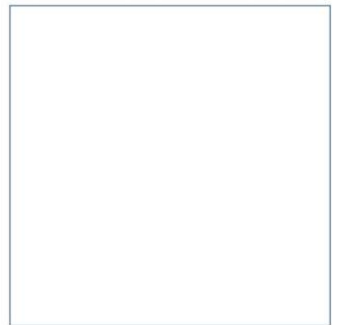
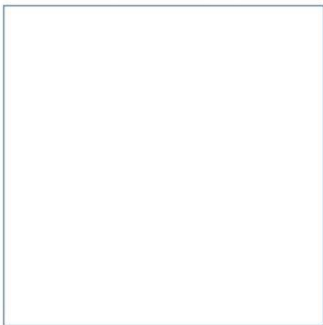
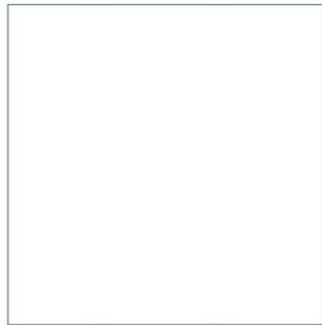


The Crown Estate

Celtic Sea Round 5 Pre Consent Survey

Metocean Moorings: Navigational Risk Assessment

December 2023



Innovative Thinking - Sustainable Solutions

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Celtic Sea Round 5 Pre Consent Survey

Metocean Moorings: Navigational Risk Assessment

December 2023



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Executive Summary

The Crown Estate (TCE) has commissioned ABPmer to carry out a Navigational Risk Assessment (NRA) as part of the Celtic Sea Pre Consent Survey (PCS) programme, Round 5. The NRA supports marine licence applications to deploy nine metocean monitoring equipment moorings, with three moorings in each of the three Round 5 Project Development Areas (PDAs), in the Celtic Sea / outer Bristol Channel area. Six of the moorings (two in each PDA) will have a surface marker buoy; three of the moorings (one in each PDA) will be sub-surface (up to 5m height above seabed) moorings with no surface marker buoy.

To inform the NRA, a marine traffic dataset has been presented. The vessel route density and vessel traffic density data were obtained from EMODnet. The survey periods selected are the months of January and August, using AIS data collected in the last two years at the time of writing (2022 and 2023). The collection of marine traffic data has identified areas of intensity through vessel patterning, which have been used to inform the creation of navigational risk assessments for the study area.

As shown by the marine traffic data, the proposed deployment sites are located to the east of the main shipping routes; to and from Land's End to Smalls; and into and out of the Bristol Channel. The proposed deployment locations also avoid the direct route to and from Milford Haven and Land's End.

To assess navigational risk, Hazard Scenarios were considered, relevant to both the deployment / retrieval stage and the operational phases. In total, 9 hazard scenarios were identified and assessed; 2 of these are relevant to the deployment / retrieval stage and 7 consider the operational phase of the proposed deployments.

A total of 20 embedded and future marine risk controls (mitigation measures) were identified (Section 5.7, Table 11 and Table 12; and Section 5.9, Table 16 and Table 17, respectively). These include newly identified controls, and existing risk controls, which would be applied as appropriate to the deployment / retrieval and operational phases. All new and existing risk controls will require appraising prior to adoption.

Following implementation of appropriate mitigation, marine risk to navigational receptors is tolerable and can be maintained within a level that is 'As Low As Reasonably Practicable'.

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1 Introduction

1.1 Background

The Crown Estate (TCE) is preparing for future rounds of offshore wind farm leasing and has identified three Project Development Areas (PDAs) in the Celtic Sea that will be leased in Round 5. To support this activity, TCE has commissioned a metocean survey (amongst other activities) to make measured data available earlier in the development cycle, to reduce the uncertainty, and hence risk, for potential developers.

TCE has commissioned the deployment of a total of nine metocean survey moorings (see Section 1.2). The moorings will be deployed for approximately 12 months, with the possibility of an extension for some or all equipment.

This Navigation Risk Assessment (NRA) has been undertaken in support of the Marine Licence applications for the deployment of these nine moorings.

This NRA also accounts for the presence of two other similar moorings owned by Celtic Sea Power Ltd (CSP), which are already deployed.

1.2 Study area overview

The regional NRA study area extent is shown in Figure 1 and detail of the local study area is shown in Figure 2.

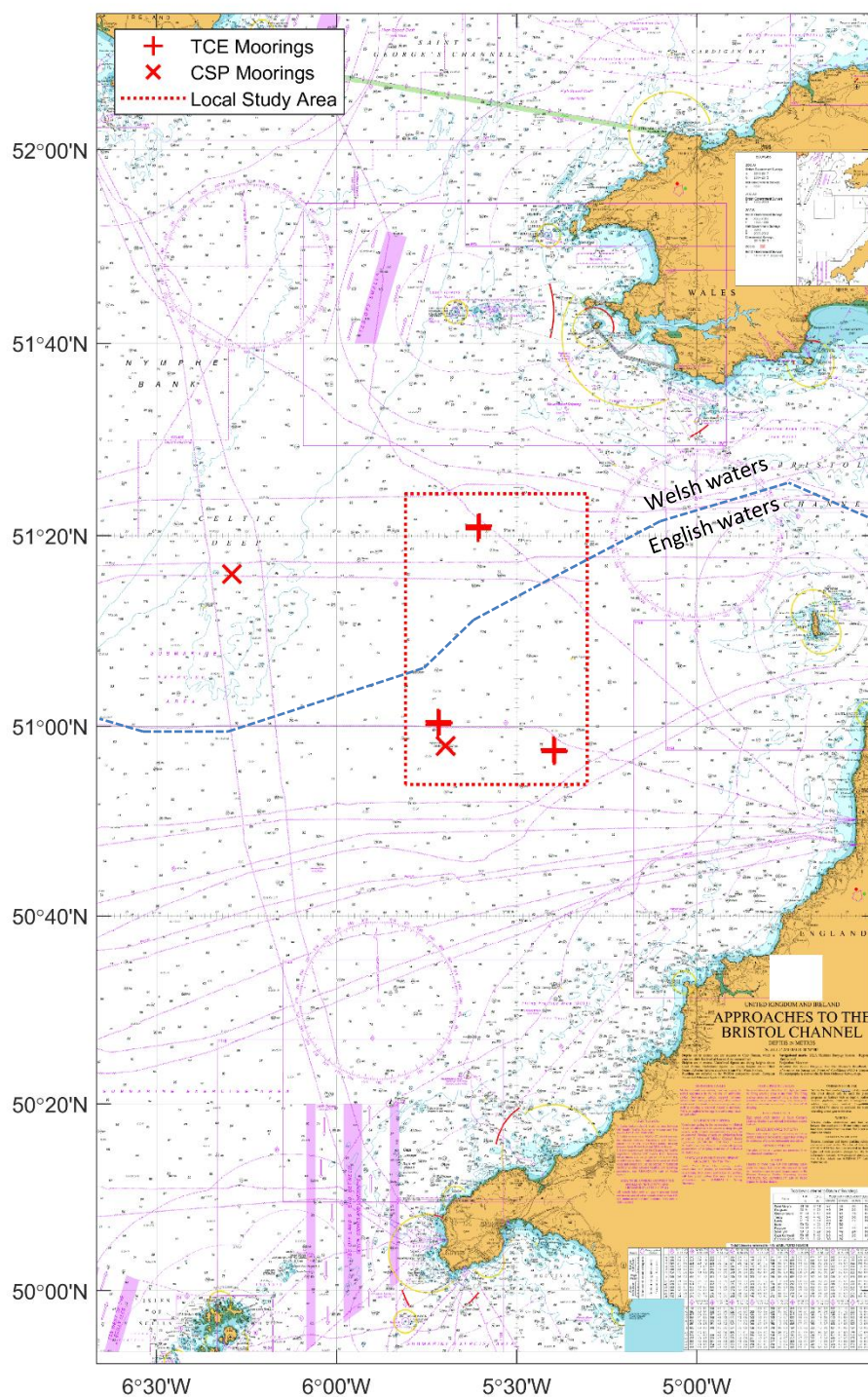
The local NRA study area delineated for the purpose of this NRA (and not related to the PDAs) encompasses the nine TCE moorings (in three groups of three moorings) and one of the two CSP moorings, with a minimum 10km buffer in all directions.

In terms of jurisdiction:

- The northerly group of moorings (Site 1A, in PDA1), is located in Welsh waters.
- The southerly two groups of moorings (Sites 3A in PDA2, and Site 4A in PDA3), are located in English waters.

The local study area is to the east of the north / south shipping lanes running between Land's and the Smalls International Maritime Organization (IMO) Traffic Separation Schemes (TSS).

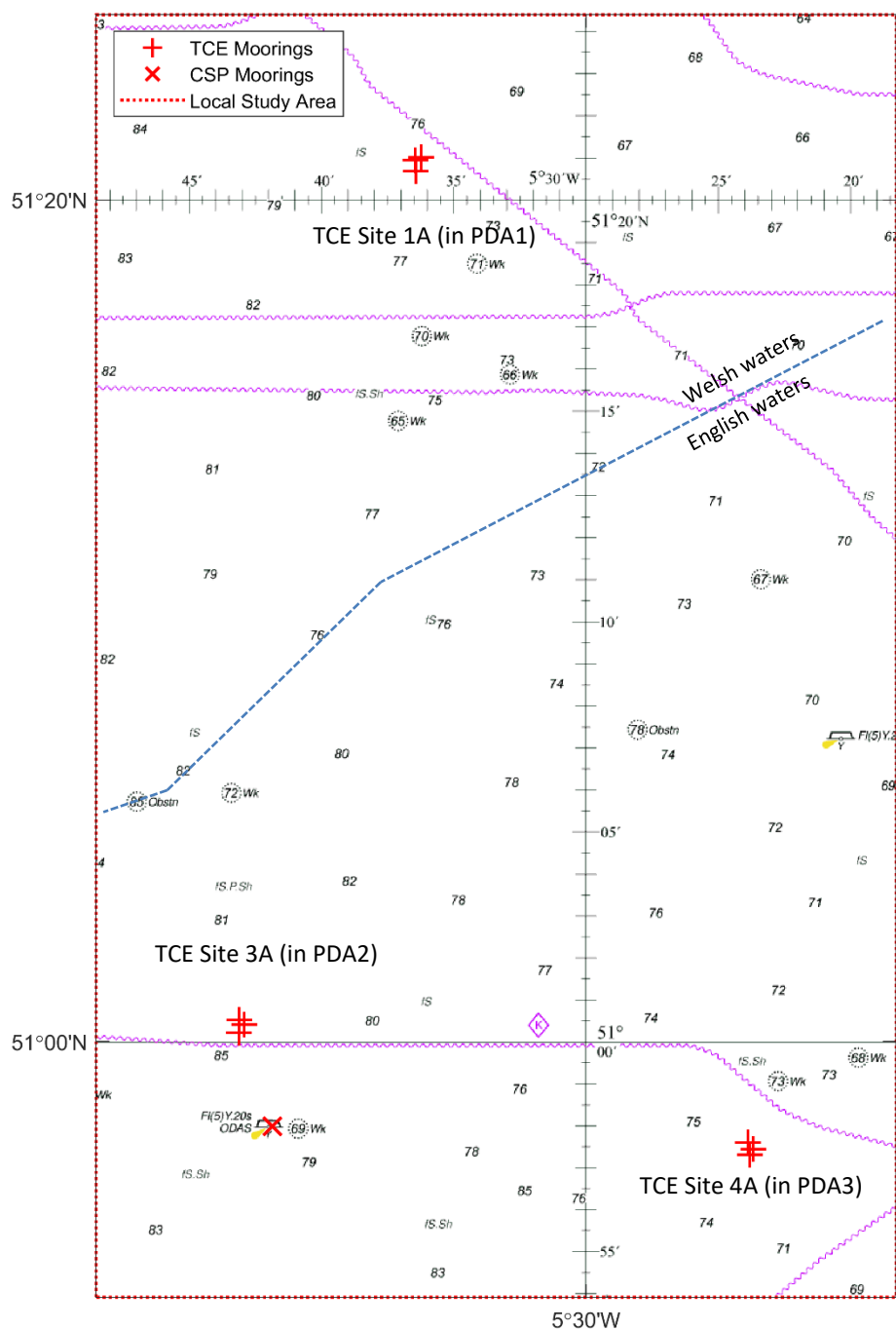
Traffic bound for the Bristol Channel largely routes to the north and south of the local study area. Traffic to and from Milford Haven to Land's End, bisects the proposed deployment positions.



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Figure 1. The regional study area, also showing the location of the proposed (9 total, in groups of 3, at 3 sites¹) TCE moorings, and the existing (2 total) CSP moorings.

¹ At the regional scale, the groups of 3 instruments at the 3 TCE sites appear to overlap. See Figure 2 and Section 2.2 for more details.



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Figure 2. The local study area, also showing the location of the proposed TCE (9 total, in groups of 3, at 3 sites) moorings, and the existing CSP (1 in the local study area) mooring.

1.3 Legislation and guidance

1.3.1 Primary legislation

International protocols and conventions relating to safety, laws of the sea and pollution apply to shipping and ports. The UK Government has a responsibility to ensure that measures are implemented in order to honour its commitments to these protocols. Not least of these, is the UK's responsibility under Article 60 (7) of the United Nations Convention on the Law of the Sea (UNCLOS), relating to provisions for 'Artificial islands, installations and structures in the Exclusive Economic Zone'. An NRA is one process by which the necessary considerations for port and harbour changes can be evaluated. Sea ports and harbours provide the interface between the land, near shore and open sea. The UK Marine Policy Statement (UK Government, 2011) identifies, in relation to marine authorities and decisions makers, that:

"Marine plan authorities and decision makers should take into account and seek to minimise any negative impacts on shipping activity, freedom of navigation and navigational safety; and ensure that their decisions are in compliance with international maritime law" (UK Government, 2011).

1.3.2 Secondary guidance

The following secondary guidance documents have been used in preparation of the NRA. These documents provide information regarding the issues that may be considered when assessing the effect of the proposed data gathering buoys on navigational safety and have been used to guide the creation of this assessment:

- MCA, Marine Guidance Note 654 (MGN 654 Merchant + Fishing) Safety of Navigation: Offshore Renewable Energy Installations (OREIs) – Guidance on UK Navigational Practice, Safety and Emergency Response (MCA, 2022);
- MCA; Methodology for Assessing the Marine Navigational Safety and Emergency Response Risks of Offshore Renewable Energy Installations (OREI) (MCA, 2021); and
- International Maritime Organization (IMO) Revised Guidelines for Formal Safety Assessment (FSA) for use in the IMO rule making process (IMO, 2018).

As the competent authority for marine safety, the MCA has been consulted in the planning and creation of the supporting NRA. In addition, in its capacity as the General Lighthouse Authority, Trinity House has been consulted with respect to the lighting and marking of the proposed project.

1.3.3 ALARP principle

The term 'ALARP' is defined as being 'as low as reasonably practicable', (DfT, 2016). ALARP is an industry-wide standard, applying to both health and maritime safety. Central to this standard is the term 'reasonably practicable'. To meet this standard, the NRA balances risk against the effort, time and money required to control the risk. ALARP (As Low As Reasonably Practicable): IMO (2018) MSC-MEPC.2/Circ.12/Rev.2 refers to:

"A level of risk that is neither negligibly low nor intolerable high. ALARP is actually the attribute of a risk, for which further investment of resources for risk reduction is not justifiable. The principle of ALARP is employed for the risk assessment procedure. Risks should be As Low As Reasonably Practicable. It means that accidental events whose risks fall within this region have to be reduced unless there is a disproportionate cost to the benefits obtained."

Risk assessment is based on a comprehensive and formal assessment of hazards and risks with a view, following assessment and mitigation of the more severe scenarios, to either eliminating the hazards and risks or to reducing them to the lowest possible state, so far as is reasonably practicable. Where a project is proposed which may alter the navigable environment, the promoter of the scheme must consult with those likely to be involved in or affected by such alterations. The overriding aim is to ensure that any consequential risk is reduced to meet the standard of ALARP.

The ALARP principle has been applied with respect to each individual assessment in this NRA to consider if the identified hazard(s) can be reduced to a point which is both 'reasonable' and 'practicable'. In so doing, within this NRA, ALARP has not been defined as a threshold or benchmark target with each hazard scenario being risk assessed to reach its own ALARP conclusion.

1.3.4 Tolerability

The concept of 'tolerability' seeks to define the point at which a risk has an unacceptable outcome (a function of frequency and consequence).

Determining whether the predicted level of risk is acceptable requires a two-part test:

- Firstly, is the risk tolerable; and
- Secondly, is the risk mitigated to ALARP.

When used as part of the assessment process, the NRA allows the Marine Licence applicant to determine whether a hazard outcome (risk) is both tolerable and ALARP.

2 Mooring Details

2.1 Overview

Full details of the planned TCE deployments (including details of each mooring, the equipment mounted, and the deployment methodology) are provided in a separate PCS document:

- **Partrac (2023) Celtic Sea Floating Offshore Wind: Risk Assessment and Method Statement. Report prepared for the Celtic Sea Pre Consent Survey Programme, on behalf of The Crown Estate.**

A copy of Partrac (2023) has been provided to the MCA and Trinity House case officers to accompany this NRA study.

A total of nine moorings will be deployed by TCE in groups of three, at three nominal sites that are located approximately central within each of the three PDAs. For the purposes of survey planning and licencing, in Partrac (2023) the sites are named Site 1A, Site 3A and Site 4A, which are located within PDA1, PDA2 and PDA3, respectively. (The site numbers originally matched PDA numbers in relation to The Crown Estate's October 2022 PDA version. Since then, PDAs have been redefined to three areas in July 2023.)

Each TCE site will comprise:

- One Floating LiDAR system (FLS) mooring;
- One directional waverider buoy mooring; and
- One sub-surface mooring.

The location of each TCE site in the regional and local study area is shown in Figure 1 and Figure 2. More details about the specific deployment locations and the relative locations of the three moorings within each site are provided in Section 2.2. It is noted that the FLS and wave buoy surface moorings will have a swing radius from the actual mooring location of 315m and 195m, respectively.

More details about the appearance and features of each mooring type are provided in Section 2.3.

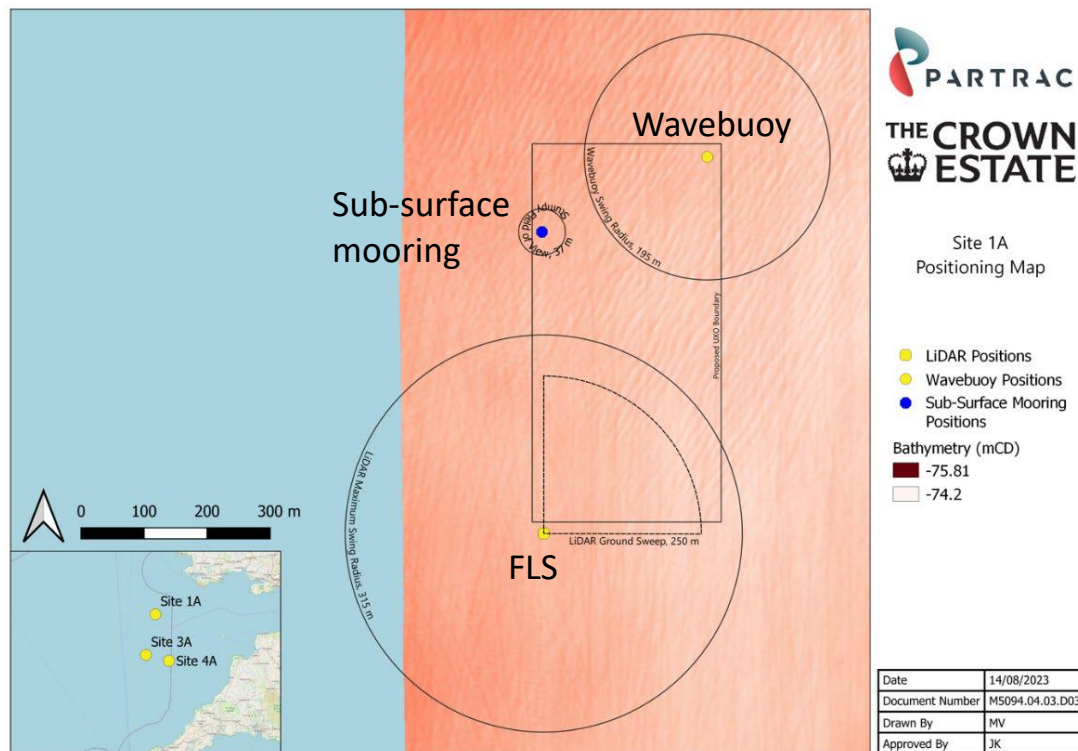
2.2 Deployment locations

2.2.1 Target deployment locations

Table 1. Target deployment locations (from Partrac, 2023)

Site Name	Equipment Type	Deployment Position				Depth (m)
		WGS84 (DMS)		WGS UTM Zone 30N		
		Latitude	Longitude	Easting (m)	Northing (m)	
Site 1A	LiDAR	51° 20' 40.92"N	5° 36' 26.28"W	318418	5691382	74
	Sub-surface	51° 20' 56.40"N	5° 36' 27.36"W	318416	5691860	74
	Wavebuoy	51° 21' 0.36"N	5° 36' 14.04"W	318678	5691979	74
Site 3A	LiDAR	51° 0' 12.60"N	5° 43' 7.68"W	309250	5653730	83
	Sub-surface	51° 0' 24.48"N	5° 42' 55.08"W	309510	5654094	83
	Wavebuoy	51° 0' 30.96"N	5° 43' 6.24"W	309300	5654293	83
Site 4A	LiDAR	50° 57' 36.00"N	5° 23' 53.16"W	331590	5648110	79
	Sub-surface	50° 57' 25.92"N	5° 23' 40.56"W	331824	5647797	77
	Wavebuoy	50° 57' 18.00"N	5° 23' 48.48"W	331663	5647560	75

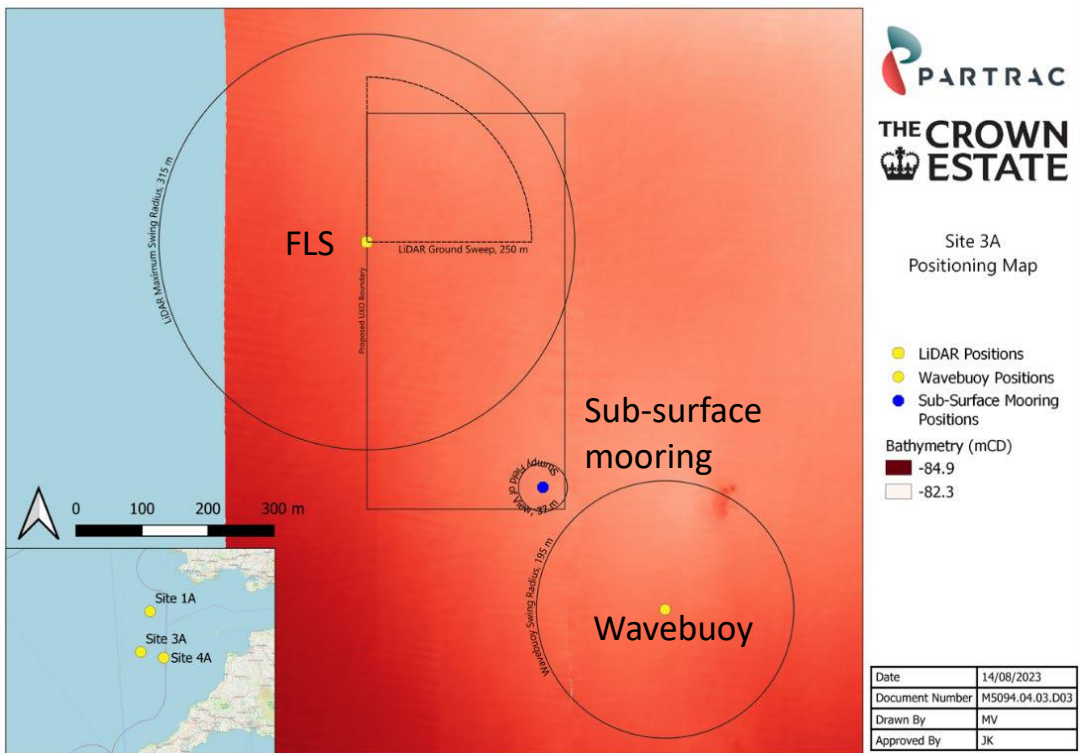
2.2.2 Site 1A detailed layout



N.B. Image clearer when slightly zoomed in.

Figure 3. Local arrangement of moorings in Site 1A (PDA1).

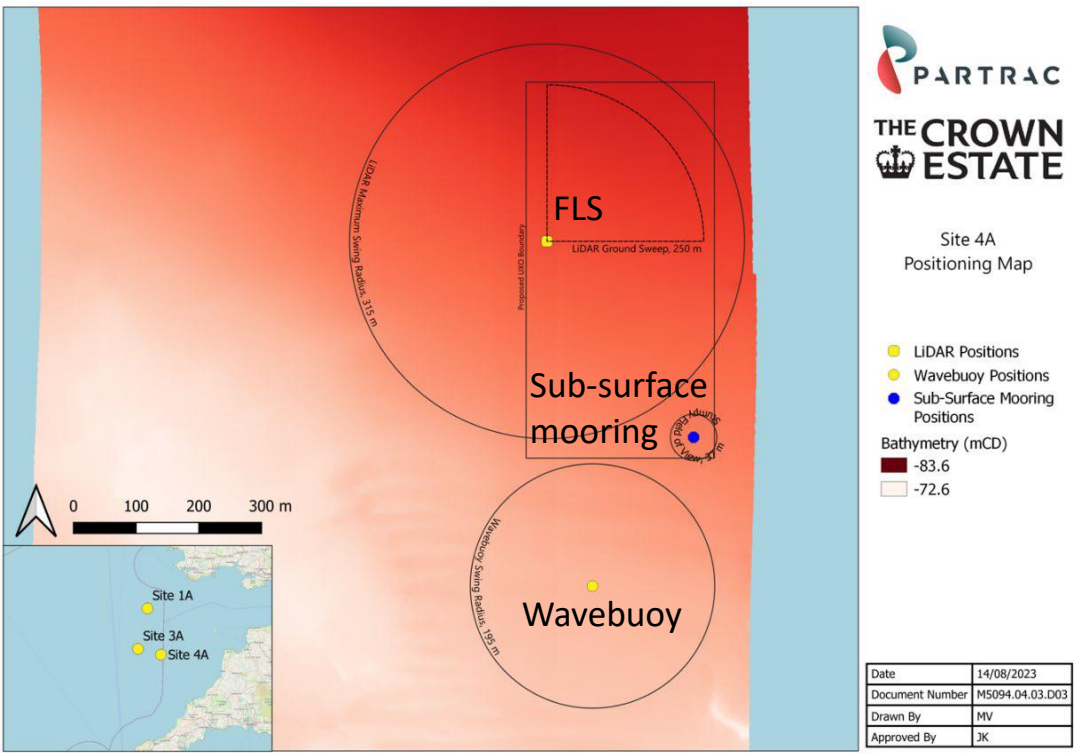
2.2.3 Site 3A detailed layout



N.B. Image clearer when slightly zoomed in.

Figure 4. Local arrangement of moorings in Site 3A (PDA2).

2.2.4 Site 4A detailed layout



N.B. Image clearer when slightly zoomed in.

Figure 5. Local arrangement of moorings in Site 4A (PDA3).

2.3 Equipment to be deployed on the moorings

2.3.1 TCE Floating LiDAR System (FLS)

Features of the Floating LiDAR buoy (Floating LiDAR System, FLS) being deployed by TCE are:

- An Eolos fls200 system;
- A yellow colour floating platform (~4x4x4xm);
- LiDAR (wind profiler);
- Current profiler and wave sensor;
- Met station;
- Solar and wind charging;
- Data and positional telemetry;
- AIS transmitter;
- Radar reflector; and
- Lights (standard marine lantern, planned Fl(5) Y.20s).

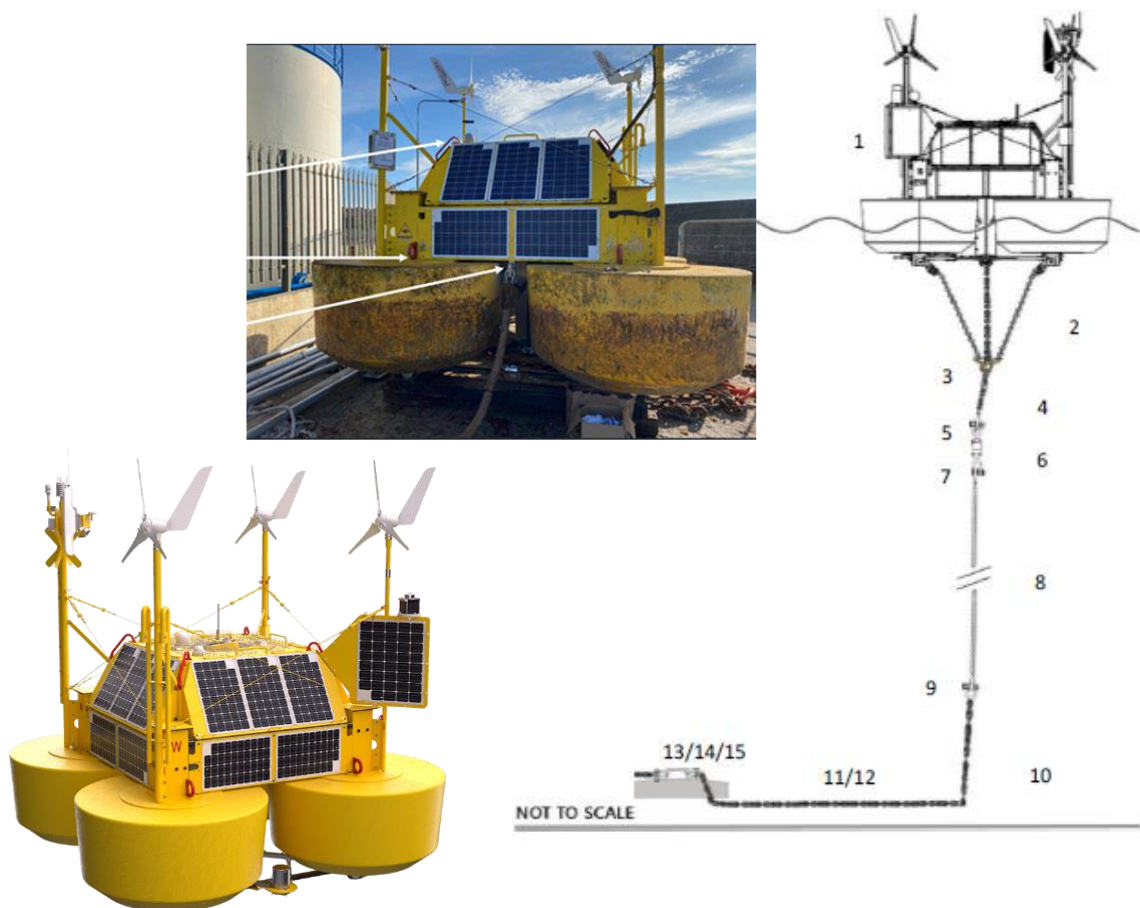


Figure 6. Indicative illustrations of the TCE FLS mooring and buoy appearance.

2.3.2 Wave Buoy

Features of the wave buoy being deployed by TCE are:

- A standard Datawell MkIII waverider buoy;
- Small metal sphere (~0.7 to 0.9m diameter) with a steel bar roll cage around;
- Sphere makes wave measurements;
- Temperature, salinity and turbidity sensors on the lower part of the mooring;
- Passive acoustic monitoring (PAM) sensors on the lower part of the mooring;
- Data and positional telemetry;
- Located ~650m from the FLS; and
- Light on antennae (normally visible up to 3nm, planned Fl(5) Y.20s).

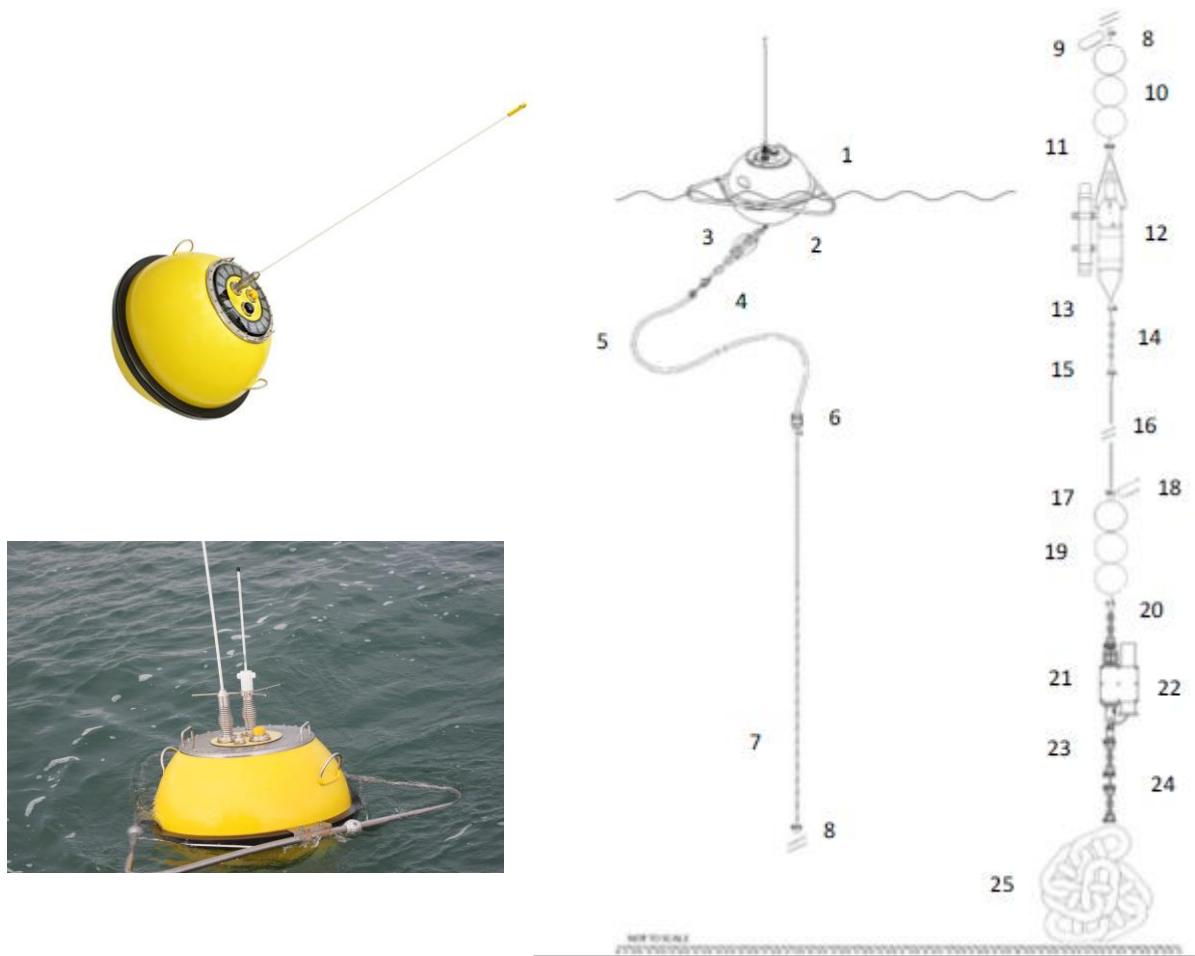


Figure 7. Indicative illustrations of the TCE wave buoy mooring and buoy appearance.

2.3.3 Sub-surface Mooring

Features of the sub-surface (i.e. near seabed) mooring being deployed by TCE are:

- Located near the seabed (the top of the mooring is only up to ~5m above seabed, up to ~1m diameter). No surface float during normal operation;
- A wave sensor and current profiler;
- Acoustic releases for recovery; and
- Located ~500m from FLS.

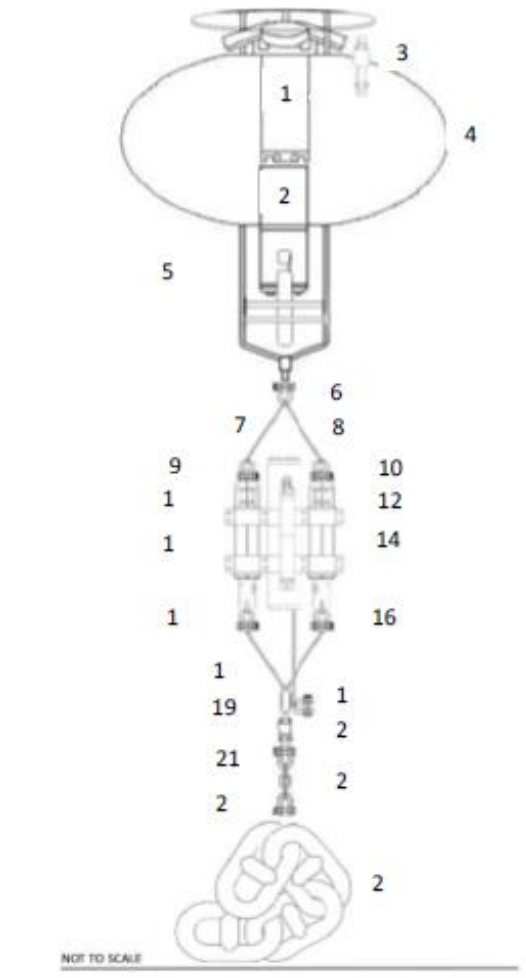


Figure 8. Indicative illustrations of the TCE subsurface mooring (not visible at the water surface).

2.3.4 CSP Floating LiDAR System (FLS)

Features of the Floating LiDAR buoy (Floating LiDAR System, FLS) being deployed by CSP are:

- An Akrocean system;
- A yellow colour floating platform (~5x3x3xm);
- LiDAR (wind profiler);
- Other measurements possible;
- Solar charging;
- Data and positional telemetry;
- AIS transmitter;
- Radar reflective; and
- Lights (standard marine lantern, Fl(5) Y.20s).



Image courtesy of <https://celticseapower.co.uk/>

Figure 9. Indicative illustration of the CSP FLS mooring and buoy appearance.

2.4 Timescales for deployment

Deployment is planned as soon as possible from the time of writing this NRA. The actual date will be subject to confirmation of all licensing requirements, suitable vessel and crew availability, and suitable weather window(s) for deployment.

2.5 Summary of mooring navigational safety features

The TCE FLS mooring will feature:

- Bright yellow colouring for ease of observation in daylight;
- AIS transmitter;
- Radar reflector;
- Lights (standard marine lantern, planned Fl(5) Y.20s);
- Data transmission to shore, including GPS location, which will be automatically monitored as an anchor watch system onshore, and that will provide means of tracking and recovery in the unlikely event of mooring failure;
- Onboard electrical systems to power the navigational aids (and other measurement devices) including suitably designed battery storage systems and local means of recharging via wind and solar;
- 3 monthly inspections of topsides and navigation safety equipment; and
- 6 monthly inspections of full mooring.

The wave buoy mooring will feature:

- Bright yellow colouring for ease of observation in daylight;
- Lights (light on antennae, 3nm range, planned Fl(5) Y.20s);
- Data transmission to shore, including GPS location, which will be automatically monitored as an anchor watch system onshore, and that will provide means of tracking and recovery in the unlikely event of mooring failure;
- Onboard electrical systems to power the navigational aids (and other measurement devices) including suitably designed battery storage systems;
- 3 monthly inspections of topsides and navigation safety equipment, and replacement of batteries; and
- 3-6 monthly inspections of full mooring.

The sub-surface mooring will feature:

- Normally within 5m of the seabed, with no surface presence;
- Bright yellow colouring for ease of observation in daylight – only relevant in the case of mooring failure; and
- 3 monthly inspections of the full mooring and replacement of batteries.

The PCS FLS mooring is seen or assumed to feature:

- Bright yellow colouring for ease of observation in daylight;
- AIS transmitter;
- Radar reflective;
- Lights (standard marine lantern, Fl(5) Y.20s);
- Data transmission to shore, including GPS location, which will be automatically monitored as an anchor watch system onshore, and that will provide means of tracking and recovery in the unlikely event of mooring failure;
- Onboard electrical systems to power the navigational aids (and other measurement devices) including suitably designed battery storage systems and local means of recharging via solar; and
- Routine inspections of topsides and navigation safety equipment and mooring.

3 Marine Traffic Analysis

3.1 Vessel traffic data sources

Vessel traffic data maps are presented as figures, for all vessel types in Section 3.2, and for all other available categories in Appendix A (with signposting to figures in Section 3.2). Data are presented for the recent calendar months of January and August (as agreed with the MCA).

The vessel traffic data have been obtained from the EMODnet Human Activities data portal (EMODnet, 2023). The statistical data are based on analysis of AIS data collected during the associated month, season or year.

The available vessel traffic data include both vessel route density and vessel traffic density data types, as described below.

The two statistical data types have been prepared by separate analysis teams. As a result, the available time period for each data type is slightly different, however, both data types are available for the required calendar months within the last two years. The vessel route density data start later (than the vessel traffic density data), but has continued to be updated through 2023. For the months / years where both types of statistics are available, they are understood to be informed by the same underlying AIS data.

