JOINT EIFAAC/ICES/GFCM WORKING GROUP ON EELS (WGEEL)

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i Executive summary

The Joint EIFAAC/ICES/GFCM Working group on eels (WGEEL) met by correspondence and video conference from September 21–28 in 2020 to assess the state of the European eel, investigate the effects of habitat loss on the eel stock and its management, review and update the Stock Annex, prepare the 2021 Data Call and report on any updates to the scientific basis of the advice, new and emerging threats or opportunities. Furthermore, data on fisheries landings, aquaculture and restocking are presented.

Analyses were carried out on two glass eel recruitment indices (comprising 28 time-series in the Elsewhere Europe area and 24 time-series in the North Sea) and one yellow recruitment index (comprising 16 time-series). Note, that some data from the current year are always provisional to allow for a small proportion of late reporting series, but this is not considered to materially affect the trends. The potential impacts of COVID-19 on the data collection and quality were noted by the WG and described in detail in the report.

The recruitment of European eel strongly declined from 1980 to 2011. The glass eel recruitment compared to that in 1960–1979 in the "North Sea" index area was 0.5% in 2020 (provisional) and 1.4% in 2019 (final). In the "Elsewhere Europe" index series it was 6.5% in 2020 (provisional) and 5.6% in 2019 (final), based on available dataseries. For the yellow eel dataseries, recruitment for 2019 was 17% (final) of the 1960–1979 level; the 2020 data collection for yellow eel is ongoing. Statistical analyses of the time-series from 1980 to 2020 show that recruitment has stopped decreasing in 2011 but the trend thereafter is rather unclear.

A Bayesian assessment model (GEREM), structured to allow the existence of potential different trends among regions, and provide absolute recruitment per zone has been run. While still preliminary, this model confirms the trend in recruitment, points out the need of new time-series of recruitment, and could in the future allow a part of the analytical assessment of the stock.

The collection of yellow and silver eel series and their biometric data, started last year, has continued and a first analysis has been run. There is a large spatial variability in trends of abundance among locations but the analysis of the long-term time-series shows that current silver eel abundance is low when compared to the pre-1980 levels. The analysis of biometric data allows a first analysis of the biological characteristics of the series and points out missing fields in data collection.

Emerging threats and opportunities that have been reported over the past decade were reviewed, and diseases, parasites, contaminants and hydropower were identified as routinely reported and thus established. Climate change was repeatedly reported in the past; yet knowledge remains limited. Moreover, the threat of the EU exit of the UK raised concerns regarding the accessability of glass eels for stocking and the potentially increased availability of glass eel from the UK being traded illegally to Asia The issue of COVID-19 was addressed and impacts were found to fall largely in three categories: i) scientific monitorings, ii) restocking programmes and iii) closures/delays in commercial fishing and loss of markets.

The WG has a new standing annual activity to examine quantification of the impacts of non-fishery factors and in 2020 i) reviewed the literature on the effects of habitat loss with a focus on the biological processes operating, ii) the national Eel Management Plans and (latest) triannual assessments identifying whether and to what extent the effects of habitat loss have been taken into account, iii) develop a workplan aiming at the quantification of habitat loss and its effect on eel production in the coming years, and iv) present a number of actual case studies. Due to the lack of appropriate data, a meaningful quantitative assessment is not possible at the moment.

Overall, the working group has made progress towards the assessment of the standing stock and spawning–stock biomass (i.e. yellow and silver eel time-series) and the implementation of an additional model for the recruitment data provides towards further analyses (e.g. with respect to regional differences). The WG identified relevant issues for future research, highlighting the limited knowledge on the complex effects of climate change as well as the need for additional and specific data collection to quantify the effects of habitat loss.

ii Expert group information

Expert group name	Joint EIFAAC/ICES/GFCM Working Group on Eels (WGEEL)
Expert group cycle	Annual
Year cycle started	2020
Reporting year in cycle	1/1
Chair	Jan-Dag Pohlmann, Germany
Meeting venue and dates	21–28 September 2020, by correspondence, 48 participants

1 Introduction

1.1 Main Tasks

The **Joint EIFAAC/ICES/GFCM Working Group on Eels** (WGEEL), chaired by Jan-Dag Pohlmann, Thünen Institute, Germany, met by correspondence, from 21–28 September 2020 to:

a) Address the generic EG ToRs from ICES, and any requests from EIFAAC or GFCM;
b) Report on developments in the state of the European eel (*Anguilla anguilla*) stock, the fisheries on it and other anthropogenic impacts;
c) Report on updates to the scientific basis of the advice, including any new or emerging threats or opportunities;
d) Report on the temporal migration patterns of European eel, and seasonality of fisheries and closures, per relevant geographical area with the aim to answer a request from the EU;
e) Review and update the Stock Annex.

In response to the ToR, the Working Group used data and information provided in response to the Eel Data call 2020 (from 22 countries) and 18 Country Report Working Documents submitted by participants (Annex 6); other references cited in the Report are given in Annex 3. A list of acronyms and glossary of terms used within this document is provided in Annex 4.

1.2 Participants

47 experts attended the meeting, representing 20 countries, along with an observer from the European Commission DG MARE. A list of the meeting participants is provided in Annex 1.

1.3 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 2020 WGEEL meeting, and for all newcomers later in the 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. Four members declared a potential CoI and offered to remove themselves from relevant discussions. The Chair, in consultation with the ICES Secretariat, considered that there was none.

1.4 The European eel: Stock Annex

The Stock Annex has been reviewed and updated and is due for another revision latest in 2023. See Chapter 6 and Annex 7.

1.5 The European eel: life history and production

During its continental phase the European eel (*Anguilla anguilla*) is distributed across the majority of coastal countries in Europe and North Africa, with its southern limit in Morocco (30°N), its northern limit situated in the Barents Sea (72°N) and spanning the entire Mediterranean basin.

The European eel life history is complex, being a long-lived semelparous and widely dispersed stock. The shared single stock is considered genetically panmictic and data indicate that the spawning area is in the southwestern part of the Sargasso Sea. The newly hatched leptocephalus larvae drift with the ocean currents to the continental shelf of Europe and North Africa, where they metamorphose into glass eels and enter continental waters. The growth stage, known as yellow eel, may take place in marine, brackish (transitional), or freshwaters. This stage may last typically from two to 25 years (and can exceed 50 years) prior to metamorphosis to the "silver eel" stage, maturation and spawning migration. Strong sexual dimorphism occurs in eels with males maturing at a younger age and smaller size. For details on the eel life cycle see Stock Annex, Annex 7.

The abundance of glass eel arriving in continental waters declined dramatically in the early 1980s to a low in 2011. The reasons for this decline are uncertain but anthropogenic impacts and oceanic factors are assumed to have major impacts on the stock. For a detailed description of factors affecting the eel stock, see Stock Annex. These factors will likely affect local production differently throughout the eel's range. In the planning and execution of measures for the recovery, protection and sustainable use of the European eel, management must therefore account for the diversity of regional conditions.

1.6 The management framework for European eel

1.6.1 EU Member State waters

Within EU Member State waters, the stock, fisheries and other anthropogenic impacts, are currently managed in accordance with Council Regulation (EC) No 1100/2007, (so-called 'Eel Regulation', EU Council 2007) "*establishing measures for the recovery of the stock of European eel*" (EU Council, 2007). This regulation sets a framework for the protection and sustainable use of the stock of European eel in EU Waters, coastal lagoons, estuaries, and rivers and communicating inland waters of Member States that flow into the seas in ICES Areas 3, 4, 6, 7, 8, 9 or into the Mediterranean Sea. For details, see the Stock Annex. Eel fisheries in EU waters are further regulated in Council Regulation (EU) No 2019/124 'Fishing Opportunities' (EU Council, 2019) and in the Commission Implementing Decision (EU) No 2018/1986 'Specific Control and Inspection Programme' (EC, 2018). General Fisheries Commission of the Mediterranean (GFCM).

The critical status of the European eel stock has been acknowledged for the Mediterranean since 2010, when a GFCM Transversal Workshop on European Eels was held in Tunisia (Salambô, Tunisia, 23–25 September 2010). Here the development of management plans for the European eel covering all subregions of the Mediterranean was recommended, as well as the engagement of GFCM in the Joint EIFAAC/ICES Working Group on Eels. In this regard, the GFCM Secretariat undertook a number of steps, and at its 37th session (2013), the GFCM Commission agreed to support an Eel Pilot Action to build a coordinated management framework for the European eel in the Mediterranean Sea. Therefore, the necessity for integration of the Mediterranean Region within the stock-wide coordination of actions for the European eel was fully acknowledged (Aalto *et al.*, 2016).Work is ongoing towards the development of an adaptive regional management plan for eel in the Mediterranean Region under the auspices of the GFCM. The GFCM Commission approved recommendation GFCM/42/2018/1 on a multiannual management plan, in the Mediterranean Sea, also promoting a specific research programme (FAO, 2019). The GFCM Research programme on European eel: towards coordination of European eel stock management and recovery in the Mediterranean has started officially in September 2020, and involves nine Countries in the Mediterranean area. The programme's general objective is to deal with issues relevant to the setting up of a coordinated framework for management, through data and information collation, collection, and analysis as well as the creation of a network of experts and institutions. For details, see Stock Annex.

1.6.2 Other countries

WGEEL receives data from EU and non-EU countries and GFCM supports more countries to achieve this. The Eel Regulation only applies to EU Member States, although other states may engage in the case of transboundary management plans, but some non-EU countries are involved in the provision of data, and reference points since many years (e.g. Norway, UK). Others have only recently been involved and further development of assessment procedures and feedback mechanisms might be required to involve them in future standardisation processes. For details, see Stock Annex.

1.6.3 Other international actors

The European eel was listed in Appendix II of the **Convention on International Trade in Endangered Species of Wild Fauna and Flora** (**CITES**) in 2007. Since 2009 when the listing came in to force, any international trade in this species needs to be accompanied by a permit. Since 2010, export out of, and import to, the EU is not allowed. The **International Union for the Conservation of Nature** (**IUCN**) listed the European eels as Critically Endangered in 2008. It was reassessed in both 2013 and 2018, and the status remains unchanged. In 2014, the European eel was added to Appendix II of the **Convention on the Conservation of Migratory Species of Wild Animals** (**CMS**), whereby signatories call for cooperative conservation actions to be developed among Range States. The European eel *Anguilla anguilla* was included on the OSPAR List of threatened and/or declining species and habitats in 2008. In 2014, the **Convention for the Protection of the Marine Environment of the North-East Atlantic** (**"OSPAR Convention"**) issued a recommendation to strengthen the protection of the European eel at all life stages in order to recover its population and to ensure that it was effectively conserved. The Baltic Sea Action Plan (BSAP) of the **Baltic Marine Environment Protection Commission (HELCOM**) contains several targets for the European eel. For details, see the Stock Annex.

1.7 Assessments to meet management needs

The European Commission obtains both recurring and *ad hoc* scientific advice from ICES on the state of the eel stock, the management of the fisheries and other anthropogenic factors that impact it, as specified in the Administrative Agreement between European Commission and ICES for 2019 (EU, 2019). In support of this advice, ICES is asked to provide the European Commission with: estimates of catches; fishing mortality; recruitment and spawning stock; relevant reference points for management; information about the level of confidence in parameters underlying the scientific advice and the origins and causes of the main uncertainties in the information available (e.g. data quality, data availability, gaps in methodology and knowledge). The Commission Implementing Decision (EU) No 2019/909 (Data Collection Framework, DCF; EC, 2019), requires Member States data, collected through this framework, to be made available to end-users, such as ICES.

ICES requests information from national representatives to the WGEEL on stock parameters, landings, restocking, and time-series (e.g. recruitment, yellow eel abundance, silver eel escapement). In July 2020, ICES issued a Data Call to request some of this information, and this was also advertised by EIFAAC and GFCM to their memberships (see below for further details).

The status of eel production in EU and non-EU Eel Management Units (Figure 1.1) is assessed by national or subnational fishery and/or environment management agencies. The terminology Eel Management Unit (EMU) has been used by WGEEL and others for several years now but with various and unrecorded definitions leading to some confusion. It most often represents a management area for eel, corresponding to a river basin district (RBD) as defined in the Water Framework Directive (WFD; EU, 2000). However, in cases of stock assessments at other spatial scales, and for stock parts lying outside the EU, EMUs have also been defined, either as being the management units used by the country (e.g. Tunisia) or as the whole country. In practice, data provision from some EMUs can be divided into further geographical subunits. This is, for instance, the case for Sweden where the EMU is national, but data can be provided to the WGEEL according to inland, west and east coast subunits. The catch from coastal areas does include eels migrating from other countries or parts of the Baltic.

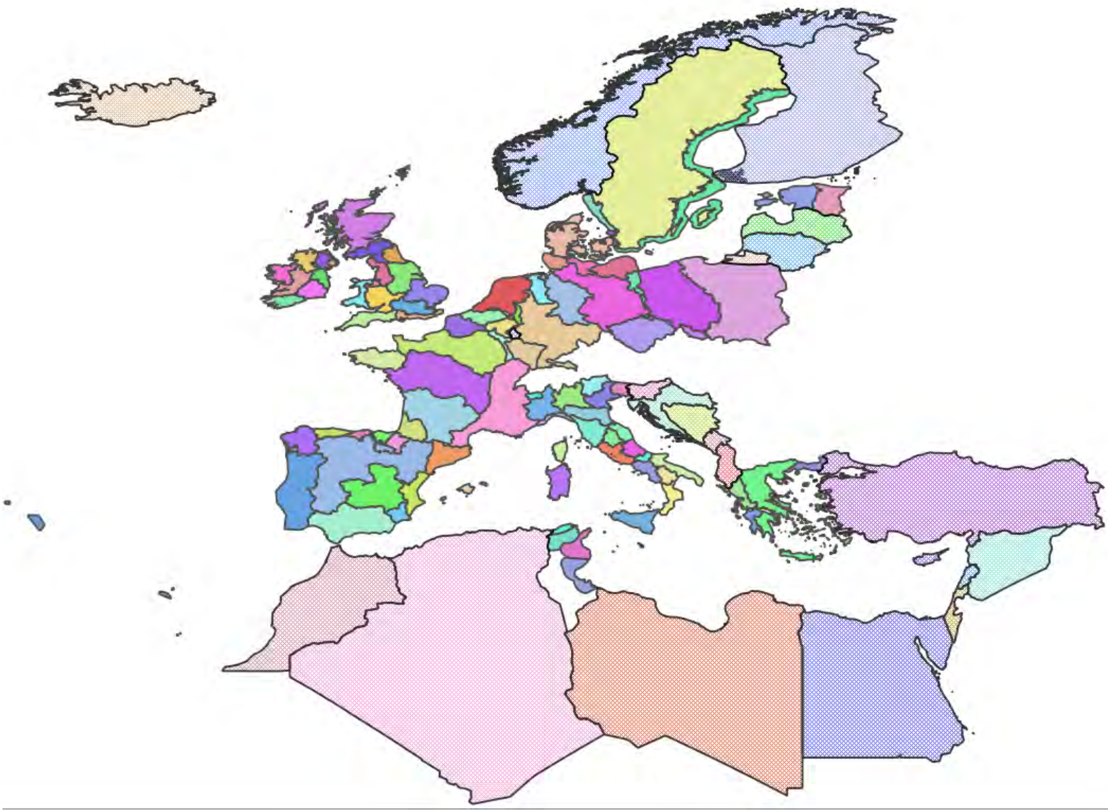

Figure 1.1. Current map of Eel Management Units (EMUs) as reported by countries or corresponding to national entities where no EMU is described at the national level.

The setting for data collection varies considerably between, and sometimes within, countries, depending on the management actions taken, the presence or absence of various anthropogenic impacts, but also on the type of assessment procedure applied. Accordingly, a range of methods may be employed to establish silver eel escapement limits (e.g. the Eel Regulation's ≥40% of B_0), management targets for individual rivers, river basins, RBDs, EMUs and nations, and for assessing compliance of current escapement with these limits/targets (e.g. for the Eel Regulation comparing $B_{current}$). These methods require various combinations of data on e.g. landings, recruitment length/age structure, restocking, abundance (as biomass and/or density) or maturity ogives, in order to estimate silver eel biomass, fishing and other anthropogenic mortality rates.

The ICES Study Group on International Post-Evaluation of Eel (SGIPEE) (ICES, 2010; 2011) and WGEEL (FAO and ICES, 2010; 2011) derived a framework for *post-hoc* combination of EMU / national 'stock indicators' of silver eel escapement biomass and anthropogenic mortality rates to an international total.

In 2019, WGEEL considered the consequences of the Precautionary Approach on advice for European eel. Based on the FAO Code of Conduct, the ICES form of advice, and the Eel Regulation, the WG developed a proposal for a coherent framework for advice on eel, consisting of a double-tiered approach: an international tier focused on the status of the whole stock and a national (or lower) tier focused on mortality levels and related management actions. In the light of this debate, the upcoming Workshop on the Future of Eel Advice (WKFEA, chaired by Estibaliz Diaz, Spain and Alain Biseau, France) will discuss the current advice, consider options for future assessment/advice and draft a roadmap towards potential new or additional advice on fishing opportunities for the European eel.

1.8 Data Call

The WGEEL annually collates data on eel in support of its work. Prior to 2017, these data were provided by countries attending the WGEEL in many complex spreadsheets, and reporting was incomplete both because some countries did not participate in the WGEEL and because of partial reporting by other countries. A Data Call hosted by ICES, EIFAAC and GFCM and covering all natural range states of the European eel was initiated in 2017, and is considered an effective mechanism to significantly improve the situation of data provision and use. For details, see the Stock Annex).

In the 2020 Data Call data on recruitment, fishery landings, recreational landings, aquaculture production, restocking, biometry and yellow eel abundance and silver eel escapement time-series were requested. The call also required the provision of metadata associated with all data.

In response to the 2019 Data Call, all national representatives gave their consent to the public use of the data stored in the database and used in the report, until revoked.

2 ToR A: Address the generic EG ToRs from ICES, and any requests from EIFAAC or GFCM

2.1 ICES Generic ToRs for Expert (Working) Groups

ICES set generic ToR for Expert Groups in 2020. Those that were considered by the WGEEL are listed below, with responses provided either following the generic ToR, in subsequent chapters of this report, the Stock Annex or in separate documents provided to ICES.

a) Consider and comment on Ecosystem and Fisheries overviews where available;

WGEEL 2020 response

The Ecosystem and Fisheries Overviews were reviewed and a list is provided below with links to the Overviews and detail of where the European eel is listed therein. WGEEL notes the following:

- There is some inconsistency in the manner in which European eel is treated across the EO and FO, with more or less detail, and there are omissions. The consistency and completeness could be improved in a future iteration of the EO and FO. WGEEL suggests that a representative from each Ecoregion could contribute directly to the next revisions of these Overviews.
- European eel is missing from the Azores EO and should be added.
- Some "Who is fishing" sections in the FO are incomplete in terms of eel fisheries.
- Detail on the bycatch of eel in some Norwegian Sea fisheries is welcomed, and the WGEEL would appreciate similar investigations from other FO.

Ecosystem overviews

Azores: The European eel is present in this ecosystem but is not listed in the overview.

WGEEL - It should at least be listed under the section on "Threatened and declining species and habitats". This section refers to "according to OSPAR" so the OSPAR listing should be checked also.

Baltic Sea: The European eel is listed under sections on "Key signals within the environment and ecosystem"; "Selective extraction of species, including incidental non-target catch"; and, "Impacts on threatened and declining fish species".

Barents Sea: The European eel is listed under section "Threatened and declining species and habitats".

Bay of Biscay and the Iberian Coast: The European eel is listed under sections on "Selective extraction of species: Impacts on commercial stocks"; "Impacts on threatened and declining fish species"; State of the ecosystem: fish"; and, "Threatened and declining species and habitats".

Celtic Seas: The European is eel listed under section "Threatened and declining species and habitats".

Greater North Sea: The European eel is listed under section "Threatened and declining species and habitats".

Icelandic Waters: The European eel is listed under section "Threatened and declining species and habitats".

Norwegian Sea: The European eel is listed under section "Threatened and declining species and habitats".

Oceanic Northeast Atlantic: The European eel is listed under sections "State of the ecosystem: Fish"; and, "Threatened and declining species and habitats".

Fisheries Overviews

Baltic Sea: The European eel is listed under sections "Who is fishing: Denmark; Poland; Sweden"; "Catches over time"; "Description of the fisheries: Longline; Trapnets and fykenets"; and, "Summary of Baltic Sea stocks in 2019".

> WGEEL – Other countries should be listed under "Who is fishing", and perhaps therefore the "Catches over time" and "Description of the fisheries" sections might need some revision.

Barents Sea: The European eel is listed under sections "Status of the fishery resources"; and, "List of stocks".

Bay of Biscay and Iberian Coast Region: The European eel is listed under sections "Description of the fisheries: Artisanal"; "Status of the resource"; and, "List of stocks".

> WGEEL – Artisanal fishing for eel is listed in the "Description of fisheries" but there are no countries listed in the "Who is fishing" – the latter should list France, Spain and Portugal if the spatial area includes estuaries.

Celtic Seas: The European eel is listed under sections "Description of the fisheries: Other fisheries"; "Status of the resource"; "Summary of Celtic Seas ecoregion stocks in 2019" and, "Scientific names of species".

> WGEEL – Eel is listed in the "Description of fisheries" but there are no countries listed in the "Who is fishing" – the latter should be updated.

Greater North Sea: The European eel is listed under sections "Description of the fisheries"; "Status of the resource"; "Summary of Greater North Sea ecoregion stocks in 2019" and, "Scientific names of species".

> WGEEL – Eel is listed in the "Description of fisheries" but there are no countries listed in the "Who is fishing" – the latter should be updated.

Icelandic Waters: The European eel is not mentioned.

Norwegian Sea: The European eel is listed under sections "Bycatch of protected, endangered, and threatened species"; "Status of the resource" and, "Scientific names of species".

> WGEEL – the detail on Bycatch is very useful as "Around 80 000 eels are caught as bycatch in the coastal trap fisheries for wrasse, but the majority of these are released unharmed. Eels migrate through the Norwegian Sea, but there is currently no significant marine fishery targeting eel." The WGEEL would like to ask the other Fisheries Overviews to confirm qualitatively or quantitatively whether or not they have bycatches of eel.

b) For the aim of providing input for the Fisheries Overviews, consider and comment for the fisheries relevant to the working group on:

1. descriptions of ecosystem impacts of fisheries

WGEEL – no new descriptions are available at this time.

2. descriptions of developments and recent changes to the fisheries

WGEEL – Since 2018, a closure of 3 consecutive months for eel commercial fishing has been in place at the EU level for eels above 12 cm in Union waters of ICES area, including in the Baltic Sea. This closure has been extended in 2019 to cover commercial and recreational fisheries for all eel life stages in EU marine and brackish waters in the North East Atlantic and the Mediterranean Sea. Such measures were rolled over to 2020. More details are available in the report of WKEELMIGRATIONS (ICES, 2020a).

3. mixed fisheries considerations, and

WGEEL – new data on bycatch of eel in marine fisheries targeting other species in the Norwegian Sea are reported in the Fisheries Overview for that ecoregion. The WGEEL does not have such data for other fisheries, but recognises it would be valuable to confirm what exists and to collate it.

4. emerging issues of relevance for the management of the fisheries;

WGEEL – Chapter 4.2 of this report describes emerging issues. Of particular note are COVID-19, the stocking of larger eels and climate change.

c) Conduct an assessment on the stock(s) to be addressed in 2020 using the method (analytical, forecast or trends indicators) as described in the stock annex and produce a **brief** report of the work carried out regarding the stock, summarising where the item is relevant:

1. Input data and examination of data quality;

WGEEL response: see Chapter 3

2. Where misreporting of catches is significant, provide qualitative and where possible quantitative information and describe the methods used to obtain the information;

WGEEL response: see Chapter 3

3. For relevant stocks (i.e., all stocks with catches in the NEAFC Regulatory Area) estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area in 2019.

WGEEL response: NEAFC stretches from southern tip of Greenland, east to the Barents Sea and south to Portugal (from their website) but the map shows that it is only outside the national waters. There is no eel fishing in the NEAFC area.

4. Estimate MSY proxy reference points for the category 3 and 4 stocks

WGEEL response: it is not possible to estimate MSY proxy reference points for the European eel; however, Chapter 5 of the WGEEL 2019 provided the most recent some discussion on this topic, and the Workshop on the Future of Eel Advice (WKFEA) will address this area in the coming months. WGEEL considers that the establishment of an appropriate and effective framework for the advice under the principles of the precautionary approach is a matter of urgency.

5. The developments in spawning–stock biomass, total stock biomass, fishing mortality, catches (wanted and unwanted landings and discards) using the method described in the stock annex;

WGEEL response: see Chapter 3.

6. The state of the stocks against relevant reference points;

WGEEL response: see Chapter 3.

7. Catch scenarios for next year(s) for the stocks for which ICES has been requested to provide advice on fishing opportunities;

WGEEL response: Historical total landings and effort data are incomplete. In addition, there was a great heterogeneity among the time-series of landings due to inconsistencies in reporting by, and between, countries. However, there has been a considerable improvement in both data consistency and area coverage since the introduction of a standardised eel Data Call in 2017. Changes in eel management practices have also affected commercial and non-commercial/recreational fisheries and the reporting of these fisheries. Therefore, ICES does not have the information needed to provide a reliable retrospective time-series of eel catch across the species' range, and as such, it is not used for the Advice. Furthermore, the understanding of the stock dynamic relationship is not sufficient to determine/estimate the level of impact that fisheries or non-fisheries anthropogenic factors (at the glass, yellow, or silver eel stage) have on the reproductive capacity of the stock.

NOTE: In response to the Eel Regulation, stock and mortality indicators were reported at the EMU level every three years since 2012; yet, they don't cover the whole species' range.

NOTE: The impact of recreational fisheries on the eel stock remains largely unquantified although landings can be thought to be at a similar order of magnitude to those of commercial fisheries.

8. Historical and analytical performance of the assessment and catch options with a succinct description of quality issues with these. For the analytical performance of category 1 and 2 age-structured assessment, report the mean Mohn's rho (assessment retrospective (bias) analysis) values for R, SSB and F. The WG report should include a plot of this retrospective analysis. The values should be calculated in accordance with the "Guidance for completing ToR viii) of the Generic ToRs for Regional and Species Working Groups - Retrospective bias in assessment" and reported using the ICES application for this purpose.

WGEEL response: The performance of the assessment has not been formally reviewed. However, the trends in recruitment indices have been confirmed using a different analyticial approach (GEREM). No catch options have been proposed so there is nothing to review.

d) Produce a first draft of the advice on the stocks under considerations according to ACOM guidelines.

A first draft of the advice on the European eel stock has been provided to ICES as a separate document.

e) Review progress on benchmark processes of relevance to the Expert Group;

WGEEL response: The European eel has not been benchmarked and this is not scheduled on the ICES calendar in the next few years. However, a process for an eel benchmark was outlined in Chapter 5 of the WGEEL 2019 report and the WKFEA will progress this in the coming months.

f) Prepare the data calls for the next year update assessment and for planned data evaluation workshops;

WGEEL response: the data call for 2021 has been discussed within the WGEEL and a draft will soon be discussed with ICES for publication as soon as possible.

g) Identify research needs of relevance for the work of the Expert Group.

WGEEL response: see chapter 4 and Annex 9.

h) Review and update information regarding operational issues and research priorities and the Fisheries Resources Steering Group SharePoint site.

Research needs and operational issues will largely depend on the outcome of WKFEA in February 2021 and will thus be updated afterwards.

i) Take 15 minutes, and fill a line in the audit spread sheet 'Monitor and alert for changes in ecosystem/fisheries productivity'; for stocks with less information that do not fit into this approach (e.g. higher categories >3) briefly note in the report where and how productivity, species interactions, habitat and distributional changes, including those related to climate-change, have been considered in the advice.

WGEEL has filled in the audit spread sheet and it is provided to ICES in a separate document.

2.2 Additional requests from EIFAAC or GFCM

In 2020, there were no additional requests from EIFAAC or GFCM.

3 ToR B: Report on developments in the state of the European eel (*Anguilla anguilla*) stock, the fisheries on it and other anthropogenic impacts

This part relates to ToR c, conduct an assessment on the stock, and j, prepare the data call for the next year. ToR c should cover a brief description of examination of data quality. This part is covered in the stock annex revision this year.

This chapter presents:

- the current analysis of trends in recruitment, for both glass eel and young yellow eel (dominated by recruits from the current year) and older yellow eel series,
- a brief description of the application of the GEREM model to assess recruitment in a Bayesian framework and the main conclusions from that work, the GEREM model is presented as a working paper at the end of the document,
- a first analysis of the trends in standing stock for yellow eel, and escapement of silver eels to the sea,
- an exploratory analysis of the new biometric data along with recommendations for further development and inclusion,
- A section presenting recommendations for next year's data call.

3.1 Recruitment

3.1.1 Data source

In this section, the latest trends in glass and yellow eel recruitment are addressed. The time-series data are derived from fishery-dependent sources (i.e. catch records) and also, from fishery-independent surveys across much of the geographic range of European eel. The stages are categorized as:

- glass eel (G), continental age 0 years,
- a mixture of glass eel and young yellow eel dominated by recruits from the same year (GY), and
- older yellow eel (Y) recruiting to continental habitats. The yellow eel series might consist of yellow eel of several ages. This is certainly the case for all series from the Baltic (mean age up to 6), some Irish sites, and sites located far upstream.

The glass eel recruitment time-series have been grouped into two geographical areas: 'continental North Sea' (NS) and 'Elsewhere Europe' (EE) (Figure 3.1.1). Previous analyses by the Working Group (FAO and ICES, 2010, p19; Bornarel *et al.*, 2018) have shown a different trend between the two sets. This is mostly due to a more pronounced decline of the 'North Sea' series compared to the 'Elsewhere Europe' series during the 1980s.

The WGEEL has collated information on recruitment from 95 time-series. Some of the time-series date back to the beginning of 20th century (yellow eel, Göta Älv, Sweden) or 1920 (glass eel, Loire, France). Among those series, 68 have been selected for further analysis in the WGEEL indices; see details on data selection and processing below. Depending on the standardization period, the number of series used can be lower and is given for each analysis.

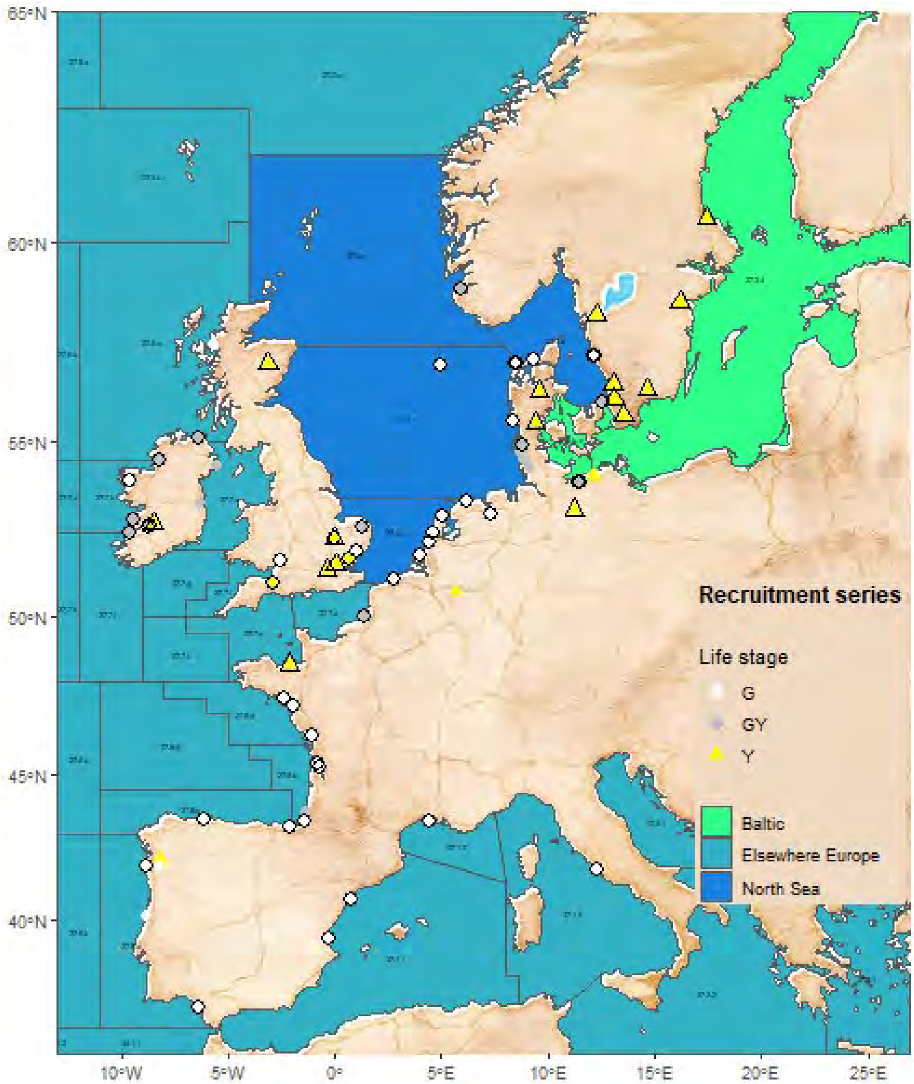

Figure 3.1.1. Map of recruitment sampling stations; the background source is the stamen watercolour openstreetmap. Bordered symbols (with a black line) are sites selected in the glm recruitment analysis.

3.1.2 Data selection and processing

Out of 95 series, 68 were used in the analysis (see Annex 8). Three rules have been used for this selection procedure:

- First, if there are two or more series from the same location, i.e. they are not independent, only one series is kept. For instance, the longer series was kept for the Severn (Severn EA) while the other series (Severn HMRC) was dropped from the list, because the two series were considered to be duplicates being based on the same fishery. Noting that the 'Severn' here actually represents all the glass eel fisheries for England and Wales but the naming convention has been used for many years so is retained for consistency.
- Second, time-series have to be at least ten years long. If a series is less than ten years long, it is excluded from the analysis. The series are, however, stored in the database until they are long enough to be included. Series FlaG, BroG, BroY, HellGY, OriaG and GuadG have been included in the analysis this year because they were had reached the ten year limit.
- Third, recruitment series that were obviously biased by restocking were excluded (e.g. Farpener Bach in Germany).

3.1.3 Number of series available

The indices for 2019 that were reported as provisional in the WGEEL 2019 report, have been updated and the final values were used in the analyses and reported here. Among the time-series based on trap indices, some have reported preliminary data for 2020 as their trapping season had not finished. Similarly, a single fisheries series has not reported for 2020 yet because of COVID-19 disruption (see also Chapter 4.2.1). As in reports from previous years, the indices given for 2020 are provisional.

The number of glass eel and glass eel + young yellow eel time-series available declined from a peak of 41 available in 2015 to 34 in 2020. The maximum number of yellow eel time-series increased to 16 in 2019 (but only seven were already available for 2020, Figure 3.1.2). Details about the series available in 2019 and 2020 are listed in Annex 8.

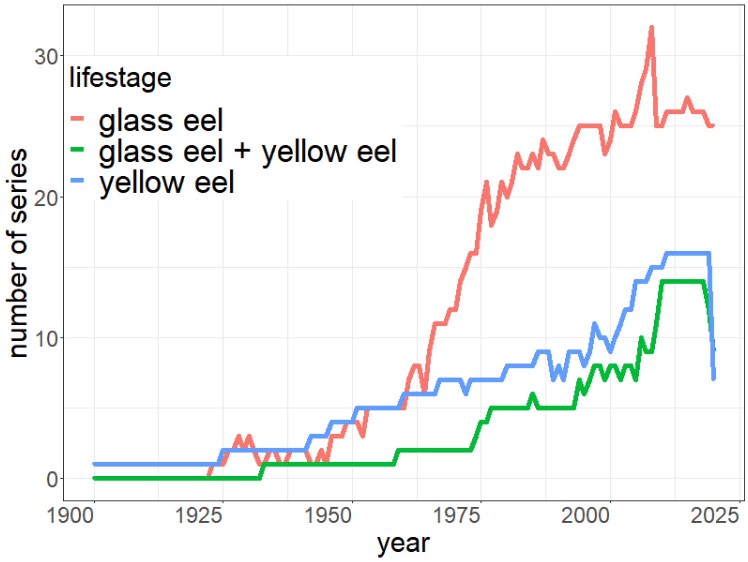

Figure 3.1.2. Trends in number of glass eel (red), glass+young yellow eel (green) and older yellow eel (blue) time-series reported in any specific year.

3.1.4 Generalised Linear Model (GLM) based trend

The WGEEL recruitment index used in the ICES Annual Stock Advice is fitted using a GLM with a Gamma distribution and a log link: *glass eel ~ year : area + site*, where *glass eel* are the individual glass eel time-series, including both pure G series and those identified as a mixture of glass and yellow eel (G+Y), *site* is the site monitored for recruitment, *area* is either the continental 'North Sea' (NS) or 'Elsewhere Europe' (EE), and *year* is the year coded as a categorical value. For yellow eel time-series, only one estimate is provided: *yellow eel ~ year + site*.

The trend was hindcast using the predictions from 1960 onwards for 52 glass eel time-series and from 1950 onwards for 16 yellow eel time-series. True zero values were excluded from the GLM analysis: 17 for the glass eel model and 20 for the yellow eel model. This treatment is parsimonious, and tests showed that it has no effect on the trend (ICES, 2017). The predictions are given in reference to the geometric mean of the 1960–1979 period.

The 2019 report gave provisional data for the 2019 values. These values are now updated. As a consequence, the level of European eel recruitment in 2019 compared to the 1960–1979 average has changed compared to last year's report. The final 2019 values remain unchanged from the provisional values reported last year for the NS (1.4%) and have decreased from 6.0% to 5.6% for the EE series.

For 2020, data are provisional and give estimates of 0.5% for the NS series and 6.5% for the EE series (Figure 3.1.3, Table 3.61.2). Note that for 2020, 12 series (six NS and four EE) have been partially impacted by COVID-19 (see also Chapter 4.2.1).

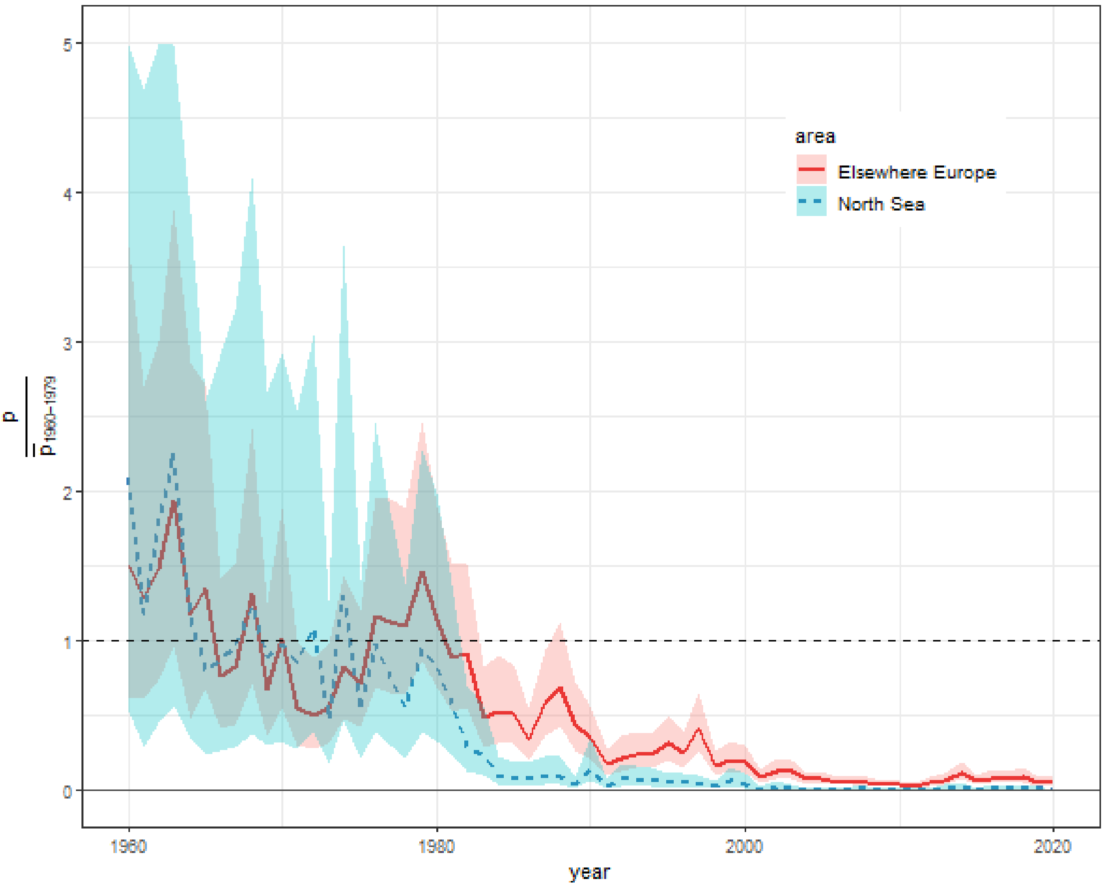

Figure 3.1.3. WGEEL recruitment index: estimated (GLM) glass eel recruitment for the continental 'North Sea' and 'Elsewhere Europe' series with 95% confidence intervals updated to 2020. The GLM (*glass eel ~ area : year + site*) was fitted on 52 time-series comprising either only glass eel or a mixture of glass eel and yellow eel. The predictions (*p*) were scaled to the 1960–1979 average ¯p1960–1979 (dashed line). In the Baltic area, recruitment occurs in the yellow eel stage only and so does not feature in this figure.

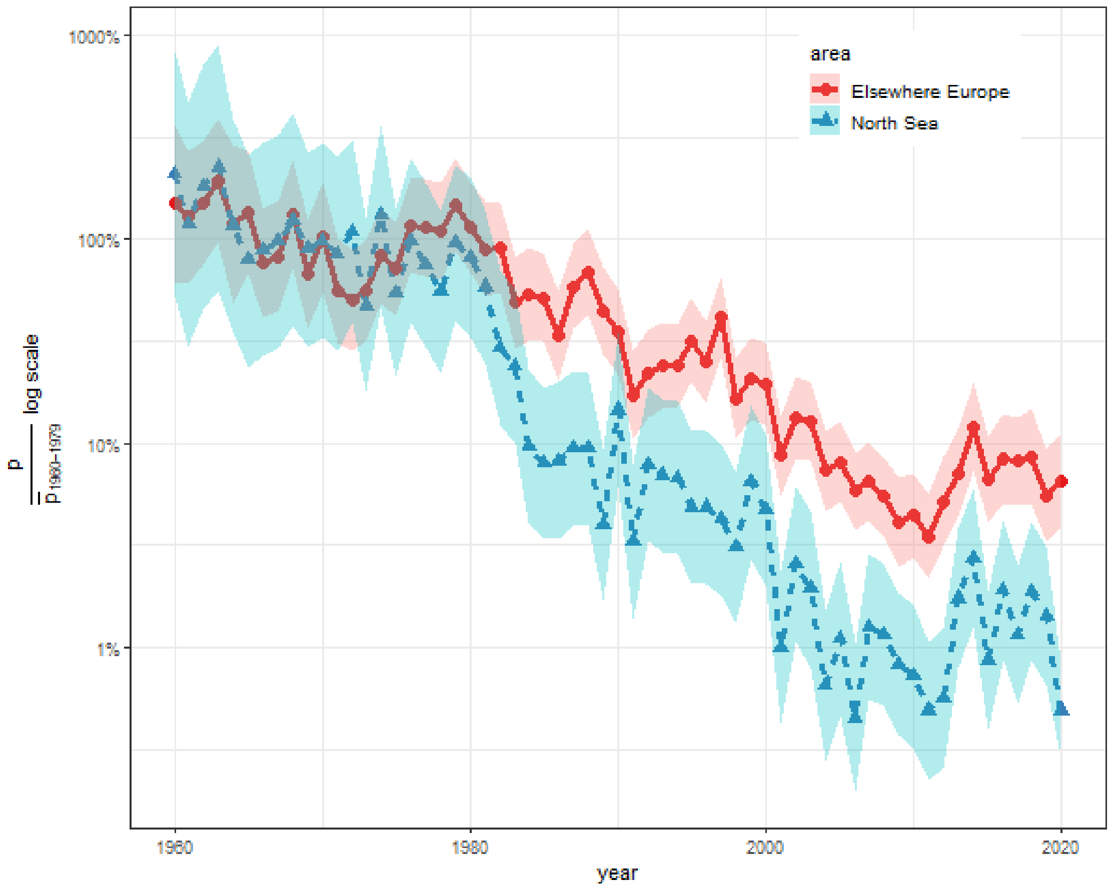

Figure 3.1.4. WGEEL recruitment index: estimated (GLM) glass eel recruitment for the continental 'North Sea' and 'Elsewhere Europe' series with 95% confidence intervals updated to 2020. The GLM (*glass eel ~ area : year + site*) was fitted on 52 time-series comprising either only glass eel or a mixture of glass eel and yellow eel. The predictions (*p*) were scaled to the 1960–1979 average ¯p1960–1979 (dashed line). In the Baltic area, recruitment occurs in the yellow eel stage only and so does not feature in this figure. Note the log scale.

For yellow eel series, most of the series have reported data until the middle of the summer and are incomplete, two series reporting in 2020 are affected by COVID-19. Therefore, the 2020 index is provisional. However, the provisional data for 2019 used in last year's report was updated and finalised: the 2019 yellow eel index was at 17% of the 1960–1979 baseline (Figure 3.1.5).

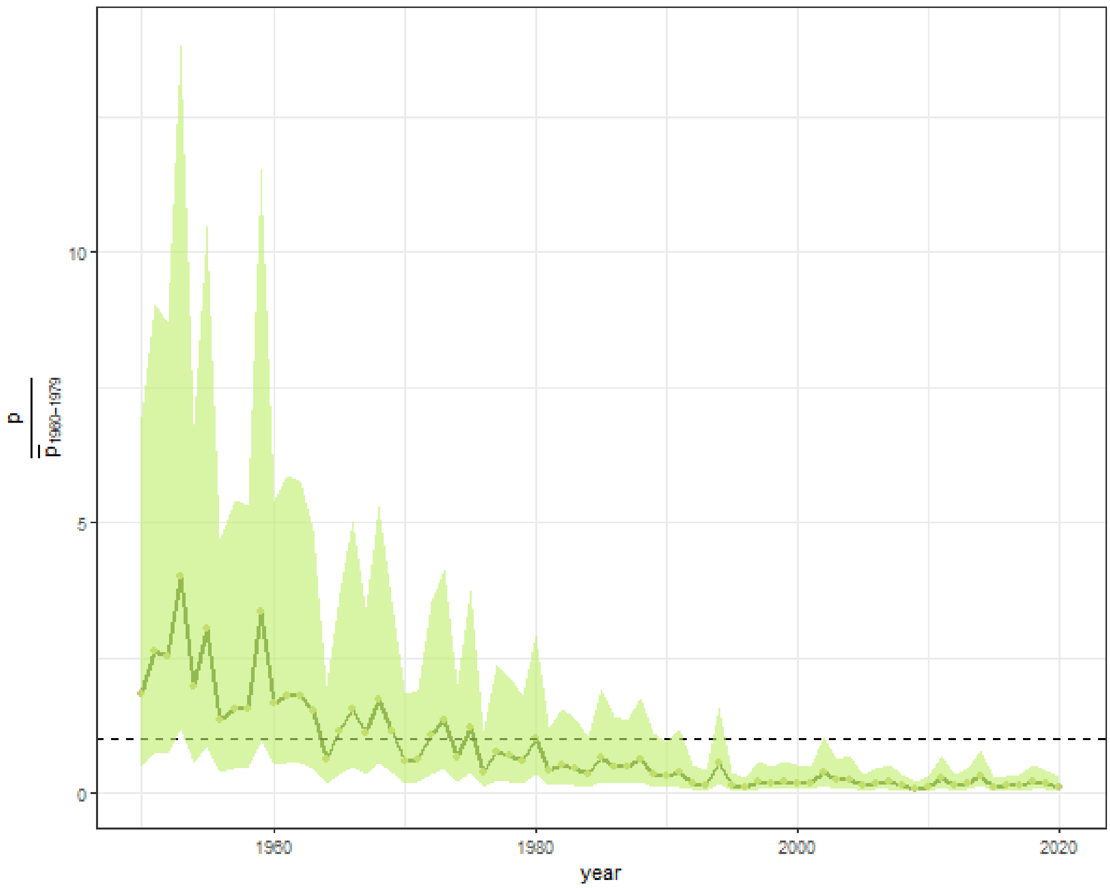

Figure 3.1.5. Yellow eel GLM recruitment trend and 95% confidence interval for Europe updated to 2020. The GLM (*yellow eel ~ year + site*) was fitted to 16 yellow eel time-series (p) and scaled to the 1960–1979 average ¯p1960–1979 (the dashed line).

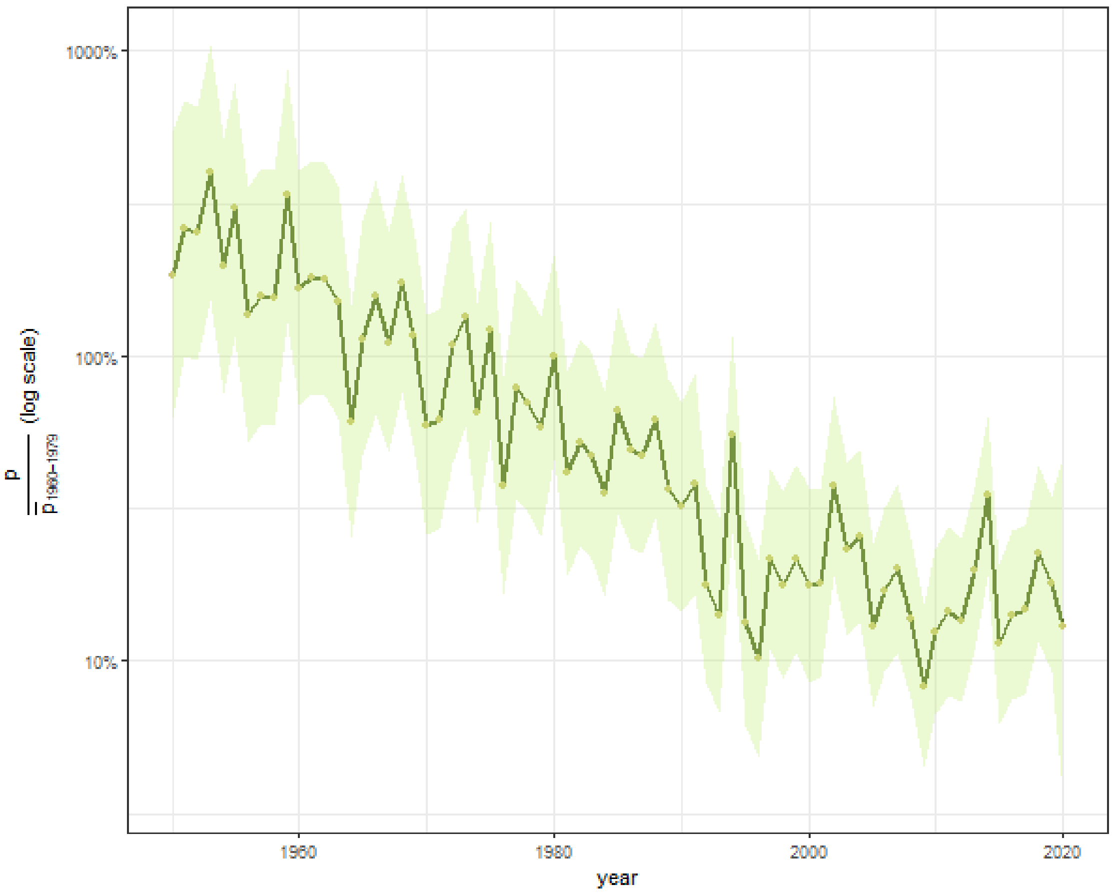

Figure 3.1.6. Yellow eel GLM recruitment trend and 95% confidence interval for Europe updated to 2020. The GLM (*yellow eel ~ year + site*) was fitted to 16 yellow eel time-series (p) and scaled to the 1960–1979 average ¯p1960–1979 (the dashed line). Note the log scale.

3.1.5 Is there a positive trend in glass eel recruitment indices?

After high levels in the late 1970s, the recruitment indices declined. In 2014, ICES identified a change in the trend of glass eel recruitment indices after 2011 (ICES, 2011 (method), ICES, 2014).

To test if the trend after 2011 is significant and positive, a model based on individual series as source data is used, where 'year' is modelled as a continuous value, whereas it is modelled as a factor in the GLM for recruitment. Also, the years used in the model are restricted to the after 1980 period, when recruitment started to decline:

$$glass\ eel \sim \alpha_{site} site + \beta_{area} Y_{\geq 1980} + \gamma_{area} Y_{>2011} + \epsilon$$

- where *glass eel* are glass eel and glass eel + yellow eel time-series, either for the 'Elsewhere Europe' or the 'North Sea' time-series,
- Y>=1980 is year (continuous) value corresponding to year from 1980 onwards,
- Y>2011 is year (continuous) from 2012 onwards,
- α_{site}, β_{area} and γ_{area} are the estimated parameters, and
- ε is a random error with mean 0 and standard deviation sigma.

To test whether there is a statistically significant change in the slope of the recruitment occurred since 2011, the coefficients for parameter gamma are tested. If significant, they indicate that a model with two lines, one before 2011 and one after, provide a better fit than a single regression line for the area selected. Moreover, the resulting slope for 2011-2020 has been tested H_0: $\beta_{area} + \gamma_{area}$ <=0 (alternative >0). This indicates whether the regression line fitted to the 2012-2020 data has a significant upward slope (and thus a recent positive trend).

The conclusion is the same as 2019, parameters 'γ_{area}' are still highly significant both in the 'EE' and 'NS' areas, and H0 is rejected for both slopes. These results confirm that there has been a significant change in the recruitment slope after 2011 and that the 2011–2020 trend is positive (Table 3.5).

However :

1. since the recruitment seems to be levelling out after the peak in 2014, the slope of the increasing trend (2011–2020) has decreased when compared to the 2019 analysis,
2. tests designed on a small window of time are very sensitive to the window,
3. it is not clear that the last point in the trend is reliable. The 2020 data remain provisional, ten series (six NS, four EE) out of 52 series have recorded significant reductions in sampling efforts directly attributed to COVID-19, and one has not yet reported (EE).
4. this analysis reproduces the same test as last year. Other options with more breakpoints and alternative models will have to be tested next year.

Table 3.1.1. Slope of the decreasing and increasing trends of the linear model.

	Slope of the decreasing trend (log scale) 1980–2011	Slope of the increasing trend >2011 (log scale) (γarea + βarea)	H0: the trend is <=0
'Elsewhere Europe'	-0.09	0.07 p < 0.001	p < 0.001
'North Sea'	-0.13	0.109 p < 0.001	p < 0.001

The conclusion remains the same, recruitment indices had been continually decreasing from 1980 to 2011 (31 years). For, the period 2011–2020, the recruitment has been increasing, and the rate of increase is significantly different from zero. But, in that period the maximum index values were reached in 2014 (12.1% and 2.7%), and the recruitment has levelled out since (Figure 3.1.4). The provisional values for 2020 indicate that it remains extremely low when compared to the reference period, at 0.5%, that is below the 1% level, for the 'NS' and 6.5% for the 'EE'.

The analysis in this chapter is restricted to a model that tests if there is a statistically significant change in the recruitment trend after 2011. As other options have not been tested this year, this means that not necessarily the best fitted model is analysed. To find the best fitted model, analysis on the number of breakpoints and the breakpoint-years would have to be conducted. Because recruitment is declining after 2014 and especially low for the North Sea in 2020, it is likely that this analysis would give a different result, compared to the analysis presented above.

Table 3.1.2. GLM *glass eel ~year: area + site* geometric means of predicted values for 53 glass eel series, values given in percentage of the 1960–1979 period.

	1960		1970		1980		1990		2000		2010		2020	
	EE	NS	EE	NS	EE	NS	EE	NS	EE	NS	EE	NS	EE	NS
0	150	208	102	98	114	81	35	15	19.4	4.7	4.5	0.7	6.5	0.5
1	128	118	56	85	89	58	17	3	8.7	1.0	3.5	0.5		
2	149	180	50	109	91	29	22	8	13.4	2.6	5.2	0.6		
3	194	225	56	47	49	24	24	7	12.9	1.9	7.2	1.7		
4	118	117	83	131	53	10	24	7	7.3	0.7	12.1	2.7		
5	135	79	72	54	52	8	32	5	8.1	1.1	6.7	0.9		
6	76	88	117	98	34	8	25	5	5.8	0.5	8.5	1.9		
7	82	97	113	75	59	9	41	4	6.5	1.3	8.2	1.2		
8	132	124	110	55	69	9	17	3	5.5	1.2	8.6	1.9		
9	68	89	147	95	45	4	21	7	4.1	0.8	5.6	1.4		

Table 3.1.3. GLM yellow eel ~ year + site geometric means of predicted values for 16 yellow eel series, values given in percentage of the 1960–1979 period. * 2020 is preliminary, based on incomplete data (seven series).

	1950	1960	1970	1980	1990	2000	2010	2020
0	183	167	59	99	32	18	12	9*
1	261	181	62	41	38	18	27	
2	252	178	108	52	18	38	14	
3	401	151	135	47	14	24	18	
4	197	61	65	35	55	25	32	
5	304	114	122	66	13	13	11	
6	136	156	38	49	10	17	13	
7	157	111	78	47	21	20	13	
8	154	173	70	61	18	14	20	
9	335	116	58	36	21	8	17	

3.1.6 Exploratory use of GEREM as a complementary tool

GEREM is a Bayesian model aiming at estimating glass eel recruitment at different nested spatial scales (overall recruitment, subregions/zone, river basins) through the analysis of available recruitment time-series (Drouineau *et al*., 2016). The model has already been applied in France (Drouineau *et al*., 2016), to a large part of Europe (Bornarel *et al*., 2018) and is currently used in the Sudoang Interreg project. The model assumes that each year, the overall recruitment $R(y)$ is distributed among various zones (i.e. subregions) which receive recruitment $R_z(y)$. Then, zone recruitment is distributed among river catchments as a function of their surface, leading to recruitment $R_{c,z}(y)$. Basically, GEREM is a mixing of a Dynamic Factor Analysis (DFA) (Zuur *et al*., 2003) and a "rule of three". Similar to a DFA model, GEREM is state–space model based on a random walk structure, which estimates common trends in a set of time-series. The rule of three is used to extrapolate absolute recruitment estimates in a river basin to recruitment in other basins in the same zone, stating that the recruitment in each basin is a simple function of its surface. After having inventoried available time-series and listed their characteristics, it is necessary to define zones. In each zone:

- river catchments should have similar trends in recruitment;
- the rule of three must apply, i.e. it should be possible to extrapolate recruitment in a basin to another basin of the same zone as a simple function of their relative surfaces;
- time-series of recruitment should be available. If not available, it is possible to use time-series such as trapping or commercial catch from which absolute recruitment can be inferred by introducing additional information on the scaling factors (trap efficiency and exploitation rate).

