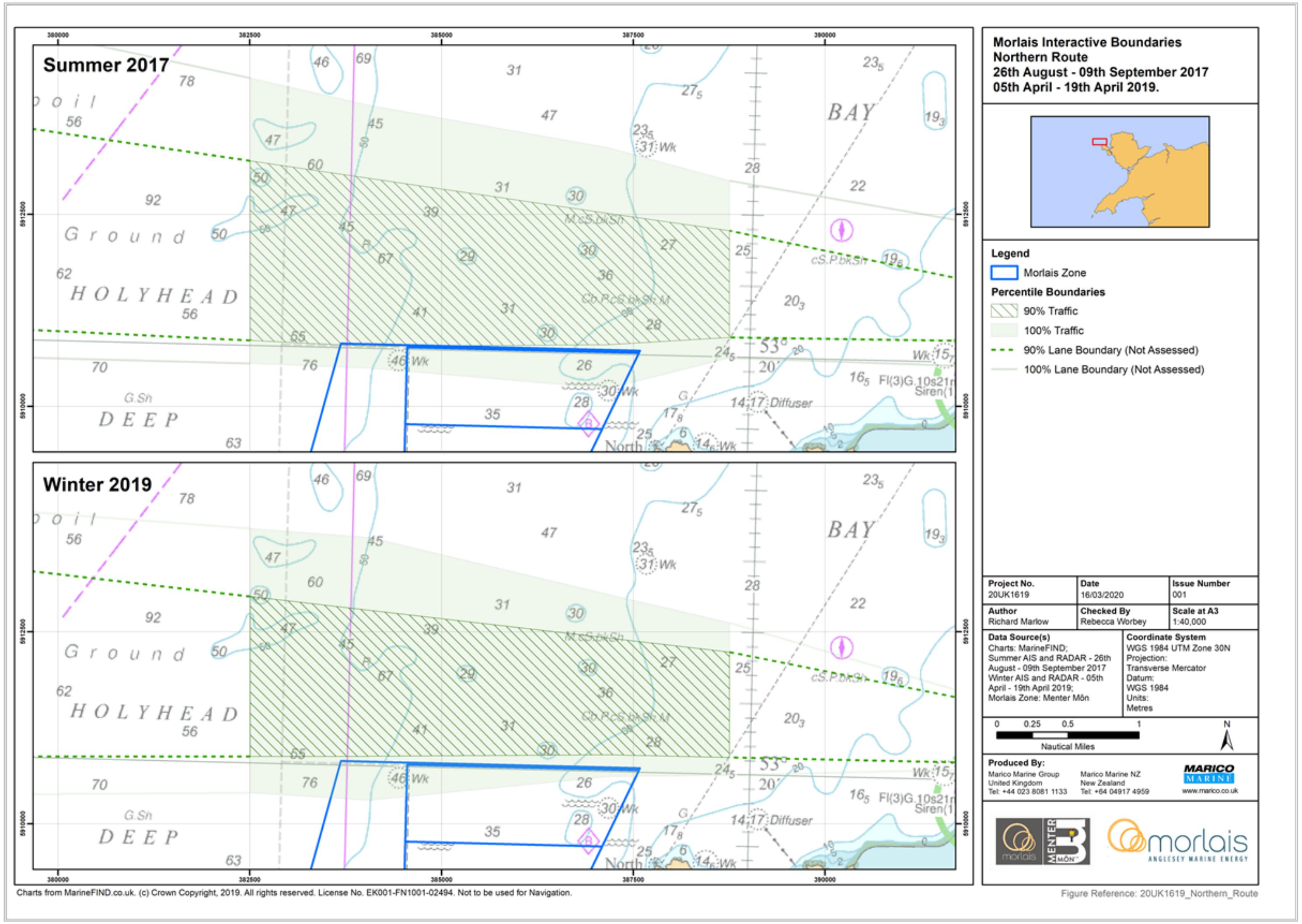


FIGURE 8: 90% SHIPPING BOUNDARIES – NORTHERN ROUTE

EASTERN (INSHORE) ROUTE

The eastern route is characterised by fishing and recreational craft and occasional service vessels. The route extends along the eastern extent of the Morlais site boundary from North Stack to Penrhyn Mawr. The route corridor is 0.26nm (474m) at South Stack.

Four gate transects were utilised to derive the 90th percentile boundaries of the eastern (inshore) route as shown in **Figure 10.** Given the propensity for these transits to be more erratic (**Figure 9**), a method was adopted whereby tracks were extracted where a vessel was clearly transiting within, and on a course to remain within, the inshore route at the point the track intersected the gate transect. Subsequently, some tracks may not have been present within each gate, if their course deviated away from the inshore route before transiting the next gate. The vessel tracks used for the analysis are shown in **Figure 9**. A total of 65 vessels transited the route during the summer 2017 period and 27 during the winter 2019 period equating to 5 vessels and 2 vessels a day respectively.

EASTERN (INSHORE) ROUTE – GATE ANALYSIS

The transits through the eastern route have been analysed according to type in **Figure 11**. The most common vessels to transit the gates in both periods were recreational vessels, accounting for 66% of all transits during the summer and 67% during the winter. Fishing vessels were of greater prominence during the summer period (12%) than the winter period (7%). RNLI lifeboats accounted for 8% of the total support vessel transits in the summer period. Support vessels accounted for a quarter of the transits in the winter period (26%) – 18% of these were survey vessels, the remaining 7% were RNLI lifeboats. Other vessels (unidentified from RADAR) accounted for the remaining 3% of transits in the summer and were not present during the winter period.