3.1.1 Vessel route density

Vessel route density:

- Website link²;
- Maps of number of vessels transiting through each 1kmx1km cell;
- Data coverage Europe-wide;
- Monthly and seasonal statistics available from January 2019 to August 2023;
- Seasonal statistics available from Spring 2019 to Summer 2023;
- Annual statistics available from 2019 to 2022;
- For vessel types:
 - Passenger (includes AIS ship type codes 60 to 69);
 - Cargo (includes AIS ship type codes 70 to 79);
 - Tanker (includes AIS ship type codes 80 to 89);
 - Fishing (includes AIS ship type code 30);
 - All Other (includes all other ship types), and
 - All Traffic (includes all ships monitored).

Details of the AIS data sources and processing methodology are provided on the website².

² <https://ows.emodnet-humanactivities.eu/geonetwork/srv/eng/catalog.search#/metadata/74eef9c6-13fe-4630-b935-f26871c8b661> (accessed 22 November, 2023)

3.1.2 Vessel traffic density

Vessel traffic density:

- Website link³;
- Maps of time (hours) spent by vessels in each 1kmx1km cell;
- Data coverage Europe-wide;
- Monthly statistics available from January 2017 to December 2022;
- Annual statistics available from 2017 to 2022;
- For vessel types:
 - Other;
 - Fishing;
 - Service;
 - Dredging or underwater ops;
 - Sailing;
 - Pleasure Craft;
 - High speed craft;
 - Tug and towing;
 - Passenger;
 - Cargo;
 - Tanker;
 - Military and Law Enforcement;
 - Unknown; and
 - All ship types.

Full details of the AIS data sources and the data processing methodology for vessel traffic density may be found in:

- https://emodnet.ec.europa.eu/sites/emodnet.ec.europa.eu/files/public/Vessel%20density%20maps_method_v1.5.pdf

³ <https://ows.emodnet-humanactivities.eu/geonetwork/srv/api/records/0f2f3ff1-30ef-49e1-96e7-8ca78d58a07c> (accessed 20 November, 2023)

3.2 Vessel traffic patterns

3.2.1 All vessel types

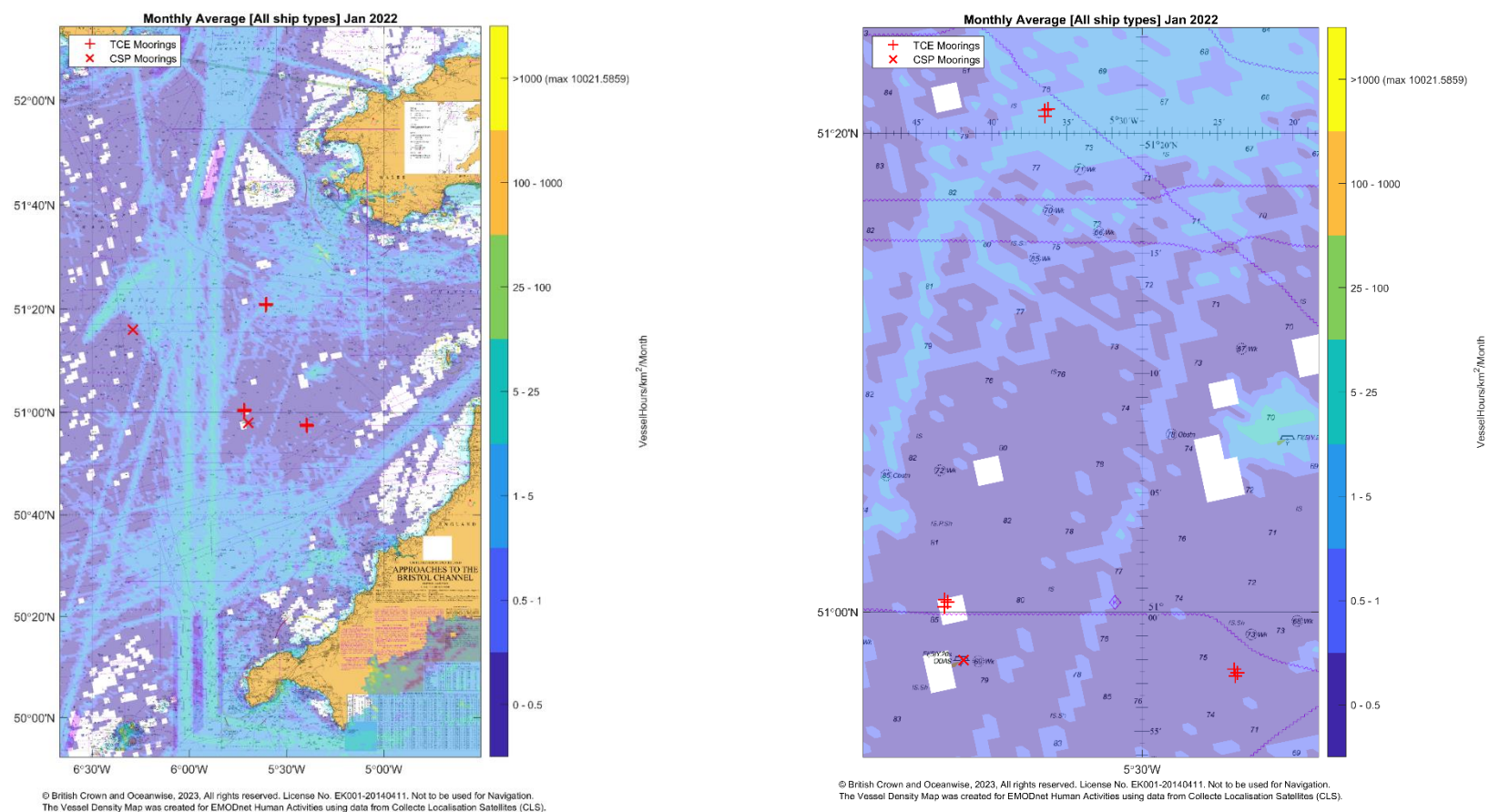


Figure 10. All vessel types – vessel traffic density (hours in 1x1km cell per month), based on AIS data from January 2022, regional and local views.

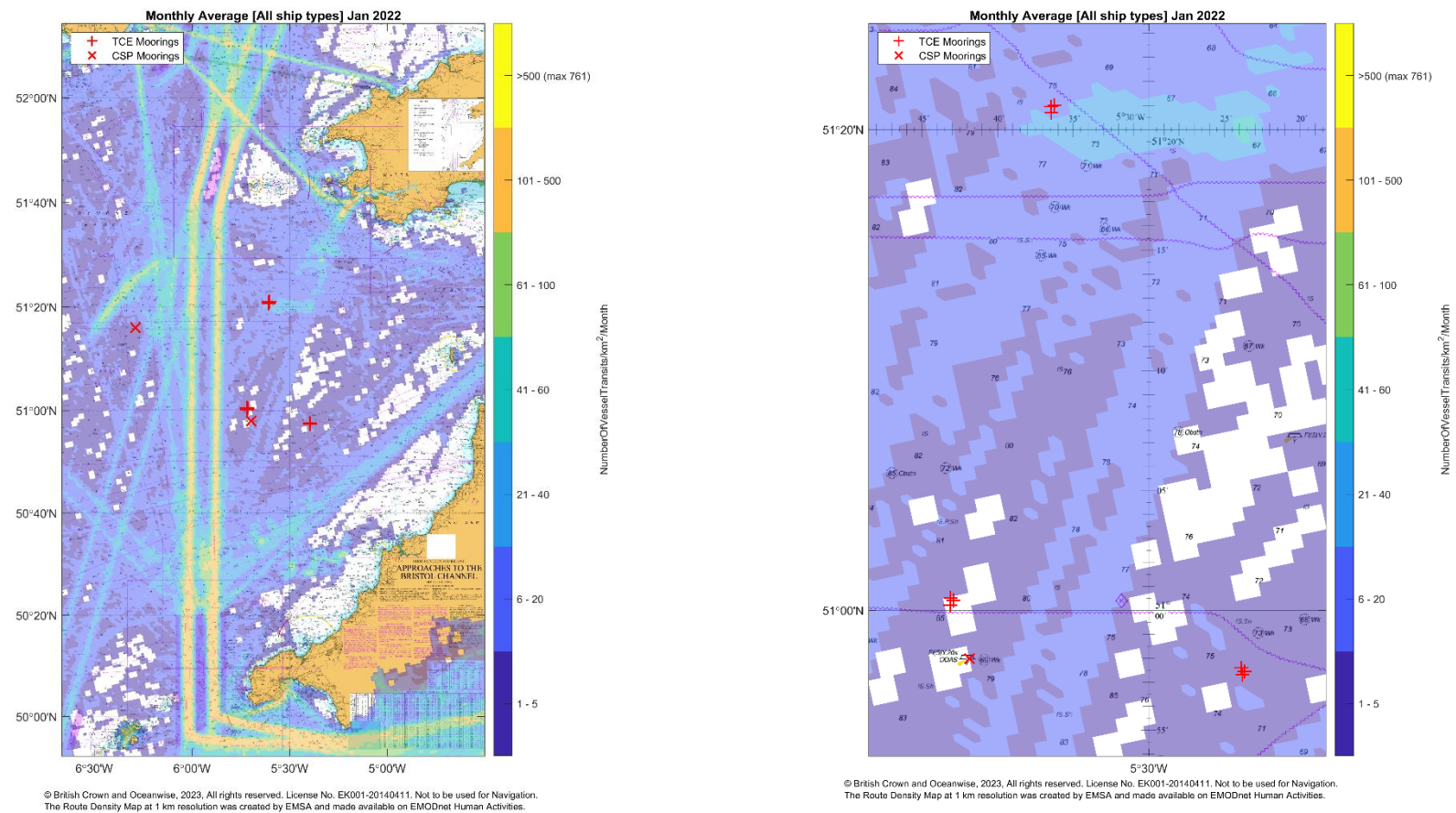


Figure 11. All vessel types – vessel route density (vessel transits crossing 1x1km cell per month), based on AIS data from January 2022, regional and local views.

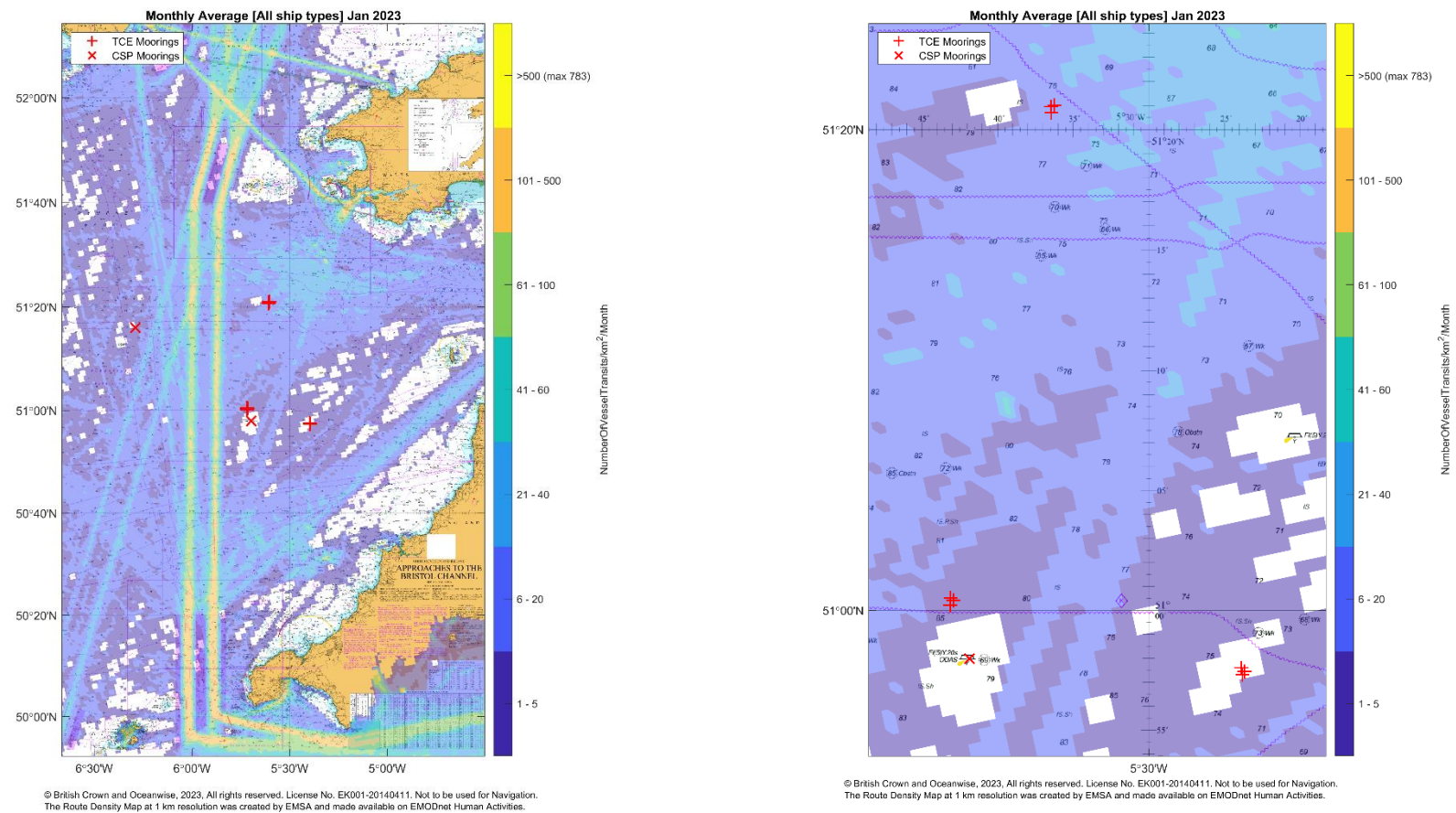


Figure 12. All vessel types – vessel route density (vessel transits crossing 1x1km cell per month), based on AIS data from January 2023, regional and local views.

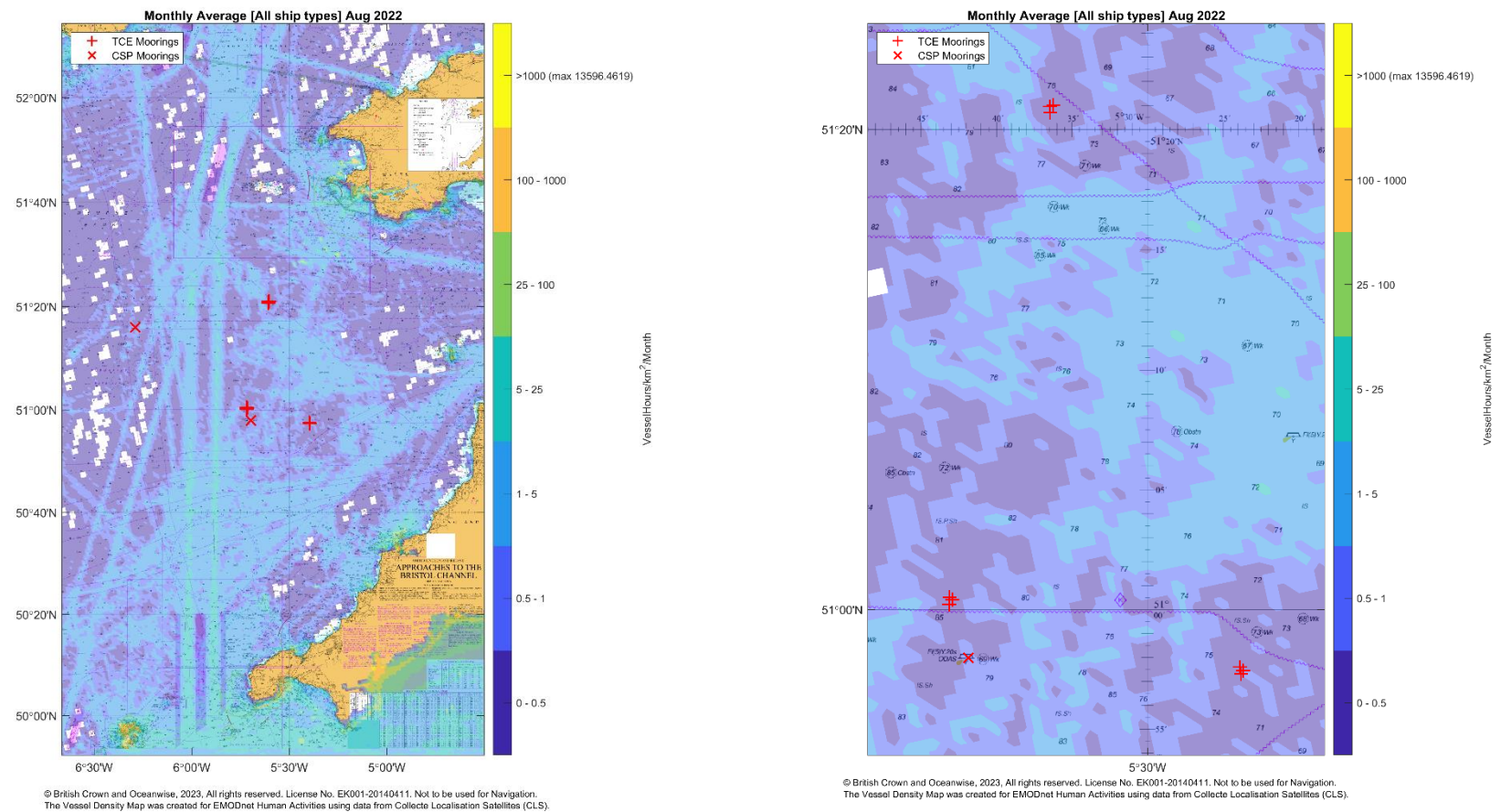


Figure 13. All vessel types – vessel traffic density (hours in 1x1km cell per month), based on AIS data from August 2022, regional and local views.

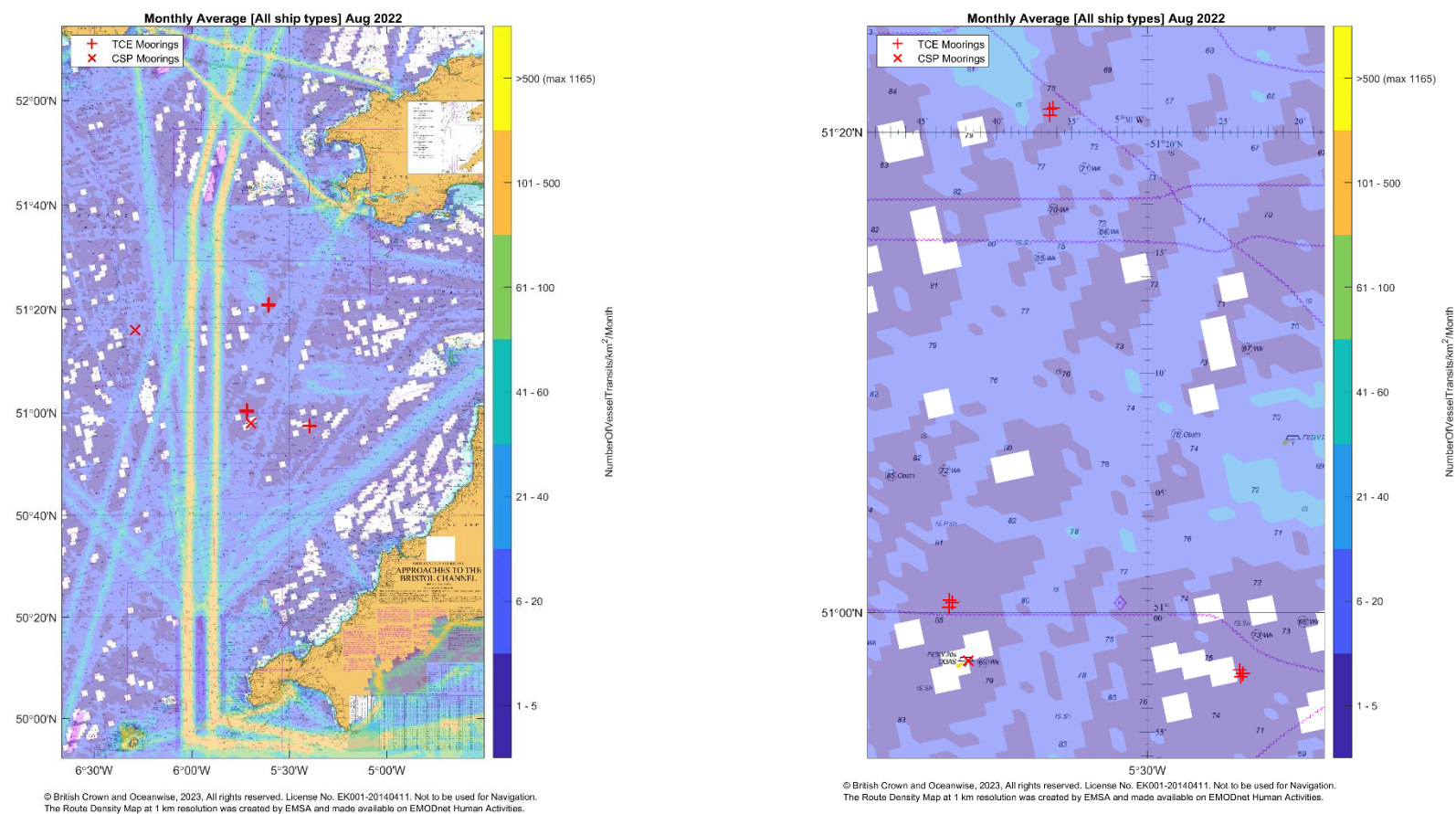


Figure 14. All vessel types – vessel route density (vessel transits crossing 1x1km cell per month), based on AIS data from August 2022, regional and local views.

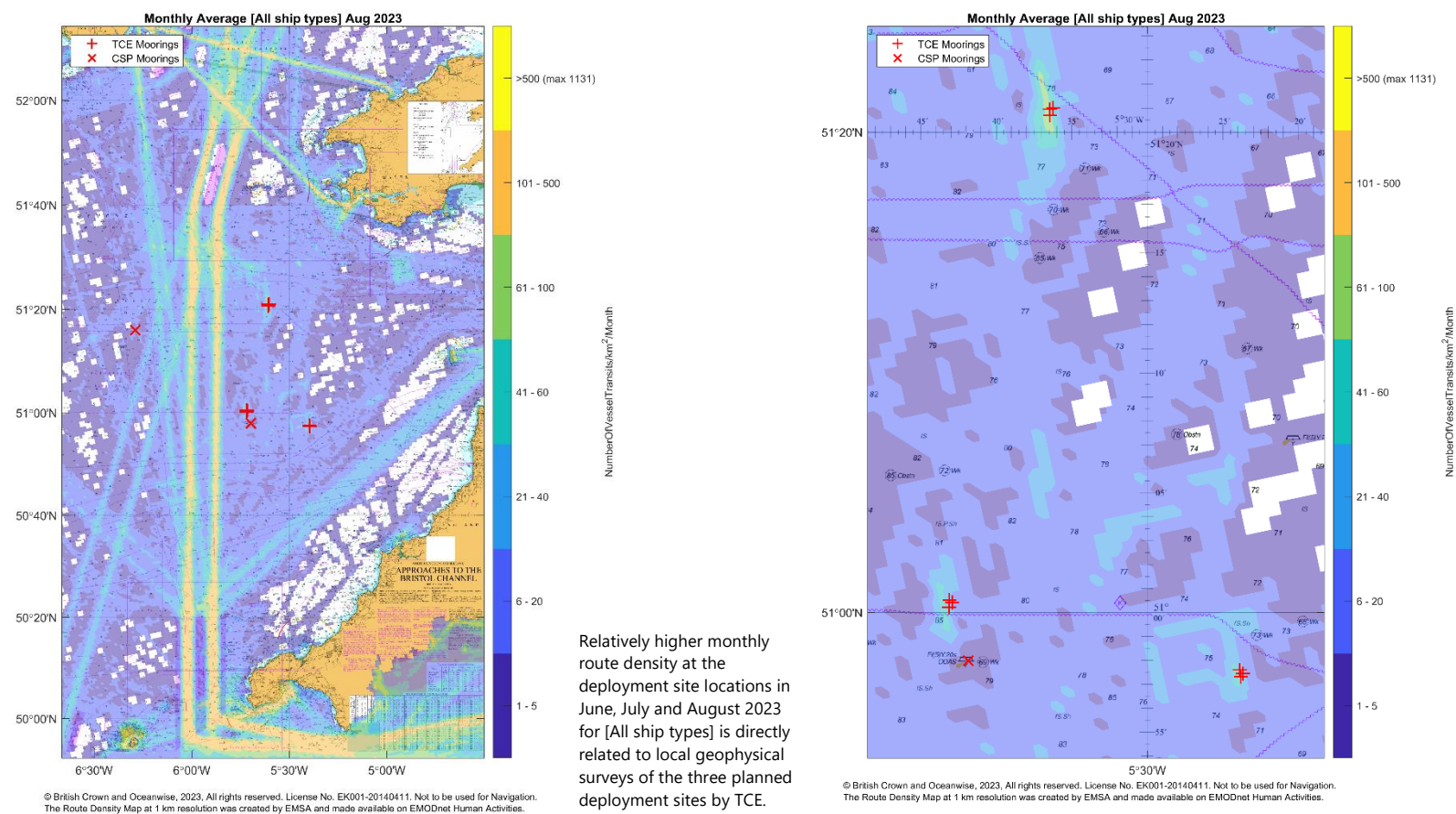


Figure 15. All vessel types – vessel route density (vessel transits crossing 1x1km cell per month), based on AIS data from August 2023, regional and local views.

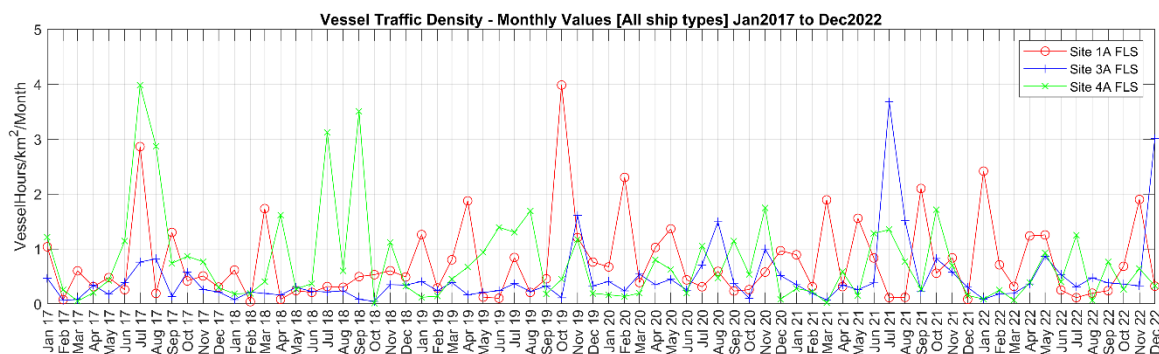


Figure 16. All vessel types – monthly vessel traffic density (vessel hours in 1x1km cell per month), based on AIS data from January 2017 to December 2022.

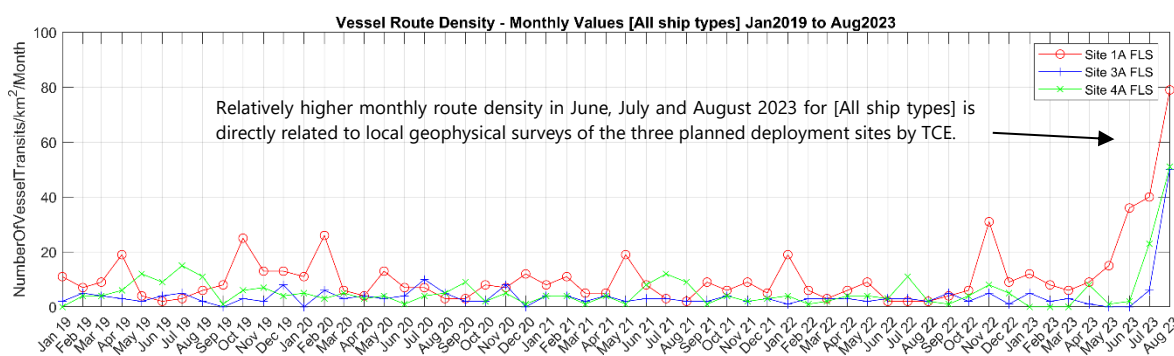


Figure 17. All vessel types – monthly vessel route density (vessel transits crossing 1x1km cell per month), based on AIS data from January 2019 to August 2023.

As shown in Figure 10 to Figure 15, there is some minor local spatial variability in the vessel traffic data values around the three deployment sites in any given month. The time series of monthly vessel route density in Figure 16 and Figure 17 illustrates the values extracted for the 1x1km cell encompassing the FLS mooring location. The nearby wave buoy and subsurface moorings are only 500-650m from the FLS, so the data shown for the FLS location are likely to be the same as, or very closely representative of all moorings at a given site.

3.2.2 Other vessel types

Maps of vessel traffic and route density, for all available vessel type categories other than [All vessel types], are provided in Appendix A.

Location specific monthly vessel traffic and route density timeseries plots, for all available vessel type categories other than [All vessel types], are provided in Appendix B.

3.3 Summary of vessel traffic data

Vessel traffic data maps (including vessel route density and vessel traffic density) show that the local study area had relatively low rates of traffic, for all vessel types, based on AIS data collected in January and August, 2022 and 2023.

The maps also show that the three deployment sites do not intersect any of the main transit routes through the local or regional study area.

Vessel traffic data extracted at the location of the FLS mooring in each site, for all months in the available data record, show that the three mooring deployment sites have consistently had relative low rates of traffic, for all vessel types, at all times of the year, for the last ~7 years.

A small increase in [Other] and consequently [All ship types] vessel traffic is observed in June to August 2023 directly due to geophysical survey activities by TCE at the three planned deployment sites.

[Tanker] vessel types transit through or near to the location of Site 1A approximately 5 to 10, occasionally up to 25 times per month. This represents the greatest amount of historical vessel activity (other than the recent geophysical survey activities in the [Other] vessel category). The number of transits for [Tankers] is typically lower (less than 2 to 5 per month) at Sites 3A and 4A.

[Fishing] vessels, typically make 2 to 15 transits per month through or near to the location of the three deployment sites (0.5 to 4 hours per month spent in the local vicinity). In Site 1A only, fishing activity increased to 30 to 40 transits per month in June and August 2023.

[Cargo] vessels, typically make 1 or 2, occasionally up to 4 transits per month through or near to the location of the three deployment sites (<0.5 hours per month spent in the local vicinity).

All other vessel categories are typically not present in the location of the three deployment sites.

Table 2 and Table 3 provide a summary of vessel traffic data values at the location of the Site 1A FLS, which provides either a representative or relatively more severe example of values for all three deployment sites.

Table 2. Vessel traffic data in January 2022, by ship type, Site 1A FLS (most severe representative location).

Vessel Category	Vessel Hours	% of Total Hours*	Vessel Transits	% of Total Transits*
Other	0.00	0.0	0	0.0
Fishing	0.23	9.7	1	5.3
Service craft	0.00	0.0	*	*
Dredging or underwater operations	0.00	0.0	*	*
Sailing	0.00	0.0	*	*
Pleasure craft	0.00	0.0	*	*
High speed craft	0.00	0.0	*	*
Tug and towing	0.00	0.0	*	*
Passenger	0.00	0.0	0	0.0
Cargo vessels	0.07	2.7	0	0.0
Tankers	2.12	87.6	18	94.7
Military or law enforcement vessels	0.00	0.0	*	*
Unknown craft	0.00	0.0	*	*
Grand Total (All vessel types)	2.42	100.0	19	100.0

* Included in [Other] category if present. Not available as a separate vessel type category for vessel route density statistics.

Table 3. Vessel traffic data in August 2022, by ship type, Site 1A FLS (most severe representative location).

Vessel Category	Vessel Hours	% of Total Hours*	Vessel Transits	% of Total Transits*
Other	0.00	0.0	0	0.0
Fishing	0.04	21.6	2	100.0
Service craft	0.00	0.0	*	*
Dredging or underwater operations	0.00	0.0	*	*
Sailing	0.15	78.4	*	*
Pleasure craft	0.00	0.0	*	*
High speed craft	0.00	0.0	*	*
Tug and towing	0.00	0.0	*	*
Passenger	0.00	0.0	0	0.0
Cargo vessels	0.00	0.0	0	0.0
Tankers	0.00	0.0	0	0.0
Military or law enforcement vessels	0.00	0.0	*	*
Unknown craft	0.00	0.0	*	*
Grand Total (All vessel types)	0.19	100.0	2	100.0

* Included in [Other] category if present. Not available as a separate vessel type category for vessel route density statistics.

4 Navigational Baseline

The following sections review the navigational baseline conditions for commercial shipping and recreational navigation within the study area. Where relevant, factors relating to the proposed buoy deployments have been drawn out. The following elements are covered in the baseline:

- Navigational environment;
- Statutory responsibilities and management procedures;
- Recreational facilities;
- Fishing activities;
- Aids to navigation;
- Metocean conditions;
- Emergency response; and
- Marine incidents.

4.1 Navigational environment

This section presents a description of the navigational features in the study area.

The proposed project is located in the eastern Celtic Sea, in the outer Bristol Channel, with a water depth of 74 m to 83 m. The seabed is generally flat, comprised of sand with small ripple and megaripple bedforms. There are no other significant bathymetric features within the boundary of the proposed project. There are several underwater cables and two other metocean moorings in the wider area.

The planned positions of the proposed mooring deployments have already taken into consideration the following adjacent IMO routing:

- Land's End Traffic Separation Scheme (TSS); and
- Smalls TSS.

And other routing:

- Land's End TSS to and from Milford Haven;
- Land's End TSS to and from the Bristol Channel ports;
- Milford Haven to Bristol Channel; and
- Milford Haven to Smalls TSS.

The Port of Milford Haven is the most significant Statutory Harbour Authority (SHA) in the vicinity of the study area and services a range of vessels that include Very Large Crude Carriers (VLCC), Q-Max LNG carriers and Chemical / Product Tankers.

4.2 Statutory responsibilities and management procedures

There are no SHA boundaries overlapping with the proposed buoy deployment sites. The closest SHA is the Port of Milford Haven, vessels navigating to or from the Port of Milford Haven are required to give advanced notice and Very High Frequency (VHF) radio confirmation to Milford Haven Vessel traffic Services (VTS). The proposed Buoy deployments are located outside of an established SHA or Local Lighthouse Authority (LLA) and therefore the competent authority with respect to navigation is the MCA and Trinity House (General Lighthouse Authority) are the competent Authority in respect to navigation lighting.

4.3 Metocean conditions

4.3.1 Waves

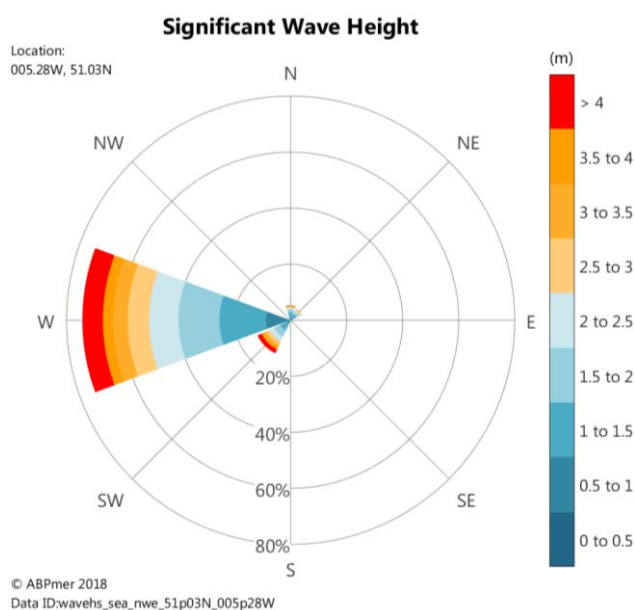


Figure 18. Wave rose for the local study area

Figure 18 shows the significant wave height for the approximate centre between the three PDAs in the Celtic Sea. This provides an indication of wave and swell conditions and identifies that the waves are primarily from directly West. There is a small predominance from the South-West and an extremely minimal predominance from North and North-West. Waves are under 2 metres in height for approximately half the time but frequently reach upwards of 4 metres.

4.3.2 Wind

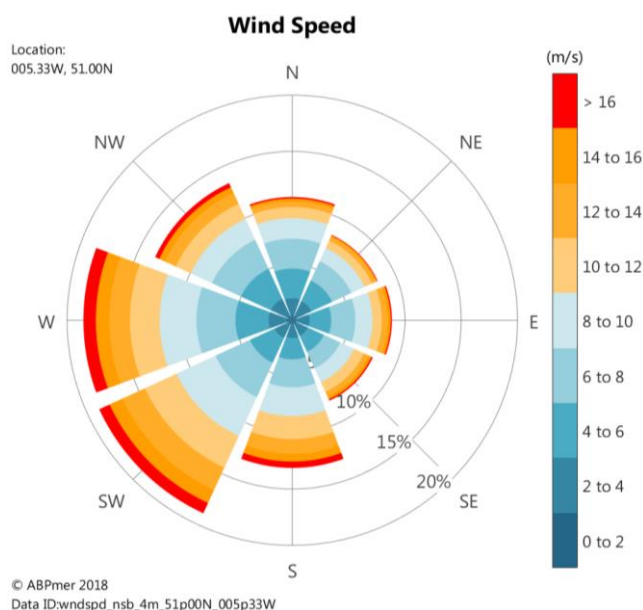


Figure 19. Wind rose for the local study area

Figure 19 shows the wind speed and direction for the approximate centre between the three PDAs in the Celtic Sea. Wind is most predominant from the West and South-West equally however there is strong prevalence in all directions with South, North-West and North each occurring for more than 10% of the time. Wind speeds are varied with each scale occurring generally equally including speeds upwards of 16 m/s (Beaufort wind force 7).

4.4 Emergency response

A range of emergency response is available within the study area. The following organisations provide resources to assist if a marine emergency occurs.

4.4.1 HM Coastguard

The MCA is responsible for the initiation and coordination of all civilian maritime search and rescue operations within the UK Maritime Search and Rescue Region. This includes the mobilisation, organisation, and tasking of adequate resources to respond to persons in distress at sea, or to persons at risk of injury or death along the shoreline within the UK. HM Coastguard has access to a range of resources including aircraft and coastal search teams. The study area falls within the jurisdiction of the Milford Haven Maritime Rescue Coordination Centre (MRCC).

4.4.2 Local rescue organisations

There are a number of lifeboat stations in the vicinity of the proposed buoy deployments, with the closest assets located at Angle.

- Tenby;
- Angle;
- Appledore; and
- Padstow .

In addition there is a Coastguard Rescue Helicopter base situated at Newquay airport in Cornwall, and an additional MRCC situated at Falmouth.

4.5 Marine Incidents

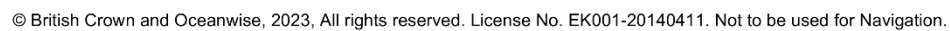
This section reviews marine incidents that have occurred within the local study area over the past 10 years (subject to the availability of data). The analysis is intended to provide a general indication as to whether the study area is in an area of low or high risk in terms of marine incidents. Data from the Marine Accident Investigation Branch (MAIB) and the Royal National Lifeboat Institution (RNLI) has been obtained, covering the following timescale:

- RNLI: complete dataset of all callouts from 2012 to 2021 inclusive (total of eight events).
- MAIB: information was interrogated, however there were no MAIB recorded incidents in the study area during the 10 year period.

Marine incident types are tabulated by year in Table 4 for the RNLI. The locations of the different incident type events are illustrated in Figure 20.

Table 4. RNLI Marine incident summary for the local study area (2012-2021)

Incident Category	Year											Annual Frequency
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total	
Capsize/Sinking	0	0	0	0	0	0	0	0	0	0	0	0
Collision	0	0	0	0	0	0	0	0	0	0	0	0
Equipment failure (vessel)	0	0	1	0	0	0	0	0	0	2	3	0.3
Fire/Explosion	0	0	0	0	0	0	0	0	0	0	0	0
Grounding	0	0	0	0	0	0	0	0	0	0	0	0
Leaks/Swamping	0	0	0	0	0	0	0	0	0	0	0	0
Other nautical safety	0	0	0	2	0	0	0	0	1	1	4	0.4
Person in distress	1	0	0	0	0	0	0	0	0	0	1	0.1
Person(s) in the water	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	0	1	2	0	0	0	0	1	3	8	0.8



ABPmer, December 2023, R.4405

5 Navigational Risk Assessment

5.1 Purpose of the NRA

The purpose of this NRA is to:

- Identify and assess potential navigation risks associated with the deployment of the proposed moorings; and, to identify risk mitigation strategies where appropriate, to achieve a risk level that is both tolerable and as low as reasonably practicable.
- Provide the MCA and Trinity House with an NRA and sufficient related information to support their assessment and approval of the planned TCE mooring deployments from a navigation risk perspective.
- MCA and Trinity House approval of the planned TCE mooring deployments from a navigation risk perspective is required by TCE to complete the requirements of an (already granted) MMO Marine Licence to deploy its moorings at Site 3A and Site 4A in English waters.
 - The MMO Marine Licence application number is MLA/2022/00239 and the licence ref is L/2022/00458/1.
 - The relevant condition from the MMO Marine Licence is: 5.2.2 The buoys must not be deployed until their locations have been agreed in writing with Trinity House. The MMO must receive a copy of this agreement no later than 24 hours before commencement of the activities. Reason: To provide detailed locations of survey equipment and to assess any impacts on navigation.
- MCA and Trinity House approval of the planned TCE mooring deployments from a navigation risk perspective is required by TCE to support a new Marine Licence application with NRW to deploy its moorings at Site 1A in Welsh waters.

