RWE Renewables UK Dogger Bank South (West) Limited

RWE Renewables UK Dogger Bank South (East) Limited

Dogger Bank South Offshore Wind Farms

Appendix 10-3 Back-calculation of the Peak Atlantic Herring Spawning Period

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Glossary

Term	Definition
Array Areas	The DBS East and DBS West offshore Array Areas, where the wind turbines, offshore platforms and array cables would be located. The Array Areas do not include the Offshore Export Cable Corridor or that part of the Inter-Platform Cable Corridor within which no wind turbines are proposed. Each area is referred to separately as an Array Area.
Dogger Bank South (DBS) Offshore Wind Farms	The collective name for the two Projects, DBS East and DBS West.
Impact	Used to describe a change resulting from an activity via the Projects, i.e. increased suspended sediments / increased noise.
Offshore Development Area	The Offshore Development Area for ES encompasses both the DBS East and West Array Areas, the Inter-Platform Cable Corridor, the Offshore Export Cable Corridor, plus the associated Construction Buffer Zones.
Offshore Export Cable Corridor	This is the area which will contain the offshore export cables between the Offshore Converter Platforms and Transition Joint Bays at the landfall.
Sediment	Particulate matter derived from rock, minerals or bioclastic matter.
The Projects	DBS East and DBS West (collectively referred to as the Dogger Bank South Offshore Wind Farms).
The Applicants	The Applicants for the Projects are RWE Renewables UK Dogger Bank South (East) Limited and RWE Renewables UK Dogger Bank South (West) Limited. The Applicants are themselves jointly owned by the RWE Group of companies (51% stake) and Masdar (49% stake).

Acronyms

Term	Definition
AbSmall	An abundance metric defined in the International Herring Larval Survey as the number of 0-ringer larvae per m^2
DBS	Dogger Bank South
IHLS	International Herring Larval Survey
KP	Kilometre Points
MMO	Marine Management Organisation
PSD	Particle Size Distribution
ST	Station numbers

1 Preface

1. This document provides information regarding the period within which Atlantic herring (*Clupea harengus*) eggs and larvae are most at risk from cable laying activities. There is no direct measurement data for eggs on the seabed within the Offshore Development Area, therefore the peak period of egg development and larval hatching must be back-calculated from larval data sampled during the International Herring Larval Survey (IHLS).

2. This document is an appendix to **Volume 7, Chapter 10 Fish and Shellfish Ecology (application ref: 7.10)**. This document is intended for use in determining the period of peak egg-laying from peak spawning information.

2 Background Information

3. The Kyle-Henney *et al*. (2024) approach is utilised within **Volume 7, Chapter 10 Fish and Shellfish Ecology (application ref: 7.10)** to identify potential spawning habitat for Atlantic herring within the Offshore Development Area, including DBS East and DBS West Array Areas and the Offshore Export Cable Corridor.

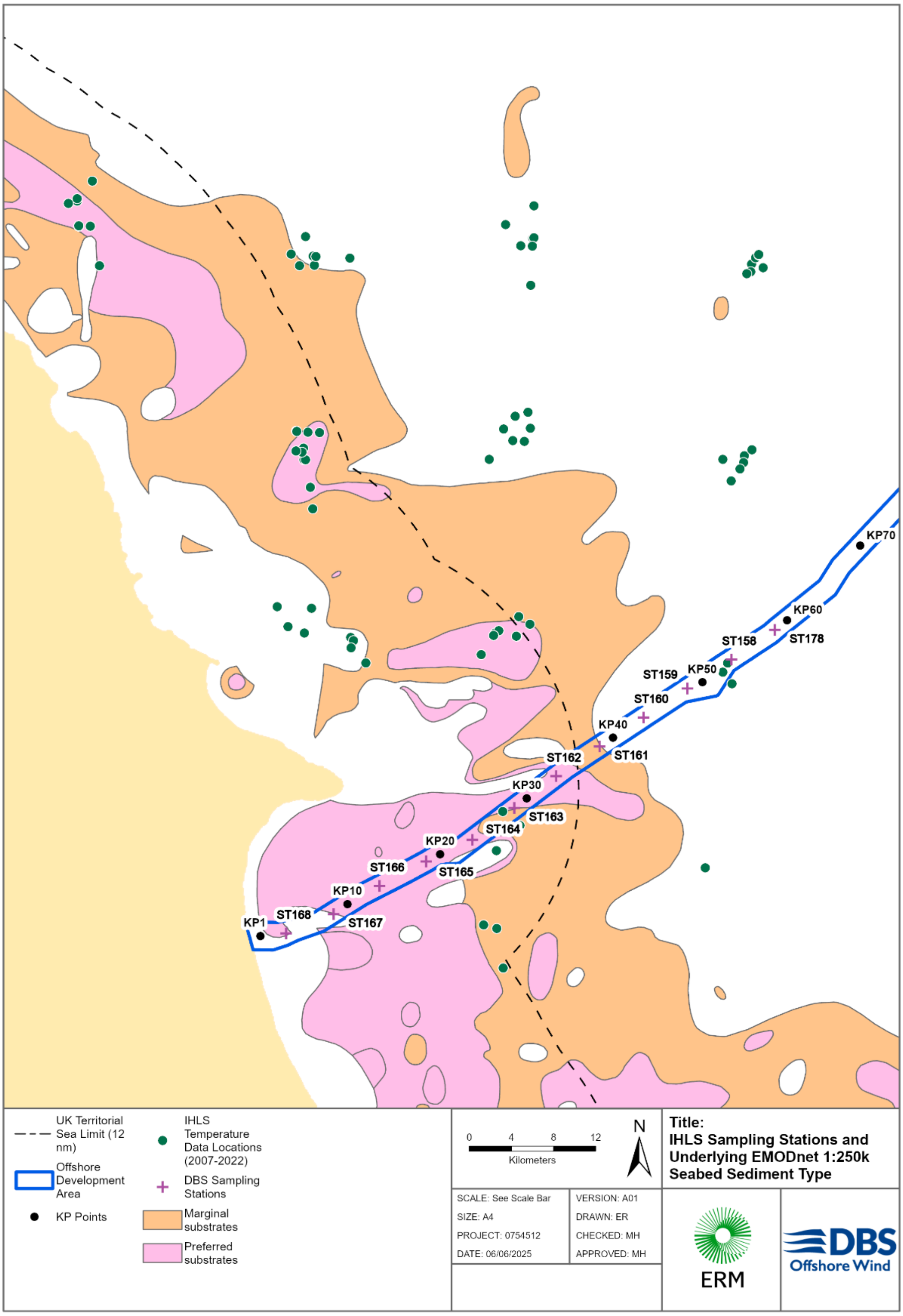
4. As stated in Kyle-Henney *et al*. (2024), the identification of potential spawning habitat may over-represent localised preferred or marginal seabed sediment types. This section uses Particle Size Distribution (PSD) data, collected by Fugro (2023) on behalf of the DBS Projects, to ground-truth the heat map in accordance with the approach recommended by Kyle-Henney *et al*. (2024).

2.1 Particle Size Distribution Analysis

5. The locations of sediment sampling stations (ST159-ST168) along the Offshore Export Cable Corridor, identified as potential spawning habitat, are shown in **Figure 2-1**[1] and **Figure 2-2**.

6. **Table 2-1** and **Figure 2-2** show the seabed sediment types between ST159-ST168 to be primarily unsuitable for spawning, with the exception of ST161-ST162 and ST167-ST168 where suitable spawning habitat has been identified. Whilst Atlantic herring have a tolerance for variation in gravel-dominated sediment types and sandy gravel, the species will not spawn in sand dominated sediment types or those containing fines (Kyle-Henney *et al*., 2024). For reference, ST167-ST168 are located between KP1-KP10; whilst ST161-ST162 are located between KP30-KP40.

[1] Station numbers (ST) and Kilometre Points (KP) are presented for reference.



SOURCE: World Topographic Map (ESRI). ICES Eggs and Larvae dataset (2007 - 2023). ICES, Copenhagen

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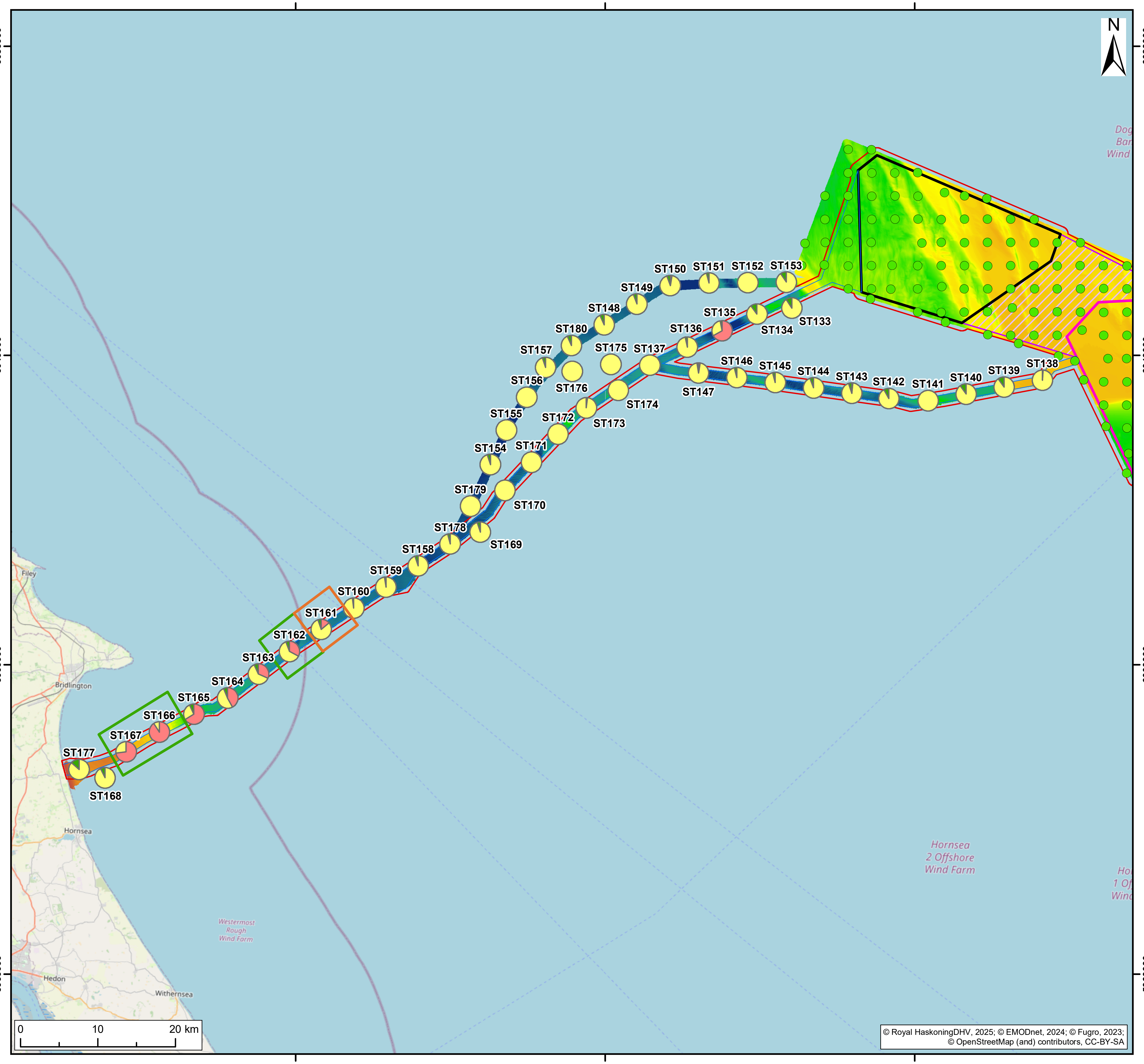
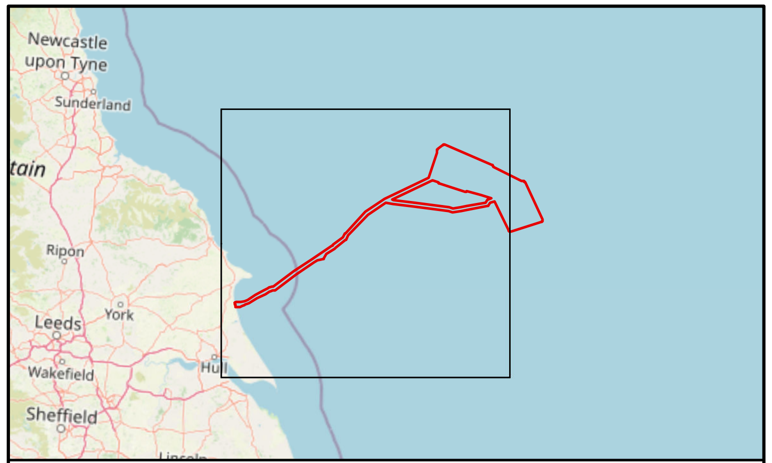
Figure 2-1: The location of International Herring Larval Survey Sampling Stations and underlying EMODnet 1:250k Seabed Sediment Type. Station numbers (ST) and Kilometre Points (KP) are presented for reference





Legend:
- Offshore Development Area
- Offshore Export Cable Corridor
- DBS East Array Area
- DBS West Array Area
- Inter-Platform Cable Corridor

Fractional Sediment Composition
- Gravel
- Sand
- Fines
- Array Station

Sediment type
- Marginal sediment type at ST161
- Preferred sediment type at ST162, ST166 & ST167

Remaining stations are unsuitable for Atlantic herring spawning activity

Bathymetry (LAT)
High : 1.90336
Low : -69.8343

SUI	REV	DATE	DESCRIPTION	DRW	CHK	APR
S2	P01	10/06/2025	Suitable for information	SM	RF	CC

Title:

Spatial variations of percentages of sand, gravel and fines, Offshore Export Cable Corridor for DBS East and DBS West (from Fugro, 2023). Green boxes indicate preferred sediment type at ST162, ST166, and ST167; and the orange box indicates the marginal sediment type at ST161. The remaining stations are unsuitable for Atlantic herring spawning activity.

Figure: 2-2 Drawing No: PC2340-RHD-OF-ZZ-DR-Z-1088

Co-ordinate system: WGS 1984 UTM Zone 31N | Page Size: A3 | Scale: 1:500,000

Project: Dogger Bank South Offshore Wind Farms

Report: Appendix 10-3 Back-calculation of the Peak Atlantic Herring Spawning Period

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DBS Offshore Wind

Table 2-1: Particle Size Distribution (PSD) data collected within the Offshore Export Cable Corridor on behalf of the Projects (Fugro, 2023). Survey stations ST159-ST168 overlap with high potential spawning habitat for Atlantic herring in Figure 2-1. Green outline rows indicate preferred sediment type at ST162, ST166, and ST167; and the orange outline row indicates the marginal sediment type at ST161.

Station	% Gravel	% Sand	% Fines	Folk Description
ST159	0.74	97.05	2.22	Sand
ST160	0.79	97.02	2.19	Sand
ST161	**13.84**	**81.02**	**5.13**	**Gravelly Sand**
ST162	**32.58**	**61.64**	**5.78**	**Sandy Gravel**
ST163	31.70	61.08	7.23	Muddy Sandy Gravel
ST164	42.29	51.48	6.23	Muddy Sandy Gravel
ST165	66.12	27.00	6.88	Muddy Sandy Gravel
ST166	**89.87**	**9.43**	**0.69**	**Gravel**
ST167	**72.78**	**26.58**	**0.63**	**Sandy Gravel**
ST168	0.07	92.78	7.15	Sand

Unsuitable Potential Spawning Habitat	Marginal Potential Spawning Habitat	Preferred Potential Spawning Habitat

7. The objective of the back-calculation approach is to identify the peak in spawning activity within the Offshore Export Cable Corridor, and then use egg and larval development rates to predict the period in which eggs are present on suitable habitat for spawning.

8. The back-calculation is underpinned by IHLS larval data, which is collected at approximately 5 m above the seabed rather than on the seabed itself (where hatching occurs). The location of IHLS sampling stations are ground-truthed as unsuitable spawning habitat (Figure 2-1), therefore it is likely that the larvae sampled within the IHLS originated from areas outside of the Offshore Export Cable Corridor, being transported by near-bed currents. The direction of currents off Flamborough Head and within the Offshore Export Cable Corridor are predominantly south-east and north-west, parallel with the shoreline (**Volume 7, Chapter 8 Marine Physical Environment (application ref: 7.8)**). Therefore, it is unlikely that significant quantities of larvae were transported in a westerly direction from the suitable habitat at ST161-ST162 to the IHLS sampling station at ST163-ST164.

3 Back-Calculation Input Parameters

9. The back-calculation utilises the following key metrics to determine the peak risk to Atlantic herring from cable laying activities:

- Minimum larval length at hatching;
- Maximum 0-ringer larval length;
- Growth rate;
- Yolk sac absorption period;
- Yolk absorption (external disappearance of the yolk sac) period;
- Egg development period.

10. Since 2003, the IHLS has been undertaken within the Banks spawning grounds between the 16-30th September (inclusive), sampling Atlantic herring larvae at approximately 5 m above the seabed. Historical IHLSs (1972-2003) have been undertaken in between 1st -15th September and / or 1st -15th October, however the peak of spawning in terms of caught larval abundance generally remained within the 16-30th September sampling period.

11. Therefore, the back-calculation approach must consider variation in larval length per day within the 16-30th September 'peak' period. For example, smaller larvae will have hatched later than larger larvae collected by the IHLS on the same day; reflecting the period in which the associated eggs were laid on the seabed.

12. The Marine Management Organisation (MMO) and its scientific advisors have provided a list of input parameters to conduct the back-calculation. These parameters are presented as follows:

- Minimum larval length at hatching = 5 mm (MMO pers. comms.);
- Maximum 0-ringer larval length = 9 mm (Dickey-Collas, 2005; MMO pers. comms.);
- Growth rate = 0.25 mm per day (Heath, 1993);
- Yolk sac absorption period = 14 days (Kotthaus, 1939 in Russell, 1976);
- Yolk absorption (external disappearance of the yolk sac) period = N/A;
- Egg development period = 9 days (Kotthaus, 1939 in Russell, 1976).

13. The following sections describe the appropriate input parameters based on literature and IHLS data from within and immediately outside of the Offshore Export Cable Corridor.

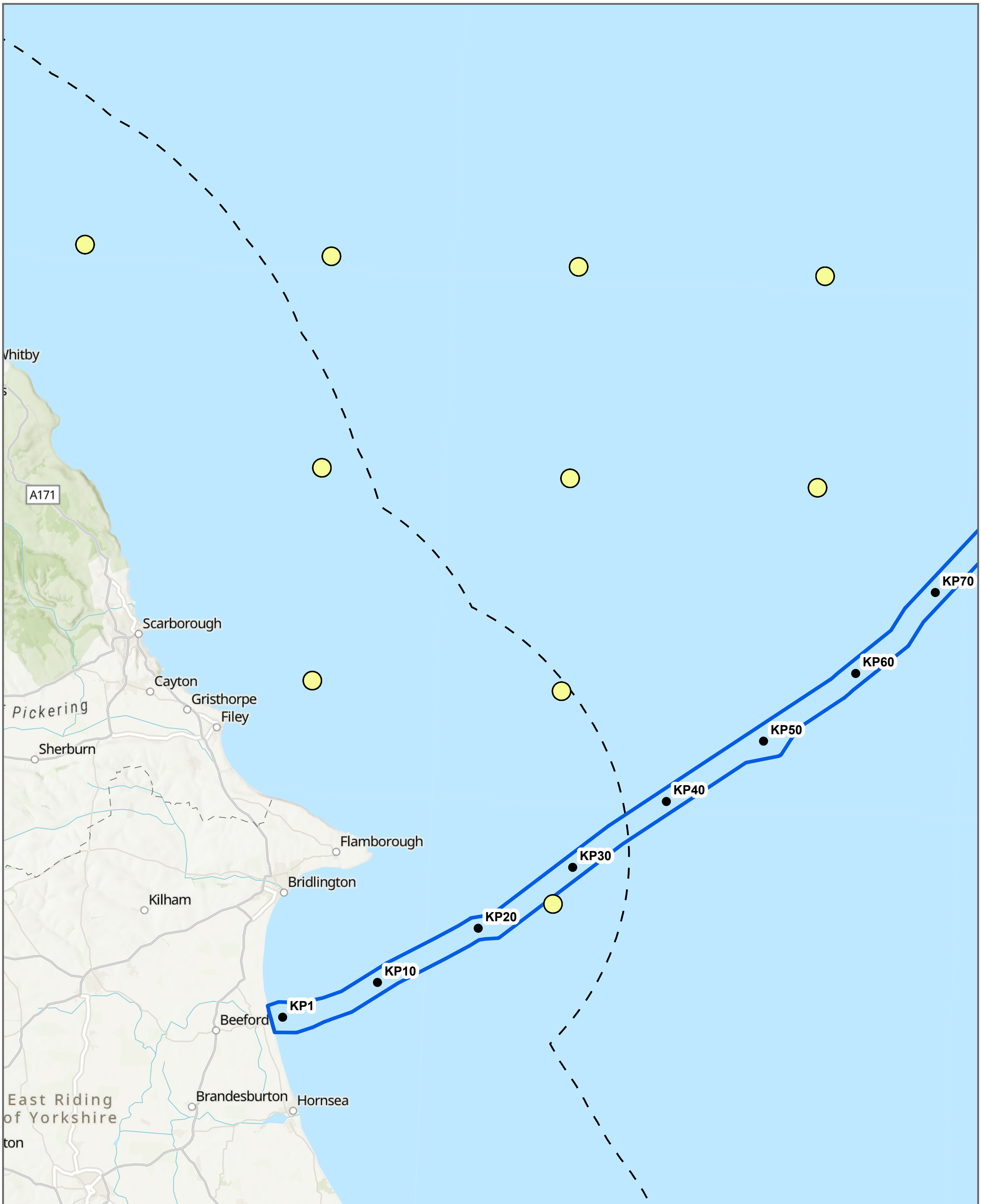
3.1 International Herring Larval Survey: Temperature

14. The IHLS survey collects and records temperature data as 'TempMaxSam' in pre-2017 surveys and 'BotTemp' in 2018-present surveys. The DBS Projects have interrogated the 2007-present IHLS dataset (ICES, 2025), with annual temperature data presented in **Figure 3-1** to **Figure 3-14**. There are no temperature data available for 2017 or 2018.

