WORKSHOP ON THE TEMPORAL MIGRATION PATTERNS OF EUROPEAN EEL (WKEELMIGRATION)

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WORKSHOP ON THE TEMPORAL MIGRATION PATTERNS OF EUROPEAN EEL (WKEELMIGRATION)

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Contents

i Executive summary

1. The **Workshop on the temporal migration patterns of European eel (WKEELMIGRATION)** was formed to answer the questions posed by the EC on the temporal migration patterns of European eel in EU areas.
2. In this report the group explored data supplied from EU Member States and Norway on time-series of fishery landings and eel monitoring, and reviewed the scientific literature to describe the period and the peak time of abundance of glass, yellow and silver eel stages in the different EU regions and through narrow straits and whether these have changed substantially since the implementation of Eel Management Plans, and whether fishery closures in 2018 and 2019 appeared to follow the relevant EC/GFCM temporal closure periods.
3. There are seasonal and geographic patterns of migration of immigrating recruits (glass eel plus older stages) and emigrating silver eel. Typically, recruits arrive later further north along the Atlantic coasts and much later in the Baltic, whereas arrival patterns in the Mediterranean are more complex. Silver eel emigrations follow the reverse pattern, typically starting earlier at the furthest distances from the oceanic spawning grounds, although there appears to be a spring emigration in the Baltic region.

   The yellow eel situation is more complex and difficult to examine as they do not typically follow discrete migrations. There may be seasonal redistributions of yellow eel in some waters but there was an absence of obvious latitudinal patterns and seasonalities.

   There were very few differences in seasonality suggested by comparisons of before and after the EMP implementation, there were only very limited data from which to make these comparisons, but the WK did not identify any biological reasons why substantial differences might have happened.

   There were limited data to examine the seasonality of glass and silver eel passage through the narrow water areas of the Baltic and Mediterranean, and the English Channel, but patterns suggested by tracking studies were consistent with migration patterns of nearby areas.

   Most of the fishery closures implemented in 2018 followed the requirements of the EC closures for that time. Many more appeared not to follow the requirements during the 2019/2020 period but these warrant further investigation before drawing strong conclusions.
4. In general, uncertainties remain because data were very limited from which to make comparisons across the desired continental geographic scale, across 20 years, and for multiple eel life stages. The WK is confident that it had access to the best available data from fishery landings and monitoring studies, albeit that the complexities of aquatic habitats, their definition and delineation, and life stages complicated analyses. However, the description of fishery closures was more complicated than envisaged, for example because closures are rarely complete across the whole EMU but instead may target certain eel stages, fishing gears or waterbodies within an EMU, and consequently further work is recommended to fully document and analyse these.
5. The WK has addressed the ToR with the available data and information, but highlighted gaps in the knowledge that limited its ability to provide complete answers.

ii Expert group information

Expert group name	Workshop on the temporal migration patterns of European eel (WKEELMIGRATION)
Expert group cycle	Annual
Year cycle started	2019
Reporting year in cycle	1/1
Chair	Alan Walker, UK
Meeting venue(s) and dates	4–6 February 2020, Copenhagen, Denmark, 12 participants
	Intersessional preparations including design of a data call, collation and analysis of data, and literature review: 16 participants

1 Request to ICES

1.1 Background

The stock of European eel (*Anguilla anguilla*) has been in a critical condition for at least two decades and ICES has been advising that all anthropogenic impacts that decrease production and escapement of silver eels should be reduced to – or kept as close to – zero as possible.

In order to support the protection of the stock the EU adopted in 2007 the Regulation 1100/2007 establishing measures for the recovery of the eel stock. This Regulation has been evaluated*. Furthermore, to step up the protection effort beyond measures taken at national level the EU has introduced since 2018 a closure period of three consecutive months via the annual "TAC and quota regulation" (Regulation 2018/120 for the 2018 fishing season, and Regulation 2019/124 for the 2019 fishing season). In 2018 the closure covered the commercial marine catches of eel longer than 12 cm in EU waters of ICES area; the three-month closure was to be set by each Member State between 1st September 2018 and 31st January 2019. In 2019 the scope of the closure was extended to cover also catches in transitional waters, recreational catches and eel at all life stages (i.e. including glass eel and elvers). Moreover, the TAC and quotas regulation for 2019 transposes the closures decided in the GFCM Recommendation for a multiannual management plan for European eel in the Mediterranean Sea GFCM/42/2018/1[1]. The consecutive three-month closure is to be set by the Member States between 1st August 2019 and 29th February 2020 for the EU waters of ICES area, and in accordance with the conservation objectives of the Recommendation and the migration patterns of eel in the waters of the Contracting Parties (CPCs) to the GFCM in the Mediterranean. For the Mediterranean, the closures were adopted as transitional measures, pending the results of an EU-funded GFCM research programme. The latter will aim *i.a.* at examining the management measures implemented in the CPCs, including the closure dates, and propose additional or alternative long-term management measures, if appropriate.

1.2 Request to ICES

In order to support the European Commission in assessing the effectiveness of the fishing closure periods set up by the Member States and in view of deciding on possible future measures to further enhance the protection and recovery of the stock of European eel, ICES is requested to give – to the extent possible – advice per relevant geographical area on the temporal migration patterns of European eel, namely:

1. The period of arrival of European glass eel on the different EU shores and the peak time, and whether this has changed substantially since before 2007; Ideally the information would be provided by eel management unit (EMU), if not possible then at the next higher aggregate level; areas outside the EU are not to be covered;
2. The period of escapement of European silver eel from the different relevant regions in the EU towards the Sargasso Sea and the peak time, and whether this has changed substantially since before 2007; Ideally the information would be provided by EMU, if not possible then at the next higher aggregate level; areas outside the EU are not to be covered;
3. The period of migration of the yellow eel, when relevant, through different relevant regions in the EU and the peak time (when, and from and to where yellow eels migrate),

[1] http://www.fao.org/gfcm/decisions/en/

and whether this has changed substantially since before 2007; Ideally the information would be provided by EMU, if not possible then at the next higher aggregate level; areas outside the EU are not to be covered Idem question 1). This question is not directly linked to the EU marine fisheries closure but more generally to the Eel Regulation and eel fisheries;

4. In the relevant cases, the period when migrating eels need to pass through narrow passages (e.g. such as the exits of the Baltic and Mediterranean) on the way to their destination, and whether this has changed substantially since before 2007;
5. Furthermore, ICES is requested to assess whether the closure periods set up under the national Eel Management Plans prior to the EU temporal closure are consistent (in terms of time periods of the closures) with the periods established following the EU closure. ICES is therefore requested for glass/silver, yellow and silver eel fisheries, to describe (i) the fishery closure periods per EMU area in place from 2000 to 2007, (ii) any changes introduced through EMPs, and (iii) in response to the EU closures in 2018 and 2019.

ICES is requested to coordinate its work with the GFCM so as to avoid possible overlaps or contradictions with the upcoming GFCM research programme.

* - Evaluation of the Eel Regulation published after the workshop; available at https://ec.europa.eu/fisheries/sites/fisheries/files/swd-2020-35_en.pdf.

2 Workshop Terms of Reference and Reporting

2.1 Terms of Reference

2019/X/FRSG The **Workshop on the temporal migration patterns of European eel (WKEELMIGRATION)**, in response to the EC request for ICES advice on the relevant geographical area and temporal migration patterns of European eel chaired by Alan Walker (United Kingdom), will work by correspondence (September 2019 to January 2020) and meet in Copenhagen, Denmark, 4–6 February 2020 to specifically answer the questions (summarized below) agreed with the EU:

i. Describe the period and the peak time of arrival of European glass eel on the different EU shores, and whether this has changed substantially since before 2007 (by eel management unit (EMU) if possible, or next higher aggregate level. Areas outside the EU are not to be covered).

ii. Describe the period and the peak time of escapement of European silver eel from the different relevant regions in the EU towards the Sargasso Sea, and whether this has changed substantially since before 2007 (by EMU and idem to 1).

iii. Describe the period and the peak time of migration of the yellow eel, when relevant, through different relevant regions in the EU (when, and from and to where yellow eels migrate), and whether this has changed substantially since before 2007 (by EMU and idem to 1).

iv. Describe in the relevant cases, the period when migrating eels need to pass through narrow passages (e.g. such as the exits of the Baltic and Mediterranean) on the way to their destination, and whether this has changed substantially since before 2007.

v. Assess whether the closure periods set up under the national Eel Management Plans prior to the EU temporal closure are consistent (in terms of time periods of the closures) with the periods established following the EU closure. This requires delivery of information on glass/silver, yellow and silver eel fisheries on (i) the fishery closure periods per EMU area in place from 2000 to 2007, (ii) any changes introduced through EMPs, and (iii) in response to the EU closures in 2018 and 2019.

To do so, a subgroup of members from WKEELMIGRATION/WGEEL will work by correspondence to update previous work from WGEEL 2004 on seasonality of fisheries by adding details on fishery closures and to collate peer-review and grey literature sources (including data from the monitoring programmes) in advance of WKEELMIGRATION (by 31st January 2020).

WKEELMIGRATION will report by 14th February 2020 for the attention of FRSG, ACOM and FAO, EIFAAC and GFCM (as partners).

2.2 Structure of the remainder of this Report

Chapter 3 of this report outlines the Methods and Data used by the WK to answer the questions posed by the EC.

Chapters 4–8 are structured according to ToRs 1–5, and designed to specifically answer the questions therein. Each chapter provides a summary answering the question by drawing on all the information available to the WK, then discusses in greater detail the information available from landings, eel monitoring and the scientific literature.

Chapter 9 provides a list of the references cited in the report, whereas Annex 7 provides a bibliography of all the literature reviewed.

Annex 1 provides a glossary of terms and acronyms used in this report.

Suggestions for improvements to data collection and collation that would help to make it easier to answer the EC questions in the future are presented throughout the report, but also collated in Annex 2 organised chapter by chapter for easy reference back to the source discussions.

Annex 3 describes in greater detail the complexities of the manner in which fishery closures were managed and reported.

Annexes 4 and 5 deal with the practicalities of the WK, giving the list of participants and the WK meeting agenda, respectively.

Annex 6 presents the data call that was designed to capture most of the information used by the WK.

Annex 8 provides the findings of the independent panel that reviewed a late draft of the WK report. Some of the Review Group recommendations were addressed in the completion of this WK report, but not all could be addressed within the available time.

Lastly, Annex 9 presents tables to e-tables describing all the data used by the WK.

2.3 ICES Code of Conduct

In 2018, ICES introduced a Code of Conduct that provides guidelines to its expert groups on identifying and handling actual, potential or perceived Conflicts of Interest (CoI). It further defines the standard for behaviours of experts contributing to ICES science. The aim is to safeguard the reputation of ICES as an impartial knowledge provider by ensuring the credibility, salience, legitimacy, transparency, and accountability in ICES work. Therefore, all contributors to ICES work are required to abide by the ICES Code of Conduct.

At the beginning of the WKEELMIGRATION meeting, the chair raised the ICES Code of Conduct with all attending member experts. In particular, they were asked if they would identify and disclose an actual, potential or perceived CoI as described in the Code of Conduct. After reflection, none of the members identified a CoI that challenged the scientific independence, integrity, and impartiality of ICES.

3 Methodology

3.1 Sources of information

In anticipation that the studies published in the scientific literature might not yield the necessary information to answer the EC questions relating to seasonality of eel migrations at the resolution combining eel stage (glass, yellow, silver), temporal (before and since implementation of the EMUs and associated management measures) and spatial (EMU, country, marine ecoregion) characteristics, the WK expanded the information sources to include data on fisheries landings and scientific monitoring programmes (though most of the latter are described in scientific papers or reports, at least for part of their time-series). The WK therefore examined and analysed these three sources of information.

As the questions posed by the EC focussed on the seasonality of eel migrations, the WK interpreted that as requiring data at a monthly resolution to examine the period and peak time of occurrence (arrival or leaving). As a consequence, the annual data collated by the joint EIFAAC/ICES/GFCM WGEEL are not of sufficient temporal resolution and a separate data collation was required.

The questions posed by the EC asked for comparisons in seasonality of eel migrations before and after 2007. That year was chosen because it was the year when Council Regulation EC 1100/2007 (EC, 2007) was published. However, few if any Eel Management Plans (EMPs) were implemented in that year, the Regulation required their implementation in 2009 and in fact some were not approved and implemented until 2010 or later, and some of the management measures specified in the EMPs were only gradually implemented thereafter. Therefore, the fisheries landings and scientific monitoring time-series were analysed for differences between the periods 2000–2009 and 2010–2019. For consistency with the temporal intervals considered for the first two data sources (landings and monitorings), these two temporal intervals were also considered for the literature review.

3.2 ICES Data call for the WK

A data call was designed to seek relevant information and data from fisheries landings, monitoring programmes, on closure periods for fisheries, for peer-reviewed and grey literature, and any other relevant information. The data call (Annex 6) was published by ICES on 14th of November 2019 and distributed to ICES Member Countries, EIFAAC Member Countries and GFCM Member Countries with the natural range of the European eel (*Anguilla anguilla*, Code EEL). Those countries were requested to provide the following for European eel in waters of the European Union:

- Data on landings from commercial fisheries in 2000–2019 (inclusive), at monthly and eel management unit scales;
- Data on eel migrations from fishery-independent sources (monitoring);
- Timing and geographic scale of closures of commercial and recreational fisheries from 2000–2019 (inclusive), at monthly and eel management unit scales; and
- Metadata associated with the above, describing the name and e-mail address of the Data Steward, and comments / description of the methods.

Sixteen EU Member States and one non-EU country (Norway) (17 in total) reported **landings data**; however, data from two countries (Greece, Belgium) were not suitable because they did not contain monthly data. For these 17 countries, monthly data were reported from 2000 to 2019 in 52 EMUs (countries and EMUs being different spatial scales).

In total, 16 glass eel (G), 30 yellow (Y) series, 27 mixed (YS) yellow + silver series and 23 (S) Silver eel series were reported, but 81 were used in the analysis because the remainder did not meet the statistical requirements (see details in Data analysis section below) (Table 3.1).

Thirteen EU Member States and one non-EU country (Norway) (14 in total) reported **monitoring series data**. In total, 154 series were provided, 12 Glass eel (G) series, 14 mixed Glass eel + yellow (GY) series, 32 yellow (Y) series, 6 mixed (YS) yellow + silver series, and 90 (S) Silver eel series. However, only 35 series met the statistical requirements for the data analysis (Table 3.1) (see data analysis section for more details).

Table 3.1. Summary of the landings and monitoring series that were received in the Data Call and those that have been used in the seasonal trend analysis. G: Glass eel, GY: Glass eel + Yellow, Yellow: Y, Yellow + Silver. YS and Silver eel: S. For landings, a series corresponds to the time series of landings in an EMU, habitat type and for a life stage.

	Monitoring		Landings	
	Reported series	Used series	Reported series	Used series
G	12	12	20	16
GY	14			
Y	32	9	56	42
YS	6	0	32	0
S	90	14	43	23

Eighteen countries reported **closures data** for 64 EMUs. Among the reported closures, 62% (8826) corresponded to commercial and 37% (5355) to recreational fisheries.

3.2.1 Data analyses

Landings and monitoring data were analysed using a similar approach to that of Chevillot *et al.* (2017) using a Bayesian model that is specifically built to estimate how landings/abundances are distributed among months. Contrary to most methods dealing with the phenology of migration that impose a Gaussian shape of the migration wave, this method does not impose any specific shapes, and as such can deal with monovariate, bivariate and asymmetric migration waves.

The model was implemented separately for each stage (i.e. glass eels, yellow eels, silver eels) and habitat type (i.e. freshwater, transitional, coastal, marine open). Moreover, to detect the potential change in the monthly pattern related to the implementation of EMPs, data were split into the two periods: 2000–2009 and 2010–2019.

Two types of analysis were carried out:

- Estimation of average monthly patterns per series of landings/monitoring in the two time periods to explore whether some changes have occurred between the periods. $\pi_{m,p}$ denotes the average proportion of landings/monitoring value that occurs in month m during 2000–2009 (p=1) or 2010–2019 (p=2). These monthly patterns can be used to assess the potential effects of fishery closure regulations and to quantify the change of monthly pattern between periods. Indeed, the similarity between the two periods can be quantified as sim=$\sum_{m=1}^{12} \min(\pi_{m,1}, \pi_{m,2})$. A value of 1 would indicate a perfect overlap between the monthly patterns of the two periods, and therefore that no change occurred. In contrast, a value of 0 would indicate that the monthly pattern has totally changed between period 1 and period 2.

- A clustering of landings/monitoring time-series displaying similar monthly patterns, π_m denotes the average monthly pattern for this cluster (average proportion that occurs in month *m* for a series of this cluster).
  - to detect whether common patterns can be detected among time-series;
  - to examine whether some series change clusters between 2000–2009 and 2010–2019;
  - to explore whether some spatial patterns emerge from the classification.

  Two statistics were computed to describe the cluster: the centroid of landings/monitoring as $\sum_{m=1}^{12} m \cdot \pi_m$ which represents the central month of the migration wave; and, the minimum number of months that covers 80% of the migration wave, as an indication of the duration of the migration wave.

Prior to analyses, the available data were examined for consistency with the statistical approach.

First, the data per year were grouped according to the eel's calendar. For example, for glass eels, the definition used by the WGEEL was used: glass eel season *y* ranges from October *y-1* to September *y*. Less information on seasonality of migration was available for yellow eels and silver eels: ICES (2019) illustrated that the seasonality of migration of silver eels can be very contrasted between the northern and southern parts of the distribution area. In view of this, the season was defined per time series such that the average landings or abundance per month were calculated and the season *y* range from this minimal month *m* of year *y* to the month *m-1* in year *y+1*.

Then, the minimal data requirements for a season to be retained in the analysis were defined as a period ranging from the last month of the season for which the landings/abundance had not yet exceeded 5% of the total on average, and the first month of the year for which the catch exceeded 95% of the total for series on average. In this way, for each series a season was only kept for the analysis if:

- data are available for at least seven months in the year,
- it was possible to define the minimal data requirements (otherwise, that would mean that the first month or the last month for which data are available exceed 5% of total catch), and the considered season fulfilled this minimum requirement,
- the total number of months per year with zero values was smaller than 3, and
- the seasonal landings were at least greater than 50 kg for yellow and silver eel.

For clustering, it was necessary to select a number of clusters to be used. To do this, the performance of the model with a number of clusters ranging from 2 to 7 was compared. Three criteria were compared to select the appropriate number of clusters:

- the deviance information criterion (DIC) as computed by Gelman *et al.* (2004) which penalizes the benefit of adding a new cluster (measured as the deviance of the model) by the increase in complexity,
- the silhouette coefficient of the model (Kaufmann and Rousseeuw, 1990) which measures whether there is more consistency between members of a cluster than between members of different clusters,
- the number of clusters 'used' by the model to avoid having 'empty' clusters.

3.3 Fishery closures

ToR 5 was to "Assess whether the closure periods set up under the national Eel Management Plans prior to the EU temporal closure are consistent (in terms of time periods of the closures) with the periods established following the EU closure." Initially this seems straightforward to answer. Assuming that 'consistent' means 'the same as', and consistent 'in terms of time periods' means 'in the same months', then the question is interpreted as:

"Are the closure periods in an EMU the same in 2007–2017 (the time of the EMP) versus 2018–2019 (the time of the EU closures)?"

Given the appropriate data, the answer could be simple: yes or no.

- Yes would mean that the same months were closed in 07–17 as in 18–19.
- No would mean that the months closed were different between 07–17 and 18–19.

However, examination of the data indicated that there would be many versions of No, including because of changes within these time periods, and fishery controls being different according to life stage, fishing type and part-area of the EMU. A more detailed explanation of the complex data combinations and their effects on analysis and interpretation is provided in Annex 3.

The WK review of the available data indicated that addressing all of these Versions of No would be very difficult to describe or explain and the answers would probably be incomplete in many, most or even all combinations. Therefore, after discussing these challenges with the representative from the EC and their ultimate requirements, it was agreed that the WK would focus this workstream on answering the following two questions.

1. Do the closures applied by Member States in 2018/2019 follow the EU Closure Regulation obligations set out in the Council Regulation (EU) 2018/120 relating to 'Measures on European eel fisheries?
2. Do the closures applied by Member States in 2019/2020 follow the EU Closure Regulation obligations set out in the Council Regulation (EU) 2019/124, which relates to 'Measures on European eel fisheries in Union waters of the ICES area, or European eel in the Mediterranean Sea (GSAs 1 to 27)?

Evolving on from the answers to these would be a further series of questions related to whether or not these closures would be in months when the target eels were migrating through the relevant areas or otherwise susceptible to the fisheries, or not? Some of the answers can be extracted from various parts of this report, but it was not possible to extend the scope of the present work and time available to explicitly answer these additional questions.

3.4 Literature review

A thorough literature search was carried out to build a spreadsheet with the information to describe the temporal migration patterns of European eel on the relevant geographic areas.

Papers were sourced through three routes: the WK data call included a request for papers and information from Member States; papers were obtained from the Web of Science and Google Scholar using the following search term combinations: escapement, recruitment, settlement or colonisation, seasonality, peak; and, scientific experts were contacted to seek papers as well as grey literature, internal reports, and unpublished data.

The papers were examined at two levels: one to identify papers useful to describe the seasonality patterns within European regions and including through narrow passages, and one to ascertain information describing whether any patterns have changed substantially between periods prior and subsequent to the implementation of the Eel Regulation. For consistency with the temporal intervals considered for the first two data sources (landings and monitorings), this temporal comparison was also conducted based on 2000–2009 vs 2010–2019. Studies reporting both quantitative (i.e. number, biomass) and qualitative data (i.e. the start and end of the migration season, or peak of occurrence occurring at a specific site) were specifically retained to determine timing of migration. Of these, when scientific literature provided suitable data as monthly occurrence over an annual cycle at the same location, monthly values were normalized to proportions according to Righton *et al.* (2016). When such information was not available but authors provided relevant evidence according to the eel migration behaviour, qualitative information was converted into ranks of occurrence per month according to a scale ranging from 0 to 4 (i.e. from 0 meaning movement was absent, to 4 maximum intensity, peak of timing). In all other cases, such as the identification of the period when migrating eels need to pass through narrow passages on the way to their destination, other scientific papers were used to support the literature review.

The search returned 63 studies (59 scientific papers and 4 grey literature documents) and yielding data from 19 countries, providing a good coverage at the EU level (Figure 3.1).

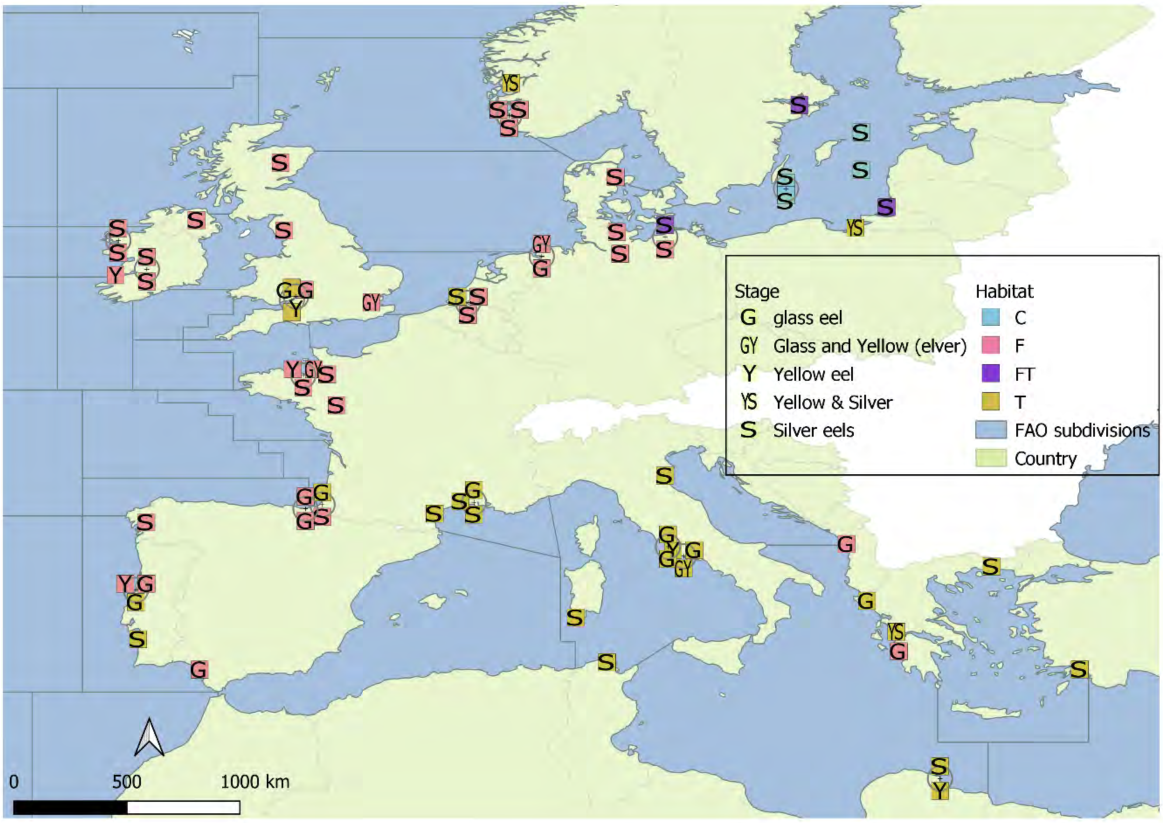


Figure 3.1. Map showing the geographical coverage area of the information collected from the literature review. Studies reviewed are reported per eel stage, per habitat type, per site, and per country. Habitat codes: C – Coastal waters; F – Freshwater; FT – Freshwater and Transitional waters; T – Transitional waters.

The review yielded 14 Glass eel (G) series including six from freshwater (F) and eight from Transitional (T) habitats, 2 mixed Glass eel + Yellow (elver) (GY) series of F and T habitats, six Yellow (Y) series including five freshwater and one transitional habitats and 43 Silver eel (S) series including 23 F and 13 T habitats, three from Freshwater and Transitional (FT) and four from Coastal waters (C).

The temporal migration patterns of eel were described separately for stage (glass eels, yellow eels, silver eels) and habitat type (freshwater, transitional, coastal waters).

The information collated from the literature, for each life stage, should be considered as a complement to the information obtained from the data call.

3.5 Issues with the way the data were collected

None of the data sources is ideal to answer the questions posed and it is important to understand some of the inherent issues with each data source, as discussed below, when analysing them and considering the results.

3.5.1 Types of Data

Landings may not truly represent the relative abundance of eel since they also reflect fishing effort and efficiency, which are influenced by commercial pressures, by regulations and controls, and by environmental conditions.

Fishery-independent sources will be less influenced by these complications, yet there are still potential sources of bias, e.g. if there is a closed season for fisheries it might increase the proportion of eels caught at a monitoring station during this period. Also, the spatial distribution of sampling locations, and the sampling methods must be considered, as they are often influenced by logistical constraints affecting the frequency of data collection, e.g. access.

3.5.2 Sampling locations

The location of the site along the migration route will affect the timing of occurrence. For example, glass eel arrive – and as such, become susceptible to exploitation by local fisheries – in waters off Portugal and Spain in October–November but not in more northerly waters of the UK, northern France and Ireland until typically January onwards. Recruits to the Baltic still have to travel through the North Sea, and those entering the Baltic may not do so until a year after their cohort first arrived in Portugal. The same general principal applies to other areas of the eels' distributional range (e.g. Northern Africa, Mediterranean): the arrival of glass eel occurs later with increasing distance from the spawning site.

Similarly, young eels will arrive at monitoring sites even a few km upstream, days or weeks after arriving at the coast, thus possibly showing different seasonal patterns on small geographic scales (e.g. separate time-series in the Ems River).

The key point is that in order to make meaningful comparisons of the seasonality of eel migrations between locations, one must understand their 'location' on the migratory 'route' and what environmental conditions might have influenced differences in timing.

3.5.3 Combined life-stages

Some fisheries and monitoring programmes report landings for combined life stages, e.g. glass eel and young yellow eel, or yellow and silver eel, but these data sets are difficult to apply in answering questions specific to glass, silver or yellow eel stages. The WK elected to interpret the question on Glass Eel (ToR 1) as relating to all recruiting eel, allowing it to include those glass/elver/young yellow mixed series. It was not possible however to do this for the Yellow/Silver combined landings and therefore some datasets were excluded from the analyses.

Member States should be encouraged/required to report time-series separately for different life stages according to the life stage that is most relevant to the purpose of the data being requested. This does mean that data could be collected as yellow and silver combined, but reported as yellow for one purpose and silver for another purpose.

In future, consideration should be given to whether mixed yellow/silver eel time-series can be treated as one or other stage, for example based on the capture gear and inferences about the likely life stage of the catch – for example, large eels that are caught migrating downstream to the sea in the autumn and winter and which include some silver eels can all be classed as silver even if some look 'yellowish' because of their common migratory behaviour.

3.6 Issues with the way the data were reported

3.6.1 Definition and delineation of Aquatic Habitat type

The annual "TAC and quota regulation" Regulation 2018/120 for the 2018 fishing season covered the commercial marine catches of eel longer than 12 cm in EU waters of ICES area, while Regulation 2019/124 for the 2019 fishing season was extended to cover also catches in transitional waters.