The model is detailed in (Drouineau *et al*., 2016) and (Bornarel *et al*., 2018). The current exercise is mainly an update from Bornarel *et al*. (2018) and we used the same zone and the nearly the same time-series but with updated values. In the future, we might use the same time-series as in the GLM approach and redefine the zones. A description of the data used in this exercise and of the parametrisation of the model is provided as working paper (Annex 9).

Unsurprisingly, estimated overall recruitment (Figure 3.1.7) shows a steep decline since the early 1980s, despite some oscillations. More recently, we observe a period of increase in the early 2010s but it seems to stabilize or slightly decrease after this. Credibility intervals are rather large at the end of the period partly because many time-series (especially French fishery based time-series) ended after the implementation of the Eel Regulation. The 2020 recruitment is estimated to be 4.57% (credibility interval [2.9%–7.32%]) and is in line with estimates from the GLM approach.

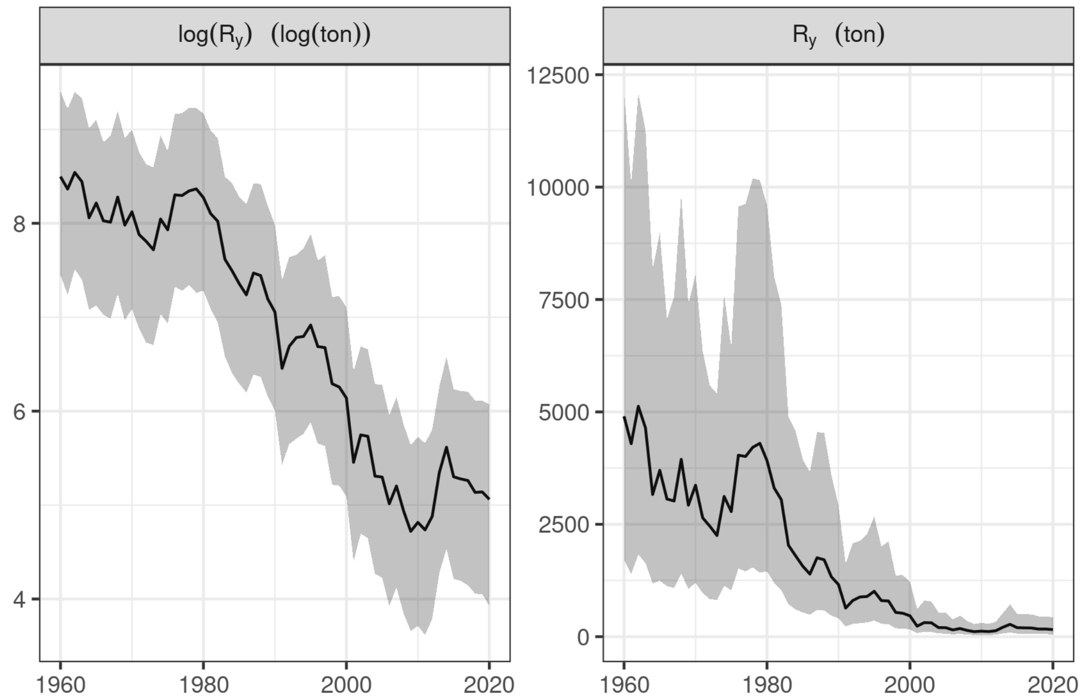

Figure 3.1.7. Overall trend in recruitment: median of the posterior distribution (solid line) and corresponding 95% credibility interval (shaded area). Recruitment is in natural scale (right panel) and log scale (left panel).

The model also provides estimated at the zone level. Figure 3.1.8 provides separated estimates for the NS and EE series, the decline in the former started earlier than ATL_F and ATL_IB. The Mediterranean area also displays a decline in the 1960s, however, estimates in this period are based on few fishery-based time-series and the assumption about constant exploitation rate and reporting rate is questionable. Moreover, it is worthwhile mentioning that there are currently only four available time-series while the zone is large and includes both lagoons and river basins. For the Channel, the lack of data in the beginning of the time-series explains the large credibility interval, therefore estimates should be taken with great care. ATL_F does not display any increase at the end of the time-series, however, results are based on a single time-series (GiscG) and, consequently, confidence intervals are rather large.

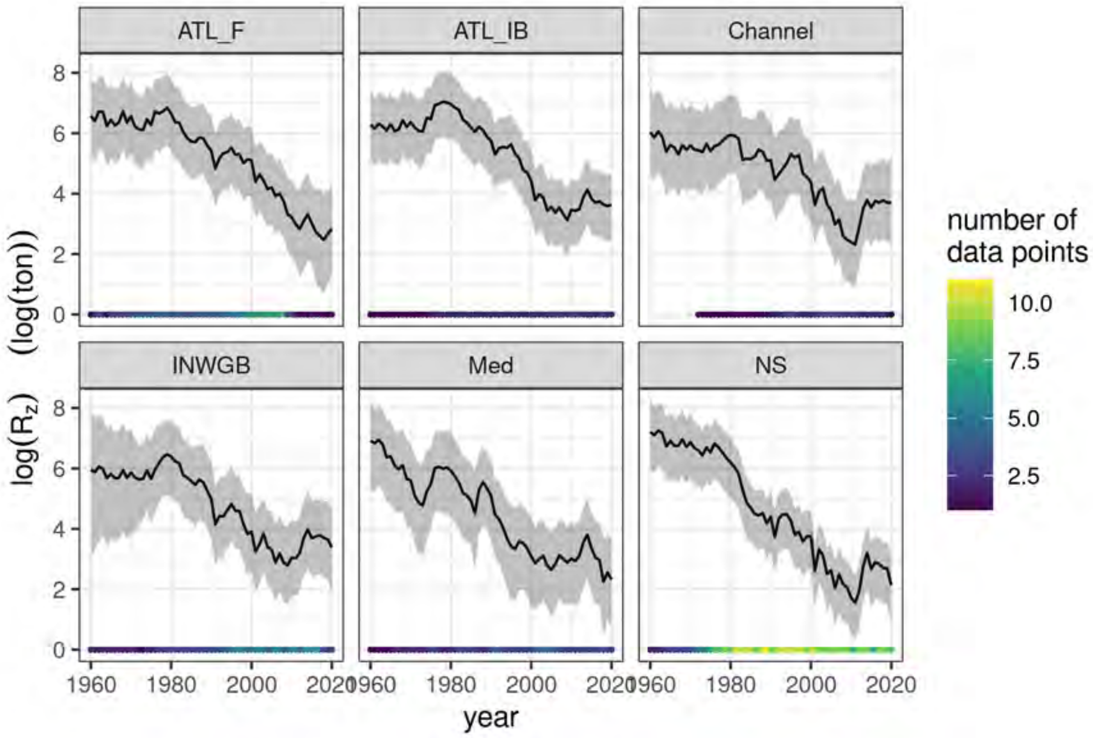

Figure 3.1.8. Trend in recruitment in each zone of the model: median of the posterior distribution (solid line) and corresponding 95% credibility interval (shaded area). The colour of the points on the x-axis indicates the number of available dataseries for the corresponding zone and year.

Model fits to observations are provided in the working paper (Annex 9).

On the whole, GEREM does not change the overall image of the recruitment as provided by the GLM analysis. It confirms the decline of recruitment since the 1980s and the currently very low level of recruitment. However, it raises additional questions regarding some potential differences in trends among zones, such as the recent decline in the recruitment received in ATL_F. While definitive conclusions cannot be drawn, this result shows the importance of establishing new monitoring time-series in areas where data are missing. As such, the monitoring network implemented in Sudoang appears to be an interesting opportunity. Regarding absolute recruitment, as already mentioned, results should be taken with great care since the number of time-series is limited and the estimates are sensitive to some parameters (see Bornarel *et al.*, 2018). However, obtaining absolute estimates is a prerequisite to any robust comparison of the importance of recruitment among zones.

Since the Eel regulation requests MS to monitor the progress towards attaining 40% of pristine silver eel escapement, the parallel estimation of absolute recruitment would allow comparison of survival rates during the continental stage among zones. As such, a better understanding on how local recruitment in river basins depends on local characteristics (e.g. basin surface, etc.) would be a valuable information for management of standing stocks and would subsequently allow improvements in the model. This calls for achieving more absolute recruitment estimates.

Despite the effort in data collection, two regions are still not considered in the model. The Baltic Sea is currently not included in the model given that recruitment time-series in this area are composed of young yellow eels with unknown age distributions. This is addressed in the GLM approach by fitting a specific GLM for yellow eel recruits. In the future, it may be possible to use time-series and studies in this zone such as the estimate from Westerberg and Wickström (2016) but will require additional assumptions to address the age shift between glass eel and yellow eel recruits from the Baltic. The situation is more critical in the Eastern and Southern Mediterranean basin where no data are available. This problem also affects the GLM approach. The implementation or collection of new time-series in this region is critical to provide a representative estimate at the population level. Despite these two missing regions, the model is applied on a large area and on regions which are thought to receive an important proportion of the recruitment and where glass eels are commercially harvested.

The idea of presenting this modelling exercise was not to replace the GLM exercise nor to conduct a benchmark exercise of models but to provide an additional tool that provides complementary information. The two modelling approaches have two different levels of complexity and provide similar general picture of the trend of recruitment. While GEREM does not provide any definitive conclusions, it raises interesting complementary questions and highlights the need for new data in some regions and of new types.

3.2 Yellow and Silver eel series for examining the standing stock and escapement

3.2.1 General introduction about the use of yellow eel and silver eel time-series

Several time-series of abundance of yellow eels and silver eels are collected throughout Europe. However, the analysis of their trends is more complex than for glass eel time-series since yellow and silver eels abundances are the results of both the general status of the population and local conditions (environmental condition, anthropogenic pressures, life-history traits, management actions,…) in localities in which they are collected (ICES, 2014). Despite these difficulties, it is interesting to explore whether some common trends exist among the available time-series and whether they can be related to some factors, especially whether some spatial patterns exist in these trends. This would be a first exploration step before moving forward in a potential assessment of the standing stock. In this context, we carry out a Dynamic Factor Analysis (DFA), a multivariate method aiming at detecting common trends in a set of time-series (Zuur *et al*., 2003). Such an exercise is worthwhile only when the number of available time-series is important, therefore, we restricted this analysis to the recent period (post-2000) and focus on recent trends. To complete the overview, we carried out gam analyses on a longer period (since 1975) to analyse the long-term trends. The trends were analysed separately for yellow and silver eels. The analysis is based on the time-series of yellow and silver eel (standing stock) time-series of abundance collected during the successive WGEEL Data Calls (see Annex 8) and contribute to the response to ToR b "Report on developments in the state of the European eel (*Anguilla anguilla*) stock, the fisheries on it and other anthropogenic impacts".

3.2.2 Yellow eel

3.2.2.1 Time-series made available

92 time-series are available to the Data Call (Figure 3.2.1), originating from 14 countries and 34 EMUs. Most of them are located in Great Britain or France. Two time-series are collected in coastal waters, five in transitional waters and 81 in freshwater. A summary of the series is presented in Annex 8.

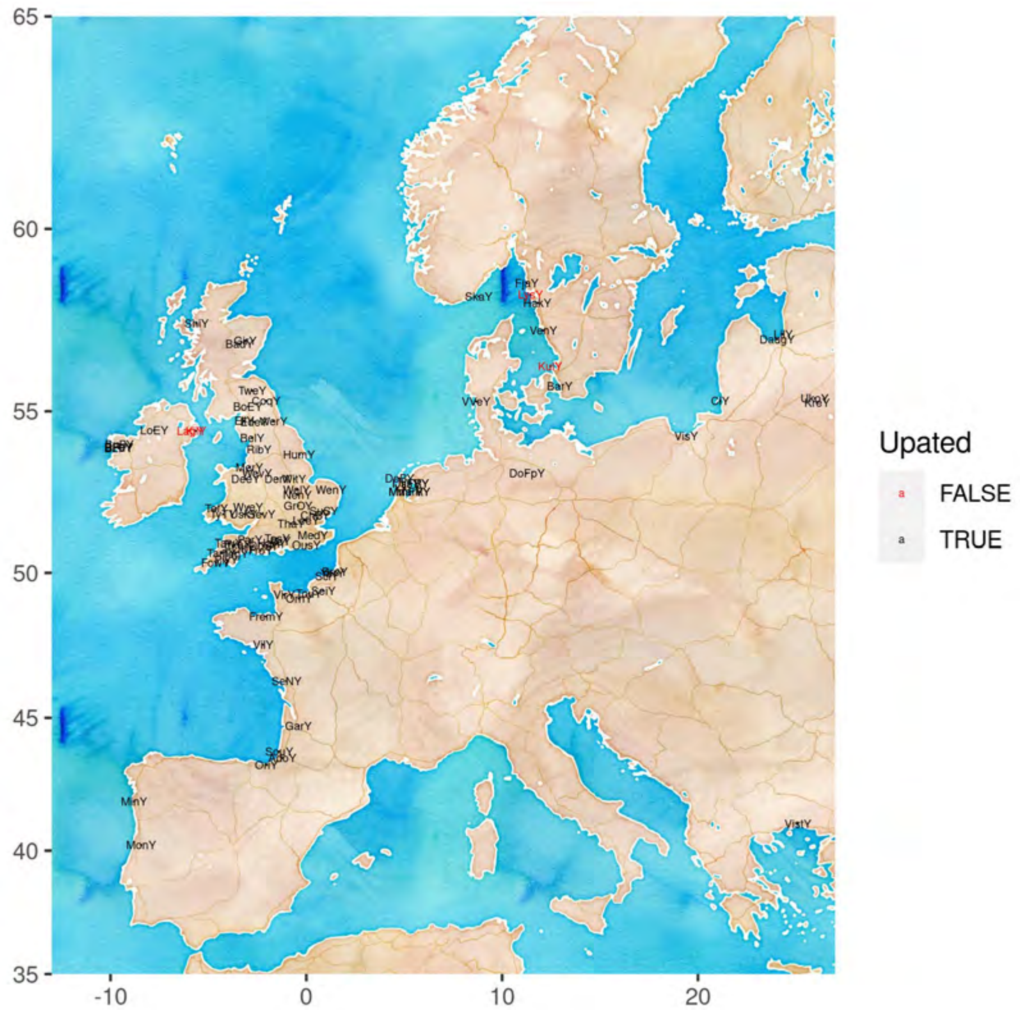

Figure 3.2.1. Map of available yellow time-series (standing stock). Updated time-series correspond to time-series for which at least one value was provided for years the three last years.

3.2.2.2 Short-term trends

Currently, few pre-2000 data were provided during the Data Calls (Figure 3.2.2) an effort should be made in the future to collect existing historical data. Many data values for 2020 were still missing when carrying out the analysis.

Figure 3.2.2. number of yellow eel time-series available per year.

In view of this, the analysis is restricted to the period ranging from 2000 to 2019, with dataseries that have at least ten observations on the period.

This leaves 58 time-series. If we plot all the series, a gam smoother indicates an overall decreasing trend (Figure 3.2.3).

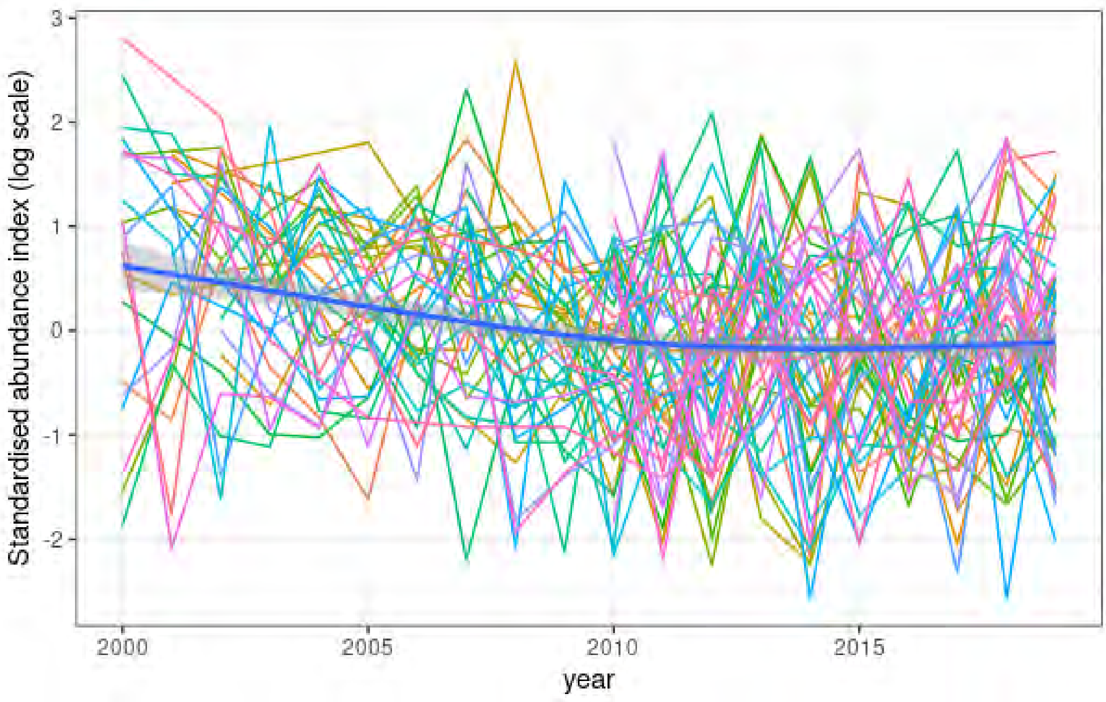

Figure 3.2.3. Yellow eel time-series and gam smoother.

When plotted per country, a simple gam smoother shows decreasing and stabilising curves in FR, NL. The same with a more pronounced increase after 2012 is estimated for ES (DK seems to display a similar trend but the time-series is shorter). On the other hand, a linear decrease is estimated in IE, GB and DE, and an increase for SE (Figure 3.2.4). An effort should be made in the future to collect historical data.

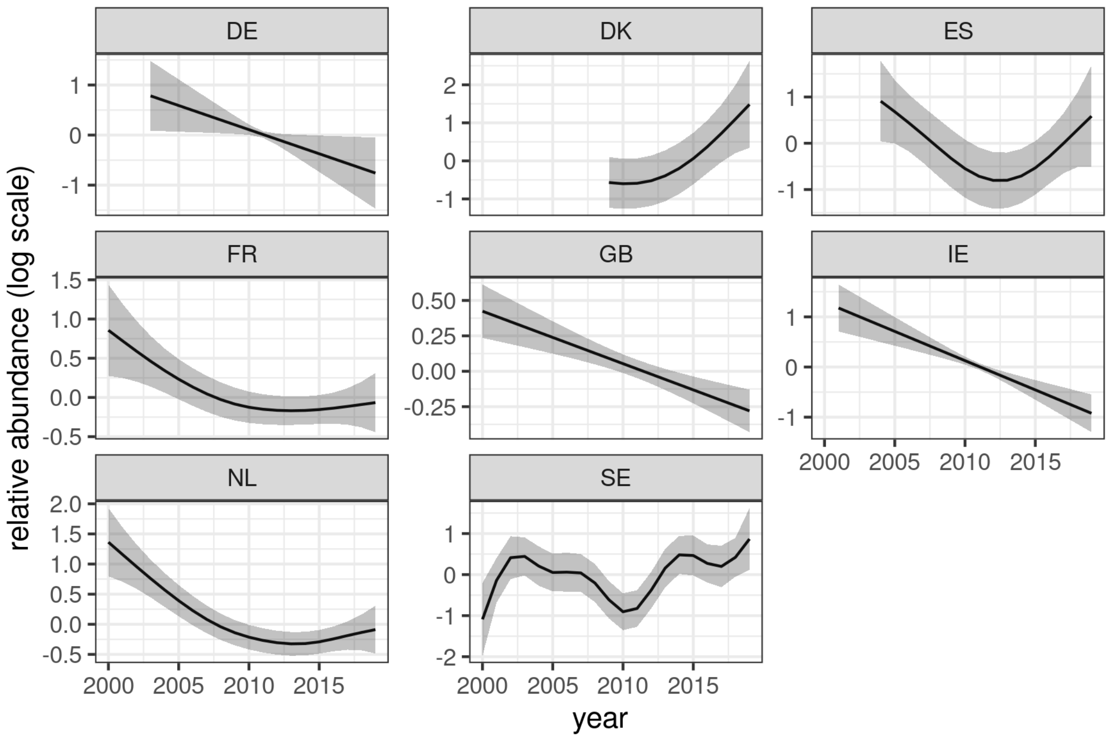

Figure 3.2.4. Trends per country in yellow eel abundance estimated by a gam (log scale)

3.2.2.2.1 Running the DFA

The DFA method is fully detailed in (Zuur *et al.*, 2003). The basic idea is to decompose each time-series into a weighted sum of a few common trends and a noise factor:

$$Y_{j,t} = \mu_j + \sum_{i=1}^{n} w_{i,j} \cdot X_{i,t} + \epsilon_{j,t} \quad \text{with } \{\epsilon_{j,t}\} \sim N(0, \Sigma)$$

with $Y_{j,t}$ the value of the series j at time t, μ_j an intercept, n the number of common trends, $w_{i,j}$ the weight of trend i in the series j, $X_{i,t}$ the value of trend i at time t and $\epsilon_{j,t}$ a normal noise, potentially correlated between series through the variance-covariance matrix Σ . Therefore, $X_{i,t}$ represent the trends common to the series and are modelled as random walks:

$$X_{i,t} = X_{i,t-1} + f_{i,t} \text{with} f_{i,t} \sim N(0, Q)$$

with $f_{i,t}$ the noise on the trend i at time t which follows a normal law, possibly correlated between trends with the variance-covariance matrix Q which can be set to the identity matrix (Zuur *et al.*, 2003). The method thus allows both to extract the common trends through the estimates of X, but also to see the importance of each trend in each series through w.

To fit the DFA, the user as to put some additional constraints. We will make three kinds of assumptions on Σ:

Σ is a diagonal matrix with equal elements in the diagonal (e.g. time-series are independent with similar values of noise);

Σ is a diagonal matrix with unequal elements in the diagonal (e.g. time-series are independent with different values of noise);

Σ is an unconstrained (e.g. time-series are potentially not independent with different values of noise). This solution was not tested for yellow eels since the number of time-series was too large compared to the number of observations.

One to four common trends are tested. The best combination of Σ and number of trends is chosen by comparing AIC criteria. Before running the DFA, values were logtransformed (few 0 values were recorded and were replaced by 10% of the lower value of the series) and scales (mean deleted and divided by the standard deviation).

3.2.2.2.2 Common trends

Two common trends were estimated after selection by AIC criteria (Table 3.2.1 and Figure 3.2.5).

Table 3.2.1. Model comparisons for yellow eel DFA.

Trends	Sigma	AIC
1	diagonal and equal	2483.42
1	diagonal and unequal	2559.71
2	diagonal and equal	2478.87
2	diagonal and unequal	2524.70
3	diagonal and equal	2488.61
3	diagonal and unequal	2498.74
4	diagonal and equal	2503.18
4	diagonal and unequal	2492.97

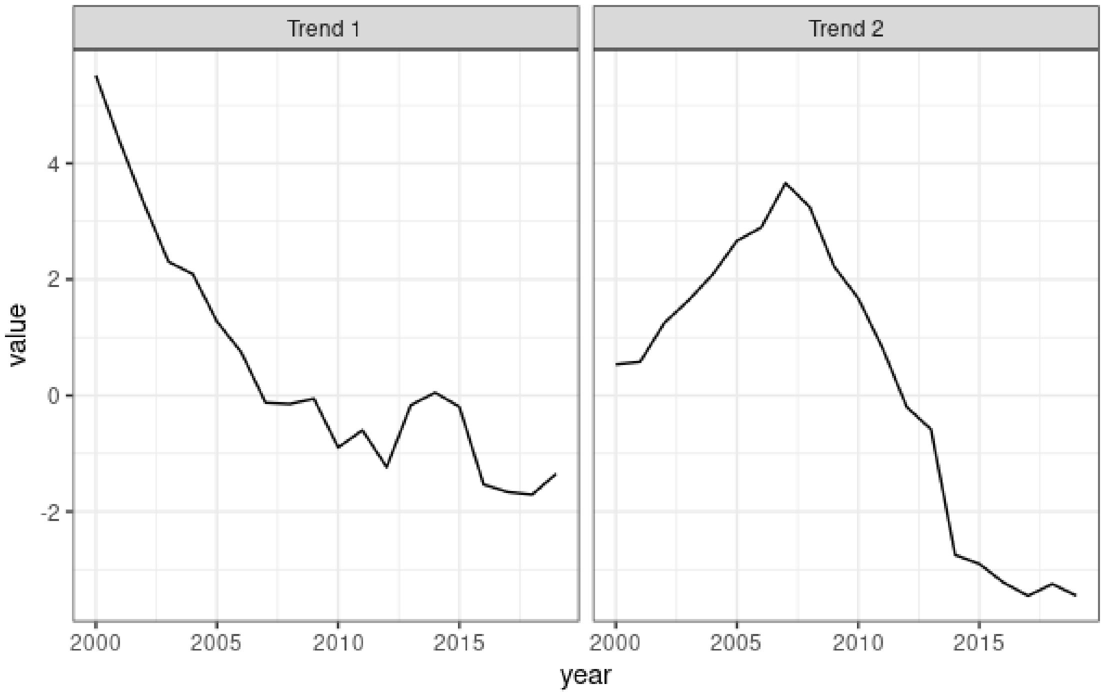

Figure 3.2.5. Estimated common trends in yellow eel time-series.

Trend 1 shows a monotonous trend over the period while trend two indicates a shift after 2007. The factor loadings *w* are displayed in the following plots (Figure 3.2.6). Following Zuur *et al*. (2003), we only focused on loading with absolute values greater than 0.1 to get the most important trends and presented on a Venn diagram (Figure 3.2.7).

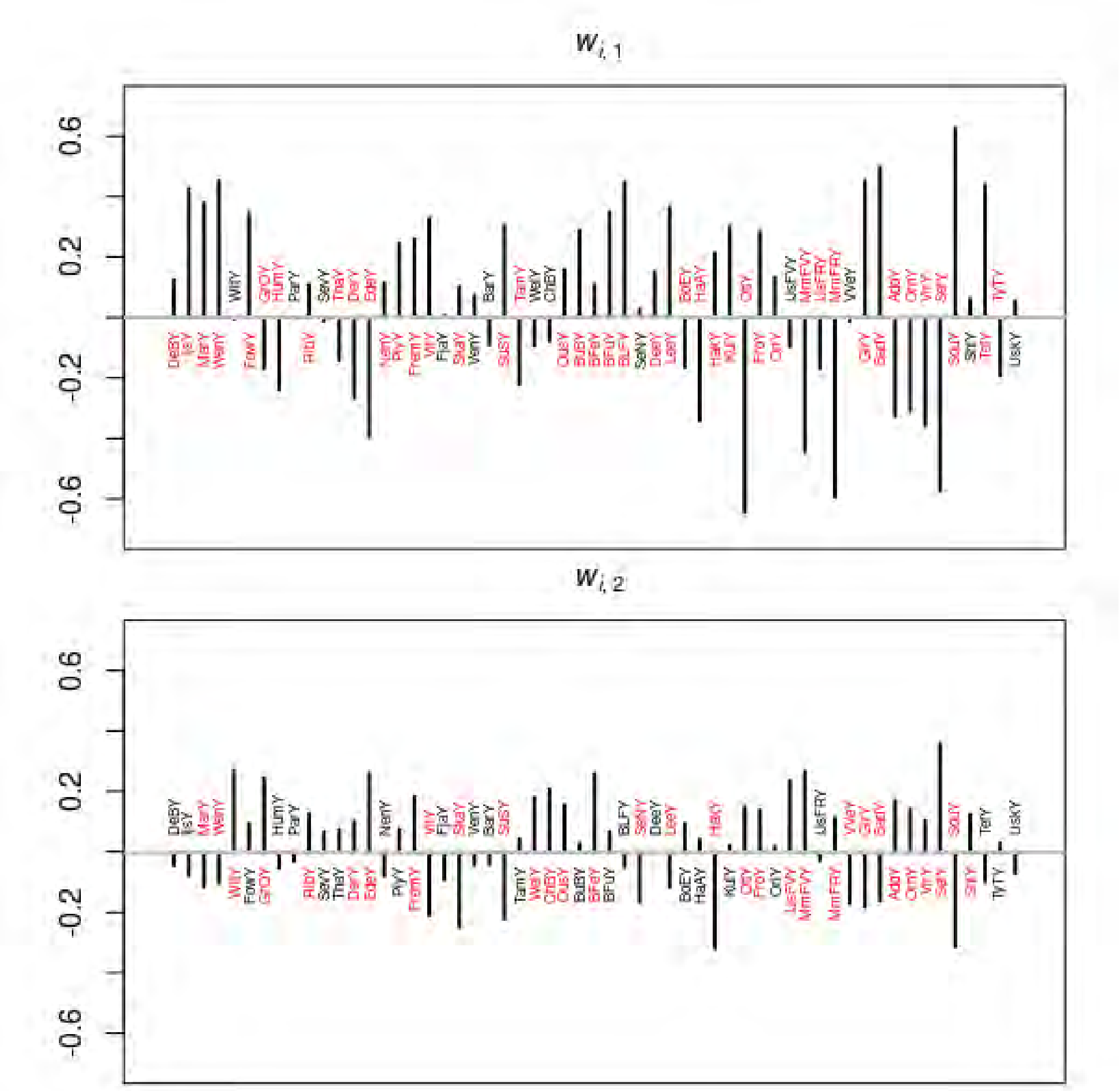

Figure 3.2.6. Factor loadings of the yellow eel DFA (red names stand for loadings absolute values greater than 0.1).

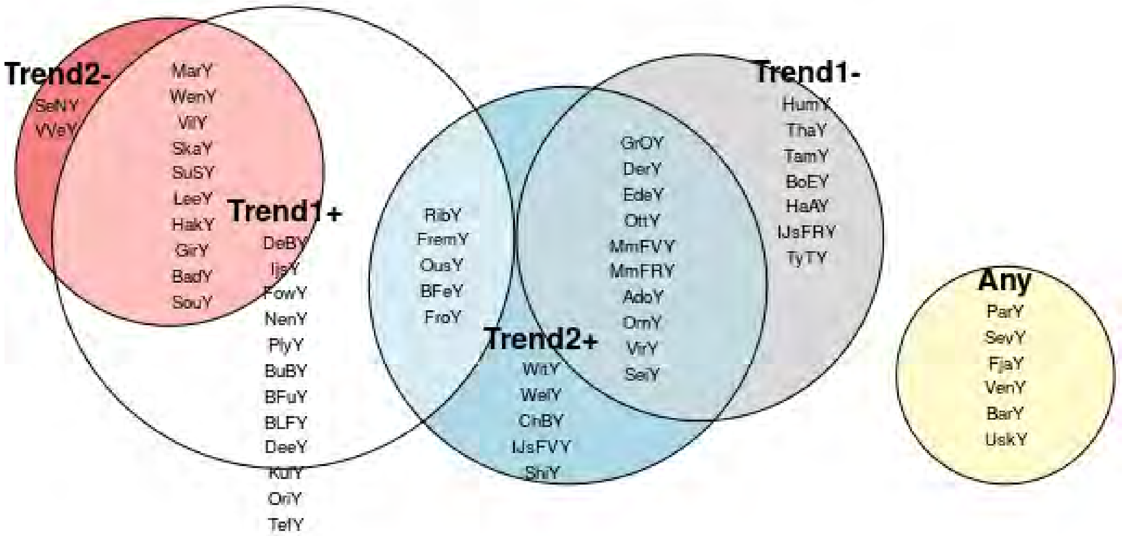

Figure 3.2.7. Venn diagram of the yellow eel DFA.

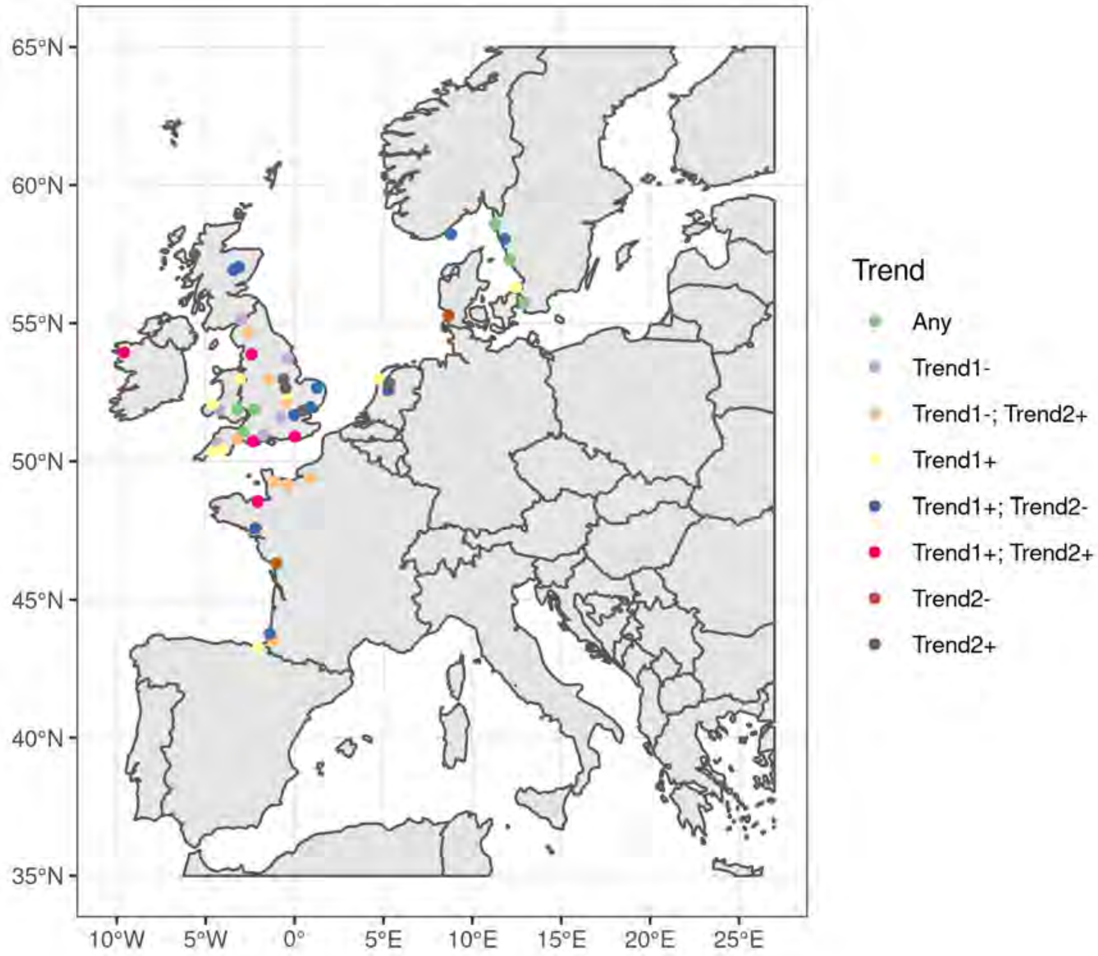

Figure 3.2.8. Spatial maps of yellow DFA loadings.

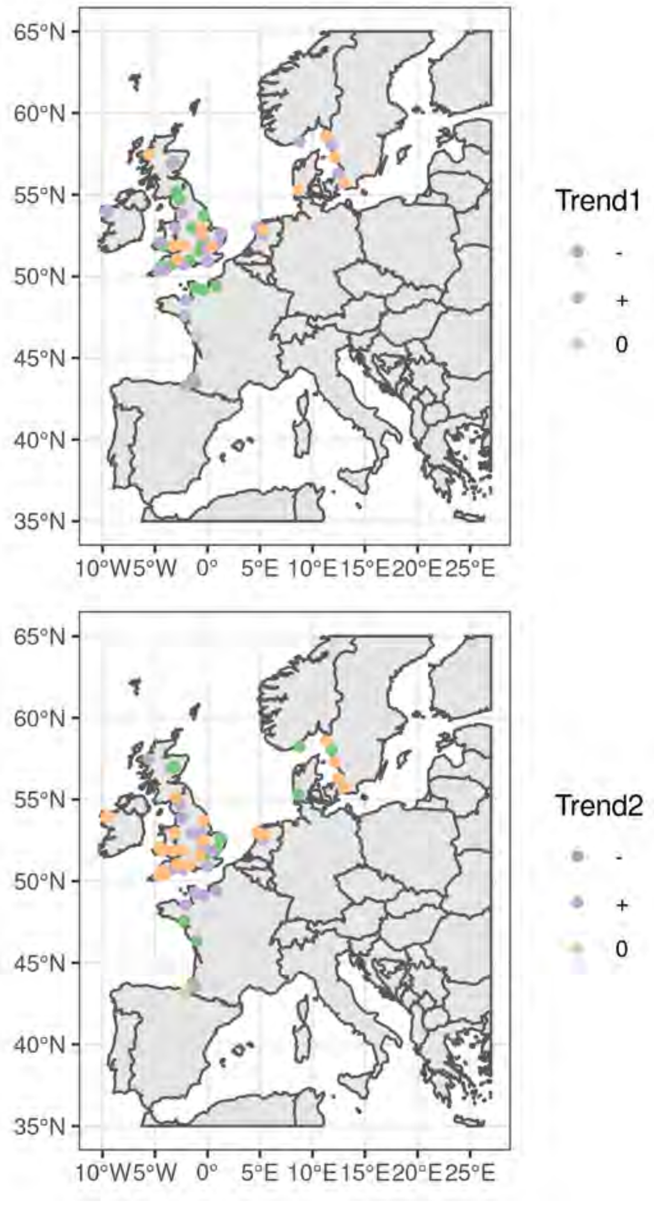

Figure 3.2.9. Spatial maps of yellow DFA loadings, detailed by trend.

Many series are positively correlated to Trend 1, indicating a constant decline of abundance since the 2000s (Figure 3.2.7). Some time-series are negatively correlated to trend 1, but among them, many are also positively correlated to trend 2, indicating a slight increase or stability at the beginning of the period and then a decrease until 2007. Regarding time-series dominated mostly by a negative correlation with trend 1 (i.e. a monotonic increase over the period), they all came from Great Britain, and half of them are located far from the coast. On the whole, it is difficult to distinguish any clear spatial pattern in the trends (Figures 3.2.8 and 3.2.9).

The fits of the DFA model to the different time-series are presented in Figure 3.2.10.

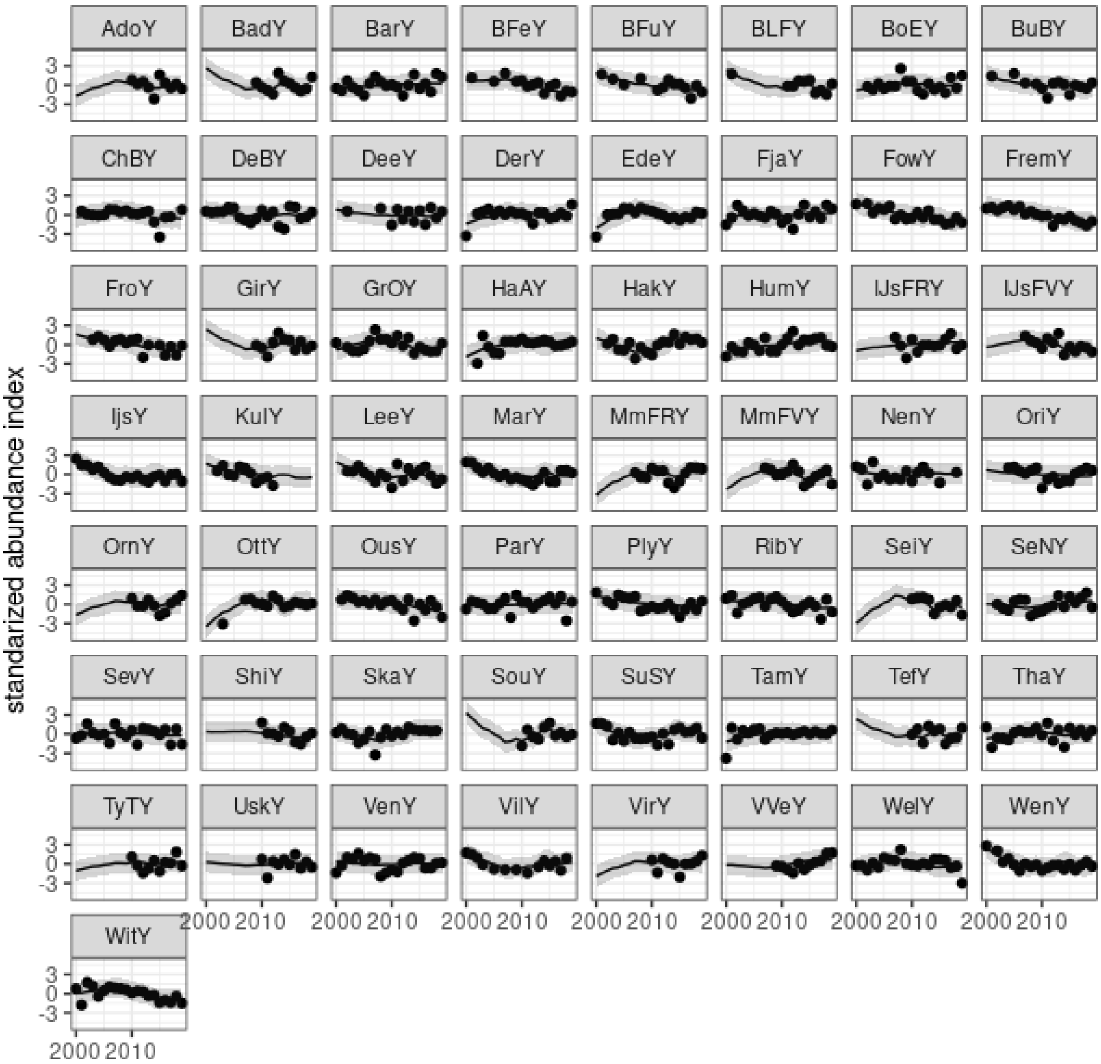

Figure 3.2.10. Yellow DFA fits to time-series.

3.2.2.3 Long-term trends

We also fitted gam over a period starting in 1975 to put the post-2000 trends in an historical perspective. For many countries, data do not start before the 2000s, so the reader should refer to the previous section (DE, DK, ES, FR). A decreasing trend is observed in most other countries (NL, NO, IE, GB) except in Sweden where an increasing trend is observed (Figure 3.2.11) though the early trend is only based on two time-series.

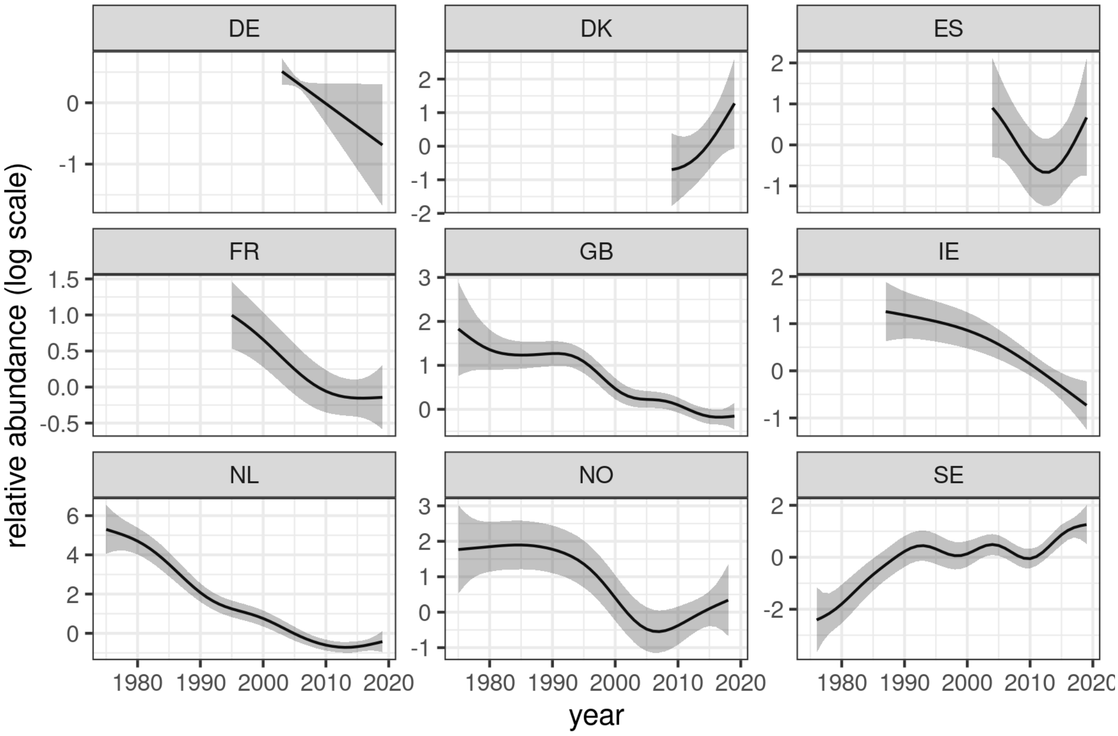

Figure 3.2.11. Trends per country in yellow eel abundance estimated by a gam.

3.2.3 Silver eel

3.2.3.1 Available time-series

41 time-series are available (Figure 3.2.12), originating from 14 countries and 25 EMUs. Most of them are located in Northern Europe. Three time-series (biomass or numbers, see Annex 8) are collected in coastal waters and 30 in freshwater, while the habitat type was not reported for five. A summary of the series is presented in Annex 8.

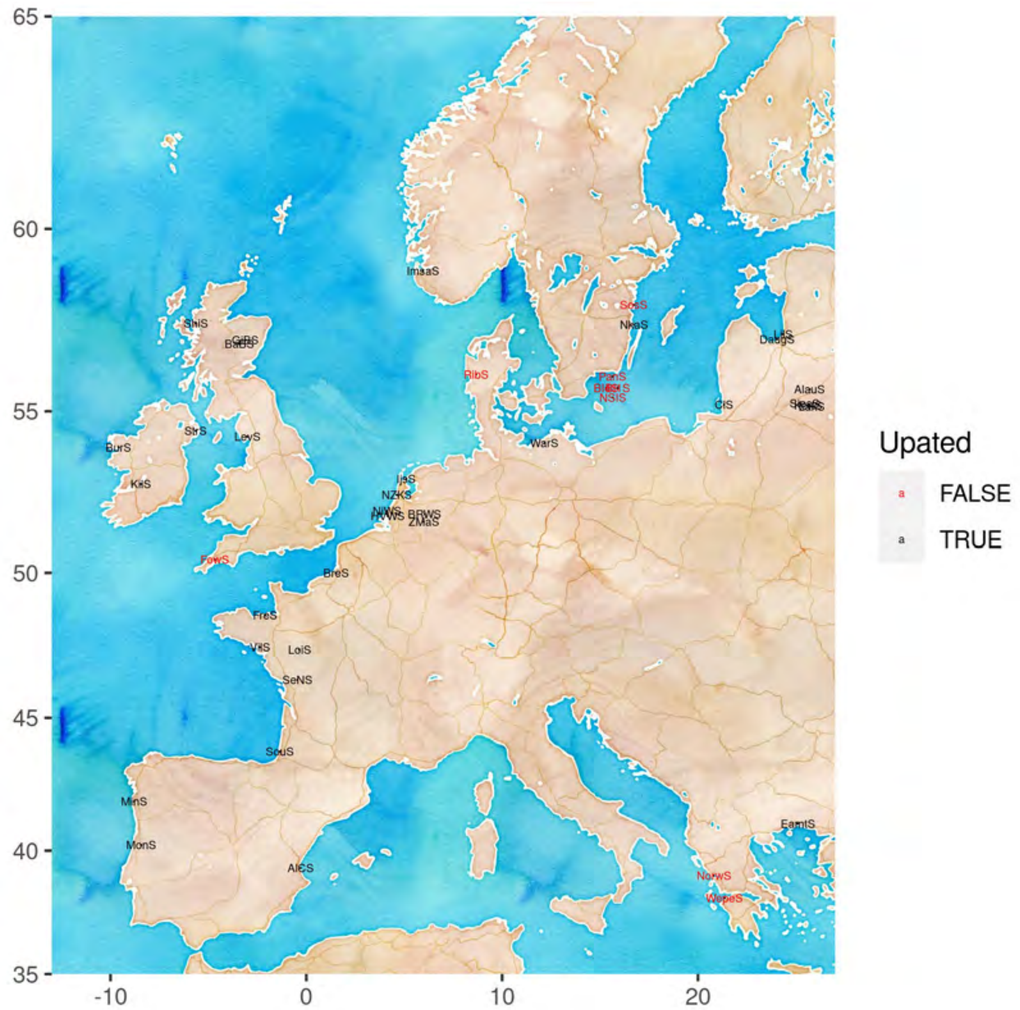

Figure 3.2.12. Map of available silver eel time-series. Updated time-series correspond to time-series for which at least one value was provided for years the three last years.

3.2.3.2 Short-term trends

Similar to yellow eels, few pre-2000 dataseries were provided during the successive Data Calls (Figure 3.2.13). In view of this, we restricted the analysis to the period 2000 to 2019, with time-series having at least ten observations over the period.

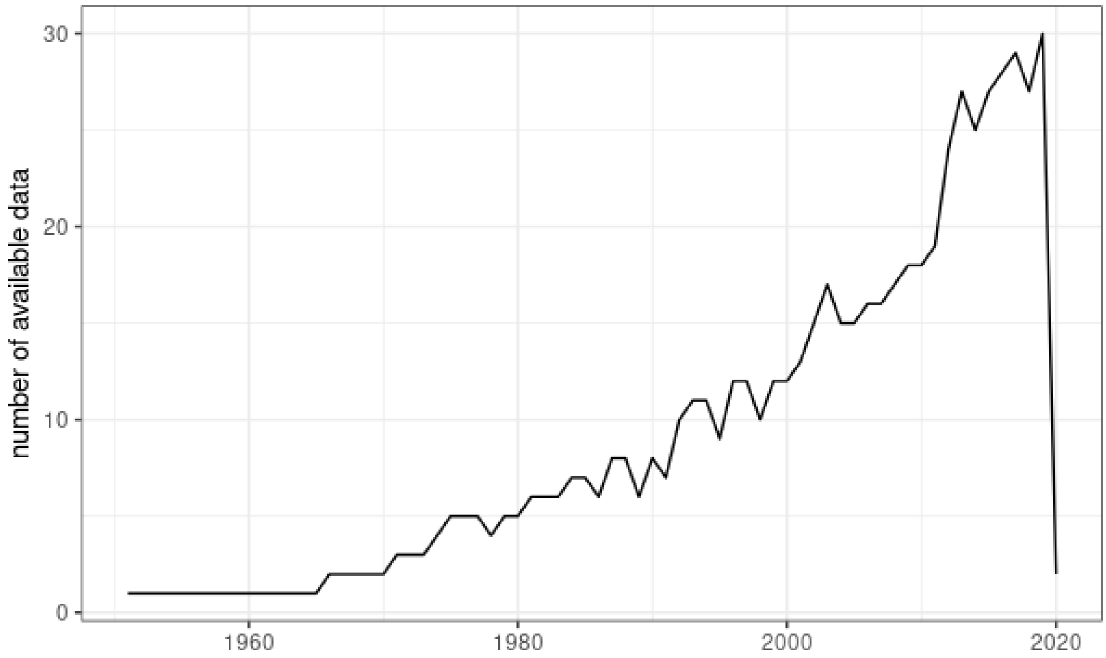

Figure 3.2.13. number of yellow eel time-series available per year.

This leaves 17 time-series. If we plot all the series, a gam smoother indicates an overall slightly decreasing trend (Figure 3.2.14).

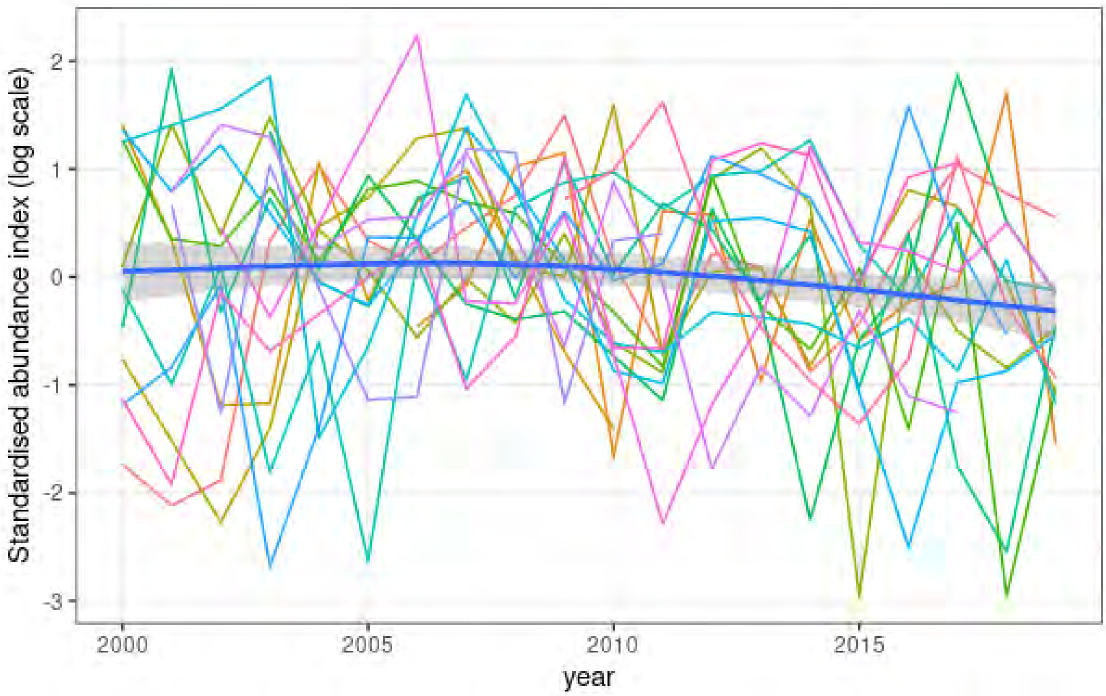

Figure 3.2.14. Silver eel time-series and gam smoother.

When plotted per country, a simple gam smoother shows decreasing trend in DK, FR, NO, the same but with a stabilization in GB (Figure 3.2.15). SE and ES display rather increasing trend, while IE is more stable. DE is erratic, especially because there are no data at the beginning of the period. The trend correspond to log transformed and scaled values.

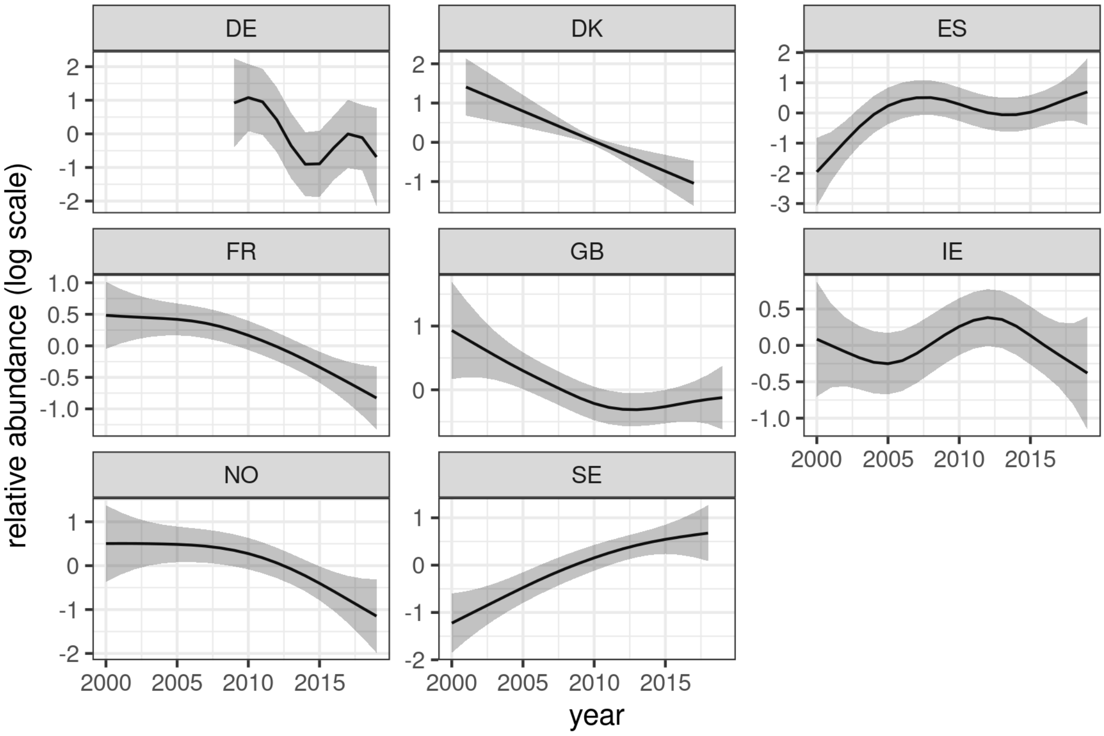

Figure 3.2.15. Trends per country in silver eel abundance estimated by a gam.

3.2.3.2.1 Running the DFA

We applied the same method as for yellow eels so readers can refer to the corresponding section for further details.

3.2.3.2.2 Common trends

The model selection leads to the estimation of a single trend (Table 3.2.2 and Figure 3.2.16).

Table 3.2.2. Model comparisons for silver eel DFA.

Trends	Sigma	AIC
1	diagonal and equal	775.04
1	diagonal and unequal	795.83
1	unconstrained	1766.49
2	diagonal and equal	792.02
2	diagonal and unequal	812.86
2	unconstrained	1884.30
3	diagonal and equal	804.19
3	diagonal and unequal	814.89
3	unconstrained	1658.10
4	diagonal and equal	821.21
4	diagonal and unequal	817.44
4	unconstrained	1804.55

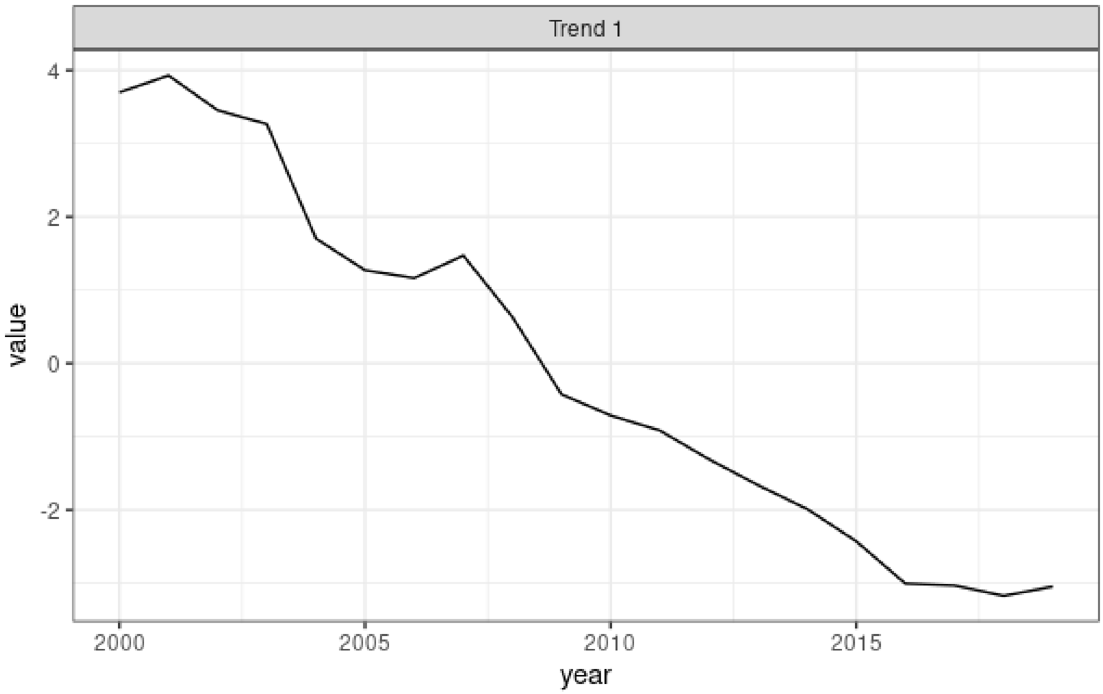

Figure 3.2.16. Estimated common trend in silver eel time-series.