15. Whilst there are limitations with respect to the sample temperature being recorded at approximately 5 m above the seabed rather than on the seabed, it is understood that the MMO recommends the IHLS temperature data as the best available evidence.

16. The figures show that the temperatures recorded within and around the Offshore Export Cable Corridor are consistently >13°C, with the exception of samples recorded between 12.8-13°C in 2008 and 2023, and samples recorded between 12-12.3°C in 2012, 2021 and 2023 (ICES, 2025).

17. For the purposes of the back-calculation, the Offshore Export Cable Corridor is characterised by average temperatures >12.8°C.



KP Points
Offshore Development Area
UK Territorial Sea Limit (12 nm)

Temperature (ºC)
<12ºC
12.01 - 12.30ºC
12.31 - 12.80ºC
12.81 - 13.00ºC
>13ºC

0 4 8 12
Kilometers

N

Title:

IHLS Temperature Data (2007)

SCALE: See Scale Bar	VERSION: A01
SIZE: A4	DRAWN: ER
PROJECT: 0754512	CHECKED: MH
DATE: 09/06/2025	APPROVED: MH

ERM

DBS Offshore Wind

PROJECTION: WGS 1984 UTM Zone 31N

SOURCE: World Topographic Map (ESRI). ICES Eggs and Larvae dataset (2007 - 2023). ICES, Copenhagen

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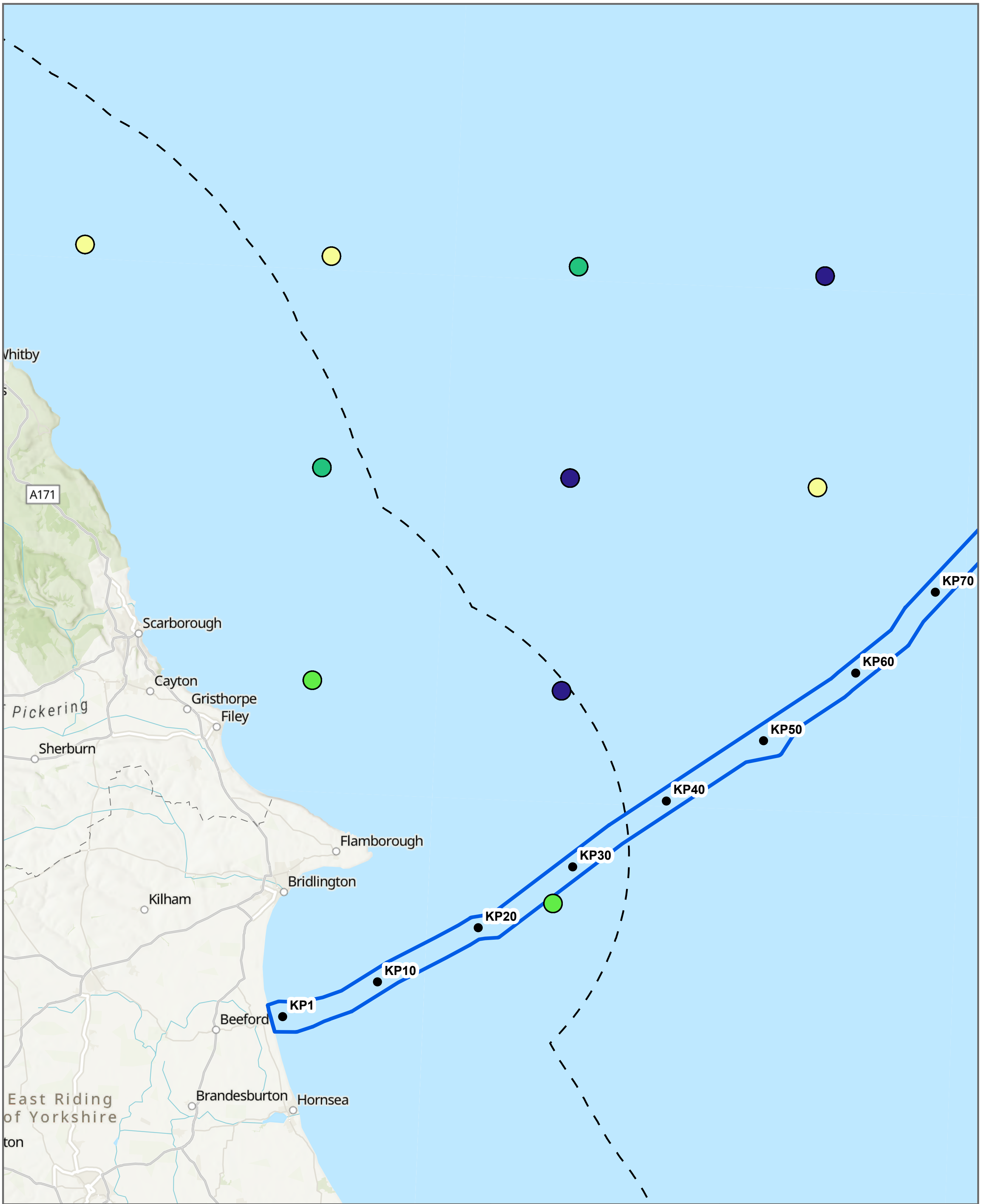

KP Points
Offshore Development Area
UK Territorial Sea Limit (12 nm)

Temperature (ºC)
- <12ºC
- 12.01 - 12.30ºC
- 12.31 - 12.80ºC
- 12.81 - 13.00ºC
- >13ºC

0 4 8 12
Kilometers

N

Title:

IHLS Temperature Data (2008)

SCALE: See Scale Bar	VERSION: A01
SIZE: A4	DRAWN: ER
PROJECT: 0754512	CHECKED: MH
DATE: 09/06/2025	APPROVED: MH

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DBS Offshore Wind

PROJECTION: WGS 1984 UTM Zone 31N

SOURCE: World Topographic Map (ESRI). ICES Eggs and Larvae dataset (2007 - 2023). ICES, Copenhagen

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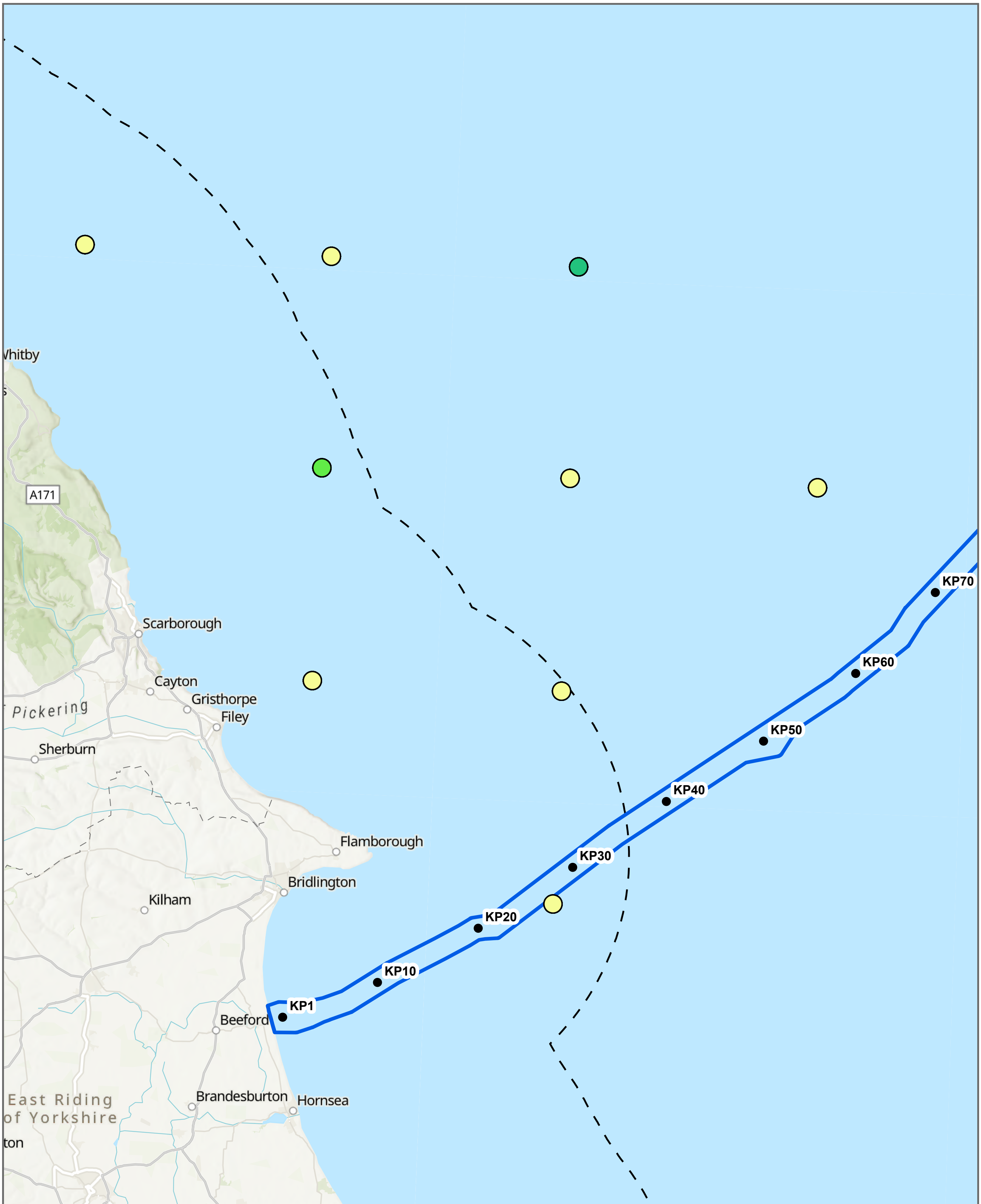

KP Points
Offshore Development Area
UK Territorial Sea Limit (12 nm)

Temperate (ºC)
<12ºC
12.01 - 12.30ºC
12.31 - 12.80ºC
12.81 - 13.00ºC
>13ºC

0 4 8 12 Kilometers

N

Title:

IHLS Temperature Data (2009)

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PROJECT: 0754512	CHECKED: MH
DATE: 09/06/2025	APPROVED: MH

PROJECTION: WGS 1984 UTM Zone 31N

SOURCE: World Topographic Map (ESRI). ICES Eggs and Larvae dataset (2007 - 2023). ICES, Copenhagen

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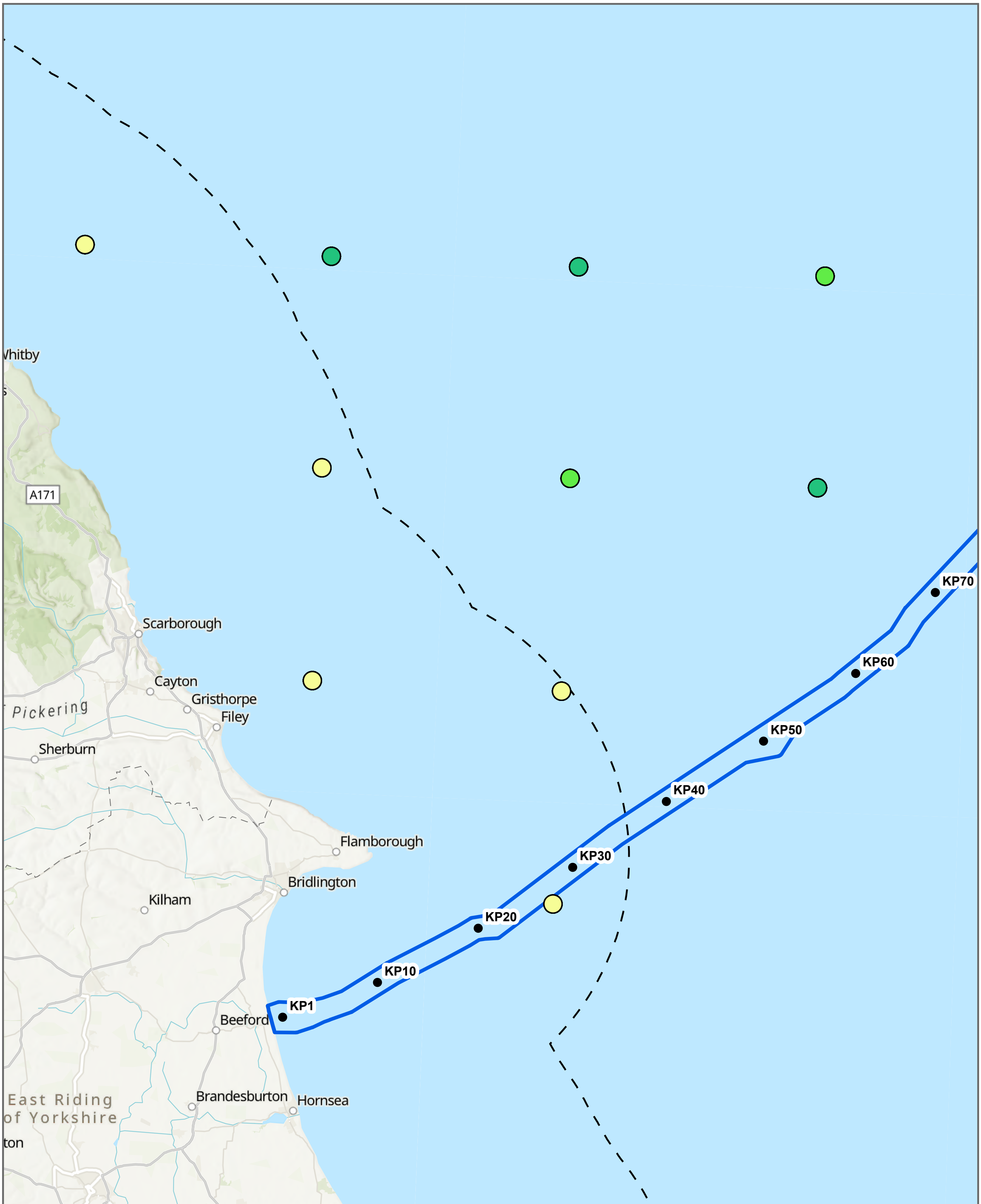

PROJECTION: WGS 1984 UTM Zone 31N

- KP Points
- Offshore Development Area
- UK Territorial Sea Limit (12 nm)

Temperature (ºC)

- <12ºC
- 12.01 - 12.30ºC
- 12.31 - 12.80ºC
- 12.81 - 13.00ºC
- >13ºC

0 4 8 12
Kilometers

N

Title:

IHLS Temperature Data (2010)

SCALE: See Scale Bar	VERSION: A01
SIZE: A4	DRAWN: ER
PROJECT: 0754512	CHECKED: MH
DATE: 09/06/2025	APPROVED: MH

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DBS Offshore Wind

SOURCE: World Topographic Map (ESRI). ICES Eggs and Larvae dataset (2007 - 2023). ICES, Copenhagen

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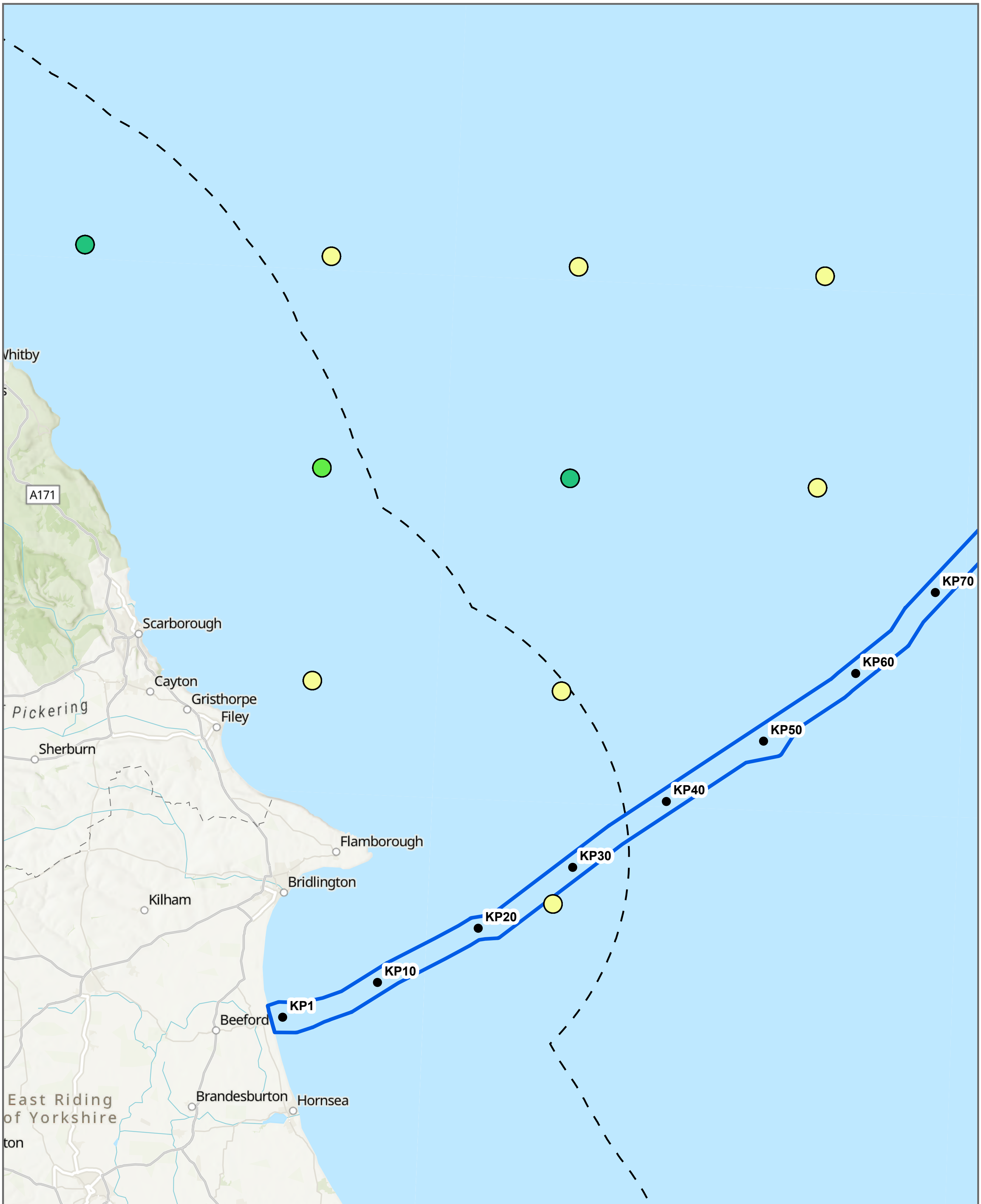

KP Points
Offshore Development Area
UK Territorial Sea Limit (12 nm)

Temperature (ºC)
- <12ºC
- 12.01 - 12.30ºC
- 12.31 - 12.80ºC
- 12.81 - 13.00ºC
- >13ºC

0 4 8 12 Kilometers

N

Title:

IHLS Temperature Data (2011)

SCALE: See Scale Bar	VERSION: A01
SIZE: A4	DRAWN: ER
PROJECT: 0754512	CHECKED: MH
DATE: 09/06/2025	APPROVED: MH

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DBS Offshore Wind

PROJECTION: WGS 1984 UTM Zone 31N

SOURCE: World Topographic Map (ESRI). ICES Eggs and Larvae dataset (2007 - 2023). ICES, Copenhagen

