Evidence on the distribution and population structure of Atlantic herring (*Clupea harengus*) in Welsh waters

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Author name: Stacy, R., Mele, I., Vella, E., Pearce, J., and Davie, S.

Author affiliation: MRAG Ltd

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Crynodeb gweithredol

Mae gan ddyfroedd Cymru ystod amrywiol o gynefinoedd gwely'r môr a cholofn ddŵr sy'n cynnal llawer o rywogaethau o bysgod morol o werth cadwraethol, ecolegol, masnachol a hamdden. Er mwyn llywio ein cyngor ar gadwraeth natur, mae Cyfoeth Naturiol Cymru (CNC) yn anelu at ddefnyddio'r dystiolaeth orau sydd ar gael ynghylch ble i ddod o hyd i'r rhywogaethau o bysgod hyn, ble mae'r ardaloedd pwysig i'r rhywogaeth, a sut y mae'r rhywogaethau yn defnyddio dyfroedd Cymru ar draws eu cylchred oes.

Mae'r adroddiad hwn wedi adolygu a syntheseiddio'r dystiolaeth sydd ar gael ar ddosbarthiad a strwythur poblogaeth y pennog (*Clupea harengus*) yn nyfroedd Cymru. Mae'r adroddiad yn darparu sylfaen dystiolaeth wedi ei choladu ar gyfer y rhywogaeth hon i'w defnyddio gan CNC, ac y mae hefyd yn nodi bylchau allweddol yn y dystiolaeth.

Dewiswyd y rhywogaeth hon fel un â blaenoriaeth gychwynnol yn seiliedig ar ein hanghenion o ran cyngor cadwraeth, ac fel y'i rhestrir o dan adran 7 o Ddeddf yr Amgylchedd (Cymru) 2016 Rhestr Adran 7: rhywogaethau a chynefinoedd o bwysigrwydd pennaf yng Nghymru | LLYW.CYMRU. Gall y dystiolaeth sydd yn yr adroddiad hwn fod yn ddefnyddiol hefyd i sefydliadau eraill wrth reoli penwaig yn nyfroedd Cymru, neu asesu effeithiau arnynt.

Mae'r adroddiad wedi cyfuno adolygiad systematig o lenyddiaeth academaidd gyhoeddedig ac adroddiadau technegol, wedi ei ategu gan ddadansoddiad pwrpasol o setiau data arolygon sy'n annibynnol ac yn ddibynnol ar bysgodfeydd sy'n bodoli eisoes, a thystiolaeth anecdotaidd pan fo ar gael. Mae'r setiau data arolwg sydd wedi eu dadansoddi yn cynnwys rhaglenni arolwg rhyngwladol sy'n mynd rhagddynt ac a gydlynir gan Gyngor Rhyngwladol Archwilio'r Môr (ICES) a rhaglenni arolwg cenedlaethol a gydlynir gan Ganolfan Gwyddorau'r Amgylchedd, Pysgodfeydd a Dyframaethu (CEFAS) a CNC, yn ogystal â setiau data hanesyddol.

Mae'r adolygiad wedi canolbwyntio ar ddyfroedd Cymru ac ardaloedd cyffiniol Môr Iwerddon, y Môr Celtaidd a Môr Hafren, gan gydnabod pwysigrwydd cysylltedd rhanbarthol. Mae'r dystiolaeth wedi ei dadansoddi a'i chyflwyno yn ôl camau bywyd allweddol a phrosesau cylchred oes (wyau, larfâu, pysgod ifanc, meithrinfeydd, oedolion a silio) er mwyn caniatáu cymhariaeth rhwng camau bywyd a rhywogaethau.

Mae penwaig yn silio mewn sawl ardal o ddyfroedd Cymru, gan gynnwys oddi ar arfordir y Gogledd, Aberdaugleddau a Môr Hafren, ac mae'r gwaith wedi ei ategu gan arolygon o wyau, dosbarthiad oedolion ac arsylwadau pysgotwyr. Mae silfeydd cysylltiedig ger Ynys Manaw ac Iwerddon hefyd yn dylanwadu ar ddyfroedd Cymru, oherwydd bod cerhyntau llanw cryf yn cludo larfae penwaig ar draws y Môr Celtaidd a Môr Iwerddon, gyda larfae penwaig yn doreithiog oddi ar y Gogledd ac Ynys Manaw. Fodd bynnag, mae bwlch data mawr yn bodoli ar gyfer Bae Aberteifi, Môr Hafren a'r Môr Celtaidd.

Mae penwaig ifanc wedi eu dosbarthu'n eang ar draws dyfroedd Cymru, yn enwedig mewn baeau ac aberoedd mewndirol, ac mae astudiaethau yn nodi meithrinfeydd penwaig hanfodol y tu allan i aber afon Dyfrdwy ac ar hyd arfordir y De. Mae penwaig llawndwf yn byw yn bennaf oddi ar y lan yn y Môr Celtaidd a Môr Iwerddon, gyda dwyseddau is wedi

eu cofnodi mewn ardaloedd ar y glannau, ond gydag ardaloedd allweddol penodol fel Aberdaugleddau ac o amgylch Ynys Môn yn cael eu nodi gan genweirwyr sy'n dal pysgod mwy yn rheolaidd ar y glannau.

Yn nyfroedd Cymru, mae penwaig o Fôr Iwerddon a'r Môr Celtaidd yn cymysgu, gyda physgod ifanc yn aml yn teithio o'r Môr Celtaidd i Fôr Iwerddon, tra bod grwpiau gwahanol yn silio ar wahanol adegau mewn ardaloedd fel Aberdaugleddau, Clovelly a Minehead.

Canfuwyd bod cwmpas ac ansawdd y dystiolaeth a nodwyd yn ystod yr adolygiad yn amrywio'n ofodol. Mae Môr Iwerddon (gan gynnwys Bae Lerpwl) yn gymharol gyfoethog o ran data ar gyfer penwaig, gyda llu o setiau data yn dangos patrymau cyson mewn llawer o achosion. Mewn cyferbyniad, mae gwybodaeth o fewn Bae Aberteifi, Môr Hafren a'r Môr Celtaidd yn fwy cyfyngedig. Yn gyffredinol, nid yw cynefinoedd bas, ar y glannau neu anodd eu samplu wedi eu cynrychioli cystal yn y data, gan adael rhai mannau problemus arfordirol yn debygol o fod heb eu cofnodi. Mae cwmpas amseryddol y data yn amrywio, gyda llawer o arolygon blynyddol yn cael eu cynnal yn ystod tymor penodol yn unig bob blwyddyn, sy'n cyfyngu ar ddealltwriaeth o amrywioldeb tymhorol a rhyngflynyddol, ac ychydig o arolygon sy'n darparu cyfres amser gyflawn a pharhaus o ddata. Yn olaf, mae ansicrwydd ynghylch union leoliad a maint y silfeydd, sy'n adlewyrchu gwahaniaethau mewn ffynonellau data a dulliau.

At ei gilydd, mae'r adroddiad yn darparu tystiolaeth sy'n nodi ardaloedd pwysig o fewn dyfroedd Cymru ar gyfer penwaig, yn enwedig ar gyfer camau cynnar bywyd. Mae'r adroddiad wedi tynnu sylw at fylchau clir mewn tystiolaeth a data ar gyfer dyfroedd Cymru ar gyfer y rhywogaethau hyn, gan gynnwys yn achos ardaloedd a thymhorau sydd wedi eu samplu'n ddigonol. I lenwi'r bylchau hyn, byddai angen gwaith monitro cyson a hirdymor, y gellid ei ymgorffori wedyn â gwybodaeth amgylcheddol ehangach.

Executive summary

Welsh waters have a diverse range of seabed and water column habitats that support many marine fish species of conservation, ecological, commercial and recreational value. To inform our nature conservation advice, Natural Resources Wales (NRW) aims to use the best-available evidence on where these fish species occur, where important areas for the species are located and how the species use Welsh waters across their life cycles.

This report has reviewed and synthesised the available evidence on the distribution and population structure of Atlantic herring (*Clupea harengus*) within Welsh waters. The report provides a collated evidence base for this species for use by NRW, and also identifies key evidence gaps.

This species was selected as initial priority species based on our conservation advice needs and as it is listed under Section 7 of the Environment (Wales) Act 2016 Section 7 list: species and habitats of principal importance in Wales | GOV.WALES. The evidence contained within this report may also be useful for other organisations when managing, or assessing impacts upon, herring in Welsh waters.

The report has combined a systematic review of published academic literature and technical reports, supported by targeted analysis of existing fisheries-independent and dependent survey datasets, and anecdotal evidence where available. The survey datasets that have been analysed include ongoing international survey programmes coordinated by the International Council for the Exploration of the Sea (ICES) and national survey programmes coordinated by Centre for Environment, Fisheries and Aquaculture Science (Cefas) and NRW, as well as historical datasets.

The review has focused on Welsh waters and adjacent areas of the Irish Sea, Celtic Sea, and Bristol Channel, recognising the importance of regional connectivity. The evidence has been analysed and presented by key life stages and life cycle processes (eggs, larvae, juveniles, nursery grounds, adults and spawning) to allow comparison between life stages and species.

Herring spawn in several areas of Welsh waters, including off the North Wales coast, Milford Haven, and the Bristol Channel, supported by egg surveys, adult distributions and fisher observations. Connected spawning grounds near the Isle of Man and Ireland also influence Welsh waters, as strong tidal currents transport herring larvae across the Celtic and Irish Seas, with herring larvae are abundant off North Wales and the Isle of Man. However, a major data gap exists for Cardigan Bay, the Bristol Channel, and the Celtic Sea.

Juvenile herring are widely distributed across Welsh waters, especially in inshore bays and estuaries, and studies identify crucial herring nursery grounds outside the Dee Estuary and along the South Wales coast. Adult herring live mainly offshore in the Celtic Sea and Irish Sea, with lower densities recorded in inshore areas, but with particular key areas like the Milford Haven and around Anglesey identified by anglers regularly catching larger fish inshore.

In Welsh waters, herring from the Irish Sea and Celtic Sea mix, with young fish frequently travelling from the Celtic Sea into the Irish Sea, while distinct groups spawn at different times in areas like Milford Haven, Clovelly, and Minehead.

The coverage and quality of evidence identified during the review has been found to vary spatially. The Irish Sea (including Liverpool Bay) is relatively rich in data for herring, with multiple datasets showing consistent patterns in many cases. In contrast, information within Cardigan Bay, the Bristol Channel and the Celtic Sea is more limited. Shallow, inshore or difficult to sample habitats are also generally less well represented within the data leaving some coastal hotspots likely unrecorded. Temporal coverage of the data varies, with many annual surveys only carried out during a specific season each year which limits understanding of seasonal and interannual variability, and with few surveys providing a complete and ongoing time-series of data. Finally, there is uncertainty in the precise location and extent of spawning grounds, reflecting differences in data sources and methods.

Overall, the report provides evidence identifying important areas within Welsh waters for herring, particularly for early life stages. The report has highlighted clear gaps in evidence and data for Welsh waters for these species including in under sampled areas and seasons. To fill these gaps, consistent and long-term monitoring would be necessary, which could then be integrated with wider environmental information.

1 Introduction

Welsh waters encompass parts of the Irish Sea, Celtic Sea, Bristol Channel, St George's Channel and Cardigan Bay, and ICES areas 7a, 7f and 7g (Figure 1). They support a diverse assemblage of marine fish species that are integral to the functioning of marine ecosystems and the sustainability of marine fisheries. Seabed and water column habitats in Welsh waters provide a wide range of environmental conditions and support many different marine fish species of conservation, ecological and commercial value.

To inform our nature conservation advice, Natural Resources Wales (NRW) aims to use the best-available evidence on where these fish species occur, where important areas for the species are located and how the species use Welsh waters across their life cycles.

To provide a collated evidence base for use by NRW, and identify evidence gaps, this report has reviewed and synthesised the available evidence on the distribution and population structure of herring (*Clupea harengus*) within Welsh waters.

This species is listed under Section 7 of the Environment (Wales) Act 2016 Section 7 list: species and habitats of principal importance in Wales | GOV.WALES and was selected by NRW as an initial priority species based on a combination of conservation, ecological and commercial value, as well as their relevance to current NRW conservation advice needs.

Herring has depleted populations in Welsh waters and is under pressure from multiple factors, including climate change, habitat degradation, and fishing mortality. The species fulfil important an trophic role and position in marine food webs, including as key prey species for a range of predators such as piscivorous fish, seabird, and marine mammal species. Finally, the species is of commercial and recreational importance in fisheries in Welsh and wider UK waters.

This report presents the results of the analysis of identified literature and data sources, which have been reviewed and synthesised to present evidence on the distribution and population structure of herring in Welsh waters. The evidence has been analysed and presented for each species by key life stages and life cycle processes (eggs, larvae, juveniles, nursery grounds, adults and spawning) to allow comparison between life stages and species.

Welsh inshore waters have been defined in this report as fully-marine and estuarine waters within 12 nautical miles of baselines, and Welsh offshore waters have been defined in this report as all waters outside 12 nautical miles of baselines to the limit of the Welsh Zone. Both Welsh inshore and offshore waters are shown on Figure 1.

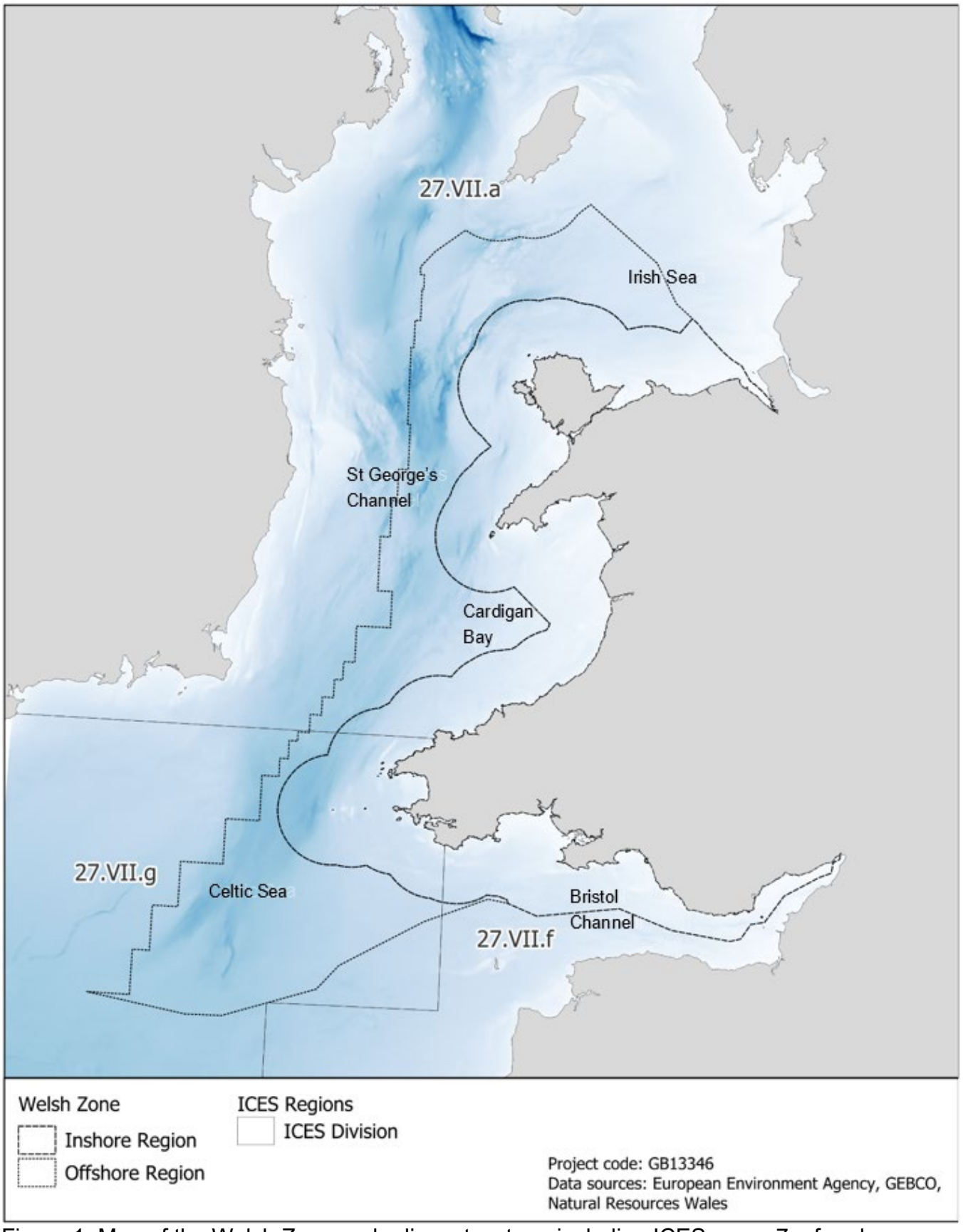


Figure 1. Map of the Welsh Zone and adjacent waters, including ICES areas 7a, f and g.

2 Evidence review methodology

2.1 Literature search

A literature review was conducted to identify published evidence sources relevant to herring in Welsh waters. All literature searches were undertaken using Google Scholar. Search strings were developed to capture key biological, ecological, behavioural, environmental, and fisheries-related themes relevant to each species. The full list of search terms used is provided in Appendix 1.

Five distinct search strings were applied for the literature search. For each search string, the first 50 search results were downloaded. Each search result was tagged according to the search string from which it was identified to retain information on search provenance.

All search results were imported into a Zotero reference library. Duplicate records were identified and removed based on title matching. Where duplicate records were identified across multiple search strings, tags were merged to ensure that papers captured by more than one search string retained all relevant search term identifiers.

Records were then screened sequentially by title and abstract to assess their relevance to the project. During screening, studies were considered relevant if they

(i) focused on populations within the assessment area (Irish and Celtic Seas recognising the importance of regional connectivity);

(ii) provided biological, ecological, behavioural, or fisheries-related information applicable to the life stages included in this study; or

(iii) addressed themes directly aligned with the project objectives (e.g. spatial distribution, habitat use and environmental drivers).

Studies lacking geographical, stock-specific, life-stage, or thematic alignment were excluded at this stage.

All search results that passed title and abstract screening were subsequently reviewed in full. Relevant information was extracted and synthesised, with findings incorporated into the report under the appropriate thematic sections. No formal meta-analysis was undertaken; instead, the review aimed to provide a structured synthesis of the available evidence to support interpretation and discussion of species distributions at various life stages.

Within the project Zotero database developed to support the literature review, references were tagged according to search origin and search strategy. References cited within the report have been provided separately in Appendix 2 with associated confidence scores based on a defined confidence assessment scoring framework.

Confidence was assessed using two criteria:

(1) type and quality of source, and

(2) applicability of the evidence to Welsh waters.

Source type and quality was categorised as either High (peer-reviewed literature or official government scientific publications), Medium (scientific grey literature), or Low (non-scientific sources such as media or blog content).

Applicability of the evidence was categorised as either High (data collected specifically within Welsh waters or at a scale explicitly including Welsh waters), Medium (data from adjacent or ecologically comparable waters), or Low (broad NE Atlantic-scale data where Welsh waters form only a small component and spatial resolution limits direct inference).

Each confidence category was assigned a numerical score (High = 5, Medium = 3, Low = 1) and scores were summed to produce an overall confidence rating of Low, Medium, or High.

2.2 Online data sources and data handling

Data on the distribution of herring in Welsh waters were identified through targeted searches of online data repositories, supplemented by information shared by NRW. Key sources included fisheries landings and recreational sea-angling data, NRW estuarine fish survey datasets, the Cefas Data Hub, Marine Scotland Directorate data, Marine Institute data, ICES data repositories (Database of Trawl Surveys (DATRAS) and egg and larvae datasets), and AquaMaps. These sources provide a mixture of fishery-dependent, and fisheries-independent data, monitoring datasets and environmental observations covering Welsh waters and adjacent areas.

ICES DATRAS data were accessed using the ICES Datras R package (ICES, 2024). Surveys intersecting Welsh waters from the database (including Beam Trawl Survey (BTS), Irish Groundfish Survey (IE-IGFS), Northern Ireland Groundfish Survey (NIGFS), Évaluation Halieutique de l'Ouest Européen (EVHOE), Scottish West Coast Groundfish Survey (SCOWCGFS), and Scottish West Coast Bottom Trawl Survey (SWC-IBTS)) were downloaded for the period 2000–2025, covering all available quarters of the year. Both haul-level and length-frequency data were retrieved for the target species. Haul positions were spatially filtered to a broad bounding box encompassing Welsh waters (longitude −8° to −2°, latitude 50° to 56°) to ensure consistency.

Length data from all datasets were used to classify individuals into juvenile and adult life stages using size thresholds reported by Campanella and van der Kooij (2021): with juveniles being classified as having a total length of ≤17 cm for herring. This approach allowed for a consistent separation of life stages across datasets where length information was available.

Spatial outputs derived from data sources were summarised using simple aggregations appropriate to the structure of each dataset. Several datasets and publications report sampling periods with reference to the quarter in which the samples were taken. To ensure consistency, we use calendar Quarters throughout this report: Quarter 1 (Q1) spans January–March, Quarter 2 (Q2) April–June, Quarter 3 (Q3) July–September, and Quarter 4 (Q4) October–December. For DATRAS data, haul-level information was summarised by

quarter and aggregated across all available years to illustrate broad seasonal spatial patterns. Where egg or larval data included developmental stages, these were mapped separately. Finally, where data were reported only by period or quarter, spatial outputs reflect those reporting structures.

Where possible, original source data were mapped directly in QGIS. In some instances, data were first processed in R to combine and/or summarise inputs before mapping. The content and resolution of spatial data and mapping varied depending on the underlying data source, with outputs designed to reflect the level of detail supported by the data.

Egg and larval data were also explored through ICES web query tools, with additional plankton survey datasets relevant to the Celtic Sea, Irish Sea, and Bristol Channel identified (including the English Channel and Celtic Sea Sardine and Anchovy plankton survey, Eastern Irish Sea (EIS) Smart Buoy Samples Project Plankton Survey and Zooplankton abundance data derived from the Plankton Imager system from the Western English Channel and Eastern Irish Sea from 2016 to 2019). However, coverage for herring within Welsh waters was extremely limited within these data. Available records were sparse, sometimes spatially inconsistent, and in several cases lacked species-level resolution or associated length or developmental information. As a result, these datasets were not analysed further for the project.

Spatial data for the project is provided in Appendix 4.

2.2.1 Common data sources

There are several data sources that are used for multiple lifestages in this report. These data sources are primarily the results of surveys conducted in or around Welsh waters. The surveys may have been single year surveys, or conducted across multiple years using the same data collection principles each time to allow changes over time to be identified. The spatial and temporal coverage of these overarching data sources are provided in Table 1, and described as follows:

- **Fisheries spawning and nursery areas in British waters (Coull *et al.*, 1998)** – This dataset provides GIS layers of the main spawning and nursery grounds for 14 commercially important species (including cod, haddock, whiting, herring, mackerel, plaice, sole, sandeels, sprat, and Norway lobster) around the UK. The maps were compiled from data collected by Fisheries Research Services (FRS) and Cefas during the 1990s and represented the widest known distribution of spawning and nursery areas based on egg, larval, juvenile, and adult fish surveys, sediment sampling, and acoustic techniques at the time. Data are presented at ICES rectangle resolution and include species-specific spawning periods and indicative nursery grounds, alongside additional layers on fishing effort and relative economic value.
- **Spawning and nursery grounds of selected fish species in UK waters (Ellis *et al.*, 2012)** – This dataset updates and complements the original Fisheries Sensitivity Maps in British Waters (Coull *et al.*, 1998) by incorporating more recent ichthyoplankton and groundfish survey data and expanding coverage to additional

species of commercial and conservation interest. There are GIS layers for spawning and nursery grounds of 21 species, including cod, herring, whiting, plaice, sole, mackerel, sandeels, and several elasmobranchs (e.g. spurdog, tope, skates, rays). Spawning grounds were inferred from egg and larval distributions in ichthyoplankton surveys, while nursery grounds were identified from juvenile occurrence and catch rates in fishery-independent trawl surveys. Data are mapped at half ICES statistical rectangle resolution, with additional layers indicating sites of higher importance where evidence permitted.

- **Spawning and nursery grounds of forage fish in Welsh and surrounding waters (Campanella and van der Kooij, 2021)** – This study used fisheries-independent acoustic and trawl survey data from 2008–2020 to map key spawning and nursery areas of forage fish across Welsh and adjacent marine waters (Irish Sea, Celtic Sea, western English Channel). A hotspot approach combined multiple surveys and years in Quarters 1 and 4, to identify persistent areas where adults and juveniles were repeatedly recorded, producing indices maps of spawning and nursery grounds.
- **Species spawning and nursery areas (Marine Institute, 2018; revised 2024)** – This dataset provides polygonal locations of spawning and nursery grounds for commercially important species, including cod, herring, haddock, mackerel, and monkfish. Methodological details on how the areas were determined are not provided.
- **Annual Egg Production Method (AEPM) surveys 1995 and 2000 (Cefas 1995; 2000)** – Surveys in 1995 and 2000 collected plankton samples across the Irish Sea to estimate stock size using counts of fish eggs and larvae. They mapped spawning activity of key species (e.g. cod, sole, plaice) and provide historical evidence on species distribution.
- **Highly mobile fish species distributions in UK waters (Cefas / ABPmer, 2010)** – This dataset provides mapped distributions for 40 taxa (22 teleosts, 17 elasmobranchs, and leatherback turtle) in UK waters, collating data from multiple fishery-independent groundfish and beam-trawl surveys conducted around the UK using GOV trawl, Portuguese High Headline Trawl (PHHT), and 4-m beam trawl gears. The surveys cover a long time-series, from the early 1980s to the late 2000s (e.g. 1982–2008 depending on survey and area), and the dataset includes presence/absence by ICES rectangle for all three gear types, relative abundance (mean individuals per one-hour tow) using GOV trawl at rectangle level, and species abundance per hour tow using PHHT and beam trawl at quarter-rectangle level.
- **Assessment of potential predators of plaice eggs and larvae in the Irish Sea (Cefas, 2023)** – This dataset originates from a Cefas-led study examining potential predators of plaice *(Pleuronectes platessa)* eggs and larvae on a well-defined spawning ground off the north Wales coast in the Irish Sea during February 2008 and 2009. The study combined vertically hauled plankton sampling, acoustic surveys, and targeted trawl sampling to characterise both early life stages and the associated fish community present on the spawning grounds. Plankton samples were preserved and systematically sorted to identify fish eggs and larvae, while

trawl data provided information on the composition and spatial distribution of potential predator and co-occurring fish species. Survey coverage extended across coastal waters within the 12-nautical-mile boundary of north Wales and into adjacent Irish Sea waters off the coast of Ireland.

- **Irish Sea Fish Egg Production Surveys (ISFEPS) (Cefas, 2010)** – This data source combines Cefas-led surveys conducted in the Irish Sea in 2006, 2008, and 2010. The surveys were carried out on a planned sampling grid covering the full Irish Sea, including waters within the 12-nautical-mile boundary of north Wales, and involved systematic plankton sampling at fixed stations during multiple research vessel cruises. The dataset provides station-level counts of fish eggs and larvae, together with associated positional data and volumes filtered.
- **Sea Angling Diary catch records 2016-2024 (Cefas, 2025)** – This dataset comprises raw recreational sea angling diary records provided by Cefas. The data consist of individual fishing-session records submitted by volunteer anglers through the Sea Angling Diary programme and include information at the event level, including year (2016 – 2024), fishing session ID, fishing platform, gear type, ICES rectangle of capture, session length (hours), species recorded, whether fish were kept or returned, and reported lengths. The dataset represents primary catch records and associated fishing effort information at the scale of individual angling trips. The Sea Angling Diary survey is not designed to collect data at the ICES rectangle spatial resolution and so may not be spatially representative, so results should be treated as indicative only.
- **Commercial fisheries landings and discards data (MMO, 2025)** – This dataset contains species-level weights of retained and, where available, discarded catch for herring from fisheries operating within Welsh waters over the most recent 10-year period (2014–2024). The data are disaggregated by year, month, gear type, vessel characteristics (particularly vessel length), catch position (at ICES statistical sub-rectangle level), and landing port. No raising of these data has been conducted with the discards data presented as supplied from the MMO.
- **DATRAS Fisheries-independent trawl survey data (ICES, 2025a)** – This database includes demersal and pelagic trawl fisheries-independent surveys using consistent survey designs, gear specifications, and haul protocols, primarily conducted under the ICES International Bottom Trawl Survey framework. Data typically span multiple decades (generally from the early 1980s onwards, depending on survey and area) and provide haul-level information on species composition, abundance (numbers and weight per haul), length-frequency distributions, survey timing, gear type, and precise spatial location (latitude–longitude and ICES statistical rectangles).
- **WFD Transitional fish surveys** (**NRW, 2025**) – This dataset comprises individual length measurements for herring collected through WFD sampling programmes across Welsh marine waters. Sampling was conducted at over 100 unique sites using a range of gears, including otter trawls, beam trawls, fyke nets, and seine nets. Each record includes site identifiers, sampling date, species name, and measured fish length, with associated metadata on sampling effort and gear characteristics.

- **Essential Fish Habitats project data (Marine Directorate, 2023)** – This dataset provides spatial predictions of Essential Fish Habitats (EFH) for 17 fish and shellfish species and life stages in Scottish waters. Offshore EFH distributions were derived using species distribution models calibrated with scientific survey catch data and environmental predictors (e.g. temperature, salinity), while inshore areas were assessed using habitat proxies based on EUNIS habitat types and expert review. Modelled and proxy-derived predictions were validated against independent survey data and expert feedback.
- **AquaMaps standardized species distribution maps (Reygondeau *et al.*, 2025)** – This database contains basic range data for fish species based their environmental "envelope" as provided by Aqua-X at the Rosenstiel School of Marine, Atmospheric, and Earth Science at the University of Miami, Florida.
- **Species occurrence records in Welsh waters (OBIS, 2025)** – The Ocean Biogeographic Information System (OBIS) is a global repository of georeferenced marine species occurrence records compiled from scientific surveys, museum collections, and citizen science observations. Records include species identification, observation date, and location (latitude–longitude), providing fisheries-independent evidence of species presence. For this study, OBIS data for herring were extracted within Welsh waters using spatial queries, and filtered to remove DATRAS survey records to avoid double-counting with other survey datasets.

Table 1. Summary of common data sources providing evidence of occurrence for herring in Welsh waters.

Source	Years	Spatial Coverage of Welsh waters	Purpose
Coull *et al.* (1998)	<1998	All Welsh waters	To produce maps of spawning and nursery areas.
Ellis *et al.* (2012)	1990 – 2008	All Welsh waters	To produce maps of spawning and nursery areas.
Campanella and van der Kooij (2021)	2008 to 2020	All Welsh waters	To produce maps of spawning and nursery areas.
Marine institute (2024)	-	All Welsh waters	To produce maps of spawning and nursery areas.
Cefas (1995; 2000)	1995 and 2000	Irish Sea (Cardigan Bay only in 1995)	To improve stock assessment for cod and plaice.
Cefas / ABPmer (2010)	1982 – 2008	All Welsh waters	To aid the selection of Marine Conservation Zones (MCZs) in England and Wales.
Cefas (2023)	2008 – 2009	Irish Sea	To provide data on fish counts, lengths and stomach contents analysis from fish caught in the Irish Sea in 2008 and 2009.
Cefas (2010)	2006, 2008, 2010	Irish Sea	To determine the distribution and abundance of cod, haddock, and plaice eggs.
Cefas (2025)	2016 – 2024	All Welsh waters	To estimate the number of sea anglers, how often they fish and their catch.

Source	Years	Spatial Coverage of Welsh waters	Purpose
MMO (2025)	2014 – 2024	All Welsh waters	To report commercial fish catch.
ICES (2025a)	2000 – 2024	All Welsh waters	To provide fisheries independent metrics of species abundance.
NRW (2025)	1997 – 2024	Welsh Estuaries	To provide data on estuarine fish species presence and abundance.
Marine Directorate (2023)	-	All Welsh waters	To provide spatial layers of Essential Fish Habitats.
AquaMaps (2025)	-	All Welsh waters	To provide species distributions based on environmental parameters.
OBIS (2025)	1912 – 2022	All Welsh waters	To provide information about the distribution and abundance of living species in the ocean.

3 Synthesis of evidence

This section presents the available evidence identified on the distribution and population structure of herring in Welsh waters. It begins with a summary of historical information on the species and general species context, followed by a summary of the evidence sources reviewed. Subsequent sections describe population distribution within Welsh waters for life stages and associated life-cycle processes, including eggs, larvae, juveniles, nursery grounds, adults, and spawning grounds. Each life stage subsection includes relevant ecological background, spatial distribution, key results and the supporting literature or survey data. Population and genetic structuring is addressed in the next subsection, followed by a summary of important uncertainties and knowledge gaps.

3.1 Historical data and information

Historical sources demonstrate that herring were once widespread, abundant and of substantial economic and cultural importance in Welsh coastal waters. Accounts dating from the 13th to mid-20th century consistently describe large seasonal aggregations around Cardigan Bay, north Wales and the Llŷn Peninsula (Moore *et al.*, 2024; Gubbay, 2009). The earliest record, from 1206, reports “great quantities” of herring at Aberystwyth (*Brut y Tywysogion*; cited in Gubbay, 2009), and by the 14th century more than 20 herring boats operated from the town. Additional “herring ports” were established at Beaumaris, Barmouth, Aberdaron, Tenby, Pembroke and Haverfordwest (Gubbay, 2009).

Through the 16th and 17th centuries, observers described great abundance throughout Cardigan Bay, with Owen (1603, in Gubbay, 2009) noting catches so widespread along the Pembrokeshire coast that it appeared “a hedge by sea” had been laid around the country, describing the herring being laid out to dry for salting and export. Nefyn on the Llŷn Peninsula became a major centre, exporting nearly 5000 barrels of salted herring in 1747 and supporting a substantial local fleet into the early 20th century (Starkey *et al.*, 2000; cited in Gubbay, 2009).

Multiple independent accounts describe large and sometimes spectacular shoals, including single-night landings of over 1.3 million fish at Aberystwyth in the 1700s, extensive shoals across north Wales in the 1800s, and early 20th-century reports of shoals up to seven miles long (Moore *et al.*, 2024). High densities of seabirds, sharks, large teleosts, dolphins and porpoises frequently accompanied these seasonal aggregations, illustrating the broader ecological role of herring as a key prey resource (Moore *et al.*, 2024).