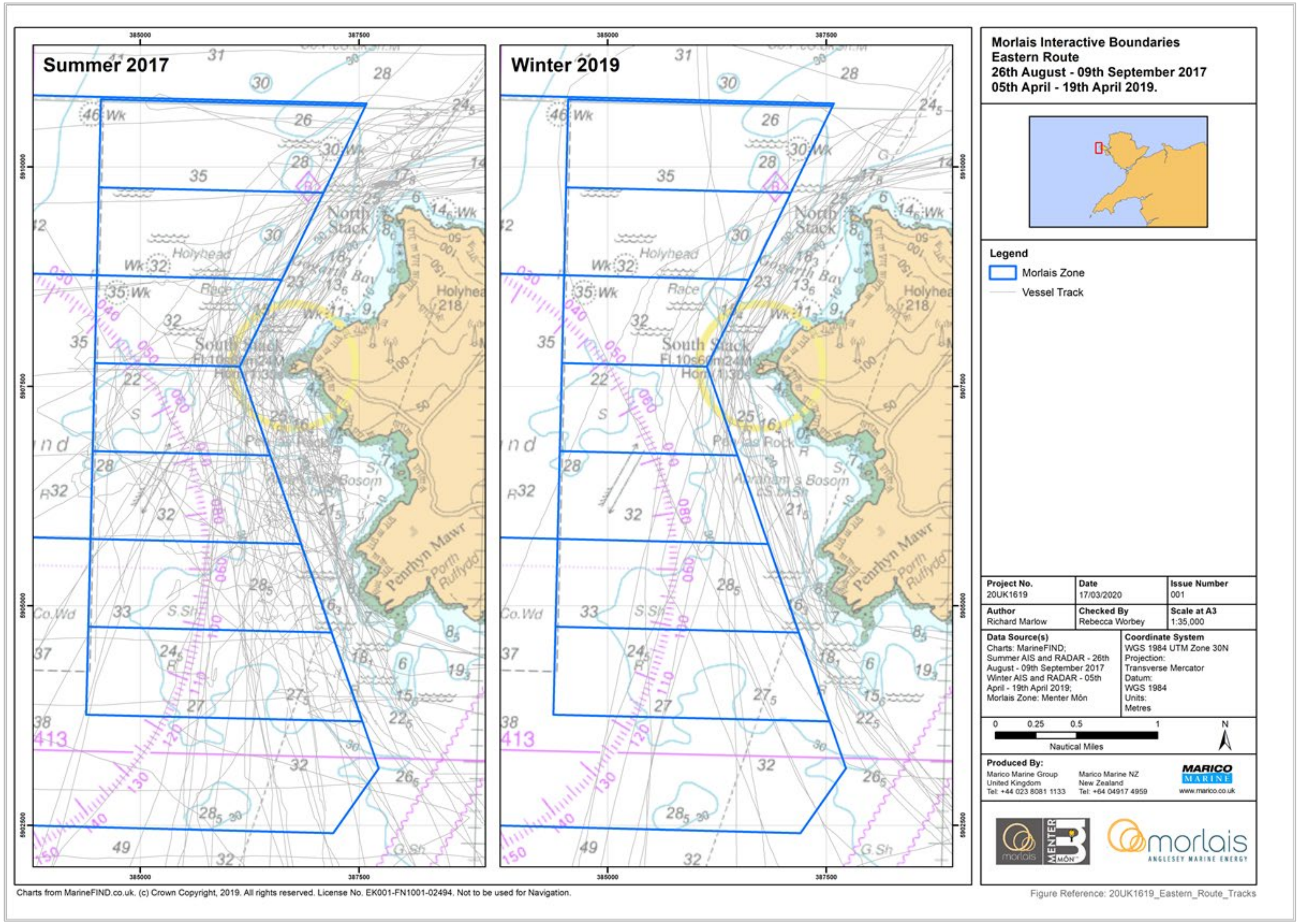


FIGURE 9: EASTERN ROUTE TRACKS

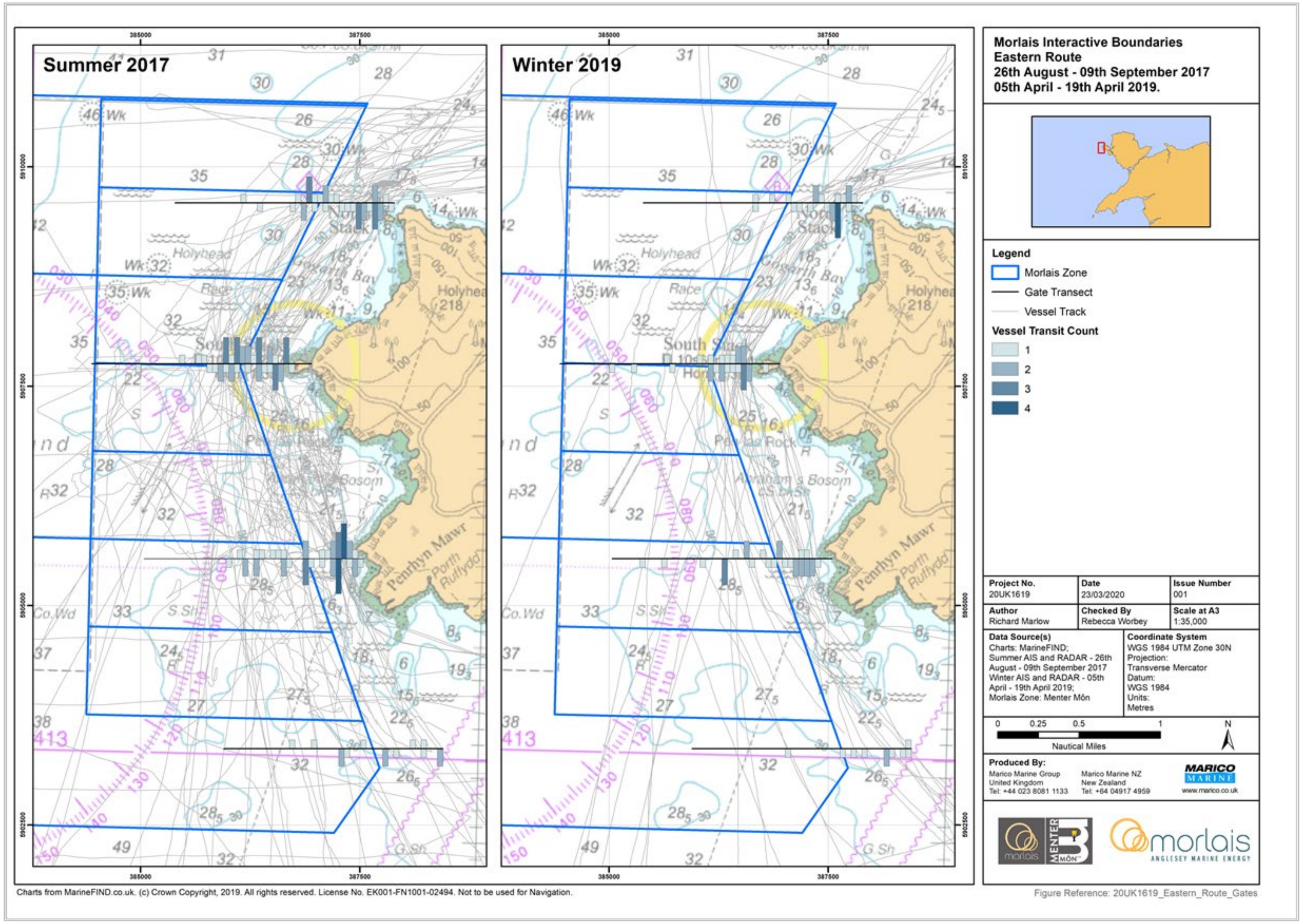
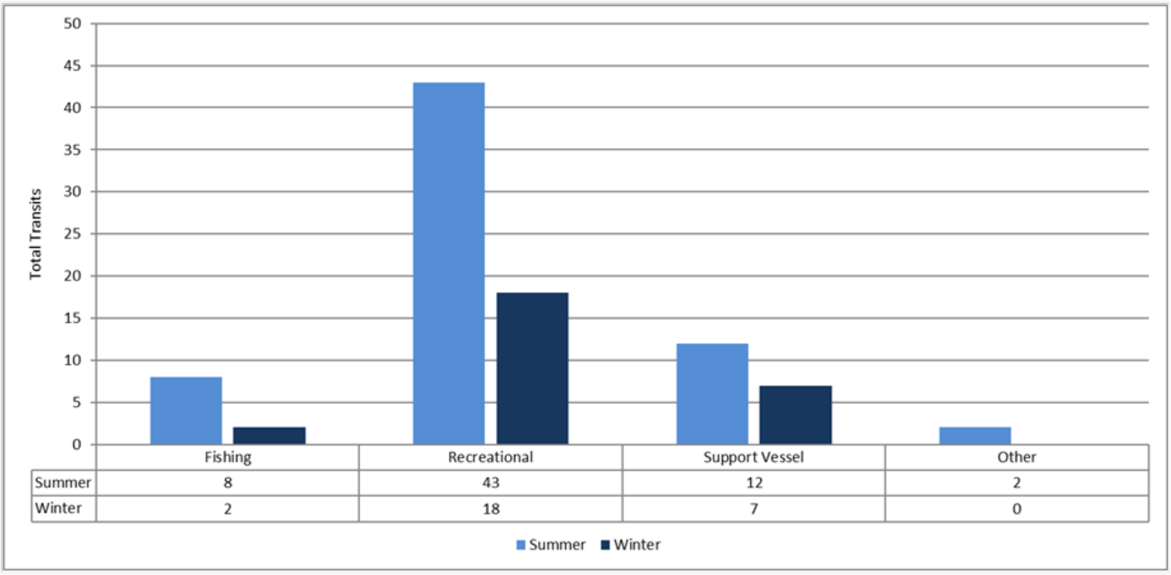


FIGURE 10: GATE ANALYSIS - EASTERN ROUTE



	Fishing	Recreational	Support Vessel	Other
Summer	8	43	12	2
Winter	2	18	7	0

FIGURE 11: FREQUENCY OF TRANSITS BY VESSEL TYPE – EASTERN ROUTE

Figure 12 demonstrates eastern route transits by LOA. Approximately one third of vessels (37%) in the summer and winter were between 10m and 14m LOA. A large proportion of tracks recorded were less than 5m LOA (45% summer, 30% winter). Please note, the length of vessels recorded from RADAR are unknown and as such were recorded as 0m LOA. These vessels are likely to be between 5 and 15m as is characteristic of recreational and fishing vessel lengths, and reflective of other typically observed vessel lengths operating within the inshore route.