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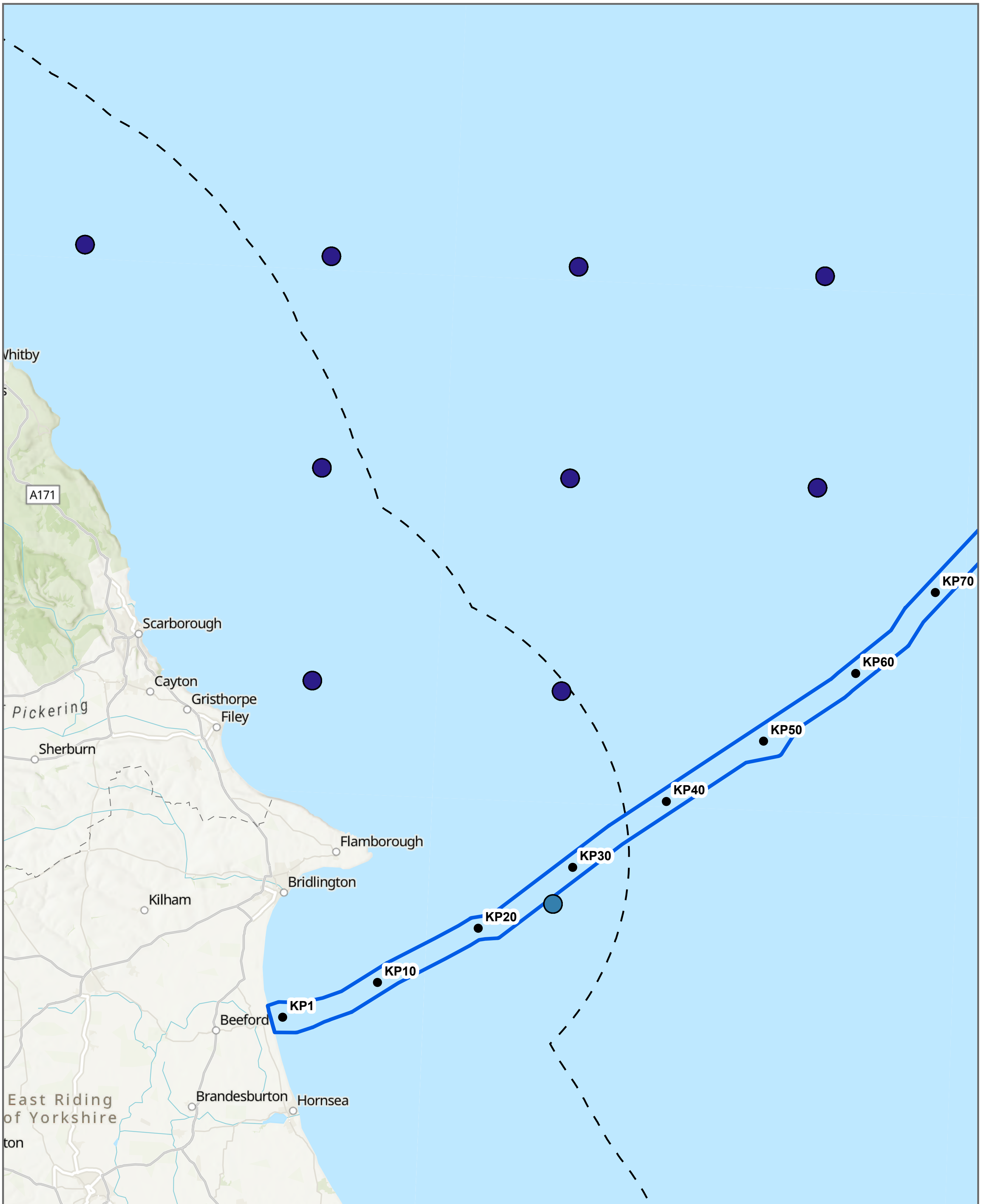

KP Points
Offshore Development Area
UK Territorial Sea Limit (12 nm)

Temperature (ºC)
- <12ºC
- 12.01 - 12.30ºC
- 12.31 - 12.80ºC
- 12.81 - 13.00ºC
- >13ºC

0 4 8 12
Kilometers

N

Title:

IHLS Temperature Data (2012)

SCALE: See Scale Bar	VERSION: A01
SIZE: A4	DRAWN: ER
PROJECT: 0754512	CHECKED: MH
DATE: 09/06/2025	APPROVED: MH

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DBS Offshore Wind

PROJECTION: WGS 1984 UTM Zone 31N

SOURCE: World Topographic Map (ESRI). ICES Eggs and Larvae dataset (2007 - 2023). ICES, Copenhagen

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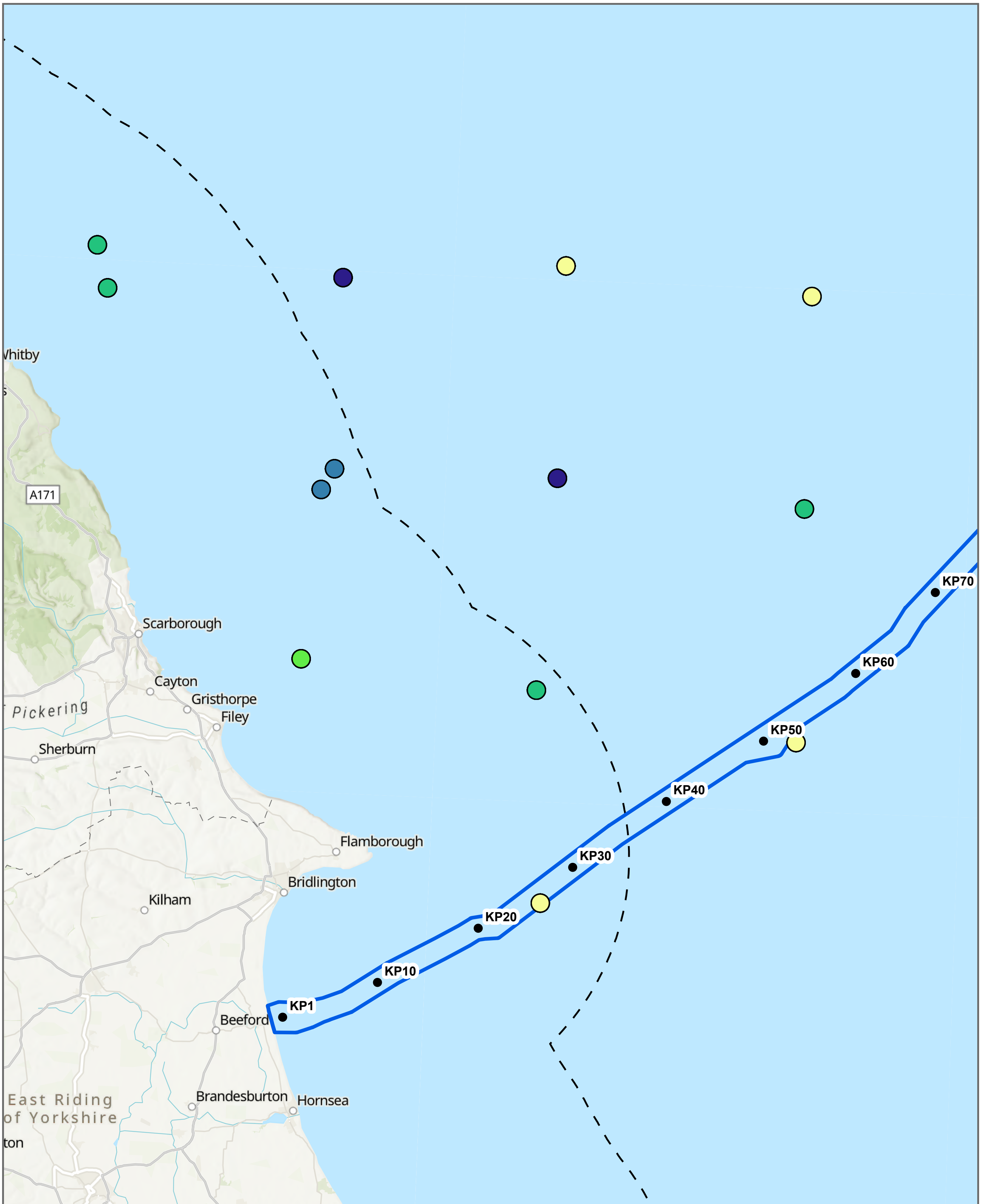

KP Points
Offshore Development Area
UK Territorial Sea Limit (12 nm)

Temperature (ºC)
<12ºC
12.01 - 12.30ºC
12.31 - 12.80ºC
12.81 - 13.00ºC
>13ºC

0 4 8 12
Kilometers

N

Title:

IHLS Temperature Data (2013)

SCALE: See Scale Bar	VERSION: A01
SIZE: A4	DRAWN: ER
PROJECT: 0754512	CHECKED: MH
DATE: 09/06/2025	APPROVED: MH

ERM

DBS Offshore Wind

PROJECTION: WGS 1984 UTM Zone 31N

SOURCE: World Topographic Map (ESRI). ICES Eggs and Larvae dataset (2007 - 2023). ICES, Copenhagen

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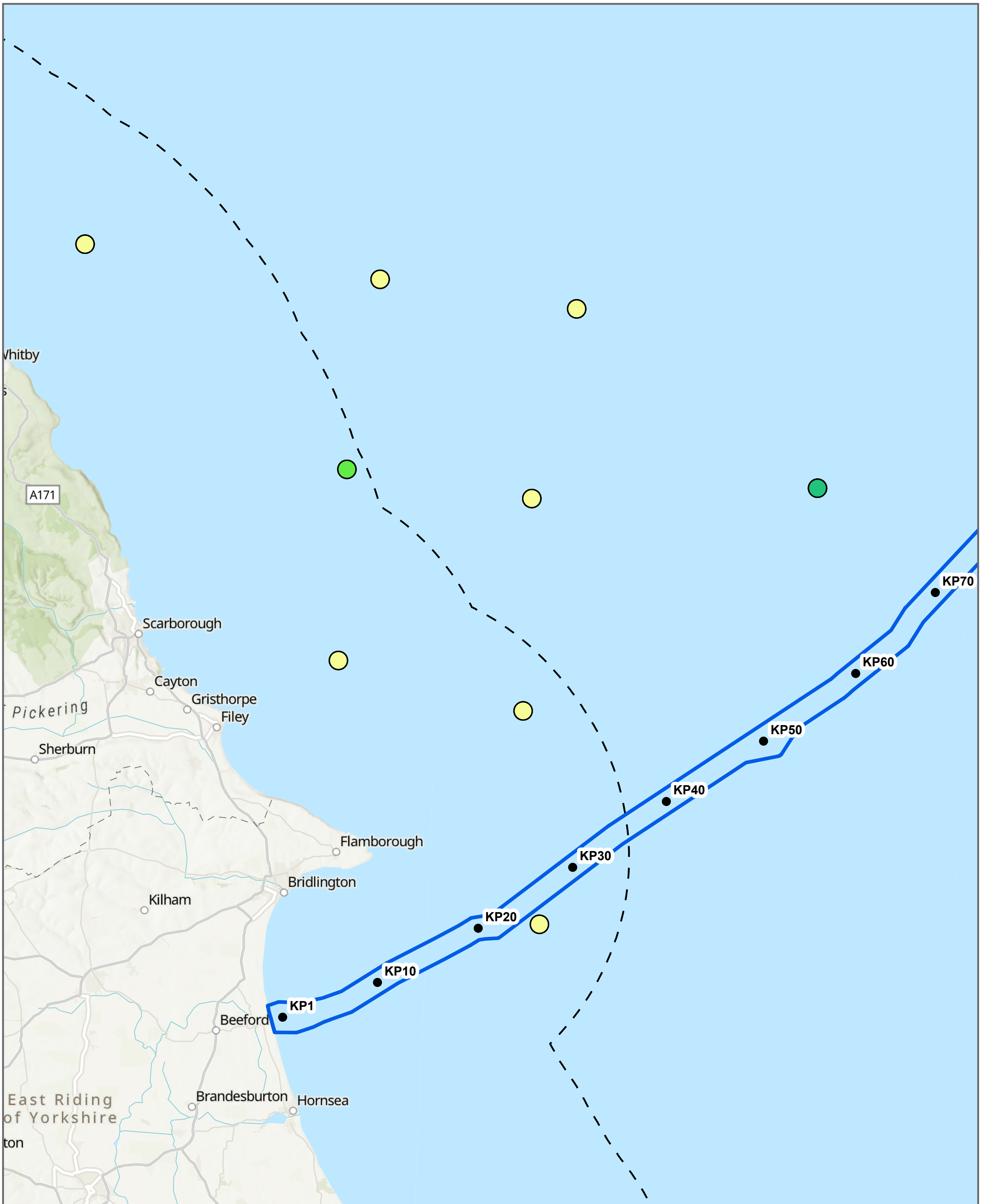

KP Points
Offshore Development Area
UK Territorial Sea Limit (12 nm)

Temperature (ºC)
<12ºC
12.01 - 12.30ºC
12.31 - 12.80ºC
12.81 - 13.00ºC
>13ºC

0 4 8 12
Kilometers
N

Title:

IHLS Temperature Data (2014)

SCALE: See Scale Bar	VERSION: A01
SIZE: A4	DRAWN: ER
PROJECT: 0754512	CHECKED: MH
DATE: 09/06/2025	APPROVED: MH

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DBS Offshore Wind

PROJECTION: WGS 1984 UTM Zone 31N

SOURCE: World Topographic Map (ESRI). ICES Eggs and Larvae dataset (2007 - 2023). ICES, Copenhagen

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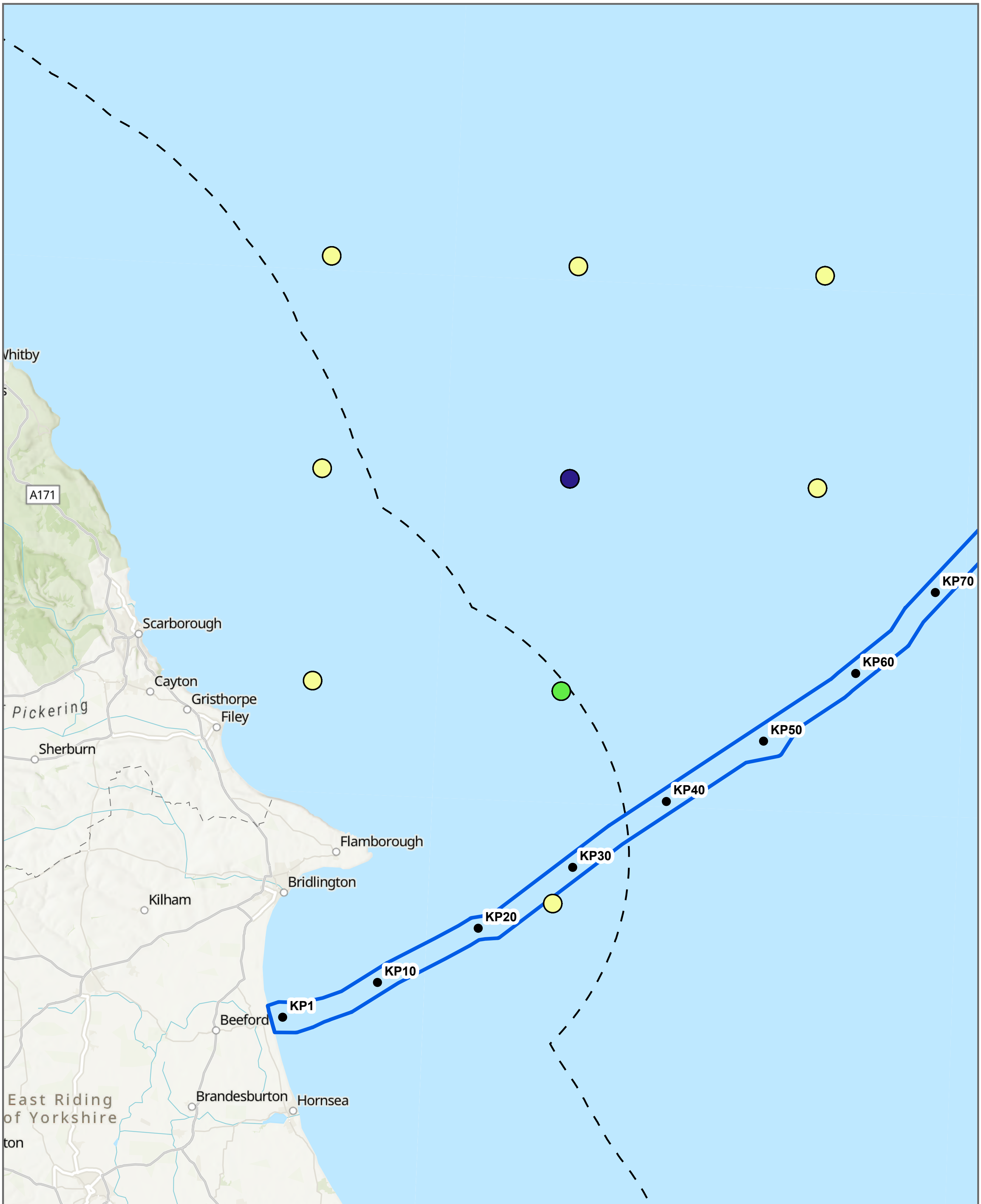

● KP Points

Offshore Development Area

UK Territorial Sea Limit (12 nm)

Temperature (ºC)
- <12ºC
- 12.01 - 12.30ºC
- 12.31 - 12.80ºC
- 12.81 - 13.00ºC
- >13ºC

0 4 8 12
Kilometers

N

Title:

IHLS Temperature Data (2015)

SCALE: See Scale Bar	VERSION: A01
SIZE: A4	DRAWN: ER
PROJECT: 0754512	CHECKED: MH
DATE: 09/06/2025	APPROVED: MH

ERM

DBS Offshore Wind

PROJECTION: WGS 1984 UTM Zone 31N

SOURCE: World Topographic Map (ESRI). ICES Eggs and Larvae dataset (2007 - 2023). ICES, Copenhagen

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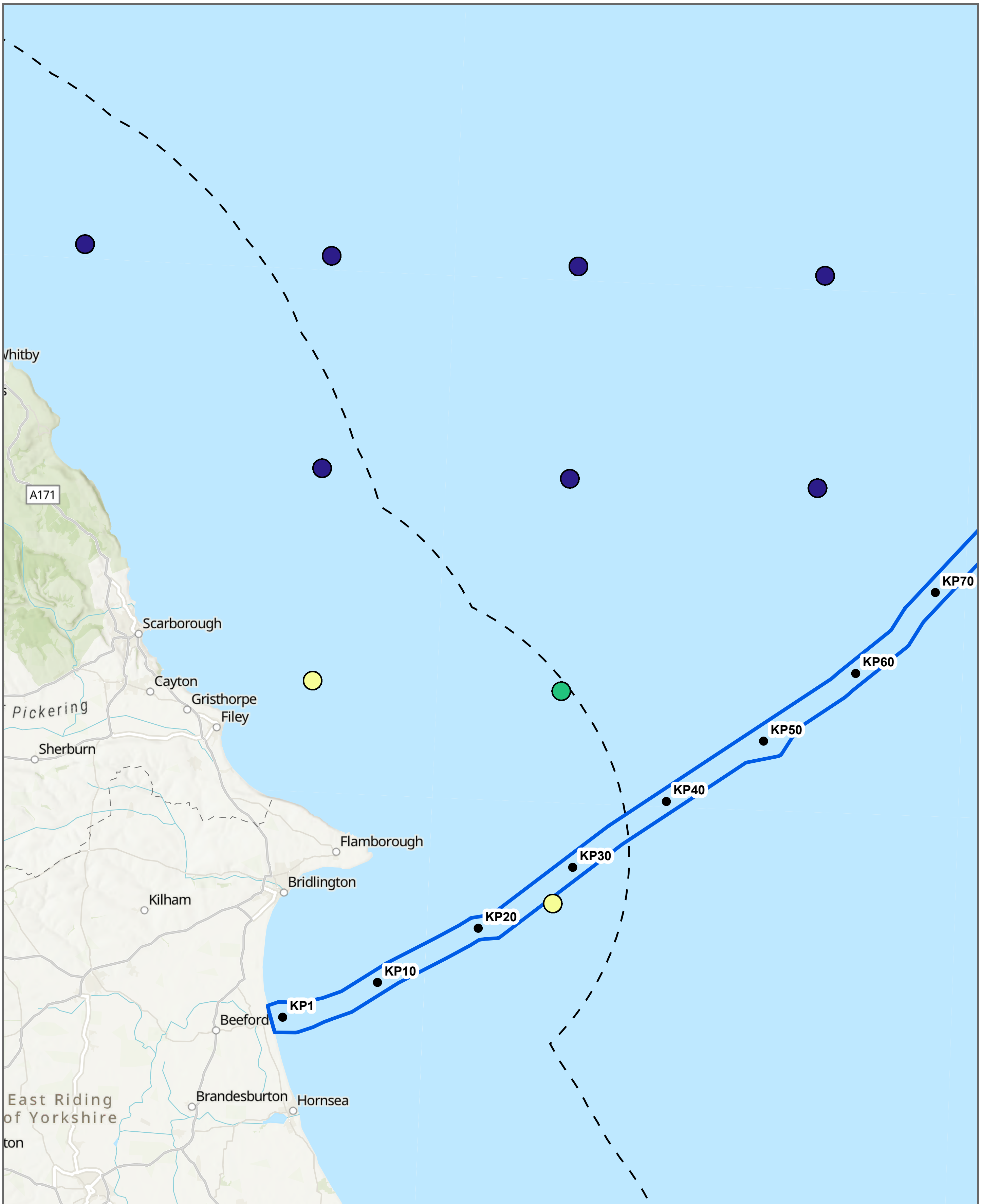


KP Points
Offshore Development Area
UK Territorial Sea Limit (12 nm)

Temperature (ºC)
<12ºC
12.01 - 12.30ºC
12.31 - 12.80ºC
12.81 - 13.00ºC
>13ºC

0 4 8 12
Kilometers

N

Title:

IHLS Temperature Data (2016)

