



Marine
Management
Organisation

Landings Enriched Approach to Positional FISHerries data (LEAPFISH)

Methodology and Quality Statement



...ambitious for our seas and coasts



Marine
Management
Organisation

LANDINGS ENRICHED APPROACH TO POSITIONAL FISHERIES DATA (LEAPFISH) METHODOLOGY AND QUALITY STATEMENT

Responsible Statistician Rebekah Paul

Editors James Pilkington
Beth Little
Sarah Laird
Callum Etridge
Bob Elliott
Matthew Hoppe
Nathan Barclay
Erika Neave

Date published: 7 October 2026

Contents

1. Background	5
1.1 Purpose	5
1.2 How these statistics were produced	6
1.3 How to interpret and use these statistics	7
1.4 Definitions and concepts	9
2. Data Sources	10
2.1 Overview of data inputs	10
2.1.1 Landings data	10
2.1.2 VMS data	10
2.1.3 Spatial data layers	11
3. Data Processing	12
3.1 Data cleaning	12
3.1.1 Landings data cleaning	12
3.1.2 VMS data cleaning	12
3.1.3 Assumptions and limitations	12
3.1.4 Quality assurance	13
3.2 Data enrichment	13
3.2.1 Spatial enrichment	13
3.2.2 Linking trip identifier to VMS records	13
3.2.3 Assignment of fishing gear to VMS records	14
3.2.4 Assumptions and limitations	14
3.2.5 Quality assurance	15
4. Estimation Methodology	16
4.1 Overview of estimation approach	16
4.2 Fishing-speed models	16
4.2.1 Overview	16
4.2.2 Preparing data for modelling	17
4.2.3 Modelling approach	17
4.2.4 All gears fishing speed model	17
4.2.5 Gear-specific fishing speed models	18
4.2.6 Producing fishing speed thresholds	18
4.2.7 Assumptions and limitations	20
4.2.8 Sensitivity and method assessment	20
4.2.9 Quality assurance	21

4.3	Classification of fishing activity state	21
4.3.1	Overview	21
4.3.2	Rule base classification	21
4.3.3	Assumptions and limitations	22
4.3.4	Sensitivity and method assessment	23
4.3.5	Quality assurance.....	24
4.4	Spatial allocation of landings to VMS positions	24
4.4.1	Calculation of ping effort.....	24
4.4.2	Preparation of landings data.....	24
4.4.3	Joining landings to VMS positions	25
4.4.4	Apportionment of landings across fishing positions	25
4.4.5	Matched and unmatched data	25
4.4.6	Assumptions and limitations	26
4.4.7	Sensitivity and method assessment	27
4.4.8	Quality assurance.....	28
5.	Outputs	29
5.1	Overview of outputs	29
5.2	Tabular dataset	29
5.3	Spatial data layer	29
6.	Revisions Policy.....	30
7.	Disclosure Control	31
8.	Statement of Quality.....	32
8.1	Statistical quality	32
8.2	Relevance	32
8.3	Accuracy and reliability.....	33
8.4	Timeliness and punctuality	37
8.5	Comparability and coherence.....	37
8.6	Accessibility and clarity	38
9.	Annex A: Published dataset field definitions	40
10.	Annex B: Fishing-speed model outputs.....	42

1. Background

1.1 Purpose

This document sets out the methodology used to produce the Landings Enriched Approach to Positional Fisheries Data (LEAPFISH) datasets. It also details the quality assessment of this new release.

LEAPFISH combines landings data with Vessel Monitoring System (VMS) data. It covers UK and Crown Dependency vessels¹ 12 metres and over. It provides estimates of fishing activity at 0.05° c-square resolution. This provides more spatial detail than available in other regular MMO releases.

LEAPFISH was developed to meet a growing need for detailed information on where fishing takes place. This information can support fisheries management and marine planning. Examples include Marine Protected Areas and offshore wind development. The MMO stopped its previous VMS outputs after parts of the methodology were identified for review. The [ad hoc VMS publication](#)², published in 2024, highlighted the need for a regular release of VMS data. It also further demonstrated the need for a clear, published processing methodology.

This document forms part of the wider LEAPFISH statistical release. The release includes:

- **Statistical summary** - headline summary and key results. Available [here](#).
- **Methodology and quality statement** - how the statistics were produced and information about their quality and limitations.
- **Tabular dataset** - the statistics in a downloadable spreadsheet. Available [here](#).
- **Spatial data layers** - the statistics as spatial data at 0.05° c-square resolution. These will be available on Defra Data Services platform shortly after the LEAPFISH 2024 statistical release.

Detailed information about the accompanying data and its structure is provided in [Section 5: Outputs](#) and [Annex A](#).

Why these statistics are being published

LEAPFISH provides regularly published, spatially detailed data on fishing activity. It builds on existing landings statistics and previous MMO releases of VMS data. The extra spatial detail supports better spatial understanding of activity where ICES rectangle-level data are too broad.

The 2024 statistics bring together:

- Landings data published through [UK Sea Fisheries Statistics \(SFS\) 2024](#)³
- VMS data for UK and Crown Dependency vessels 12 metres and over

¹ Includes Isle of Man vessels, and vessels registered in Jersey and Guernsey when fishing English quota.

² [Ad-hoc Statistical Release of Vessel Monitoring System \(VMS\) and Landings data, UK & Crown dependency 12 meter and over vessels, 2020-2022 - GOV.UK](#)

³ <https://www.gov.uk/government/statistics/uk-sea-fisheries-annual-statistics-report-2024>

Official Statistics in Development

These statistics are published as [Official Statistics in Development](#)⁴. This means that:

- The statistics are still being developed. Methods, data sources and outputs may change.
- Users should consider the limitations in this document before using the statistics.
- Publishing at this stage supports transparency. User feedback will help improve future releases.
- The 2024 data are the first version of LEAPFISH. The methodology will be reviewed and improved in future releases.

We welcome your feedback on these statistics, including the methodology, accompanying data and suggestions for future development. Please share your feedback: [LEAPFISH 2024 Feedback Survey](#).

1.2 How these statistics were produced

LEAPFISH combines fisheries landings data with vessel tracking (VMS) data. This is done to estimate where fishing activity has taken place. VMS data are cleaned and have spatial and gear information added. VMS positions are labelled as either fishing or steaming. Landings data are cleaned and then are matched to VMS positions. Landings are matched using a combination of vessel, trip, date, and location. The weight and value of landings is shared across all matching VMS pings. The landings and effort data are summarised and identifying information is removed before publication.

Input data

VMS data comes from fisheries databases, where it is matched to vessel registry information. Landings data come from our Annual UK Sea Fisheries Statistics (SFS). This is the best available source for landings data. For more details on input data, see Chapter 2 [Data Sources](#), pages 10 to 11.

Cleaning the data

Data are checked and cleaned before processing. This ensures that the input datasets are accurate and trustworthy. Duplicates and data errors such as invalid coordinates, course and speed are removed from the VMS dataset. Overlapping trips and trips that fall within another trip are identified and removed from landings data. For more details, see Chapter 3.1 [Data cleaning](#), pages 12 to 13.

Adding information to the data

Spatial information and gear information is added to the VMS data. These steps allow fishing activity to be identified across different areas and by different gears. This includes details such as whether the position is on land or in harbour. It also includes whether the position is within UK waters. The trip reference number from logbook data is joined to VMS data using vessel identifier and date/time to allow other logbook information to be joined at later stages.

Gear and mesh are matched from logbooks, first directly using trip identifier and activity date, then using vessel and activity date. Where multiple gear-mesh combinations occur, the combination with the greatest live weight is selected. For unmatched records, the dominant gear and mesh are assigned from the trip and then vessel. Dominance is determined by the number of fishing days and secondarily by live weight. Where

⁴ <https://osr.statisticsauthority.gov.uk/who-we-are/policies/official-statistics-policies/official-statistics-in-development/>

no logbook match is available, gear is assigned from UK licence data (without mesh size). For more details, see Chapter 3.2 [Data enrichment](#), pages 13 to 15.

Determining fishing speed limits

Different types of fishing gear are typically used at different vessel speeds. LEAPFISH analyses vessel speed data for each gear and uses statistical models to estimate the speeds most likely to represent fishing activity. These gear-specific speed ranges are then used to help identify fishing positions. For more details, see Chapter 4.2 [Fishing-speed models](#), pages 16 to 21.

Identifying fishing positions

Not all VMS positions represent fishing activity. Some positions may represent vessels travelling (steaming), in harbour, or on land. LEAPFISH classifies each VMS position as either fishing or non-fishing activity. This is based on fishing speed thresholds, trip records, and location. This helps ensure that landings are only linked to positions where fishing is likely to have taken place. For more details, see Chapter 4.3 [Classification of fishing activity state](#), pages 21 to 24.

Allocating landings to fishing positions

Landings data are linked to VMS fishing positions using a hierarchical matching process. First, landings are matched using the vessel, trip, activity date, ICES rectangle, and Exclusive Economic Zone (EEZ). This represents the most detailed and highest confidence match. Where an exact match cannot be found, a series of fallback matching rules are applied. The matching requirements are gradually relaxed, with ICES rectangle removed first, followed by EEZ, date, and then trip. Before the final stage of matching on vessel alone, a match on vessel and date is included to account for landings with missing trip identifiers. Once matched, the weight and value of landings are shared across the linked fishing positions. Positions representing a greater amount of fishing effort receive a larger share of the landings. Fishing effort is the time represented by each fishing ping. This helps ensure that landings are linked to the most likely fishing locations in a proportional manner. For more details, see Chapter 4.4 [Spatial allocation of landings to VMS positions](#), pages 24 to 28.

Producing the datasets

The landings live weight, value and fishing effort are summarised into standard spatial grid cells and grouped by gear type. Information that could identify individual vessels or organisations is removed to avoid disclosing sensitive information. For more details, see Chapter 5 [Outputs](#), page 29.

1.3 How to interpret and use these statistics

LEAPFISH provides estimates of fishing activity and associated landings for UK and Crown Dependency vessels 12 metres and over. The estimates should be used whilst considering the limitations set out below.

These statistics are appropriate for:

- Analysing where fishing activity occurs and how it varies by area and gear
- Fisheries management, marine planning and analysis of interactions with other marine uses
- Comparing spatial patterns in UK 12m+ fishing activity

What you should understand about the approach

This approach estimates where fishing takes place and allocates landings to that activity. Users should consider the following:

1. **Fishing activity is estimated from VMS positions.** Positions classified as fishing are used to estimate activity within each c-square, but do not confirm fishing at that exact location or time.
2. **Fishing classification contains uncertainty.** LEAPFISH uses speed, location and reported activity information to classify VMS positions as fishing or non-fishing. Positions with missing, zero or low speeds can still be classified as fishing where other classification rules are met. Fishing can occur above the modelled fishing-speed threshold, while low-speed activities such as drifting, waiting or sheltering can be misclassified as fishing. VMS positions are required to be reported at two-hour intervals, so shorter fishing operations between positions may not be captured.
3. **Fishing effort is estimated from positions classified as fishing.** Fishing effort only includes positions classified as fishing, while time spent at sea includes both fishing and non-fishing activity. Fishing effort is still counted where no landings are allocated. For static gears, vessel time does not capture other aspects of fishing effort, such as the amount of gear deployed or how long the gear remains in the water.
4. **Landings are allocated to fishing positions based on time.** Landings are shared across matched positions in proportion to fishing time, although catches may in practice be concentrated in particular hauls or locations.
5. **Uncertainty in landings allocation varies by matching stage.** Later matching stages use less trip, date or location information and generally have more uncertainty. Where no matching fishing positions are found, landings may be allocated using less detailed information. As a result, LEAPFISH figures may not exactly match reported landings, including those in SFS statistics.
6. **Reported ICES rectangles can affect where landings are allocated.** Vessels are only required to record the ICES rectangle where the majority of catch was taken that day. This can concentrate matched landings in one rectangle even where fishing occurred across several.
7. **LEAPFISH does not cover the whole fishing fleet.** It covers UK and Crown Dependency vessels 12 metres and over, not under-12 metre or non-UK vessels.

The sensitivity assessments in this methodology show where these uncertainties may have the greatest effect on the results.

These statistics are not appropriate for:

- Treating allocated weight, value or effort as direct evidence of fishing at a specific location
- Determining where or when an individual vessel was fishing or assessing individual vessels or skippers
- Enforcement or compliance purposes
- Estimating activity for the under-12 metre or non-UK fleet

1.4 Definitions and concepts

Fishing trip: a voyage that starts when a fishing vessel leaves port and ends when the vessel returns to port. 'Trip' and 'voyage' are used interchangeably.

Logbook: a paper or electronic record of fishing activity, including what was caught, how it was caught and where.

Landing: fish or shellfish caught and brought ashore. LEAPFISH reports landings by weight and value.

Live weight: the estimated weight of fish or shellfish when caught, before any processing at sea. It is calculated from landed weight using standard conversion factors. This is the default weight measure.

Landed weight: the weight of fish or shellfish when landed. It may be lower than live weight where catch is processed at sea.

Sales note: a record of the first sale of commercially caught fish or shellfish.

Landed value: the value of fish or shellfish at first sale, in pounds sterling (£). Values are not adjusted for inflation or exchange rates.

VMS position or ping: a vessel position reported through a Vessel Monitoring System (VMS) device, with information including location, date and time.

Steaming: when a vessel is travelling rather than fishing, for example, from port to fishing grounds.

Time spent at sea⁵: the estimated time a vessel spends at sea, including both fishing and non-fishing activity. Measured in hours. Sometimes referred to as 'vessel presence'.

Fishing effort: the estimated time a vessel spends fishing, measured in hours. It is calculated from VMS positions classified as fishing and is counted whether or not landings are allocated.

ICES rectangle: an area measuring 1° longitude by 0.5° latitude used to report fisheries data.

FAO division: a defined area within an FAO major fishing area used to report fisheries data.

C-square: a standard geographic grid used to report spatial data. LEAPFISH uses c-squares at 0.05° × 0.05° resolution.

Exclusive Economic Zone (EEZ): a maritime area within which a coastal state has rights over natural resources, including fisheries.

⁵ Time spent at sea differs from the 'days at sea' effort measure in UK sea fisheries annual statistics. Days at sea covers over-10-metre vessels and uses logbook trip timings. Time spent at sea covers vessels 12m+ and is derived from VMS positions after leaving and before returning to harbour. The figures are therefore not directly comparable.

2. Data Sources

2.1 Overview of data inputs

LEAPFISH combines information on vessel movements, fishing activity and landings from several fisheries datasets. The main data inputs are:

- VMS data, providing vessel positions and movement information.
- Landings and logbook data, providing information on trips, landings, fishing gear, fishing areas and species.
- Vessel register data, providing vessel characteristics.
- Reference and spatial data, providing geographic boundaries and fisheries reporting areas.

The datasets are linked using vessel and trip information. Together, they allow fishing activity and landings to be allocated spatially. The following sections describe each data source in more detail.