The factor loadings are displayed in the Figure 3.2.17 (importance of each trend in each time-series) and corresponding Venn diagram in Figure 3.2.18.

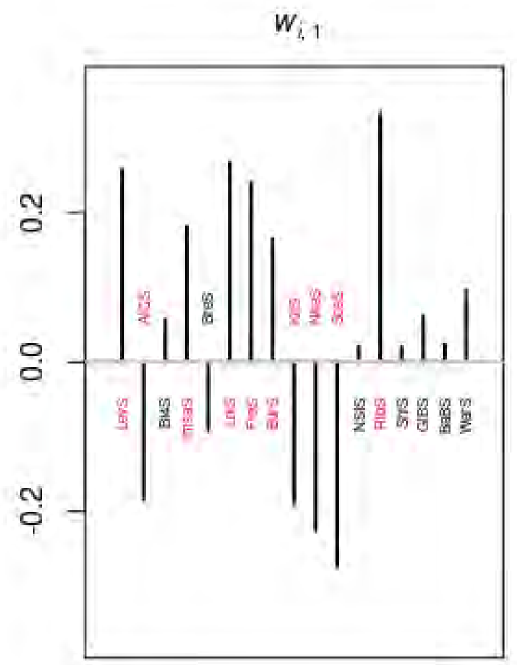

Figure 3.2.17. Factor loadings of the silver eel DFA (red names stand for loadings absolute values greater than 0.1).

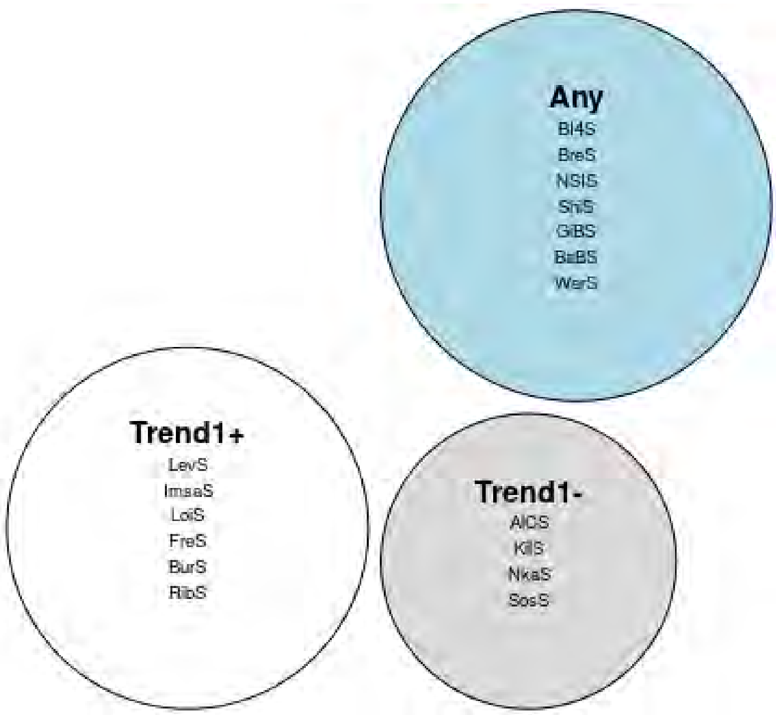

Figure 3.2.18. Venn diagram of the silver eel DFA.

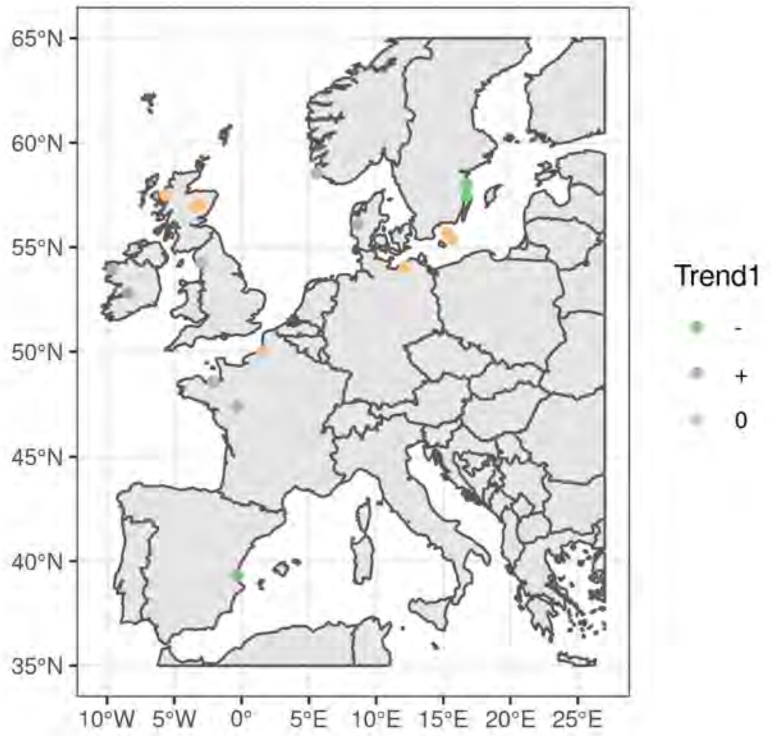

Figure 3.2.19. Spatial maps of silver DFA loadings (+ stands for a positive correlation to trend 1).

About 35% of the series are positively correlated to trend 1 indicating a decline in the abundance (Figure 3.2.17). However, about 24% are negatively correlated suggesting an increase, and about 41% are not correlated to any trends, suggesting some stability. As for yellow eels, there is no obvious spatial pattern in the trends (Figure 3.2.19).

DFA fits to data are presented in Figure 3.2.20.

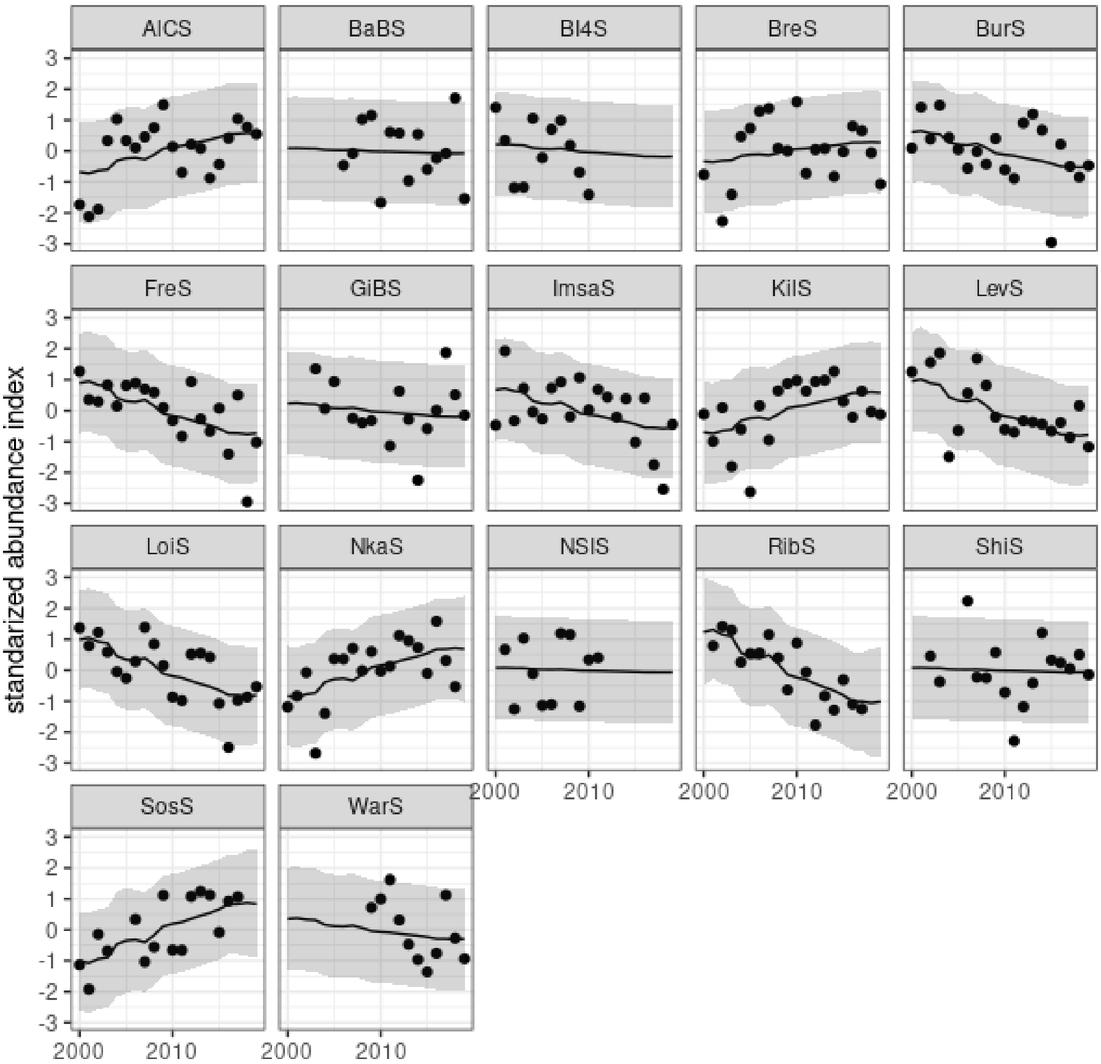

Figure 3.2.20. Silver DFA fits to time-series.

3.2.3.3 Long-term trends

We also fitted gam over a period starting in 1975 to put the post-2000 trends in an historical perspective. For Germany and Denmark, time-series are short (see previous section). For Spain, Great Britain, Norway and Ireland, the abundances are very low with respect to the late 1970s levels (Figure 3.2.21). However, the dynamic is slightly different among countries:

- an early decrease in the late 1970s in IE or GB and then a relative stability;
- a decrease in the late 1980s in Spain and then a period of stability or small increase;
- a rather monotonic decrease in Norway.

In France, an increase is observed in the 1980s and then decreased. Finally, and similarly to yellow eels, Sweden is the only country displaying an increase of abundance, especially after the 1980s.

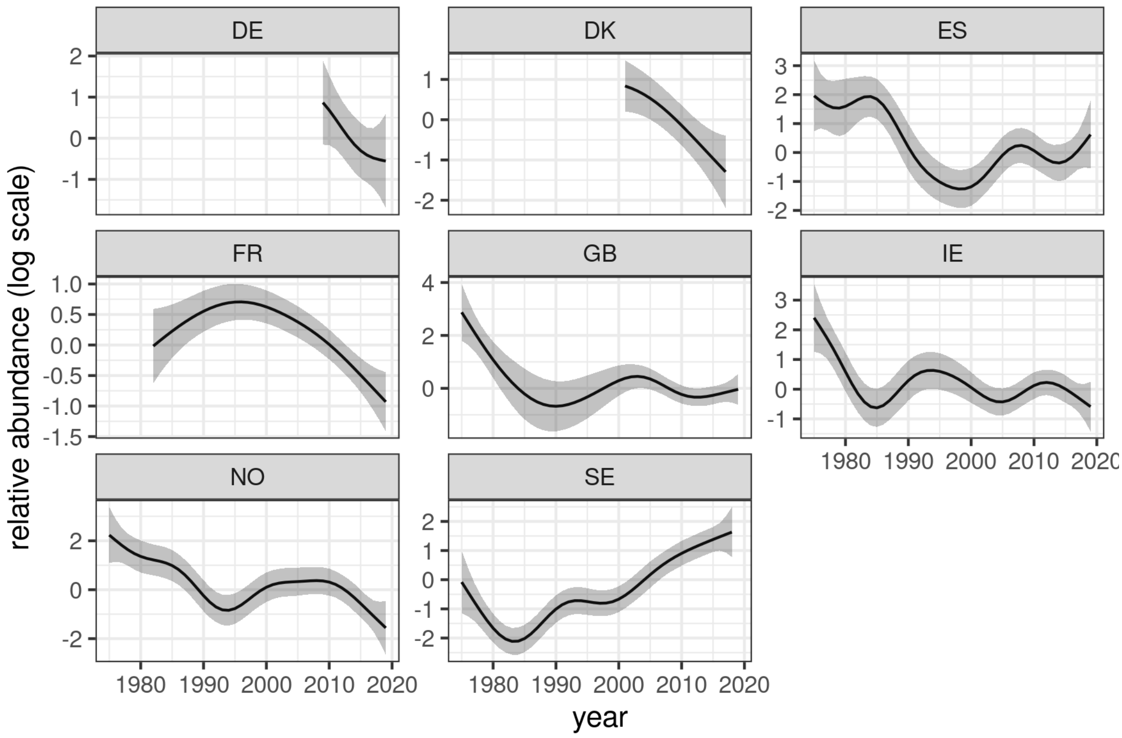

Figure 3.2.21. Trends per country in silver eel abundance estimated by a gam.

3.2.4 General discussion about the trends

Yellow and silver eels time-series of abundance have been collected in at least 14 countries all over Europe for as long as nearly a century. This is a first attempt to analyse the provided data. As explained in the introduction, such as analysis is challenging due to the complexity of the life of the species and its fractal dimension during the continental growth phase (Dekker, 2000b).

Two complementary analyses were used: a DFA analysis to depict common trends in the recent period and a GAM analysis on the long term. In the short term, while the majority of the time-series indicate a declining trend of abundance, this general picture hinders very contrasted situations and increases of abundance of yellow eels and silver eels have been observed in some river basins. This contrast is likely to be related to different factors (environmental conditions, anthropogenic pressures, management practices) among river basins and there is no clear spatial pattern in the trends. Interestingly, while a shift of trend was detected for yellow eel around 2007 (trend 2), this shift occurred before or just after the implementation of the Eel Regulation so that this cannot be the only direct cause. Various reasons may explain such a shift such as changes in management practices, changes in monitoring protocol in anticipation or in response to EMP, but also changes in local environmental conditions. On the whole, since other trends are nearly monotonic, it suggests that the Eel Regulation has not led to major changes in the abundance of yellow and silver eels in these basins, but this is not necessarily a surprise since the growth phase last from five to 20 years depending on the habitats and sex (Vøllestad, 1992).

The few available time-series allow to put the recent trends into an historical perspective. Though results on the long old time should be taken with caution given the limited time-series, most of them display a decreasing trend since the 1975. Some variations exist among countries. While the decrease starts as soon as the beginning of the period in many countries, the decrease appears to start later in Spain. As such, it would have occurred about five years after the decline in recruitment, i.e. about the duration of the growth phase in southern Europe. France also shows an increase at the beginning of the time-series, but data only started in the mid-1980s, so it is impossible to conclude for older years. Moreover, this increase is concomitant with some increasing oscillations, for example in Ireland, so this may have been a temporary situation. Sweden display atypical increasing trends compared to other countries. It is difficult to conclude on the reasons of these trends, but we can suggest that fishery closure in Western Sweden may have played a role, and restocking may also have played a role (though it occurs mainly in Inland EMUs).

As a first analysis, the results do provide a very partial overview of what have indeed happened. It would be worthwhile to collect more series and to carry out further analyses to understand the reasons of these different trends. More specifically, it would be interesting to analyse whether the distance to the sea (data not available currently) plays a role in the results. Other factors, such as monitoring method or particular management measure (restocking, barrier's mitigation, fishery closure, …) may also be analysed. As a next step, it would be interesting to compare trends with recruitment, for example to check whether the difference in trends between the North Sea and Elsewhere Europe persists for the standing stock, and with mortalities estimates in each EMU.

3.3 Spatial and temporal trends in eel biometry

Eels life-history traits are complex and interact with anthropogenic pressures (Mateo *et al.*, 2017). The assessment of escapement can yield contrasted results if evaluated as number, biomass or egg production (Mateo *et al.*, *2017*; Briand *et al.*, 2018) and a positive relation of glass eel length and recruitment has been found in some studies (Dekker, 1998; Briand *et al*., 2019). For that reason, biometric data have been included in the WGEEL Data Call since 2019 with the objective to bring insights to the eel assessment provided by the WGEEL

Two kinds of data are currently stored depending on their origin. (i) Some biometric are collected during monitoring programmes that are also providing time-series of abundance to the WGEEL. For these data, the sampling sites are already described in the database and biometric data are stored in a dedicated table. (ii) Other monitoring programmes also collect biometric data, such as traditional DCF programme. In that case, the biometric data are stored in a specific table along with information about the location, EMU, habitat type and the number of eels collected. Information from both sources can be summarized in a source table via inheritance properties in the database (the fields shared by the child table are all visible in the mother table).

When introduced, Data Calls to new data have to be checked for their integrity. Part of the checks are performed at the structural level during integration but other checks require a thorough analysis of the data, their trends and their patterns, and also the detection of outliers or missing field.

A first exploratory spatial and temporal analysis of the data has identified some spatiotemporal trends (see Annex 9). However, the low number of series with biometric data in some stages and the insufficient details on the monitoring protocols and sites, makes it currently impossible to clearly disentangle whether those patterns arise from methodological differences among series (e.g. sampling gear, monitoring season), local environmental (e.g. habitat type, distance to the sea) or anthropogenic (e.g. restocking) influences, or large scale life traits patterns. However, it has been useful to identify complementary information that must be collected in order to make a complete analysis of the data. In this way, when reporting biometry data, it is recommended to:

- for those series in which a mixture of stages is reported (e.g. mixed glass eel/yellow series), an approximate percentage of each stage should be indicated,
- in the series, the sampling method should be specified, alongside with any additional precisions that may bias the captured sizes,

- it is recommended to include information about the sampling timing that might influence biometrics,
- It should be indicated whether there have been changes in the series that may lead to a change in the time trend (e.g. period or sampling method).

3.4 Trend in fisheries

This section presents and describes data from commercial, recreational and non-commercial fisheries, aquaculture production and restocking of eel. Data can be reported by eel life stage (glass, yellow, silver), habitat type (freshwater, tidal, marine) and by eel management unit (EMU) where possible. Historical series for which these details are not available are reported by country. The current database structure allows aggregation by country or region if necessary. The landings data presented have been reported to the WGEEL, either through responses to the 2020 Data call, in Country Reports in previous years, or integrated by the WGEEL during data calls.

Care should also be taken with the interpretation of the landings as indicators of the stock, since the catch statistics now reflect the status of reduced activity as well as of stock levels. Currently, no analyses of under-reporting has been carried out, and this would be necessary to apply to all landings series, especially recreational landings and historical data.

The following numbers can be provided to summarize the tends:

- commercial landings are declining, a long-term continuing trend, from a level of around 10 000 t in the 1960s, reported commercial landings have now dropped to around 2100 tonnes (glass eel + yellow eel + silver eel) in 2019;
- glass eel commercial landings show a sharp decline since 1980 from 2000 tonnes to around 40–60 tonnes since 2009 onwards (60 t in 2018);
- yellow and silver raw landings have diminished from a level of 10 000 t at the beginning of the 1980s to 2700 t in 2018;
- reconstructed commercial yellow and silver eels landings have declined from around 20 000 t in the 1950s to 2000–3500 t around 2009 (2700 t in 2019).

For recreational landings, a decline is also observed from a level of 580 t in the 1980s to around 240 tonnes (glass eel + yellow eel + silver eel) in 2019:

- glass eel recreational landings have been almost divided by ten since the 1980s (mean landings (1978–2009): 169 t) with mean landings since 2010 around 1.4 tons;
- mean yellow and silver eels recreational landings are around 509 t (from 1985 to 2016) and decreased to 250 t since 2017.

3.4.1 Commercial fisheries landings

Landings data come from the Eel data call and the WGEEL database data for commercial fisheries. When data are absent and presumed missing for a country/year, a predicted catch is used. This "correction" is based on a simple GLM extrapolation of the log-transformed landings (after Dekker, 2003), with year and countries as the explanatory factors. This is applied as one means to account for non-reporting, but it is not a complete solution.

Note that for glass eel as well as for yellow and silver eels, some countries have not always reported their landings. Thus, even with the corrected version of the figures the total given here should be considered as a minimum. Care should also be taken with the interpretation of the landings as indicators of the stock, since the catch statistics now reflect the status of reduced activity as well as of stock levels.

Figure 3.4.1 presents the time-series up to and including 2020 for total commercial glass eel landings as reported by five countries in the Eel Data Call and additional data provided via the Country Reports. Figure 3.4.2 presents the same time-series but corrected for missing data (see above), with an inset box showing the proportion of data corrected per year. This proportion is rather low, except for 2009. Glass eel landings show a sharp decline since 1980 from 2000 tonnes to around 40–60 tonnes since 2009 onwards. The commercial glass eel fisheries in 2019 and 2020 are 60 t for five countries (ES, PT, FR, GB, IT) and 55 t for three countries (FR, ES, PT, GB data not available yet), respectively. The mean glass eel commercial fisheries for the previous five years (2014–2018) is reported as 59 t.

Figure 3.4.3 presents the time-series up to 2019 for total commercial yellow eel landings as reported by 22 counties in the data call and from the WGEEL database. Figure 3.4.4 presents the same time-series but corrected for missing data, with an inset box showing the proportion of data corrected per year. Landings from yellow and silver eel commercial fisheries (Y, S, YS) add up to 2696 t in 2018 -for 20 country reports- and 2093 t in 2019, with only 17 countries with data available for report, respectively. Yellow and Silver eel commercial fisheries averaged 2679 t over the five previous years (2014–2018).

Reconstructed commercial yellow and silver eels have declined from around 20 000 t in the 1950s to 2000–3500 t around 2009. The reported reconstructed yellow and silver landings for three years, 2017, 2018 and 2019 (Y, S, YS) are 2393 t, 2267 t, and 2700 t, respectively with a mean of 2691 t for the previous five years (2014–2018).

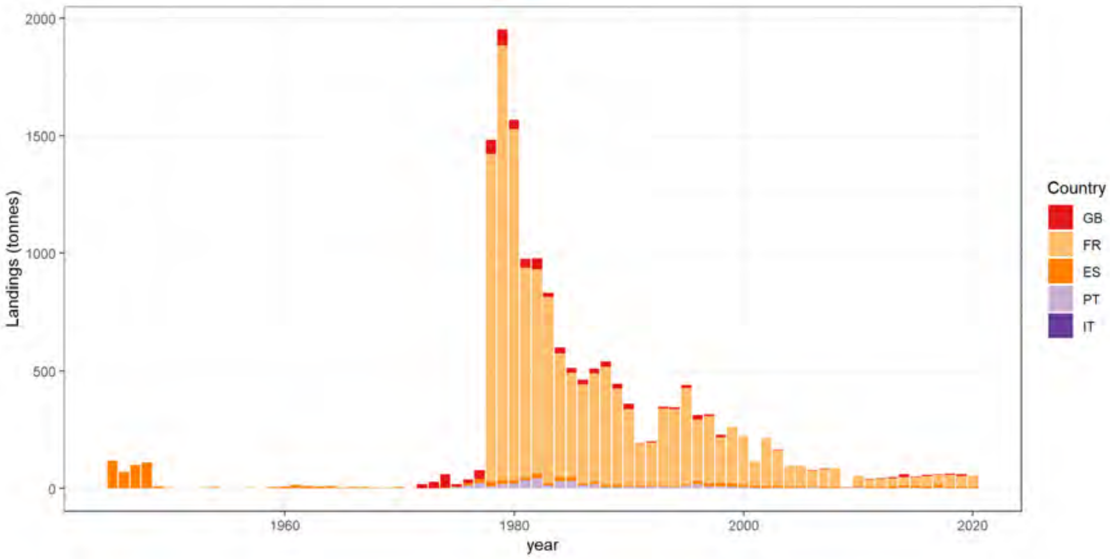

Figure 3.4.1. Time-series of reported commercial glass eel fishery landings (tonnes), by country. United Kingdom (GB), France (FR), Spain (ES), Portugal (PT) and Italy (IT) are included combining information from the Data call 2020 and the WGEEL database. See next graph for reconstructed landings. Data for recent years are provisional or incomplete and may change in future data calls. For more details, see Annex 9.

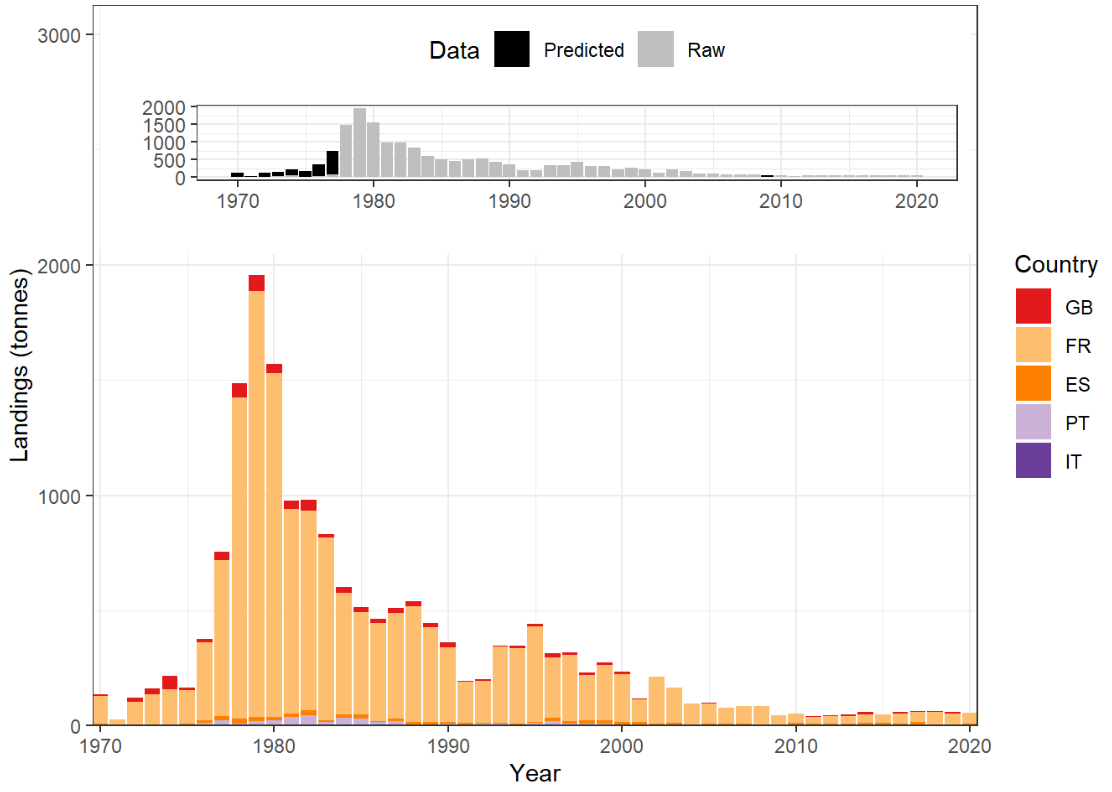

Figure 3.4.2. Time-series of reported or reconstructed commercial glass eel fishery landings (tonnes), 1970–2020, by country. United Kingdom (GB), France (FR), Spain (ES), Portugal (PT) and Italy (IT) combining information from the Data call 2020 and the WGEEL database, and a reconstruction of the non-reported countries/years combinations (see text). The inset box shows the proportion of data reconstructed per year. Data for recent years are provisional or incomplete and may change in future data calls. For more details, see Annex 9.

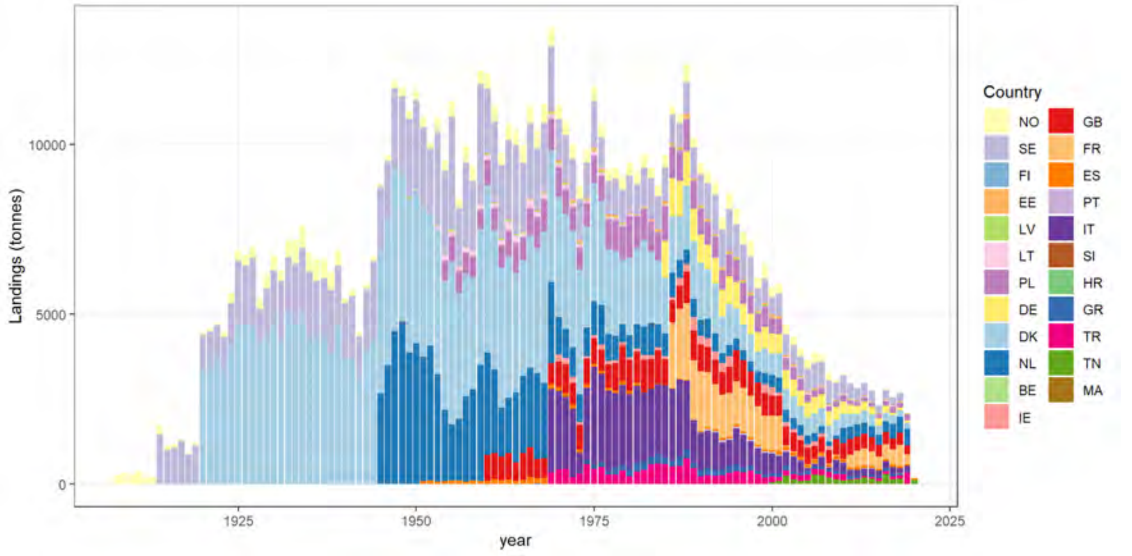

Figure 3.4.3. Time-series of reported commercial yellow (Y), silver (S) and yellow-silver (YS) eel fishery landings (tonnes) 1908–2020, by country, Norway (NO), Sweden (SE), Finland (FI), Estonia (EE), Latvia (LV), Lithuania (LT), Poland (PL), Germany (DE), Denmark (DK), Netherlands (NL), Belgium (BE), Ireland (IE), United Kingdom (GB), France (FR), Spain (ES), Portugal (PT), Italy (IT), Slovenia (SI), Croatia (HR), Greece (GR), Turkey (TR), Tunisia (TN) and Morocco (MA), combining information from the Data call and the WGEEL database. Data for recent years are provisional or incomplete and may change in future data calls. For details, see Annex 8.

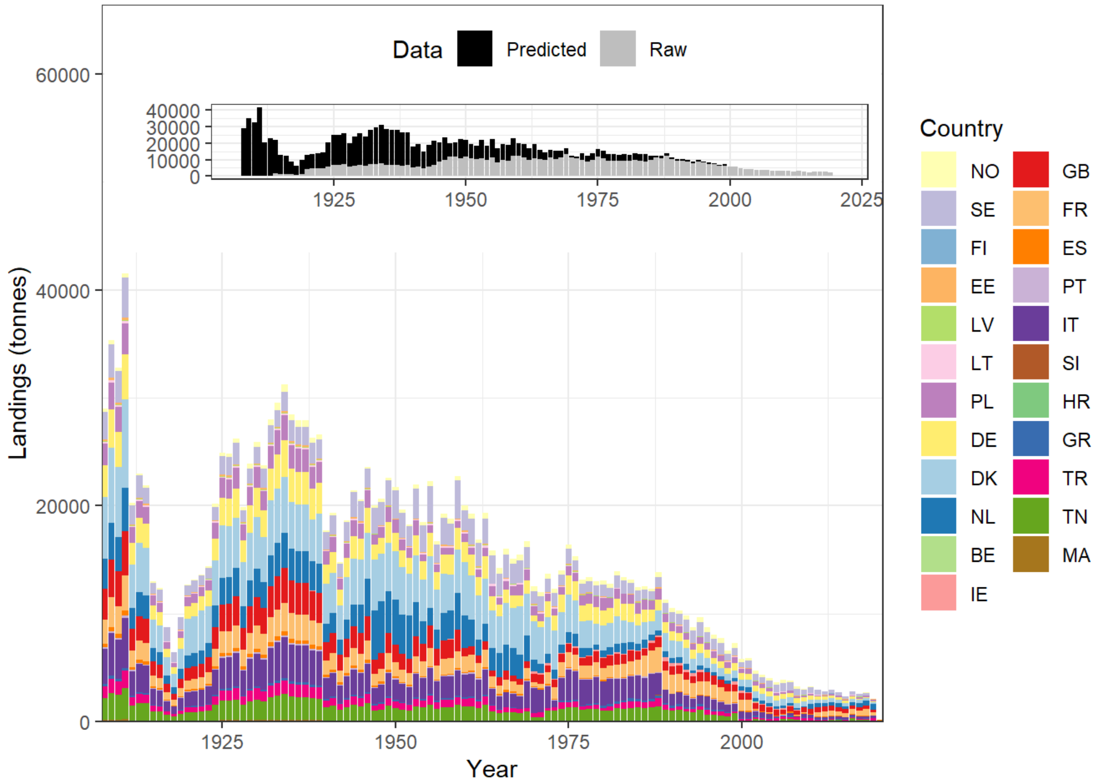

Figure 3.4.4. Time-series of reported or reconstructed commercial yellow and silver eel fishery landings (tonnes), by country, Norway (NO), Sweden (SE), Finland (FI), Estonia (EE), Latvia (LV), Lithuania (LT), Poland (PL), Germany (DE), Denmark (DK), Netherlands (NL), Ireland (IE), United Kingdom (GB), France (FR), Spain (ES), Portugal (PT), Italy (IT), Croatia (HR), Slovenia (SI), Greece (GR), Turkey (TR), Tunisia (TN) and Morocco (MA) combining information from the Data call, the WGEEL database and a reconstruction of the non-reported countries/years combinations. Inset box shows the proportion of reconstructed landings, per year. Data for recent years are provisional or incomplete and may change in future data calls. For details, see Annex 8.

3.4.2 Recreational and non-commercial fishing

Recreational and non-commercial fishing is the capture or attempted capture of living aquatic resources mainly for leisure and/or personal consumption. Recreational and non-commercial fishery covers active fishing methods including rodandline, spear, and hand–gathering and passive fishing methods including nets, traps, pots, and setlines. Recreational fisheries for glass eel used to exist in France and Spain, but have been forbidden in France from 2010.

Figure 3.4.5 presents the data available to the WGEEL on recreational landings for glass eel from two countries. Spain and FR report a recreational fishery for glass eel, with landings estimated as 0.86 t and 0.66 t for 2019 and 2020, respectively. The mean glass eel recreational fisheries of the previous five years (2014–2018) is 1.94 t.

Figure 3.4.6 presents the data available on recreational landings of yellow and silver eel combined. Recreational landings for yellow and silver eel combined were 245 t for 2018 (11 countries reporting), 241 t for 2019 (ten countries reporting). The mean yellow and silver eel recreational fisheries for the previous five years (2014–2018) is 463 t. Note that France has reported an expert estimate for 2006 and only a small part of the recreational landings for which reporting is mandatory the other years. This effectively doubled the landings from all countries in this year compared to others. It highlights that the data reported are incomplete and while trends over time might be informative, the data cannot be used to suggest total landings.

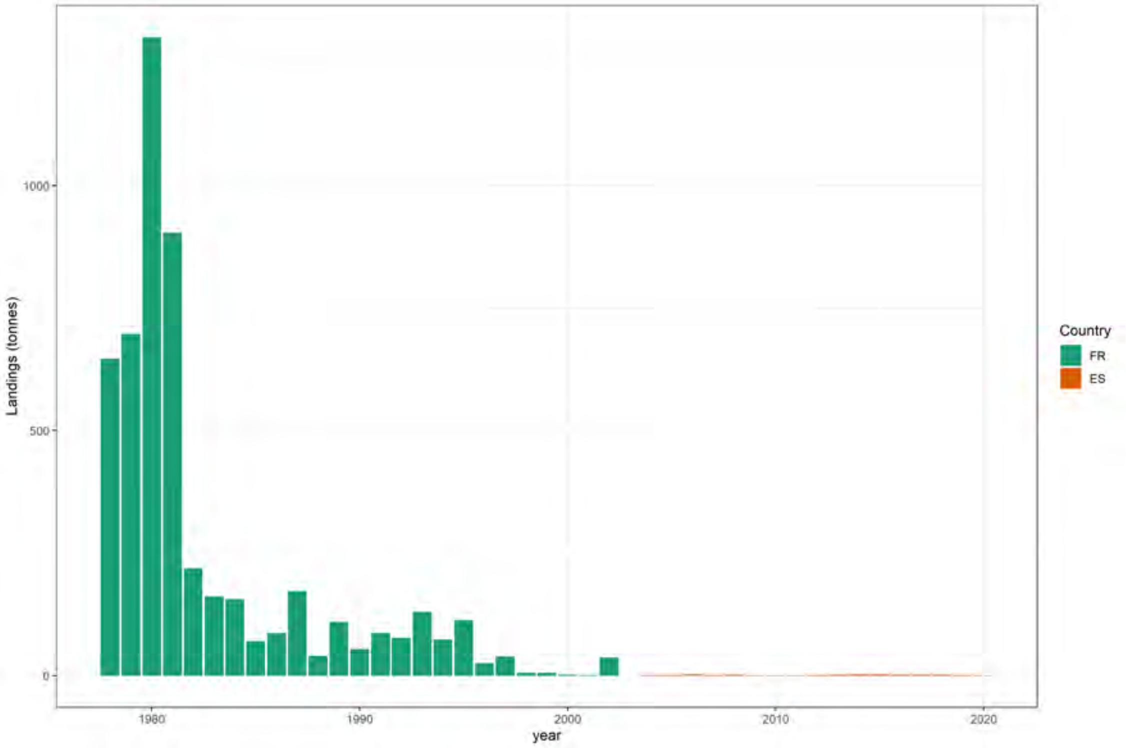

Figure 3.4.5. Time-series of reported recreational glass eel fishery landings (tonnes), by country France (FR), Spain (ES) combining information from the Data call and the WGEEL database. Data for recent years are provisional or incomplete and may change in future data calls. For more details, see Annex 8.

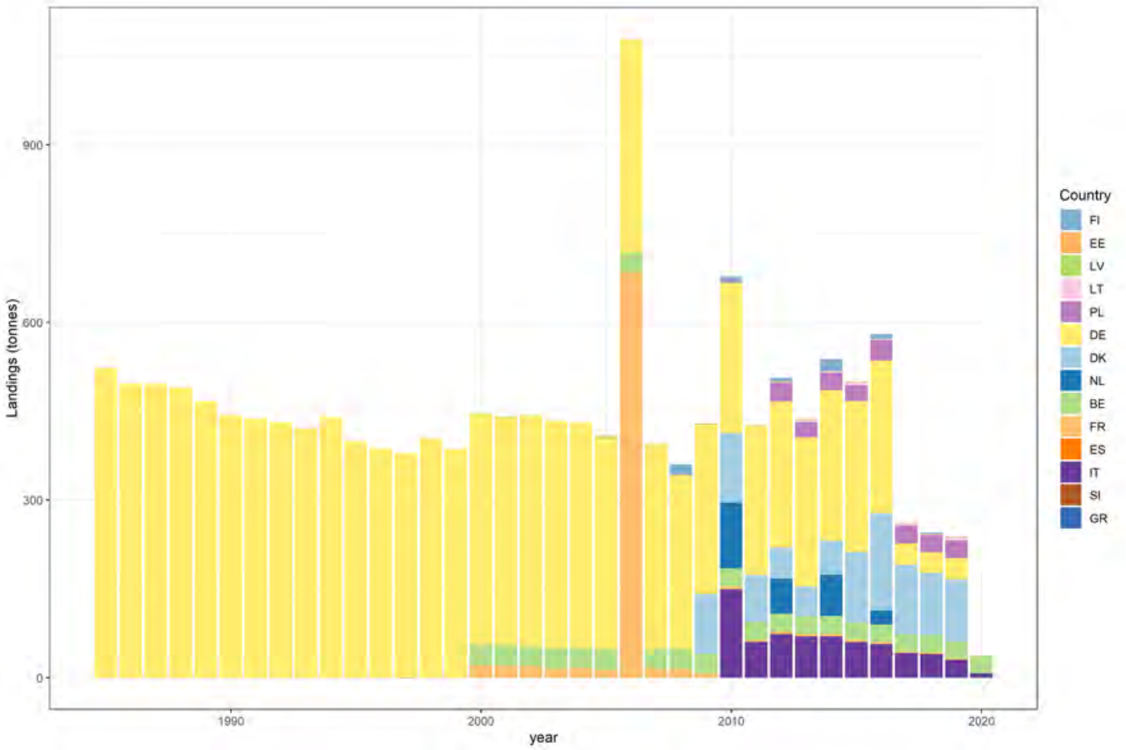

Figure 3.4.6. Time-series of reported or recreational yellow and silver eel fishery landings (tonnes), by country Finland (FI), Estonia (EE), Latvia (LV), Lithuania (LT), Poland (PL), Germany (DE), Denmark (DK), Netherlands (NL), Belgium (BE),France (FR), Spain (ES), Italy (IT), Slovenia (SI), Greece (GR), combining information from the Data call. Data for recent years are provisional or incomplete and may change in future data calls. For more details, see Annex 8.

3.4.3 Illegal, unreported and unregulated landings

Illegal, unreported and unregulated fishing (IUU) is by its nature very difficult to quantify, and misreporting may therefore be substantial. Most countries did not report any IUU in their Country Reports. However, seizure of illegal gears, or other legal measures were reported from Belgium, Ireland, The Netherlands, and Sweden in their Country Reports. Organized illegal glass eel trade is supplied by legally caught and IUU caught eel. This trade has high priority by Europol (the European Union's law enforcement agency) among environmental crimes, due to its economic significance, the poor status of the eel stock, and the large number of organisms affected. Related police action and court decisions have been covered by a large number of news reports during the past year. In addition, illegal eel trade from range states is an issue of concern for the Convention on International Trade in Endangered Species. To summarize, while IUU fisheries certainly exist for glass, yellow and silver eel, there are insufficient data available to quantify their effect on the total stock size or status at any level of certainty.

3.5 Releases

Data have been reported on restocking comprising eels released at the glass eel phase, either directly (G), or after a quarantine (QG), after a period of some months of growth in aquaculture (OG), at the yellow eel (Y) or silver eel (S) stage or mixed life stages: Glass + Yellow eel (G+Y) and Yellow + Silver eel (Y+S). There is also a spatial element that complicates matters, ranging from the capture and movement of eel only a few 10th or 100th of metres within the same waterbody to bypass an obstacle, to eel being moved several 100 km from one country or ecoregion to another.

As there is still some inconsistency or variation in the way that countries report some of these actions, the WGEEL broadly categorises them as ”releases”, though the term “restocking” is still used here for some circumstances.

Data on the amount of restocked eel were obtained from the responses to the Data call in 2020; however, the data for 2019 and 2020 for restocking are incomplete due to de the delayed data availability.

The Data call requires the provision of both numbers and weights per EMU to evaluate the average weight of each line of data entered. As the database is not structured to handle two different columns for quantities, the initial checks on the consistency are done during data integration.

The restocking of glass eel peaked in the 1980s but part of the decrease is not showing as German data are lacking for the period before 1980, followed by a steep decline to a low in 2009 (Figure 3.5.1). The amount of glass eels restocked increased until 2014 when the lower market prices guaranteed a larger number of glass eels could be purchased for fixed restocking budgets. However, glass eel restocking has decreased since then.

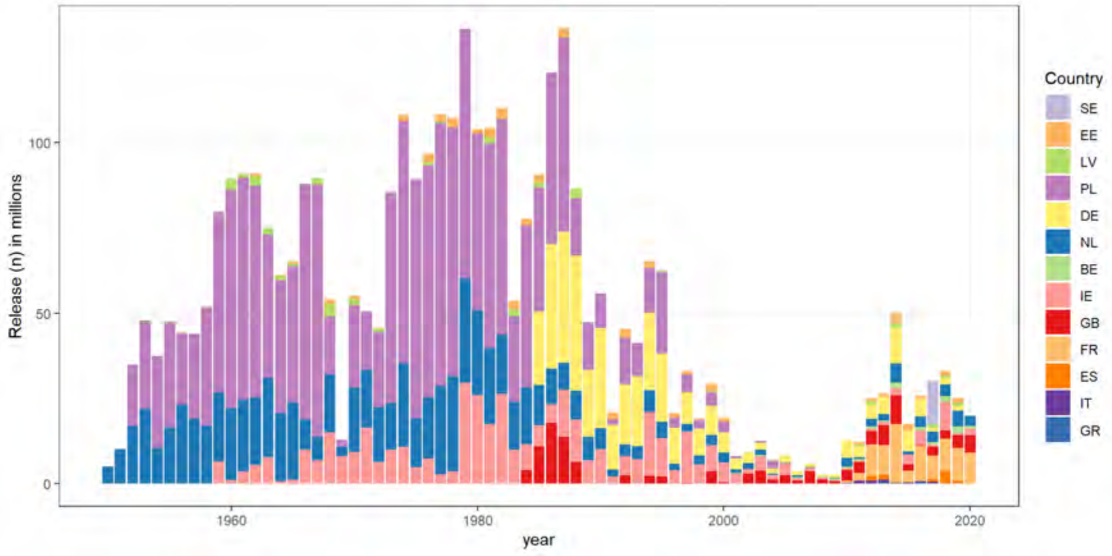

Figure 3.5.1. Reported releases of glass eel (in millions) per country, Sweden (SE), Estonia (EE), Latvia (LV), Poland (PL), Germany (DE), Netherlands (NL), Belgium (BE), Ireland (IE), United Kingdom (GB), France (FR), Spain (ES), Italy (IT) and Greece (GR).

During the 1940–1960 period, Sweden had a large restocking programme [1] for yellow eel (not shown in Figure 3.5.2). The activity decreased in the 1970s and increased again in the 1980s. Germany started to stock yellow eels in 1985. In the Netherlands stocking with young yellow eel has been performed since pre-war time. First with wild origin fish and later with eels raised in aquaculture.

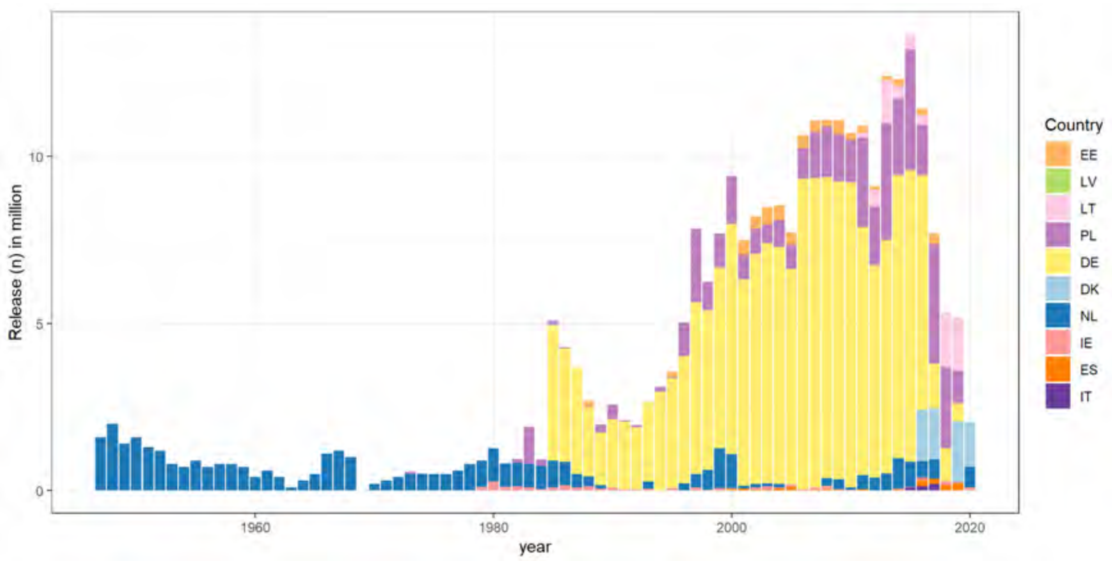

Figure 3.5.2. Reported releases of yellow eels and on-grown eel (in millions) per country[1], Estonia (EE), Latvia (LV), Lithuania (LT), Poland (PL), Germany (DE), Denmark(DK), Netherlands (NL), Ireland (IE),Spain (ES) and Italy (IT)). Data for recent years are provisional or incomplete and may change in future data calls. Sweden not shown. For more details, see Annex 8.

[1] Note current data for Sweden are under revision and are not complete.

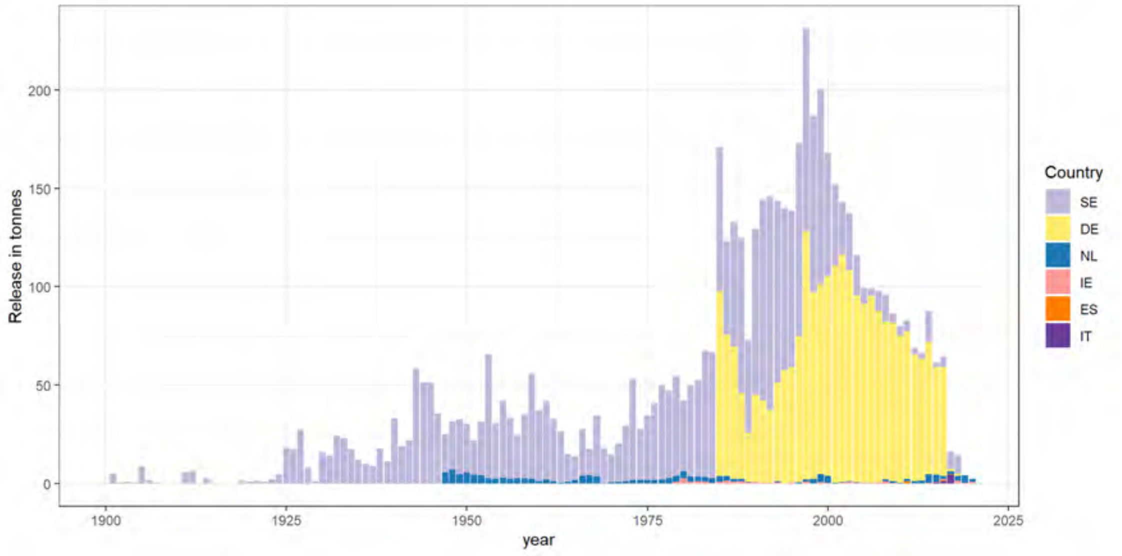

Figure 3.5.3. Reported releases of yellow eels and on-grown eel (in millions) per country Same figure as 3.5.2 but in weight. Data for recent years are provisional or incomplete and may change in future data calls. For more details, see Annex 8.

In contrast, some silver eels, caught by the fishery and therefore recorded as landings, are later released in the Mediterranean outside the lagoons in Greece and France. They are reported as released silvers (Figure 3.5.4). In Ireland and Sweden Trap and Transport (TandT) of silver eels from upstream to downstream sites in rivers have been implemented.

In Sweden within the TandT-program, approximately 119 000 kg silver eels were transported downstream by road between 2013 and 2019.

In Finland, eels are trapped on the river Vääksynjoki running from Lake Vesijärvi in the upper reaches of the Kymijoki watercourse, 150 km from the sea. The eels caught in this trap are tagged and released into the sea at Kymijoki estuary below hydropower dams.

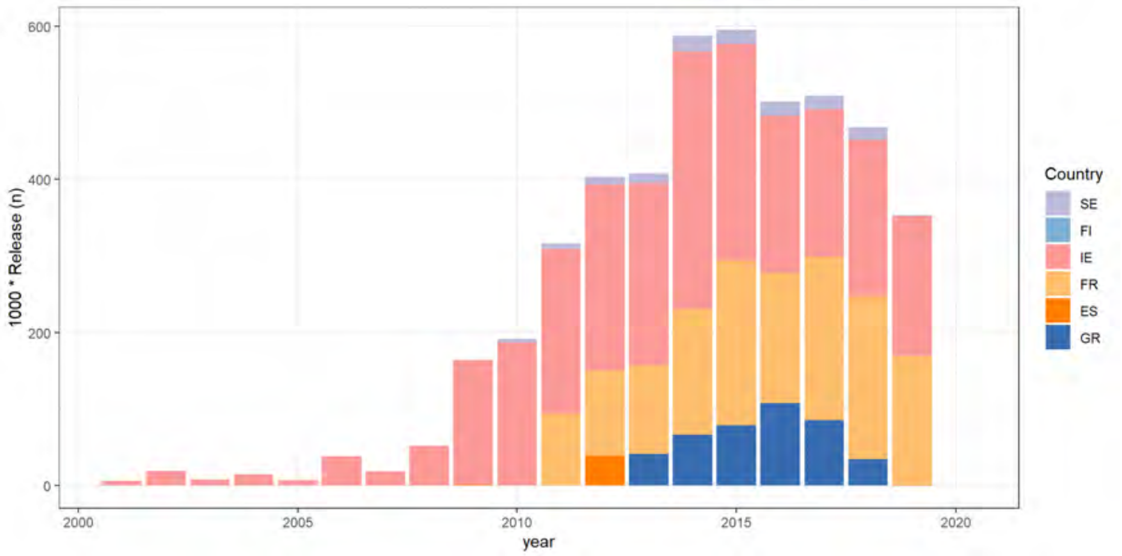

Figure 3.5.4. Reported releases of silver eel (in thousands) per country, Sweden (SE), Finland (FI), Ireland (IE), France (FR), Spain (ES), and Greece (GR). Data for recent years are provisional or incomplete and may change in future data calls. For more details, see Annex 9.

Only Sweden and Finland have reported quarantined glass eel restocking (Figure 3.5.5). Quarantined glass eel restocking peaked in the 1990s, decreased in the early 2000s and increased again after the implementation of the Eel Regulation.

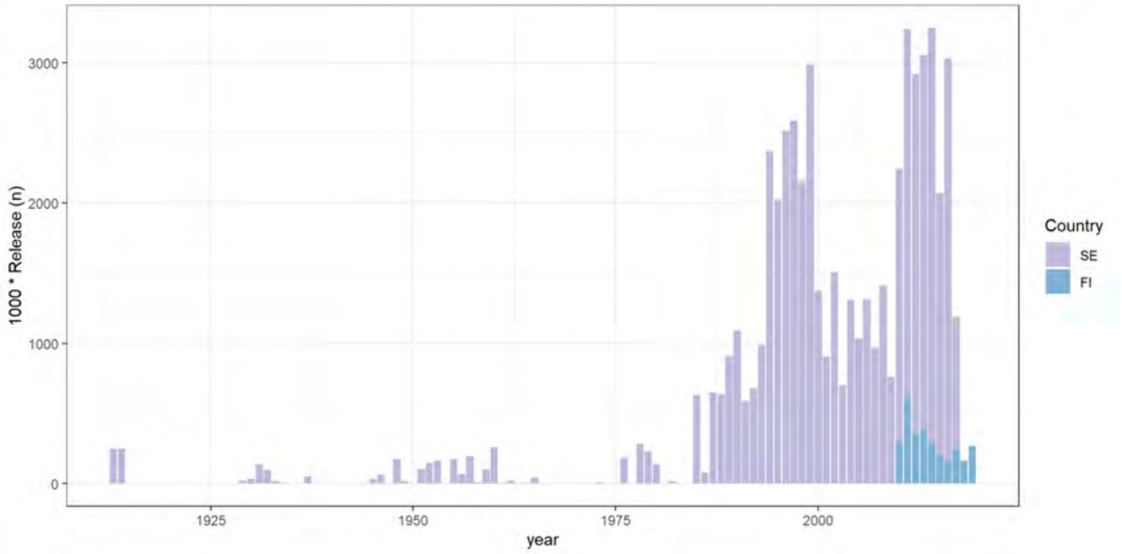

Figure 3.5.5. Reported releases of Quarantined glass eel (in thousands) per country, Sweden (SE) and Finland (FI). Data for recent years are provisional or incomplete and may change in future data calls. For more details, see Annex 9.

The restocking of on-grown eels has constantly increased since 2000 and reached a maximum in 2014 (Figure 3.5.6). Poland restocked most on-grown eels until 2016. Denmark has stocked on-grown eels since 1987 (but is missing from the Figure).

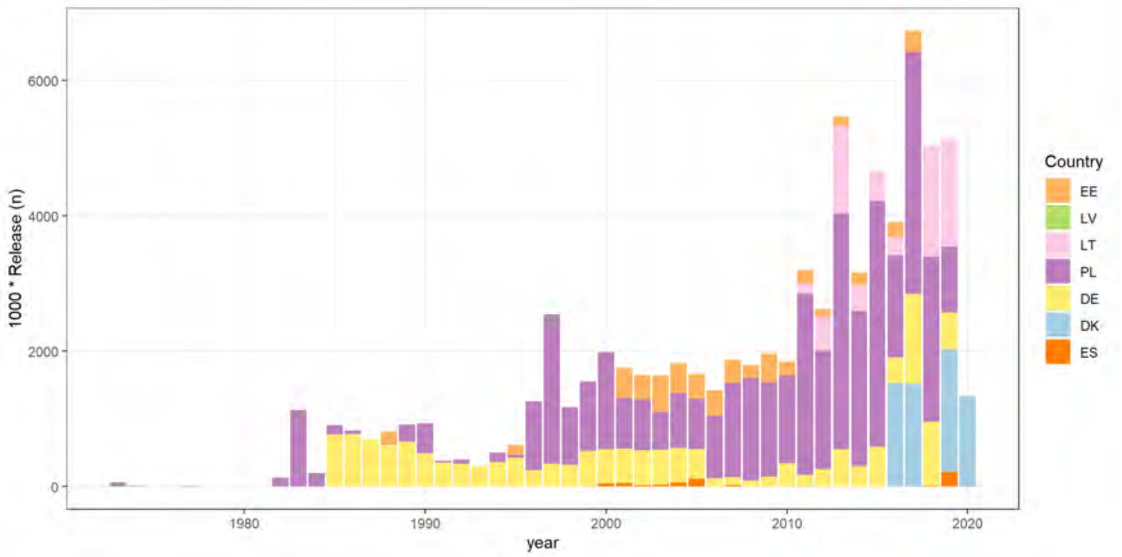

Figure 3.5.6. Reported releases of on-grown glass eel (in thousands) per country, Estonia (EE), Latvia (LV), Lithuania (LT), Poland (PL), Germany (DE), Denmark (DK) and Spain (ES). Data for recent years are provisional or incomplete and may change in future data calls. For more details, see Annex 9.