Evidence also indicates substantial temporal variability. Periods when herring “entirely quit” parts of Cardigan Bay were recorded in the 18th century (Pennant 1776; 1796, in Moore *et al.*, 2024), and witnesses to the Buckland & Walpole Inquiry (1879) recalled both exceptional abundance and marked declines during the 19th century (cited in Gubbay, 2009). Similar variations continued into the early 20th century, with occasional near-complete absences reported from traditional fishing grounds (Board of Agriculture and Fisheries, 1906; in Moore *et al.*, 2024). Notably, historical accounts primarily report exceptionally large shoals, and less abundant periods may have gone unrecorded, reflecting both lower fishing pressure and the tendency to note only newsworthy events.

Olsen’s Piscatorial Atlas (1883) shows herring were widely distributed across most Welsh marine areas, with spawning grounds located closer inshore along the north coast and extending offshore across Cardigan Bay and into the Bristol Channel.

Herring has been an important resource for the coastal and fishing communities in Wales. In the first decades of the 20th century, with three fisheries believed to be active in the Milford Haven area: a winter, a spring and a summer / autumn fishery. Hickling (1946) analysed data from 1933 until 1940 in these three fisheries, and concluded that they belong to the same stock, as landings between the winter and summer / autumn fishery are correlated and show consistent patterns. In landings from 1925 until 1939, on average, the weight of caught herring was 80 cwt (approximately 4t) per vessel per trip, with the summer and spring fishery catching larger herring than the winter fishery.

Sampling and studies on herring in the 1940s consisted of weirs, primarily designed for salmon, that naturally trapped young herring, providing a “natural” sampling method. Daniel (1947) investigated the growth rate of 0-group whitebait herring along the North Wales coast using samples collected from Penrhyn weirs in the Menai Strait between 1939 and 1942. Samples generally consisted of the entire catch, length measurements and scale examinations to identify the formation of the first winter ring, which indicates minimal growth periods. Comparisons were also made with growth data from Plymouth and Clyde herring populations, showing that North Wales herrings grew more slowly than those from Plymouth and Clyde. Year-to-year variation was significant, with 1941 herring being smaller and growing less rapidly than those in 1939. The study concluded that these whitebait herrings were likely of local origin from North Wales, spawned in late autumn in November–December.

Together, these historical records and early spatial datasets demonstrate that herring were once both widespread and seasonally abundant in Welsh waters, supporting fisheries for many centuries.

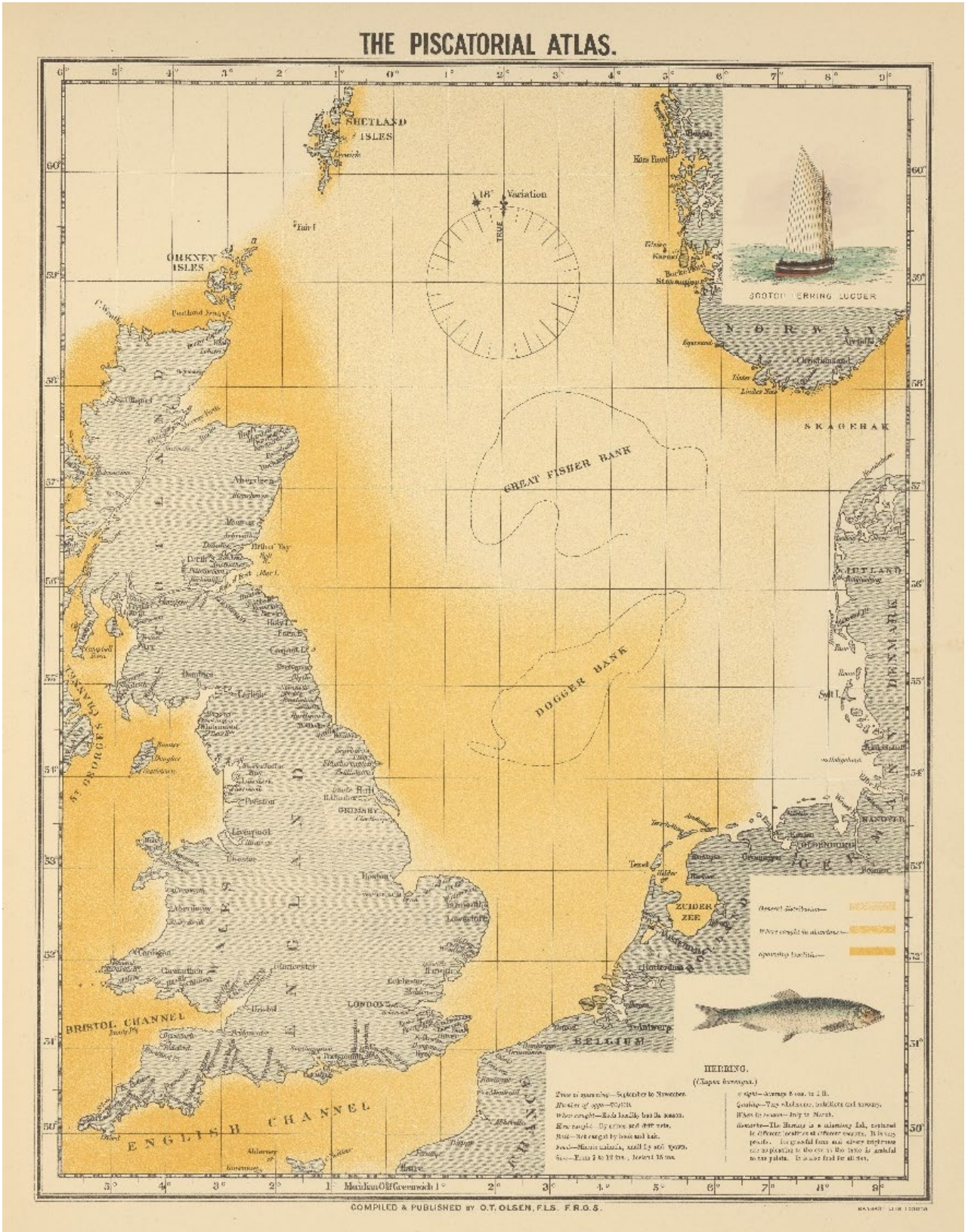


Figure 2. Olsen's Piscatorial Atlas – herring distribution. Herring distribution is depicted using qualitative shading to indicate *general distribution*, *where caught in abundance*, and *spawning localities* (Source: Olsen, 1883).

3.2 Summary of evidence sources reviewed

The literature review initially identified 250 academic papers and technical reports relating to the defined search terms for herring. After removing 110 duplicates, 140 unique records remained. Screening by title excluded a further 53, and abstract screening reduced the list to 26 papers considered likely to contain information relevant to this study. A PRISMA flowchart documenting this process is provided in Appendix 1.1 Additional sources were provided by NRW and incorporated to supplement the evidence base and address identified information gaps. Sources of digital spatial data used in this study have been summarised by life cycle and process in Table 2.

Table 2. Source of digital spatial data collated from online source / data portals summarised by lifecycle and process stage for herring. “A” represents absence of evidence and “P” represents presence of evidence.

Source	Egg	Larvae	Juvenile	Nursery	Adult	Spawning
Fisheries spawning and nursery areas in British waters (Coull *et al.*, 1998)	A	A	A	P	A	P
Spawning and nursery grounds of selected fish species in UK waters (Ellis *et al.*, 2012)	A	P	P	P	A	A
Spawning and nursery grounds of forage fish in Welsh and surrounding waters (Campanella and van der Kooij, 2021)	A	A	P	A	A	P
Species spawning and nursery areas (Marine Institute, 2018; revised 2024)	A	A	A	P	A	P
Annual Egg Production Method (AEPM) surveys 1995 and 2000 (Cefas 1995; 2000)	A	P	A	A	A	A
Highly mobile fish species distributions in UK waters (Cefas / ABPmer, 2010)	A	A	A	A	P	A
Assessment of potential predators of plaice eggs and larvae in the Irish Sea (Cefas, 2023)	A	P	A	A	A	A
Irish Sea Fish Egg Production Surveys (ISFEPS) (Cefas, 2010)	A	P	A	A	A	A
Sea Angling Diary catch records 2016-2024 (Cefas, 2025)	A	A	A	A	P	A
Commercial fisheries landings and discards data (MMO, 2025)	A	A	A	A	P	A

Source	Egg	Larvae	Juvenile	Nursery	Adult	Spawning
DATRAS Fisheries-independent trawl survey data (ICES, 2025a)	A	A	P	A	P	A
WFD Transitional fish surveys (NRW, 2025)	A	A	P	A	P	A
Essential Fish Habitats project data (Marine Directorate, 2023)	A	A	A	A	A	A
AquaMaps standardized species distribution maps (AquaMaps, 2025)	A	A	A	A	P	A
Species occurrence records in Welsh waters (OBIS, 2025)	A	A	A	A	P	A

3.3 Population distribution

This section describes herring population distribution in Welsh and surrounding waters in the Irish and Celtic Seas. The evidence is presented through sequential life stages and life cycle processes.

3.3.1 Life stage – eggs and life cycle process – spawning grounds

The locations of spawning grounds are the same as the locations of herring eggs given, they adhere to the seabed during incubation until the larvae hatch. For this reason, this section has combined the evidence of herring eggs with studies on spawning grounds, describing the spatial distribution of herring eggs and spawning grounds in the Irish and Celtic Seas.

Herring deposit eggs which adhere directly onto the substrate, spawning in high-oxygen environments that favour egg survival (Ellis *et al.*, 2012). These are usually high-energy areas, with strong currents and coarse substrates, such as gravel, small rocks, shingle, coarse sand, broken mollusc shells and photosynthesising marine plants such as kelp or maerl (Jonker, 2023). The eggs are laid in dense layers and remain fixed to the seabed until hatching, on average, two to three weeks later. Therefore, spawning grounds are inferred directly from the location of eggs located in surveys. This contrasts with broadcast-spawning species, such as cod, whose pelagic eggs drift widely and therefore have distinct egg-stage datasets (Ellis *et al.* 2012).

Spawning timing varies between the Welsh-relevant stocks: Irish Sea herring (7.a(N)) spawn from September to November, with slightly later spawning on the Irish coast than around the Isle of Man (ICES, 2017). Celtic Sea herring (7.g-j) are both autumn/winter spawners, typically spawning from late September and February (ICES stock annex;

standard ICES descriptions). In addition there is a genetically and morphologically distinct spring-spawning herring stock in the Milford Haven (ICES, 2023).

Data related to the distribution of herring spawning grounds in Welsh waters were identified through three geospatial datasets comprising of:

- Fisheries spawning and nursery areas in British waters (Coull *et al.*, 1998);
- Spawning and nursery grounds of forage fish in Welsh and surrounding waters (Campanella and van der Kooij, 2021); and
- Species spawning and nursery areas (Marine Institute, 2018; revised 2024).

The published literature reviewed also included:

- Spawning of herring in Milford Haven (Clarke and King, 1985);
- Workshop on a research roadmap for Bristol and Western Channel Herring WKRRBWCH (ICES, 2024);
- Herring Assessment Working Group for the Area South Of 62° N (ICES, 2021);
- Herring Assessment Working Group for the Area South of 62°N. (ICES, 2023); and
- The Bristol Channel Herring project. Breaking down barriers to regional management of fish stocks (Devon and Severn IFCA, 2023).

Further detail on each dataset is provided in Appendix 3.

3.3.1.1 Synthesis of eggs and spawning grounds

There are herring spawning grounds in Welsh waters off the North Wales coast between the Dee Estuary and Anglesey, both inshore and offshore. Lower intensity spawning grounds are also present in the Bristol Channel (e.g. Clovelly), and in and outside the Milford Haven (Figure 56). Other areas with high relevance for herring spawning for Welsh waters are the Manx spawning grounds, east of the Isle of Man, and the Mourne spawning grounds off the Northern Irish coast. Further supporting evidence on wider herring spawning areas in Irish and Scottish waters are provided in Appendix 5, and it should be recognised that tidal currents can result in movement of herring larvae into and out of Welsh waters from these wider spawning areas.

In North Wales, there are anecdotal records from anglers observing herring in the Menai Strait (notably around Gallows Point) in spawning condition or carrying eggs during the autumn. While unverified, these observations are consistent with the habitat characteristics and strong tidal flow of the Menai Strait and align with the observed distribution of herring adults and larvae in North Wales waters, lending further support to the relevance of this area for spawning activity.

The identification of herring spawning areas in the Bristol Channel at Minehead and Clovelly, including both the Clovelly winter- and genetically-distinct autumn-spawners, support that herring may spawn locally and form distinct stocks in the Bristol Channel. A small-scale herring fishery has operated in the inner Bristol Channel for many centuries (D&S IFCA, 2023). Although there is currently no published scientific evidence

documenting the precise spawning grounds in the Bristol Channel, such a scenario would be consistent with herring ecology in other major UK estuaries, and is supported by fishers' observations of herring in spawning condition over decades of drift and stake netting off Minehead and Clovelly.

Key results:

- **Egg distribution is assumed to be the same as spawning grounds, as eggs are laid and firmly attached to the substrate, where they hatch into larvae. Only one study has directly sampled herring eggs in Welsh waters, and this was in the Milford Haven, while all the other studies and datasets inferred the location of spawning grounds from adult and larval distributions.**
- **Other herring spawning grounds relevant to Welsh waters include Clovelly in the Bristol Channel, the Manx and Mourne spawning grounds in the Irish Sea, and several of the spawning grounds on the south east coast of Ireland as they may provide larvae to Welsh waters, or adult fish may make spawning migrations to them.**

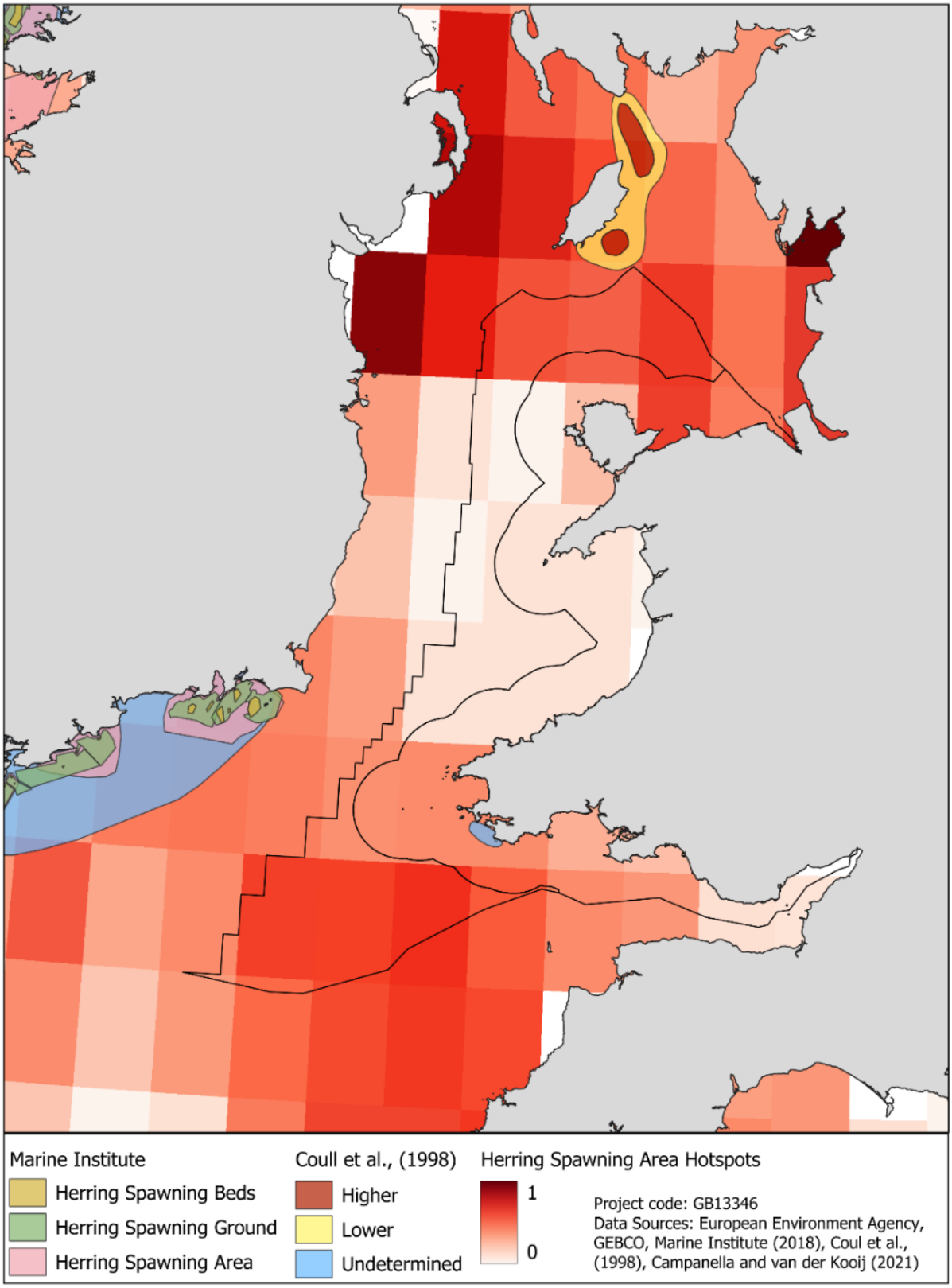


Figure 3. Composite of layers describing the presence of herring spawning areas, compiling three sources (Source: Coull *et al.*, 1998, Campanella and van der Kooij, 2021 and Marine Institute, 2024)

3.3.2 Life stage – larvae

Herring larvae remain in nearshore, sheltered areas like bays and estuaries for several weeks to a few months after hatching.

Data related to the distribution of herring larvae in Welsh waters were identified through five geospatial datasets and three research papers. The datasets reviewed comprised of:

- ICES Egg and Larvae data (ICES, 2025b); Assessment of potential predators of plaice eggs and larvae in the Irish Sea (Cefas, 2023);
- Spawning and nursery grounds of selected fish species in UK waters (Ellis *et al.*, 2012);
- Annual Egg Production Method (AEPM) surveys 1995 and 2000 (Cefas 1995; 2000); and
- Irish Sea Fish Egg Production Surveys (ISFEPS) (Cefas, 2010).

The published literature reviewed comprised of:

- The location of spawning of Irish Sea herring (*Clupea harengus*) (Dickey-Collas *et al.*, 2001);
- An Inventory of Irish Herring Spawning Grounds (O'Sullivan *et al.*, 2013); and
- Exploring the microzooplankton–ichthyoplankton link: A combined field and modelling study of Atlantic herring (*Clupea harengus*) in the Irish Sea (Bils *et al.*, 2016).

3.3.2.1 Synthesis of larvae

From the literature and data review, there is evidence of herring larvae off the North Wales coast, with high relative abundance indices between the Dee Estuary and Anglesey (Figure 64). ICES larvae data also highlight the presence of larvae in the eastern waters of the Isle of Man. Studies in Cardigan Bay, the Bristol Channel and the Celtic Sea, for herring larvae are lacking, resulting in a significant evidence gap for this area.

Key results:

- **Herring larvae have been recorded in higher abundances off the North Wales coast between the Dee Estuary and Anglesey. Higher abundances of larvae in the Irish Sea are also recorded around the Isle of Man near the Manx spawning ground as well as on the east coast of Ireland, around the Mourne spawning ground.**
- **There is insufficient data available on herring larvae in Cardigan Bay, the Bristol Channel or the Celtic Sea to draw conclusions on distribution.**

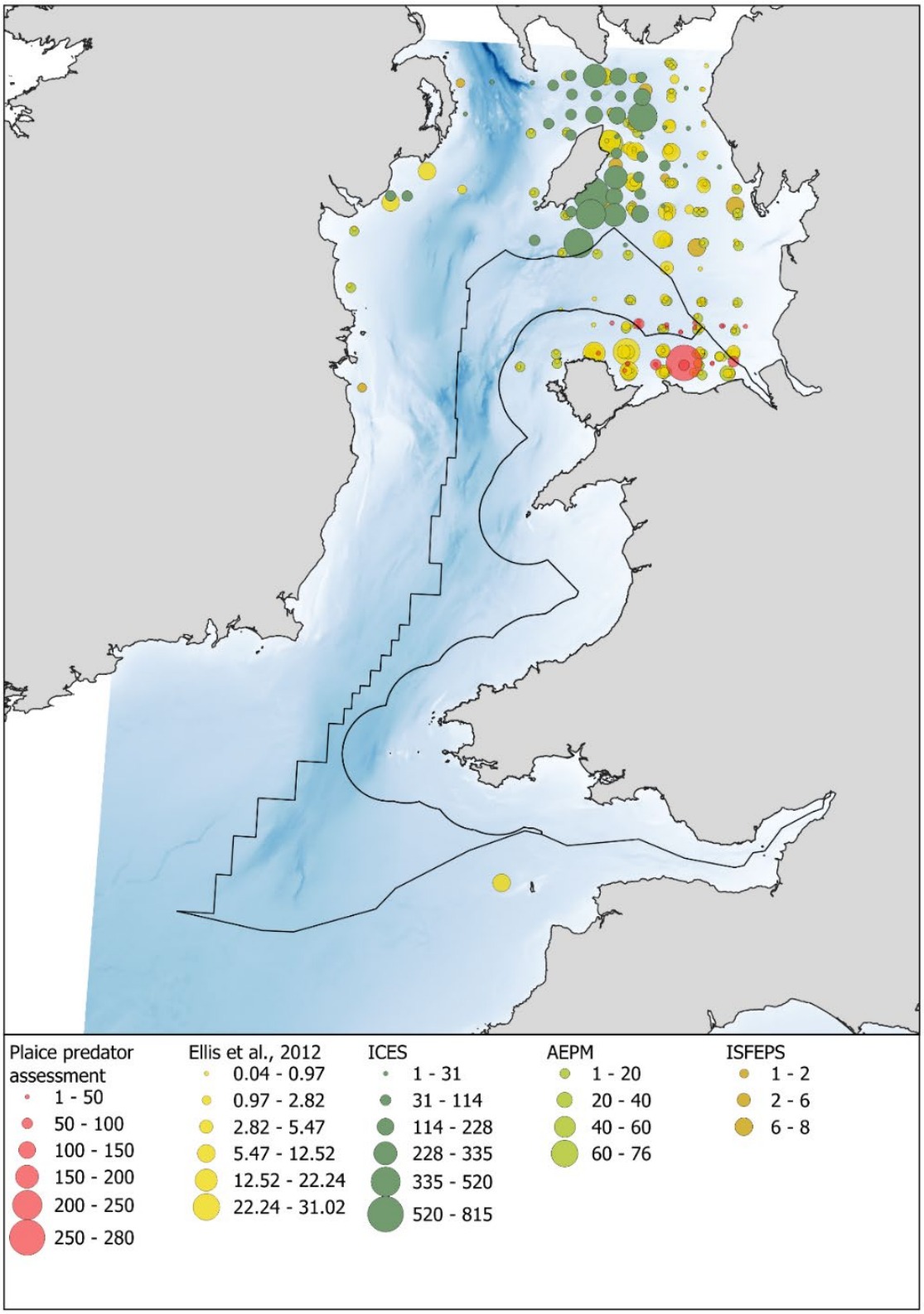


Figure 4. Composite herring larvae layers map compiling five sources (Sources: Cefas, 2023; Ellis *et al.* 2012; ICES, 2025a; Cefas, 1995; 2000; 2006; 2008; 2010). Legend units are number of larvae recorded per sample. Individual datasets are described in detail in Appendix 3.

3.3.3 Life stage – juveniles

Juvenile herring typically use inshore waters and estuaries as nursery areas, where food availability is high. As they grow, herring gradually move offshore, often on a seasonal basis, to join deeper and more open waters, with these movements influenced by temperature, food supply and tidal conditions. Studies have shown that herring identify spawning and feeding grounds as juveniles and then show site fidelity to these areas as adults (Corten, 2002). Herring stock monitoring has shifted from larval surveys in the 1970s–1980s to acoustic surveys since 1989, which now provide the only tuning indices within stock assessments. These survey data show immature herring predominantly in coastal waters, comprising 32.8% of total stock biomass and 81.5% of total stock numbers (ICES, 2021b).

Data related to the distribution of juvenile herring in Welsh waters were identified through five geospatial datasets as well as an acoustic survey report from the Marine Institute (2024) and two published scientific papers. The datasets reviewed comprise of:

- Spawning and nursery grounds of selected fish species in UK waters (Ellis *et al.*, 2012);
- Spawning and nursery grounds of forage fish in Welsh and surrounding waters (Campanella and van der Kooij, 2021);
- DATRAS Fisheries-independent trawl survey data (ICES, 2025a);
- Sea Angling Diary catch records 2016-2024 (Cefas, 2025); and
- WFD Transitional fish surveys (NRW, 2025).

The published literature reviewed comprised of:

- Celtic Sea Pelagic Ecosystem Survey Report (Marine Institute, 2024);
- Tracing populations of Atlantic herring (*Clupea harengus L.*) in the Irish and Celtic Seas using otolith microstructure (Brophy and Danilowicz, 2002); and
- Otolith shape analysis: its application for discriminating between stocks of Irish Sea and Celtic Sea herring (*Clupea harengus*) in the Irish Sea (Burke *et al.*, 2008).

3.3.3.1 Synthesis of juveniles

Figure 71 combines the available juvenile herring layers and illustrates that juvenile herring have been recorded throughout Welsh waters. This distribution is supported by Ellis *et al.* (2012), who assessed sampling stations over time to evaluate persistence based on the percentage of hauls containing juvenile herring. Their analysis shows that in samples in Welsh waters off the North Wales coast, in Cardigan Bay, and in the Bristol Channel there was a recorded juvenile herring presence in approximately 70% of hauls.

However, the DATRAS dataset does not appear to fully corroborate these findings, likely due to the more offshore fisheries-independent bottom-trawl surveys on which DATRAS is based, which are limited in their ability to sample certain habitats, such as shallow inshore areas or areas of rough ground and do not target herring due to the demersal nature of the

surveys. DATRAS records do indicate substantial juvenile herring numbers in surveys conducted in Welsh offshore waters in the Celtic Sea.

The most recent review and synthesis of juvenile herring distribution, provided by Campanella and van der Kooij (2021) broadly supports the juvenile distributions shown by the other datasets. This convergence across multiple datasets is particularly clear in waters off the east coast of Ireland and west of the Isle of Man. Campanella and van der Kooij (2021) also identify hotspot areas around the Pembrokeshire coast and the Dee Estuary, which are not reflected in either the DATRAS dataset or the findings of Ellis *et al.* (2012). However, these hotspots align with evidence from NRW WFD survey data indicating juvenile presence in inshore areas, especially within estuaries which are typically locations that large survey vessels cannot effectively sample.

Key results:

- **Juvenile herring are recorded widely across Welsh waters, with a high presence in hauls inshore off the North Wales coast, in Cardigan Bay, and in the Bristol Channel, including Carmarthen Bay and Swansea Bay, indicating the presence of likely nursery grounds in these areas.**
- **Additional juvenile hotspots, such as off Pembrokeshire and the Dee Estuary, align with inshore and estuarine survey evidence and spawning grounds.**

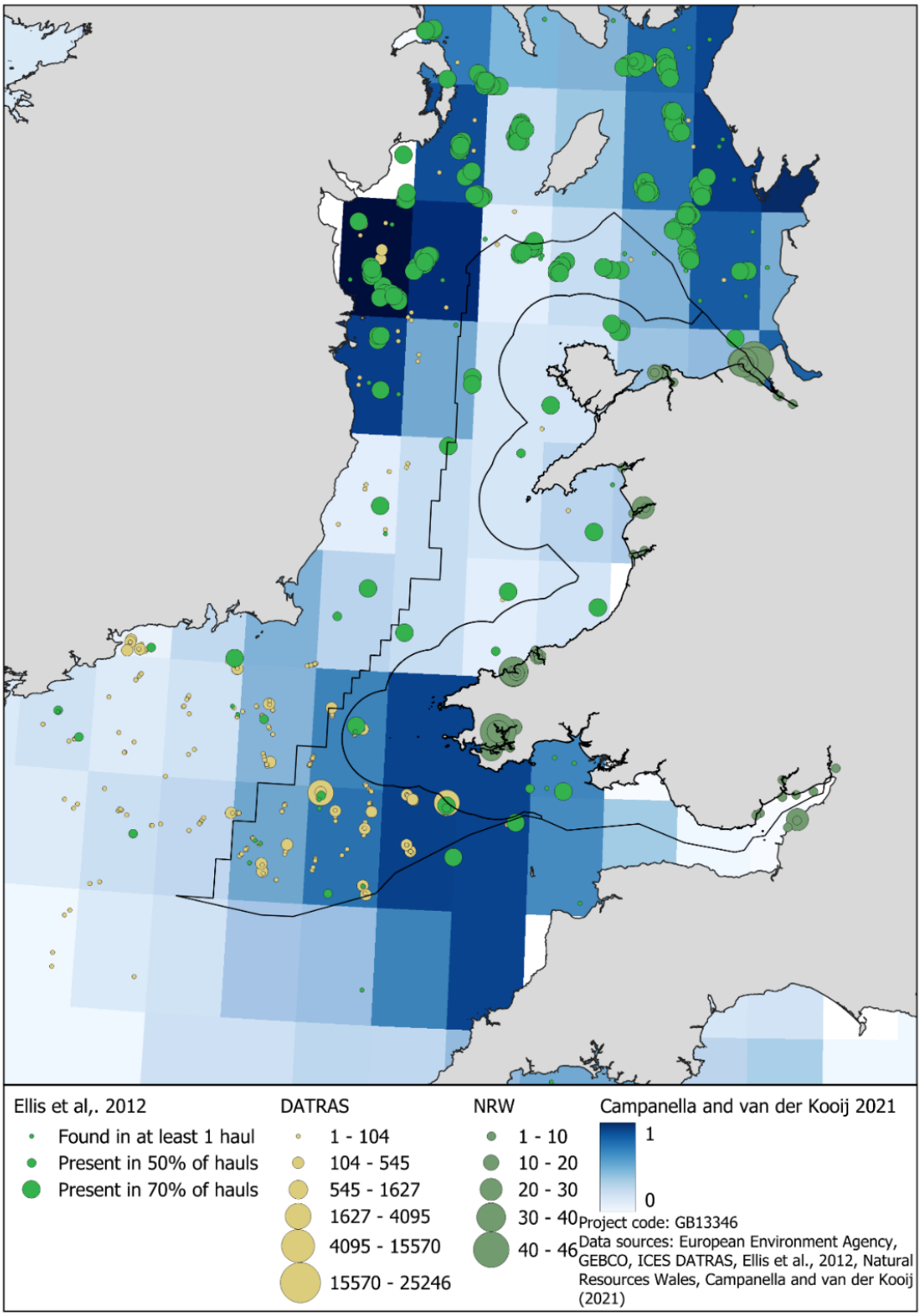


Figure 5. Overlaid points showing the proportion of presence (Ellis *et al.*, 2012) and counts (ICES, 2025a; and NRW, 2025) and raster layers (Campanella and van der Kooij, 2021) for juvenile herring. Raster layer of juvenile herring from Q1 and Q4 are overlaid using a multiplicative blending mode, enabling the visualisation of both layers (Sources: Ellis *et al.,* 2012; ICES, 2025a; Natural Resources Wales, 2025; Campanella and van der Kooij, 2021). Individual datasets are described in detail in Appendix 3.

3.3.4 Life cycle process – nursery grounds

Data related to the distribution of herring nursery ground in Welsh waters were identified through 3 geospatial datasets as well as a report from ICES (2018). The datasets reviewed comprise of:

- Spawning and nursery grounds of selected fish species in UK waters (Ellis *et al.*, 2012);
- Fisheries spawning and nursery areas in British waters (Coull *et al.*, 1998); and
- Species spawning and nursery areas (Marine Institute, 2018; revised 2024).

3.3.4.1 Synthesis of nursery grounds

Spatial data sources describing herring nursery grounds in Welsh waters are limited to Coull *et al.* (1998) and Ellis *et al.* (2012). Both sources identify nursery grounds outside the Dee Estuary, extending across both inshore and offshore Welsh waters. The data from Ellis *et al.* (2012) categorises this area as a high intensity nursery area. This nursery area is a continuation of a wider area located across the western Irish Sea. The layers provided by Ellis *et al.* (2012) also highlight low-intensity nursery areas inshore from Porthcawl to Pembrokeshire in the Bristol Channel (Figure 74).

Key results:

- **Herring nursery grounds are identified in Liverpool Bay and the Dee Estuary in North Wales, and in Carmarthen Bay and Swansea Bay in South Wales, consistent with the important juvenile areas identified in Section 3.3.3.**
- **Other coastal nursery grounds are identified in the Irish Sea off the north west coast of England, Solway Firth and along the southern and eastern coast of Ireland.**

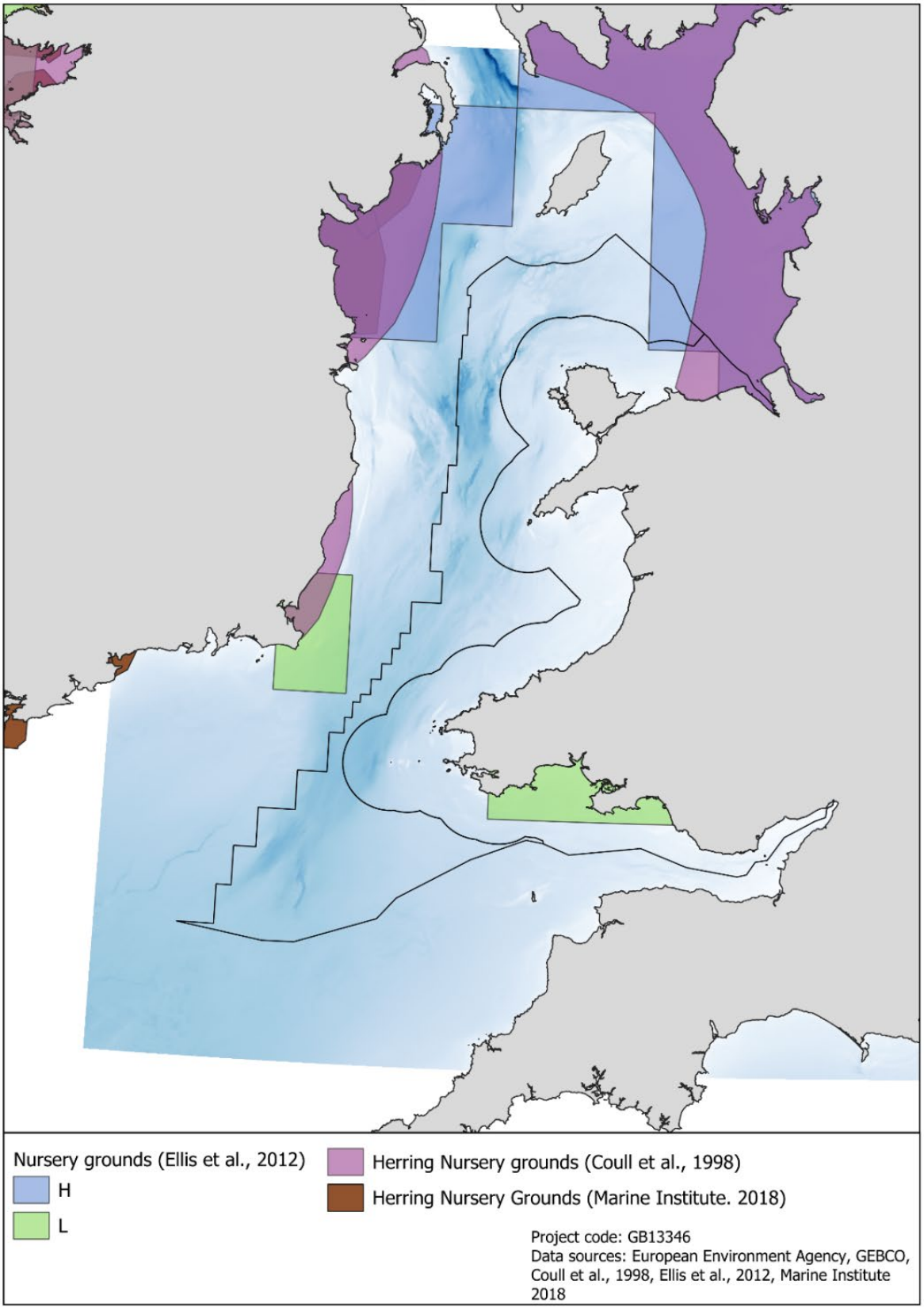


Figure 6. Composite nursery ground layers map compiling three sources (Coull *et al.*, 1998, Ellis *et al.*, 2012 and Marine Institute, 2018).