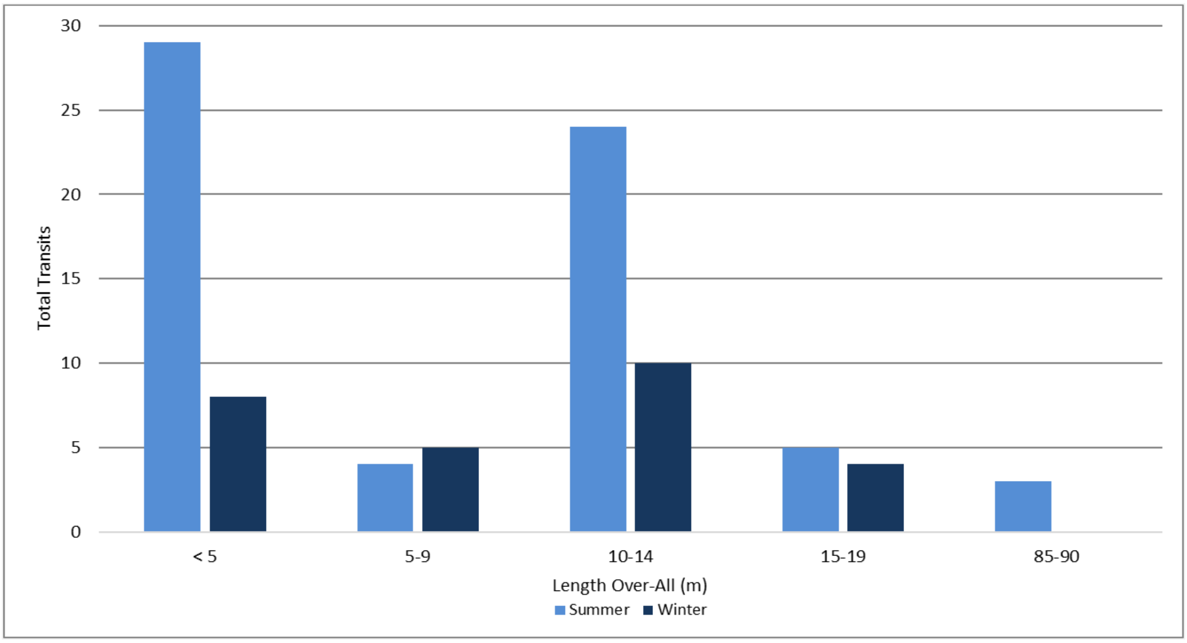


FIGURE 12: VESSEL TRANSITS BY LOA – EASTERN ROUTE

EASTERN ROUTE - 90% SHIPPING BOUNDARIES

The results of the 90% assessment for the eastern route is given in **Figure 13**. A polygon representing the outer limits of 100% of the assessed vessel tracks has been included for comparison.

The results show that the 90% boundary overlaps the eastern extent of the Morlais site boundary at all gate locations, up to a maximum of 530m (0.29nm).

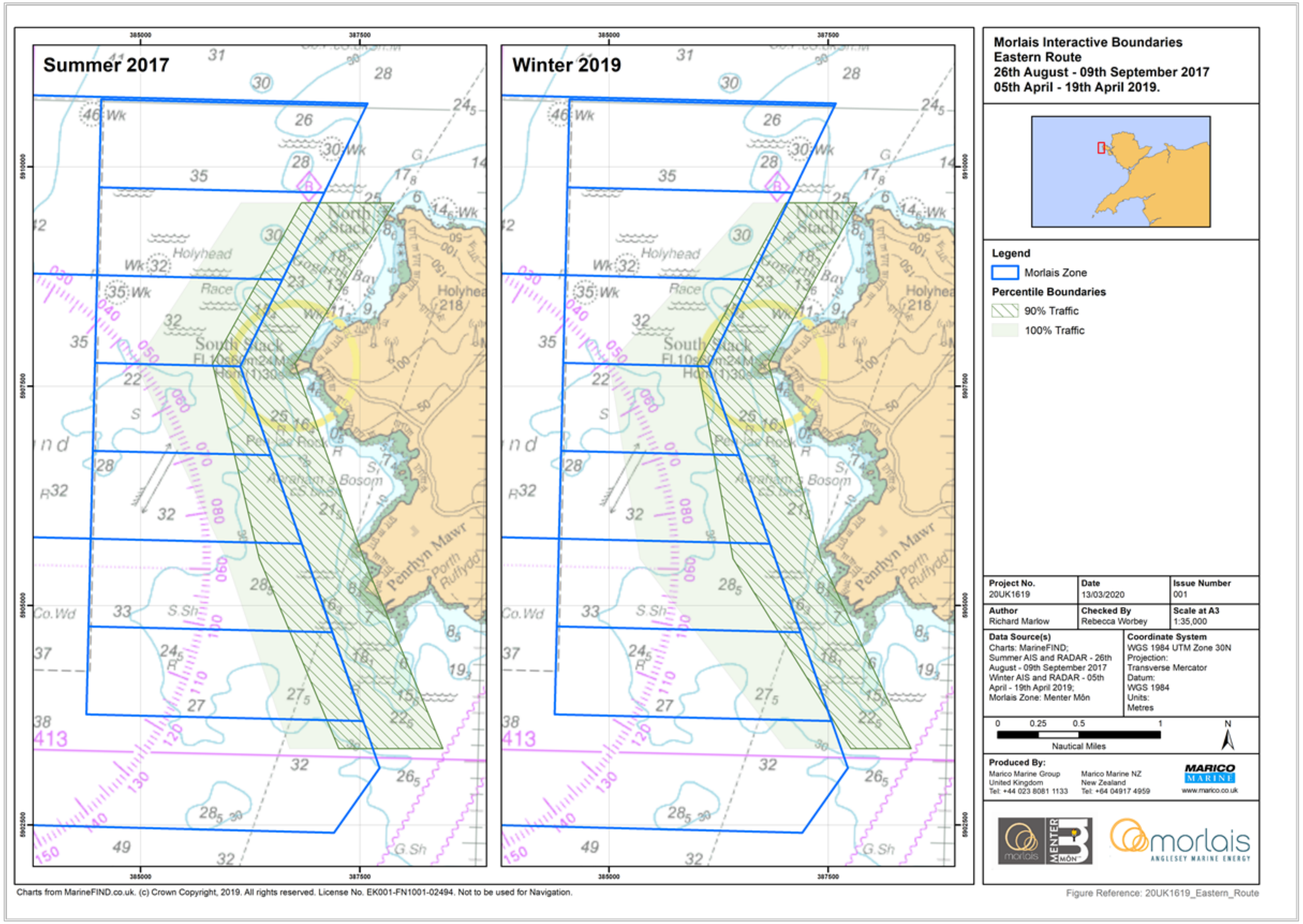


FIGURE 13: 90% SHIPPING BOUNDARIES – EASTERN ROUTE

VESSELS AT ANCHOR

Engine failures whilst using a transit lane might necessitate emergency or unplanned anchoring, restricting available sea room for other vessels. Dependant on the depth of water, the swinging circle of a large vessel may be wide. Vessel routes must, therefore, allow sea room enough for vessels to maintain a safe berth from the swinging circle of the vessel at anchor.