5.2 The assessment team

The study team comprises of the following team from ABPmer:

- Rod Lewis- Associate Maritime Consultant;
- Harry Aitchison -Maritime Consultant;
- Jake Norris – Maritime Consultant; and
- David Lambkin- Principal Metocean Consultant (scheme context and AIS data interpretation / presentation).

5.3 Hazard identification

The identification of Hazards associated with the proposed buoy deployments has been undertaken by the assessment team, considering, in addition to the data collected and analysed, the following:

- Previous knowledge and experience of NRA;
- Supporting scheme information (written literature); and
- Scheme context (David Lambkin).

The Marine Licence application is supported by a separate Risk Assessment and Method Statement prepared by Partrac that covers the deployment and retrieval of the buoys. In consideration of this, many of the hazards associated with the deployment and retrieval are scoped out of this NRA. However,

one relevant Hazard has remained in scope, namely, the risk of vessel collision during deployment and retrieval of the buoys.

5.4 Hazard definitions

The first step in the NRA process is the consideration of potential hazards resulting from the proposed scheme. Table 5 provides hazard category definitions, taken from the MCA: 'Methodology for Assessing the Marine Navigational Safety and Emergency Response Risks of OREI (MCA, 2021b).

Four of these hazard categories have been scoped out of this NRA. These are shown in Table 6, along with the reason. The rationale considers relevant elements of the deployment and retrieval as well as the operational requirements for the proposed deployments, and the potential outcomes, in terms of navigational hazards.

Table 5. Hazard category definitions

Category	Description
Foundering	To sink below the surface of the water.
Collision	Collision is defined as a vessel striking, or being struck by, another vessel, regardless of whether either vessel is under way, anchored or moored; but excludes hitting underwater wrecks.
Allision	Defined as a violent contact between a vessel and a fixed structure.
Contact	Contact is defined as a vessel striking, or being struck by, an external object that is not another vessel or the sea bottom. Sometimes referred to as impact.
Fire	Fire is defined as the uncontrolled process of combustion, characterised by heat or smoke or flame or any combination of these.
Explosion	An explosion is defined as an uncontrolled release of energy, which causes a pressure discontinuity or blast wave.
Loss of hull integrity	Loss of hull integrity is defined as the consequence of certain initiating events that result in damage to the external hull, or to internal structure and sub-division, such that any compartment or space within the hull is opened to the sea or to any other compartment or space (where it is not designed to be).
Flooding	Flooding is defined as sea water, or water ballast, entering a space, from which it should be excluded, in such a quantity that there is a possibility of loss of stability leading to capsizing or sinking of the vessel.
Grounding	Grounding is defined as the ship coming to rest on, or riding across, underwater features or objects, but where the vessel can be freed from the obstruction by lightening and/or assistance from another vessel (e.g. tug) or by floating off on the next tide.
Stranding	Stranding is defined as being a greater hazard than grounding and is defined as the ship becoming fixed on an underwater feature or object such that the vessel cannot readily be moved by lightening, floating off, or with assistance from other vessels (e.g. tugs).
Capsizing	The overturning of a vessel after attaining negative stability.
Machinery related accidents	Machinery related accidents are defined as any failure of equipment, plant and associated systems which prevents, or could prevent if circumstances dictate, the ship from manoeuvring or being propelled or controlling its stability.

Category	Description
Payload related accidents	Payload related accidents include loss of stability due to cargo shifting and damage to the vessel's structure resulting from the method employed for loading or discharging the cargo. This category does not include incidents which can be categorised as Hazardous substance, Fires, Explosions, Loss of hull integrity, Flooding accidents etc.
Hazardous substance accidents	Hazardous substance accidents are defined as any substance which - if generated as a result of a fire, accidental release, human error, failure of process equipment, loss of containment, or overheating of electrical equipment - can cause impairment of the health and/or functioning of people or damage to the vessel. These materials may be toxic or flammable gases, vapours, liquids, dusts, or solid substances.
Accidents to personnel	Accidents to personnel are defined as those accidents which cause harm to any person on board the vessel e.g. crew, passengers, stevedores; which do not arise as a result of one of the other accident categories. Essentially, it refers to accidents to individuals, though this does not preclude multiple human casualties as a result of the same hazard, and typically includes harm caused by the movement of the vessel when underway, slips, trips, falls, electrocution and confined space accidents, food poisoning incidents, etc.

Table 6. Hazard categories scoped out

Scoped Out: Hazard Category	Rationale
Stranding / Grounding	The deployments are in a minimum of 74m water depth
Loss of hull integrity	Scoped out as the deployments do not change the potential for a vessel to either have a loss of hull integrity or flooding without it being as a consequence of another hazard category.
Flooding	
Accidents to the general public	The proposed deployments will not have any interactions with the general public, so this category has been scoped out.
Payload related accidents	Deployments fall outside of the definition.

5.5 Hazard scenarios

From the hazard categories scoped into the NRA, the study team at ABPmer has identified the following specific hazard scenarios (listed in Table 7 and Table 8), which relate to either the scheme deployment / retrieval or operational phases. In total, 9 hazard scenarios are identified for the NRA.

The risk assessments in Appendix B may identify consequences that align with other hazard categories (particularly when worst credible outcomes are considered). The hazard scenarios in Table 7 and Table 8 are considered by the assessment team to be the root hazard scenarios.

Table 7. Deployment / retrieval phase hazard scenarios

Assessment Number	Hazard Category	Hazard Scenario Title
1	Collision	Recreation or fishing vessel collides with deployment / retrieval craft
2	Collision	Commercial vessel collision with deployment / retrieval craft

Table 8. Operational phase hazard scenarios

Assessment Number	Hazard Category	Hazard Scenario Title
3	Contact	Recreation or fishing vessel contact with LiDAR buoy
4	Contact	Recreation or fishing vessel contact with wave buoy
5	Contact	Commercial vessel - contact with LiDAR buoy
6	Contact	Commercial vessel - contact with wave buoy
7	Other	Fishing vessel snags trawl gear on unmarked wave and current profiler 5m from seabed in 70m water depth
8	Other	Failure of LiDAR mooring – navigational hazard
9	Other	Failure of wave buoy mooring – navigational hazard

The hazard scenarios identified in Table 7 and Table 8 have been considered according to their 'Most Likely' and 'Worst Credible' outcomes. This provides the option to consider very serious outcomes, which could credibly occur, along with outcomes that are less serious, but could occur on a more frequent basis. The full working and outcome description of each scenario, presented as a full NRA, is provided in table format in Appendix B.

The assessment of risk is based upon the descriptions of the 'Most Likely' and 'Worst Credible' to determine the outcome in respect of effect to people, property, the environment, and reputation. In making the assessment, the outcome from each scenario using the receptors of 'people, property, environment and reputation was evaluated to give a baseline risk with **no mitigation** measures in place.

5.6 Hazard scenario causes

Each hazard scenario was considered to determine its possible causes both individually, or in combination. Table 9 and Table 10 give a frequency (count) of the causes identified during the assessment process for the deployment and operational phases of the proposed buoy deployments.

Table 9. Cause frequency for the deployment / retrieval phase

Cause	Frequency
Adverse weather conditions	2
Human error/fatigue - marine personnel	2
Vessel breakdown or malfunction	2
Equipment failure - steering/propulsion	2
Restricted visibility	2

Cause	Frequency
Equipment failure - vessel navigation	2
Notice to Mariners failure to observe	2
Human error/fatigue - commercial vessel	1
Human error/fatigue - recreational vessel	1

Table 10. Cause frequency for the operational phase

Cause	Frequency
Adverse weather conditions	7
Human error/fatigue - marine personnel	7
Vessel breakdown or malfunction	6
Equipment failure - steering/propulsion	6
Restricted visibility	6
Reduction in safe navigable space	1
Equipment failure - vessel navigation	5
Inadequate maintenance/inspection	6
Human error/fatigue - commercial vessel	7
Failure of Aid to Navigation (out of position/unlit)	5
Failure of mooring systems	1

All identified causes feature consistently for the deployment / retrieval stage. The most common identified causes for the operational phase are adverse weather and human error with a frequency of 7.

5.7 Embedded risk controls

Each hazard scenario has been considered in light of embedded risk controls. It should be noted that embedded risk controls, in the context of marine safety, relate to processes, practices and available safety resources that are currently implemented and items identified as part of deployment scheme. For example, these might include international regulations (such as the International Regulations for Preventing Collisions at Sea (COLREGS)(IMO, 1972)), or search and rescue provision (such as the UK Coastguard service or RNLI).

Table 11 and Table 12 present the embedded risk controls with a frequency count of the number of assessments to which they apply for the deployment / retrieval and operational phases respectively.

Table 11. Embedded risk controls for the deployment / retrieval phase

Control	Frequency
Emergency services equipment - third party	2
International COLREGS 1972 (as amended)	2
The International Convention for the Safety of Life at Sea (SOLAS)	2
The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW)	1
AIS/Radar coverage	2
Passage planning	2
ISM Code – compliance with	1

Table 12. Embedded risk controls for the operational phase

Control	Frequency
Emergency services equipment - third party	7
SOLAS	7
STCW	6
ISM Code – compliance with	6
Vessel maintenance	1
Passage planning	4
Availability of latest hydrographic information	4

5.8 Risk evaluation embedded.

After determining which controls are applicable to each hazard scenario, an embedded risk score was calculated by determining the reduction in likelihood and consequence for each risk control should it be implemented, using the professional judgement of the assessor; these reductions were then applied to the frequency and consequence of the scenario to give the overall risk score. Table 13 and Table 14 show the hazard scenarios after embedded risk controls have been considered.

Table 13. Hazard scenarios for the deployment / retrieval phase

Hazard Category	Hazard Scenario	Baseline Risk	Current Risk
Collision	Recreation or fishing vessel collides with deployment / retrieval craft	3.56	3.4
Collision	Commercial vessel collision with deployment / retrieval craft	4.13	4.0

Table 14. Hazard scenarios for the operational phase.

Hazard Category	Hazard Scenario	Baseline Risk	Current Risk
Contact	Recreation or fishing vessel contact with LiDAR buoy	2.94	2.8
Contact	Recreation or fishing vessel contact with wave buoy	3.63	3.5
Contact	Commercial vessel - contact with LiDAR buoy	2.88	2.74
Contact	Commercial vessel - contact with wave buoy	3.69	3.55
Other	Fishing vessel snags trawl gear on unmarked wave and current profiler 5m from seabed in 70m water depth	3.31	3.18
Other	Failure of LiDAR buoy mooring – navigational hazard	3.5	3.37
Other	Failure of wave buoy mooring – navigational hazard	3.63	3.5

The risk scores associated with each of the 9 hazard scenarios has been set on a scale of no Risk to Very High Risk. The classification of each score is given in Table 15.

Table 15. Risk score rating

Classification	Outcome
Very High Risk	VH
High Risk	Hig
Significant Risk	Sig
Moderate Risk	Mod
Low Risk	Low
Negligible Risk	Neg
No Risk	Non

5.9 Additional (future) risk controls

Additional controls have been identified to ensure that risk levels are reduced to a level which is considered to be ALARP. These additional controls are safety recommendations which were then assigned a likelihood and consequence reduction to allow the calculation of a Future risk score. The identified measures, if fully adopted, should be incorporated into Partrac's deployment / retrieval methodology and as elements of the operational phase of the buoy deployments.

Table 16 details the additional controls which were identified as recommendations for potential mitigation for the buoy deployments deployment / retrieval phase along with the frequency in which they were applied to the hazard scenarios.

Table 17 details the additional controls which were identified as recommendations for potential mitigation for the buoy deployments operational phase along with the frequency in which they were applied to the hazard scenarios.

Table 16. Additional controls for the deployment / retrieval phase

Control	Frequency
Promulgation of information*	1
Notices to mariners	1
Weather forecasting	1

* Includes ongoing engagement and information sharing with local fisheries via the Cornish Fisheries Producers Organisation (CFPO)

Table 17. Additional controls for the operational phase

Control	Frequency
Promulgation of information- Navtex / safety broadcasts	7
Notices to mariners	5
Contracted infrastructure periodic inspection / recovery	7
LiDAR buoy AIS transponders and Radar reflectors	3
Trinity House approved lighting scheme	6
On station promulgation and onshore monitoring	6
Communications - UKHO	7

5.10 Risk evaluation: future

Following the application of the additional (future) risk controls, the outcome of each hazard scenario in respect of the assessed future risk has been determined. The future risk outcome takes into account the likelihood reduction and consequence reduction from each proposed risk control. Table 18 and Table 19 present the future risk level for the hazard scenarios after the additional controls have been applied.

Table 18. Future risk for the deployment / retrieval phase

Hazard Category	Hazard Scenario	Baseline Risk	Current Risk	Future Risk
Collision	Recreation or fishing vessel collides with deployment / retrieval craft	3.56	3.4	2.4
Collision	Commercial vessel collision with deployment / retrieval craft	4.13	3.99	2.99

Table 19. Future risk for the operational phase

Hazard Category	Hazard Scenario	Baseline Risk	Current Risk	Future Risk
Contact	Recreation or fishing vessel contact with LiDAR buoy	2.94	2.8	1.8
Contact	Recreation or fishing vessel contact with wave buoy	3.63	3.5	2.5
Contact	Commercial vessel - contact with LiDAR buoy	2.88	2.74	1.74
Contact	Commercial vessel - contact with wave buoy	3.69	3.55	2.55
Other	Fishing vessel snags trawl gear on unmarked wave and current profiler 5m from seabed in 70m water depth	3.31	3.18	2.18
Other	Failure of LiDAR buoy mooring – navigational hazard	3.5	3.37	2.37
Other	Failure of wave buoy mooring – navigational hazard	3.63	3.5	2.5

6 Conclusion and Summary

6.1 Summary of the NRA

In total, 9 hazard scenarios were identified and assessed. Of these, 2 of these relate to mooring deployment and retrieval activities and 7 relate to the operational phase.

A total of 20 embedded and future marine risk controls (mitigation measures) were identified (Section 5.7, Table 11 and Table 12; and Section 5.9, Table 16 and Table 17, respectively).

These controls comprised of newly identified controls and existing risk controls which would be applied as appropriate to the deployment / retrieval and operational phases.

All new and existing risk controls will require appraising prior to adoption.

6.2 ALARP and tolerability statements

Following implementation of appropriate mitigation, marine risk to navigation receptors is tolerable and can be maintained within a level that is As Low As Reasonably Practicable.

7 References

Department for Transport (DfT) (2016). Port Marine Safety Code. November 2016

International Maritime Organization (IMO) (2018). Revised Guidelines For Formal Safety Assessment (FSA) For Use In The IMO Rule-Making Process. Revision 2, 09 April 2018.

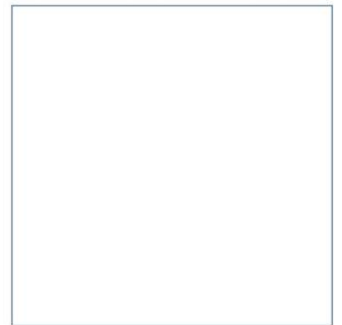
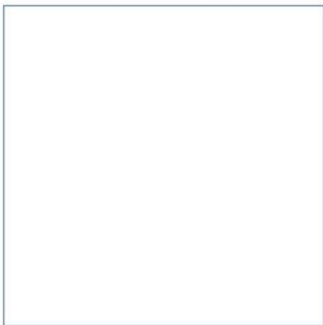
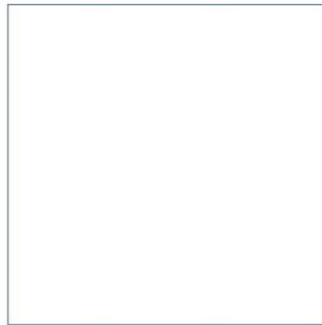
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Partrac, (2023). Celtic Sea Floating Offshore Wind: Risk Assessment and Method Statement. Report prepared for the Celtic Sea Pre Consent Survey Programme, on behalf of The Crown Estate.

UK Government, (2011). UK Marine Policy Statement: HM Government, Northern Ireland, Executive Scottish, Government Welsh Assembly Government. March

Appendices



Innovative Thinking - Sustainable Solutions

A Maps of Vessel Traffic and Route Density Statistics

A.1 Vessel Traffic Density (January 2022)

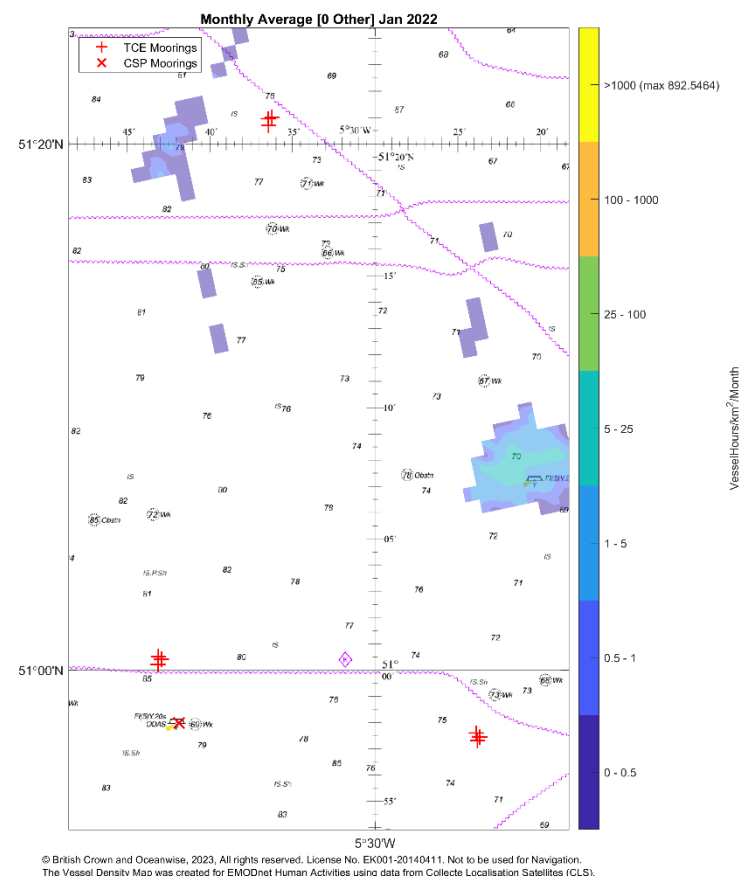
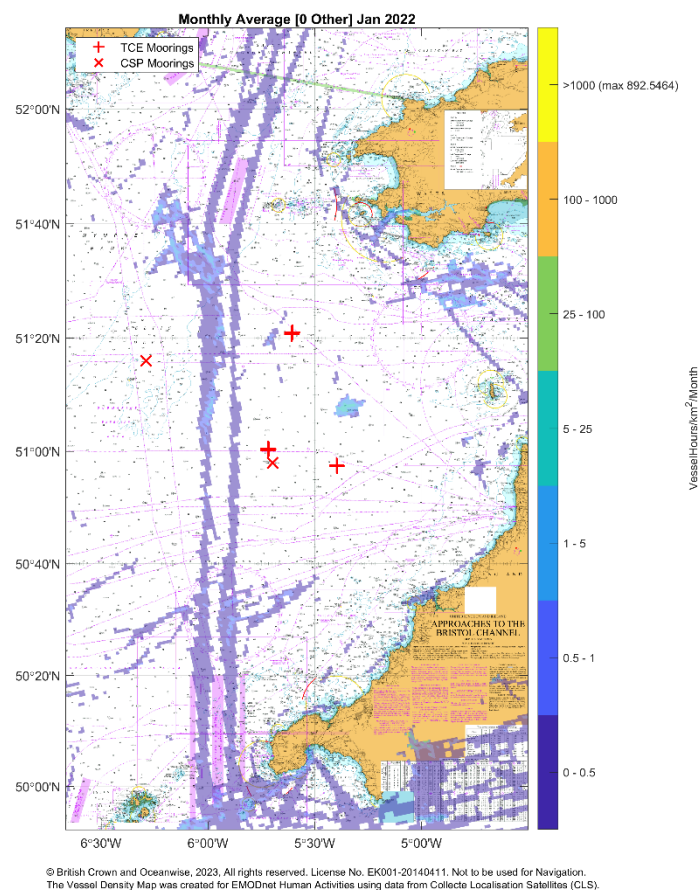


Figure A1. Other vessel types – vessel traffic density (hours in 1x1km cell per month), based on AIS data from January 2022, regional and local views.

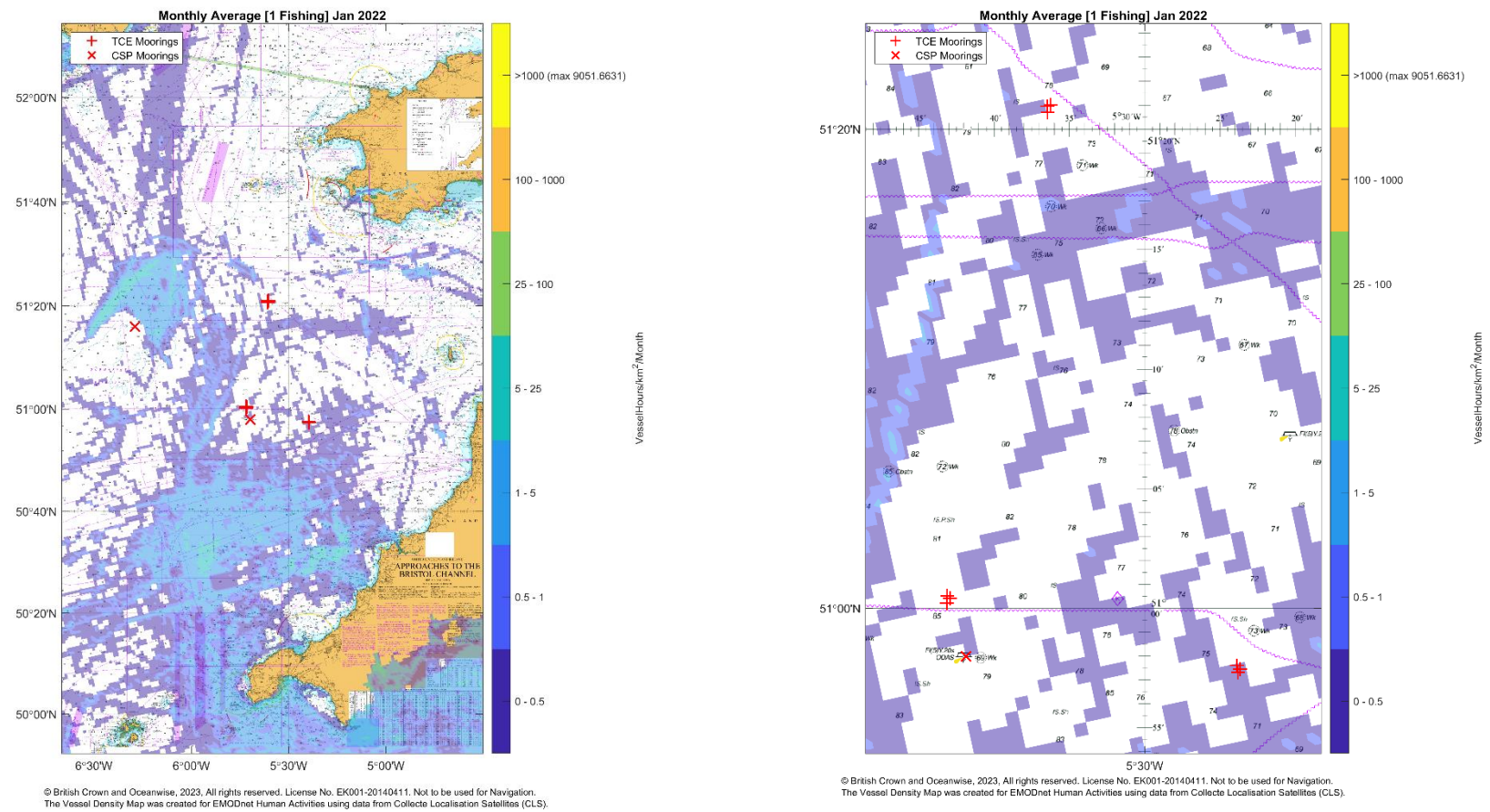


Figure A2. Fishing vessel types – vessel traffic density (hours in 1x1km cell per month), based on AIS data from January 2022, regional and local views.

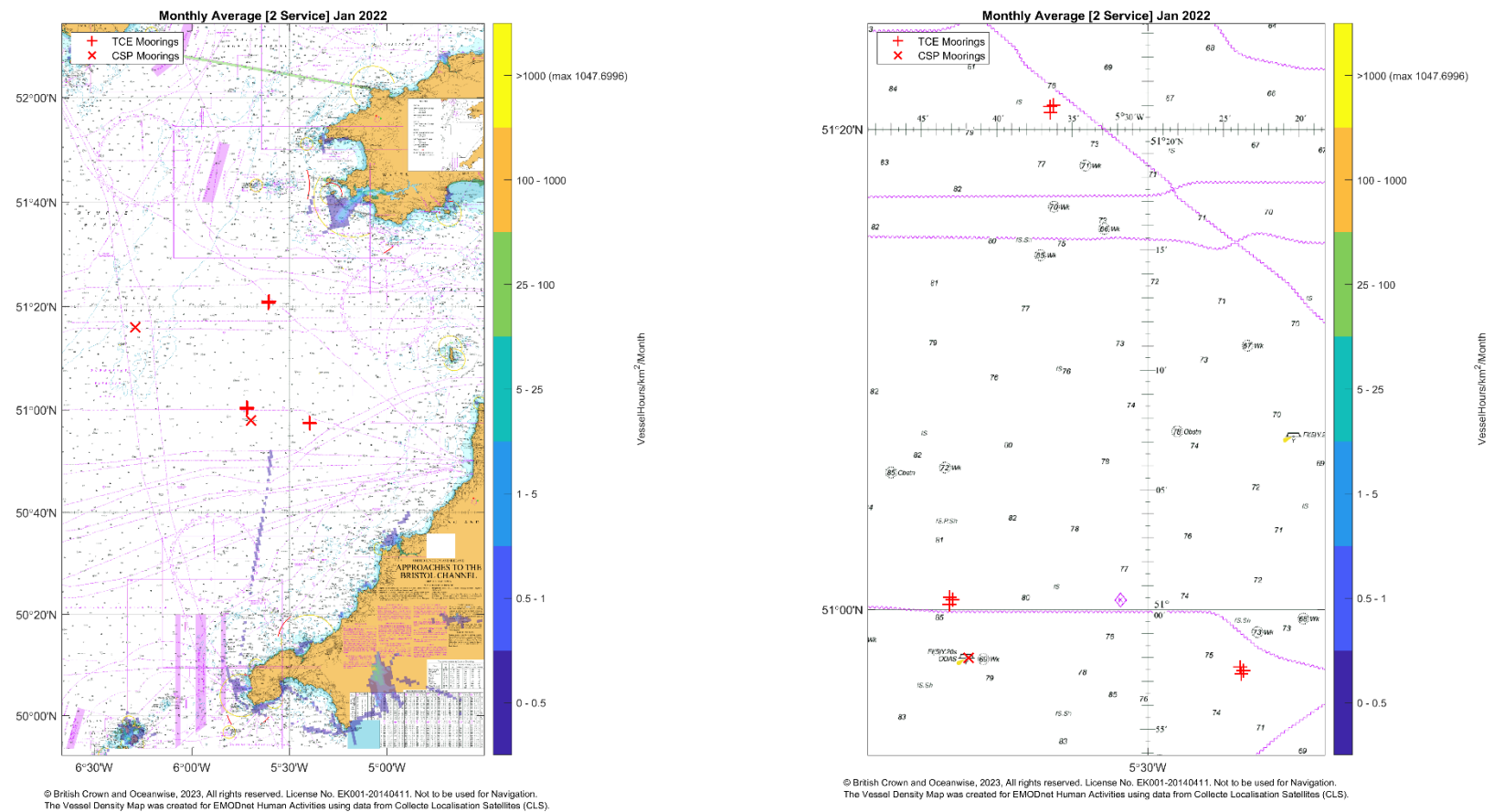


Figure A3. Service craft vessel types – vessel traffic density (hours in 1x1km cell per month), based on AIS data from January 2022, regional and local views.

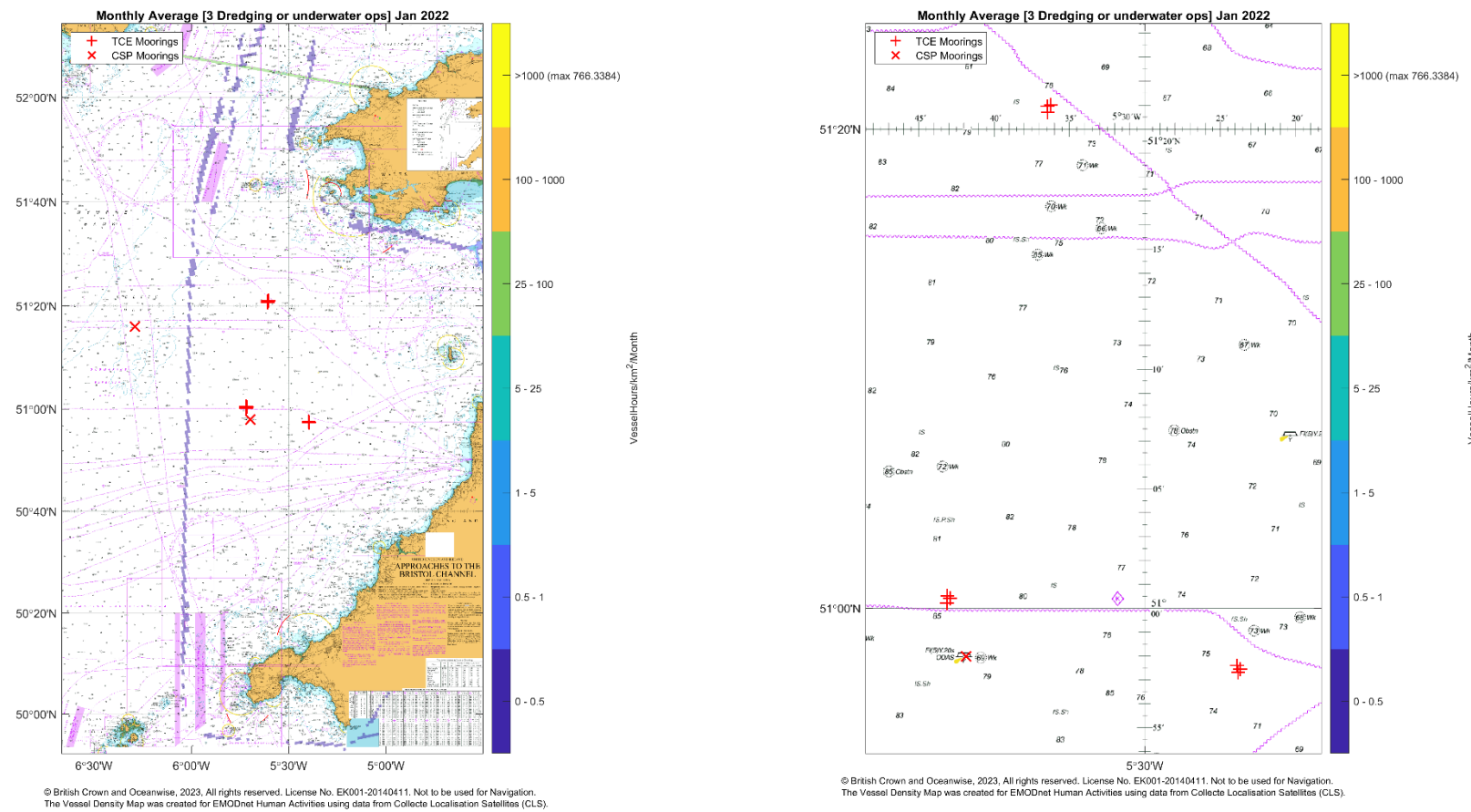


Figure A4. Dredging or underwater operations vessel types – vessel traffic density (hours in 1x1km cell per month), based on AIS data from January 2022, regional and local views.

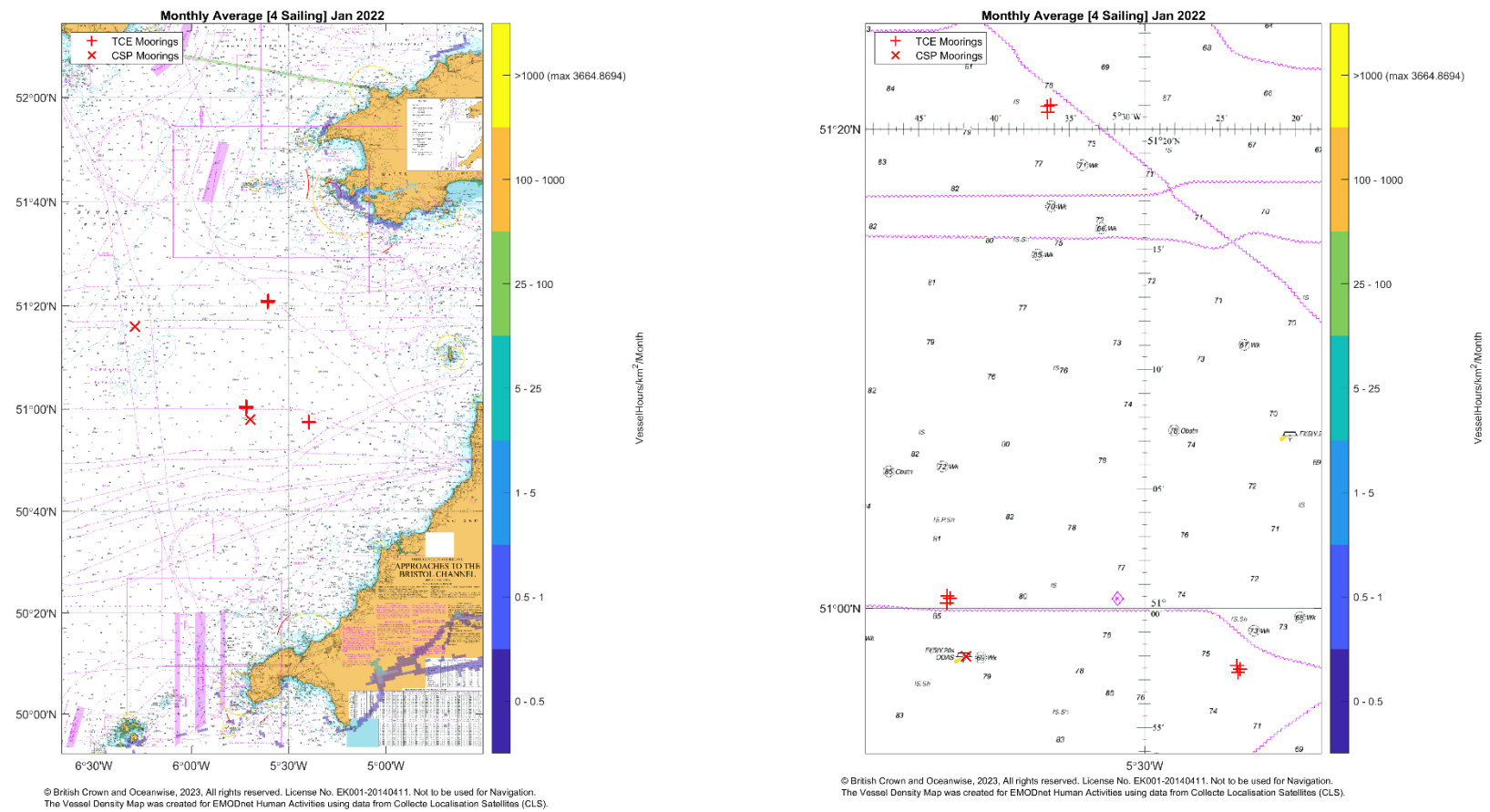


Figure A5. Sailing vessel types – vessel traffic density (hours in 1x1km cell per month), based on AIS data from January 2022, regional and local views.

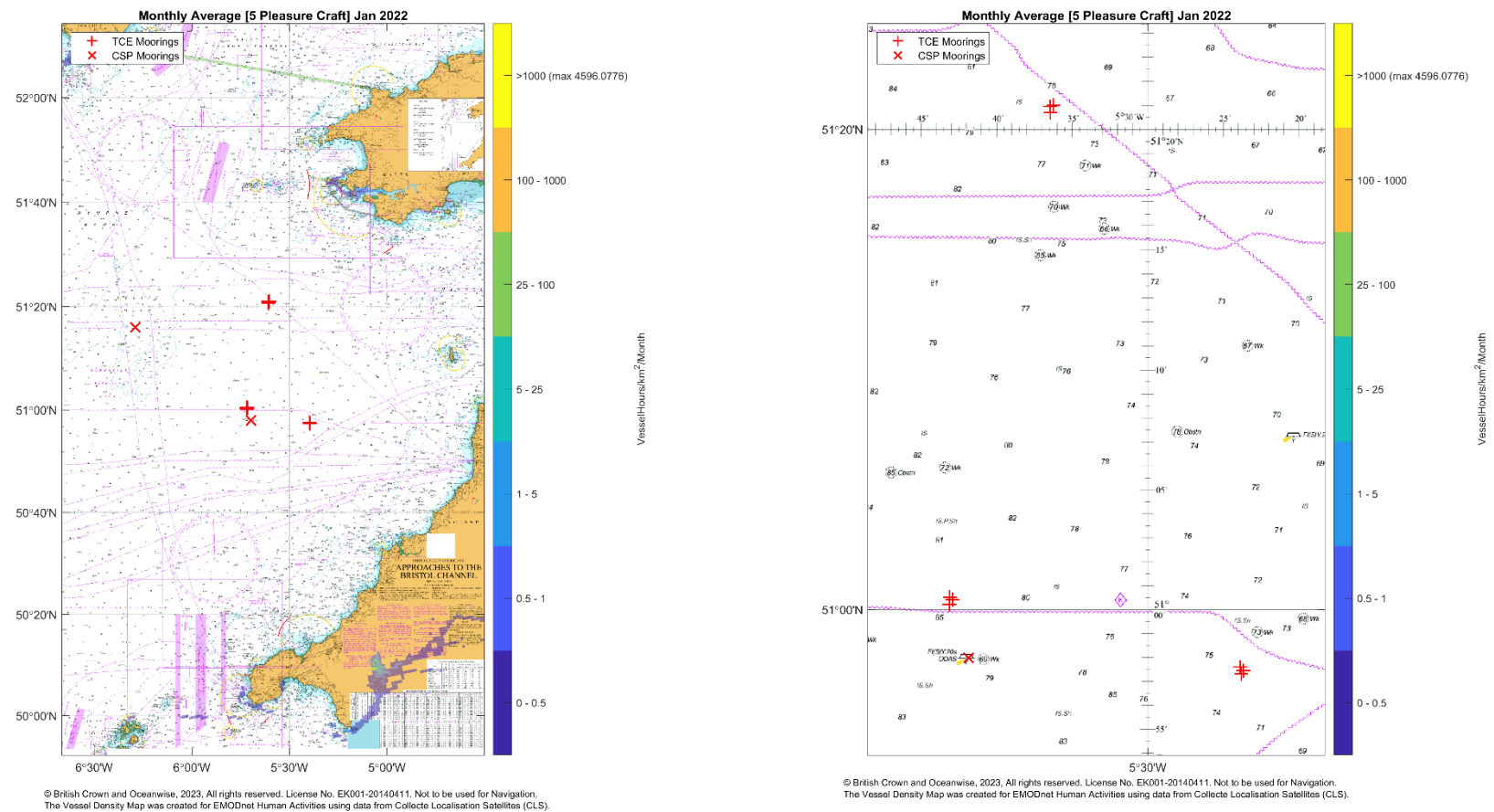


Figure A6. Pleasure craft vessel types – vessel traffic density (hours in 1x1km cell per month), based on AIS data from January 2022, regional and local views.