2.1.1 Landings data

Landings data record the fish landed by commercial fishing vessels, including the species, weight and value of the catch. They are based on administrative data collected through logbooks, landings declarations and sales notes. These data are used to produce annual UK SFS. Further information on how the data are collected and processed is available [here](#)⁶.

LEAPFISH uses the underlying 2024 UK SFS dataset, with additional voyage information added. Key variables include species, live weight, landed weight, value, gear, mesh size and vessel identifier. Further information on the source data and methodology is provided in Annex B of the [UK SFS report 2024](#)^{Error!}
Bookmark not defined.

In the UK, the Record Your Catch App (also known as Catch App or Catch Recording) is required for English and Welsh commercial fishing vessels under 10m in length that fish in UK waters. This data is not used within LEAPFISH because this approach only covers vessels that are transmitting VMS and are 12 metres and over in length.

2.1.2 VMS data

Vessel Monitoring System (VMS) data provide information on the location and movement of commercial fishing vessels. Each position report, or 'ping', records the vessel's location at a point in time, along with information such as speed, course and timestamp.

UK commercial fishing vessels of 12 metres and over are required to transmit VMS positions at least every two hours. Some vessels report more frequently. Further information on VMS requirements is available on [GOV.UK](#)⁷ website.

⁶ <https://www.gov.uk/guidance/fishing-activity-and-landings-data-collection-and-processing>

⁷ <https://www.gov.uk/government/publications/vessel-monitoring-system-devices/device-requirements>

In the UK, VMS requirements apply to commercial fishing vessels measuring 12 metres overall length and above. Some vessels under 12 metres may also transmit VMS positional information, but these vessels are not included in LEAPFISH.

For LEAPFISH, VMS data are linked to vessel information and filtered to UK and Crown Dependency vessels of 12 metres and over during 2024. The data include vessel identifiers, location, timestamp, speed and course. Spatial information, including ICES rectangle, is also added during processing. Further information on cleaning and processing is provided in Section 3.1.2.

LEAPFISH 2024 does not include Inshore Vessel Monitoring System (I-VMS) data or fishing activity by vessels under 12 metres. Further information on I-VMS is available from the [MMO guidance](#)⁸.

2.1.3 Spatial data layers

Spatial layers are used to identify VMS positions in relation to land, ports and fisheries boundaries. All spatial layers are standardised to the same coordinate reference system (ETRS89-extended / LAEA Europe).

Coastline

The coastline layer combines [Ordnance Survey](#)⁹ data for Great Britain with 1m resolution [Eurostat](#)¹⁰ data for the rest of the world. It is used to identify VMS positions located on land.

Ports

Port locations for the UK, Crown Dependencies and Europe are used to identify positions associated with ports and harbours. A 3 km buffer is applied around each port. Further information on the published port layer will be made available on Defra Data Services Platform shortly after the statistics release.

UK Exclusive Economic Zone (EEZ)

[UK Hydrographic Office data](#)¹¹ are used to identify positions within UK waters. The layer includes Isle of Man waters but not Guernsey or Jersey waters. The implications of this are described in Section 3.2.4.

⁸ <https://www.gov.uk/guidance/inshore-vessel-monitoring-system-i-vms-devices-for-under-12-metre-fishing-vessels-registered-in-england>

⁹ <https://www.ordnancesurvey.co.uk/products/boundary-line>

¹⁰ © EuroGeographics <https://ec.europa.eu/eurostat/web/gisco/geodata/administrative-units/countries>

¹¹ [UK Hydrographic Office Maritime Limits and Boundaries | ADMIRALTY Marine Data Portal](#)

3. Data Processing

3.1 Data cleaning

3.1.1 Landings data cleaning

Landings data are cleaned and standardised to produce a dataset suitable for subsequent gear, mesh size and landings to VMS linkage analyses.

The landings dataset is filtered to UK fishing vessels, including Crown Dependencies (CD), that are 12 metres in length or greater. The dataset is then filtered to remove voyages that occurred entirely outside of the timeseries. Records where the return datetime occurred before the departure datetime are considered errors and removed.

Nested voyages (where one voyage is fully contained within another voyage) are removed. Where voyage periods overlap in time, overlap groups are identified within each vessel and the voyage with the highest live weight tonnage landed is retained.

3.1.2 VMS data cleaning

VMS data are filtered to UK and CD vessels that are 12 metres in length or greater. A set of cleaning steps are then applied to VMS data.

Records with identical vessel identifier (RSS number) and timestamp are considered duplicates and are removed. Small ping intervals are defined as a record occurring less than 3 minutes since the previous ping for each vessel; these are considered pseudo-duplicates and removed. During the cleaning phase, the ping interval is the time in minutes between a ping and the previous ping for each vessel.

Erroneous pings are removed. This includes records with missing coordinates, latitude less than -90 or more than 90, or longitude less than -180 or more than 180. Also removed are records with impossible course/heading (less than 0 or more than 360), speeds less than 0 knots or more than 30 knots (high speed anomalies).

Pings with missing speed and/or course are inconsistent with standard VMS position reports and may represent non-positional transmissions (e.g. system or diagnostic messages) or data quality issues. These records retained for this analysis but will be reviewed further in future releases.

After data cleaning, 4,483,322 VMS records remain in the 2024 data.

3.1.3 Assumptions and limitations

Landings data come from UK SFS, so the assumptions and limitations of those source data also apply to LEAPFISH. See [UK Sea Fisheries Annual Statistics Report 2024](#) for more information.

It is assumed that overlapping or nested voyage records are duplicates or errors that can be removed. For overlapping voyages, the voyage with the greatest tonnage is retained. Where voyage times are missing, the start and end of the day are used, which increases uncertainty.

VMS cleaning removes duplicate and potentially invalid records. Records with the same vessel identifier and timestamp are treated as duplicates. Positions less than three minutes apart and speeds above 30 knots are also removed and assumed to be incorrect.

Data cleaning processes may remove a small number of valid VMS records. Errors in position, speed, course, vessel or voyage information may also remain. Missing speed and course pings are retained.

3.1.4 Quality assurance

Landings data are sourced from the annual UK SFS series. Details of the methodology and quality assurance procedures used in producing the dataset are available in the latest [UK Sea Fisheries Annual Statistics Report 2024](#)^{Error! Bookmark not defined.}.

During VMS data cleaning, missing data are explored to ensure that crucial fields do not have substantial amounts of missing data. Histograms of speed and course are inspected to identify extreme outliers likely to be errors; none are found in 2024. Sufficient spatial precision (at least 5 decimal places) of coordinates is checked. Coordinates are plotted to identify and remove extreme geographical outliers that are clear errors, for example, pings in the Pacific or Indian Ocean in 2024.

3.2 Data enrichment

3.2.1 Spatial enrichment

Spatial information is added to VMS positions to identify whether they are on land, in harbour, within UK waters, or within the 0 to 6 and 6 to 12 nautical mile zones. All spatial data use the same coordinate reference system (ETRS89-extended). See Section 2.1.3 for details of the spatial layers.

In 2024, 16.6% of VMS positions were identified as on land and 44.2% as in harbour. Within UK waters, 46.4% were within 0 to 6 nautical miles and 5.6% within 6 to 12 nautical miles. Overall, 75.4% of VMS positions were within UK waters.

Each VMS position is also assigned to a 0.05° c-square using its longitude and latitude.

3.2.2 Linking trip identifier to VMS records

Landings records are used to assign a unique fishing trip identifier from the landings data to VMS positions by matching on vessel identifiers (RSS number) and where the VMS ping occurred within the corresponding trip departure and return date-time window. Trip identifier provides the basis for integration of trip-level fisheries information, including gear, mesh and landings.

3.2.3 Assignment of fishing gear to VMS records

Fishing gear and mesh size are assigned to VMS records using SFS landings data and, where needed, UK fishing licence records.

A hierarchical approach uses the most detailed information that can be matched:

1. **Trip and activity date:** gear and mesh are matched from landings for the same trip and day. Where more than one combination is recorded, the gear with the highest live weight is used.
2. **Vessel and activity date:** where no trip match is available, gear and mesh are matched using vessel and day. The combination with the highest live weight is used.
3. **Trip:** where no daily match is available, the dominant gear and mesh for the trip are used.
4. **Vessel:** where trip information is unavailable, the vessel's dominant gear and mesh for the year are used.
5. **Fishing licence:** where no landings-based match is available, gear is assigned from valid UK fishing licence records. Licence data do not include mesh size.

Dominant gear and mesh are based on the number of fishing days, with live weight used to break ties.

In 2024, 2.2% of VMS records remain unmatched after all assignment stages; this reflects vessels that are absent from or have errors in both the landings and licence datasets.

3.2.4 Assumptions and limitations

Spatial data

The spatial enrichment relies on the accuracy of the underlying spatial datasets. The 3 km harbour buffer may include some genuine fishing activity outside ports. See Section 4.3.4 for further assessment.

The UK EEZ layer includes Isle of Man waters, while landings data identify the Isle of Man separately. This difference may affect how some landings and VMS positions are matched by fishing zone.

There is a small overlap between the 0 to 6 and 6 to 12 nautical mile zones due to differences in the source boundaries. Positions in both zones are assigned to the 6 to 12 nautical mile zone. This affected 57 VMS records in 2024.

Gear assignment

Gear assignment assumes that vessels generally use one main gear within a fishing day. In 2024, 99.88% of trip-days used one gear.

Where several gears are recorded, the gear with the highest live weight is used for trip-day and vessel-day matches. At broader matching levels, the dominant gear is based on the number of fishing days.

The matching hierarchy assumes that trip information is more reliable than vessel-level information, and vessel-level information is more reliable than licence information.

3.2.5 Quality assurance

Spatial layers are peer reviewed by GIS specialists. Automated checks confirm valid geometry and coordinate reference systems. Layers are also plotted with VMS positions and visually checked for spatial alignment.

For gear assignment, coverage is checked after each matching stage, and duplicate checks confirm that VMS records are not duplicated. Remaining unassigned vessels are checked against SFS landings and UK licence data for other available gear information.

4. Estimation Methodology

4.1 Overview of estimation approach

The purpose of LEAPFISH is to estimate the spatial distribution of fishing activity and associated landings from vessel monitoring system (VMS) and fisheries landings data. While landings data provide information on what was caught during a fishing trip, they only provide spatial information at ICES rectangle level. Conversely, VMS data provide detailed information on vessel movements but do not contain information on catches.

To address this, LEAPFISH combines VMS and landings data through a three-stage process;

1. Vessel speed data are used to derive gear-specific fishing-speed thresholds and identify what speeds are likely to indicate fishing activity.
2. A rule-based classification combines speed, timing, location and reported landings information to distinguish fishing from non-fishing positions.
3. Reported landings are linked to the resulting fishing positions and apportioned according to the relative fishing effort represented by each position.

The resulting dataset provides spatially distributed estimates of fishing effort, landings live weight and landed value that can be used to support fisheries management, marine planning and analytical assessments.

4.2 Fishing-speed models

4.2.1 Overview

Fishing activity typically occurs at lower speeds compared to steaming. By grouping reported speeds, patterns emerge which can be used to separate lower-speed fishing activity from higher-speed steaming behaviour.

Statistical modelling is used to produce fishing speed thresholds. These thresholds can be applied to each VMS position to estimate whether a vessel was more likely to have been fishing than steaming at the time of the observation. This helps to minimise the inclusion of transiting behaviour when allocating landings to individual VMS positions.

Fishing behaviour varies between gear types, resulting in different operational fishing speeds. Trawlers typically fish at moderate towing speeds, whereas passive gears such as pots and gillnets are associated

with lower hauling speeds ([Lee et al., 2010¹²](#); [Muench et al., 2018¹³](#)). A single threshold is unlikely to represent all fishing methods accurately, therefore, where enough data are available, separate thresholds for each gear type are produced. An all-gear fallback threshold is developed for gears where an appropriate model could not be produced.

4.2.2 Preparing data for modelling

The modelling VMS dataset used is produced in prior stages of the processing pipeline (see section 3 Data Processing for more information). Most importantly, the VMS records are linked to fishing gear information. To provide meaningful data for modelling purposes, records are excluded where vessel speed is missing, positions are located in harbour areas or on land, or gear information is missing. In 2024, 44.9% of the original dataset are retained for modelling. Of these, 3.7% have a recorded vessel speed of zero.

4.2.3 Modelling approach

Vessel speed distributions are analysed using Gaussian mixture models (GMMs). This modelling approach is used to distinguish fishing and non-fishing activity using vessel tracking data ([Mendo et al., 2019¹⁴](#)).

A GMM identifies groups of observations with similar values. LEAPFISH uses a two-component model to represent two broad activity states:

1. Fishing, which generally occurs at lower speeds while fishing gear is being used.
2. Non-fishing, including steaming or transit, which generally occurs at higher speeds.

The model estimates the average speed and variation in speed for each activity state. The same variance is assumed for both states.

More complex methods, such as hidden Markov models, were considered and may be explored in future development.

4.2.4 All gears fishing speed model

A statistical model is initially fitted to all eligible VMS observations to understand whether vessel speed alone provides sufficient separation between fishing and non-fishing behaviour.

In 2024 data, the model identifies two clear behavioural states. The lower-speed state has an average speed of 2.7 knots and is interpreted as fishing activity. The higher-speed state has an average speed of 8.0 knots and is interpreted as steaming activity. Fishing and steaming behaviours are generally well

¹² Lee, J., South, A.B. and Jennings, S. (2010). Developing reliable, repeatable, and accessible methods to provide high-resolution estimates of fishing-effort distributions from vessel monitoring system (VMS) data. *ICES Journal of Marine Science*, 67(6), pp.1260-1271. <https://doi.org/10.1093/icesjms/fsq010>

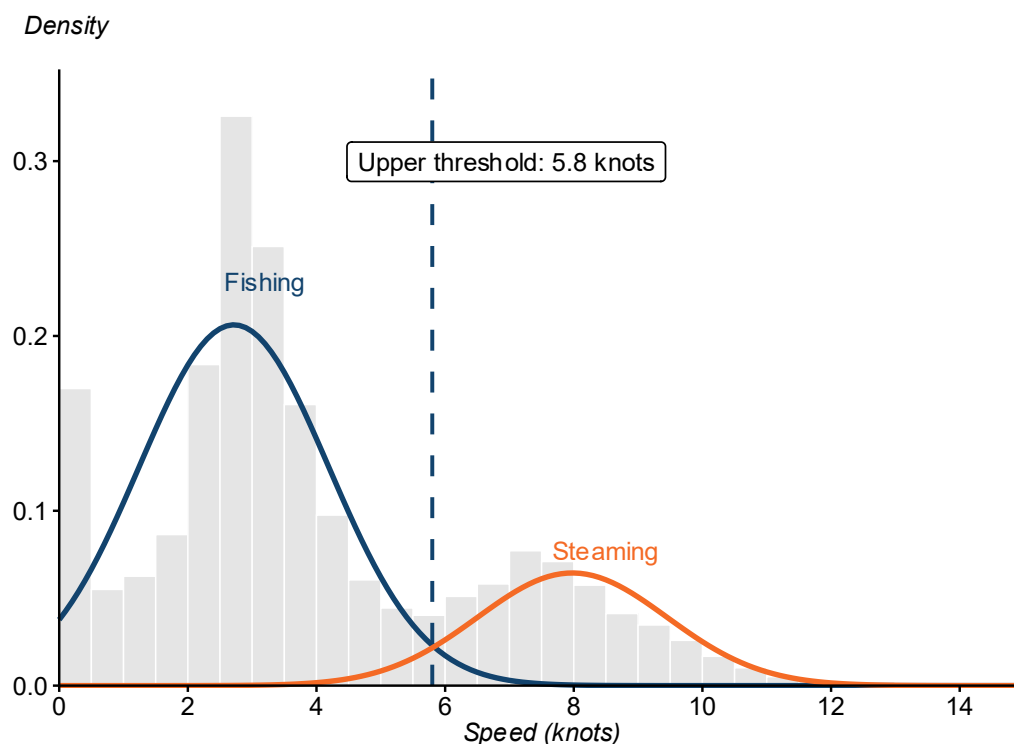
¹³ Muench, A., DePiper, G.S. and Demarest, C. (2018). On the precision of predicting fishing location using data from the vessel monitoring system (VMS). *Canadian Journal of Fisheries and Aquatic Sciences*, 75(7), pp.1036-1047. <https://doi.org/10.1139/cjfas-2016-0446>

¹⁴ Mendo, T., Smout, S., Photopoulou, T. and James, M. (2019). *Identifying fishing grounds from vessel tracks: model-based inference for small scale fisheries*. *Royal Society Open Science*, 6, 191161. <https://doi.org/10.1098/rsos.191161>

distinguished by vessel speed, with some overlap at intermediate speeds, see Figure 1. More information is provided in [Annex B: Fishing-speed model outputs](#).