The following formula from the Admiralty Manual of Seamanship has been utilised to calculate the length of cable required within a given depth of water:

$$\text{Amount of cable required (in shackles)} = 1.5 * \sqrt{Depth\ (metres)}$$

Swinging distances are calculated from the length of cable required, plus the length of the vessel. Safety margins, the minimum comfortable passing distance from another vessel should also be considered when assessing swinging distances. In applying this parameter, a safe distance is ensured in scenarios with adverse timing and environmental influences. A general safety allowance for larger vessels is considered to be three cables (555.6m), or two ships lengths.

Figure 14 demonstrates the swinging distances of the 2 largest vessels from the analysis period within the northern and eastern (inshore), to assess the impact to sea-room when anchored. Based on the above formula with an average water depth of 35m, the passenger vessel STENA ADVENTURER (211m LOA) would require 455m of sea-room and the 86m LOA Trinity House vessel PATRICIA, offshore of South Stack in water depths averaging 30m, would require 311m of sea-room. It should be noted that these are minimum estimations with no additional safety allowances applied.

TURNING CIRCLES

Standard turning circles for vessels are worked on six times the ship’s length. This is a particularly good assumption when vessels on ocean or deep-sea passage will not have the same manoeuvrability as when engines and systems are prepared for port approach.

Analysis has been undertaken to establish the maximum turning circles of vessels within both the eastern (inshore) and northern routes. Irish Ferries operated ULYSSES at a LOA of 209m would require a 1,224m turning circle whereas 86m LOA Trinity House vessel PATRICIA would require 516m. The results are presented in **Figure 15**.