However, national and international legislations use and apply to a diverse range of aquatic habitat types, including e.g. freshwater, brackish, saline, estuary, transitional, marine, seawater, coastal, marine open, Union Waters, or ICES Areas. Few of these are well defined in spatial mapping terms, and often definitions and delineations are different between countries or jurisdictions. For example, the 2018 EC Closure Regulation applied to Union Waters in ICES Areas, but there does not seem to be a single delineation of those waters or areas – Union Waters are waters under the jurisdiction of EU Member States but are sometimes wrongly considered to be only the shared waters, and although maps might appear to 'draw' the boundary between saline and fresh waters for ICES Areas, the legal basis for such lines seems lacking leading to uncertainty as to where the ICES Area stops within rivers.

Furthermore, the definition of habitat types, such as transitional waters, is seemingly inconsistent between Member States, potentially even in EMUs within a single country, and perhaps even between the institutions charged with responding to data calls. These all serve to complicate any habitat-specific controls or analyses. **Future consideration ought to be given to agreeing common rules for defining and delineating aquatic habitat types.** Note that it might be that such rules already exist, but if that is the case then they are not being applied consistently in all circumstances.

The matter is further complicated by MS reporting landings not to single habitat types but to combinations such as total landings in Fresh and Transitional waters. **In future, Member States should be encouraged/required to report landings separately for each aquatic habitat type.** Thus, the scope of habitat-specific analyses and comparability between EMUs is limited. Throughout the workshop, habitat definitions were used as reported in the data call by Member States.

3.6.2 Interpretation of the data requests and the treatment of 'empty' data

A clear distinction has to be made between the reporting of actual 0-values, i.e. that a measurement has been made and the observation is 0 units, versus no data were collected and non-reporting of data. The reasons for non-reporting can be grouped into i) data not being collected, ii) data were collected but not reported, iii) data were collected but not suitable (e.g. landings data were collected on a yearly basis but not monthly), or iv) the call for data is not pertinent (e.g. request for landings data when fisheries are closed). While the latter is essentially equal to a reported 0-value, all of the former indicate that a value exists but is unknown.

Though the data call requested responders to specify their reasons for non-reporting, the practical application is admittedly difficult (this requires an entry for every possible combination of life stage, habitat type, fisheries type, month, year and EMU; though several tools, e.g. combinations of life stages, were implemented to help with this issue). As a result, data that were not available were often simply not reported and therefore neither was the reason for non-reporting.

For this reason, it was generally not possible to determine whether non-reported data represent 0-values or not. This issue mainly concerns landings data and is particularly problematic when calculating monthly percentages (e.g. when data for several months were provided with no indication on landings/absence of landing for the remainder of the year). Therefore, analyses were limited to datasets with sufficient information.

Note that EMU-specific data in Annex 9 shows all data, meaning they represent monthly percentages of reported landings (as opposed to monthly percentages of actual landings, though these are possibly the same). For example, if for a given year data were only reported in a single month, these will account for 100% of reported landings, though in the case of non-reported catches in one or more other months, they are less than 100% of the actual catches.

The data call for this WK asked the Member States to indicate whether fishery closures were in response to EMPs or the more recent EC closures (i.e. from 2018 onwards). However, it was clear that this caused the potential for confusion where closures already existing prior to 2018 were appeared to follow the EC Closure Regulations – should these be labelled as EMP or EC? The solution was to ignore the labels and focus on the years and habitats where closures occurred.

Another issue for the reporting of closures was how to treat those EMUs where there was no fishery to close. It would appear that in many such cases, no report was provided because logically there was no closure to report. However, that meant that a shallow examination of the available data would suggest that nothing was closed, which might suggest a non-compliance, but in fact there was nothing to close. In all likelihood, complete failure to report closures for an EMU most probably meant there was no fishery to close and therefore these can be ignored in the analyses. **For future data requests however, it should be made clear that full reporting is required for any EMU that had a fishery during any part of the reporting period, and that not reporting an EMU will be understood to mean that no fishery has ever occurred there.**

For all figures, maps and tables presented in this report, the absence of an EMU does not necessarily indicate that a fishery does not exist, it may also be because the data have not been reported or because they have been reported but did not meet the statistical criteria to be used in the respective analysis.

4 ToR 1 - the period and the peak time of arrival of European glass eel on the different EU shores, and whether this has changed substantially since before 2007

4.1 Summary

The WK interpreted glass eel in the ToR to mean 'recruits' and therefore included young yellow eels in the analyses where these were known to be the recruiting stage in some areas.

The three information sources used in this study (landings, monitoring series and literature) confirm that glass eel arrival follows a south to north gradient in the Atlantic region.

While glass eel can be found recruiting all year round in Portugal (Domingos, 1992) and in the Bay of Biscay (Désaunay *et al.*, 1996a; Arribas *et al.*, 2012), it has, like most temperate species a clearly seasonal pattern of migration with migration peak centred around winter (Briand and Jellyman, 2007). In the Atlantic, there is a clear geographic pattern in the timing of this seasonal migration. Tesch (1977) describes the arrival of glass eel in the Northwest Atlantic as starting in September in the Coast of Spain and France and then progressively later into the Channel and North Sea. More recently, the arrival to Portugal may be from October, and thereafter continuing north (Domingos, pers. comm.). The main migration season has a duration of four to five months, with most landings centred around three months. There might be some shifts in the migration peaks with a one month shift between an early and late season (Dekker, 1998) but the timing of migration at a particular location is generally stable unless recruitment is affected by local factors, such as floods or periods of cold water (Briand, 2019).

The temporal patterns of recruitment in the Mediterranean are more complex than in the Atlantic, and it is difficult to define the duration of the recruitment season and the peaks in migration. According to the distribution of landings, glass eel arrival in the Spanish Mediterranean starts in November–December and lasts until January–March, with a peak in January. A review of timing of entry of glass eels in continental waters in the Mediterranean and to its seasonal periodicity has been performed by Kara and Quignard (2019), based on old and more recent publications, that highlights that most of the ascent occurs between December and March. Some studies suggest that in the Mediterranean, especially in coastal lagoons, recruitment might occur on a wider period (also all year-round), but with seasonal peaks within the year due to the influence of local environmental, climatic and hydromorphological factors of single sites (Elie and Rochard, 1994; Kara and Quignard, 2019).

It should be noted that there may be recruitment before and after the identified periods, as the fishery, sampling and surveys tend to focus on the months of greatest abundance. However, any such recruitment on the temporal margins is thought to be relatively minor when compared to total recruitment.

4.2 Detailed examination of the information provided by landings, monitoring and the literature

4.2.1 Landings

The cluster analysis identified three groups of EMUs according to the glass eel season landings distribution (Figure 4.1). Glass eel landings are generally distributed over three or four months.

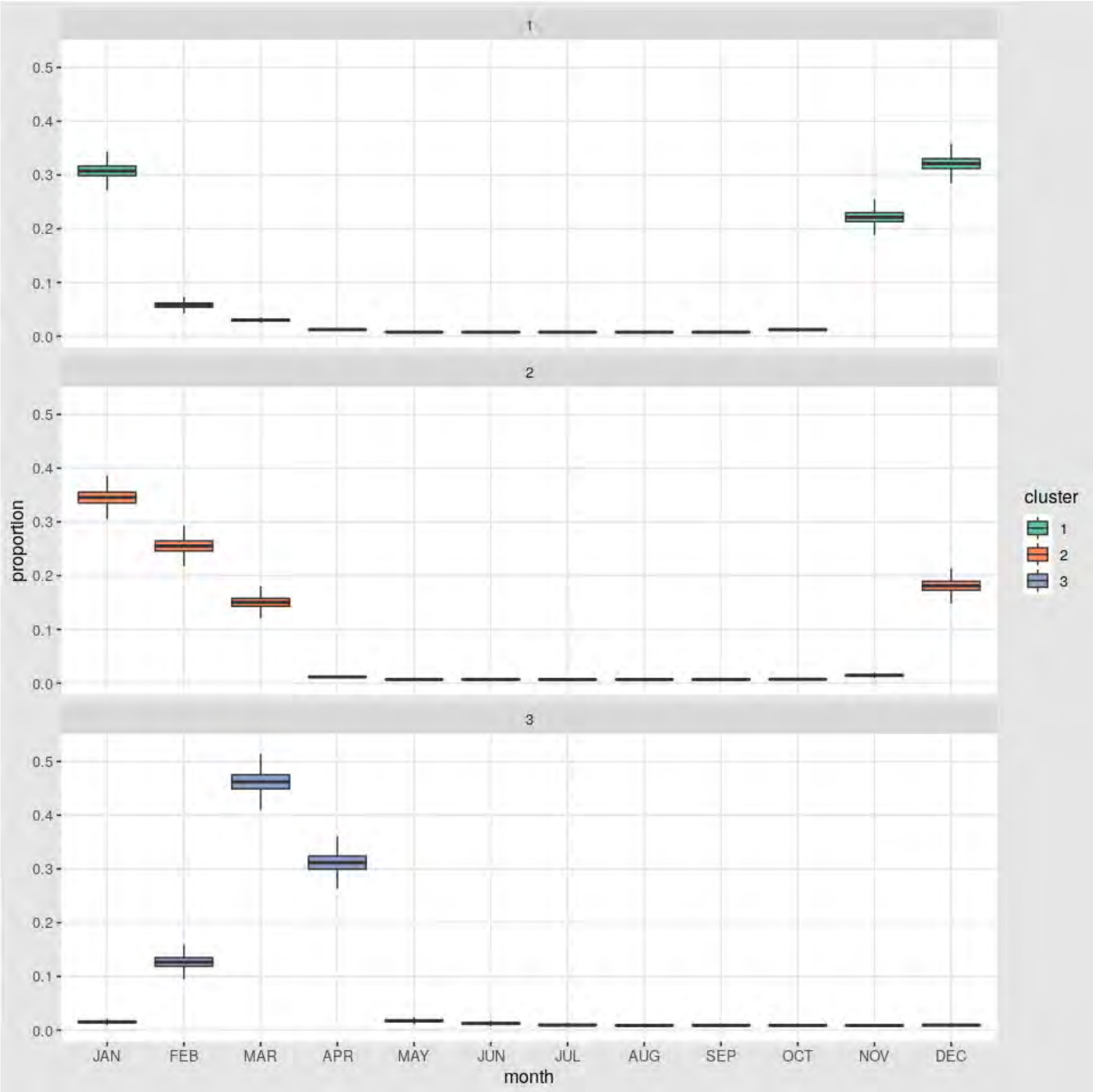


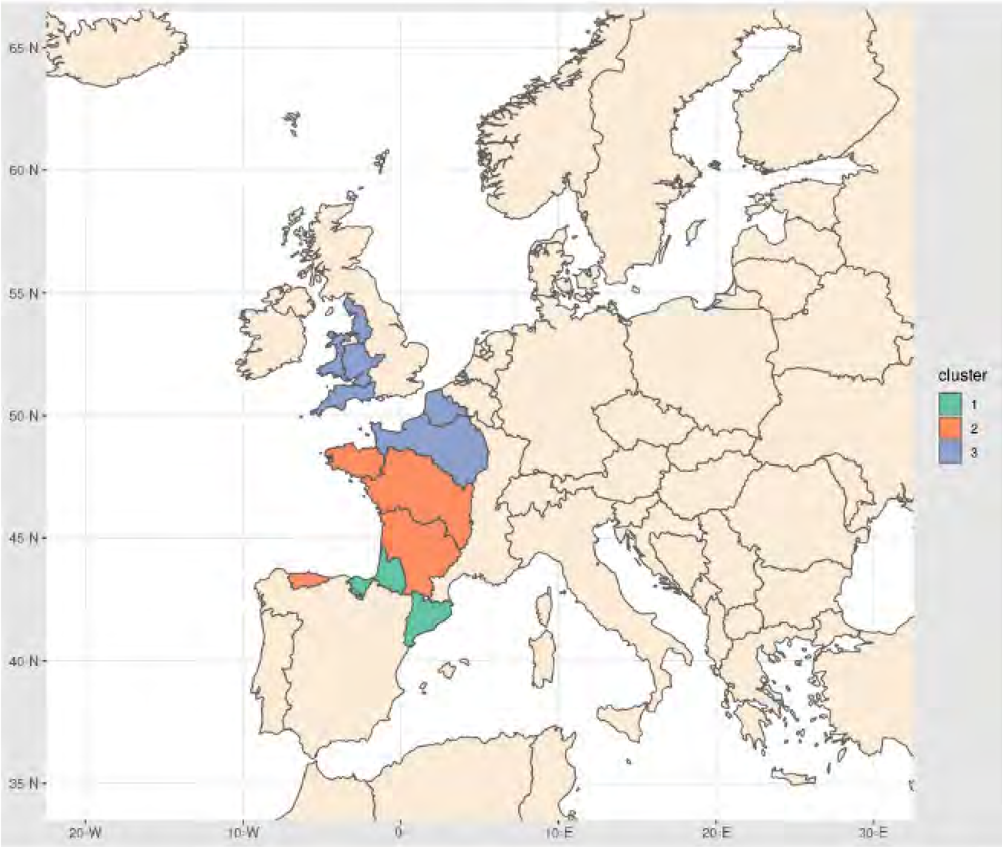
Figure 4.1. Monthly pattern of Glass eel landings for the three clusters. Boxplots indicate the posterior distribution of the expected proportions (y axis) per month (x axis).

The seasonal distribution of landings for each cluster was as follows (Figure 4.1):

- **Cluster 1** (includes three series of the more southern EMUs in 2000–2009 and six in 2010–2019): glass eel landings start in November and last until January and the months with highest landing are December and January.
- **Cluster 2** (includes three series of the medium latitude EMUs in 2000–2009 and four in 2010–2019): landings start in December and finish in March, thus starting a month later and lasting longer than Cluster 1, but landings peak in January.

- **Cluster 3** (includes six series of the more northern latitude EMUs in 2000–2009 and three in 2010–2019): landings start in February and last until April with highest landings in March.

In most cases, the clustering corresponds to a latitudinal distribution of the EMUs, with the landings distribution following a south to north gradient. However, two EMUs in Spain that according to their latitude should have been in Cluster 1 were assigned to Cluster 2: Asturias EMU in 2000–2009 and Valencia EMU in 2010–2019. This could be explained by changes in the fishing season. Before 2010, fishing was allowed in Asturias from November to March while in the nearby EMU of the Basque Country the fishing season was from October to February. In the case of Valencia, the duration of the fishing season after 2010 has been from December to March, so there is no early catching unlike in adjacent basins.



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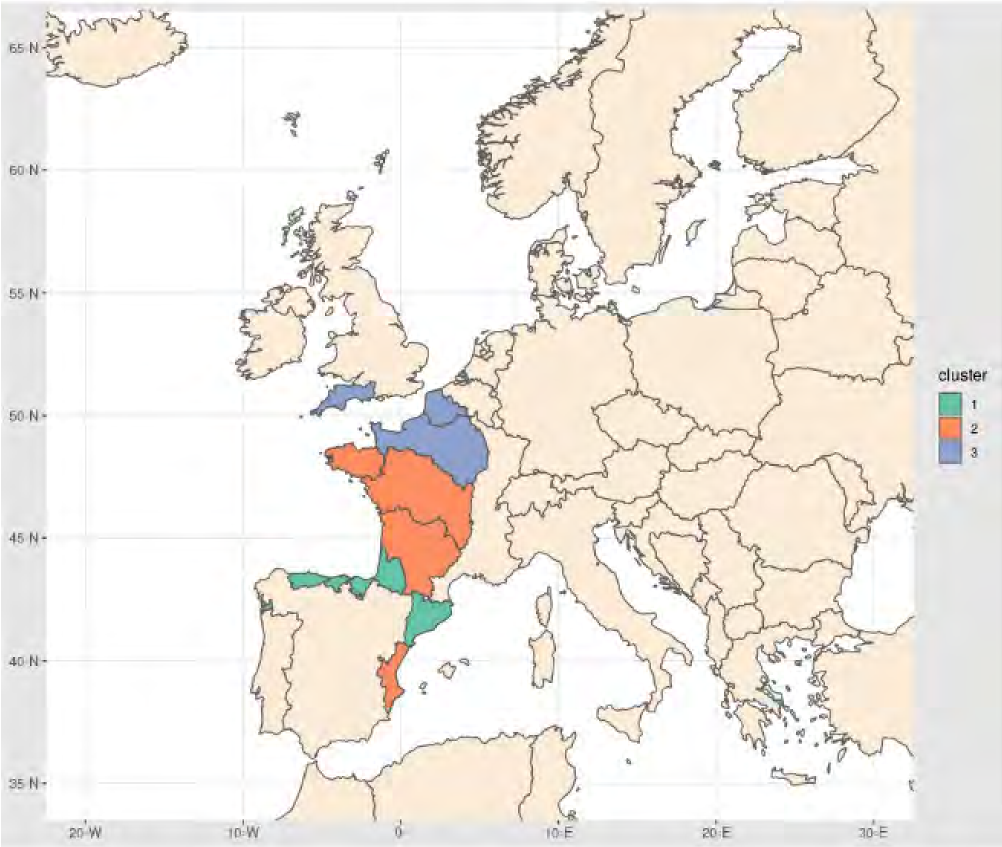


Figure 4.2. EMU clustering of the glass eel landings monthly patterns according to the cluster analysis. The top map represents 2000–2009 while the lower map represents 2010–2019. Note that the absence of an EMU on the map does not necessarily indicate that a fishery does not exist, it may be also be because the data were not reported or because they have been reported but did not meet the statistical criteria to be used in the analysis.

The temporal distribution of landings by year and EMU is detailed in Annex 9. Figure 4.3 shows the example of the EMU of Garonne (FR_Garo). In this case, it can be seen how the landings and the fishery-independent series follow the same time distribution.

Figure 4.3. Monthly distribution of glass eel landings in the FR_Garo from 2000 to 2018. Bars indicate the percentage of the total annual landings happening in that month. The purple line indicates landings (kg). The red, blue and green lines indicate the abundance obtained in the glass eel monitoring series. A small square at the top of each graph indicates whether the fishery has been closed during that month. The number inside the square indicates the percentage of the decrease in landings that the closure will cause. The blue colour indicates that the closure is due to the implementation of the EMP and the pink colour indicates that the closure has been due to other reasons.

For those EMUs for which data are available for both time periods (2000–2009 vs 2010–2019), no differences were found in the average monthly landing patterns between the two periods as demonstrated by the fact that there were assigned to the same group in the cluster analysis (Figure 4.1) and the similarity analysis (Table 4.1).

Table 4.1. Similarity indices (1 perfect overlap, 0 no overlap) of monthly patterns in glass eel landings per EMU before (<2010) and after EMP implementation (≥2010). The index values represent the median of the posterior distribution and the values inside square brackets represent the 95% credibility intervals.

EMU	Similarity index
ES_Astu	0.83 [0.74–0.91]
ES_Basq	0.74 [0.64–0.83]
ES_Cata	0.86 [0.77–0.93]
FR_Adou	0.75 [0.65–0.85]
FR_Arto	0.71 [0.64–0.79]
FR_Bret	0.83 [0.73–0.92]
FR_Garo	0.83 [0.72–0.91]
FR_Loir	0.88 [0.78–0.95]
FR_Sein	0.77 [0.60–0.91]
GB_SouW	0.72 [0.55–0.88]

4.3 Eel monitoring

It should be noted that many time-series result from the counting of eels in traps at migration obstacles (e.g. “BroG”, “EmsB”, “EmsH”,”ImsaGY”, “Liff”, “ShaE”, “ShiF”, “StGeG”, “Grey”). There is often a difference in timing before glass eel arriving into an estuary will ascend an eel trap, related to temperature and physiological adaptation.

The cluster analysis identified five groups of eel monitoring series according to the seasonal trends in glass eel abundance (Figure 4.4). Cluster 1 corresponds to series from southwestern Europe, in both time periods (Figure 4.5). Clusters 2 to 5 corresponds to northern Europe: Clusters 2 and 3 correspond to series in Great Britain and Germany, 4 to Ireland and 5 to Norway.

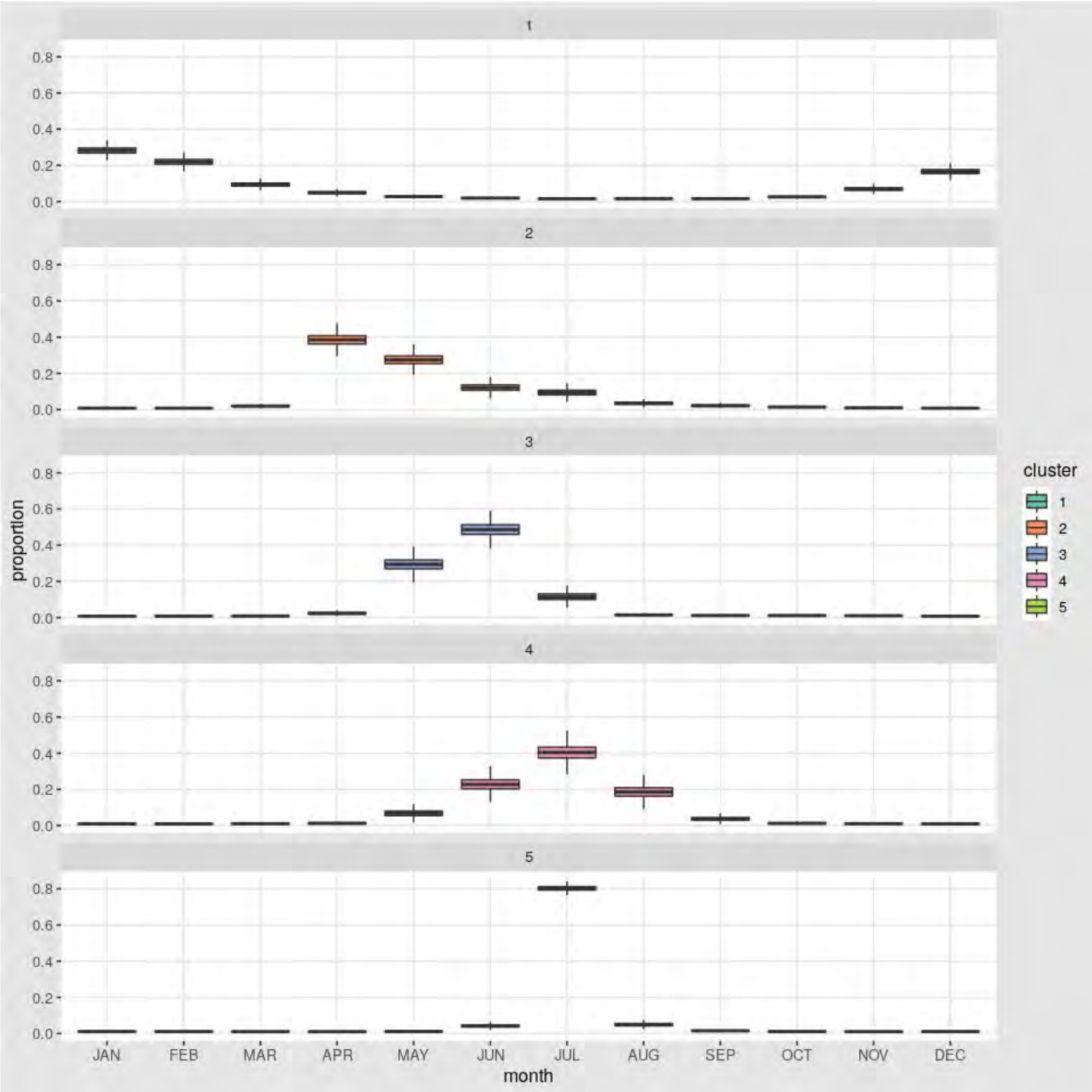


Figure 4.4. Monthly pattern of glass eel monitoring for the five clusters. Boxplots stand for the posterior distribution of the expected proportions (y axis) per month (x axis).

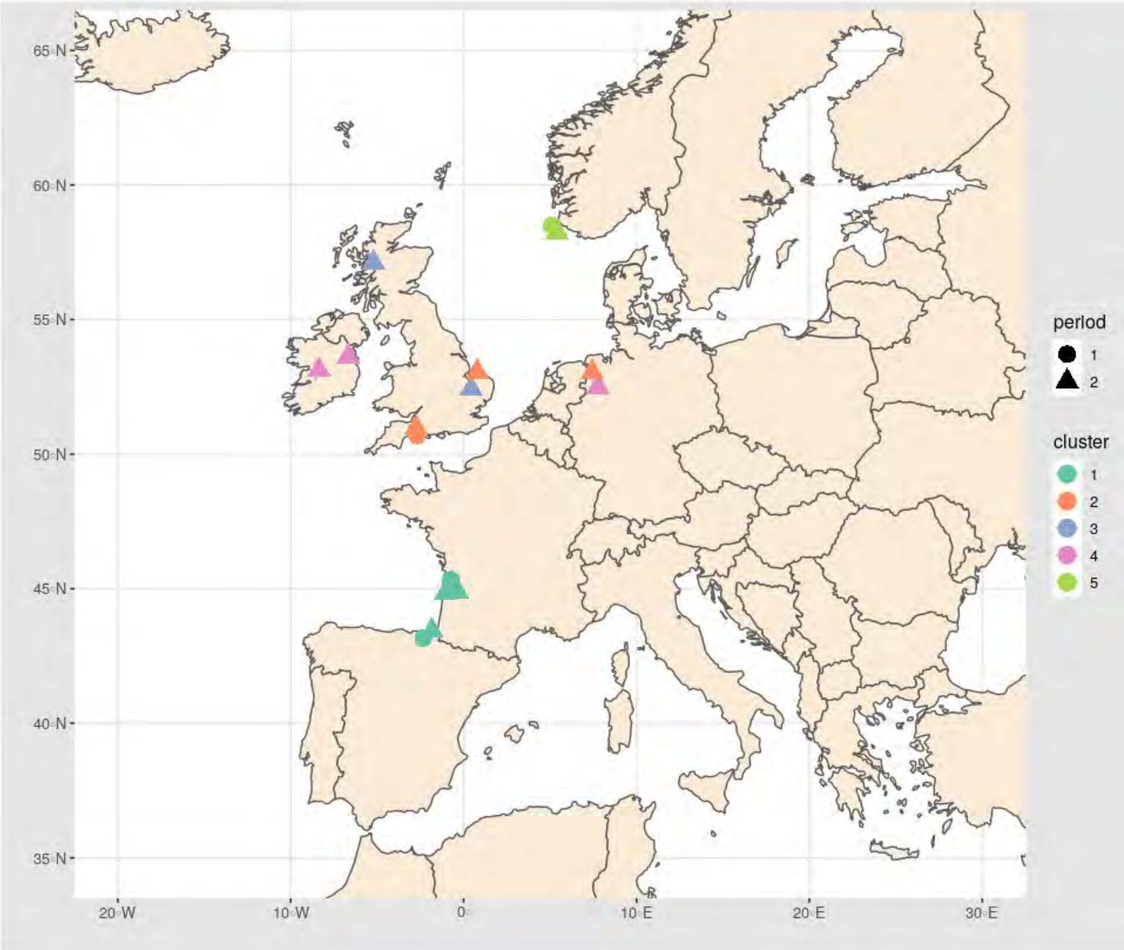


Figure 4.5. Spatial distribution of the eel monitoring glass eel time series according to the cluster analysis of seasonal distributions. Circles represent 2000–2009 and triangle represent 2010–2019.

The length of the recruitment season varies between clusters (from three to five months) and is longer than that identified in the landings section. This is probably because the sampling season is longer than the fishing season.

The seasonal distribution of glass eel series follows a south to north gradient. The seasonal distribution for each cluster as follows (Figure 4.4):

- **Cluster 1** (contains 5 series from southwestern Europe): glass eel arrival typically starts in November and lasts until April, peaking in January.
- **Cluster 2** (containing 4 series in Great Britain and Germany): glass eel arrival typically starts in April and lasts until July, peaking in April.
- **Cluster 3** (containing 2 series in Great Britain): glass eel arrival typically starts in May and lasts until August, peaking in July.
- **Cluster 4** (contains 3 series from Ireland): glass eel (pigmented stages) active upstream migration from tidal to freshwater typically starts in May and lasts until August, peaking in July. Note this is not therefore an indicator of arrival time in tidal waters.

- **Cluster 5** (contains 2 series from Norway): elver (young yellow eel) arrival in freshwater typically starts in June and lasts until August, peaking in July when almost all the arrival happens.

For those series for which data are available for 2000–2009 and 2010–2019, no differences were found in the average monthly landing patterns between the two periods as demonstrated by the fact that there were no differences in the assignation to clusters (Figure 4.4) and the similarity analysis (Table 4.2).

Table 4.2. Similarity indices (1 perfect overlap, 0 no overlap) of monthly patterns in glass eel monitoring per time-series before (<2010) and after EMP implementation (≥2010). The index values represent the median of the posterior distribution and the values inside square brackets represent the 95% credibility intervals.

Series	Similarity index
GiSc	0.88 [0.80–0.94]
Grey	0.71 [0.55–0.85]
ImsaGY	0.93 [0.89–0.96]
Oria	0.71 [0.53–0.86]

4.3.1 Literature review

The literature review covers 14 sites from nine countries including Glass eel series and mixed Glass eel + Yellow (elver) (GY) from freshwater and transitional habitats. The review includes studies from both scientific monitoring and fishery-dependent studies (Table 4.3). Multi-year studies have been monthly averaged per site facilitating the identification of broad migration periods and peaks for each locality.

The information collated from the literature should be considered as a complement to the information obtained from the data call provided to the WK. As mentioned above, there was a general absence of data within each study to make comparisons between the two periods, i.e. 2000–2009 vs 2010–2019.

Figure 4.6 presents a qualitative point of view of the information extracted from the papers.