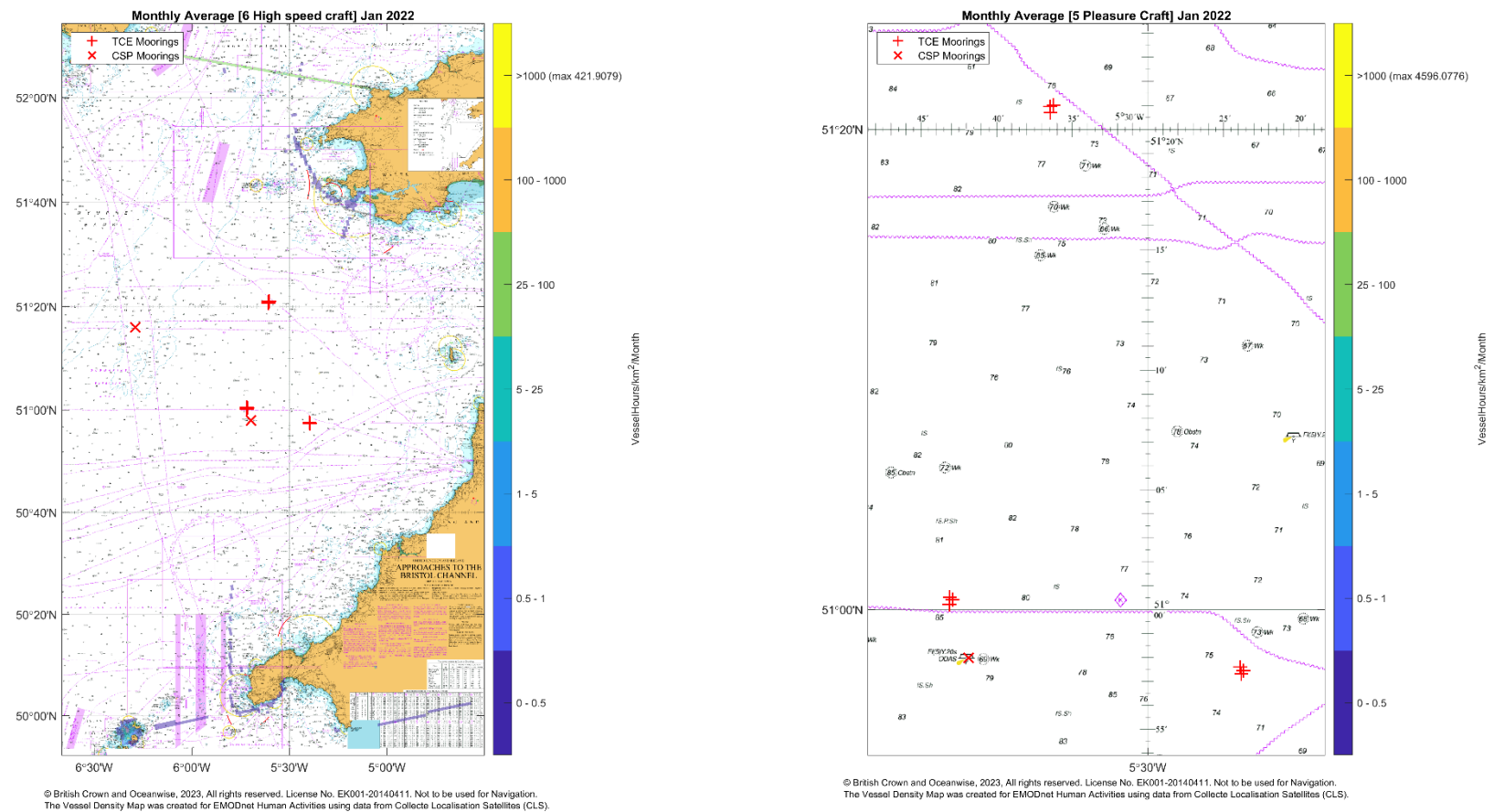


Figure A7. High speed craft vessel types – vessel traffic density (hours in 1x1km cell per month), based on AIS data from January 2022, regional and local views.

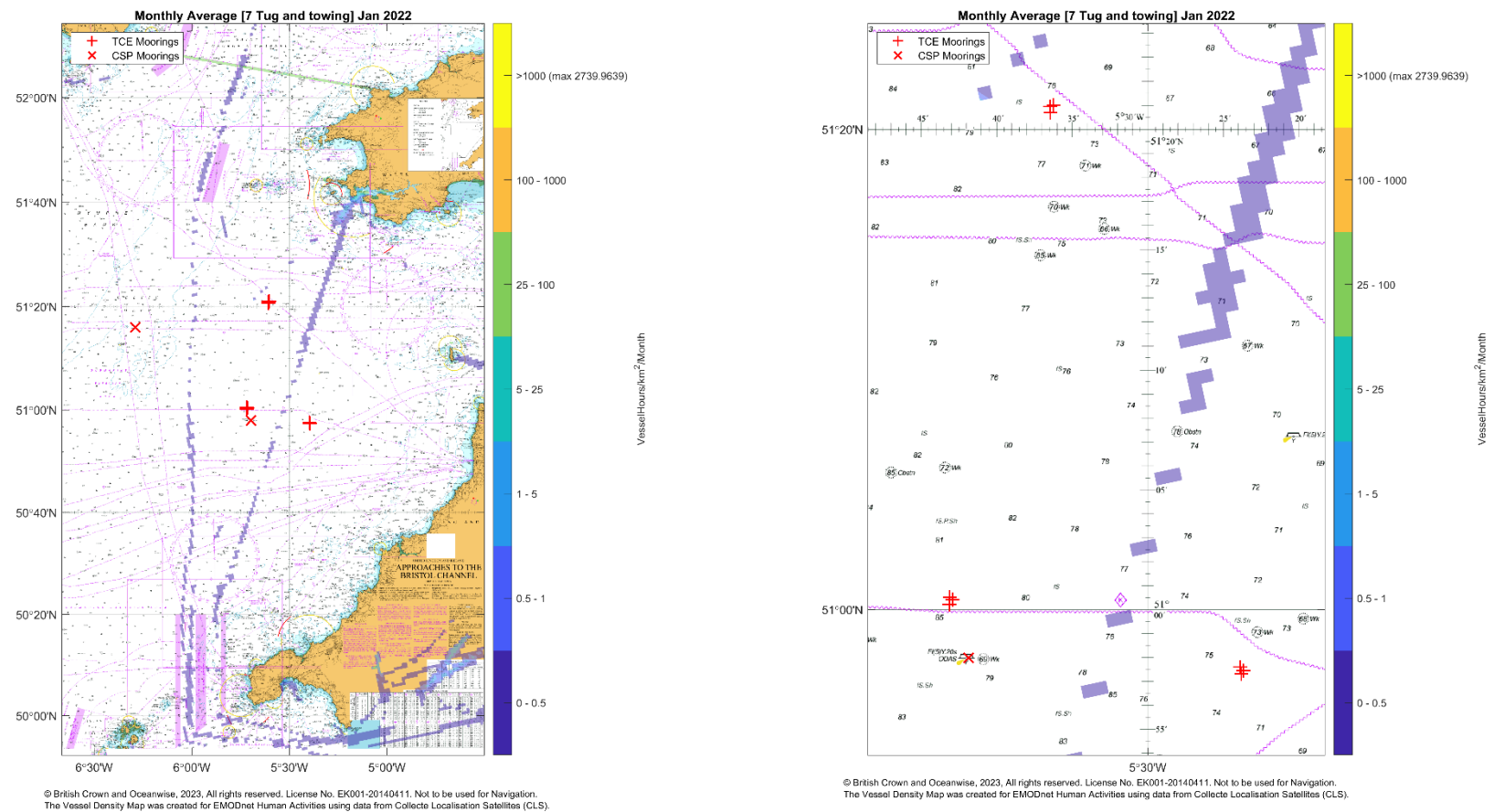


Figure A8. Tug and towing vessel types – vessel traffic density (hours in 1x1km cell per month), based on AIS data from January 2022, regional and local views.

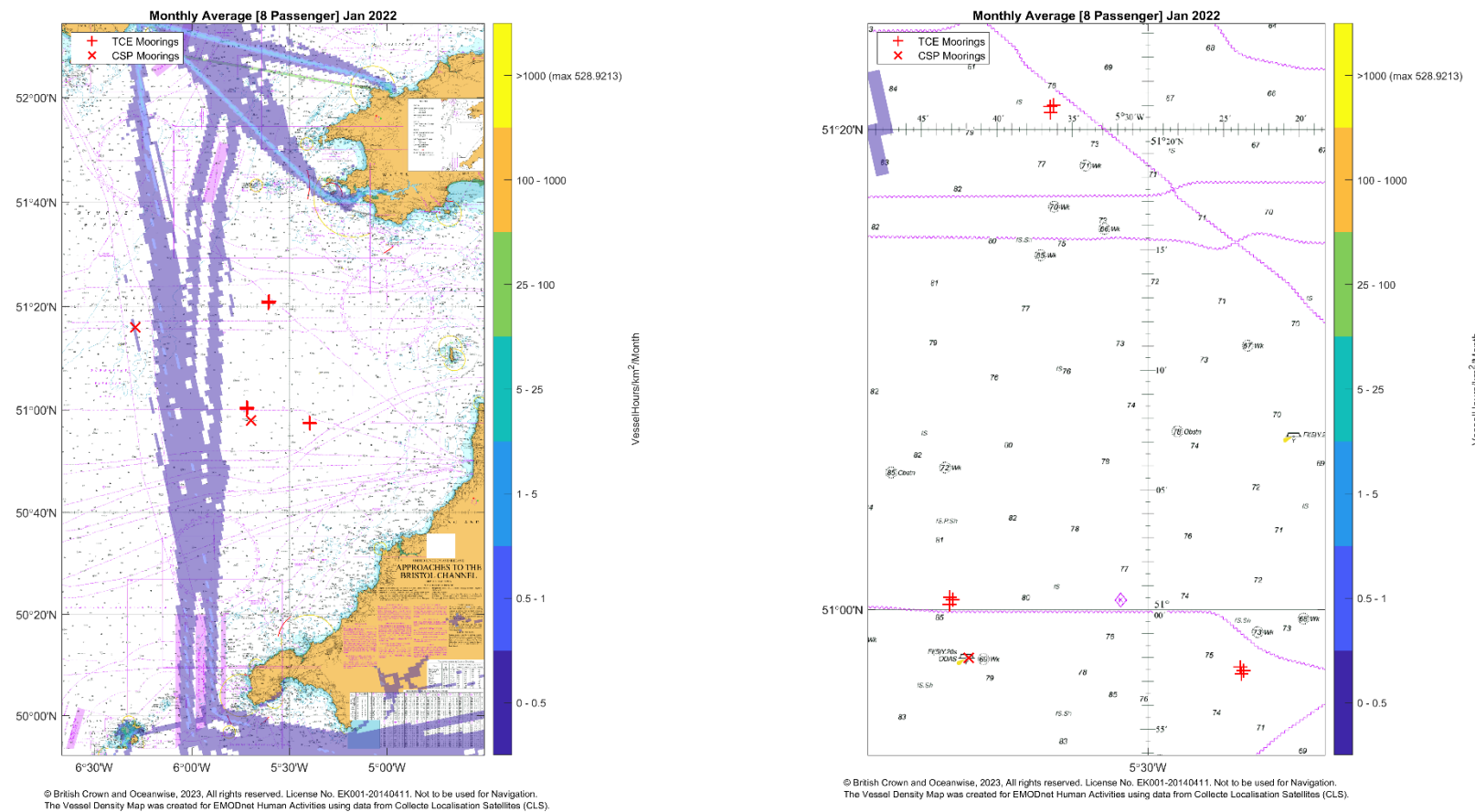


Figure A9. Passenger vessel types – vessel traffic density (hours in 1x1km cell per month), based on AIS data from January 2022, regional and local views.

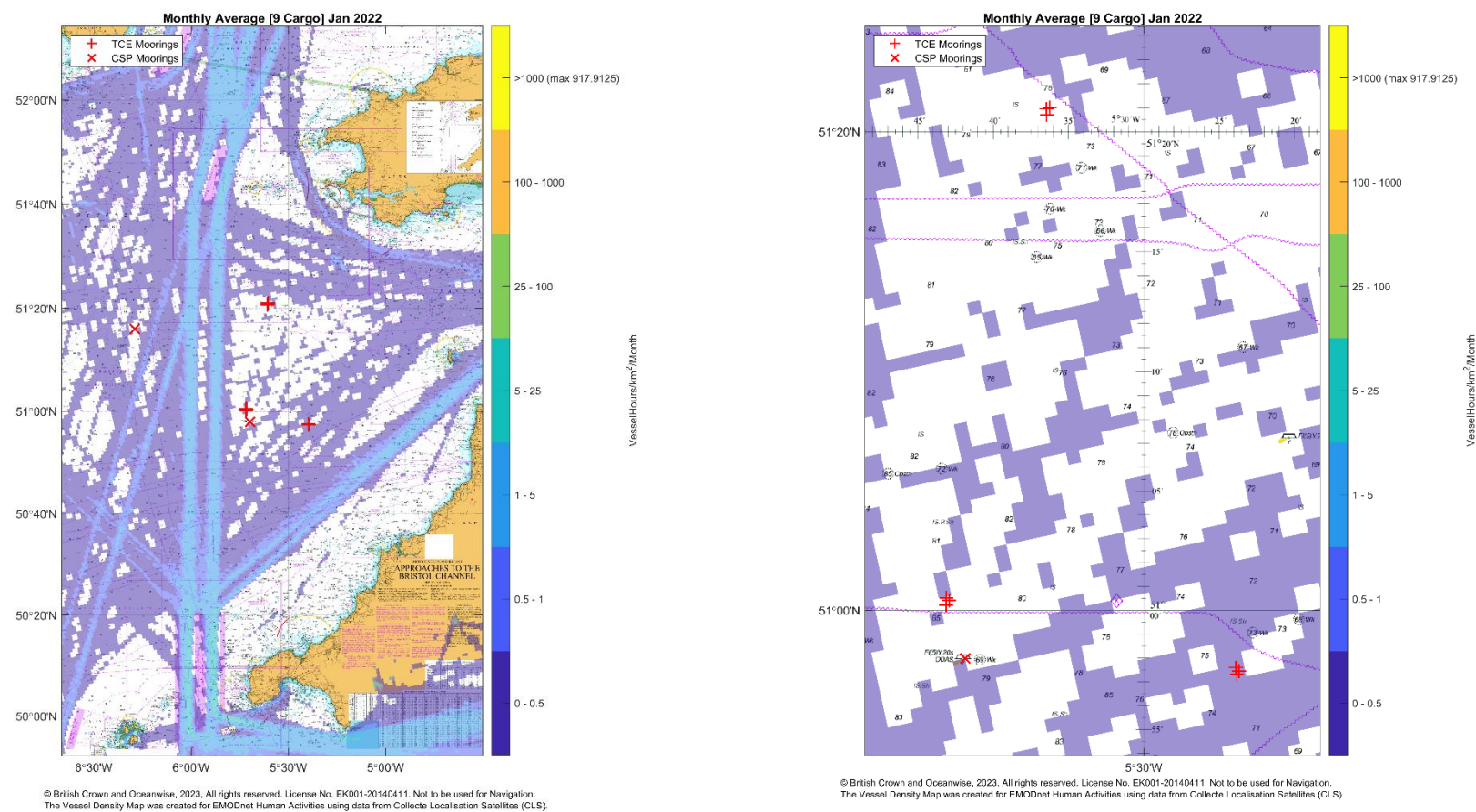


Figure A10. Cargo vessel types – vessel traffic density (hours in 1x1km cell per month), based on AIS data from January 2022, regional and local views.

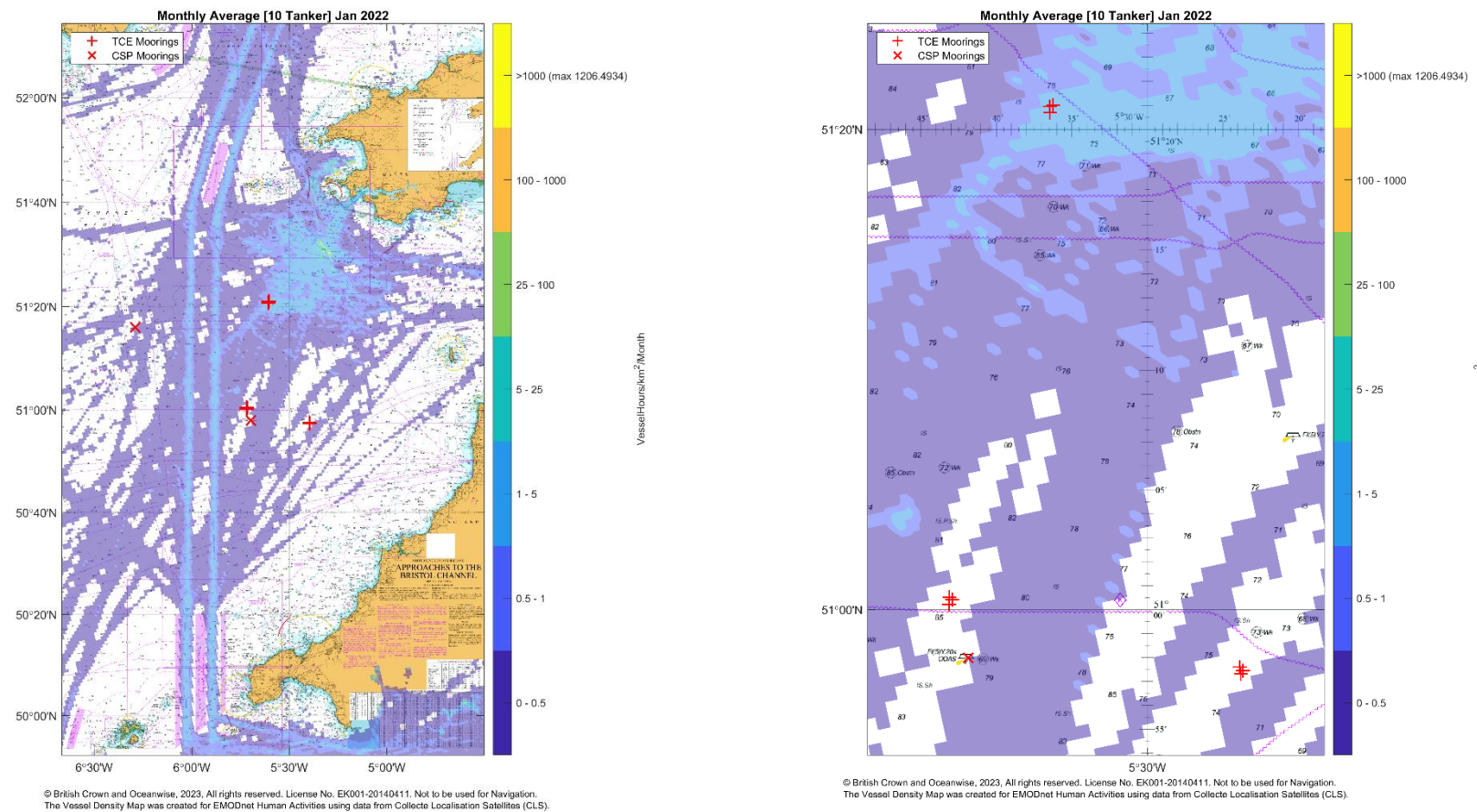


Figure A11. Tanker vessel types – vessel traffic density (hours in 1x1km cell per month), based on AIS data from January 2022, regional and local views.

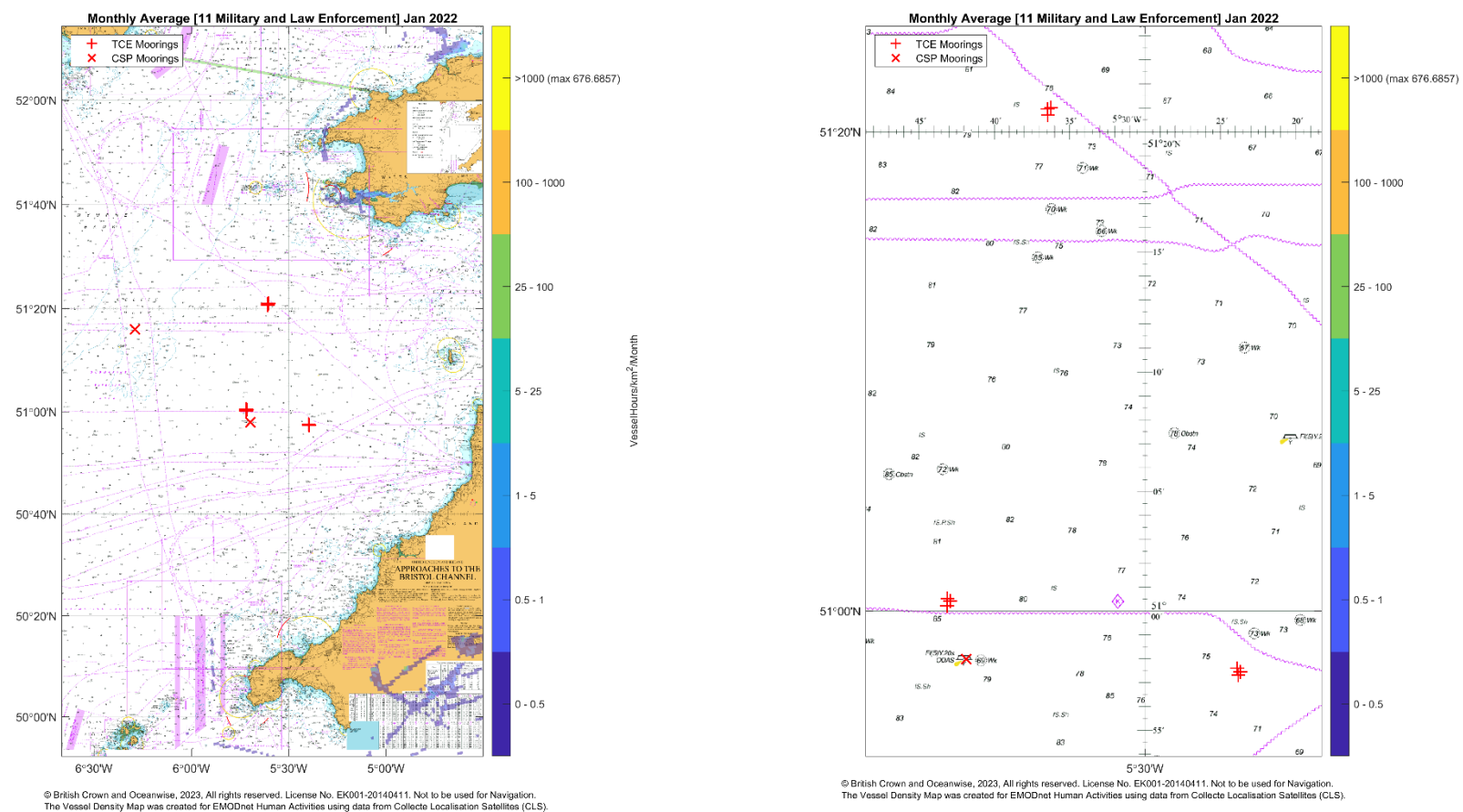


Figure A12. Military or law enforcement vessel types – vessel traffic density (hours in 1x1km cell per month), based on AIS data from January 2022, regional and local views.

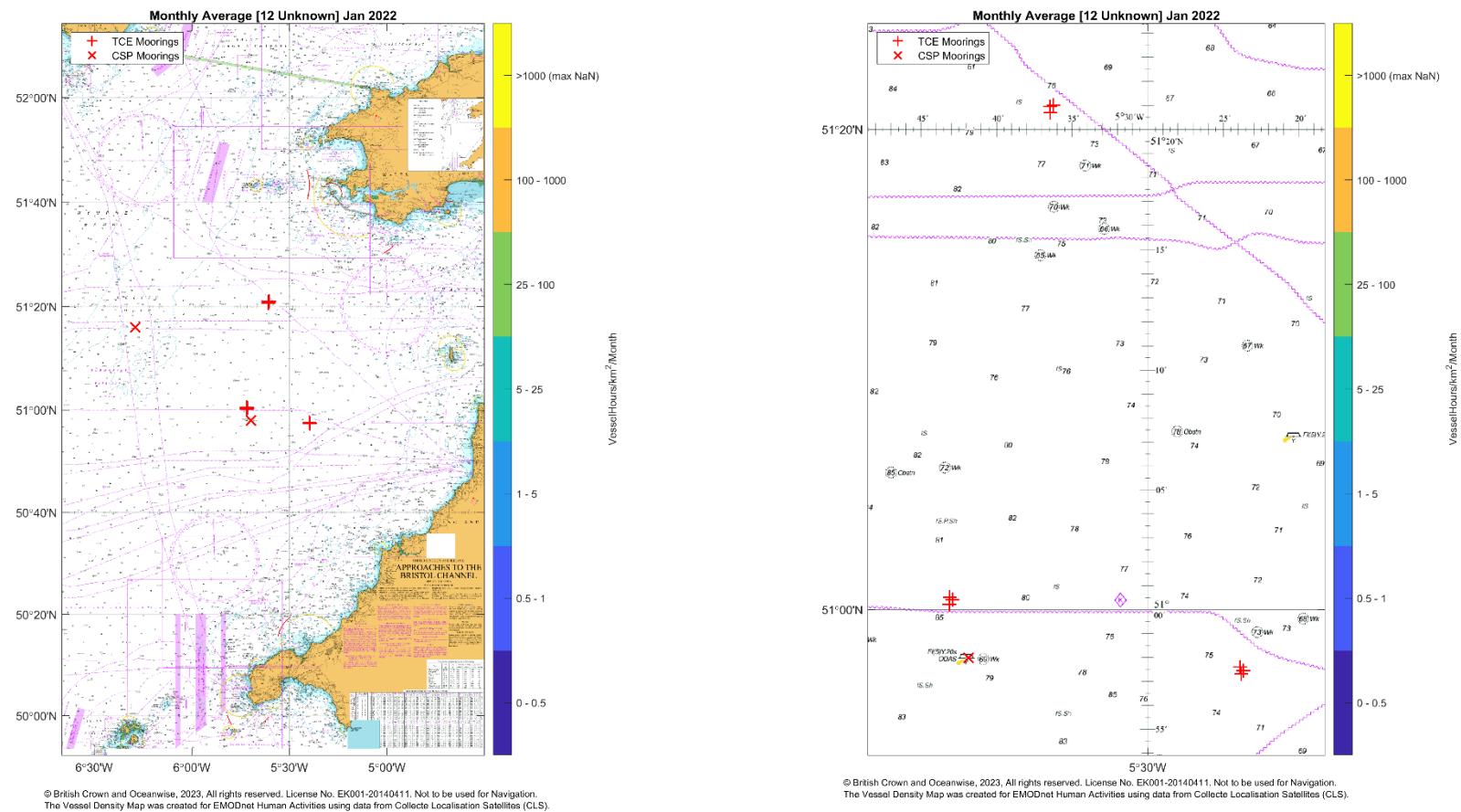


Figure A13. Unknown vessel types – vessel traffic density (hours in 1x1km cell per month), based on AIS data from January 2022, regional and local views.

A.2 Vessel Route Density (January 2022)

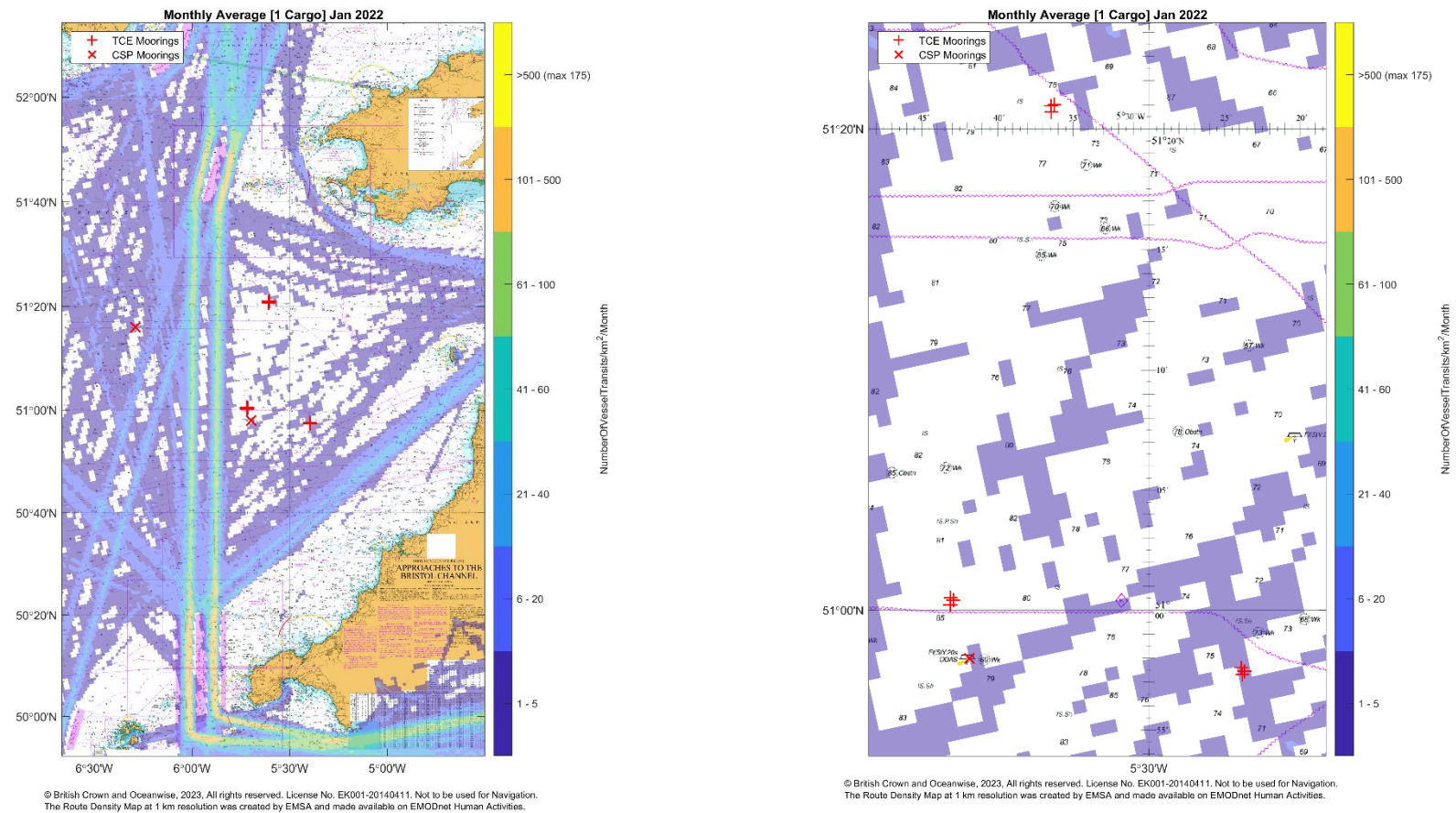


Figure A14. Cargo vessel types – vessel route density (vessel transits crossing 1x1km cell per month), based on AIS data from January 2022, regional and local views.

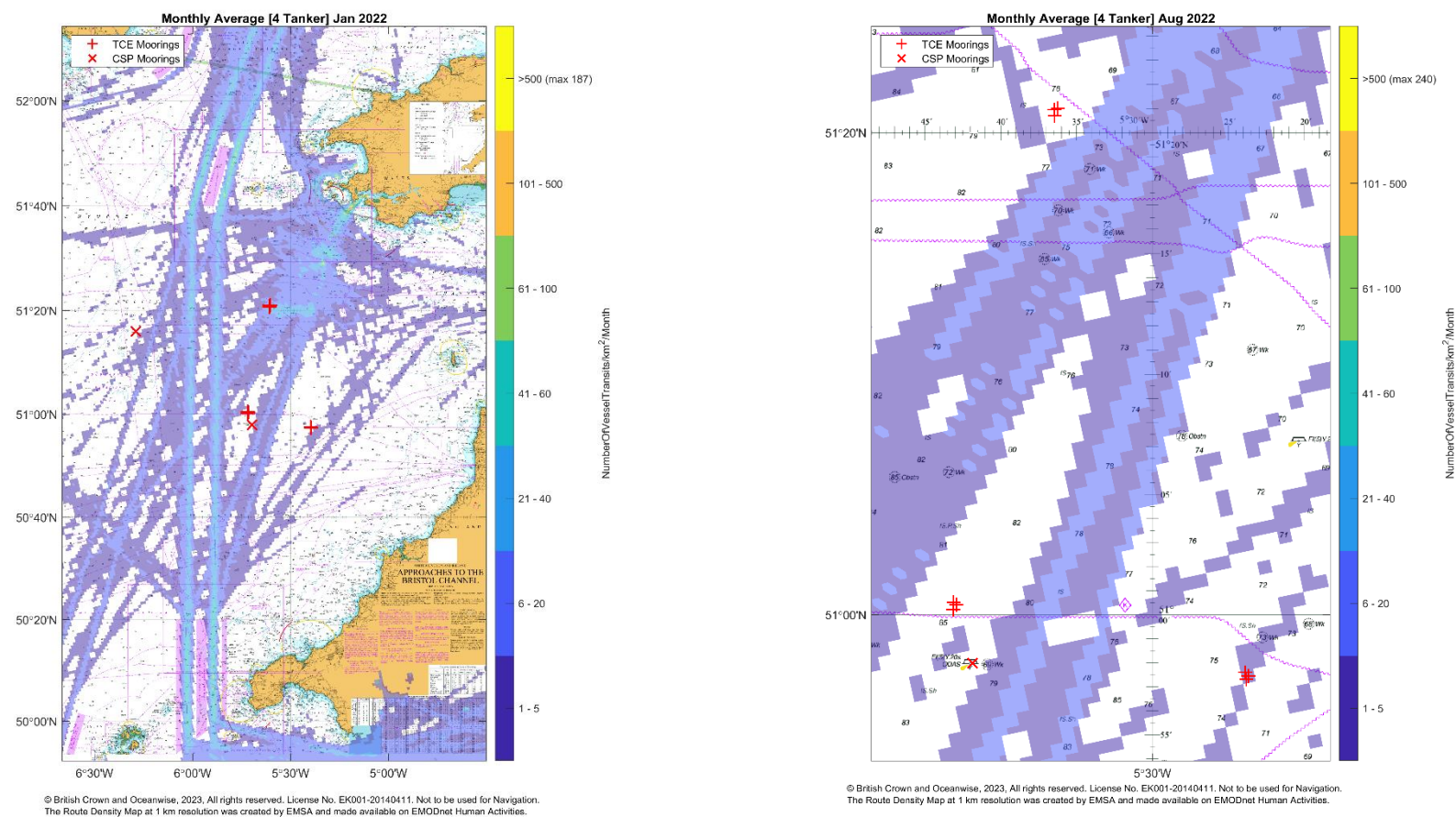


Figure A15. Tanker vessel types – vessel route density (vessel transits crossing 1x1km cell per month), based on AIS data from January 2022, regional and local views.

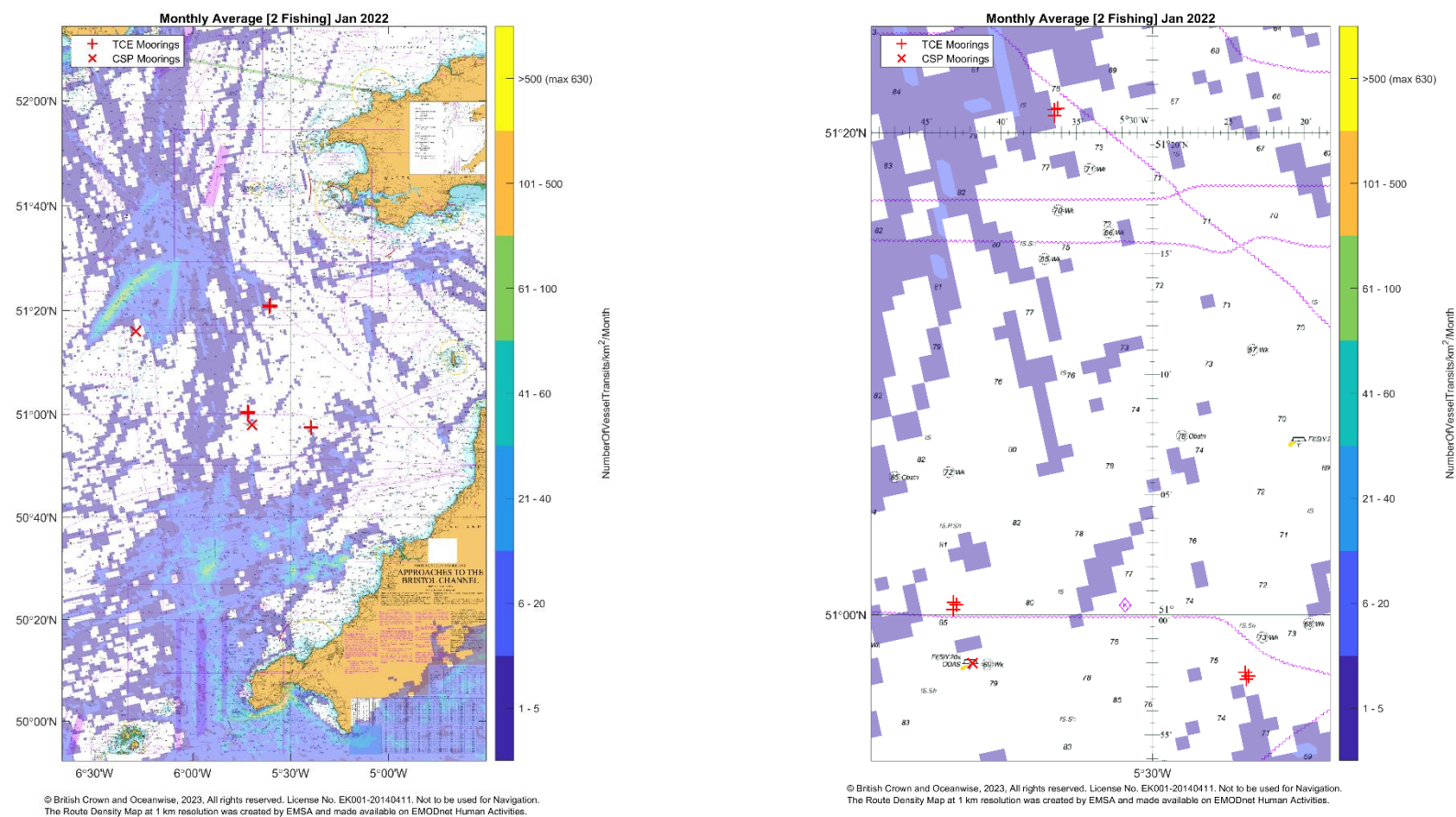


Figure A16. Fishing vessel types – vessel route density (vessel transits crossing 1x1km cell per month), based on AIS data from January 2022, regional and local views.

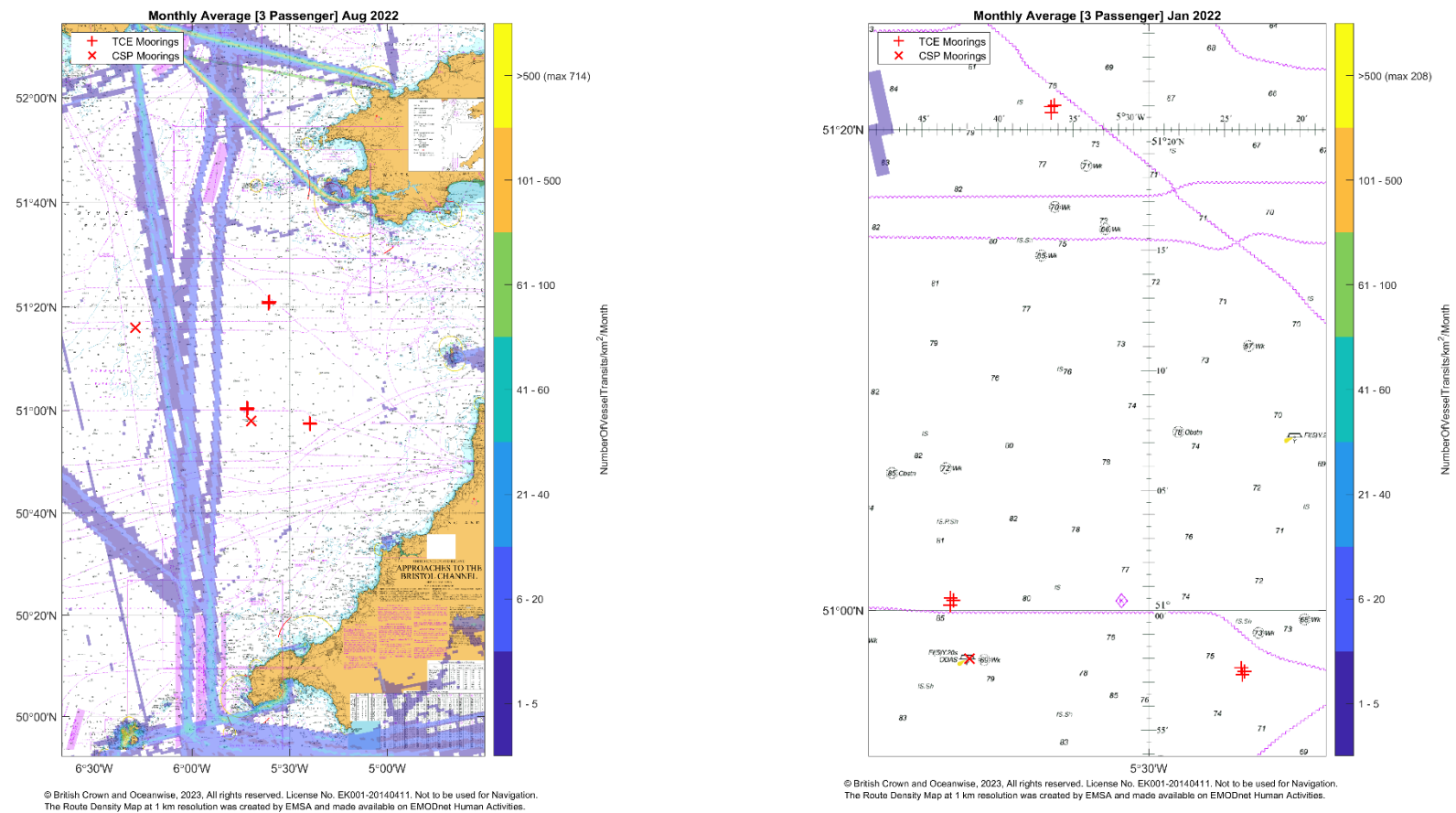


Figure A17. Passenger vessel types – vessel route density (vessel transits crossing 1x1km cell per month), based on AIS data from January 2022, regional and local views.