SCALE: See Scale Bar
SIZE: A4
PROJECT: 0754512
DATE: 09/06/2025

VERSION: A01
DRAWN: ER
CHECKED: MH
APPROVED: MH

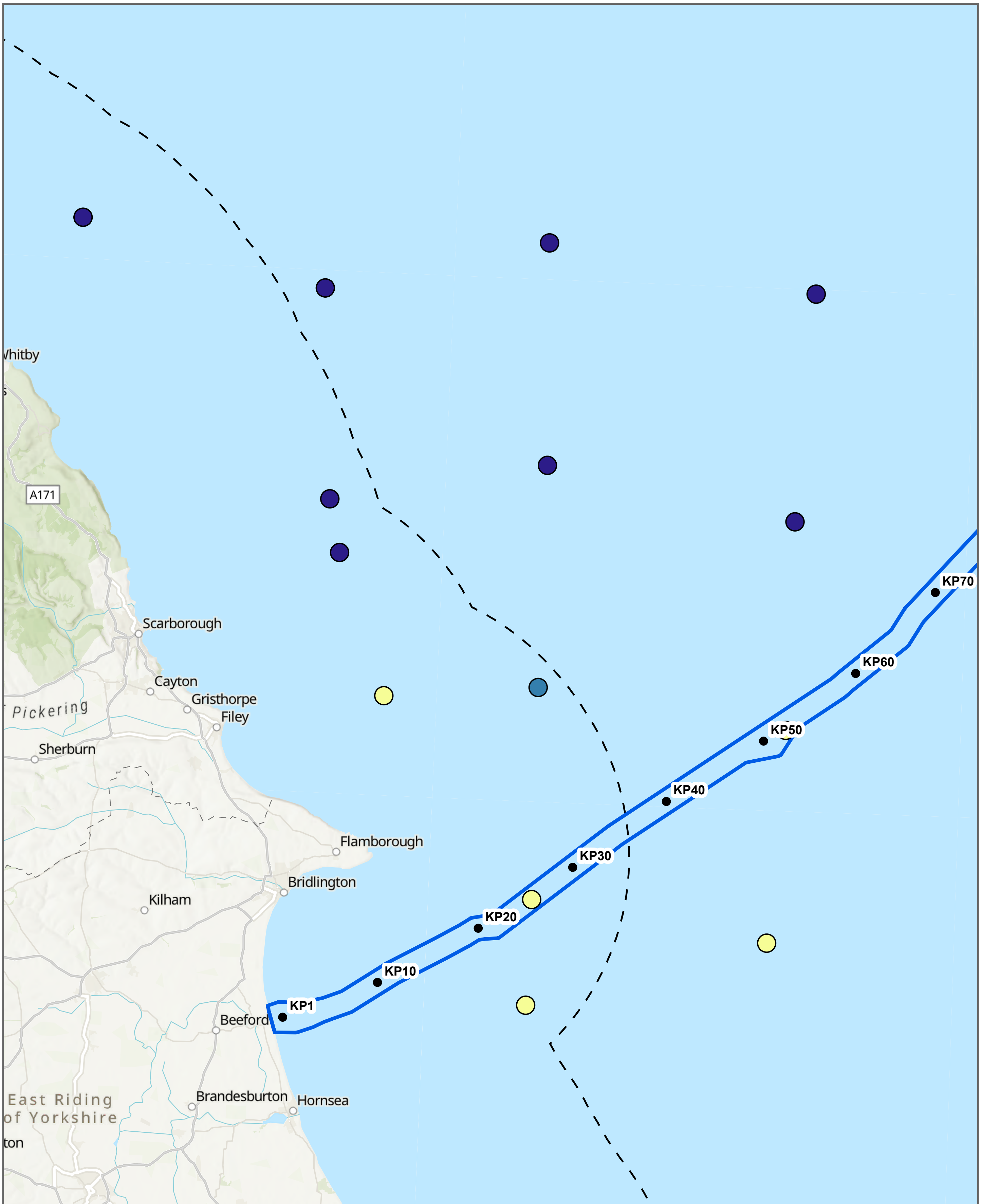
ERM

DBS Offshore Wind

PROJECTION: WGS 1984 UTM Zone 31N

SOURCE: World Topographic Map (ESRI). ICES Eggs and Larvae dataset (2007 - 2023). ICES, Copenhagen

Path: Z:\Projects\J0754512 - Dogger Bank\04_Drawing\Pro\J0754512 - Dogger Bank.aprx / J0754512-MAP-12.10-2016Temperature-01



PROJECTION: WGS 1984 UTM Zone 31N

- KP Points
- Offshore Development Area
- UK Territorial Sea Limit (12 nm)

Temperature (ºC)
- <12ºC
- 12.01 - 12.30ºC
- 12.31 - 12.80ºC
- 12.81 - 13.00ºC
- >13ºC

0 4 8 12
Kilometers

N

Title:

IHLS Temperature Data (2019)

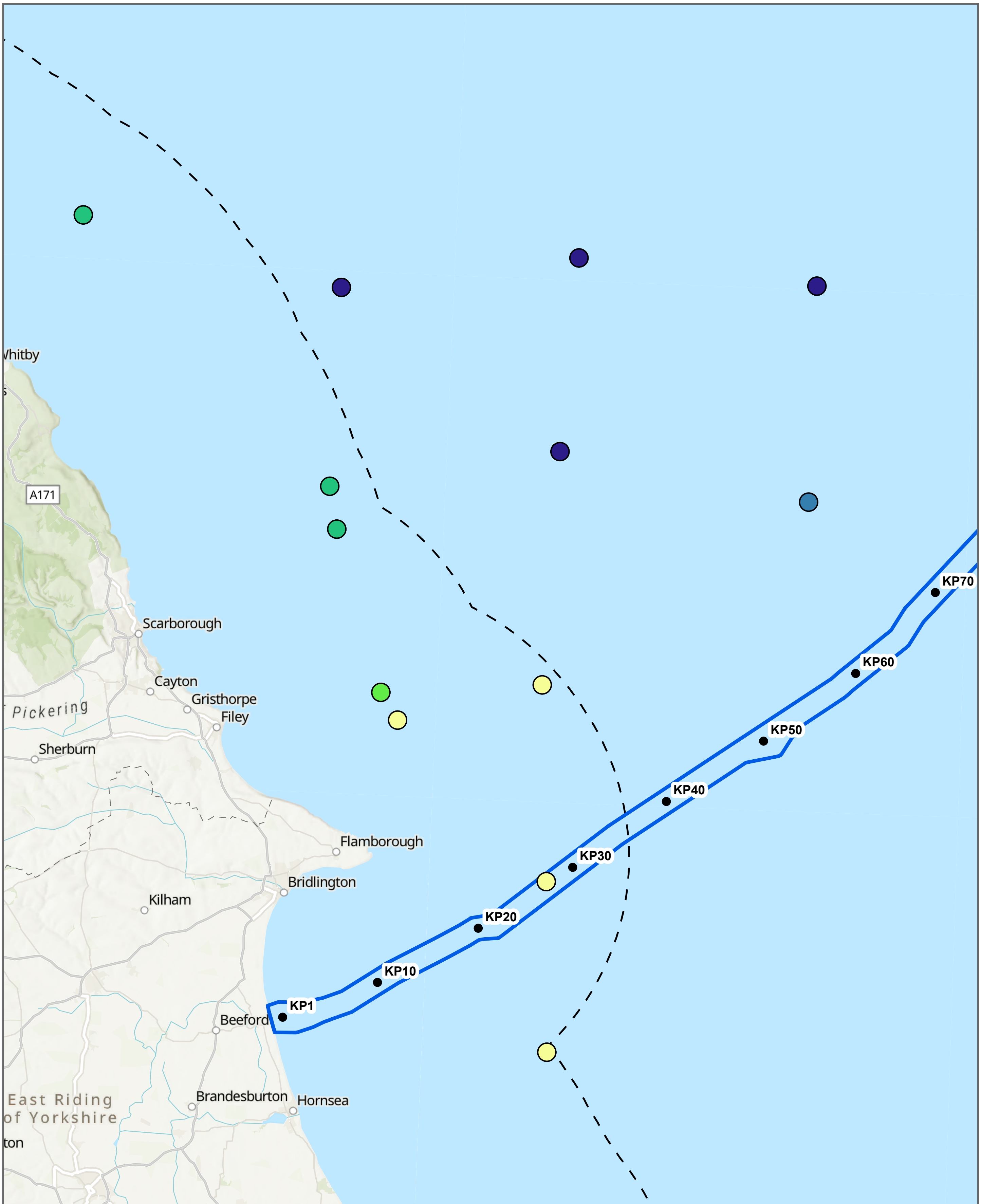
SCALE: See Scale Bar	VERSION: A01
SIZE: A4	DRAWN: ER
PROJECT: 0754512	CHECKED: MH
DATE: 09/06/2025	APPROVED: MH

ERM

DBS Offshore Wind

SOURCE: World Topographic Map (ESRI). ICES Eggs and Larvae dataset (2007 - 2023). ICES, Copenhagen

Path: Z:\Projects\J0754512 - Dogger Bank\04_Drawing\Pro\J0754512 - Dogger Bank.aprx / J0754512-MAP-12.11-2019Temperature-01



KP Points
Offshore Development Area
UK Territorial Sea Limit (12 nm)

Temperature (ºC)
- <12ºC
- 12.01 - 12.30ºC
- 12.31 - 12.80ºC
- 12.81 - 13.00ºC
- >13ºC

0 4 8 12
Kilometers

N

Title:

IHLS Temperature Data (2020)

SCALE: See Scale Bar	VERSION: A01
SIZE: A4	DRAWN: ER
PROJECT: 0754512	CHECKED: MH
DATE: 09/06/2025	APPROVED: MH

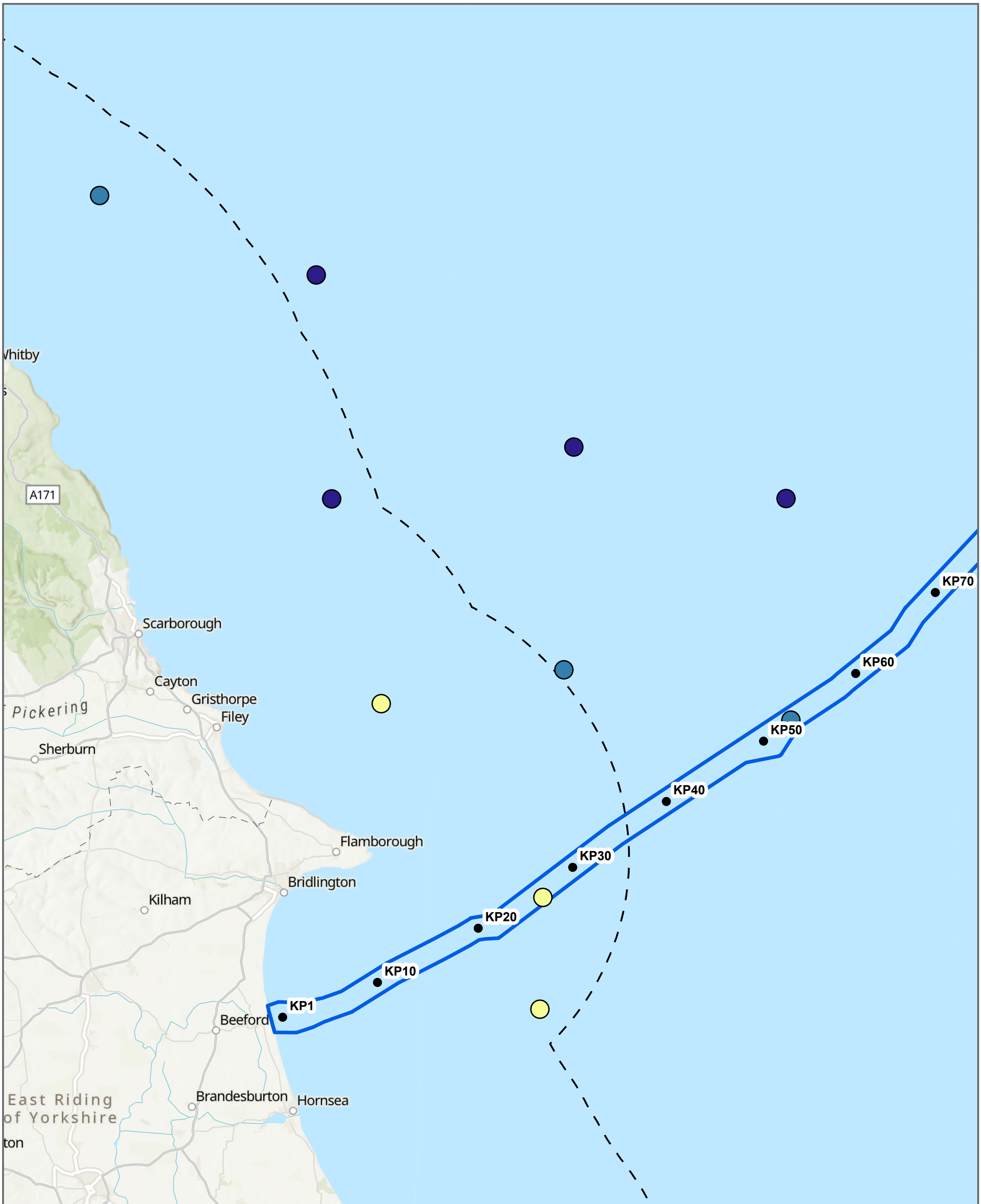
ERM

DBS Offshore Wind

PROJECTION: WGS 1984 UTM Zone 31N

SOURCE: World Topographic Map (ESRI). ICES Eggs and Larvae dataset (2007 - 2023). ICES, Copenhagen

Path: Z:\Projects\J0754512 - Dogger Bank\04_Drawing\Pro\J0754512 - Dogger Bank.aprx / J0754512-MAP-12.12-2020Temperature-01



KP Points

Offshore Development Area

UK Territorial Sea Limit (12 nm)

Temperature (ºC)

- <12ºC
- 12.01 - 12.30ºC
- 12.31 - 12.80ºC
- 12.81 - 13.00ºC
- >13ºC

0 4 8 12

Kilometers

N

Title:

IHLS Temperature Data (2021)

SCALE: See Scale Bar	VERSION: A01
SIZE: A4	DRAWN: ER
PROJECT: 0754512	CHECKED: MH
DATE: 09/06/2025	APPROVED: MH

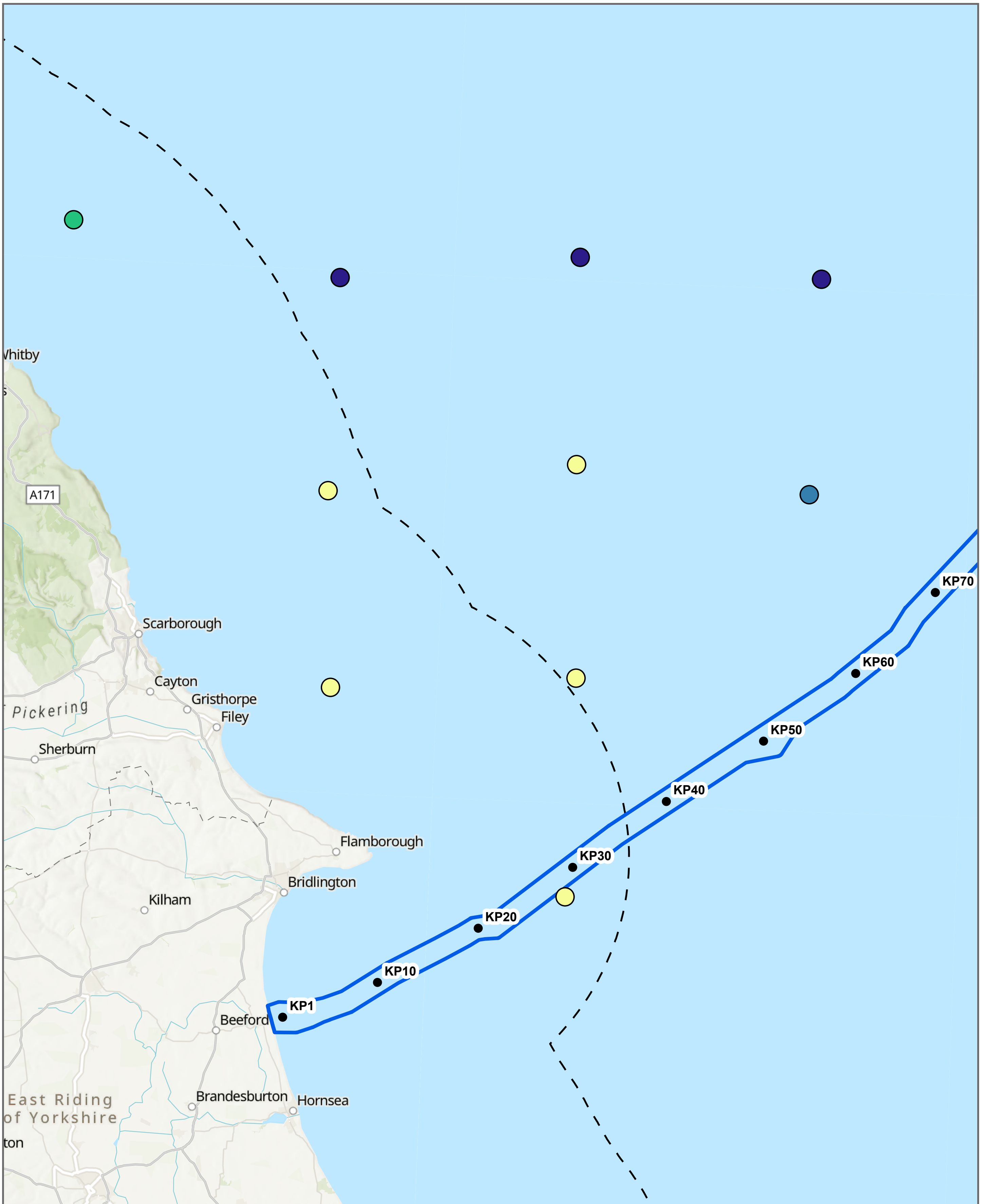
ERM

DBS Offshore Wind

PROJECTION: WGS 1984 UTM Zone 31N

SOURCE: World Topographic Map (ESRI). ICES Eggs and Larvae dataset (2007 - 2023). ICES, Copenhagen

Path: Z:\Projects\J0754512 - Dogger Bank\04_Drawing\Pro\J0754512 - Dogger Bank.aprx / J0754512-MAP-12.13-2021Temperature-01



KP Points
Offshore Development Area
UK Territorial Sea Limit (12 nm)

Temperature (ºC)
- <12ºC
- 12.01 - 12.30ºC
- 12.31 - 12.80ºC
- 12.81 - 13.00ºC
- >13ºC

0 4 8 12
Kilometers

N

Title:

IHLS Temperature Data (2022)

SCALE: See Scale Bar	VERSION: A01
SIZE: A4	DRAWN: ER
PROJECT: 0754512	CHECKED: MH
DATE: 09/06/2025	APPROVED: MH

ERM

DBS Offshore Wind

PROJECTION: WGS 1984 UTM Zone 31N

SOURCE: World Topographic Map (ESRI). ICES Eggs and Larvae dataset (2007 - 2023). ICES, Copenhagen

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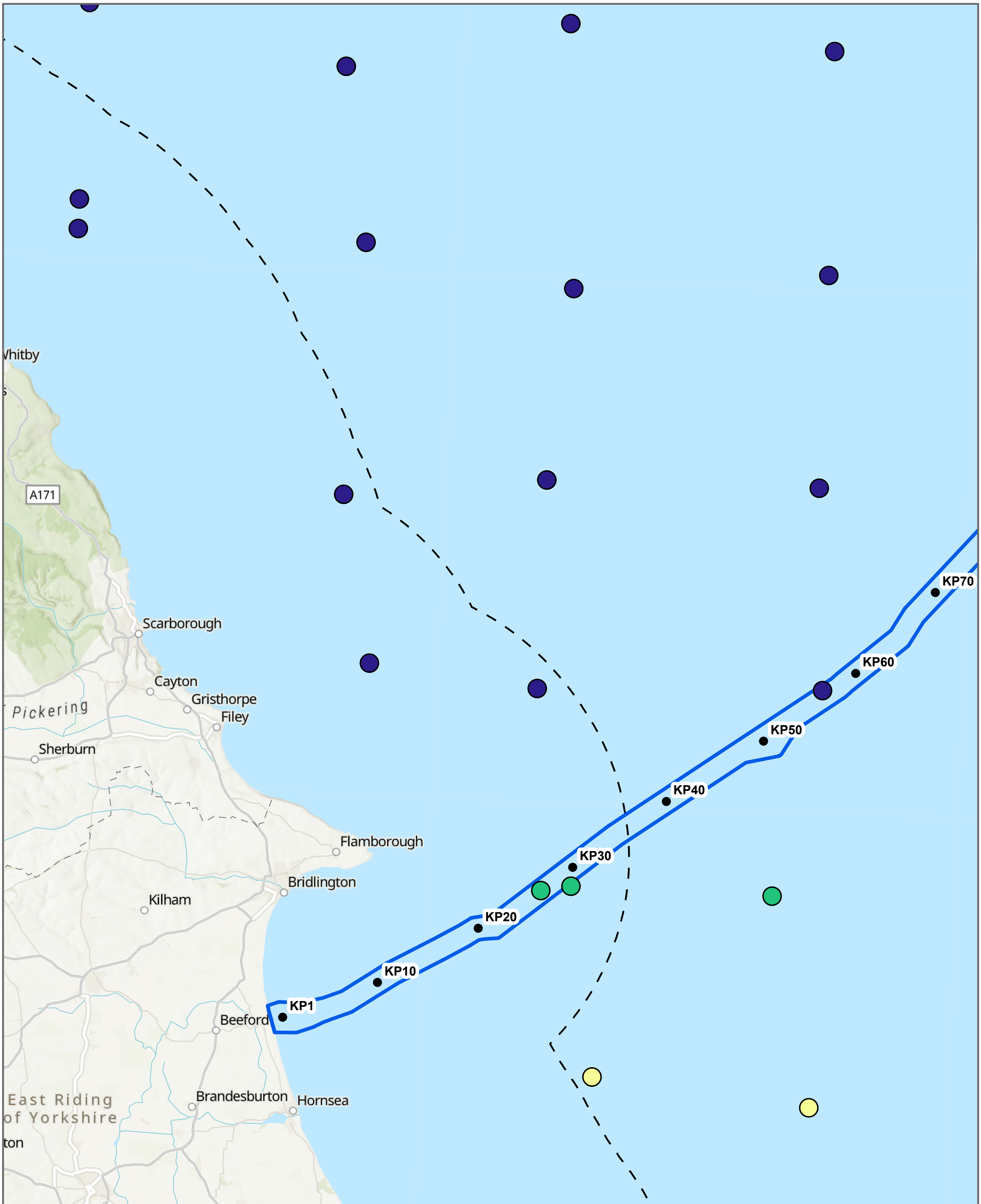