The same trend as with the recruitment data provided to the WK was observed: the arrival of glass eels occurs later in the year in the northern part of the distribution (spring, early summer) compared to the south (mostly autumn and winter) (Figure 4.6). As expected, the peak arrival of later stages of recruits i.e. young yellow eels (glass + young yellow: GY) occurs approximately two months later than glass eels (Figure 4.6).

However, there are differences between the Mediterranean and the Atlantic regions. While glass eel can be found recruiting all year round in Portugal (Domingos, 1992) and in the Bay of Biscay (Désaunay *et al*., 1996a; Arribas *et al*., 2012), it has, like most temperate species a clearly seasonal pattern of migration with migration peak centred around winter (Briand and Jellyman, 2007). In the Atlantic, there is a clear geographic pattern in the timing of this seasonal migration. Tesch (1977) describes the arrival of glass eel in the Northwest Atlantic as starting in September in the coast of Spain and France, and then progressively progressing into the North Sea and the Channel. More recently, the arrival to Portugal may be from October, and thereafter continuing north (Domingos, pers. comm.). The main migration season has a duration of four to five months, with most landings centred around three months. There might be some shifts in the migration peaks with a one month shift between an early and late season (Dekker, 1998) but the timing of migration at a particular location is generally stable unless recruitment is affected by local factors, such as floods or periods of cold water (Briand, 2019).

According to the studies (Figure 4.6 and Table 4.3), glass eel arrival in the Atlantic starts in October in Portugal in the Minho, Mondego and Lis (Antunes and Weber, 1996, Domingos, 1992) and will peak around December–January. The same pattern is shown into Spain, when the arrival starts in October (Oria) and shows a peak in December.

Further along the coast the immigrating glass eels will be detected in number around November in the South of France, and December in the Vilaine (North of the Bay of Biscay) and only in January in the Channel. Glass eel recruitment starts in Adour (France) in November peaking in December- January (Casamajor *et al*., 2000) and February in the Vilaine (Briand, 2019).

Recruitment starts in March in Germany, peaking in May and lasting until June. Glass eels are detected in the Heligoland Bight (Germany) in February and only reach the Skagerrak in March.

The main migration season has a duration of four to five months, with most catches centred around three months. There might be some shifts in the migration peaks with a one-month shift between an early and late season (Dekker, 1998) but the timing of migration at a particular location is generally stable unless recruitment is affected by local factors, such as floods or periods of cold water (Briand, 2019).

In the Baltic or where recruitment requires a migration upstream, the migration performed by young yellow eels will mostly be driven by different environmental factors than those described for the coastal migration of glass eel and their entrance into the estuaries. There is also a delay before glass eel arriving into an estuary can ascend an eel trap, and therefore the data collected here might provide different patterns according to the stage considered. This is probably the case for Norway where the arrival starts in June, peaks in July and ends in August.

The arrival and temporal patterns in the Mediterranean are more complex than in the Atlantic (Figure 4.6 and Table 4.3). According to a study in the French Mediterranean (Vaccares/Grau de la Forcade), the arrival begins in January, lasts until April with a peak in February. In Italy, most studies identify that the season starts in December (Tiber river and Fogliano lagoon), although the end varies between February and March and the same happens with the peak, which has been identified in January–February. In Greece, the beginning of the arrival at the Salgiada lagoon occurs in October, the peak in December and the end in March; in Alfios River the period is December to April, peaking in February. This temporal pattern coincides with the one presented in the review by Kara and Quignard (2019). This great range of months found in both reviews could be explained by the fact that in the Mediterranean, especially in coastal lagoons, recruitment might occur on a wider period (also all year-round), but with seasonal peaks within the year due to the influence of local environmental, climatic and hydromorphological factors of single sites (Elie and Rochard, 1994; Kara and Quignard, 2019).

Table 4.3. List and characteristics of the scientific studies reviewed dealing with timing and the peak time of arrival of glass eel. Sites are ordered according to latitude.

Author	Country	Site	Habitat	Stage	Management period	Year of sampling	Study type	Gear
Hegedis *et al*., 2005	Montenegro	Bojana	F	G	Pre-2010	1998	scient. monit.	fykenet
Diekmann *et al*., 2019	Germany	Ems	F	G	Post-2010	2014–2017	scient. monit	trawl
Diekmann *et al*., 2019	Germany	Ems	F	GY	Post-2010	2013–2017	scient. monit	trawl
Zompola *et al*., 2008	Greece	Salgiada	T	G	Pre-2010	1999–2000	scient. monit.	fykenet
Zompola *et al*., 2008	Greece	Alfios	F	G	Pre-2010	1999–2000	scient. monit.	fykenet
Leone *et al*., 2016	Italy	Fogliano	T	G	Post-2010	2012–2013	scient. monit.	Trap
Leone *et al*., 2016	Italy	Fogliano	T	GY	Post-2010	2012–2013	scient. monit.	Trap
Ciccotti *et al*., 1995	Italy	Tiber	T	G	Pre-2010	1991–1992	scient. monit.	fykenet
Chiappi, 1920	Italy	Tiber	T	G	Pre-2010	1922–1929	fishery depend.	fykenet
Walmsey *et al*., 2018	Great Britain	Severn /Bristol	T	G	Post-2010	2012–2013	scient. monit	trawl
Crivelli *et al*., 2008	France	Vaccares/Grau de la Forcade	T	G	Pre-2010	2004	scient. monit.	Trap
Bru *et al*., 2009	France	Adour	T	G	Pre-2010	1999–2004	fishery depend.	fykenet
Aranburu *et al*., 2015	Spain	Oria	F	G	pre–post-2010	2003–2014	scient. monit.	trawl
Domingos, 1992	Portugal	Mondego	T	G	Pre-2010	1988–1990	scient. monit	Tela
Stratoudakis *et al*., 2018	Portugal	Lis	F	G	pre–post-2010	1996–1997 2013–2014	fishery depend.	handnet
Arribas *et al*., 2012	Spain	Guadalquivir	F	G	Pre-2010	1997–2006	scient. monit.	Trawl

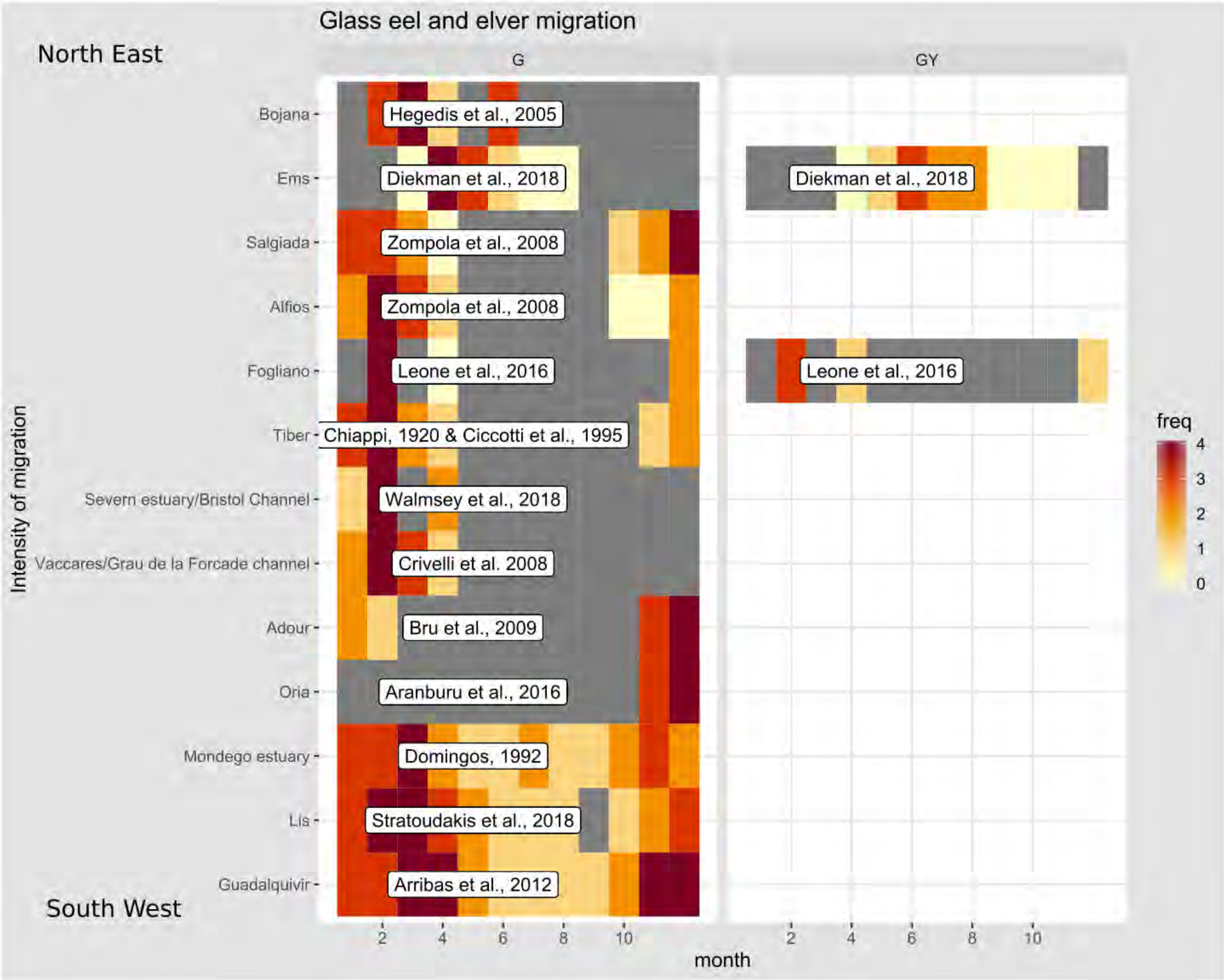


Figure 4.6. Qualitative description of the period and the peak time of arrival of European glass eel (G) and young yellow eels (GY) on the different EU shores obtained from the scientific literature. Qualitative information is converted into ranks of occurrence per month according to a scale range from 0 to 4 (i.e. from 0 movements absent to 4 maximum intensity, the peak of timing). Sites are ordered according to latitude.

5 ToR 2 - the period and the peak time of escapement of European silver eel from the different relevant regions in the EU towards the Sargasso Sea, and whether this has changed substantially since before 2007

5.1 Summary

All data sources - landings, monitoring series and literature - indicated that migration starts earlier and extends over a longer time period with increasing distance (i.e. to the north/east) to the spawning grounds in the Sargasso Sea (also see Amilhat *et al*., 2016; Derouiche *et al*., 2016; Capoccioni *et al*., 2014). Furthermore, seasonality appears linked to habitat, with landings occurring earlier and over an extended time period in freshwater as compared to coastal waters.

Depending on habitat and geographic location, migration/landings can i) peak as early as April/May, followed by a second peak between September and October (to the north, mostly Baltic though this might be a late finish from the year before rather than an early start), ii) start between August and October with a peak between September and December (gradually later to the south/west), or iii) start between November and January with a peak between December and February (Mediterranean). Patterns in the Baltic and the Mediterranean are sometimes very different (little overlap, see monitoring/landings) from the rest of the species distribution.

The timing of silver eel migration/landings is, however, influenced by a broad range of environmental factors. Given the heterogeneity of the available data and information in scientific literature, particularly the small number of EMUs with 'complete' datasets - i.e. covering different time periods and habitats within the same EMU - the scope for analyses is limited.

Concerning the effect of EMPs on the seasonality of migration/landings, the few EMUs with sufficient data to compare the periods before (2000–2009) and after (2010–2019) the implementation of EMPs revealed no notable differences in the seasonal patterns of migration/landings were found, but far more extensive data would be required before one could draw any sound conclusions.

5.2 Detailed examination of the information provided by landings, monitoring and the literature

5.2.1 Landings

Silver eel landings time-series were examined separately for two aquatic habitat types: coastal/transitional/marine open, and freshwater.

Coastal/Transitional/Marine Open

Due to the limited data available, clusters were identified using pooled data of coastal, transitional and marine open waters whereas the results are displayed separately - marine open not shown, only one dataset reported.

The cluster analysis identified four groups according to the seasonality of silver eel landings in coastal, transitional and marine open waters (Figure 5.1). In general, landings occur later and over a shorter time period from Cluster 1 to 4 (with the exception of Cluster 2).

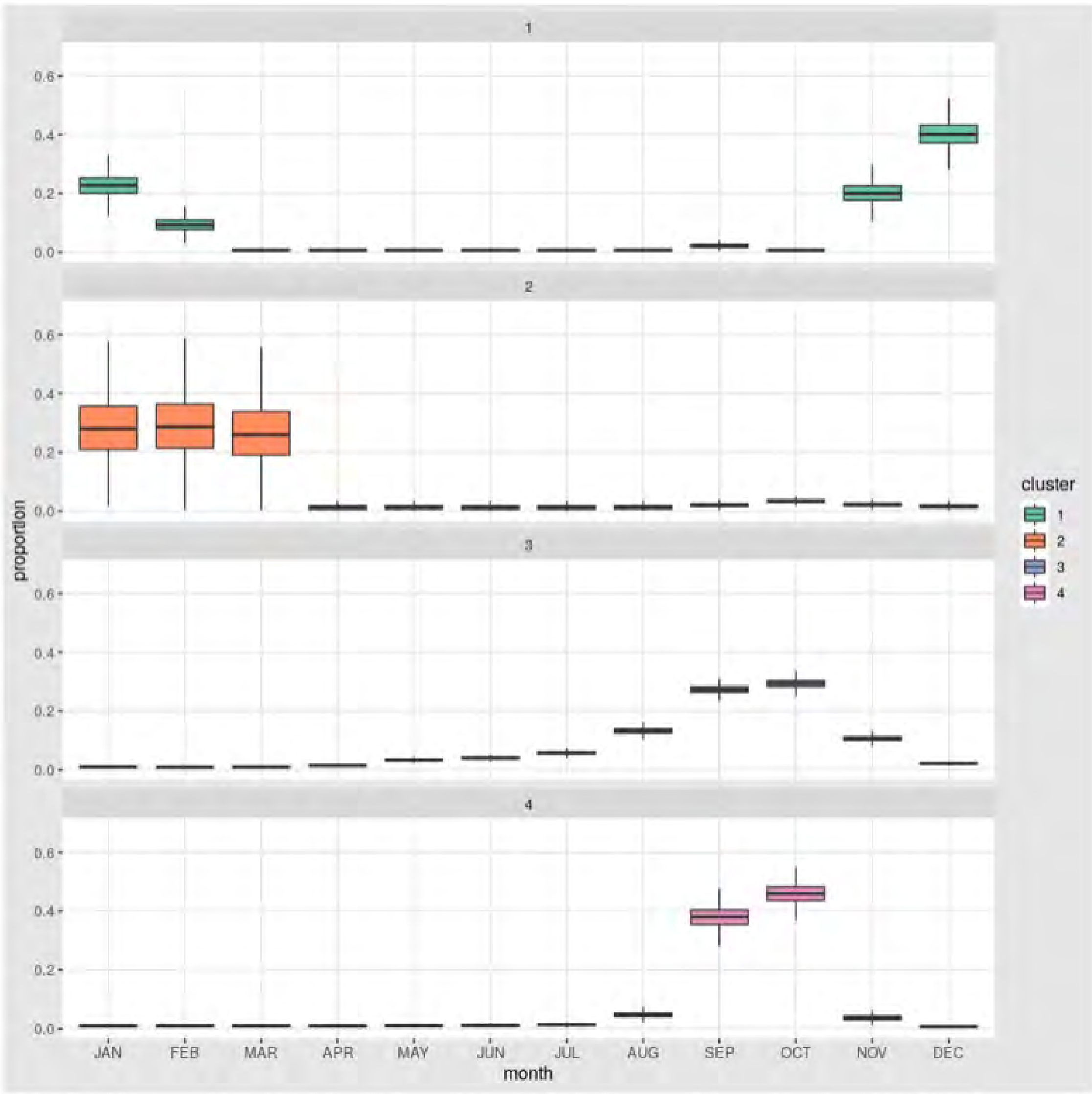
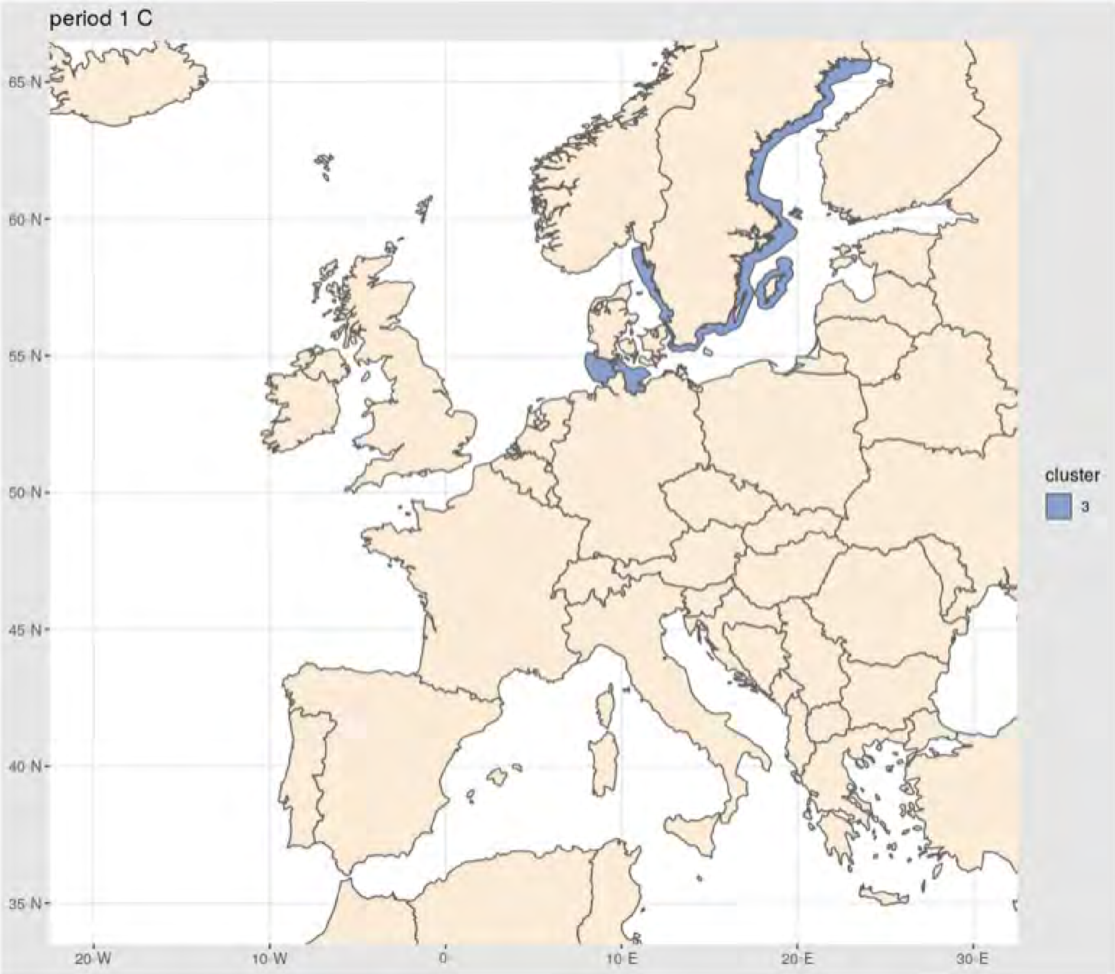


Figure 5.1. Monthly patterns of silver eel landings series in coastal, transitional and marine open waters for the four clusters.

Though the small set of available factor combinations (EMU, habitat, time period) limits the scope for conclusions, some results can be highlighted (Figure 5.2, Table 5.1):

- **Clusters** 1 & 2 are exclusive to the Mediterranean. 1: (transitional, FR_Cors) starting earlier with a distinct peak and 2: (coastal, ES_Murc) starting later with no distinct peak.
- **Cluster** 3, starting earlier with a less pronounced peak (i.e. landings occur over a longer time period), is predominantly found in areas further to the east.
- **Cluster** 4, starting slightly later and with a more pronounced peak (i.e. landings occur over a shorter time period), is found further to the west.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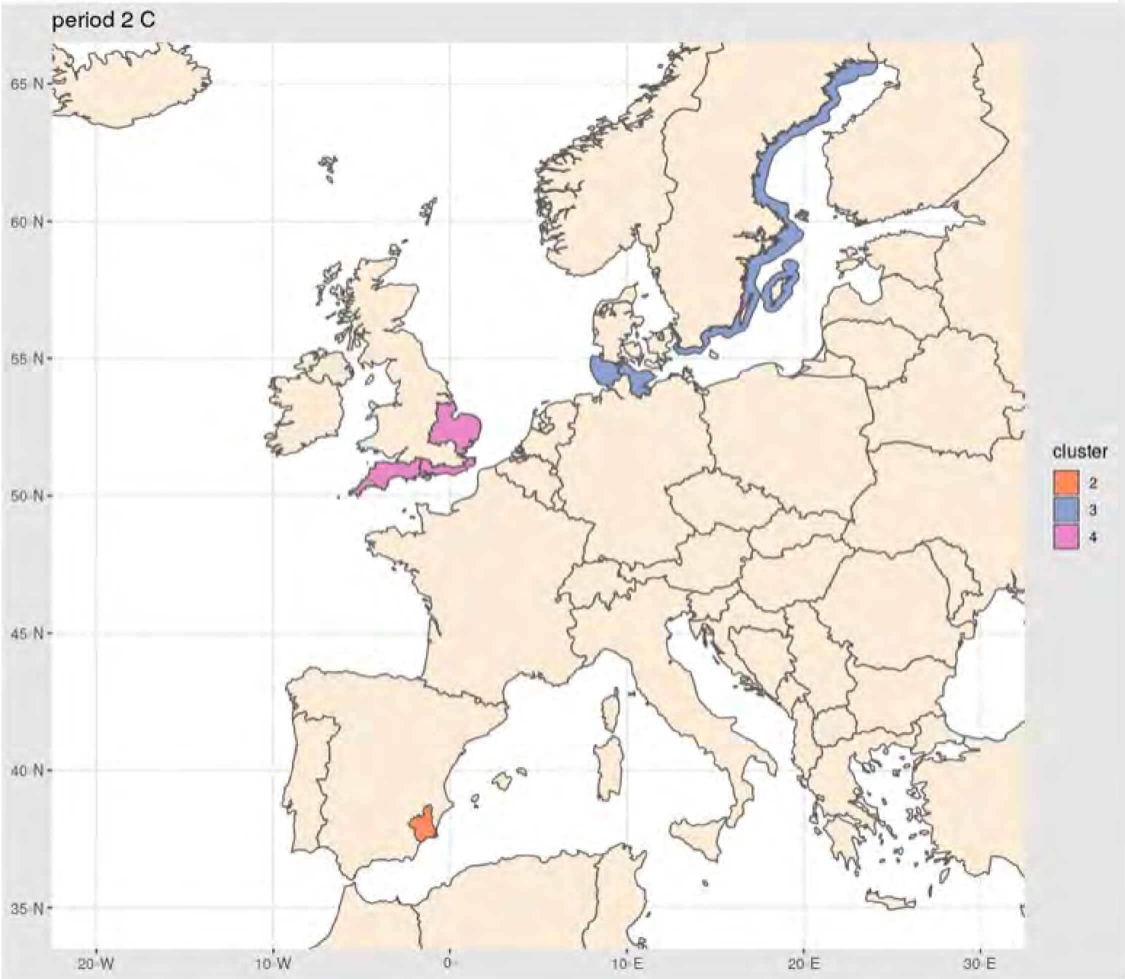
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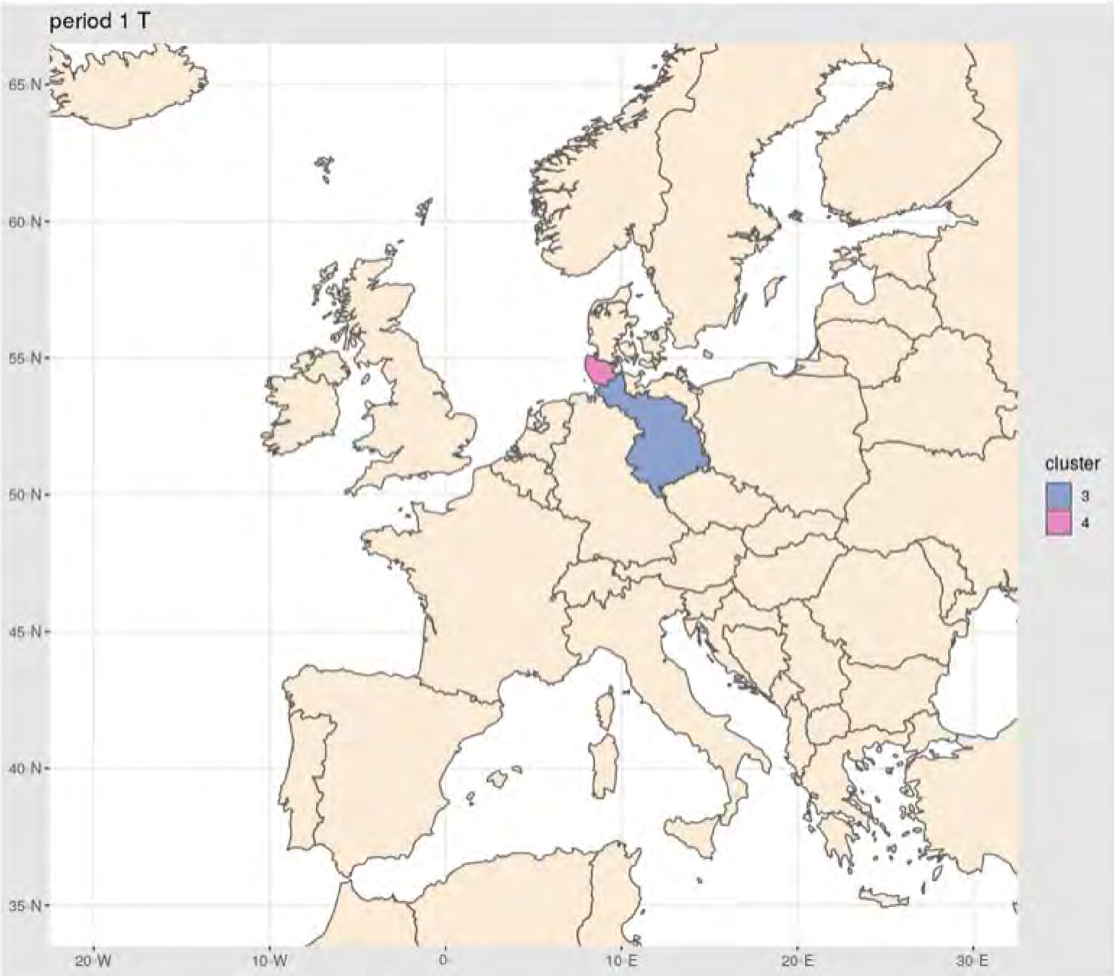
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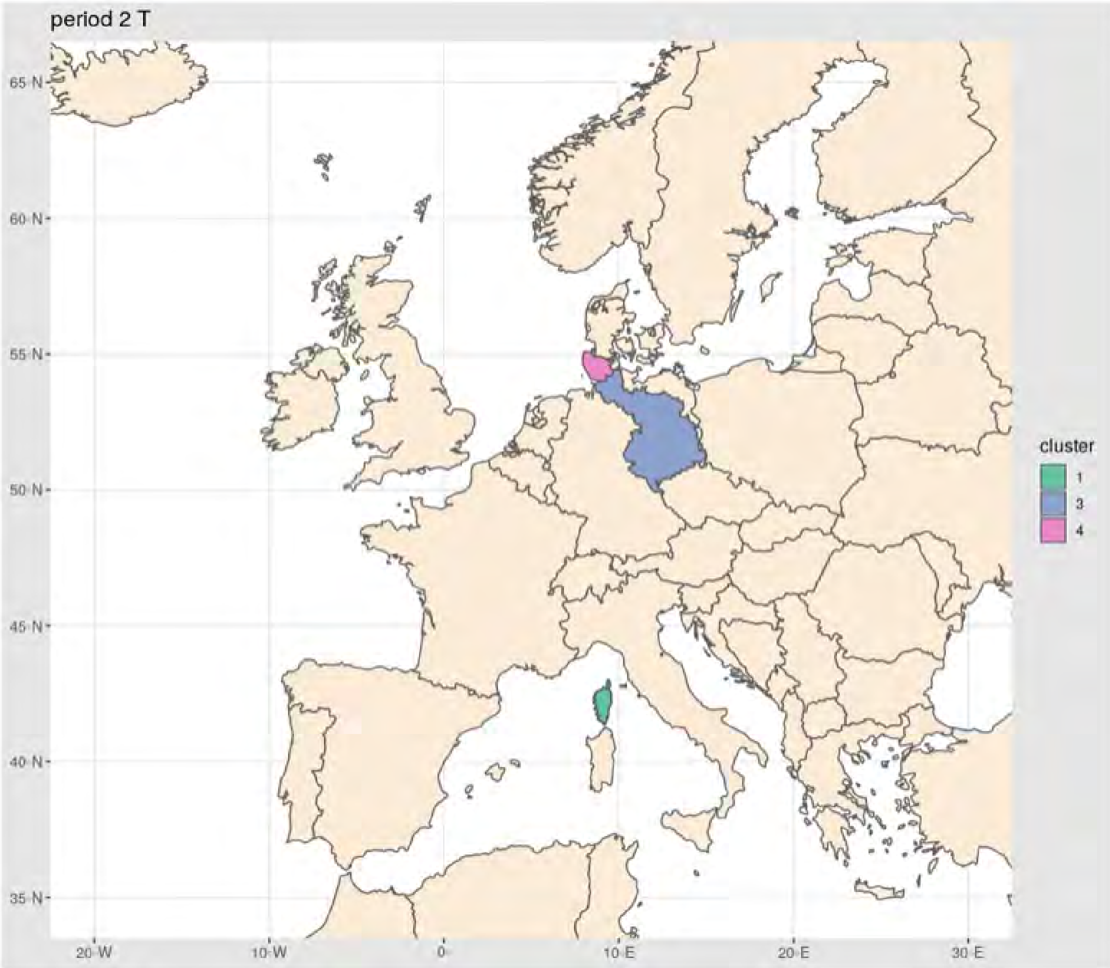


Figure 5.2. EMU clustering of the silver eel landings seasonal distribution according to the cluster analysis before (top two panels - Period 1: 2000–2009) and after (lower two panels - Period 2: 2010–2019) EMP implementation in coastal (top, C) and transitional (bottom, T) waters. * Note: the absence of an EMU on the map does not necessarily indicate that a fishery does not exist, it may be also be because the data were not reported or because they did not meet the statistical criteria to be used in the analysis.