This all-gears model is used to produce the fallback upper fishing speed threshold of 5.8 knots, with speeds above this value classified as steaming. This fallback was used for VMS records linked to gear codes that do not have a gear-specific model available. This includes gears with insufficient observations for modelling.

Figure 1: Modelled fishing and steaming speed distributions for all gears



Description of Figure 1: The figure shows modelled speed distributions for fishing and steaming across all gears. Fishing speeds are concentrated at lower speeds, peaking at 2.7 knots, while steaming speeds are concentrated at higher speeds, peaking at 8.0 knots. The upper fishing speed threshold dashed line is shown at 5.8 knots, where the two distributions cross over.

4.2.5 Gear-specific fishing speed models

Statistical models are developed for individual gear types with sufficient observations (at least 1,000 VMS pings) using the same approach applied to the all-gears model. This allowed fishing-speed distributions to be estimated separately for individual gear groups and provided thresholds that reflected differences in fishing behaviour across fisheries.

4.2.6 Producing fishing speed thresholds

Fishing-speed thresholds are derived from the statistical models. The models represent the estimated likelihood that a vessel speed observation belongs to either the fishing or steaming behavioural component. The threshold is defined as the vessel speed at which fishing and steaming behaviour are equally likely.

This can be described as $P(\text{Fishing}) = 0.50$. Speeds below this threshold are classified as fishing activity, while speeds above this threshold are classified as steaming activity.

While some genuine fishing may occur above this threshold, increasing the threshold would increase the risk of misclassifying steaming positions as fishing, whereas decreasing it would increase the risk of misclassifying fishing positions as steaming.

No lower speed threshold is utilised in this approach, as most models had a lower threshold of 0 knots. The objective is to distinguish fishing-related activity from higher-speed steaming behaviour, rather than classify different forms of low-speed activity. The temporal resolution of VMS data was not seen as sufficient on its own to reliably classify further activities such as fishing, gear handling, drifting or sheltering at sea.

Table 1: Fishing-speed thresholds by gear code

Gear code	Gear name	VMS records	Fishing threshold (knots)
OTB	Otter trawls – bottom	635,552	5.8
DRB	Boat dredges	446,371	5.3
TBB	Beam trawls	214,756	7.4
FPO	Pots	200,042	4.5
OTT	Otter twin trawls	164,518	5.4
PTB	Pair trawls – bottom	78,651	6.3
SSC	Scottish seines	64,447	5.4
TBN	Nephrops trawls	60,479	5.0
GNS	Set gillnets (anchored)	47,182	5.0
OTM	Otter trawls – midwater	26,507	6.8
LLS	Set longlines	22,994	5.6
LL	Longlines (not specified)	16,197	5.1
GN	Gillnets (not specified)	9,148	4.8
HMD	Mechanized dredges	8,243	2.8
PTM	Pair trawls – midwater	6,801	6.4
TB	Bottom trawls nei	6,503	4.9
FIX	Traps (not specified)	2,084	3.5
GTR	Trammel nets	1,911	4.9
PS	With purse lines (purse seines)	1,386	3.7
GND	Driftnets	861	5.8
SV	Boat or vessel seine	419	5.8
PS1	Purse seine - one boat	17	5.8
LA	Without purse lines (lampara)	0	5.8
MIS	Miscellaneous gear	0	5.8

4.2.7 Assumptions and limitations

The fishing-speed models rely on several assumptions.

The key assumptions are:

- Vessel speed can reliably distinguish fishing from steaming, with fishing generally occurring at lower speeds.
- Vessel behaviour can be represented by two broad states: fishing and non-fishing.
- Vessels using the same gear have broadly similar speed patterns.

The key limitations are:

- Fishing and steaming speeds can overlap. Some fishing may occur above the selected threshold and some non-fishing activity below it.
- Two behavioural states may not capture all vessel activity. Searching, waiting and handling fishing gear may have different speed patterns.
- The model may not fully represent variation in vessel speeds. Speed patterns can vary between vessels and between fishing and steaming activity.
- Some gears do not have enough data for a gear-specific threshold. These gears use the all-gears threshold, which adds uncertainty.
- Errors or gaps in speed, gear or spatial data can affect the model.

Future development may draw on fishing-gear expertise and additional evidence, such as observer data, to assess classification and refine gear-specific fishing-speed rules.

4.2.8 Sensitivity and method assessment

Sensitivity analyses are undertaken to evaluate the robustness of model-fitting decisions and evaluate alternative methodological options.

Number of behavioural states

Three-component models were tested to assess the effect of using two broad activity states. The all-gears threshold changed little, from 5.8 to 5.7 knots. The weighted mean absolute difference across gear models was 0.38 knots, although larger changes occurred for some gears. The two-component model was retained as a consistent and interpretable approach. More complex behaviour for some gears will be reviewed in future development.

Variance structure

The effect of the equal-variance assumption was tested by allowing the Bayesian Information Criterion (BIC) to select between equal- and unequal-variance models. BIC selected unequal variance for 15 of 19 gear models. The all-gears threshold fell from 5.8 to 5.3 knots, with larger changes for some gears. However, unequal variance produced substantial overlap between fishing and steaming components for some important gears. Equal variance was therefore retained to provide a more consistent interpretation and separation between the two broad activity states.

Alternative thresholds

Alternative probability thresholds were tested against the selected $P(\text{Fishing}) = 0.50$ threshold. For the all-gears model, the upper threshold increased from 5.8 knots at P50 to 6.3 at P25 and 6.7 at P10. P50 was retained because it is the point where the model gives equal probability to fishing and steaming. Lower probability thresholds would include speeds where steaming is more likely than fishing.

Fishing-probability overlap

Overall, 2.52% of VMS records had intermediate fishing probabilities between 0.30 and 0.70. Fourteen of the nineteen gear models had fewer than 5% of records in this range, and all had fewer than 10%. This suggests that the models generally separate fishing and steaming speeds clearly, although overlap is greater for some gears.

4.2.9 Quality assurance

Automated checks confirm that required fields are present, record counts are consistent, and models fit the expected two-component structure. Checks also confirm that the lower-speed component represents fishing and that each gear has an appropriate speed threshold.

Further checks include visual review of speed distributions, component separation and sensitivity testing. These checks support the use of minimum sample sizes for gear-specific models and fallback thresholds where needed.

4.3 Classification of fishing activity state

4.3.1 Overview

This stage classifies each VMS position as fishing or non-fishing using spatial, temporal and activity information.

Each position is initially treated as potential fishing activity. A sequence of rules is then used to identify positions where fishing is unlikely and mark them as non-fishing. Positions not identified by any rule are classified as fishing.

The rules identify likely non-fishing activity rather than confirm that fishing occurred. Positions classified as fishing are eligible to receive allocated landings through the process described in Section 4.4.

4.3.2 Rule base classification

VMS positions are tested against the following rules in sequence:

1. Within a harbour
2. On land
3. Not linked to a fishing trip
4. Not linked to reported fishing activity within ± 1 day
5. After End of Fishing (EOF) message
6. Above the applicable fishing-speed threshold

In harbour rule

Positions within 3 km of a mapped port are classified as non-fishing. This removes activity associated with ports and harbours. In 2024, this rule excluded 44.2% of all positions.

On land rule

Positions identified as being on land are classified as non-fishing. See section 3.2.1 for details. In 2024, this rule excluded 4.3% of all positions and 7.7% of positions reaching this stage.

Trip linkage rule

Positions not linked to a valid fishing trip are classified as non-fishing. These may relate to non-fishing activity or errors in reported trip information. In 2024, this rule excluded 8.0% of all positions and 15.6% of positions reaching this stage.

Reported fishing rule

Positions not linked to reported fishing activity are classified as non-fishing. A ± 1 -day tolerance allows for differences between reported dates and the timing of fishing activity. In 2024, this rule excluded 0.6% of all positions and 1.3% of positions reaching this stage.

End of fishing rule

Positions after the reported End of Fishing (EOF) time are classified as non-fishing. EOF marks the point when no further fishing is expected during the trip. In 2024, this rule excluded 2.2% of all positions and 5.2% of positions reaching this stage.

Speed threshold rule

Positions above the applicable fishing-speed threshold are classified as non-fishing. Gear-specific thresholds are used where available. Otherwise, the all-gears threshold of 5.8 knots is used. For more details see Section 4.2. Where speed is missing, the speed rule cannot be applied. Classification then relies on the preceding rules. In 2024, this rule excluded 7.6% of all positions and 18.7% of positions reaching this stage.

After all rules were applied, 33.1% of all VMS positions were classified as fishing and were eligible to receive allocated landings.

4.3.3 Assumptions and limitations

The fishing-state classification relies on several assumptions.

The key assumptions are:

- Positions that pass the location, trip, fishing-date, End of Fishing and speed rules are more likely to represent fishing activity.
- Vessel speed helps distinguish fishing from higher-speed steaming. Where a gear-specific threshold is unavailable, the all-gears threshold is an appropriate fallback.
- Gear and trip information is accurate. This includes gear, trip times, fishing dates and End of Fishing information.
- The spatial and date rules are assumed to provide a reasonable basis for classification. This includes harbour and coastline data and the ± 1 -day tolerance around reported fishing dates.

The key limitations are:

- The method identifies likely fishing activity, not directly observed fishing. Speed cannot always distinguish fishing from other vessel behaviour.
- Missing speed and the lack of a lower speed threshold add uncertainty. Some non-fishing activity may therefore be classified as fishing.
- VMS data do not provide a continuous record of vessel activity. Positions are required to be reported at two-hour intervals, so shorter fishing operations can take place between positions and may not be captured. This can lead to fishing activity being over- or underestimated.
- Errors or gaps in reported or spatial data can affect classification. This includes fishing activity data, harbour locations, coastline data and VMS positions.
- Some classification rules can exclude genuine fishing or retain non-fishing activity. For example, the ± 1 -day tolerance may retain activity on adjacent days, while the 3 km harbour buffer may exclude fishing close to ports.

4.3.4 Sensitivity and method assessment

Sensitivity tests assessed key method choices that could affect fishing-state classification. These included fishing-speed thresholds, missing speed, the 3 km harbour buffer and the ± 1 -day tolerance around reported fishing dates. The use of the all-gears fallback threshold was also assessed.

Upper fishing-speed threshold

Of positions reaching the speed rule with valid speed, 21.0% exceeded the applicable threshold and were classified as non-fishing. Most were well above the threshold. The median difference was 2.3 knots and only 8.6% were within 0.5 knots. This suggests that most exclusions are not caused by small changes around the selected threshold. However, genuine fishing above the threshold may still be excluded.

Missing vessel speed

In 2024, 10.9% of positions reaching the speed rule had no speed information and could not be assessed against the fishing-speed threshold. These are classified as potential fishing. Missing speed therefore introduces uncertainty into fishing-state classification.

No lower fishing-speed threshold

The fitted models produced a lower fishing-speed threshold of 0 knots. Among fishing-classified positions with valid speed, 9.5% of fishing time occurred below 1 knot and 19.8% below 2 knots. The effect varied substantially between gears.

A universal lower threshold would therefore reduce estimated fishing activity and affect some gears more than others. No lower threshold was applied because there was insufficient evidence available that these low-speed positions represented non-fishing activity.

Harbour buffer

The 3 km harbour buffer mainly removed stationary or very-low-speed positions. In 2024, 96.7% of harbour positions with valid speed were travelling at 1 knot or less, with a median speed of 0 knots. This provides further assurance that the buffer mainly removes activity associated with ports and harbours.

±1-day reported-fishing tolerance

Removing the ±1-day tolerance would reduce classified fishing positions by 7.9% and estimated fishing time by 7.3%. The tolerance therefore has a meaningful effect on classification. It was retained to reduce the risk of excluding genuine fishing that occurred across midnight but was recorded against a single date.

All-gears fallback threshold

The all-gears threshold was used for only 0.09% of positions with valid speed. Fishing activity relying on this threshold represented about 0.12% of estimated fishing time. Its effect on the overall results is therefore small.

4.3.5 Quality assurance

Quality assurance checks confirm that the exclusion rules operate as intended. Rule-level results and final fishing classifications are reviewed for consistency. A classification waterfall shows the cumulative effect of each rule.

4.4 Spatial allocation of landings to VMS positions

This stage links landings data to VMS positions classified as fishing. A hierarchy of matching rules is used, starting with the most detailed match and relaxing the criteria where needed. Matched landings are then apportioned across fishing positions in proportion to the fishing effort represented by each position.

4.4.1 Calculation of ping effort

Ping effort is the time represented by each VMS position. It is calculated as the midpoint between the time since the previous position and the time to the next position. Ping effort is calculated in minutes for both fishing and non-fishing positions.

Ping effort is calculated across each vessel's VMS records because trip identifiers are not available for all records. Missing ping effort is set to 120 minutes, the standard VMS reporting interval. In 2024, this affected 1,506 records.

Ping effort above 120 minutes is capped at 120 minutes so that long intervals, such as those between trips, do not have too much influence on landings apportionment. In 2024, 864,681 positions were capped. Ping effort ranges from 3 to 120 minutes.

4.4.2 Preparation of landings data

Landings fields are standardised before matching to VMS data. This includes dates and fields such as the UK EEZ indicator.

In 2024, 162 records from Scottish vessels were missing trip identifiers due to a known database issue. These records represent 9,811 tonnes of live weight and £13.6 million in landed value and are retained for later matching.