3.3.5 Life stage – adults

Adults feed on planktonic organisms and show temporal movements in response to changes in this resource. Adult herring undertake regular seasonal migrations, moving inshore and into estuaries during certain periods, often associated with feeding opportunities and spawning activity. These inshore movements typically coincide with warmer months, when plankton productivity is higher and feeding conditions are favourable for energy accumulation. As temperatures decline, adult herring generally migrate offshore to deeper waters, where they overwinter in more stable environmental conditions and continue feeding.

Data related to the general distribution of adult herring (>17.5 cm) in Welsh waters were identified through six geospatial datasets as well as an academic paper by Volkenandt *et al.* (2014) and a report by ICES (2025c). The datasets reviewed comprise of:

- Highly mobile fish species distributions in UK waters (Cefas / ABPmer, 2010);
- DATRAS Fisheries-independent trawl survey data (ICES, 2025a);
- Commercial fisheries landings and discards data (MMO, 2025);
- Species occurrence records in Welsh waters (OBIS, 2025);
- WFD Transitional fish surveys (NRW, 2025); and
- Sea Angling Diary catch records 2016-2024 (Cefas, 2025).

3.3.5.1 Synthesis of adults

From the data collection and literature review, adult herring distribution appears to extend further offshore than juveniles, though surveys in Welsh inshore waters have confirmed the presence of adult herring in relatively lower numbers, with occurrence records in around the Bristol Channel, Milford Haven and Anglesey.

The presence of herring in these areas is corroborated by adult herring distribution data from sea angling records concentrated around the Pembrokeshire and Anglesey coast. Despite the low numbers of adult herring recorded, consistent records of larger herring in the Menai Strait and on the west coast of Pembrokeshire has been recorded in sea angling data.

The offshore distribution of adults observed in some of the datasets largely reflects the timing and location of surveys, with the Cefas 2010 Portuguese high-headline trawl survey conducted in Q1 and the DATRAS surveys mainly in Q4, both with a primarily offshore distribution of sampling stations. Seasonal inshore movements, particularly during the winter spawning period, may not be fully captured in these datasets. It has previously been noted that adults are found throughout Welsh waters (CCW, 2011) and that herring in Welsh waters may be from autumn or winter spawned stock (Nash *et al.*, 2001).

Herring catches, discards and abundance rates are concentrated outside of Welsh waters, in the Irish Sea and parts of the Celtic Sea. Both the MMO and ICES DATRAS data show a high presence of adult herring in Welsh offshore waters in the Celtic Sea, with high number of herring caught, landed and discarded in ICES area 7g (Figure 84).

Key results:

- **Adult herring have been infrequently captured in surveys and commercial landings in Welsh waters, with small catches mainly near the Bristol Channel, Milford Haven and Anglesey, with most catches and discards occurring outside Welsh waters, around the Isle of Man, northeast of Ireland and in Irish waters of the Celtic Sea.**
- **Catch and survey data show a notable adult herring presence in Welsh offshore waters in the Celtic Sea, particularly in ICES area 7g, where higher numbers are recorded.**
- **There is a significant data gap regarding adult herring distribution in Welsh inshore waters, as existing survey data (e.g. beam trawl surveys) are not well suited to pelagic species. Targeted sampling using more appropriate gears (e.g. otter trawls or acoustic surveys) would be required to improve confidence in adult distribution patterns.**

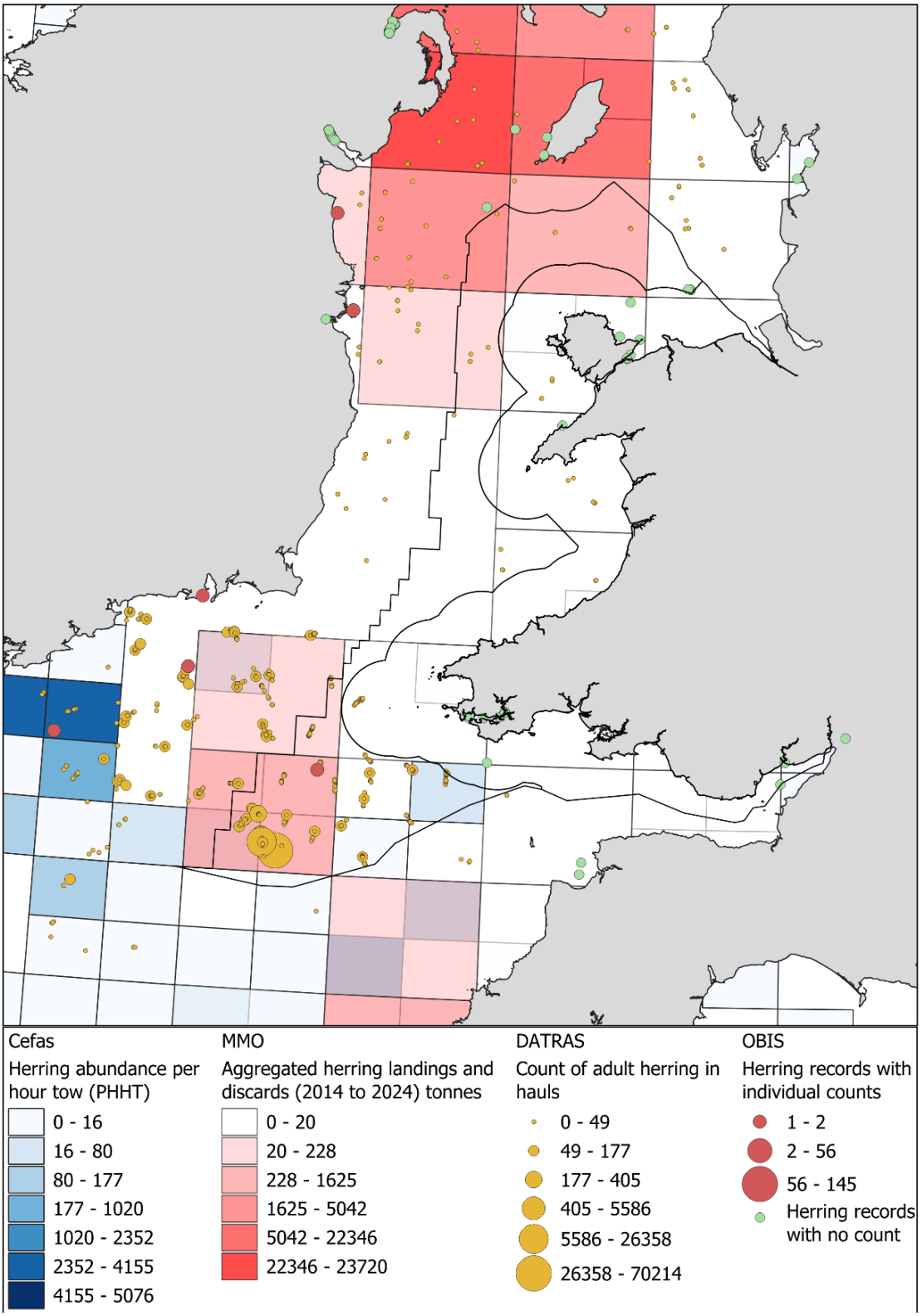


Figure 7. Composite of layers describing the presence of adult herring (Sources: Cefas, 2010; MMO, 2025; ICES, 2025a, OBIS, 2025). Individual datasets are described in detail in Appendix 3.

3.4 Population and genetic structure

This section describes herring population and genetic structure in Welsh and surrounding waters.

3.4.1 Genetic studies

Genetic analyses of herring in the Irish Sea and surrounding waters, have not provided unequivocal evidence of genetically isolated populations, despite the use of various studies, including meristic traits, allele frequencies, and microsatellite markers. These studies also do not support complete panmixia. The available evidence suggests that levels of mixing are sufficient to maintain gene flow across the wider region, while the majority of individuals exhibit fidelity to local populations and spawning grounds. As a result, genetic homogeneity likely reflects intermittent exchange rather than extensive demographic mixing. In combination with tagging evidence for regional spawning fidelity, this behavioural structuring supports the treatment of ICES Divisions 7.a (Irish Sea) and 7.e–k (Celtic Sea and Western Channel) as separate management units (ICES, 2025b).

Genetic research on Atlantic herring populations across the North Atlantic reveals a complex interplay between broad-scale connectivity and localised adaptation. Clustering analyses using 156 single nucleotide polymorphism (SNP) markers demonstrated that Irish Sea herring align closely with those from the Celtic Sea, English Channel, and western Ireland, while showing weaker genetic affinities to Shetland and the central North Sea (Bekkevold *et al.*, 2015). This pattern suggests a strong genetic similarity across the southern parts of the UK, with regional differentiation within the broader metapopulation.

Whole-genome sequencing of 28 population samples provided further resolution, identifying a Chr6 haplotype strongly associated with ecological adaptation to habitats around Britain and Ireland (Han *et al.*, 2020). This haplotype occurs at particularly high frequencies in spawning populations near the Isle of Man, the Downs near the English Channel, and the Celtic Sea (Han *et al.*, 2020), reinforcing the idea of local adaptation within a shared genetic framework (ICES, 2021). Such adaptations likely reflect selective pressures from environmental variables such as temperature, salinity, and food availability, which differ across these spawning grounds.

Temporal analyses using ancient DNA, dating back over a millennium (1,300 years), revealed remarkable stability in genetic structure among British, Irish, and North Sea autumn–winter spawners (Atmore *et al.*, 2024). These populations appear to form a single metapopulation subdivided into three subcomponents based on Multiple System Atrophy (MSA) using 82 diagnostic single-nucleotide polymorphisms: Isle of Man, Celtic Sea/Downs, and North Sea. However, comparisons with modern samples indicate a decline in genetic diversity since the 20th century, likely driven by historical overfishing and stock collapses (Atmore *et al.*, 2024), underscoring the long-term evolutionary consequences of anthropogenic pressures (Bekkevold *et al.*, 2015).

Recent ICES assessments add another layer of complexity, confirming that Celtic Sea and Irish Sea herring are genetically distinct from each other and from ICES Division 6a populations (ICES, 2021). Furthermore, survey data from 2021–2022 highlight substantial

but unquantified mixing between Irish Sea, Celtic Sea, and adjacent Bristol Channel/Cardigan Bay components, particularly west of the Isle of Man (ICES, 2023). This mixing complicates management strategies, as stock boundaries do not align neatly with genetic or ecological realities.

The ICES Workshop on a Research Roadmap for Bristol and Western Channel Herring (2023) analysed extensive herring genetic data from over 7,000 samples collected across the Celtic Sea, Irish Sea, Bristol Channel and Mevagissey. Fish were genotyped using a multispecies SNP array, generating data for more than 3,200 markers per individual. Results showed clear genetic structuring by spawning season and location. Spring and autumn spawners were significantly differentiated, with two distinct spring-spawning groups in the Bristol Channel that also differed morphologically, including the Milford Haven herring stock. Autumn and winter spawners were structured between seas, and the Mevagissey sample was genetically distinct, aligning more closely with winter-spawning populations further north.

Taken together, these findings depict Irish Sea herring as part of a broader south-western metapopulation, characterised by shared genetic ancestry, localised adaptation, and dynamic mixing. The presence of adaptive haplotypes alongside evidence of historical diversity loss and ongoing inter-stock interactions emphasizes the need for conservation and management approaches that account for both evolutionary processes and ecological connectivity (ICES, 2023).

3.4.2 Egg and larval transport

Post-spawning egg and larval distributions are influenced by prevailing tidal and residual current regimes in the Celtic Sea, Irish Sea, and Bristol Channel. Transport pathways from known or inferred spawning grounds may therefore result in the advection of early life stages away from their point of origin. In the wider region, dominant circulation patterns include northward transport from the south-east coast of Ireland into the Irish Sea, followed by eastward flow towards the Isle of Man, as well as southward transport from the northern Irish Sea towards the Isle of Man. In the Celtic Sea, residual flows from the vicinity of Trevose Head extend eastwards into the Bristol Channel.

These circulation patterns are likely to influence the spatial distributions of eggs and larvae presented in the preceding sections. As a result, the presence of eggs or larvae in a given area does not necessarily indicate local spawning activity, particularly in regions subject to strong tidal advection. Interpretation of egg and larval data therefore carries inherent uncertainty and must be considered alongside information on adult distribution, spawning behaviour, and movement patterns. The integration of early life-stage observations with adult data is necessary to distinguish between areas of spawning activity and areas of passive accumulation driven by physical transport processes.

Regarding populations structure, evidence across the Irish Sea, Celtic Sea, and adjacent North-East Atlantic areas indicates that herring have a complex mixed-stock structure within the population. Larval drift from the eastern Celtic Sea into the Irish Sea followed by juvenile residency and a return migration southwards implies that catches taken in the Irish Sea can influence recruitment to the Celtic Sea stock (ICES, 2018; ICES, 2021b).

Modelling of larval dispersal from the Celtic Sea by Deschepper *et al.* (2020) indicates that only a small fraction of larvae (<5%) reach the Irish Sea under both tidal and non-tidal scenarios, reinforcing the largely separate stock structure of the Celtic and Irish Sea regions (ICES, 2024). While occasional dispersal is possible, consistent with recognised movement of Celtic Sea juveniles into the Irish Sea, additional studies (Appendix 4) confirm minimal mixing at the larval stage, supporting the view that the Irish and Celtic Sea herring largely remain genetically and demographically distinct. Multiple stock discrimination techniques including tagging, otolith microstructure, and otolith shape demonstrate that juveniles of Celtic Sea migrate into the Irish Sea. Most mixing occurs when fish are 1-2 years of age with marked interannual variability (15–60%) in the age 1+ winter biomass during 2006–2010 (ICES, 2021).

In the Irish Sea, recent acoustic surveys indicate a mixed stock composed of locally spawned autumn fish together with winter-hatched juveniles thought to originate from the Celtic Sea. Survey trawl data show heterogeneous spatial patterns among age groups, with age 1+ and older fish concentrated around Northern Ireland spawning banks and west of the Isle of Man, while microstructure analyses confirm that winter-hatched fish regularly enter pre-spawning aggregations earlier than spring-spawning herring (ICES, 2023).

Regionally, sampling from south Wales (2018) points to discrete autumn–winter spawning stocks off Clovelly and Minehead that are genetically and morphologically distinct from the Celtic Sea stock (Clarke, 2020). These findings build on earlier evidence of a separate spring-spawning group off Milford Haven along the northern Bristol Channel. Small-scale artisanal fisheries in the northern Devon and Seven IFCA District appear to target these local Minehead stocks although Bristol Channel stock structure remains uncertain and herring movements track temperature regimes and plankton availability (Devon and Severn IFCA, 2021).

3.4.3 Synthesis of population and genetic structure

Although highly mobile, herring are thought to form localised stocks with differences in spawning times and locations. Within Welsh waters, herring of both the Irish Sea and Celtic Sea are more likely to be mixing in the Irish Sea, however, in the Celtic Sea and Bristol Channel, herring stocks are more likely to be only Celtic Sea herring stocks.

Furthermore, the stock identity of the western Celtic Seas which may contribute individuals to Welsh waters through advection of larvae or migration of juveniles and adults, remains uncertain despite evidence of links between 7j to 7b and 6aS; for assessment and management, 7aS, 7g, and 7j have been treated as a single unit since 1982 (ICES, 2021b). Molloy (1968) also indicated possible connections between juvenile fish in 7j and those in the 7g area of the Celtic Sea.

At a broader scale, comparative work across the North Atlantic identifies seven main populations differentiated by otolith shape, with these differences correlated with spawning time, a signal of strong environmental effects and divergent life-history strategies and suggests Irish populations may have evolved independently relative to other North-East Atlantic groups (Libungan *et al.*, 2015).

Collectively, these dynamics complicate cohort tracking and biomass estimation, and benchmark evaluations conclude that both the fishery and surveys operate on a mixed stock, necessitating assessment methods that explicitly account for multiple biological components.

Key results:

- **Irish Sea herring form part of a wider south-western metapopulation while retaining local adaptation, with genomic analyses showing a shared southern genetic backgrounds across the Irish Sea, Celtic Sea and Downs components.**
- **Long-term assessments such as ICES, indicate three autumn–winter subpopulations (Isle of Man, Celtic Sea/Downs and North Sea), declining genetic diversity between them since the 20th century, and evidence of substantial but unquantified mixing between Irish Sea, Celtic Sea and Bristol Channel/Cardigan Bay components, particularly west of the Isle of Man.**
- **Herring in the Irish Sea, Celtic Sea, and surrounding regions form a mixed-stock system with substantial movement and exchange; juveniles from the Celtic Sea often enter the Irish Sea and contribute significantly to winter biomass.**
- **Distinct regional groups persist, including a separate spring-spawning group off Milford Haven, autumn–winter spawning herring stocks off Clovelly and Minehead, and an autumn-winter spawning population in the Celtic Sea.**

3.5 Summary of uncertainties and gaps

This section describes the uncertainties and evidence gaps identified during the review of herring population distribution and structure evidence. Important uncertainties and evidence gaps identified are:

- Inshore waters and estuaries are poorly represented in available datasets with the exception of WFD sampling data in estuaries (NRW, 2025) and Sea Angling Diary data (Cefas, 2025).
- Offshore trawl surveys have limited ability to sample juvenile herring due to gear limitations, and limited ability to sample adult herring as trawls generally target demersal species using beam and otter trawl gear.
- Depth constraints limit spatial coverage, with some mapped products excluding waters shallower than 20m depth, while offshore survey vessels cannot operate effectively in shallow coastal zones, likely underestimating the importance of nearshore habitats.
- Survey spatial coverage is fragmented, with most programmes focusing on either the Irish Sea or Celtic Sea, rarely both concurrently, and there is sparse data coverage in areas such as Cardigan Bay which may be especially important given the observed northward mixing of Celtic Sea juveniles into the Irish Sea..
- Integration of trawl survey data with acoustic surveys evidence improves interpretation, but this is only available for the Celtic Sea.
- The availability and extent of herring egg surveys is limited with only one study referring to results from physical egg samples.

- In addition to direct egg observations, habitat-based methods have been developed to predict potential herring spawning areas, such as the Atlantic Herring Potential Spawning Habitat method (Kyle-Henney *et al.*, 2024), which integrates seabed substrate and ecological data to identify likely spawning grounds. Use of this method in conjunction with the empirical data presented in this section may increase confidence in potential spawning habitats of herring in Welsh waters, but it should also be noted that herring may spawn more widely than inferred based on presumed suitable habitat availability.
- Identification of small juvenile clupeids, including herring, and their discrimination from alosids (shads) is challenging in the field, resulting in a risk of misidentification.
- Limited year-round coverage and survey timing constrain interpretation of herring distributions at different life stages.
- Qualitative evidence from recreational sea angling indicates continued herring presence in inshore and coastal waters across multiple seasons, but these records do not provide quantitative estimates of abundance or recruitment.

4 Conclusions and discussion

This section synthesises the evidence collated for herring to identify broad spatial patterns, data availability, and key uncertainties in their use of Welsh waters. This section focuses on life-stage connectivity, spatial structure, data coverage, and highlights implications for future monitoring and management.

The methodological approach taken to this review could be applied to additional species in future work. Herring are, however, a relatively data-rich species in Welsh waters and so data gaps and uncertainties may be more significant for other species.

4.1 General trends in life stages and spatial distribution

Herring have spawning and nursery grounds in Welsh waters of the Irish Sea and Celtic Sea indicating the importance of Welsh waters at maintaining wider Irish Sea and Celtic Sea populations, with herring having distinct spawning populations in Welsh waters.

Inshore bays, estuaries, and sheltered coastal habitats in Welsh waters of both the Irish Sea and the Bristol Channel serve as primary nursery grounds, supporting juveniles before offshore seasonal migrations commence and wider dispersal occurs in sub-adult and adults phases.

Adult densities in Welsh waters are generally lower than juvenile densities, with adults showing a wider distribution and higher abundance in deeper Irish Sea and Celtic Sea waters. Adults show seasonal movements into and through Welsh waters, reflecting broader metapopulation connectivity rather than long-term residency.

Connectivity between life stages and between areas inside and outside Welsh waters is a consistent pattern: eggs and larval movements into nursery grounds from spawning grounds is evident, along with juvenile dispersal from nursery grounds to wider adult populations across the Irish Sea and Celtic Sea.

4.2 Spatial coverage and data strengths

The Irish Sea off the North Wales coast are the well characterised regions for herring, with alignment in evidence across multiple datasets for many of the life stages of the species reviewed.

Historical datasets and older analyses complement contemporary analysis of the latest survey data, allowing insights into temporal changes in spatial distribution and also verification of conclusions through time.

Genetic, otolith, and tagging studies provide evidence of population connectivity, regional mixing, and metapopulation structure, which informs understanding of broader stock dynamics.

4.3 Limitations and uncertainties

Survey effort and spatial coverage is uneven. Many studies only focus on parts of Welsh waters, making the ability to compare data across Welsh waters complex. Furthermore, Cardigan Bay, the Bristol Channel and the Celtic Sea are underrepresented in egg, larval, juvenile, and adult sampling compared to the Irish Sea for all the species reviewed.

Temporal and interannual replication is also limited across datasets. While surveys such as ICES DATRAS provide annual coverage, sampling is concentrated in specific quarters (primarily Q1, Q3 and Q4), with limited representation of Q2 and transitional periods. Many other datasets provide only short-term or seasonally restricted sampling. This constrains interpretation of seasonal habitat use, larval abundance, and juvenile dispersal, particularly in Cardigan Bay and the Bristol Channel where long-term monitoring over multiple seasons is sparse.

Standard trawl-based surveys using larger vessels are limited in their ability to sample shallow or structurally complex habitats, which may lead to further underrepresentation of these areas in available datasets.

Spawning ground mapping shows inconsistencies across sources. Differences in observed distributions may reflect methodological variation, variable survey effort, and temporal changes. Older sources may be documenting areas that were historically relevant but no longer function as key spawning grounds, which requires further investigation.

Environmental and ecological drivers such as water temperature, prey availability, and seabed substrates, are recognised as important for recruitment and dispersal of the three species but are inconsistently integrated across datasets, limiting predictive capability.

4.4 Recommendations

Overall, enhancing and expanding established long-term survey programmes and datasets, offers a robust pathway for improving stock assessments and understanding spatial population dynamics.

Recommendation 1. Expand survey coverage:

- Target under-sampled regions, particularly Cardigan Bay, other inshore/estuarine areas, and areas with complex seabed habitats, for all life stages considering non-destructive sampling methods for sensitive habitats.
- Conduct egg and larval sampling via ichthyoplankton trawls to more closely identify spawning grounds of the species.
- Recent ichthyoplankton and fish sampling has been conducted at a local scale for development projects in the Severn Estuary, Milford Haven, Anglesey and the Dee Estuary. Welsh universities also hold fish survey datasets from research and teaching cruises. A recommendation to review and integrate these data is suggested.

Recommendation 2. Standardise life-stage mapping:

- Develop best-practice methods for mapping spawning grounds and nursery habitats by species, integrating egg, larval and juvenile data with influencing environmental variables such as water depth, water temperature and substrate type.

Recommendation 3. Integrate environmental drivers:

- Incorporate plankton abundance, temperature, hydrodynamics, and substrate type into species distribution models to improve predictions of recruitment and habitat suitability. While some general SDMs exist, bespoke models for herring in Welsh waters are not identified in this study.

Recommendation 4. Link genetic and demographic data:

- Current ICES stock units (7a, 7b–k, etc.) provide a useful framework for assessment, but they do not fully capture localised connectivity or metapopulation dynamics.
- Genetic evidence, tagging, and otolith microchemistry indicate populations in Welsh waters are influenced by wider Irish Sea and Celtic Sea dynamics. Integrating these data into stock benchmarking could refine management units to reflect ecological connectivity, ensuring that the contribution of nursery and juvenile habitats are properly accounted for in stock management.

Recommendation 5. Implement long-term monitoring and temporal replication:

- Regular, multi-year surveys with spatial and temporal replication would be required to capture interannual variability in nursery ground use, larval abundance, and juvenile dispersal.
- Ensure coverage spans key spawning periods for the species under investigation, allowing temporal comparisons and better understanding of environmental influences on recruitment.
- Improving spatial resolution of commercial and recreational catch data would complement survey-based monitoring, helping to identify size distributions, local abundances, and areas of concentrated juvenile or adult presence.

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Nash, R. D. M., Dickey-Collas, M. and Milligan, S. P., 2000. The location of spawning of Irish Sea herring (*Clupea harengus*). *Journal of the Marine Biological Association of the United Kingdom*, 80(5), pp.913-923.

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Rogers, S.I. and Ellis, J.R., 2000. Changes in the demersal fish assemblages of British coastal waters during the 20th century. *iCES Journal of marine Science*, *57*(4), pp.866-881.

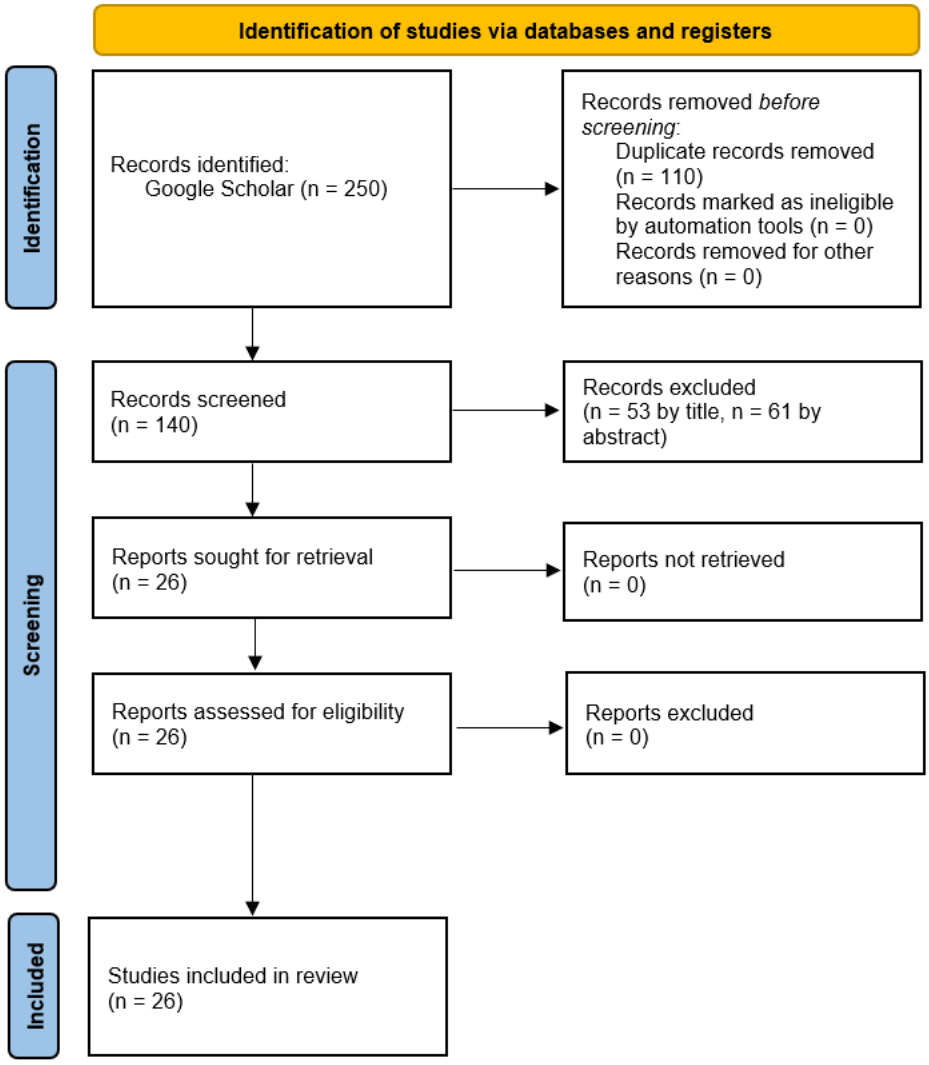
Scottish Government, Marine Directorate. 2023. Essential Fish Habitats Project Data. doi: 10.7489/12450-1

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Appendix 1: Literature search terms used

Atlantic herring (*Clupea harengus*)
(Atlantic herring OR *Clupea harengus*) AND ("Wales" OR "UK" OR "Celtic" or "Irish" OR "VII") AND "distribution"
(Atlantic herring OR *Clupea harengus*) AND ("Wales" OR "UK" OR "Celtic" or "Irish" OR "VII") AND ("egg" OR "larvae" OR "juvenile" OR "adult")
(Atlantic herring OR *Clupea harengus*) AND ("Wales" OR "UK" OR "Celtic" or "Irish" OR "VII") AND ("spawn*" OR "nursery" OR "feeding")
(Atlantic herring OR *Clupea harengus*) AND ("Wales" OR "UK" OR "Celtic" or "Irish" OR "VII") AND ("population" OR "genetic*" OR "migration" OR "home range")
(Atlantic herring OR *Clupea harengus*) AND ("Survey" OR "Sampling" OR "Monitoring")



Appendix 2: Literature confidence scores

Confidence was assessed using two criteria: type and quality of source and applicability of evidence to Welsh waters. For both criteria, scores were assigned numerically as High = 5, Medium = 3, and Low = 1. The two scores were summed to give an overall confidence score (range 2–10), which was then classified as Low (2–4), Medium (5–7), or High (8–10).