In general, these results suggest that silver eel landings occur earlier and over a prolonged time period with increasing distance to the spawning grounds. An effect of the EMPs on the seasonality of landings could not be found for available data, since there was no difference in clusters before and after the implementation within the same EMU. This is further supported by the comparison of similarities in monthly patterns of silver eel landings before and after the implementation of EMPs per EMU, which showed no notable difference with an overlap of 68–90% (Table 5.1). This is comparable to the results found for monitoring series (which would presumably not be affected by the implementation of EMPs).

Table 5.1. Similarity indices (1 perfect overlap, 0 no overlap) of monthly silver eel landings patterns per EMU in transitional, coastal and marine open habitats. Values stand for the median of the posterior distribution and the 95% credibility intervals (2.5%, 97.5%).

EMU	Similarity Index
DE_Eide_C	0.71 [0.56–0.85]
DE_Eide_T	0.68 [0.52–0.84]
DE_Elbe_T	0.76 [0.60–0.88]
DE_Schl_C	0.76 [0.60–0.88]
DK_total_MO	0.90 [0.82–0.95]
SE_East_C	0.86 [0.77–0.93]

The temporal distribution of landings by year, life stage, habitat and EMU is detailed in Annex 9. Figure 5.3 shows an example of coastal, transitional and marine open landings of silver eel in the SE_East EMU.

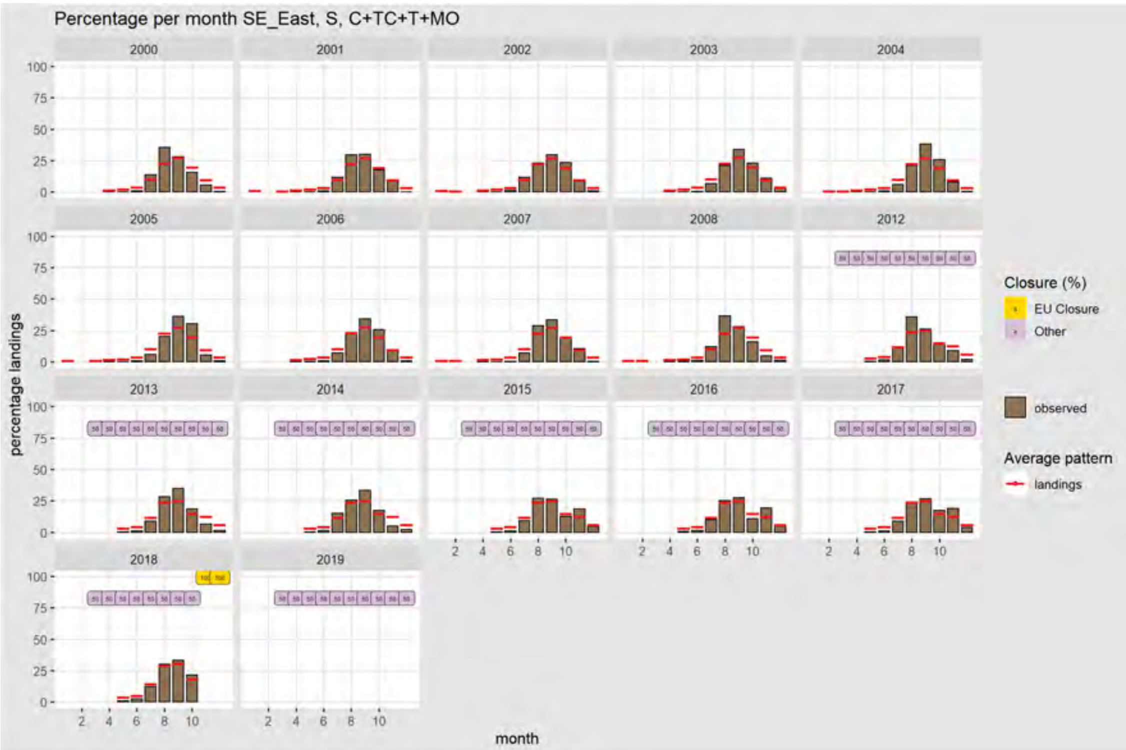


Figure 5.3. Monthly distribution of silver eel landings in the SE_East EMU from 2000 to 2019. Bars indicate the percentage of total annual observed landings per month. The red lines indicate the average landings for the periods before and after the implementation of EMPs (i.e. for 2000–2009 the average pattern of these years is shown; for 2010–2019, the average pattern of these years is shown). A small square at the top of each graph indicates whether the fishery has been closed during that month. The number inside the square indicates the expected percentage of the decrease in landings that the closure will cause. Grey squares indicate that the closure was reported as being due to the implementation of the EMP while the yellow colour indicates that the closure was reported as being due to the EC Closure regulations. In cases where monitoring time-series are available, monthly values will be indicated by coloured dots.

Freshwater

The cluster analysis identified five groups according to the seasonality of silver eel landings in freshwater (Figure 5.4). In general, landings occur later and over a shorter time period, comparing Cluster 1 through 5, with notable migrations in spring in Clusters 1 and 3.

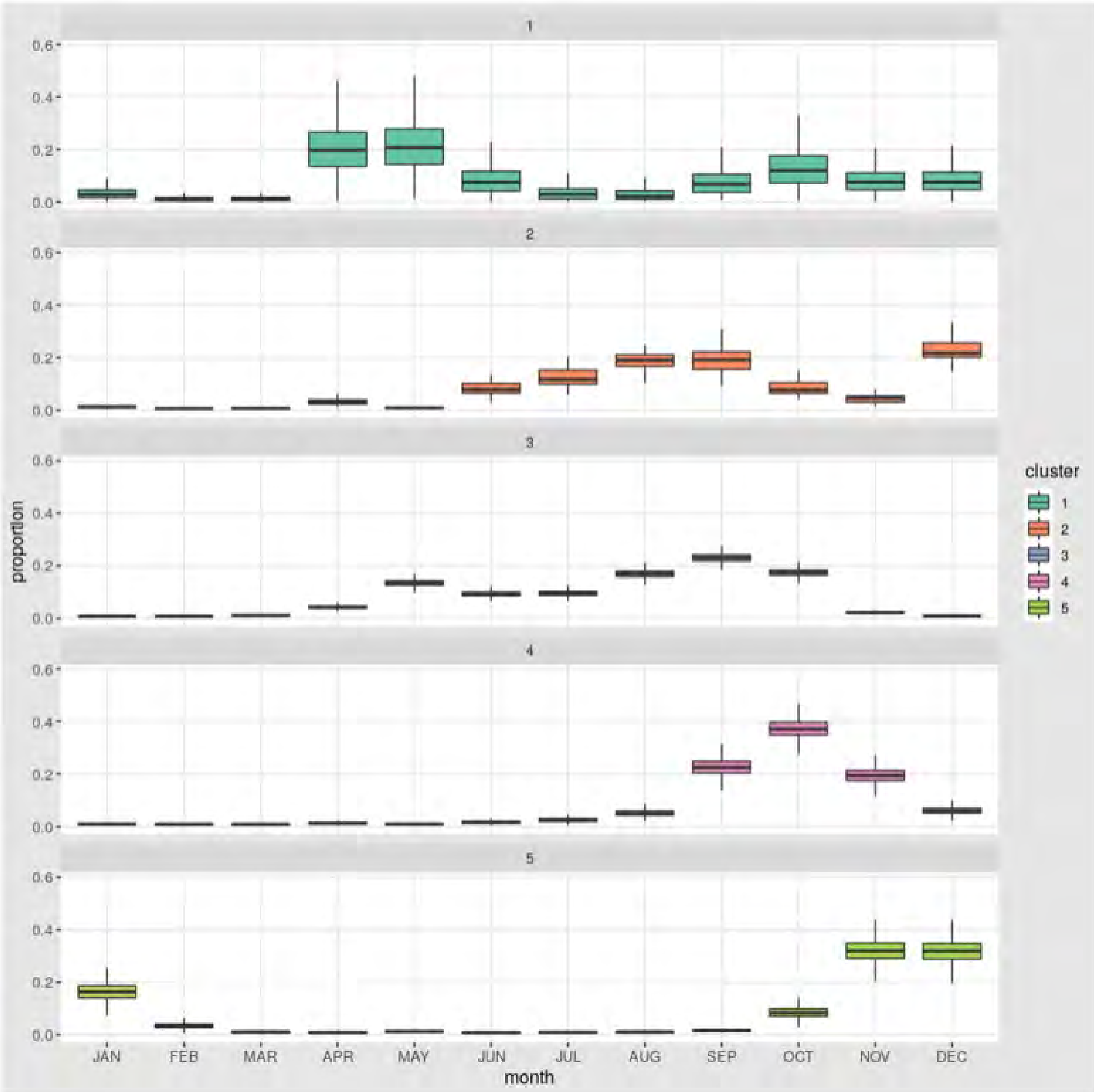


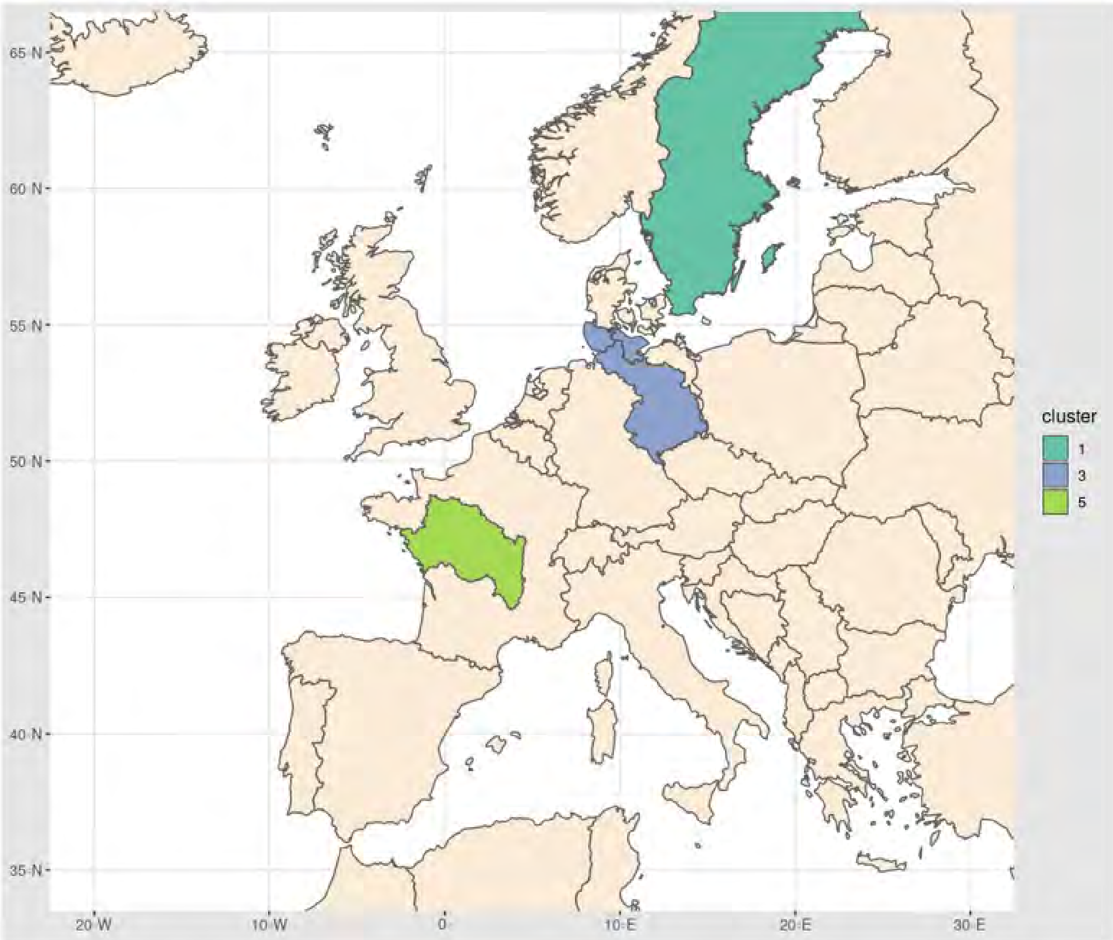
Figure 5.4. Monthly patterns of silver eel landings series seasonal distribution in freshwater for the five clusters.

As in coastal, transitional and marine open waters, data on silver eel landings in freshwater are limited e.g. data from the Mediterranean are completely absent. A total of 11 EMUs provided sufficient data to be analysed; five had data available both prior to, and after the implementation of the EMPs. The following results can be highlighted (Figure 5.5, Table 5.2):

- As in coastal and transitional waters, there is a general trend towards an earlier occurrence of landings over a prolonged time period - i.e. less pronounced peak - with increasing distance to the spawning grounds (i.e. to the northeast of the continental range).
- A shift in the landings seasonality after the implementation of EMPs occurred in a single EMU: SE_Inla. The change from Cluster 1 to 2 - both exclusively found in Sweden - highlights that landings occurred later and for a shorter time period after the implementation of the EMP, particularly eliminating landings in spring. This could be indicative of a

change in fisheries (though no closure was reported); yet, data prior to the implementation are limited to a single year (2006) and thus this result should be treated with caution.

- At least in the northeast, landings of silver eel in freshwater occurred earlier and over a longer period compared to coastal and transitional waters.



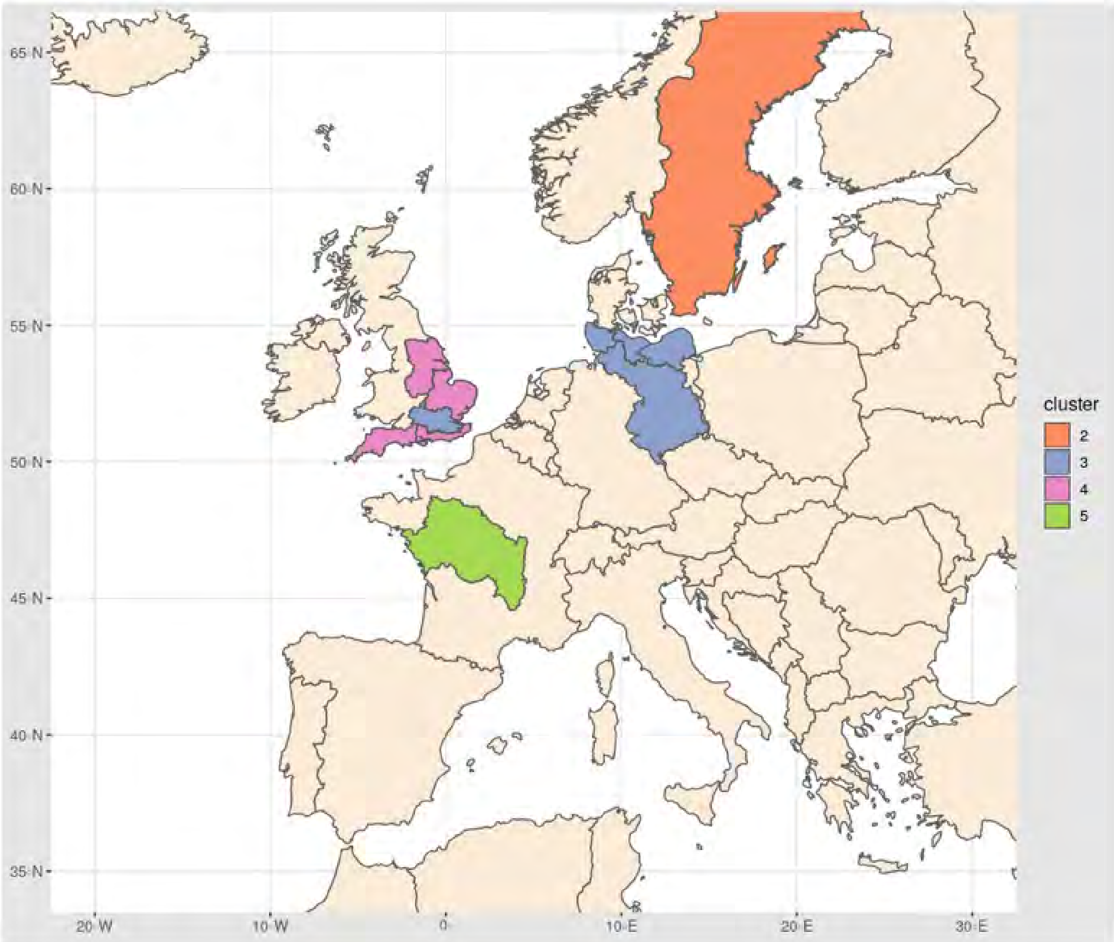


Figure 5.5. EMU clustering of the silver eel landings seasonal distribution in freshwater according to the cluster analysis for 2000–2009 (top) and 2010–2019 (lower). Note: the absence of an EMU on the map does not necessarily indicate that a fishery does not exist, it may be also be because the data were not reported or because they did not meet the statistical criteria to be used in the analysis.

Similar to transitional, coastal and marine open waters, the results do not give any indication of a shift in the seasonality of landings in freshwater after EMPs were implemented, which is further supported by the high degree of similarity pre- and post-EMP (Table 5.2).

Table 5.2. Similarity indices (1 perfect overlap, 0 no overlap) of monthly patterns per EMU between periods for silver eel in freshwater habitats. Values represent the median of the posterior distribution and the 95% credibility intervals (2.5%, 97.5%).

EMU	Similarity index
DE_Eide_F	0.76 [0.59–0.88]
DE_Elbe_F	0.70 [0.55–0.83]
DE_Schl_F	0.74 [0.60–0.86]
FR_Loir_F	0.76 [0.61–0.88]
SE_Inla_F	0.50 [0.35–0.65]

5.2.2 Eel monitoring

Available monitoring series covered an area from the Bay of Biscay to the Baltic Sea (including series on the British Isles), thus providing good geographic coverage of, but also limiting analyses to, the northerly part of the distributional range of European eels. The cluster analysis identified six groups according to the seasonality of silver eel monitoring time-series (Figure 5.4). In general, silver eel migration starts later and occurs over a shorter time period, from Cluster 1 to 6, with migration in spring occurring only in Clusters 1 and 2.

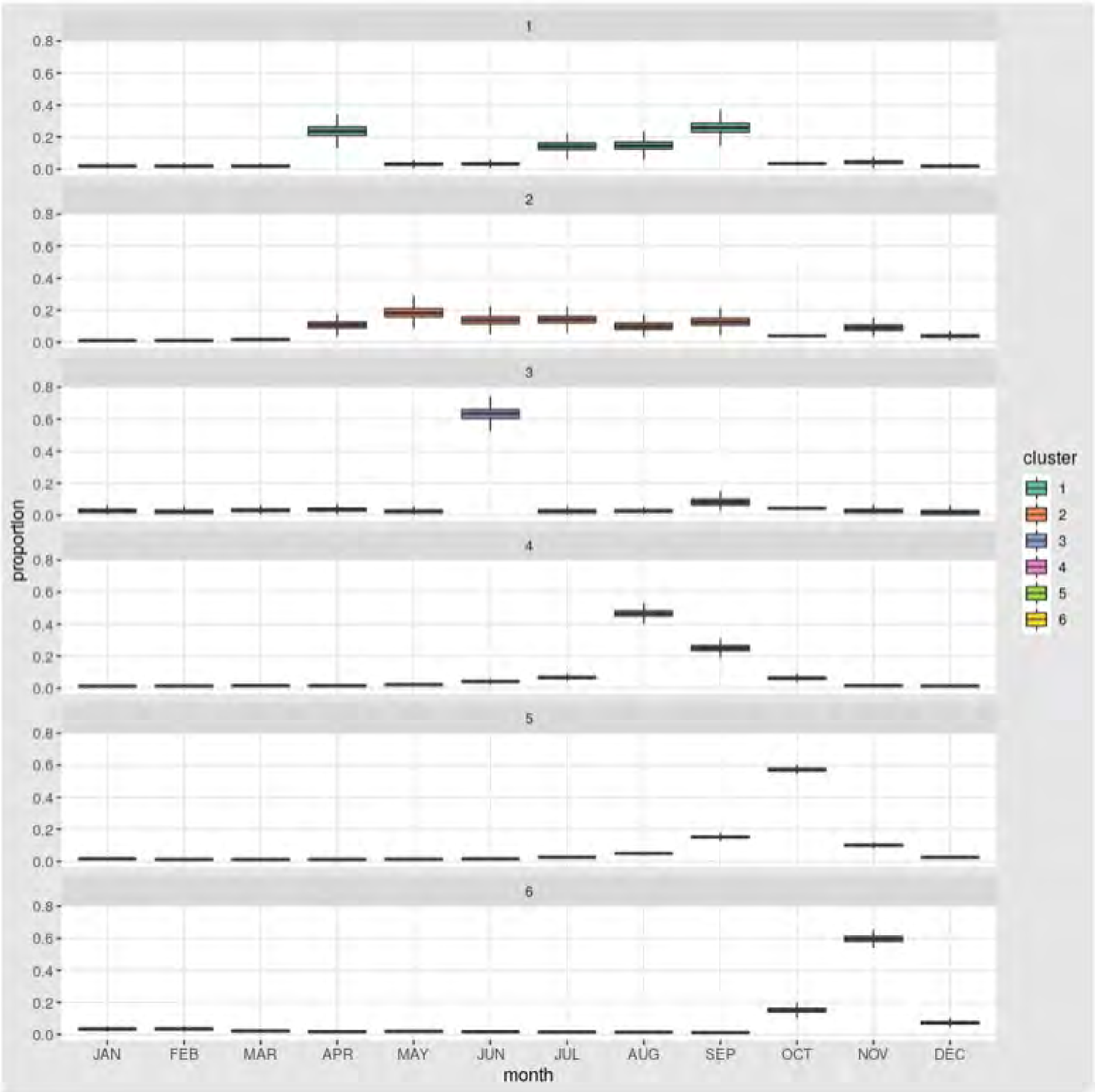


Figure 5.6. Monthly patterns of silver eel monitoring series in freshwater for the six clusters.

The monitoring time-series of silver eel migration further supports the trend outlined for landings of silver eels:

- The migration season starts earlier in the year and lasts longer in areas further away from the spawning grounds. In contrast, silver eel occurred in monitoring series closer to the spawning area (e.g. Bay of Biscay or Ireland) later, and the period of occurrence was relatively short and with a distinct migration peak.

- A shift in the seasonality of migration was detected in only one of nine time-series with data available prior to, and after the implementation of EMPs (BadB, that shifted from Cluster 1 to 4). It is possible, however, that this shift, and particularly the high abundance of silver eel in April prior to the implementation of the EMPs is an artefact. Due to low overall abundance in some years, even a minor increase in absolute abundance during a month, for example coinciding with a dry winter but wet spring, could have had a major impact on the relative seasonal distribution.
- Cluster 2 is exclusively found in the Baltic and is unique in terms of the early starting, prolonged migration period (ignoring Cluster 1 which may be anomalous, as explained above because this pattern was only found in BadB).

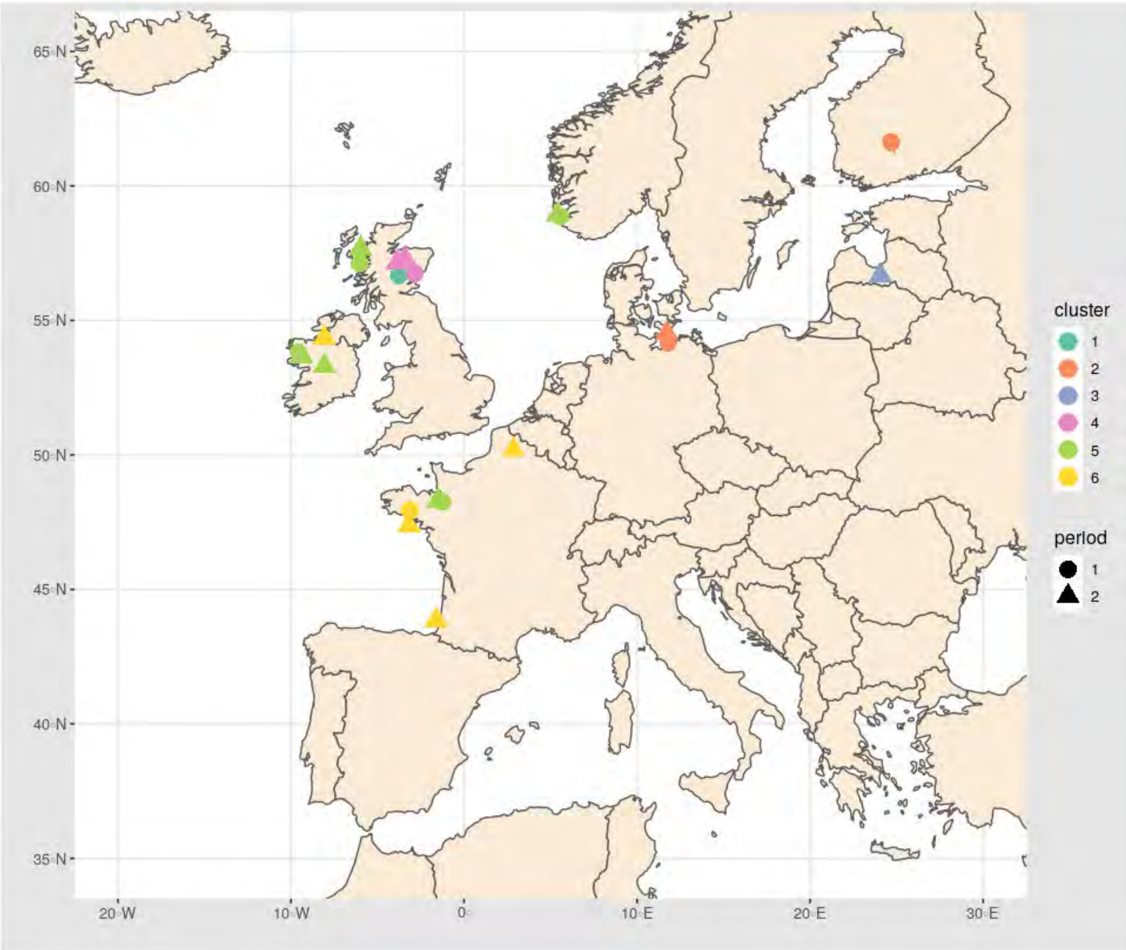


Figure 5.7. Spatial distribution of silver eel monitoring time-series seasonal clustering for 2000–2009 (circles) and 2010–2019 (triangles).

Since monitoring time-series are presumably less - or not directly - affected by management measures, no difference in the seasonality of migration was expected between the periods before and after the implementation of the EMPs. This assumption is generally supported by the results. If management measures in the EMPs had impacted the seasonality of fishery landings, but not monitoring series, it would be further expected that the similarities (pre- and post-EMP) would be greater between monitoring series (Table 5.3) than between landings series (Tables 5.1 and 5.2). This is not the case, however, thus providing evidence that the seasonality of silver eel migration patterns was not affected by the implementation of EMPs.

Table 5.3. Similarity indices (1 perfect overlap, 0 no overlap) of monthly patterns in glass eel monitoring per time-series before (<2010) and after EMP implementation (≥2010). The index values represent the median of the posterior distribution and the values inside square brackets represent the 95% credibility intervals.

Series	Similarity index
BadB	0.59 [0.50–0.68]
BurS	0.82 [0.74–0.89]
GirB	0.79 [0.70–0.87]
ImsaS	0.89 [0.81–0.95]
OirS	0.65 [0.56–0.73]
ScorS	0.74 [0.65–0.84]
Shie	0.90 [0.82–0.94]
WarS	0.71 [0.57–0.84]

5.2.3 Literature review

The literature review covers 36 sites from 19 countries including freshwater, transitional and coastal habitats. Few studies in the scientific literature specifically quantify peak time or period of escapement of European silver eel. Where period of migration is quantified, it is based on fish trap data where a complete census of seaward movements facilitates the calculation of cumulative percentiles (i.e. 5% signalling the start of the run, 95% the end, after Sandlund *et al*., 2017). The timing of peak escapement (in rivers) is dependent on broad level environmental factors such as lunar phase, in addition to local timing of flood events (Cullen and McCarthy, 2003; Vøllestad *et al*., 1986), which reflect the highly coordinated and typically nocturnal movement of silver eels. As such, the peak migration period (i.e. the temporal window during which the highest proportion counts in a given year occur) may span only a few nights per migration season. Nevertheless, this review provides additional Europe-wide data, albeit at the monthly time step, related to the seaward migration of silver eels in catchments that were not available through the data call. The literature dataset includes studies from both scientific monitoring and fishery-dependent studies (Table 5.4) and results are reported according to geographical coverage, range of habitats (pristine and subject to anthropogenic infrastructure) and monitoring methods.