4.4.3 Joining landings to VMS positions

Only VMS positions classified as fishing are eligible for landings allocation. A six-stage matching hierarchy is used. Each stage uses less detailed matching information to allocate remaining unmatched landings.

The matching stages are:

- Stage 1: vessel + trip + date + ICES rectangle + EEZ
- Stage 2: vessel + trip + date + EEZ
- Stage 3: vessel + trip + date
- Stage 4: vessel + trip
- Stage 5: vessel + date
- Stage 6: vessel

Stage 1 uses the most detailed matching criteria. Later stages remove spatial or temporal criteria where no match is found. Stage 5 allows landings with missing trip identifiers to be matched while retaining the activity date. Stage 6 uses vessel identifier alone and has the greatest spatial and temporal uncertainty.

After each stage, matched landings and VMS positions are removed before the next stage. Unmatched landings are grouped to the matching criteria before their weight and value are apportioned across the matched fishing positions. Unmatched landings and fishing positions are retained and reported after the final stage.

4.4.4 Apportionment of landings across fishing positions

For each matched landings group, total ping effort is calculated across all matched fishing positions. Each position receives a share of the landings in proportion to its ping effort. Positions representing more fishing time therefore receive a larger share of the live weight, landed weight and value.

4.4.5 Matched and unmatched data

In 2024, a total of 1,237,167 of 1,483,086 fishing VMS positions (83.4%) were matched to landings.

Table 2 shows the live weight matched at each stage. Stage 1 matched 86.7% of live weight. Across all six stages, 99.8% was matched, representing 694,060 tonnes of live weight and £981.7 million in landed value.

Table 2: SFS landings live weight matched at each stage, 2024

Stage	Matched weight (t)	Matched (%)	Cumulative matched (%)	Remaining unmatched weight (t)
Input	0	0.0%	0.0%	695,499
Stage 1	602,673	86.7%	86.7%	92,825
Stage 2	53,473	7.7%	94.3%	39,352
Stage 3	10,163	1.5%	95.8%	29,189
Stage 4	9,126	1.3%	97.1%	20,063
Stage 5	466	0.1%	97.2%	19,596
Stage 6	18,157	2.6%	99.8%	1,439

Stage 2 matches occur where no suitable fishing positions are found within the reported ICES rectangle. As ICES rectangle is present in both datasets, this may reflect differences between the rectangle reported in landings data and the locations of VMS fishing positions. It may also reflect the fact skippers are only required to report the ICES rectangle where the majority of catch was taken that day combined with up to two-hour VMS reporting intervals.

After all stages, 1,439 tonnes (0.2%) of live weight and £1.5 million in landed value remained unmatched. Unmatched landings were recorded for 18 vessels. One vessel had no VMS positions and accounted for 26% of unmatched live weight.

4.4.6 Assumptions and limitations

The spatial allocation of landings relies on several assumptions.

The key assumptions are:

- Landings are apportioned in proportion to the fishing time represented by each VMS position. This assumes that catch is broadly related to time spent fishing.
- The default and maximum ping effort of 120 minutes provide a reasonable estimate where intervals are missing or longer than the standard reporting interval.
- Only VMS positions classified as fishing are eligible to receive landings. This assumes the fishing-state classification provides a reasonable estimate of fishing activity.
- The matching hierarchy assumes that more detailed vessel, trip, date and location information generally provides a better basis for linking landings to fishing positions.

The key limitations are:

- Catch may not be distributed in proportion to fishing time. It may be concentrated in particular hauls or locations.
- Errors in fishing-state classification can affect where landings are allocated.
- Matching uncertainty generally increases at later stages as spatial and temporal information is removed. Stage 6 uses vessel identifier alone and has the greatest uncertainty.
- A detailed match does not always mean the spatial allocation is certain. Stage 1 uses the ICES rectangle reported in the logbook. Where VMS data indicate fishing across several rectangles but only one is reported, landings remain within the reported rectangle.
- Landings are included based on the date they were landed and may therefore relate to fishing activity in the previous year. At later matching stages, where activity date is not used as a matching

criterion, these landings may be allocated to VMS positions in the reporting year. In 2024, approximately 1,087 tonnes (0.2% of landings by weight) related to fishing activity in 2023. Of these, approximately 944 tonnes were matched at Stage 4 using vessel and trip, and 142 tonnes at Stage 6 using vessel alone. Less than 1 tonne remained unmatched.

- Not all fishing effort has associated landings. In 2024, 82.6% of fishing-effort hours were linked to positions receiving allocated live weight. The remaining 17.4% still count as fishing effort.
- After all matching stages, 0.2% of landings remained unmatched and are not included in the spatially allocated landings.

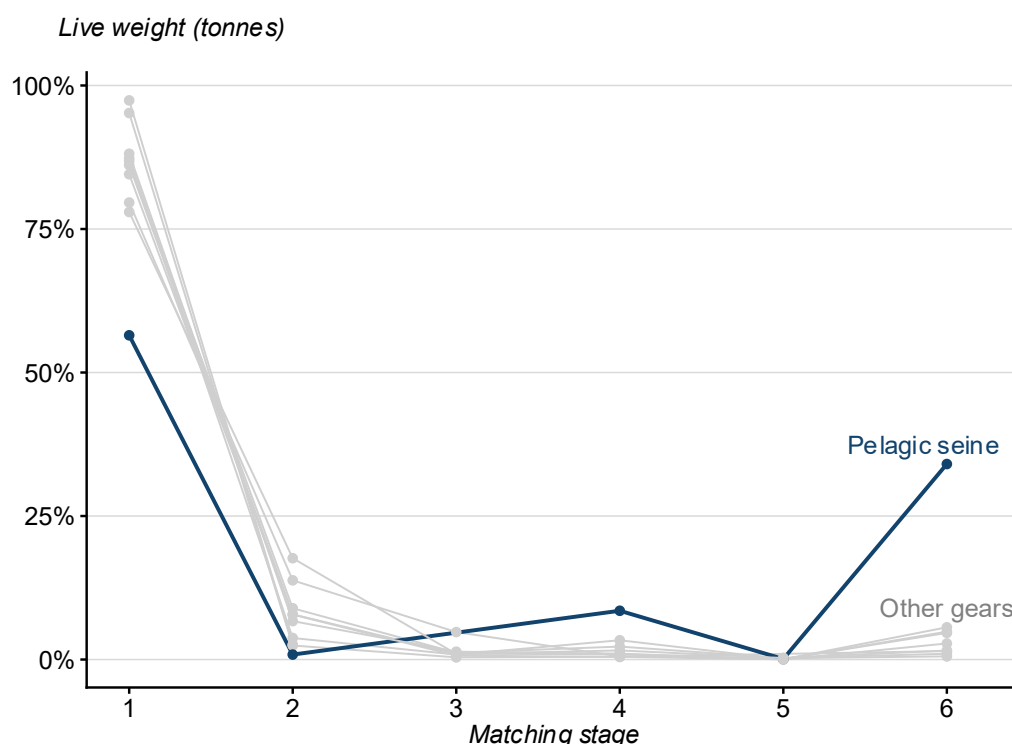
4.4.7 Sensitivity and method assessment

Several sensitivity tests are included to help understand where the allocation of landings is most dependent on method choices and/or data issues, and where confidence in the outputs may be lower.

Matching stages for each gear category

The proportion of live weight allocated at each matching stage was assessed by gear. Most gear groups had more than 75% of live weight allocated at Stage 1, with most remaining landings allocated at Stage 2. Pelagic seine is the exception.

Figure 2: Percentage of live weight allocated at each matching stage for each gear group



Description of Figure 2: Most gear categories have the majority of live weight allocated at Stage 1. Pelagic seine showed a different pattern, with a substantial proportion allocated at Stage 6.

Matching stages for each ICES rectangle

Matching stages are also assessed by ICES rectangle. Each rectangle is assigned the stage accounting for the largest share of its allocated live weight. The analysis included 161 rectangles with more than 10 tonnes of live weight.

Stage 1 is dominant in 105 rectangles (65%), while Stage 6 is dominant in 27 rectangles (17%). This shows that allocation uncertainty varies between areas, with some rectangles relying more heavily on fallback matching.

Ping effort distribution

Landings are apportioned across fishing positions using the fishing time represented by each VMS ping. Differences in ping intervals can therefore affect how landings are allocated.

Ping effort varies between gears. Median ping effort ranged from 15 minutes for dredges to 120 minutes for pelagic trawls, longlines and pelagic seine (Table 3). Variation was also found between ICES rectangles, with median ping effort ranging from 3 to 120 minutes.

These differences may affect the relative weighting of fishing positions and therefore the spatial allocation of landings.

Table 3: Ping effort distribution for each gear category

Gear category	Median	Interquartile range	% near two-hour interval
Dredge	15.0	112.5	28.7
Beam trawl	60.7	117.0	41.7
Demersal seine	61.0	109.0	38.7
Demersal trawls	77.8	105.0	44.1
Other mobile gears	90.9	72.2	37.8
Drift and fixed nets	95.1	99.0	45.7
Pots and traps	95.3	102.2	46.7
Pelagic trawls	120.0	66.4	55.5
Longlines	120.0	54.0	60.5
Pelagic seine	120.0	24.9	62.9

4.4.8 Quality assurance

Quality assurance checks are applied throughout the allocation process. These include:

- Ping effort: checking missing values and values outside the expected range.
- Input and matching data: checking completeness of key matching fields and uniqueness of aggregated landings groups.
- Matching and apportionment: checking that joins do not duplicate VMS records and that allocated landings sum to the original totals. Match rates and unmatched landings and fishing positions are also reviewed.

5. Outputs

5.1 Overview of outputs

The detailed LEAPFISH data contain vessel-level information and cannot be published. For publication, the data are aggregated by spatial area and gear to protect sensitive information. See Section 7 for information on disclosure control.

Before aggregation, gear categories are simplified for publication. They follow those used in UK SFS, except pelagic seine, other mobile gears and unknown/NULL gears are combined as 'Other gears'.

The LEAPFISH release includes:

- [Tabular dataset \(ODS\): the published spreadsheet.](#)
- [Statistical summary \(PDF\): key findings, maps and commentary.](#)
- Methodology and quality statement (PDF): methodology, quality and limitations.
- Spatial data layers: published through the Defra Data Services Platform.

5.2 Tabular dataset

The tabular dataset contains the published statistics, metadata and field definitions.

Data are aggregated by year, 0.05° c-square, ICES rectangle and gear category. Vessel and trip-level information is removed. Published measures are time spent at sea, fishing effort, live weight, landed weight and landed value. Time spent at sea excludes positions identified as on land or in harbour. Effort is reported in hours, landings weight in tonnes and landed value in pounds sterling (£). Values are rounded to two decimal places and are not adjusted for inflation or exchange rates.

Field names and definitions are provided in Table 6 in Annex A.

5.3 Spatial data layer

Spatial data layers are produced at year, 0.05° c-square and gear category level for mapping and spatial analysis. Four layers are published:

- Live weight (tonnes)
- Landed value (£)
- Time spent at sea (hours)
- Fishing effort (hours)

All layers use ETRS89 and will be available through Defra Data Services Platform shortly after the statistics release.

6. Revisions Policy

Regular revisions

The Marine Management Organisation revisions policy is to produce revised figures each year to ensure that users have access to the latest data available. There are several potential causes of revisions to this publication:

1. **Receipt of additional data.** Despite strict data reporting requirements, some data are not processed at the time of publication.
2. **Revisions to data sources.** Corrections are made to database entries throughout the year where these are thought to be incorrect.
3. **Rectification of data processing errors.** Where data are found to have been incorrectly processed for a previous publication, these errors are corrected as soon as possible.
4. **Updates to data processing methodology.** Where changes are made to the processing methodology as part of the ongoing development of this official statistics release, data will be revised for previous years to account for material changes to final data.

Users should always refer to the latest figures published by the Marine Management Organisation. Previous editions of all publications are made available online on the Marine Management Organisation website should users wish to examine the effect of revisions in further detail.

The Marine Management Organisation adheres to the Department for the Environment, Food and Rural Affairs' policy on revisions and errors. Further information can be found in the [Statement on Revisions and Errors](#)¹⁵.

Unexpected revisions

In exceptional circumstances, revisions may be made outside the normal annual revision cycle. This may occur where delaying correction of an identified error until the next scheduled revision would risk users relying on inaccurate information. Such errors may relate to the published statistics, underlying source data, or data processing methodology.

Where an unscheduled revision is required, the Marine Management Organisation will correct the affected data as soon as possible and publish a clear explanation of the nature of the error, the impact on previously published figures, and the changes made. Revisions that may have a material impact on users' understanding or use of the statistics will be clearly identified within the publication and supporting documentation.

¹⁵ <https://www.gov.uk/government/publications/defra-policy-statement-on-revisions-and-corrections>

7. Disclosure Control

Disclosure control is an important part of the [Code of Practice for Statistics](#)¹⁶ and helps ensure that published statistics do not reveal personal, confidential or commercially sensitive information. It also aims to prevent users from combining published statistics with other available information to infer details about individual fishers, vessels or fishing businesses.

A disclosure control assessment was undertaken to evaluate the risk that sensitive information could be identified from the published LEAPFISH outputs. Controls were applied to balance the protection of sensitive information with the usefulness of the published statistics. This supports compliance with UK GDPR and the [Data Protection Act 2018](#)¹⁷.

The following disclosure controls were applied before publication:

- Vessel identifier, owner information, trip identifier, vessel length group, vessel nationality, administrative port and fisheries administration fields were removed to reduce the risk of identifying individual vessels or fishing businesses.
- Activity dates were aggregated to calendar year to reduce the risk of identifying vessel activity on specific dates.
- Data are provided by gear group rather than gear code, with less common gears combined into broader groups.
- Data were aggregated to 0.05° c-squares rather than individual VMS positions. The published statistics therefore represent estimated activity at c-square level, not individual vessel activity.
- Vessel counts are not published because, at this spatial scale, they could increase the risk of identifying individual vessels or fishing businesses when combined with other information.
- Species information is not included.

Additional suppression based on vessel counts was also tested. Applying a minimum vessel-count threshold would remove around 50% of published c-squares, 17% of estimated landings weight and 12% of landed value. This would substantially reduce the coverage and usefulness of the published statistics. Landings weight, value and fishing effort were prioritised because they provide more informative measures of fishing activity than vessel counts. Vessel counts were therefore removed instead of applying additional cell suppression.

The assessment also considered whether LEAPFISH outputs could be combined with other publicly available information, such as landings statistics or vessel registers, to identify sensitive vessel-level information. The published data contain no vessel identifiers and are substantially more aggregated than the source data.

Taking account of these controls and the disclosure assessment, the risk of identifying sensitive vessel-level information was considered low. Additional suppression was therefore not considered proportionate.