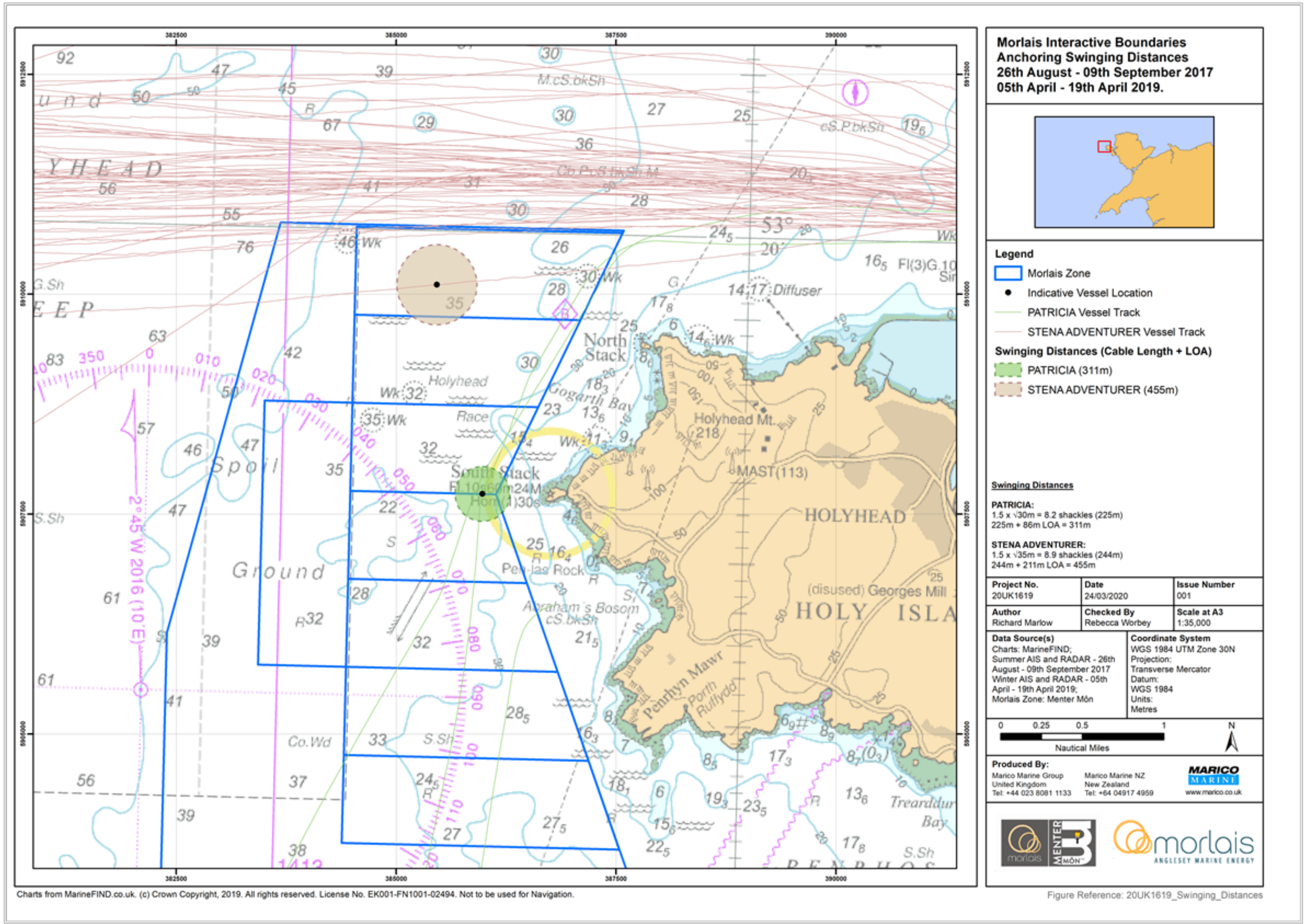


FIGURE 14: SWINGING DISTANCES WHILE AT ANCHOR

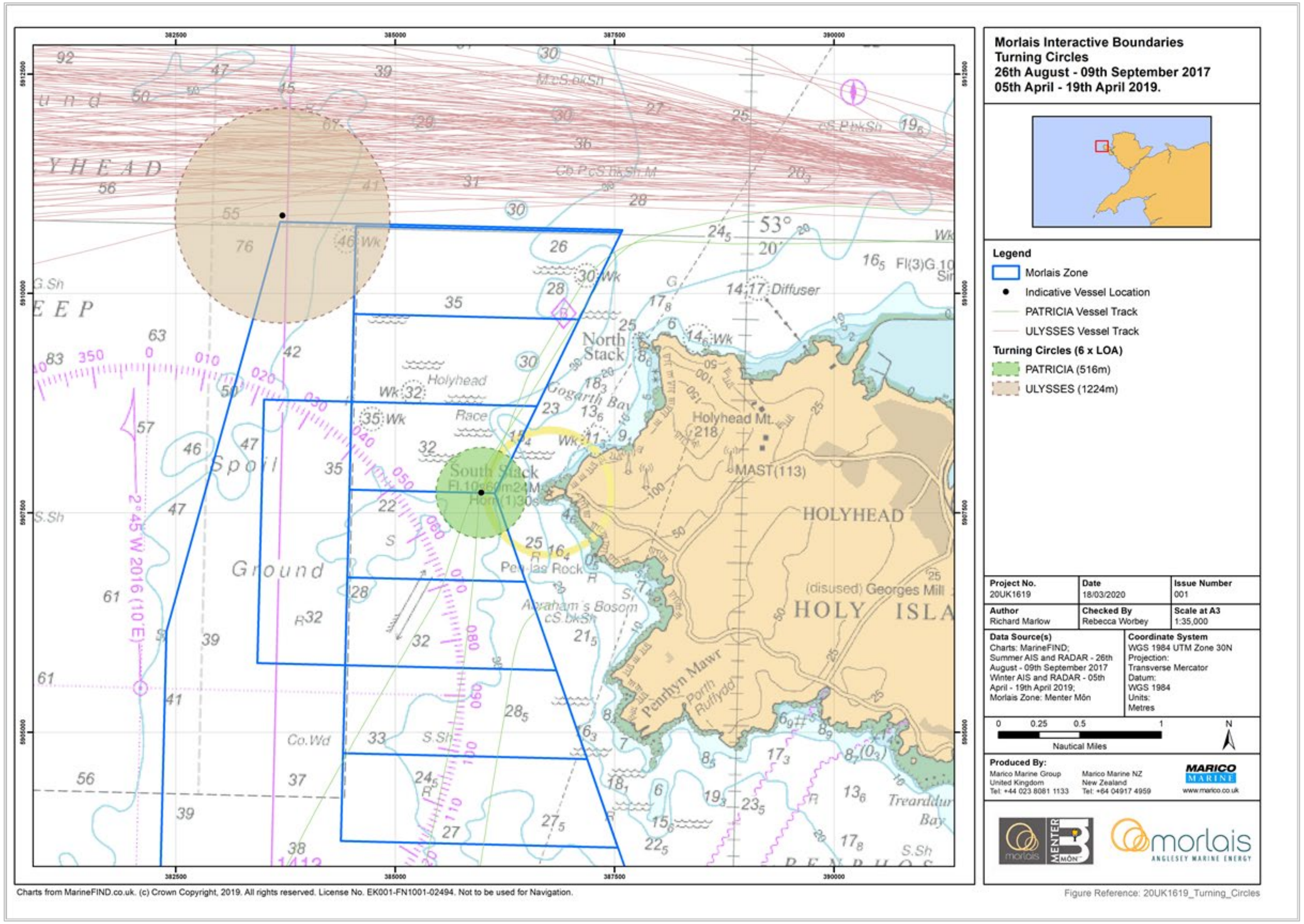


FIGURE 15: TURNING CIRCLES

HISTORIC INCIDENTS

Engine failures whilst using a transit lane might necessitate emergency or unplanned anchoring, restricting available sea room for other vessels needing to maintain a safe berth from the swinging circle of the vessel at anchor.

Marine Accident Investigation Branch data has been analysed to establish historic rates of mechanical failure in vicinity of the northern and eastern routes. In the 20-year period between 1997 and 2015 there were six reported machinery failures equating to < 1 every 3 years. All recorded mechanical failures occurred within vicinity of the inshore passage, five of which occurred to fishing vessels of between 7m and 28m LOA and one was attributed to 26m LOA dry cargo vessel. The most recent mechanical failure was in 2010. There were no mechanical failures recorded by ferries within the northern route.