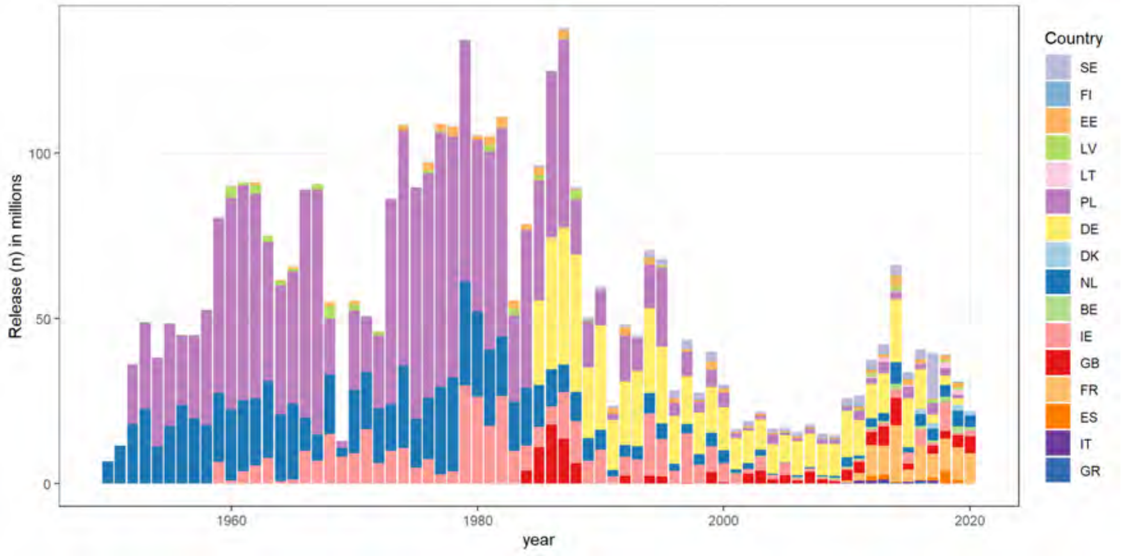

Figure 3.5.7. Reported releases of all stages (Y, YS, OG, S, QG) (in millions) per country, Sweden (SE)[2], Finland (FI), Estonia (EE), Latvia (LV), Lithuania (LT), Poland (PL), Germany (DE), Denmark (DK), Netherlands (NL), Belgium (BE), Ireland (IE), United Kingdom (GB), France (FR), Spain (ES), Italy (IT) and Greece (GR). Data for recent years are provisional or incomplete and may change in future data calls. For more details, see Annex 9.

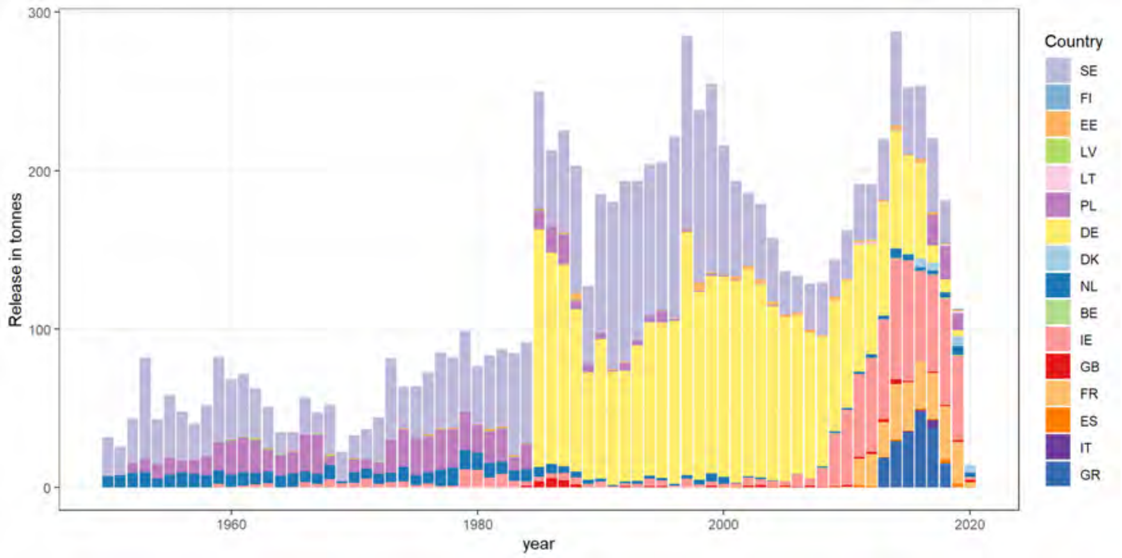

Figure 3.5.8. Reported released of all stages (Y, YS, OG, S, QG) (in tonnes) per country Sweden (SE)[3], Finland (FI), Estonia (EE), Latvia (LV), Lithuania (LT), Poland (PL), Germany (DE), Denmark (DK), Netherlands (NL), Belgium (BE), Ireland (IE), United Kingdom (GB), France (FR), Spain (ES), Italy (IT) and Greece (GR). Data for recent years are provisional or incomplete and may change in future data calls. For more details, see Annex 9.

[2] NOTE DATA FOR SWEDEN ARE INCOMPLETE IN NUMBER.

[3] NOTE DATA FOR SWEDEN ARE COMPLETE FOR WEIGHT.

3.6 Aquaculture

Aquaculture production data are derived from responses to the Data call 2020.

The aquaculture production increased until the end of the 1990s. It started to decline from the mid-2000s from 8000–9000 tonnes to approximately 4000–5000 tonnes now (Figure 3.6.1).

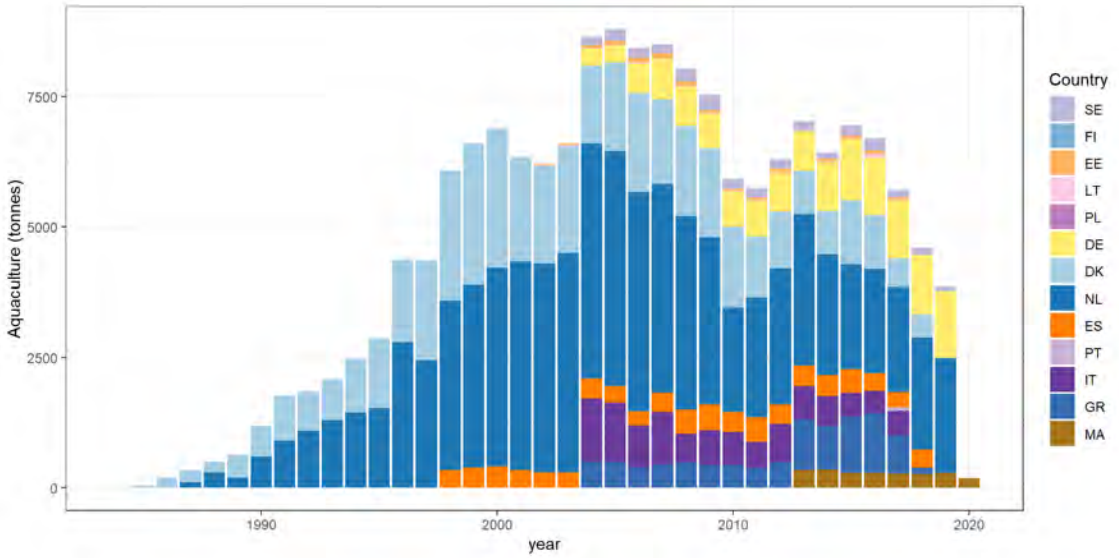

Figure 3.6.1. Reported aquaculture production of European eel in Europe from 1984 onwards, in tonnes, in Sweden (SE), Finland (FI), Estonia (EE), Lithuania (LT), Poland (PL), Germany (DE), Denmark (DK), Netherlands (NL), Ireland (IE), Spain (ES), Portugal (PT), Italy (IT), Greece (GR) and Morocco (MA). Data for recent years are provisional or incomplete and may change in future data calls. For more details, see Annex 9.

3.7 Preparation of Data Call 2021

In 2021, biomass, mortalities and habitat data will be requested in the Data Call as they will be reported by EU Member States. Those data have already been part of the 2018 Data Call (ICES, 2018) and the lack of experience (that was only the second Data Call for the WGEEL) and standardisation have generated a lot of issues when estimates collected at the EMUs scales were used to make estimations at the international level. The major problems (with biomass, mortalities or habitat data) have been described in a github issue (https://github.com/ices-eg/wg_WGEEL/issues/168). In this chapter, based on Data Call 2018 feedbacks, we will propose elements of standardisation to ease next Data Call.

3.7.1 Technical proposal for standardisation

Here are technical instructions to standardise the data call for biomass, mortalities and habitat:

1. Data should by reported by EMU and habitat (Freshwater ‘F’, Transitional water ‘T’, Coastal water ‘C’, or all habitat ‘AL’) and should never be split by ICES division.
2. Life stage for biomass should only be silver eel (‘S’).
3. Mortalities data have to be provided as total lifespan mortalities (thus lifestage ‘AL’). If mortalities data per lifestage are available, they can also be provided as complementary information.
4. Mortalities should be computed in number, not biomass.

5. For pristine biomass (B_0) the year should be arbitrarily fixed to 0 and there is no reason that B_0 changes over time since it refers to a pristine situation.
6. The Lifestage used for habitat surface should only be all habitat ('AL') since there is no reason for variable available habitats among stages.

Furthermore, Countries Reports should describe the method used to estimate stock indicators and habitats quantification. This should include lifespan duration use in these calculations. This is crucial to ensure that comparisons are indeed possible among estimates.

Given the previously described problems encountered in the 2018 data call, countries are asked to resubmit all data in data call 2021.

To ease the process of standardising the data, all biomass, mortalities and habitat data collected in 2018 will be tagged as quality 'discarded_wgeel_2020', so that data provider will be asked to resubmit their data following the new format.

3.7.2 How restocking should be integrated into stock indicators?

ICES (2018) has elaborated on how the restocking should be accounted for in the stock indicators. We will here just repeat the main conclusions and their consequences for the 2021 Data Call.

While restocking is recognised as one of the possible measures to restore the stock, the inclusion of (positive) effect of restocking in stock indicators should be consistent. The estimation of $B_{current}$ is relatively straightforward: eels of restocked origin contribute to the actual escapement (if and where), and therefore, $B_{current}$ should include the contribution from restocking. B_0 and B_{best} being the production not impacted by human factors, respectively with historical (high) recruitment and with current recruitment, they should not contain any contribution from eels of restocked origin. Finally restocking should not be included as a positive effect in mortalities (ΣH hence ΣA) as it will constitute a case of "double-banking" (already being included in $B_{current}$) and as it is not precautious (allowing virtually unlimited anthropogenic mortalities to be compensated by large restocking programme).

Many countries estimate ΣA as $-\ln(B_{current} / B_{best})$, however since restocking is included in $B_{current}$ and not in B_{best}, this leads to a ΣA including restocking and therefore to a not-precautious situation of "double-banking". Therefore, if this proxy is to be used, countries should correct either $B_{current}$ (subtracting) or B_{best} (adding) for the effect of restocking only for the computation of the proxy (they should still report $B_{current}$ with restocking and B_{best} without restocking).

3.7.3 Should mortalities come from Year-wise or cohort-wise analysis?

There are two approaches to calculate mortalities for a given year: either summing up values of mortalities experienced by all year class that particular year (year-wise also called pseudo-cohort analysis) or summing up values of mortalities experienced by the final cohort (silver eels) during their entire life (cohort-wise analysis).

To illustrate the two approaches, let's consider an eel population made of ten year classes, the tenth being the silver eel escapement (Figure 3.7.1). The same anthropogenic mortality rate (A) apply to all year-classes for a given year. As an illustrative example, this mortality rate is cut by 10% every year due to a management plan. We want to report $\sum A$ and biomasses for the year 2020. In the following, the relationship between $\sum A$ and biomass indicators will be made explicit ICES (2018) recommended that in that case biomasses should be expressed in numbers (which is done here).

The year-wise option sums up mortalities from 2020 (all equal to 0.10) giving a ∑A of 1.05. This calculation reflects the current management regime and informs on the mortality that the last cohort would experience during its lifespan under a *status quo* scenario. This is the approach usually used in marine fisheries stock assessment. Theoretically, estimated ∑A as a ratio of $B_{current}$ and B_{best} would require to have predictions of B_{best} and $B_{current}$ for 2029.

The cohort-wise option sums up mortalities experienced during the entire life of the 10th year class from 2020 (0.1 for 10th year class in 2020, 0.12 for 9th year class in 2019, …) giving a ∑A of 1.76. This thus reflect the management regime of the last decade that have been experienced by the current escaping silver eel. With this option ∑A can be calculated with the ratio of $B_{current}$(2020) to B_{best}(2020), B_{best}(2020) being the escapement that would have occurred in 2020 if the 2011 recruitment would have experienced only natural mortality.

	A	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020		M = 0,1
year class	1	0,3	0,27	0,24	0,22	0,20	0,18	0,16	0,14	0,13	0,12	0,10		
	2	0,3	0,27	0,24	0,22	0,20	0,18	0,16	0,14	0,13	0,12	0,10		
	3	0,3	0,27	0,24	0,22	0,20	0,18	0,16	0,14	0,13	0,12	0,10		
	4	0,3	0,27	0,24	0,22	0,20	0,18	0,16	0,14	0,13	0,12	0,10		
	5	0,3	0,27	0,24	0,22	0,20	0,18	0,16	0,14	0,13	0,12	0,10		
	6	0,3	0,27	0,24	0,22	0,20	0,18	0,16	0,14	0,13	0,12	0,10		
	7	0,3	0,27	0,24	0,22	0,20	0,18	0,16	0,14	0,13	0,12	0,10		
	8	0,3	0,27	0,24	0,22	0,20	0,18	0,16	0,14	0,13	0,12	0,10		
	9	0,3	0,27	0,24	0,22	0,20	0,18	0,16	0,14	0,13	0,12	0,10		
	10	0,3	0,27	0,24	0,22	0,20	0,18	0,16	0,14	0,13	0,12	0,10		
												1,05	1,76	

Year-wise (pseudo-cohort)
Cohort-wise

	R	100	90	80	150	300	250	220	210	200	210	220									
	B (in #)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
year class	1	67	62	57	109	223	189	170	165	159	169	179									
	2	45	46	44	41	81	169	146	133	131	128	138	146								
	3	30	31	33	32	31	61	130	115	106	105	104	112	119							
	4	20	21	22	24	24	23	47	102	91	85	86	85	92	97						
	5	14	14	15	16	18	18	18	37	81	73	69	70	69	75	79					
	6	9	9	10	11	12	13	14	14	30	65	60	57	57	57	61	64				
	7	6	6	7	7	8	9	10	11	11	24	53	49	46	47	46	50	53			
	8	4	4	4	5	5	6	7	8	9	9	19	43	40	38	38	38	40	43		
	9	3	3	3	3	4	4	5	5	6	7	7	16	35	32	31	31	31	33	35	
$B_{current}$ (in #) –>	10	2	2	2	2	2	3	3	4	4	5	6	6	13	29	26	25	25	25	27	28
ΣA =-LN(Bc/R)-10*M												1,76	1,59	1,45	1,34	1,25	1,18	1,12	1,08	1,06	1,05
B_{best} (in #) –>										B_{best} = R * exp(-10 M)	37	33	29	55	110	92	81	77	74	77	81
ΣA =-LN(Bc/Bbest)											1,95	1,76	1,59	1,45	1,34	1,25	1,18	1,12	1,08	1,06	1,05

Figure 3.7.3. Stock indicators for a theoretical eel population to illustrate year-wise (in red) and cohort-wise (in blue) analysis.

Both options are mathematically correct, but they do not answer to the same question: year-wise analysis informs of the current management and how it will impact future escaping silver eel if it stays as it is, while cohort-wise analysis informs of past management and explain the level of current escapement. SGIPEE (ICES, 2011) noticed that the year-wise analyse is in line with the conventional ICES procedures and the standard Precautionary Diagram to show the full effect of management measures taken even though the effect on biomass has not yet fully occurred. Moreover, the cohort-wise approach raises problem of comparison among countries since the lifespan of eels is highly variable among countries (growth phase can last from five to 20 years depending on growth habitats). However, recognising the current practices and work to be done to converge toward a common practice, the 2021 data call will allow to report with either approach, providing the approach is clearly specified.

3.7.4 Main recommendations for 2021 data call

- Restocking should be included only in $B_{current}$;
- When $\sum A$ is calculated as the ratio between $B_{current}$ and B_{best}, biomasses should be expressed in numbers in that calculation and both biomasses should come from the same recruitment year (i.e. in the example above both from 2011 or both from 2020). If restocking is included in $B_{current}$, the ratio between $B_{current}$ and B_{best} no longer reflects the total mortality $\sum A$.

Report mortalities along with the approach used.

4 ToR C: Report on updates to the scientific basis of the advice, including any new or emerging threats

This chapter discusses updates in science, relevant for the management and protection of the eel. First, focus is on the loss of habitats over time and its effect on eel. Then, an overview of recent publications on new and emerging threats is given.

4.1 Habitat loss

In this section, we discuss the loss of eel habitats over time, including both the destruction of habitats, and inaccessibility of habitats due to migration barriers. The focus is on understanding the processes, and building up to a later quantification of the impact of habitat loss on the production of eel. Mitigation and remedial actions (migration facilities, assisted migration or restocking, habitat creation and restoration) as important and relevant as they are, will be covered only briefly.

4.1.1 Introduction on habitat loss

WGEEL 2018 identified a need for reviewing scientific studies and new data on non-fishery factors contributing to direct and indirect losses of eel, at a frequency appropriate to refreshing advice based on the availability of new information. The group concluded that where the stock-level impact of such factors can be quantified, leading to renewed advice on the benefits of mitigation measures additional to existing fishery controls, a rolling programme of reviews should be undertaken, with a specifically tasked subgroup examining one theme per year.

The first three areas proposed by WGEEL in 2018 (ICES, 2018) for review were (1) impact of hydropower and water pumping operations, (2) loss of eel habitat and (3) effects of contaminants and parasites. The impact of hydropower and water pumping operations being covered in the 2019 WGEEL report (ICES, 2019), a review of the impact of habitat loss on eel stocks was now included in the 2020 workplan for WGEEL, under ToR b) “Report on developments in the state of the European eel (*Anguilla anguilla*) stock, the fisheries on it and other anthropogenic impacts.”

In this section, we will (a) review the literature on the effects of habitat loss with a focus on the biological processes operating, (b) review the national EMPs and (latest) triannual assessments identifying whether and to what extent the effects of habitat loss have been taken into account, (c) develop a workplan aiming at the quantification of habitat loss and its effect on eel production in the coming years, and (d) present some actual case studies.

Given the limited time available during the meeting of WGEEL, the literature review (Section 4.1.2 below) will not be exhaustive, but it provides an overview covering the major aspects and processes involved. The review of EMPs and assessments, presented in Section 4.1.3 below, indicates that the impacts of habitat loss are considerable and complex, but rarely fully worked out and quantified. Consequently, there was no option to (improve the) quantification based on the available information during the meeting, or using the information available in currently running projects.

In 2016, the EU 2020 Horizon project Adaptive Management of Barriers in European Rivers (AMBER; see www.amber.international) was established. The project set out to apply adaptive management to the operation of barriers in European rivers to achieve a more effective and efficient restoration of stream connectivity. In June 2020, the project launched the first pan-European Atlas of instream barriers. The Atlas contains information on 630 000 barriers including thousands of small weirs, ramps, fords and culverts. It is estimated that as 1/3 of these barriers were not recorded on any countries inventories the actual number could be over 1 million. Traditionally river managers focused efforts on large dams; however, the AMBER project has shown that 85% of barriers are weirs and other small structures. Many of these barriers recorded in the ATLAS are obsolete, and could be removed to reconnect our waterways.

However, the AMBER project being focused on migration barriers (i.e. in existing habitats), this information was considered insufficient for the current assessment of the effects of all kinds of habitat loss. It was therefore decided to develop a forward strategy for the quantification of habitat loss and its impact on eel production (see Section 4.1.4, below), to be addressed by WGEEL (or elsewhere) in its coming meetings. This will allow building up a full quantification of the effects of habitat loss, and set a framework for evaluating mitigating measures (present and future).

The term "habitat loss" is more complex than it may seem at first glance, as it can involve “complete loss (destruction)” of habitat, “inaccessibility of habitats” or “degraded habitats”, and also relates to newly created habitats. To add more complexity, even a reduced accessibility could be seen as “habitat loss”, because if only 30% of the local stock access the habitat due to a barrier, it would be lost for the remaining 70%. WGEEL notes this complexity and considers the following section of the report as a first step to address this issue. In order to address this complexity adequately, we do not narrow down our analysis to any of the three interpretations here. Instead, all potential issues are explained in short sections. WGEEL is aware that the issue “habitat loss” requires further attention in the future.

The analysis of the impact of habitat loss, initiated here, will be relevant to eel recovery policies, including the Eel Regulation, and the GFCM Eel Pilot Action; to environmental protection policies, including the EU Water Framework Directive, Habitat Directive and Biodiversity Strategy.

4.1.2 Literature overview, biological processes, remedies

This section provides a primary review of the literature on the impact of habitat loss on eel stock and production. Though we took the literature used in national EMPs and assessments as our starting point, the focus here is on the biological processes affected, not on the quantification of the habitat surface and/or the quantitative effect on the eel stock in any specific area. Information in the national EMPs is dealt with in Section 4.1.3, below. Quantification of habitat loss and its effect in Section 4.1.4, below.

4.1.2.1 Introduction on the literature overview

It is broadly reported that habitat loss has a significant impact on eel production. For example, Chen *et al.* (2014) estimated, using satellite imagery, that 76.8% of effective habitat area had been lost in 16 rivers in East Asia from 1970 to 2010. A rapid literature review was carried out during the WGEEL meeting to identify research documenting habitat loss and its effects on eel growth and distribution. However, studies with direct relevance to the quantification of eel habitat and loss of eel habitat are limited and disparate. Furthermore, some relevant papers, reports, etc. may possibly not be found under the typical key words in literature databases. E.g. papers on habitat loss due to river regulation in the (late) Middle Ages may not have been related to eel at all, while that habitat loss has relevance to the eel. Consequently, the current review is considered as preliminary, and it is recommended to expand on it in future, in parallel with the further developments described below.

From the 56 references gathered during the meeting, 30 were scientific papers, ten were the National EMPs and Progress Reports and finally 16 belonged to the grey literature. Studies with direct relevance to the quantification of eel habitat loss are limited, as highlighted in Table 4.1.1 There were only 12 scientific papers some quantification of eel habitat, and only two in the grey literature. On the other hand, seven EMPs included quantitative on eel habitat (and loss). Regarding the question "Is habitat loss quantified – time trend or change" there is balance between those with no direct reference and with direct reference. Finally, little information is published regarding the "quantification of the impact of habitat loss on eel production" as can be observed in Table 4.1.1.

Table 4.1.1. Summary of literature study.

	Is habitat quantified?	Is habitat loss quantified – time trend or change?	Is the impact of habitat loss on eel production quantified?
Papers yes	11	15	6
Papers no	19	15	24
EMPs yes	10	6	5
EMP no	0	4	5
Grey literature yes	2	5	0
Grey literature no	14	11	16

4.1.2.2 Physical barriers

For diadromous species like the European eel, a key problem is their inability to reach the upstream part of riverine systems (as glass eels or young yellow eels), and to migrate back to the sea (as yellow or silver eel). This inability is not only the result of hydropower dams, but also due to the presence of many kinds of barriers (small, medium, large size, permanent or temporary barriers, etc.). The most common types of barriers to eel passage, apart from hydropower plants, are weirs, ford- bridges, sluices, etc. There are numerous papers describing the impact of barriers in delaying or blocking migration of European eel. These indicate that barriers of any size can have the same impact on migratory species, as they inhibit their migration, intensify the habitat destruction or reduce the availability of habitat (Lucas and Batley, 1996; Ovidio and Philippart, 2002; Haponski *et al.*, 2007). Much of the relevant literature refers to the impact that river damming, artificial river diversion projects and channelization might have in rivers' catchment areas, like environmental deterioration of rivers or hydro-geomorphological changes (e.g. Mertzanis and Mertzanis, 2013; Mertzanis *et al.*, 2011).

One more potential impact is increased glass eel mortality due to increased abundance below the barriers they cannot pass. For example, according to Mouton *et al.* (2011) barriers might be responsible for preventing the upstream migration of glass eels and thus increase the predation risk. Additionally, the increased density below the barriers might enable exploitation.

A further impact that might be related to the inhibition of upstream migration and the high abundance of yellow eels, is the sex determination of the species. Davey and Jellyman (2005), support the idea that in high abundance, male eels tend to dominate, while high proportions of female silver eels might be the result of very low population density or poor conditions for growth in these habitats. Additionally, there is evidence that yellow eels exhibit cannibalistic behaviour, probably due to high density (Sinha and Jones, 1967; Wattendorf, 1979).

4.1.2.3 Habitat destruction

Dekker (2003) outlined potential factors contributing to the recruitment collapse for the European eel, these related to the loss of good quality yellow eel habitat including loss of wetlands due to land reclamation by drainage, pollution and the over abstraction of water from rivers and lakes. There has been considerable loss of habitat across the European eel range states (Europe and North Africa) over the last century (Feunteun, 2002). The reclamation of land within the coastal zones is extensive but the reclamation within transitional waters with drainage schemes for floodplains coupled with dredging schemes for access to shipping has to take a toll on the quality of the habitat remaining for the eel. It is difficult to quantify the habitat lost due to river regulation and channelization but to put the loss into perspective in Germany about $^2/_3$ of the historic wetland areas are missing today (BMU and BfN, 2009) and these habitats include a large amount of potential high quality eel habitat.

Feunteun (2002) proposed using the eel as a bio-indicator of environmental changes stating that when eel disappears from a river, the aquatic system is in a bad state and restoration is required. However, the eel is a resilient species and can adapt to different conditions with the opportunity to migrate to better conditions or habitat be it in coastal, transitional or freshwater habitat if its available (Arai *et al*., 2006; Daverat *et al*., 2006; Marohn *et al*., 2013).

4.1.2.4 Habitat degradation

River systems in their natural state provide a range of ecosystem services. However, hundreds of years of interference has interrupted these processes resulting in degraded river systems (Gilvear *et al*., 2013). Non-structural barriers to eel distribution include lack of habitat, poor water quality and reduced water levels (Benejam *et al*., 2010). Land reclamation through river channelization and drainage schemes has resulted in river channels devoid of biodiversity in substrate, vegetation and macro-invertebrates. Structural diversity such as cobbles, woody debris, undercut banks act as a refuge for young/small eels (Domingos *et al*., 2006; Laffaille *et al*., 2003). Riparian vegetation is often removed in channels with ongoing maintenance programmes. Vegetation acts as a cover/refuge but also as a food source, supplying invertebrates into the water (Itakura *et al*., 2015; Oscoz *et al*., 2005; Richardson *et al*., 2010; Ryan and Kelly-Quinn, 2015). This lack of cover could increase the natural mortality rate on eels through increased predation. Degraded habitat can have a negative impact on the quality of the eels these rivers produce, through low growth rates, increased silvering age, etc.

Addy *et al*. (2016) state that river restoration should aim to reinstate characteristic river habitat and biodiversity. They river restoration as: the re-establishment of natural physical processes (e.g. variation in flow and sediment movement), features (e.g. sediment sizes and river shape such as meanders) and physical habitats of a river system (including submerged, bank and floodplain areas). Some EMUs have listed habitat restoration in their national management plans. It is difficult to quantify the impact of river restoration on eel production and escapement (ICES, 2013), but that does not mean there is no benefit from it. There is a lot of information in the literature on river restoration, rehabilitation and enhancement; however, the focus is not on reporting the benefits to European eel.

For eels, the link between abundance and habitat quality may not be straightforward Brehmer *et al*. (2013) found no link between relative abundance of European eel and habitat quality (eutrophication and ecotoxicity levels) in three coastal lagoons. The authors concluded that the impact could be on the growth and mortality rates at different life stages, but this requires further information. There are many reports highlighting the different habitat required for large and small eels (Degerman *et al*., 2019; Laffaille *et al*., 2004) showing that habitat heterogeneity is a requirement for fish biodiversity within our systems (Guégan *et al*., 1998). Therefore, drained channels with low flow and habitat homogeneity will have lower abundance of eel or be restricted to certain length classes.

These degraded channels outlined above will be less resilient to the effects of climate change, and this will be an additional pressure on the current eel stocks. Climate proofing rivers may require the provision of both riparian tree cover and functioning river processes to replicate more natural stream temperature dynamics (O'Briain *et al.*, 2020). River restoration, working with natural processes and natural flood management, is a cost-effective response to a changing climate. Re-connection of backwaters and former wetland habitats will also help to improve ecosystem functions and resilience of river systems.

4.1.2.5 The role of eel in ecosystems

The influence of the eel on its environment is less studied. Dekker (2008) suggest the services provided by the European eel in our waterbodies is wide ranging. A reduction in the density of eels and other diadromous species entering European rivers can have ecological consequences at least in i) foodwebs; ii) nutrient cycling; iii) abiotic properties of the ecosystem; and iv) relationships with other organisms (predation, facilitation processes, parasitism) (Costas-Dias *et al.*, 2009). Eels have the ability to alleviate the pressure of eutrophication (Laffaille *et al.*, 2000) by consuming and removing nutrients. The eels are important in the movement of nutrients (nitrogen and phosporous) and redistributing carbon between fresh and marine waters (Holmlund and Hammer, 1999; Schmitz *et al.*, 2010; Fawcett *et al.*, 2015). The interdependent nature of ecosystems suggests there might still be more services provided or bolstered by European eel that have yet to be acknowledged (Costanza *et al.*, 1997). There is a need to document what happens in our ecosystems when the eel is absent.

4.1.2.6 Predator–prey interactions

The absence of a keystone species from one ecosystem might result in the spread of other species, as for instance exemplified by invasive decapods. There is evidence that European eel can act as a predator species for freshwater crayfish, i.e. the native noble crayfish *Astacus astacus* (Svärdson, 1972), the red swamp crayfish *Procambarus clarkii* (Aquiloni *et al.*, 2010; Musseau *et al.*, 2015) and American Signal Crayfish *Pacifastacus leniusculus* in UK (an ongoing project for the control *P. leniusculus* population). The effectiveness of the European eel to predate crayfish is believed to be the result of their ability to detect crayfish by odour (Blake and Hart, 1995) and to enter crayfish burrows (Aquiloni *et al.*, 2010). However, where elvers and *P. clarkia* coexist, the eels tend to be excluded from sites where the red swamp crayfish is abundant. Domingos *et al.* (2006) indicate that the interaction between both species may also be detrimental for small eels due to predation and/or competition for space. European eel can be the prey for other species too. Predators of European eel might be birds, like *Phalacrocorax carbo*, other fish species and mammals.

4.1.2.7 Water flow

River flow plays a major role in glass eel recruitment to continental waters, probably because of their attraction by inland cues or flow regimes (Tesch, 2003). Strong positive relationships between the river flow and glass eel migration were found in the Mondego (Domingos, 1992), Guadalquivir (Arribas *et al.*, 2012) and Minho estuaries (Correia *et al.*, 2018), and therefore, larger catchments potentially attract more glass eels through the larger plume of freshwater odour stimuli they create (Tesch, 2003), as is the case with the Severn in the United Kingdom (Aprahamian *et al.*, 2007). Although intense rainfall increases freshwater discharges and river plumes in the open sea (Otero *et al.*, 2008), river flow regulation in many catchments all over Europe, may play a detrimental effect on the attraction of glass eels to continental waters exerting a negative effect on the eel population. While this cannot be considered habitat loss because the habitat is there, it may become unattractive for recruitment, and explain the relation found by Kettle *et al.* (2011) between decline of the European eel and changing hydrology in southwest Europe and northwest Africa.

The flow regime in rivers is highly dependent on rainfall patterns, which have become more variable in recent years due to climate change. Predictive climate scenarios indicate that the arid and semi-arid regions of the planet, including the Mediterranean, will be highly exposed to the impacts of climate change, namely the increase in temperature and the decrease in annual precipitation rates, resulting in prolonged periods of drought (Karaouzas *et al.,* 2018). A future increase of extreme low flow events is expected in Mediterranean regions according to most global and regional circulation models (IPCC, 2014), with a negative impact on habitat availability and quality.

Water scarcity, which is driven by climate and water demand, prevails in several European river basins with different water stress levels, affecting around 15–25% of total European territory, with the southern and western parts of Europe, as the most affected (EEA, 2019). More than half of southern Europe lives under water scarcity conditions, of which agriculture and public water supply, including in relation to tourism, are the main drivers. Particularly in spring and summer, water scarcity in southern Europe prevails and the outer boundaries of this scarcity are expanding. Very intensive irrigation in the Po Basin (Italy), Guadiana (Portugal and Spain), and Segura (Spain), is the main cause of the severe water stress experienced throughout almost the entire year in these basins (EEA, 2019). Because of high pressure on public water supplies and the use of water for cooling in energy generation, some basins in western and northern Europe, e.g. the Oder in the Czech Republic, Germany and Poland, the Zealand in Denmark and the Thames in the United Kingdom, may also experience water scarcity, as shown by the Water Exploitation Index (WEI), which measures the level of water scarcity by comparing water use with the renewable freshwater resource available (https://www.eea.europa.eu/data-and-maps/indicators/use-of-freshwater-resources-3/assement-4) accessed 25 September 2020).

Water abstraction strongly affects rivers and streams in arid and semi-arid ecosystems, particularly where there is a Mediterranean climate, but climate change will also affect rainfall patterns across Europe acting as a stressor on the eel population (Benejam *et al.,* 2010; San-Martín *et al.,* 2020). Considering the Mediterranean region, natural and human-induced climate change, in combination with the overexploitation of water resources, has resulted in a 20% decrease in river run-off within the past half century, simultaneously increasing the frequency and duration of low flows (Karaouzas *et al.,* 2018).

Temporary rivers and streams, abundant in the Mediterranean region dry during summer resulting in habitat loss for the fish communities (Magalhães *et al.,* 2007; Arthington *et al*., 2014; Karaouzas *et al*., 2018). In large permanent rivers from this region, the rivers never dry, but the flow is so low that the longitudinal connectivity is interrupted by the creation of pools where fish become prisoned and subject to extreme habitat conditions. In these regions, water abstraction may change a permanent stream to a temporary one, increasing the duration and magnitude of droughts and limiting the stream's ability to support aquatic biota (Benejam *et al*., 2010). During dry periods, the natural disturbance associated with the change from lotic to lentic conditions, combined with high temperature, causes a sharp decline in environmental quality, with major effects on biotic assemblage structure and dynamics (Magalhães *et al*., 2007; Arthington *et al*., 2014). The reduction in river width and depth leads to a concentration of fish in isolated pools, which can result in increased mortality. The high temperature during summer and eutrophication in certain cases, associated with high densities of fish leads to lack of oxygen and biotic interactions among fish, which can be detrimental to the eel. Finally, the shallow habitat during summer and the concentration of fish in these pools, favours predation by avian species.

4.1.2.8 Remedial and mitigating measures

Remedial and mitigating measures may include fish passes, assisted migration, restocking, rewetting projects, and many more. These are discussed here only very briefly. Under the Eel Management Plans and other EU Directives, a number of countries have implemented mitigation measures including opening up habitat above barriers through the use of eel ladders. There has been a push on "re-wetting" schemes including the restoration of wetlands (Moss, 1983; Root-Bernstein and Frascaroli, 2016), reconnecting wetland to rivers, coastal managed realignment (Colclough *et. al*., 2005; Mossman *et. al.*, 2012; Townend *et. al.*, 2010) and other habitat creation projects (van Liefferinge, 2012). Some opportunity mapping has been undertaken (Ramsar, 1971) but a greater focus on this is encouraged in the future. Many schemes provide multiple benefits and may be driven by other species, (e.g. to benefit birds). It is important to optimise these opportunities to maximise ecological outcomes, also for eel.

4.1.3 Habitat loss in national Eel Management Plans and assessments

Members of the WGEEL were asked to fill out a questionnaire form "Country EMP habitat loss questionnaire". Data were received from all countries with one or more EMPs. For countries outside the EU, without EMP (Norway, Turkey, Tunisia and Morocco), responses were received based on the latest Country Report to answer the questions as accurately as possible. A summary of the questionnaire results is shown in Table 4.1.2 for those countries with EMPs and Table 4.1.3 for those countries that do not have EMPs.

Table 4.1.2. Summary of the questionnaire responses on information relating to habitat loss in EMP/ triannual assessment reports (Y= Yes, N= No, NP= Not Pertinent; R= rivers, L= lakes, T= transitional/estuaries, C= coastal).

Country	Number of EMU's	Are the same assessment meth-	Habitat types quantified in EMP (RLTC)	Time period for setting B_0	Does B_0 habitat include all habitat	Does EMP cover habitat loss due	Does EMP cover habitat loss due
BE	4	Y	RLT	Arbitrarily defined- no specific time period	Y	Y	Y
DE	9	Y	RLTC (Partially)	1950–1980	Y	N	Y
DK	2	Y	RLT	Pre-1960s	Y	Y	Y
EE	2	N	RLTC	1930s	N	Y	Y
ES	12	Y	RTC	Pre-anthropogenic (GIS)	N	Y	Y
FI	1	Y	RLT	NP	NP	Y	Y
FR	11	Y	RLTC	B_0 derived from $B_{current}$	N	Y	Y
GR	4	Y	T	NP	N	N	N
IE	6	Y	RLT	Pre-anthropogenic (GIS)	Y	Y	Y
IT	9	Y	RLT	Pre-1980s	Y	Y	Y
LT	2	Y	RLT	Pre-1980s	Y	Y	Y
LV	2	Y	RLTC	NP	N	Y	Y
NL	2	Y	RLTC	1950s	N	NP	NP
PL	2	Y	LTC	Pre-1980s	N	Y	Y
PT	2	Y	RT	Pre-1980s	N	Y	Y
SE	2	Y	RC	1920s and 1950s	Y	Y	Y
UK	14 (+1)	Y	RLT	GIS mapping of current habitat, incl. above barriers irrespective of barrier age	N	Y	Y

Table 4.1.3. Summary of the questionnaire responses on information relating to habitat loss taken from Country Reports and other data available for countries that are non-EU member states with no EMP based on the Eel Regulation (Y= Yes, N= No, NP= Not Pertinent; R= rivers, L= lakes, T= transitional/estuaries, C= coastal).

Country	Habitat types quantified in Country Report (RLTC)	Time period used to asses pristine habitat	Does pristine assessment (B0) include all habitat lost?	Does Country Report cover habitat loss due to barriers to upstream eel migration?	Does Country Report cover habitat loss due to barriers to downstream migration (this includes hydropower)?
MO	RTC	NP	NP	Partially	Partially
NO	NP	NP	NP	N	N
TN	RLT	1980	Y	N	N
TR	NP	NP	NP	Partially	Partially

For the majority of countries, wetted area was quantified for the different types of water habitat types (rivers, lakes and transitional/estuarine, and coastal habitats). The least information has been quantified in relevant coastal habitats. Of those countries with EMPs, there are three, which have not yet quantified the wetted area of lakes. Some countries have no transitional and coastal waters in their EMU, or it not included in the EMP.

The assessment of the pristine state of the stock (B_0) rarely included **all** habitat lost, and in most cases the analysis remained unquantified. For those countries that have quantified habitat loss in their pristine assessment the focus has been on the existence of upstream and downstream barriers to eel migration. These barriers have existed for differing periods, quantification focusing on existing river networks. There are notable omissions in assessment of habitat lost completely, as associated with land drainage, land reclamation and flood defence.

For the calculation of pristine spawner escapement, the Eel Regulation gives the pragmatic option to use data (including habitats) for rather recent periods (pre-1980s). The majority of Countries used this option. Hence, these calculations relate to habitats available at this period. However, much habitat loss due to land reclamation, river regulation/straightening, loss of floodplain areas, lowered water levels due to mining activities, building of reservoirs, dams/barriers and flood defence measures already occurred earlier. Consequently, the historic losses have usually not been considered in the assessments and EMP's, while ICES advice to restore spawner escapement (to 30-50% of pristine) did not take any historic habitat loss into account (ICES, 2002), not fully aware yet of the importance of non-fisheries impact; this implies assuming that all pristine habitats were accessible. It will be important to reconsider this structural mismatch between advice and policy, when the impact of habitat loss has been quantified, the coming years.

There is variability around the timescales over which anthropogenic impacts on habitat loss due to barriers have been considered. Many countries refer to the pre-1980 period as set out in the Eel Regulation, others refer to an earlier period; the earliest of which was the 1920, with several Countries focusing on the time period between 1950 and 1970. The timing and rate of habitat loss appears to differ between countries. It is clear that greater understanding is needed to allow more accurate quantification of habitat lost that would otherwise have supported European eel.

There is variability in the number of Countries addressing the mitigation of habitat loss; most commit to address this concern, while five did not yet address habitat loss. Overviews on the planning and implementation of measures on mitigating the effects of hydropower installations, pumping stations, migration barriers and habitat quality in general have been given by ICES (2013, 2014) and Hanel *et al*. (2019).

Very few Countries currently consider habitat loss due to water abstraction in the EMPs; abstraction can lead to increased frequency and extent of the drying events, on a seasonal or permanent basis, or can lead to prevention of access of eel to reservoirs due to screening exclusion to prevent entrainment. The quantification of entrainment mortality is considered in some EMPs. A single country (UK) considers water quality aspects in some EMPs, but without quantification. Only Ireland refers to habitat quality within its EMPs, incorporating information related to WFD assessments, i.e. not eel-specific quantification.

4.1.4 Quantification of habitat loss, coming Data Calls

In 2010, WGEEL (ICES, 2010) made a first assessment of the available habitats per habitat type and country, revealing a lack of consistency within and between countries, with respect to the estimation, as well as its use in national assessments. Though habitat loss is often mentioned as a factor contributing to the decline of the stock, the national assessments of the stock status (see above) still differ considerably, in whether or not they have taken habitat loss into account, and if so, how they deal with it. Because of that, the impact of habitat loss on the eel stock (now and before) cannot be quantified right now. Additionally, recent efforts to quantify habitats on a regional basis indicate that the collection of information is laborious (e.g. the ongoing SUDOANG project in the southwest of Europe, https://sudoang.eu/wp-content/uploads/2020/02/Short-summarySukarreitaworkshop.pdf). It is therefore recommended, to include data on habitat loss in a coming data call, with a view to document a) currently available habitat, by habitat type and country, b) loss of habitat over time, c) impact of that loss on eel production. Based on the information collated in such a data call, the habitat loss, as well as its impact on the eel stock, can then be assessed. This will enable planning and prioritisation of habitat restoration projects e.g. in the context of the EU WFD and the EU Biodiversity Strategy, as well as steer future data collection.

As for the loss of surface area, it will be important to note when (which years/decades) habitat loss occurred, to enable a coherent integration over countries, as well as to avoid a Shifting Baseline (Pauly, 1995). Whereas a full reconstruction of truly pristine habitats is to be preferred for theoretical reasons, practical considerations (data availability) plea for more recent reference years. Noting that 1980 marked the onset of the recruitment decline (Dekker, 2000a; Bornarel *et al*., 2018; current report), and 1950 the onset of the downward trend in landings (Dekker, 2003; current report), it is recommended to collect information for the following reference years: current, 1980, 1950, and as early as is achievable (and to avoid work-overload, to focus on current and 1950 only, in the estimation of eel stock indicators, discussed below).

When considering the loss of habitats and the resulting effects on the eel stocks, it should be noted though that anthropogenic activities also resulted in the creation of new habitats (channels, artificial lakes, etc.), even if this happened at a much smaller scale. Hence, such effects should be considered in future analyses, including the question of the quality of these habitats for eel production.

Apart from the crude area of surface waters, and their decline over time, it will be important to quantify the effects on the eel stock adequately. In the context of the international stock assessment, as conducted by WGEEL, based on the (triannual) national stock assessments, it will suffice to assess the impact of habitat loss per EMU (and by habitat type, if achievable). The more detailed assessment, amongst others enabling a prioritisation of habitat restoration projects for selected sites, will then remain on the national level. Depending on the local circumstances, the assessment model and technology will differ, but it might be worthwhile to consider some level of standardisation (as is currently done in the SUDOANG project, for instance).

Habitat loss and other anthropogenic impacts often interact. Amongst others, blockage of upstream habitats might increase the density of the eel stock downstream, facilitating predation or fishing. This complicates assessing the effect of habitat loss as such, considerably. It is therefore recommended to focus the analysis on the effect of habitat loss only, in a (hypothetical) situation without any other anthropogenic impact. That is: to assess the effect of habitat loss on the calculation of B_{best} and B_0 only (thus excluding $B_{current}$ and ΣA).

Above, it was noted that national assessments (reporting on $B_{current}$, B_{best} and B_0, amongst others) differ in the way they treat available and lost habitats. While some derive estimates for the current habitats only (e.g. extrapolations from current or recent stock statuses, or the carrying capacity of current habitats), others include the historically lost habitats, implicitly or explicitly (e.g. estimates based on historical catches, or production potential of the full recruitment). To avoid confusion, it will be important to clarify how these indicators and the impact of habitat loss has been estimated. This might be achieved, if the data call explicitly asks for these indicators from a specified amount of habitat.

Summarising the above, it is recommended to add to a coming Data Call:

For each EMU, and for each habitat type (freshwater, transitional, coastal, marine):

a) An estimate of the surface area (wetted area, in km² or ha), for current, 1980, 1950 and the earliest year available (if <1950).
b) An estimate of B_{best} and B_0 (biomass), under the assumption that the available habitat area is as current, and
c) An estimate of B_{best} and B_0 assuming that the available habitat is as in 1950 (assuming all other circumstances are as current).

The process to come to a reliable estimate of past and present surface areas might be laborious and time-consuming. Since 2021 is a triannual assessment year, it might be preferable to add this expansion to the data call in 2022, and start the preparatory work for that in (late) 2021, at the national level.

4.1.5 Case studies

This section presents a number of case studies, with the intention to provide a realistic view on the complexities encountered when analysing habitat loss. Some of these cases were selected for their representativeness, others for specific characteristics. They are presented here in arbitrary order.

4.1.5.1 Coastal areas of Denmark

Many marine coastal habitats are degraded by anthropogenic activities including dredge fisheries, e.g. trawling (Freese *et al*., 1999; Gage *et al*., 2005; Jennings and Kaiser, 1998), extractions of marine sand and gravel in coastal areas (de Groot, 1986; 1996; Desprez, 2000; ICES, 2015b), or affected by frequent and severe occurrences of hypoxia (Breitburg *et al*., 2018; Schmidtko *et al*., 2017), phytoplankton blooms (Diaz and Rosenberg, 2008; Chapman, 2016) and pollution (Sühring *et al*., 2016a; Vince and Hardesty, 2016).

A number of special conditions apply in Danish coastal waters. First and foremost, the inland Danish waters are very much affected by anthropogenic activity other than fishing and especially by very large supplies of nutrients from land, which for decades has affected the benthic fauna in virtually all the coastal areas (Eigaard *et al*., 2020). Influence with nutrients will thus affect whole basins, e.g. whole fjords, while fishing with dredging gear will primarily have a local effect in exactly the area where fishing is taking place.

An intense mussel fishery is taking place in Danish waters, regulated by Executive Order no. 764 of 19/06/2017 and Executive Order no. 1388 of 03/12/2017. In addition to the legal regulations, the former Ministry of Food, Agriculture and Fisheries established a mussel policy, which was published in early July 2013. The policy is based on the mussel production must be sustainable and comply with EU environmental directives (Ministry of Food, Agriculture and Fisheries 2013). A yearly amount of 37 000–43 000 tons of blue mussels (*Mytilus edulis*) has been caught in the period 2015–2019 in Danish waters.

In Denmark, more than 55 km^2 of stone reefs have been removed mostly from water depths lower than 10 meters (Helmig *et al*., 2020). Stone fishing were banned in 2010 (LBK nr 124 af 26/01/2017). Sand and gravel extraction is still allowed, covering an area of 650 km^2 (2017) and in the period 1990–2018, 4–13 mio m^3 sand and gravel have been extracted each year (Statistics Denmark, Petersen, 2018). The extraction is carried out in water depth between >6–<30 m (Petersen, 2018).

Studies on habitat use of European eels have mostly been conducted in freshwater, even though a significant part of the population never enters freshwater (Tsukamoto *et al*., 1998). These indicated that European eels selects a diversity of habitats often in relation to habitat grain size (Ibbotson *et al*., 2002; Laffaille *et al*., 2003). A study of benthic marine habitat selection of European eel elvers, showed a significant influence from gravel size and the presence of vegetation and pointed to the need for further understanding of marine habitat preferences by eels (Christoffersen *et al*., 2018). In consequence, Schwartzbach (2020) followed up on the habitat preference studies by Christoffersen *et al*. (2018), focusing on the elver size preferences for burial cavities and for mussel beds. In this study, the results showed clear elver preference for the mus-sel substrate, less preferred were large and small-sized gravel while sand substrate was avoided (Schwartzbach, 2020). In addition, it was found that when elvers were offered shelter in different diameter sizes, they preferred shelter equivalent to the smallest cavity sizes observe in the mussel and large gravel substrates.

A part from the above, Eelgrass meadows are important biotopes for many crustacean and fish species being either migratory or stationary (Baden *et al*., 2003). Since the 1980s, extensive losses of eelgrass, in the order of 10 000 ha (Moksnes *et al*., 2016) have occurred on the NW coast of Sweden, with a decrease in coverage of more than 60% (Baden *et al*., 2003; Nyqvist *et al*., 2009), and an estimated loss of ecosystem services worth >350 million US$ (based on three ecosystem functions; fish habitat, carbon and nitrogen uptake; Cole and Moksnes, 2016). These losses have largely been attributed to the effects of coastal eutrophication and overfishing (Moksnes *et al*., 2008; Baden *et al*., 2010; 2012). Eels are common throughout the eelgrass meadows from the Skagerrak to the Baltic. The importance of vegetation for the occurrence and abundance of glass- and young eels on shallow sandy bottoms in Sweden and Denmark was stressed by Westerberg *et al*. (1983) using drop-trapping as sampling method.

4.1.5.2 River Kävlingeån in Sweden

River Kävlingeån is situated at 55° 41' 54.53"N, E 13° 33' 13.66"E, i.e. in the southernmost part of Sweden. Kävlingeån drains to Öresund, the strait between Sweden and Denmark. The catchment is in total 1200 km^2 including some lakes as Vombsjön and Krankesjön. Almost one third of the drainage were wetted during the 1800′. Vombsjön with an area of 11.8 km^2 has been one of the most productive eel lakes in Sweden currently yielding about 3.5 tons per year, corresponding to 3 kg/ha. Yields from this lake might have been at least the double in the 1960s when natural recruitment was higher and the lake was restocked (Weijman-Hane, 1969).

There are a few minor mills and hydropower plants between the lakes and the sea, but young eels are able to reach and pass upstream via an elvertrap at the outlet of Lake Vombsjön (Tollgren and Walldén, 2017). In addition this lake has been restocked in most years since the early 1970s.

Between 1938 and 1943, this river system was changed quite drastically by digging, canalizing, lowering of lakes, etc. The purpose at that time was to gain more farmland and decrease flooding. As a result, the wetted area decreased with 90% and the whole ecosystem changed. A faster runoff created serious erosion, flooding further downstream and other environmental problems.

Figure 4.1.1 shows the difference in wetted areas between the early 1800s and 1950s.

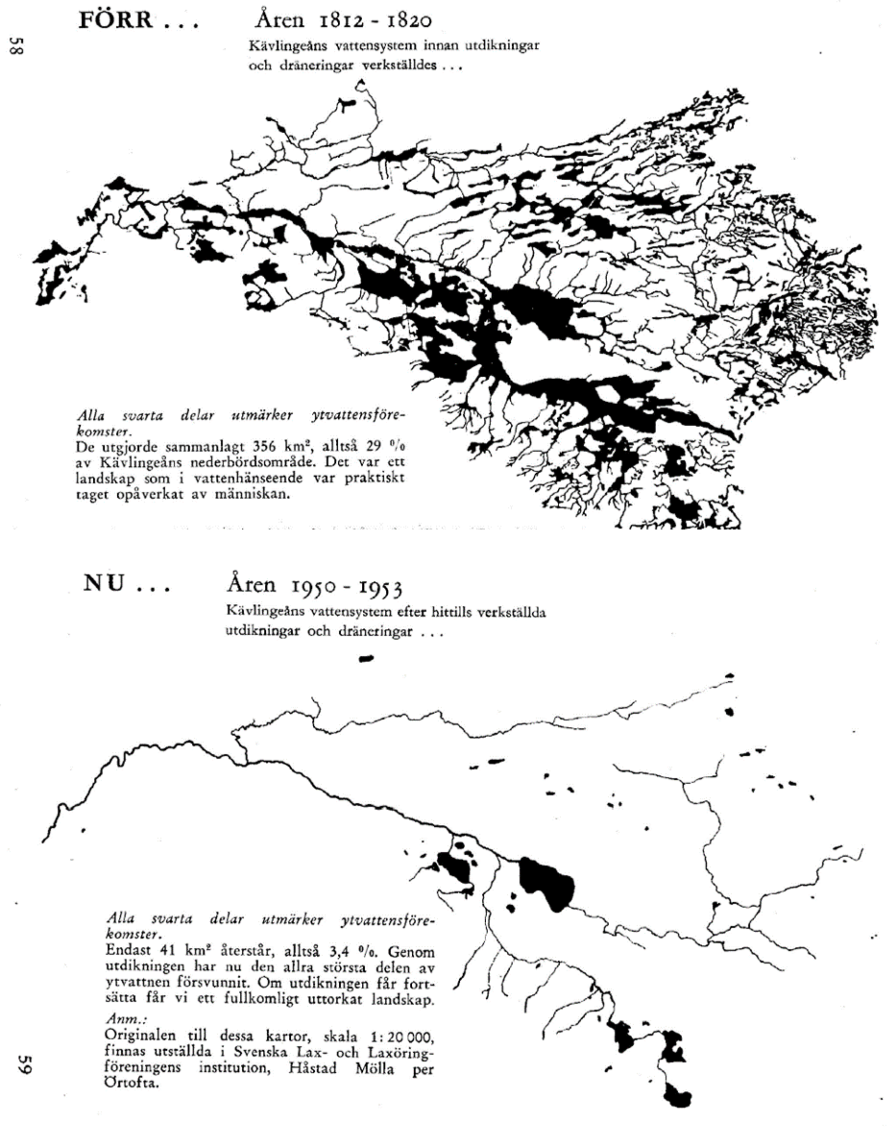

Figure 4.1.1. Maps of the Kävelingeån drainage area, before and after the major draining; from Wolf (1956).

A very rough estimate of lost production based on the very conservative fishing yield 3.5 kg/ha and a loss of 90% wetted area gives a possible yield of 35 tons from this catchment before draining. This assumes the lost habitats were as productive as Lake Vombsjön itself (today) and that there were enough recruits for the undisturbed habitats. Data from a nearby river (Lagan) indicates there were not a lack of recruits in that time. However, it is not known if the water pollution at that time did impaired recruitment. If today's fishery takes some 50% of the production, implying 70 tons of potential spawners could have been produced from this system.

Assuming the three hydropower stations existing already in the 1930s killed eels to the same extent as today, a considerable amount of spawners must still have reached the sea in those days.

There are currently attempts to restore some of the wet areas lost with the purpose to retain water and nutrients longer, avoiding flooding downstream, and increasing biodiversity, etc. Creating new dams in parallel with the main stream and to restore the meandering structure of the river seems to work, but an increased predation from large pikes on tagged silver eels was reported (Olsson *et al*., 2009).

This example may be an extreme case, probably the worst in southern Sweden, to be taken as a warning what could go so wrong and be so difficult to repair, if possible. Thus, it is not representative for the rest of the country, though similar but less drastic projects were implemented all over the country.

4.1.5.3 Lake Hjälmaren (Norrström catchment) in Sweden

Lake Hjälmaren is the fourth lake in size in Sweden, a shallow eutrophic lake of 478 km^2 (today). It is situated at 59°13'13.41"N, 15°47'12.72"E and drains through Lake Mälaren and Stockholm to the Baltic Sea (Håkansson, 1978). In recent years, which is between 2000 and 2009, the catch of eels was 19 tons corresponding to 0.4 kg per hectare. There are five hydropower stations between the sea and the lake making a natural recruitment impossible as well as introducing high mortalities in silver eels migrating downstream.

This lake was lowered between 1878 and 1888 on request mainly from farmers around the lake, despite an interest of maintained water levels from both shipping and hydropower stakeholders. The lake was then lowered by 1.3 meters and the water level amplitude decreased. With that the wetted area decreased by 190 km^2 corresponding to 28% and new farmland was gained (Lennqvist, 2007).

As a shallow, productive lake, Hjälmaren produced 19 tons of eel (i.e. landings). With an assumed yield of 0.4 kg per hectare (today) the decrease in wetted area could have decreased the former potential yield by 7.6 tons, assuming that also the shallow areas lost did produce the same as the remaining area. That eels were produced also upstream this lake is not considered in this rough calculation. The actual total production of silver eels must have been much higher depending on the efficiency in the fishery.

In short term, within the residence time of the eels present at the time of lowering, they must have become a bit more concentrated. However, at such low densities in a lake situated far up in the system that effect was probably not of importance. By that, changes in mortality, growth rates, sex differentiation, etc. do not seem to have been of any major importance. The effect was probably mainly a lower total production of silver eels from this lake. However, with an assumed mortality in the HPP’s already existing at that time quite few spawners were able to reach the Baltic Sea.

Theoretically, Lake Hjälmaren could be dammed again to restore wetlands, but in reality with all farmland, forests, new low-lying settlements, etc. this will never happen. In recent years restocking and the fishery for eel has decreased in this lake in favour of species as pike perch and crayfish.

The lowering of Hjälmaren was perhaps one of the most noticed cases due to the size of wetted area lost, but nevertheless represents what has happened in many or most lakes in Sweden.

4.1.5.4 The Iberian Peninsula

The Iberian Peninsula, where eels were abundant in the past, has been strongly affected by the construction of dams that made much of their pristine habitat inaccessible. In a historical study Clavero and Hermoso (2015) compared current occurrence of the eel on the Iberian peninsula, to the information on village economics (including fisheries), provided by Madoz (1845–1850) and some earlier sources. Clavero and Hermoso conclude that 80% of the eel habitat in the Iberian Peninsula is lost mainly due to river fragmentation by dams.

To conduct their work, the authors collected over 10 000 historical freshwater fish records from Spain in the 19th and 16th centuries, as well as over 25 000 records from the global biodiversity information facility (GBIF) to characterize historical and current European eel distribution in the Iberian Peninsula. The eel has nowadays completely disappeared from vast areas in inland Spain where it had been commonly recorded in the 19th century. Figure 4.1.2 shows the comparison in probability of occurrence of eel between the 19th century and current days. As can be seen in the maps, distribution models showed that eel had been widely distributed throughout the Iberian Peninsula in the 19th century, being especially common around the coast (estuaries, coastal lagoons, small coastal streams and the lower reaches of large rivers, which implies that most of the riverine areas are lost.