Citation	Confidence - type of source (base on evidence type)Quality of source -	Confidence - applicability of location	Overall confidence
Atmore, L.M., van Der Jagt, I., Boilard, A., Häberle, S., Blevis, R., Dierickx, K., Quinlan, L.M., Orton, D.C., Hufthammer, A.K., Barrett, J.H. and Star, B., 2024. The Once and Future Fish: Assessing a Millennium of Atlantic Herring Exploitation Through Mixed-Stock Analysis and Ancient DNA. Global Change Biology, 30(12), p.e70010.	High	Low	Medium
Bekkevold, D., Helyar, S.J., Limborg, M.T., Nielsen, E.E., Hemmer-Hansen, J., Clausen, L.A. and Carvalho, G.R., 2015. Gene-associated markers can assign origin in a weakly structured fish, Atlantic herring. ICES Journal of Marine Science, 72(6), pp.1790-1801.	High	Low	Medium
Bils, F., Moyano, M., Aberle, N., Hufnagl, M., Alvarez-Fernandez, S., & Peck, M. A. 2017. Exploring the microzooplankton–ichthyoplankton link: a combined field and modeling study of Atlantic herring (*Clupea harengus*) in the Irish Sea. Journal of Plankton Research, 39(1), 147-163.	High	Medium	High
Brophy, D. and Danilowicz, B.S., 2002. Tracing populations of Atlantic herring (*Clupea harengus* L.) in the Irish and Celtic Seas using otolith microstructure. ICES Journal of Marine Science, 59(6), pp.1305-1313.	High	High	High
Campanella, F., & van der Kooij, J. 2021. Spawning and nursery grounds of forage fish in Welsh and surroundings waters. Cefas Project Report for RSPB. Available at: https://data.cefas.co.uk/view/21465.	High	High	High
Cefas 1995. Irish Sea Annual Egg Production Method (AEPM) plankton survey. Dataset 2633. Centre for Environment, Fisheries & Aquaculture Science (Cefas) Data Portal. Available at: https://data.cefas.co.uk/view/2633 (Accessed: 5 October 2025).	High	High	High

Citation	Confidence - type of source (base on evidence type)Quality of source -	Confidence - applicability of location	Overall confidence
Cefas 2000. Irish Sea Annual Egg Production Method (AEPM) plankton survey. Dataset 2641. Centre for Environment, Fisheries & Aquaculture Science (Cefas) Data Portal. Available at: https://data.cefas.co.uk/view/2641 (Accessed: 5 October 2025).	High	High	High
Cefas 2006. Irish Sea fish egg production survey 2006. Dataset 3799. Centre for Environment, Fisheries & Aquaculture Science (Cefas) Data Portal. Available at: https://data.cefas.co.uk/view/3799 (Accessed: 5 October 2025).	High	High	High
Cefas 2008. Irish Sea fish egg production survey 2008. Dataset 3798. Centre for Environment, Fisheries & Aquaculture Science (Cefas) Data Portal. Available at: https://data.cefas.co.uk/view/3798 (Accessed: 5 October 2025).	High	High	High
Cefas 2009. Assessment of potential predators of plaice eggs and larvae in the Irish Sea (Dataset 727). Centre for Environment, Fisheries & Aquaculture Science (Cefas) Data Portal. Available at: https://data.cefas.co.uk/view/727 (Accessed: 5 October 2025).	High	High	High
Cefas and ABPmer 2010. Highly mobile fish species distributions in UK waters. Lowestoft: Cefas. Available at: https://data.cefas.co.uk/view/154 (Accessed: 5 October 2025)	High	High	High
Cefas 2010. Irish Sea fish egg production survey 2010. Dataset 2620. Centre for Environment, Fisheries & Aquaculture Science (Cefas) Data Portal. Available at: https://data.cefas.co.uk/view/2620 (Accessed: 5 October 2025).	High	High	High
Clarke, D.R. and King, P.E., 1985. Spawning of herring in Milford Haven. Journal of the Marine Biological Association of the United Kingdom, 65(3), pp.629-639.	High	High	High
Coull, K.A., Johnstone, R. and Rogers, S.I., 1998. Fisheries sensitivity maps in British waters. Published and distributed by UKOOA Ltd, 9. Available at: https://data.cefas.co.uk/view/149	High	High	High
Daniel, R.J., 1947. The Growth-Rate of Whitebait Herring of the North Wales Coast. ICES Journal of Marine Science, 15(1), pp.42-60.	High	High	High

Citation	Confidence - type of source (base on evidence type)Quality of source -	Confidence - applicability of location	Overall confidence
Deschepper, I., Lyons, K., Lyashevska, O., & Brophy, D. 2020. Biophysical models reveal the role of tides, wind, and larval behaviour in early transport and retention of Atlantic herring (*Clupea harengus*) in the Celtic Sea. Canadian Journal of Fisheries and Aquatic Sciences, 77(1), 90–107.	High	Medium	High
Devon & Severn Inshore Fisheries and Conservation Authority. 2023. The Bristol Channel Herring Project: Breaking down barriers to regional management of fish stocks [Infographic/Report]. https://www.devonandsevernifca.gov.uk/wp-content/uploads/2023/09/BreakingDownBarrierstoRegionalManagementofFishStocks.pdf	High	Medium	High
Dickey-Collas, M., Nash, R.D. and Brown, J., 2001. The location of spawning of Irish Sea herring (*Clupea harengus*). Journal of the Marine Biological Association of the United Kingdom, 81(4), pp.713-714.	High	High	High
Ellis, J.R., Milligan, S.P., Readdy, L., Taylor, N. and Brown, M.J. 2012. Spawning and nursery grounds of selected fish species in UK waters. Sci. Ser. Tech. Rep., Cefas Lowestoft, 147: 56 pp. Available at: https://data.cefas.co.uk/view/153	High	High	High
Gubbay, S. 2009. A selective review of historical information about the marine environment around Wales. A report to WWF Cymru.	Medium	High	High
Hickling, C.F., 1946. The herring fisheries at Milford Haven. Journal of the Marine Biological Association of the United Kingdom, 26(3), pp.408-420.	High	High	High
Hyder, K., Edwards, W. and Radford, Z. 2024. Sea Angling Diary Catch, Participation and Economic Estimates 2016-2021. Cefas, UK. V1. doi: https://doi.org/10.14466/CefasDataHub.151	High	High	High
ICES 2017. Stock Annex: Herring (*Clupea harengus*) in Division 7.a North of 52°30'N (Irish Sea). ICES Stock Annexes. Report. https://doi.org/10.17895/ices.pub.18622565.v1	High	High	High
ICES. 2021. Herring Assessment Working Group for the Area South of 62° N (HAWG). ICES Scientific Reports. 3:12. 779 pp. https://doi.org/10.17895/ices.pub.8214	High	High	High
ICES. 2023. Herring Assessment Working Group for the Area South of 62° N (HAWG). 837 pp. ICES Scientific Reports. 5:23. https://doi.org/10.17895/ices.pub.22182034	High	High	High

Citation	Confidence - type of source (base on evidence type)Quality of source -	Confidence - applicability of location	Overall confidence
ICES. 2024. icesDatras R package, version 1.4.1. Available from CRAN. URL: https://github.com/ices-tools-prod/icesDatras (Accessed: 27/10/2025).	High	High	High
ICES, 2024. Workshop on a Research Roadmap for Bristol and Western Channel Herring (WKRRBWCH; outputs from 2023 meeting) (report). ICES Scientific Reports. https://doi.org/10.17895/ices.pub.25868119.v1	High	High	High
ICES, 2025a. ICES Database on Trawl Surveys (DATRAS), ICES, Copenhagen, Denmark. https://datras.ices.dk	High	High	High
ICES (2025b) Eggs and larvae dataset. Available at: https://eggsandlarvae.ices.dk (Accessed: 5 October 2025	High	High	High
ICES. 2025c. Working Group on International Pelagic Surveys (WGIPS). ICES Scientific Reports. 7:54. 131 pp. https://doi.org/https://doi.org/10.17895/ices.pub.28890038	High	High	High
Jonker, A., 2023. Mapping essential fish habitats of herring (*Clupea harengus*) and mackerel (Scomber scombrus) in the North East Atlantic (Doctoral dissertation, MS Thesis, University of Wageninge, Wageningen, Netherlands).	High	Medium	High
Kyle-Henney, M., Reach, I., Barr, N., Warner, I., Lowe, S., & Lloyd Jones, D. 2024. Identifying and Mapping Atlantic Herring Potential Spawning Habitat: An Updated Method Statement (Version 6.0). MarineSpace Ltd & ERM Ltd.	Medium	Medium	Medium
Libungan, L.A., Óskarsson, G.J., Slotte, A., Jacobsen, J.A. and Pálsson, S., 2015. Otolith shape: a population marker for Atlantic herring *Clupea harengus*. Journal of Fish Biology, 86(4), pp.1377-1395.	High	Medium	High
Marine Institute 2018. Species spawning and nursery areas. Available at: https://atlas.marine.ie (Accessed: 27/10/2025).	High	High	High
Moore, A. B., Brander, K., Evans, S., Holm, P., & Hiddink, J. G. 2024. Century-scale loss and change in the fishes and fisheries of a temperate marine ecosystem revealed by qualitative historical sources. Fish and Fisheries, 25(5), 876-894.	High	High	High

Citation	Confidence - type of source (base on evidence type)Quality of source -	Confidence - applicability of location	Overall confidence
Natural Resources Wales (2025) NRW Marine Fish Surveys 1997–2024: Species counts and length measurements. Available at: https://datamap.gov.wales/layergroups/geonode:nrw_marine_fish_surveys (Accessed: 30 January 2026).	High	High	High
OBIS 2025. Ocean Biodiversity Information System. Intergovernmental Oceanographic Commission of UNESCO. Available at: https://obis.org (Accessed: 27/10/2025).	Medium	High	High
O'Donnell, C., Mullins, E. and Daly, E. 2025. Celtic Sea Herring Acoustic Survey Cruise Report 2024, 09–29 October 2024. FEAS Survey Series; 2024/04. Galway: Marine Institute. Available at: https://oar.marine.ie/entities/publication/e2b2bac7-e562-44d8-87f2-ec7104b036ee (Accessed: 30 January 2026).	High	High	High
Olsen, S. 1883. The piscatorial atlas of the North Sea, English Channel and St George's Channel. Fishing News (Books) Ltd, London.	High	High	High
Oriel Wind Farm Project. 2024. Herring spawning technical report (Appendix 09-02, Volume 2B EIAR). Oriel Wind Farm Project Environmental Impact Assessment Report. Retrieved March 16, 2026, from https://www.pleanala.ie/publicaccess/EIAR-NIS/319799/Oriel%20Wind%20Farm%20Project%20-%20Planning%20Application/EIAR/Volume%202B%20EIAR%20Chapters%207-16%20and%20associated%20technical%20appendices/09-02%20Herring%20Spawning%20Technical%20Report.pdf	Medium	Medium	Medium
O'Sullivan, D., O'Keefe, E., Berry, A., Tully, O. and Clarke, M., 2013. An inventory of Irish herring spawning grounds. Marine Institute.	High	Medium	High
Reygondeau, G., Egorova, Y., Boerder, K., Tittensor, D.P., Kaschner, K., Kesner-Reyes, K., Bailly, N. and Cheung, W.W., 2025. AquaX: An enhanced and revised AquaMaps framework to model marine species distributions and biodiversity. bioRxiv, pp.2025-10.	High	Medium	High
Rogers, S.I. and Ellis, J.R., 2000. Changes in the demersal fish assemblages of British coastal waters during the 20th century. iCES Journal of marine Science, 57(4), pp.866-881.	High	Medium	High
Scottish Government, Marine Directorate. 2023. Essential Fish Habitats Project Data. doi: 10.7489/12450-1.	High	High	High

Citation	Confidence - type of source (base on evidence type)Quality of source -	Confidence - applicability of location	Overall confidence
Van der Kooij, J., Campanella, F. and Rodríguez Climent, S., 2021. Pressures on forage fish in Welsh Waters. Cefas Project Report for RSPB.	High	High	High
Volkenandt, M., Berrow, S., O'Connor, I., Guarini, J-M., and O'Donnell, C., 2014. Prespawning herring distribution in the Irish Celtic Sea between 2005 and 2012. – ICES Journal of Marine Science, 72: 498–507.	High	Medium	High

Appendix 3: Population distribution datasets

A3.1. Life stage – eggs and life cycle process – spawning grounds

A3.1.1. Fisheries spawning and nursery areas in British waters (Coull *et al.*, 1998)

Spatial coverage: All Welsh waters

Herring spawning ground data were derived from the Fisheries Spawning and Nursery Areas dataset, based on the Fishery Sensitivity Maps in British Waters (Coull *et al.*, 1998). Within mapped areas, the majority of herring spawning is identified as occurring outside of Welsh waters, particularly around the eastern Isle of Man and adjacent Irish Sea regions (Figure 50).

Within Welsh waters, the only area showing consistent evidence of potential herring spawning is off the Pembrokeshire coast near the mouth of the Milford Haven, though with undetermined intensity, with no other clear spawning grounds identified along the remainder of the Welsh coast. These patterns reflect where survey data have recorded reproductive indicators rather than the absence of spawning elsewhere.

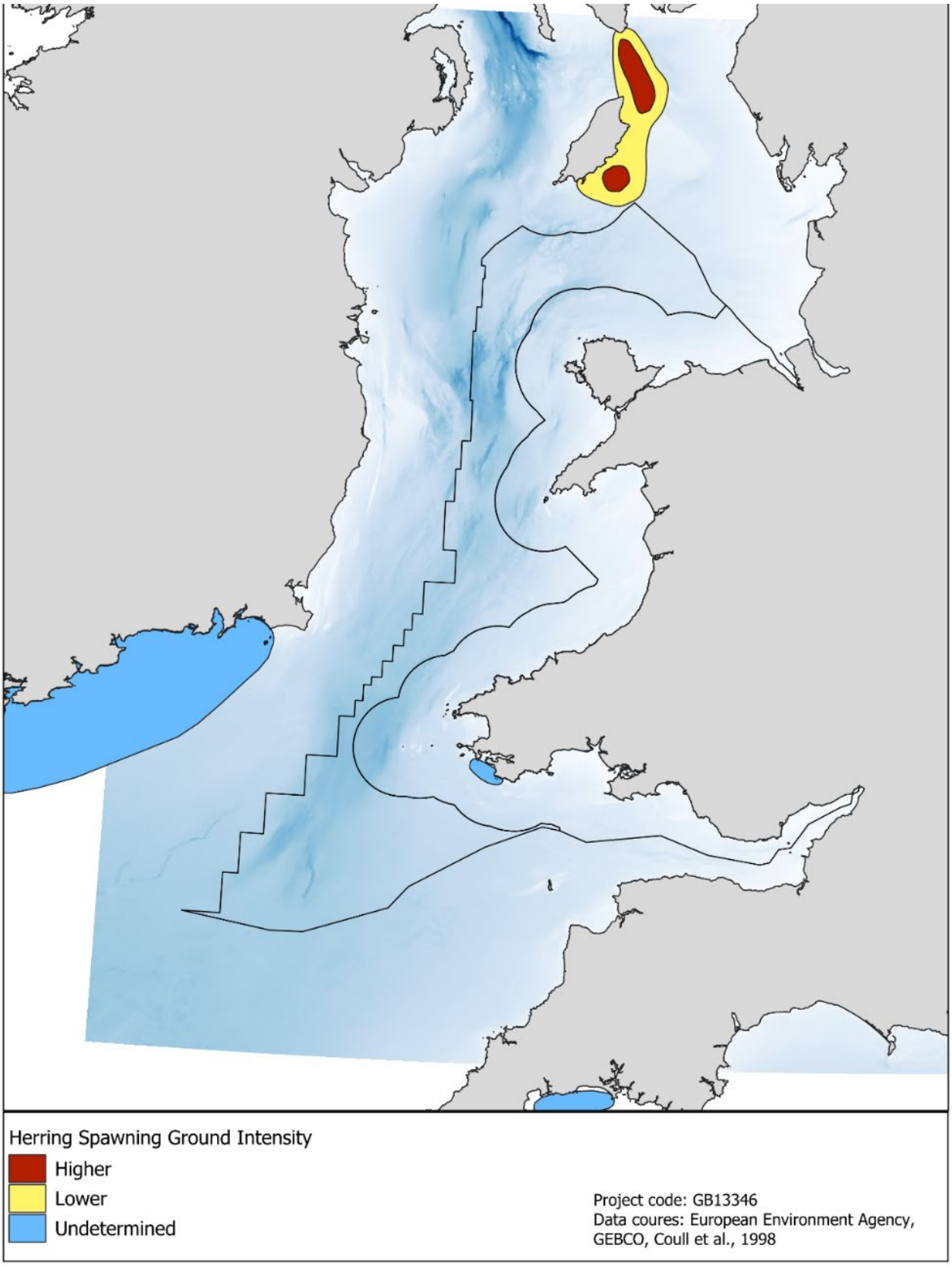


Figure 8. Locations of herring spawning grounds (Source: Coull *et al.,* 1998).

A3.1.2. Spawning and nursery grounds of forage fish in Welsh and surrounding waters (Campanella and van der Kooij, 2021)

Spatial coverage: All Welsh waters, excluding close inshore and estuaries.

The dataset from Campanella and van der Kooij (2021) provides inferred herring spawning grounds based on the distribution of adult herring during the main autumn and winter spawning periods (Q1 and 4). Adult hotspot maps were used as a proxy for spawning locations, with the assumption that areas of high adult density correspond to likely spawning grounds.

In Welsh waters, these maps indicate that inshore Welsh waters off the North Wales coast between Anglesey and the Great Orme, and outside the Dee Estuary, are potential spawning hotspots in Q1, while there are potential hotspots in both Q1 and Q4 in the outer Bristol Channel, but with lower intensity than northern areas (Figure 51).

The adult distributions also extend offshore, highlighting that adult presence does not necessarily indicate spawning, particularly as this offshore habitat may be unsuitable for egg deposition. However, apparent inshore patterns should be interpreted with caution, as survey coverage was limited to stations deeper than 20 m, potentially under-representing true inshore and estuarine spawning activity.

Notably, known spawning grounds along the southern Irish coast were not captured, likely due to limited survey coverage or reduced spawning stock biomass in the Celtic Sea. These patterns suggest that while the analysis captures major Welsh and Irish Sea spawning areas, some smaller or more isolated spawning sites are likely to be underrepresented.

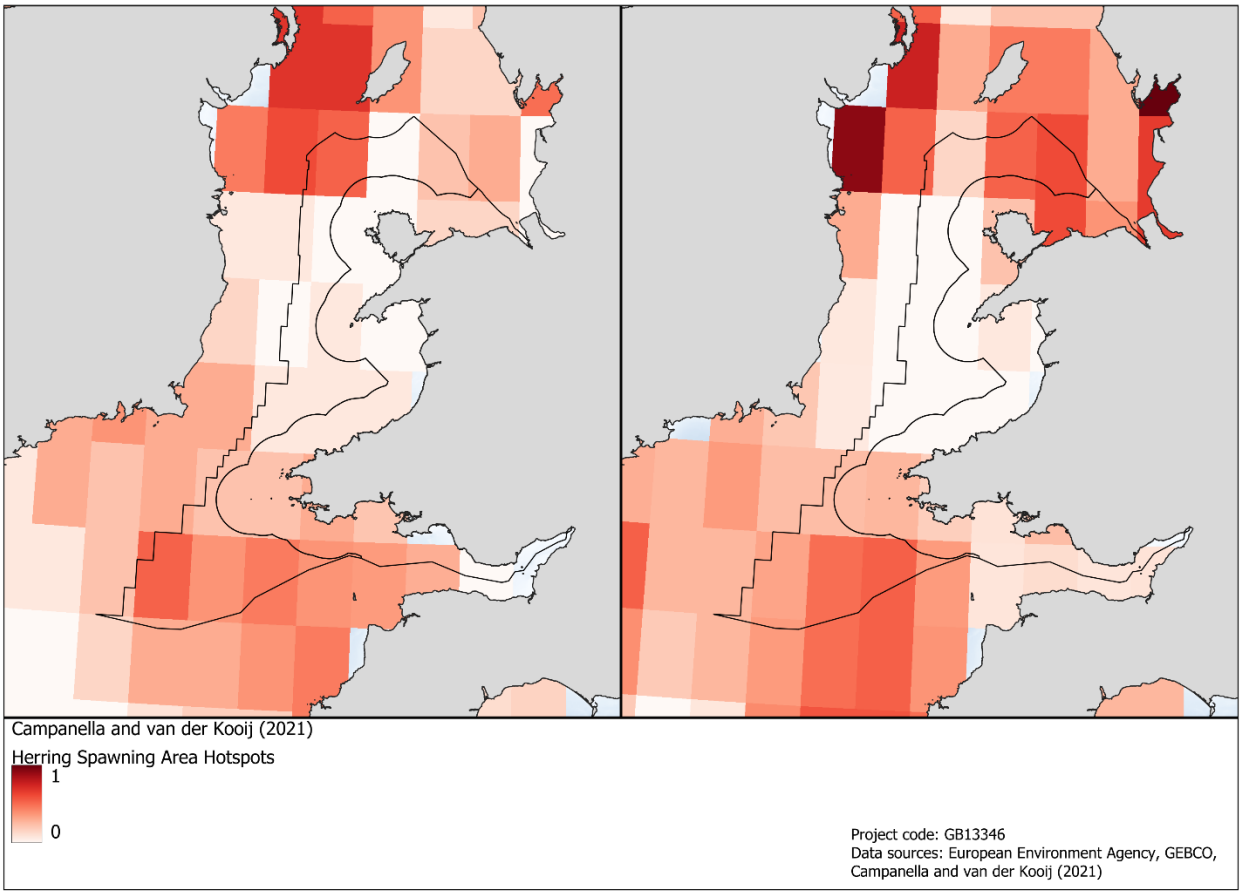


Figure 9. Herring spawning area hot spots Q4 (left) and Q1 (right) (2008 – 2021) (Source: Campanella and van der Kooij, 2021)).

A3.1.3. Species spawning and nursery areas (Marine Institute, 2018; revised 2024)

Spatial coverage: Irish waters

The Marine Institute's Species Spawning and Nursery Areas dataset provides spatial layers identifying nursery grounds for commercially important fish species, including herring.

This dataset is primarily focused on Irish waters and does not cover Welsh waters. It is included here for reference and is included within the associated spatial dataset, providing context on the location and distribution of habitats associated with herring spawning grounds in the wider Celtic Sea region. The data contain fine scale data related to grounds including spawning beds, spawning grounds and spawning areas.

A3.1.4. Spawning of herring in Milford Haven (Clarke and King, 1985)

Spatial coverage: Milford Haven, Pembrokeshire

Despite the presence of an important herring fishery in Milford Haven, the location of the spawning grounds was only confirmed in 1981 with a dive survey, locating herring eggs at Burton Point, Castle Reach and near Pennar Gut (Figure 52). Eggs were sampled at Burton Point, and at Castle Reach in 1982, though plankton hauls at low tide in April 1981 showed a discontinuous distribution with yolk sac larvae present in both areas. It is unlikely that these larvae could have been transported 2-3 km upstream at low water, therefore it was considered by the authors reasonable to conclude that herring eggs were deposited in both Castle Reach and Burton Point.

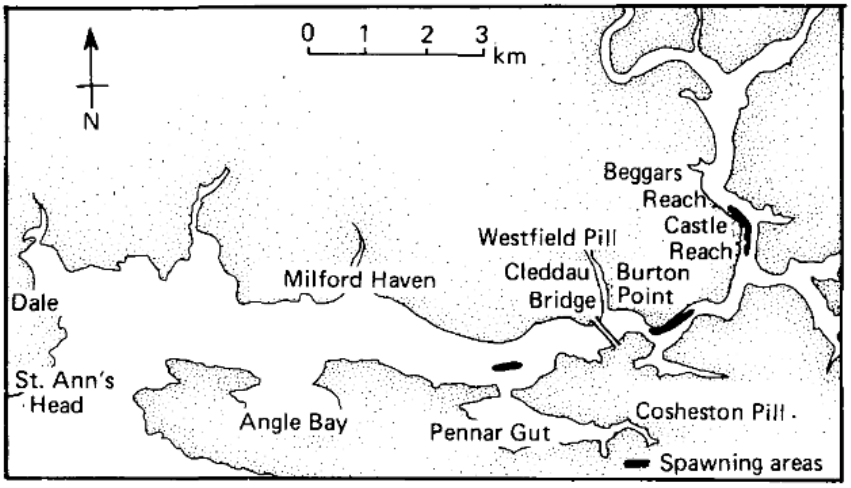


Figure 10. Herring spawning grounds in Milford Haven (Clarke and King, 1985)

A3.1.5. Workshop on a research roadmap for Bristol and Western Channel Herring WKRRBWCH (ICES, 2024)

Spatial coverage: Milford Haven, Pembrokeshire

In the Milford Haven, summer ichthyoplankton survey data have been collected by Pembroke Power Station since 2009. From 2012 onwards, these include entrainment data on eggs and larvae that can pass through the drum screens of the power station. The datasets could include eggs and larvae from both autumn and spring spawners, with genetic testing of fish indicating that 42% of eggs were from spring spawning herring stocks.

In 2018 and 2019, Swansea University carried out fishing, grab sampling and larval surveys to assess the current status of the spring-spawning population in Milford Haven. Spawning adults were captured in the Castle Reach, confirming that a spawning population remains. However, sampling on historic spawning grounds at Burton Point and

Castle Reach in the Milford Haven Waterway in March and April 2018, including 259 grab samples and 20 larval hauls, found no eggs and very few larvae. A more systematic survey in 2019, with frequent grab sampling and regular larval surveys across multiple sites, produced similar results, with few larvae and no eggs detected.

A3.1.6. Herring Assessment Working Group for the Area South Of 62° N (ICES, 2021)

Spatial coverage: Irish Sea

Herring in the Irish Sea comprises two spawning groups (Manx, Figure 53 and Figure 62 and Mourne, Figure 54). From the late 1980s up to the early 2000s, the contribution of the Mourne spawning component declined in line with the overall reduction in stock size. An increase in activity on the Mourne spawning area has been observed since 2006. In the past decade, there have been problems in assessing the stock, partly as a consequence of the variability of spawning migrations and mixing with the Celtic Sea stock.

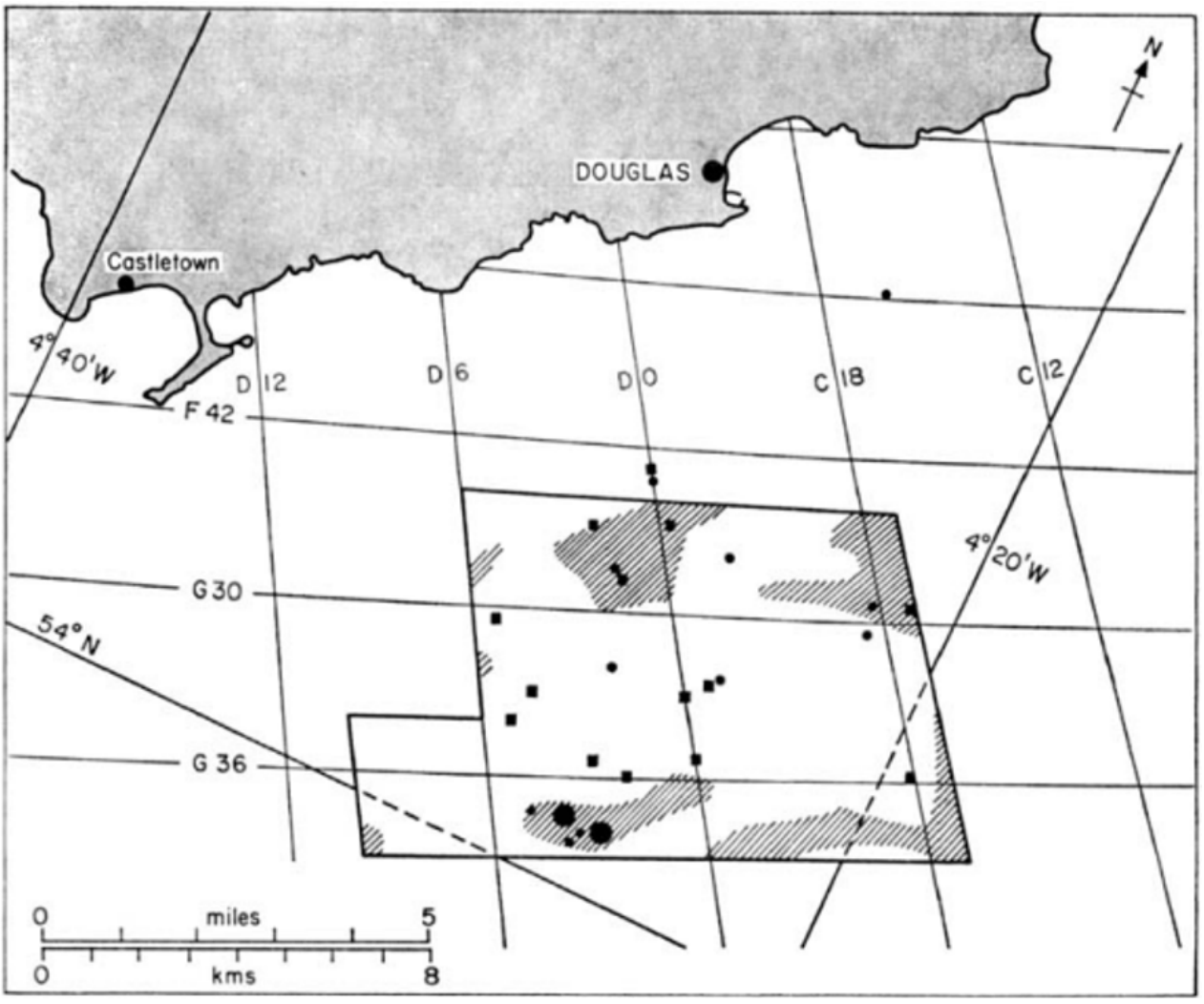


Figure 11. Manx spawning area and spawning beds off the coast of the Isle of Man. Small black squares show spawning loci, informed by larval distributions. Small black spots refer

to small numbers of eggs between 1948 and 1956. Large black spots show spawning beds in 1968. Shading indicates ‘spawning gravel’ within the area surveyed (Source: Bowers, 1969)

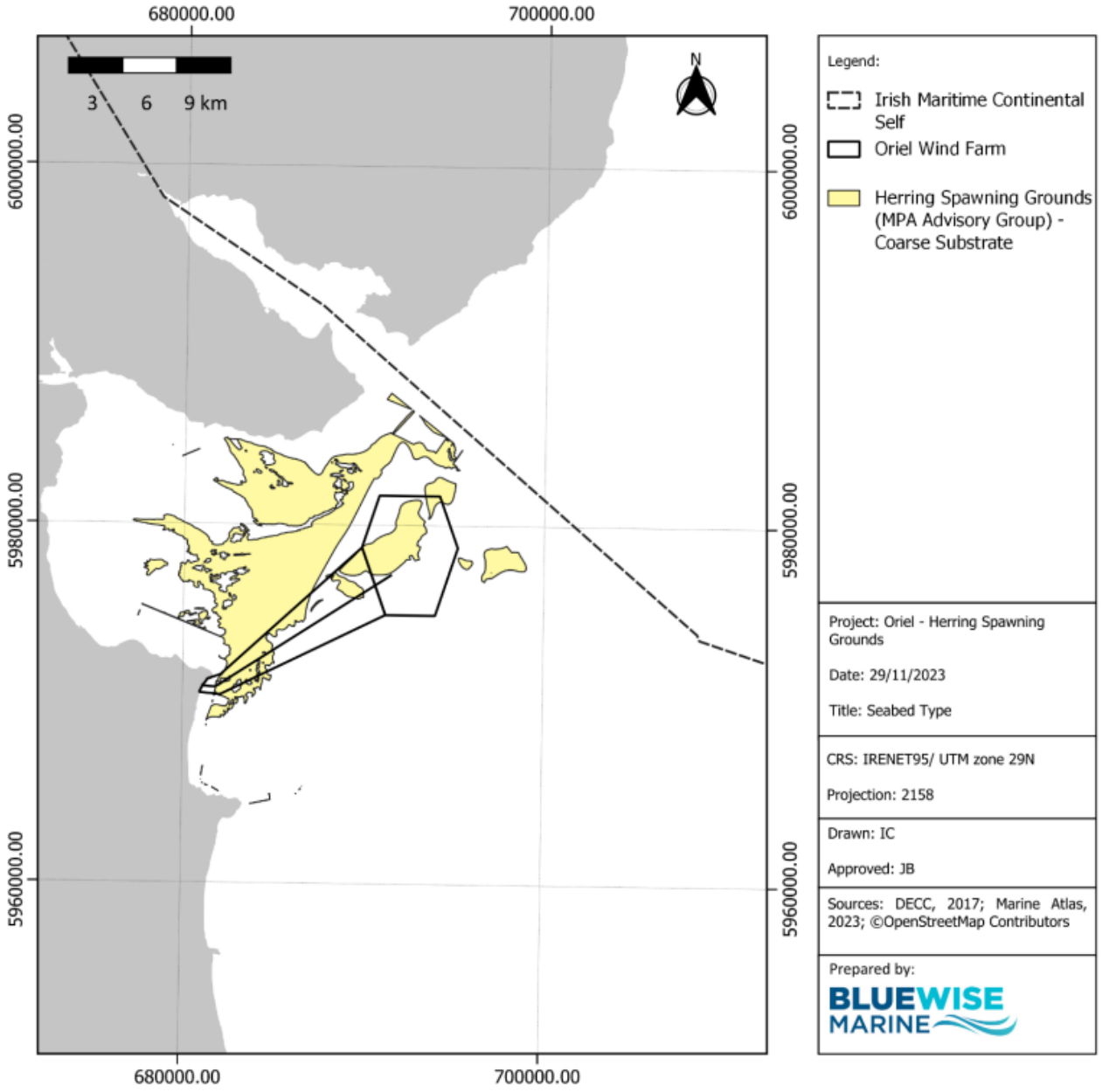


Figure 12. Coarse substrate forming the Mourne herring spawning grounds (Source: Oriel Wind Farm Project, 2024).

A3.1.7. Herring Assessment Working Group for the Area South of 62°N. (ICES, 2023)

Spatial coverage: Irish Sea

An acoustic survey in Northern Irish waters investigated the variability of population estimates, tracking spawning migration into the Irish Sea via the North Channel, toward the spawning grounds of the Douglas Bank. These areas consistently hold over 75% of the spawning stock biomass (SSB), and the survey provides an SSB index specifically from fish on or near the spawning grounds. Historic density maps show substantial temporal and spatial variability in ground occupation, driven by interannual shifts in migration timing. The survey confirms high herring abundance, though with notable year-to-year variation tied to the dynamics of fish movement onto the Douglas Bank spawning areas.

A3.1.8. The Bristol Channel Herring project. Breaking down barriers to regional management of fish stocks (Devon and Severn IFCA, 2023)

Spatial coverage: Bristol Channel

The Bristol Channel Herring Project, developed under the North Devon Marine Pioneer Programme, was initiated in response to local fishermen’s reports of herring spawning activity within the inner Bristol Channel and Severn Estuary. The project rationale notes that no scientifically documented spawning ground has been formally identified in the Bristol Channel, although the presence of suitable habitat and the existence of a small, long-standing local fishery have prompted investigation into the possibility of a discrete spawning component.

The mapped areas in Figure 55 are based on fishers' observations of herring behaviour, distribution and spawning state on capture over decades of drift and stake netting. The Clovelly autumn spawners are a distinct genetic stock (including being distinct from the Clovelly winter spawners and the Minehead spawning fish) (ICES WKRRBWCH, 2023).

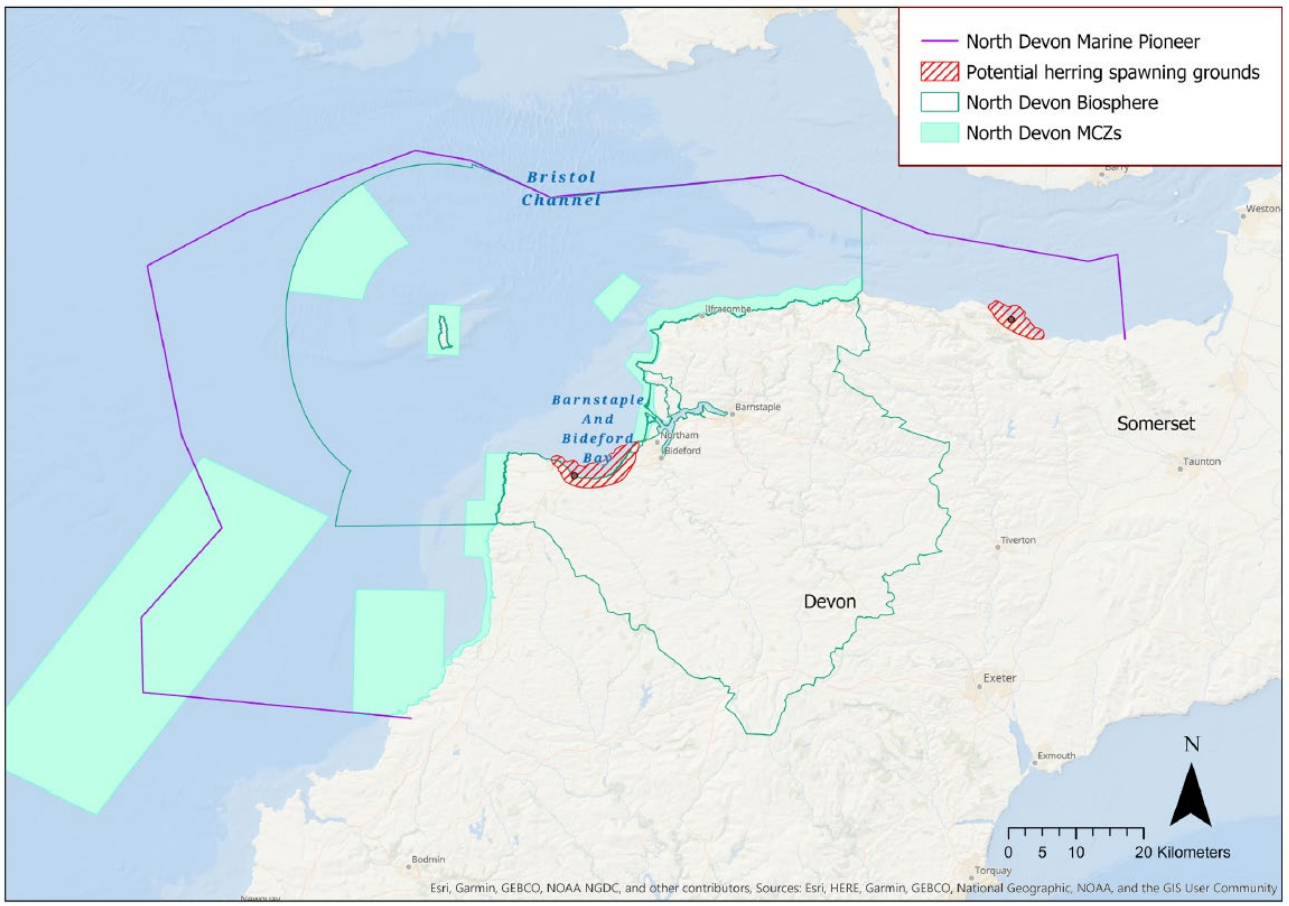


Figure 13. Location of potential herring spawning grounds at Clovelly and Minehead. (Source: Devon and Severn IFCA, 2023).