KP Points

Offshore Development Area

UK Territorial Sea Limit (12 nm)

Temperature (ºC)

- <12ºC
- 12.01 - 12.3ºC
- 12.3 - 12.8ºC
- 12.81 - 13.00ºC
- >13ºC

0 4 8 12
Kilometers

N

Title:

IHLS Temperature Data (2023)

SCALE: See Scale Bar	VERSION: A01
SIZE: A4	DRAWN: ER
PROJECT: 0754512	CHECKED: MH
DATE: 09/06/2025	APPROVED: MH

ERM

DBS Offshore Wind

PROJECTION: WGS 1984 UTM Zone 31N

SOURCE: World Topographic Map (ESRI). ICES Eggs and Larvae dataset (2007 - 2023). ICES, Copenhagen

Path: Z:\Projects\J0754512 - Dogger Bank\04_Drawing\Pro\J0754512 - Dogger Bank.aprx / J0754512-MAP-12.15-2023Temperature-01

3.2 International Herring Larval Survey: Abundance

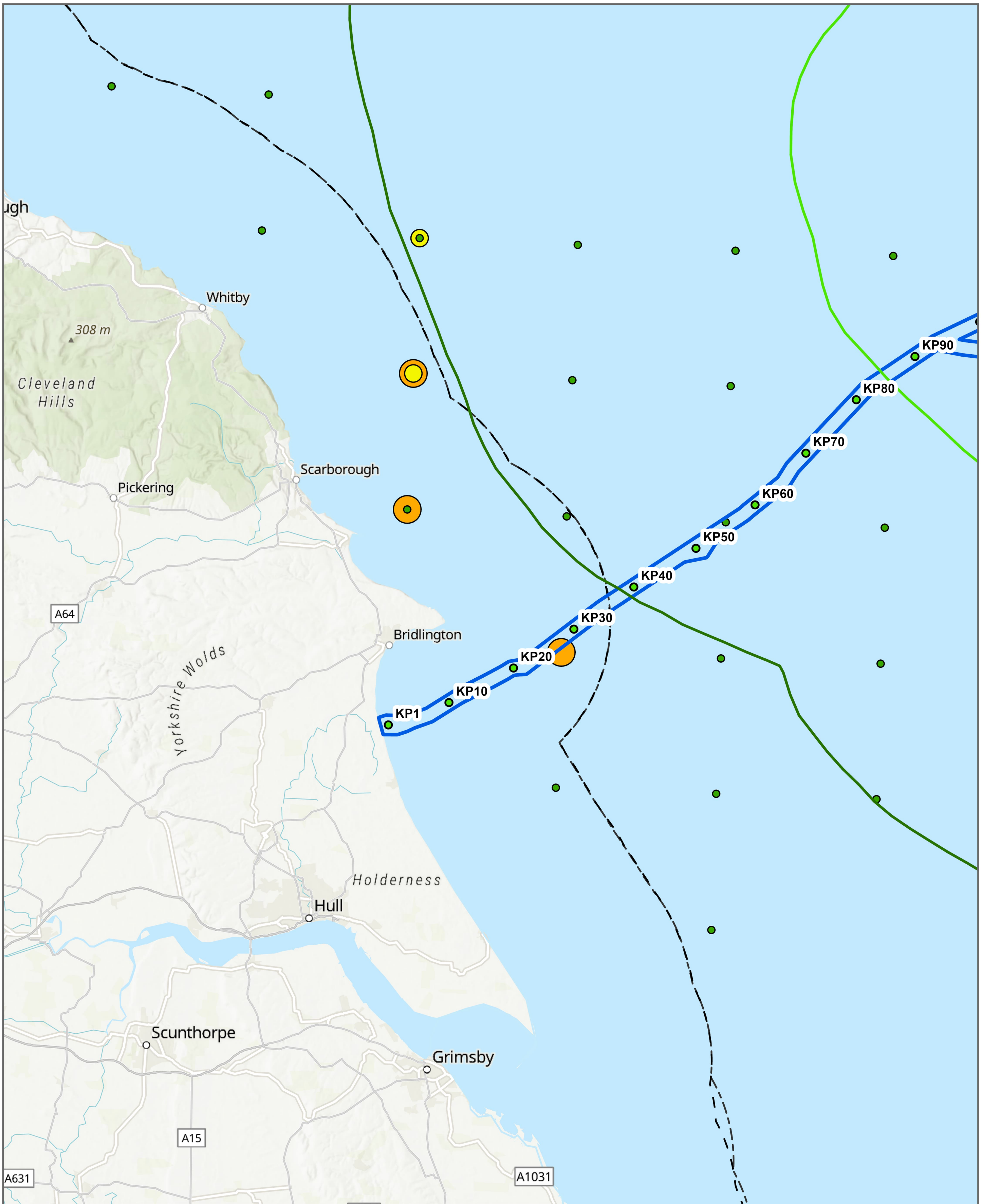
18. The primary objective of the IHLS is to collect abundance and biometric data for Atlantic herring larvae to inform ICES stock assessments. As for the temperature data, annual larval abundance (measured as number per m²) is presented in **Figure 3-16** to **Figure 3-28**. Due to a change in survey method and other limiting factors (e.g. weather and COVID-19), the abundance data for post-2017 monitoring is limited and does not reflect the magnitude of previous spawning activity. Therefore, ten years of abundance data from 2007-2017 have been used to identify the timing of peak spawning activity for the purposes of back-calculation.

19. The biometric data within the IHLS abundance dataset allows a prediction of the larval length classes present at the sampling station during collection, which in turn allows for an approximation of the stage of development on the day of capture. Variation in length can therefore be identified to ensure that precaution is applied within the back-calculation.

20. The two IHLS stations within the immediate vicinity of the Offshore Export Cable Corridor (**Figure 2-1**). are located within areas ground-truthed as unsuitable spawning habitat for Atlantic herring, with the station at ~KP25 being represented as muddy sandy Gravel (located between ST163-St164) and the station at ~KP55 being represented as Sand (located at ST158). Please refer to **Figure 2-2** showing these locations.

21. The IHLS station of interest, located within the Offshore Export Cable Corridor and overlaps with potential spawning habitat, did not record any 0-ringer larvae for the period 16th -21st September in any year between 2007-2017 (ICES, 2025). The majority of larvae were caught from 24-29 September, with length classes between 7-9mm (**Figure 3-29**). Similar abundance data are shown in **Figure 3-30** for the IHLS station located in unsuitable spawning habitat. It is noted that both IHLS stations within the Offshore Export Cable Corridor recorded a peak in 8mm larvae on 24th September 2015 (**Figure 3-29** and **Figure 3-30**). The total cumulative abundance caught at both stations during the 2007-2017 period is shown in **Figure 3-31**.

22. Whilst the actual number of 9mm larvae caught on this date is comparatively low, the back-calculation will include a scenario for 9mm larvae caught on 22nd September.



KP Points
Offshore Development Area
UK Territorial Sea Limit (12 nm)
Disturbance Threshold (based on Hawkins et al., 2014)
135dB
Key UWN Thresholds (Popper et al., 2014)
186dB

2007 Larval Abundance per m²
0 - 50
51 - 200
201 - 600
601 - 1,200
1,201 - 10,000
10,001 - 56,258

0 4 8 12 16 20
Kilometers
N

Title:
IHLS survey data
Caught values (2007)

SCALE: See Scale Bar	VERSION: A01
SIZE: A4	DRAWN: MW
PROJECT: 0754512	CHECKED: MH
DATE: 4/16/2025	APPROVED: MH

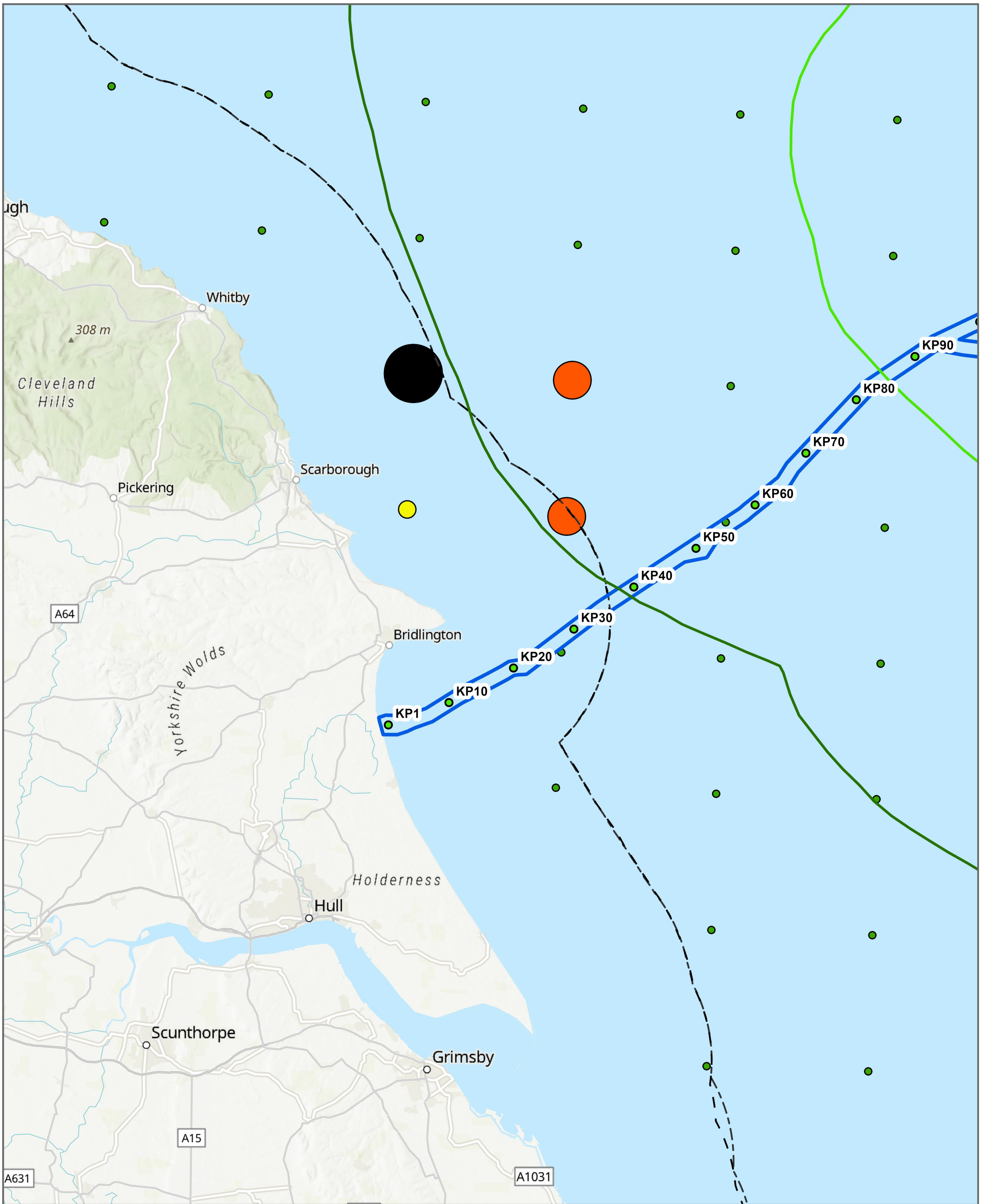
ERM

Figure 3-16

PROJECTION: WGS 1984 UTM Zone 31N

SOURCE: World Topographic Map (ESRI). ICES Eggs and Larvae dataset (2007 - 2023). ICES, Copenhagen

Path: Y:\Projects\J0754512 - Dogger Bank\04_Drawing\Pro\J0754512 - Dogger Bank.aprx / J0754512-MAP-110.1-2017CaughtValues-01



KP Points
Offshore Development Area
UK Territorial Sea Limit (12 nm)
Disturbance Threshold (based on Hawkins et al., 2014)
135dB
Key UWN Thresholds (Popper et al., 2014)
186dB

2008 Larval Abundance per m^2
0 - 50
51 - 200
201 - 600
601 - 1,200
1,201 - 10,000
10,001 - 56,258

0 4 8 12 16 20
Kilometers

N

Title:
IHLS survey data
Caught values (2008)

SCALE: See Scale Bar
SIZE: A4
PROJECT: 0754512
DATE: 4/16/2025

VERSION: A01
DRAWN: MW
CHECKED: MH
APPROVED: MH

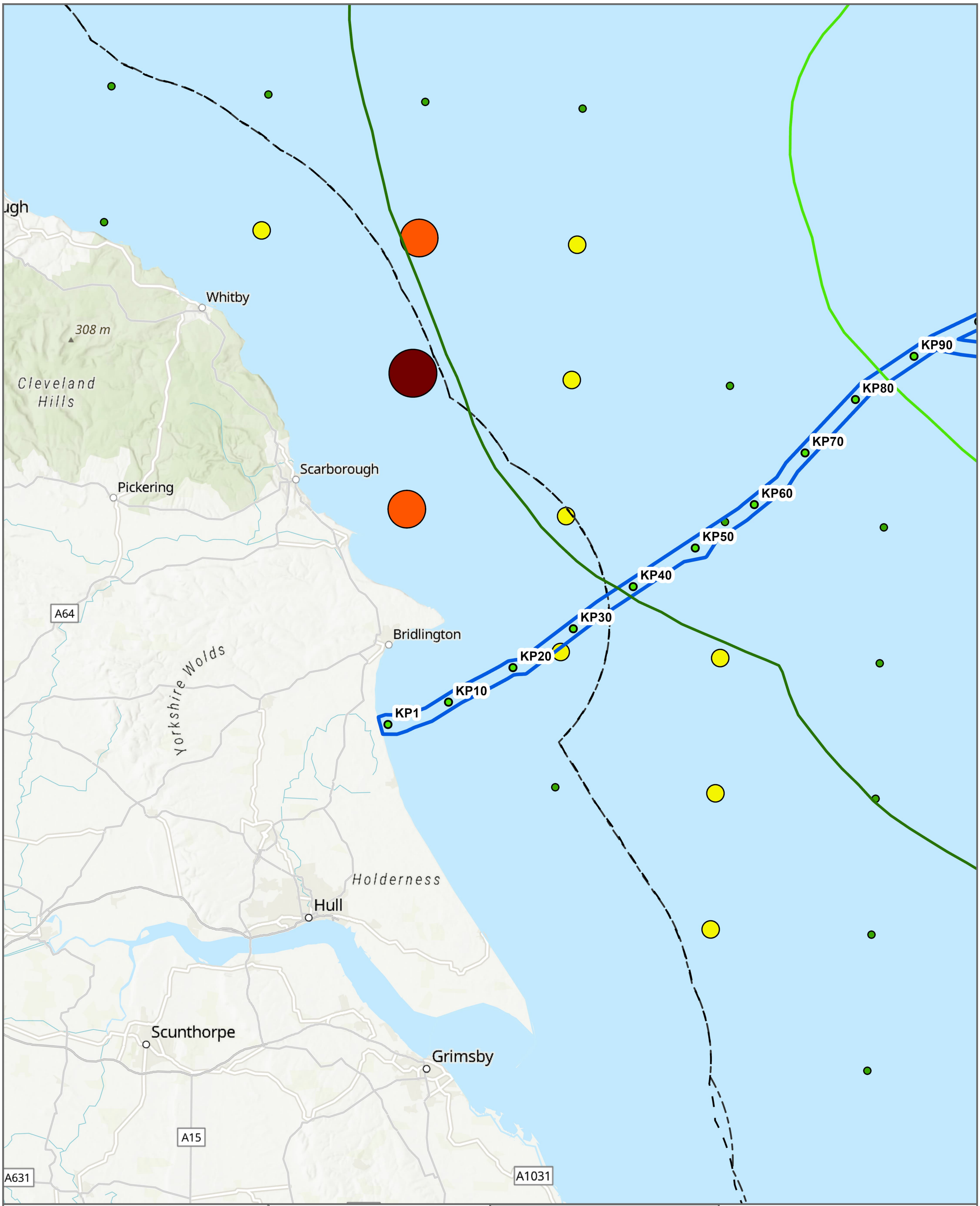
ERM

Figure 3-17

PROJECTION: WGS 1984 UTM Zone 31N

SOURCE: World Topographic Map (ESRI). ICES Eggs and Larvae dataset (2007 - 2023). ICES, Copenhagen

Path: Y:\Projects\J0754512 - Dogger Bank\04_Drawing\Pro\J0754512 - Dogger Bank.aprx / J0754512-MAP-110.2-2008CaughtValues-01



KP Points
Offshore Development Area
UK Territorial Sea Limit (12 nm)
Disturbance Threshold (based on Hawkins et al., 2014)
135dB
Key UWN Thresholds (Popper et al., 2014)
186dB

2009 Larval Abundance per m^2
0 - 50
51 - 200
201 - 600
601 - 1,200
1,201 - 10,000
10,001 - 56,258

0 4 8 12 16 20
Kilometers
N

Title:
IHLS survey data
Caught values (2009)

SCALE: See Scale Bar
SIZE: A4
PROJECT: 0754512
DATE: 4/16/2025

VERSION: A01
DRAWN: MW
CHECKED: MH
APPROVED: MH

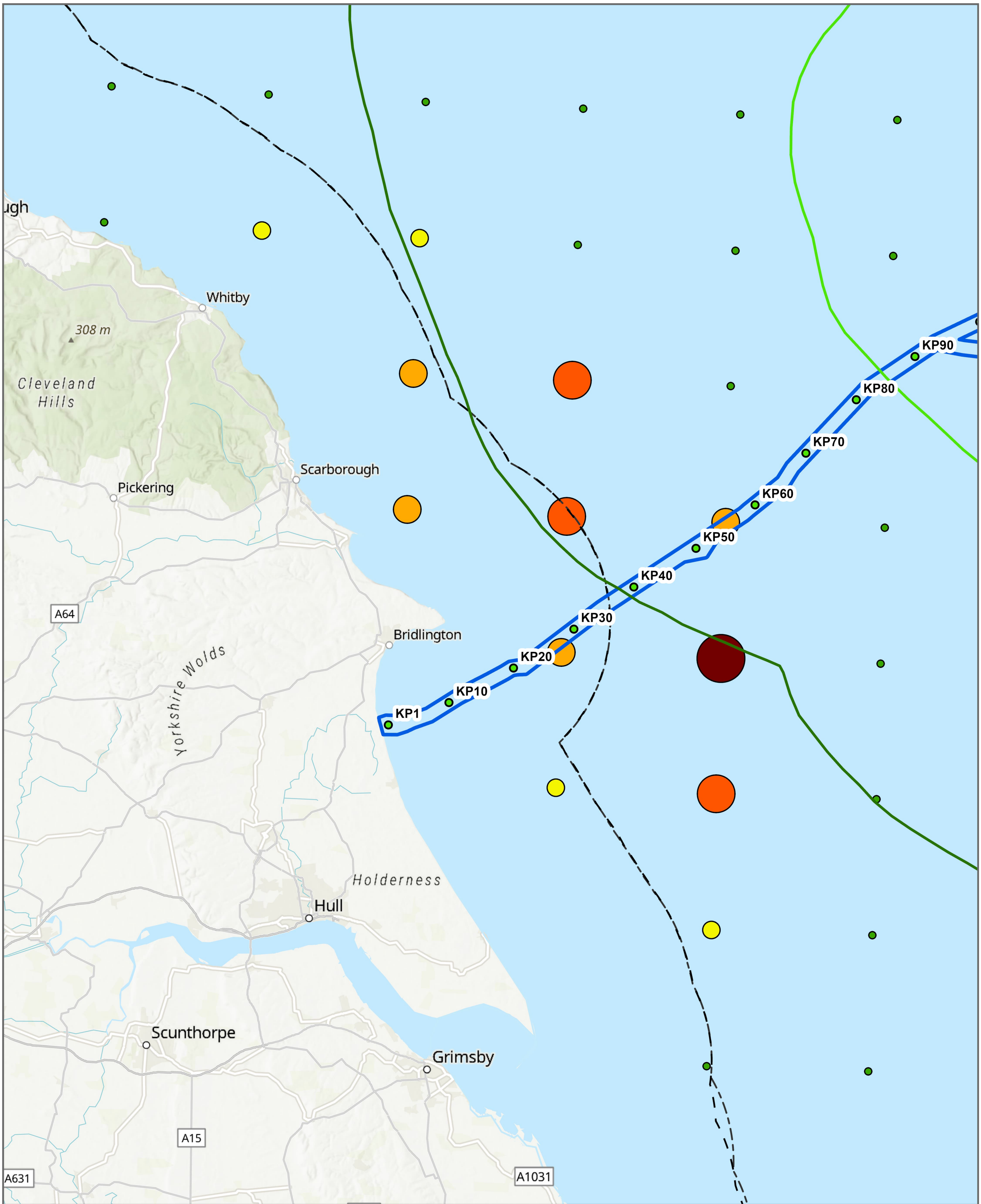
ERM

Figure 3-18

PROJECTION: WGS 1984 UTM Zone 31N

SOURCE: World Topographic Map (ESRI). ICES Eggs and Larvae dataset (2007 - 2023). ICES, Copenhagen

Path: Y:\Projects\J0754512 - Dogger Bank\04_Drawing\Pro\J0754512 - Dogger Bank.aprx / J0754512-MAP-110.3-2009CaughtValues-01