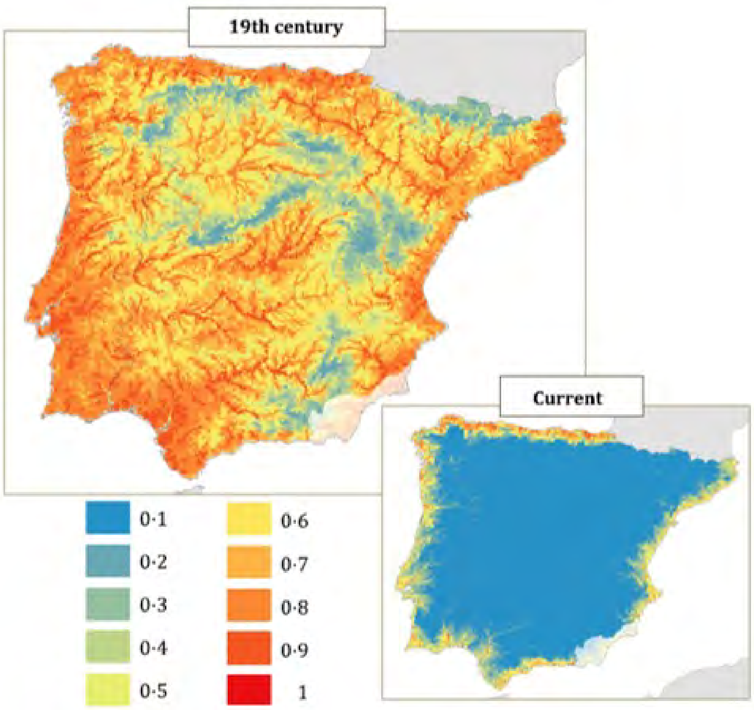

Figure 4.1.2. Probability of occurrence of eel in the Iberian Peninsula in the 19th century and at present. (From Clavero and Hermoso, 2015).

Central and southern Iberia have some of the most regulated and fragmented river systems worldwide (Liermann *et al.*, 2012) and the pressure on river basins has increased and is expected to continue increasing under climate change scenarios (Karaouzas *et al.*, 2018). As such, the largest international rivers on the Iberian Peninsula, Douro, Tagus and Guadiana, where eels used to colonize the river basins, going upstream through Portugal into Spain, are now largely obstructed and the eel no longer reaches Spain as already concluded by Doadrio (2002). In the Douro river, access to the Spanish part of the river was blocked prior to 1970 when the dams Saltos del Duero between the 1950s and 1970s (Velasco *et al.*, 1989). However, the construction in 1985 of the Crestuma-Lever dam located 21 km from the river mouth, created a 96% loss of habitat for the eel in this river (Mota *et al.*, 2016). However, some Spanish dams (Saltos del Duero) built in the border between both countries had already obstructed the access of eel to Spain before 1970. In the Tagus river, the eel distribution is limited by the Belver dam (150 km from the river mouth), which was built in the 1950s. More recently, in the Guadiana river, the connectivity of the river was interrupted by the construction of the Alqueva dam, located 120 km from the river mouth, impeding the colonization of the river to sites further upstream, including the Spanish part of the river basin.

Several diadromous fishes have declined dramatically due to dam construction (Limburg and Waldman, 2009), and neither the eel nor the Iberian Peninsula is an exception to this pattern. Based on other sources, and similarly to the results obtained by Clavero and Hermoso (2015), Mota *et al.* (2016) also concluded that the eel disappeared from important catchment areas (Figure 4.1.3). This Figure 4.1.3 shows that the distribution of eel in the Iberian Peninsula is restricted to the lower reaches of rivers, close to the coastal areas, which is illustrated by the location of dams that represent the first obstruction to the colonization of the river basins.

Figure 4.1.3. The potential habitats for diadromous fish species in the hydrographical network of the Iberian Peninsula. The first obstacles in the main course of the rivers are marked by dots. Dark grey: available habitat for diadromous fish; Bright grey: inaccessible habitat for diadromous fish. (From Mota *et al.*, 2016).

4.1.5.5 The Comacchio lagoon in Italy

The Comacchio lagoon, on the Adriatic coast of Northern Italy, is an example of massive intervention due to reclamation in a site where eel has been exploited for ages, and is of interest in exploring relationships between the loss of habitat and the local eel stock.

Geologically, the area of Comacchio was an inundated lowland that filled by progressive silting due to sediments brought in the plain by Alpine streams as well as by sand deposited from the Adriatic Sea. The resulting marshland was a very large swamp area connected to the sea, with poor drainage and characterized by the infiltration of saltwater into the ground. There is archaeological evidence that in the area there was some fishery exploitation, including eel, since Roman times (De Leo and Gatto, 2001), while precise information on when the transformation of the area begun is not exactly known. Historical evidence (Bertram, 1873) indicates that in 1229, when the Prince D'Este became Lord of Comacchio, the local community entered a phase of expansion that also involved the development of local fisheries. The first organization schemes begun, and the first reclamation works were implemented to optimize the setting of the large swamp area and its hydraulic management for the specific purpose of fisheries. The first interventions consisted in diverting seawater and inserting openings in the natural barriers of the lagoon. Canals and ponds were built and endowed with floodgates to regulate the inflow and outflow of water, and the migration of the fish.

The total wetted area at the end of the seventeenth century was approximately 44 000 ha, and it was organized in a series of basins (Valli) of which the communication with the sea and with the adjacent river Reno and channels were strictly regulated. The local economy strongly relied across the centuries on the lagoon fisheries, that targeted different fish, but with eel representing the main resource. Over the centuries, the continuous accumulation of sediments from the adjacent delta of the Po river and the related expansion of the coastline influenced the exchanges of the Valli with the sea, and the salinity increased to an extent that limited fish production. As a consequence, a number of reclamation interventions occurred, also following the increased human population and the need of land and services.

Reclamation works begun in 1872, and have continued nearly to the present, with two significant interruptions. The first stop occurred in 1896, after the reclamation of the southern margins of the lagoon area, as sufficient land had been obtained. Reclamation was resumed at the end of First World War and continued in the Fascist era, to be interrupted again in 1935, when energies were diverted to the conquest of Ethiopia. At the end of the Second World war, with the increased demand for agricultural land, reclamation in the area was resumed (the Bonora Plan), and for its implementation a specific legislation was approved that involved newly-created public agencies. Important interventions occurred in this reclamation plan that envisaged also drainage and extraction of saline waters by pumping, digging of canals and drying and deep ploughing of the reclaimed areas.

The most intensive habitat loss then occurred in the periods 1916–1930 and 1966–1967 (Figure 4.1.4, Table 4.1.4). In 1970, the lagoon had lost more than 80% of its initial area. Evidence of eutrophication started soon to emerge, due to the superficial run-off by the surrounding agricultural land and the consequent in-puts of fertilizers to the lagoon.

In its present setting (Figure 4.1.5), the Comacchio lagoon is a semi-closed ecosystem inserted within the Regional Park of the Po River Delta (Emilia Romagna Region) covering an area of approximately 10 000 ha (13 000 ha if land areas within the lagoon are also considered, such as islands and sandbanks). It consists of three main basins, Valle Campo, Valle Magnavacca and Valle Fossa di Porto, plus some minor valli (Fattibello, Spavola, Zavelea, Molino, Southern valli) some of which are privately owned. Valle Campo (~1600 ha) is also private and wholly separated. The other two (8470 ha in total) are a single basin recognized as the most critical area for biodiversity conservation within the Regional Park of the Po River Delta.

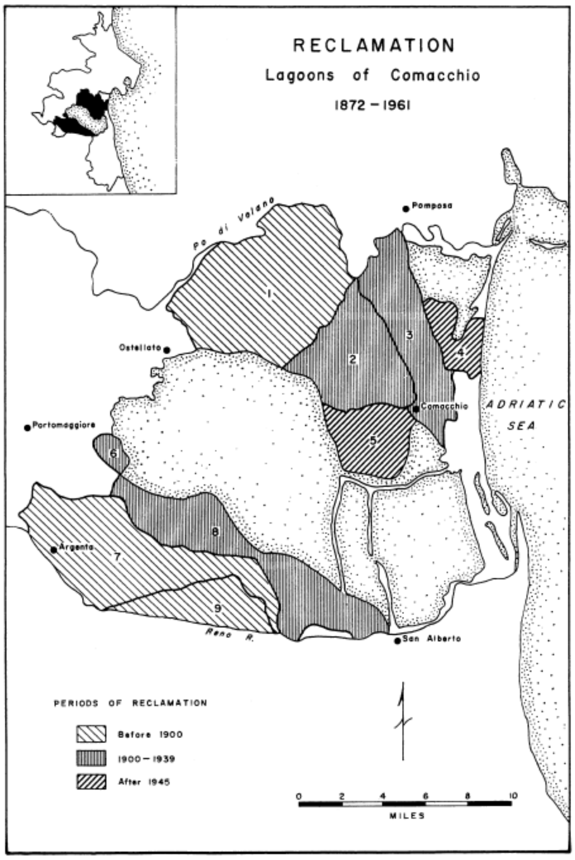

Figure 4.1.4. Shows the reclamation works occurred between 1872 and 1961, picture from Wheeler (1965).

Figure 4.1.5. Present extent of the Comacchio lagoon, and the location of the three main basins (since 1982), picture from Aschonitis *et al*. (2017).

As stated above, the lagoon of Comacchio has always been the site of an important fishery in the North Adriatic, and in particular, the eel fishery has specific historical and ecological relevance, being one of the most conspicuous in Italy and in the Mediterranean for longevity, fishing area, and landed biomass.

Fishing was and is still performed through gateways by fish barriers, e.g. V-shaped screens of selective size, called lavorieri, where adult fish are caught while migrating to the sea for reproduction, that also catch escaping silver eels. The lagoon has always been exploited for the commercial fishery, with no permission for any recreational fishing activity apart in some of the minor valli. The silver eel catch in this system represents ~100% of the silver eel migrating population. After 1988, the lagoon was recognized as an important area for biodiversity conservation, and the commercial fishing stopped, but monitoring continued for scientific purposes.

Official catches from the Comacchio fishery have been recorded for more than 200 years, the mean total fish production per hectare in the period 1781–1982 amounting to 16.4 + 6.5 kg, with fluctuations being due mainly to adverse climatic conditions in certain years (see Figure 4.1.6). Important mortalities caused by local stressors have been occurring in fact along this long period, also documented. The leading causes of such mortality events were hypersalinity, frost and ice, and the flooding of the Reno River (Table 4.1.5). The combination of hypersalinity and frost, followed by ice cover, was the most local severe stressor owing to the shallowness of the lagoon (0.5–1.5 m) (Rossi and Cataudella, 1998).

Specifically for eel, the Comacchio fishery has been operating based mostly on natural recruitment, and its yield consists nearly entirely of silver eels, which are caught during migration at the sluice gate connecting the lagoons to the sea. A long time-series is available for eel yields starting from 1781 up to 2013 (Figure 4.1.6). Up to the middle 1970s, the eel fishery had been very productive, with annual yields of >15 kg/ha. Starting from the middle 1970s, catches dropped to a few kilograms per hectare. Mean catches in the 1980s–1990s were about 6 kg/ha for eel and 15 kg/ha/year for total fish yields, and yields have not recovered since.

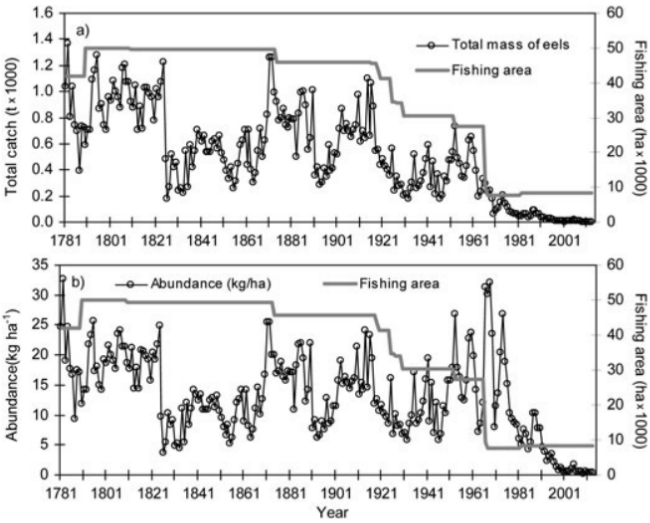

Figure 4.1.6. Eel fishing area (ha) together with (a) the annual variation of silver eel catches (tonnes x1000) and (b) abundance of silver eels (kg ha^{-1}) in the Comacchio lagoon for the period 1781–2013, from Aschonitis *et al*. (2017).

The ultimate reasons for the yield reductions and eel catch decline have been investigated and widely discussed (De Leo and Gatto, 1996; 2001; Ciccotti, 2015; Rossi, 1979; Castaldelli *et al*., 2014; Aschonitidis *et al*., 2015; 2016; 2017). It is generally agreed that the decrease in total yield for this complex of valli arises from the drastic reduction in surface due to reclamation, but all authors agree that a number of other factors have also been playing a role.

According to De Leo and Gatto (2001), the eel production decline, with a drop to >5 kg/ha, must be somehow related to a general reduction of natural recruitment in the North Adriatic Sea, which might be partially dependent upon local phenomena occurring in the lagoons. Aschonitis *et al.*, 2017, agree that the decrease in total yield arises from the drastic reduction in surface of the lagoons (Figure 4.1.6). The strong decrease that has interested eel catches is anyhow to be connected to the drastic decline that eel local stocks have faced since the late 1980s across the entire distribution area. After 1970, biomass production started to decline, and after the year 2000, it dropped to critical levels. The loss of habitat for the reclamation of a large portion of the lagoon complex in 1966–1967 was almost certainly the most critical local stressor, causing a decline in total biomass. The total catch was reduced significantly approximately ten years after the land reclamations of 1966, and this suggests, according to these authors a possible relationship with habitat loss. On the other hand, there was an increasing trend of production (biomass of silver eel caught per unit area) during the period 1920–1980 and especially 1960–1980 (a period of widespread habitat loss). After 1980, the abundance started to decrease and dropped at the lowest values during 1990, which is 25 years after the last widespread habitat loss of 1966. Therefore, local stressors may have influenced the local eel population, but attention should also be paid to the effects of global stressors, because of this coinciding with a general eel decline of species observed globally.

The Comacchio eel population is fairly well known, as it has been studied for decades (Colombo and Rossi, 1978; Gatto *et al.*, 1982; Rossi *et al.*, 1987–1988; Rossi and Cataudella, 1988). Aschonitis *et al.* (2015 performed recently a stock assessment analysis, estimating stock and recruitment at least ten times lower than estimates obtained using data from the 1980s (De Leo and Gatto, 1996; De Leo *et al.*, 2009).

Recent insights have been added by Castaldelli *et al.* (2014) based on yellow and silver eel morphology and physiology (sex, age, length) data from a monitoring in 2011, that were compared with the previous study by Rossi (1979), which used data from 1974. Results showed (a) that the population reached ~98% feminisation rate in 2011 with respect to ~77% in 1974, (b) that the population exhibited faster maturation rates (younger, longer and heavier silver eels ready to migrate), and (c) that the observed age classes of the eel population were reduced from 15 in 1974 to 11 in 2011 (14+ and 10+ years old, respectively, starting from 0+ age). These changes, and especially the high feminization rate, are considered a strong evidence of the population collapse which took place in the lagoon, as feminization is strongly negatively correlated with population density (Roncarati *et al.*, 1997; Krueger and Oliveira, 1999; Tzeng *et al.*, 2002; Han and Tzeng, 2006).

In conclusion, the case study of the Comacchio lagoons and its eel stock highlights some important issues. The first human interventions in the area started centuries ago and had the initial purpose of improving the swamp area for the specific purpose of fisheries; this allowed the flourishing of an eel fishery that lasted for centuries, targeting mainly silver eels with catches that consisted nearly 100% of escaping spawners from these environments. Notwithstanding continued habitat loss for human interventions, up to the end of the 19th century the management of the lagoons was effective to sustain the eel local stock and its exploitation, even if important mortalities impacted the stock due to climatic (frost, ice) and local factors (flooding, salinity) that affected heavily the lagoon because of its peculiar features, mainly its shallowness.

Successive reclamation interventions due to the need of land for agriculture drastically changed the scenario, and the heavily reduced lagoon surface, along with the increased anthropogenic pressure on the lagoon due to the change of use of the surrounding landscape, brought about a progressive and drastic reduction of the eel stock, as reflected by the drop in eel productions. Such a decrease is considered to be also related to effects of local factors, such as eutrophication and dystrophic events, outbreaks of pathologies and less effective glass eel recruitment to the lagoons.

The case study of the Comacchio lagoon, for which an important eel fishery has been recorded for over two centuries along with a detailed documentation of reclamation interventions and habitat loss and changes, highlights two important issues. The habitat loss that has been occurring has certainly played a prevailing role in the decline of the eel catch and of the eel local population. The escapement from this lagoon however has always been extremely low, if any, because of the high efficiency of the catch at the fish barrier that seized nearly 100% of silver eels. The case study also points to the role that local environmental and climatic conditions, habitat alterations and socio-economic changes have had on the evolution of the fishery and of the local stock, coincident in a period in which the eel global stock has been has encountered a similar situation on a global level and for which also causative factors on a global scale have been called into question (Drouineau *et al.*, 2018).

To disentangle the interactions between the different levels is very difficult, but it is perhaps worth saying that a similar situation has been happening, with the necessary differences, in many lagoons over the Mediterranean. Therefore, an overview of the coastal lagoons in the Mediterranean is given in the following section, addressing habitat loss but also but also with mention to aspects such as lagoons inaccessibility, lagoon habitat degradation and lagoon management models. Such overview might be useful in order to envisage some useful hints in view of a strategy for eel restoration in lagoon habitats of the Mediterranean.

Table 4.1.4. Gain/loss of fishing area during the period 1781–2013 in the Comacchio Lagoon.

Year	Region (local nomenclature of different subbasins of the lagoonal complex)	Fishing area (ha) gain[+]/loss[-]
1790	Scattered parts in the peripheral territory	+8000
1810	Ucceliera, Almentieri and Montalbano	-500
1874	Gallare	-3730
1916	Part of Ponti	-130
1919	Trebba	-2140
1920	Ponti and Raibosola	-2150
1925	Mantello	-6750
1927	Bosco and Poazzo	-500
1930	Isola and Volano	-3750
1953	Pega, Rillo and Zavelea	-2900
1966	Mezzano, Fattibello and Spavola	-17950
1967	Ravennate	-1870
1982	Part of Ravennate	+840
Total habitat gain/loss (ha) for the period 1781–2013		-33530

Table 4.1.5. Recorded mortality events in the Comacchio Lagoon.

Year	Conditions
1787	Frost and ice cover
1790	Hypersalinity
1822	Hypersalinity
1823	Hypersalinity
1824	Hypersalinity
1825	Hypersalinity + frost and ice cover
1826	Hypersalinity
1830	Frost and ice cover
1834	Hypersalinity
1843	Flooding of Reno River
1850	Frost and ice cover
1851	Frost and ice cover
1859	Flooding of Reno River
1862	Flooding of Reno River
1869	Frost and ice cover
1872	Hypersalinity
1877	Mortality from unidentified reasons
1879	Frost and ice cover
1882	Mortality from unidentified reasons
1883	Mortality from unidentified reasons
1887	Mortality from unidentified reasons
1890	Frost and ice cover + mortality from undefined reasons
1891	Mortality from unidentified reasons
1892	Hypersalinity + frost and ice cover
1893	Hypersalinity
1896	Flooding of Reno River
1917	Hypersalinity
1918	Frost and ice cover
1925	Frost and ice cover
1927	Hypersalinity + frost and ice cover
1970	Outbreak of infection by *Argulus foliaceus*
1982	Mortality from unidentified reasons*
1985	Frost and ice cover + mortality from undefined reasons*

***Probably due to picocyanobacteria blooms.**

4.1.5.6 Mediterranean coastal lagoons

Coastal lagoons are highly productive environments, characterized by the presence of boundaries and transitions between land and water domains. In these habitats strong physical and ecological gradients exist that make them complex, heterogeneous and dynamic systems (Cataudella *et al*., 2015). Such environmental heterogeneity structures the spatiotemporal organization of lagoon fish assemblages in terms of species diversity and abundance (Kara and Quignard, 2018). Within lagoon fish assemblages, that include resident and marine migrant species (Koutrakis *et al*., 2005; Elliot *et al*., 2007), the eel has always been an important species because of its role and abundance, as well as for its economic importance (Pérez-Ruzafa and Marcos, 2012).

Eel lagoon fisheries have been historically consistent in the Mediterranean region, (Perez-Ruzafa and Marcos, 2012; Cataudella *et al*., 2015; Aalto *et al*., 2016), due to a general rapid eel growth in these highly productive habitats compared to northern Europe (Tesch, 2003). In lagoons, eel productivity (1–168 kg ha-1), yields (3–1600 kg ha-1) and catches have always been highly variable (Perez-Ruzafa and Marcos, 2012; Cataudella *et al*., 2015; Aalto *et al*., 2016). Such heterogeneity among lagoons in eel production and eel catch has been depending on many aspects, e.g. specific ecological characteristics of each lagoon, its productivity, its quality status as well as on the structure of the fish assemblage and to local management strategies that may have favoured other commercial species (fish or shellfish). A steep decline has been occurring between 1950 and 2012, attributed to changes in environmental quality, albeit associated with those factors intrinsic to the eel stock that are responsible of the eel decline throughout its entire distribution range (Aalto *et al*., 2016).

The ecological features of coastal lagoons, and primarily water exchange dynamics with the adjacent open sea, are of the utmost importance in determining lagoon water quality and trophic state, also influencing composition and abundance of biota, and in particular of fish communities (Pérez-Ruzafa *et al*., 2007). The efficiency of exchanges between lagoon and sea through the tidal channels is of the utmost importance for eel, affecting both glass eel recruitment to the lagoon and silver eel escapement to the sea. Furthermore, over time Mediterranean coastal lagoons have been affected by several anthropogenic impacts, resulting in loss of habitat and habitat degradation.

The exact role of habitat loss, inaccessibility of lagoon habitats and of habitat quality on eel local stocks, and on the overall Mediterranean fraction of the eel global stock, has never been explicitly addressed, notwithstanding the amount of literature dealing with many aspects of eel biology and ecology for local stocks in Mediterranean coastal lagoons.

An inventory of Mediterranean lagoons that addressed its present number, extent and location was provided within a GFCM Project in 2014 (Project LaMed-2). Its main objective was to explore the main issues in dealing with interactions between aquaculture and capture fisheries in Mediterranean coastal lagoons in its sustainability dimensions (environmental, economic, social and governance). Within the work carried out in the LaMed Project, an inventory of Mediterranean coastal lagoons was compiled to gather existing information on sites, their environmental features as well as human activities carried out within lagoons and in surrounding areas, with particular reference to aquaculture and capture fisheries. Such information has been provided through Country Reports, performed by expert and GFCM National Focal Points, and allowed to perform a review of the state of Mediterranean coastal lagoons and to identify the main issues related to environment and to the human activities carried out in these areas (GFCM Studies and Reviews n. 95, Ciccotti, 2015).

Within this review, summarized in Cataudella *et al*., 2015, some information was made available, that concerns aspects such as coastal lagoons habitat loss by reclamation in the Mediterranean area, coastal habitats degradation and lagoons management aspect related to lagoon fisheries.

This information might be useful to understand the role and importance of coastal lagoons habitats for eel stocks in this region, even if no specific analysis was performed, and to address further needs for data in the future.

Currently, over 400 coastal lagoons exist in the Mediterranean region, that range from very large to extremely small in size, for a total area of 5800 km^2 ha and located across 23 Countries (Cataudella *et al*., 2015). This surface is the relic of a much larger extent of wetlands in the entire Mediterranean region, and a great part of the original areas covered by coastal lagoons have disappeared today. Different consumptive uses of lagoons areas and of the surrounding land, such as agriculture, industry, urban development has contributed to the contraction of the overall coastal lagoon surface.

No exact figures are available for the whole extent of the loss of lagoon surface. As an example, it is worth to consider that in pre-Roman times wetlands amounted in Italy to over 3 million hectares, but decreased to 1 300 000 hectares in 1865, and to the present 160 000 hectares of coastal lagoons (Rossi Doria and Bevilacqua, 1984; Ciccotti, 2015; Italy Country Report in GFCM).

In most Mediterranean countries, reclamation interventions deeply changed the coverage and the fate of these habitats. The first land and water management intervention date back to 5000 BC, in Mesopotamia and Ancient Egypt. The Ancient Romans carried out many reclamation interventions in the Pontine Marshes and in Tuscany, on the west coast of Italy. It was anyway in the late 19th and early 20th century that Mediterranean wetlands suffered the most radical contraction when many European countries initiated programs of landscape sanitation to drain lowland marshes (Webb, 2009). The demographic increase, the need for larger areas for agriculture, but also the urgency to address malaria that affected populations in many rural areas led to massive land reclamation, also facilitated by the introduction of mechanization.

In Spain, the process of draining wetlands started in the mid-19th century. It was accelerated after 1918 with the introduction of a law to reclaim wetlands for agriculture and break the malaria cycle in the western Mediterranean. Wetlands in Spain have undergone a major regression in size: around 60% of Spanish wetlands disappeared in the last 40 years (GFCM Spain Country Report).

Some important examples in Italy are : (1) the land reclamation in Maremma, carried out in 1828–1830, where most coastal wetlands disappeared; (2) the Bonifica of the Pontine Marshes in the 1930s, where only the four coastal lagoons of Caprolace, Monaci, Fogliano and Sabaudia survived; (3) the Comacchio Reclamation programme which reduced by around 80% the extension of the Comacchio Valli (that are portions of lagoon, extremely variable in dimensions, enclosed by embankments, communicating directly or indirectly with the sea, from Ardizzone *et al*., 1988) from the original 73 000 hectares to the current 13 000 hectares; (4)the reduced surface of Venice Lagoon due to the deviation of some rivers in the 18th century to avoid sand input into the lagoon, (5) reclamation for agriculture in the19th–early 20th century, increased urbanization and industrial development in Porto Marghera in the period 1924–1960 (GFCM Italy Country Report).

Egyptian coastal lagoons lost about 25% of their surface area in the last ten years and delta lagoons (Edku, Burullus and Manzala) about 60–75% of their surface in the last 60 years due to siltation, the spread of aquatic weeds, conversion of land and parts of the lagoons in fish farms (El Mezayn, 2010; GFCM Egypt Country Report). Indeed, the increase of swamps area is an indicator of increasing land reclamation, which starts with transferring sand deposits from the shore to make dikes, let water evaporate then fill the swamps with sand and clay (Abdel Rahman and Sadek, 1995). It is estimated that about 100 000 hectares of reclaimed land in Egypt were converted to aquaculture ponds in the last 30 years. Fish farmers still try to expand their farms by filling new areas inside the lagoons, despite the measures established by government authorities to stop encroaching on lagoon shores and to control husheshoshas that are aquaculture ponds inside a lagoon (GFCM Egypt Country Report).

More than 50% of the Albanian coastal wetlands was lost due to development of drainage projects and a marshland reclamation scheme after the 1950s (GFCM Albania Country Report). The wetlands surface in the Amvrakikos Gulf in Greece decreased from 65% in 1945 to 41% in 1999, due to the increase of artificial and cultivated areas (GFCM Greece Country Report).

A comprehensive estimation of wetlands and coastal lagoons surface in the Mediterranean is given by the Mediterranean Wetlands Observatory, 2012, that states that these habitats the Mediterranean region represent 18.5 (± 3.5) million ha of wetlands (across 27 Mediterranean countries), that represents between 1% and 2% of the world's wetlands. The figures given include swamps and marshes, and represents 1.7 to 2.4% of the total area of the 27 Mediterranean countries. The area lost is estimated at least in 50% of the wetlands that existed in 1900. These losses continue, although the rate has seemingly slowed down in the EU Mediterranean countries. The total area of wetlands now includes ca. 23% of man-made wetlands.

Such enormous extent of wetlands and coastal lagoon habitat lost in the Mediterranean is a share of habitat that must be considered definitively lost generally to biodiversity. Specifically for coastal lagoons, it is lost habitat to fish production because not available any more to colonization for migrant fish species dealing with coastal lagoons in any phase of their life cycle, eel among them.

It is perhaps worth saying that many coastal lagoons survived through time and to reclamation programmes only because fish production represented an income of social and economic interest. Many coastal lagoons as can be seen today are the results of the interaction of natural dynamics and management by man for centuries, as witnessed by the presence of coastal populations who lived on coastal lagoons several thousand years ago. Several Mediterranean coastal lagoons would not have survived without the continuous management by local communities aimed at enhancing fish production or hunting, thus enabling the physical conservation of these environments but also safeguarding their biodiversity value.

The work carried out within the LaMed-2 project has highlighted the main issues regarding the ecological features of Mediterranean lagoons in light of their intrinsic fragility as well as the environmental concerns recently raised and the management strategies applied in different countries and at different times. Management models have in fact been developed throughout the Mediterranean area, thus making it possible to identify strategies, which have been either successful or detrimental. Traditional management patterns include artisanal capture fisheries typically targeting high-value euryhaline fish, eel being one of the most valuable and targeted primarily in many lagoons across the region. These fisheries are generally supported by natural recruitment, although restocking practices may sometimes be applied to enhance fisheries production, thus creating an overlap between artisanal capture fisheries and traditional aquaculture practices.

A common feature of all coastal lagoons in the Mediterranean, and generally the result of increasing pressure on the coastal zones and on lagoons ecosystems, is the progressive decrease of productivity and consequently yields that are caused by the combination of overexploitation and environmental constraints as well as a shift in captures species composition. This has sometimes led to a declining interest shown towards fisheries and lagoon management schemes, not to mention in particular disregard for hydrological interventions.

In general, with low tide regimes such as those typical of the Mediterranean Sea, water exchange with the sea, either periodically or all year round, is quite limited, and a correct hydraulic management through human intervention becomes thus more than ever important. For example, in emergencies, when water circulation and exchange have to be enhanced, hydraulic devices allow water to be artificially pumped into lagoons to avoid dystrophic crises (e.g. in the Orbetello lagoon, Italy). Additionally, as movements of sediments by currents and wave action along the coast cause siltation of the mouth, continuous cleaning of communications channels between the lagoon and the sea is required. Hydraulic management not only facilitates water circulation within the lagoon and between the lagoon and the sea, but also contributes to enhance the distribution of trophic resources and the migration of juveniles into the lagoons and attract fish during the migrating phase, thus stimulating a positive rheotaxis behaviour of many fish species (Ardizzone *et al*., 1988) and of eel as well. For this species, it might be that where lagoon's connections to the seas are badly managed or management is abandoned, this might make the lagoon habitat inaccessible to eel, with recruitment and escapement impaired or annulled, similar to what happens to other marine migrant fish species. In this respect, the role of hydraulic management, besides being a key issue for the survival of coastal lagoons over time, could prove to be a crucial question to address in dealing with eel local stocks management in Mediterranean lagoons for restoration and conservation.

Anthropogenic coastal activities are responsible for important ecosystem alterations of Mediterranean coastal lagoons in several ways: eutrophication, bacterial contamination, algal blooms (toxic or not), anoxia and fish mortality can influence the productivity, and sometimes the conservation and even the survival of lagoon living resources. Regardless of the intrinsic variables of lagoon production, one can reasonably affirm that a decreasing trend in fish yields has been observed in all Mediterranean coastal lagoons over the last 30 years and important environmental occurrences have certainly contributed to this reduction (Cataudella *et al*., 2015). The production decline in lagoons is primarily due to habitat degradation and to changes of the lagoon's ecological conditions in general (Mediterranean Wetlands Observatory, 2012).

Other causes that can affect the productivity of lagoons are: reduced juveniles recruitment due to increased fishing activities along the coasts; altered colonization dynamics and rates due to the reduction of seawater and freshwater flows; and effects of predators such as ichthyophagous birds, which have caused a significant reduction in the yields of Mediterranean coastal lagoons, especially in the last years.

All this is relevant to the eel. Habitat loss, changes in environmental quality and ecological functionality of coastal lagoons, socio-economic changes and the resulting increased anthropogenic pressure, certainly played a role on eel decrease in the Mediterranean, in combination with factors intrinsic to the eel global stock, primarily the overall decline in recruitment (Aalto *et al*., 2016). Notwithstanding this, a preliminary assessment of pristine, potential, and actual escapement of silver eels from lagoons across the Mediterranean basin estimated a present escapement level of 35% of the pristine that could potentially reach 54% by substantially reducing fishing mortality (Aalto *et al*., 2016).

Recently, Capoccioni *et al*. (2020), based on an integrated evaluation approach of lagoon environmental quality and eel spawner quality, have suggested that many transitional waters in the Mediterranean might be identified as "essential eel habitats", where important conservation measures should be implemented to protect this sensitive species, such as a total eel fisheries ban coupled to habitat protection. In the Mediterranean region, 74 lagoons (for an overall surface of more than 501 000 ha) are at present protected under the Ramsar Convention (Ramsar, 1972), and many are within international frameworks for habitat protection (Natura2000, https://ec.europa.eu/environment/nature/natura2000/index_en.htm; Site of Community Importance – SCI, EC 1992). Considering the potential eel production and escapement from Mediterranean lagoons (Aalto *et al*., 2016) and the perspective requirement for specific management frameworks in the Mediterranean region (FAO, 2018), the role of these environments might prove to be crucial for the recovery of the global eel stock and a potential key factor in contributing to its conservation.

The perspective role of such habitats in the Mediterranean area in contributing to conservation efforts for eel recovery, has been recently confirmed by the observation of eels from Mediterranean crossing the Strait of Gibraltar to continue their migration into the Atlantic Ocean (Amilhat *et al*., 2016).

4.1.6 Conclusions and recommendations on habitat loss

The review of the effects of habitat loss on the eel stock, presented above, indicates that those effects are noted in many studies, in national assessments and Eel Management Plans, but rarely fully taken into account in assessing the state of the stock. Additionally, the (quantitative) information on habitat loss available for analysis is incomplete, often inconsistent. It is therefore recommended to include information on habitat loss and its effect on eel in a coming data call (suggested: 2022), in order to enable a more in-depth analysis. A first outline of requirements for this data call have been outlined (above), but details will need to be worked out (possibly in a wider data-workshop).

Noting that (impacts of) habitat loss often are practically irreversible, it is recommended to consider the effects of irreversible impacts on the objectives, targets, indicators and protective measures for sustainable management of the eel stock (for instance, in the discussion by WKFEA).

4.2 New and emerging threats and opportunities

This chapter answers ToR C and Generic ToR g: *Report on updates to the scientific basis of the advice, including any new or emerging threats or opportunities.* The information is drawn from that provided in Country Reports, plus that brought to the attention of WGEEL by all those attending the 2020 virtual meeting.

4.2.1 Covid 19 impact statements across WGEEL

As with all aspects of life in 2020 the effects of the Covid19 pandemic reached right across the nations represented at WGEEL with varying degrees of impact and at different times (indicative of the seasonality associated with working with eels). Many Country Reports and the associated Data Call for this year contained Covid19 impact statements, which were reviewed and are outlined under this ToR following discussion by the group that this should be seen as an *emergent threat*.

The impacts fell largely into three groups:

- Interruption/cessation of scientific monitoring and national stocking programmes (across all life stages).
- Interruption/cessation of national stocking programmes (glass eel and on-grown yellow eel stages).
- Closure/delay in commercial fishing (glass eel and yellow eel stages) due to movement restrictions and/or loss of markets as a consequence of social lockdowns.

4.2.1.1 Scientific disruption

Many scientific institutes reported reductions in fieldwork activities, stocking, sampling of yellow eels, silver eel escapement monitoring and significant backlogs of laboratory processing.

Moreover of the 68 Datasets currently included in the recruitment trend used in the advice for the 2020 Data call, twelve (17%) recorded significant reductions to these sampling efforts directly attributed to Covid19 impacts. The bulk of these reductions occurred across the western edge of

Europe (Figure 4.2.1), coinciding with the spread of Covid19 across the continent during spring affecting six sites from the North Sea (NS series), four from the Elsewhere series (EE), and two for Yellow eel recruitment.

Out of the total dataset (the database also includes series too short, or too biased to be included in the analysis) 17 out 95 series were affected.

Note that of those index series used to assess recruitment trends only one normally reported at the time of WGEEL was absent (SeEAG on the Severn UK).

The fuller impacts of COVID-19 disruption will roll into 2021 as some Countries reported 2020 data as provisional; 2020 will always be 'special' and analyses of data should consider whether it is a one-year anomaly or has longer term effects (as people leaving the fishery might suggest).

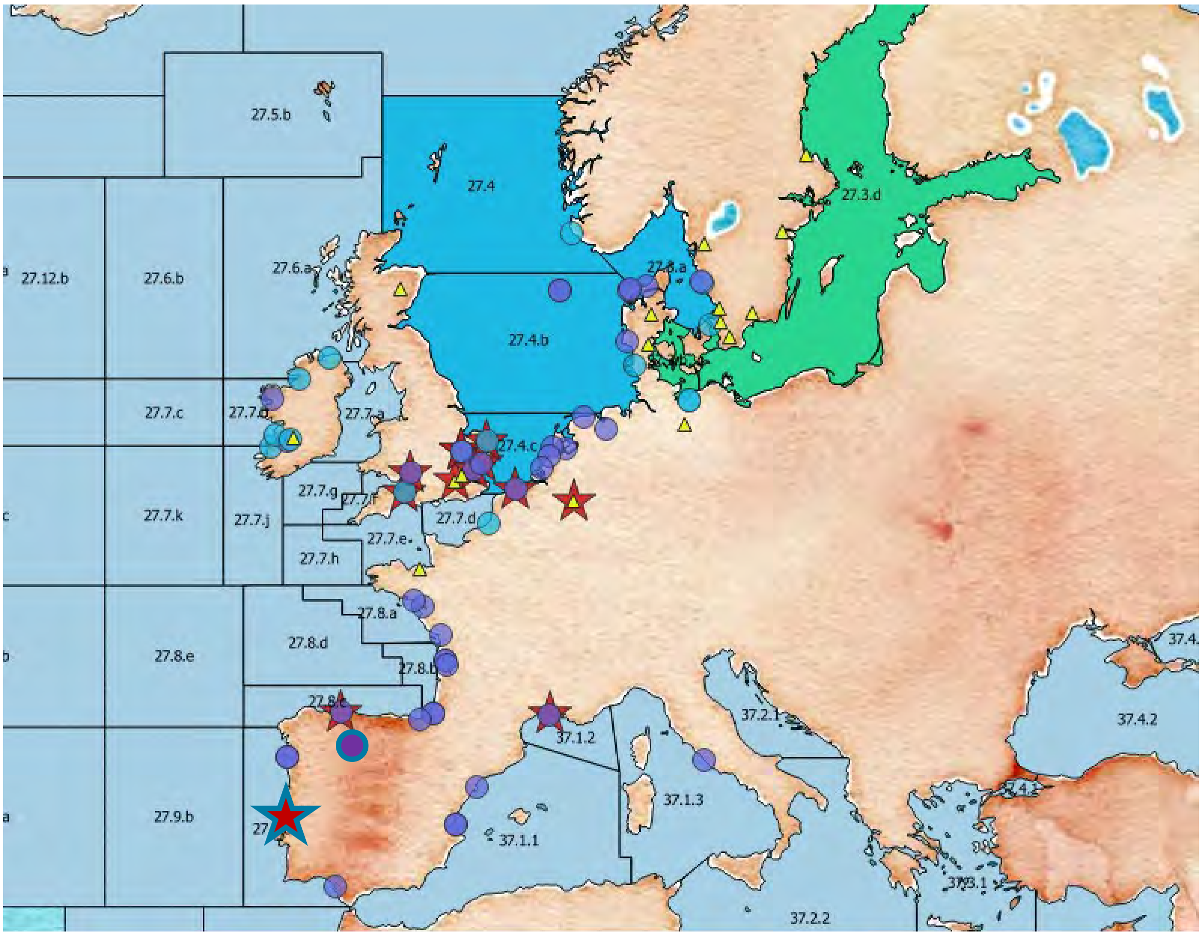

Figure 4.2.1. WGEEL recruitment series, and those series impacted by Covid19 in 2020 where a disruption of data collection was reported are marked with a red star.

4.2.1.2 Fishery disruption

Much of the reported disruption to commercial eel fisheries was focused on suspensions of glass eel fisheries that are in season during late spring and delays to the opening of yellow eel fisheries throughout more inland portions of the EU.

Information on financial support schemes for fisheries was not available from all countries but a range of Furlough, "tie up" and hardship payment initiatives where operable in Poland, Holland, UK and France.

However, whilst of obvious short-term financial benefit to fishers and their families, a frequent comment from these communities was that after a prolonged enforced break from the activity of fishing, many may decide never to return, even as markets re-open and restrictions are lifted. An additional consideration within these comments was the typical older age of eel fishers as a contributing factor to the unlikelihood of their return having "broken the link with the mind-set" for what it takes to fish eel.

As of September 2020, the market demand for eel across Europe remains low after a summer of falling consumption driven by reduced tourism and increasing local lockdowns. However, in some regions, reductions in fishing capacity combined with the current market demand has led to a new equilibrium in terms of improved livelihood for those that returned to fishing.

4.2.1.3 Summary of National Covid19 Impacts (in relation to eel)

Denmark

Denmark had a contract with an eel farm to deliver 2–5 gram eel for stocking; the company claimed *force majeure* due to Covid 19 and were unable to deliver on the contract. Denmark was therefore unable to purchase the planned number of glass eel and as such, the number of stocked eel in 2020 was significantly reduced by ca. 30%.

Belgium

In 2020, monitoring of the glass eel recruitment at River Yser started on 3 February and stopped on 5 March. On 6 March, there was a malfunction at the sluice, after that water level was too high to perform the monitoring and on 19 March monitoring was not allowed any more due to Covid-19. Fishing effort was thus much lower than during other years, and fishing was only performed during start of the season. Considering the very low fishing effort and the temporal bias in fishing, comparison of the 2020 data with recruitment data of previous years is not appropriate. Due to technical problems at the sluice and to COVID-19 measures, the 2020 data of the Yser glass eel recruitment series are incomplete and not representative, and should not be used for statistical purposes, nor for international stock assessment and should be treated as "NON-AVAILABLE" for international assessments.

In 2020, Wallonia ordered 220 kg glass eel for stocking in Walloon waters. However, the supplier was not able to provide the glass eel due to the lockdown restrictions thus no glass eel could be stocked in Wallonia in 2019.

UK

Across the southern half of England, the collection of glass eel recruitment data from all of the sampling points (including index catchments used in recruitment analyses) by the Environment Agency were significantly reduced due to movement restrictions and staff availability.

In Northern Ireland, COVID-19 impacts have been minimal on dataseries for GB_NorE. However, the effects on GB_Neag have been larger. The collection of recruitment data has remained unaffected, but the commercial fishing season on Lough Neagh did not begin in May as usual, opening on 1st July with a much reduced fishing fleet than in previous years (36 boats compared to 87). This lower number is influenced by government Furlough scheme payments to self-employed workers (such as fishermen) and the loss in continental markets for yellow eel as a direct result of lockdowns/loss of tourism in Holland and Germany.

These changes are anticipated to remain through the coming months and thus into the silver eel migration period and associated silver eel fishery on the River Bann exiting L. Neagh. Plans are in place to incept a Scientific Fishery during key lunar darks through the autumn and winter of 2020 to enable EMP compliance assessments to continue.

Field working and laboratory analysis of materials has taken a significant impact in terms of travelling solo to sites, reduced staff presence at fieldwork, additional preparation time and working conditions in laboratories (now on rotational basis to reduce staff numbers). COVID-19 guidance on working practices has meant a reduced capacity for on-boat working and created significant backlogs in sample analysis.

Portugal

COVID-19 restrictions impacted on the scientific series for recruitment that was initiated in Mondego in 2017; the collection of data was interrupted from March resulting in the absence of data collection for three months out of the normal assessment over seven.

Italy

During the present year, eel coordination across all sectors involved in eel work has been greatly reduced or absent. All of this is as a direct consequence of reduced activities linked to the long lock-down due to COVID-19 pandemic. This has also been reflected in the delayed response to international reporting obligations and Data Calls.

Greece

The period February 2020 until June or July 2020 was the period with the most "severe" impact on eel fisheries. In certain lagoons, due to the local lockdowns, the fishermen were not allowed to go the their installations and check the traps. Additionally, the exports of eels to EU countries were minimized and even reached almost to 0 due to border closures. In scientific terms, the impacts were the same due to movement restrictions as scientists were not allowed to go in the field.

4.2.2 The use of larger (discarded) farm eels for stocking

In intensive eel culture, size grading is employed regularly e.g. every three or four weeks during the growth phase at commercial eel farms. The effect of grading is to improve growth rate of small individuals by removing the suppressing effect of larger individuals (Personal communication, Eel farmer M. Lauritzen).

Size grading the same cohort of glass eel many times may result in the creation a residual group of slow growing eel. When you are purchasing on-grown eel for stocking at an eel farm, only the eel famer will have an idea of the growth potential (fast, medium or slow). As a customer, you have no instant way to control the growth potential of the eel you buy. The Danish stocking programme use on-grown eel of 2–5 gram purchased from eel farms. To avoid slow growing eel from eel farms, it is a condition in the contract with delivering eel farms that eel for stocking should originate from glass eel caught in the same year and never be more than eight months between capture and stocking.

On-grown eel from aquaculture are commonly used for stocking in the countries around the Baltic Sea. Some countries e.g. Sweden and Finland keep the eel in quarantine for about nine weeks and the stocking size is 1.2 gram (Wickström and Sjöberg, 2014). The Danish stocking programme uses on-grown eel of 2–5 gram assuming a better survival compared to glass eel (Rasmussen and Geertz Hansen, 2001) and in Germany 5–8 gram on-grown eel are used (Simon *et al*., 2013).

It is debatable if there is any advantage in stocking on-grown eel compared to glass eel (ICES, 2016b) and it has been suggested that the body size advantage of on-grown eel is lost to natural recruits after 5–6 years (White and Knights, 1994) or after 3–4 years (Simon and Dorner, 2013). Dainys *et al*. (2017) in the laboratory experiment found that on-grown eels have no advantage in survival compared with glass eels when fed with *Chironomus* spp. larvae, likely because eels must switch their diet from artificial to natural food, a transition to which at least some on-grown eels appear unable to cope. Relative growth rate (as proportion of initial weight) of glass eels was found to be higher than on-grown eels. In contrast to these results, Holmgren and Mosegaard (1996) found that “late starters” had the same capacity for fast growth as their earlier starting counterparts, whilst Pedersen *et al*. (2017) observed that farmed on-grown eel grew better than wild eel of the same body mass (3 gram) in controlled pond experiments. Further experiments comparing 3 gram and 9 gram eel as stocking material in a Danish Fjord concluded that larger 9 gram eel are more expensive and have a less biomass increase compared to 3 gram eel (Pedersen and Rasmussen, 2016).

In view of the lack of evidence there seems to be no advantage in using larger eel for restocking and that conversely the use of larger farmed eel for restocking may risk an increase in the spread of disease agents from the farm, sexual bias in on-grown eels (ICES, 2016b) and the use of slower growing eel due to their repeated grading.

4.2.3 Review of previously listed Threats by WGEEL

WGEEL have reported on emerging threats and opportunities as a specific ToR in each of the previous five years (ICES 2015a, 2016a, 2017, 2018b, 2019a). However, this does not mean that they had not been reported previously as a noted impact on eel populations at previous WGEEL meetings. The general threat types highlighted in the each of these five years are summarised in Table 4.2.1. The threat posed by Contaminants appears in all five years, Diseases in four years, Climate Change and hydropower in three years, predators and parasites in two years whilst the remainder (Marine Renewable Energy, Recreational Fishing) appear in a single year.

A number of different potential threats to the stock of European eel throughout its distribution range are mentioned in reports and publications with some of them broadly accepted as established while others are occassionally, repeatedly or newly noted as emerging threats. Some of the non-fishery impacts such as diseases, parasites, contaminants, hydropower, etc. however, are occasionally listed as emerging threats even though they have already been present for a sustained period of time, and should thus be recognised as established threats.

While some of these reported threats are newly emerging (e.g. a newly identified eel virus), there is the danger of overlooking the fact that these previous summaries refer to threats that, once identified, should be regarded as current and ongoing. In many cases, these areas of threats have a relatively long history (decades) yet the mitigation measures that have been implemented have tended to be minor and incremental rather than decisive, and thus scope for action may remain, or analyses are yet to be complete.

As such, it is recommended that this section is not seen in isolation but as part of a continuum from previous WGEEL reports which included the 2018 recommendation for establishing a standing annual activity/subgroup package tasked with taking forward quantification of non-fishery impacts in 2019–2021.

- Impacts of hydropower turbines and pumping stations (2019);
- Impacts on habitat availability to eel (2020);
- Effects of contaminants on reproductive potential (2021).

4.2.3.1 Viruses

Even though a number of different viruses and diseases in eels occur naturally in wild populations in the background, research projects and information on viruses in eels (HVA EVEX IPNV/EVE EPV) have been consistently been reported by different countries in recent years (Swedish Country Report 2017 in Annex 6 and Wickström, personal communication; also see previous Reports WGEEL 2017; WGEEL 2018, WGEEL 2019. Extraordinarily hot summers caused by climate change apparently have the potential to amplify the prevalence of such of these diseases and virus infections (REFs). Also, the spreading of these diseases through the introduction of infected seed stock into wild populations appears to remain a pertinent threat to the stock (Kullmann *et al*., 2018).

4.2.3.2 Contaminants

WGEEL considered contaminants and effects on reproductive potential as one factor contributing to non-fishery mortality with potential for quantitative assessment. In a recent comprehensive review paper by Belpaire *et al.* (2019), the authors give a broad overview of state of knowledge; knowledge gaps and research needs regarding contaminants and potential impact on the species on population and stock levels and discuss implications for management of the species.

In a study on the body transformation during artificial maturation, Freese *et al.* (2019) described how eels use their body as a storehouse not only for lipid-derived energy provision for locomotion, but also for minerals, as they transfer minerals such as phosphorous and calcium from bones and somatic tissues into their gonads. The study revealed that also potentially toxic metals are being transferred during maturation with potential adverse consequences for the developing offspring.

A number of other publications provided evidence that organic and inorganic contaminants such as dioxin-like substances and metals are redistributed from somatic body tissues into the gonads during maturation and migration potentially leadings to critical concentrations posing threat to the wellbeing of developing eggs and early life stages of eels after spawning (Sühring *et al*., 2015; 2016b; Nowosad *et al*., 2018; Freese *et al*., 2017; 2019). These findings strengthen the perception that contaminants in eels from polluted waterbodies may have detrimental effects on spawner quality and spawning capacity of local eel populations, which needs to be considered in future assessment and management.

In a study by Bourillon *et al.* (2020), the authors present a tentative approach to benchmark potential spawner quality of eels based on the impact of each studied stressor / quality indicator proportionate to the collectivity of all sampled individuals. The analytical data revealed that eels from all studied habitats were affected or impacted by the here studied contaminants and parasites and that there are indeed some differences between the origins or growth habitats of the fish. Also, an approach on quality assessment of silver eels to support management in Mediterranean coastal lagoons was published recently by Capoccioni *et al*., 2020. In this study, silver eels were sampled and investigated for a range of contaminants, viruses and parasite infections resulting in an overall good status of the eels from the investigated area.

Table 4.2.1. Summary of threats identified by WGEEL, 2015, 2016, 2017, 2018, 2019.

Threat	2015	2016	2017	2018	2019	2020
Contaminants	y	y	y	y	y	
Parasites			Y	y		
Diseases	y		y	y	y	
Hydropower	y			y	y	
Marine renewable energy	y					
Predators	y			y		
Invasive species	y					
Climate change	y	y		y		

4.2.3.3 Hydropower/pumping stations

These were extensively reviewed and with the limited data available to WGEEL in 2019, quantified as of similar level of impact as eel fisheries (ICES, 2019).

4.2.3.4 Climate change

The threat of climate change on eel populations has been a consistent feature in Country Reports and ICES reports since this specific ToR was first included in 2015. The concerns and reasons behind those concerns remain the same:

- Climate change and potentially associated changes in ocean conditions having an impact between silver eel departure, reproduction and glass eel return to the coast – the oceanic "black box".
- Factors in freshwater potentially affecting silver eel capacity to escape and breed successfully – contaminants burden. Much of the current discussions into the effects of climate change are directed towards the marine environment but freshwater habitats should not be omitted particularly given the likelihood of dual impacts on migratory animals such as diadromous fish.
- Habitat loss – reduction of freshwater habitats are already evident as a consequence of changing climate over time within the distribution range of eel e.g. Desertification processes are occurring extensively both in the Mediterranean and in central and eastern European countries (Zdruli, 2012). The increase in drought conditions and/or heavy precipitation events, contribute to enhance the risk of further desertification processes, which are highly accelerated by pressures on land use. Intensive agriculture, besides destroying the soil, overexploits water resources, which in already depleted areas exacerbate the effects of climate change. (See Section 4.1.2.7).

In discussion the group agreed, as in previous WGEEL meetings (ICES, 2018), that this issue was too big for a regular session of WGEEL and would recommend that a specific themed work shop on climate change and its impacts on European eel should be held.

4.2.4 New or emerging threats in 2020

4.2.4.1 Implications of EU Exit of UK (Trade Issues)

Following group discussions and a review of the 16 Country Reports submitted in 2020, only Finland, France and Sweden, mentioned a ***new or emerging threat***, which was the EU Exit of the UK. This may result in a ban on the movement of eel specimens between the EU and the UK as a consequence of the CITES Regulation in relation to European Eel Trade. ICES (2018) reported that several countries which relied on stocking in their EMPs, with UK glass eels, raised concerns that access to these could become difficult after the UK leaves the EU, and thus threaten their National stocking programmes. This continued to be the case with Finland and Sweden in 2020.

In their Country Report Sweden noted that in the past Swedish national authorities had mostly used glass eels from the River Severn (UK) but recently had problems with disease in glass eels from another source (resulting in the destruction of 3 million glass eel in quarantine), and have since, preferred sourcing additional glass eel from the UK.

French concerns were focused on the increased availability of glass eel from the UK being traded illegally to Asia.

4.2.5 Science and opportunities

A review of Country Reports and recently published literature provide some insights into new scientific findings for eel and upcoming research opportunities (Table 4.2.2).

In Denmark a telemetry study on silver eel migration was started (in 2019) which has full acoustic receiver coverage at transects across the exits from the Baltic Sea (Figure 4.2.2). The study is joined by research institutions from Denmark (DTU Aqua), Sweden (SLU Aqua), Estonia (Estonian University of Life Sciences), Germany (Thünen-Institute of Fisheries Ecology), Belgium (Ghent University), Lithuania (Lithuanian Nature Research Centre), Finland (Luke Natural Resources Institute) and Latvia (Institute of Food Safety, Animal Health and Environment). A total of 860 silver eels will be tagged throughout the Baltic region during 2019–2021 with majority of these eels expected to be included in the study. DTU Aqua is working on making the receiver transects in the belts and sounds permanent, which will allow future research on eel migration behaviour to use this infrastructure. Sweden joined this initiative and up today have three areas prepared with hydrophones to collect signals from migrating eels and DTU-aqua have another three in the outlet straits of the Baltic Sea.

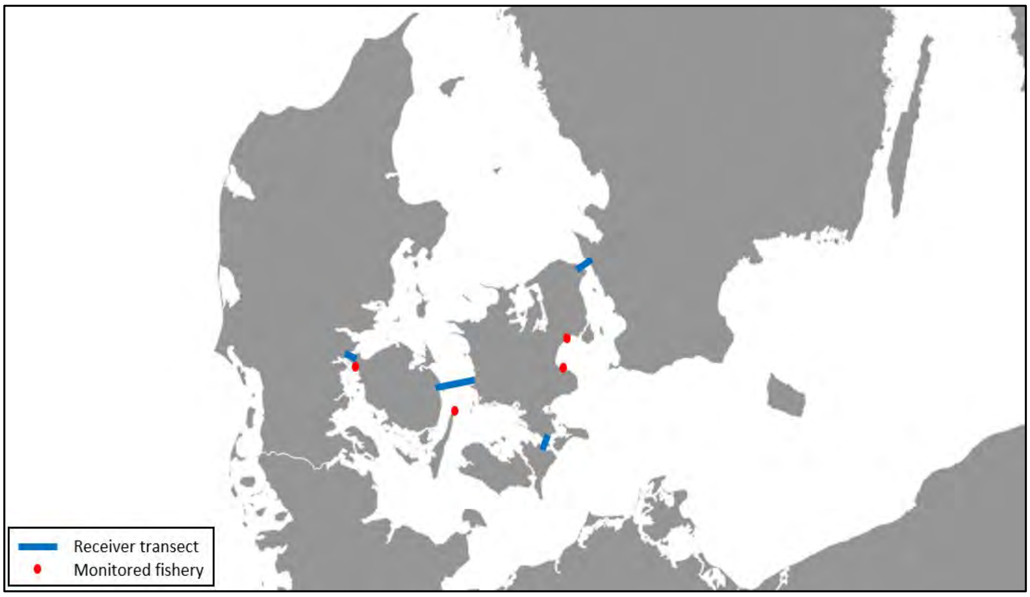

Figure 4.2.2. Location of receiver transects (blue lines) and monitored fisheries (red dots) in the Danish belts and sounds.

In Estonia, long time eel restocking, commercial fishery and environmental data from L. Võrtsjärv was analysed to see whether significant relationships exist within the data. A seven-year gap (as this was the most common age group in the commercial catch) between the restocking and yield was introduced to see which abiotic and biotic factors during the first year of restocking affect the yield the most. It was found that cyanobacterial biomass and summer water temperature during the year of restocking had the strongest negative impact on the yield seven years after, while the number of restocked individuals and copepod biomass had a positive effect. During particular fishing year, however, the yield was most notably positively affected by total phosphorous concentration, number of individuals restocked seven years before and metazooplankton biomass in the lake (Bernotas *et al.*, 2020).

In Finland, a first observation of a spontaneously matured female eel was made in an aquarium house in the city of Kotka. The eel was 43 years old, held in the aquarium house since 2002 and was originally restocked as glass eel in 1978. The specimen had an estimated gonadosomatic index (GSI) of 47, only half of the oocytes were hydrated and matured, indicating that European eels are polycyclic batch spawners. It was hypothesized that substances released by other maturing and spawning fishes in the aquarium might have triggered puberty of the eel (Palstra *et al.*, 2020).

In Germany, the bioaccumulation potential of alizarin red S (ARS) in eel muscle tissue was evaluated. As ARS has been used for mass marking eels an understanding of its bioaccumulation potential was needed to classify ARS as "harmless" due to a potential risk to consumers' health. Using the technique of liquid chromatography mass spectrometry, an ARS detection protocol was developed and the bioaccumulation potential of ARS in European eel muscle tissue was estimated. This new method for ARS detection showed that the bioaccumulation of ARS in edible fish muscle was highly unlikely (Kullmann *et al.*, 2020). In another Study, in the German River EMS, the Thuenen Institute of Fisheries Ecology in cooperation with the federal state of Lower Saxony started a mark and recapture study involving acoustic telemetry to quantify eel escapement in this management unit. Outcomes of the study will be compared with modelled escapement numbers to validate and potentially improve metrics in the German eel model (GEM). In a parallel project to these efforts eDNA analyses will be conducted in order to investigate possible correlations of eel eDNA with silver eel abundance during spawning migration.

In Sweden, a study performed by Nilsson *et al.* (2020); found that juvenile ascending elvers tended to prefer small habitats with pebble substrate, and this preference is not changed in the presence of piscivore scent. However, larger yellow eels in lotic environments tended to prefer coarser substrates, high temperatures and a large distance to the river mouth (Degerman *et al.*, 2019). Leander *et al.* (2020) evaluated two acoustic telemetry systems for monitoring downstream migrating eel and salmon and found that they had different advantages and disadvantages. In Lake Malaren catches of eel in fykenets over recent years have contained an increasing ratio of barium chloride-marked eels (from a stocking in 2011). When more data have been obtained from a few years more of sampling, the growth of these eels can be compared to the growth of eels market with Alizarin from an earlier marking experiment in 1997.