¹⁶ <https://osr.statisticsauthority.gov.uk/the-code-of-practice-for-statistics/>

¹⁷ <https://www.legislation.gov.uk/ukpga/2018/12/contents>

8. Statement of Quality

8.1 Statistical quality

As producers of official statistics, it is the MMO's responsibility to manage and report the quality of statistics, clearly and concisely, to support everybody who needs to use them. Quality is subjective. The role of producers of official statistics is to provide users enough information to enable them to determine if these statistics are appropriate or sufficient for their individual requirements.

The [Code of Practice](#) Error! Bookmark not defined. for official statistics defines quality statistics as statistics that fit their intended uses, are based on appropriate data and methods and are not materially misleading.

This assessment considers the quality of statistics using the quality framework as set out by the Civil Service Analysis Function. This provides a consistent framework in which to ensure official statistics meet the principles for quality as set out in the UK [Code of Practice for Statistics](#) Error! Bookmark not defined..

This quality framework sets out five dimensions by which statistical quality can be assured:

- Relevance
- Accuracy and Reliability
- Timeliness and Punctuality
- Comparability and Coherence
- Accessibility and Clarity

This statement of quality reports the findings of the assessment against each of these criteria using 2024 LEAPFISH data.

8.2 Relevance

Relevance is the degree to which statistics meet the current and potential needs of users.

The MMO publishes official statistics for a wide range of users, including government departments, academics, members of the fishing industry, non-governmental organisations (NGOs) and the general public. As the statistics are freely available on GOV.UK, it is not possible to identify all users. Instead, we consider types of users and their potential needs.

User needs vary according to purpose. Different quality dimensions will be more important for different types of users. For example, accurate data are required for quota allocation and uptake monitoring, licencing decisions based on track record, compliance and enforcement activities within MMO.

In contrast, reliability and comparability may be more relevant for policy delivery and development, where changes over time are important. For example, in developing and monitoring Fisheries Management Plans, Marine Protected Areas and marine spatial planning, and contributing to the evidence base for global fish stock assessments and internal quota negotiations.

MMO statistical releases are intended to reliably report fishing activity of the UK fleet over time. LEAPFISH is specifically intended to report fishing activity over fine spatial areas. Therefore accuracy, reliability and comparability are considered most important for the purposes of this assessment.

Users require different levels of detail from these statistics. For monthly and annual official statistics, the MMO publishes a statistical report presenting the headline findings for users seeking high-level insights. An underlying dataset containing data at a more disaggregated level is also published to enable users to undertake further analysis. LEAPFISH follows this approach, providing a statistical summary of the key findings alongside an underlying dataset. This enables expert users to analyse fishing activity by gear category across different spatial areas. Spatial data layers are also published, allowing users with GIS capabilities to visualise and conduct further spatial analysis of this data.

These statistics are being published to:

- Address evidence gaps in the spatial distribution of fishing activity and landings
- Build on existing landings statistics and previously published VMS analyses
- Support fisheries management, marine spatial planning, and policy development

8.3 Accuracy and reliability

Accuracy is the closeness between an estimated result and the (unknown) true value.

LEAPFISH landings estimates were assessed by comparing landings derived from LEAPFISH-linked VMS data against landings reported in the UK SFS dataset for 2024. While neither dataset can be considered a direct measure of the true location of all fishing activity, SFS represents the source landings data used within the LEAPFISH allocation process and therefore provides the most appropriate benchmark for assessing agreement between datasets.

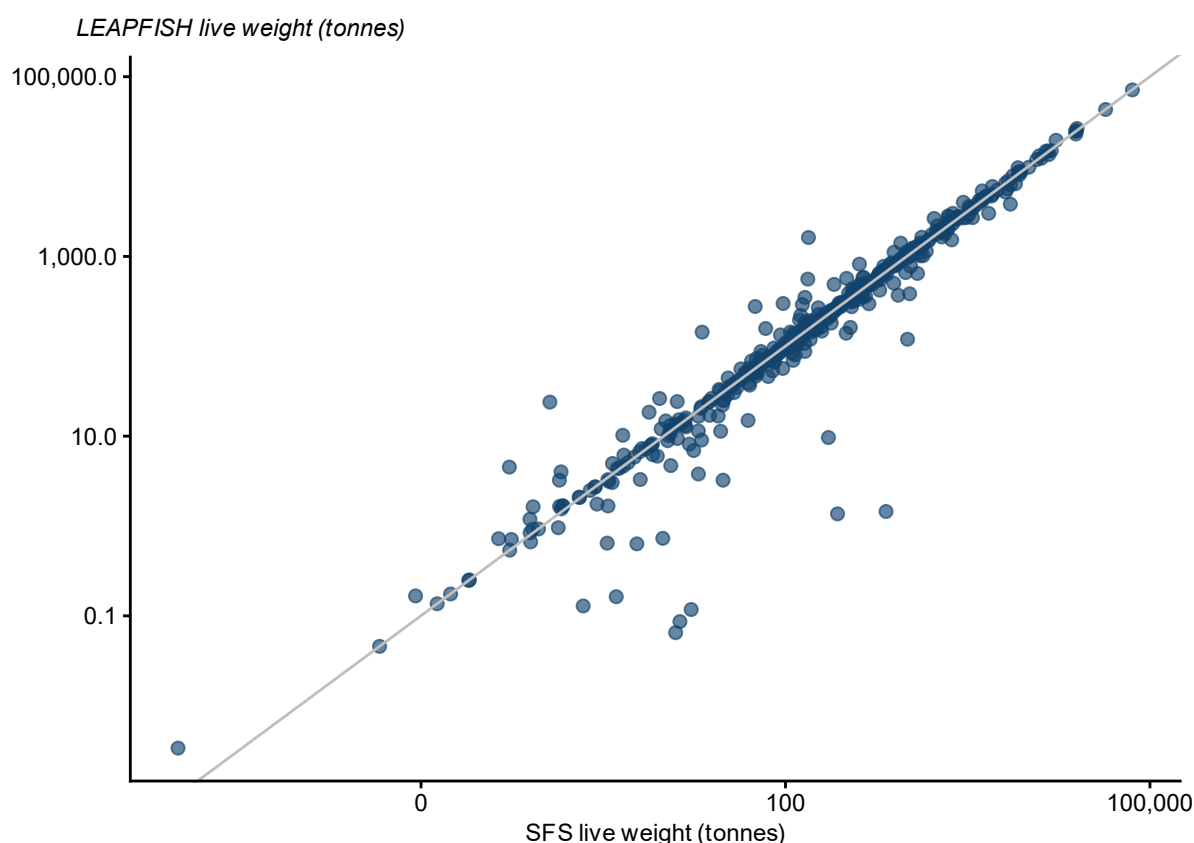
Comparisons were restricted to UK vessels of 12 metres and over and voyages overlapping the 2024 calendar year. Landings were compared at national, temporal, spatial and fishery levels to assess the extent to which LEAPFISH reproduced patterns observed in SFS.

The total live weight reported in SFS during 2024 was 695.5 thousand tonnes, compared with 694.1 thousand tonnes estimated by LEAPFISH, a difference of approximately 1.4 thousand tonnes, or 0.2% of total reported landings. LEAPFISH therefore captured approximately 99.8% of landings reported in SFS, indicating very high agreement overall.

Landings were also compared by month using activity dates. Monthly totals showed extremely strong agreement, with a correlation coefficient (r) of 0.999 between datasets. LEAPFISH successfully reproduced the seasonal pattern of fishing activity throughout the year, with only minor differences in individual months and no evidence of persistent under- or over-estimation.

At finer spatial scales, agreement remained strong but was lower than observed for national and monthly totals. Comparisons at ICES rectangle level demonstrated strong spatial agreement ($r = 0.967$), although localised discrepancies were observed in some rectangles, reflecting differences in the spatial allocation of landings. These differences are expected within a spatial allocation model and reflect uncertainty associated with assigning trip-level landings to individual fishing locations. Broader levels had higher levels of agreement, with correlations of 0.999996 by gear type and 0.999985 by FAO division.

Figure 3: Live weight by ICES rectangle in SFS and LEAPFISH, 2024



Description of Figure 3: Each point compares SFS and LEAPFISH live weight for an ICES rectangle. Most points lie close to the equal-weight line, indicating close agreement between the estimates, with some differences at lower weights. Both axes use a logarithmic scale to allow smaller and larger weights to be compared clearly.

Overall, LEAPFISH provides a detailed representation of reported fishing activity for vessels 12 metres and over, consistent with the source data. Agreement exceeded 99% at the national level, while correlations across monthly, gear and division breakdowns were consistently above 0.99. LEAPFISH is therefore considered a robust and accurate source for estimating the spatial distribution of fishing activity and associated landings.

Reliability is the closeness of early estimates to subsequent estimated values.

As with other statistical outputs derived from administrative data, revisions to LEAPFISH may occur when source datasets are updated, quality assurance processes identify anomalies, or methodological improvements are implemented.

For LEAPFISH estimates to be considered reliable, revisions should not greatly alter the interpretation of fishing activity patterns. Users should be able to reach similar conclusions regardless of whether they are using preliminary or subsequently revised estimates.

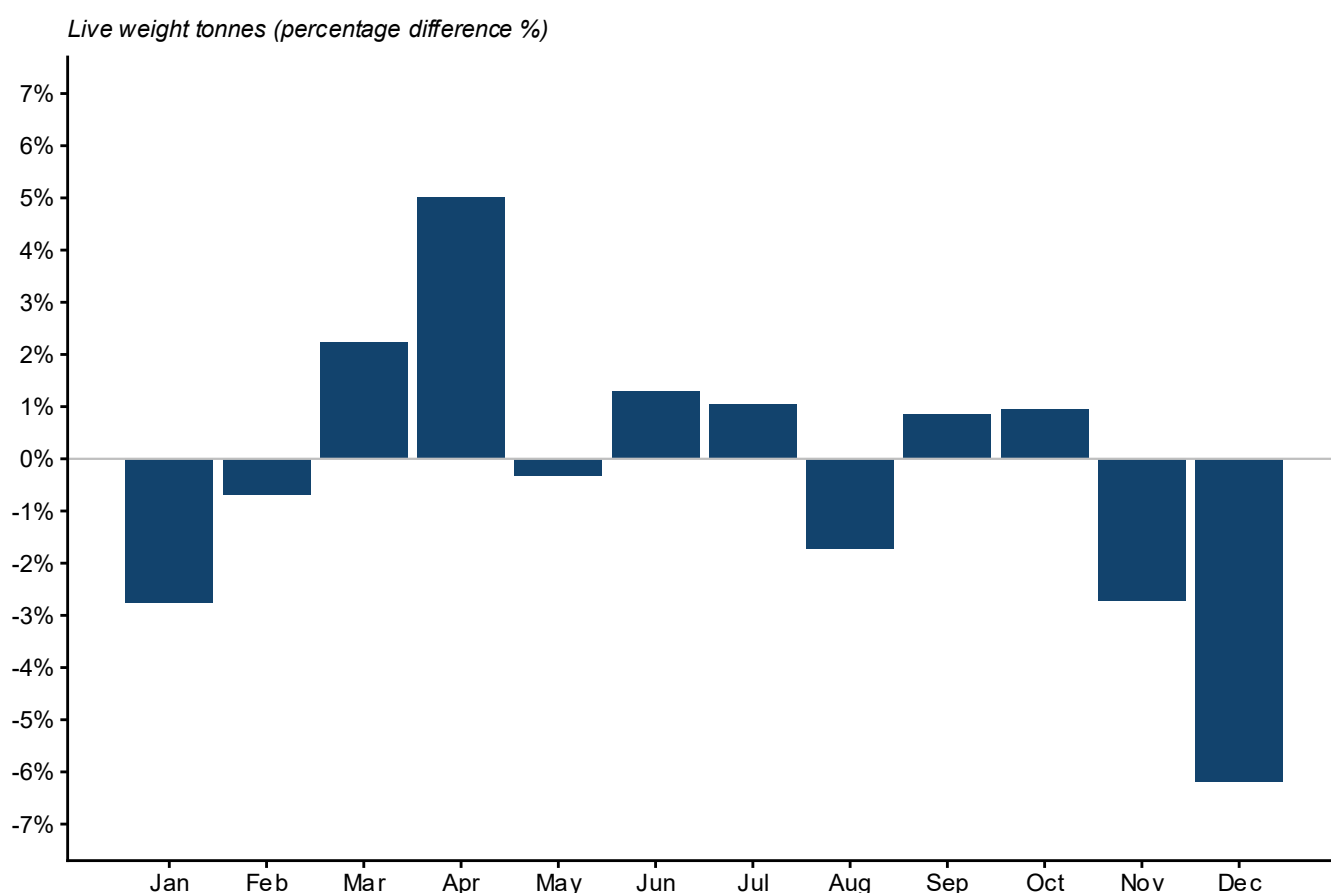
As direct comparisons of preliminary and revised LEAPFISH estimates were not available, reliability was assessed by examining whether the LEAPFISH allocation process preserved the key characteristics of the

source SFS landings data. The assessment focused on whether temporal trends, fleet characteristics and broad spatial patterns remained stable following allocation.

The monthly comparison indicates that LEAPFISH preserves seasonal patterns in fishing activity. Peaks and troughs in monthly landings were reproduced consistently, suggesting that conclusions relating to the timing and intensity of fishing activity are largely unaffected by the allocation process.

Differences between monthly LEAPFISH and SFS estimates are small relative to total monthly landings and proportions fluctuated around zero. No evidence was identified of a systematic tendency for the allocation process to consistently over- or under-estimate landings through the year.

Figure 4: Difference between LEAPFISH and SFS monthly landings estimates, 2024



Description of Figure 4: Bars show the percentage difference between LEAPFISH and SFS live weight estimates by month. Differences are generally small, ranging from around -6% to 5%, with the largest positive difference in April and the largest negative difference in December.

Reliability was greatest when results were considered at broader levels of aggregation. The close agreement observed for gear and FAO division comparisons indicates that conclusions regarding fleet behaviour, fishing methods and regional patterns remain stable following application of the LEAPFISH methodology.

At finer spatial scales, estimates are inherently more sensitive to allocation assumptions. Small changes in vessel activity records, trip boundaries or matching procedures can result in noticeable differences at

individual ICES rectangles. Consequently, individual rectangle estimates should be interpreted with greater caution than national or regional summaries.

The largest discrepancies were limited to a relatively small number of ICES rectangles and represented a minor proportion of total landings volume. The observed variation is consistent with the uncertainty expected in any model-based approach that allocates trip-level landings to fishing locations and does not greatly affect the overall spatial distribution of fishing activity.