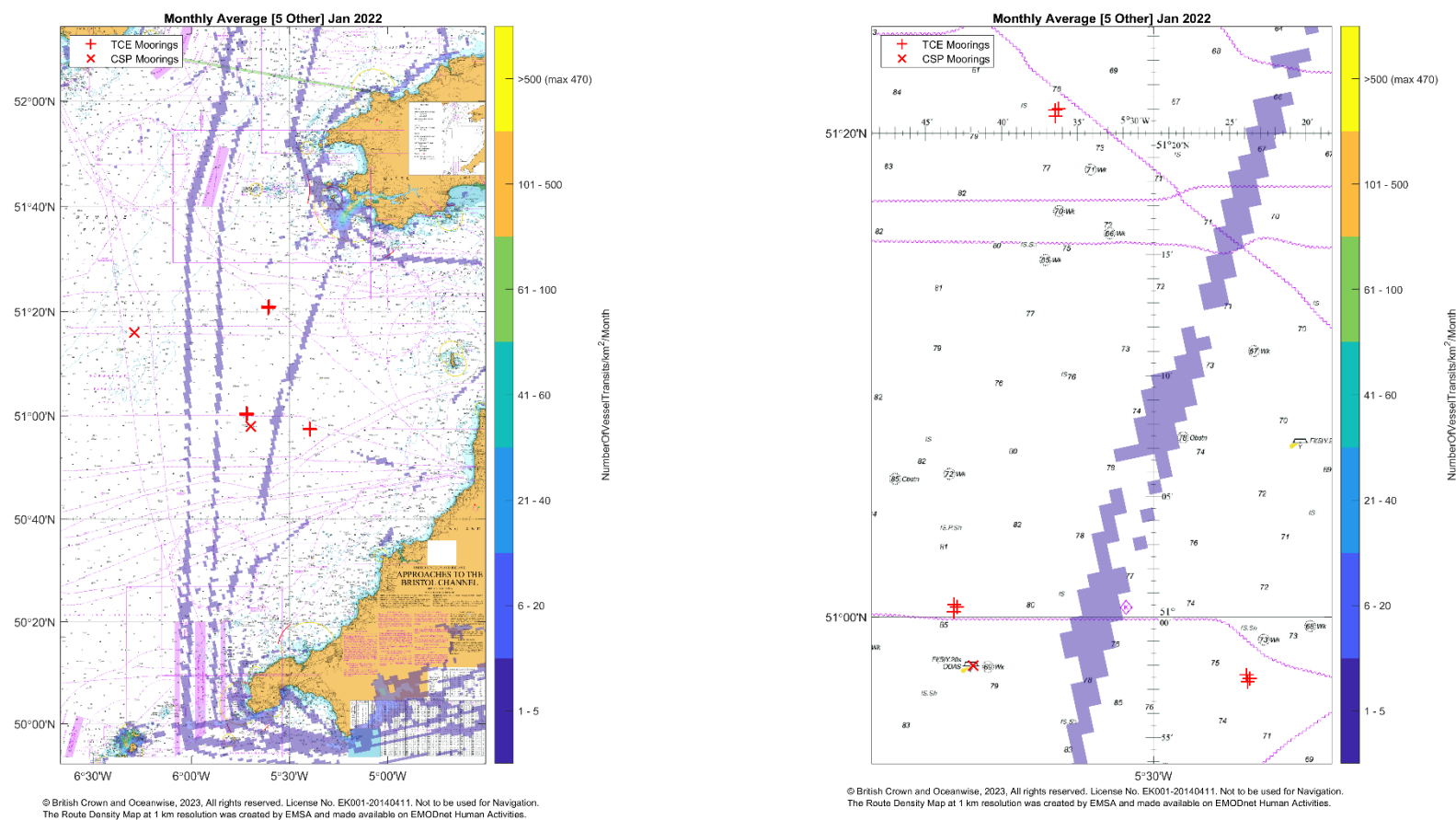


Figure A18. Other vessel types – vessel route density (vessel transits crossing 1x1km cell per month), based on AIS data from January 2022, regional and local views.

A.3 Vessel Route Density (January 2023)

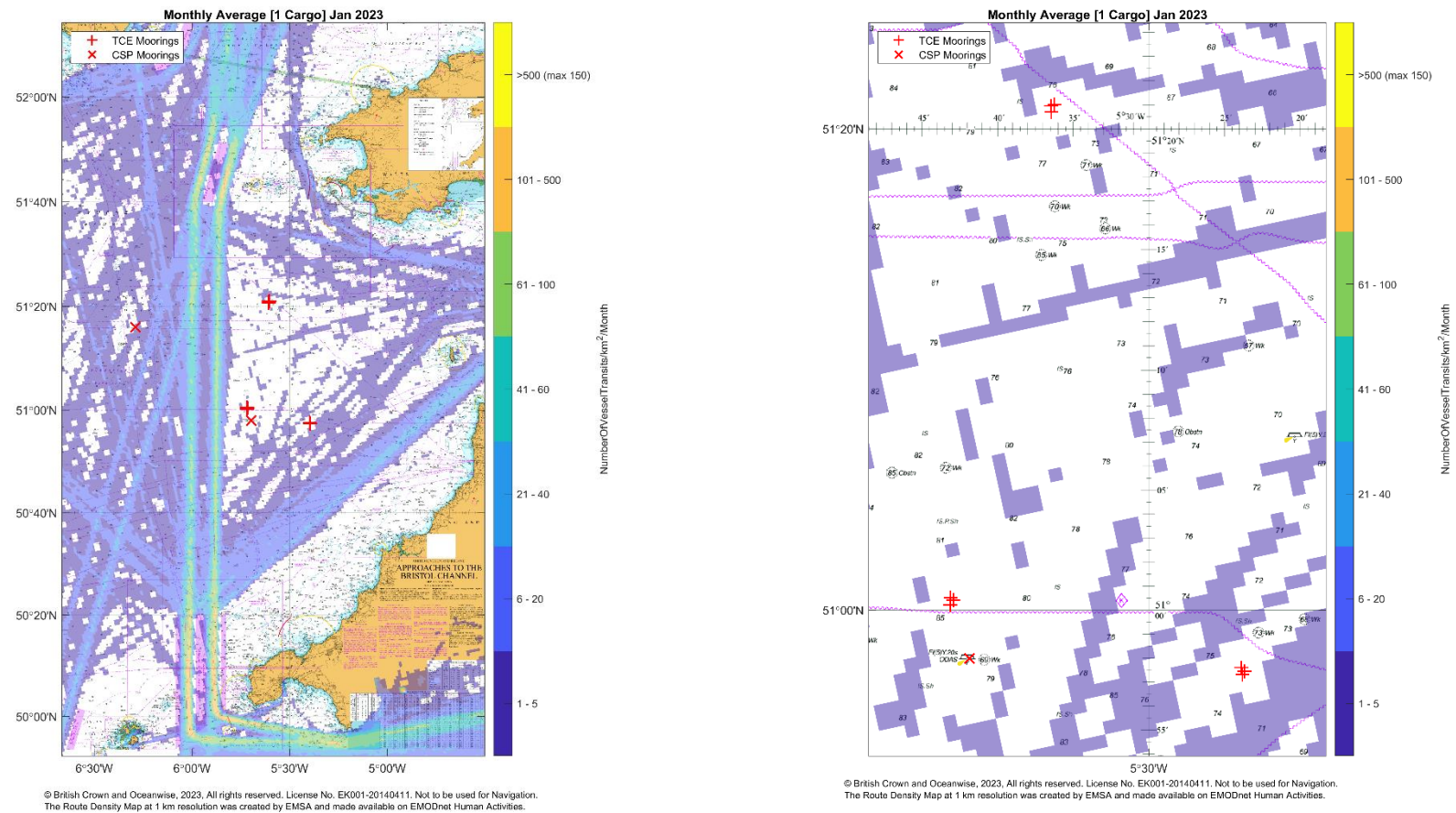


Figure A19. Cargo vessel types – vessel route density (vessel transits crossing 1x1km cell per month), based on AIS data from January 2023, regional and local views.

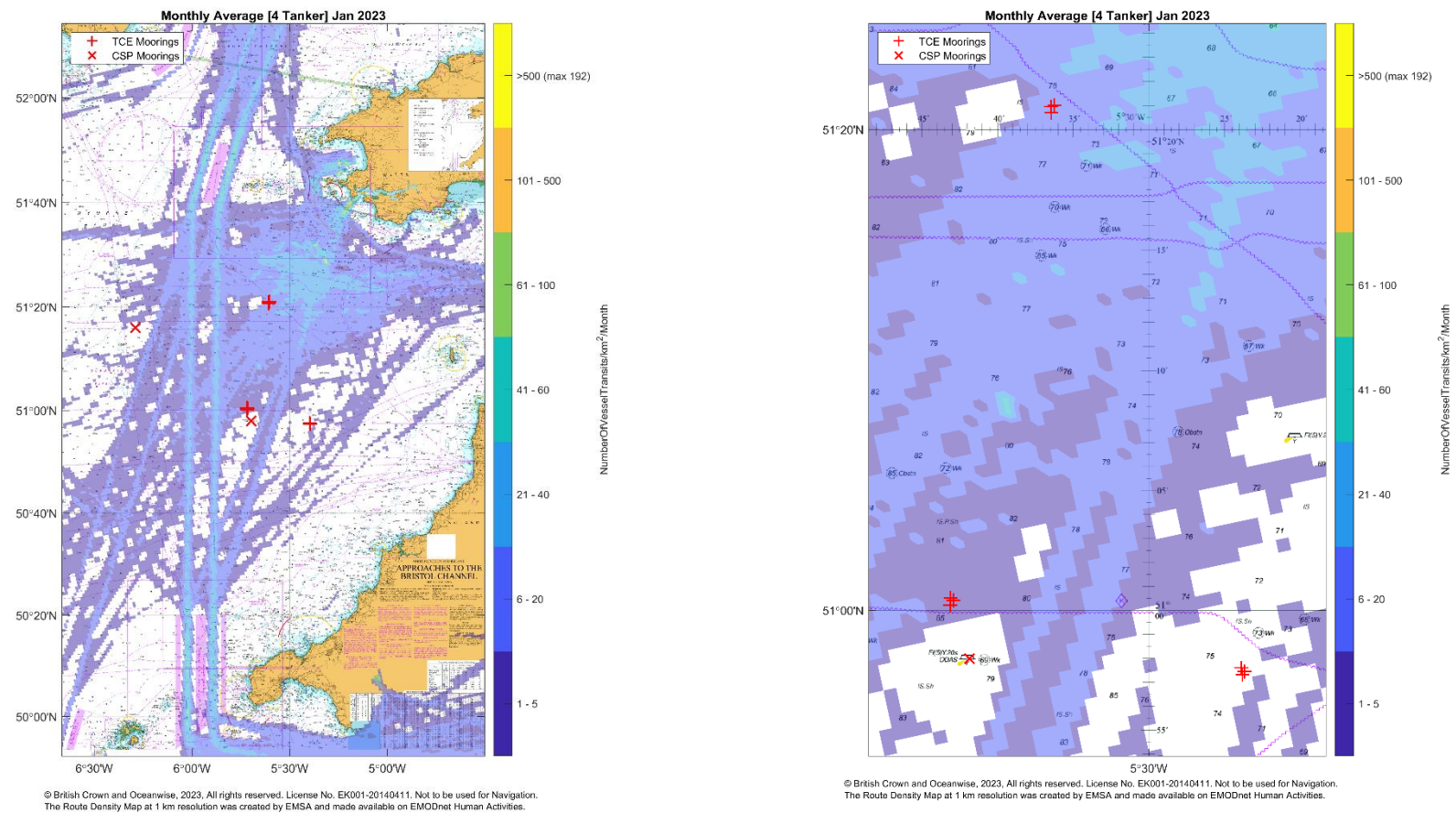


Figure A20. Tanker vessel types – vessel route density (vessel transits crossing 1x1km cell per month), based on AIS data from January 2023, regional and local views.

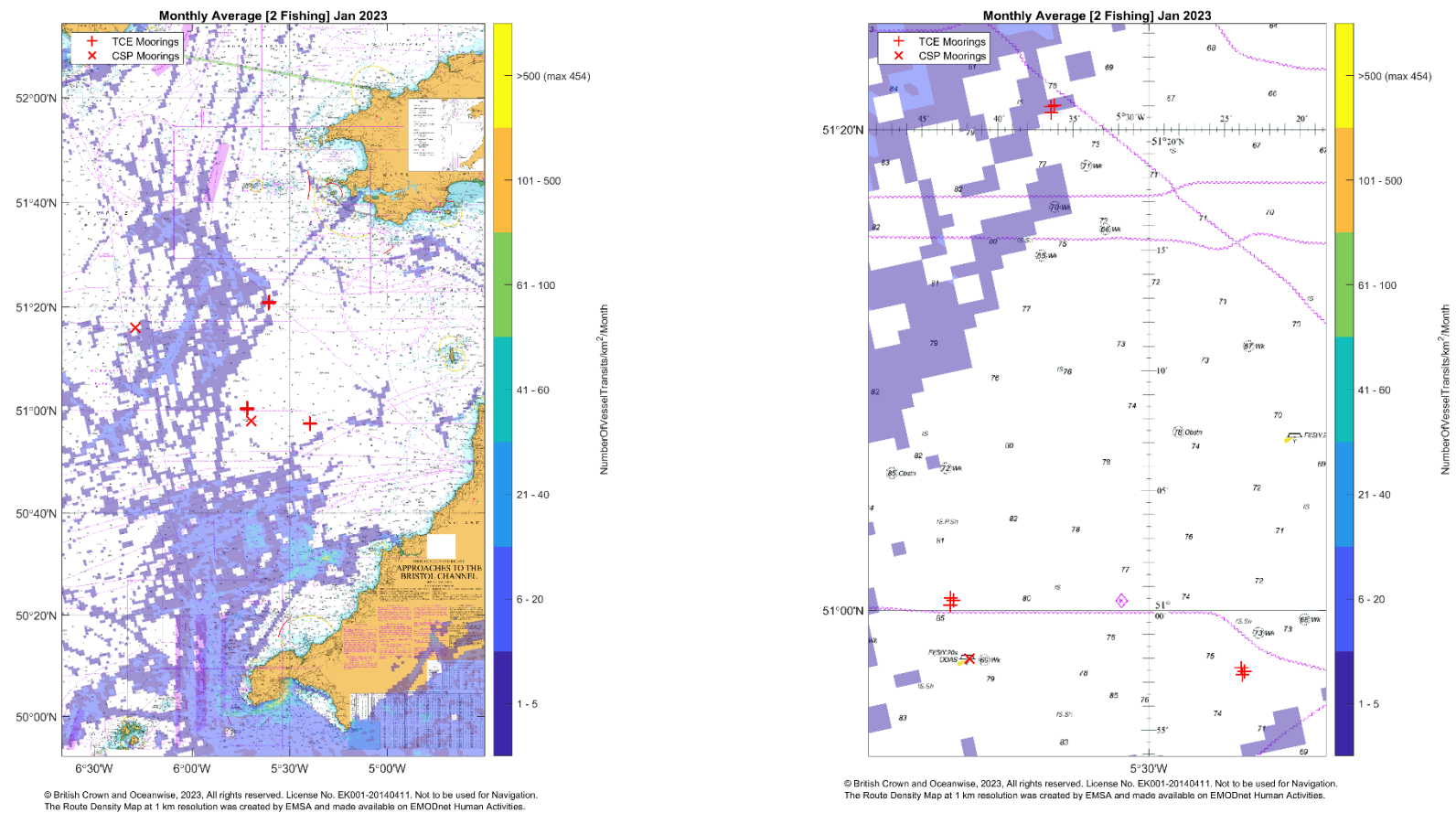


Figure A21. Fishing vessel types – vessel route density (vessel transits crossing 1x1km cell per month), based on AIS data from January 2023, regional and local views.

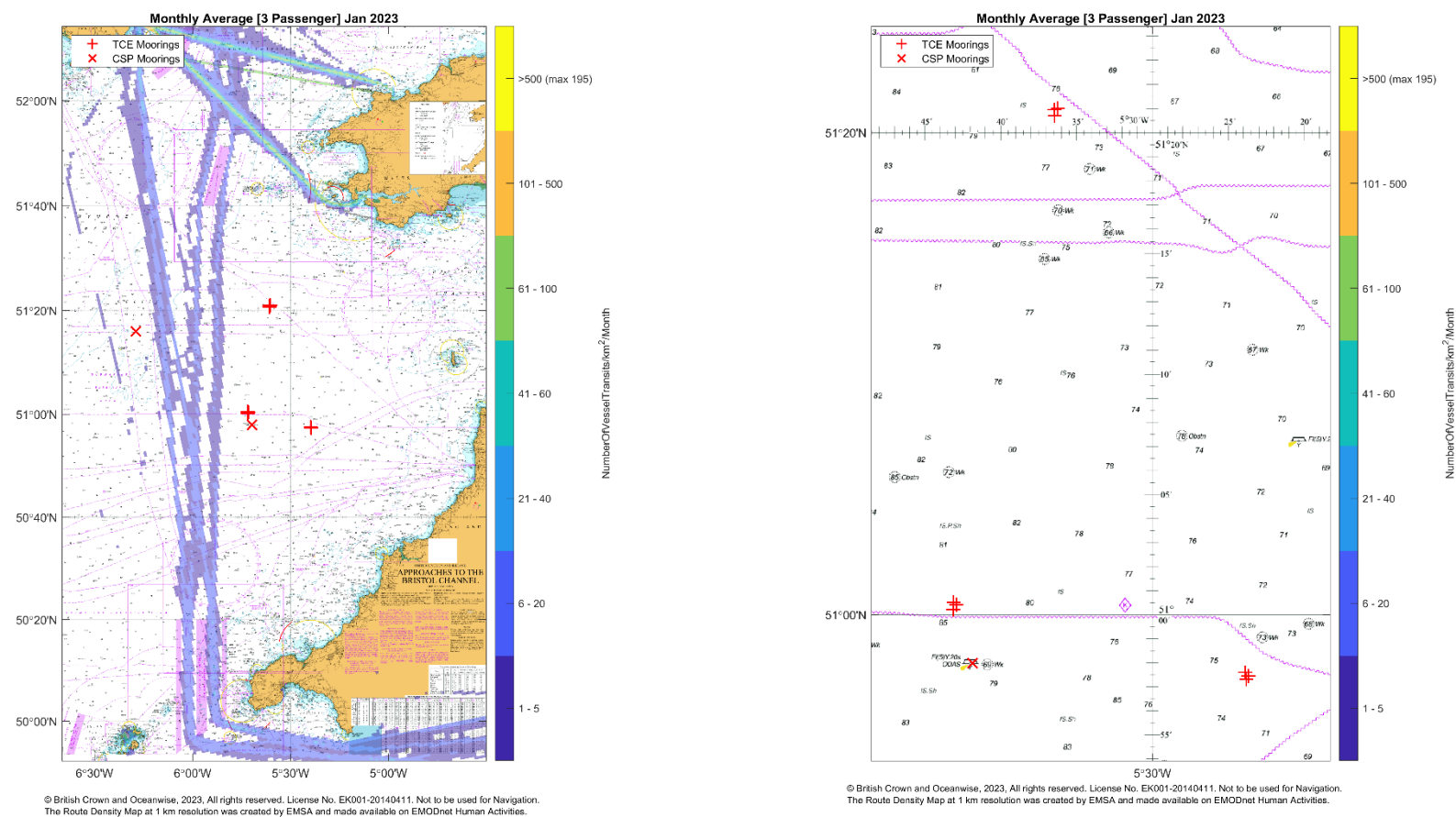


Figure A22. Passenger vessel types – vessel route density (vessel transits crossing 1x1km cell per month), based on AIS data from January 2023, regional and local views.

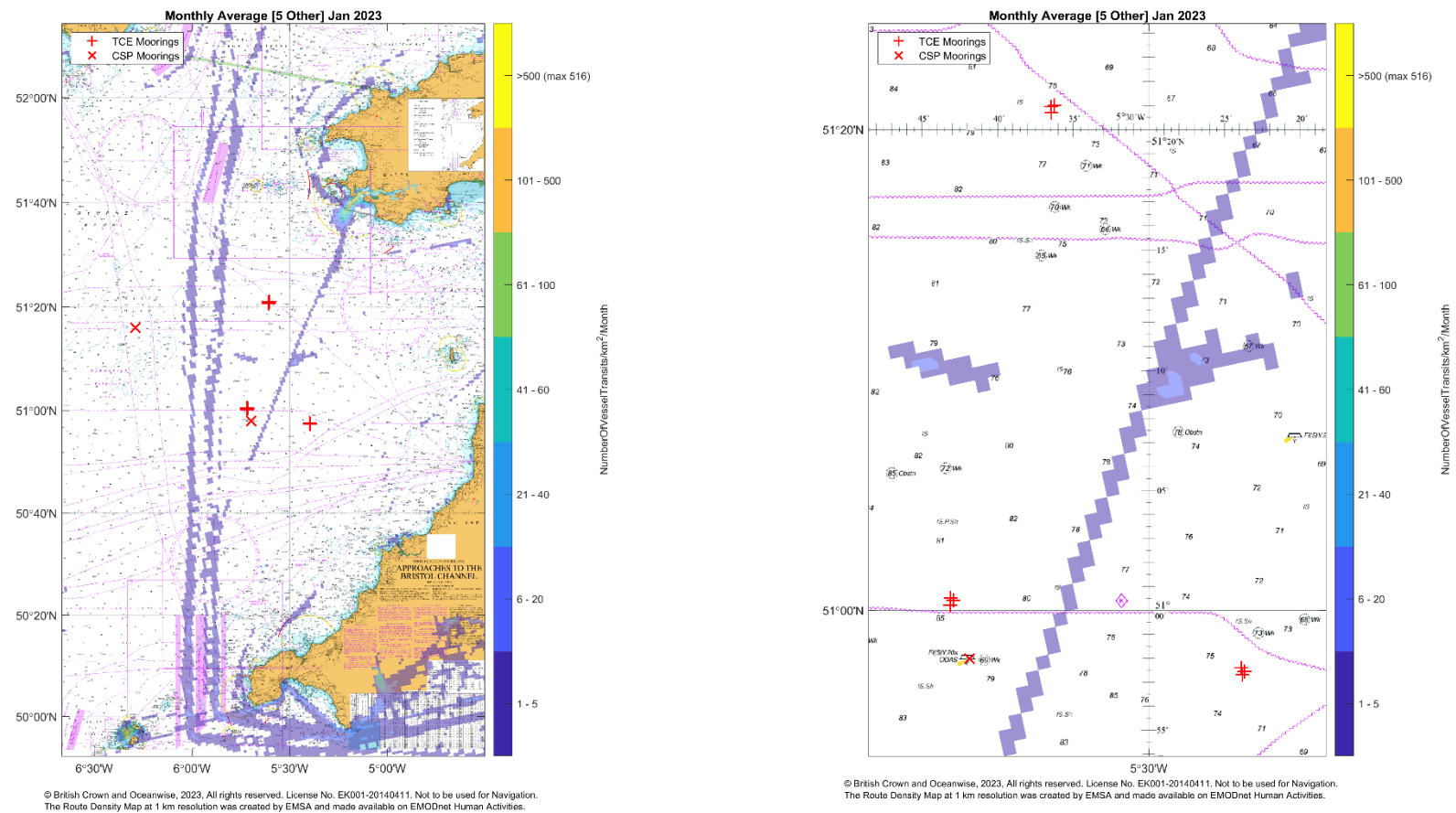


Figure A23. Other vessel types – vessel route density (vessel transits crossing 1x1km cell per month), based on AIS data from January 2023, regional and local views.

A.4 Vessel Traffic Density (August 2022)

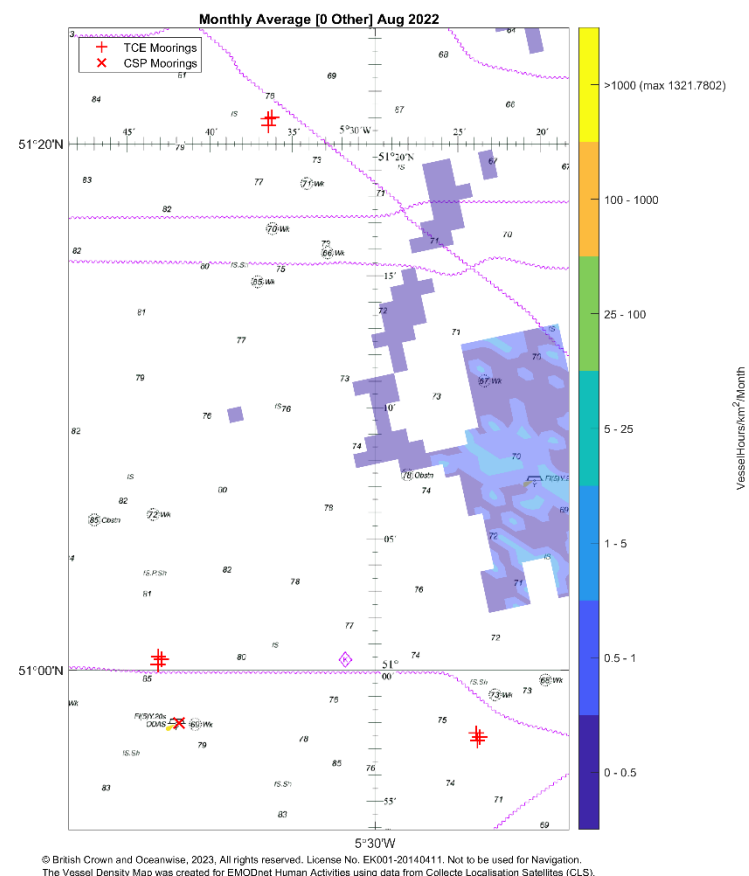
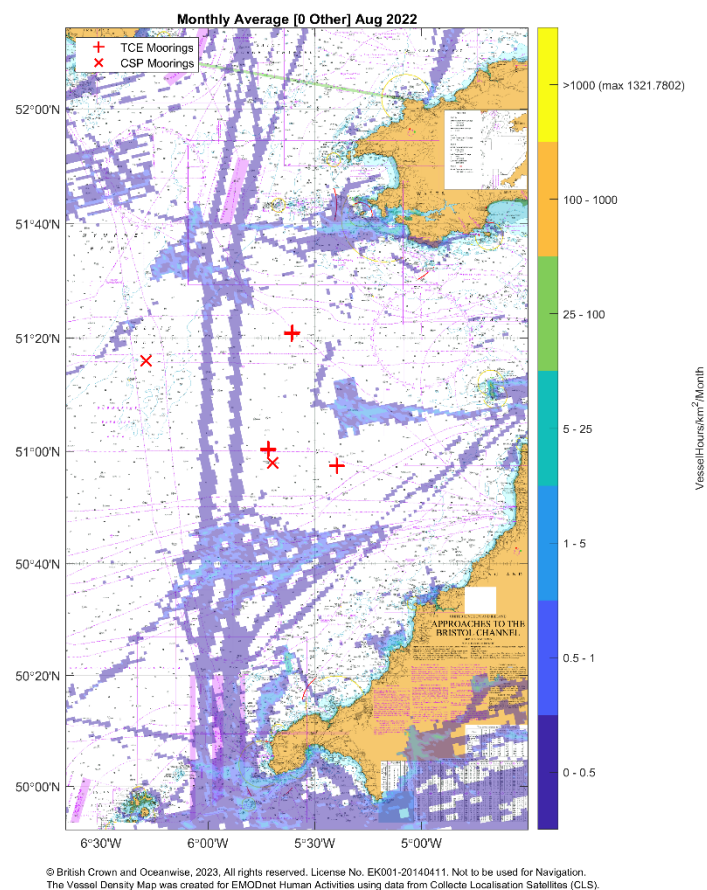


Figure A24. Other vessel types – vessel traffic density (hours in 1x1km cell per month), based on AIS data from August 2022, regional and local views.

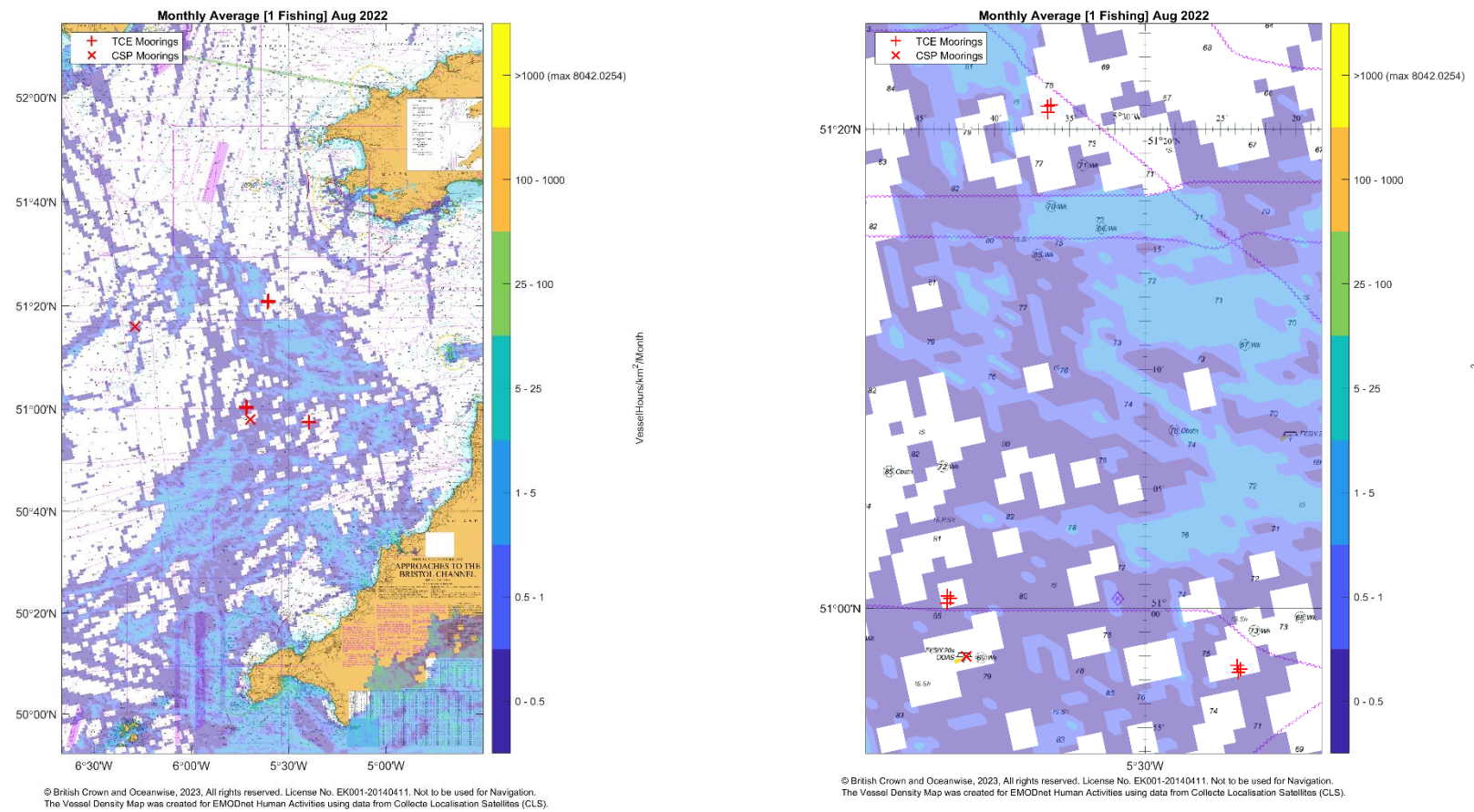


Figure A25. Fishing vessel types – vessel traffic density (hours in 1x1km cell per month), based on AIS data from August 2022, regional and local views.

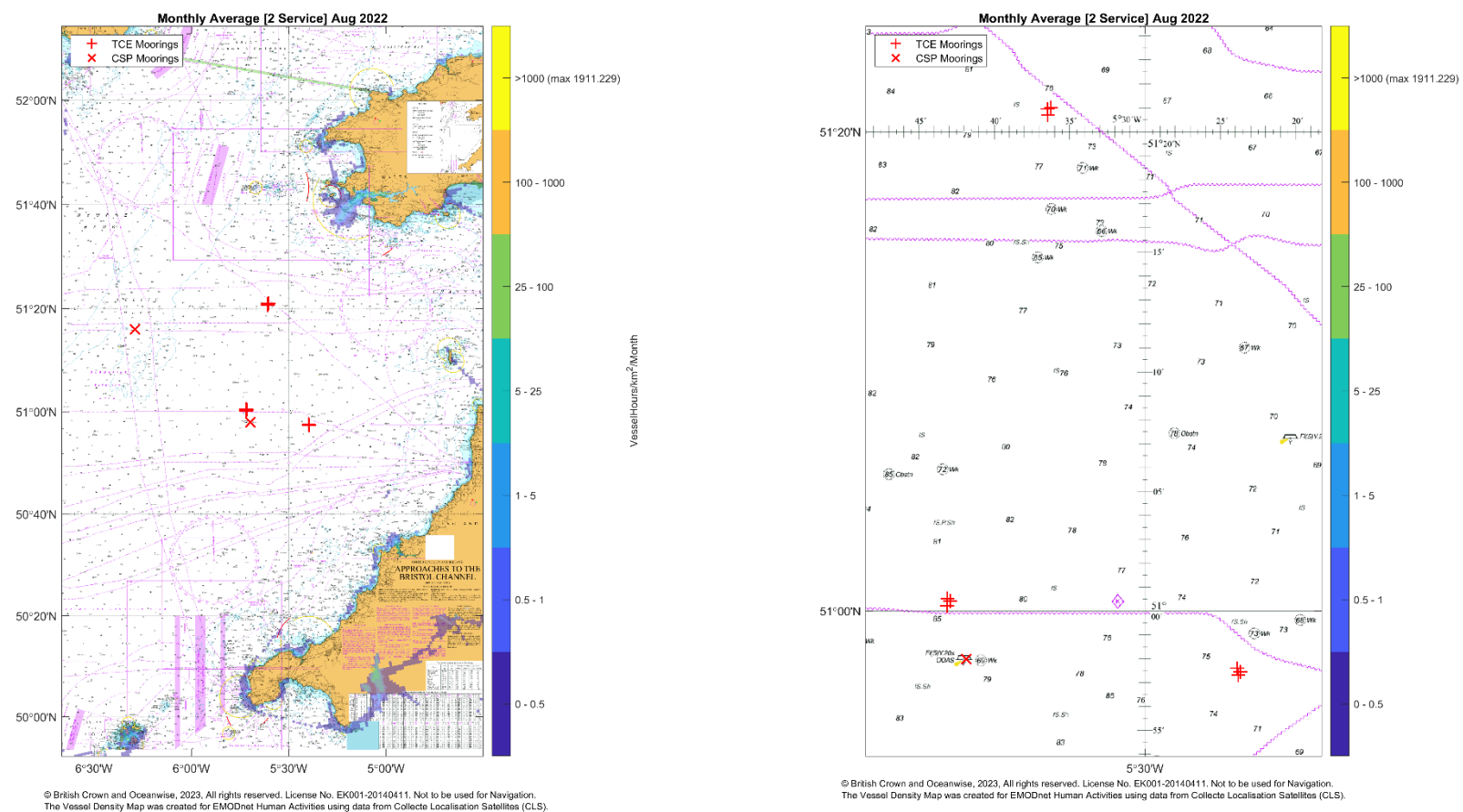


Figure A26. Service craft vessel types – vessel traffic density (hours in 1x1km cell per month), based on AIS data from August 2022, regional and local views.

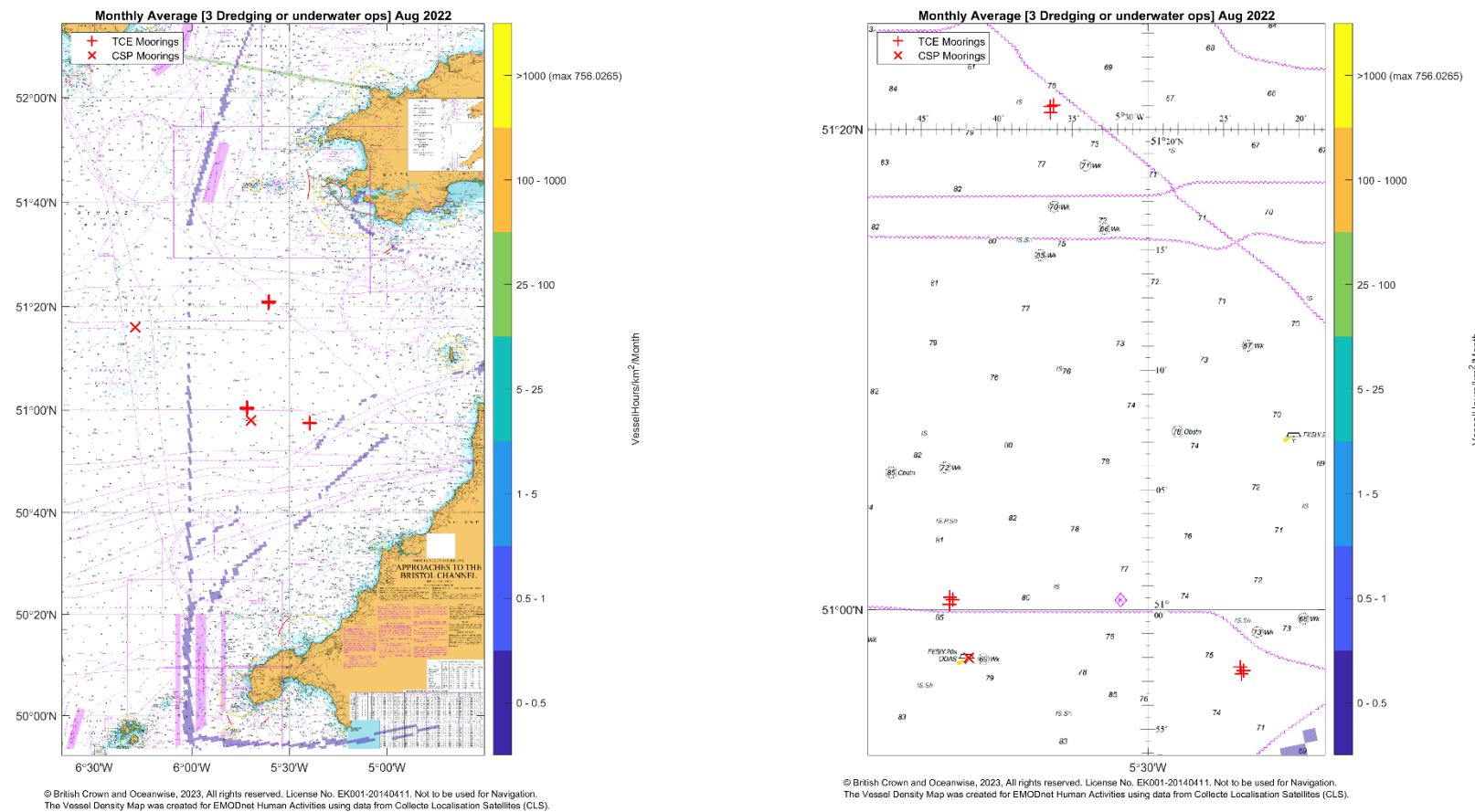


Figure A27. Dredging or underwater operations vessel types – vessel traffic density (hours in 1x1km cell per month), based on AIS data from August 2022, regional and local views.

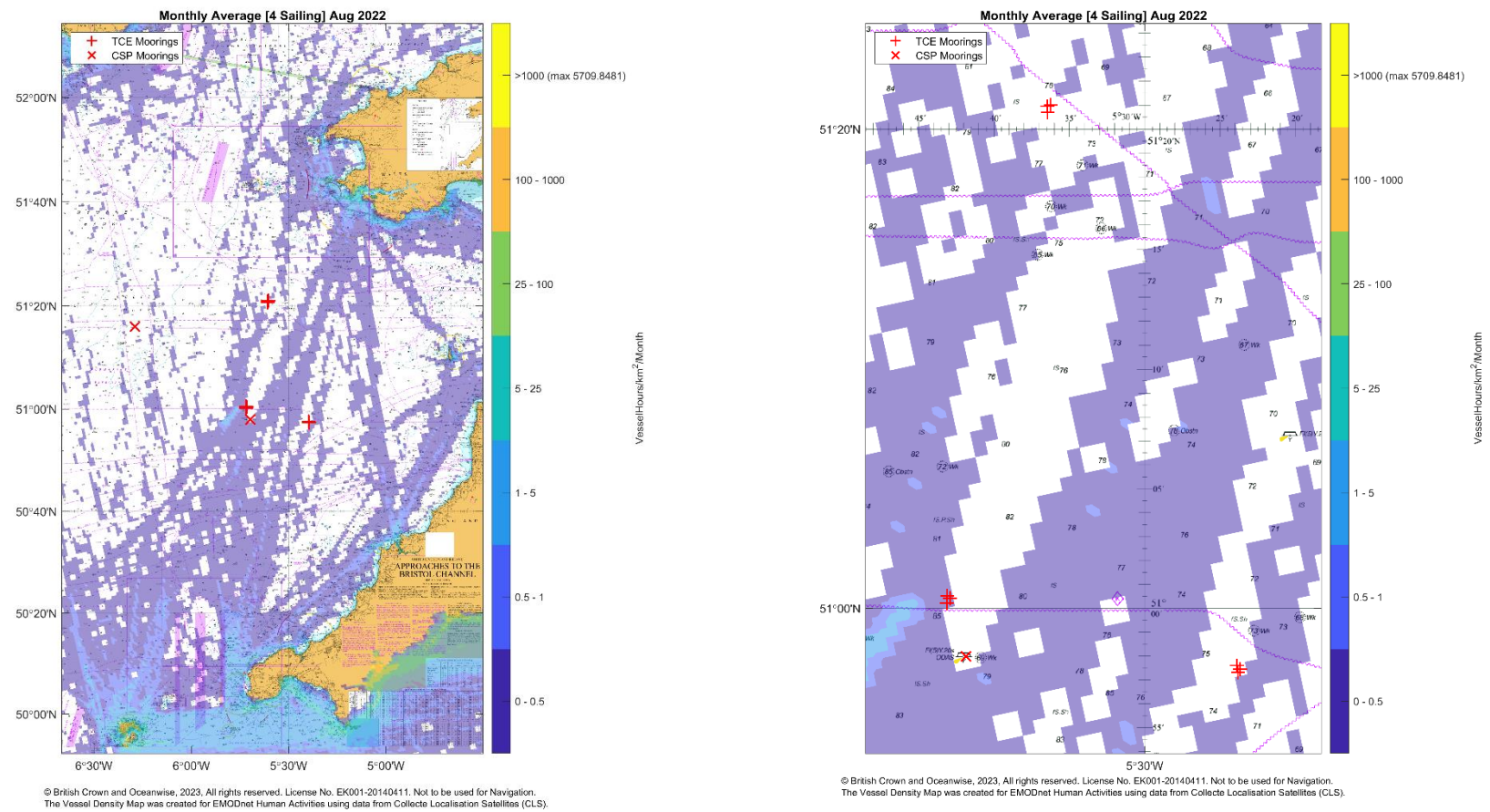


Figure A28. Sailing vessel types – vessel traffic density (hours in 1x1km cell per month), based on AIS data from August 2022, regional and local views.