A3.2. Life stage – larvae

A3.2.1. ICES Egg and Larvae data (ICES, 2025b)

Spatial coverage: Offshore waters of the Irish and Celtic Seas

The ICES egg and larvae dataset covers 48,188 hauls sampled between 1992 and 2025 in all months except October. Coverage in Welsh and surrounding waters is extremely limited throughout this period (Figure 57). Only one haul occurred within the 12 nm Welsh inshore boundary containing no herring larvae. In Welsh offshore waters, 7 stations were sampled, six of which were in the Celtic Sea and St George's Channel, and one close to the boundary of the median line in Welsh waters of the Irish Sea, which did detect herring larvae although in low abundance (Figure 57). Sampling effort was largely concentrated in the North Sea, West of Scotland, and the waters west and south of Ireland, with the area between Wales and Ireland rarely surveyed. Beyond this, the only nearby occurrences appear around the southern, eastern and northern coast of the Isle of Man (Figure 57).

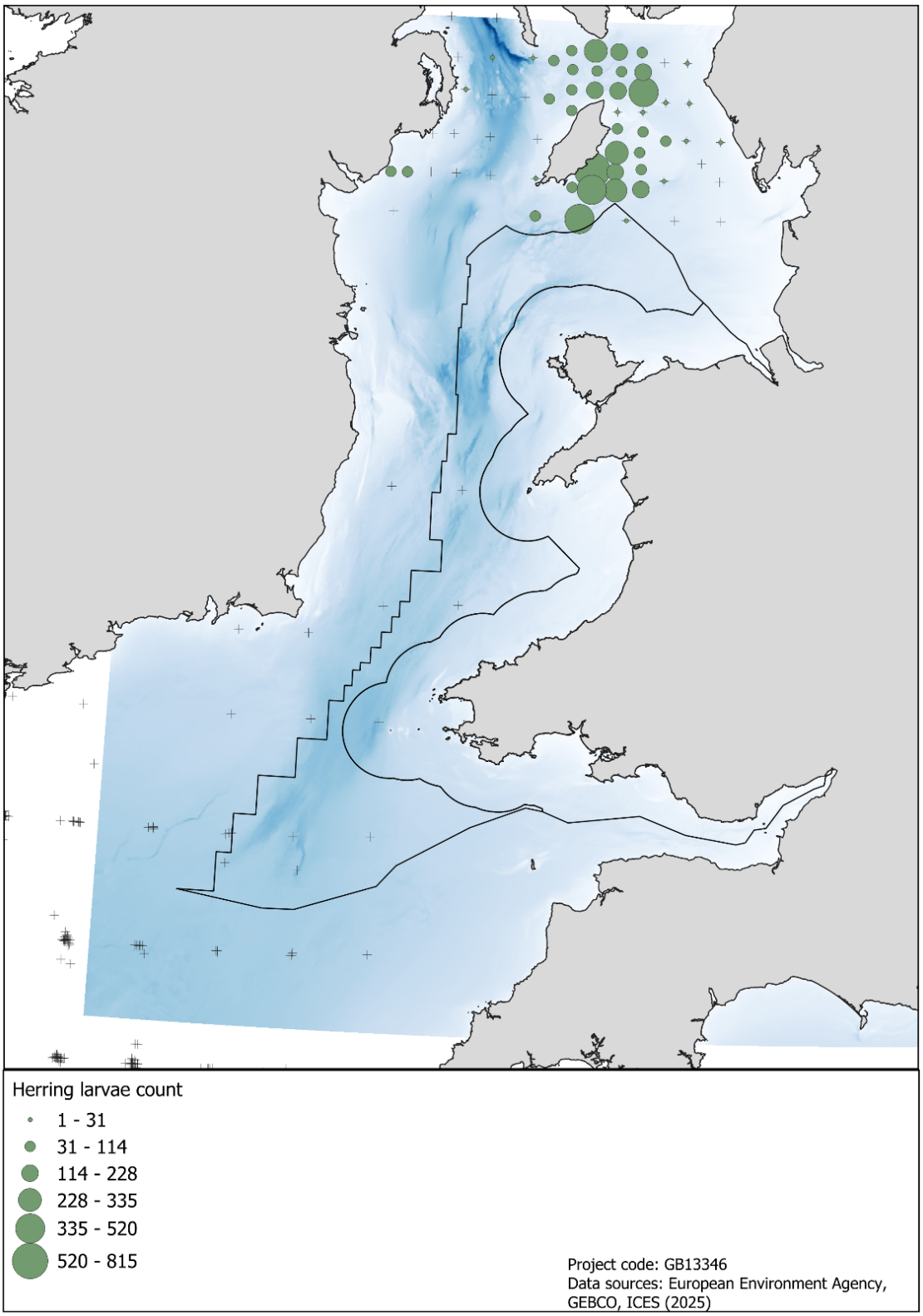


Figure 14. Point count data of herring larvae recorded in the ICES Egg and Larvae database. Black crosses denote sampling stations with zero abundance counts (Source: ICES, 2025b).

A3.2.2. Assessment of potential predators of plaice eggs and larvae in the Irish Sea (Cefas, 2023)

Spatial coverage: Irish Sea

This study assessed potential predators of plaice eggs and larvae in the Irish Sea in February 2008 and 2009, on a well-described plaice spawning ground off the north Wales coast. The data indicate herring larvae were recorded in samples taken along the North Wales coast, within outer Welsh waters as well as within English waters (Figure 58). The sampling location with the highest concentration of herring larvae were found within Welsh inshore waters north of The Great Orme, where a maximum value of 280 larvae per m^3 was recorded. The counts of larvae for all other sites range between 1 and 82 per m^3.

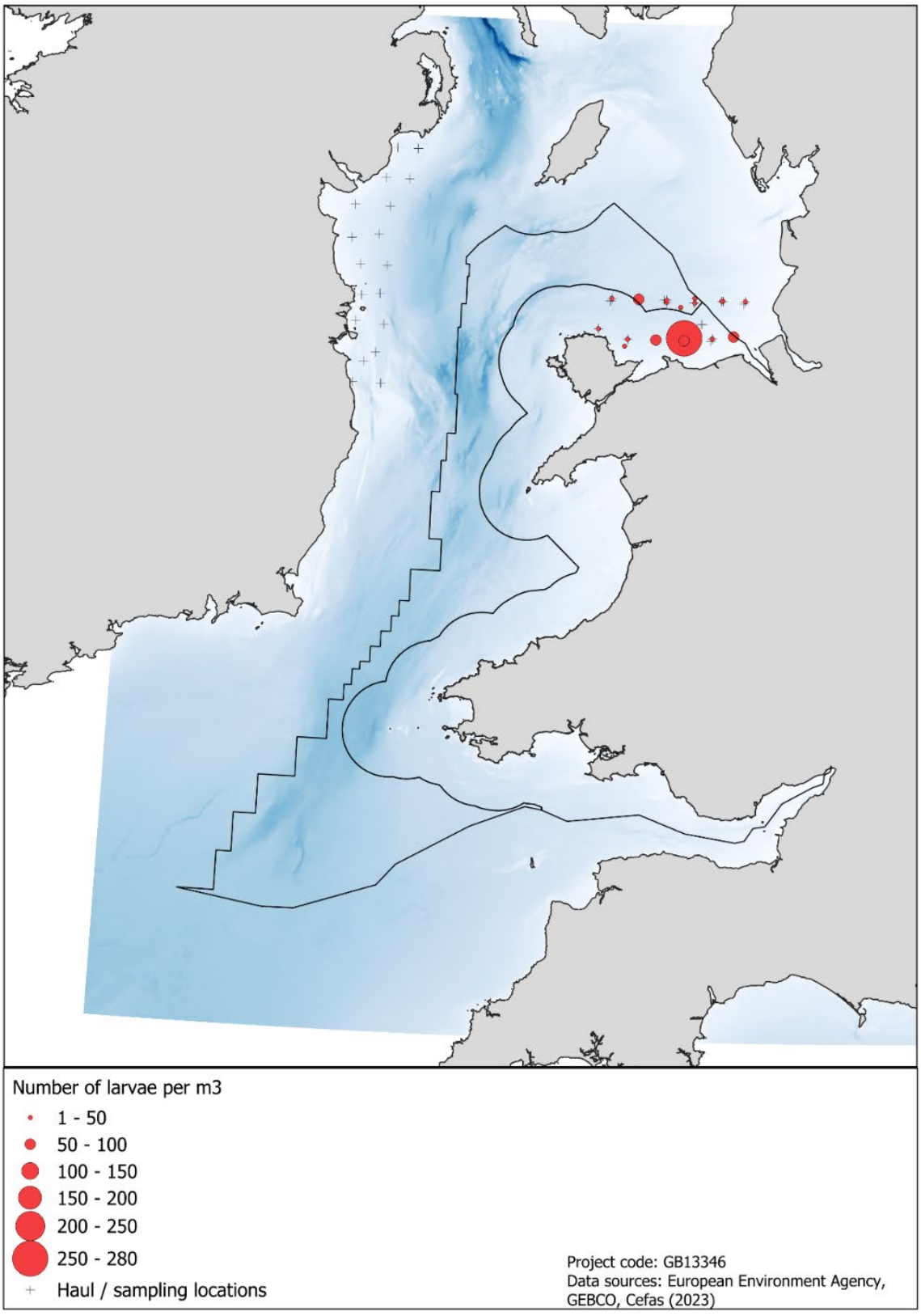


Figure 15. Number of herring larvae sampled by Cefas in the assessment of plaice predators in the Irish Sea survey (Source: Cefas, 2023).

A3.2.3. Spawning and nursery grounds of selected fish species in UK waters (Ellis *et al.*, 2012)

Spatial coverage: All Welsh waters, excluding close inshore and estuaries.

Ellis *et al.* (2012) present the distribution of herring larvae based on surveys conducted in 1990, 1991, 1995, 2000, 2004, 2006 and 2008. Herring larvae were identified across five survey series: the 1991 Sole survey, the Bristol Channel Plankton Survey, the Eastern Irish Sea Survey, the International Herring Larval Survey and ISEPS.

Herring larvae sampled in Welsh and surrounding waters were mainly recorded along off the North Wales coast from Anglesey to the Dee Estuary (Figure 59). Few herring larvae were recorded in Welsh offshore waters. In areas surrounding Welsh waters, high values of relative abundance were recorded in the waters east of the Isle of Man.

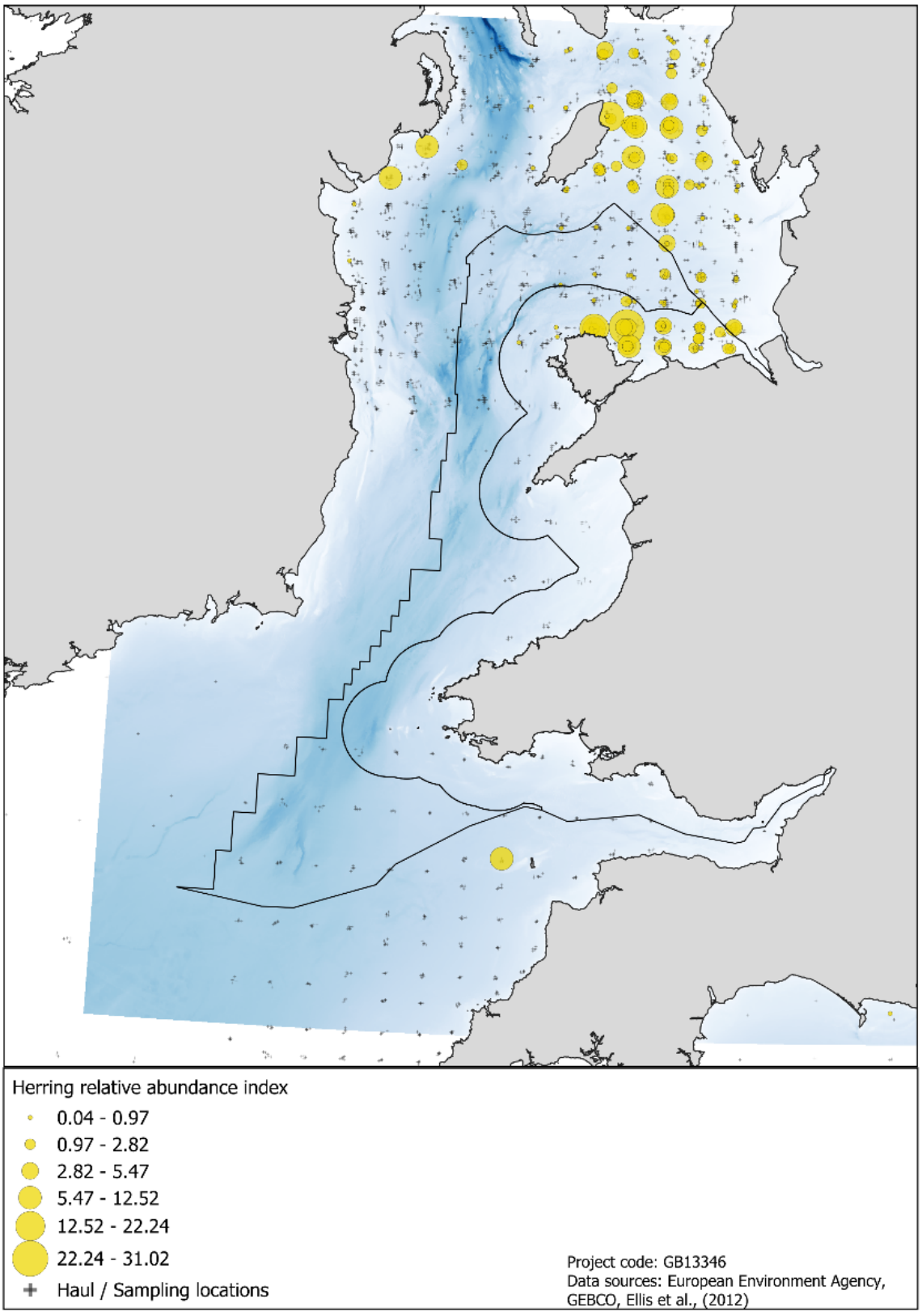


Figure 16. Distribution and index of abundance of herring larvae in Welsh and surrounding waters. Black crosses denote sampling stations with zero records (Source: Ellis *et al.,* 2012)

A3.2.4. Annual Egg Production Method Survey (AEPM) surveys 1995 and 2000 (Cefas, 1995; Cefas, 2000)

Spatial coverage: Irish Sea, and Cardigan Bay in 1995 only

The Annual Egg Production Method survey (AEPM), carried out in 1995 and 2000, provides survey coverage across the northern Irish sea, extending into waters within the 12 nm area of Cardigan Bay. Records of herring larvae identified in haul samples are found mainly in the north-eastern Irish sea, including within Welsh inshore waters. The highest recorded value of herring larvae from this survey series was located off the east coast of the Isle of Man, with stations to the southeast of the island also identifying moderate number of herring larvae.

Within Welsh waters, the highest concentration of herring larvae were found along the north Wales coast from Anglesey to the Dee Estuary within Welsh inshore waters, with stations closer to the coast identifying more than those further offshore (Figure 60). Stations sampled within Welsh offshore waters contained fewer herring larvae than those inshore.

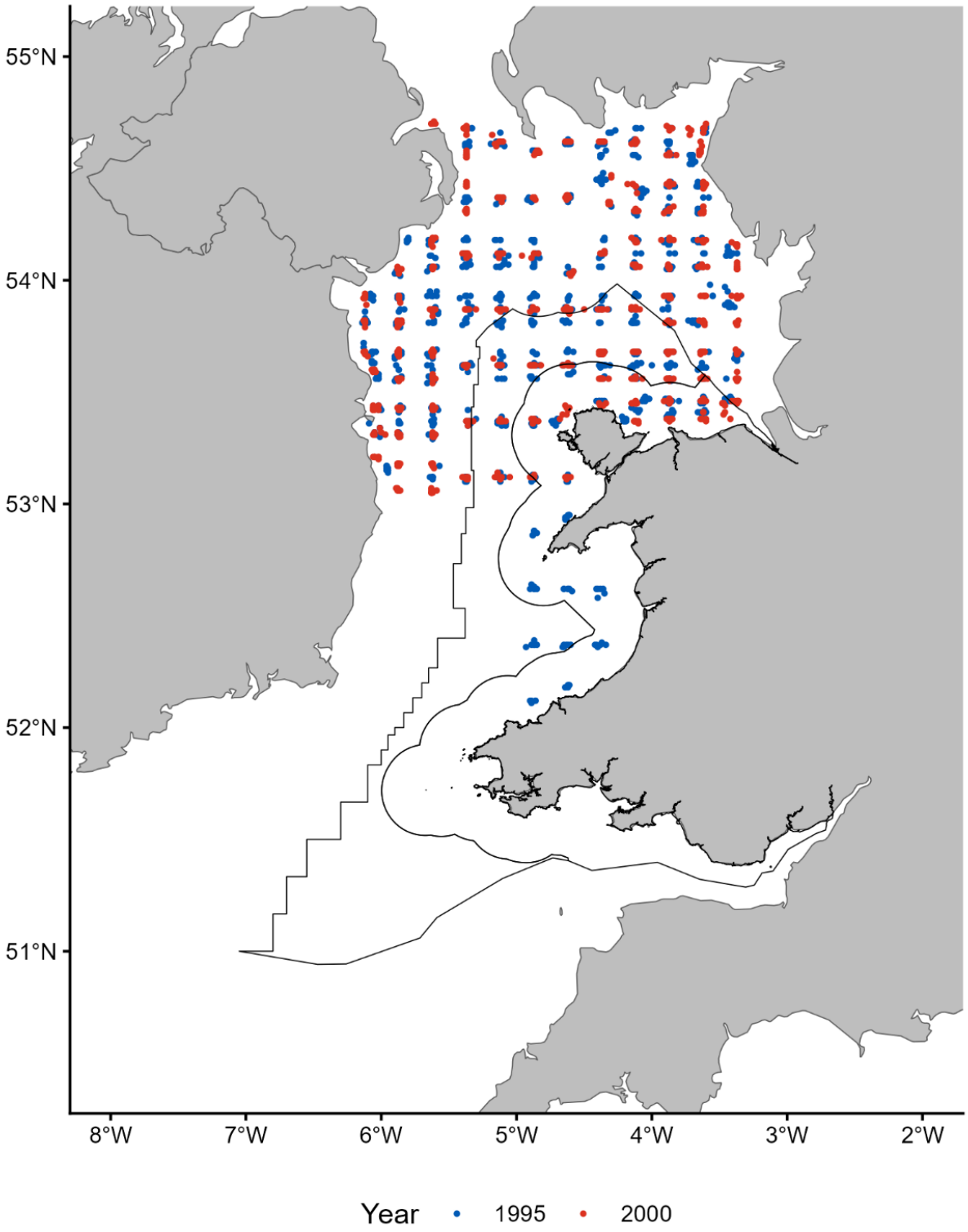


Figure 17. AEPM sampling stations from 1995 and 2000 surveys (Source: Cefas, 1995; Cefas, 2000).

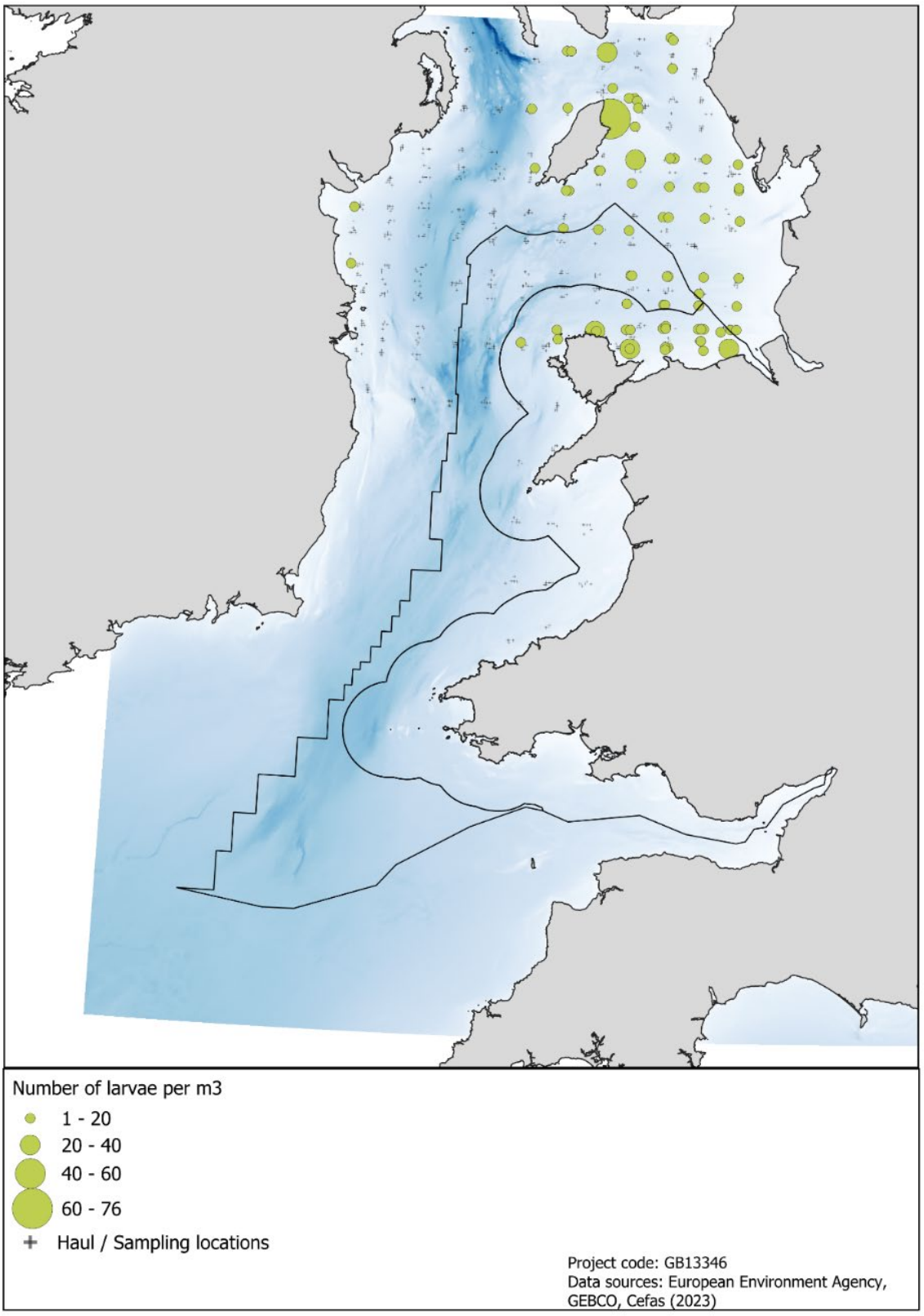


Figure 18. Number of herring larvae in Annual Egg Production Method survey hauls. Black crosses denote sampling stations (Source: Cefas, 1995; 2000).

A3.2.5. Irish Sea Fish Egg Production Surveys (ISFEPS) (Cefas, 2010)

Spatial coverage: Irish Sea

The Irish Sea Fish Egg Production Surveys were conducted throughout January to April in 2006, 2008, and 2010 across the northern Irish Sea. Survey coverage included stations within Welsh waters throughout both outer areas, although surveys did not extend further south than the Llŷn Peninsula. No herring larvae were recorded within Welsh waters. All stations with herring larvae present were located to the south-east of the Isle of Man, and the associated count values were low (Figure 61). These herring surveys occurred in Q3 and 4, which may account for the low numbers and overall low abundance observed.

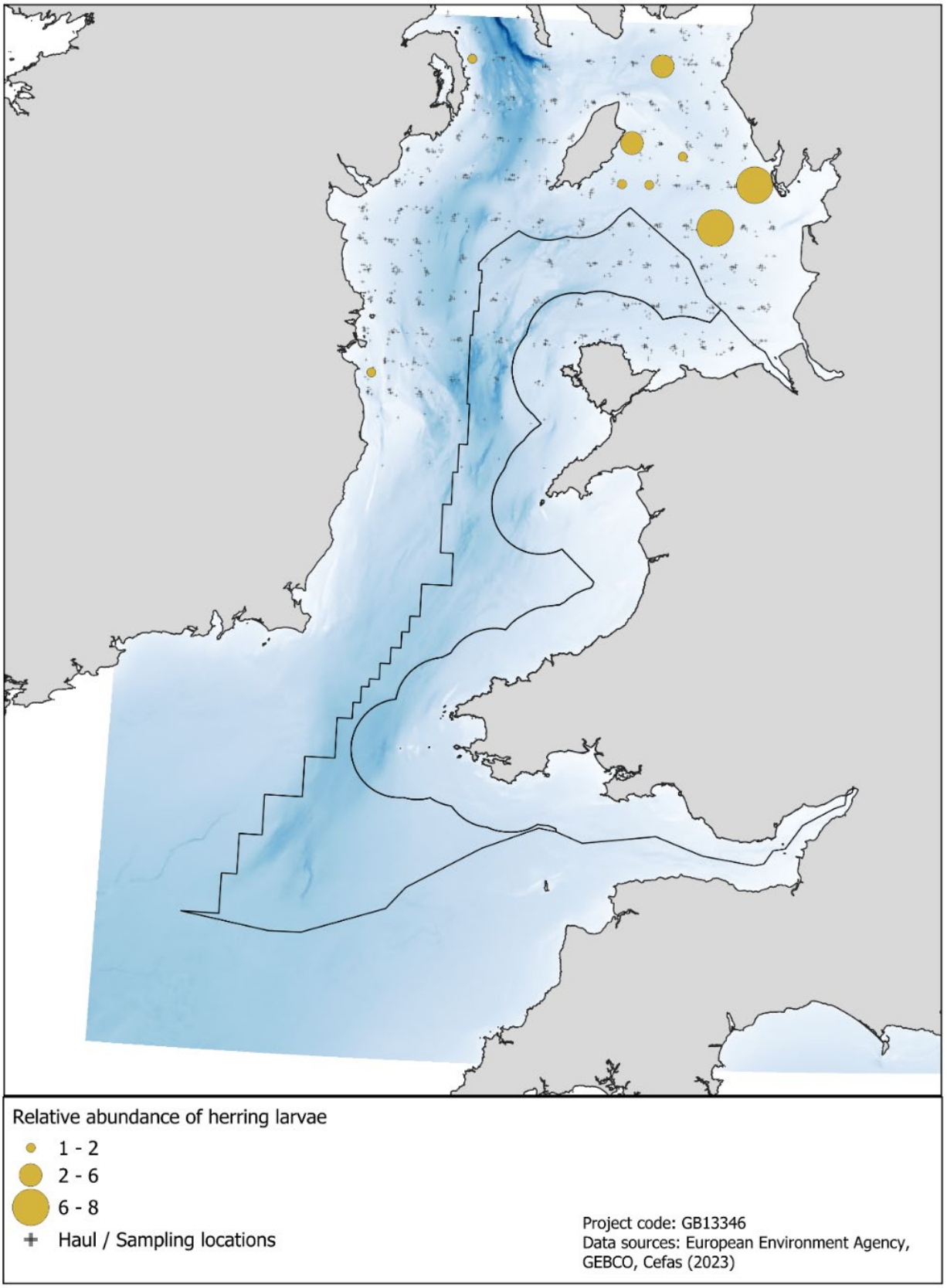


Figure 19. Relative abundance of herring larvae across Irish Sea Fish Egg Production Surveys (Source: Cefas, 2023).

A3.2.6. The location of spawning of Irish Sea herring (Clupea harengus) (Dickey-Collas *et al.*, 2001)

Spatial Coverage: Irish Sea

The University of Liverpool conducted larval surveys for herring, focusing on the Douglas Bank spawning grounds off the coast of the Isle of Man, during the 1998-2000. The northern part of the Irish Sea hosts two historical spawning areas, the Mourne and Douglas Banks. Larvae recorded on the Douglas Bank were likely spawned locally, as the circulation of the western Irish Sea in early autumn is weakly southward with no connectivity to the eastern Irish Sea. The study, therefore, suggests that the Isle of Man is a spawning ground for herring in the Irish Sea, while it also highlights that no larvae were found in the Mourne spawning area throughout the 1990s (Figure 62).

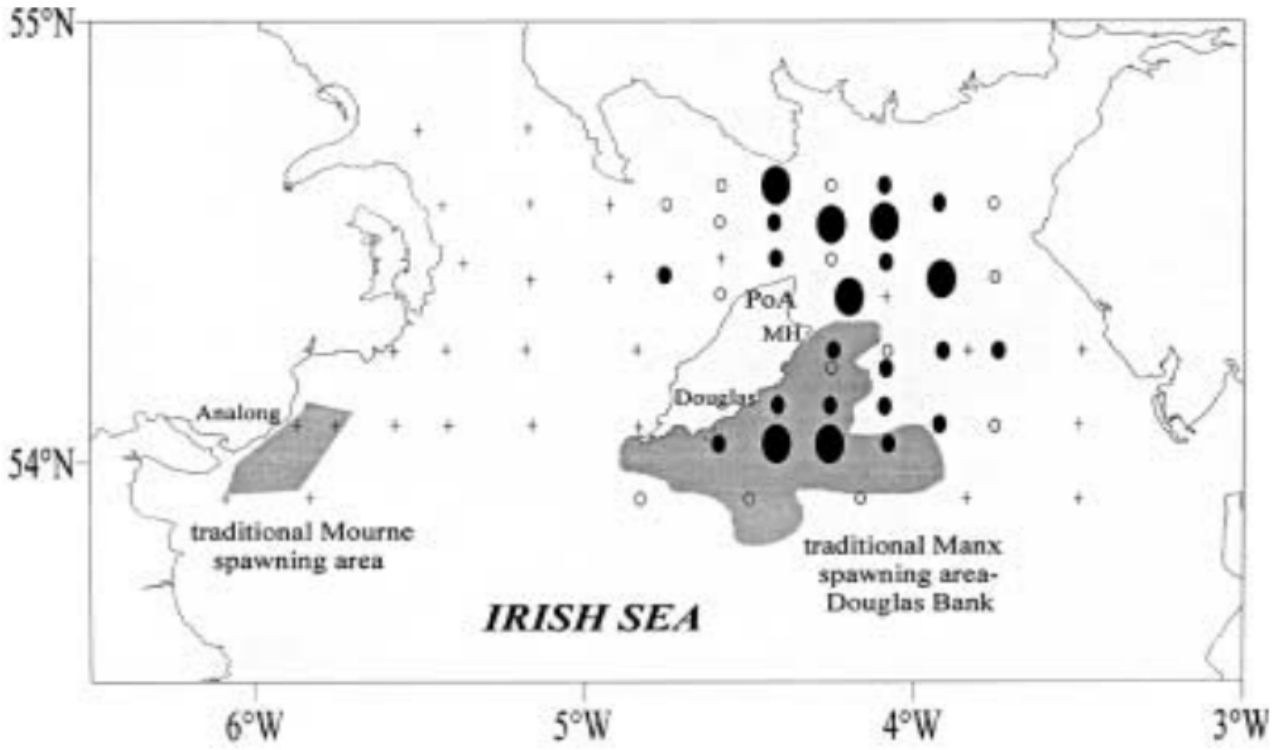


Figure 20. Distribution of larvae from surveys (1998-2000) with traditional spawning grounds on grey, and larval occurrence (empty circle = larvae caught in one-year, small circle = larvae caught in two years, large circle = larvae caught for three years. (Source: Dickey-Collas *et al.*, 2001).

A3.2.7. An Inventory of Irish Herring Spawning Grounds (O'Sullivan *et al.*, 2013)

Spatial Coverage: Irish waters

Larval dispersal has also been studied in Irish waters, where known spawning areas were modelled according to the known seasonal currents and flows (Maps shown in Appendix 5). Predicted dispersal of herring larvae was mapped, extending into Welsh waters in two cases. In the first instance, larvae hatched from October / November spawners in Dunmore East and East Cork are predicted to drift into Welsh waters in St George's Channel and the Irish Sea. Secondly, autumn larvae from Donegal West and North are expected to drift into Welsh offshore waters in the Irish Sea.

A3.2.8. Exploring the microzooplankton–ichthyoplankton link: A combined field and modelling study of Atlantic herring (Clupea harengus) in the Irish Sea (Bils *et al.*, 2017)

Spatial coverage: Irish Sea

The abundance, distribution and growth of herring larvae was assessed with the abundance, biomass and composition of micro- and small meso-zooplankton in Bils *et al.*, (2017) during November 2012 and 2013. In the study area, it was found that microzooplankton biomass was highest in eastern areas, in the vicinity of the main spawning grounds of herring (Figure 63). The presence and abundance of increased dinoflagellates and reduced copepodites zooplankton were significantly correlated with the abundance of larval herring, explaining 20% of the overall variation in larval abundance.