In the United Kingdom, a new project will focus on understanding eel behaviour to assess the effectiveness of existing and new technologies for minimizing entrainment of eels, especially adult silver eels during downstream migration at pumping stations and develop innovative measures to provide applied outcomes. The research will focus on understanding the spatial distribution of eels in pumped catchments, the processes that lead to entrainment and the effectiveness of altered operating regimes, fish-friendly pumps and novel downstream bypass channels for minimizing entrainment. Acoustic telemetry, multibeam imaging sonar, eDNA and flow modelling techniques will be applied In the study. It is anticipated to revise guidance for mitigating eel entrainment at pumping stations and water intakes at national, European and global levels.

In the United Kingdom, several studies were focused on the behaviour of eels to find better ways to improve passage and protection at flood control structures, weirs, hydropower sites and other intakes were studied. The studies showed significant impacts of some river structures on migrating eels, and that by understanding eel behaviour in relation to flow at such structures and intakes operational changes can be made at critical times of year to minimise delays and entrainment and improve passage. The success of 'trap and transport' from reservoirs to river systems has also been assessed. A project is in progress to improve eel pass design and performance. This evidence will help to inform guidance for provision of eel passes.

A scoping study by several United Kingdom institutions in 2017 confirmed the presence of European eel populations on several islands within the Azores archipelago, which means there was the chance to track eels from a point closer to their speculative spawning area which greatly increases the chance of success using current technology (Previously the waters around the Azores were the last point to which an eel has been tracked using satellite tags). An international partnership project is underway with the specific objective to track the migration routes and behaviours of eel from the Azores to their spawning area. A total of 26 silver eels have been satellite tagged in 2018 and 2019 revealing the next stage of their journey to the Sargasso Sea. Locating where eels spawn is critical for understanding the reasons for their decline and conserving this globally important species.

Mark–release–recapture trials were conducted to determine the exploitation rate of glass eel by handheld dip nets in the Severn Estuary in the spring of 2020. The glass eel marked with Rhodamine B were released in two batches of 20, 455 and 27, 923 with respective recapture rates of 891 ± 100 4.36% (± 0.49) and 373 ± 172. Subsequent exploitation rates were estimated to be 4.36% (± 0.49) in trial 1 and 1.33% (± 0.62) in trial 2. The size of the glass eel population from trial 1 was estimated to be 24.69 t (22.46–28.81) and the overall exploitation rate of the fishery for the season was 7.8% (6.7–8.6%). Comparisons are made with studies in other estuaries and with conservation targets set by the Eel Regulation and the Eel Management Plan for the Severn. The study suggests the fishery is not the main cause of the Severn RBD failing to meet escapement targets.

In United Kingdom PhD project is started on phenology and ecology European eel during their marine to freshwater transition. The study aims (1) to Evaluate the migration phenology of glass eel in Europe, with testing of relationships between the timings of freshwater arrival with latitude and longitude, and sea and freshwater temperatures, and assess their probable migration routes in relation to ocean currents; (2) Quantify the length, age composition and trophic (feeding) ecology data of glass eels and elvers across European rivers, with a focus on early arrivals and in the migration peak; (3) For a specific river catchment, test the temporal and spatial relationships between juvenile eel stage (glass/elver/yellow eel) and their lengths, ages and trophic ecology; (4) In the same catchment assess the ecology of elvers and yellow eels within specific sites in their initial years of freshwater residence, including their movements.

In Turkey, the long-term (1974–2016) European eel time-series landing data from Köyceğiz lagoon are published by Tosunoğlu and Saygı (2019). Changes in landings, status of eel stock and fishing opportunities in the lagoon are discussed. Turkey has participated in a research programme on multiannual management plan for European eel in Mediterranean which is coordinated by GFCM; the project is at the initial data collection stage.

In Ireland, a study was carried out where catch data from a standardized fykenet fishing survey was compared with a single species *A. anguilla* eDNA survey in five freshwater lakes. The results demonstrated that eDNA sampling is more sensitive for detecting eel presence in low eel population environments than standard survey methods and may be a useful non-invasive tool for monitoring *A. anguilla* species distribution (Weldon *et al*., 2020).

In Belgium**,** Nzau Matondo *et al.* (2020) evaluated methods to evaluate restocking practices. Based on two glass eel restocking events using a single release site/point and multiple sites per river performed in upland rivers (>340 km from the North Sea), the recruitment success of stocked eels was scientifically evaluated during a three-year study using multiple capture–mark–recapture methods and mobile telemetry. Results suggest that telemetry can help to rapidly assess cryptic juvenile eel stocks with good accuracy under a limited number of capture–mark–recapture sessions. Artificial dispersal of glass eels on several productive habitats/sites per river appears to be the better-suited practice for restocking.

Two new Belgian studies were published on the morphology of eel. Baan *et al.* (2020) described changes in cranial morphology after silvering, while De Meyer *et al.* (2020) discussed how the understanding of the eel's morphology can play an important role in function of management measures, as functional morphological studies provide useful insights on how species perform behaviours that are vital for survival, such as feeding and locomotion. In addition, they allow us to evaluate how environmental changes can affect or limit such crucial behaviours. Consequently, when making conservation decisions, functional morphology represents an important component that should be taken into account. Hence, in this paper, an overview is given of studies on the eel's morphology that demonstrate both its relation with ecology and behaviour, but are also relevant for developing and installing specific management measures.

Steendam *et al*. (2020) described burrowing behaviour in three stages of eel. In this study, substrate preference and burrowing performance was evaluated in three life stages: glass, elver and yellow eel. This study thus provides novel information about the eel's behaviour and possible habitat use, which can contribute in developing more efficient conservation measures.

Shipping canals can serve as important migration routes, offering a short cut between freshwater and the sea. In contrast, the navigation locks may act as barriers to migration, causing delays and migration failures. To better understand these issues for downstream migrating fish, Vergeynst *et al.* (2020) studied the behaviour of eels in the Belgian Albert Canal. The study discusses the factors influencing fish behaviour, and migration efficiency.

In a submitted Belgian paper, Pauwels *et al*. (n.d.) assessed the rate of eel injury and mortality, and the physical conditions during downstream passage of eel through Archimedes hydrodynamic screws. Three of the six ship lock complexes on the Albert canal are equipped with a hydropower plant, generating electricity with three 10 m head Archimedes hydrodynamic screws. Assuming that on average 9% of all silver eels which try to pass downstream near the ship lock complexes on the Albert canal pass via the hydropower plant, that around 17% of them get killed or severely injured, and that this happens at every of three ship lock complexes being equipped with a hydropower plant, means that 4,5% of all silver eels migrating downstream through the Albert canal are lost from the population due to passage of the hydropower stations.

Table 4.2.2. Opportunities identified by WGEEL 2020.

Opportunity	2020
Invasive species	
Advances in telemetry	y
Environmental DNA	y
Advances in artificial reproduction	
Advances in genetic/bio- markers	
New stocking info	
Stock assessment advance	
New migration info	
New habitat use info	y
New hydropower mitigation measures	y
GFCM development	
Convention on migratory species proposal	
Improved GE catch reporting	
New min size limit study	
New GE estimation model	
New larval feeding info	
New stocking info	

4.2.6 Additional International data sources for European eel (other than ICES Datacall)

See Section 3.2 within the Stock Annex for a fuller review of the range of legislative measures the European eel falls under and their associated data collection requirements from which additional information on eel stocks should be available. WGEEL suggests that points of contact and awareness of eel data collection opportunities should be established within these respective groups to aid in the transfer of knowledge and data.

4.2.7 Conclusions

- The impacts of Covid-19 fell largely into three groups: Interruption/cessation of scientific monitoring, national stocking programmes (across all life stages) and the closure/delay in commercial fishing (glass eel and yellow eel stages) due to movement restrictions and/or loss of markets as a consequence of social lockdowns.
- There remains an as yet unquantified impact on the number of fishers that have permanently left this livelihood. The fuller impacts of COVID-19 disruption will roll into 2021 as some Countries reported 2020 data as provisional; 2020 will always be 'special' and analyses of data should consider whether it is a one-year anomaly or has longer term effects.
- Limited data available suggest there is no advantage in using larger eel (discarded from farms) for restocking and that conversely the use of such eel for restocking may risk disease spread, sexual bias and the use of slower growing eel.
- A number of different potential threats to the stock of European eel throughout its distribution range continue to feature in reports and publications with some of them broadly being accepted as established while others are irregularly, repeatedly or newly noted as emerging threats. Non-fishery impacts such as diseases, parasites, contaminants, hydropower, etc. no longer tend to be routinely reported as emerging threats given they have been present for a long time and should be considered established.
- Finland and Sweden, countries which rely on stocking in their EMPs, with UK glass eels, raised concerns that access to these could become difficult after the UK leaves the EU, and thus threaten their National stocking programmes. French concerns were focused on the increased availability of glass eel from the UK being traded illegally to Asia.
- The threat of climate change on eel populations has been a consistent feature in Country Reports and ICES reports since this specific ToR was first included in 2015. The concerns and reasons behind those concerns remain the same given the diadromous nature of the eel life cycle.

4.2.8 Recommendations

WGEEL recommends a theme session at the ASC examining the effects of climate change on diadromous species, followed by a workshop to discuss the effects of climate change on European eel populations, their associated conservation efforts and stock recovery actions across its natural range. However, in recognizing the extensive list of tasks for 2021, a workshop will not be officially recommended for then.

5 ToR D: Report on the temporal migration patterns of European eel, and seasonality of fisheries and closures, per relevant geographical area with the aim to answer a request from the EU

This ToR was addressed by a separate workshop. The Executive Summary is provided below, followed by links to the WK report and the ICES Advice to the European Commission.

The **Workshop on the temporal migration patterns of European eel (WKEELMIGRATION)** worked in 2019 and 2020 to answer the questions posed by the EC on the temporal migration patterns of European eel in EU areas.

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.

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.

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.

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.

Click here for the Workshop report (ICES, 2020a).

Click here for the ICES Advice (ICES, 2020b).

6 ToR E: Review and update the Stock Annex

A Stock Annex for the European eel was drafted at the Joint EIFAAC/ICES/GFCM Working Group on Eel (WGEEL) 2015 meeting, finalised in 2016 and reviewed in 2020. In 2020, all sections of the Stock Annex were thoroughly reviewed and updated. Emphasis was given on the transfer of standard information from the Annual WGEEL Report to the Stock Annex in order to keep the Annual Report as short and informative as possible. The updated Stock Annex provides detailed descriptions of the eel's life cycle, biology, natural range and distribution area and describes the eel stock and factors affecting eel production and escapement. Further, the development of eel advice, the management frameworks for eel and the analysis of recruitment for the provision of ICES Stock Advice are described. Information on the yearly Joint ICES/GFCM/EIFAAC Eel Data Call is also presented in detail. This Stock Annex is intended as a reference document to provide background to the annual advice and report. In principle, information contained in the Stock Annex should not be repeated in the annual reports of the WGEEL. However, some information is replicated here, where the WGEEL considered it appropriate. The revised version is available from the ICES website (link).

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Annex 2: Resolutions

Uploaded to Resolutions Forum.

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Annex 4: Acronyms and Glossary

Acronyms

Acronyms	Definition
AA	Administrative Agreement, typically the recurring agreement between ICES and the EC
ACFM (ICES)	Advisory Committee on Fisheries Management
ACOM (ICES)	Advisory Committee on Management
ADGEEL	Advice drafting group on eel, for ICES
AIC	Akaike Information Criterion
AngHV-1	Anguillid herpes virus 1
ANCOVA	Analysis of Covariance
ANOVA	Analysis of Variance
BERT	Bayesian Eel Recruitment Trend model
BIC	Bayesian Information Criterion
CCM	Catchment Characterisation and Modelling
CITES	Convention on International Trade in Endangered Species of Flora and Fauna
CMS	Convention on the Conservation of Migratory Species of Wild Animals
COMM	European Commission, also EC is used.
CPUE	Catch per unit of effort
CR	Country Report
CandR	Catch and release
CUSUM	Cumulative Sum Control Chart
DAERA	Department of Agriculture, Environment and Rural Affairs (N. Ireland)
DBEEL	Database on Eel (from EU POSE project)
DCF	Data Collection Framework of the European Union
DEMCAM	Demographic Camargue Model
DG-MARE	Directorate-General for Maritime Affairs and Fisheries, European Commission
DLS	Data-Limited Stocks
EC	European Commission, also COMM is used.

Acronyms	Definition
e-DNA	Environmental DNA
EDA	Eel Density Analysis (model, France)
EIFAAC	European Inland Fisheries and Aquaculture Advisory Commission
EIFAC	European Inland Fisheries Advisory Commission – became EIFAAC in 2008
EMP	Eel Managment Plan
EMU	Eel Management Unit
EFF	European Fisheries Fund
EQD	Eel Quality Database
EROD	Ethoxyresorufin-O-deethylase
ESAM	Eel Stock Assessment Model
EU	European Union
EU MAP	The European Multi-Annual Plan, previously the DCF
EVEX	Eel Virus European X
FAO	Food and Agriculture Organisation
FEAP	The Federation of European Aquaculture Producers
GAM	Generalised Additive Model
GEM	German Eel Model
GFCM	General Fisheries Commission of the Mediterranean
GIS	Geographic Information Systems
GLM	Generalised Linear Model
GlobAng	French Model of Eel Population Dynamics
GST	Glutathione-S-transferase
HPS	Hydropower Station
ICES	International Council for the Exploration of the Sea
IMESE	Irish model for estimating silver eel escapement
IUCN	International Union for the Conservation of Nature
IUU	Illegal, Unreported and Unregulated fisheries
LAM	Lifetime anthropogenic mortalities
LHT	Life-history Trait

Acronyms	Definition
LVPA	Length-based Virtual Population Assessment
L50	L50 = the length (L) at which half (50%) of a fish species may be able to spawn
MS	Member State, typically used in reference to EU Member States but not only
MSY	Maximum Sustainable Yield
NAO	North Atlantic Oscillation
NA	Not applicable
NC	Not collected, code to explain an empty data value cell
ND	No data, code to explain an empty data value cell
NDF	Non-detriment Finding
NP	Not pertinent, code to explain an empty data value cell
NR	Not recorded, code to explain an empty data value cell
POSE	Pilot projects to estimate potential and actual escapement of silver eel (EU project)
RBD	River Basin District, typically as defined according to the EU Water Framework Directive
RGMAREEL	Workshop on Fisheries Related Impacts on Silver eels 2017
RG-TEMPP	Review of the Trans-border management plan for European eel, *Anguilla anguilla*, in the Polish-Russian zone of the Pregola River basin and Vistula Lagoon
RS_EMP	Review Service – Evaluation of Eel management Plans 2010
SAC	The GFCM Scientific and Advisory Committee on Fisheries
SCICOM	The Science Committee of ICES
SGAESAW	Study Group on anguillid eels in saline waters 2009
SGIPEE	Study Group on International Post-Evaluation on Eels 2010, 2011
SLIME	Restoration the European Eel population; pilot studies for a scientific framework in support of sustainable management (EU project)
SMEP II	Scenario-based Model for Eel Populations, vII (model applied in England and Wales, UK)
SPR	Estimate of spawner production per recruiting individual.
SQL	Special purpose programming language for managing data
SRG	Scientific Review Group of the European Commission
SSB	Spawning–Stock Biomass
STECF	Scientific, Technical and Economic Committee for Fisheries, European Commission
ToR	Terms of Reference

Acronyms	Definition
VPA	Virtual Population Analysis
WG	Working Group
WFD	Water Framework Directive, European Directive
WGEEL	Joint EIFAAC/ICES/GFCM Working Group on Eels
WKBALTEEL	Workshop on Baltic Eel 2010
WKBECEEL	Working Group on Biological Effects of Contaminants in Eel 2016
WKEELCITES	Workshop on Eel and CITES 2015
WKEELDATA	Workshop on Designing an Eel Data Call 2017
WKEELDATA2	Second Workshop on designing an Eel Data Call 2019
WKEELMIGRATION	Workshop on the Temporal Migration patterns of European Eels 2020
WKEMP	Workshop on Evaluating Management Plans 2018
WKEPEMP	The Workshop on Evaluating Progress with Eel Management Plans 2013
WKESDCF	Workshop on Eels and Salmon in the Data Collection Framework 2012
WKFEA	Workshop on the Future of Eel Advice 2021
WKLIFE	Workshop on the Development of Assessments based on LIFE-history traits and Exploitation Characteristics
WKPGMEQ	Workshop of a Planning Group on the Monitoring of Eel Quality under the subject “Development of standardized and harmonized protocols for the estimation of eel quality”
WKSTOCKEEL	Workshop on Eel Stocking 2016
WKTEEL	Workshop on Tools for Eel 2018
WGRFS	Working Group on Recreational Fisheries Surveys
YFS1	Young Fish Survey: North Sea Survey location
IYFS	International Young Fish Survey

Glossary

Anthropogenic	Caused by humans
Assisted migration	The practice of trapping and transporting juvenile eel within the same river catchment to assist their upstream migration at difficult or impassable barriers, without significantly altering the production potential (B_{best}) of the catchment
Bootlace, fingerling	Intermediate sized eels, approx. 10–25 cm in length. These terms are most often used in relation to restocking. The exact size of the eels may vary considerably. Thus, it is a confusing term.
Catch	The WGEEL uses the term catch(es) to mean fish that are caught but not necessarily landed. See landings below
Depensation	The effect on a population when a decrease in spawners leads to a faster decline in the number of offspring than in the number of adults.
Eel River Basin or Eel Management Unit	"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.
Escapement	The amount of eel that leaves (escapes) a waterbody, after taking account of all natural and anthropogenic losses. Most commonly used with reference to silver eel–silver eel escapement.
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 group, including some pigmented eel.
Index river	To be defined
Landings	The WGEEL uses the term Landings to mean fish that are brought ashore.
Leptocephalus	Flat and transparent marine larval stage of eel, on migration from spawning ground to continental waters, between pre-Leptocephalus and metamorphosis to glass eel
Lifestage	Defined stage in the life cycle of eel, whether leptocephalus, glass eel, yellow eel, or silver eel.
Limit reference point	A Limit Reference Point indicates a state of a fishery and/or a resource which is considered to be undesirable, and which management action should avoid.
Non-detriment finding (NDF)	In relation to CITES, the competent scientific authority has advised in writing that the capture or collection of the specimens in the wild or their export will not have a harmful effect on the conservation status of the species or on the extent of the territory occupied by the relevant population of the species.
On-grown eels	Eels that are grown in culture facilities for some time before being restocked. Whether the time is to meet quarantine requirements, for the receiving environment conditions to be suitable, or as part of the culture and grading purpose.
Pre-leptocephalus	First larval stage of eel, between hatching from ovum and leptocephalus
Production	The amount of fish produced from a waterbody. Sometimes referred to for silver eel in terms as escapement + anthropogenic losses, or production–anthropogenic losses = escapement.

Anthropogenic	**Caused by humans**
River Basin District (RBD)	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.
Restocking	The practice of adding fish [eels] to a waterbody from another source, to supplement existing populations or to create a population where none exists.
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. Silver eel undertake downstream migration towards the sea, and subsequently westwards. This phase mainly occurs in the second half of calendar years, although some are observed throughout winter and following spring.
Target reference point	A Target Reference Point indicates to a state of fishing and/or a resource which is considered to be desirable and at which management action, whether during development or stock rebuilding, should aim. FAO, 1995.
To silver (silvering)	Silvering is a requirement for downstream migration and reproduction. It marks the end of the growth phase and the onset of sexual maturation. This true metamorphosis involves a number of different physiological functions (osmoregulatory, reproductive), which prepare the eel for the long return trip to the Sargasso Sea. Unlike smoltification in salmonids, silvering of eels is largely unpredictable. It occurs at various ages (females: 4–20 years; males 2–15 years) and sizes (body length of females: 50–100 cm; males: 35– 6 cm) (Tesch, 2003).
Trap and Transport	Capturing downstream migrating silver eel for transportation around hydropower turbines
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 (‘elvers’ and bootlace).

Stock Reference Points and Data Call terms

Age	The age of eel in years., with part years as plus growth (e.g, 0+, 1+), starting at recruitment to coastal waters. Glass eel are defined as 0+
Aggregate habitat (AL)	Data Call term for aggregrated habitats where data are commined across habitat categories
A_{lim}	Limit anthropogenic mortality: Anthropogenic mortality, above which the capacity of self-renewal of the stock is considered to be endangered and conservation measures are requested (Cadima, 2003).
A_{pa}	Precautionary anthropogenic mortality: Anthropogenic mortality, above which the capacity of self-renewal of the stock is considered to be endangered, taking into consideration the uncertainty in the estimate of the current stock status.
Aquaculture production	The biomass of eel harvested in aquaculture during a time frame; e.g. a year.
Baltic region	The countries bordering the Baltic Sea; sometimes other countries in the catchment are also included.
bio_age	mean age
bio_g_in_gy	proportion (in %) of glass eel [100 for only glass eel ; 0 for only yellow eel; the proportion if mix of glass and yellow eel]
bio_length	mean length in mm
bio_sex_ratio	sex ratio express as a proportion of female; between 0 (all males) and 100 (all females)
bio_year	year during which biological samples where collected
bio_weight	mean individual weight in g
$B_{current}$ or B_{curr}	The Current escapement biomass: The amount of silver eel biomass that currently escapes to the sea to spawn, corressponding to the assessment year.
B_{best}	The amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the current stock, included re-stocking practices, hence only natural mortality operating on stock. The Best achievable escapement biomass under present conditions: escapement biomass corresponding to recent natural recruitment that would have survived if there was only natural mortality and no restocking, corressponding to the assessment year.
B_0	The amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the stock. Reference point for the theoretical maximum quantity of silver eel expressed as biomass that would have escaped from a defined eel producing area, in the absence of any anthropogenic impacts.
B_{lim}	Limit spawner escapement biomass, below which the capacity of self-renewal of the stock is considered to be endangered and conservation measures are requested (Cadima, 2003).
B_{MSY}	Spawning–stock biomass (SSB) that is associated with the Maximum Sustainable Yield.
$B_{MSY-trigger}$	Value of spawning–stock biomass (SSB) which triggers a specific management action, in particular: triggering a lower limit for mortality to achieve recovery of the stock.
B_{pa}	Precautionary spawner escapement biomass: The spawner escapement biomass, below which the capacity of self-renewal of the stock is considered to be endangered, taking into consideration the uncertainty in the estimate of the current stock status.

Commercial Fisheries	Fisheries with sale of catch for commercial gain.
Coastal waters	WFD coastal waters
das_comment	Comment (including comments about data quality for this year).
das_effort	Effort (if used)
das_value	Value
das_year	Year
Eel mannagement unit (EMU)	Eel management unit defined in an Eel Management plan under the Eel Regulation 1100/2007.
F	Fishing mortality rate
FAO areas	See http://www.fao.org/fishery/area/search/en
F_{lim}	F_{lim} is the fishing mortality which in the long term will result in an average stock size at B_{lim}.
F_{pa}	ICES applies a precautionary buffer F_{pa} to avoid that true fishing mortality is above F_{lim}.
F-rec	recreational fishing mortality, per reporting year, in kg
Fresh waters	Waters with zero salinity
F_{MSY}	F_{MSY} is estimated as the fishing mortality with a given fishing pattern and current environmental conditions that gives the long-term maximum yield.
G	Code in Data Call for data comprising Glass eel only as defined in Glossary
G+Y	Code in Data Call for data comprising a Glass eel with yellow eel mix
GEE-n	Glass eel equivalents in numbers – the quantity of eel expressed as equivalent number of glass eel. Method provided in ICES (2013) report p 103.
Glass eel recruitment series	Time-series enumerating glass eel recruiting from the sea into continental waters.
GLM	Generalized linear model (used by ICES to predict and fill in gaps in the data)
Habitat	Waters occupied by eel, whether fresh, transitional, coastal or marine
ICES statistical rectangles	See http://gis.ices.dk/sf/index.html?widget=StatRec
Inland waters	Fresh waters, not under the jurisdiction of Marine fisheries management (i.e. the CFP).
Landings from fisheries	Commercial landings include any eel taken from the water and landed on the market. Recreational landings include any eel taken from the water by recreational fisheries. Other landings include eel caught for assisted migration, translocation.
Length in mm	Total length measured from tip of nose to tip of tail (TL)
Longitude	x (longitude) EPSG:4326. WGS 84 (Google it)
Latitude	y (latitude) EPSG:4326. WGS 84 (Google it)
M	Natural Mortality

North Sea	For the purposes of ICES eel management, taken as ICES sea areas IV_a, IV_b, IV_c and inflowing fresh water systems
Marine waters	(Abbreviated MO) Open marine waters
q_aqua_kg	Aquaculture production (kg) in reporting year
q_aqua_n	Aquaculture production (number of eel) in reportng year
Fisheries - Recreational	Recreational (= non-commercial) fishing is the capture or attempted capture of living aquatic resources mainly for leisure and/or personal consumption.
Releases	Eel released to the wild after capture
R_{target}	The Geometric Mean of observed recruitment between 1960 and 1979, periods in which the stock was considered healthy.
R(s)	The amount of eel (<20 cm) restocked into national waters annually
S	Code in Data Call for data comprising Silver eel
Sea region (division)	ICES Sea area statisitical rectangle. Where required for freshwater eel habitats, is the sea area the River basin drains to.
SEE–n	Silver eel equivalents in numbers – the quantity of eel expressed as equivalent number of silver eel
SEE_com	Commercial fishery silver eel equivalents
SEE rec	Recreational fishery silver eel equivalents
SEE_hydro	Mortility in hydropower, pumps and water intakes, etc. expressed as Silver eel equivalents
SEE_habitat	Silver eel equivalents relating to anthropogenic influences on habitat (quantity/quality)
SEE_release	Silver eel equivalents relating to release activity
SEE_other	Silver eel equivalents from `other` sources
Silver eel abundance series	Time-series of abundance of silver eel determined by consistent regular count or survey (usually by capturing migrating silver eel)
ser_nameshort	short name of the recruitment series, this must be four letters + stage name, e.g. VilG, LiffGY, FremS, the first letter is capitalised and the stage name too.
ser_namelong	long name of the recuitment series eg `Vilaine estuary` for the Vilaine
ser_typ_id	type of series 1= recruitment series, 2 = yellow eel standing stock series, 3 silver eel series
ser_effort_uni_code	unit used for effort, it is different from the unit used in the series, for instance some of the Dutch series rely on the number hauls made to collect the glass eel to qualify the series, see units sheet.
ser_comment	This comment should at least include a short description of the methods, give an idea on the size of the eels and the proportion of glass eel, whether it is mixed (e.g. glass and yellow) or not, possible biases (e.g. by restocking) and a mention if the series is special in any way (e.g. very old/long) Note that this text will be displayed as a description of the series in the shiny app, thus consider the "readability".

ser_uni_code	Units used in the series, see tr_units_uni sheet
ser_lfs_code	Lifestage see tr_lifestage_lfs sheet
ser_hty_code	Habitat type see tr_habitattype_hty (F=Freshwater, MO=Marine Open,T=transitional, AL=aggregate...)
ser_locationdescription	This should provide a description of the site, e.g. if ist far inland, in the middle of a river, near a dam, etc. Also please specify the adjectant marine region (Baltic, North Sea), etc. (e.g. "Bresle river trap 3 km from the sea" or IYFS/IBTS sampling in the Skagerrak-Kattegat" Note that this text will be displayed as a description of the site in the shiny app, thus consier the "readability".
ser_emu_nameshort	The codes of the emu (emu_nameshort) in sheet tr_emu_emu. In case you provide data for each EMU separately then you don't need to fill in for AL and vice versa
ser_cou_code	The cou_code in the tr_country_cou table
ser_area_division	Fao code of sea region (division level) see tr_fao_area (column division)(https://github.com/ices-eg/WGEEL/wiki). These codes are for use only in the case of Coastal and Marine Open waters – otherwise you can leave it blank. ICES statistical rectangles (http://gis.ices.dk/sf/index.html?widget=StatRec) and FAO areas map (http://www.fao.org/fishery/area/search/en)
ser_tblcodeid	This should refer to the id of the series once inserted in ICES station table, currently void : ignore
ser_x	x (longitude) EPSG:4326. WGS 84
ser_y	y (latitude) EPSG:4326. WGS 84
ser_sam_id	The sampling type corresponds to trap partial, trap total, see tr_samplingtype_sam (sam_id)
Silver eel abundance series	Time-series of abundance of silver eel determined by consistent regular count or survey (usually by capturing migrating silver eel)
Skagerrak-Kattegat	For the purposes of ICES eel management, taken as ICES Sea areas III_b, III_c and inflowing fresh water systems
SPR	Spawner per recruit: estimate of spawner production per recruiting individual.
%SPR	Ratio of SPR as currently observed to SPR of the pristine stock, expressed in percentage. %SPR is also known as Spawner Potential Ratio.
Standing stock	The total stock of eel present in a waterbody at a point in time, expressed as a number of individuals or total biomass
sumA	total Anthropogenic mortality, per reporting year , in kg
sumF	total Fishing Mortality per reporting year, in kg
sumH	total non fishing Anthropogenic mortality, per reporting year in kg
sumF_com	Mortality due to commercial fishery, summed over age groups in the stock.
SumF_rec	Mortality due to recreational fishery, summed over age groups in the stock.
SumH_hydro	Mortality due to hydropower (plus water intakes, etc.) summed over the age groups in the stock (rate)

SumH_habitat	Mortality due to anthropogenic influence on habitat (quality/qauntity) summed over the age groups in the stock (rate)
SumH_other	Mortality due to other anthropogenic influence summed over the age groups in the stock (rate)
SumH_release	Mortality due to release summed over the age groups in the stock (rate: negative rate indicates positive effect of release)
Transitional waters	WFD transitional waters, implies reduced salinity
Transport/relocation operations	When eels have been collected somewhere in traps and transported to other places where they appear as “release” for the purposes of data recording
ΣF	The fishing mortality rate, summed over the age-groups in the stock.
ΣH	The anthropogenic mortality rate outside the fishery, summed over the age-groups in the stock.
ΣA	The sum of anthropogenic mortalities, i.e. ΣA = ΣF + ΣH.
Y	Code in Data Call for data comprising yellow eel only
Yellow eel abundance series	Time-series of abundance of yellow eel determined by consistent regular count or survey
Yellow eel recruitment series	Time-series enumerating yellow eel where this life stage is first observed at a site or is the stage at which eel enter freshwaters
Yellow eel standing stock series	Time-series of abundance of yellow eel determined by consistent regular count or survey
“3Bs and ΣA”	Refers to the three biomass indicators (B_0, B_{best} and $B_{current}$) and anthropogenic mortality rate (ΣA).
40% EU Target	From the Eel regulation (1100/2007): “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.

Annex 5: Meeting Agenda and Subgroups

Monday 21st September

09:00–10:15	Welcome, tour de table, reminder of ToR, adopting the agenda, declarations of potential Conflict of Interests, rules and procedures, etc.
10:15–10:45	Chair's report on activities in last year.
10:45–11:15	Report on WKEELMIGRATION (Alan Walker)
11:15–11:45	Update on WKFEA (Estibaliz Diaz)
11:45–12:00	Productivity scoring task (attached)
12:00–12:45	SG 1: Data call
12:45–13:30	Lunch
13:30–14:15	SG 2: Stock Annex
14:15–15:00	SG 3: Habitat loss and related issues
15:00–15:45	SG 4: Science and emerging threats
15:45-16:45	Presentation of six Country Reports (maximum of ten minutes per report)
16:45–17:30	All Task Groups breakout

Tuesday 22nd September

09:00–10:00	Presentations of six Country Reports (maximum ten minutes per country)
10:00–12:30	All Task Groups breakout
12:30–13:30	Lunch
13:30–14:00	Presentation of the Eel Regulation's evaluation, Katarzyna Janiak (DG MARE)
14:00–17:00	All task groups breakout
17:00–17:30	Plenary to review any urgent actions or discussion points

Wednesday 23rd September

09:00–10:00	Presentations of six Country Reports (maximum ten minutes per country)
10:00–12:30	All Task Groups breakout
12:30–13:30	Lunch
13:30–14:00	Update on CITES/CMS, Matthew Gollock
14:00–17:00	All task groups breakout
17:00–17:30	Plenary to review any urgent actions or discussion points

Thursday 24th September

09:00–09:30 Presentation of three Country Reports

09:30–11:00 All Task Groups break out

11:00–12:30 Discuss draft advice

12:30–13:30 Lunch

13:30–17:30 Task groups finalise and QA their report sections

17:30 Deadline for providing report sections to Jan-Dag for compilation

Friday 25th September

09:00–17:30 Reading

Saturday 26th September

10:00–12:30 Plenary to agree on the report

12:30–13:30 Lunch

13:30–18:00 Plenary to agree on the report

Sunday 27th September

Reading / Work over report sections / Whatever

Monday 28th September

09:00–13:00 Tying up loose ends, finalising the report and plans for 2020

13:00 **Close Working Group**

Annex 6: Country Reports 2019–2020: Eel stock, fisheries and habitat reported by country

In preparation for the Working Group, participants of each country have prepared a Country Report, in which the most recent information on eel stock and fishery is presented. These Country Reports aim at presenting the best information that does not necessarily coincide with the official status.

Participants from the following countries provided an updated report to the 2020 meeting of the Working Group on Eels:

- Belgium
- Denmark
- Estonia
- Finland
- Germany
- Greece
- Ireland
- Italy
- Latvia
- Lithuania
- Netherlands
- Norway
- Poland
- Portugal
- Spain
- Sweden
- Turkey
- The United Kingdom of Great Britain and Northern Ireland

For practical reasons, this report presents the Country Reports in electronic format only (URL).

Country Reports 2019/2020

Annex 7: Stock Annex

The table below provides an overview of the WGEEL Stock Annex. Stock Annexes for other stocks are available on the ICES website Library under the Publication Type “Stock Annexes”. Use the search facility to find a particular Stock Annex, refining your search in the left-hand column to include the *year*, *ecoregion*, *species,* and *acronym* of the relevant ICES expert group.

Stock ID	**Stock name**	**Last updated**	**Link**
Anguilla anguilla	European eel	September 2020	*Anguilla anguilla*

Annex 8: Additional tables and figures for chapter 3

Table 1. Short description of the sampling sites for European eel recruitment data. Area: NS = 'North Sea', EE = 'Elsewhere Europe'. First year and Last year indicate the first year and last year in the time-series, and the values given in the n+ and n- columns indicate the number of years with values (n+) and the number of years when there are missing data (n-) within the series. Life stage: GY = glass eel and young yellow eel, G = glass eel, Y = yellow eel. Unit for the data collected is given (*nr = number; index = calculated value following a specified protocol, nr/m² = number per square metre, nr/h = number per hour, kg/boat/d = kg per boat per day*). Habitat: C = coastal water (according to the EU Water Framework Directive, WFD), F = freshwater, MO = marine water (open sea), T = transitional water with lower salinity (according to WFD). *Kept: 0 = missing, 1 = good quality, 3 = not used due to poor quality, 4 = data are used, but there are warnings on its quality.*

code	area	min	max	n+	n-	life stage	sampling type	unit	habitat	kept
RingG	NS	1981	2020	40	0	G	sci. surv.	index	C	1
YFS1G	NS	1975	1989	15	0	G	sci. surv.	index	MO	1
YFS2G	NS	1991	2020	30	0	G	sci. surv.	index	MO	1
EmsG	NS	1946	2001	56	0	G	com. catch	kg	T	1
EmsHG	NS	2014	2019	6	0	G	trap	nr	T	0
WaSG	NS	2015	2020	6	0	G	sci. surv.	nr	T	0
KlitG	NS	2008	2020	13	0	G	sci. surv.	nr/m2	F	1
NorsG	NS	2008	2020	13	0	G	sci. surv.	nr/m2	F	1
SleG	NS	2008	2020	13	0	G	sci. surv.	nr/m2	F	1
VidaG	NS	1971	1990	20	0	G	com. catch	kg	T	1
KatwG	NS	1977	2020	44	5	G	sci. surv.	index	T	1
LauwG	NS	1976	2020	45	4	G	sci. surv.	nr/h	T	1
RhDOG	NS	1938	2020	83	1	G	sci. surv.	index	T	1
RhIjG	NS	1969	2020	52	5	G	sci. surv.	index	T	1
StelG	NS	1971	2020	50	0	G	sci. surv.	index	T	1
YserG	NS	1964	2020	57	1	G	sci. surv.	kg	T	1
BurrG	EE	1987	2020	34	18	G	trap	kg	F	1
MaigG	EE	1994	2018	25	4	G	trap	kg	F	1
BeeG	NS	2006	2020	15	0	G	trap	.	F	1
BroG	NS	2011	2020	10	0	G	trap	.	F	1
FlaG	NS	2007	2020	14	0	G	trap	.	F	1
SeEAG	EE	1972	2020	49	2	G	com. catch	t	T	1
SeHMG	EE	1979	2020	42	4	G	com. catch	t	T	3
ShiFG	EE	2017	2020	4	0	G	trap	nr	F	0
ShiMG	EE	2014	2020	7	0	G	trap	nr	T	0

code	area	min	max	n+	n-	life stage	sampling type	unit	habitat	kept
AdCPG	EE	1928	2008	81	40	G	com. cpue	kg/boat/d	T	1
AdTCG	EE	1986	2008	23	0	G	com. catch	t	T	1
GiCPG	EE	1961	2008	48	1	G	com. cpue	kg/boat/d	T	1
GiScG	EE	1992	2020	29	0	G	sci. surv.	index	T	1
GiTCG	EE	1923	2008	86	28	G	com. catch	t	T	1
LoiG	EE	1924	2008	85	6	G	com. catch	kg	T	1
SevNG	EE	1962	2008	47	25	G	com. cpue	kg/boat/d	T	1
VacG	EE	2004	2020	17	0	G	trap	nr	T	1
VilG	EE	1971	2015	45	3	G	trap	t	T	1
AlbuG	EE	1949	2020	72	5	G	com. catch	kg	T	1
AlCPG	EE	1982	2020	39	5	G	com. cpue	kg/boat/d	T	1
EbroG	EE	1966	2020	55	3	G	com. catch	kg	T	1
GuadG	EE	1998	2007	10	0	G	sci. surv.	index	T	1
MiSpG	EE	1975	2020	46	0	G	com. catch	kg	T	1
NaloG	EE	1953	2020	68	0	G	com. catch	kg	T	1
OriaG	EE	2006	2020	15	0	G	sci. surv.	nr/m3	T	1
MiPoG	EE	1974	2020	47	0	G	com. catch	kg	T	1
MiScG	EE	2018	2020	3	0	G	sci. surv.	nr/h	T	0
MondG	EE	1989	2020	32	28	G	sci. surv.	kg/d	T	0
TibeG	EE	1975	2006	32	0	G	com. catch	t	T	1

Table 1. Continued. Short description of the recruitment sites (continued: mixed glass and yellow eel series).

code	area	min	max	n+	n-	life stage	sampling type	unit	habitat	kept
ImsaGY	NS	1975	2020	46	0	GY	trap	nr	F	1
ViskGY	NS	1972	2019	48	0	GY	trap	kg	F	1
BrokGY	NS	2012	2020	9	0	GY	trap	nr	T	0
EmsBGY	NS	2013	2019	7	0	GY	trap	nr	F	0
FarpGY	NS	2007	2019	13	0	GY	trap	nr	F	3
HHKGY	NS	2010	2013	4	0	GY	trap	nr	T	0
HoSGY	NS	2010	2010	1	0	GY	trap	nr	T	0
LangGY	NS	2015	2020	6	0	GY	trap	nr	T	0
VerlGY	NS	2010	2020	11	0	GY	trap	nr	T	1
WiFG	NS	2006	2019	14	0	GY	trap	nr	T	1
WisWGY	NS	2004	2019	16	0	GY	trap	nr	F	1
HellGY	NS	2010	2020	11	0	GY	sci. surv.	nr	T	1
VeAmGY	NS	2017	2020	4	0	GY	trap	kg	T	0
ErneGY	EE	1959	2020	62	2	GY	trap	kg	F	1
FealGY	EE	1985	2018	34	14	GY	trap	kg	F	1
InagGY	EE	1996	2018	23	4	GY	trap	kg	F	1
LiffGY	EE	2012	2020	9	0	GY	trap	kg	F	0
ShaAGY	EE	1977	2020	44	0	GY	trap	kg	F	1
BannGY	EE	1933	2020	88	0	GY	trap	kg	F	1
BeeGY	NS	2019	2020	2	0	GY	trap	nr	F	0
BroE	NS	2011	2020	10	0	GY	trap	.	F	3
FlaE	NS	2007	2020	14	0	GY	trap	.	F	3
GreyGY	EE	2009	2020	12	0	GY	trap	nr	F	1
NmiGY	NS	2009	2020	12	0	GY	trap	nr	F	1
StraGY	EE	2012	2019	8	0	GY	trap	nr	F	0
BresGY	EE	1994	2020	27	0	GY	trap	nr	F	1
SousGY	EE	2013	2019	7	0	GY	trap	nr	F	0

Table1. Continued. Short description of the recruitment sites (yellow eel series).

code	area	min	max	n+	n-	life stage	sampling type	unit	habitat	kept
DalaY	NS	1951	2019	69	3	Y	trap	kg	F	1
GotaY	NS	1900	2020	121	12	Y	trap	kg	F	1
KavlY	NS	1992	2019	28	0	Y	trap	kg	F	1
LagaY	NS	1925	2019	95	0	Y	trap	kg	F	1
MorrY	NS	1960	2019	60	0	Y	trap	kg	F	1
MotaY	NS	1942	2019	78	0	Y	trap	kg	F	1
RonnY	NS	1946	2019	74	9	Y	trap	kg	F	1
DoElY	NS	2003	2019	17	0	Y	trap	nr	F	1
WaSEY	NS	2015	2020	6	0	Y	sci. surv.	nr	T	0
GudeY	NS	1980	2020	41	0	Y	trap	kg	F	1
HartY	NS	1967	2020	54	1	Y	trap	kg	F	1
MeusY	NS	1992	2020	29	3	Y	trap	nr	F	4
ShaPY	EE	1985	2020	36	0	Y	trap	kg	F	1
BeeY	NS	2019	2020	2	0	Y	trap	nr	F	0
BroY	NS	2011	2020	10	0	Y	trap	.	F	1
GirnY	NS	2008	2020	13	0	Y	trap	nr	F	1
MertY	NS	2012	2020	9	0	Y	trap	nr	F	0
MillY	NS	2012	2019	8	0	Y	trap	nr	F	0
MolY	NS	2005	2020	16	0	Y	trap	nr	F	1
OatY	EE	2013	2020	8	2	Y	trap	nr	F	0
RodY	NS	2005	2019	15	0	Y	trap	nr	F	1
FreY	EE	1997	2019	23	0	Y	trap	nr	F	1
MiSpY	EE	2019	2020	2	0	Y	trap	kg	F	0

Table 2. Series updated to 2020 (that were included in the analyses), though noting some may have been partial counts and therefore data are provisional. Codes for stages are G = glass eel, GY = glass eel + young yellow eel, Y = yellow eel, Area NS = 'North Sea', EE = 'Elsewhere Europe', Division = FAO marine division. Series ordered by stage and from North to South.

Site	Name	Coun.	Stage	Area	Division	Kept
RingG	Ringhals scientific survey	SE	G	NS	27.3.a	1
YFS2G	IYFS2 scientific estimate	SE	G	NS	27.3.a	1
SleG	Slette A	DK	G	NS	27.4.b	1
KlitG	Klitmoeller A	DK	G	NS	27.3.a	1
NorsG	Nors A	DK	G	NS	27.3.a	1
LauwG	Lauwersoog scientific estimate	NL	G	NS	27.4.b	1
RhDOG	Rhine DenOever scientific estimate	NL	G	NS	27.4.c	1
RhIjG	Rhine Ijmuiden scientific estimate	NL	G	NS	27.4.c	1
KatwG	Katwijk scientific estimate	NL	G	NS	27.4.c	1
StelG	Stellendam scientific estimate	NL	G	NS	27.4.c	1
YserG	Ijzer Nieuwpoort scientific estimate	BE	G	NS	27.4.c	1
BurrG	Burrishoole	IE	G	EE	27.7.b	1
BroG	Brownshill_Glass_<80mm	GB	G	NS	27.4.c	1
SeEAG	Severn EA commercial catch	GB	G	EE	27.7.f	1
BeeG	Beeleigh_Glass_<80mm	GB	G	NS	27.4.c	1
FlaG	Flatford_GE_<80mm	GB	G	NS	27.4.c	1
GiScG	Gironde scientific estimate	FR	G	EE	27.8.b	1
VacG	Vaccares	FR	G	EE	37.1.2	1
AlCPG	Albufera de Valencia commercial CPUE	ES	G	EE	37.1.1	1
MiSpG	Minho spanish part commercial catch	ES	G	EE	27.9.a	1
AlbuG	Albufera de Valencia commercial catch	ES	G	EE	37.1.1	1
NaloG	Nalon Estuary commercial catch	ES	G	EE	27.8.c	1
EbroG	Ebro delta lagoons	ES	G	EE	37.1.1	1
OriaG	Oria scientific monitoring	ES	G	EE	27.8.b	1
MiPoG	Minho portugese part commercial catch	PT	G	EE	27.9.a	1
ImsaGY	Imsa Near Sandnes trapping all	NO	GY	NS	27.4.a	1
VerlGY	Verlath Pumping Station	DE	GY	NS	27.4.b	1

Site	Name	Coun.	Stage	Area	Division	Kept
HellGY	Hellebaekken	DK	GY	NS	27.3.a	1
ErneGY	Erne Ballyshannon trapping all	IE	GY	EE	27.7.b	1
ShaAGY	Shannon Ardnacrusha trapping all	IE	GY	EE	27.7.b	1
GreyGY	Greylakes_Elvers (<120mm)	GB	GY	EE	27.7.f	1
BannGY	Bann Coleraine trapping partial	GB	GY	EE	27.6.a	1
NmiGY	New Mills Elvers/Yellow (>120mm)	GB	GY	NS	27.4.c	1
BresGY	Bresle	FR	GY	EE	27.7.d	1
GotaY	Gota Alv trapping all	SE	Y	NS	27.3.a	1
GudeY	Guden A Tange trapping all	DK	Y	NS	27.3.a	1
HartY	Harte trapping all	DK	Y	NS	27.3.b, c	1
ShaPY	Shannon Parteen trapping partial	IE	Y	EE	27.7.b	1
GirnY	Girnock Burn trap scientific estimate	GB	Y	NS	27.4.b	1
MolY	Thames-Molesey weir	GB	Y	NS	27.4.c	1
BroY	Brownshill_Yellow_>120 mm	GB	Y	NS	27.4.c	1

Table 3. Series updated to 2019 see Table 3.1 for codes. Series ordered from north to south.

Site	Name	Coun.	Stage	Area	Division
ViskGY	Viskan trapping all	SE	GY	NS	27.3.a
WiFG	Frische Grube	DE	GY	NS	27.3.b, c
WisWGY	Wallensteingraben	DE	GY	NS	27.3.b, c
KavlY	Kavlingean trapping all	SE	Y	NS	27.3.b, c
DalaY	Dalalven trapping all	SE	Y	NS	27.3.d
MotaY	Motala Strom trapping all	SE	Y	NS	27.3.d
MorrY	Morrumsan trapping all	SE	Y	NS	27.3.d
RonnY	Ronne A trapping all	SE	Y	NS	27.3.a
LagaY	Lagan trapping all	SE	Y	NS	27.3.a
DoElY	Dove Elde eel ladder	DE	Y	NS	27.4.b
RodY	Thames - Roding	GB	Y	NS	27.4.c
FreY	Fremur	FR	Y	EE	27.7.e

Table 4. Series stopped or not updated to 2019, see Table 3.1 for codes. Series ordered by last year.

Site	Name	Coun.	Stage	Area	Division	Last Year
YFS1G	IYFS scientific estimate	SE	G	NS	27.3.a	1989
VidaG	Vidaa Hojer sluice commercial catch	DK	G	NS	27.4.b	1990
EmsG	Ems Herbrum commercial catch	DE	G	NS	27.4.b	2001
TibeG	Tiber Fiumara Grande commercial catch	IT	G	EE	37.1.3	2006
GuadG	Guadalquivir scientific monitoring	ES	G	EE	27.9.a	2007
AdCPG	Adour Estuary (CPUE) commercial CPUE	FR	G	EE	27.8.b	2008
AdTCG	Adour Estuary (catch) commercial catch	FR	G	EE	27.8.b	2008
GiCPG	Gironde Estuary (CPUE) commercial CPUE	FR	G	EE	27.8.b	2008
GiTCG	Gironde Estuary (catch) commercial catch	FR	G	EE	27.8.b	2008
LoiG	Loire Estuary commercial catch	FR	G	EE	27.8.a	2008
SevNG	Sevres Niortaise Estuary commercial CPUE	FR	G	EE	27.8.a	2008
VilG	Vilaine Arzal trapping all	FR	G	EE	27.8.a	2015
FealGY	River Feale	IE	GY	EE	27.7.j	2018
InagGY	River Inagh	IE	GY	EE	27.7.b	2018
MaigG	River Maigue	IE	G	EE	27.7.b	2018

Table 5. Individual datapoints for 2020 and 2019 that are excluded from the analyses. Stages: G = glass eel, GY = glass eel + yellow eel, Y = yellow eel; Division = FAO marine division. Kept: 0 = missing; 3 = not used due to poor quality; 4 = data are used, but there are warnings on its quality.

Name	Stage	Country	Division	Year	Kept	Comment
BroG	G	GB	27.4.c	2019	4	In 2019 the trap was not running continuously throughout the year- this will therefore be an underestimate.
SeHMG	G	GB	27.7.f	2019	4	Provisional data- outstanding query
BeeG	G	GB	27.4.c	2020	4	Provisional data as of June 2020.
BroG	G	GB	27.4.c	2020	4	Provisional data as of June 2020.
BurrG	G	IE	27.7.b	2020	4	Date 27 July: Still trapping.
FlaG	G	GB	27.4.c	2020	4	Provisional data as of 25/07/2020.
GiScG	G	FR	27.8.b	2020	4	provisional data, Since 2020 a new method was used to calculate the index
NaloG	G	ES	27.8.c	2020	4	In March (allowed from 20 to 27) only a few fishermen were active because of the reduced price of glass eel due to the COVID-19.
SeEAG	G	GB	27.7.f	2020	0	Not yet available due to COVID-19 office access limitations.
SeHMG	G	GB	27.7.f	2020	4	Note that UK trade of glass eel has been impacted by COVID-19- elver station closure within season will have impacted upon effort
ShiFG	G	GB	27.6.a	2020	0	COVID-19 prevented collection
VacG	G	FR	37.1.2	2020	4	due to COVID-19, the glass eel monitoring was stop since mid-march then one month of monitoring was not made at the end of the migration period
WaSG	G	DE	27.3.d	2020	4	provisional data from February (19th) to August (20th)
YserG	G	BE	27.4.c	2020	3	Monitoring started on 3 February and stopped on 5 March. On 6 March there was a malfunction at the sluice, after that water level was too high to perform the monitoring and on 19 March monitoring was not allowed any more due to COVID-19.
BroE	GY	GB	27.4.c	2019	4	In 2019 the trap was not running continuously throughout the year- this will therefore be an underestimate.
GreyGY	GY	GB	27.7.f	2019	4	In 2019 the camera trap was not running continuously throughout the year- this will therefore be an underestimate.
SousGY	GY	FR	27.8.b	2019	4	provisional data
WiFG	GY	DE	27.3.b, c	2019	4	data only from April to July due to pump damage
WisWGY	GY	DE	27.3.b, c	2019	4	data only from April to June due to low water

Name	Stage	Country	Division	Year	Kept	Comment
BeeGY	GY	GB	27.4.c	2020	4	Provisional data as of June 2020. Two weeks at the start of the run- end of March/early April monitoring impacted by COVID-19 trap not monitored within this period.
BresGY	GY	FR	27.7.d	2020	4	provisional data, last update 11/07/2020
BroE	GY	GB	27.4.c	2020	4	Provisional data as of June 2020. Two weeks at the start of the run- end of March/early April monitoring impacted by COVID-19- trap not monitored within this period.
BrokGY	GY	DE	27.4.b	2020	4	Provisional figure, 07/08/2020
FlaE	GY	GB	27.4.c	2020	4	Provisional data as of 25/07/2020.
GreyGY	GY	GB	27.7.f	2020	4	Provisional data as of June 2020. Monitoring impacted by COVID-19- monitoring did not start until 19th May 2020 so is a significant underestimate missing the early part of the migration window.
LangGY	GY	DE	27.4.b	2020	4	Provisional figure, 07/08/2020
LiffGY	GY	IE	27.7.a	2020	4	Date 27 July - still trapping.
NmiGY	GY	GB	27.4.c	2020	4	Partial count for 2020 (until 19/07/2020).
VeAmGY	GY	BE	27.4.c	2020	3	Monitoring started on 3 March and stopped on 19 March. Since 19 March monitoring was not allowed any more due to COVID-19.
VerlGY	GY	DE	27.4.b	2020	4	Provisional figure, 07/08/2020
BroY	Y	GB	27.4.c	2019	4	In 2019 the trap was not running continuously throughout the year- this will therefore be an underestimate.
FreY	Y	FR	27.7.e	2019	4	source F. Charrier report Fremur 2019, the low numbers observed throughout the year can be explained by the installation of a new trap at Pont-Avet (downstream), which short-circuited the ascents to Bois Joli. (7247 counted at pont avet)
GotaY	Y	SE	27.3.a	2019	0	No data as the eel pass was not opened this year
MorrY	Y	SE	27.3.d	2019	0	This eel pass is not running in 2019
RonnY	Y	SE	27.3.a	2019	0	This eel pass and series is now formally closed
WaSEY	Y	DE	27.3.d	2019	4	regular monitoring from April to October
BeeY	Y	GB	27.4.c	2020	4	Provisional data as of June 2020. Two weeks at the start of the run- end of March/early April monitoring impacted by COVID-19- trap not monitored within this period.
BroY	Y	GB	27.4.c	2020	4	Provisional data as of June 2020
GotaY	Y	SE	27.3.a	2020	0	This eel pass is not running
MertY	Y	GB	27.4.c	2020	4	Provisional count as of July 2020

Name	Stage	Country	Division	Year	Kept	Comment
MeusY	Y	BE	27.4.c	2020	3	In 2020 up to 17 August, 84 eels were caught (biomass 2352.2 g). Sizes of eels caught ranged from 12.4 cm to 67.3 cm (median 22.8 cm). Maximum CPUE was 40 individuals per day. This observed number of eels caught has been impacted by the COVID-19 pandemic and includes both wild and restocked eels.
MiSpY	Y	ES	27.9.a	2020	4	Provisional data
MolY	Y	GB	27.4.c	2020	4	Provisional count as of June 2020
OatY	Y	GB	27.7.f	2020	4	Partial count for 2020 (until end of June 2020).
WaSEY	Y	DE	27.3.d	2020	4	provisional data from February (19th) to August (20th)

Table 6a. Short description of the sampling sites for European eel yellow and silver eel standing stock data. First year and Last year indicate the first year and last year in the time-series, and the values given in the n+ and n- columns indicate the number of years with values (n+) and the number of years when there are missing data (n-) within the series. Life stage: Y = yellow eel standing stock, S = silver. Sampling gear were inferred from comments made by data providers in their answers to the Data Call, more precise information will be collected next year .Unit for the data collected is given (*nr = number; index = calculated value following a specified protocol, nr/m² = number per square metre, nr/h = number per hour, kg/boat/d = kg per boat per day*). Habitat: C = coastal water (according to the EU Water Framework Directive, WFD), F = freshwater, MO = marine water (open sea), T = transitional water with lower salinity (according to WFD). *Kept short and kept long indicate whether the series was used (0) or not (1) for short-term trend and long-term trends analyses.*

code	country	first year	last year	n+	n-	life stage	sampling gear	unit	habitat	kept short	kept long
WarS	DE	2009	2019	11	0	S	stow net	nr	F	1	1
RibS	DK	2001	2017	17	0	S	net	kg/ha	F	1	1
AlCS	ES	1951	2020	65	5	S	net	kg	T	1	1
BreS	FR	1982	2020	34	5	S	trap	nr	F	1	1
FreS	FR	1996	2019	24	0	S	trap	nr	F	1	1
LoiS	FR	1987	2019	33	0	S	stow net	index	F	1	1
SeNS	FR	2013	2019	7	0	S	trap	nr	F	0	0
SouS	FR	2011	2018	8	0	S	trap	nr	F	0	0
VilS	FR	2013	2019	6	1	S	counter	nr	F	0	0
BaBS	GB	2006	2019	14	0	S	trap	nr	F	1	1
FowS	GB	2010	2016	6	1	S	counter	nr	F	0	0
GiBS	GB	1966	2019	31	23	S	trap	nr	F	1	1
LevS	GB	2000	2019	19	1	S	counter	nr	F	1	1
ShiS	GB	1999	2019	17	4	S	trap	nr	F	1	1
StrS	GB	2016	2019	4	0	S	trap	nr	F	0	0
EamtS	GR	2009	2019	9	2	S	trap	kg	T	0	0
NorwS	GR	2012	2017	5	1	S	trap	kg	T	0	0
WepeS	GR	2015	2015	1	0	S	trap	kg	T	0	0
BurS	IE	1971	2019	48	1	S	trap	nr	F	1	1
KilS	IE	2000	2019	20	0	S	net	kg	F	1	1
AlauS	LT	2019	2019	1	0	S	trap	nr	F	0	0
ClS	LT	2018	2019	2	0	S		nr	T	0	0
KertS	LT	2019	2019	1	0	S	trap	nr	F	0	0
LakS	LT	2019	2019	1	0	S	trap	nr	F	0	0

code	coun-try	first year	last year	n+	n-	life stage	sampling gear	unit	habi-tat	kept short	kept long
SiesS	LT	2019	2019	1	0	S	trap	nr	F	0	0
DaugS	LV	2015	2019	5	0	S	fykenet	nr	F	0	0
LilS	LV	2017	2019	3	0	S	fykenet	nr	F	0	0
BRWS	NL	2013	2019	6	1	S	fykenet	index	F	0	0
HVWS	NL	2012	2019	7	1	S	fykenet	index	F	0	0
IjsS	NL	2012	2019	8	0	S	fykenet	index	F	0	0
NiWS	NL	2012	2019	8	0	S	fykenet	index	F	0	0
NZKS	NL	2012	2019	7	1	S	fykenet	index	F	0	0
ZMaS	NL	2012	2019	6	2	S	fykenet	index	F	0	0
ImsaS	NO	1975	2019	45	0	S	trap	nr	F	1	1
MinS	PT	2018	2019	2	0	S	electrofish-ing	nr/m2	F	0	0
MonS	PT	2017	2019	3	0	S	electrofish-ing	nr/m2	F	0	0
NkaS	SE	1979	2018	40	0	S	fykenet	index	C	1	1
SosS	SE	1974	2017	41	3	S	fykenet	nr	C	1	1
BI1S		1991	2011	16	5	S	bottom trawl	index		0	1
BI4S		1991	2010	20	0	S	bottom trawl	index		1	1
NSIS		1988	2011	22	2	S	bottom trawl	index		1	1
PanS		1984	2005	16	6	S	bottom trawl	index		0	1
DoFpY	DE	2003	2019	16	1	Y	trap	nr	F	1	1
VVeY	DK	2009	2020	12	0	Y	electrofish-ing	nr/m2	F	1	1
OriY	ES	2004	2019	16	0	Y	electrofish-ing	nr/m2	F	1	1
AdoY	FR	2010	2019	10	0	Y	electrofish-ing	index	F	1	1
BreY	FR	2012	2019	8	0	Y	electrofish-ing	index	F	0	0
FremY	FR	1995	2019	25	0	Y	electrofish-ing	nr/m2	F	1	1

code	coun-try	first year	last year	n+	n-	life stage	sampling gear	unit	habi-tat	kept short	kept long
GarY	FR	2010	2018	9	0	Y	electrofish-ing	nr/m2	F	0	0
OrnY	FR	2010	2019	10	0	Y	electrofish-ing	index	F	1	1
SciY	FR	2010	2019	9	1	Y	electrofish-ing	index	F	0	0
SeiY	FR	2010	2019	10	0	Y	electrofish-ing	index	F	1	1
SeNY	FR	2002	2019	18	0	Y	electrofish-ing	index	F	1	1
SouY	FR	2010	2019	10	0	Y	electrofish-ing	index	F	1	1
TouY	FR	2011	2019	6	3	Y	electrofish-ing	index	F	0	0
VilY	FR	1998	2018	16	5	Y	electrofish-ing	nr/m2	F	1	1
VirY	FR	2010	2019	10	0	Y	electrofish-ing	index	F	1	1
YerY	FR	2010	2019	9	1	Y	electrofish-ing	index	F	0	0
BadY	GB	2009	2019	11	0	Y	electrofish-ing	nr/m2	F	1	1
BelY	GB	1992	2018	9	18	Y	electrofish-ing	nr/m2	F	0	0
BoEY	GB	1985	2019	21	14	Y	electrofish-ing	nr/m2	F	1	1
ChBY	GB	1983	2019	31	6	Y	electrofish-ing/net	nr/m2	F	1	1
CoqY	GB	1993	2019	22	5	Y	electrofish-ing	nr/m2	F	0	0
DeeY	GB	2002	2019	12	6	Y	net	nr/m2	F	1	1
DerY	GB	1991	2019	21	8	Y	electrofish-ing	nr/m2	F	1	1
DoSY	GB	2001	2019	19	0	Y	electrofish-ing	nr/m2	F	0	0
EdeY	GB	1975	2019	23	22	Y	electrofish-ing	nr/m2	F	1	1
EllY	GB	2005	2018	8	6	Y	electrofish-ing	nr/m2	F	0	0

code	country	first year	last year	n+	n-	life stage	sampling gear	unit	habitat	kept short	kept long
ExeY	GB	1995	2019	24	1	Y	electrofishing	nr/m2	F	0	0
FowY	GB	1977	2019	33	10	Y	electrofishing	nr/m2	F	1	1
FroY	GB	2003	2019	16	1	Y	electrofishing	nr/m2	F	1	1
GirY	GB	2009	2019	11	0	Y	electrofishing	nr/m2	F	1	1
GrOY	GB	1986	2019	33	1	Y	electrofishing/net	nr/m2	F	1	1
HaAY	GB	2002	2019	18	0	Y	electrofishing	nr/m2	F	1	1
HumY	GB	1981	2019	39	0	Y	electrofishing	nr/m2	F	1	1
ItcY	GB	2001	2019	18	1	Y	electrofishing	nr/m2	F	0	0
KilY	GB	2017	2017	1	0	Y	fykenet	nr	F	0	0
LagY	GB	2011	2011	1	0	Y	fykenet	nr	F	0	0
LeeY	GB	1987	2019	21	12	Y	electrofishing	nr/m2	F	1	1
MedY	GB	1993	2019	24	3	Y	electrofishing	nr/m2	F	0	0
MerY	GB	1994	2019	20	6	Y	electrofishing	nr/m2	F	0	0
NenY	GB	1979	2018	27	13	Y	electrofishing	nr/m2	F	1	0
OttY	GB	1998	2019	15	7	Y	electrofishing	nr/m2	F	1	0
OusY	GB	1998	2019	20	2	Y	electrofishing	nr/m2	F	1	1
ParY	GB	1990	2019	25	5	Y	electrofishing	nr/m2	F	1	1
PlyY	GB	1982	2019	24	14	Y	electrofishing	nr/m2	F	1	1
RibY	GB	1984	2019	34	2	Y	electrofishing	nr/m2	F	1	0
SevY	GB	1976	2019	43	1	Y	electrofishing	nr/m2	F	1	1

code	country	first year	last year	n+	n-	life stage	sampling gear	unit	habitat	kept short	kept long
ShiY	GB	2010	2019	10	0	Y	electrofishing	nr/m2	F	1	1
SuSY	GB	1980	2019	32	8	Y	electrofishing	nr/m2	F	1	1
TamY	GB	1984	2019	29	7	Y	electrofishing	nr/m2	F	1	0
TawY	GB	1996	2019	20	4	Y	electrofishing	nr/m2	F	0	0
TefY	GB	2010	2019	10	0	Y	net	nr/m2	F	1	1
TegY	GB	1996	2019	19	5	Y	electrofishing	nr/m2	F	0	0
TesY	GB	2001	2019	19	0	Y	electrofishing	nr/m2	F	0	0
ThaY	GB	1985	2019	35	0	Y	electrofishing	nr/m2	F	1	1
TweY	GB	2009	2019	4	7	Y	electrofishing	nr/m2	F	0	0
TyTY	GB	2010	2019	10	0	Y	net	nr/m2	F	1	1
UskY	GB	2010	2019	10	0	Y	electrofishing	nr/m2	F	1	1
WelY	GB	1982	2019	31	7	Y	electrofishing	nr/m2	F	1	1
WenY	GB	1986	2019	27	7	Y	electrofishing	nr/m2	F	1	1
WerY	GB	1995	2019	21	4	Y	electrofishing	nr/m2	F	0	0
WevY	GB	1994	2018	19	6	Y	electrofishing/net	nr/m2	F	0	0
WitY	GB	1985	2019	33	2	Y	electrofishing	nr/m2	F	1	1
WyeY	GB	1985	2019	32	3	Y	electrofishing	nr/m2	F	0	0
VistY	GR	2019	2019	1	0	Y	fykenet	kg	F	0	0
BFeY	IE	1973	2019	18	29	Y	fykenet	nr/net/day	F	1	1
BFuY	IE	1987	2019	15	18	Y	fykenet	nr/net/day	T	1	1
BLFY	IE	1987	2019	12	21	Y	fykenet	nr/net/day	T	1	1
BuBY	IE	1987	2019	16	17	Y	fykenet	nr/net/day	F	1	1

code	coun-try	first year	last year	n+	n-	life stage	sampling gear	unit	habi-tat	kept short	kept long
LoEY	IE	2011	2018	4	4	Y	fykenet	index	F	0	0
ClY	LT	2019	2019	1	0	Y	trap	nr	T	0	0
KreY	LT	2019	2019	1	0	Y	longline	nr	F	0	0
UkoY	LT	2019	2019	1	0	Y	longline	nr	F	0	0
DaugY	LV	2015	2019	5	0	Y	fykenet	nr	F	0	0
LilY	LV	2017	2019	3	0	Y	fykenet	nr	F	0	0
DeBY	NL	1960	2019	60	0	Y	net	index		1	1
IJsFRY	NL	2007	2019	13	0	Y	electrofish-ing	index	F	1	1
IJsFVY	NL	2007	2019	13	0	Y	electrofish-ing	index	F	1	1
IjsY	NL	1989	2019	31	0	Y	electrofish-ing beamtrawl	nr/m2	F	1	1
MarY	NL	1989	2019	31	0	Y	electrofish-ing beamtrawl	nr/m2	F	1	1
MmFRY	NL	2007	2019	13	0	Y	electrofish-ing	index	F	1	1
MmFVY	NL	2007	2019	13	0	Y	electrofish-ing	index	F	1	1
SkaY	NO	1925	2018	89	5	Y	beach seine	nr/haul	C	1	1
VisY	PL	2017	2019	3	0	Y	fykenet	nr	T	0	0
MinY	PT	2018	2019	2	0	Y	electrofish-ing	nr/m2	F	0	0
MonY	PT	2017	2019	3	0	Y	electrofish-ing	nr/m2	F	0	0
BarY	SE	1977	2019	41	2	Y	fykenet	nr	MO	1	1
FjaY	SE	1998	2019	21	1	Y	fykenet	nr	MO	1	1
HakY	SE	2002	2019	18	0	Y	fykenet	nr	MO	1	1
KulY	SE	2002	2012	11	0	Y	fykenet	nr	MO	1	1
LysY	SE	2002	2005	4	0	Y	fykenet	nr	MO	0	0
VenY	SE	1976	2019	42	2	Y	fykenet	nr	MO	1	1

Table 6b. Glass eel commercial fisheries landings (in tonnes) from 1984 to 2020, reported by countries: United Kingdom, France, Spain, Portugal, Italy.