When examining the data included in this literature review, the following four broad caveats must be considered:

- First, an EU-wide assessment of silver eel migration seasonality relies on reliable long-term high-frequency count time-series. Such data are available for a range of habitats through which silver eels migrate (i.e. lagoons, rivers, canals and reservoirs); yet seasonality related data for seaward migrating silver eels are limited by capture efficiency and the operational period of trapping and counting devices. Moreover, data from each trap/counter location represents seasonality in only one sea-entry catchment (or inland subcatchment) and thus are not necessarily representative of all eels in that region, particularly if there is anthropogenic infrastructure (e.g. large dams that impede migration, Acou *et al*., 2008).

- Second, silver eels are classified as seaward migrating based on several monitoring methodologies, each of which having its own counting efficiency. At reservoirs, capture efficiency in traps located downstream of surface bypasses varied between ~15–80% (Gosset *et al*., 2005; Marohn *et al*., 2014), while capture efficiency in lagoons varies depending on nets and barrier infrastructure (Amilhat *et al*., 2009; Charrier *et al*., 2012; Correia *et al*., 2019; MacNamara *et al*., 2014). Permanent in-river traps that span entire river widths offer complete census data (e.g. Burrishoole, Ireland; and Imsa, Norway included in the data call); note, some complete data are available for the Fremur River, France, though captures in this trap are heavily dependent on overspill of an upstream reservoir (Acou *et al*., 2008). Incomplete trapping also occurs in permanent in-river traps (e.g. in rio Ulla (Cobo *et al*., 2014)), and calculations of average seasonality in these traps are based on assumed constant efficiency across years. Data from acoustic detection of previously tagged individual silver eels migrating through rivers or canals provides information on variation among individuals and migration period width, but apparent peak migration times are less useful, owing to small sample sizes (Stein *et al*., 2016; Verhelst *et al*., 2018a). In-river capture in fishing gear, such as river-width stownets, facilitate large catches and reliable estimates of seasonality in terms of peaks and periods (Parsons *et al*., 1977; Reckordt *et al*., 2014).
- Third, the onset of migration is related to geographical location (Amilhat *et al*., 2016; Capoccioni *et al*., 2014) and thus to the distance that migrating eels have to travel to get the Sargasso Sea (Derouiche *et al*., 2016).
- Fourth, silver eels vary in their maturity, sex and behaviour upon entry to the sea and may take up coastal residency following sea entry (Aarestrup *et al*., 2008). For example, total escapement within a given lagoon may change from year to year depending on environmental conditions and the age structure of the other stages in the eel population (Amilhat *et al*., 2009). In large rivers, on the other hand, eels may take several years before reaching the estuary (Amilhat *et al*., 2009). Therefore, environmental conditions, hydrographic conditions of the system, habitat type, small or large catchments, tidal or no tidal systems, influence interannual variation in migration peak and period within a specific catchment.

For those reasons, it is difficult to clearly define the duration of the escapement season and the peaks in migration of European silver eel from the different relevant regions in the EU towards the Sargasso Sea.

Besides, as mentioned before, no studies in this review explicitly referred to the periods before (2000–2009) and after (2010–2019) implementation of EMPs. As such, we cannot make a direct comparison between these two periods. However, a handful of multi-year studies included in this review did present monthly eels counts (or monthly percentages) that facilitated quantification of broad migration periods and peaks for these localities.

Figures 5.8 and 5.9 illustrate the peaks and periods of silver eel migration gleaned from the literature review in terms of (i) a qualitative perspective where data were limited, and (ii) a quantitative perspective, where times series could be directly extracted from published time-series.

Seasonality of silver eel migration in the northern extent of its range in river systems is typically described by a unimodal distribution commencing during July to September and ceasing during October to January (e.g. in Northern Ireland and Norway: Davidsen *et al*., 2011; Parsons *et al*., 1977). Notably, season-specific recording in northern Norway was a consequence of ice cover from December to March. Indeed, silver eels mostly migrated in August in northern Norway (Bergersen and Klemetsen, 1988), and in September and October in the River Imsa, southern Norway (Vøllestad *et al*., 1986) as well as in the Burrishoole River, Ireland (Poole *et al*., 1990). Based on the literature considered here, inter-annual variation in migration peak exhibits no more than three month's range. A four-year study on the border of Belgium and the Netherlands of acoustically tagged silver eels observed peak migrations in October (2012), but migrating eels were recorded from July to January considering data for all years (Verhelst *et al*., 2018a). At the Halsou hydro-electric dam on the Nive river in France, data were not documented outside October to December, so a seasonal migrating period could not be quantified, although peak migration occurred in October (2000) or November (1999, 2001) (Durif *et al*., 2002, 2008; Gosset *et al*., 2005). In the Ulla River, NW Spain, silver eels swim downstream with peak counts occurring October (Cobo *et al*., 2014).

While year-round recording was relatively rare and in Spain and Germany revealed similar patterns to seasonally specific monitoring (Cobo *et al*., 2014; Marohn *et al*., 2014), spring migration periods were recorded in Germany (Reckordt *et al*., 2014; Stein *et al*., 2016). These spring migrations might relate to winter dormancy as a consequence of continental cold winters (Westerberg and Sjöberg, 2015). Interannual variation in migration peak and period revealed in three years of year-round trap operation at the Schwentine reservoir bypass trap in Germany indicated that peak migration occurred between September (2011) and November (2009, 2010), but migrating silver eels were recorded in all months (Marohn *et al*., 2014). Spring peak migrations also occurred in the Fremur river, France (Acou *et al*., 2008), notably as a consequence of dam overspill.

In the southern and east Mediterranean, the season spans October until early March, with peaks mainly in November–December (Rossi and Cannas, 1984; Amilhat *et al*., 2009; Aschonitis *et al*., 2017; Correia *et al*., 2019). In transitional waters, especially coastal lagoons, silver eels mostly start migrating in autumn with a peak in November–December. Migration occurs in November in Santo André lagoon, Portugal (Correia *et al*., 2019)) and also in Bages-Sigean Lagoon, France (Amilhat *et al*., 2009), while in Italian lagoons, migration peaks in December and January (Comacchio and Porto Pino). In Greece (Vistonis-Porto Lagos, MacNamara *et al*., 2014) and Turkey the escapement season runs from October to early March, with peaks in December and January (Tosonoglu *et al*., 2017). In North Africa, where eel studies are relatively few, silver eel escapement starts in Tunisia (Ichkeul Lake, Wadi Tinja-Bizerta lagoon) in late October and lasts until early February (Hizem Habbechi, 2014) with a peak in December. The same pattern occurs in Libya (Umm Hufayan lagoon) (Abdalhamid *et al*., 2018).

Table 5.4. List and characteristics of the scientific studies reviewed dealing with timing and peak of silver eel escapement. Sites are ordered according to latitude.

Author	Country	Site	Habitat	Management period	Year of sampling	Study type	Gear
Davidsen *et al.*, 2011	Norway	Halselva	F	Pre-2010	2000–2010	scient. monit.	wolf trap
Sjöberg *et al.*, 2017	Sweden	Lake Mälaren, Baltic sea	FT	Pre-2010	2006–2008	scient. monit.	tag
Bergersen and Klemetsen, 1988	Norway	Anononymous	F	Pre-2010	Pre-1998	scient. monit.	trap
Hvidsten, 1985	Norway	Imsa	F	Pre-2010	1975–1981	scient. monit.	trap
Vøllestad *et al.*, 1986	Norway	Imsa	F	Pre-2010	Pre-1999	scient. monit.	trap
Sandlund *et al.*, 2017	Norway	Imsa	F	pre–post-2010	1975–present	scient. monit.	trap
Swedish catch statistics	Sweden	Baltic Sea ICES 5G6	C	Pre-2010	1999–2009	scient. monit.	trap
Chadwick *et al.*, 2007	Scotland	Girnock Burn, Dee	F	Pre-2010	1967–1981	scient. monit.	trap
Jepsen and Pedersen, unpublished	Denmark	Gudenaa	FT	Pre-2010	2006	scient. monit.	tag
Dainys *et al.*, 2017	Lithuania	Neris, Siesartis, Žeimena, Nemunas/ Curonian	FT	Post-2010	2014	scient. monit	fykenet
Parsons *et al.*, 1977	Ireland	Bann, Lough Neagh	F	Pre-2010	1961–1969	Fishery-depend.	net
Bolland *et al.*, 2019	Great Britain	Anononymous	F	Post-2010	2015	scient. monit.	sonar
Frost, 1945	Great Britain	Cunsey Beck, Newby Bridge	F	Pre-2010	1942–1945	scient. monit.	trap
Marohn *et al.*, 2014	Germany	Schwentine	F	Post-2010	2010–2011	scient. monit.	trap
Reckordt *et al.*, 2014	Germany	Warnow	F	pre–post-2010	2008–2011	scient. monit.	fykenet
Poole *et al.*, 1990	Ireland	Burrishoole	F	Pre-2010	1985–1988	scient. monit.	trap

Author	Country	Site	Habitat	Management period	Year of sampling	Study type	Gear
Sandlund *et al*., 2017	Ireland	Burrishoole	F	pre–post-2010	1970–present	scient. monit.	trap
Stein *et al*., 2016	Germany	Elbe	F	pre–post-2010	2007–2011	scient. monit.	sonar
Moriarty, 1990	Ireland	Shannon Killaloe Wier	F	Pre-2010	1965–1987	Fishery-depend.	net
Verbiest *et al*., 2012	Belgium	Meuse	F	Pre-2010	2007	scient. monit.	fykenet + electr.
Verhelst *et al*., 2018a	Belgium	Schelde	T	Post-2010	2012–2015	scient. monit.	tag
Saerens, 2017	Belgium	Schelde	T	Post-2010	2015–2016	scient. monit.	Tag
Acou *et al*., 2008	France	Le Frémur Pont es Omnes	F	Pre-2010	1996–2004	scient. monit.	Trap
Aschonitis *et al*., 2017	Italy	Comacchio	T	Post-2010	2011	Fishery-depend.	fykenet + barrier
Charrier *et al*., 2012	France	Or	T	Pre-2010	2009–2010	Fishery-depend.	fykenet + net
Acou, personal communication	France	Oir	F	Pre-2010	2000–2005	scient. monit.	Trap
Durif and Elie, 2008	France	Loire	F	Pre-2010	1990–2001	Fishery-depend.	stownet
Crivelli, unpublished data	France	Fumemorte, Camargue	T	Pre-2010	2001–2007	Fishery-depend.	fykenet
Durif *et al*., 2002	France	Nive, barrage Halsou	F	Pre-2010	1999	scient. monit.	trap+ telemetry
Durif *et al*., 2008	France	Nive, barrage Halsou	F	Pre-2010	1999–2001	scient. monit.	Trap/electro + tag
Gosset *et al*., 2005	France	Nive, barrage Halsou	F	Pre-2010	1999–2001	scient. monit.	Trap
Amilhat *et al*., 2009	France	Bages-Sigean	T	Pre-2010	2007	Fishery-depend.	fykenet + net
Cobo *et al*., 2014	Spain	Ulla rio	F	pre–post-2010	1999–2011	scient. monit.	trap

Author	Country	Site	Habitat	Management period	Year of sampling	Study type	Gear
MacNamara *et al.*, 2014	Greece	Vistonis-Porto Lagos	T	Post-2010	2012–2013	Fishery-depend.	barrier
Rossi and Cannas, 1984	Italy	Porto Pino	T	Pre-2010	1979–1981	Fishery-depend.	fykenet + barrier
Correia *et al.*, 2019	Portugal	Santo André	T	pre–post-2010	2011–2012 2016–2017	Fishery-depend.	fykenet
Derouiche *et al.*, 2016	Tunisia	Ichkeul Lake, Wadi Tinja - Bizerta	T	Post-2010	2013–2014	fishery depend.	fykenet + barrier
Tosunoğlu *et al.*, 2017	Turchia	Enez, Homa, Karina, Akköy, Güllük, Köyceğiz	T	Post-2010	2014–2015	Fishery-depend.	fykenet + barrier
Abdalhamid *et al.*, 2018	Libya	Umm Hufayan	T	Post-2010	2015	scient. monit.	fykenet + net

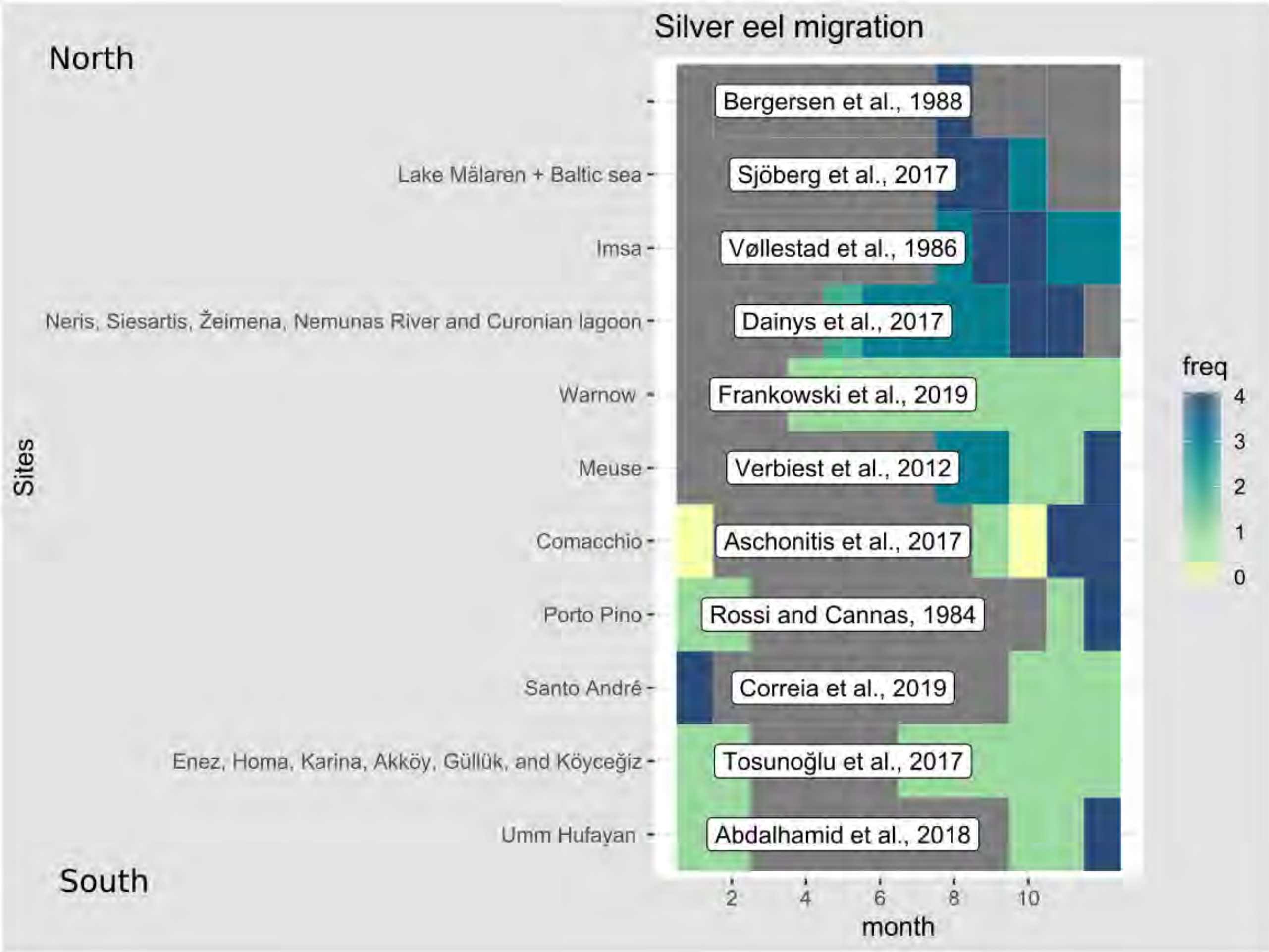


Figure 5.8. Qualitative description of the silver eel seasonality patterns and peaks of occurrence from the different EU shores obtained from the scientific literature. Qualitative information is converted into ranks of occurrence per month

according to a scale ranging from 0 to 4 (i.e. from 0 movements absent to 4 maximum intensity, the peak of timing). Sites are ordered according to latitude. Grey colour means no data.

Figure 5.9. Monthly pattern of silver eel migration obtained from the literature review when data as monthly occurrence over the annual cycle at the same location were available. Monthly values are normalized to proportions. Sites are ordered according to latitude.

6 ToR 3 - the period and the peak time of migration of the yellow eel, when relevant, through different relevant regions in the EU (when, and from and to where yellow eels migrate), and whether this has changed substantially since before 2007

6.1 Summary

Contrary to silver eels and glass eels, which must undertake a migration to complete their life cycle, yellow eels can settle where they arrive as glass eel, without having to migrate elsewhere to spend their growth phase. Before reaching a total length of 20 cm, eels undergo an ontogenetic shift and change their behaviour to become sedentary, i.e. resident (Imbert *et al*., 2010). Despite not migrating, yellow eels can display seasonal peaks of activity and movements (Vøllestad, 1986; Baras *et al*., 1998; Tesch, 2003). Several biases may arise in the analysis of landings or monitoring time-series due to this behaviour. Depending on the predominance of young or older yellow eels, the time-series analysed may reflect the activity of young yellow eels that are moving upstream to colonize the basin, or the seasonality of the feeding activity of older yellow eels. Because eels tend to be less abundant with distance from the sea, and size tends to increase (Naismith and Knights, 1993), there is a predominance of young yellow eels in lowland reaches, which implies the time-series from different locations should not be compared because the results will be biased due to the typical distribution of the species in a water basin. Moreover, sampling methods also can also bias the observations: some monitoring methods (typically counting upstream of a fishway) may favour eels moving upstream over resident eels.

In this context, the spatial pattern in seasonality was much less obvious than for other life stages, especially in landings, though landings in the Mediterranean area (FR_Cors, ES_Murc) seem to differ from Northern Europe. In many situations, the seasonality of the fishery is longer than the seasonality of monitoring, probably because of the sampling method used in scientific monitoring: landings are recorded from spring to autumn (and potentially winter in Mediterranean area) while monitoring is concentrated in spring (France), or summer (Northern Europe). This absence of obvious latitudinal patterns and the seasonality of landings is consistent with observations of ICES (2005). However, as with much of the analyses reported here, findings should be taken with caution given the limited availability of data.

6.2 Landings

Yellow eel fisheries take place in all aquatic habitat types and hereafter have been separately considered for marine and coastal, transitional and freshwater habitats.

- Marine / Coastal

Since the number of EMUs in which a fishery in the marine habitat takes place is very few, we analysed coastal and marine landings in a single clustering analysis. The method leads to three clusters: a first cluster peaking in winter, another peaking in summer (Cluster 2) and a third peaking in summer/autumn (Cluster 3) (Figure 6.1).

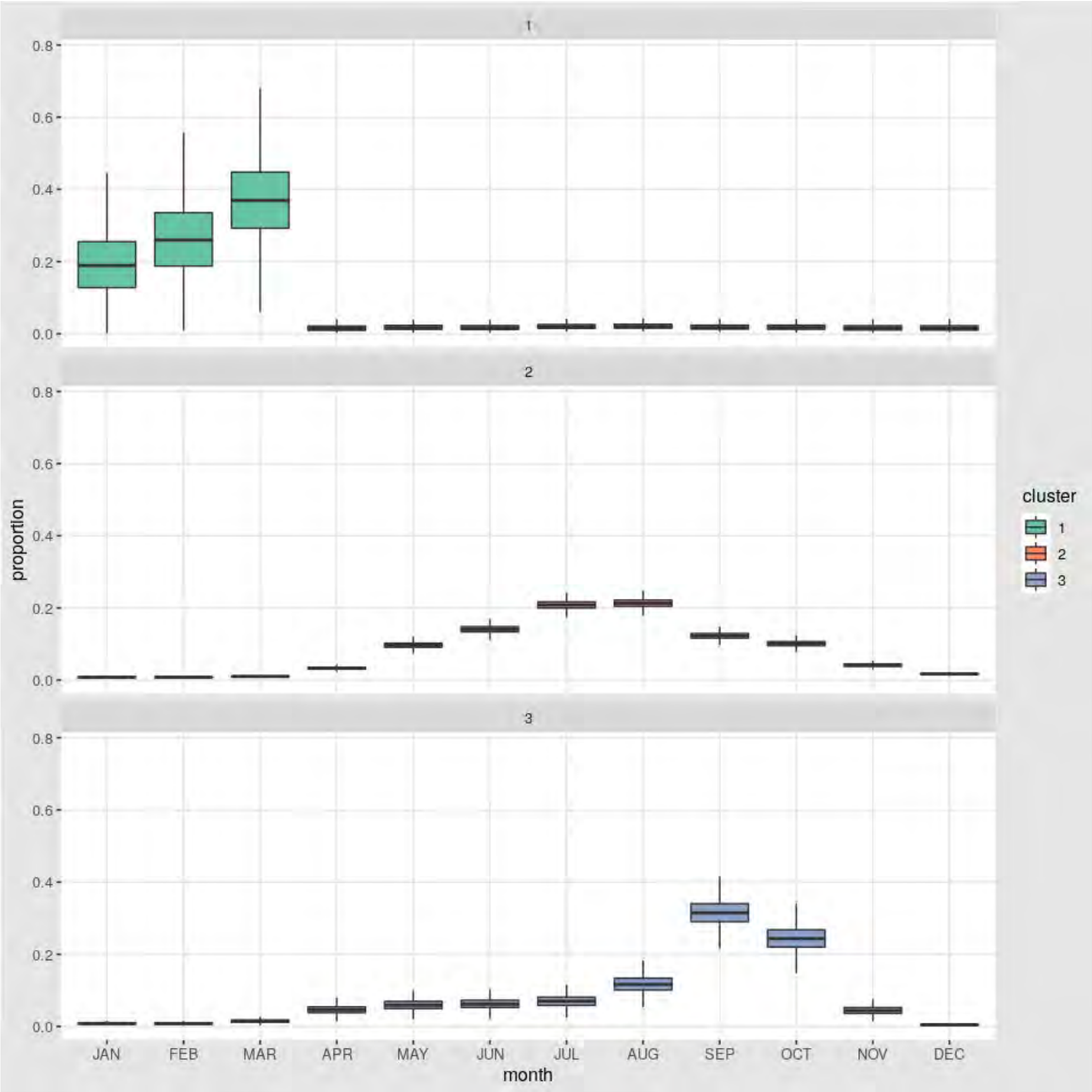
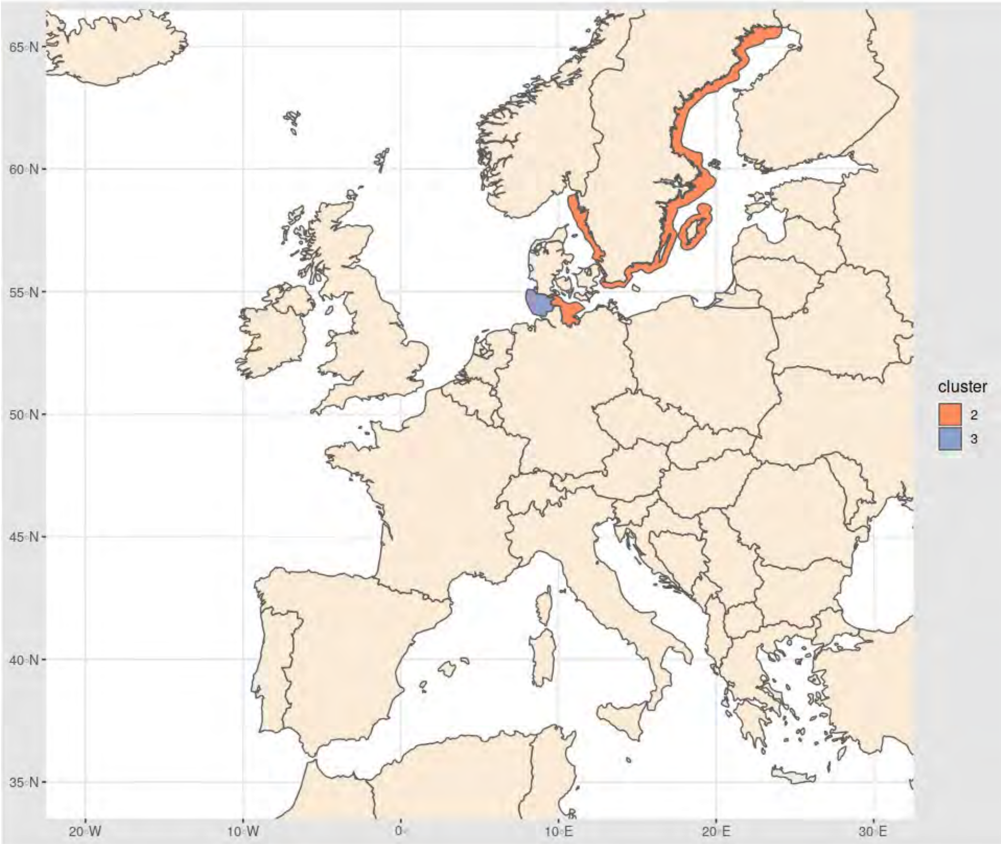


Figure 6.1. Monthly patterns of yellow eel landings in coastal/marine habitat for the three clusters. Boxplots indicate the posterior distribution of the expected proportions (y axis) per month (x axis).

Since the number of EMUs in southern Europe is scarce (Figure 6.2), it is impossible to look for spatial patterns. Nevertheless, we observe no change of classification between 2000–2009 and 2010–2019, and similarity indices were very high (Table 6.1).


65 N
60 N
55 N
50 N
45 N
40 N
35 N
20 W
10 W
0
10 E
20 E
30 E
cluster
2
3

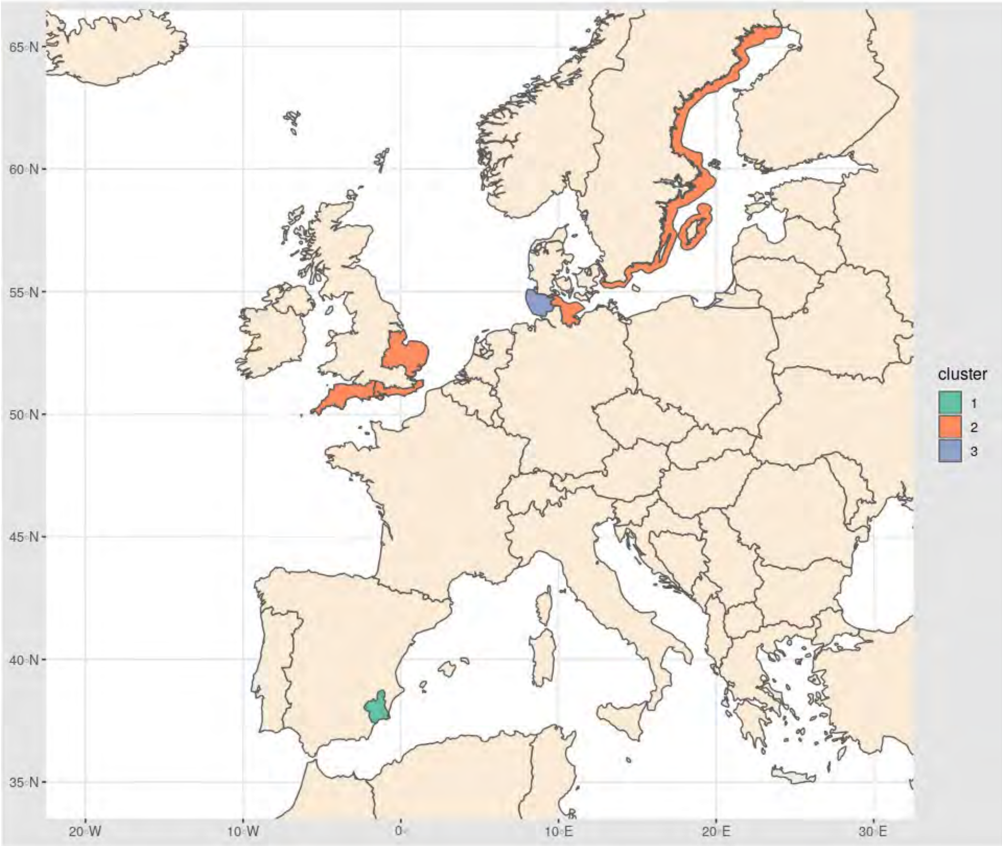


Figure 6.2. EMU clustering of the yellow eel landings monthly patterns in coastal/marine habitats according to the cluster analysis for 2000–2009 (upper) and 2010–2019 (lower). Denmark landings in marine water (not displayed on the map since they do not correspond to an EMU) were classified in Cluster 2 for both periods. Note: the absence of an EMU on the map does not necessarily indicate that a fishery does not exist, it may be also be because the data were not reported or because they did not meet the statistical criteria to be used in the analysis.

Table 6.1. Similarity indices (1 perfect overlap, 0 no overlap) of monthly patterns per EMU between periods for yellow eels in coastal (C) or marine (M) habitats. Values present the median of the posterior distribution and the 95% credibility intervals (2.5%, 97.5%).