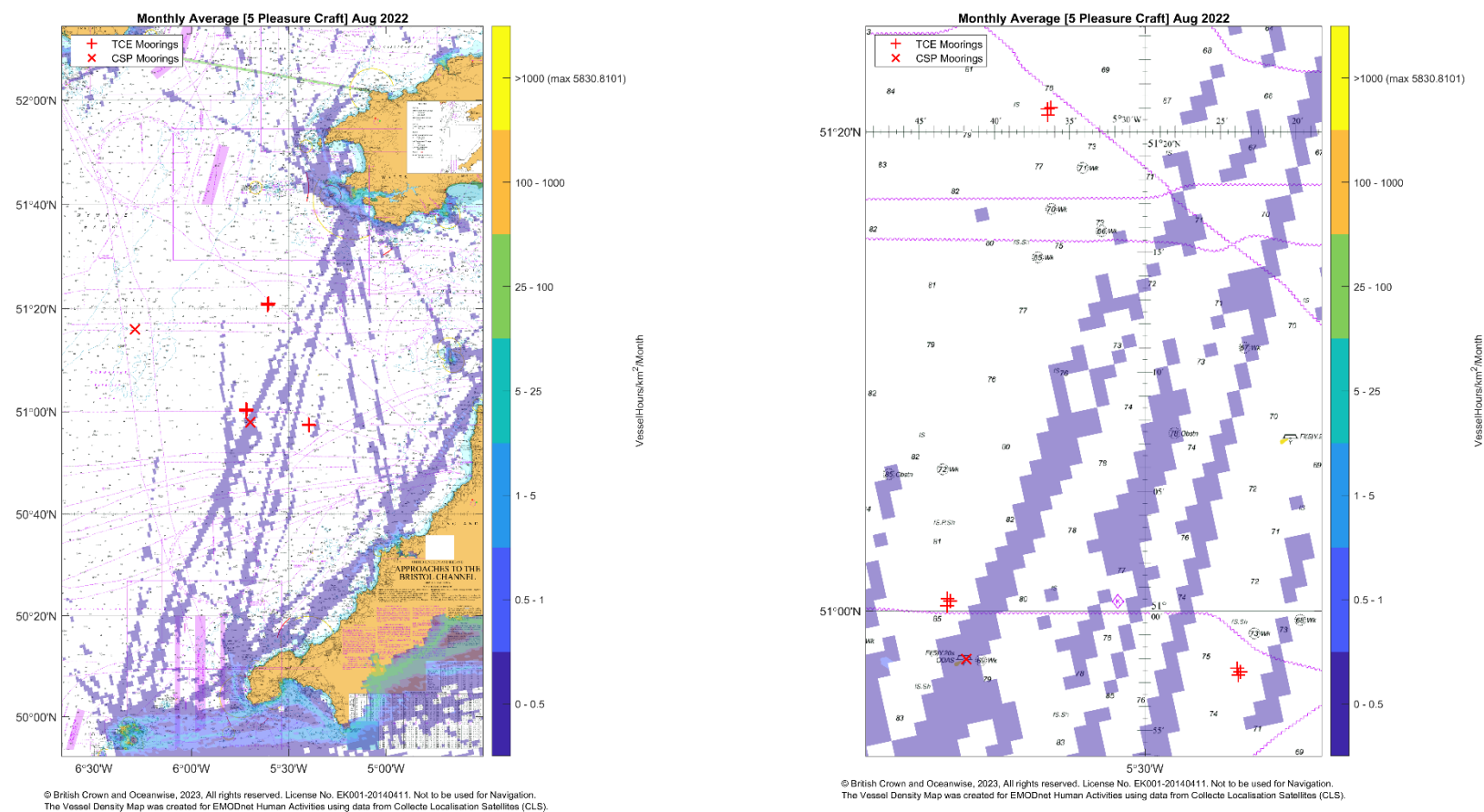


Figure A29. Pleasure craft vessel types – vessel traffic density (hours in 1x1km cell per month), based on AIS data from August 2022, regional and local views.

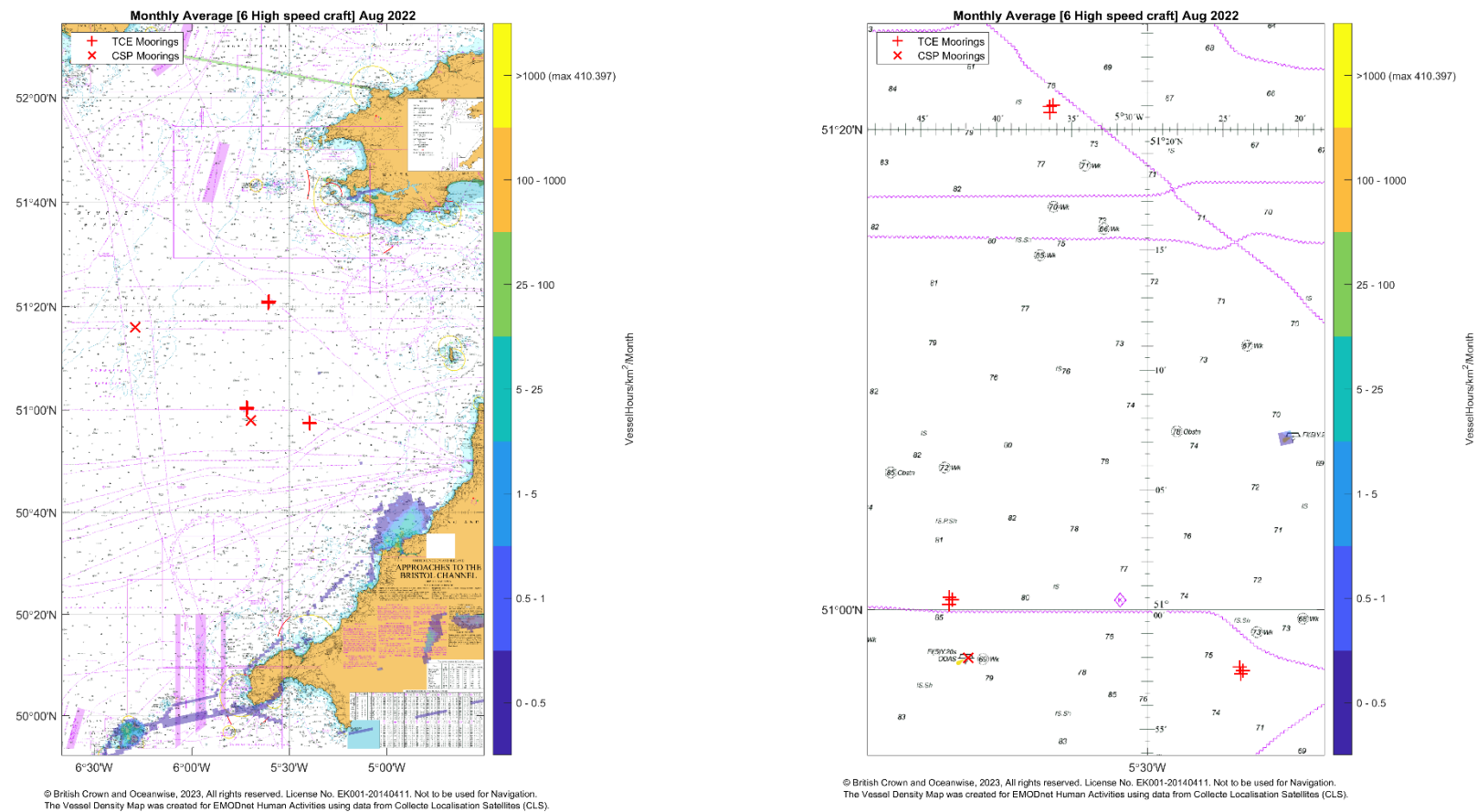


Figure A30. High speed craft vessel types – vessel traffic density (hours in 1x1km cell per month), based on AIS data from August 2022, regional and local views.

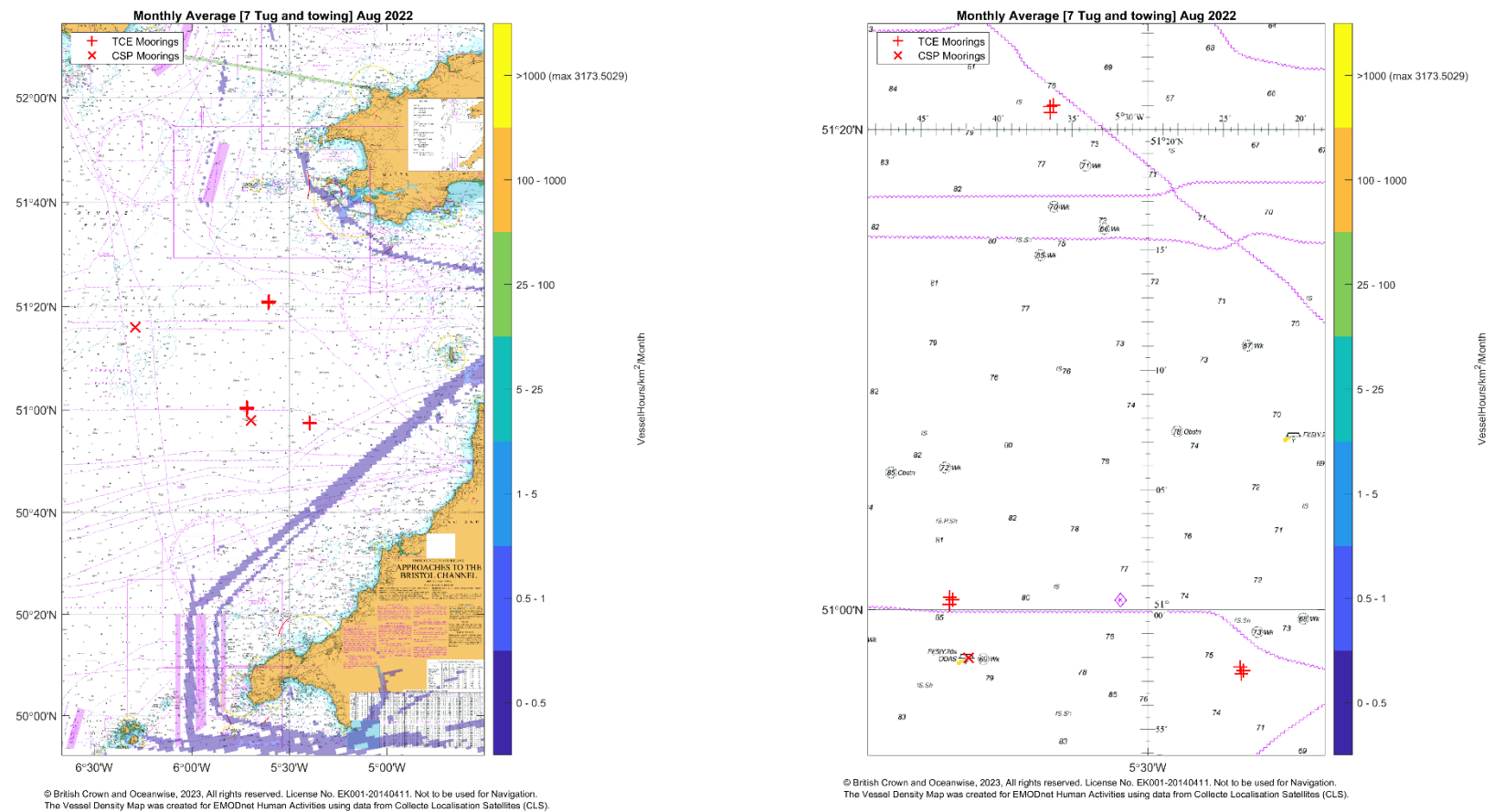


Figure A31. Tug and towing vessel types – vessel traffic density (hours in 1x1km cell per month), based on AIS data from August 2022, regional and local views.

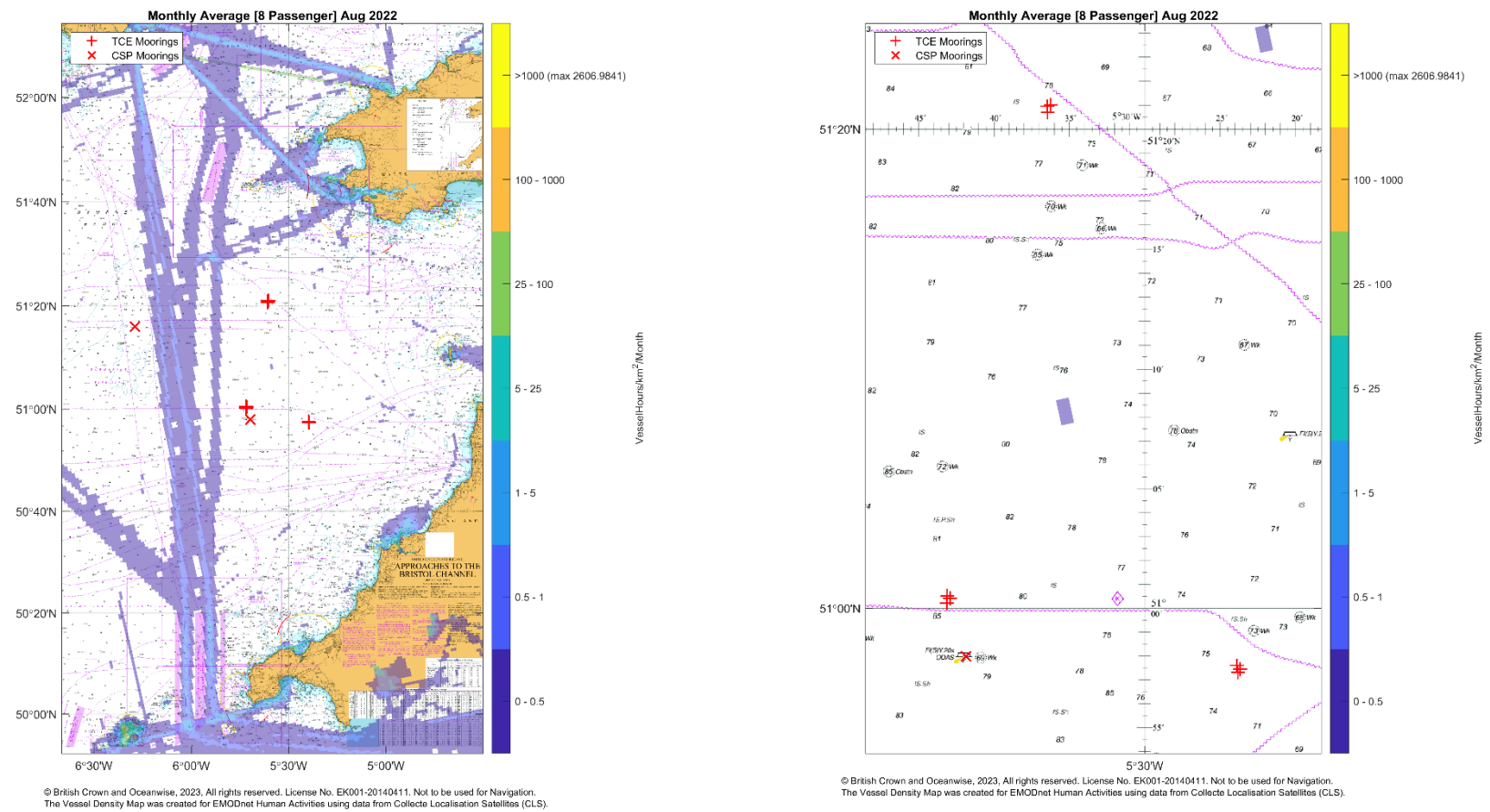


Figure A32. Passenger vessel types – vessel traffic density (hours in 1x1km cell per month), based on AIS data from August 2022, regional and local views.

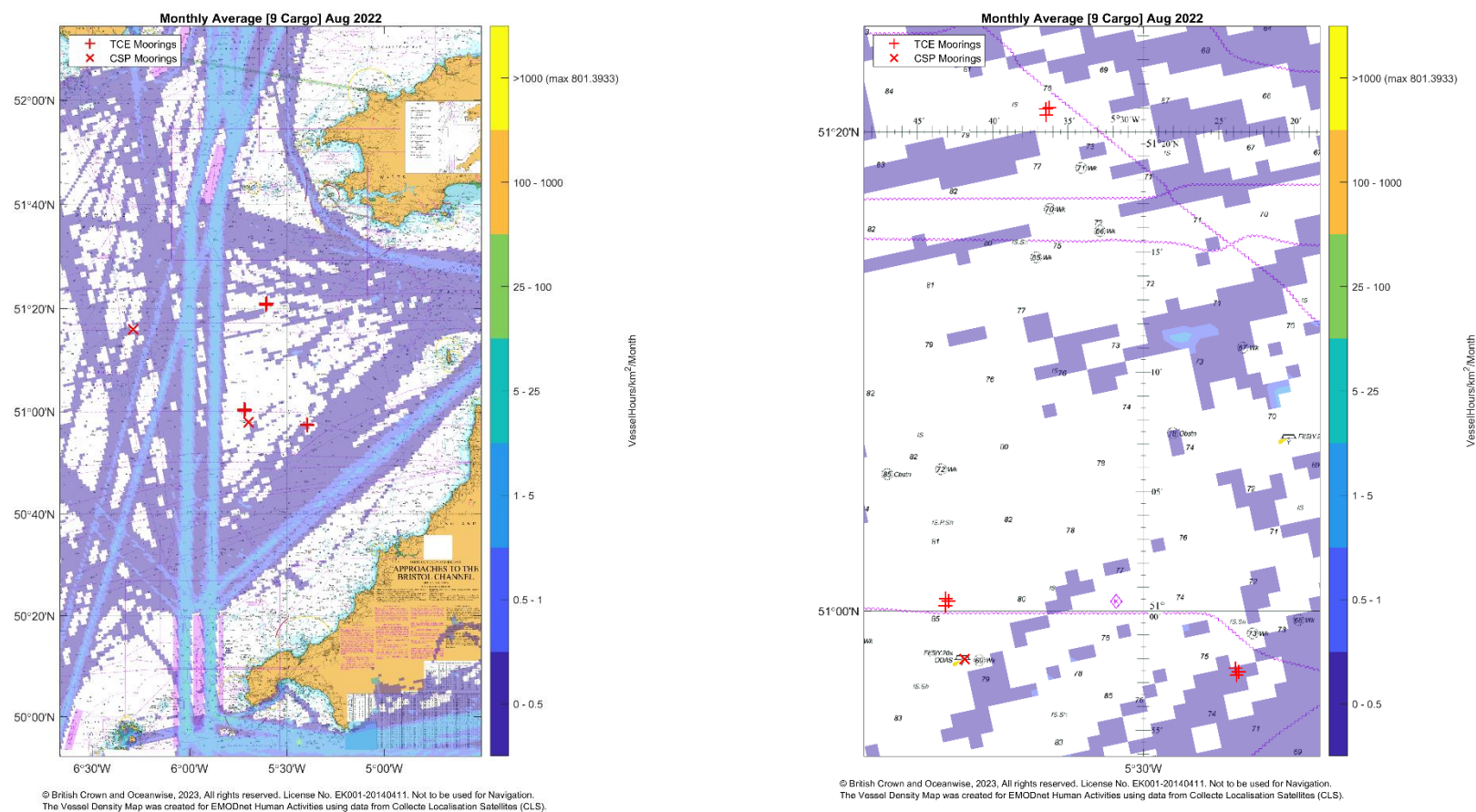


Figure A33. Cargo vessel types – vessel traffic density (hours in 1x1km cell per month), based on AIS data from August 2022, regional and local views.

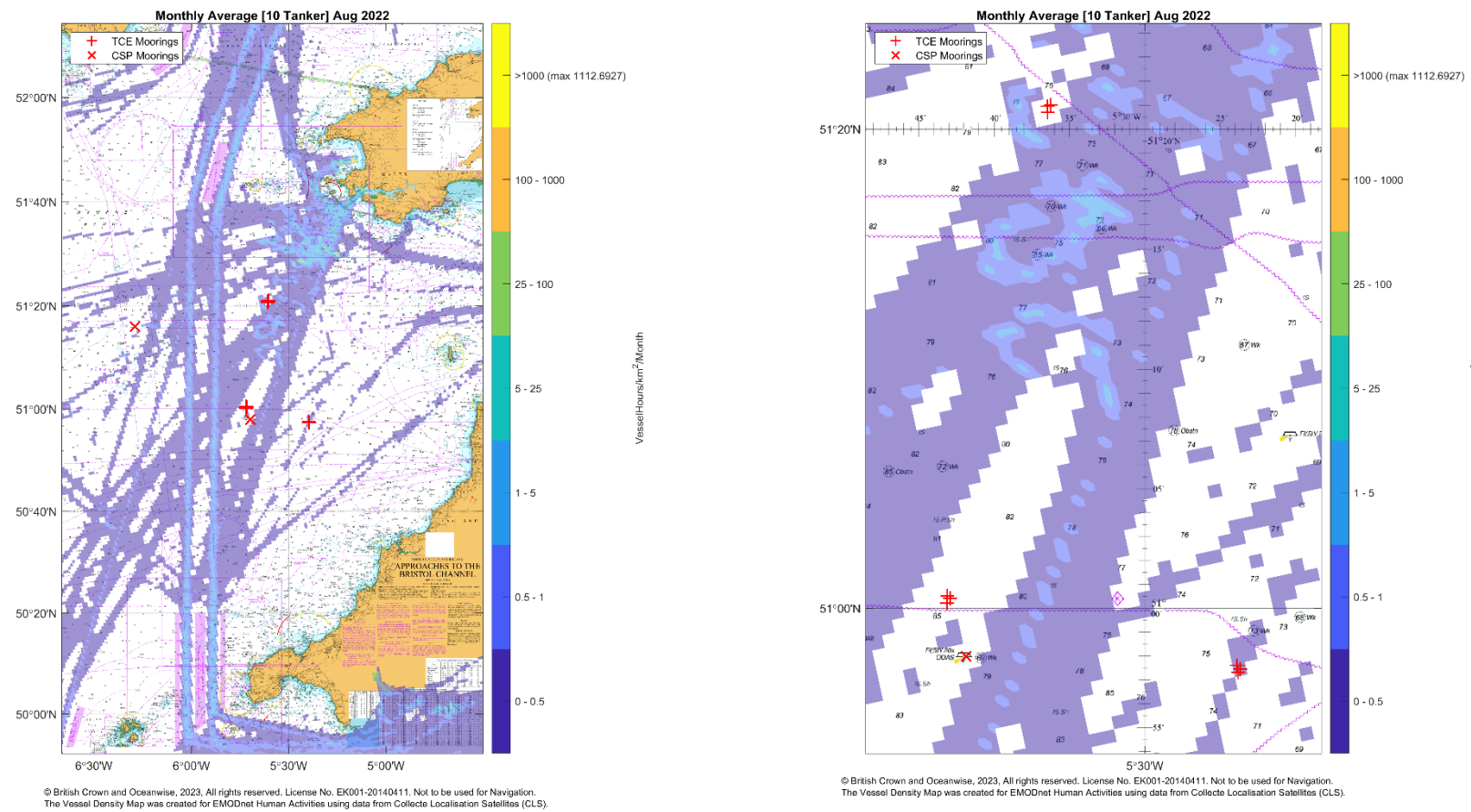


Figure A34. Tanker vessel types – vessel traffic density (hours in 1x1km cell per month), based on AIS data from August 2022, regional and local views.

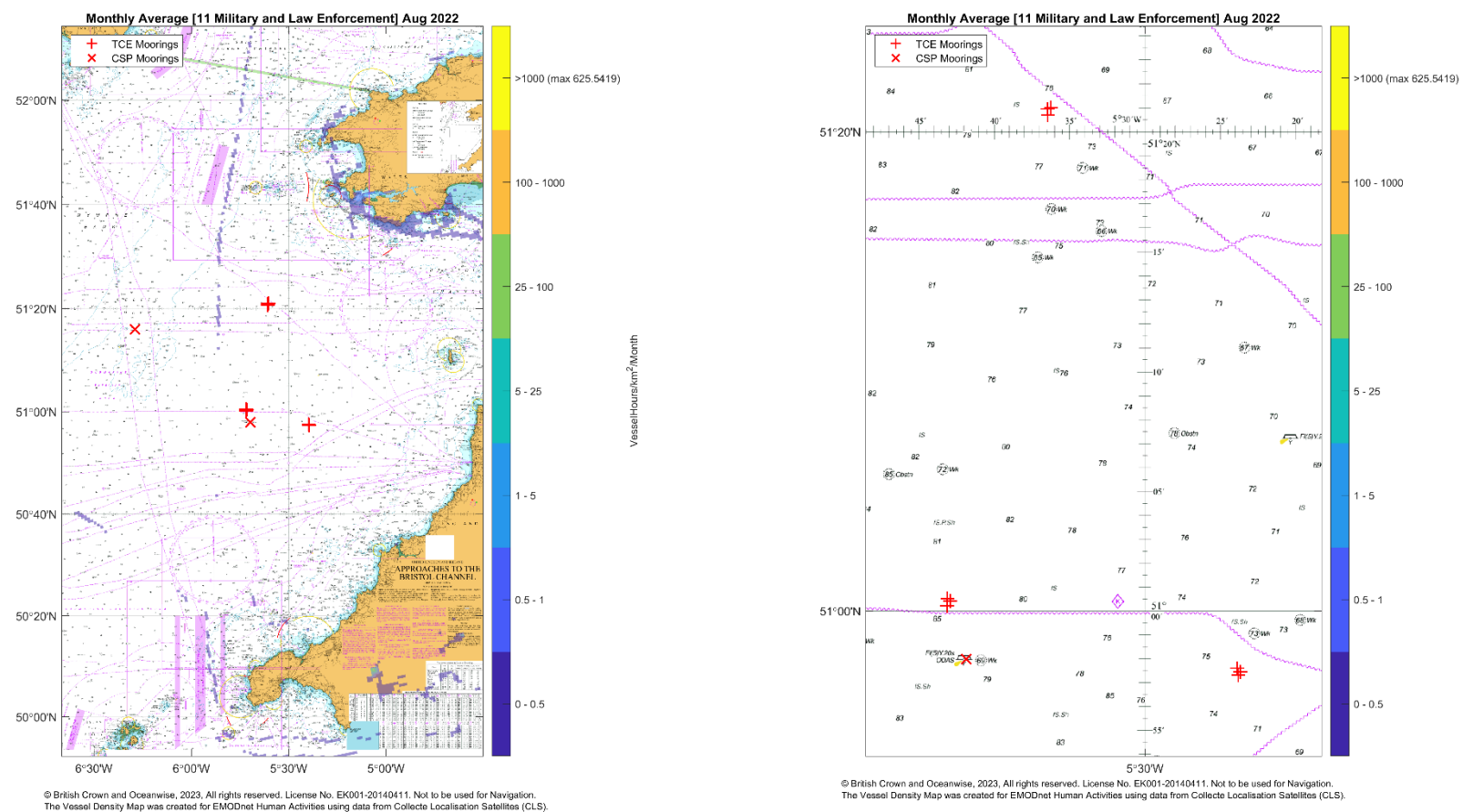


Figure A35. Military or law enforcement vessel types – vessel traffic density (hours in 1x1km cell per month), based on AIS data from August 2022, regional and local views.

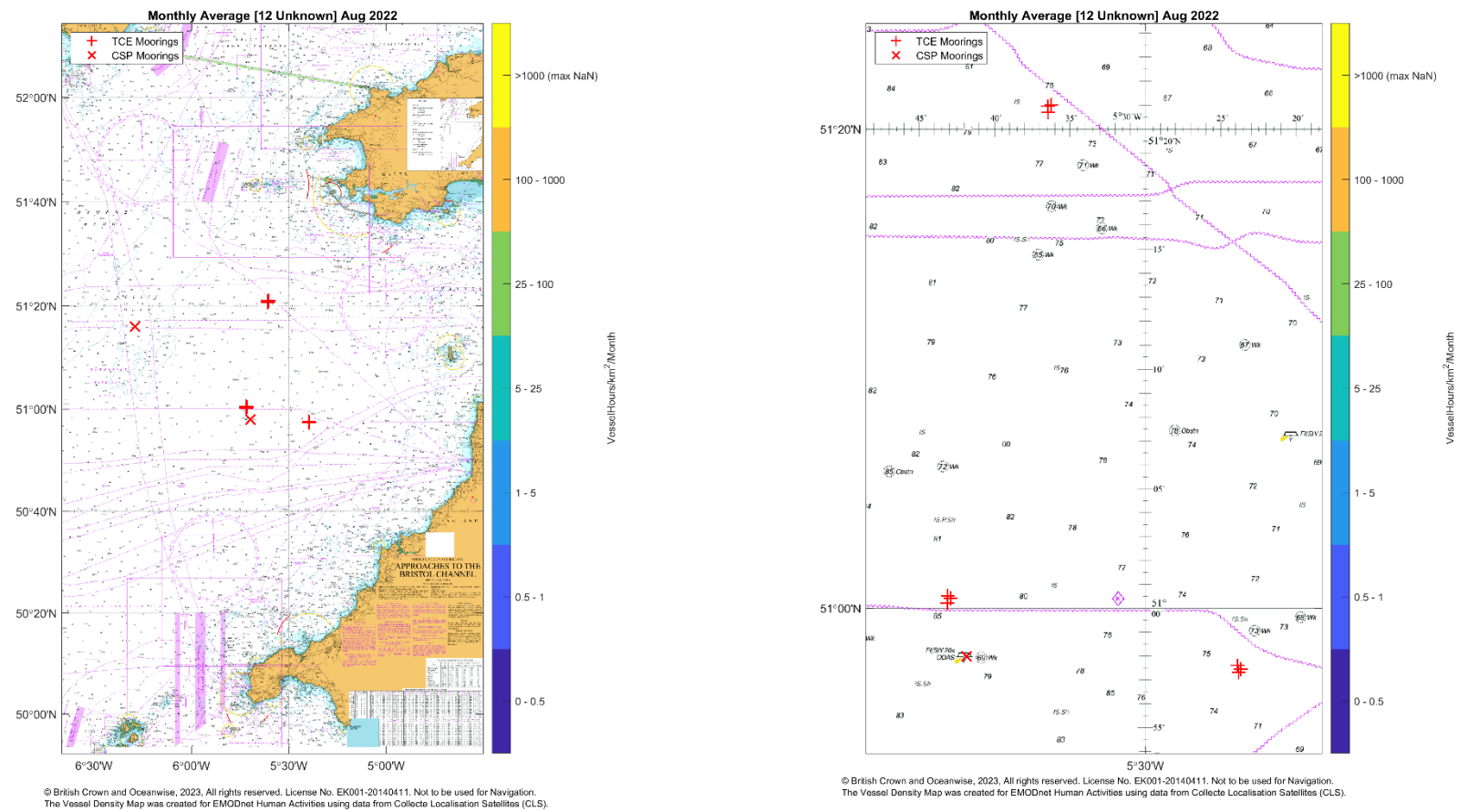
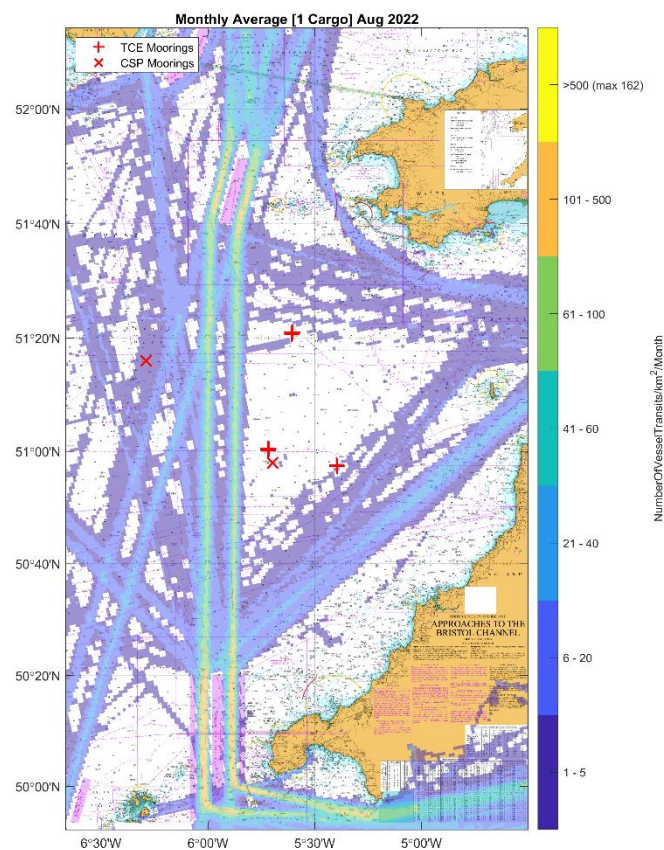
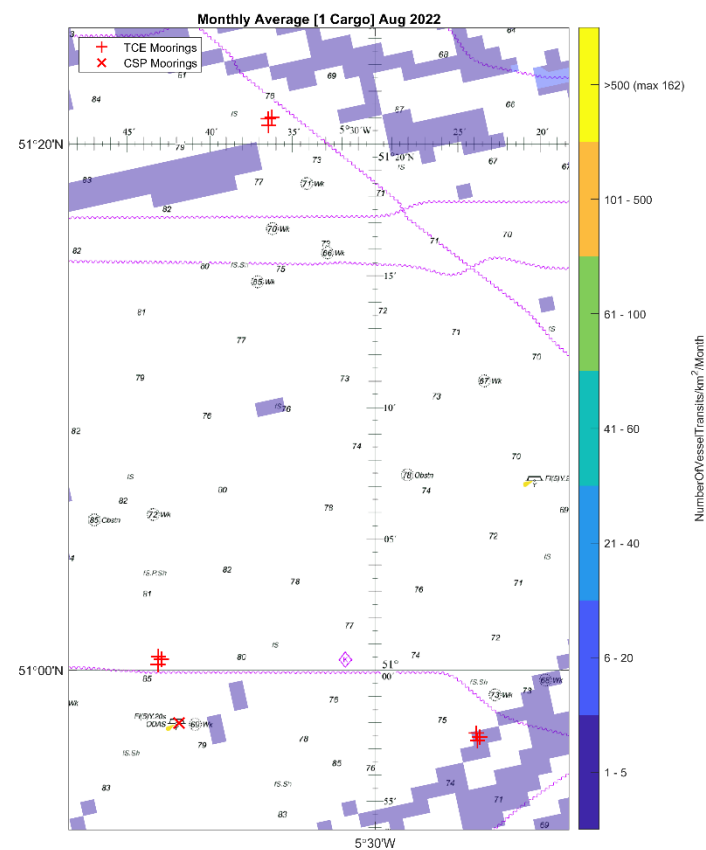


Figure A36. Unknown vessel types – vessel traffic density (hours in 1x1km cell per month), based on AIS data from August 2022, regional and local views.

A.5 Vessel Route Density (August 2022)



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The Route Density Map at 1 km resolution was created by EMSA and made available on EMODnet Human Activities.

Figure A37. Cargo vessel types – vessel route density (vessel transits crossing 1x1km cell per month), based on AIS data from August 2022, regional and local views.

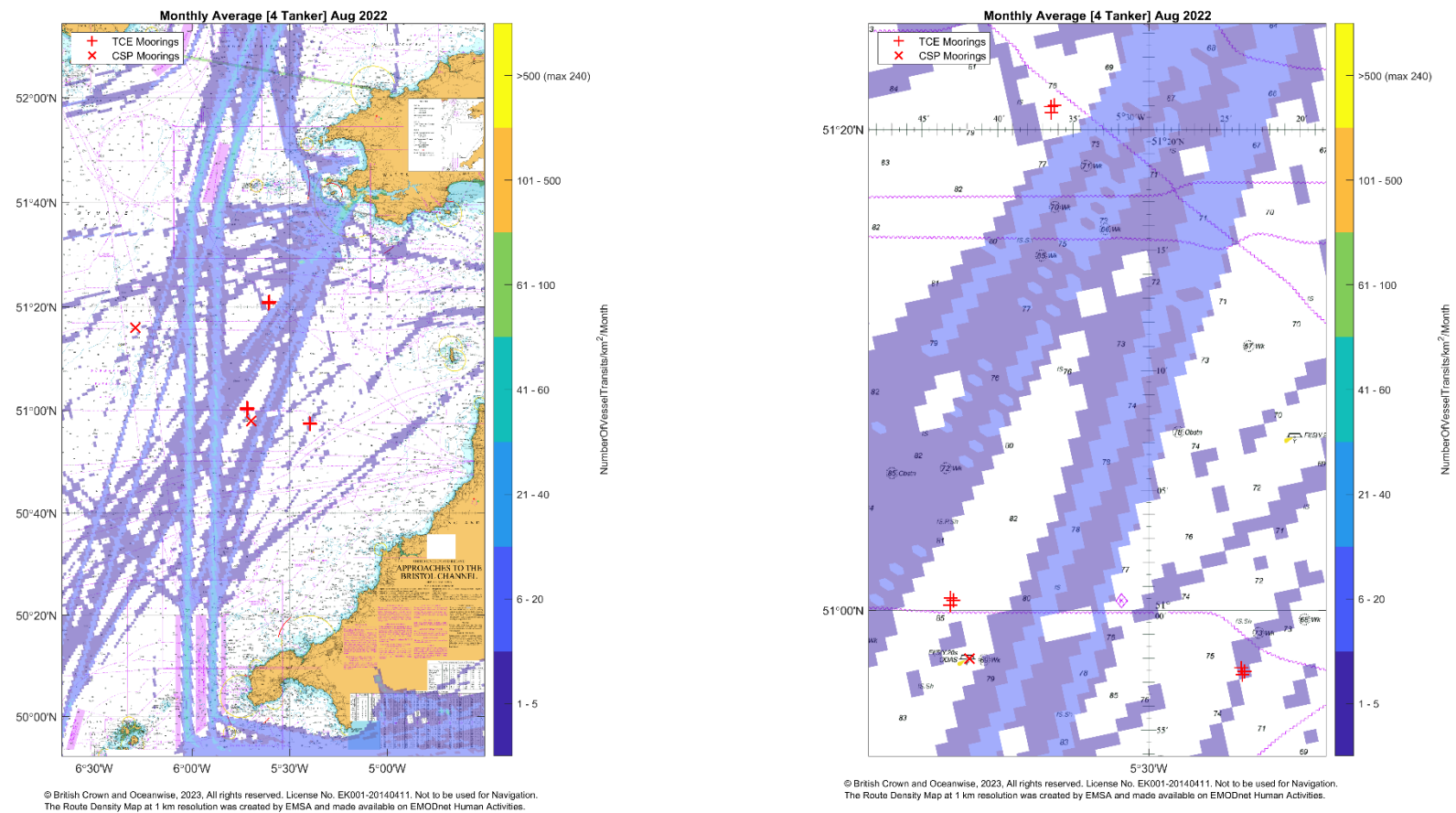


Figure A38. Tanker vessel types – vessel route density (vessel transits crossing 1x1km cell per month), based on AIS data from August 2022, regional and local views.