Year	UK	France	Spain	Portugal	Italy	sum
1945			119			119
1946			72			72
1947			100			100
1948			111			111
1949			9			9
1950			4			4
1951			2			2
1952			0			0
1953			3			3
1954			6			6
1955			0.906			0.906
1956			0.884			0.884
1957			3			3
1958			0.402			0.402
1959			7			7
1960			9			9
1961			17			17
1962			11			11
1963			8			8
1964			11			11
1965			4			4
1966			6			6
1967			5			5
1968			4			4
1969			4			4
1970			5			5
1971			1			1
1972	17		1			18

Year	UK	France	Spain	Portugal	Italy	sum
1973	28		1			29
1974	58		2	2		62
1975	10		3	6		19
1976	13		12	13		38
1977	39		18	23		80
1978	61	1393	22	7		1483
1979	67	1850	17	18		1952
1980	40	1491	15	20		1566
1981	37	890	13	36		976
1982	48	866	19	44		977
1983	17	791	10	13		831
1984	25	528	16	32		601
1985	20	444	18	30		512
1986	19	423	6	14		462
1987	21	461	9	19		510
1988	21	504	10	5		540
1989	21	410	10	6		447
1990	21	325	5	9		360
1991	1	179	7	6		193
1992	5	183	4	9		201
1993	6	329	5	7		347
1994	10	329	2	6		347
1995	12	413	5	11		441
1996	19	262	15	17		313
1997	9	287	12	9		317
1998	11	195	14	9		229
1999	0	242	14	7		263
2000	0	206	11	6		223
2001	0.809	101	12	2		115.809

Year	UK	France	Spain	Portugal	Italy	sum
2002	0.521	202	9	2		214.521
2003	2	151	10	3		169
2004	0.97	89	5	2		105.97
2005	2	89	6	2		108
2006	1	67	4	5		84
2007	2	77	5	2		92
2008	0.817	79	5	2		93.817
2009	0.291		4	3		9.291
2010	1	41	6	5		53
2011	2	31	5	2		40
2012	3	34	5	2		44
2013	6	34	7	2		49
2014	12	35	11	2	0.425	60.425
2015	3	36	9	3	0.159	51.159
2016	4	46	7	0.856	0.06	57.916
2017	3	43	11	4	0.146	61.146
2018	4	53	5	1	0.243	63.243
2019*	6	49	4	0.587	0.243	59.83
2020*		48	6	0.891		54.891

*** Data for 2019 and 2020 incomplete.**

0 = No catch.

Empty cell = No information or Not collected or Not pertinent.

Table 7a. European eel. Official commercial landings (tonnes) of yellow and silver eel (1960–2020) in Norway (NO), Sweden (SE), Finland (FI), Estonia (EE), Latvia (LV), Lithuania (LT), Poland (PL), Germany (DE), Denmark (DK), Netherlands (NL), Belgium(BE), combining information from the 2020 Data call and the WGEEL database (other countries in Table 6b). German data after 2016 are incomplete.

Year	NO	SE	FI	EE	LV	LT	PL	DE	DK	NL	BE
1908	268										
1909	327										
1910	303										
1911	384										
1912	187										
1913	213										
1914	282	1461									
1915	143	997									
1916	117	1078									
1917	44	1284									
1918	35	884									
1919	64	1145									
1920	80	970							3413		
1921	79	1072							3443		
1922	94	926							3760		
1923	140	948							3396		
1924	290	1201							4130		
1925	325	1714							4880		
1926	341	1707							4726		
1927	354	2011							4648		
1928	325	1040							4117		
1929	425	1394							4375		
1930	450	1529							4773		
1931	329	1795							4195		
1932	518	1589							5088		
1933	694	1494							5014		
1934	674	1769							5171		
1935	564	1951							4316		
1936	631	1654							4332		

Year	NO	SE	FI	EE	LV	LT	PL	DE	DK	NL	BE
1937	603	1725							4329		
1938	526	1871							3849		
1939	434	1774							4662		
1940	143	1626							3709		
1941	174	1822							3717		
1942	131	1226							3140		
1943	136	1828							3917		
1944	150	2320							4245		
1945	102	1906							4169	2668	
1946	167	1745							4269	3492	
1947	268	2347			10	8			4784	4502	
1948	293	2212			10	14			4386	4799	
1949	214	2329			50	21			4492	3873	
1950	282	2628			10	29			4500	4152	
Year	NO	SE	FI	EE	LV	LT	PL	DE	DK	NL	BE
1951	312	2311			10	32			4400	3661	
1952	178	1848			10	39			3900	3978	
1953	371	2756			20	80			4300	3157	
1954	327	2459			20	147	609		3800	2085	
1955	451	3338			40	163	732		4800	1651	
1956	293	1702			20	131	656		3700	1817	
1957	430	2494			20	168	616		3600	2509	
1958	437	2024			20	149	635		3300	2674	
1959	409	3522			24	155	566		4000	3413	
1960	430	1905			37	165	733		4937	2999	
1961	449	2387			43	139	640		4110	2452	
1962	356	2171			41	155	663		4122	1443	
1963	503	2334			56	260	762		4166	1618	
1964	440	2612		3	37	225	884		3505	2068	
1965	523	2051		0.3	35	125	682		3402	2268	
1966	510	2219		2	33	238	804		3901	2339	

Year	NO	SE	FI	EE	LV	LT	PL	DE	DK	NL	BE
1967	491	1835		3	39	153	906		3679	2524	
1968	569	2052		3	28	165	943		4476	2209	
1969	522	1922		49	36	134	935		3878	2389	
1970	422	1209		62	29	118	847		3558	1111	
1971	415	1391		60	29	124	722		3378	853	
1972	422	1204		73	25	126	696		3429	857	
1973	409	1212		69	27	120	645		3656	823	
1974	368	1034		51	20	86	691		2977	840	
1975	407	1391		82	19	114	810		3485	1000	
1976	386	935		72	24	88	761		3054	1172	
1977	352	989		66	16	68	868		2502	783	
1978	347	1076		63	18	70	910		2492	719	
1979	374	954		28	21	57	979		1904	530	
1980	387	1112		26	9	45	1214		2288	664	
1981	369	887		22	10	27	944		2227	722	
1982	385	1161		14	12	28	911		2541	842	
1983	324	1212		29	9	23	868		2119	937	
1984	310	963		72	12	27	819		1871	691	
1985	352	1029		75	18	29	1022	1097	1630	679	
1986	272	829		61	19	32	921	1119	1672	721	
1987	282	700		67	25	20	887	1031	1279	538	
1988	513	933		110	15	23	943	1018	1878	425	
1989	313	903		55	13	21	813	964	1696	526	
1990	336	918		61	13	19	768	830	1675	472	
1991	323	1060		52	14	16	670	725	1465	573	
1992	372	1154		39	17	12	638	762	1451	548	
1993	340	1121		59	19	10	568	790	1080	293	
1994	472	1265		47	19	12	635	833	1200	330	
1995	454	950		45	38	9	642	778	892	354	
1996	353	1053		55	24	9	629	603	752	300	
Year	NO	SE	FI	EE	LV	LT	PL	DE	DK	NL	BE

Year	NO	SE	FI	EE	LV	LT	PL	DE	DK	NL	BE
1997	467	1065		59	25	11	526	616	797	285	
1998	331	646		44	30	17	544	567	597	323	
1999	447	702		65	26	18	599	645	717	332	
2000	281	531		67	14	22	444	591	628	368	3
2001	304	643		67	17	23	435	569	707	440	3
2002	311	591		50	10	26	373	544	614	371	3
2003	240	565		49	10	24	366	498	648	311	3
2004	237	583		39	11	32	337	475	546	311	3
2005	249	676		31	10	45	220	455	534	256	3
2006	293	732		33	8	32	184	472	596	241	
2007	194	702		31	10	30	181	424	537	197	
2008	211	671	1	31	13	27	160	406	466	148	
2009	69	514	2	22	5	17	161	374	467	109	
2010	32	525	2	19	9	38	173	366	422	444	
2011	0	450	2	16	6	23	119	279	370	371	
2012	0	340	2	18	6	16	119	245	317	353	
2013	0	374	1	17	5	28	137	265	356	321	
2014	0	324	1	17	4	15	117	232	346	321	
2015	0	246	0.609	14	5	12	102	224	282	293	
2016	3	279	1	15	4	28	138	205	265	314	
2017	11	244	1	16	9	24	173	80	257	422	
2018	3	250	1	18	6	20	146	87	182	461	0
2019*	4		0.344	22	6	9	168	67	183	484	
2020*											

*** Data for 2019 and 2020 are incomplete.**

0 = No landings.

Empty cell = No data or Not Collected or Not Pertinent.

Table 7b. European eel. Official commercial landings (tonnes) of yellow and silver eel (1960–2020) in Ireland (IE), United Kingdom (UK), France (FR), Spain (ES), Portugal (PT), Italy (IT), Slovenia (SI), Croatia (HR), Greece (GR), Turkey (TR), Tunisia (TN) and Morocco (MA), combining information from the 2020 Data call and the WGEEL database.

Year	IE	UK	FR	ES	PT	IT	SI	HR	GR	TR	TN	MA	sum
1908													268
1909													327
1910													303
1911													384
1912													187
1913													213
1914													1743
1915													1140
1916													1195
1917													1328
1918													919
1919													1209
1920													4463
1921													4594
1922													4780
1923													4484
1924													5621
1925													6919
1926													6774
1927													7013
1928													5482
1929													6194
1930													6752
1931													6319
1932													7195
1933													7202
1934													7614
1935													6831

Year	IE	UK	FR	ES	PT	IT	SI	HR	GR	TR	TN	MA	sum
1936													6617
1937													6657
1938													6246
1939													6870
1940													5478
1941													5713
1942													4497
1943													5881
1944													6715
1945													8845
1946													9673
1947													11919
1948													11714
1949													10979
1950													11601
1951				90									10816
1952				102									10055
1953				80									10764
1954				98									9545
1955				103									11278
1956				106									8425
1957				80									9917
1958				115									9354
1959				100									12189
1960		772		98									12076
1961		768		154									11142
1962		696		115									9762
1963		788		137									10624
1964		549		92									10415

Year	IE	UK	FR	ES	PT	IT	SI	HR	GR	TR	TN	MA	sum
1965		784		130									10000.3
1966		881		192					15				11134
1967		569		164					19				10382
1968		586		176					5				11212
1969		606		136		2469			3	342			13421
1970	200	752		119		2300			0	441			11168
1971	200	842		107		2113			0	460			10694
1972	200	633		119		1997			4	220			10005
1973	91	723		100		588			15	315			8793
1974	67	765		93		2122			130	588			9832
1975	79	762		78		2886			134	448			11695
1976	150	622		83		2596			159	499			10601
1977	108	691		80		2390			89	282			9284
1978	76	824		67		2172			225	283			9342
1979	110	1045		97		2354			185	396			9034
1980	75	912		90		2198			227	224			9471
1981	94	907		98		2270			251	374			9202
1982	144	943		20		2025	0.795		255	424			9705.795
1983	117	866		18		2013	0.67		201	588			9324.67
1984	88	973		11		2050	1		285	616			8789
1985	87	750		17		2135	2		190	583			9695
1986	87	651	1944	13		2134	3		152	517			11147
1987	230	684	2062	21		2265	2		266	543			10902
1988	215	934	2265	14		2027	2		268	756			12339
1989	400	875	1746	5	27	1243	1		156	472			10229
1990	256	784	1778	9	26	1088	2		194	230			9459
1991	245	737	1645	50	47	1097	1		209	262			9191
1992	234	715	1321	54	59	1084	0.061		185	245			8890.061
1993	260	671	1280	66	68	782	0.066		182	261			7850.066

Year	IE	UK	FR	ES	PT	IT	SI	HR	GR	TR	TN	MA	sum
1994	300	778	1280	51	53	771	0.718		201	329			8576.718
1995		900	1280	69	47	1047	0.01		201	390			8096.01
1996		805	1280	62	51	953	0.012		151	342			7422.012
1997		731	1223	61	49	727	0.002		137	400			7179.002
1998		693	1150	49	47	666	0.003		88	300			6092.003
1999	250	668	1005	53	46	634			81	200			6488
2000	250	587	1009	59	44	588	0.004		88	176	53		5803.004
2001	98	583	1024	133	30	520	0.019		93	122	93		5904.019
2002	123	551	30	109	54	415	0.009		136	147	251		4709.009
2003	111	552	21	102	21	446			77	158	137		4339
2004	136	472	13	93	18	379			58	165	95		4003
2005	101	476	8	93	14	75	0.002		116	176	107		3645.002
2006	133	383	15	121	20	56	0.014		77	162	288		3846.014
2007	114	450	26	88	21	277	0.009		90	179	257		3808.009
2008	108	399	31	73	14	56	0.031		71	171	194		3251.031
2009	0	460	42	100	16	330	0.002		78	158	141		3065.002
2010	0	461	20	82	22	265	0.003		59	182	114		3235.003
2011	0	456	368	66	12	190	0		83	28	122		2961
2012	0	415	473	90	8	182	0		55	38	141		2818
2013	0	427	504	92	5	172	0.001		38	48	180	23	2993.001
2014	0	406	434	74	7	185	0	0.516	58	56	137	23	2757.516
2015	0	341	357	50	6	170	0	0.149	60	71	95	4	2332.758
2016	0	347	443	64	5	205	0	0.595	84	75	299	7	2781.595
2017	0	322	434	83	2	214		0.56	62	81	149	2	2586.56
2018*	0	365	617	71	4	159		0.61	41	111	153	2	2697.61
2019*	0	267	292	47	2	210		0.562		330			2091.906
2020*	0			60							126		186

*** Data for 2019, 2020 are incomplete.**

0 = No catch.

Empty cell = No data or Not Collected or Not Pertinent.

Table 8. European eel. Recreational landings (tonnes) of glass eel (1978–2020) in countries where fisheries exist, France (FR) and Spain (ES) combining information from the 2020 Data call and the WGEEL database.

Year	FR	ES	sum
1978	647		647
1979	697		697
1980	1303		1303
1981	904		904
1982	219		219
1983	161		161
1984	156		156
1985	71		71
1986	87		87
1987	172		172
1988	40		40
1989	110		110
1990	54		54
1991	87		87
1992	77		77
1993	130		130
1994	74		74
1995	113		113
1996	25		25
1997	39		39
1998	6		6
1999	6		6
2000	2		2
2001	1		1
2002	37		37
2003	0		0
2004	0	0.858	0.858
2005	0	1	1

Year	FR	ES	sum
2006	1	2	3
2007	0	1	1
2008	0	2	2
2009	0	0.439	0.439
2010	0	0.821	0.821
2011	0	0.389	0.389
2012	0	1	1
2013	0	2	2
2014	0	2	2
2015	0	2	2
2016	0	2	2
2017	0	2	2
2018	0	2	2
2019*	0	0.865	0.865
2020*	0	0.662	0.662

*** Data for 2019 and 2020 incomplete.**

0 = No landings.

Empty cell = No data or Not Collected or Not Pertinent.

Table 9a. European eel. Recreational landings of yellow and silver eel (1980–2020) (tonnes) in FI Finland, EE Estonia, LV Latvia, LT Lithuania, PL Poland, DE Germany, DK Denmark, NL Netherlands, BE Belgium , FR France, ES Spain (to be continued for other countries in next table), combining information from the 2020 Data call and WGEEL database. German data after 2016 are incomplete.

Year	FI	EE	LV	LT	PL	DE	DK	NL	BE	FR	ES
1980											
1981											
1982											
1983											
1984											
1985						523					
1986						496					
1987						495					
1988						490					
1989						467					
1990						444					
1991						438					
1992						432					
1993						421					
1994						439					
1995						400					
1996						387					
1997						378					
1998						403					
1999						386					
2000			2			391			34	21	
2001			1			386			34	20	
2002			1			389			34	19	
2003			0.418			385			34	15	
2004			0.655			380			34	17	
2005		2	3			357			34	13	
2006		1	0.326			359			34	684	

Year	FI	EE	LV	LT	PL	DE	DK	NL	BE	FR	ES
2007		0.958	0.34			346			34	15	
2008	17	1	0.183			293			34	15	
2009		1	0.69			286	100		34	7	
2010	10	1	0.348			253	118	111	30	5	
2011		0.98	0.383			251	80		30	3	
2012	5	0.612	0.415	1	32	246	52	59	30	5	
2013		0.589	0.738	3	27	251	50		30	5	
2014	20	0.536	0.503	2	30	254	57	70	30	4	
2015		0.744	0.45	5	26	256	118		30	4	
2016	8	0.634	0.17	2	34	258	164	24	30	3	
2017		0.579	0.45	3	31	36	117		30	3	
2018	2	1	0.166	0.587	30	34	105		30	3	
2019*		0.615	0.258	6	30	35	105		30	1	0.265
2020*									30		

Table 9b. European eel. Recreational landings of yellow and silver eel (1980–2020) (tonnes) in Italy (IT), Slovenia (SL), Greece (GR) combining information from the 2020 Data call and WGEEL database. Countries omitted include those where recreational landings are prohibited, as well as those that have not reported.

Year	IT	SI	GR	sum
1980		0		0
1981		0		0
1982		0		0
1983		0		0
1984		0		0
1985		0		523
1986		0.07		496.07
1987		0.14		495.14
1988		0.134		490.134
1989		0.11		467.11
1990		0.06		444.06
1991		0.058		438.058
1992		0.092		432.092
1993		0.078		421.078
1994		0.036		439.036
1995		0.029		400.029
1996		0.143		387.143
1997		0.207		378.207
1998		0.088		403.088
1999		0.023		386.023
2000		0.004		448.004
2001		0.02		441.02
2002		0.033		443.033
2003		0.004		434.422
2004		0.006		431.661
2005		0		409
2006		0.004		1078.33
2007		0		396.298

Year	IT	SI	GR	sum
2008		0		360.183
2009		0		428.69
2010	150	0		678.348
2011	61	0		426.363
2012	74	0		505.027
2013	70	0		437.327
2014	70	0		538.039
2015	60	0		500.194
2016	57	0		580.804
2017	41			262.029
2018	38		1	244.753
2019*	30			238.138
2020*	7			37

*** Data for 2019 and 2020 incomplete.**

0 = No landings or No information (not collected or no fisheries).

Empty cell = Not reported.

Table 10a. European eel. Release of glass eel in millions from 1950 to 2020, reported by countries SE Sweden, EE Estonia, LV Latvia, PL Poland, DE Germany, NL Netherlands, BE Belgium(to be continued for other countries in next table).combining information from the 2020 Data call and the WGEEL database.

Year	SE	EE	LV	PL	DE	NL	BE
1950						5	
1951						10	
1952				18		17	
1953				26		22	
1954				27		10	
1955				31		16	
1956		0.2		21		23	
1957				25		19	
1958				35		17	
1959				53		20	
1960		0.06	3	64		21	
1961			1	65		21	
1962		0.9	3	62		20	
1963			2	42		23	
1964		0.2	1	39		20	
1965		0.7	0.693	40		22	
1966				69		9	
1967			2	74		7	
1968		1	4	17		17	
1969				2		3	
1970		1	2	24		19	
1971				17		17	
1972		0.1	1	22		16	
1973				62		14	
1974		2		71		24	
1975				70		14	
1976		3	0.851	68		18	
1977		2	0.52	77		26	

Year	SE	EE	LV	PL	DE	NL	BE
1978		3		73		28	
1979				73		31	
1980		1		52		25	
1981		3	2	60		22	
1982		3	0.29	63		17	
1983		2	2	25		14	
1984		2		48		17	
1985		2	1	36	22	12	
Year	SE	EE	LV	PL	DE	NL	BE
1986				50	37	10	
1987		2	0.26	57	38	8	
1988			3	17	40	8	
1989				14	20	7	
1990				10	29	6	
1991		2		2	13	2	
1992		2		14	17	4	
1993				10	21	4	
1994		2		13	23	6	
1995			0.572	24	20	5	
1996		1		3	11	2	
1997		0.9		5	9	2	
1998		0.5		2	8	2	
1999		2	0.294	4	9	3	
2000		1		3	6	3	
2001				0.701	3	0.9	0.162
2002			0.251		3	2	
2003				0.506	2	2	0.324
2004			0.06	2	2	0.3	

Year	SE	EE	LV	PL	DE	NL	BE
2005			0.12		2	0.1	
2006			0.003		1	0.582	0.33
2007			0.015		1	0.216	
2008					0.51	0	0.351
2009					0.787	0.3	0.456
2010					5	3	0.429
2011		0.68	0.304		3	0.529	0.48
2012		0.91	1		4	2	0.618
2013		0.89			5	2	0.432
2014		3	1		10	6	2
2015		2			6	0.863	
2016		0.9			5	3	1
2017	13		1		1	3	0.727
2018		1	0.715		2	4	2
2019*		2	0.69		1	5	2
2020*						3	0.9

Table 10b. European eel. Release of glass eel in millions from 1950 to 2020, reported by countries: IE Ireland, UK United Kingdom, FR France, ES Spain, IT Italy, GR Greece, combining information from the 2020 Data call and the WGEEL database.

Year	IE	UK	FR	ES	IT	GR	sum
1950							5
1951							10
1952							35
1953							48
1954							37
1955							47
1956							44.2
1957							44
1958							52
1959	7						80
1960	1						89.06
1961	4						91
1962	6						91.9
1963	8						75
1964	0.743						60.943
1965	1						64.393
1966	10						88
1967	7						90
1968	15						54
1969	8						13
1970	9						55
1971	16						50
1972	6						45.1
1973	10						86
1974	11						108
1975	5						89

Year	IE	UK	FR	ES	IT	GR	sum
1976	7						96.851
1977	3						108.52
1978	4						108
1979	30						134
1980	26						104
1981	17						104
1982	26						109.29
1983	10						53
1984	8	4					79
1985	6	11					90
1986	5	18					120
1987	14	14					133.26
1988	13	6					87
1989	7	0					48
1990	10	0					55
1991	2	0					21
1992	6	2					45
1993	7	0					42
1994	19	2					65
1995	11	2					62.572
1996	4	0.1					21.1
1997	15	0.2					32.1
1998	6	0.052					18.552
1999	8	4					30.294
2000	6	0.45					19.45
2001	3	0					7.763
2002	1	3					9.251
2003	4	4					12.83

Year	IE	UK	FR	ES	IT	GR	sum
2004	1	1					6.36
2005	4	2					8.22
2006	0.616	1					3.531
2007	1	4					6.231
2008	0.418	1					2.279
2009	0.375	0.719			0		2.637
2010	0.444	3	0.627		0.3		12.8
2011	0.318	3	2	0.014	0.9		11.225
2012	0.647	4	9	1	0.9		24.075
2013	0.972	6	9	1	0.9	0.419	26.613
2014	2	8	17	0.245		0.204	49.449
2015	3	2	3	0.045	0.366	0.017	17.291
2016	4	0.053	10	0.003	0.21	0.471	24.637
2017	0.685	2	7	0.767	0.437	0.149	29.765
2018	8	2	9	4		0.094	32.809
2019*	0.476	4	10	0.982			26.148
2020*	2	5	9				19.9

*** Data for 2019 and 2020 incomplete.**

0 = No catch.

Empty cell = No data or Not Collected or Not Pertinent.

Table 11. European eel. Releases for yellow eel from 1947 to 2020 in millions, reported by countries EE Estonia, LV Latvia, LT Lithuania, PL Poland, DE Germany, DK Denmark, NL Netherlands, IE Ireland, ES Spain, IT Italy, combining information from the 2020 Data call and the WGEEL database. German data after 2016 are incomplete.

Year	EE	LV	LT	PL	DE	DK	NL	IE	ES	IT	sum
1947							2				2
1948							2				2
1949							1				1
1950							2				2
1951							1				1
1952							1				1
1953							0.8				0.8
1954							0.7				0.7
1955							0.9				0.9
1956							0.7				0.7
1957							0.8				0.8
1958							0.8				0.8
1959							0.7				0.7
1960							0.4				0.4
1961							0.6				0.6
1962							0.4				0.4
1963							0.1				0.1
1964							0.3				0.3
1965							0.5				0.5
1966							1				1
1967							1				1
1968							1				1
1969							0				0
1970							0.2				0.2
1971							0.3				0.3
1972							0.4				0.4

Year	EE	LV	LT	PL	DE	DK	NL	IE	ES	IT	sum
1973				0.064			0.5				0.564
1974				0.014			0.5				0.514
1975							0.5				0.5
1976							0.5				0.5
1977				0.008			0.6				0.608
1978							0.8				0.8
1979							0.8	0.105			0.905
1980				0			1	0.265			1.265
1981							0.7	0.107			0.807
1982				0.135			0.7	0.122			0.957
1983				1			0.7	0.088			1.788
1984				0.199			0.7	0.042			0.941
1985				0.135	4		0.8	0.099			5.034
1986				0.048	3		0.7	0.156			3.904
1987				0	3		0.4	0.099			3.499
1988	0.18			0.01	2		0.3	0.127			2.617
1989				0.247	2		0.1	0.058			2.405
1990				0.441	2		0	0.098			2.539
1991				0.03	2		0	0.037			2.067
1992				0.064	2		0	0.047			2.111
1993				0.001	2		0.2	0.061			2.262
1994				0.138	3		0	0.013			3.151
1995	0.15			0.043	3		0	0.08			3.273
1996				1	4		0.2	0.01			5.21
1997				2	5		0.4	0.091			7.491
1998				0.848	5		0.6	0.026			6.474
1999				1	5		1	0.071			7.071
2000				1	7		1	0.039	0.044		9.083

Year	EE	LV	LT	PL	DE	DK	NL	IE	ES	IT	sum
2001	0.44			0.753	6		0.1	0	0.054		7.347
2002	0.36			0.751	7		0.1	0.068	0.023		8.302
2003	0.54			0.558	7		0.1	0.088	0.032		8.318
2004	0.44			0.806	7		0.1	0.032	0.065		8.443
2005	0.37			0.74	6		0	0.066	0.114		7.29
2006	0.38			0.918	9		0	0.047	0.002		10.347
2007	0.33			1	9		0	0.076	0.017		10.423
2008	0.19			2	9		0.23	0.131	0.016		11.567
2009	0.42			1	9		0.3	0.015	0.03		10.765
2010	0.21			1	9		0.062	0.016	0.013		10.301
2011	0.2		0.152	3	7		0.408	0.011	0.039		10.81
2012	0.12		0.494	2	6		0.392	0.003	0		9.009
2013	0.13		1	3	7		0.506	0.003	0.004		11.643
2014	0.19		0.38	2	8		0.903	0.038	0.021		11.532
2015			0.45	4	9		0.742	0.033		0.085	14.31
2016	0.22		0.273	2	7	2	0.49	0.092	0.183	0.122	12.38
2017	0.31		0	4	1	2	0.574	0.014	0.15	0.2	8.248
2018		0.003	2	2	0.969			0.135	0.156		5.263
2019*			2	0.98	0.537	2		0.038	0.219		5.774
2020*						1	0.619	0.092			1.711

*** Data for 2019 and 2020 incomplete.**

0 = No catch.

Empty cell = No data or Not Collected or Not Pertinent.

Table 12. European eel. Releases for silver eel from 2001 to 2020 in millions, reported by countries SE Sweden, FI Finland, IE Ireland, Fr France, ES Spain, GR Greece. Combining information from the 2020 Data call and the WGEEL database.

Year	SE	FI	IE	FR	ES	GR	sum
2001			0.006				0.006
2002			0.02				0.02
2003			0.008				0.008
2004			0.014				0.014
2005			0.008				0.008
2006			0.038				0.038
2007			0.018				0.018
2008			0.052				0.052
2009			0.163		0.001		0.164
2010	0.005		0.187				0.192
2011	0.008		0.215	0.094			0.317
2012	0.01		0.243	0.111	0.039		0.403
2013	0.013		0.238	0.116		0.042	0.409
2014	0.021	0	0.336	0.164		0.067	0.588
2015	0.018	0	0.284	0.214		0.079	0.595
2016	0.017	0	0.206	0.17		0.108	0.501
2017	0.017	0	0.193	0.213		0.086	0.509
2018	0.016	0	0.205	0.212		0.035	0.468
2019*		0	0.182	0.169	0.001		0.352
2020*					0.001		0.001

*** Data for 2019 and 2020 incomplete.**

0 = No catch.

Empty cell = No data or Not Collected or Not Pertinent.

Table 13. European eel. Releases for quarantined glass eel from 1913 to 2019 in millions, reported by countries SE Sweden, FI Finland. Combining information from the 2020 Data call and the WGEEL database.

Year	SE	FI	sum
1913	0.25		0.25
1914	0.25		0.25
1915	0.002		0.002
1929	0.023		0.023
1930	0.035		0.035
1931	0.14		0.14
1932	0.096		0.096
1933	0.02		0.02
1934	0.006		0.006
1937	0.052		0.052
1939	0.003		0.003
1944	0.001		0.001
1945	0.035		0.035
1946	0.065		0.065
1948	0.177		0.177
1949	0.018		0.018
1951	0.107		0.107
1952	0.147		0.147
1953	0.164		0.164
1955	0.174		0.174
1956	0.07		0.07
1957	0.197		0.197
1958	0.011		0.011
1959	0.1		0.1
1960	0.259		0.259
1961	0.007		0.007
1962	0.022		0.022

Year	SE	FI	sum
1964	0.004		0.004
1965	0.041		0.041
1970	0.002		0.002
1972	0.001		0.001
1973	0.01		0.01
1976	0.184		0.184
1978	0.284		0.284
1979	0.23		0.23
1980	0.138		0.138
1982	0.02		0.02
1985	0.634		0.634
1986	0.08		0.08
1987	0.648		0.648
1988	0.637		0.637
1989	0.914		0.914
1990	1		1
1991	0.586		0.586
1992	0.681		0.681
1993	0.987		0.987
1994	2		2
1995	2		2
1996	3		3
1997	3		3
1998	2		2
1999	3		3
2000	1		1
2001	0.908		0.908
2002	2		2

Year	SE	FI	sum
2003	0.702		0.702
2004	1		1
2005	1		1
2006	1		1
2007	0.972		0.972
2008	1		1
2009	0.763		0.763
2010	2	0.306	2.306
2011	3	0.612	3.612
2012	3	0.354	3.354
2013	3	0.394	3.394
2014	3	0.294	3.294
2015	2	0.204	2.204
2016	3	0.158	3.158
2017	0.947	0.241	1.188
2018		0.163	0.163
2019*		0.269	0.269

*** Data for 2019 incomplete.**

0 = No catch.

Empty cell = No data or Not Collected or Not Pertinent.

Table 14. European eel. Releases for on-grown glass eel from 1973 to 2020 in millions, reported by countries: EE Estonia, LV Latvia, LT Lithuania, PL Poland, DE Germany, DK Denmark, ES Spain. Combining information from the 2020 Data call and the WGEEL database.

Year	EE	LV	LT	PL	DE	DK	ES	sum
1973				0.064				0.064
1974				0.014				0.014
1977				0.008				0.008
1980				0				0
1982				0.135				0.135
1983				1				1
1984				0.199				0.199
1985				0.135	0.768			0.903
1986				0.048	0.778			0.826
1987				0	0.703			0.703
1988	0.18			0.01	0.623			0.813
1989				0.247	0.666			0.913
1990				0.441	0.493			0.934
1991				0.03	0.354			0.384
1992				0.064	0.336			0.4
1993				0.001	0.308			0.309
1994				0.138	0.362			0.5
1995	0.15			0.043	0.423			0.616
1996				1	0.247			1.247
1997				2	0.337			2.337
1998				0.848	0.323			1.171
1999				1	0.526			1.526
2000				1	0.51		0.044	1.554
2001	0.44			0.753	0.508		0.054	1.755
2002	0.36			0.751	0.511		0.023	1.645
2003	0.54			0.558	0.511		0.032	1.641

Year	EE	LV	LT	PL	DE	DK	ES	sum
2004	0.44			0.806	0.51		0.065	1.821
2005	0.37			0.74	0.439		0.114	1.663
2006	0.38			0.918	0.123		0.002	1.423
2007	0.33			1	0.127		0.017	1.474
2008	0.19			2	0.085			2.275
2009	0.42			1	0.146			1.566
2010	0.21			1	0.345			1.555
2011	0.2		0.152	3	0.176			3.528
2012	0.12		0.494	2	0.262			2.876
2013	0.13		1	3	0.555			4.685
2014	0.19		0.38	2	0.301			2.871
2015			0.45	4	0.588			5.038
2016	0.22		0.273	2	0.376	2		4.869
2017	0.31		0	4	1	2		7.31
2018		0.003	2	2	0.948		0.008	4.959
2019*			2	0.98	0.537	2	0.219	5.736
2020*						1		1

*** Data for 2019 and 2020 incomplete.**

0 = No catch.

Empty cell = No data or Not Collected or Not Pertinent.

Table 15a. European eel. Aquaculture for all stages in tonnes from 1984 to 2021 reported by countries: SE Sweden, FI Finland, EE Estonia, LT Lithuania, PL Poland, DE Germany, DK Denmark. (To be continued for other countries in next table). Combining information from the 2020 Data call and the WGEEL database.

Year	SE	FI	EE	LT	PL	DE	DK
1984							18
1985							40
1986							200
1987							240
1988							195
1989							430
1990							586
1991							866
1992							748
1993							782
1994							1034
1995							1324
1996							1568
1997							1913
1998				2			2483
1999				2			2718
2000				1			2674
2001				5			2000
2002			20	17			1880
2003			40	20			2050
2004	158		50	9		328	1500
2005	222		80	8		329	1700
2006	191		100	12		567	1900
2007	175		100	13		774	1617
2008	248		90	11		749	1740
2009	286		60	12		667	1707
2010	186		40	8		681	1537
2011	182		50	13		692	1156

Year	SE	FI	EE	LT	PL	DE	DK
2012	186		70	4		744	1093
2013	184	0	0	7		758	824
2014	128	1	56	14		926	842
2015	208	1	52	0.41	0.6	1176	1234
2016	234	0	61	73	0.981	1099	1033
2017	154	0	50	0	3	2313	550
2018	130				3	1132	439
2019*	81					1285	

Table 15b. European eel. Aquaculture for all stages in tonnes from 1984 to 2021 reported by countries: NL Netherlands, ES Spain, PT Portugal, IT Italy, GR Greece, MA Morocco, sum. Combining information from the 2020 Data call and the WGEEL database.

Year	NL	ES	PT	IT	GR	MA	sum
1984							18
1985							40
1986							200
1987	100						340
1988	300						495
1989	200						630
1990	600						1186
1991	900						1766
1992	1100						1848
1993	1300						2082
1994	1450						2484
1995	1540						2864
1996	2800						4368
1997	2450						4363
1998	3250	347					6082
1999	3500	383					6603
2000	3800	411					6886
2001	4000	339					6344
2002	4000	295					6212
2003	4200	292					6602
2004	4500	377		1220	500		8642
2005	4500	321		1131	500		8791
2006	4200	275		807	385		8437
2007	4000	369		1000	454		8502
2008	3700	460		551	489		8038
2009	3200	493		677	428		7530
2010	2000	392	0.285	641	428		5913.285
2011	2300	468	0.562	510	372		5743.562

Year	NL	ES	PT	IT	GR	MA	sum
2012	2600	373	0.886	737	490		6297.886
2013	2900	393	2	642	971	340	7021
2014	2300	406	2	572	837	350	6434
2015	2000	454	0.89	460	1084	280	6950.9
2016	2000	330	3	432	1148	282	6695.981
2017	2005	292	66	478	732	274	6917
2018	2155	346			128	257	4590
2019*	2200					289	3855
2020*						183	183

*** Data for 2019incomplete.**

0 = No catch.

Empty cell = No data or Not Collected or Not Pertinent.

Annex 9: Working papers

9.1 Exploratory use of GEREM as a complementary tool

This working paper presents the methodological details about the implementation of the model GEREM used in Section 3.1.6 of the report. Further details are available in Drouineau *et al.* (2016), Bornarel *et al.* (2018).

9.1.1 Material and Methods

9.1.1.1 Zone definition

We used the same zones as Bornarel *et al*. (2018) (Figure 1):

- a North Sea zone (NS)
- a Channel zone which covers Southwestern Great Britanny and NorthWestern France
- ATL_F which covers the French coast along the Bay of Biscay
- ATL_IB which extends from the Cantabrian Sea to the Gibraltar Strait
- Med which extends from the Gibraltar Strait to Sicilia
- A zone that covers Ireland and the northwestern part of Great Britain (INWGB)

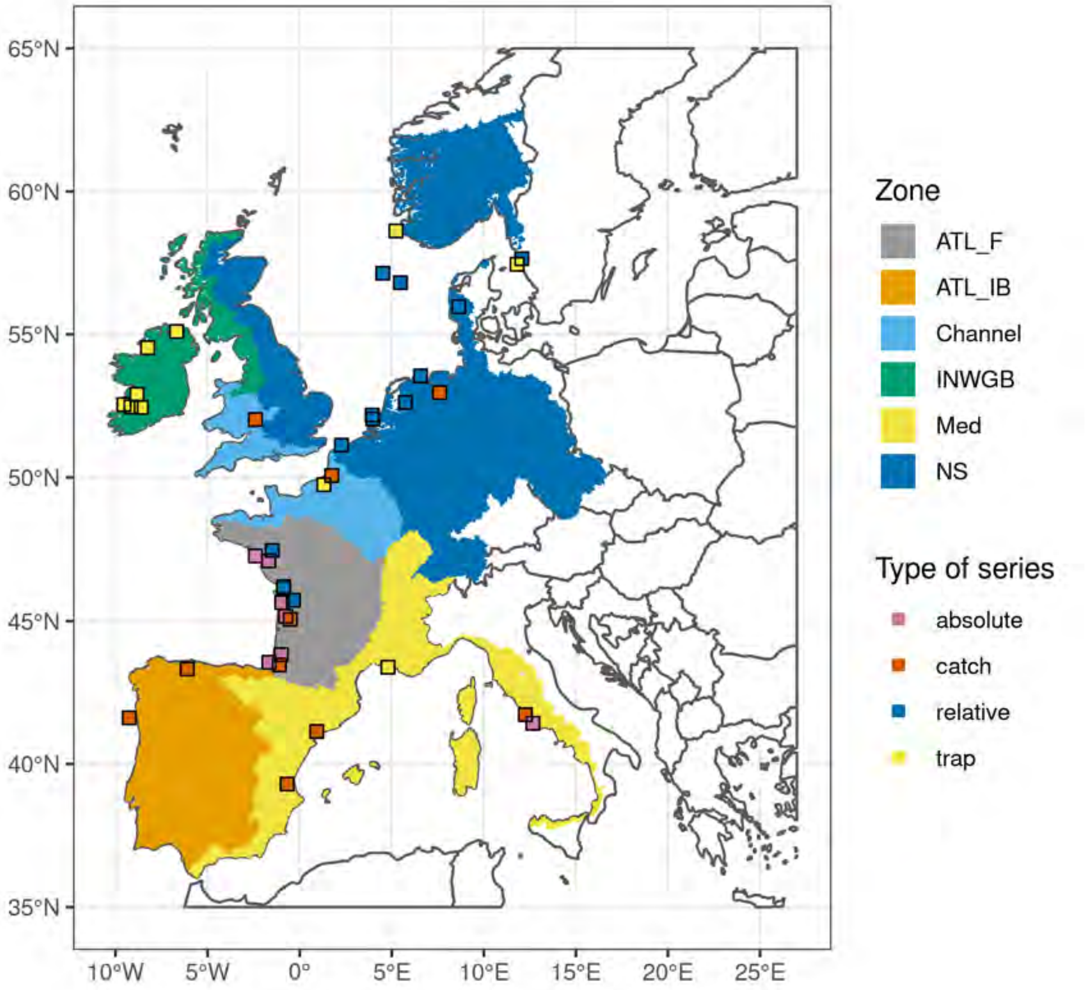

Figure 1. Zone definition and available data.

9.1.1.2 Modification in the model

In first versions of GEREM, river recruitment in a river basin was assumed to be a deterministic proportion of the corresponding zone recruitment, with the proportions equal to a simple function of the river basin area S_(c,z) to mimic a multinomial distribution (equation (1)):

$$R_{c,z}(y) \sim N\left(R_z(y)\cdot w_{c,z}, R_z(y)\cdot w_{c,z}\cdot\left(1-w_{c,z}\right)\right)$$
$$\text{with} w_{c,z} = \frac{S_{c,z}^{\beta}}{\sum_{b\in z} S_{b,z}^{\beta}} \qquad (eq\!:1)$$

Here, we slightly modified this relationship to account for local heterogeneity among river basins. More specifically, we incorporated a random effect on weights (equation (2)):

$$w_{c,z} = \frac{S_{c,z}^{\beta} \cdot e^{\varepsilon(c,z)}}{\sum_{b \in z} S_{b,z}^{\beta} \cdot e^{\varepsilon(b,z)}} \qquad (eq{:}\,2)$$
$$\text{with } \varepsilon(b,z) \sim N\left(-\frac{1}{2} \cdot \sigma, \sigma^2\right)$$

9.1.1.3 Available Data

Table 1 summarises the data used to fit the model. While time-series are available in all zones, most absolute estimates come from ATL_F. In other zones, trap monitoring and commercial catches can inform on absolute estimates given but this requires making assumption on trapping efficiency or on exploitation rates. We also note that the number of time-series is limited in the Channel area. Conversely, there are many time-series in ATL_F, but most of them ended after the implementation of the French Eel Management Plan (Ministère de l'Ecologie, de l'Energie, du Développement durable et de l'Aménagement du Territoire, Onema, and de l'Agriculture 2010) and presently, there is only one still updated time-series. We also note that the Mediterranean zone is large with only four available time-series. Most of the time-series are used by the WGEEL and were described in previous section. However; following Bornarel *et al.* (2018), eight additional time-series were added (details can be found in their article). AdGERMA, GiGEMAC, SeGEMAC, ChGEMAC, LoGREMA and Tiber (Beaulaton and Briand, 2007; Bru *et al.*, 2009) correspond to estimate of absolute recruitments from models. Somme is a time-series of commercial catch in an estuary in which the exploitation rate is assumed to be very high. The Oria time-series are absolute estimates provided by a statistical analysis (Aranburu *et al.*, 2016).

Table 1. Available time-series of recruitment.

Series	Type	Zone	Surface (km²)	First Year	Last Year	Nb data
AdGERMA	absolute	ATL_F	16,860.90	1999	2005	7
AdTCG	catch	ATL_F	16,860.90	1986	2008	23
ChGEMAC	absolute	ATL_F	9,526.10	2007	2008	2
GiGEMAC	absolute	ATL_F	79,605.10	1999	1999	1
GiScG	relative	ATL_F	79,605.10	1994	2020	27
GiTCG	catch	ATL_F	79,605.10	1961	2008	47
LoGERMA	absolute	ATL_F	116,981.00	2004	2006	3
LoiG	relative	ATL_F	116,981.00	1960	2008	49
SeGEMAC	absolute	ATL_F	754.60	2007	2010	4
SevNG	relative	ATL_F	3,398.40	1962	2008	22
VilG	absolute	ATL_F	10,490.40	1971	2015	42
MinG	catch	ATL_IB	16,985.10	1975	2020	46
NaloG	catch	ATL_IB	4,886.50	1960	2020	61
Oria	absolute	ATL_IB	4,886.50	2006	2018	7
BresGY	trap	Channel	743.00	1994	2020	27
SeEAG	catch	Channel	11,381.50	1972	2019	46
Somme	catch	Channel	6,223.40	1991	2012	18
BannGY	trap	INWGB	5,810.90	1960	2020	61
ErneGY	trap	INWGB	4,338.70	1960	2020	59
FealGY	trap	INWGB	1,166.20	1985	2017	19
InagGY	trap	INWGB	252.60	1996	2017	17
MaigG	trap	INWGB	1,080.50	1994	2017	19
ShaAGY	trap	INWGB	11,618.60	1977	2020	44
AlbuG	catch	Med	886.30	1960	2020	57
EbroG	catch	Med	85,611.80	1966	2020	52
TibeG	catch	Med	17,861.00	1975	2006	32
Tiber	absolute	Med	17,861.00	1991	2005	7
VacG	trap	Med	456.00	2004	2020	17

Series	Type	Zone	Surface (km²)	First Year	Last Year	Nb data
EmsG	catch	NS	12,185.10	1960	2001	42
ImsaGY	trap	NS	127.00	1975	2020	46
KatwG	relative	NS	160,221.40	1977	2020	39
LauwG	relative	NS	160,221.40	1976	2020	39
RhDOG	relative	NS	160,221.40	1960	2020	61
RingG	relative	NS	NP	1981	2020	40
StelG	relative	NS	160,221.40	1988	2020	33
VidaG	relative	NS	1,386.70	1971	1990	20
ViskGY	trap	NS	2,373.00	1972	2019	48
YFS1G	relative	NS	NP	1975	1989	15
YFS2G	relative	NS	NP	1992	2020	28
YserG	relative	NS	1,485.80	1964	2020	55

Available time-series are assumed to be proportional to real abundance in the river basin with a scaling factor constant through time (otherwise the time-series would not be a recruitment abundance index). For absolute estimates, this scaling factor is set to 1 by definition (e.g. absolute estimates provide direct estimates of real abundance in average). For traps, we use vague priors on trap efficiency to give an insight on the possible recruitment (Figure 2) we used a vague prior between 0 and 0.35. Indeed, fishway passabilities are often estimated around 1/3 (Briand *et al*., 2005; Drouineau *et al*., 2015; Jessop, 2000; Noonan, Grant, and Jackson, 2012) therefore, our prior assumes that the observed abundance, corrected for the passability (e.g. multiplied by 3) is a minimum bound for the overall recruitment. For commercial time-series, the scaling factor corresponds to the exploitation rate and we used a uniform prior between 0 and 1 (e.g. commercial catch is a minimum value for recruitment), except for the Somme River, in which, based on expert knowledge and following Bornarel *et al*. (2018), we assumed a large exploitation rate.

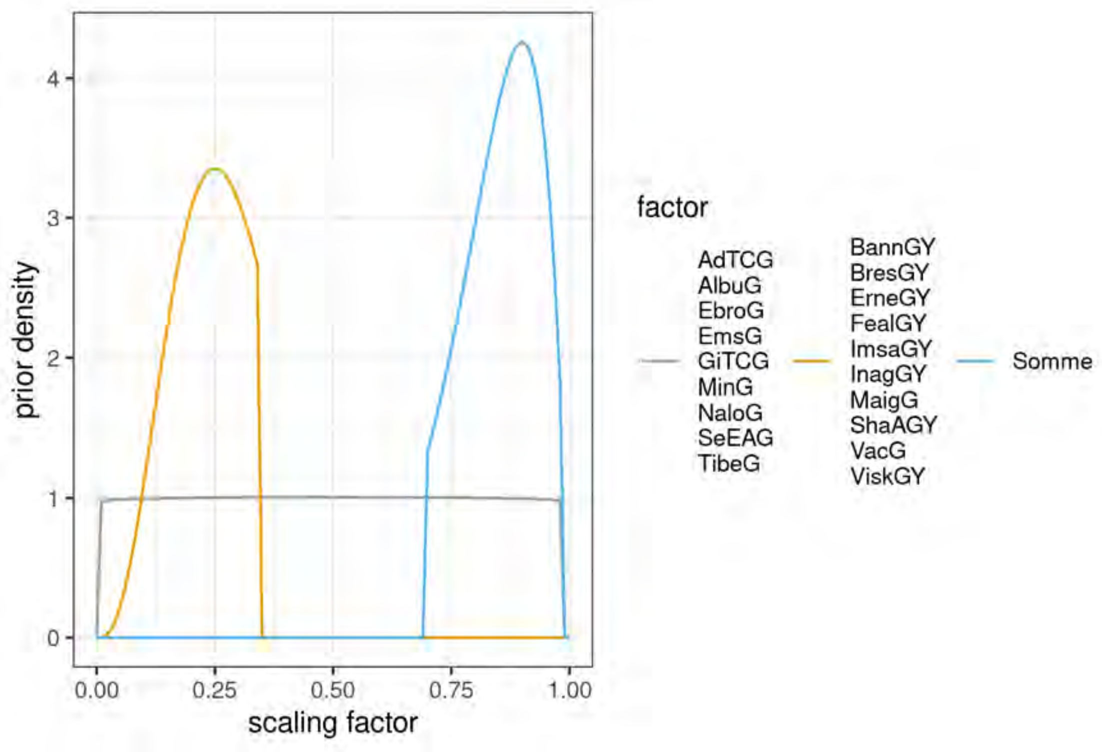

Figure 2. Priors for exploitation rates and trap efficiency.

9.1.1.4 Running the model

Three independent MCMC chains are run in parallel using JAGS (Plummer, 2003) through R package runjags (Denwood, 2016). Chains were run 50 000 iterations, with a thinning of 50 iterations, after an initial burn in period of 100 000 iterations. Gelman and Rubin diagnostics were used to check model convergence (Gelman and Rubin, 1992).

9.1.2 Results

Gelman R hat statistics was below 1.05 for 75.7% of the parameters, demonstrating a good convergence of the model though not perfect for all parameters (Figure 3).