EMU	Habitat type	Similarity index
DE_Eide	C	0.75 [0.60–0.87]
DE_Schl	C	0.75 [0.61–0.86]
DK_total	M	0.85 [0.78–0.91]
SE_East	C	0.78 [0.66–0.88]

- Transitional habitat

Four clusters were defined with Cluster 1 peaking in spring/early summer, Cluster 2 peaking in August and Clusters 3 and 4 peaking in autumn but with a slight first peak earlier in the year (Figure 6.3).

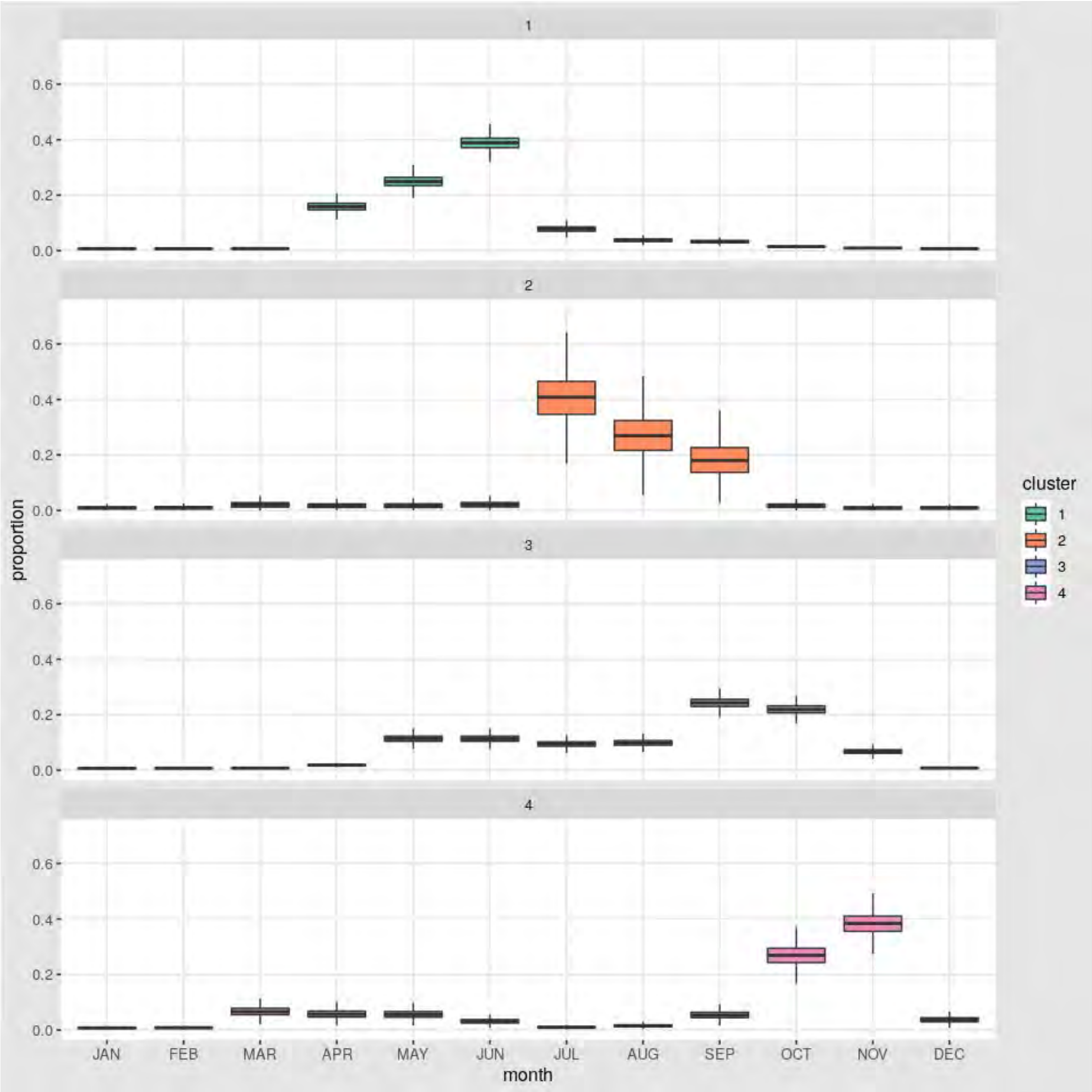
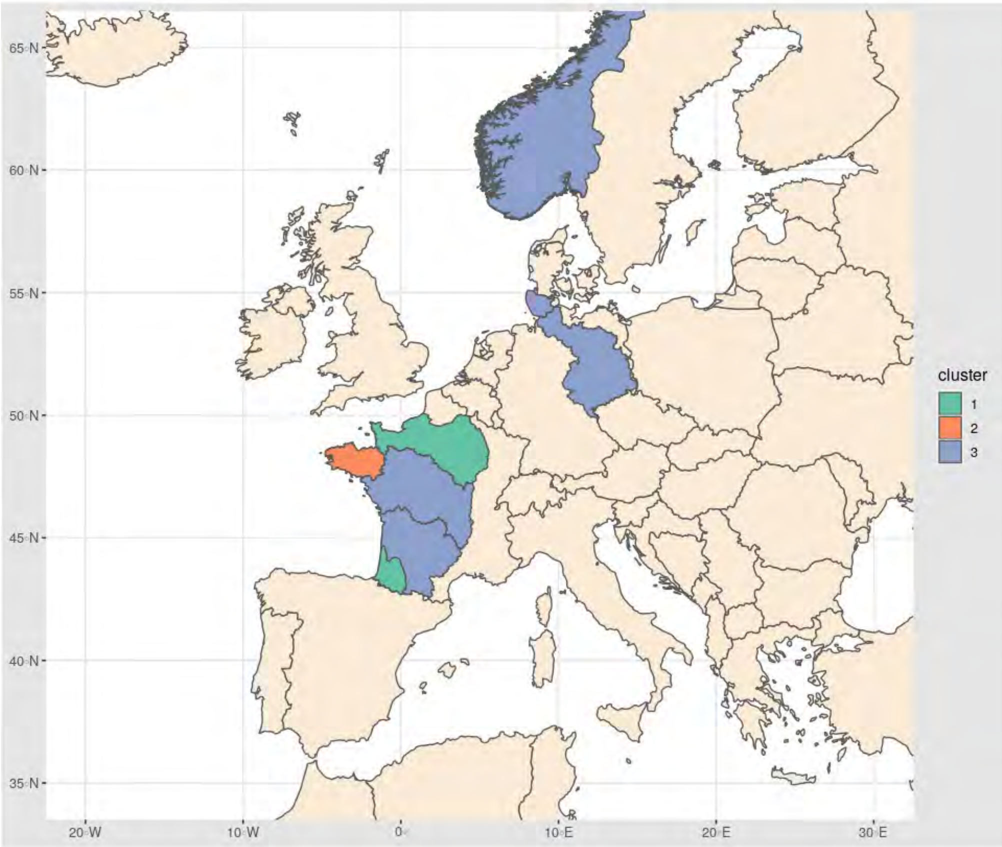


Figure 6.3. Monthly patterns of yellow eel landings in transitional habitat for each cluster. Boxplots indicate the posterior distribution of the expected proportions (y axis) per month (x axis).

Some French EMUs are not classified in the same cluster between period 1 and period 2 (Figure 6.4). However, this result should be taken with caution since for these EMUs, only one season was available in period 1 (FR_Adou, FR_Brit, FR_Sein) or period 2 (FR_Sein). Similarity indices (Table 6.2) also suggest a change in seasonality of landings for yellow eel in transitional habitats, especially in French EMUs, but the limited data availability calls for caution. Interestingly, FR_Cors, the only Mediterranean EMU, belongs to a separate cluster. For Norway, data were only available for period 1 because of the implementation of a fishery closure in transitional water in 2010.


65 N
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cluster
1
2
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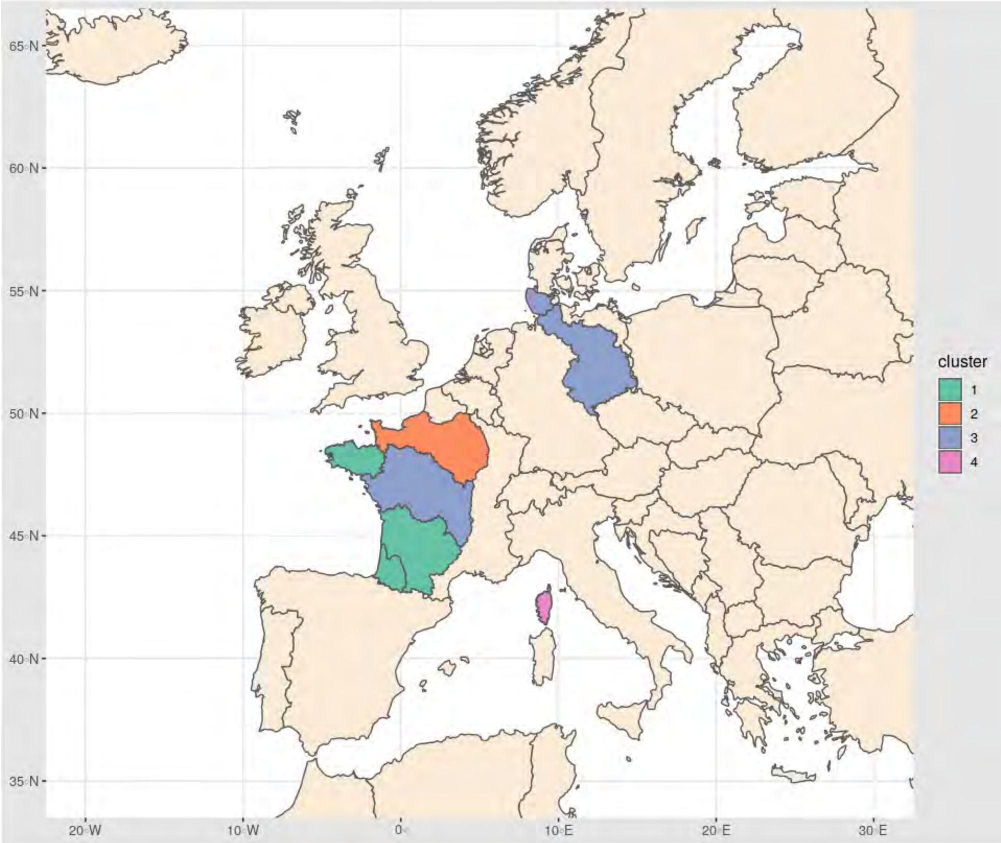


Figure 6.4. EMU clustering of the monthly patterns in yellow eel landings in transitional habitats according to the cluster analysis for 2000–2009 (upper) and 2010–2019 (lower).

Table 6.2. Similarity indices (1 perfect overlap, 0 no overlap) of monthly patterns per EMU between periods for yellow eels in transitional habitats. Values present the median of the posterior distribution and the 95% credibility intervals (2.5% and 97.5%).

EMU	Similarity index
DE_Eide	0.66 [0.49–0.81]
DE_Elbe	0.76 [0.62–0.88]
FR_Adou	0.72 [0.54–0.87]
FR_Bret	0.58 [0.42–0.73]
FR_Garo	0.60 [0.44–0.75]
FR_Loir	0.66 [0.49–0.80]
FR_Sein	0.14 [0.09–0.21]

- Freshwater

Three clusters were defined. Clusters 1 and 2 indicate a very long fishing season (especially Cluster 1), while Cluster 3 is bivariate with a peak in June and a second peak in October (Figure 6.5).

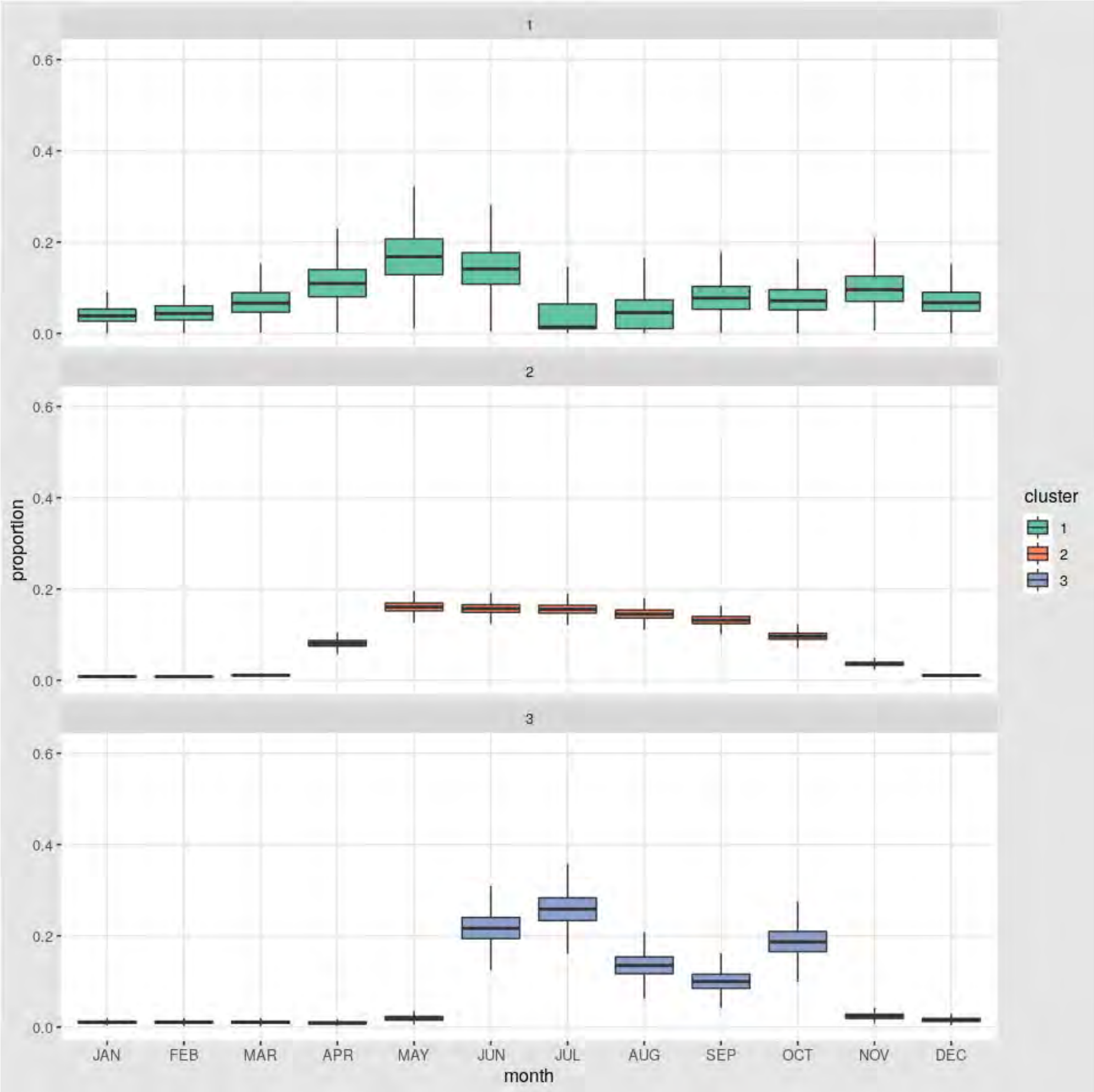
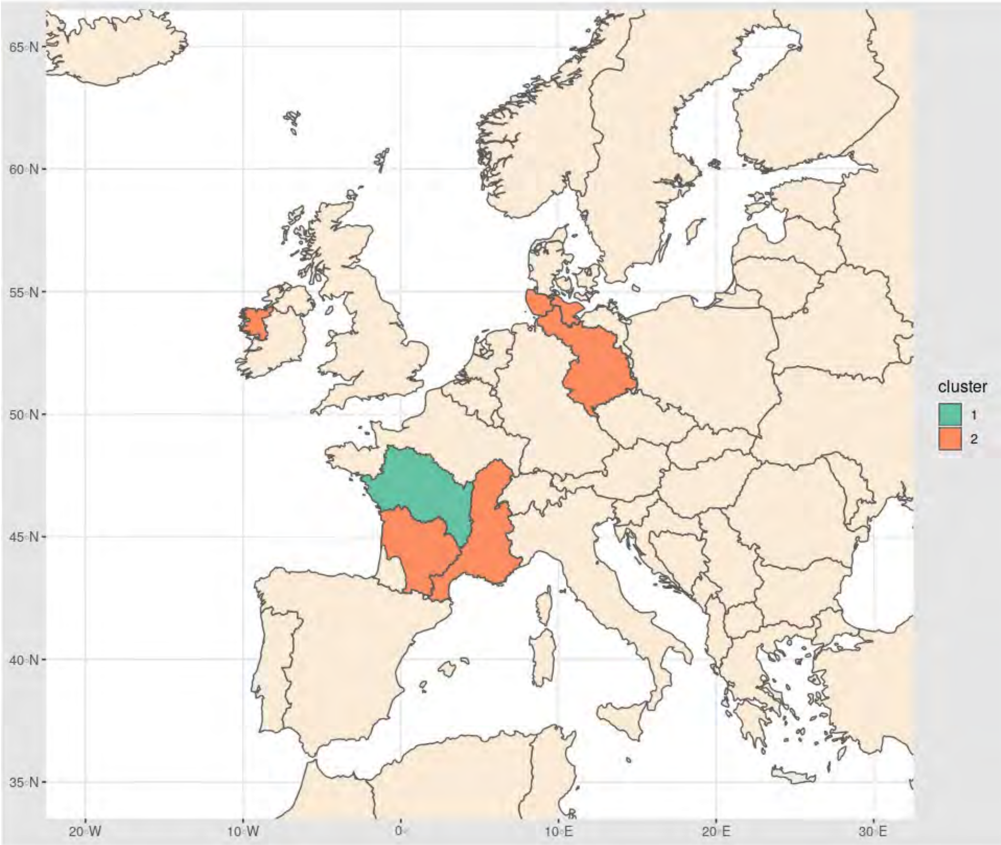


Figure 6.5. Monthly patterns of yellow eel landings in freshwater habitat for each cluster. Boxplots present the posterior distribution of the expected proportions (y axis) per month (x axis).

No spatial pattern appears (Figure 6.6) and the comparison between periods was only possible for three EMUs, with high similarities in all three cases (Table 6.3).


65°N
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cluster
1
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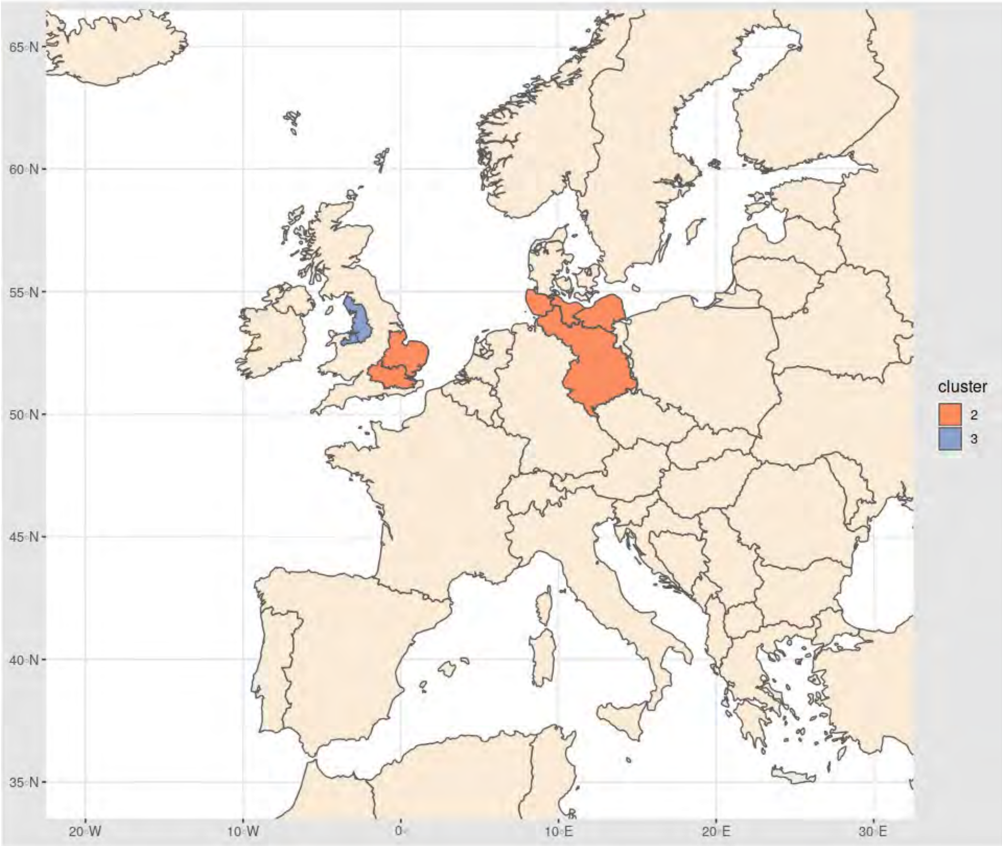

Figure 6.6. EMU clustering of the monthly patterns of yellow eel landings in freshwater habitats according to the cluster analysis for 2000–2009 (upper) and 2010–2019 (lower).

Table 6.3. Similarity indices (1 perfect overlap, 0 no overlap) of monthly patterns per EMU between periods for yellow eels in freshwater habitats. Values present the median of the posterior distribution and the 95% credibility intervals (2.5%, 97.5%).

EMU	Similarity index
DE_Eide	0.70 [0.52–0.84]
DE_Elbe	0.76 [0.61–0.87]
DE_Schl	0.74 [0.60–0.86]

6.3 Eel monitoring

Five clusters were defined for yellow eel monitoring (Figure 6.7). The first cluster correspond to a widespread season ranging from April to November. The three following clusters correspond to shorter seasons (from 2 to 4 months), with a progressive shift of the peak from spring/early summer (Cluster 2), towards summer (Cluster 3) and autumn (Cluster 4).

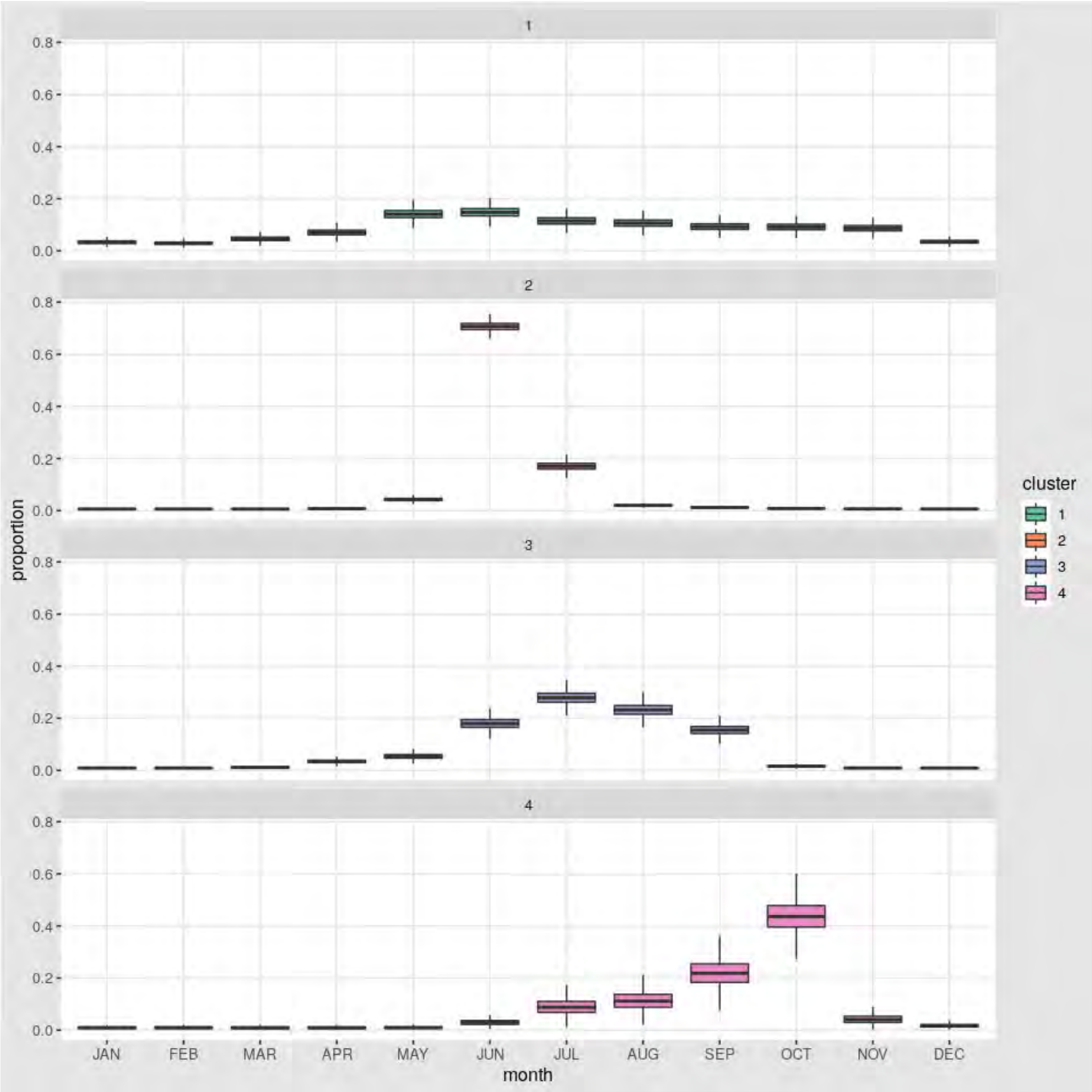

Figure 6.7. Monthly patterns of yellow eel monitoring for each cluster. Boxplots present the posterior distribution of the expected proportions (y axis) per month (x axis).

A spatial pattern appears to show a spring peak of activity in southern Europe and a summer/autumn peak of activity in more northerly parts (Figure 6.8). However, these patterns should be taken with great caution given previous comments on the behaviour of yellow eels and the diversity of sampling methods in the time series (most come from upstream traps in fishways, but others from either estuarine or upstream obstacles, or from an electrofishing sampling). The atypical pattern of the Vilaine series (the only one in Cluster 1) with a very widespread season may, for example, be due to the strict estuarine position of the fishway, which may lead to a large predominance of young yellow eels and to more stable environmental conditions throughout the year.

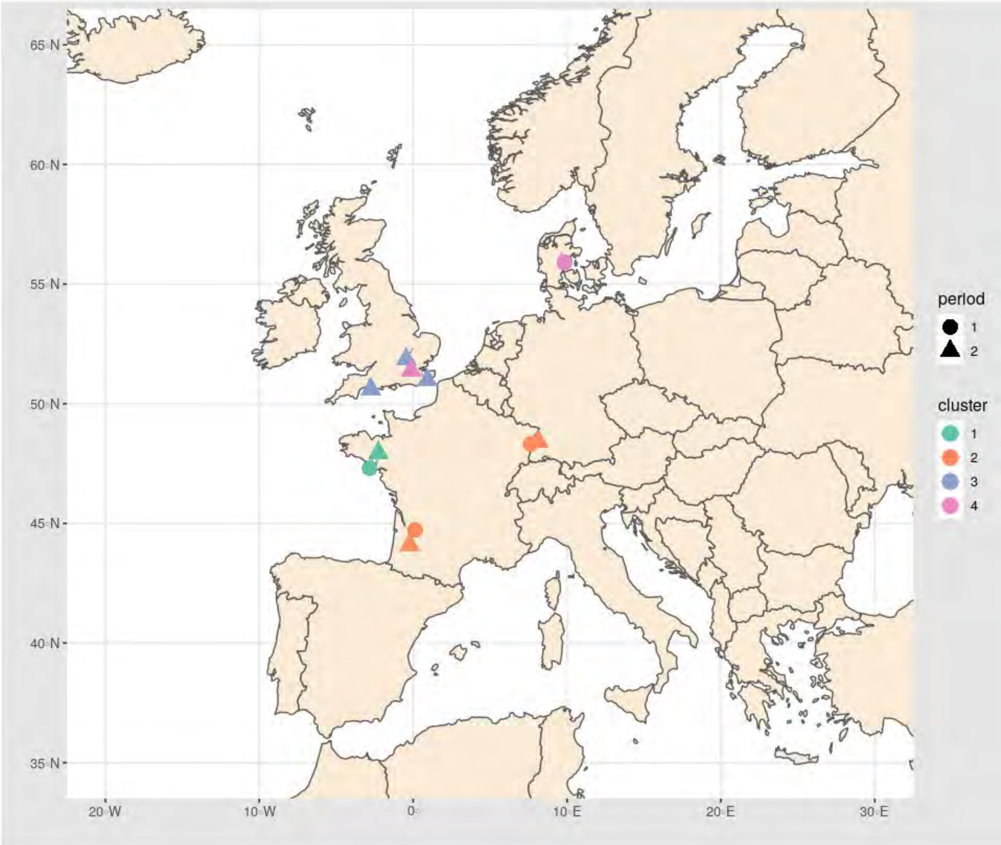

Figure 6.8. Spatial distribution of yellow eel monitoring time series seasonal clustering for 2000–2009 (circles) and 2010–2019 (triangles).

No series changed clusters between period 1 and period 2 and the patterns were very similar for both time periods (Table 6.4, Figure 6.8).

Table 6.4. Similarity indices (see methods section) of monthly patterns between period 1 and period 2 for each time series. Values present medians of the posterior distributions and 95% credibility intervals (2.5%, 97.5%).