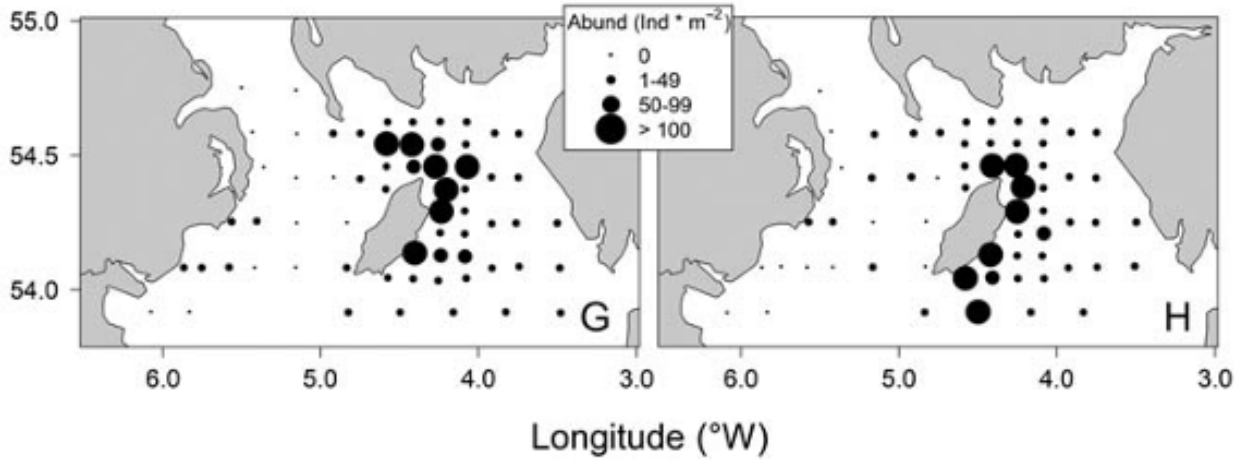


Figure 21. Herring larvae during the November survey in 2012 (G) and 2013 (H), for larvae larger than 12 mm in the study area (Source: Bils *et al.*, 2017).

A3.3. Life stage – juveniles

A3.3.1. Spawning and nursery grounds of selected fish species in UK waters (Ellis *et al.*, 2012)

Spatial coverage: All Welsh waters, excluding close inshore and estuaries.

Ellis *et al.* (2012) present the distribution of juvenile herring (<17.5 cm) based on 12 ground fish surveys series between 1982 and 2008 (Figure 65). Within Welsh waters sampling stations indicate high coverage across the Irish Sea and much lower coverage across Cardigan Bay and the Bristol Channel.

The compiled surveys indicate that the highest maximum abundance of juveniles were found in English and Irish waters offshore from the east and west coasts of the Isle of Man. The abundance records of juvenile herring in Welsh waters were generally lower with the highest concentrations in Welsh offshore waters near the Isle of Man.

While the relative abundance of juvenile herring appears minimal in Welsh waters compared with neighbouring waters, juveniles were consistently sampled during the surveys. Despite the low coverage of sampling stations in Welsh inshore waters, 70% of the hauls caught juvenile herring. This suggests that juvenile herring are consistently present in Welsh waters, both inshore and offshore, but with lower overall relative abundance than other areas of the Irish Sea.

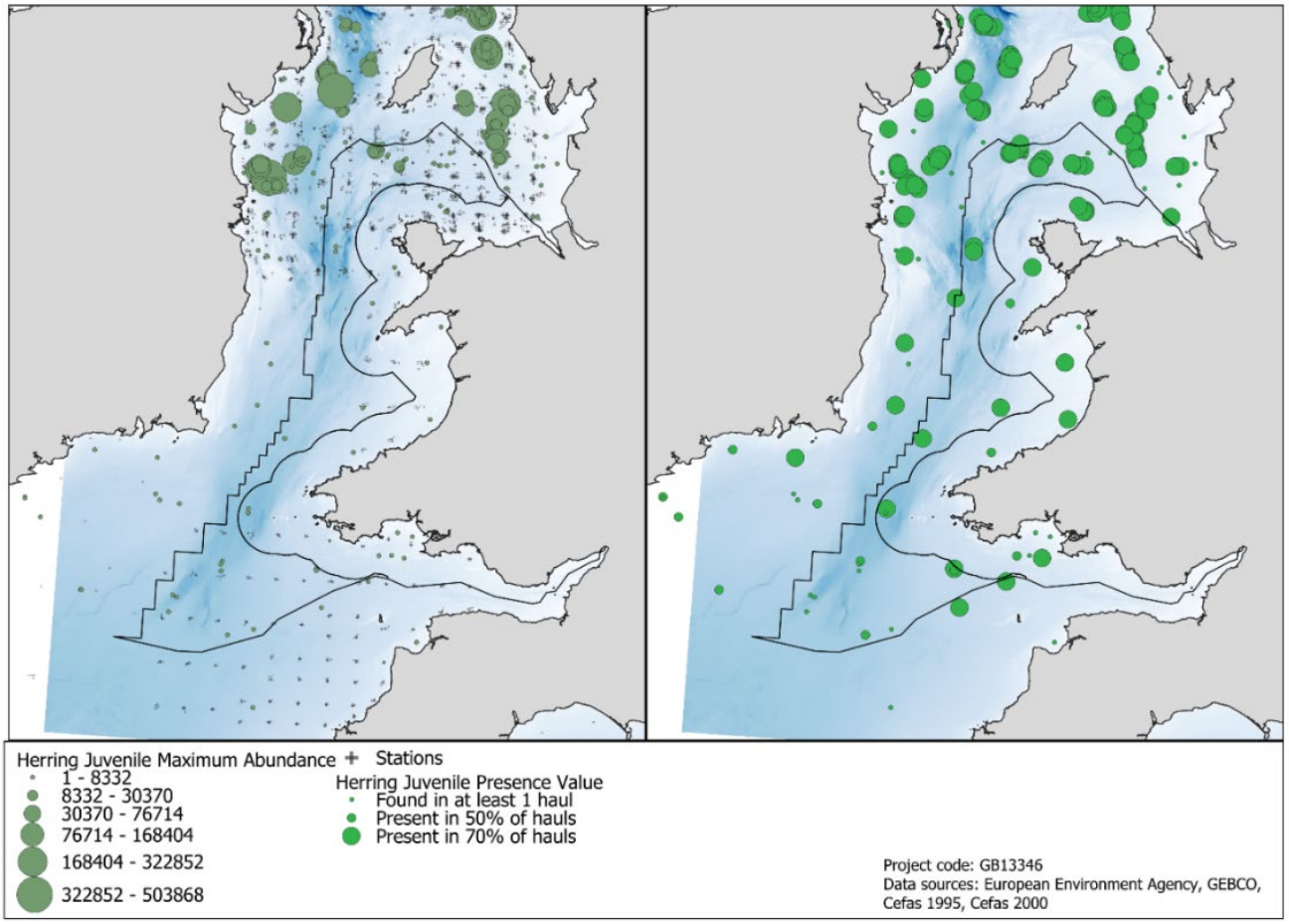


Figure 22. Juvenile herring presence and abundance in Cefas surveys, expressed as abundance (left) and presence in hauls (right) (Source: Ellis *et al.,* 2012).

A3.3.2. Spawning and nursery grounds of forage fish in Welsh and surrounding waters (Campanella and van der Kooij, 2021)

Spatial coverage: All Welsh waters, excluding close inshore and estuaries.

A Cefas report by Campanella and van der Kooij (2021) analysed data from ten fisheries-independent surveys conducted between 2008 and 2020 to identify spawning and nursery grounds of forage fish in Welsh and surrounding waters.

Figure 66 shows the distribution of juvenile herring hotspots in Q1 (Jan – March) and Q4 (Oct – Dec). The study defined juvenile herring as individuals less than 17 cm in length. In Q4 the waters around Pembrokeshire, extending southwards in offshore waters, show a consistent hotspot for juvenile herring. In contrast, the north coast of Wales shows a relatively low persistence of juvenile herring.

By the following Quarter in Q1, the area around Pembrokeshire appears to become less of a prominent hotspot. As this scale is relative, this reduction may reflect higher relative

abundance elsewhere such as in Morecambe Bay or off Mourne, where juveniles occurring offshore in Q4 may move inshore in Q1. Similarly, much of the North Wales coast again shows low relative persistence of juvenile hotspots in Q1, although an elevation is evident in waters in the Dee Estuary.

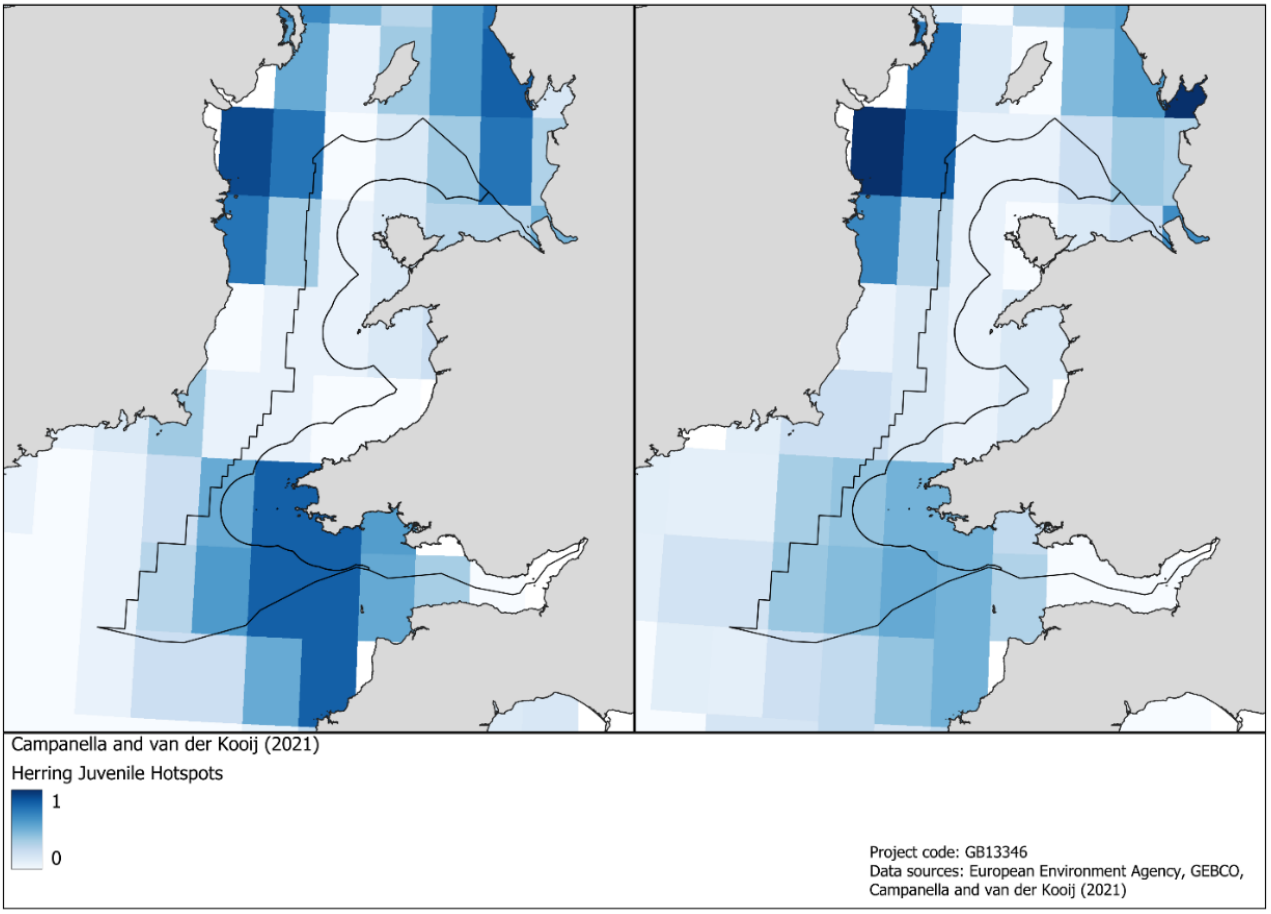


Figure 23. Herring juvenile area hot spots Q4 (left) and Q1 (right). (Source: Campanella and van der Kooij, 2021)

A3.3.3. DATRAS Fisheries-independent trawl survey data (ICES, 2025a)

Spatial coverage: All Welsh waters, excluding close inshore and estuaries.

Juvenile herring (<17.5 cm) data were retrieved from the ICES DATRAS database for areas covering the Irish Sea and much of the Celtic Sea. The data retrieved are a continuous dataset of annual surveys from 2000 to 2025. Coverage across Welsh waters is not homogeneous, with sampling effort concentrated along the northern and southern coasts. Sampling along the west coast, including the Cardigan Bay area, is present across multiple years and at several sites; however, overall spatial coverage throughout the west coast, in both inshore and outer Welsh waters, remains low.

Records indicate that the highest numbers of juvenile herring per haul occurred in Welsh offshore waters in the Celtic Sea. Only a small number of records show juvenile herring within inshore waters around Pembrokeshire, and to a lesser extent in the northern part of Cardigan Bay (Figure 67). Juvenile herring were also sampled along the eastern and southern coasts of Ireland, although in relatively lower numbers than in Welsh waters of the Celtic Sea.

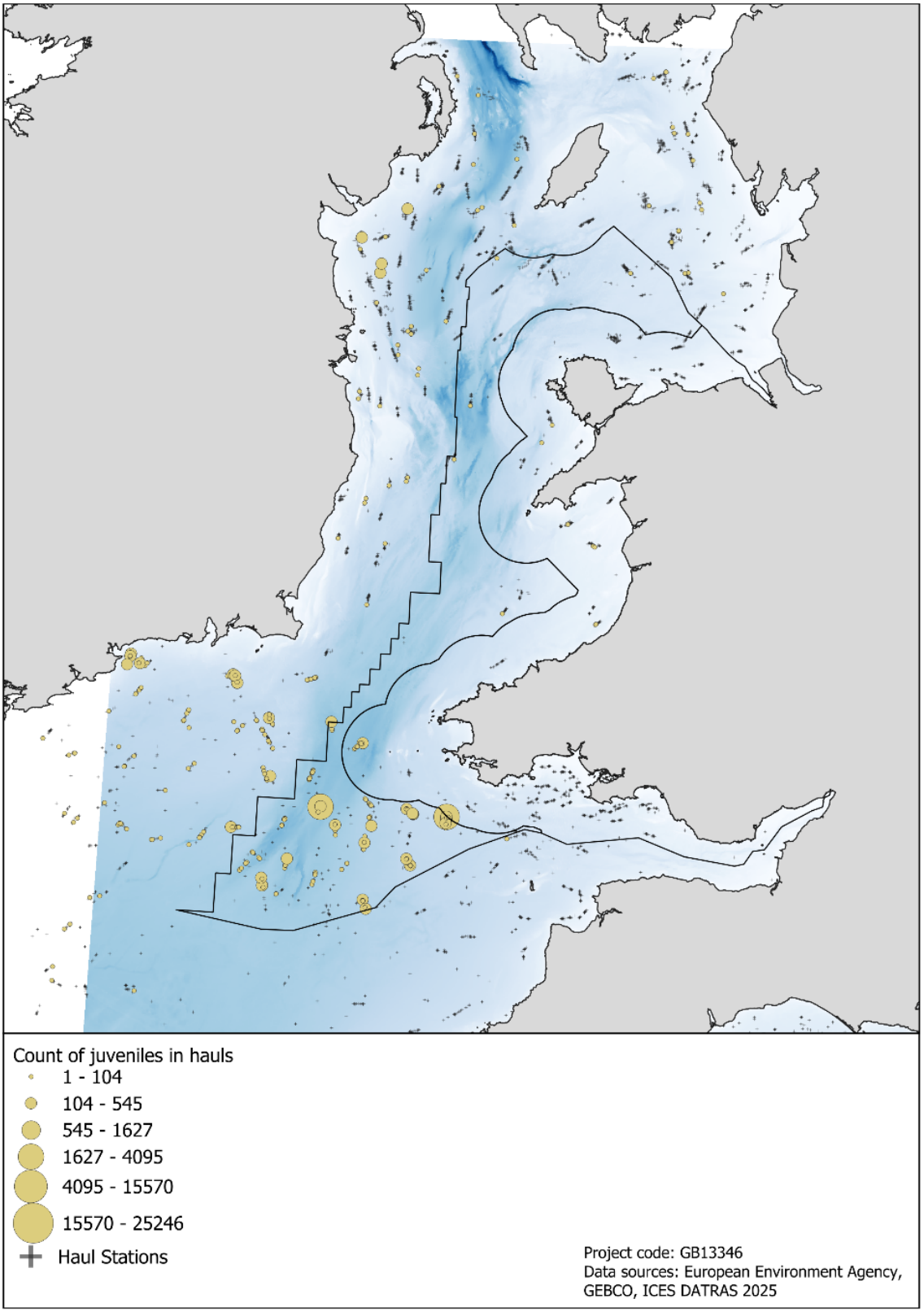


Figure 24. Distribution of survey hauls containing juvenile herring (<17.5 cm) from the DATRAS database. Points are scaled by the number of juveniles recorded in each haul (Source: ICES, 2025a).

A3.3.4. WFD Transitional fish surveys (NRW, 2025)

Spatial coverage: Welsh estuaries

Spatial data from NRW was reviewed and contained point data of herring with associated lengths over the period 1997 to 2025, though not all estuaries were sampled each year. The earliest records of herring juveniles (<17.5 cm) are from 2005 with the most recent from 2025. These records show juvenile herring presence across several estuaries and bays around Wales. Further descriptions have been included below, with each description based on an area and presented in in Figure 68.

Bristol Channel

Juvenile herring were recorded in trawl, fyke and seine net samples during June, September, October and November in 2008, 2009, 2010, 2013, 2014 and 2015. Sites with confirmed juvenile presence at various points in the Bristol Channel including Bedwin Sands (Otter trawl), Blackstone Rock (Fyke net), Cardiff Grounds (Fyke net), Clevedon Golf Course (Fyke net), Peterstone (Otter trawl), Sand Bay Point and Sedbury Park. Counts were generally low, with the greatest sample overall containing 21 individuals (Blackstone Rock, Fyke net).

Milford Haven

Juvenile herring were sampled using seine nets, fyke nets, otter trawls and beam trawls throughout the Milford Haven Estuary in June and September during 2010, 2012, 2013, 2014, 2015 and 2016. Sampling sites were widely distributed across the inner estuary, including Beggars Reach, the Carew River, the East and Upper Western Cleddau, Pennar Flats, Picton Point, Nato Jetty and the Main Channel. The Upper Western Cleddau seine-net site consistently recorded higher counts across multiple years (2008, 2011, 2015 and 2016).

Southern Cardigan Bay (Nevern and Teifi Estuaries)

Juvenile herring were captured using seine nets and otter trawls within both the River Nevern and Afon Teifi estuaries during May, September, October and November in 2011, 2012, 2013, 2014, 2015, 2018 and 2021. Counts were generally higher in the Nevern, with a maximum of 39 individuals recorded at the Lower Nyfer site. In the Teifi Estuary, the highest count was 12 individuals.

Northern Cardigan Bay (Dyfi, Mawddach and Glaslyn Estuaries)

In the Dyfi, Mawddach and Glaslyn estuaries, juvenile herring were sampled exclusively using seine nets during June and once in September in 2004 and 2005. One record of five individuals was reported from the Glaslyn Estuary, three records from the Dyfi, and six records from the Mawddach, where the highest individual count (25 juveniles) was recorded.

North Coast (Conwy and Dee Estuaries)

Juvenile herring were recorded in the Conwy and Dee estuaries using seine nets, fyke nets, otter trawls and beam trawls during May, September, October and November in 2008, 2009, 2011, 2012, 2014, 2015, 2018 and 2024.

In the Conwy, most records were collected just outside the estuary and involved low counts (2–12 individuals), with a single in-estuary record near Llansanffraid Glan Conwy. In the Dee Estuary, larger juvenile counts were recorded overall. The highest numbers were observed in the English sector of the estuary; however, within Welsh waters multiple juvenile records were also present. Low counts were observed within the inner estuary (mainly from seine nets), while higher counts occurred near the estuary mouth, particularly at Mostyn Bank and Talacre, sampled using both trawls and seine nets.

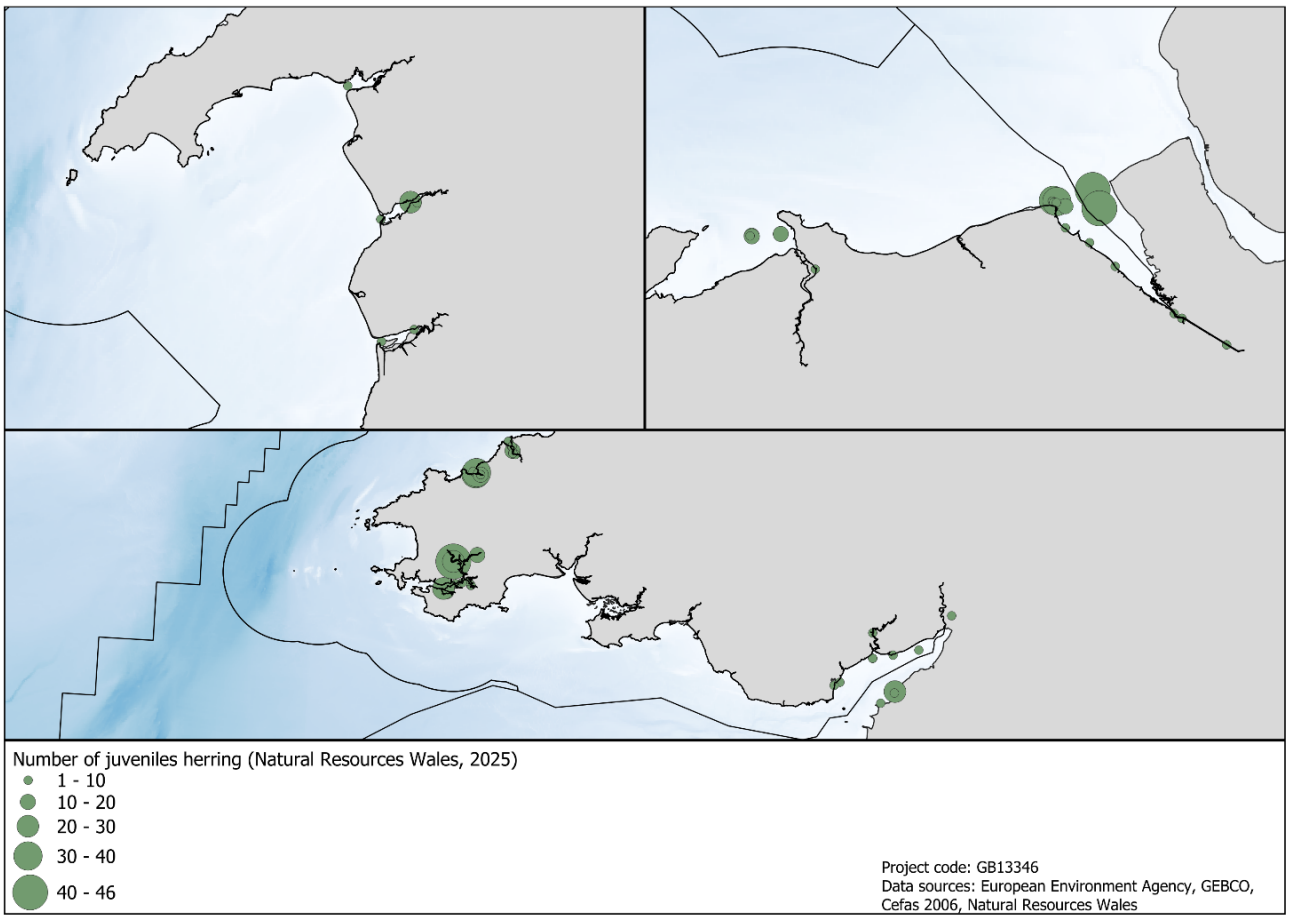


Figure 25. Number of juvenile herring in sampling consolidated by Natural Resources Wales Top left = Northern Cardigan Bay (Dyfi, Mawddach and Glaslyn Estuaries), Top right = North Coast (Conwy and Dee Estuaries), bottom = Pembrokeshire/Ceredigion (River Nevern and River Teifi Estuaries), Milford Haven and Bristol Channel (Source: NRW, 2025)

A3.3.5. Sea Angling Diary catch records 2016-2024 (Cefas, 2025)

Spatial coverage: All Welsh waters

Very few juvenile herring are reported in the Sea Angling Diary dataset between 2016 and 2024 (Figure 69). A single individual was recorded in ICES rectangles 35E6 and 33E5, with higher counts in 35E5 around Anglesey. Table 6 summarises the catches by length class and ICES rectangle, showing that most juveniles recorded fall in the 15–17 cm size range.

Table 3. Number of juvenile (<17 cm) herring caught and recorded in Sea Angling Diary data (2016 – 2024).

Length classes (cm)	ICES Rectangle 33E5	ICES Rectangle 35E5	ICES Rectangle 35E6
[10,15)	1	0	0
[15,17)	0	10	1

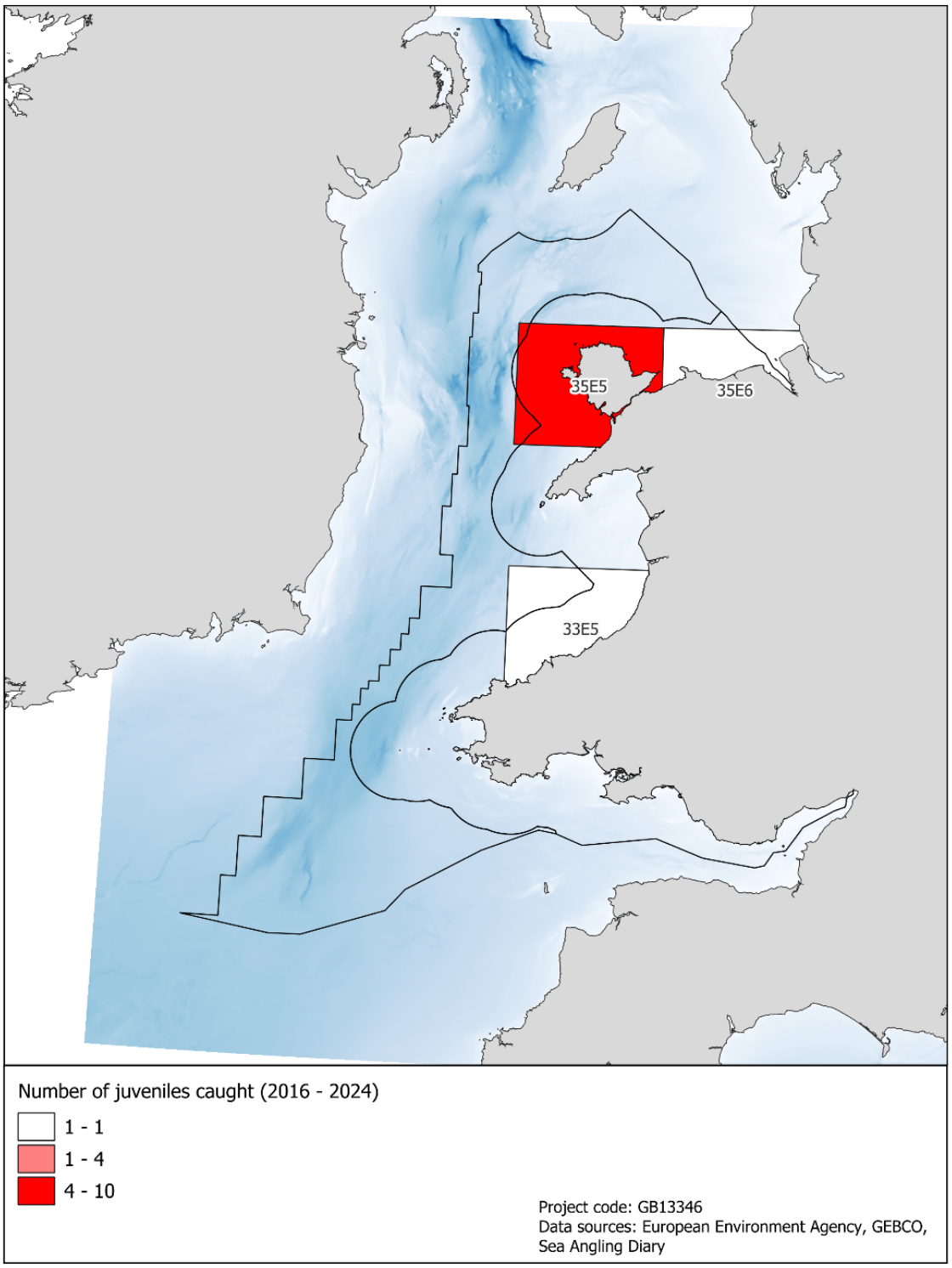


Figure 26. Number of juvenile (>17 cm) herring caught and recorded in Sea Angling Diary data (2016 – 2024) (Source: Cefas, 2025).

A3.3.6. Celtic Sea Pelagic Ecosystem Survey Report (Marine Institute, 2024)

Spatial coverage: Celtic Sea and St George's Channel

The 2024 Celtic Sea Pelagic Ecosystem Survey (CSPES) surveyed offshore areas of the Irish Sea and Celtic Sea in October 2024 using systematic acoustic transects and targeted trawl sampling. The framework included acoustic, and biological data collection in ICES Divisions 7.a South, 7g and 7j during October.

A total of 260 herring were aged during the survey. All herring were less than 1 year of age, defined as 0 winter-ring juveniles with an average length of 12.5 cm. The presence of these juveniles was concentrated in the eastern Irish Waters and Western offshore Welsh waters. The herring samples in Welsh waters were mainly located in St. George's Channel (Figure 70). Immature (less than 1 year old) herring were present in more than 72% of hauls and across all core strata, appearing within mixed-species layers dominated by sprat.

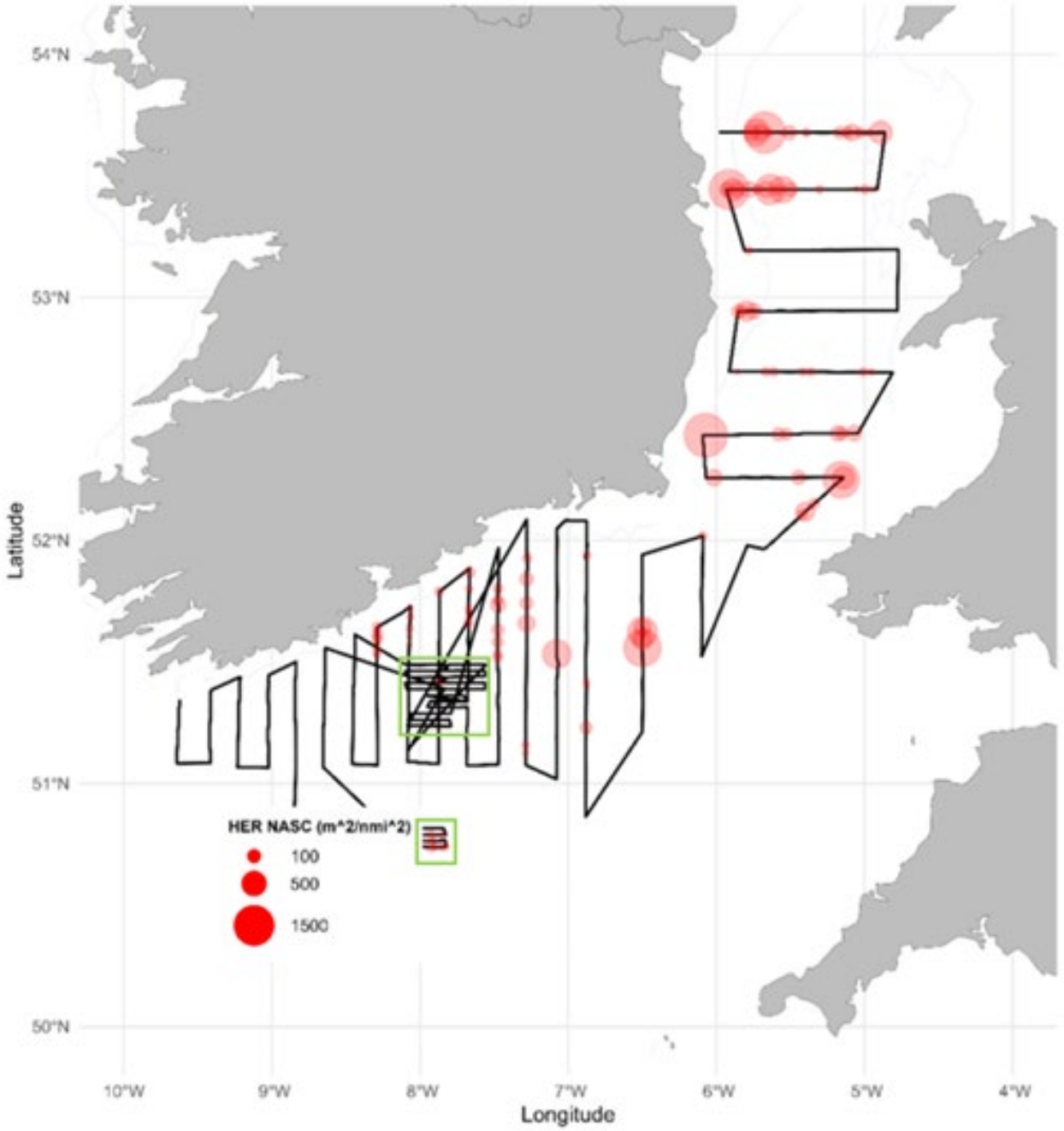


Figure 27. Herring distribution of weighted herring distribution in 2024 (right) from combined core and adaptive survey effort (green boxes) (Source: Marine Institute, 2024).

A3.3.7. Tracing populations of Atlantic herring (Clupea harengus L.) in the Irish and Celtic Seas using otolith microstructure (Brophy and Danilowicz, 2002)

Spatial coverage: Irish Sea

Otolith microstructure analysis of juvenile herring collected from the Celtic and Irish Seas in 1999 and 2000 was used to differentiate between autumn- and winter-spawned juveniles. Two distinct larval growth patterns were observed: widely spaced otolith increments indicative of fast growth, and closely spaced increments associated with slow growth. These results showed that fast-growing juveniles originated from winter spawning, while slow-growing fish were autumn-spawned.