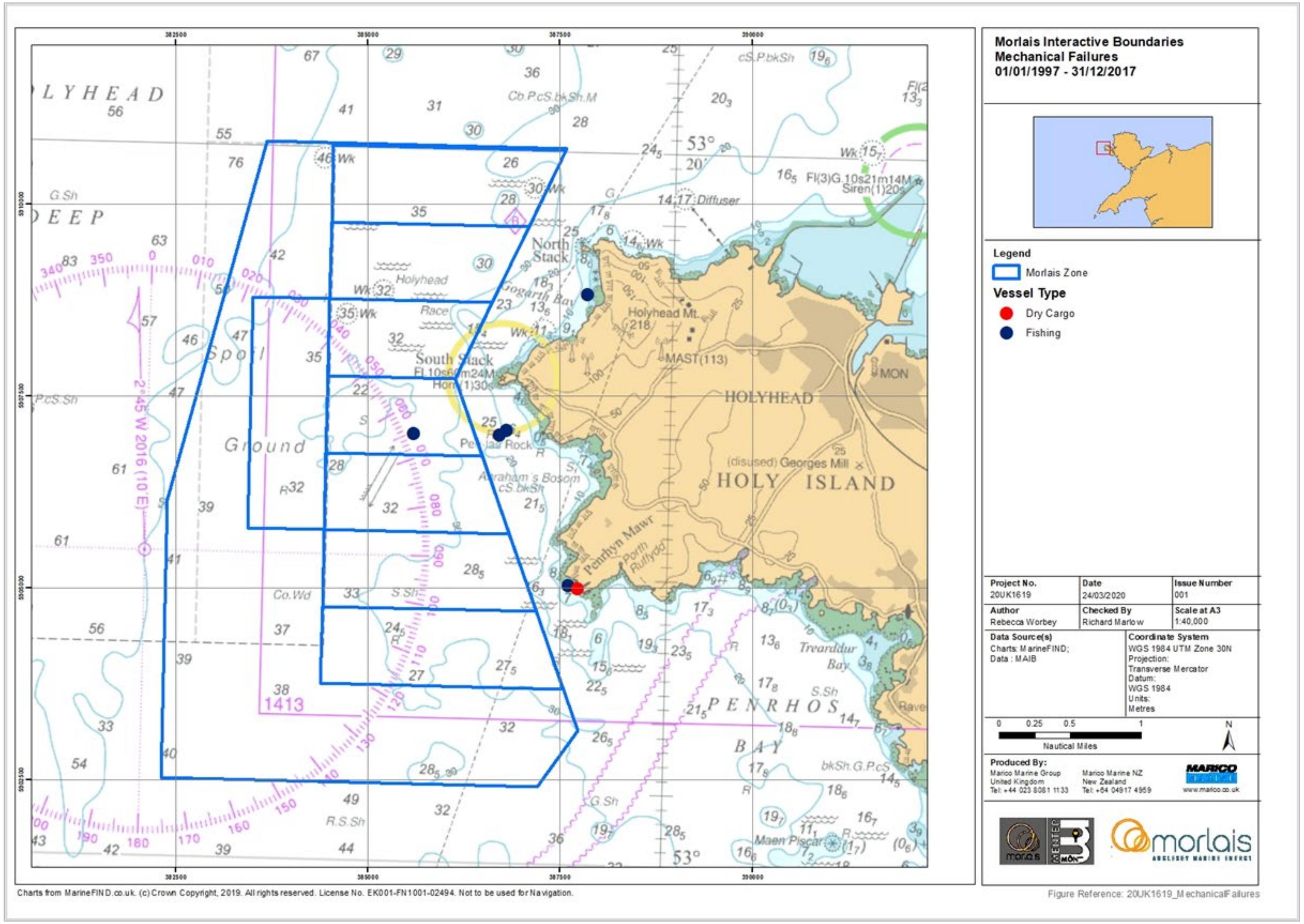


FIGURE 16: MECHANICAL FAILURES BY VESSEL TYPE (1997 – 2017)

RESULTS

The results of the 90th percentile analysis, in reference to the MGN 543 shipping route guidance template shown within **Table 3**, are shown in **Table 5.**

Given the tolerability criteria specified within **Table 3**, both interactive boundaries are assessed to be intolerable. This is particularly true for the eastern route where the 90% route boundaries across all gates extending within the MDZ boundary by between 0.07nm and 0.17nm at South Stack. A complete list of measurements for A-C criteria depicted within **Figure 2** is given in **Annex A.**

TABLE 6: INTERACTIVE BOUNDARY ASSESSMENT RESULTS

Criteria			Result (m)		Result (nm)		Tolerability
			Summer	Winter	Summer	Winter	
Northern Route							
C	Turbine boundary to nearest shipping 90% traffic level		-19	55.5	-0.01	0.03	Intolerable
Eastern Route							
C	Turbine boundary to nearest shipping 90% traffic level	Worst Case	-537	-482	-0.29	-0.26	Intolerable
		South Stack	-315	-130	-0.17	-0.07	

SUMMARY

NORTHERN ROUTE

An assessment of sea room requirements using data supported by the PIANC assessment for channel design, has been undertaken that concluded that, in general, an obstacle free (buffer) zone of 2nm should be maintained between windfarms and shipping lanes. Should a similar buffer be required between the northern MDZ boundary and the ferry route this would cause either a significant re-route of the ferry route or MDZ boundary re-design.

It is considered that there is opportunity for the northern interactive boundary to be flexible as discussed below:

- The northern boundary is dominated by ferry's that are operated by experienced crew along a well-established route. Bridge tams are normally of high-standard and, therefore, vessels have high bridge awareness.
- The ferry route is not limited to the north, as such adequate sea room requirements are maintained and four ships should be safely able to pass one another maintaining a distance of two ship's lengths in accordance with best practice and as stipulated within MGN 543, Annex 3. The likelihood of four ferries passing is minimal.
- Ferry engines are instantly available to immediate manoeuvre and ferries are highly manoeuvrable, in comparison to a standard commercial vessel of a similar size.
- Anchoring is well practiced and will minimally restrict sea-space owing to the availability of sea-space to the north.
- The availability of support service access to the northern route from Holyhead RNLI is unimpacted as vessels may route to north the MDZ boundary to access vessels in need of assistance within the northern route.
- Engine failures, which could necessitate emergency or unplanned anchoring, restricting the available sea room for other users are rare with no mechanical failures recorded in proximity to the northern route within 20 years of MAIB data between 1997 and 2017.

EASTERN ROUTE

Given the existing MDZ eastern boundary location, the maximum available navigable space within the inshore route past South Stack is 0.26nm (474m). As such, it is unlikely to for 90% of inshore route traffic to be able to fall within tolerable limits given the tolerability criteria outlined within **Table 3** and given the requirement to transit at a safe distance from the shore.

Opportunities for the interactive boundary to be flexible are limited within the eastern inshore route:

- Vessels are unable to distance themselves from the device boundary to provide more comfort without significant penalty owing to the proximity of the shore. Admiralty Sailing Directions states that there is a rocky islet with dangerous tidal races to the west of South Stack (53˚18'.41N 4˚41'.98W). Therefore, vessels need room enough to be able to transit at a safe distance from the shoreline, to prevent being set-on to the shore by the tidal race and inclement sea conditions.

- While there is opportunity for flexibility from a device perspective, there are spatial limitations owing to the position of the tidal stream.