KP Points
Offshore Development Area
UK Territorial Sea Limit (12 nm)
Disturbance Threshold (based on Hawkins et al., 2014)
135dB
Key UWN Thresholds (Popper et al., 2014)
186dB

2010 Larval Abundance per m^2
- 0 - 50
- 51 - 200
- 201 - 600
- 601 - 1,200
- 1,201 - 10,000
- 10,001 - 56,258

0 4 8 12 16 20
Kilometers
N

Title:
IHLS survey data
Caught values (2010)

SCALE: See Scale Bar	VERSION: A01
SIZE: A4	DRAWN: MW
PROJECT: 0754512	CHECKED: MH
DATE: 4/16/2025	APPROVED: MH

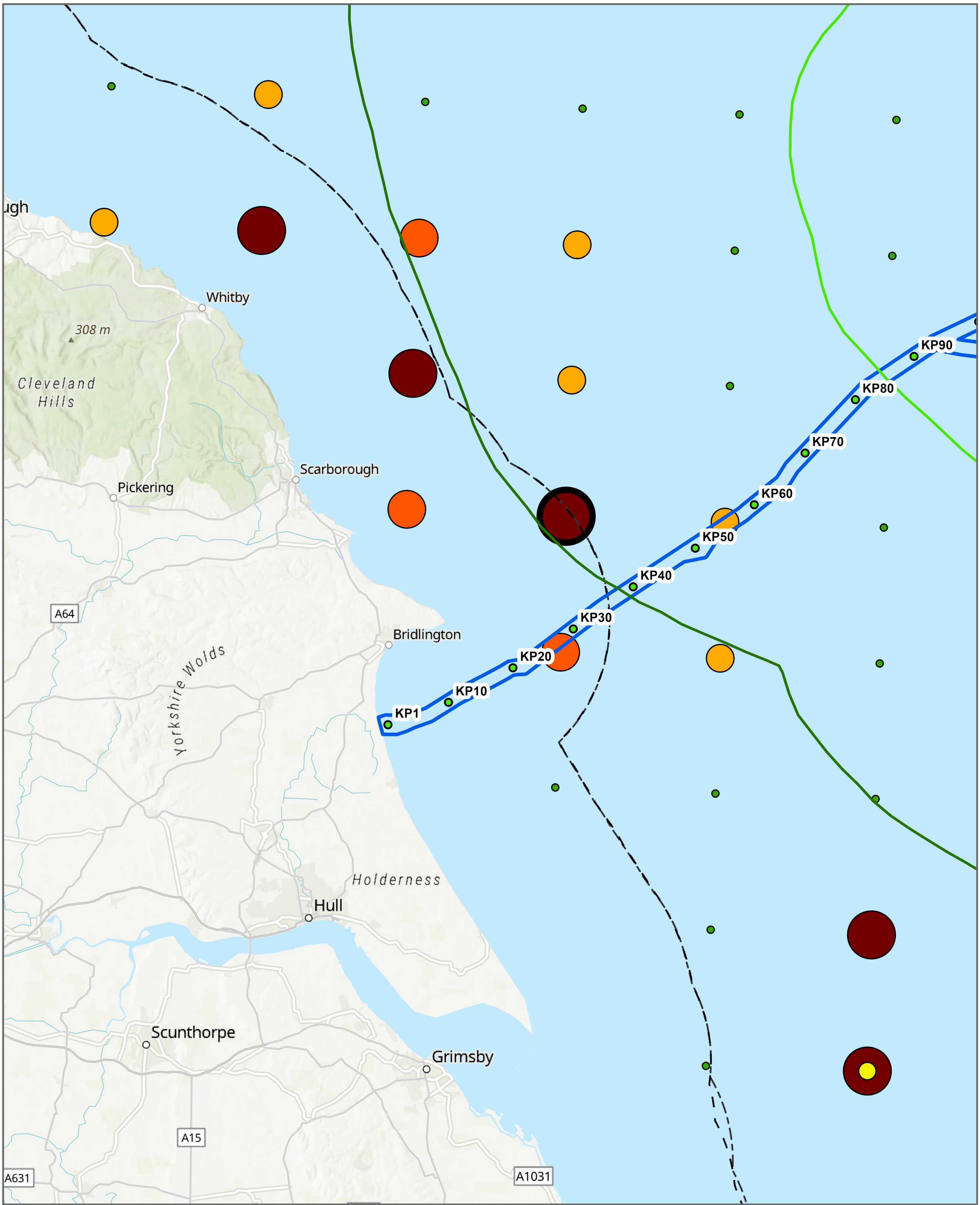
ERM

Figure 3-19

PROJECTION: WGS 1984 UTM Zone 31N

SOURCE: World Topographic Map (ESRI). ICES Eggs and Larvae dataset (2007 - 2023). ICES, Copenhagen

Path: Y:\Projects\J0754512 - Dogger Bank\04_Drawing\Pro\J0754512 - Dogger Bank.aprx / J0754512-MAP-110.4-2010CaughtValues-01



KP Points
Offshore Development Area
UK Territorial Sea Limit (12 nm)
Disturbance Threshold (based on Hawkins et al., 2014)
135dB
Key UWN Thresholds (Popper et al., 2014)
186dB

2011 Larval Abundance per m²
- 0 - 50
- 51 - 200
- 201 - 600
- 601 - 1,200
- 1,201 - 10,000
- 10,001 - 56,258

0 4 8 12 16 20
Kilometers

N

Title:
IHLS survey data Caught values (2011)

SCALE: See Scale Bar
SIZE: A4
PROJECT: 0754512
DATE: 4/16/2025

VERSION: A01
DRAWN: MW
CHECKED: MH
APPROVED: MH

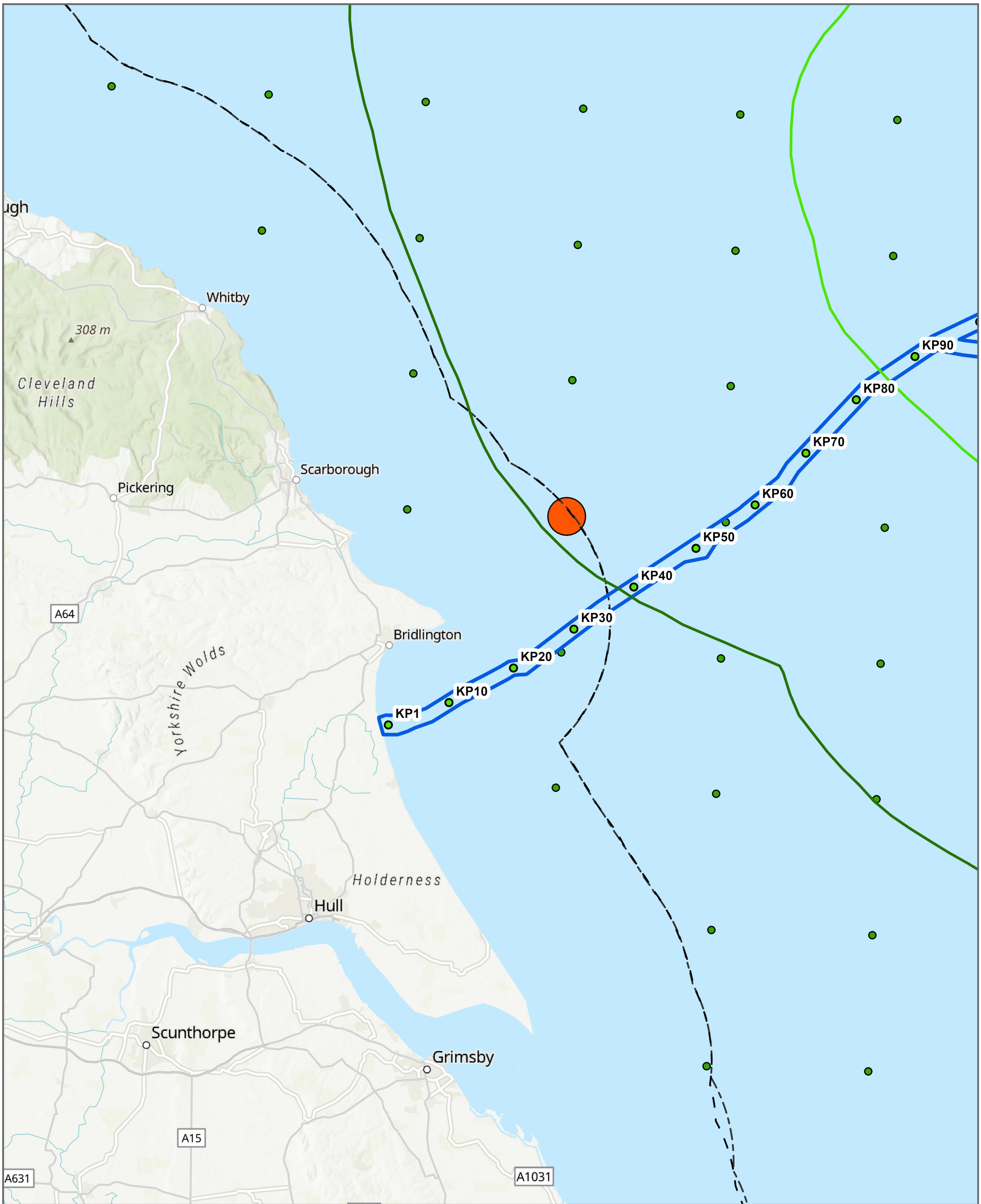
ERM

Figure 3-20

PROJECTION: WGS 1984 UTM Zone 31N

SOURCE: World Topographic Map (ESRI). ICES Eggs and Larvae dataset (2007 - 2023). ICES, Copenhagen

Path: Y:\Projects\J0754512 - Dogger Bank\04_Drawing\Pro\J0754512 - Dogger Bank.aprx / J0754512-MAP-110.5-2011CaughtValues-01



KP Points
Offshore Development Area
UK Territorial Sea Limit (12 nm)
Disturbance Threshold (based on Hawkins et al., 2014)
135dB
Key UWN Thresholds (Popper et al., 2014)
186dB

2012 Larval Abundance per m^2

- 0 - 50
- 51 - 200
- 201 - 600
- 601 - 1,200
- 1,201 - 10,000
- 10,001 - 56,258

0 4 8 12 16 20
Kilometers

N

Title:
IHLS survey data
Caught values (2012)

SCALE: See Scale Bar	VERSION: A01
SIZE: A4	DRAWN: MW
PROJECT: 0754512	CHECKED: MH
DATE: 4/16/2025	APPROVED: MH

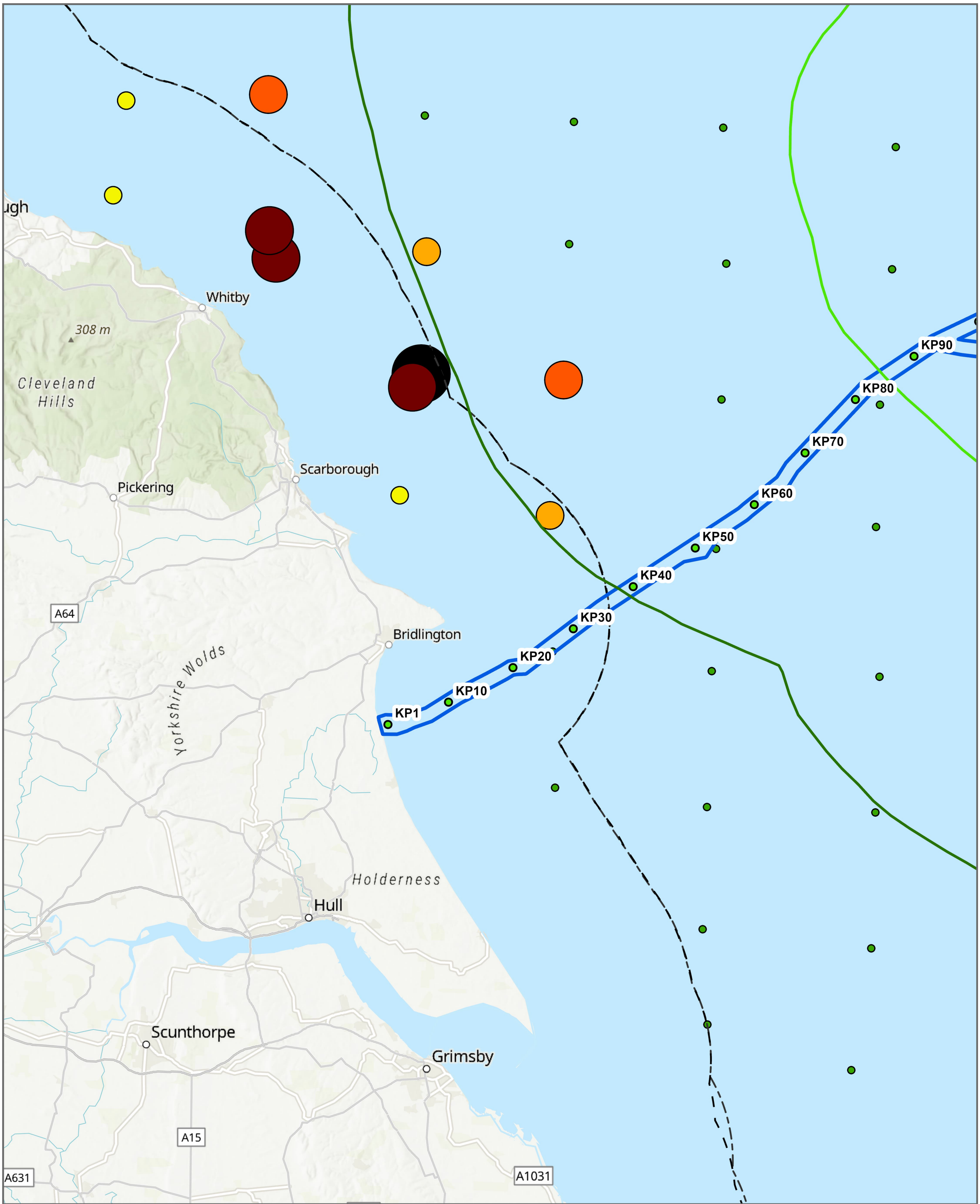
ERM

Figure 3-21

PROJECTION: WGS 1984 UTM Zone 31N

SOURCE: World Topographic Map (ESRI). ICES Eggs and Larvae dataset (2007 - 2023). ICES, Copenhagen

Path: Y:\Projects\J0754512 - Dogger Bank\04_Drawing\Pro\J0754512 - Dogger Bank.aprx / J0754512-MAP-110.6-2012CaughtValues-01



KP Points
Offshore Development Area
UK Territorial Sea Limit (12 nm)
Disturbance Threshold (based on Hawkins et al., 2014)
135dB
Key UWN Thresholds (Popper et al., 2014)
186dB

2013 Larval Abundance per m^2
- 0 - 50
- 51 - 200
- 201 - 600
- 601 - 1,200
- 1,201 - 10,000
- 10,001 - 56,258

PROJECTION: WGS 1984 UTM Zone 31N

Title:
IHLS survey data
Caught values (2013)

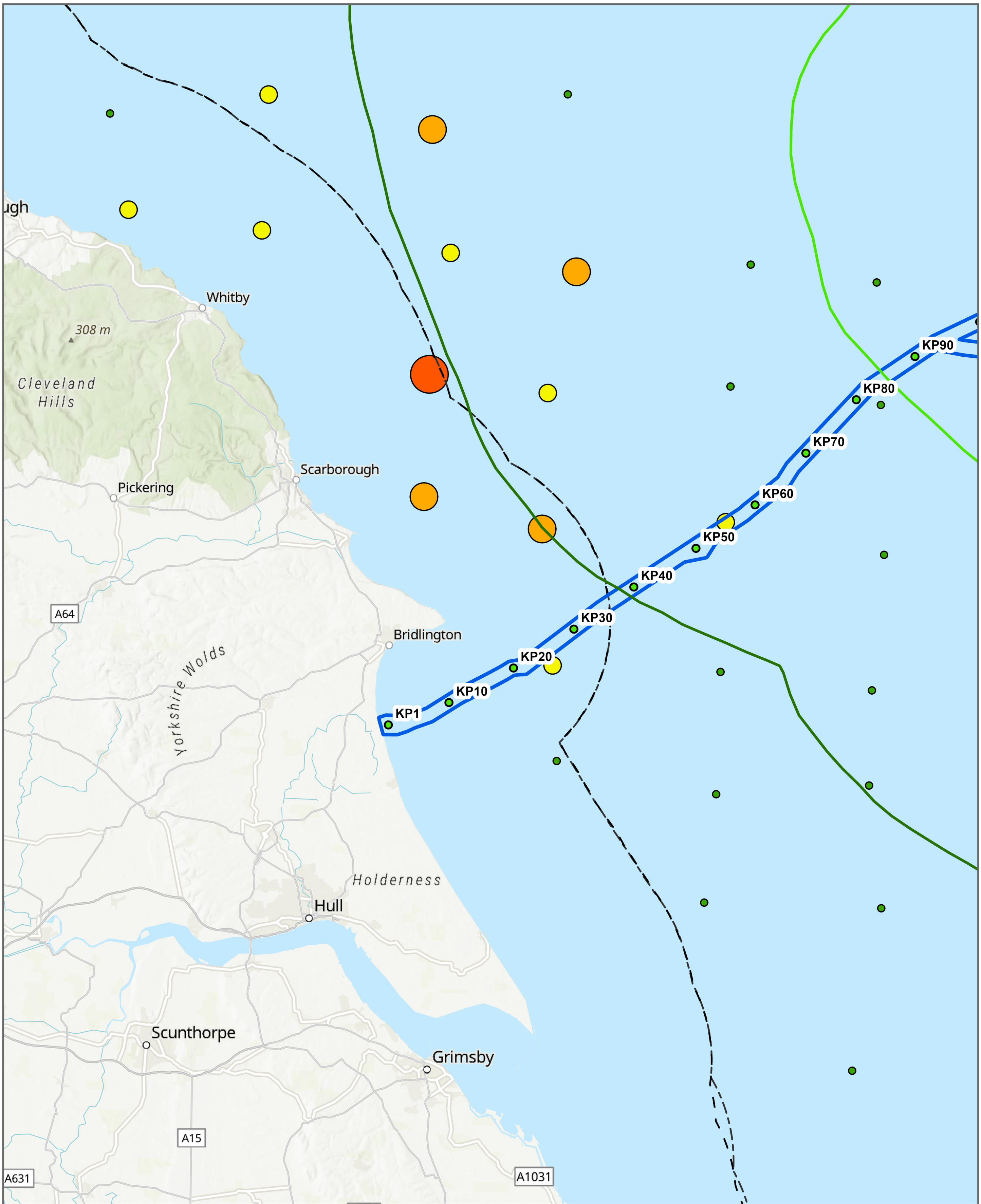
SCALE: See Scale Bar	VERSION: A01
SIZE: A4	DRAWN: MW
PROJECT: 0754512	CHECKED: MH
DATE: 4/16/2025	APPROVED: MH

ERM

Figure 3-22

SOURCE: World Topographic Map (ESRI). ICES Eggs and Larvae dataset (2007 - 2023). ICES, Copenhagen

Path: Y:\Projects\J0754512 - Dogger Bank\04_Drawing\Pro\J0754512 - Dogger Bank.aprx / J0754512-MAP-110.7-2013CaughtValues-01



KP Points
Offshore Development Area
UK Territorial Sea Limit (12 nm)
Disturbance Threshold (based on Hawkins et al., 2014)
135dB
Key UWN Thresholds (Popper et al., 2014)
186dB

2014 Larval Abundance per m²
0 - 50
51 - 200
201 - 600
601 - 1,200
1,201 - 10,000
10,001 - 56,258

0 4 8 12 16 20
Kilometers

N

Title:
IHLS survey data Caught values (2014)