Series	Similarity index
GarY	0.78 [0.70–0.87]
RhinY	0.86 [0.73–0.95]
VilY2	0.81 [0.72–0.89]

In Annex 9, we display detailed results per EMU, habitat type and life stage. Here we provide the example of EMU FR_Garo freshwater habitat, for both landings and monitoring data (Figure 6.9). It illustrates how for yellow eels, monitoring data display a much more restricted seasonality (dots) than landings (bars: observations, horizontal lines average pattern). It also illustrates how the implementation of EMP closures since 2011 has reduced the fishing season.

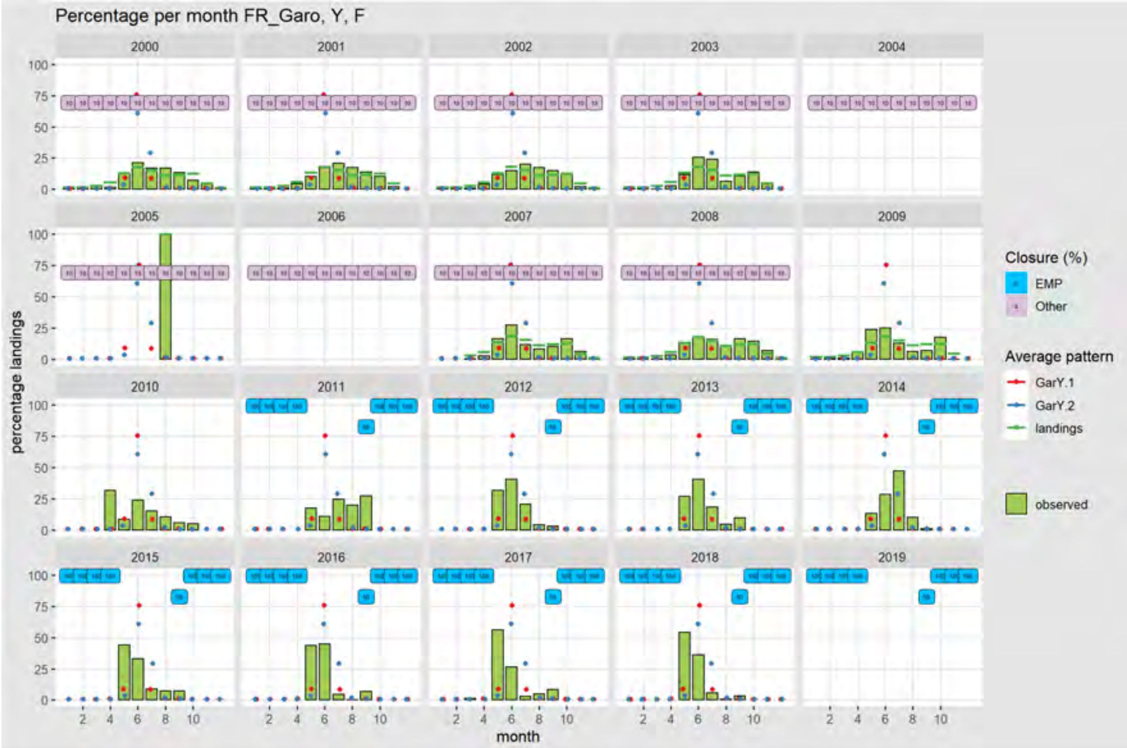

Figure 6.9. Monthly distribution of yellow eel landings in freshwater habitat in EMU FR_Garo from 2000 to 2019. Bars indicate the percentage of the total annual landings happening in that month. The green line indicates the average pattern of landings (kg). Blue and reds dots illustrate the average monthly pattern of monitoring time-series. A small square at the top of each graph indicates whether the fishery has been closed during that month. The number inside the square indicates the percentage of the decrease in landings that the closure will cause. The blue colour indicates that the closure is due to the implementation of the EMP and the pink colour indicates that the closure has been due to other reasons such as the EC Closure regulations.

6.4 Literature review

The yellow eel phase of the life cycle is the continental life stage, which can inhabit fully marine, coastal transitional and inland freshwaters. Yellow eels are relatively sedentary (Imbert *et al.*, 2010) and according to Nyman (1972) "the only period in the life of the European eel where a non-migratory phase may be observed". Many of the younger, smaller individuals will however, make progressive movements upstream through catchments. Therefore, yellow eels that are not actively moving upstream (such as those caught in "elver traps", which are referred to as "young" yellow eels in the recruitment time-series analysis) do not typically display seasonal or annual migrations in the same way as glass eel or silver eel. In fact, despite being frequently described as an upstream migration, the movement to colonize a given catchment is not compulsory in their life, and therefore, not a migration.

The literature available on yellow eel activity is diverse, but it does not cover the distribution range consistently in reference to the colonization of the catchments, being mostly focused on the Atlantic coast where glass eel recruitment occurs. This information is exclusively for the period prior to 2010. As for the activity of yellow eels, despite not covering the entire range, the literature review includes information before and after 2010. The literature datasets include studies from scientific monitoring and fishery-dependent sources, though are dominated by the former (Table 6.5).

Overall, the literature review provided eight sites (Figure 6.10) from five countries (Ireland, UK, France, Italy and Portugal) where data on monthly landings of small eels could be analysed. Except for the Fogliano in the Mediterranean, all yellow eels were monitored with the help of traps. In general, based on the monthly qualitative/quantitative information available from the literature throughout the distribution range, the progression of eels upriver starts earlier in southern latitudes, particularly in the Mediterranean, with a peak in April, whereas in northern latitudes this movement is longer in time and exhibits a later peak, which extends until July and declines until September/October before it ends.

Yellow eel fisheries show a typical seasonal pattern, and this is often closely linked to yellow eel activity because most fisheries rely on fixed gears (Corsi and Ardizzone, 1985) such as fykenets, traps and poundnets. Yellow eel landings reflect feeding activity which is highest in the spring months and tails off through late summer (Tesch, 2003) in the northern countries. In southern countries, yellow eel landings are usually higher during spring, early summer and autumn months (Domingos, pers. comm.; Leone pers. comm.).

Feeding activity of yellow eels is correlated with water temperature (Nyman, 1972) and when these temperatures drop below a certain threshold (8°C, Nyman, 1972) this activity ceases. Vollestad (1986) reports this lower threshold to be between 2.5 and 9.6°C, Riley *et al*., (2011) reported no activity in a UK stream below 10°C, and Verhelst *et al*., (2018b) concluded eel activity was lowest when temperature was also below 10°C in a Belgian freshwater polder area. Therefore, fishing for yellow eel and yellow eel CPUE is often related to seasonal eel activity and hence why fisheries often focus on yellow eels in the warmer months of the year. Regardless of temperature, yellow eels show strong diel activity, with peak activity often taking place soon after dark (e.g. Poole, 1994; Tesch, 2003; Riley *et al*., 2011; Walker *et al*., 2014; Barry, 2015).

Assessments of seasonal yellow activity are typically based on fishing surveys and eel tagging experiments. In terms of fishing surveys, Vollestad (1986) used fykenets in a Norwegian tidal waterbody and found CPUE to vary through the season, with highest CPUE occurring at highest water temperatures. Similar observations were made in the west of Ireland (Poole, 1994), with CPUE relatively high from April to September and low for the months of October to March. Correlations between activity and temperature based on tagging experiments are less consistent than CPUE; for example, in the UK, Riley *et al*. (2011) found that PIT tagged yellow eel activity was greatest when water temperatures were increasing in late spring, while in Belgium, Baras *et al*. (1998) observed peak activity occurred at water temperatures above 16°C.

Despite less information available in the literature, high water temperatures may also be a limiting factor in the activity of yellow eels as proven by a slight decrease in landings during warm summer months, in the southern distribution range (e.g. Portugal, Italy) or even in the northern parts, as the Vistula Bay in Poland (Psuty and Wilkońska, 2009). According to Sadler (1979) the optimum temperature for the European eel is circa 23°C, which implies extremes in temperature, above the optimum may have an adverse effect on eel activity. Although more typical of the summer months in the southern range, the effect of high temperatures on eel activity had already been highlighted by Deelder (1984) who stated that fishermen who use bait know that in midsummer eels interrupt feeding. The effect of high temperatures on rivers draining into the Mediterranean (Europe and North Africa) is greater than the effect on estuaries where the larger size (depth and width) and the mixture with sea water moderate the temperature.

It seems appropriate that local water temperature conditions to which eels are acclimated may be used to predict increases and peaks in eel activity, and subsequent fishing pressure on yellow eel. This reduction in activity results in a decrease of landings during some warm summer months. Although typical of southern Europe and North Africa, such conditions have also been observed in other European rivers, such as the Scheldt (Verhelst *et al*., 2018b) and Meuse (Baras *et al*., 1999) in Belgium, and the Itchen (Riley *et al*., 2011) in the UK, located in northern latitudes. Using eel tagging experiments, Verhelst *et al*., (2018b) reported that yellow eels were more active at the end of summer, when temperature was lower (mean temperature 19.3°C) than in midsummer when temperature reached its maximum (mean water temperature 20.2°C) and Riley *et* *al*., (2011) also observed low number of movements in July, when temperature reached a maximum of 19.2°C between 19:30 and 20:30 h.

There was a lack of data within each study that referred to the periods before and after the implementation of EMPs, and so did not allow for a meaningful comparison between these time periods. As noted elsewhere, the information collated from the literature should be considered as a complement to the information obtained from the data call.

In conclusion, there are sensible periods for the yellow eel fishery restrictions and measures that might have a potentially positive effect on the stock. However, given the strong relationship between eel activity and water temperature, climate change may have a significant impact on how predictable these activity patterns are in the future.

Table 6.5. List and characteristics of the scientific studies reviewed dealing with yellow eel activity and timing of yellow eel colonization. Sites are ordered according to latitude.

Author	Country	Site	Habitat	Management period	Year of sampling	Study type	Gear
Psuty *et al.*, 2009	Poland	Vistula	T	Pre-2010	1995–2006	Fishery-depend.	Fykenet + Barrier
Moriarty, 1986	Ireland	Shannon	F	Pre-2010	1973–1985	scient. monit	Trap+ ladder
White and Knights, 1997	Great Britain	Severn and Avon	F	Pre-2010	1991–1993	scient. monit	Trap+ ladder
Naismith and Knights, 1988	Great Britain	Thames	F	Pre-2010	1985–1987	scient. monit	Trap
Riley *et al.*, 2011	Great Britain	Itchen	F	Post-2010	2007–2009	scient. monit	Pit-tags
Baras *et al.*, 1998	Belgium	Meuse	F	Pre-2010	1996	scient. monit	Tagging (transmitters)
Verhelst *et al.*, 2018b	Belgium	Scheldt	F	Post-2010	2012–2015	scient. monit	Tagging (transmitters)
Legault, 1994	France	Arguenon	F	Pre-2010	1992	scient. monit	Trap+ ladder
Leone *et al.*, 2016	Italy	Fogliano	T	Post-2010	2012–2013	scient. monit	Fykenet + tube
Domingos *et al.*, 2019	Portugal	Mondego	F	Post-2010	2017–2019	scient. monit	Trap+Ladder
Abdalhamid *et al.*, 2018	Libya	Umm Hufayan	T	Post-2010	2015	scient. monit	Poundnet

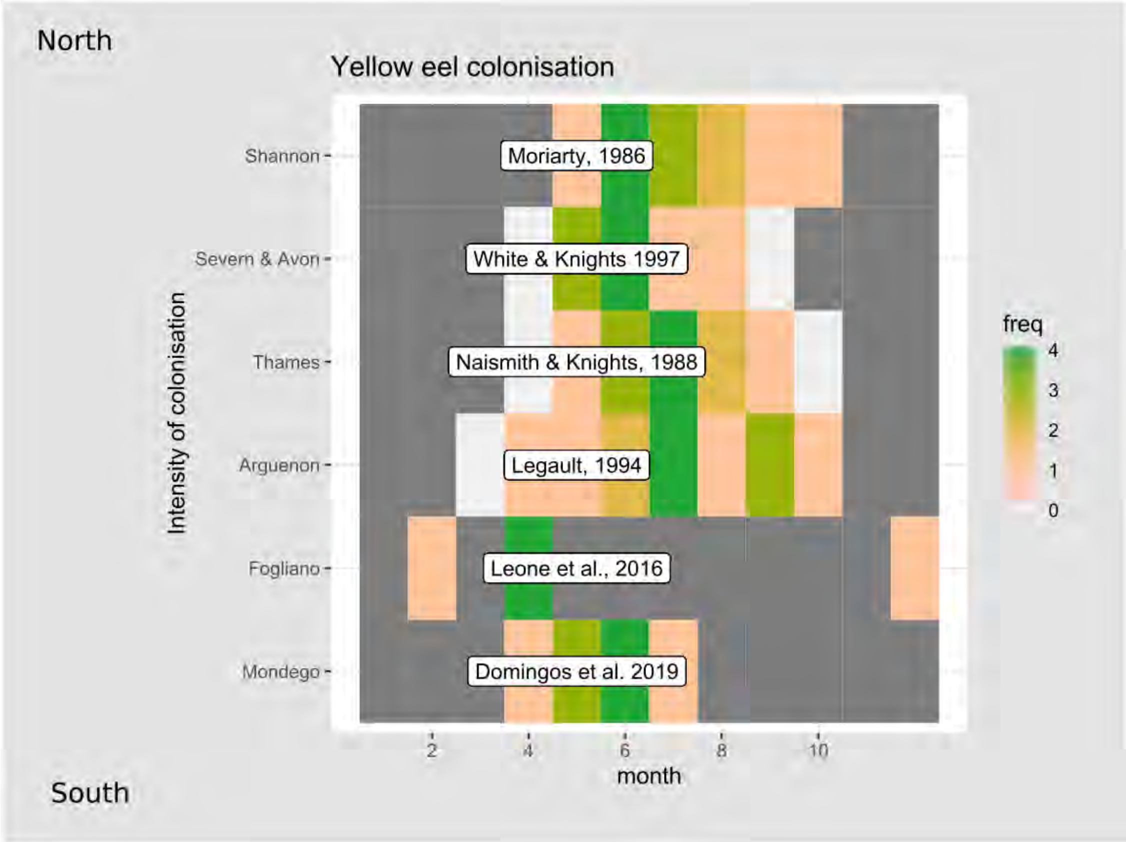

Figure 6.10. Qualitative description of the yellow eel seasonality patterns obtained from the scientific literature. Qualitative information is converted into ranks of occurrence per month according to a scale ranging from 0 to 4 (i.e. from 0 movements/absent to 4 maximum intensity of colonisation). Sites are ordered according to latitude.

7 ToR 4 - the period when migrating eels need to pass through narrow passages (e.g. such as the exits of the Baltic and Mediterranean) on the way to their destination, and whether this has changed substantially since before 2007

The fishing pressure on eels is likely greater in the narrow passages on their way to their growing habitats (glass eels), or the breeding area (silver eels). Both life stages are targeted by fisheries in different locations and at different times. When routes and timing of migration are known by fishermen, fish species become more vulnerable to capture.

We considered three narrow passages in EU waters, located on the migratory route of European eel: 1) the English Channel; 2) the passage to/from the Baltic Sea, particularly, the Kattegat; and 3) the passage to/from the Mediterranean Sea (Figure 7.1). These passages are used by glass eels on their way to the growth areas located in coastal and freshwater habitats (estuaries, coastal lagoons, rivers and lakes), as well as by silver eels on their way to the spawning area in the Sargasso Sea. In addition to eels that have settled in coastal waters, the Baltic and the Mediterranean receive all silver eels that escape from EU Member States waters draining into these basins, namely from Finland, Estonia, Latvia, Lithuania, Poland, Germany, Sweden and Denmark, in the first case and Greece, Croatia, Slovenia, Italy, France and Spain, in the second case. In addition, other northern countries contribute to the silver eels in the Baltic, and other GFCM countries also contribute with silver eels for the Mediterranean.

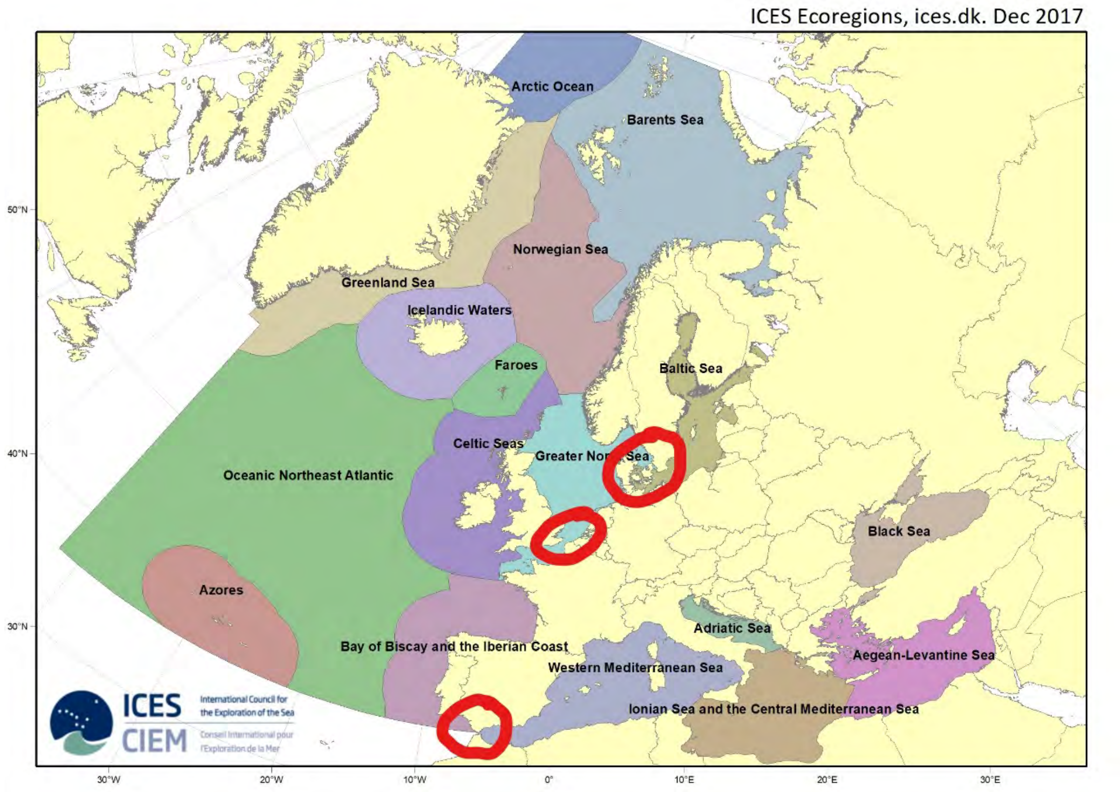

Figure 7.1. ICES Ecoregions, with the three Narrow Straits considered in this chapter highlighted with red borders.

The period when migrating eels need to pass through these narrow passages on the way to their destination varies according to their locations and the stage in the eel life cycle. Overall, silver eels descend rivers when temperature and photoperiod decrease (Vøllestad *et al.*, 1986; Bruijs and Durif, 2009). This occurs earlier at northern latitudes (Vøllestad *et al.* 1986). In northern countries, silver eels usually start their downstream migration in late summer and early autumn (Sandlund *et al*., 2017). In general, the downstream migration starts in September and the migration period may extend until January, with a peak in October–November (Table 5.4 and Figure 5.2). Passage through the Danish straits occurs from September to December with a peak in November (Prigge *et al*., 2013; Pedersen, pers. comm.). Silver eels are sometimes caught by shrimp trawlers in the Skagerrak during late November, early December (unpublished data from IMR, Norway).

More puzzling are the reports of downstream migrations in Baltic river basins in the spring with a peak in April (Prigge *et al*., 2013, also refer to data call data), but it is unclear whether these eels are on their reproductive migration and would immediately continue their migration through the straits; alternatively these may be late in the migratory phase from the previous autumn/winter.

In southern latitudes, in areas where silver eels must escape through the Gibraltar Strait, the migration occurs slightly later, starting in October and extending until January (Table 5.4 and Figure 5.2). Silver eels tagged with PSAT (pop-up satellite tags), were tracked during their migration towards the Sargasso Sea between southern France and 300 km off the coast of Portugal. They swam at a speed of 8.4 km/h and passed through the Gibraltar Strait in March 2016, after being tagged in early December 2015 (Amilhat *et al*., 2016).

For glass eels, the trend is opposite, with arrival of glass eels occurring earlier in the southern part of the distribution compared to the northern part (Figures 4.2, 4.5 and 4.6). Landings of glass eels in the Mediterranean estuaries and lagoons occur later than in the Atlantic estuaries, where the migratory season usually starts in October–November and may extend to February–March. There is a lack of information on the timing when glass eels enter the Mediterranean. However, the first landings in Mediterranean river basins, occur in November (River Tiber, Italy), December (River Alfios, Greece) and January (Vaccarès Lagoon, France) (Table 4.3, Figure 4.6). In some cases, glass eels are caught all year such as in the rivers Guadalquivir (Spain) and Mondego (Portugal). Most glass eels that pass through the English Channel are mostly recruited there and there are no glass eel fisheries after this passage, in countries bordering the North Sea (Creutzberg, 1961).

There is no reason to expect changes in periods of migration (recruitment and escapement) through the narrow passages before and after 2010. If changes have occurred, they would be in the abundance or relative proportions but not in the seasonality of the passages. In any case, we found no obvious changes in the migration patterns.

In addition to the aforementioned narrow passages that operate at a larger scale, the WK would like to note that, at local scale, some configurations may lead to the concentration of migrating eels in narrow passages. Typically, dams or the exit/entrance of lagoons are zones in which migrating eels are highly concentrated, making them vulnerable to fisheries and other impacts.

8 ToR 5 - whether the closure periods set up under the National Eel Management Plans prior to the EU temporal closure are consistent (in terms of time periods of the closures) with the periods established following the EU closure

As discussed in Chapter 4, examination of the available data on fishery closure measures indicated that answering the original ToR would have been very complicated and uninformative. Therefore, after discussing these challenges with the representative from the EC and their ultimate requirements, it was agreed that the WK would focus this workstream on assessing the recent compliance of EU Member States in implementing EC Closure Regulations during 2018 and 2019. We focussed on the following two questions:

1. Do the closures applied by Member States in 2018/19 follow the EU Closure Regulation obligations set out in the Council Regulation (EU) 2018/120 relating to 'Measures on European eel fisheries?
2. Do the closures applied by Member States in 2019/20 follow the EU Closure Regulation obligations set out in the Council Regulation (EU) 2019/124, which relates to 'Measures on European eel fisheries in Union waters of the ICES area, or European eel in the Mediterranean Sea (GSAs 1 to 27)?

8.1 Data and analyses

Information on the closure periods was requested through the Data Call. Eighteen countries (EU MS and Norway) responded providing relevant information on eel fisheries closures, based on eel life-stage, habitat, EMUs and months.

The data submitted relating to closures - 325 from 64 EMUs - were analysed to determine whether they followed EU legislation adopted in 2018 and 2019. The complexities described in Annex 3 meant that even this task proved far more challenging and time consuming than planned. In some cases, there were uncertainties as to whether the closures followed the legislation, and there were instances where national/subnational regulations do not align with the required EU closures.

Neither year's analysis takes into account the nine closures from EMUs that were submitted with little information, and no closure data - DE Rhei; FR_Meus; FR_Rhin; GB_Neag; GB_NorE - in these instances, it was obviously not possible to make a determination as to whether or not they followed the international legislations. Further, there were a number of EMUs that did not have data submitted, where it was assumed that 'silence' indicated that a fishery did not exist or had already been closed. These assumptions should be tested.

For the better visualization of the closure data, pivot tables were prepared for each country, indicating the years, months, EMUs, the type of closure (Total, partial in time or space, etc.), whether the closure was in response to the Regulation (EMP) or EU closures (EU) and an evaluation of the effect of the closure for the selected month in percentage terms. Links to these pivot tables and a full table of reported closures can be found in Annex 9, but below is a broad discussion of the findings followed by a table summarising the closures reported for 2018 and 2019.

Question 1: Do the closures applied by Member States in 2018/19 follow the EU Closure Regulation obligations set out in the Council Regulation (EU) 2018/120 relating to 'Measures on European eel fisheries?

In 2018, Article 10 of Council Regulation (EU) 2018/120 relating to 'Measures on European eel fisheries' stated:

It shall be prohibited for Union fishing vessels and third country vessels, as well as for any commercial fisheries from shore, to fish for European eel of an overall length of 12 cm or longer in Union waters of ICES area, including in the Baltic Sea, for a consecutive three-month period to be determined by each Member State between 1 September 2018 and 31 January 2019. Member States shall communicate the determined period to the Commission not later than 1 June 2018.

This specifically applied to ICES waters; in 2018, the GFCM adopted, in Recommendation GFCM/42/2018/1, the following measure for Contracting Parties (CPCs):

… establish an annual fishing closure of three consecutive months where landing European eel shall be prohibited. In order to decrease fishing mortality effectively, the closure period shall be defined by the CPCs in their national management plan, together with its fisheries and the gear targeting European eel.

The fishing closure period shall be consistent… …with national management plans in place and with the temporal migration patterns of European eel in the CPC concerned.

This came in to force as of 01/01/19.

Answer: According to the MS responses to the WK data call, in 2018 there were 155 closures submitted. We have assumed that any in the mixed habitat type of 'Coastal (C) and/or Transitional (T) waters' are not fully marine and are exempt from the EU legislation. As such, only one closure appeared to not follow the relevant legislation (Table 8.1).

Question 2: Do the closures applied by Member States in 2019/20 follow the EU Closure Regulation obligations set out in the Council Regulation (EU) 2019/124, which relates to 'Measures on European eel fisheries in Union waters of the ICES area, or European eel in the Mediterranean Sea (GSAs 1 to 27)?

In 2019, the EU, in order to '*…establish a level playing field across the Union…*' proposed closures aligned with GFCM measures. Article 11 of Council Regulation (EU) 2019/124, which relates to 'Measures on European eel fisheries in Union waters of the ICES area' stated:

Any targeted, incidental and recreational fishery of European eel shall be prohibited in Union waters of the ICES area and brackish waters such as estuaries, coastal lagoons and transitional waters for a consecutive three-month period to be determined by each Member State between 1August 2019 and 29 February 2020. Member States shall communicate the determined period to the Commission not later than 1 June 2019.

Further, Article 42 of the same Regulation, which relates to 'European eel in the Mediterranean Sea (GSAs 1 to 27)' stated:

1. All activities by Union vessels and other Union fishing activities catching European eel, namely targeted, incidental and recreational fisheries, shall be subject to the provisions of this Article.

2. This Article shall apply to the Mediterranean Sea and to brackish waters such as estuaries, coastal lagoons and transitional waters.

3. It shall be prohibited to fish for European eel in Union and international waters of the Mediterranean Sea, for a consecutive three-month period to be determined by each Member State. The fishing closure *period shall be consistent with the conservation objectives set out in Regulation (EC) No 1100/2007, with national management plans in place and with the temporal migration patterns of European eel in the Member States concerned. Member States shall communicate the determined period to the Commission no later than one month before the entry into force of the closure and in any case no later than 31 January 2019.*

Answer: In 2019, there were 161 closures submitted in the Data Call. One hundred and twenty six appeared to follow the updated EU (ICES Region) and GFCM (Mediterranean basin) legislation whereas 35 did not (see Table 8.1). Those that did not follow the regulations were due to closures being outside of the required date range, not having consecutive months and/or only being partial temporal/spatial closures.

Table 8.1. Country and EMU summary of the potential closures reported to the WK for 2018 and 2019 that do not appear to follow the requirements of the relevant regulations. In the following table the period of closure in each EMU is presented along with the reason of closure reported by the Member State, in terms if it is based on an EMP or the EU Closure Regulation, or any other regional or national law. Additionally, the type of closure (Total or Partial in time or space and a series of combinations), the type of fisheries (Commercial or Recreational) and the eel life stage that the closure concerns.