- Generally, recreational vessels will be able to reverse course and turn, within 6 times their length. Large recreational / fishing vessels up to 20m (**Figure 12**) will therefore be able to complete a turn within 120m. Larger vessels utilising the route such as 86m LOA Trinity House vessel PATRICIA, will require over 500m and as such would struggle to complete a turn within the available space in the vicinity of South Stack and other promontories.

- The vessel traffic frequency is lower than that of the northern route with approximately 5 vessel transits per day in summer and 2 pe day in winter. As such, the propensity for meeting and overtaking other vessels is significantly lower when compared to the northern route.

- As opposed to ferries, recreational and small fishing vessels generally have less experienced crew and are less able to respond quickly to an emergency.

- While some yachts are instantly able to access anchors, others must undo a lock to get the anchor back on deck and, therefore, readiness to use anchors depends upon the vessel class. It is noted, however, that owing to the depth of water, the vast majority of vessels (small recreational vessels for example) utilising the inshore route will not be able to anchor as, they will not have the available cable length to reach the sea-bed.

- Engine failures, which could necessitate emergency or unplanned anchoring, restricting the available sea room for other users are rare with six mechanical failures recorded in proximity to the eastern inshore route within 20 years of MAIB data between 1997 and 2017.

It should be noted, application of the Annex 3 template and guidance relates primarily to the assessment of commercial routeing. As such, the appropriateness of its application to the eastern route, utilised comparatively infrequently by smaller craft with typically erratic transit patterns is debateable. Additional methods of assessment, including qualitative assessment of standard best practice from mariner and stakeholder feedback should, therefore, also be considered in the determination of the eastern interactive boundary.

CONCLUSION

This assessment has concluded that, when the MGN 543 Interactive boundary formula, as described within Annex 3, is strictly applied both the northern and eastern boundaries are intolerable. This is particularly true for the eastern, inshore route. Additional supporting analysis has been undertaken to establish the degree to which their assessment may be flexible and has determined that while there is potential for flexibility at the northern interactive boundary, opportunities for flexibility along the eastern boundary are limited. Precisely where an interactive boundary should lie requires flexible definition and agreement and advice should be sought from regulators based on the evidence provided to determine their appropriateness.

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CHIRP Maritime (2017), Anchoring and Anchoring Equipment: https://www.chirpmaritime.org/wp-content/uploads/2017/12/2017-12-Anchoring-and-Anchoring-Equipment.pdf.

IMO (1972) Convention on the International Regulations for Preventing Collisions at Sea (COLREGs).

Marico Marine (2018), 18UK1479_MorlaisNRA_Issue-03.

MCA (2016) MGN 543 Offshore Renewable Energy Installations Safety Response, Annex 3: shipping template, assessing wind farm boundary distances from shipping routes.

UKHO (2017), Admiralty Sailing Directions NP37 – West Coast of England and Wales Pilot

ANNEX B – IB ASSESSMENT RESULTS

IB01

Criteria			Result (m)		Result (nm)		Tolerability
			Summer	Winter	Summer	Winter	
Northern Route							
A	Turbine boundary to shipping route median*		870.4	1,018.6	0.44	0.45	N/A
B	Turbine boundary to nearest shipping route edge		-500	-518.6	-0.16	-0.28	N/A
C	Turbine boundary to nearest shipping 90% traffic level		-18.5	55.6	-0.01	0.03	Intolerable
D	Turbine boundary to further shipping 90% traffic level		1,740	1,667	0.94	0.90	N/A
E	Turbine boundary to further shipping route edge		2,537	2,185	1.37	1.18	N/A
Eastern Route							
A	Turbine boundary to shipping route median*	Worst Case					N/A
		South Stack	148	333	0.08	0.18	
B	Turbine boundary to nearest shipping route edge	Worst Case	-1,185	-1,537	-0.64	-0.83	N/A
		South Stack	-1,185	-1,130	-0.64	-0.61	
C	Turbine boundary to nearest shipping 90% traffic level	Worst Case	-537	-482	-0.29	-0.26	Intolerable
		South Stack	-315	-130	-0.17	-0.07	
D	Turbine boundary to further shipping 90% traffic level	Worst Case	630	537	0.34	0.29	N/A
		South Stack	630	685	0.34	0.37	
E	Turbine boundary to further shipping route edge	Worst Case	630	537	0.34	0.29	N/A
		South Stack	474	474	0.26	0.26	

* Based on median of 90th percentile route

IB02

Criteria			Result (m)		Result (nm)		Tolerability
			Summer	Winter	Summer	Winter	
Northern Route							
A	Turbine boundary to shipping route median*		2,074.24	2,037.2	1.12	1.1	N/A
B	Turbine boundary to nearest shipping route edge		555.6	592.64	0.3	0.32	N/A
C	Turbine boundary to nearest shipping 90% traffic level		1,018.6	1,111.2	0.55	0.6	Tolerable
D	Turbine boundary to further shipping 90% traffic level		2,889.12	2778	1.56	1.5	N/A
E	Turbine boundary to further shipping route edge		3,704	3,407.68	2	1.84	N/A
Eastern Route							
A	Turbine boundary to shipping route median*	Worst Case	481.52	481.52	0.26	0.26	N/A
		South Stack	592.64	740.8	0.32	0.4	
B	Turbine boundary to nearest shipping route edge	Worst Case	-685.24	-1037.12	-0.37	-0.56	N/A
		South Stack	-685.24	-629.68	-0.37	-0.34	
C	Turbine boundary to nearest shipping 90% traffic level	Worst Case	-37.04	14.816	-0.02	0.008	Intolerable
		South Stack	185.2	370.4	0.1	0.2	
D	Turbine boundary to further shipping 90% traffic level	Worst Case	888.96	981.56	0.48	0.53	N/A
		South Stack	1000.08	1000.08	0.54	0.54	
E	Turbine boundary to further shipping route edge	Worst Case	888.96	981.56	0.48	0.53	N/A
		South Stack	1000.08	1000.08	0.54	0.54	