SCALE: See Scale Bar
SIZE: A4
PROJECT: 0754512
DATE: 4/16/2025
VERSION: A01
DRAWN: MW
CHECKED: MH
APPROVED: MH

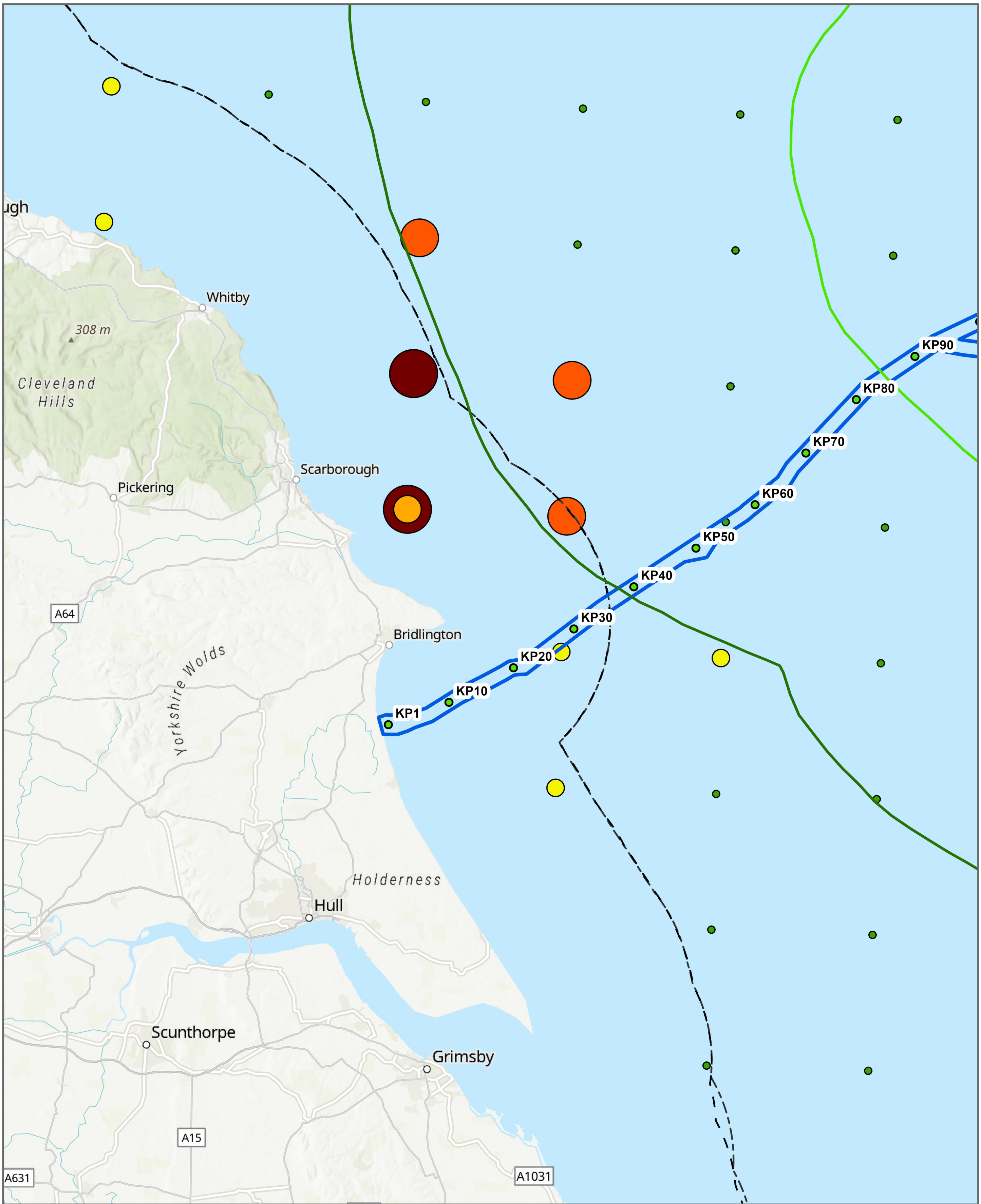
ERM

Figure 3-23

PROJECTION: WGS 1984 UTM Zone 31N

SOURCE: World Topographic Map (ESRI). ICES Eggs and Larvae dataset (2007 - 2023). ICES, Copenhagen

Path: Y:\Projects\J0754512 - Dogger Bank\04_Drawing\Pro\J0754512 - Dogger Bank.aprx / J0754512-MAP-110.8-2014CaughtValues-01



KP Points
Offshore Development Area
UK Territorial Sea Limit (12 nm)
Disturbance Threshold (based on Hawkins et al., 2014)
135dB
Key UWN Thresholds (Popper et al., 2014)
186dB

2015 Larval Abundance per m²
- 0 - 50
- 51 - 200
- 201 - 600
- 601 - 1,200
- 1,201 - 10,000
- 10,001 - 56,258

0 4 8 12 16 20
Kilometers

N

Title:
IHLS survey data
Caught values (2015)

SCALE: See Scale Bar	VERSION: A01
SIZE: A4	DRAWN: MW
PROJECT: 0754512	CHECKED: MH
DATE: 4/16/2025	APPROVED: MH

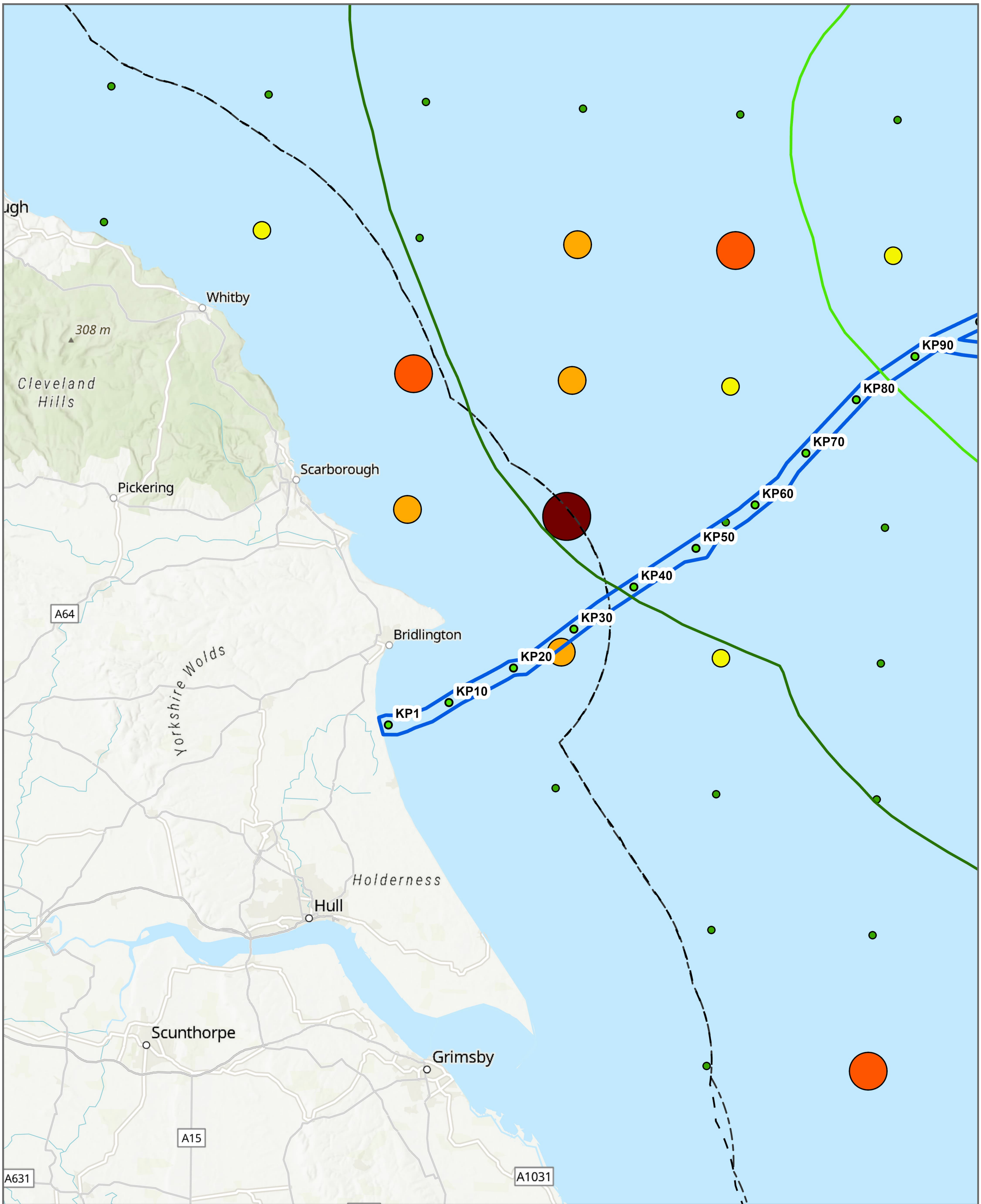
ERM

Figure 3-24

PROJECTION: WGS 1984 UTM Zone 31N

SOURCE: World Topographic Map (ESRI). ICES Eggs and Larvae dataset (2007 - 2023). ICES, Copenhagen

Path: Y:\Projects\J0754512 - Dogger Bank\04_Drawing\Pro\J0754512 - Dogger Bank.aprx / J0754512-MAP-110.9-2015CaughtValues-01



PROJECTION: WGS 1984 UTM Zone 31N

KP Points
Offshore Development Area
UK Territorial Sea Limit (12 nm)
Disturbance Threshold (based on Hawkins et al., 2014)
135dB
Key UWN Thresholds (Popper et al., 2014)
186dB

2016 Larval Abundance per m²
- 0 - 50
- 51 - 200
- 201 - 600
- 601 - 1,200
- 1,201 - 10,000
- 10,001 - 56,258

0 4 8 12 16 20
Kilometers
N

Title:
IHLS survey data
Caught values (2016)

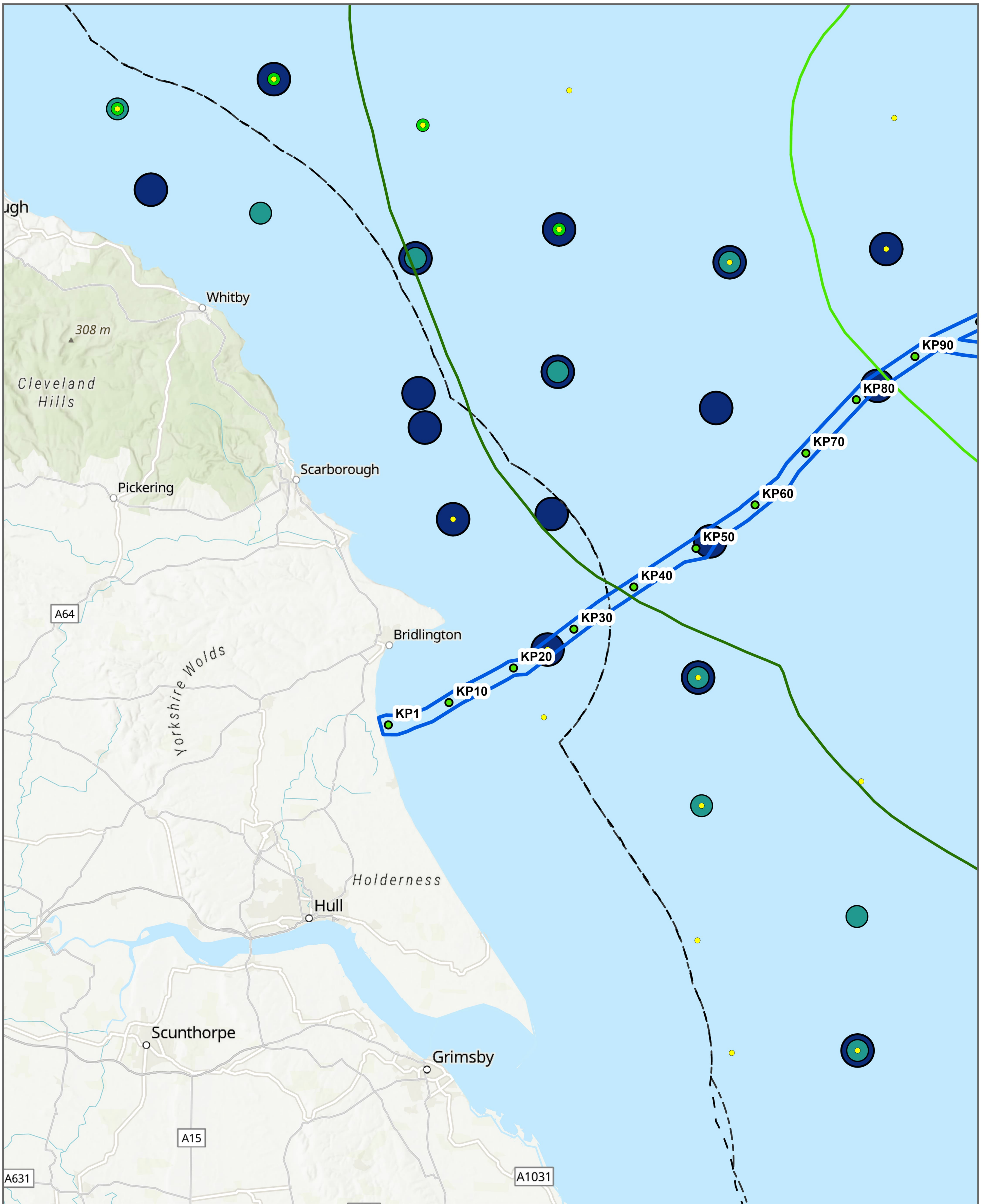
SCALE: See Scale Bar	VERSION: A01
SIZE: A4	DRAWN: MW
PROJECT: 0754512	CHECKED: MH
DATE: 4/16/2025	APPROVED: MH

ERM

Figure 3-25

SOURCE: World Topographic Map (ESRI). ICES Eggs and Larvae dataset (2007 - 2023). ICES, Copenhagen

Path: Y:\Projects\J0754512 - Dogger Bank\04_Drawing\Pro\J0754512 - Dogger Bank.aprx / J0754512-MAP-110.10-2016CaughtValues-01



KP Points
UK Territorial Sea Limit (12 nm)
Disturbance Threshold (based on Hawkins et al., 2014)
135dB
Key UWN Thresholds (Popper et al., 2014)
186dB

2019 Larval Abundance per m^2
1 - 6
7 - 13
14 - 25
26 - 57

0 4 8 12 16 20
Kilometers

N

Title:
IHLS survey data Caught values (2019)

SCALE: See Scale Bar	VERSION: A01
SIZE: A4	DRAWN: MW
PROJECT: 0754512	CHECKED: MH
DATE: 4/16/2025	APPROVED: MH

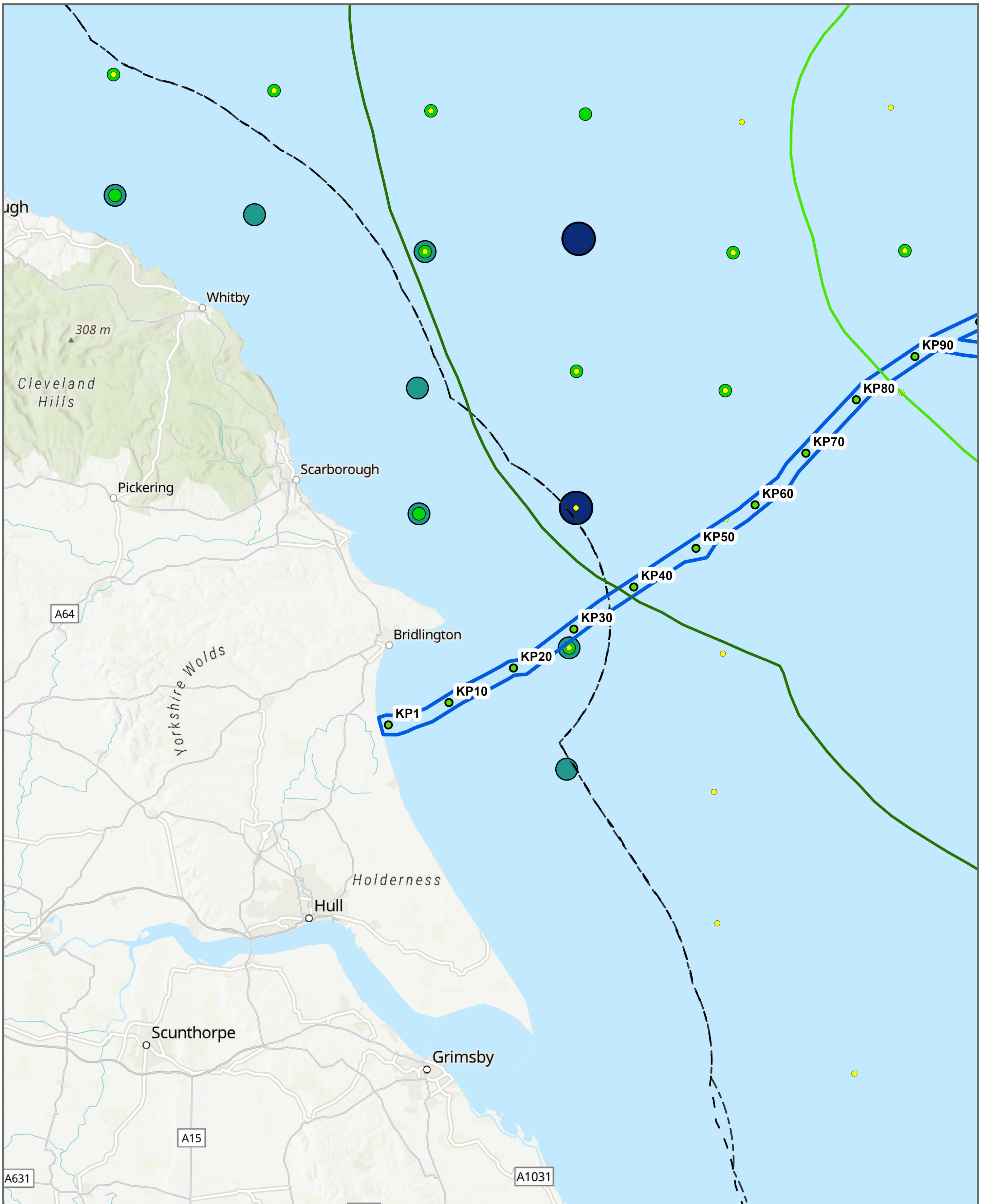
ERM

Figure 3-26

PROJECTION: WGS 1984 UTM Zone 31N

SOURCE: World Topographic Map (ESRI). ICES Eggs and Larvae dataset (2007 - 2023). ICES, Copenhagen

Path: Y:\Projects\J0754512 - Dogger Bank\04_Drawing\Pro\J0754512 - Dogger Bank.aprx / J0754512-MAP-110.11-2019CaughtValues-01



KP Points

UK Territorial Sea Limit (12 nm)

Disturbance Threshold (based on Hawkins et al., 2014)

135dB

Key UWN Thresholds (Popper et al., 2014)

186dB

2022 Larval Abundance per m^2

1 - 6

7 - 13

14 - 25

26 - 57

0 4 8 12 16 20

Kilometers

N

Title:
IHLS survey data
Caught values (2022)

SCALE: See Scale Bar	VERSION: A01
SIZE: A4	DRAWN: MW
PROJECT: 0754512	CHECKED: MH
DATE: 4/16/2025	APPROVED: MH

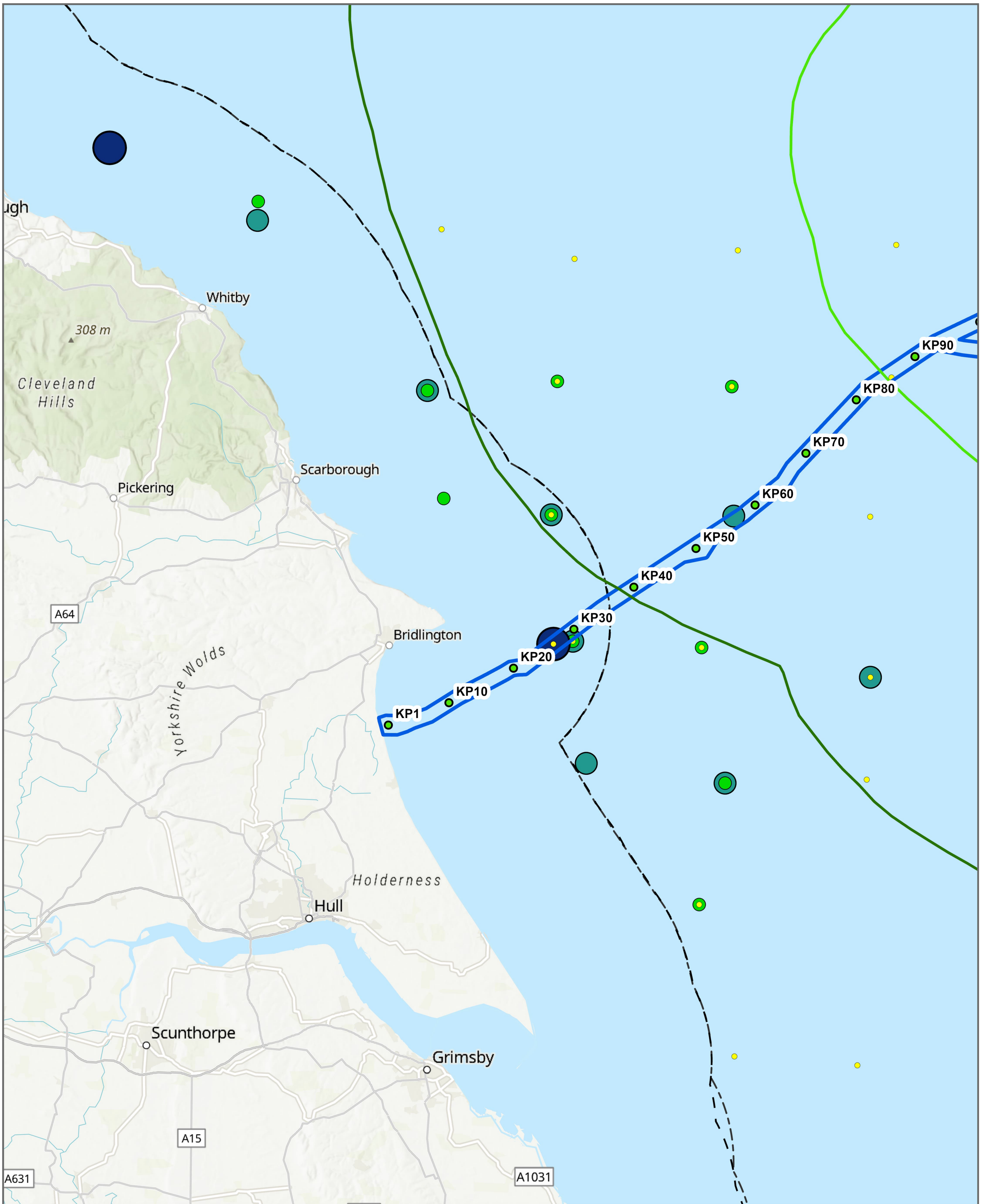
ERM

Figure 3-27

PROJECTION: WGS 1984 UTM Zone 31N

SOURCE: World Topographic Map (ESRI). ICES Eggs and Larvae dataset (2007 - 2023). ICES, Copenhagen