Table 4: Top 10 ICES rectangles where SFS exceeded LEAPFISH estimates by at least 1 tonne

ICES rectangle	SFS (t)	LEAPFISH (t)	Weight discrepancy (t)	Percentage (%)
49E5	7,103	3,802	3,301	46.5
48E7	4,708	3,011	1,697	36.1
50F1	24,563	22,955	1,608	6.55
38D6	7,828	6,432	1,397	17.8
29E4	6,472	5,199	1,272	19.7
48F0	14,710	13,560	1,150	7.82
50F0	6,681	5,644	1,037	15.5
46E4	1,011	119	891	88.2
37E5	7,116	6,239	877	12.3
32F0	2,336	1,527	808	34.6

Table 5: Top 10 ICES rectangles where LEAPFISH exceeded SFS estimates by at least 1 tonne

ICES rectangle	SFS (t)	LEAPFISH (t)	Weight discrepancy (t)	Percentage (%)
47E8	16,884	19,579	2,694	16.0
41E0	8,208	9,695	1,487	18.1
41E1	155	1,621	1,466	947.5
48E8	25,116	26,462	1,345	5.36
45E0	4,169	5,344	1,175	28.2
37D6	2,911	4,005	1,094	37.6
32F1	1,673	2,645	972	58.1
47F0	5,046	5,985	939	18.6
48E6	12,307	13,161	853	6.9
47E7	13,976	14,794	818	5.9

Overall, the assessment suggests that LEAPFISH estimates are stable and robust for analyses undertaken at national, monthly, gear and FAO division scales. While greater uncertainty exists at individual ICES rectangles, the differences introduced through the allocation process are generally small relative to total landings volumes and do not significantly alter conclusions drawn from aggregated analyses.

Consequently, LEAPFISH is considered sufficiently reliable for most statistical, analytical and policy applications.

8.4 Timeliness and punctuality

Timeliness refers to the time gap between the reference period for the statistics and the publication date. A reference period is the time period for which statistical results are collected or calculated.

The initial publication of LEAPFISH data was published in October 2026, using landings data for 2024 published in UK SFS 2024 in December 2025. This delay is due to the amount of time taken to develop the new methodology used within LEAPFISH.

LEAPFISH data for 2025 are provisionally scheduled to be published in Spring 2027 along with a backdated time series from 2021 to 2023. This will use landings data from the UK SFS 2025 publication scheduled for 29 October 2026.

Once the time series is backdated, the timeliness will be improved in subsequent publications. The intention is that regular updates to LEAPFISH will follow the publication of the corresponding UK SFS release. SFS is usually published at the end of quarter three in the year following the reference period.

Punctuality is the time lag between the planned and actual dates of publication for the statistics.

LEAPFISH data will be published after the release of the corresponding annual UK SFS release. They form a supplementary publication to be used alongside the annual SFS release to provide a better understanding of the spatial granularity of landings by the over 12 metre UK and CD fleet.

All MMO official statistics releases are published according to the [publication schedule](#)¹⁸ and provisional publication dates are preannounced as soon as they are known, ideally at least 12 months in advance in line with the Code of Practice. Release dates are confirmed at least four weeks in advance. Any delay or changes to pre-announced release dates are agreed by the Chief Statistician and promptly announced to users with reasons provided for the change.

8.5 Comparability and coherence

Comparability is the degree to which statistics can be compared over time, region or another domain.

LEAPFISH uses the same method to allocate landings to fishing locations across all vessels, gears, areas and time periods. It also uses the same data sources (SFS and VMS data) throughout. This means the estimates can generally be compared across fishing areas and fleet segments.

The accuracy assessment showed that LEAPFISH closely matches the underlying SFS landings data. Total landings differed by only 0.2%, while agreement remained extremely high when data is grouped by month, gear type and FAO division. This suggests that LEAPFISH does not greatly affect comparisons of fishing activity over time, between regions or between different parts of the fleet.

¹⁸ https://www.gov.uk/search/research-and-statistics?content_store_document_type=upcoming_statistics&organisations%5B%5D=marine-management-organisation&public_timestamp%5Bfrom%5D=&public_timestamp%5Bto%5D=

Comparability is lower at finer spatial scales, where larger differences were observed for some individual rectangles (see section 8.3 Accuracy and reliability). As a result, comparisons at individual ICES rectangle level should be treated with greater caution than comparisons at broader spatial scales.

This assessment relates to the 2024 LEAPFISH methodology. Future changes to data sources or allocation methods could affect comparability over time and will be documented where they occur.

Overall, LEAPFISH estimates are considered comparable across gear types and broad geographic areas. Users can have a high degree of confidence when comparing results at these levels, although greater caution is needed when comparing estimates for individual ICES rectangles.

Coherence is the degree to which statistical processes that generate two or more outputs use the same concepts and harmonised methods. Coherent processes allow statistics from two sources to be compared and reconciled and increase the value of the statistics.

LEAPFISH uses the same landings data that underpin the annual UK SFS and combines these with vessel activity data to estimate where fishing took place. This means LEAPFISH is not creating a new measure of fishing activity but adds additional spatial information to existing fisheries data.

LEAPFISH is expected to be coherent with the underlying annual SFS landings. In 2024, LEAPFISH only differed to SFS by 0.2% (see section 8.3 Accuracy and reliability). LEAPFISH therefore remains closely aligned with readily available published official statistics.

Users should reach very similar conclusions when using LEAPFISH and official annual landings statistics at national, regional and fishery scales. The main additional value provided by LEAPFISH is the ability to analyse the spatial distribution of fishing activity and landings at finer geographic scales.

While LEAPFISH is expected to be coherent with the annual UK SFS, some differences may be observed when comparing LEAPFISH outputs with monthly SFS releases or quota uptake reports. These differences can arise because datasets are extracted at different points in time, may be subject to subsequent revisions, and are produced for different statistical or operational purposes. Users comparing outputs should therefore ensure that equivalent reporting periods and data snapshots are being used.

8.6 Accessibility and clarity

Accessibility is the ease with which users can access the statistics and data. It is also about the format in which data are available and the availability of supporting information.

LEAPFISH data are included only within the standalone LEAPFISH publication series. All statistical reports, including commentary and data tables are freely available on the GOV.UK website. This includes all previous and archived statistical releases.

All releases are available in a format that meets accessibility guidelines and legislation, including data tables in open data source (ODS) format.

This methodology document contains all supporting documentation for the LEAPFISH statistical series. A description of the relevant methodologies will be included with each statistical release, either as part of the report or clearly linked.

Clarity refers to the quality and sufficiency of the commentary, illustrations, accompanying advice and technical details.

The methodology for producing LEAPFISH is still under development and may see changes to the way in which data are processed and presented over time due to user feedback. Therefore, the statistical series will be published as Official Statistics in Development until the methodology has stabilised.

Users should consider the stage of development and inherent limitations when using these statistics, particularly for high-stakes policy or operational decisions. Their fitness for purpose will depend on the intended use case.

This methodology provides full details of the assumptions, caveats and limitations that need to be considered when using LEAPFISH data.

9. Annex A: Published dataset field definitions

This annex describes the structure and content of the published LEAPFISH tabular dataset. The published dataset is aggregated and identifying fields are removed before publication. Table 6 defines the fields included in the published dataset.

Table 6: LEAPFISH field definitions

Field Name	Field Description
Year	Year in which the VMS activity occurred, based on the date of the VMS position. VMS activity is restricted to the reporting year. Landings are included based on the date they were landed and may therefore relate to fishing activity that occurred in the previous year. In 2024, approximately 0.2% of landings by weight related to fishing activity in 2023.
C-square	C-square is an acronym for the concise spatial query and representation system, a system of spatially unique, location-based identifiers obtained by progressively subdividing 10° by 10° World Meteorological Organization squares into increasingly fine grids. There are numerous spatial resolutions possible using c-square (10 degree grid, 5 degree grid, 1 degree grid etc.), however, this release used 0.05 degrees resolution. This resolution has been selected for the purposes of aggregating and anonymising VMS point data as well as to harmonise with the temporal resolution available for UK vessels of 12 metres and over VMS data (ping intervals of 2 hours or less). More information on c-squares can be found here ¹⁹ .
Rectangle	The International Council for the Exploration of the Sea (ICES) uses sub-divisions of the sea each approximately 30 nautical miles by 30 nautical miles in size; although more detailed landings data exists ICES rectangle remains the highest resolution of reported spatial landings data available for every UK commercial fishing vessel. See here ²⁰ for more information.
Gear category	Grouping categories of gear used. These are the same categories that are used in MMO's annual Sea Fisheries Statistics publication. These are 'Demersal trawls', 'Dredge', 'Pelagic trawls', 'Demersal seine', 'Pots and traps', 'Beam trawl', 'Drifts and fixed nets', 'Longlines', and 'Other gears'. Other gears is a combination of 'Pelagic seine', 'Other mobile gears', and 'Unknown/NULL' categories; these are combined to mitigate disclosure risk. More information on fishing gear can be found here ²¹ .
Live Weight (tonnes)	Quantity of fish caught adjusted for any processing completed before landing to reflect the true weight of fish when taken out of the sea. The MMO uses the live weight for the majority of analysis and monitoring as it better reflects the total weight of fish extracted from the sea. Unless there is a specific reason to use landed weight (such as for direct comparison with HMRC trade data), the MMO recommends the use of live weight. In this dataset, weight is provided in tonnes rounded to two decimal places.

¹⁹ https://assets.publishing.service.gov.uk/media/6447a18af126830011ca675a/MMO1264_U12m_Fishing.pdf

²⁰ <https://www.ices.dk/data/maps/Pages/ICES-statistical-rectangles.aspx>

²¹ <http://www.fao.org/fishery/topic/1617/en>

Landed Weight (tonnes)	Quantity of fish when landed into port. This may be less than the live weight caught if fish have been processed (e.g. gutted or shelled) on board a vessel before landing into port. In this dataset, weight is provided in tonnes rounded to two decimal places.
Value (£)	Value of fish in pound sterling (£) at first point of sale. These figures are nominal and so have not been adjusted for inflation. The MMO recommends this is taken into account when completing any economic analysis or comparing value data over time. Any sales recorded in a currency other than Sterling (GBP) are converted to GBP for consistency.
Time spent (hours)	This is the sum of estimated time (hours) spent in an area by all UK and Crown Dependency 12 metre and over vessels. This variable has been measured by summing the time difference between all VMS recordings ('pings') in an area. Pings identified as being on land or in harbour are removed, therefore this is considered time spent at sea. VMS legislation requires location information for the vessel every 2 hours; however, the frequency can differ such as 3 minute or 1 hour ping intervals.
Fishing effort (hours)	This is the sum of estimated time (hours) spent fishing in an area by all UK and Crown Dependency 12 metre and over vessels. This variable has been measured by calculating the time difference between all VMS recordings ('pings') in an area and summing the time for pings that have been assigned as fishing activity. Assigning fishing activity is done using gear-specific speed profiles. Fishing effort is counted whether or not landings are allocated to those positions.

10. Annex B: Fishing-speed model outputs

This annex presents the all-gear and gear-specific statistical model (Gaussian mixture model) outputs supporting the fishing-speed classification methodology. The accompanying tables and figures show the fitted model parameters, vessel-speed distributions and derived upper fishing-speed thresholds by gear.

Table 7: All gears Gaussian mixture model component parameters

Component	Mean Speed (knots)	Standard Deviation	Mixing Proportion
Fishing	2.7	1.5	76%
Steaming	8.0	1.5	24%

Table 8: Gear-specific Gaussian mixture model component parameters

Gear code	VMS records	Fishing mean (knots)	Steaming mean (knots)	SD (knots)	Upper threshold (knots)
OTB	635,552	2.7	8.1	1.2	5.8
DRB	446,371	2.6	7.3	1.2	5.3
TBB	214,756	3.7	8.4	1.6	7.4
FPO	200,042	2.2	6.8	1.5	4.5
OTT	164,518	2.5	7.6	1.2	5.4
PTB	78,651	3.1	9.1	1.1	6.3
SSC	64,447	1.7	9.0	1.5	5.4
TBN	60,479	2.2	7.1	1.0	5.0
GNS	47,182	2.1	7.3	1.5	5.0
OTM	26,507	1.7	12.1	2.2	6.8
LLS	22,994	1.8	8.9	1.4	5.6
LL	16,197	1.5	8.4	1.3	5.1
GN	9,148	2.3	6.9	1.4	4.8
HMD	8,243	0.1	5.5	1.2	2.8
PTM	6,801	2.9	10.1	2.3	6.4
TB	6,503	1.8	7.1	1.2	4.9
FIX	2,084	0.1	6.7	0.6	3.5
GTR	1,911	2.5	6.8	1.4	4.9
PS	1,386	0.5	7.3	1.5	3.7

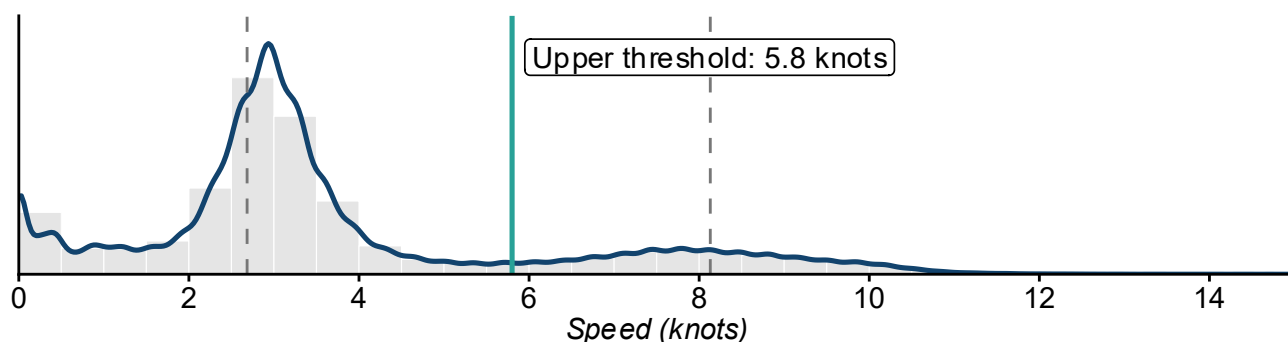
Note: Gear codes follow the [FAO International Standard Statistical Classification of Fishing Gear \(ISSCFG\)](#)²². Fishing and steaming represent the lower- and higher-speed components, respectively, of the two-component equal-variance Gaussian mixture models. SD is the standard deviation shared by both components. The upper threshold is the vessel speed at which the posterior probability of fishing falls to 0.50. Only gears for which a gear-specific model was fitted are shown.