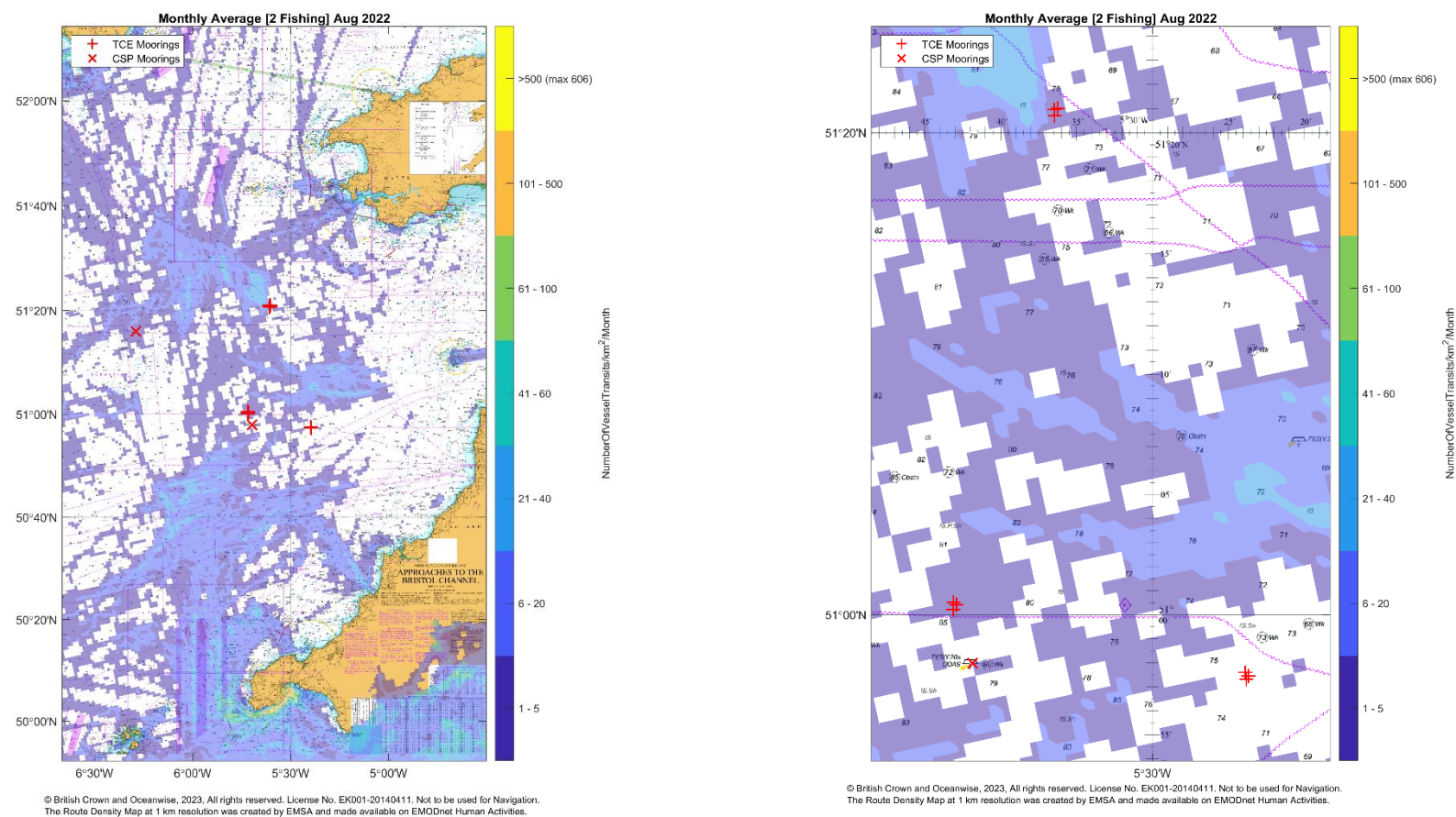


Figure A39. Fishing vessel types – vessel route density (vessel transits crossing 1x1km cell per month), based on AIS data from August 2022, regional and local views.

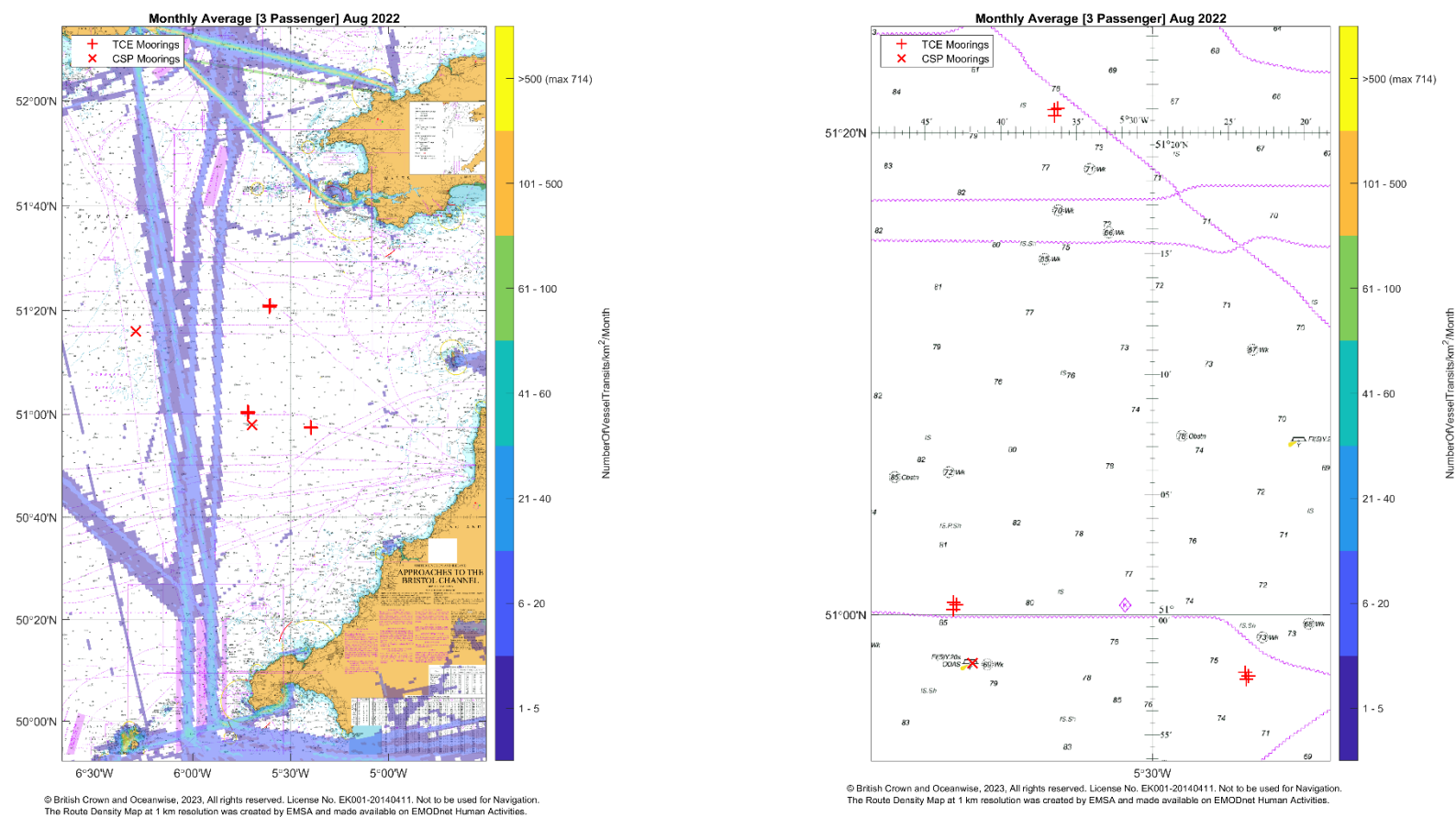


Figure A40. Passenger vessel types – vessel route density (vessel transits crossing 1x1km cell per month), based on AIS data from August 2022, regional and local views.

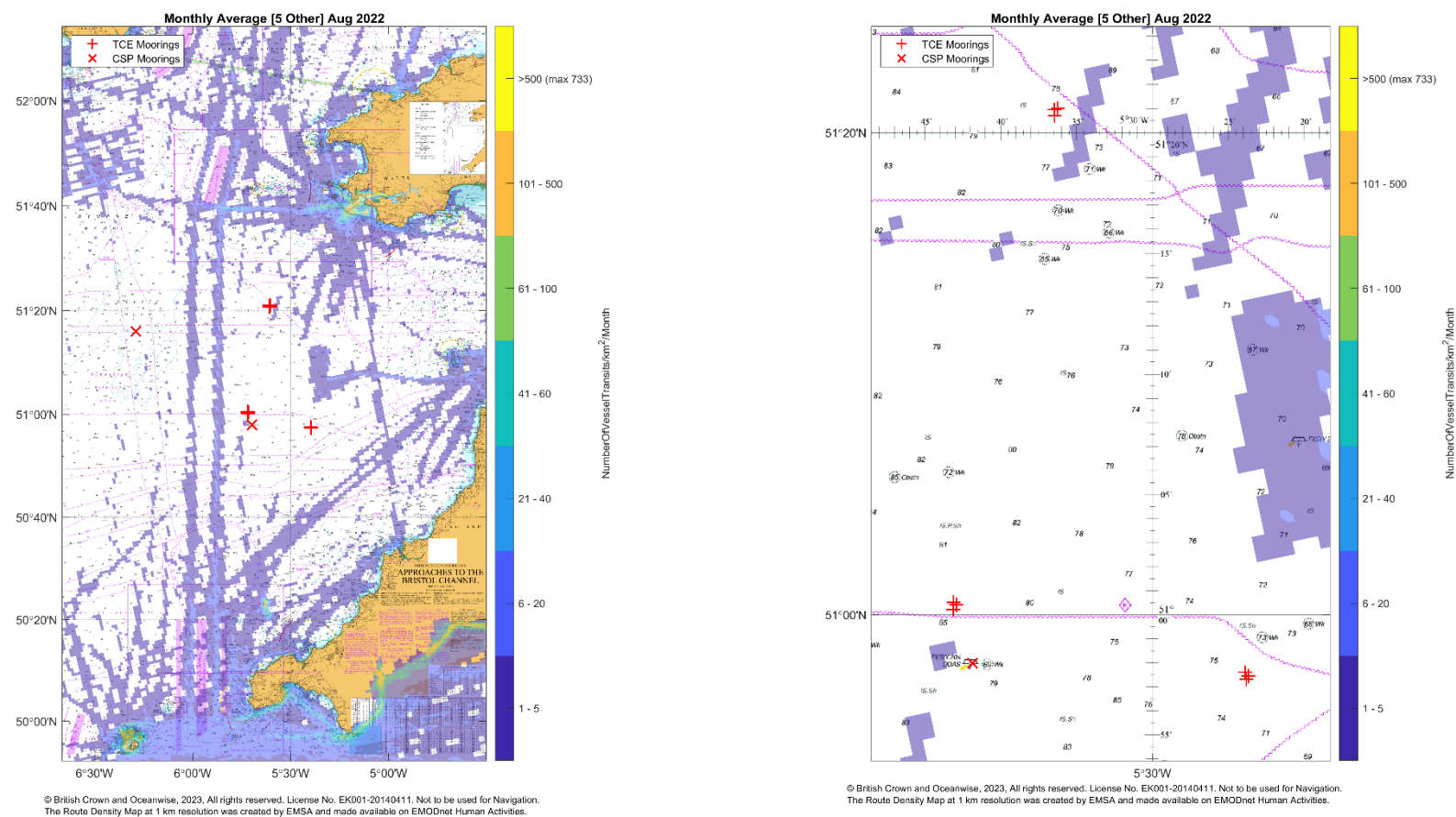


Figure A41. Other vessel types – vessel route density (vessel transits crossing 1x1km cell per month), based on AIS data from August 2022, regional and local views.

A.6 Vessel Route Density (August 2023)

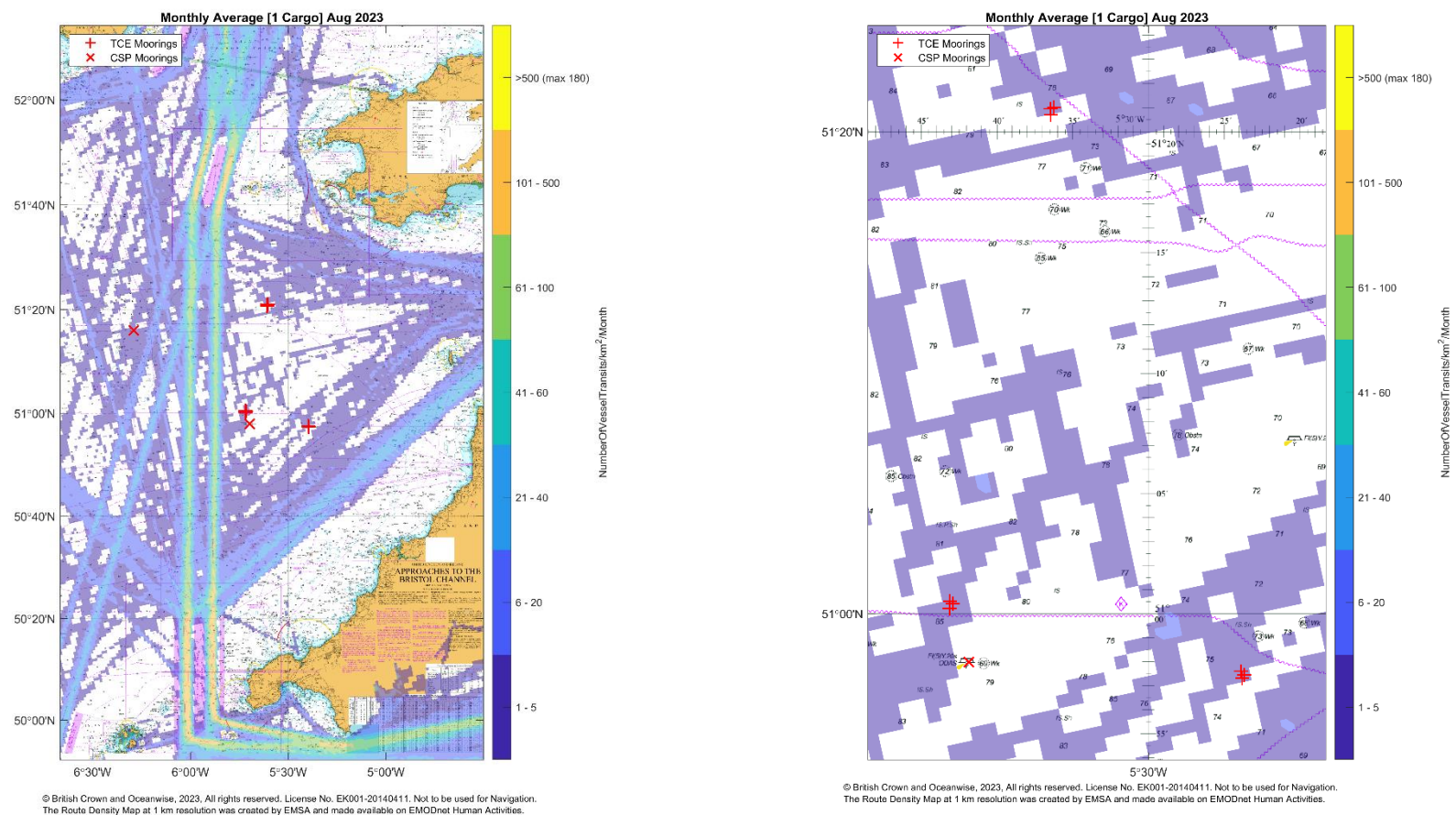


Figure A42. Cargo vessel types – vessel route density (vessel transits crossing 1x1km cell per month), based on AIS data from August 2023, regional and local views.

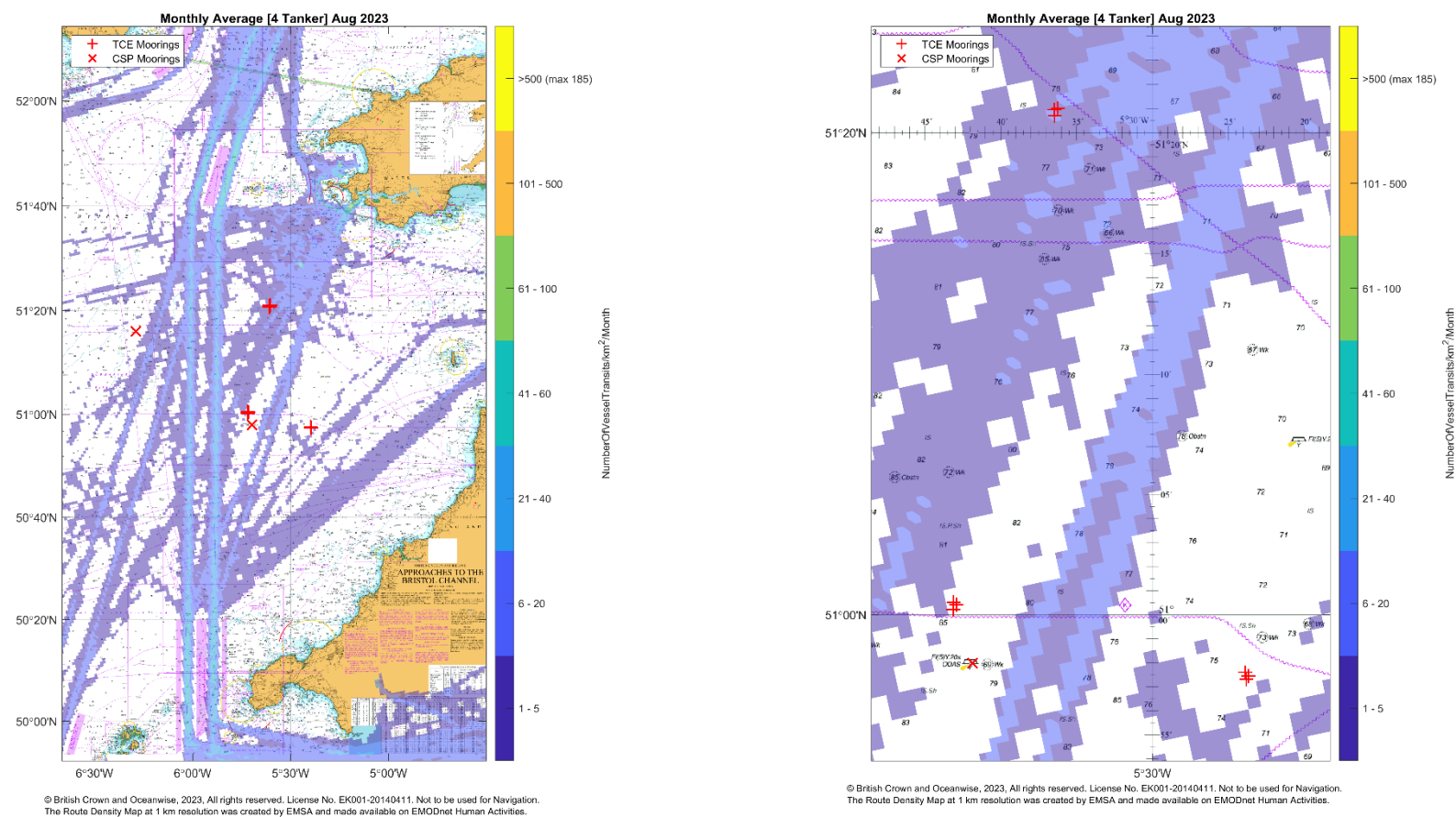


Figure A43. Tanker vessel types – vessel route density (vessel transits crossing 1x1km cell per month), based on AIS data from August 2023, regional and local views.

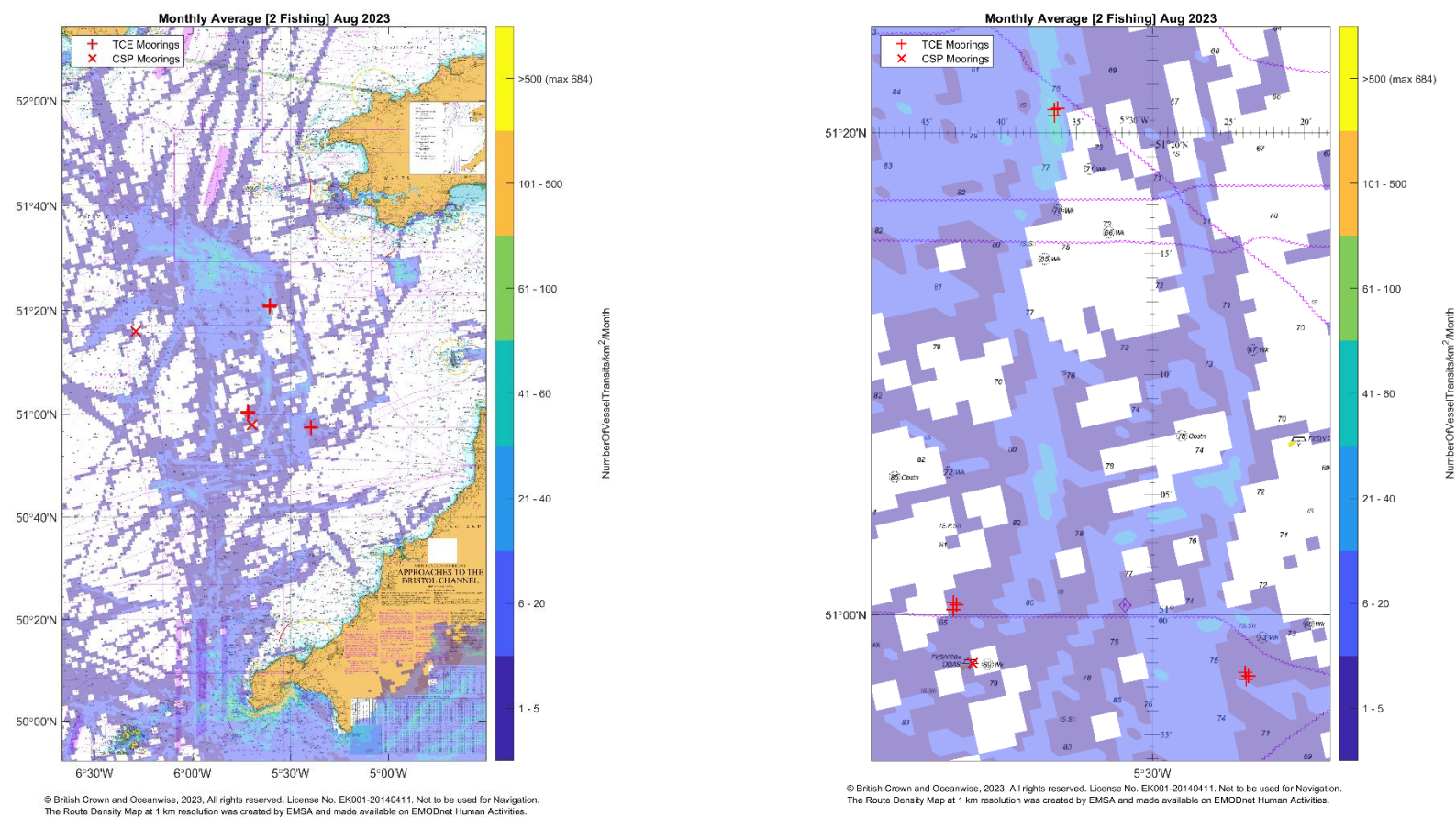


Figure A44. Fishing vessel types – vessel route density (vessel transits crossing 1x1km cell per month), based on AIS data from August 2023, regional and local views.

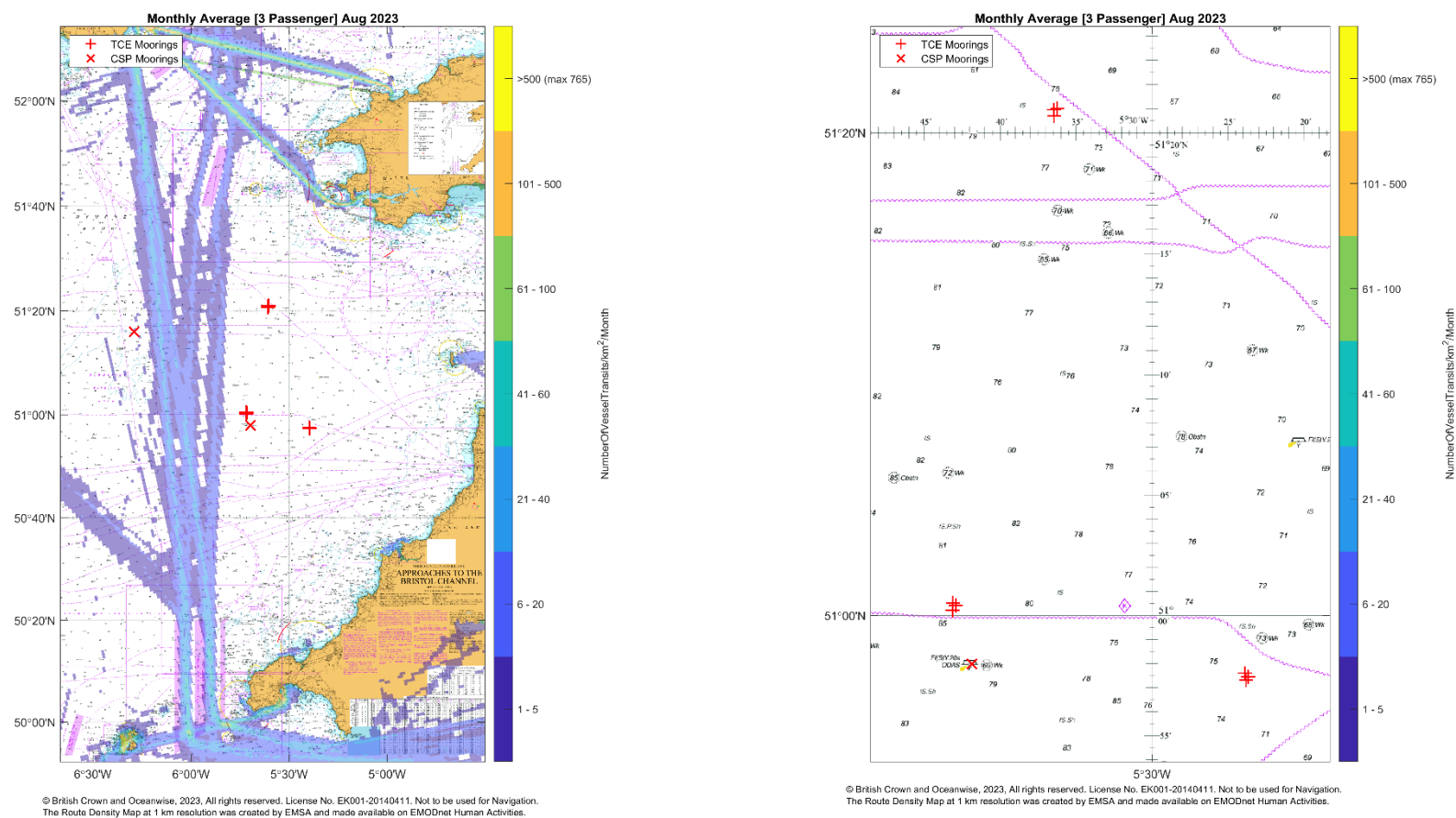


Figure A45. Passenger vessel types – vessel route density (vessel transits crossing 1x1km cell per month), based on AIS data from August 2023, regional and local views.

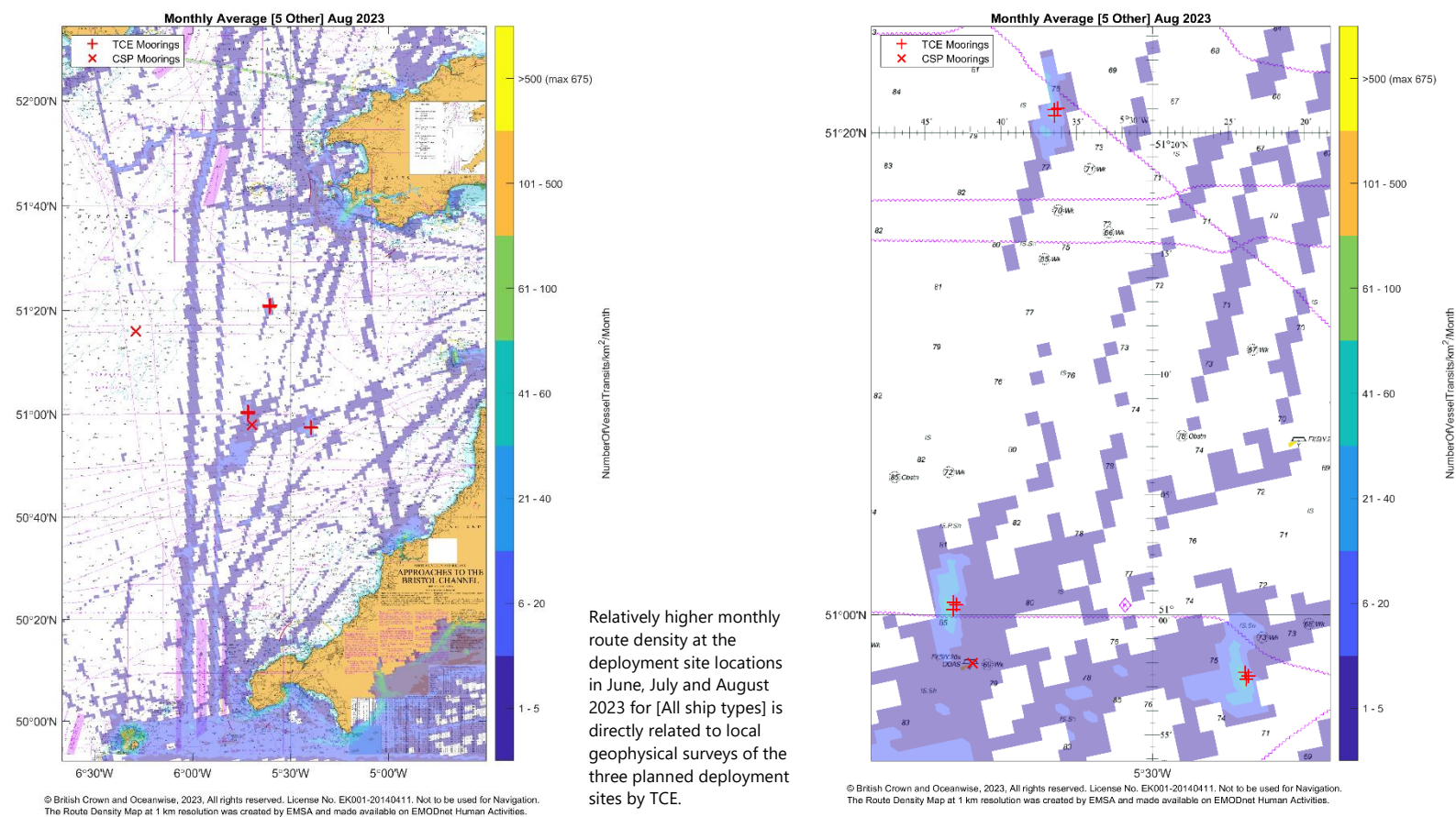


Figure A46. Other vessel types – vessel route density (vessel transits crossing 1x1km cell per month), based on AIS data from August 2023, regional and local views.

B Location Specific Vessel Traffic and Route Density Statistics

B.1 Other

The following map figures are presented in Appendix A:

- Other vessel types – vessel traffic density – January 2022 (Figure A1);
- Other vessel types – vessel route density – January 2022 (Figure A18);
- Other vessel types – vessel route density – January 2023 (Figure A23);
- Other vessel types – vessel traffic density – August 2022 (Figure A24);
- Other vessel types – vessel route density – August 2022 (Figure A41); and
- Other vessel types – vessel route density – August 2023 (Figure A46).

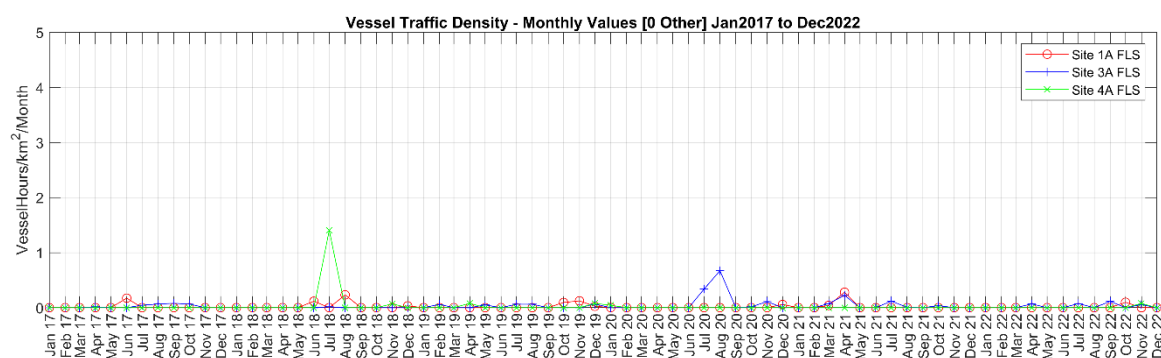


Figure B1. Other vessel types – monthly vessel traffic density (vessel hours in 1x1km cell per month), based on AIS data from January 2017 to December 2022.

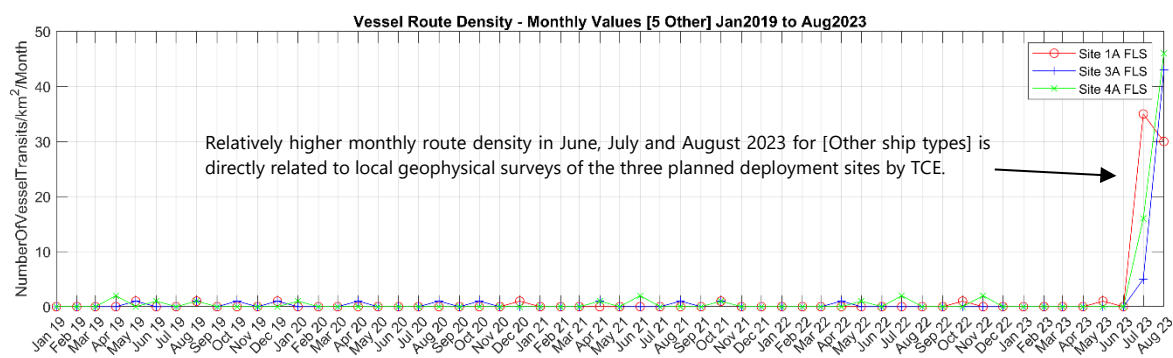


Figure B2. Other vessel types – monthly vessel route density (vessel transits crossing 1x1km cell per month), based on AIS data from January 2019 to August 2023.

B.2 Fishing

The following map figures are presented in Appendix A:

- Fishing vessel types – vessel traffic density – January 2022 (Figure A2);
- Fishing vessel types – vessel route density – January 2022 (Figure A16);
- Fishing vessel types – vessel route density – January 2023 (Figure A21);
- Fishing vessel types – vessel traffic density – August 2022 (Figure A25);
- Fishing vessel types – vessel route density – August 2022 (Figure A39); and
- Fishing vessel types – vessel route density – August 2023 (Figure A44).

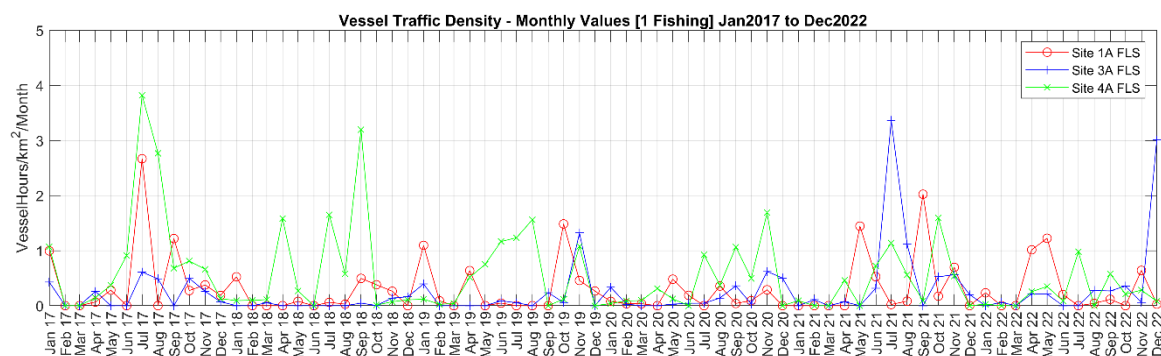


Figure B3. Fishing vessel types – monthly vessel traffic density (vessel hours in 1x1km cell per month), based on AIS data from January 2017 to December 2022.

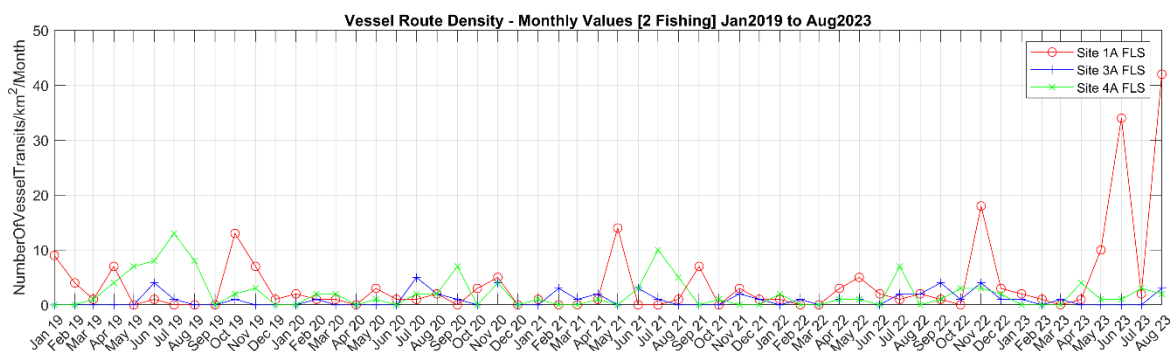


Figure B4. Fishing vessel types – monthly vessel route density (vessel transits crossing 1x1km cell per month), based on AIS data from January 2019 to August 2023.

B.3 Service craft

The following map figures are presented in Appendix A:

- Service craft vessel types – vessel traffic density – January 2022 (Figure A3); and
- Service craft vessel types – vessel traffic density – August 2022 (Figure A26).

(There are no separate vessel route density data maps available for this vessel category, however, these vessels are part of the 'All' (Section 3.2.1) and 'Other' (Section B.1) vessel type route density data).

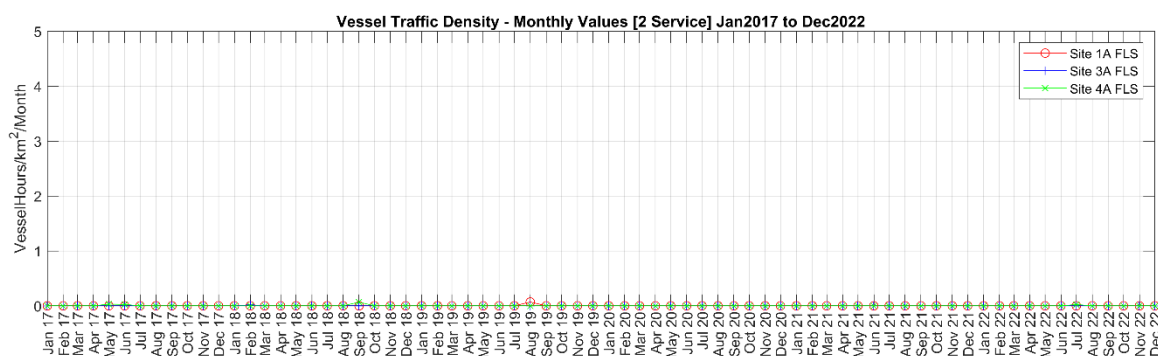


Figure B5. Service craft vessel types – monthly vessel traffic density (vessel hours in 1x1km cell per month), based on AIS data from January 2017 to December 2022.

B.4 Dredging or underwater operations

The following map figures are presented in Appendix A:

- Dredging or underwater operations vessel types – vessel traffic density – January 2022 (Figure A4); and
- Dredging or underwater operations vessel types – vessel traffic density – August 2022 (Figure A27).

(There are no separate vessel route density data maps available for this vessel category, however, these vessels are part of the 'All' (Section 3.2.1) and 'Other' (Section B.1) vessel type route density data).

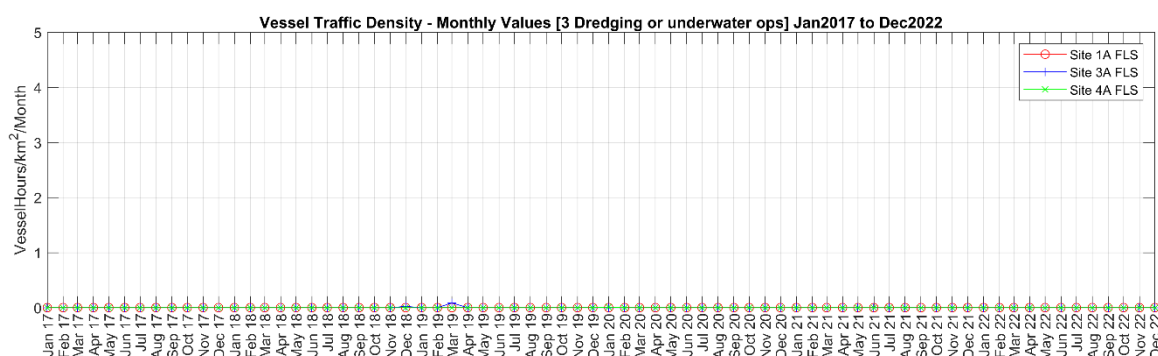


Figure B6. Dredging or underwater operations vessel types – monthly vessel traffic density (vessel hours in 1x1km cell per month), based on AIS data from January 2017 to December 2022.

B.5 Sailing

The following map figures are presented in Appendix A:

- Sailing vessel types – vessel traffic density – January 2022 (Figure A5); and
- Sailing vessel types – vessel traffic density – August 2022 (Figure A28).

(There are no separate vessel route density data maps available for this vessel category, however, these vessels are part of the 'All' (Section 3.2.1) and 'Other' (Section B.1) vessel type route density data).