Nursery areas in the western Irish Sea were generally dominated by winter-spawned herring, whereas autumn-spawned fish were more common at eastern sites. The authors suggest that, given the regional distribution of spawning adults, most winter-spawned juveniles are likely to originate from the Celtic Sea, with differences in larval growth among nursery areas suggesting drift of Celtic Sea herring into the Irish Sea during the larval stage.

A3.3.8. Otolith shape analysis: its application for discriminating between stocks of Irish Sea and Celtic Sea herring (Clupea harengus) in the Irish Sea (Burke *et al.*, 2008)

Spatial coverage: Irish Sea

Juvenile herring measuring 7–19 cm were sampled, with 244 individuals analysed. Based on otolith increment widths, 118 fish were identified as autumn-spawned and 126 as winter-spawned. The spatial distribution was strongly segregated: 97% of autumn-spawned juveniles were collected from eastern Irish Sea stations, while 92% of winter-spawned fish occurred at western stations. Winter-spawned juveniles from the Celtic Sea were predominantly found west of the Isle of Man, whereas autumn-spawned Irish Sea juveniles were concentrated to the east. This clear spatial separation indicates that the two stocks occupy distinct nursery areas within the Irish Sea.

A3.4. Life cycle process – nursery grounds

A3.4.1. Fisheries spawning and nursery areas in British waters (Coull *et al.*, 1998)

Spatial coverage: All Welsh waters

This attempt to identify herring nursery areas provides a broad indication of where juvenile herring are likely to occur in high numbers. The inferred nursery grounds encompass

extensive stretches of coastal waters in Scotland, England, and Ireland in the Irish Sea, extending into Welsh waters in Liverpool Bay (Figure 72).

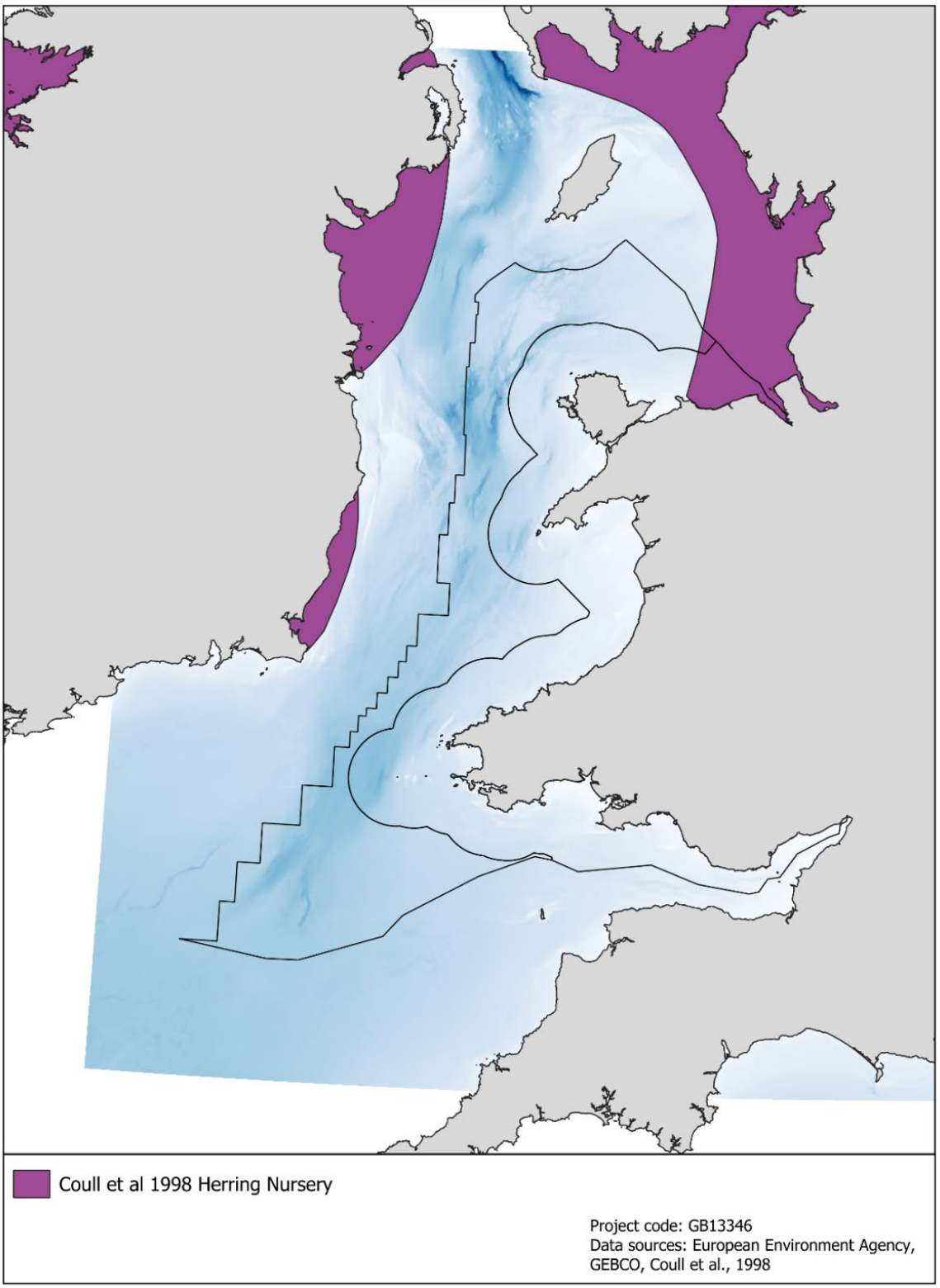


Figure 28. Herring nursery grounds in Welsh and surrounding water (Source: Coull *et al.*, 1998).

A3.4.2. Spawning and nursery grounds of selected fish species in UK waters (Ellis *et al.*, 2012)

Spatial coverage: All Welsh waters

The nursery areas identified by Ellis *et al.* (2012) are categorised into high and low intensity zones, as illustrated in Figure 73. Their analysis indicates that within Welsh waters, two nursery areas are present. A high-intensity nursery area is off the coast of North Wales in Liverpool Bay and the Dee Estuary and this forms part of a broader inferred nursery zone extending from Welsh waters northwards into English and Scottish waters. A lower-intensity nursery area lies entirely within Welsh inshore waters covering Carmarthen Bay and Swansea Bay to Porthcawl.

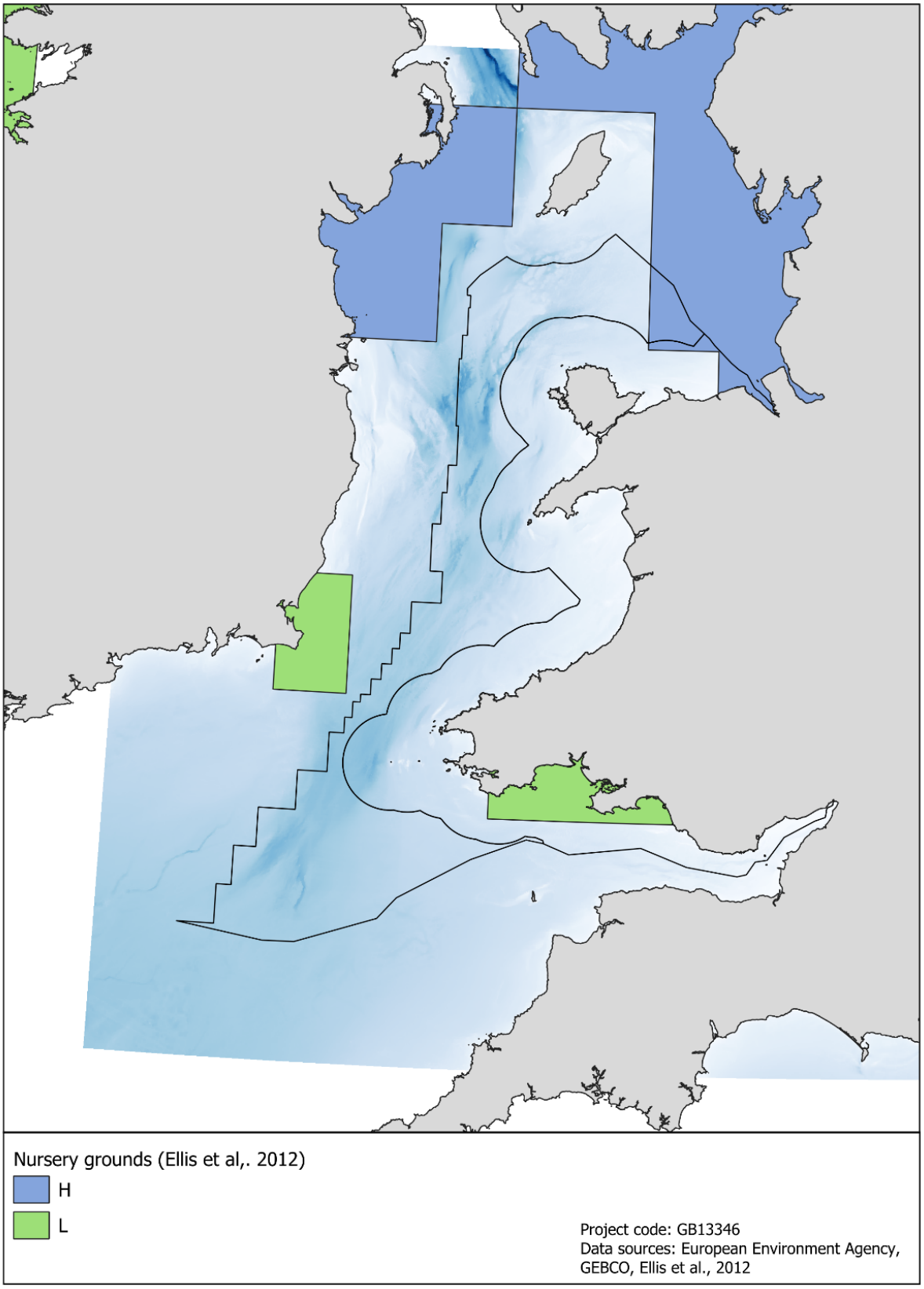


Figure 29. Herring nursery grounds in Welsh and surrounding waters featuring high and low intensity areas (Ellis *et al.*, 2012).

A3.4.3. Species spawning and nursery areas (Marine Institute, 2018; revised 2024)

Spatial coverage: Irish waters

The Marine Institute's Species Spawning and Nursery Areas dataset provides spatial layers identifying nursery grounds for commercially important fish species, including herring.

The dataset is referenced here for completeness of the evidence review and is provided within Figure 74 and the accompanying spatial dataset for contextual purposes only, illustrating the broader distribution of spawning and nursery habitats in the wider Celtic Sea region. While not directly relevant to the Welsh assessment, it may be of value for future spatial modelling or comparative analyses. The data contain fine scale data related to grounds including nursery areas, spawning beds, spawning grounds and spawning areas.

A3.4.4. Stock Annex: Herring in Divisions 7. a South of 52 30'N, 7. g, 7. h, 7. j and 7. k (Irish Sea, Celtic Sea, and southwest of Ireland) (ICES, 2018)

Spatial coverage: Irish waters

Nursery grounds are thought to be quite discrete, and several areas of importance are known, including the western coast of the Irish Sea, Dungarvan Bay, and the bays of SW Ireland.

A3.5. Life stage – adults

A3.5.1. Highly mobile fish species distributions in UK waters (Cefas / ABPmer, 2010)

Spatial coverage: All Welsh waters

This dataset provides herring distribution derived from fisheries-independent groundfish surveys conducted across UK waters (Cefas, 2010). Although the dataset does not distinguish between herring life stages, it offers a broad-scale indication of adult distribution patterns in the Irish and Celtic seas.

Limited numbers of adult herring were recorded during the surveys in Welsh waters, likely given the limitation of the Portuguese high-headline trawl survey gear used at catching herring, rather than an indication of actual abundance. The highest numbers of recorded adult herring were found in the Celtic Sea between Cornwall and Ireland, with higher concentrations offshore of Newquay and east of Cork. Some herring, but with low abundance, were sampled in inshore waters in Wales, off Pembrokeshire, Anglesey, and in the Severn Estuary (see Figure 75).

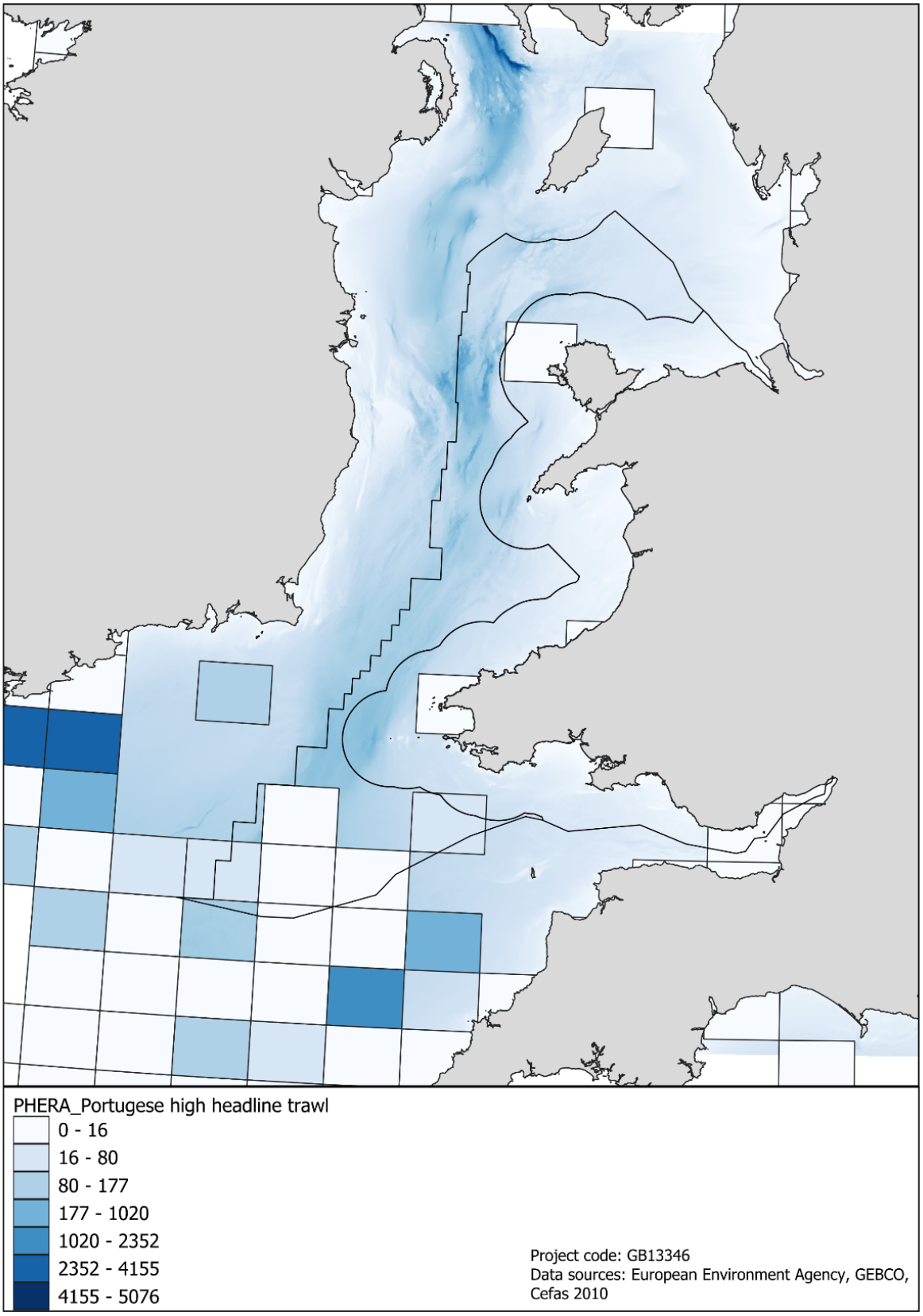


Figure 30. Herring abundance per hour tow using a Portuguese high headline trawl (Source: Cefas / ABPmer, 2010).

A3.5.2. DATRAS Fisheries-independent trawl survey data (ICES, 2025a)

Spatial coverage: All Welsh waters, excluding close inshore and estuaries.

Haul data obtained through the ICES DATRAS API included 2,364 hauls containing herring of both adult and juvenile sizes. After linking these hauls to the associated length data it resulted in 1,103,484 individual length measurements of herring from 538 stations collected between 2000 and 2025.

A map depicting adult herring distribution as an aggregate across all years is shown in Figure 76. The figure indicates that adult herring sampled in survey hauls over the 25-year dataset are recorded in greatest numbers in Welsh offshore waters. Survey hauls were conducted across multiple months (months 2, 3, 4, 6, 9, 10, 11 and 12), so the observed distribution may partly reflect the seasonal timing of surveys, although the offshore concentration remains evident across the dataset. High numbers are also evident in waters east of Ireland and in English waters of the Irish Sea.

The Welsh offshore waters in the Celtic Sea show consistently high numbers of adult herring, including one instance of notably high abundance (n=??). Within Welsh inshore waters, adult herring are mainly recorded at sampling stations within Cardigan Bay, as well as in areas off the coast of Anglesey and North Wales. These records are derived from survey hauls conducted in quarters 1 and 4, and may therefore reflect the seasonal timing of surveys during the spawning periods when adults move inshore. Samples in Camarthen Bay, did not record adult herring, despite substantial sampling effort. Sampling was conducted in Camarthen Bay using a beam trawls which was targeting benthic-oriented fish species. As herring are pelagic species, the null results could be linked with inappropriate sampling gear rather than the absence of herring. However, previous samples using beam trawls have recorded herring (REF) and as such, if they were present in the area, herring likely only occurred in low numbers.

Figure 77 depicts the annual and quarterly (Q1 and Q4) total catch in number and mean length of adult herring sampled in surveys extracted from the DATRAS database. This provides information on the seasonal movements of adult herring. These months coincide with the known spawning times of the stocks and demonstrate, across most years, the movement of adults from offshore areas to inshore waters where spawning takes place. This suggests that the inshore presence of adults during these surveys is likely to be primarily associated with spawning migrations rather than seasonal feeding movements.

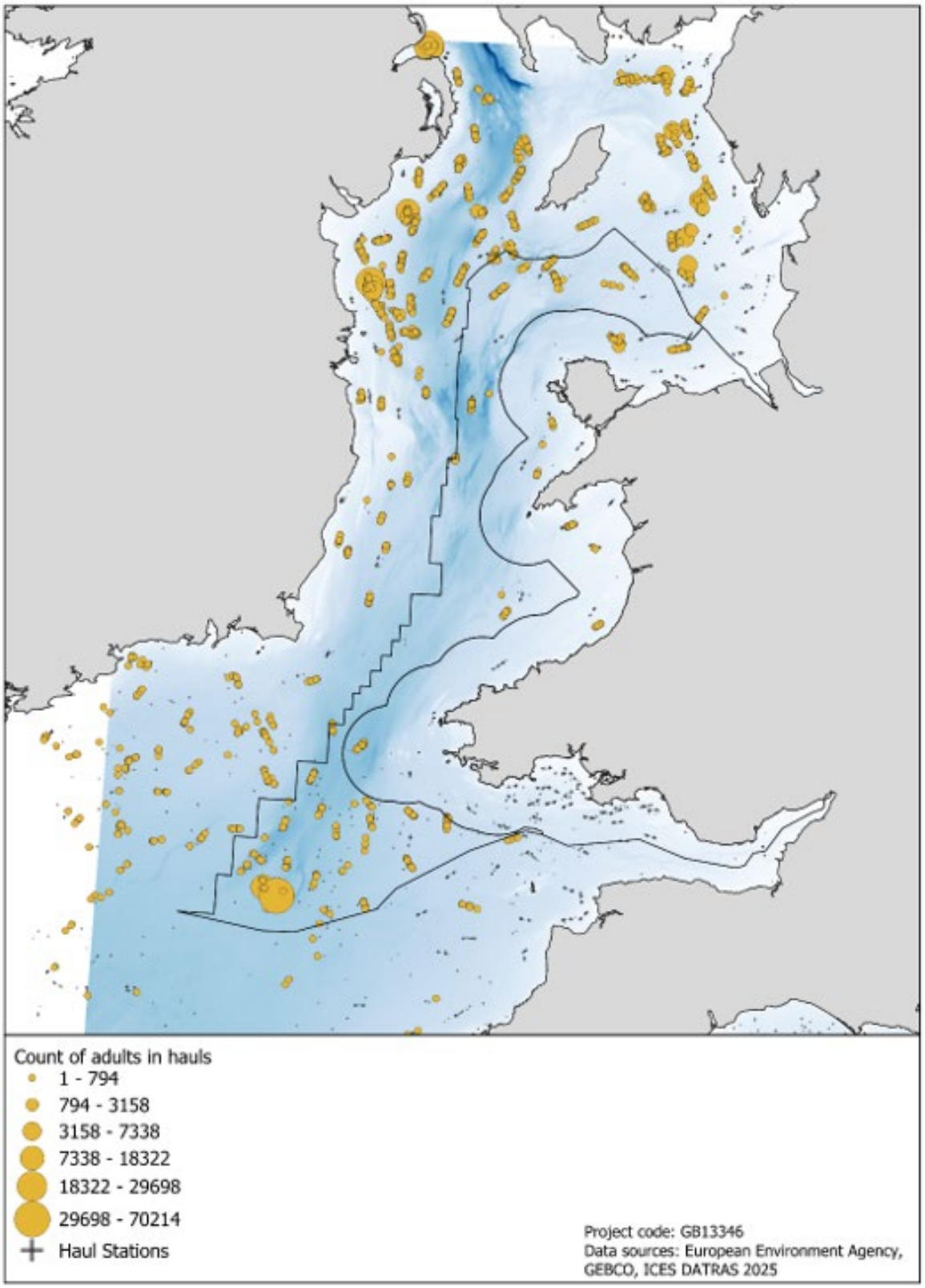


Figure 31. Distribution of survey hauls containing adult herring (>17.5 cm) from the ICES DATRAS database (2000 – 2025). Points are scaled by the number of juveniles recorded in each haul (Source: ICES, 2025a)

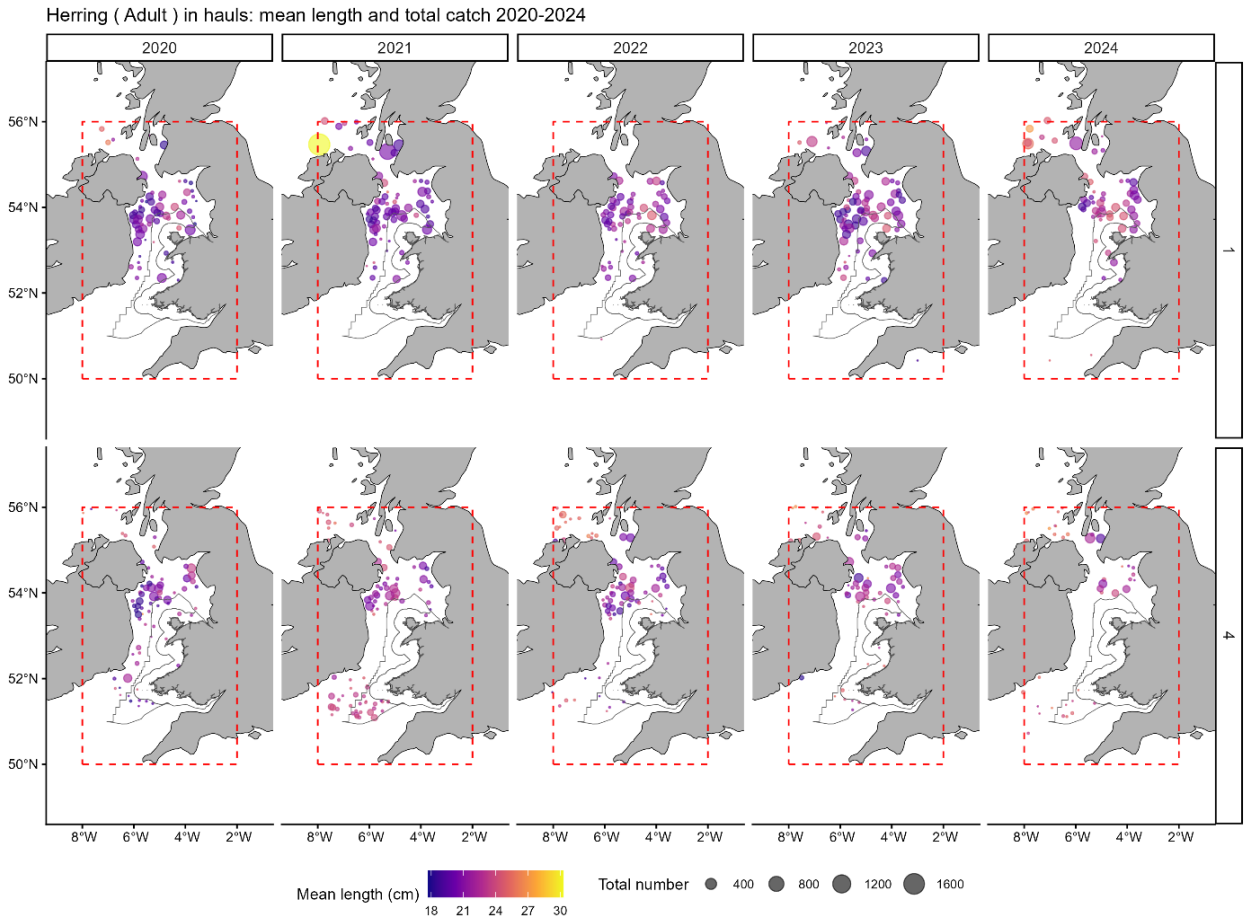


Figure 32. Annual total number and mean length of adult herring sampling in ICES DATRAS associated survey in Q1 and Q4 between 2020 and 2024 (ICES, 2025a)

A3.5.3. Commercial fisheries landings and discards data (MMO, 2025)

Spatial coverage: All Welsh waters

Commercial landings and discards data were obtained from the MMO, covering the period 2014–2024 across FAO Area 27 divisions 7.a, 7.f and 7.g. For this assessment, landings and discards from all years, gear types, and vessel segments were aggregated and mapped at the ICES sub-rectangle level to provide a broad indication of where fishing activity encounters herring, rather than a measure of underlying stock distribution.

Commercial landings and discards of herring are minimal in Welsh Waters, with most ICES sub-rectangles contributing less than 20 tonnes across the full 2014–2024 time series (Figure 78). Over this period the highest cumulative quantities of herring were caught in areas around the Isle of Man and along the North-Eastern coast of Ireland, where totals exceed more than 20,000 tonnes. Elevated cumulative catches and discards are also evident in outer south Wales and north Devon waters, typically ranging between 100 and 500 tonnes.

Differences in cumulative catches between the Celtic Sea and Irish Sea reflect contrasting stock status and management histories rather than differences in data availability or mapping approach. Herring in the Celtic Sea (ICES divisions 7.g–h and 7.a south of 52°30’N) has been subject to progressively restrictive management since the mid-2000s, with ICES advice for zero catch under the MSY approach from 2020 onwards and management limited to a small monitoring TAC, indicating the principal absence of a directed commercial fishery and the predominance of unavoidable bycatch (ICES, 2021). In contrast, Irish Sea herring (division 7.a north of 52°30’N) represents a distinct stock that has continued to support managed commercial fishing activity under TAC regulation, resulting in higher and more spatially concentrated cumulative catches, particularly around the Isle of Man and the north-eastern Irish coast (ICES, 2017).

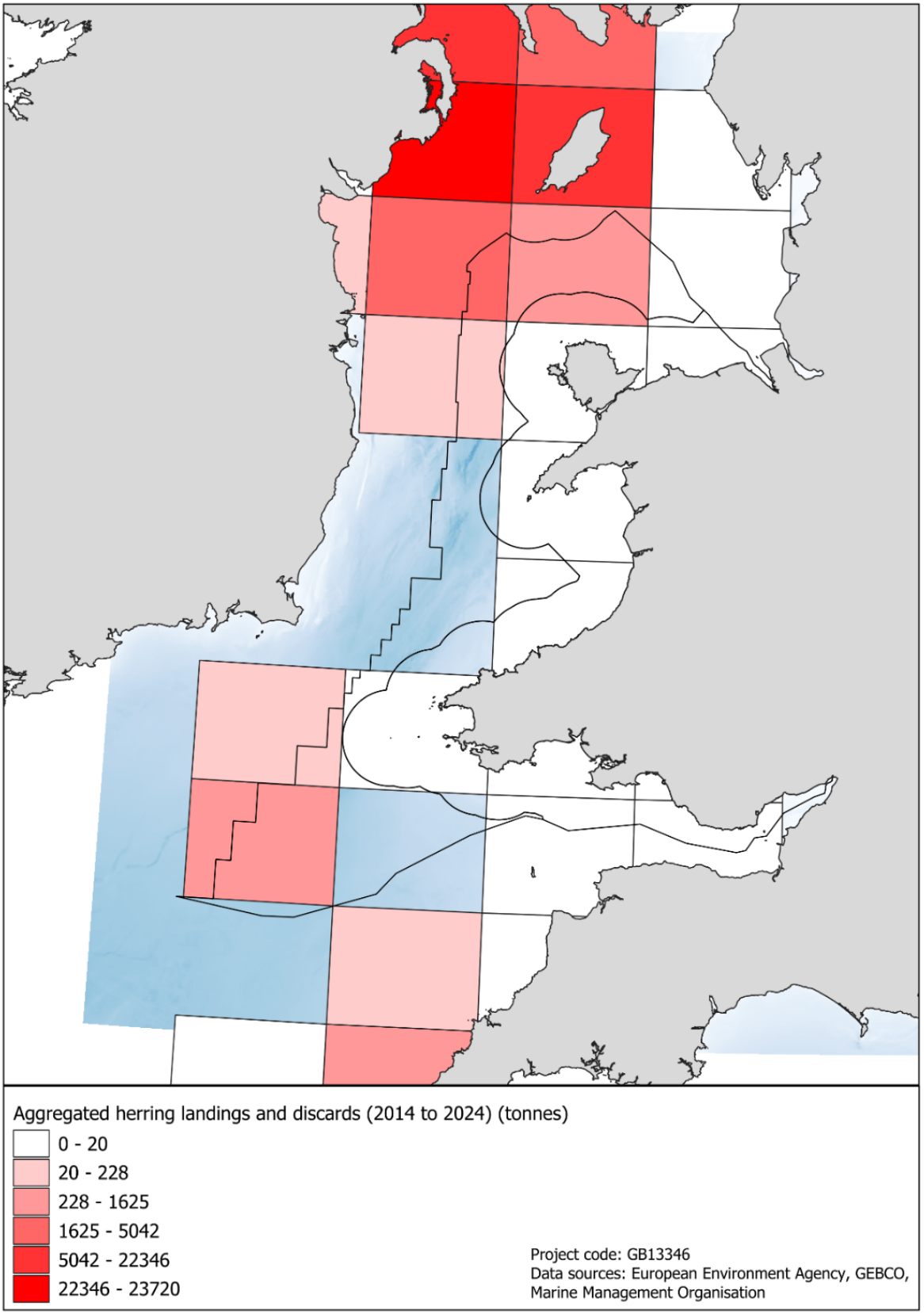


Figure 33. Aggregated herring landings and discards (t) from 2014 to 2024 across ICES sub-rectangles (MMO, 2025).

A3.5.4. Species occurrence records in Welsh waters (OBIS, 2025)

Spatial coverage: All Welsh Waters

Herring occurrence data for Welsh waters was extracted from the Ocean Biodiversity Information System (OBIS). OBIS records span multiple decades and encompass observations from different seasons, although many are associated with standard research surveys. Life-stage and length information were not available. Individual counts were present for some records, while others reported only presence; for consistency, count data were used where available and count-absent records were treated as single individuals. Herring occurrences are distributed across all Welsh waters albeit in low numbers (often of only one or two individuals) and generally less than 10 (Figure 79).

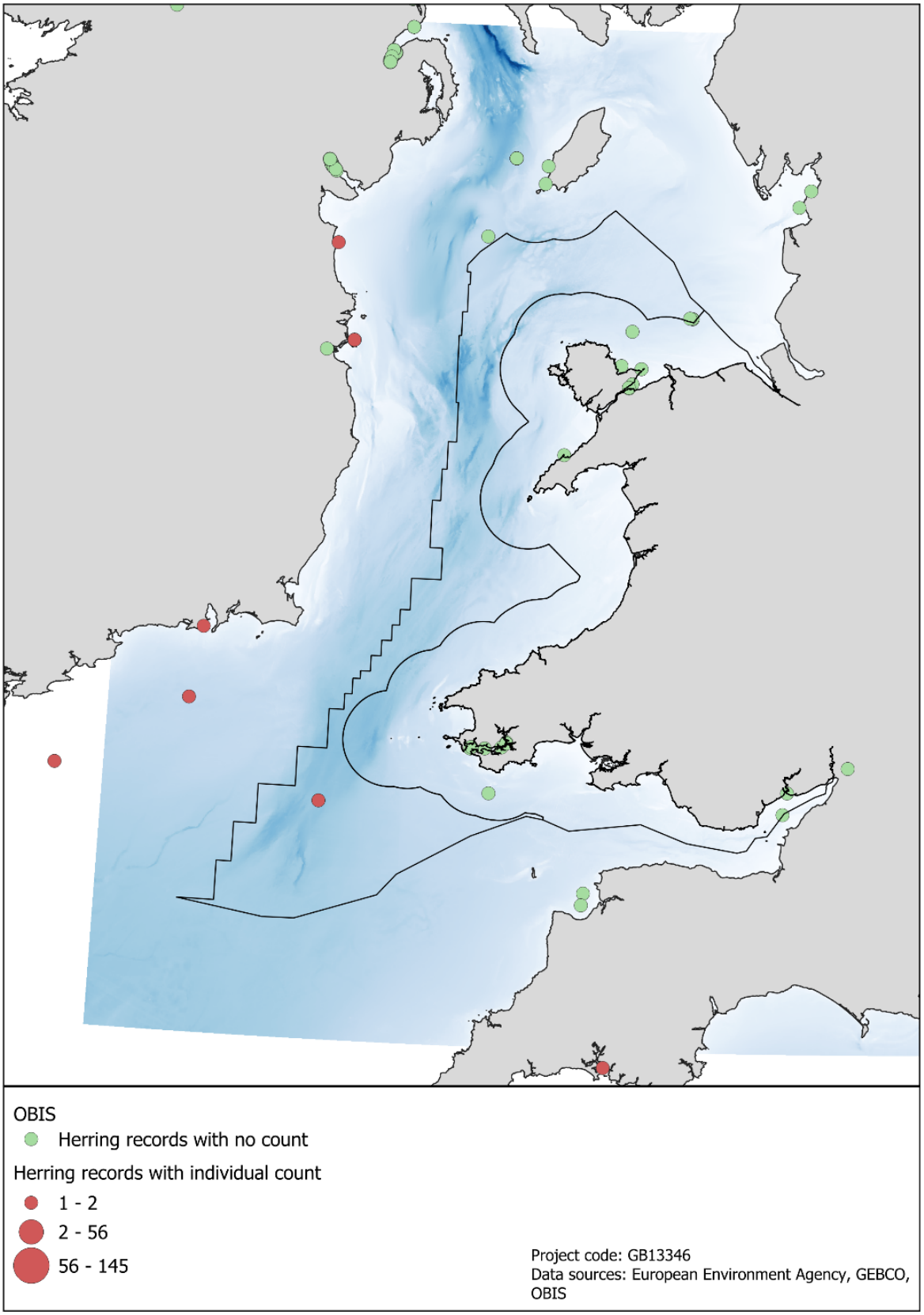


Figure 34. OBIS records of herring (2000 to 2025; excluding DATRAS data) (Source: OBIS, 2025)

A3.5.5. Sea Angling Diary catch records 2016-2024 (Cefas, 2025)

Spatial coverage: All Welsh waters

Data from Sea Angling Diary catches show catches of herring adults around Wales, with increased densities in ICES rectangle 32E4, located around the coast of Pembrokeshire and Anglesey (35E5). Some records do not have associated length data, however, a broadly similar pattern is observed, except for the ICES rectangle 35E6 (Dee Estuary) which contains the highest number of unmeasured herring (Figure 81).