²² <https://openknowledge.fao.org/items/4de1cb7a-34e3-4645-ae94-0cfc3ef4ad70>

Figure 5: Vessel speed distributions and Gaussian mixture model outputs by gear

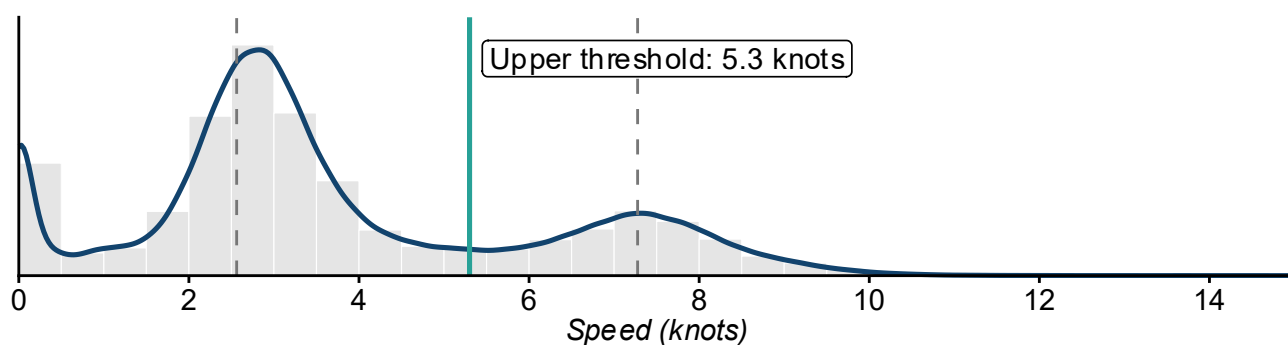
Otter trawls - bottom (OTB)

Records: 635,552 | Fishing mean: 2.7 knots | Steaming mean: 8.1 knots | SD: 1.2 knots



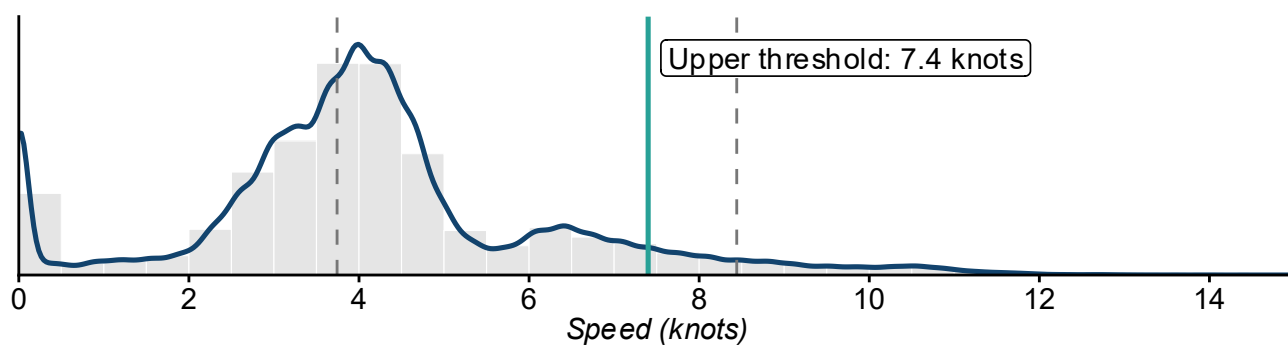
Boat dredges (DRB)

Records: 446,371 | Fishing mean: 2.6 knots | Steaming mean: 7.3 knots | SD: 1.2 knots



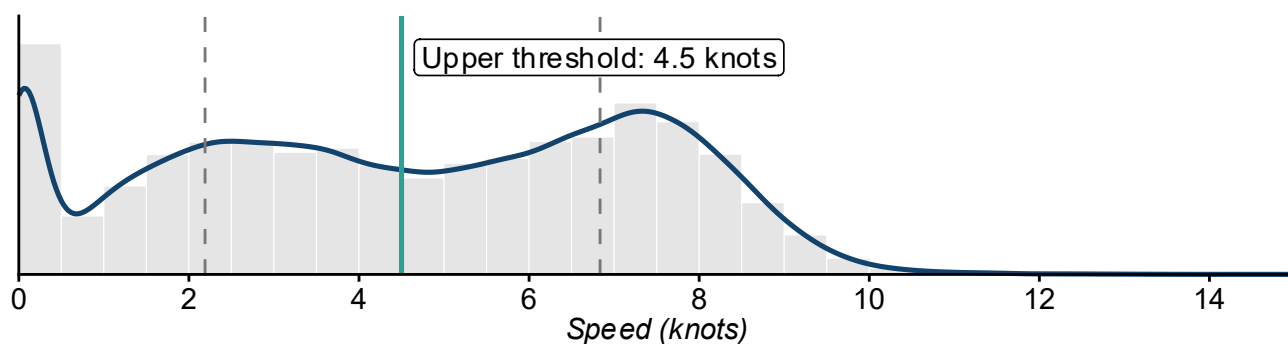
Beam trawls (TBB)

Records: 214,756 | Fishing mean: 3.7 knots | Steaming mean: 8.4 knots | SD: 1.6 knots



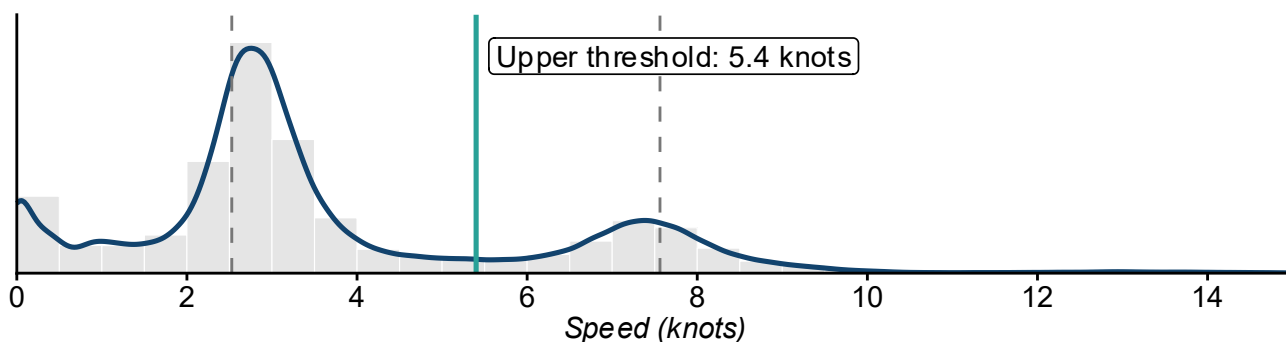
Pots (FPO)

Records: 200,042 | Fishing mean: 2.2 knots | Steaming mean: 6.8 knots | SD: 1.5 knots



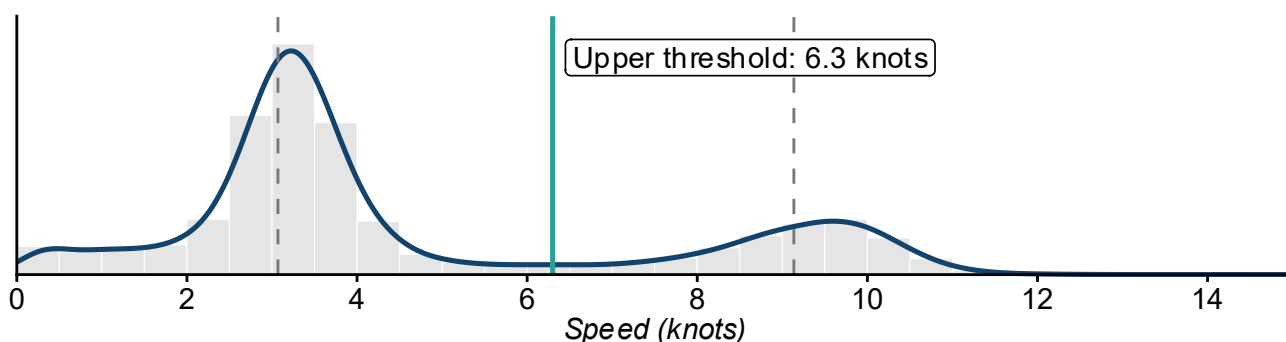
Otter twin trawls (OTT)

Records: 164,518 | Fishing mean: 2.5 knots | Steaming mean: 7.6 knots | SD: 1.2 knots



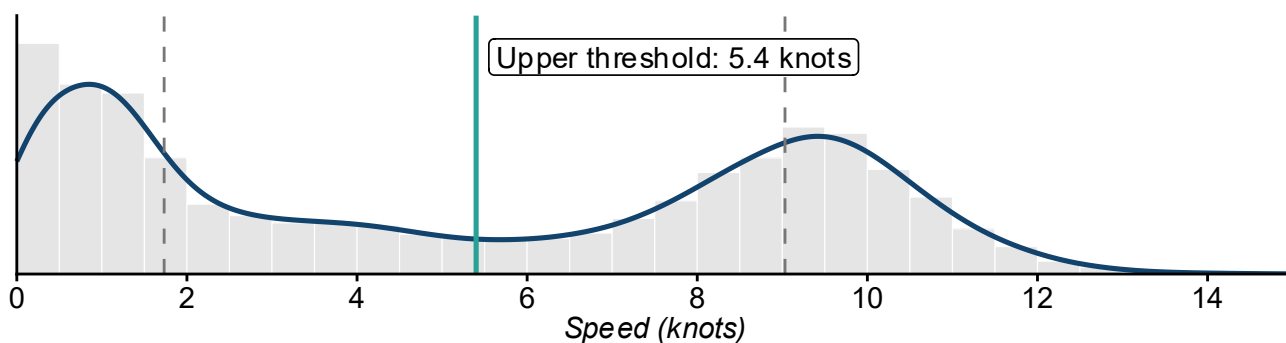
Pair trawls - bottom (PTB)

Records: 78,651 | Fishing mean: 3.1 knots | Steaming mean: 9.1 knots | SD: 1.1 knots



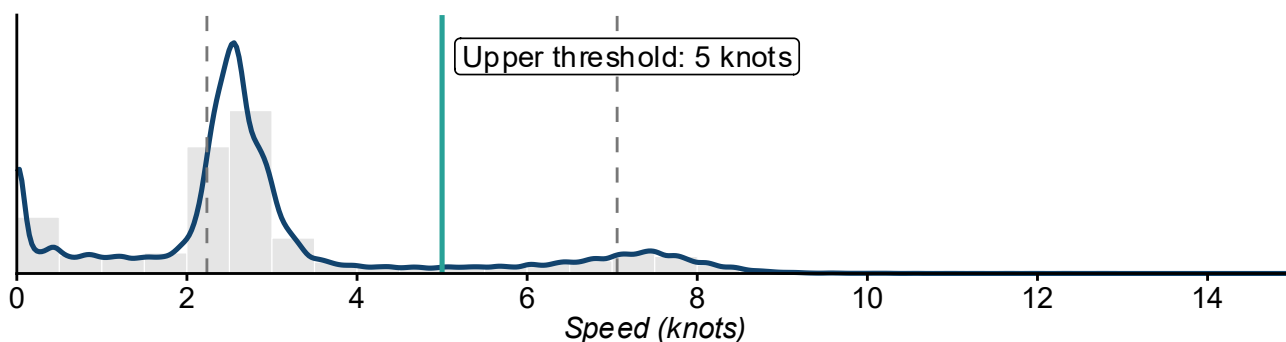
Scottish seines (SSC)

Records: 64,447 | Fishing mean: 1.7 knots | Steaming mean: 9.0 knots | SD: 1.5 knots



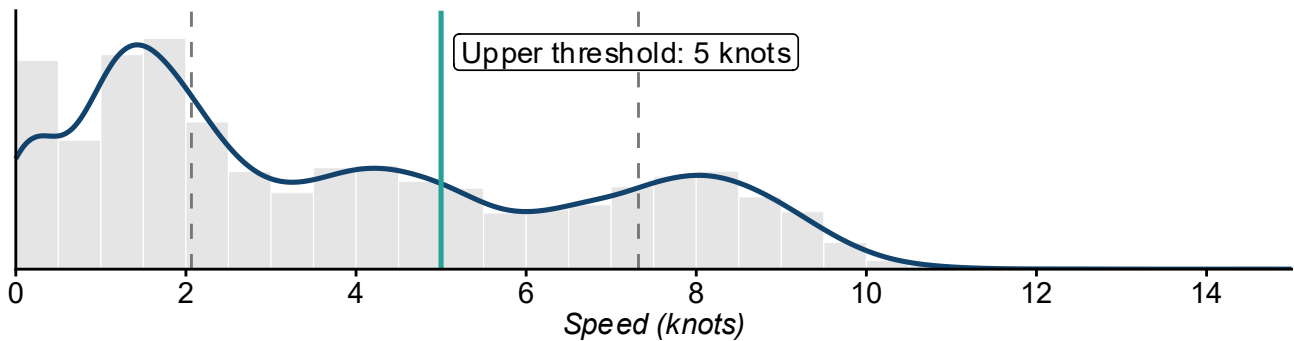
Nephrops trawls (TBN)

Records: 60,479 | Fishing mean: 2.2 knots | Steaming mean: 7.1 knots | SD: 1.0 knots



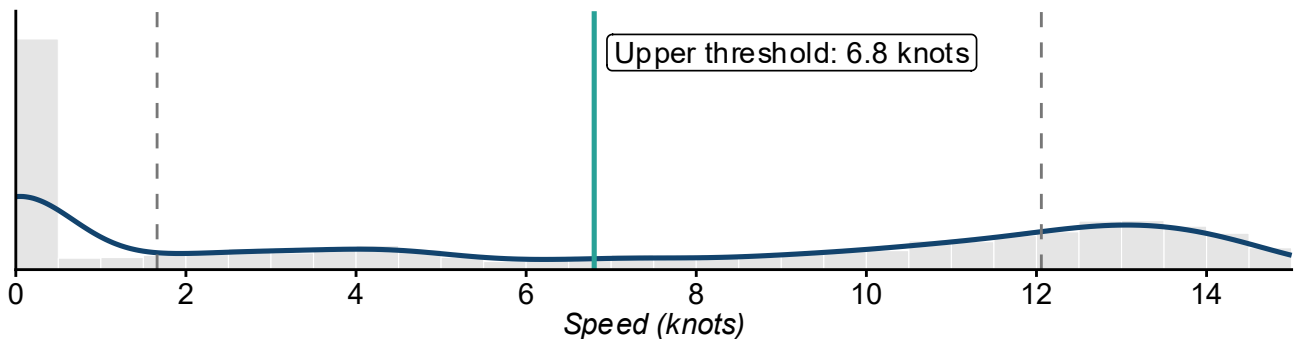
Set gillnets (anchored) (GNS)

Records: 47,182 | Fishing mean: 2.1 knots | Steaming mean: 7.3 knots | SD: 1.5 knots



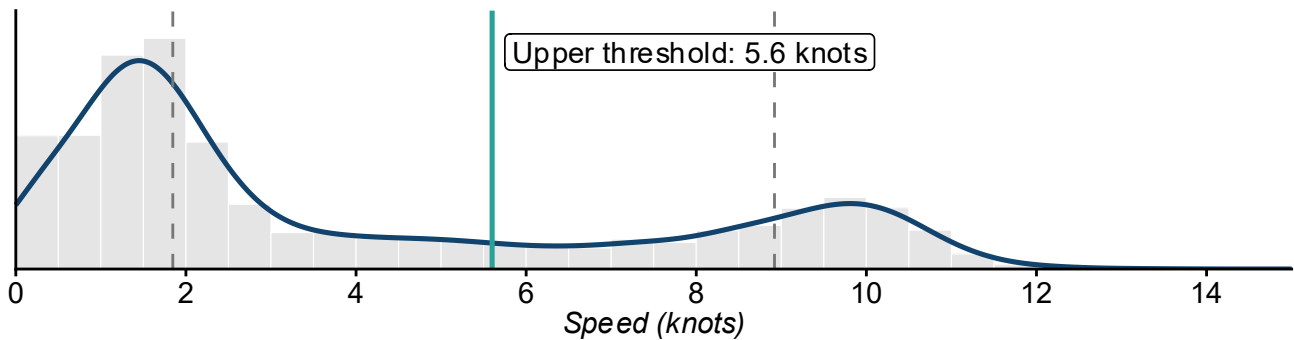
Otter trawls - midwater (OTM)