Country	EMU	Year of Closure	Reason for closure	Type of fisheries	Type of closure	Life stage	Habitat	Period of closure
Germany	DE_Eide	2019	EU Regulation	Commercial	Partial in space	Yellow and Silver	Coastal	30% partial close during the months November, December, January
		2019	EMP	Commercial	Partial in space	Yellow and Silver	Coastal	5% closure across the year
		2019	EMP	Recreational	Partial in space	Yellow and Silver	Coastal	5% closure across the year
		2019	EU Regulation	Recreational	Partial in space	Yellow and Silver	Coastal	30% partial close during November and December
	DE_Elbe	2019	EMP	Commercial	Partial in space	Yellow and Silver	Transitional & Coastal	5% spatial closure across the year
		2019	EMP	Recreational	Partial in space	Yellow and Silver	Transitional & Coastal	5% spatial closure across the year
		2019	EU Regulation	Recreational	Partial in space	Yellow and Silver	Transitional & Coastal	55% partial close during the months November, December, January
	DE_Schl	2019	EMP	Commercial	Partial in space	Yellow and Silver	Coastal	5% spatial closure across the year
		2019	EMP	Recreational	Partial in space	Yellow and Silver	Coastal	5% spatial closure across the year
		2019	EU Regulation	Commercial	Partial in space	Yellow and Silver	Coastal	30% partial close during January, November and December

Country	EMU	Year of Closure	Reason for closure	Type of fisheries	Type of closure	Life stage	Habitat	Period of closure
		2019	EU Regulation	Recreational	Partial in space	Yellow and Silver	Coastal	30% partial close during January, November and December
Denmark	DK_total	2018	EMP	Recreational	Total & Partial in Time	Yellow and Silver	Marine Waters	100% - June and July; 65% temporal May
		2019	EMP	Recreational	Total & Partial in Time	Yellow and Silver	Marine Waters	100% - June and July; 65% temporal May
Spain	ES_Cata	2019	Other	Commercial	Total	Yellow and Silver	Transitional	100% - March, April, May, June, July, August and September; 50% October
		2019	Other	Commercial	Total & Partial in Time	Glass eels	Transitional	100% - April, May, June, July, August, September; 50% March and October
Spain	ES_Gali	2019	EMP	Commercial	Partial in space	Yellow and Silver	Freshwater & Transitional & Coastal	30% spatial in February and March; 15% in April and October
		2019	EMP	Commercial	Partial in space & Time	Yellow and Silver	Freshwater & Transitional & Coastal	15% spatial and temporal in July, August and September
France	FR_Arto	2019	EMP	Commercial	Total & Partial in Time	Yellow	Transitional	100% - January, August, September–December; 50% temporal February and July
		2019	EMP	Recreational	Total & Partial in Time	Yellow	Transitional	100% - January, August, September–December; 50% temporal February and July
	FR_Bret	2019	EMP	Commercial	Total & Partial in Time	Yellow	Transitional	100% - January, February, March, October–December; 50% spatial April and September
		2019	EMP	Recreational	Total & Partial in Time	Yellow	Transitional	100% - January, August, September–December; 50% spatial February and July
	FR_Cors	2019	EMP	Commercial	Total & Partial in Time	Silver	Transitional	100% - March - August; 50% temporal in September; 15% temporal in February

Country	EMU	Year of Closure	Reason for closure	Type of fisheries	Type of closure	Life stage	Habitat	Period of closure
	FR_Garo	2019	EMP	Commercial	Total + Partial in space	Yellow	Transitional	100% - January, February, March, November and December; 50% spatial in April and October
		2019	EMP	Recreational	Total & Partial in Time	Yellow	Transitional	100% - January, February, March, November and December; 50% temporal in April and October
	FR_Loir	2019	EMP	Commercial	Total & Partial in Time and space	Yellow	Transitional	100% - January, February, March, November and December; 50% spatial and temporal in July, August, September, October
		2019	EMP	Recreational	Total & Partial in Time	Yellow	Transitional	100% - January, February, March, November and December; 50% temporal in July, August, September, October
France	FR_Sein	2019	EMP	Commercial	Total & Partial in Time	Yellow	Transitional	100% - January, August to December; 50% temporal in February and July
		2019	EMP	Recreational	Total & Partial in Time	Yellow	Transitional	100% - January, March, August to December; 50% temporal in February and July
Great Britain	GB_NorW	2019	EMP	Commercial	Partial in space	Yellow and Silver	Freshwater & Transitional & Coastal	Total closure 15% spatial
	GB_Tham	2019	EMP	Commercial	Partial in space	Yellow and Silver	Transitional	Total closure 10% spatial
Latvia	LV_Latv	2019	EU Regulation	Commercial	Total	Yellow and Silver	Coastal	No data
		2019	EU Regulation	Recreational	Total	Yellow and Silver	Coastal	No data
Nederland	NL_Neth	2019	Other	Commercial	Partial in space	Yellow and Silver	Freshwater & Transitional	%5 spatial closure across the year due to polluted rivers

Country	EMU	Year of Closure	Reason for closure	Type of fisheries	Type of closure	Life stage	Habitat	Period of closure
		2019	EMP	Commercial	Total	Glass, Yellow and Silver	Freshwater & Transitional & Coastal	90% closure in September, October and November
Sweden	SE_East	2019		Commercial	Total	Yellow and Silver	Coastal	No data
	SE_West	2019		Commercial	Total	Yellow and Silver	Coastal	No data

8.2 Recommendations

It was very difficult to understand the spatial and temporal distribution of fishery closures, and therefore to be confident of whether or not closures followed the EC Closure Regulations. More detailed checks with data providers should be pursued to resolve these issues. In addition, however, we will all need to find a better way to report and record such closures, to improve our understanding and analyses.

It is suggested that Member States could be asked to list and describe all their fisheries per EMU, and then to explain how these have been closed in response to the EC Closure Regulations.

This list and/or description would itself be very complicated, but would probably have to include at least the following datapoints:

- EMU;
- Life stage or fish size range;
- Fishing gear;
- Aquatic habitats fished;
- Contained in national or shared waters;
- Months when the fishery would be expected to catch fish if it operated;
- Months when fishing is permitted;
- Months closed in response to EC Closure regulations.

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Annex 1: Glossary and Acronyms

ACRONYMS	DEFINITION
ACOM (ICES)	Advisory Committee
CPUE	Catch per unit of effort
CoI	Conflict of Interest
CPC	Contracting Parties, used in this report specifically for the GFCM
DCF	Data Collection Framework, related to the EU MAP
DG MARE	Directorate-General for Maritime Affairs and Fisheries, European Commission
EC	European Commission
EIFAAC	European Inland Fisheries & Aquaculture Advisory Commission
EMP	Eel Management Plan
EMU	Eel Management Unit
EU	European Union
EU MAP	The European Union Multi Annual Plan, related to the DCF
FAO	Food and Agriculture Organisation
FRSG (ICES)	The Fisheries Resources Steering Group for ICES
GFCM	General Fisheries Commission of the Mediterranean
GIS	Geographic Information Systems
GSA (GFCM)	GFCM Geographical Sub-Areas
ICES	International Council for the Exploration of the Sea
IMR	Institute of Marine Research from Norway
MS	Member State, in this report specifically referring to MS of the EU
RBD	River Basin District
TAC	Total allowable catches
ToR	Terms of Reference
WG	Working Group
WGEEL	Joint EIFAAC/ICES/GFCM Working Group on Eel
WKEPEMP	The Workshop on Evaluating Progress with Eel Management Plans
WFD	Water Framework Directive
WKEMP	ICES Workshop on Eel Management Plans

Eel Management Unit (Eel River Basin)	"Member States shall identify and define the individual river basins lying within their national territory that constitute natural habitats for the European eel (eel river basins) which may include maritime waters. If appropriate justification is provided, a Member State may designate the whole of its national territory or an existing regional administrative unit as one eel river basin. In defining eel river basins, Member States shall have the maximum possible regard for the administrative arrangements referred to in Article 3 of Directive 2000/60/EC [i.e. River Basin Districts of the Water Framework Directive]." EC No. 1100/2007.
Elver	Young eel, in its first year following recruitment from the ocean. The elver stage is sometimes considered to exclude the glass eel stage, but not by everyone. To avoid confusion, pigmented 0+ cohort age eel are included in the glass eel term.
River Basin District	The area of land and sea, made up of one or more neighbouring river basins together with their associated surface and groundwaters, transitional and coastal waters, which is identified under Article 3(1) of the Water Framework Directive as the main unit for management of river basins. The term is used in relation to the EU Water Framework Directive.

Definition: 40% EU Target: "The objective of each Eel Management Plan shall be to reduce anthropogenic mortalities so as to permit with high probability the escapement to the sea of at least 40% of the silver eel biomass relative to the best estimate of escapement that would have existed if no anthropogenic influences had impacted the stock". The WGEEL takes the EU target to be equivalent to a reference limit, rather than a target.

Eel life stage codes

ACRONYM	LIFE STAGE	DESCRIPTION
G	Glass eel	Young, unpigmented eel, recruiting from the sea into continental waters. WGEEL consider the Glass eel term to include all recruits of the 0+ cohort age. In some cases, therefore, this also includes the early pigmented stages.
GY	Glass eel + Yellow eel	A mixture of glass and Yellow eel, some traps have historical data where Glass eel and Yellow eel were not separated, although they were dominated by Glass eel. Can also be used to declare missing data for both Glass eel fishery and Yellow eel fishery.
Y	Yellow eel	Life-stage resident in continental waters. Often defined as a sedentary phase, but migration within and between rivers, and to and from coastal waters occurs and therefore includes young pigmented eels (small eels sometimes called elvers or bootlace eels). In particular, some recruitment series either far up in the river or in the Baltic consist of multiple age classes of young Yellow eel, typically from 1 to 10+ years of age- they are referred to as Yellow eel Recruits.
YS	Yellow eel+ Silver eel	A mixture of Yellow and Silver eel
S	Silver eel	Migratory phase following the Yellow eel phase. Eel in this phase are characterized by darkened back, silvery belly with a clearly contrasting black lateral line, enlarged eyes and pectoral fins. Silver eel undertake downstream migration towards the sea. This phase mainly occurs in the second half of calendar years, although some are observed throughout winter and following spring.
GS	Glass eel + Silver eel	Can be used to declare missing data for both Glass eel fishery and Silver eel fishery.
GYS	Glass eel + Yellow eel + Silver eel	Can be used to declare missing data for all stages

Eel habitat codes

ACRONYM	DESCRIPTION
F	Freshwater
T	WFD Transitional water - implies reduced salinity but not freshwater
C	WFD Coastal water
FT	Freshwater + Transitional
FC	Freshwater + Coastal
TC	Transitional + Coastal
FTC	Freshwater + Transitional + Coastal
MO	Marine water (open sea)

Country Codes

CODE	COUNTRY
BE	Belgium
DE	Germany
DK	Denmark
EE	Estonia
ES	Spain
FI	Finland
FR	France
GB	Great Britain
GR	Greece
HR	Croatia
IE	Ireland
IT	Italy
LT	Lithuania
LV	Latvia
NL	Netherlands
NO	Norway
PL	Poland
PT	Portugal
SE	Sweden

Annex 2: Recommendations

Chapter 3: Methods

- Member States should be encouraged/required to report time-series separately for different life stages according to the life stage that is most relevant to the purpose of the data being requested.
- In future, consideration should be given to whether mixed yellow/silver eel time-series can be treated as one or other stage, for example based on the capture gear and inferences about the likely life stage of the catch; for example, large eels that are caught migrating downstream to the sea in the autumn and winter and which include some silver eels can all be classed as silver even if some look 'yellowish' because of their common migratory behaviour.
- Future consideration ought to be given to agreeing common rules for defining and delineating aquatic habitat types.
- In future, Member States should be encouraged/required to report landings separately for each aquatic habitat type.
- For future data requests however, it should be made clear that full reporting is required for any EMU that had a fishery during any part of the reporting period, and that not reporting an EMU will be understood to mean that no fishery has every occurred there.

Chapter 4: ToR 1 Glass eel

None.

Chapter 5: ToR 2 Silver eel

None.

Chapter 6: ToR 3 Yellow eel

None.

Chapter 7: ToR 4 Narrow Straits

None.

Chapter 8: Closures

It was very difficult to understand the spatial and temporal distribution of fishery closures, and therefore, to be confident of whether or not closures followed the EC Closure Regulations. More detailed checks with data providers should be pursued to resolve these issues. In addition, however, we will all need to find a better way to report and record such closures, to improve our understanding and analyses.

It is suggested that MS could be asked to list and describe all their fisheries per EMU, and then to explain how these have been closed in response to the EC Closure Regulations.

This list and/or description would itself be very complicated, but would probably have to include at least the following datapoints:

- EMU;
- Life stage or fish size range;
- Fishing gear;
- Aquatic habitats fished;
- Contained in National or shared waters;
- Months when the fishery would be expected to catch fish, if it operated;
- Months when fishing is permitted;
- Months closed in response to EC Closure regulations.

Annex 3: Complexities of comparisons between closures

It was down to workshop participants to interpret the data that were submitted through the Data Call. It quickly became apparent that there would be a number of challenges to this, in the context providing responses to the workshop ToRs. Below we outline these, primarily as background to how the response to ToR 5 evolved from what was initially requested, to what had been presented in Chapter 8.

Closure types

Submitted data indicated that closures established could be straightforward or multifaceted

a) Some closures were only applied to select life stages – e.g. glass eel, yellow eel or silver eel, or a combination of these.
b) Some closures were only applied to select habitat types (freshwater, transitional, coastal or combinations).
c) Some closures were temporal, e.g. applying only to certain months.
d) Some closures were geographical, e.g. applied to certain waterbodies (select rivers) within the EMU.
e) Some closures applied to only recreational and not commercials fisheries, or vice versa.

These selections meant that as well as complete closure of the entire EMU for all life stages and fishery types, there were many combinations of partial closure relating to life stage, habitat, location and time. The reporting and subsequent analysis of these combinations of partial closures is very difficult.

In addition to this, areas where complete closures have pre-existed the Regulation (2007) have been interpreted differently; some have been coded as 100% EMP closure, some have been coded as N/A or blank as they have not been in response to any legislation. This dual interpretation has confounded analysis in some instances.

Differences within the years of the two time periods

a) Countries implemented a range of spatial and/or temporal closures for both commercial and recreational fisheries across exploited life stages in response to the Regulation and subsequent establishment of EMPs. These were not consistent between countries/EMUs or, in some cases, between years for individual countries/EMUs.
b) The closure requirements in 2018 and 2019 were different in terms of the aquatic habitats they covered, the eel life stages and the fishery types. In 2018, Article 10 of Council Regulation (EU) 2018/120 relating to 'Measures on European eel fisheries' stated:

It shall be prohibited for Union fishing vessels and third country vessels, as well as for any commercial fisheries from shore, to fish for European eel of an overall length of 12 cm or longer in Union waters of ICES area, including in the Baltic Sea, for a consecutive three-month period to be determined by each Member State between 1 September 2018 and 31 January 2019. Member States shall communicate the determined period to the Commission not later than 1 June 2018.

This specifically applied to ICES waters; in 2018, the GFCM adopted, in Recommendation GFCM/42/2018/1, the following measure for Contracting Parties (CPCs):

… establish an annual fishing closure of three consecutive months where landing European eel shall be prohibited. In order to decrease fishing mortality effectively, the closure period shall be defined by the CPCs in their national management plan, together with its fisheries and the gear targeting European eel.

The fishing closure period shall be consistent… …with national management plans in place and with the temporal migration patterns of European eel in the CPC concerned.

This came in to force as of 01/01/19, and as such, in 2019, the EU, in order to '…*establish a level playing field across the Union…*' proposed closures aligned with GFCM measures.

Article 11 of Council Regulation (EU) 2019/124, which relates to 'Measures on European eel fisheries in Union waters of the ICES area' stated:

Any targeted, incidental and recreational fishery of European eel shall be prohibited in Union waters of the ICES area and brackish waters such as estuaries, coastal lagoons and transitional waters for a consecutive three-month period to be determined by each Member State between 1 August 2019 and 29 February 2020. Member States shall communicate the determined period to the Commission not later than 1 June 2019.

Further, Article 42 of the same Regulation, which relates to 'European eel in the Mediterranean Sea (GSAs 1 to 27)' stated:

1. All activities by Union vessels and other Union fishing activities catching European eel, namely targeted, incidental and recreational fisheries, shall be subject to the provisions of this Article.

2. This Article shall apply to the Mediterranean Sea and to brackish waters such as estuaries, coastal lagoons and transitional waters.

3. It shall be prohibited to fish for European eel in Union and international waters of the Mediterranean Sea, for a consecutive three-month period to be determined by each Member State. The fishing closure period shall be consistent with the conservation objectives set out in Regulation (EC) No 1100/2007, with national management plans in place and with the temporal migration patterns of European eel in the Member States concerned. Member States shall communicate the determined period to the Commission no later than one month before the entry into force of the closure and in any case no later than 31 January 2019.

As a consequence, in some EMUs at least, the closures will be different between these two years.

c) The closures legislation described above left it for Member States in the ICES area to select the three months of closures from a five-month period in 2018. In 2019, the updated legislations required Member States to select a three-month period of closure from seven (ICES area) or 12 (GFCM area) months. For the ICES area, the window for closures increased by two months, and did not require that the closed periods be the same months in 2018 and 2019.

These factors have resulted in inconsistencies between closures in 2018 and 2019.

Spatial definitions of habitat types within EMUs (fresh, transitional, coastal, marine) and whether fisheries are located in waters covered by the EU Closures or not

The EU Closure adopted in 2018 specifically related to fisheries in marine waters of the ICES area, while in 2019, this was broadened to include estuaries, coastal lagoons and transitional waters and also the Mediterranean Sea. It is recognised that Member States use different approaches to spatially define some of these terms, and there are potentially inconsistencies in interpretation and application of the EU Closures. For example, it was stated in the German submission, '*…closures were implemented but there were seemingly different interpretations or conflicts with other laws concerning the definition of transitional and coastal waters. Thus, the practical application of closures differed across Germany*.'

Challenges created by the way the data were collected

Designating a closure as being due to the EMP or EU

In simple terms, the comparison between the periods of the EMP implementation versus the EU closures is that of 2007–2017 vs 2018–2019. However, this could be interpreted as a comparison of the closures implemented in response to the EU Eel Regulation (EC 1100/2007) against the more recent EU Closures. The countries reporting to the WK were asked to indicate whether closures were in response to one or other. This difference in interpretation means that where EMP closures are consistent with the requirements of EU closures, there are instances where they have been coded as EMP in the data call. This has had impact on the analysis.

Differences in the way the results could be interpreted

This is not a complication of the analysis, as such, but needs to be considered when interpreting the results. The Regulation obliged Member States to set up their Eel Management Plans, which could include various measures, e.g. reducing commercial fishing activity, restricting recreational fishing. In some cases, this resulted in closures, but these were not explicitly required under the Regulation. So, if a Member State chose not to implement closures between 2007–2017 but did between 2018–2019, they would be following the legislative requirements but not exhibiting consistency between the two periods.

Conclusions

Examining the above complications, it is unsurprising that there were inconsistencies in data between EMP and EU closures. As such, it is important to acknowledge that while we could report that the closures were not consistent between the two time periods, that would not immediately indicate that they did not follow regulations, nor indeed, that they were ineffective in protecting eels. EU closures may expand and/or adjust EMP closures, such that they are better aligned with location, life-stage migration and/or appropriate habitat type, and as a result, are more effective in reducing fishing mortality. This ultimately means they are '*…consistent with the conservation objectives set out in Regulation (EC) No 1100/2007, with national management plans in place and with the temporal migration patterns of European eel in the Member States concerned*' (Council Regulation (EU) 2019/124).

Annex 4: List of participants

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Annex 5: Meeting agenda

WK Meeting at ICES HQ, H. C. Andersens Boulevard 44–46, 1553 Copenhagen V, Denmark, 4th to 6th February 2020, North Sea Room.

Meeting Aim: to draft the Workshop report and Advice

Draft agenda

Tuesday 4th February 2020, start at 1000h.

1000–1030 Introductions and practical information for the WK.

1030–1130 Fisheries and Monitoring subgroup to report on what they have done and found

1130–1230 Fisheries Closures subgroup to report on what they have done and found

1330–1430 Literature Review subgroup to report on what they have done and found.

1430–1530 Finalise report structure

1530–1730 Draft report

Wednesday 5th February 2020

0900–1700 Report drafting.

Thursday 6th February 2020

0900–1700 Discuss and agree the report, and draft the advice

Meeting ends at 1700h on Thursday.

Annex 6: Data call

The data call is inserted in full in the pages below.

Annex 7: Bibliography for the Literature Review

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Annex 8: Review of the draft report of the Workshop on the temporal migration patterns of European eel (WKEELMIGRATION)

21 February 2020

Background

Context and mandate of the Review Committee

The Workshop on the temporal migration patterns of European eel (WKEELMIGRATION) was formed to answer the questions posed by the EC on the temporal migration patterns of European eel in EU areas. This Workshop worked by correspondence, and then met on 4–6 February 2020 in Copenhagen. Its draft report (DR) was circulated on 17 February 2020. During the week of 17 February, a Review Committee (RC) met by correspondence to review the DR. The committee consisted of David Cairns (Canada) (Chair), Martin Castonguay (Canada), and Henrik Sparholt (Denmark).

The contract with committee members defines their task as:

"*Produce a short report that will focus on reviewing whether the group have provided enough evidence based information to answer the specific questions on the request from the EU to ICES regarding migration patterns of European eel according to the agreed process*."

WKEELMIGRATION was also given a Terms of Reference (ToR) which was similar to the request from the EU to ICES. The RC considers that its mandate is to evaluate fulfilment of WKEELMIGRATION's DR with both the EU request and with the ToR.

Code of conduct

In 2018, ICES introduced a Code of Conduct that provides guidelines to its expert groups on identifying and handling actual, potential or perceived Conflicts of Interest. It further defines the standard for behaviours of experts contributing to ICES science. The aim is to safeguard the reputation of ICES as an impartial knowledge provider by ensuring the credibility, salience, legitimacy, transparency, and accountability in ICES work. Therefore, all contributors to ICES work are required to abide by the ICES Code of Conduct.

The chair of the RC raised the ICES Code of Conduct with committee members. In particular, they were asked if they would identify and disclose any actual, potential or perceived Conflict of Interest as described in the Code of Conduct. After reflection, none of the members (including the chair) identified a Conflict of Interest that challenged the scientific independence, integrity, and impartiality of ICES.

Section 1 Request to ICES and Section 2 WK Terms of Reference and Reporting

These sections are intended to help readers understand the background of migration-related EU rules and the role and purpose of the WKEELMIGRATION DR. The DR quotes from the 2018 and 2019 migration-related EU Regulations, the request to ICES, and the ToR. For the 2019 regulation, there are provisions for the Mediterranean areas which interface with GFMC regulations. The ToR for WKEELMIGRATION contains Supporting Information and Scientific Justification sections, which are not presented in the DR.

The RC was uncertain whether it fully understood the closure rules, especially those imposed in 2019 in the Mediterranean area. For example, according to the ToR's Scientific Justification section, in 2019 the scope of the closure was extended to cover also catches in transitional waters, recreational catches and eel at all life stages (i.e. including glass eel and elvers). Does this mean all eels of all stages in all waters of EU Member States? Does it mean recreational catches and catches of all life stages in transitional waters?

The RC recommends that the full text of the relevant EU and GFCM regulations, the request to ICES, and the ToR be put in either the report text or appendices. It further recommends that text be revised to give greater clarity on geographical boundaries, including the boundaries of ICES areas and the extents of GFCM contracting nations, and migration-related rules, especially regarding differences between the Atlantic/Baltic and Mediterranean areas.

The EU migration-related regulation for 2018 does not give criteria by which Member States should choose the three month closure periods, but the regulation for 2019, for the Mediterranean area only, states that the closure period should be consistent with the conservation objectives of the 2007 Eel Regulation. The RC recommends that WKEELMIGRATION consider noting this information in the report.

The DR states without further comment that the 2007 Eel Regulation has been evaluated. The report should note that the evaluation has been published and is available at https://ec.europa.eu/fisheries/sites/fisheries/files/swd-2020-35_en.pdf.

Section 3 Methodology

The DR used landings and indices obtained from a data call, and information in scientific literature, to characterize seasonality of eel migrations. Data from the data call and information from scientific literature were analysed separately, by different methods. However, in some cases series described in scientific publications were also obtained by the data call. The RC recommends that the degree of overlap between series covered by the data call and scientific literature be indicated, so that readers will understand the number of series upon which conclusions are drawn.

The DR measured seasonality in data call datasets by using a Bayesian technique that assigns series to clusters with similar patterns, and seasonality in information from scientific literature by a graphical rank-order method. An important additional potential use of seasonality data is to allow seasonal patterns to be predicted for areas for which field measures are unavailable. Neither the cluster technique nor the rank-order technique is well-suited to this purpose. The RC recommends that migration seasonality be further modelled by regressing peak month of migration against distance from the spawning site and possibly other environmental parameters. If the model has sufficient explanatory power, it could be used to estimate peak migration periods by EMU across the eel's range. This would address the request that information be provided by EMU, if not possible then at the next higher aggregate level.

P. 43, Chapter 6, yellow eel migration

The ToR asks for information on the period of migration of the yellow eel. The text gives convincing evidence that most sources of information are unreliable for this purpose, due to causes that include the frequently non-migratory behaviour of yellow eels and the possibility that monitoring results or catch rates vary due to factors unrelated to migration. Nevertheless the DR conducted an analysis of yellow eel series using the analytic approaches used for clearly migratory phases (glass and silver eels). The RC recommends that seasonality in yellow eel migrations be evaluated only from series that are clearly linked to migration (e.g. fish fence and ladder counts).

Technical edits

P. 5. A list of EU countries that reported landings would be useful (full country names, not just acronyms). Also, are there EU countries where eel fisheries occur that did not report landings? A list of all non-EU countries where European eel fisheries occur would give readers a sense of how widespread is the European eel distribution outside the EU, and also a sense of the potential benefit at the species level of EU-led eel management measures.

P. 7. A map of EMUs would be useful.

P. 7. Table 3.1 gives the number of monitoring datasets obtained from the data call. However, the text says that Table 3.1 gives the number of landings datasets. Numbers of both types of series should be tabulated.

P. 7. Split this sentence that starts as follows in two: "Do the closures in an EMU in 2018/19 follow the EU Closure . . . . "

P. 8. "In view of this, the season was defined per time-series such that the average monthly landings or abundance was calculated . . . " Does this mean landings per month averaged over a year, or does it mean landings of a particular month averaged over all the years of the time-series?

P. 8. "Yet exceeded 5% of the total in average, and the first month of the year for which the catch has exceeded 95% of the total for series in average." The meaning is not clear. There would be few months which have catches >95% of the annual average catch. Does it mean the month by which cumulative catch is >95% of the annual average catch?

P. 8. "Data are not missing for more than five months," It would be clearer to say "data are available for seven months or less per year."

P. 8. "The total number of months per year with zero values was smaller than three." This means that for a series to be retained for analysis it must have ten or more months per year where there are recorded landings or non-zero index values. This is an unexpectedly stringent criterion. It would seem more likely that eel migrations would generally have a duration of several months at most, rather than nearly a year.

P. 10. As a pelagic spawning fish, say "spawning site" (note singular) not "spawning grounds".

P. 16. Figure 4.1. The legend shows four clusters, but there are only three panels that show clusters.

P. 19. According to Figure 4.5, cluster 3 includes two series from Great Britain (not two series from Great Britain or Germany). Cluster 4 includes two series from Ireland and one from Germany (not three series from Ireland).

P. 21. Figure 4.4. This and other plots in this section should indicate the geographic range (i.e. whether or not Mediterranean sites are included).

P. 26. Figure 4.6. It would be useful to indicate the region (Atlantic/Baltic, Mediterranean) and country in the plot.

P. 28. What EMU does the first row of Table 5.1 correspond to?

P. 28. Figure 5.3. Unexpected: 50% reduction in landings due to EU closure in all cases.

P. 33. Modify the last sentence of the first paragraph: "This is not the case, however, thus providing evidence that seasonality of silver eel migration patterns was not affected by implementation of EMPs."

P. 34. This is may be a complicating factor, but not a caveat: Third, the onset of migration is related to geographical location (Amilhat *et al*., 2016; Capoccioni *et al*., 2014) and thus to the distance that migrating eels have to travel to get the Sargasso Sea (Derouiche *et al*., 2016).

P. 39. Figure 5.8. Does grey mean no data? Please specify in legend.

P. 41. Yellow American eels can continue migrating upstream until they reach about 30 cm. The 20 cm cited by Imbert (2010) may not be applicable throughout the range of the European eel.

P. 43. The yellow eel migration section lacks some Swedish dataseries (monitoring in Motala, Stockholm, Dalälven north of Stockholm). These series also point to the ability of elvers and young yellow eels to migrate some 1000 km in the Baltic system (ICES Advice 2007, Book 9). Is it possible that similar longshore migrations occur along the coasts of the Atlantic and the North Sea?

P. 54. "In fact, despite being frequently described as an upstream migration, the movement to colonize a given catchment is not compulsory in their life, and therefore, not a migration." Yellow eels do display partial migrations, with a fraction of yellow eels displaying a genuine upstream migration, which will be seasonal and protracted, taking place over many consecutive seasons before eels become resident at some point.

P. 62. The report states the following: Further, there were a number of EMUs that did not have data submitted, where it was assumed that 'silence' indicated that a fishery did not exist or had already been closed. These assumptions should be tested. How would you plan to test these assumptions once the report is finished? Would this specific topic be revisited at a later stage? If there is no specific plan, suggest deleting the sentence.

Pp. 79–80. Annex 3 on the complexity of comparisons between closures is quite informative, to the point that perhaps it should be brought into the main body of the text.

Conclusions

a) The compilation of data on European eel migratory seasonality, especially for glass eels, is a new and valuable contribution to European eel science, and should be published.

b) The mandate of the RC is to ask if the DR provides sufficient evidence-based information to answer the data request.

Data request Items 1) to 4): Describe the seasonality of glass eel arrival, silver eel departure, yellow eel migrations, and transit through narrow passages (exits of the Baltic and Mediterranean Seas), and whether seasonality has changed substantially since before 2007.

RC's answer: The DR does a thorough job of compiling data on migrating glass and silver eels and transit through narrow passages. The analytic methods (cluster analysis, graphical analysis of ranked data) appear statistically sound. However, these methods don't allow estimation of migratory patterns in areas without field data. Regression modelling might provide such estimations.

Migratory timing of yellow eels is estimated to a large extent from monitoring and landings data that may have little or no connection to eel migrations. A more reliable characterisation of yellow eel migratory timing would come from series which are directly tied to yellow eel migrations

Data request Item 5) (This was modified from the original request). Do the closures applied by Member States conform to the EU Closure Regulation for the Atlantic, Baltic, and Mediterranean areas?

RC's answer: This question was addressed satisfactorily, although the complexity and the high variability of eel management measures precludes firm and complete answers.

c) It is important to understand what WKEELMIGRATION was not asked to do. WKEELMIGRATION was not asked to evaluate whether timing of closures matched eel migration timing, thereby reducing harvest and yielding a conservation benefit. However by assembling and analysing pertinent data WKEELMIGRATION has laid the groundwork for such an evaluation.

Annex 9: Data tables

The data tables can be seen here