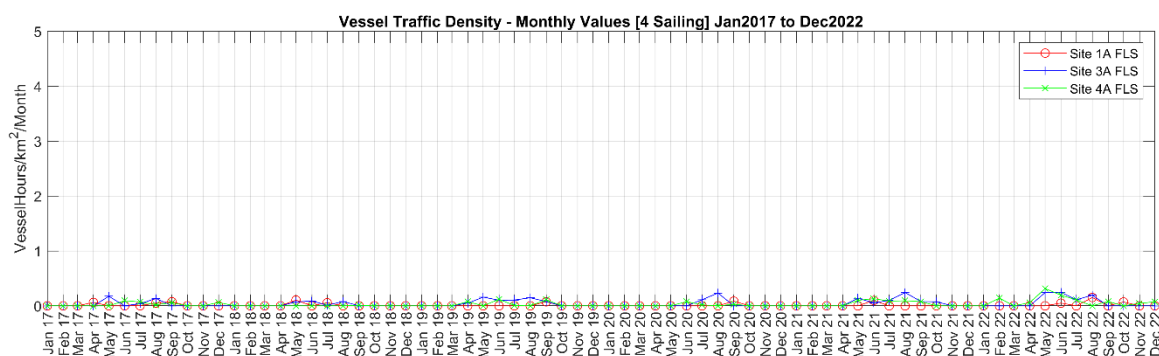


Figure B7. Sailing vessel types – monthly vessel traffic density (vessel hours in 1x1km cell per month), based on AIS data from January 2017 to December 2022.

B.6 Pleasure craft

The following map figures are presented in Appendix A:

- Pleasure craft vessel types – vessel traffic density – January 2022 (Figure A6); and
- Pleasure craft vessel types – vessel traffic density – August 2022 (Figure A29).

(There are no separate vessel route density data maps available for this vessel category, however, these vessels are part of the 'All' (Section 3.2.1) and 'Other' (Section B.1) vessel type route density data).

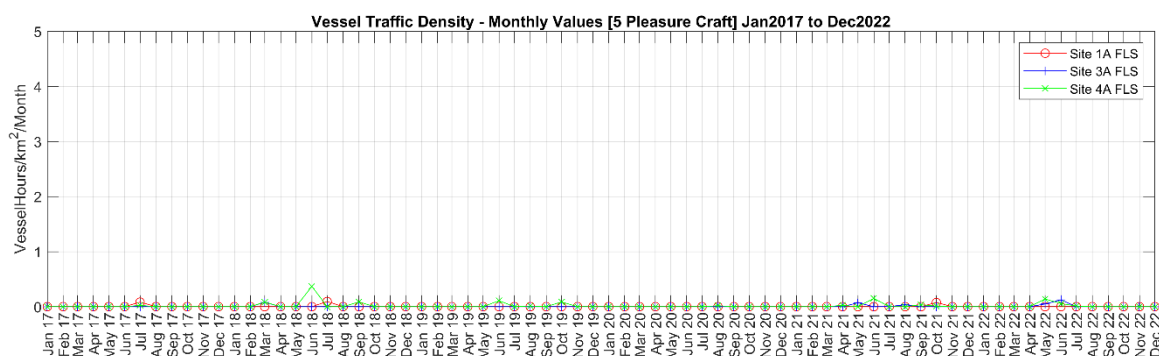


Figure B8. Pleasure craft vessel types – monthly vessel traffic density (vessel hours in 1x1km cell per month), based on AIS data from January 2017 to December 2022.

B.7 High speed craft

The following map figures are presented in Appendix A:

- High speed craft vessel types – vessel traffic density – January 2022 (Figure A7); and
- High speed craft vessel types – vessel traffic density – August 2022 (Figure A30) .

(There are no separate vessel route density data maps available for this vessel category, however, these vessels are part of the 'All' (Section 3.2.1) and 'Other' (Section B.1) vessel type route density data).

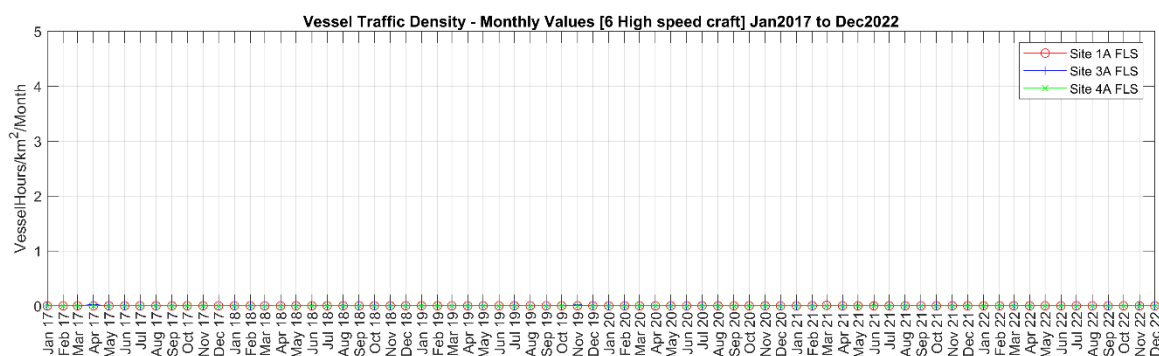


Figure B9. High speed craft vessel types – monthly vessel traffic density (vessel hours in 1x1km cell per month), based on AIS data from January 2017 to December 2022.

B.8 Tug and towing

The following map figures are presented in Appendix A:

- Tug and towing vessel types – vessel traffic density – January 2022 (Figure A8)
- Tug and towing vessel types – vessel traffic density – August 2022 (Figure A31)

(There are no separate vessel route density data maps available for this vessel category, however, these vessels are part of the 'All' (Section 3.2.1) and 'Other' (Section B.1) vessel type route density data).

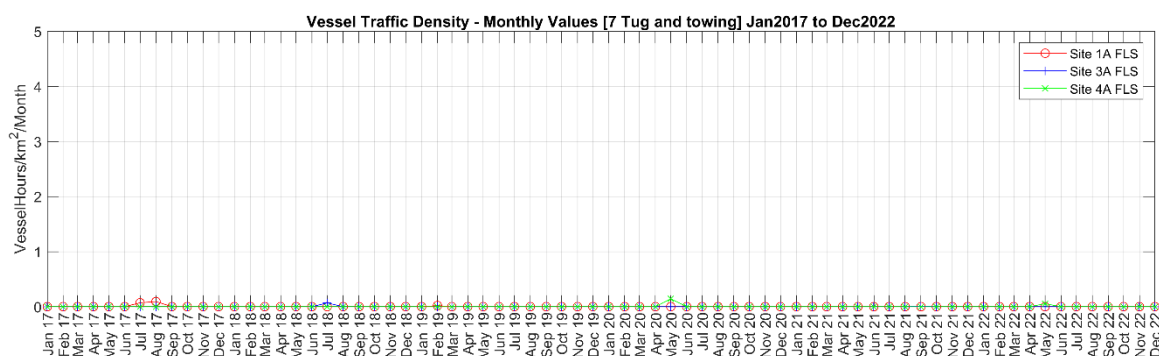


Figure B10. Tug and towing vessel types – monthly vessel traffic density (vessel hours in 1x1km cell per month), based on AIS data from January 2017 to December 2022.

B.9 Passenger

The following map figures are presented in Appendix A:

- Passenger vessel types – vessel traffic density – January 2022 (Figure A9)
- Passenger vessel types – vessel route density – January 2022 (Figure A17)
- Passenger vessel types – vessel route density – January 2023 (Figure A22)
- Passenger vessel types – vessel traffic density – August 2022 (Figure A32)
- Passenger vessel types – vessel route density – August 2022 (Figure A40)
- Passenger vessel types – vessel route density – August 2023 (Figure A45)

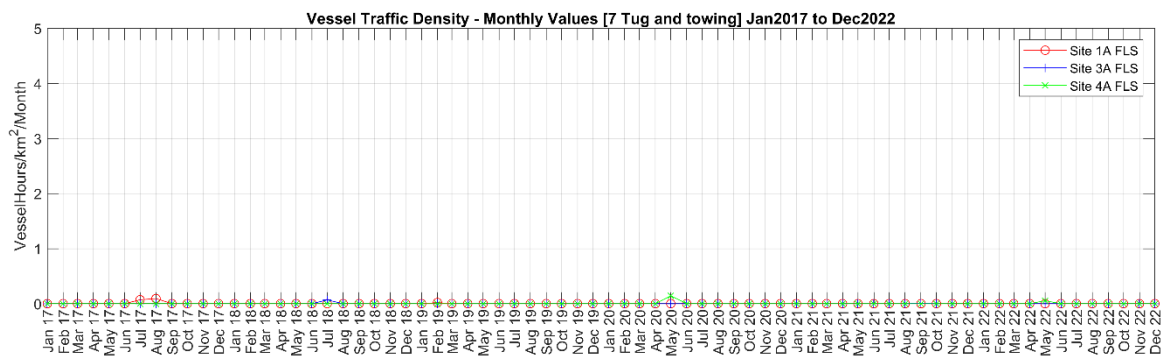


Figure B11. Passenger vessel types – monthly vessel traffic density (vessel hours in 1x1km cell per month), based on AIS data from January 2017 to December 2022.

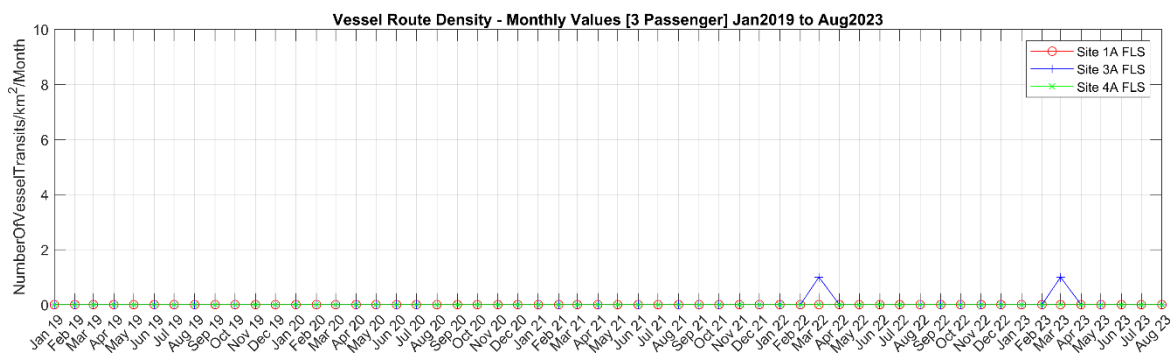


Figure B12. Passenger vessel types – monthly vessel route density (vessel transits crossing 1x1km cell per month), based on AIS data from January 2019 to August 2023.

B.10 Cargo vessels

The following map figures are presented in Appendix A:

- Cargo vessel types – vessel traffic density – January 2022 (Figure A10);
- Cargo vessel types – vessel route density – January 2022 (Figure A14);
- Cargo vessel types – vessel route density – January 2023 (Figure A19);
- Cargo vessel types – vessel traffic density – August 2022 (Figure A33);
- Cargo vessel types – vessel route density – August 2022 (Figure A37); and
- Cargo vessel types – vessel route density – August 2023 (Figure A42).

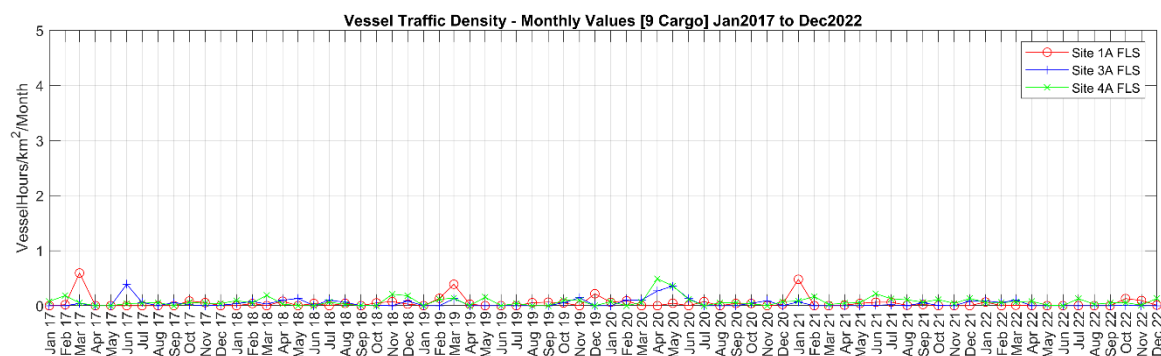


Figure B13. Cargo vessel types – monthly vessel traffic density (vessel hours in 1x1km cell per month), based on AIS data from January 2017 to December 2022.

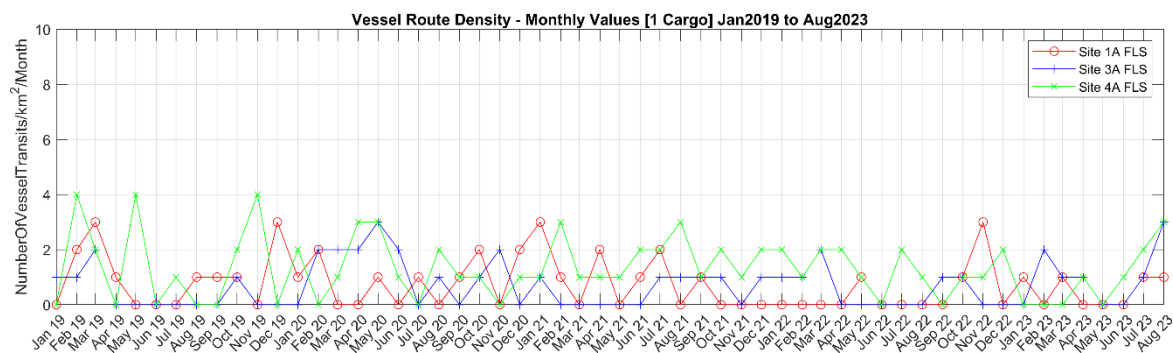


Figure B14. Cargo vessel types – monthly vessel route density (vessel transits crossing 1x1km cell per month), based on AIS data from January 2019 to August 2023.

B.11 Tankers

The following map figures are presented in Appendix A:

- Tanker vessel types – vessel traffic density – January 2022 (Figure A11);
- Tanker vessel types – vessel route density – January 2022 (Figure A15);
- Tanker vessel types – vessel route density – January 2023 (Figure A20);
- Tanker vessel types – vessel traffic density – August 2022 (Figure A34);
- Tanker vessel types – vessel route density – August 2022 (Figure A38); and
- Tanker vessel types – vessel route density – August 2023 (Figure A43).

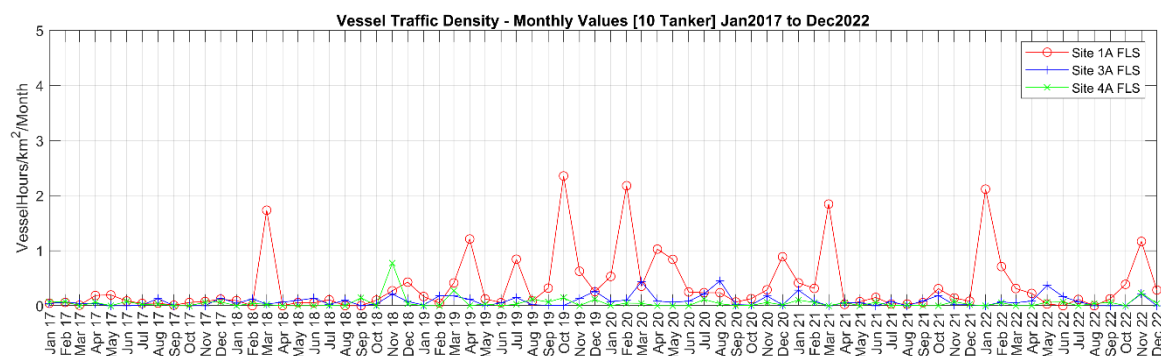


Figure B15. Tanker vessel types – monthly vessel traffic density (vessel hours in 1x1km cell per month), based on AIS data from January 2017 to December 2022.

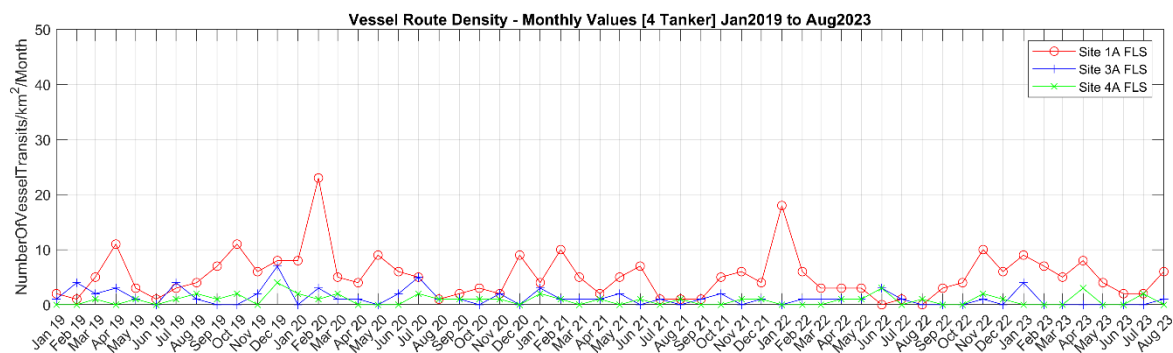


Figure B16. Tanker vessel types – monthly vessel route density (vessel transits crossing 1x1km cell per month), based on AIS data from January 2019 to August 2023.

B.12 Military or law enforcement vessels

The following map figures are presented in Appendix A:

- Military or law enforcement vessel types – vessel traffic density – January 2022 (Figure A12); and
- Military or law enforcement vessel types – vessel traffic density – August 2022 (Figure A35).

(There are no separate vessel route density data maps available for this vessel category, however, these vessels are part of the 'All' (Section 3.2.1) and 'Other' (Section B.1) vessel type route density data).

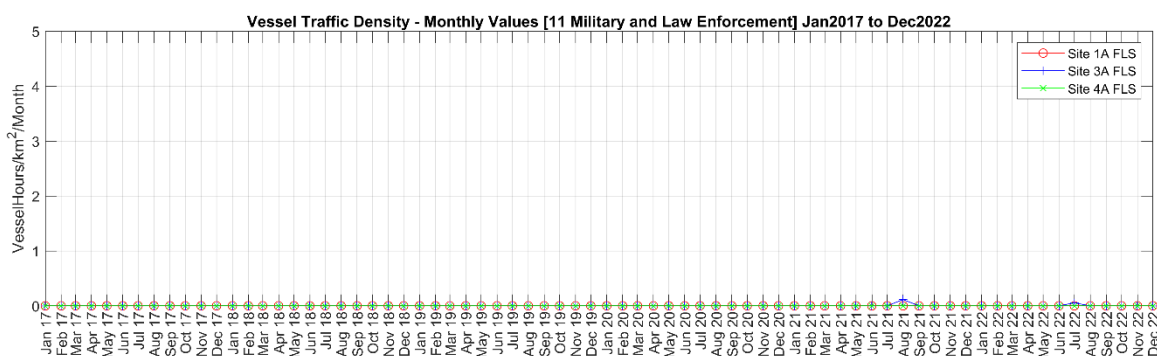


Figure B17. Military or law enforcement vessel types – monthly vessel traffic density (vessel hours in 1x1km cell per month), based on AIS data from January 2017 to December 2022.

B.13 Unknown craft

The following map figures are presented in Appendix A:

- Unknown vessel types – vessel traffic density – January 2022 (Figure A13); and
- Unknown vessel types – vessel traffic density – August 2022 (Figure A36).

(There are no separate vessel route density data maps available for this vessel category, however, these vessels are part of the 'All' (Section 3.2.1) and 'Other' (Section B.1) vessel type route density data).

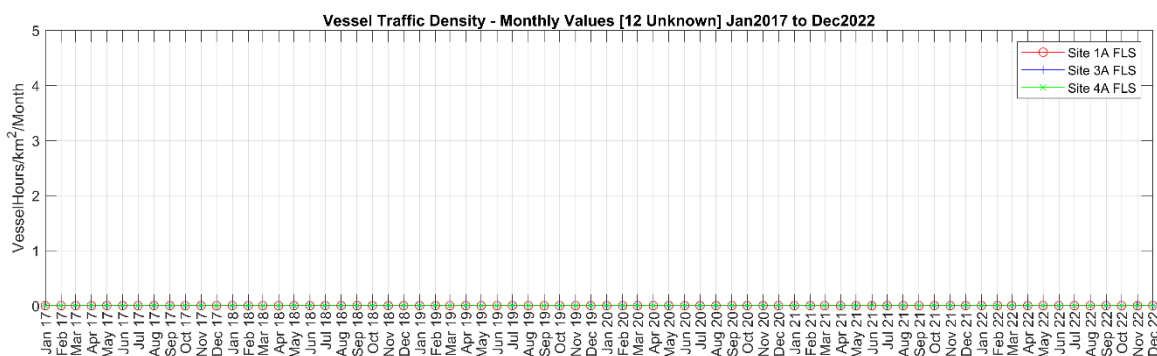


Figure B18. Unknown vessel types – monthly vessel traffic density (vessel hours in 1x1km cell per month), based on AIS data from January 2017 to December 2022.

C Hazard Scenario Risk Assessments

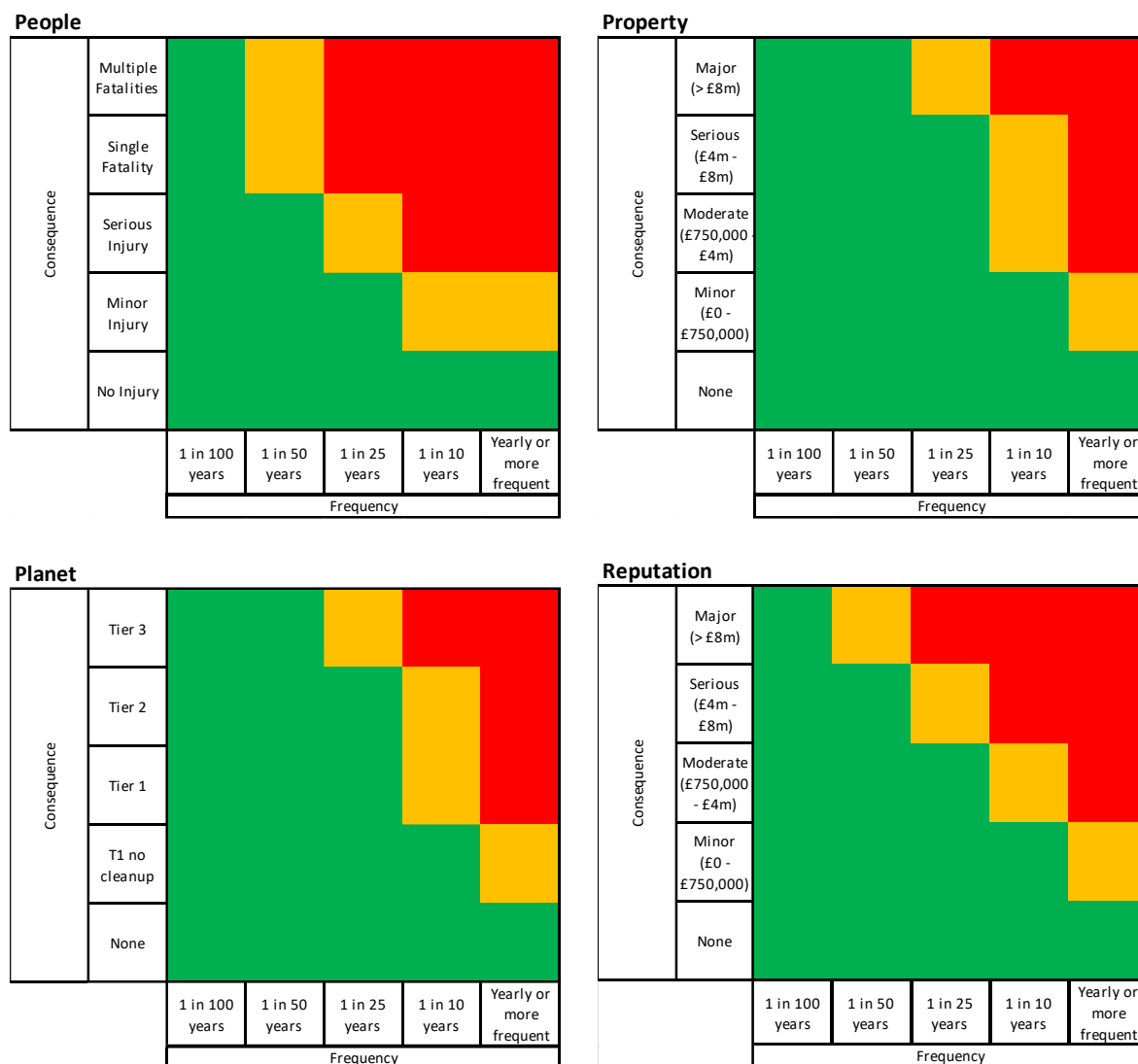


Figure C1. Hazard scenario risk assessment significance matrices

Table C1. Risk Assessment Hazard Scenario 1 – Recreation or fishing vessel collides with deployment / retrieval craft

Hazard Scenario Title		Deployment Collision Fishing Recreational		Risk Reference	*Ref	Hazard Category	*Cat		
Worst Credible Scenario		Most Likely Scenario		Causes	Control	Consequence Reduction	Likelihood Reduction	Completeness	Comment
Fishing / Recreational vessel collides with Deployment vessel whilst restricted in ability to maneuver. Fishing /Rec vessel sinks, multiple fatalities, pollution		Fishing / Recreational Vessel collides with Deployment vessel whilst restricted in ability to maneuver. Glancing blow Fishing /Rec vessel light damage, no injuries, no pollution		Inadequate vessel procedures	Emergency services (Third Party)	Medium	None	In Place	
				Human error /fatigue Fishing-Recreational	COLREGS 1972	None	Low	In Place	
				Restricted visibility	AIS RADAR coverage	None	Low	Future	
				Equipment failure	SOLAS	Low	Low	In Place	
				Communication failure	Passage planning	None	Low	In Place	
				N2M failure to observe	N2M	None	Medium	Future	
				Adverse weather conditions	Weather forecasting	Low	Medium	Future	
Embedded Worst Case Frequency	Embedded Worst Case Consequence		Embedded Most Likely Frequency	Embedded Most Likely Consequence					
1	People	4	3	People	0				
	Property	2		Property	1				
	Planet	1		Planet	0				
	Reputation	2		Reputation	1				
Risk Ranking	3.56	Tolerable	Tolerable	Tolerable	Tolerable				
Tolerability	Tolerable	Tolerable	Tolerable	Tolerable	Tolerable				

Table C2. Risk Assessment Hazard Scenario 2 – Commercial vessel collision with deployment / retrieval craft

Hazard Scenario Title		Deployment Collision Commercial Vessel		Risk Reference	*Ref	Hazard Category	*Cat		
Worst Credible Scenario		Most Likely Scenario		Causes	Control	Consequence Reduction	Likelihood Reduction	Completeness	Comment
Large Commercial vessel collides with Deployment vessel whilst restricted in ability to maneuver. Deployment vessel is sunk with multiple fatalities and moderate pollution.		Large Commercial vessel collides with Deployment vessel whilst restricted in ability to maneuver. Glancing blow, Deployment vessel is lightly damaged, no injuries and no pollution.		Inadequate vessel procedures	Emergency services (Third Party)	Medium	None	In Place	
				Human error /fatigue commercial	COLREGS 1972	None	Low	In Place	
				Restricted visibility	SOLAS	Low	Low	In Place	
				Equipment failure	Passage planning	None	Low	In Place	
				Communication failure	ISM	None	Low	In Place	
				N2M failure to observe	N2M	None	Low	Future	
				Vessel breakdown	Weather forecasting	None	Medium	Future	
Embedded Worst Case Frequency	Embedded Worst Case Consequence		Embedded Most Likely Frequency	Embedded Most Likely Consequence					
1	People	4	3	People	0				
	Property	3		Property	1				
	Planet	3		Planet	0				
	Reputation	3		Reputation	2				
Risk Ranking	4.13	Tolerable	Tolerable	Tolerable	Tolerable				
Tolerability	Tolerable	Tolerable	Tolerable	Tolerable	Tolerable				

Table C3. Risk Assessment Hazard Scenario 3 – Recreation or fishing vessel contact with LiDAR buoy

Hazard Scenario Title			Operational Contact Commercial LiDAR			Risk Reference	*Ref	Hazard Category	*Cat		
Worst Credible Scenario			Most Likely Scenario			Causes	Control	Consequence Reduction	Likelihood Reduction	Completeness	Comment
Commercial vessel makes heavy contact with LiDAR buoy. Light damage to Commercial vessel, LiDAR buoy sunk, no pollution, minor injury.			Commercial vessel makes glancing contact with LiDAR buoy. no damage to Commercial vessel, LiDAR buoy moderate damage, no pollution, no injury.			Adverse weather conditions	Emergency services equipment - third party	Low	None	In Place	
						Human error/fatigue - marine personnel	SOLAS	Low	Low	In Place	
						Vessel breakdown or malfunction	STCW	None	Low	In Place	
						Equipment failure - steering/propulsion	ISM Code – compliance with	None	Low	In Place	
						Restricted visibility	Passage planning	None	Medium	In Place	
						Reduction in safe navigable space	Availability of latest hydrographic information	None	Medium	Partial	
						Equipment failure - vessel navigation	Promulgation of information - / Navtex / safety broadcasts	None	Medium	Future	
Embedded Worst Case Frequency	Embedded Worst Case Consequence		Embedded Most Likely Frequency	Embedded Most Likely Consequence		Inadequate maintenance/inspection	Notices to mariners	None	Medium	Future	
						Human error/fatigue - commercial vessel	Contracted infrastructure periodic inspection / recovery	None	Medium	Future	
1	People	2	3	People	0	Failure of Aid to Navigation (out of position/unlit)	LIDAR buoy AIS transponders and Radar reflectors	None	Medium	Future	
	Property	2		Property	1		Trinity House approved lighting scheme	None	Low	Future	
	Planet	1		Planet	0		On station promulgation and onshore monitoring	None	Low	Future	
	Reputation	2		Reputation	1		Communications - UKHO	None	Low	Future	
Risk Ranking	2.94	Tolerable	Tolerable	Tolerable	Tolerable						
Tolerability	Tolerable	Tolerable	Tolerable	Tolerable	Tolerable						

Table C4. Risk Assessment Hazard Scenario 4 – Recreation or fishing vessel contact with wave buoy

Hazard Scenario Title			Operational Contact Recreation/ Fishing Wave Buoy			Risk Reference	*Ref	Hazard Category	*Cat		
Worst Credible Scenario			Most Likely Scenario			Causes	Control	Consequence Reduction	Likelihood Reduction	Completeness	Comment
Recreational / Fishing vessel makes heavy contact with wave buoy. Heavy damage to recreational / Fishing vessel, wave buoy sunk, no pollution, serious injury.			Recreational / Fishing vessel makes glancing contact with wave buoy. Light damage to recreational / Fishing vessel, wave buoy moderate damage, no pollution, no injury.			Adverse weather conditions	Emergency services equipment - third party	Low	None	In Place	
						Human error/fatigue - marine personnel	SOLAS	Low	Low	In Place	
						Vessel breakdown or malfunction	STCW	None	Low	In Place	
						Equipment failure - steering/propulsion	ISM Code – compliance with	None	Low	In Place	
						Restricted visibility	Passage planning	None	Medium	In Place	
						Reduction in safe navigable space	Availability of latest hydrographic information	None	Medium	Partial	
						Equipment failure - vessel navigation	Promulgation of information - / Navtex / safety broadcasts	None	Medium	Future	
Embedded Worst Case Frequency	Embedded Worst Case Consequence		Embedded Most Likely Frequency	Embedded Most Likely Consequence		Inadequate maintenance/inspection	Notices to mariners	None	Medium	Future	
						Human error/fatigue - commercial vessel	Contracted infrastructure periodic inspection / recovery	None	Medium	Future	
2	People	2	4	People	0	Failure of Aid to Navigation (out of position/unlit)	Trinity House approved lighting scheme	None	Low	Future	
	Property	2		Property	1		On station promulgation and onshore monitoring	None	Low	Future	
	Planet	0		Planet	0		Communications - UKHO	None	Low	Future	
	Reputation	2		Reputation	1						
Risk Ranking		3.63	Tolerable	Tolerable	Tolerable	Tolerable					
Tolerability		Tolerable	Tolerable	Tolerable	Tolerable	Tolerable					

Table C5. Risk Assessment Hazard Scenario 5 – Commercial vessel - contact with LiDAR buoy

Hazard Scenario Title			Operational Contact Commercial LiDAR				Risk Reference	*Ref	Hazard Category	*Cat		
Worst Credible Scenario			Most Likely Scenario				Causes	Control	Consequence Reduction	Likelihood Reduction	Completeness	Comment
Commercial vessel makes heavy contact with LiDAR buoy. Light damage to Commercial vessel, LiDAR buoy sunk, no pollution, minor injury.			Commercial vessel makes glancing contact with LiDAR buoy. No damage to Commercial vessel, LiDAR buoy moderate damage, no pollution, no injury.				Adverse weather conditions	Emergency services equipment - third party	Low	None	In Place	
							Human error/fatigue - marine personnel	SOLAS	Low	Low	In Place	
							Vessel breakdown or malfunction	STCW	None	Low	In Place	
							Equipment failure - steering/propulsion	ISM Code – compliance with	None	Low	In Place	
							Restricted visibility	Passage planning	None	Medium	In Place	
							Reduction in safe navigable space	Availability of latest hydrographic information	None	Medium	Partial	
							Equipment failure - vessel navigation	Promulgation of information- / Navtex / safety broadcasts	None	Medium	Future	
Embedded Worst Case Frequency	Embedded Worst Case Consequence		Embedded Most Likely Frequency	Embedded Most Likely Consequence		Inadequate maintenance/inspection	Notices to mariners	None	Medium	Future		
						Human error/fatigue - commercial vessel	Contracted infrastructure periodic inspection / recovery	None	Medium	Future		
1	People	1	3	People	0	Failure of Aid to Navigation (out of position/unlit)	LiDAR buoy AIS transponders and Radar reflectors	None	Medium	Future		
	Property	2		Property	1	Trinity House approved lighting scheme	None	Low	Future			
	Planet	1		Planet	0	On station promulgation and onshore monitoring	None	Low	Future			
	Reputation	2		Reputation	1	Communications - UKHO	None	Low	Future			
Risk Ranking	2.88	Tolerable	Tolerable	Tolerable	Tolerable							
Tolerability	Tolerable	Tolerable	Tolerable	Tolerable	Tolerable							

Table C6. Risk Assessment Hazard Scenario 6 – Commercial vessel - contact with wave buoy

Hazard Scenario Title			Operational Contact Commercial Wave Buoy			Risk Reference	*Ref	Hazard Category	*Cat		
Worst Credible Scenario			Most Likely Scenario			Causes	Control	Consequence Reduction	Likelihood Reduction	Completeness	Comment
Commercial vessel makes heavy contact with wave buoy. Superficial damage to Commercial vessel, wave buoy sunk, no pollution, no injury.			Commercial vessel makes heavy contact with wave buoy. Superficial damage to Commercial vessel, wave buoy light damage, no pollution, no injury.			Adverse weather conditions	Emergency services equipment - third party	Low	None	In Place	
						Human error/fatigue - marine personnel	SOLAS	Low	Low	In Place	
						Vessel breakdown or malfunction	STCW	None	Low	In Place	
						Equipment failure - steering/propulsion	ISM Code – compliance with	None	Low	In Place	
						Restricted visibility	Passage planning	None	Medium	In Place	
						Reduction in safe navigable space	Availability of latest hydrographic information	None	Medium	Partial	
						Equipment failure - vessel navigation	Promulgation of information- / Navtex / safety broadcasts	None	Medium	Future	
Embedded Worst Case Frequency	Embedded Worst Case Consequence		Embedded Most Likely Frequency	Embedded Most Likely Consequence		Inadequate maintenance/inspection	Notices to mariners	None	Medium	Future	
						Human error/fatigue - commercial vessel	Contracted infrastructure periodic inspection / recovery	None	Medium	Future	
3	People	0	4	People	0	Failure of Aid to Navigation (out of position/unlit)	Trinity House approved lighting scheme	None	Low	Future	
	Property	2		Property	1	On station promulgation and onshore monitoring	None	Low	Future		
	Planet	0		Planet	0	Communications - UKHO	None	Low	Future		
	Reputation	1		Reputation	1						
Risk Ranking		3.69	Tolerable	Tolerable	Tolerable	Tolerable					
Tolerability		Tolerable	Tolerable	Tolerable	Tolerable	Tolerable					

Table C7. Risk Assessment Hazard Scenario 7 – Fishing vessel snags trawl gear on unmarked sub-surface buoy 5m from seabed in 70m water depth

Hazard Scenario Title			Other Fishing vessel snags gear on wave profiler			Risk Reference	*Ref	Hazard Category	*Cat		
Worst Credible Scenario			Most Likely Scenario			Causes	Control	Consequence Reduction	Likelihood Reduction	Completeness	Comment
Trawler snags sub-surface buoy (5m from sea bed), sinker is snagged and stops trawler. Crew have to cut away trawl gear in poor weather. Crew member lost overboard and not recovered.			Trawler snags sub-surface buoy (5m from sea bed). Trawler does not notice. Vessels fishing gear is damaged, sub-surface buoy damaged beyond repair, no pollution, no injuries.			Adverse weather conditions	Emergency services (Third Party)	Low	None	In Place	
						Human error (Fishing Vessel)	SOLAS	Medium	None	In Place	
						Equipment failure (vessel)	Vessel maintenance	None	Low	In Place	
						Navigation					
						Failure of Aid - out of position	Passage planning	None	Medium	In Place	
							Latest hydrographic information	None	Medium	Partial	
							Promulgation of information - / Navtex / safety broadcasts	None	Medium	Future	
Embedded Worst Case Frequency			Embedded Worst Case Consequence			Embedded Most Likely Frequency			Embedded Most Likely Consequence		
1	People	3	2	People	0						
	Property	1		Property	1						
	Planet	1		Planet	1						
	Reputation	2		Reputation	2						
Risk Ranking			3.31			Tolerable			Tolerable		
Tolerability			Tolerable			Tolerable			Tolerable		

Table C8. Risk Assessment Hazard Scenario 8 – Failure of LiDAR mooring – navigational hazard

Hazard Scenario Title			Other Operational Failure of LiDAR Mooring			Risk Reference	*Ref	Hazard Category	*Cat		
Worst Credible Scenario			Most Likely Scenario			Causes	Control	Consequence Reduction	Likelihood Reduction	Completeness	Comment
LiDAR mooring fails - LiDAR Buoy drifts into heavy traffic area. Recreational craft makes heavy contact, sinks, multiple loss of life, minor pollution.			LiDAR Mooring fails - LiDAR Buoy drifts into heavy traffic area. Commercial craft makes heavy contact, Minor damage to Commercial craft, LiDAR sinks, minor injury.			Adverse weather conditions	Emergency services equipment - third party	Low	None	In Place	
						Human error/fatigue - marine personnel	SOLAS	Low	Low	In Place	
						Vessel breakdown or malfunction	STCW	None	Low	In Place	
						Equipment failure - steering/propulsion	ISM Code - compliance with	None	Low	In Place	
						Restricted visibility	Promulgation of information - / Navtex / safety broadcasts	None	Low	Future	
						Inadequate maintenance/inspection	Contracted infrastructure periodic inspection / recovery	None	Medium	Future	
						Failure of Aid to Navigation (out of position/unlit)	LiDAR buoy AIS transponders and Radar reflectors	None	Medium	Future	
Embedded Worst Case Frequency			Embedded Worst Case Consequence			Embedded Most Likely Frequency			Embedded Most Likely Consequence		
1	People	4	2	People	1						
	Property	1		Property	1						
	Planet	1		Planet	1						
	Reputation	2		Business Continuity	1						
Risk Ranking			3.50			Tolerable			Tolerable		
Tolerability			Tolerable			Tolerable			Tolerable		

Table C9. Risk Assessment Hazard Scenario 9 – Failure of wave buoy mooring – navigational hazard

Hazard Scenario Title			Other Operational Failure of Wave Buoy Mooring			Risk Reference	*Ref	Hazard Category	*Cat		
Worst Credible Scenario			Most Likely Scenario			Causes	Control	Consequence Reduction	Likelihood Reduction	Completeness	Comment
Wave buoy mooring fails. Wave buoy drifts into heavy traffic area. Recreational craft makes heavy contact, Moderate Damage to vessel and wave buoy, serious injury, no pollution.			Wave buoy mooring fails. Wave buoy drifts into heavy traffic area. Commercial craft makes heavy contact, Minor Damage to vessel and wave buoy, no injury, no pollution.			Adverse weather conditions	Emergency services equipment - third party	Low	None	In Place	
						Human error/fatigue - marine personnel	SOLAS	Low	Low	In Place	
						Vessel breakdown or malfunction	STCW	None	Low	In Place	
						Equipment failure - steering/propulsion	ISM Code – compliance with	None	Low	In Place	
						Restricted visibility	Promulgation of information - / Navtex / safety broadcasts	None	Low	Future	
						Inadequate maintenance/inspection	Contracted infrastructure periodic inspection / recovery	None	Medium	Future	
						Failure of mooring systems	Trinity House approved lighting scheme	None	Low	Future	
Embedded Worst Case Frequency		Embedded Worst Case Consequence		Embedded Most Likely Frequency		Embedded Most Likely Consequence		On station promulgation and onshore monitoring	None	Medium	Future
								Communications - UKHO	None	Low	Future
2		People 2 Property 1 Planet 1 Reputation 2		3		People 0 Property 1 Planet 1 Reputation 1					
Risk Ranking		3.63		Tolerable		Tolerable					
Tolerability		Tolerable		Tolerable		Tolerable					

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