Records: 26,507 | Fishing mean: 1.7 knots | Steaming mean: 12.1 knots | SD: 2.2 knots



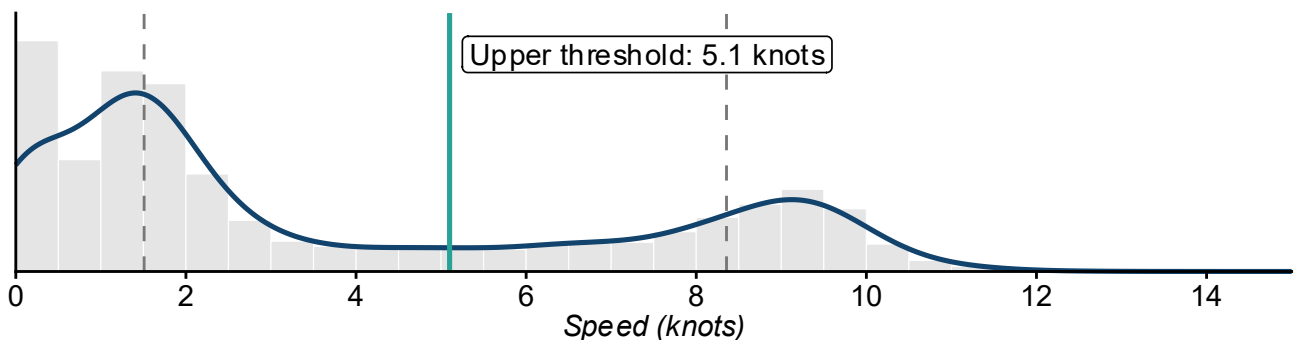
Set longlines (LLS)

Records: 22,994 | Fishing mean: 1.8 knots | Steaming mean: 8.9 knots | SD: 1.4 knots



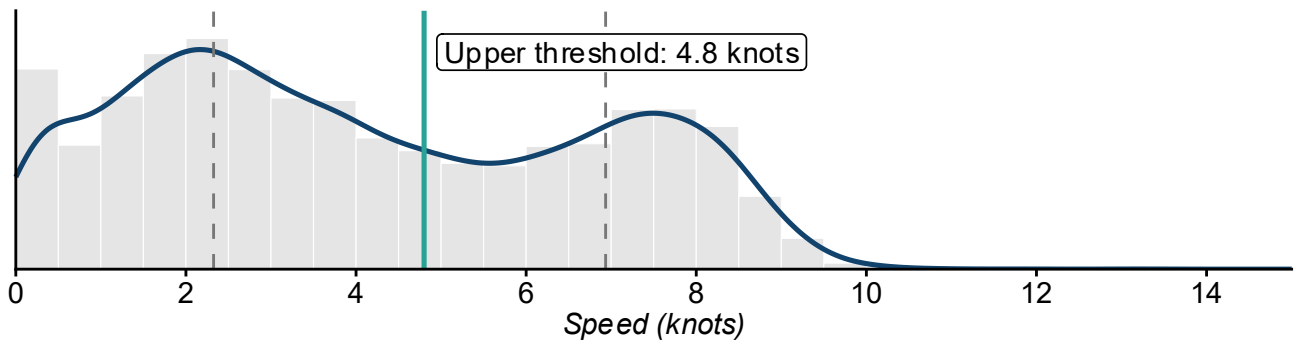
Longlines (not specified) (LL)

Records: 16,197 | Fishing mean: 1.5 knots | Steaming mean: 8.4 knots | SD: 1.3 knots



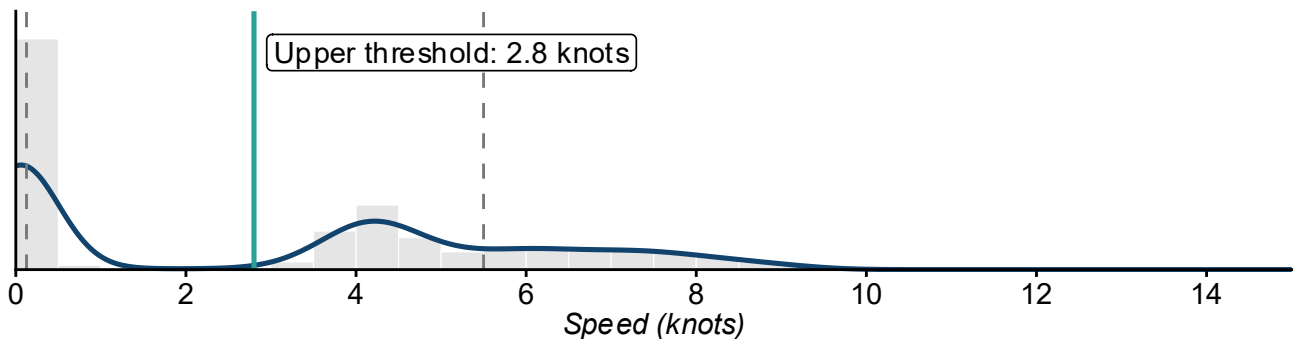
Gillnets (not specified) (GN)

Records: 9,148 | Fishing mean: 2.3 knots | Steaming mean: 6.9 knots | SD: 1.4 knots



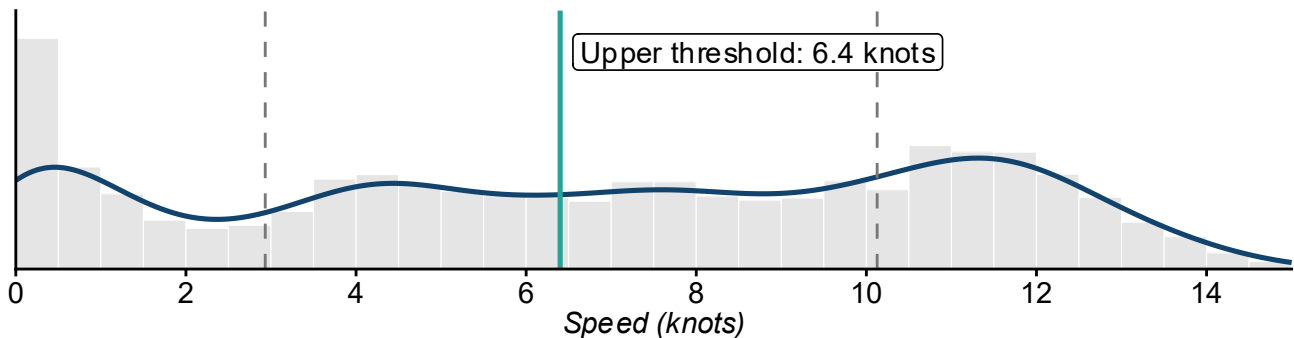
Mechanized dredges (HMD)

Records: 8,243 | Fishing mean: 0.1 knots | Steaming mean: 5.5 knots | SD: 1.2 knots



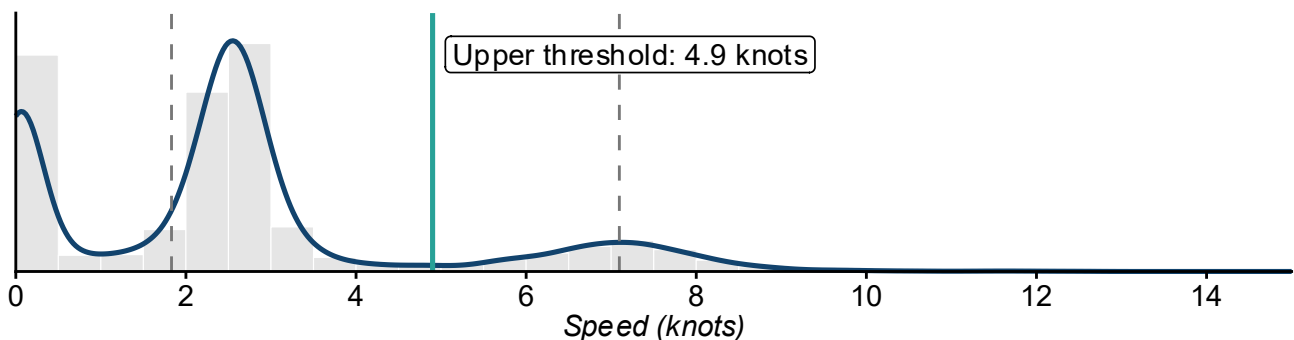
Pair trawls - midwater (PTM)

Records: 6,801 | Fishing mean: 2.9 knots | Steaming mean: 10.1 knots | SD: 2.3 knots



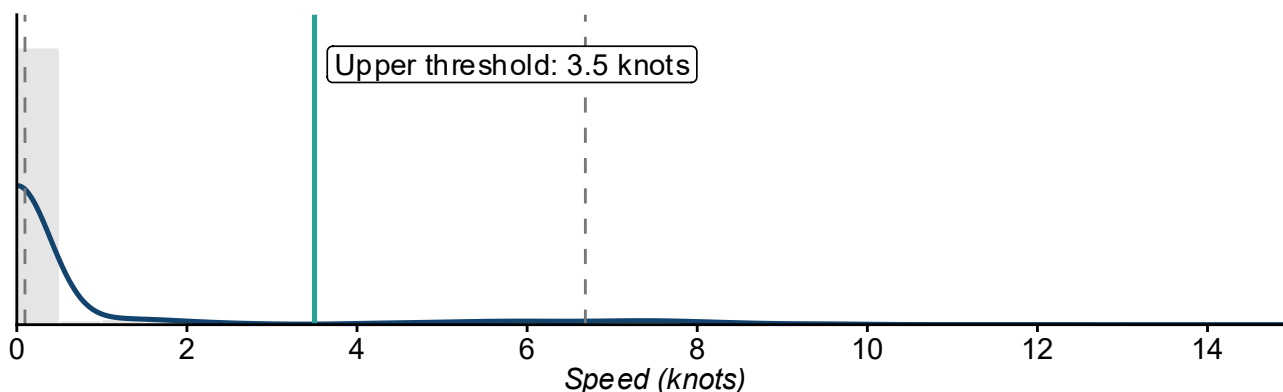
Bottom trawls nes (TB)

Records: 6,503 | Fishing mean: 1.8 knots | Steaming mean: 7.1 knots | SD: 1.2 knots



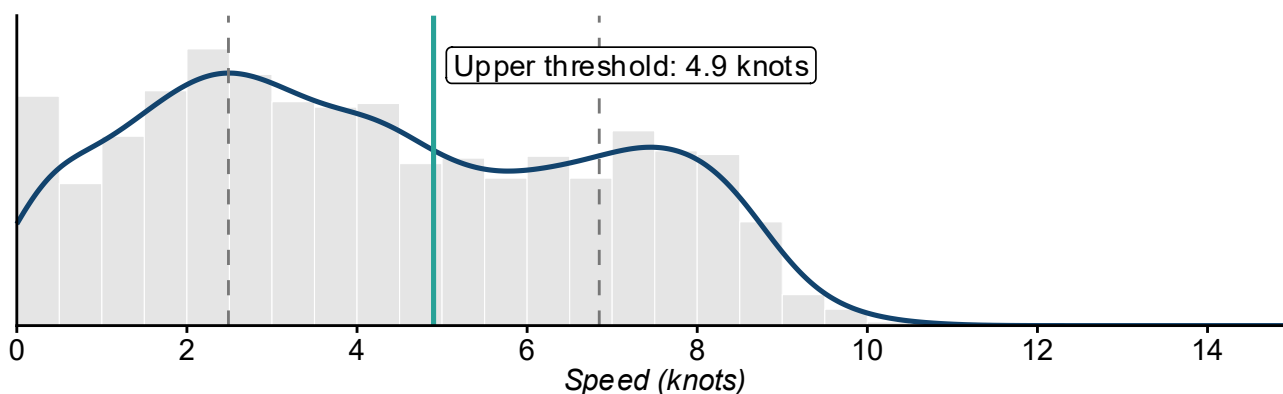
Traps (not specified) (FIX)

Records: 2,084 | Fishing mean: 0.1 knots | Steaming mean: 6.7 knots | SD: 0.6 knots



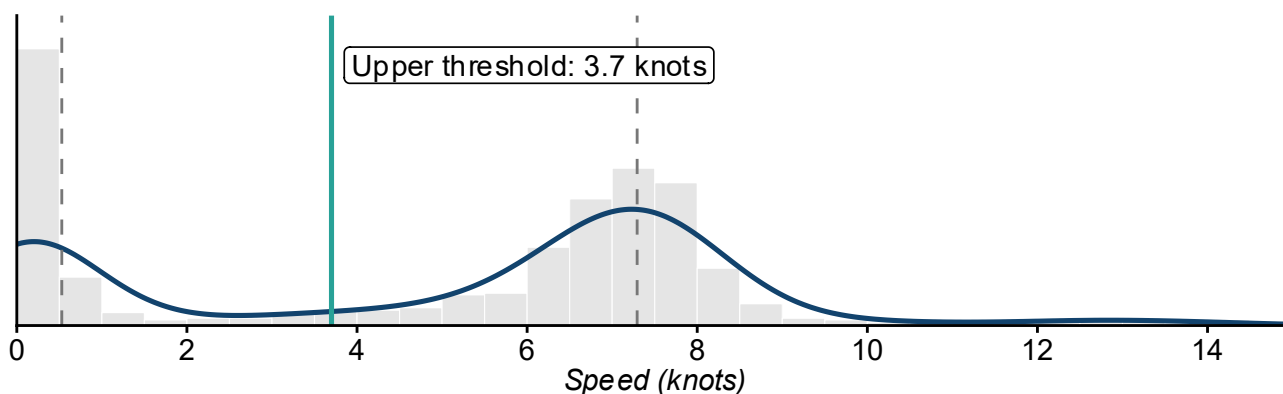
Trammel nets (GTR)

Records: 1,911 | Fishing mean: 2.5 knots | Steaming mean: 6.8 knots | SD: 1.4 knots



With purse lines (purse seines) (PS)

Records: 1,386 | Fishing mean: 0.5 knots | Steaming mean: 7.3 knots | SD: 1.5 knots



Description of Figure 5: Modelled speed distributions vary across the 19 gears shown. The upper fishing speed threshold ranges from 2.8 knots for mechanized dredges to 7.4 knots for beam trawls. Grey histograms and blue curves show the observed distribution of vessel speeds for each gear. Grey dashed lines indicate the mean speeds of the modelled fishing and steaming components. The teal line shows the upper fishing-speed threshold, corresponding to $P(\text{Fishing}) = 0.50$. SD is the shared standard deviation of the two components. Y-axis values are omitted because the charts are intended to show the shape of the speed distributions and derived thresholds rather than support comparisons of density magnitude between gears. All charts use a common 0 to 15 knot speed scale.