Path: Y:\Projects\J0754512 - Dogger Bank\04_Drawing\Pro\J0754512 - Dogger Bank.aprx / J0754512-MAP-110.12-2022CaughtValues-01



KP Points
UK Territorial Sea Limit (12 nm)
Disturbance Threshold (based on Hawkins et al., 2014)
135dB
Key UWN Thresholds (Popper et al., 2014)
186dB

2023 Larval Abundance per m²
1 - 6
7 - 13
14 - 25
26 - 57

0 4 8 12 16 20
Kilometers

N

Title:
IHLS survey data
Caught values (2023)

SCALE: See Scale Bar
SIZE: A4
PROJECT: 0754512
DATE: 4/16/2025

VERSION: A01
DRAWN: MW
CHECKED: MH
APPROVED: MH

ERM

Figure 3-28

PROJECTION: WGS 1984 UTM Zone 31N

SOURCE: World Topographic Map (ESRI). ICES Eggs and Larvae dataset (2007 - 2023). ICES, Copenhagen

Path: Y:\Projects\J0754512 - Dogger Bank\04_Drawing\Pro\J0754512 - Dogger Bank.aprx / J0754512-MAP-110.13-2023CaughtValues-01

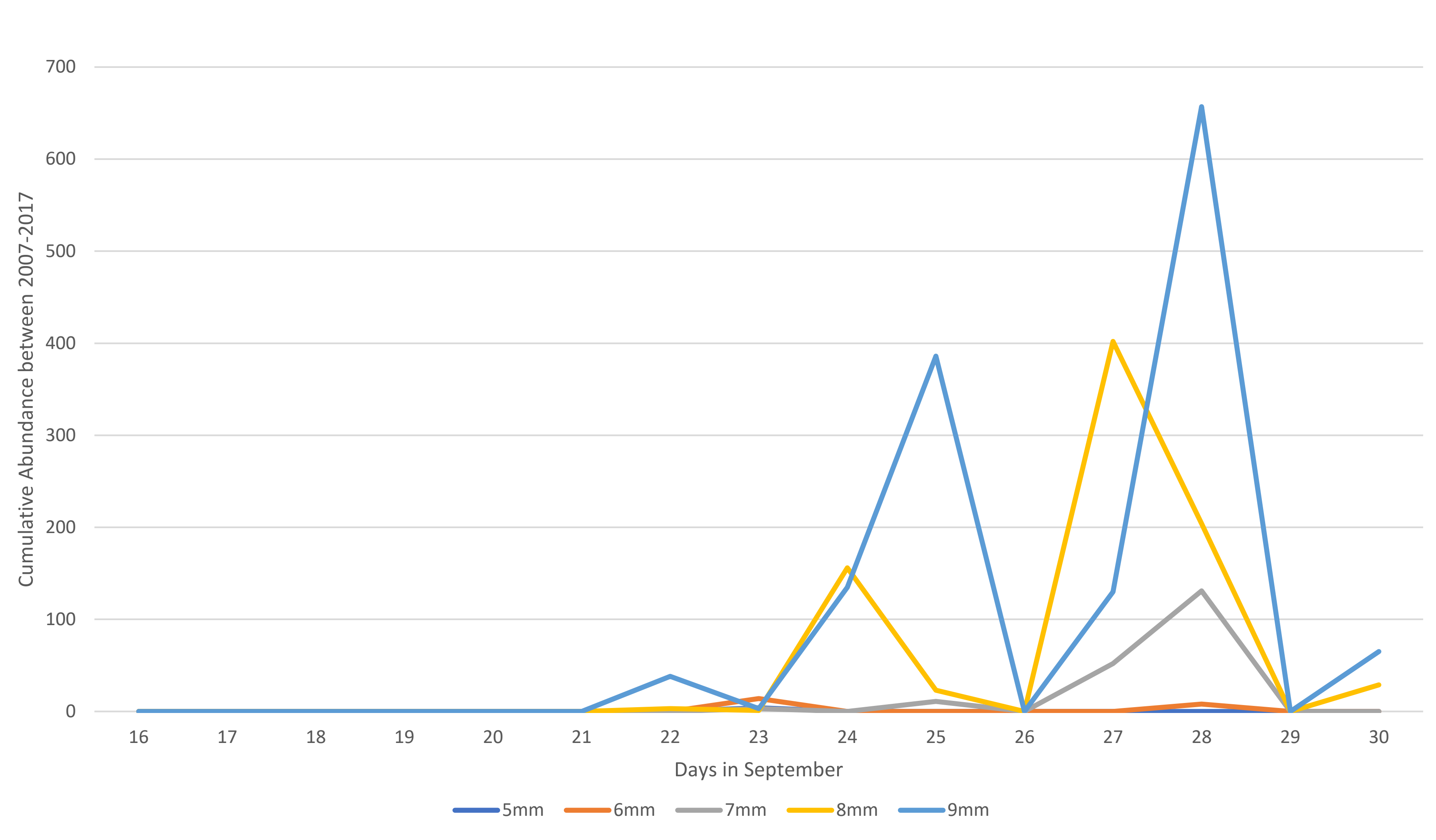


Figure 3-29: International Herring Larval Survey cumulative abundance per length class in areas defined as suitable spawning habitat within the Offshore Export Cable Corridor

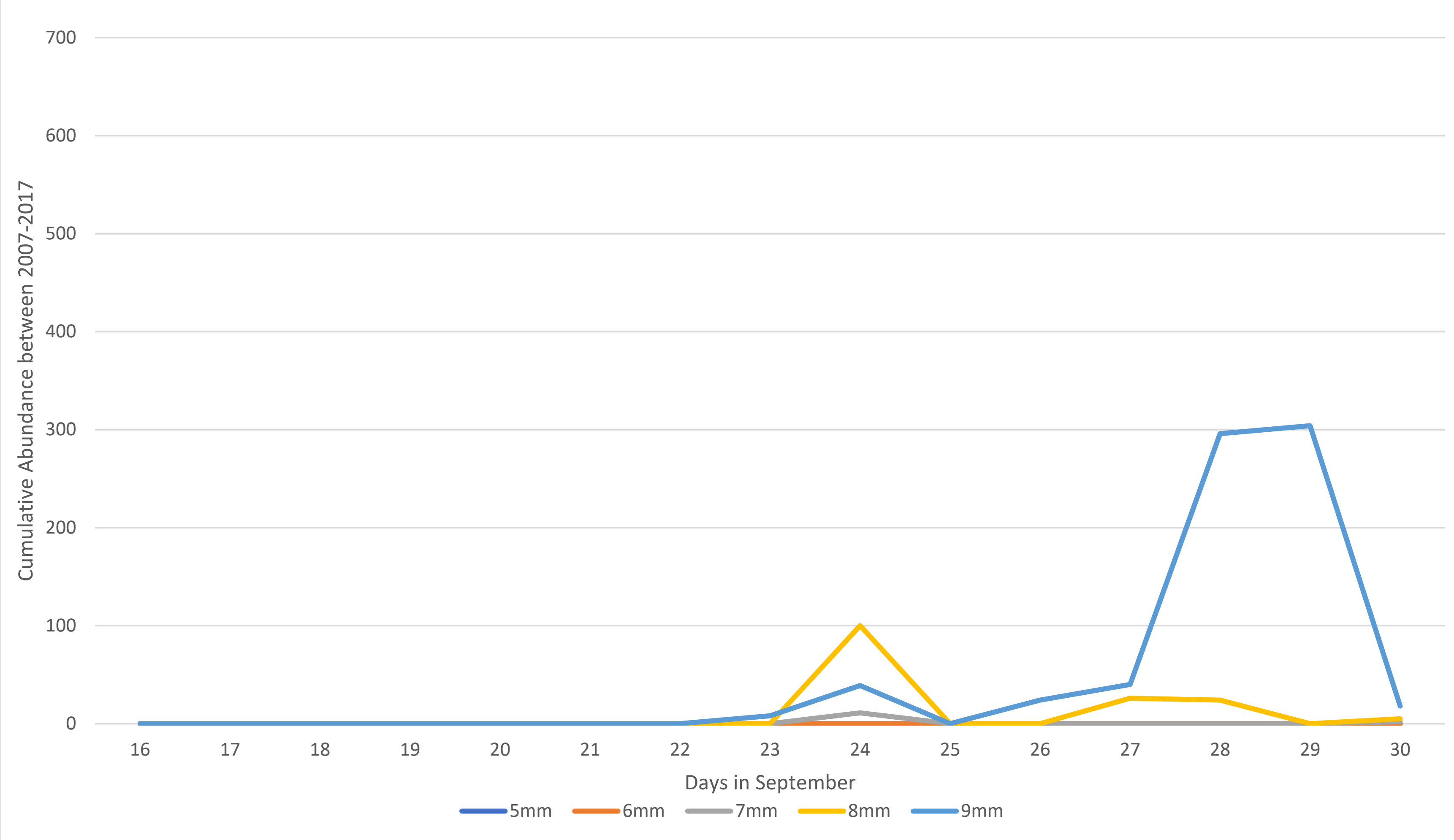


Figure 3-30: International Herring Larval Survey cumulative abundance per length class in areas defined as unsuitable spawning habitat within the Offshore Export Cable Corridor

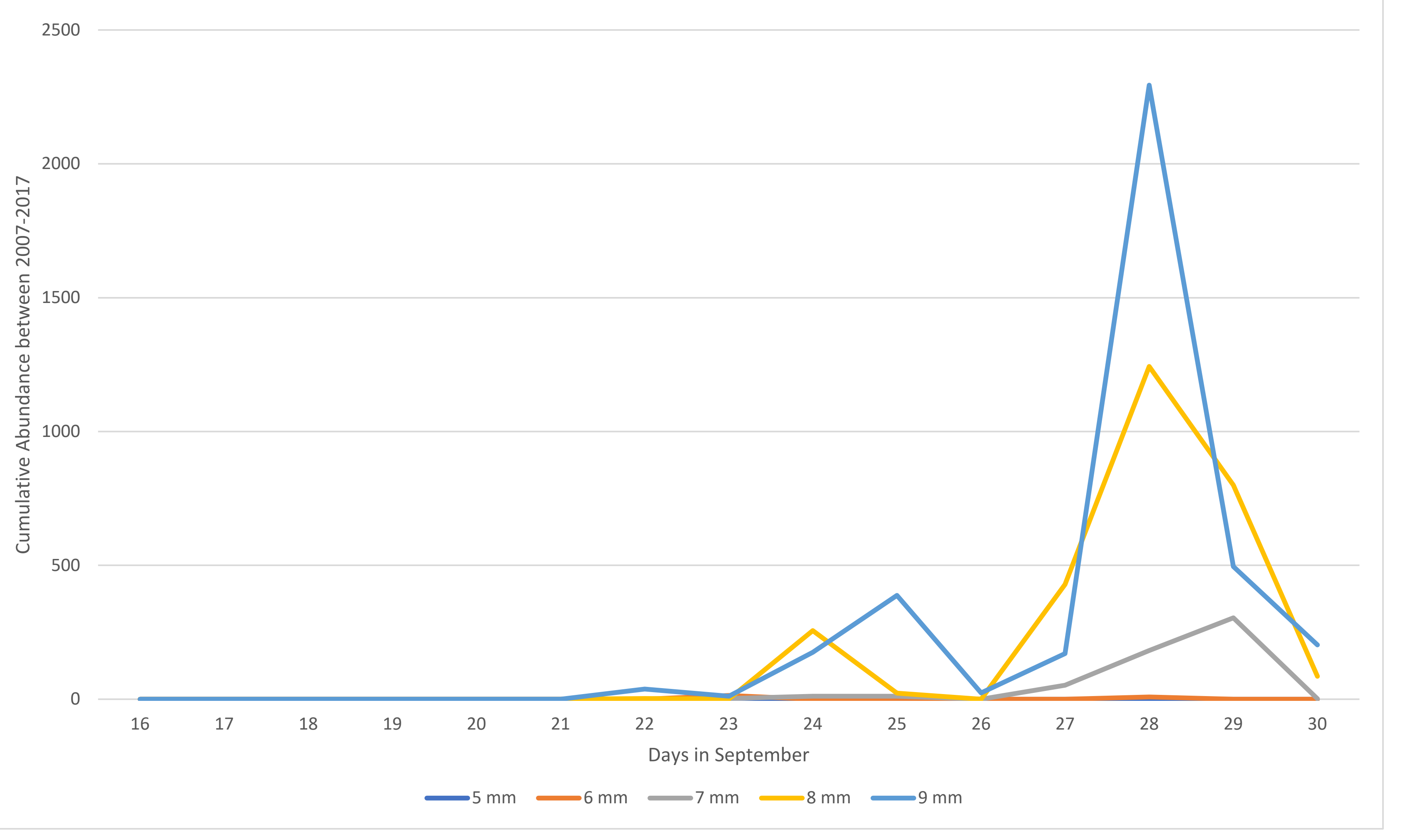


Figure 3-31: International Herring Larval Survey total cumulative abundance per length class within the Offshore Export Cable Corridor

3.3 Egg Development, Yolk Absorption, and Yolk Sac Absorption Periods

23. Several of the back-calculation's input parameters are temperature-dependent and based on a number of sources.

24. The temperature-dependent input parameters defined by Kotthaus (1939) in Russell (1976) are shown in **Table 3-1** and **Table 3-2**.

Table 3-1: The temperature dependent egg development periods defined by Kotthaus (1939) in Russell (1976)

Average Temperature (°C)	Egg Development Period (Days)
12.3	7-9
10.7	10-12
8.7	14-18
8.3	17-20

Table 3-2: The temperature-dependent yolk and yolk sac absorption periods defined by Kotthaus (1939) in Russell (1976)

Average Temperature (°C)	External Disappearance of the Yolk Sac (Days)	Full Absorption of the Yolk Sac (Days)
12.8	3	9
12.0	5	14
10.7	7	16
10.3	7	20

25. When considering a temperature of >12.8°C, the egg development period is <7 days, the yolk absorption / external disappearance of the yolk sac period is <3 days, and the yolk sac absorption period is <9 days. The 0.25 mm per day growth rate is maintained during the yolk absorption period and the yolk sac absorption period.

26. It is noted that Atlantic herring larvae increase in buoyancy as the yolk is absorbed / depleted, and rise into the water column away from the seabed (Dickey-Collas *et al.*, 2009). When in the water column, larvae are no longer considered at risk from cable-laying activities.

4 Back-Calculation Method

27. The Applicants consider that the following metrics are fit for purpose along with respective justifications, to define the periods at which there is potential risk to Atlantic herring eggs and larvae:

- Minimum larval length at hatching = 5 mm (MMO pers. comms.);
- Maximum 0-ringer larval length = 9 mm (Dickey-Collas, 2005; MMO pers. comms.);
- Growth rate = 0.25 mm per day (Heath, 1993);
- Yolk sac absorption period = N/A:
  - The yolk sac is absorbed once the yolk has been depleted / absorbed, at which time larvae are no longer negatively buoyant and are instead present within the water column (Dickey-Collas *et al*., 2009);
  - At this time, larvae are no longer subject to direct disturbance of the seabed during cable laying activities[2]. This metric should not be used to inform the back-calculation for habitat disturbance.
- Yolk absorption (external disappearance of the yolk sac) period = 3 days (Kotthaus, 1939 in Russell, 1976):
  - Larvae are negatively buoyant whilst absorbing the yolk within the yolk sac (Dickey-Collas *et al*., 2009). Larvae in this stage are therefore considered to be associated with the seabed and subject to direct disturbance of the seabed during cable laying activities. This metric should be used to inform the back-calculation instead of the yolk sac absorption stage;
  - Larvae within this period are growing at a rate of 0.25 mm per day, and will therefore be 5.75 mm when the yolk is absorbed.
- Egg development period = 7 days (Kotthaus, 1939 in Russell, 1976):
  - The Applicants do not consider the minimum temperature of 12.3°C used to define the MMO's position of a 9 day period to be reflective of the temperatures within the Offshore Development Area. The IHLS data shows that the Offshore Development Area is consistently >13°C, resulting in an egg development period of <7 days as a precaution.

28. The Projects' back-calculation has been performed over the following scenarios to adequately capture the variability in timing of spawning within the immediate vicinity of the Offshore Export Cable Corridor:

- Scenario 1 – egg development for 5 mm larvae caught on 16th September.
- Scenario 2 - egg development and growth period for 6mm larvae caught on 16th September.

[2] It is noted that Atlantic herring larvae within the water column are tolerant of increased concentrations of suspended sediment (Griffin *et al*., 2009; Kiørboe *et al*., 1981).

- Scenario 3 - egg development and growth period for 8mm larvae caught on 23rd September.
- Scenario 4 - egg development and growth period for 9mm larvae caught on 22nd September.

29. The back-calculation has an inherent variability dependent on whether it is conducted on 16th September (inclusive) or up to the 16th September (exclusive).

30. The back-calculation and resulting timelines for all scenarios for inclusive days and exclusive days are presented in sections 4.1 and 4.2. The MMO's back-calculation is presented alongside these scenarios for comparison.

4.1 Inclusive Back-Calculation

Scenario	August																							
	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	26	26	27	28	29	30	31
1 (5 mm on 16th September)																									
2 (6 mm on 16th September)																									
3 (8 mm on 24th September)																									
4 (9 mm on 22nd September)																									
MMO Example			Egg Development (9 days, >12.3°C)									Yolk Sac Absorption (14 days, >12°C)													

Scenario	September																												
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1 (5 mm on 16th September)										Egg Development (7 days, >13°C)							Yolk Absorption (3 days, >13°C)													
																	Hatched Larvae in IHLS Samples													
2 (6 mm on 16th September)						Egg Development (7 days, >13°C)							Yolk Absorption (3 days, >13°C)				Hatched Larvae in IHLS Samples													
													5 mm to 6 mm Growth Period (4 days)																	
3 (8 mm on 24th September)						Egg Development (7 days, >13°C)							Yolk Absorption (3 days, >13°C)													Hatched Larvae in IHLS Samples					
													5 mm to 8 mm Growth Period (12 days)																	
4 (9 mm on 22nd September)	Egg Development (7 days, >13°C)						Yolk Absorption (3 days, >13°C)																Hatched Larvae in IHLS Samples							
							5 mm to 9 mm Growth Period (16 days)																							
MMO Example	5 mm to 9 mm Growth Period (16 days)																Hatched Larvae in IHLS Samples													

4.2 Exclusive Back-Calculation

Scenario	August																								
	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1 (5 mm on 16th September)																									
2 (6 mm on 16th September)																									
3 (8 mm on 24th September)																									
4 (9 mm on 22nd September)																									
MMO Example		Egg Development (9 days, >12.3°C)									Yolk Sac Absorption (14 days, >12°C)														

Scenario	September																													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1 (5 mm on 16th September)									Egg Development (7 days, >13°C)							Yolk Absorption (3 days, >13°C)														
																Hatched Larvae in IHLS Samples														
2 (6 mm on 16th September)					Egg Development (7 days, >13°C)							Yolk Absorption (3 days, >13°C)				Hatched Larvae in IHLS Samples														
												5 mm to 6 mm Growth Period (4 days)																		
3 (8 mm on 24th September)					Egg Development (7 days, >13°C)							Yolk Absorption (3 days, >13°C)												Hatched Larvae in IHLS Samples						
												5 mm to 8 mm Growth Period (12 days)																		
4 (9 mm on 22nd September)	Egg Development (7 days, >13°C)					Yolk Absorption (3 days, >13°C)																Hatched Larvae in IHLS Samples								
						5 mm to 9 mm Growth Period (16 days)																								
MMO Example	5 mm to 9 mm Growth Period (16 days)															Hatched Larvae in IHLS Samples														

5 Back-Calculation Results

31. The back-calculations presented in sections 4.1 and 4.2 show that the peak period in which eggs and recently hatched larvae are associated with the seabed occurs in early September.

32. The MMO's example back-calculation assumes that larvae will be 5 mm on 16/17th August, then grow for 14 days during yolk sac absorption to 8.5 mm on 30th/31st August, and then grow again for an additional 16 days prior to the 16th September. Assuming the same growth rate, any larvae caught on 16th September would be 12.5 mm in length and will no longer be 0-ringers. The MMO's example back-calculation is therefore not appropriate for determining the start of peak spawning within the Offshore Export Cable Corridor based on 0-ringer larvae collected by the IHLS. Please refer to Kyle-Henney *et al.* (2024) for further information on how 0-ringer data is used to inform the location of potential spawning habitat. Atlantic herring larvae do not stop growing whilst the yolk is depleted and the yolk sac is absorbed (Fischbach *et al*., 2023). In effect, the MMO's example back-calculation double-counts the growth period.

33. Based upon the limited number of 9 mm larvae caught on 22nd September 2015 (38 larvae), the **precautionary** back-calculated risk to Atlantic herring eggs and larvae in the vicinity of the Offshore Export Cable Corridor from cable-laying activities is expected to begin on **30th August** (Scenario 4).

34. However, when determining the peak in spawning activity, the first significant quantities of larvae are 8 mm in length and caught within the Offshore Export Cable Corridor on 24th September. The **peak** back-calculated risk to Atlantic herring eggs and larvae in the vicinity of the Offshore Export Cable Corridor from cable-laying activities is expected to begin on **5th September** (Scenario 3).

35. Based on the precautionary back-calculation and the peak back-calculation, the peak spawning period for Atlantic herring in the area surrounding the Offshore Export Cable Corridor is considered to occur throughout September. Given the limited extent of potential spawning habitat along the Offshore Export Cable Corridor, it is unlikely that cable-laying activities will result in a significant effect on Atlantic herring spawning within the region.

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