Overall, the Sea Angling Diary data indicate that adult herring are recorded in the greatest numbers around Pembrokeshire and Anglesey, with lower numbers caught in adjacent waters along the North Wales coast and in Cardigan Bay.

Table 4. Number of adult (>17 cm) herring caught and recorded in Sea Angling Diary data by ICES rectangle (2016 – 2024).

Length Class (cm)	32E4	32E5	32E6	33E5	34E5	35E5	35E6
[17,20)	0	0	0	1	0	0	28
[20,25)	100	0	0	0	20	40	1
[25,30)	0	0	0	1	0	6	0
Adult total	100	0	0	2	20	46	29
Unmeasured total	2	24	1	0	6	61	144

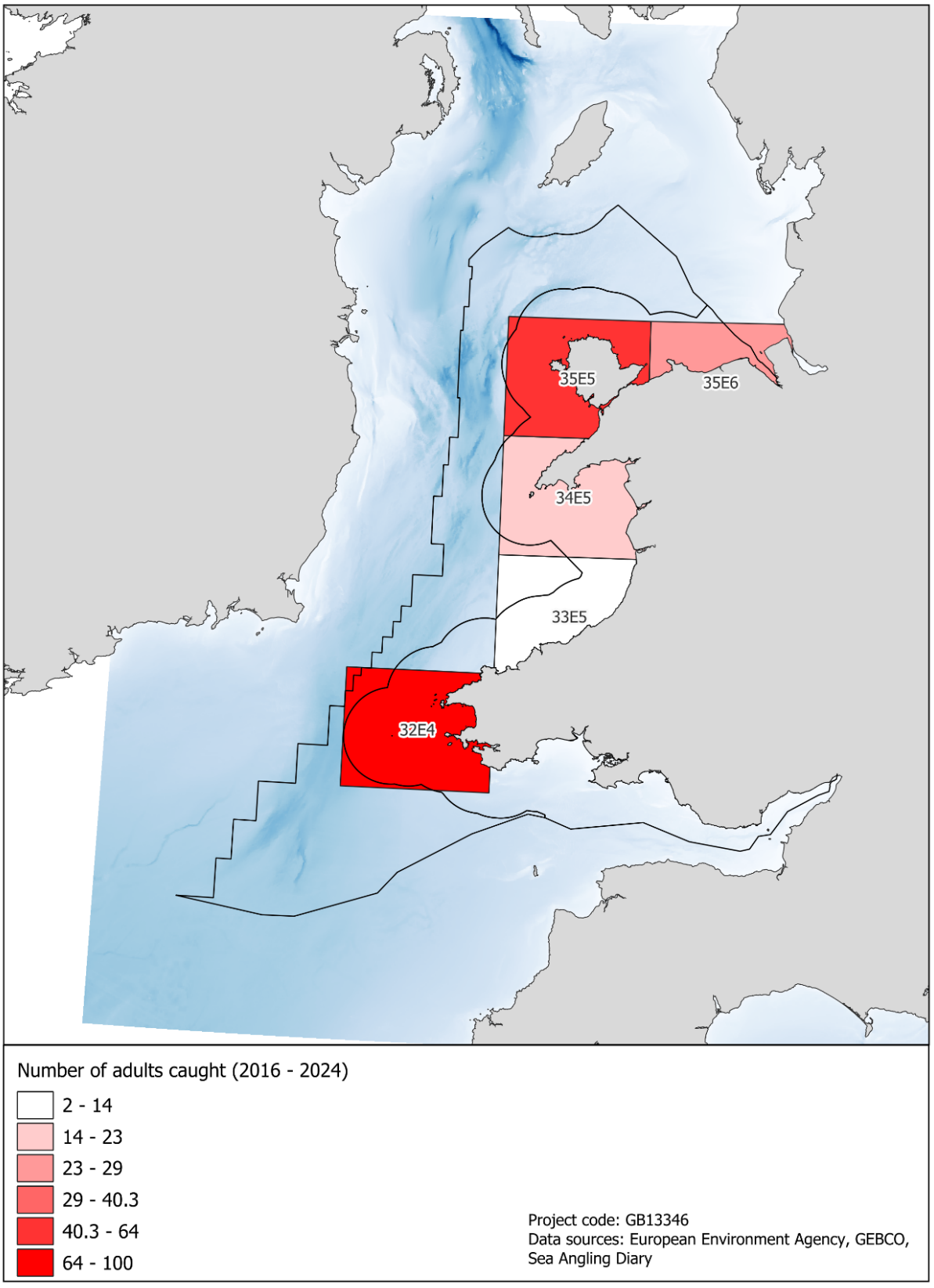


Figure 35. Number of adult (>17 cm) herring caught and recorded in Sea Angling Diary data (2016 – 2024) (Source: Cefas, 2025).

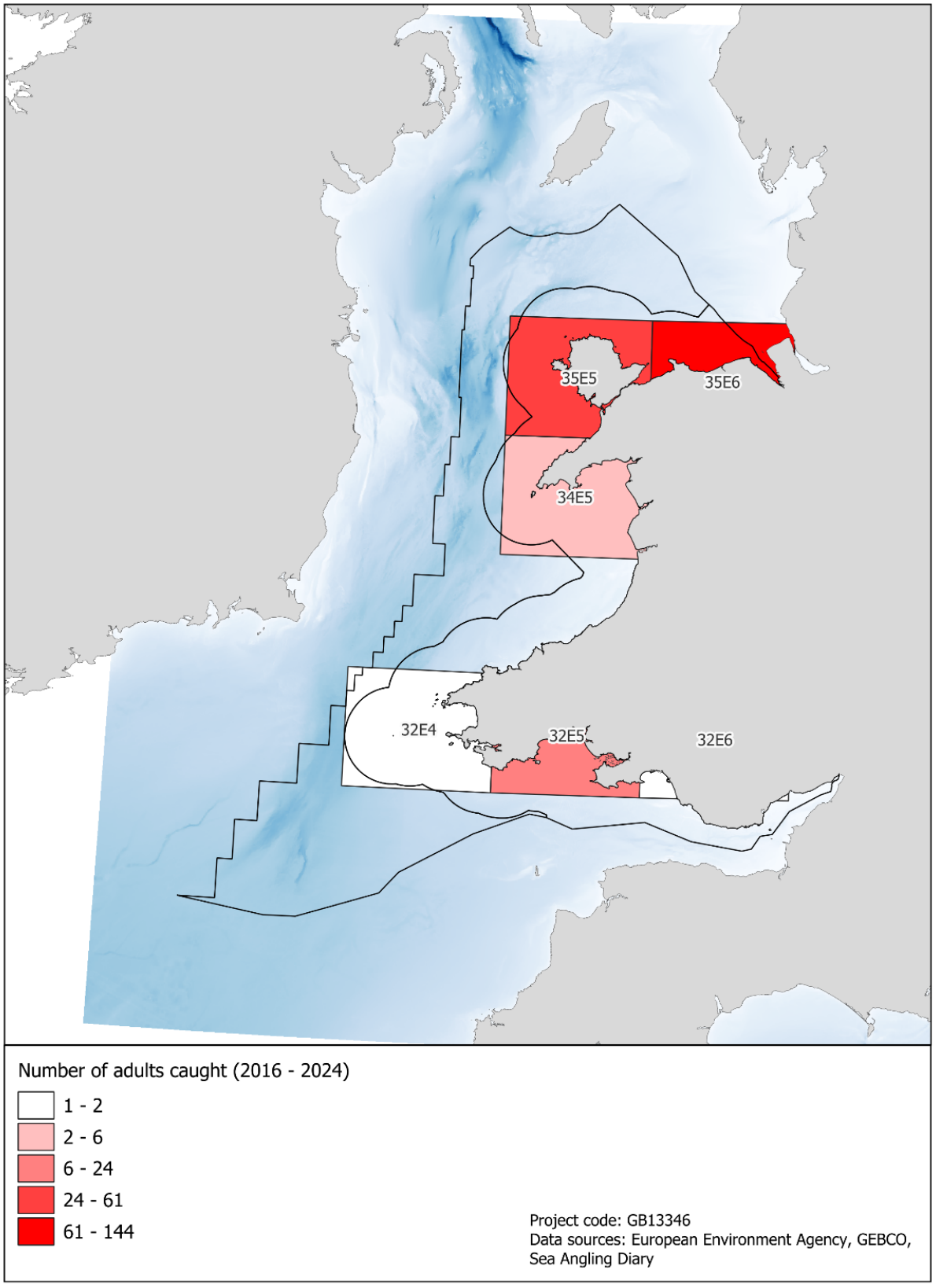


Figure 36. Number of unmeasured herring caught and recorded in Sea Angling Diary data (2016 – 2024).

A3.5.6. WFD Transitional fish surveys (NRW, 2025)

Spatial coverage: Welsh estuaries

Adult herring recorded in WFD surveys in Welsh estuaries are primarily found along the North Wales coast, with smaller numbers recorded in the Teifi and Nevern estuaries in Cardigan Bay (Figure 82). The earliest records date from 2002 and the most recent from 2016. All adult herring were sampled in October and November using otter trawls, though estuaries were not sampled each year during the period of the dataset.

In the Dee Estuary, adult herring were recorded in 2002, 2007, 2009, 2010, 2011, 2015 and 2016. Abundances were typically low (1–6 individuals per sample), with the highest count recorded in 2009 (46 individuals). Fewer records are available from the Teifi and Nevern Estuaries. In 2014, two adults were recorded in the Teifi Estuary and 34 in the Nevern Estuary.

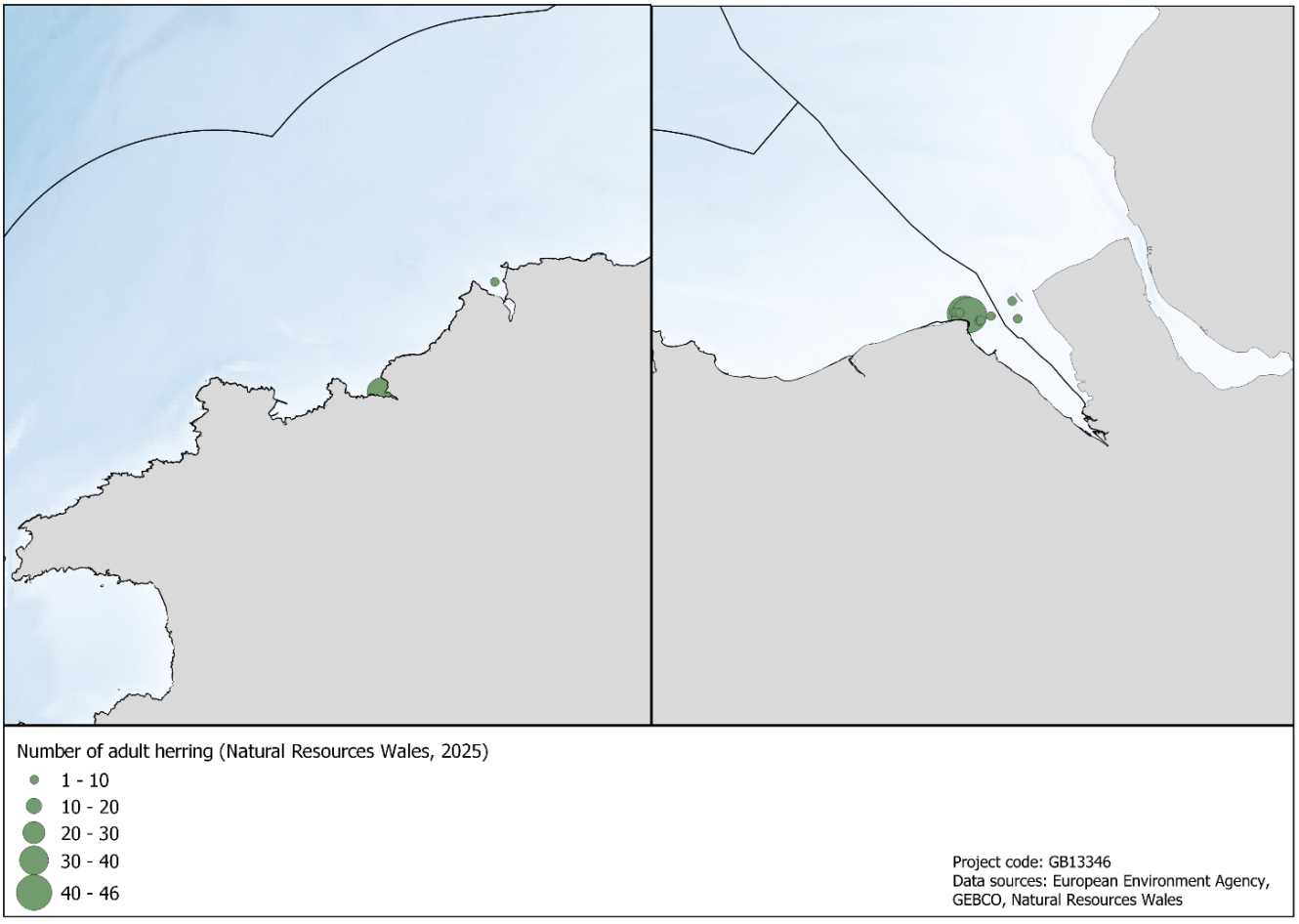


Figure 37. Number of adult herring recordedin WFD sampling conducted by NRW. Left map is the Nevern and Teifi estuaries; Right map is the Dee Estuary (Source: NRW, 2025).

A3.5.7. Prespawning herring distribution in the Irish Celtic Sea between 2005 and 2012 (Volkenandt *et al.* 2014)

Spatial coverage: Irish waters of the Celtic Sea

Distribution patterns and habitat use of Atlantic herring in the Celtic Sea were investigated using data from annual acoustic stock assessment surveys conducted between 2005 and 2012 (Figure 83). Herring densities were highest inshore near spawning grounds and declined offshore. During the spawning migration, shoals showed a clustered but otherwise random spatial distribution. Analysis of density variograms revealed high local variability comparable to variability at the regional scale, indicating the absence of a continuous spatial structure across the study area.

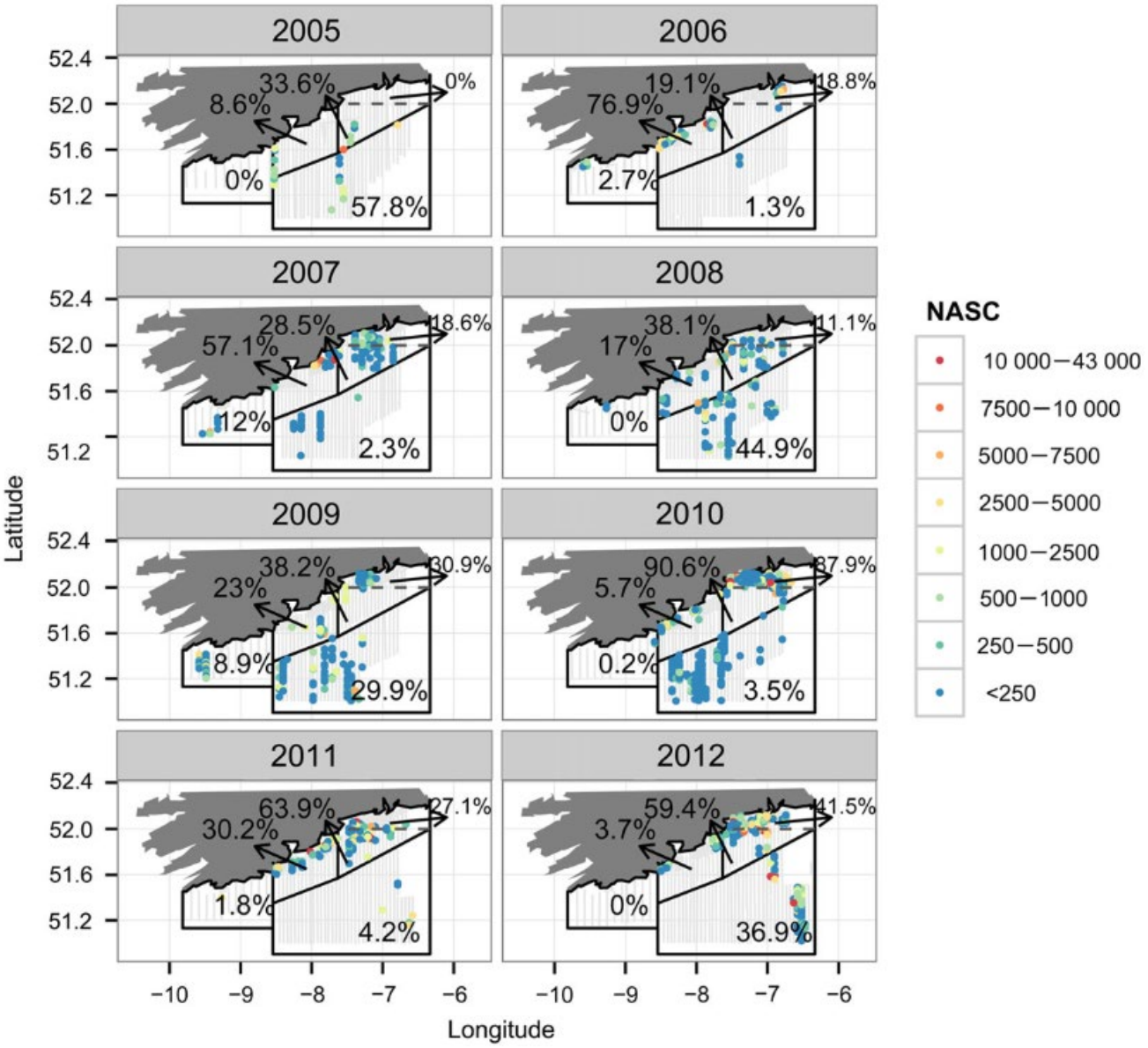


Figure 38. Herring nautical area scattering coefficient (NASC) distribution from 2005 to 2012 (coloured points). The numbers give the percentage of NASC within the herring spawning box (north of 52°N, grey dotted line) is shown (Source: Volkenandt *et al.*, 2014).

A3.5.8. Working Group on International Pelagic Surveys (WGIPS) (ICES, 2025c)

Spatial coverage: All Welsh waters

Acoustic surveys provide the main fishery-independent evidence on herring distribution in Welsh and adjacent waters. The most relevant coverage comes from the Irish Sea surveys (7.a North) and the PELTIC and CSHAS surveys operating across 7.f–7.g and the wider Celtic Sea (ICES, 2025c).

Division 7.a (Irish Sea)

The *7.a North* survey is the primary source of herring distribution information for 7.a. In 2024, the survey showed age 1+ herring (generally defined as adult or mature herring) concentrated along the eastern Northern Irish coast close to the North Channel, with further aggregations on known spawning banks around the Isle of Man, including the western and northern coasts of the Isle of Man. The areas surveyed at the edge of the Irish Sea basin such as those in western and southern 7.a nearer Welsh waters were dominated by juvenile herring. Spatial patterns remain heterogeneous between years, but the core concentrations consistently occur in the northern parts of the Irish Sea.

The *7.a Spawn* survey in late September–October targets herring migrating onto the Douglas Bank spawning grounds. It typically contributes more than 75% of the SSB index. The 2024 estimate (20,806 t) was the lowest in the series, with weather-related behavioural shifts (survey took place after severe storm, possibly impacting stock behaviour) and lack of biological samples adding uncertainty. Nevertheless, the survey reaffirms that peak presence in 7.a is strongly linked to the northern spawning grounds to the west and north of the Isle of Man.

Divisions 7.f and 7.g (Bristol Channel and northern Celtic Sea)

Herring in 7.f and 7.g are best represented by the PELTIC and CSHAS acoustic survey programmes. Although the PELTIC survey is not designed specifically for herring, it regularly records herring in the Bristol Channel (7.f) and along the transition zone into 7.g, providing useful evidence on autumn distributions south of Wales. Spatial patterns vary annually, but detections in 7.f are common enough to indicate seasonal presence in Welsh waters linked to wider Celtic Sea dynamics.

The CSHAS time-series provides the main index for the Celtic Sea stock in 7.g. In 2024, no mature herring were encountered in the northern Celtic Sea or southern Irish Sea components, with catches dominated by 0-group fish. While this limits use of the 2024 data, earlier years show strong age-specific consistency and confirm that mature Celtic Sea herring can occur in 7.g in some years, contributing to movements into Welsh waters.

A3.6. Additional supporting data sources for herring

A3.6.1. Species Spawning and Nursery Areas (Marine Institute, 2018)

Spatial coverage: Ireland

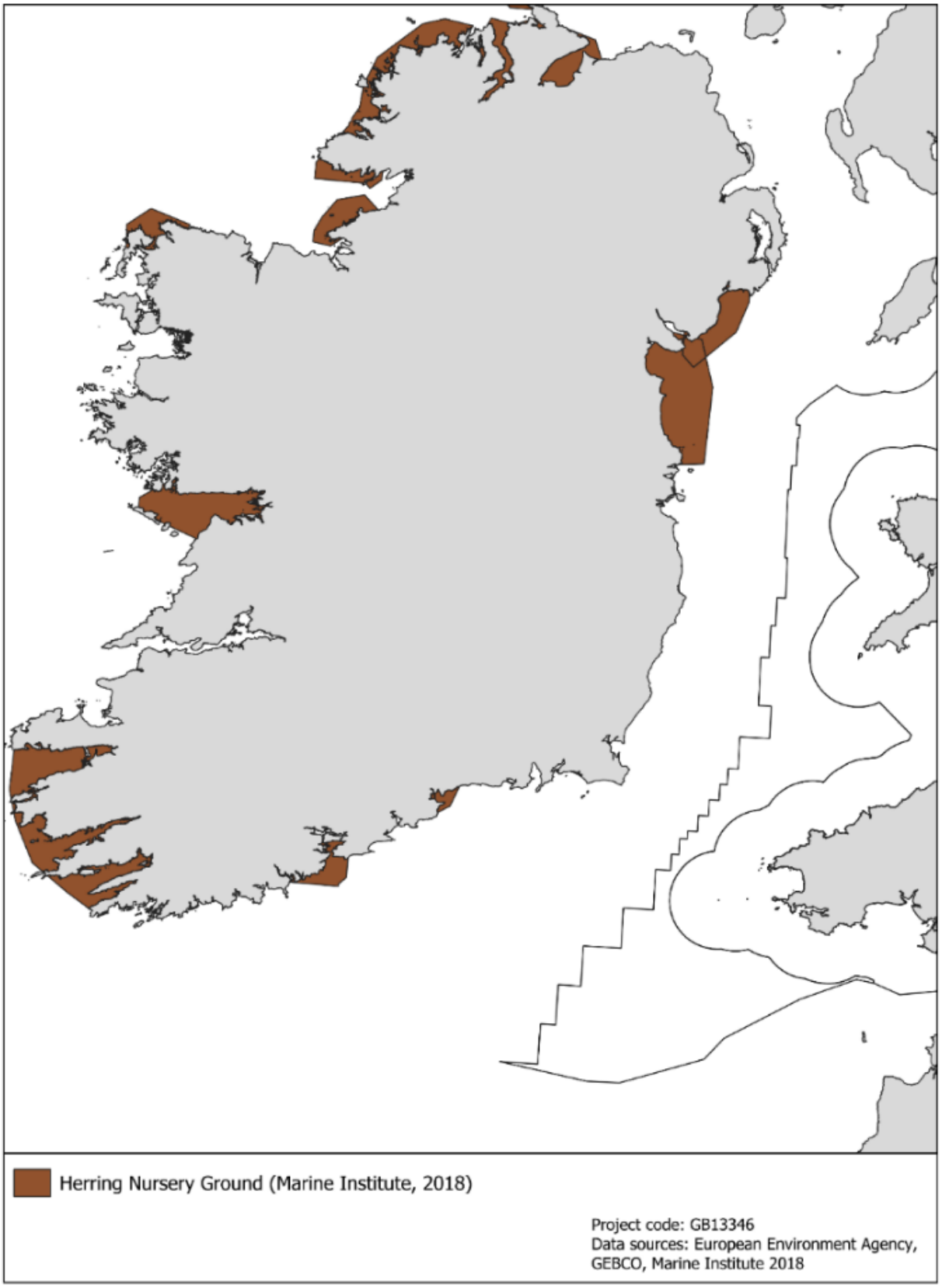


Figure 39. Herring nursery grounds in Irish waters (marine Institute, 2018)

A3.6.2. Species Spawning and Nursery Areas (Marine Institute, 2018)

Spatial coverage: Ireland

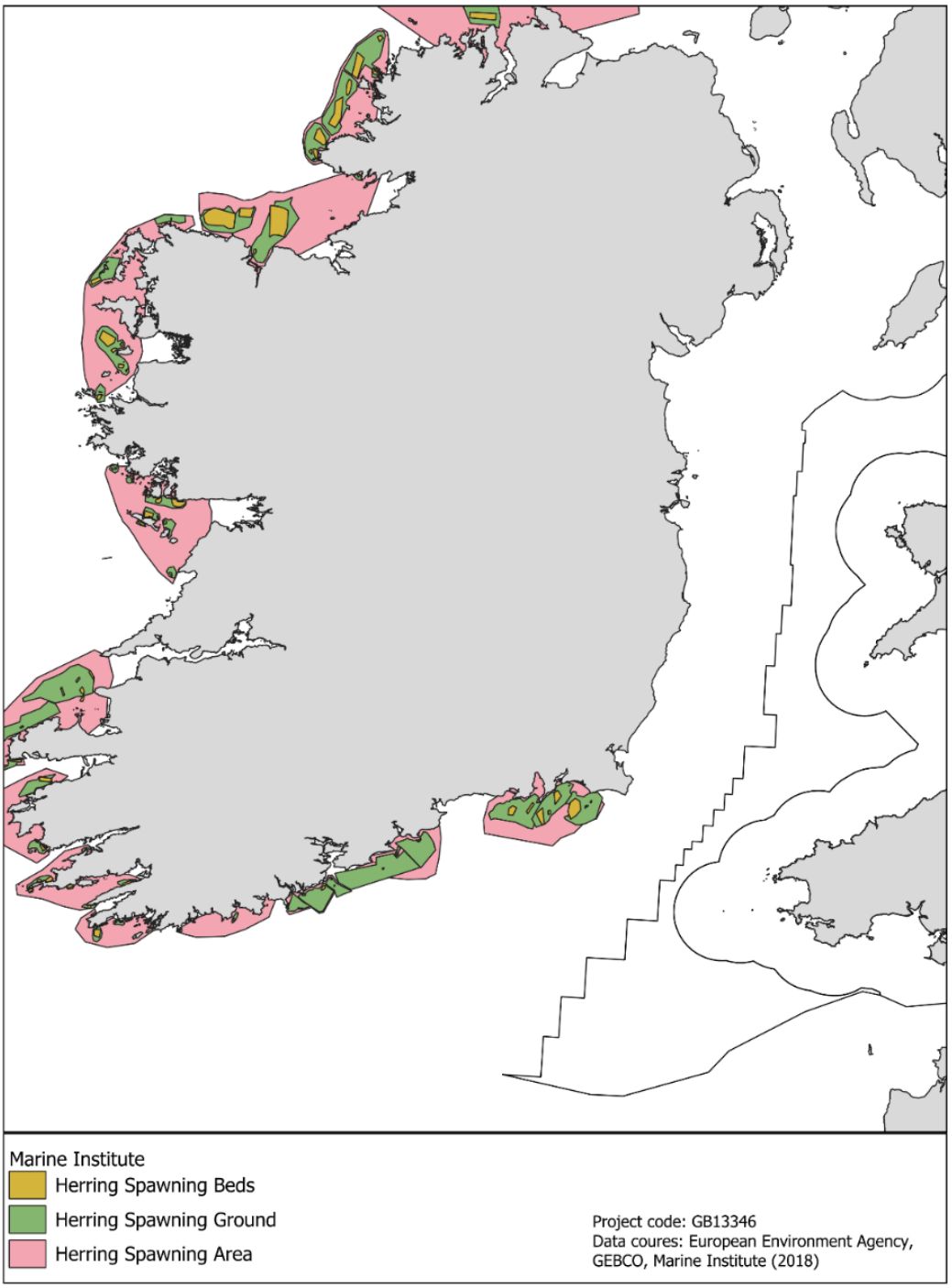


Figure 40. Herring spawning beds, grounds, and areas (Marine Institute, 2018)

A3.6.3. An Inventory of Irish Herring Spawning Grounds (Marine Institute, 2013; ICES, 2018)

Spatial coverage: Celtic and Irish sea areas 7a, 7g, 7h, 7j, 7k

The spawning grounds for herring in the Celtic Sea are well known and are located inshore close to the coast (Figure 114). These spawning grounds may contain one or more spawning beds on which herring deposit their eggs. Individual spawning beds within the spawning grounds have been mapped and consist of either gravel or flat stone. Spawning grounds tend to be vulnerable to anthropogenic influences such as dredging and sand and gravel extraction.



Figure 41. Spawning grounds of herring along the south coast of Ireland on the Celtic Sea and Eastern Atlantic (Marine Institute, 2013; ICES, 2018).

A3.6.4. Essential spawning grounds of Scottish herring: current knowledge and future challenges (Frost and Kiele, 2021)

Spatial coverage: Scotland

Due to the paucity of direct egg observations, most spawning grounds have been described by the presence of young larvae, catch data of herring in spawning condition and fish predating on herring eggs. Frost and Kiele (2021) gathered information on herring spawning grounds in Scotland, merging information based on the different survey techniques applied, including manual collection of herring eggs from the seabed, grab sampling, larvae surveys, location of recently hatched and/or young larvae, and fisheries catch locations of ripe or running herring. In addition, herring lays eggs in high energy grounds, with preferred spawning temperatures of Scottish herring being between 5–14 °C, on coarse substrate with kelp or maerl habitats.

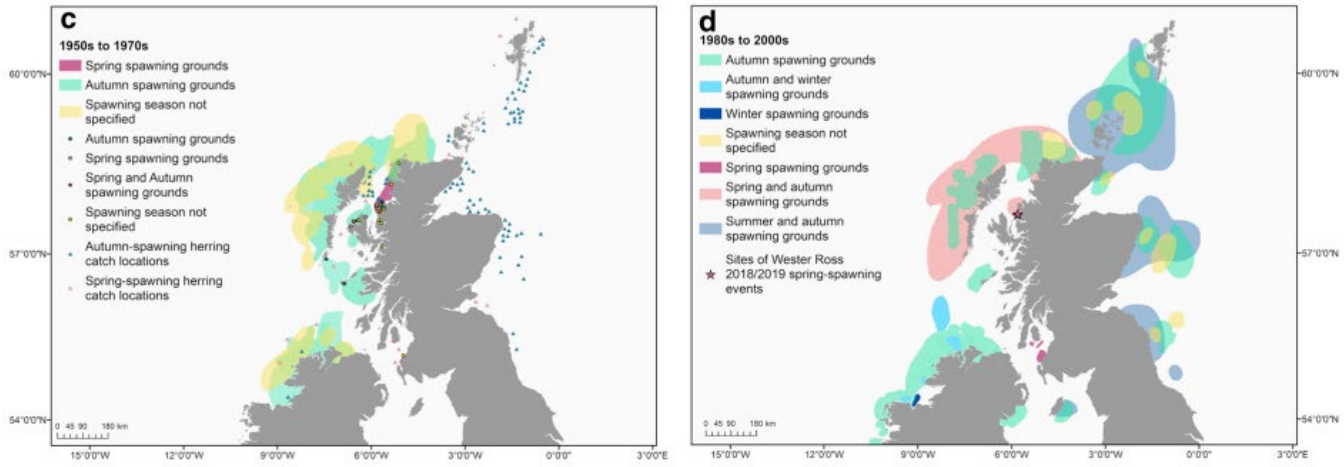


Figure 42. Identified spawning grounds for Scottish herring, where the historical data includes locations in the Irish Sea as c = Occurrence of spawning herring ('Spring'), herring eggs (W-coast Clyde and Wester Ross areas, 'Spring') and herring larvae ('Autumn' and 'Season not specified'); d = Occurrence of spawning herring ('Spring' and 'Autumn'), herring eggs (W-coast Clyde area, 'Spring') and herring larvae ('Spring', 'Summer', 'Autumn' and 'Season not specified'). Point locations are also included for historic data on the catch locations of ripe or running herring, historic spawning grounds mentioned by fishers, and spawning grounds filmed off Wester Ross in 2018/2019.

Appendix 4: Data archive appendix

Data outputs associated with this project are archived on server–based storage at Natural Resources Wales, in NRW's internal GIS folders with metadata number NRW_DS161645.

The data archive contains:

[A] The final report in Microsoft Word and Adobe PDF formats.

[B] A GIS geodatabase containing the spatial datasets reviewed in the report.

Metadata for this project is publicly accessible through Natural Resources Wales' Data Discovery Service https://metadata.naturalresources.wales/geonetwork/srv (English version) and https://metadata.cyfoethnaturiol.cymru/geonetwork/cym/ (Welsh Version). The metadata is held as record no NRW_DS161645.

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