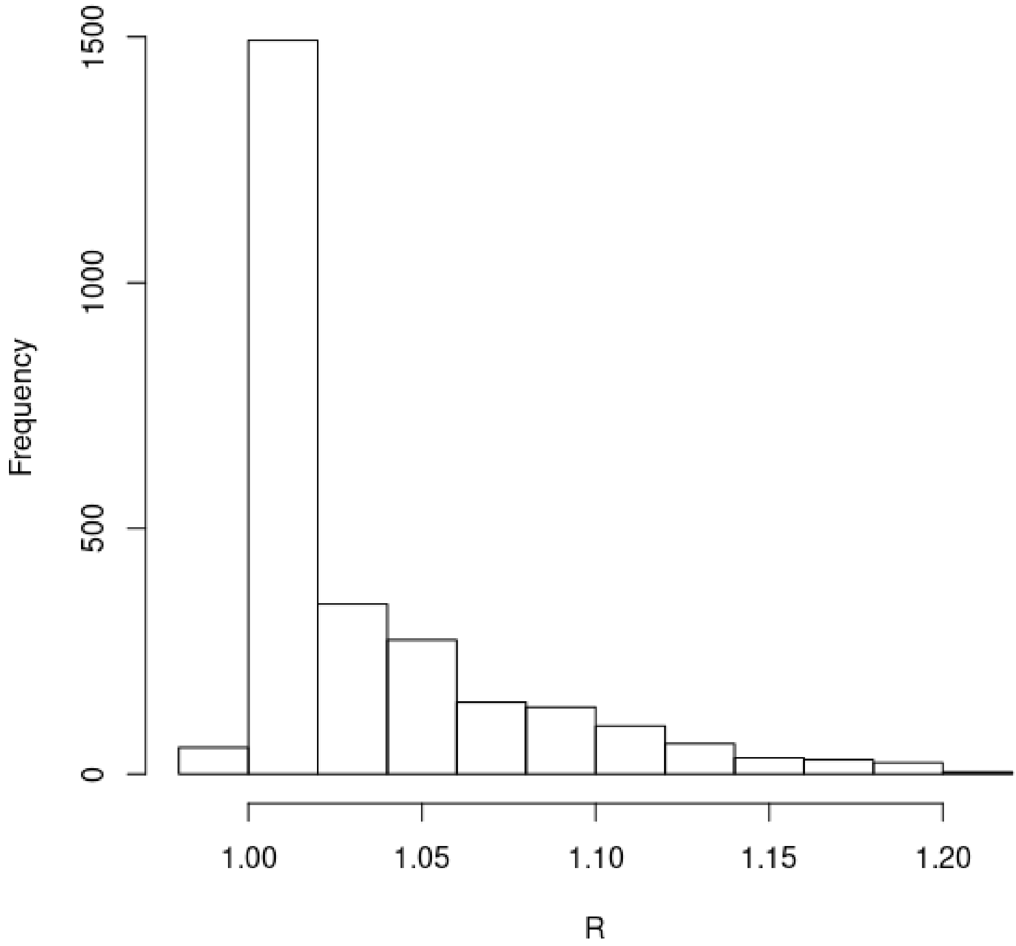

Figure 3. Distribution of Gelman R statistics.

9.1.2.1 Overall recruitment and zone recruitment

Unsurprisingly, overall recruitment (Figure 4) shows a steep decline since the early 1980s, despite some oscillations. More recently, we observe a period of increase in the early 2010s but it seems to stabilise or slightly decrease after this. Credibility intervals are rather large at the end of the period partly because many time-series (especially French fishery based time-series) ended after the implementation of the Eel Regulation. The 2020 recruitment is estimated to be 4.57% (credibility interval [2.9%–7.32%]).

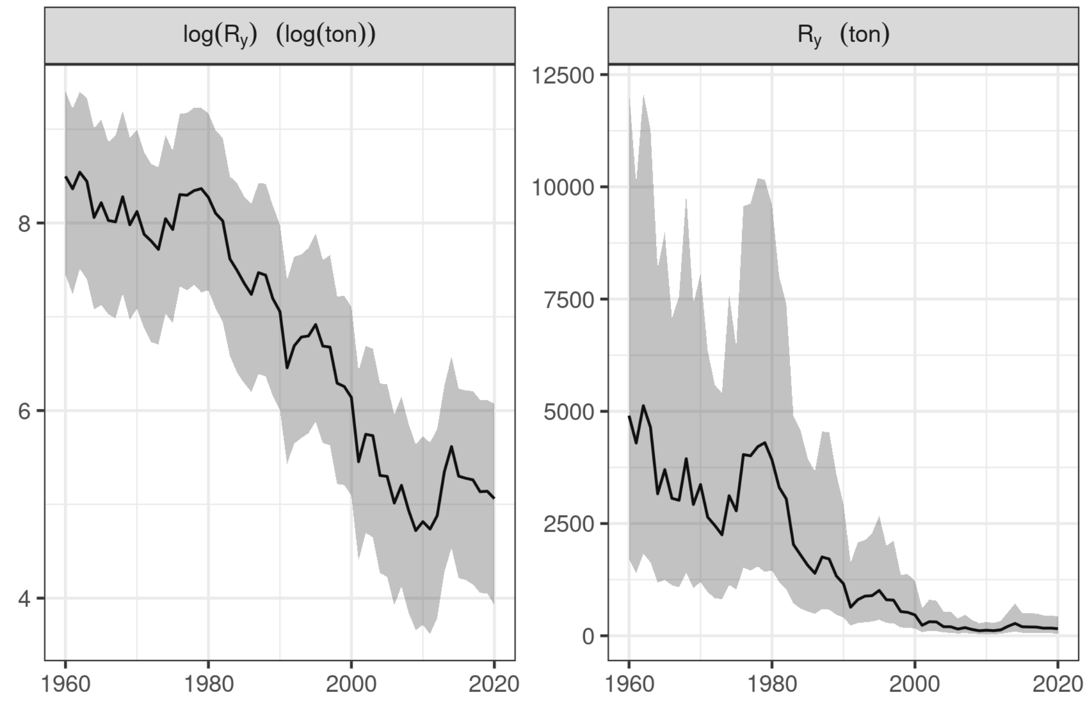

Figure 4. Overall trend in recruitment: median of the posterior distribution (solid line) and corresponding 95% credibility interval (shaded area). Recruitment is in natural scale (right panel) and log scale (left panel).

At the zone level (Figure 5), all zones display a decrease of recruitment. As already observed by WGEEL, which provides separated estimates for the NS and EE series, the decline in the former started earlier than ATL_F and ATL_IB. The Mediterranean area also displays a decline in the 1960s; however, estimates in this period are based on few fishery-based time-series and the assumption about constant exploitation rate and reporting rate is questionable. Moreover, it is worthwhile mentioning that there are currently only four available time-series while the zone is large and includes both lagoons and river basins. For the Channel, the lack of data in the beginning of the time-series explains the large credibility interval; therefore, estimates should be taken with great care. ATL_F does not display any increase at the end of the time-series, however, results are based on a single time-series (GiscG) and, consequently, confidence intervals are rather large.

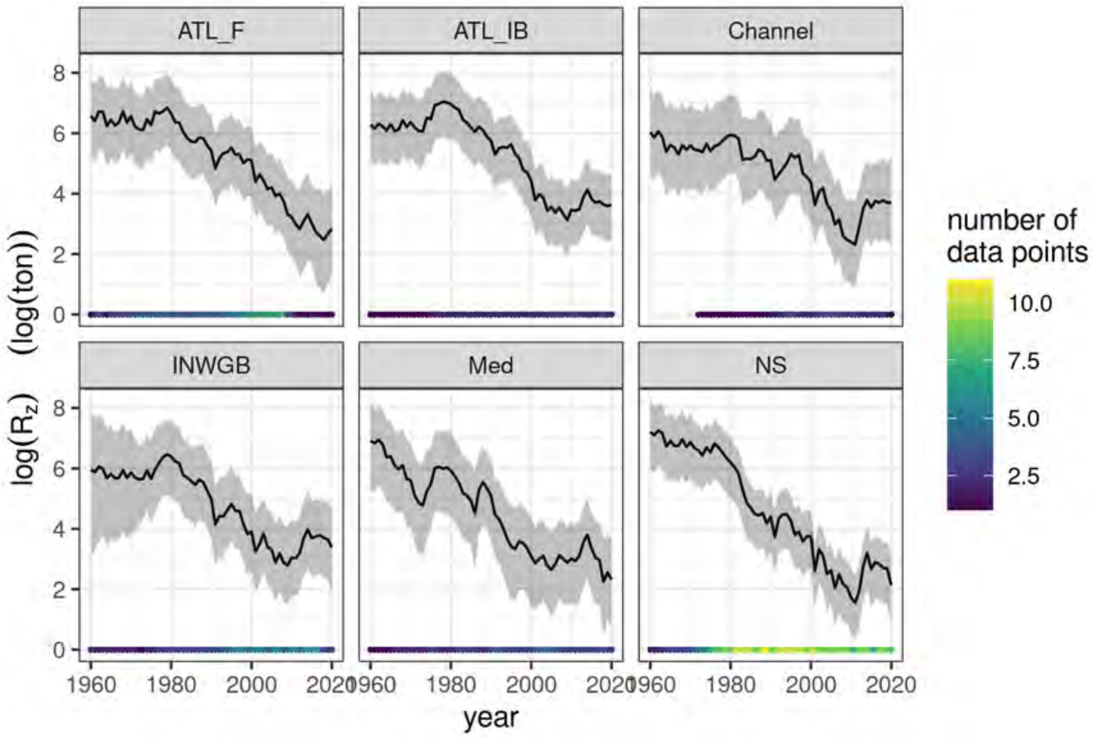

Figure 5. Trend in recruitment in each zone of the model: median of the posterior distribution (solid line) and corresponding 95% credibility interval (shaded area). The colour of the points on the x-axis indicates the number of available dataseries for the corresponding zone and year.

It is also possible to analyse the proportions of recruitment arriving in each zone of the model (Figure 6). However, these results should be taken with great care: credibility intervals are large and some zones estimates are based on few absolute (or trap/commercial catch) time-series. The proportions of recruitment have been estimated since 2010, but these estimates are based on the single still updated time-series in this zone, so they should be taken with care.

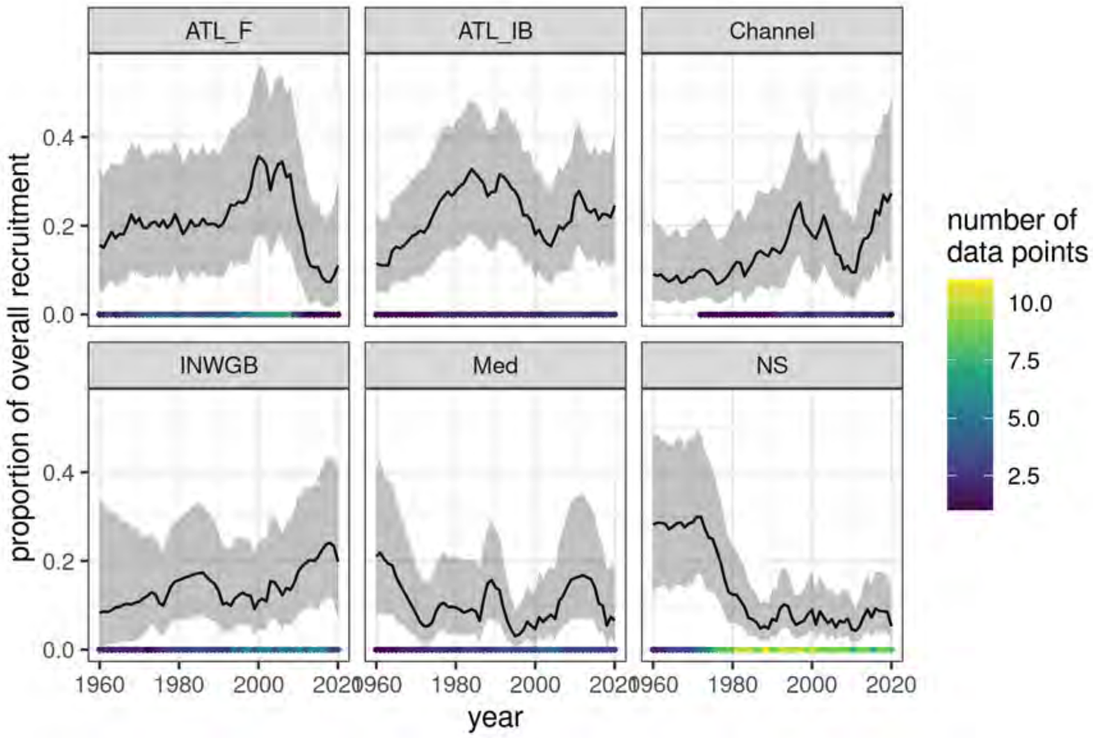

Figure 6. Proportions of overall recruitment arriving in each zone: median of the posterior distribution (solid line) and corresponding 95% credibility interval (shaded area).

9.1.2.2 Model fits to observations

Figures 7, 8, 10 and 9 show how the model fits observations. In most situations, the model appropriately mimics the trends and the visual inspection is satisfactory. A pattern in residuals is visible for EmsG and TibeG, that both display more pronounced decreasing trends in recent years compared to other time-series. EmsG and TibeG are two fishery-based time-series based on total catch; their trends can be interpreted as the effect of declining effort and to partly reflect the collapse of a fishery. Similarly, a pattern is visible for ErneGY with an overestimation before 1980. This is likely to correspond to a modification on the trap, which has greatly improved its efficiency afterwards. The inclusion of a random effect has improved the results by allowing to account for a potential variability at the local scale. A discussion of potential source of variation can be found in the supporting information of Bornarel *et al*. (2018). This leads to two conclusions regarding the results:

- the trends seem well estimated when data are available (see the credibility intervals in Figure 3.2 as soon as data are missing),
- while absolute estimates seem well fitted, results should be evaluated in the light of the large credibility intervals, which increase even more in the absence of observations.

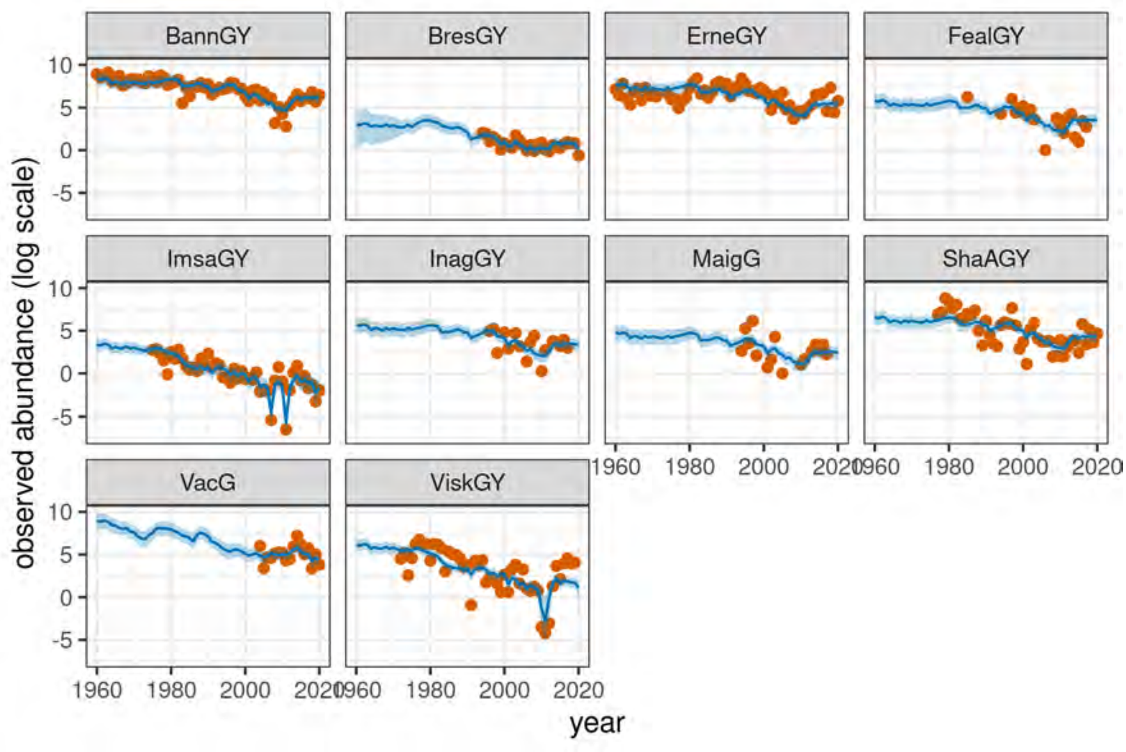

Figure 7. Model fits to trap time-series. Blue lines indicate medians of the posterior distributions of the value predicted by the model, and blue ribbons corresponding 95% credibility interval. Red dots stands for observations. Each panel corresponds to one of the time-series used in the model.

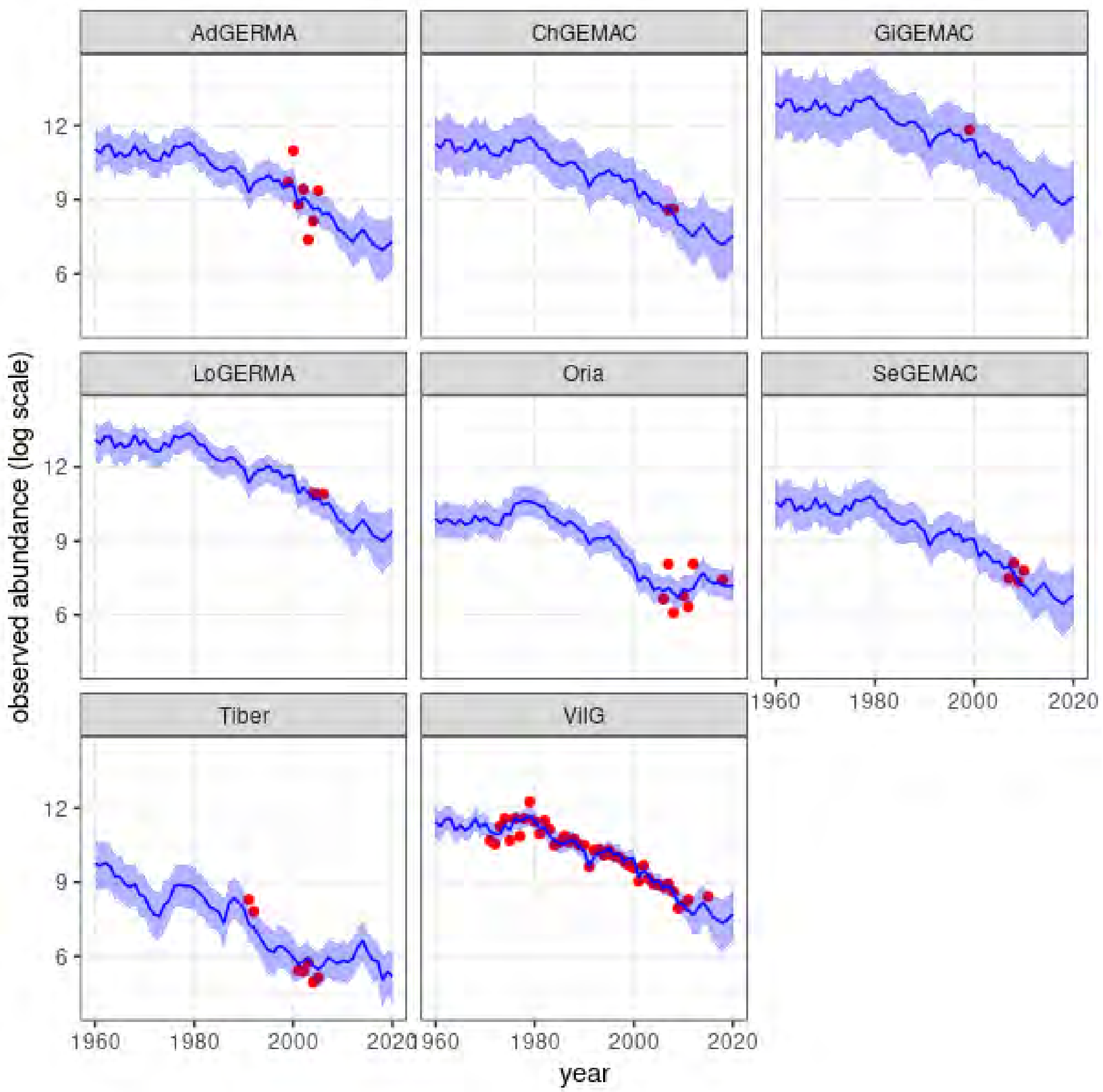

Figure 8. Model fits to absolute time-series. Blue lines indicate medians of the posterior distribution of the value predicted by the model, and blue ribbons corresponding 95% credibility interval. Red dots stands for observations. Each panel corresponds to one of the time-series used in the model.

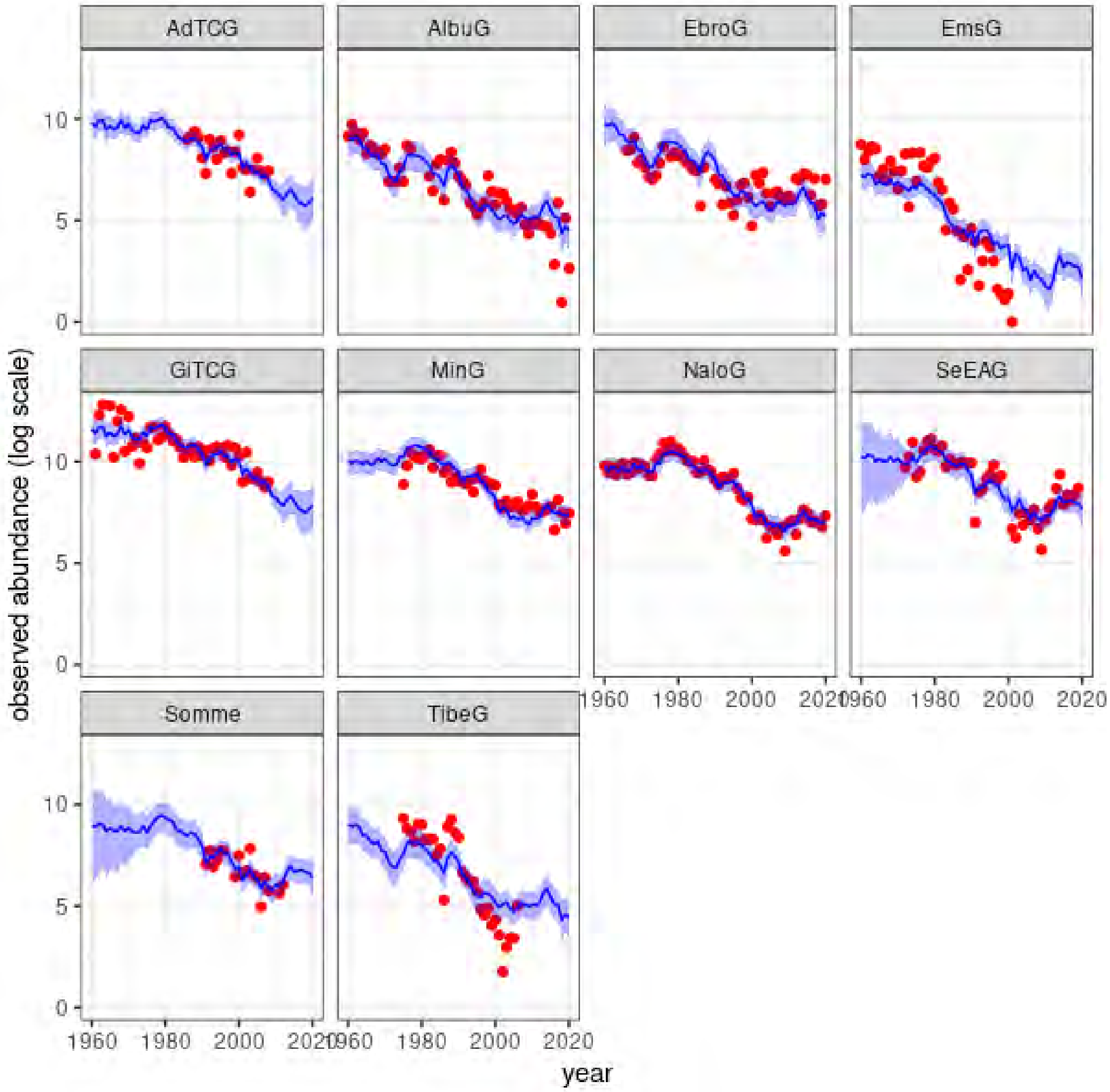

Figure 9. Model fits to available catch time-series. Blue lines indicate medians of the posterior distribution of the value predicted by the model, and blue ribbons corresponding 95% credibility interval. Red dots stands for observations. Each panel corresponds to one of the time-series used in the model.

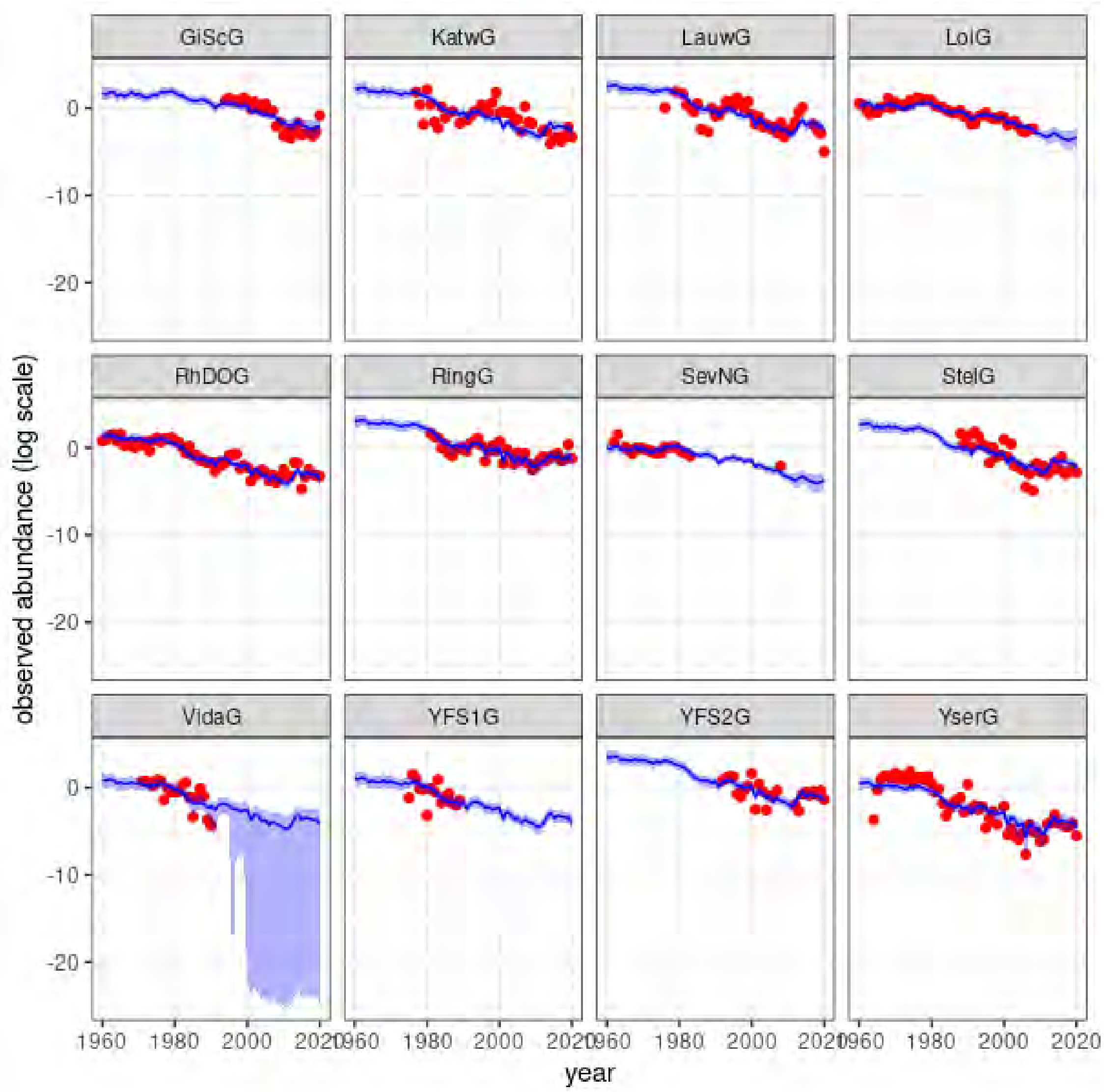

Figure 10. Model fits to relative time-series. Blue lines indicate medians of the posterior distribution of the value predicted by the model, and blue ribbons corresponding 95% credibility interval. Red dots stands for observations. Each panel corresponds to one of the time-series used in the model.

9.1.3 References

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9.2 Spatial and temporal trends in eel biometry

Eels life-history traits are complex and interact with anthropogenic pressures (Mateo *et al.*, 2017). The assessment of escapement can yield contrasted results if evaluated as number, biomass or egg production (Mateo *et al., 2017*; Briand *et al.*, 2018) and a positive relation of glass eel length and recruitment has been found in some studies (Dekker, 1998; Briand *et al.*, 2019). For that reason, biometric data have been included in the WGEEL Data Call since 2019 with the objective to bring insights to the eel assessment provided by the WGEEL.

A first exploratory spatial and temporal analysis of the data has been made of the biometric data collected in the Data Call to detect if there are differences depending on the locations and types of habitat in eel length, weight and sex ratio. Biometric data were collected during the data call in parallel to the time-series of abundance. A table with the information received is presented at the end of the document. In this document, the code of the habitat was appended (e.g. F, T or C) and targeted life stages (e.g. G, GY, Y, S) to the name of the time-series in order to facilitate the recognition. For example, the series of glass eel in the transitional waters of the Mondego is called

MondGT (Mondego, Glass eel, Transitional). For each series, data providers were asked to provide the average yearly length and weight (if possible detailed by sex) and sex ratio.

Three types of analysis were carried out:

- To compare allometric growth among sites, a log-log linear regression was used to determine whether the change in weight was isometric or allometric regarding the growth in length. Higher slopes indicate higher weight gain and therefore better condition. ANCOVA, with site as a covariate, was used to compare the log–log regression models. The obtained slopes were compared to the distance to Gibraltar using a Mann Kendall correlation. In this analysis, time-series were treated independently for glass and silver eels, while data were pooled by country and habitat type for yellow eels. Series (i.e. row of the table) containing fewer than five data were excluded from the analysis.
- To detect spatial patterns in biometry (length, weight, per sex when available), average biometry per EMU, stage, habitat types and sex (when available) was computed. All years and time-series were pooled together. Mann Kendall tests were then used to detect correlations between the considered traits and spatial positions of the biometry measurements. Here, spatial coordinates are characterised by distances as the crow flies from Gibraltar: this distance is used as a proxy of latitude, which is known to be correlated to life-history traits (Kettle *et al.*, 2011; Vøllestad, 1992), but allows the consideration of the Mediterranean basin. The glass eel has not been included in this analysis since their biometry is seasonal and therefore depend on the sampling protocol.
- To explore the existence of temporal trends in biometry, average biometry (length, weight, sex ratio) per EMU, habitat and year was computed in the case of yellow and silver eels. For glass eel and glass/yellow eel mixes series, the analysis was made at the series level since in those stage biometry is too sensitive to the timing of the sampling. Then, Mann-Kendall trend tests were used to detect significant temporal trends. The analysis was restricted to EMU/habitat in which at least five years of data were available.

As the analysis has been done with an average value per year, the analysis does not detect extreme values and individual variability.

9.2.1 Spatial trends in biometrical parameters

9.2.1.1 Glass/yellow mixed eel series

In this exercise, the recruitment series containing only glass eel were not included, since the biometry of glass eel vary a lot depending on season and can hardly be compared with recruitment time-series composed of mixed glass eels /yellow eel series.

The relationship between length and weight differs significantly between the different series (ANCOVA: p <0.000). (Table 1, Figure 1). The StraGYF series has a very low slope and is also very close to not being significant (p = 0.04574). Given the recorded length, this might correspond to glass eels that are not feeding yet. On the opposite for BannGYF series, the slope is higher while glass eels have approximately the same length. This suggests that glass or young yellow eels are gaining weight very quickly, probably just after they have restarted feeding. Indeed, different experts (Rigaud, Evans and Briand, personal communication) have noticed that glass eels gain weight very quickly while their length does not grow when feeding is resumed. Thus, the differences in those series might correspond to the differences in the stages considered. Other factors such as the sampling season can also play a since growth is higher in early stages and length might significantly increase from one month to another.

For the ImsaGYF and SousGYF series, the slope is lower than that of BannGYF, probably because the lengths are closer to the yellow eel phase where the weight gain is lower. It would be necessary to have a greater knowledge of the stages used to calculate the averages length and the time of the season where the sampling was carried out to draw definitive conclusions.

Table 1. Relation of annual average glass/yellow eel mixed series weight (log gr eel) with standard length (log mm eel) in different GYF series.

Serie	Equation	r2	p
BannGYF	Log weight = 8.41 log SL -15.87	0.778	0.0016
ImsaGYF	Log weight = 3.36 log SL -6.66	0.984	<00001
SousGYF	Log weight = 2.74 log SL – 5.36	0.991	<00001
StraGYF	Log weight = 0.82 log SL - 1.97	0.991	<00001

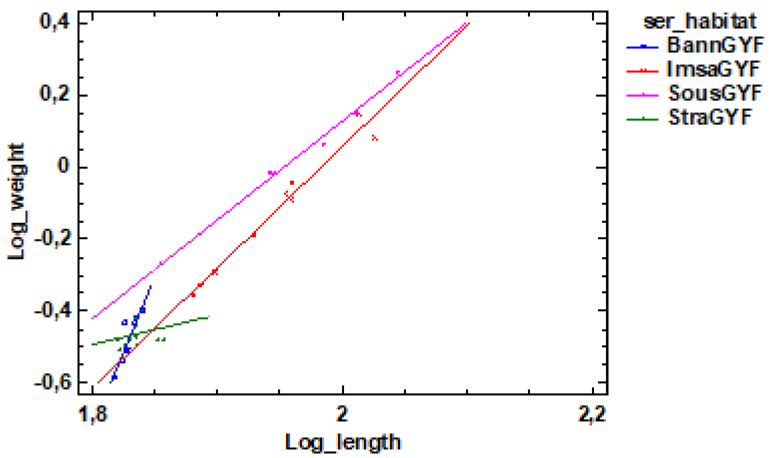

Figure 4. Relation of annual average glass/ yellow mixed eel weight (log gr eel) with standard length (log mm eel) in different GYF series (each line correspond to a GYl monitoring time-series).

The slope of this relationship does not display any obvious latitudinal pattern (Figure 2), but the absence of precise information such as the different, different seasonality and the limited number of available dataseries makes it impossible to draw any conclusions.

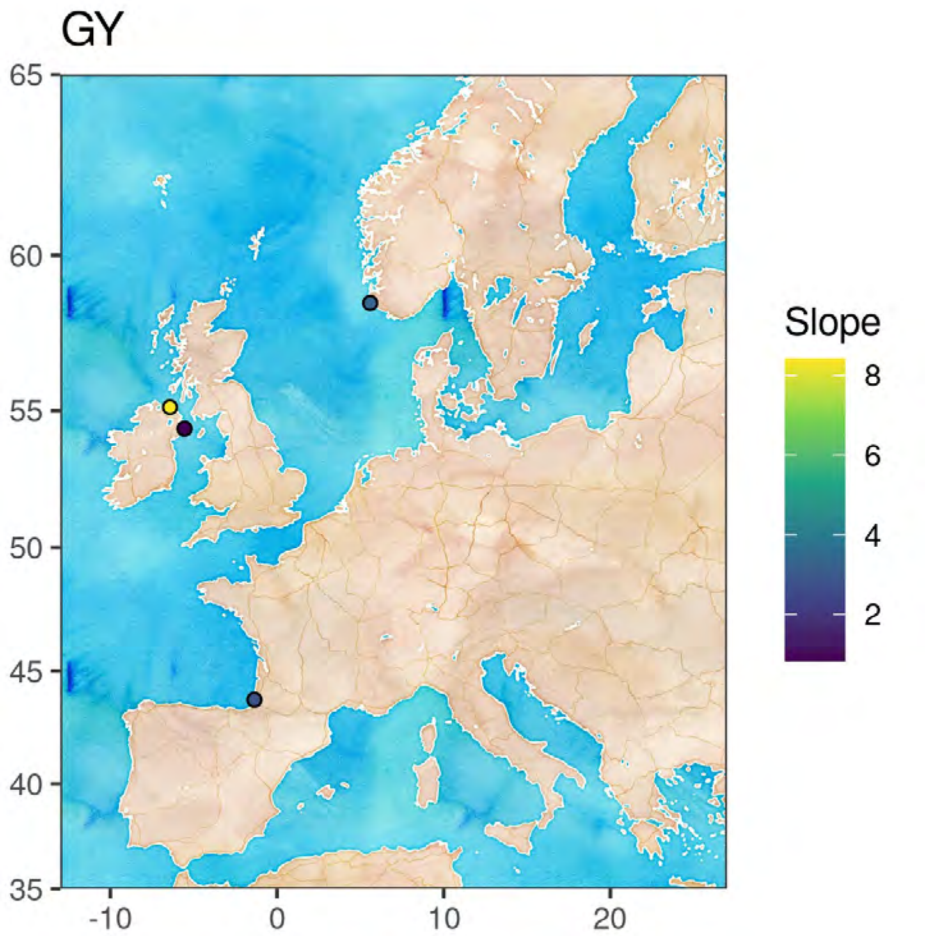

Figure 2. Slopes of length–weight regressions for different mixed glass/ yellow mixed time-series in freshwater habitat. A dot corresponds to a GY recruitment time-series.

9.2.1.2 Yellow eel standing stock series

For yellow eel, sex disaggregated data were scarce; so sex-disaggregated yellow eel analysis was not performed.

Many different gears are used to monitor yellow eel standing stock (Annex 9), each one having different selectivity. As such, the comparisons of length is not straightforward. A rough comparison of the length of monitored standing stock yellow eel showed a positive relation with the distance to Gibraltar (Kendall correlation test; tau=0.38, p.value=0.01) (Figure 3). However, this is likely related to difference in sampling gears since most southern time-series use electrofishing which have a wide selectivity range, while many northern time-series uses fykenet which are selective towards large eel. Therefore, in order to draw definitive conclusion it would be necessary to have detailed information on the catching methods and the bias they introduce in the size structure.

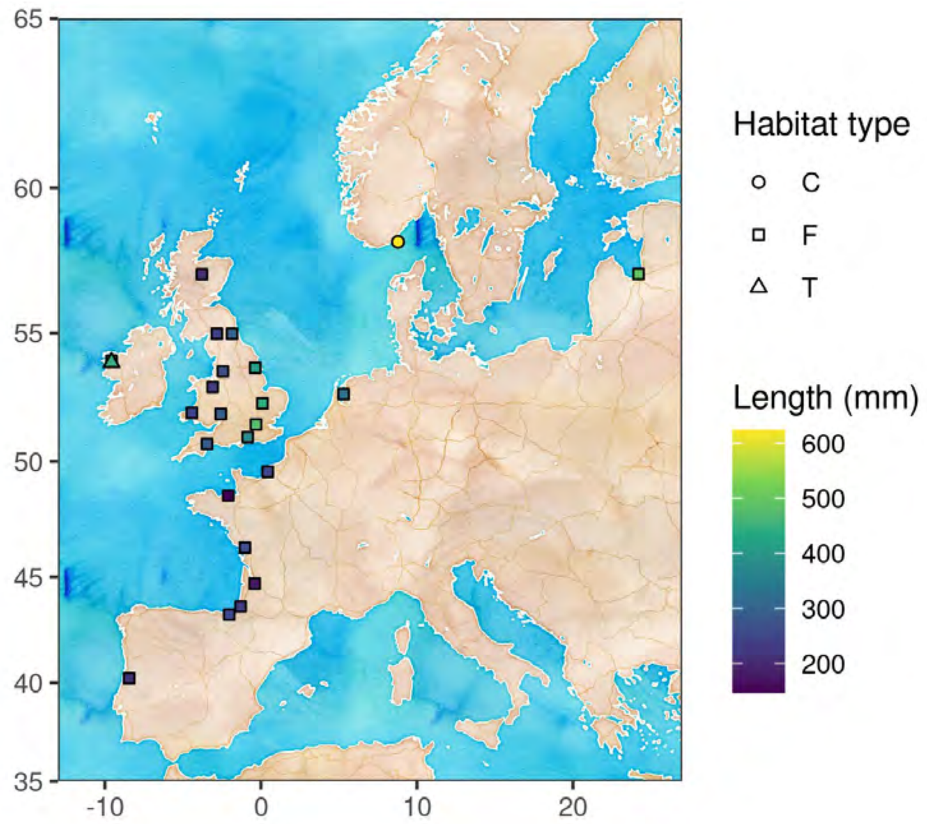

Figure 3. Average length of yellow eels. Each dot corresponds to the average value across years and time-series in a given EMU and habitat type. The length is indicated by the colour scale and the habitat type by the geometric shape.

As for the length, the monitored yellow eel standing stock weight increases with the distance to Gibraltar (Kendall correlation test; tau=0.34, p.value=0.03) (Figure 4); but as mentioned in the case of length, no definitive conclusions can be drawn as the analysis includes average weights obtained by different sampling gears.

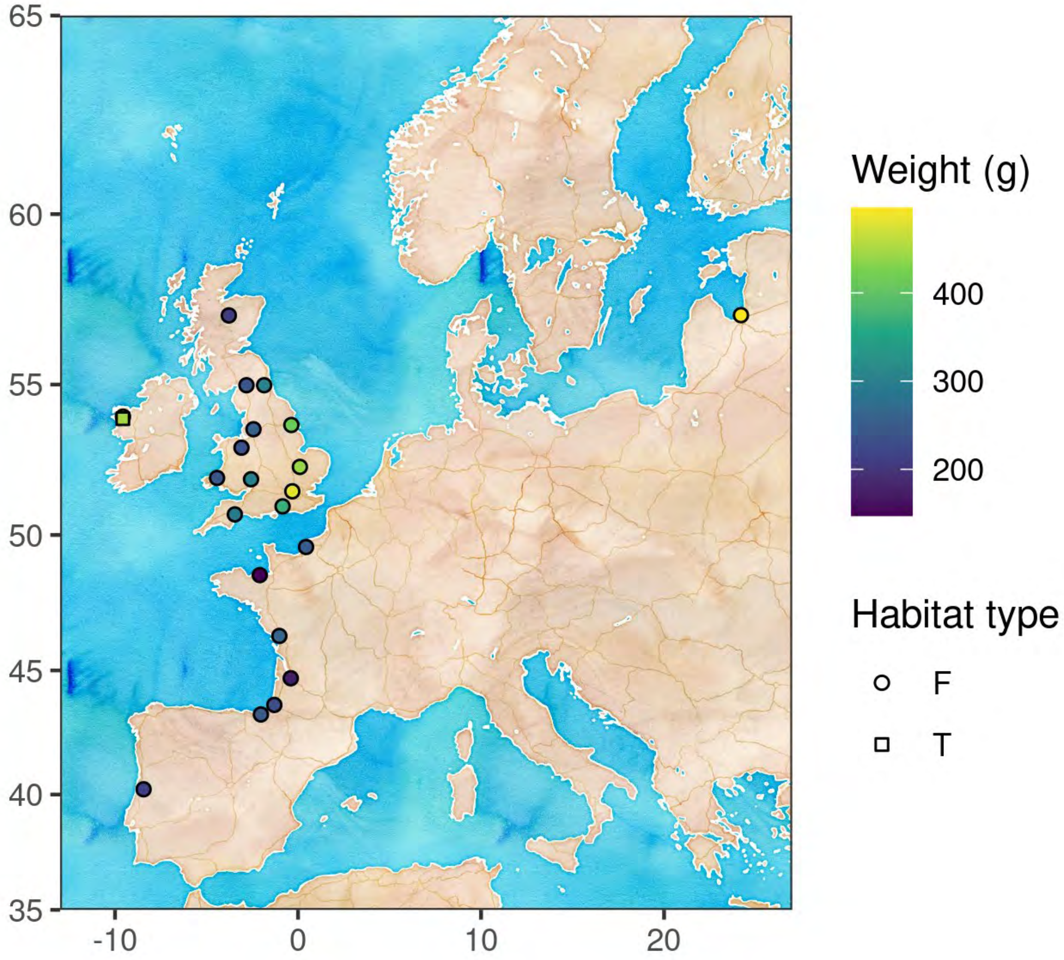

Figure 4. Average weight of yellow eels. Each dot corresponds to the average value across years and time-series in a given EMU and habitat type. The length is indicated by the colour scale and the habitat type by the geometric shape.

The relationship between average annual length and weight differs significantly between the different yellow country x habitat (ANCOVA: $p < 0.000$). However, the differences are not as great as in the case of the GY series. This can be explained by different factors (Table 4, Figure 6). First, standing stock yellow eel series corresponds to a more homogeneous sedentary stage, compared to GY recruitment, which brings together non-feeding glass eels and feeding elvers, migratory glass eel and sedentary small yellow eel. Furthermore, their growth is smoother than GY and consequently, the biometry is less sensitive to the monitoring seasonality. Finally, in this analysis, yellow eel series have been grouped by country, which buffers the overall variability. Still Portugal shows a very high slope compared to the others. However, the number of measurements in Portugal is limited and the range of length is narrow compared to other countries.

Table 4. Relation of annual average yellow eel weight (log gr eel) with standard length (log mm eel) per country and habitat.

Serie	Equation	R2	P
ESF	Log weight = 2.90 log SL – 5.29	0.887	< 0.0001
FRF	Log weight = 2.35 log SL – 3.92	0.847	< 0.0001
GBF	Log weight = 2.93 log SL – 5.44	0.975	< 0.0001
IEF	Log weight = 3.35 log SL -6.64	0.988	< 0.0001
IET	Log weight = 3.54 log SL -7.14	0.975	< 0.0001
LTF	Log weight = 2.94 log SL -5.53	0.999	< 0.0001
LVF	Log weight = 3.17 log SL – 6.24	0.993	< 0.0001
PTF	Log weight = 4.22 log SL -8.44	0.870	< 0.0001

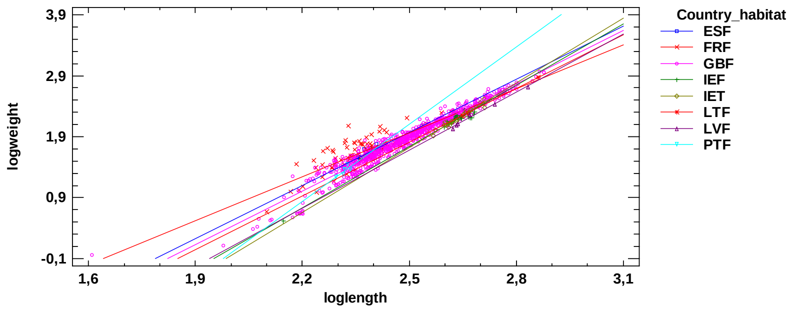

Figure 5. Regression of annual average yellow eel weight (log gr eel) with average standard length (log mm eel) in per country.

The slopes of the length–weight relationships did not show any clear relation with latitude (Figure 6).

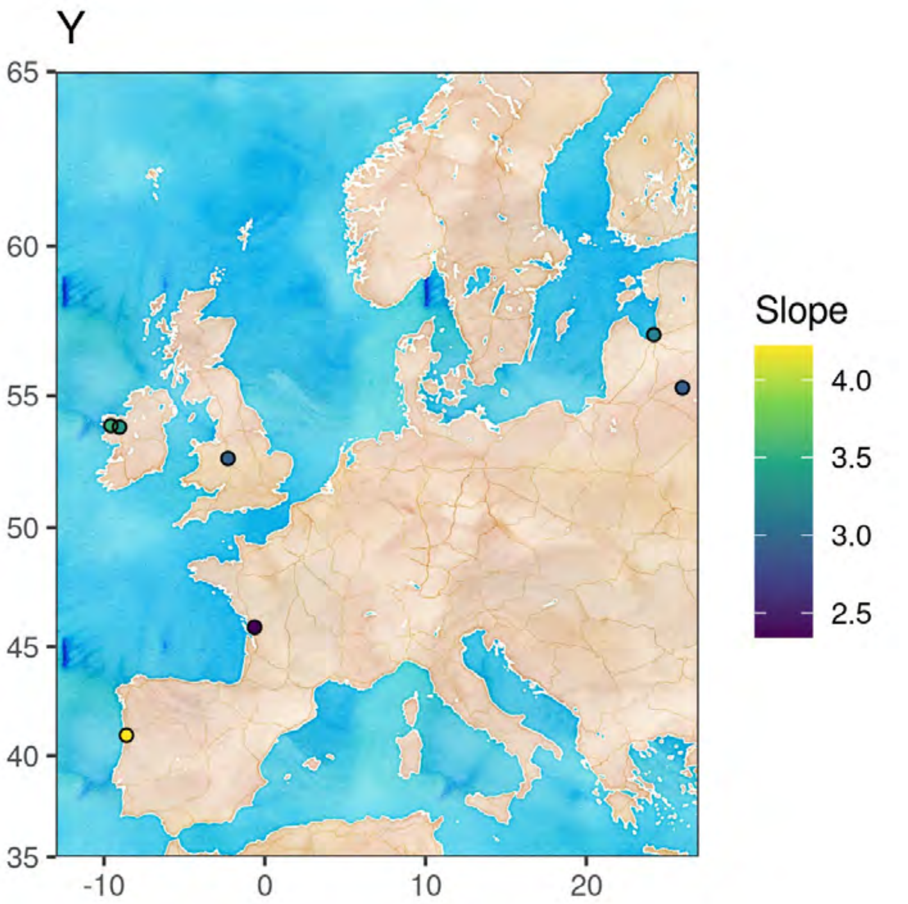

Figure 6. Slopes of length–weight regressions for different yellow time-series in. A dot corresponds to a country x habitat (mostly F, except IE where there are both T and F).

9.2.1.3 Silver eel series

As for yellow eel, different sampling gears are used for silver eels (Annex 9) and difference in selectivity is likely to influence the length of caught silver eels. The Kendall correlation test does not detect any significant relation with the distance to Gibraltar (tau=0.09, p = 0.76). The smallest silver eels were found in GB_Scot F, FR_Adou F and IE_West F (Ireland), and the largest ones in NO_total F and GR_NorW T (Figure 7). There are not enough sex disaggregated data to detect sex-specific length-patterns.

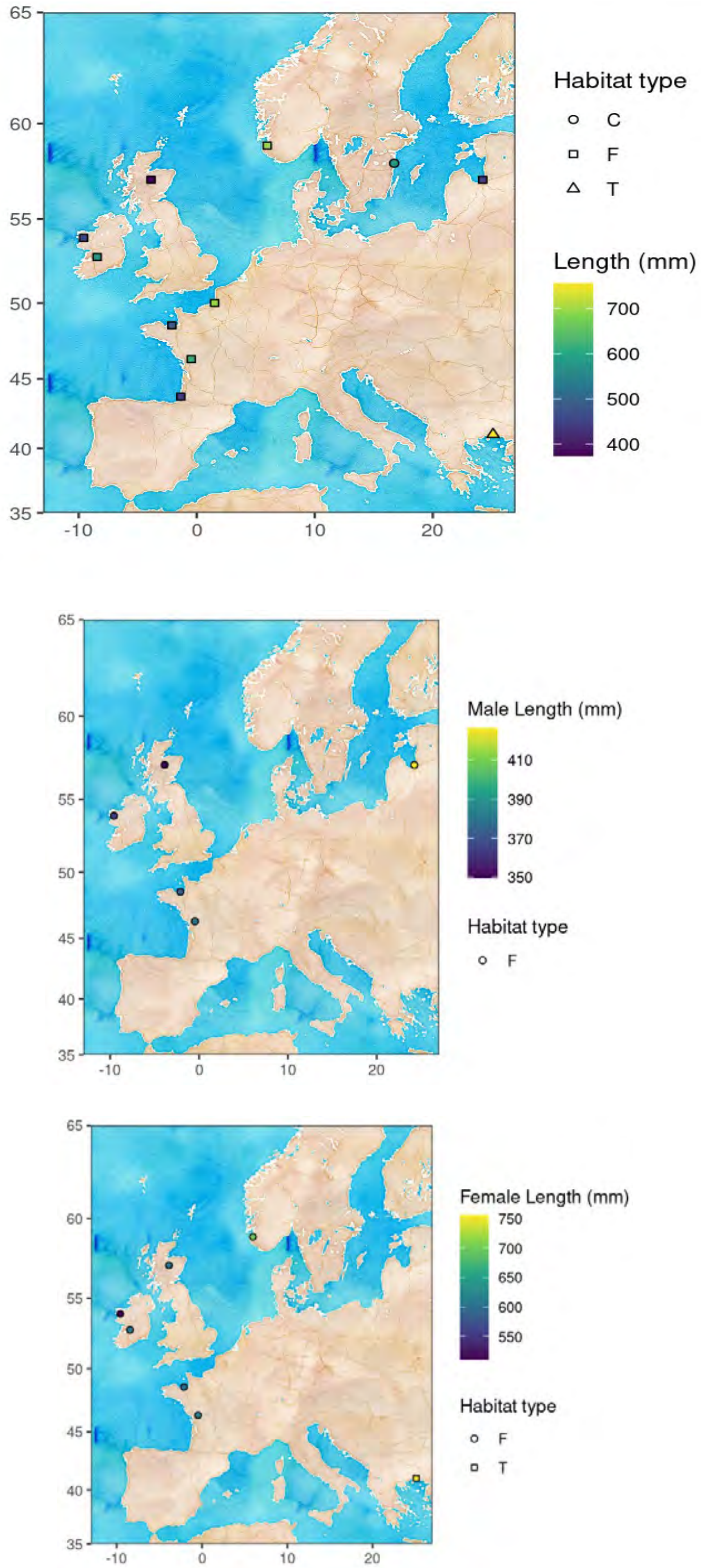

Figure 7. Average length of silver eels (upper panel). Each dot corresponds to the average value across years and time-series in a given EMU and habitat type. The length is indicated by the colour scale and the habitat type by the geometric shape. Sex-disaggregated lengths are presented in bottom panels

Results for weight are very similar than for length (Figure 8). The Kendall correlation test does not detect any significant relation with the distance to Gibraltar (tau= 0.14, p.value = 0.71). There are not enough sex disaggregated data to detect sex-specific weight pattern.

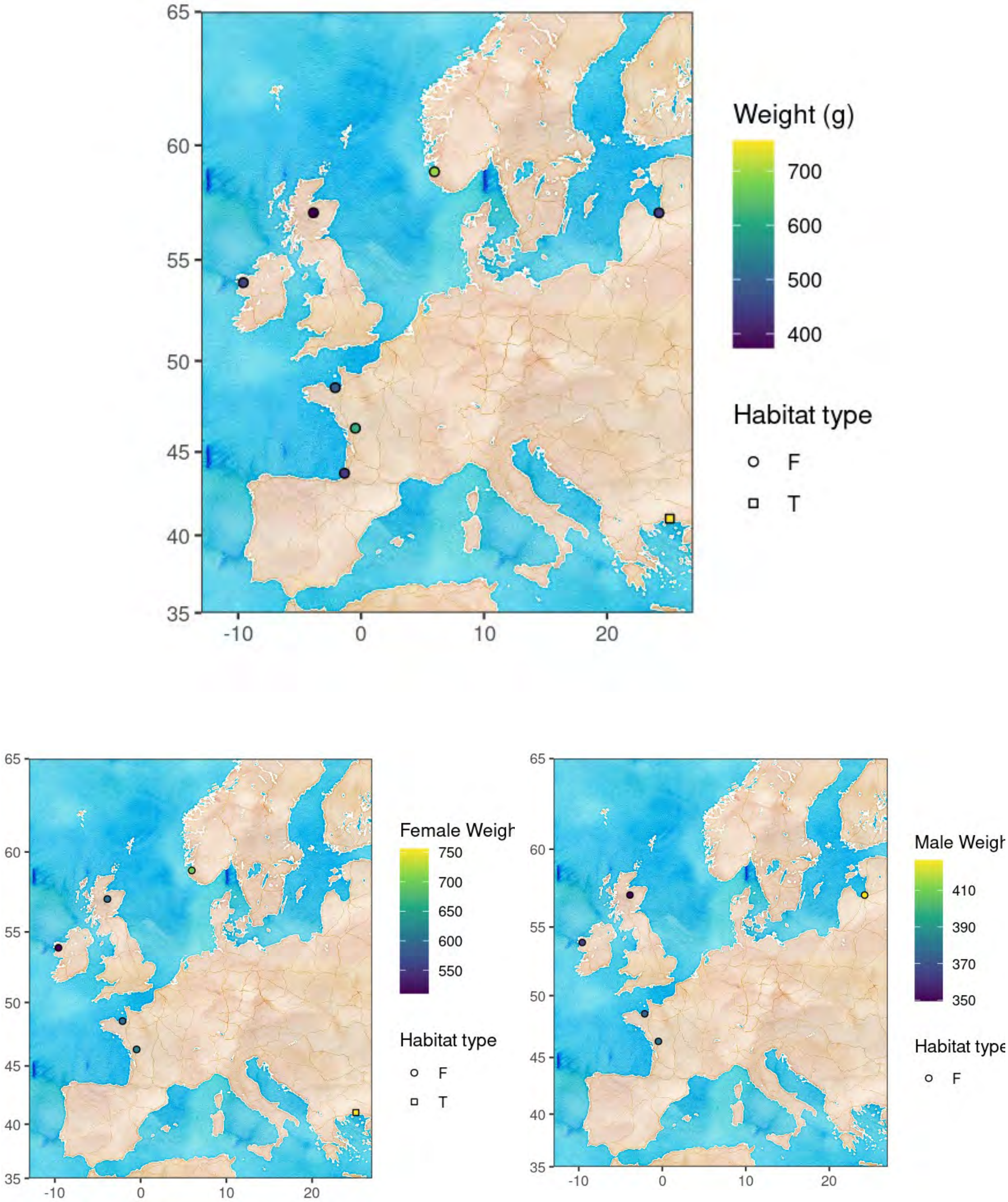

Figure 8. Average weight of silver eels (upper panel). Each dot corresponds to the average value across years and time-series in a given EMU and habitat type. The length is indicated by the colour scale and the habitat type by the geometric shape Sex-disaggregated weights are presented in bottom panels.

The relationship between length and weight differs significantly between the different silver eel series (ANCOVA: p <0.0001). (Table 5, Figure 9). However, no relationship was found between the slope of this relationship and latitude (Figure 10).

Table 5. Relation of average annual silver eel weight (log gr eel) with standard length (log mm eel). Note that the Imsa series only contains female data.

Serie	Equation	r2	*P*
BaBSF	Log weight = 4.98 log SL – 10.75	0.962	<0.0001
BurSF	Log weight = 2.83 log SL – 5.23	0.878	<0.0001
EamtST	Log weight = 3.17 log SL – 6.09	0.958	<0.0001
FreSF	Log weight = 3.30 log SL – 6.46	0.970	<0.0001
GiBSF	Log weight = 4.04 log SL – 8.44	0.998	<0.0001
ImsaSF	Log weight = 2.54 log SL – 4.40	0.930	<0.0001
NorwST	Log weight = 3.47 log SL – 6.96	0.998	<0.0001
SeNSF	Log weight = 2.94 log SL – 5.54	0.992	<0.0001
ShiSF	Log weight = 3.19 log SL -6.21	0.984	<0.0001
SouSF	Log weight = 3.91 log SL -8.10	0.987	<0.0001

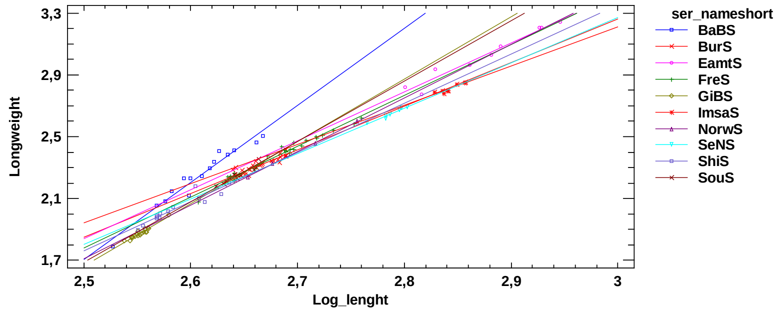

Figure 9. Relation of average annual silver eel weight (log gr eel) with standard length (log mm eel) in different sampling points (each line corresponds to a silver eel monitoring time-series). Note that the Imsa series only contains female data.

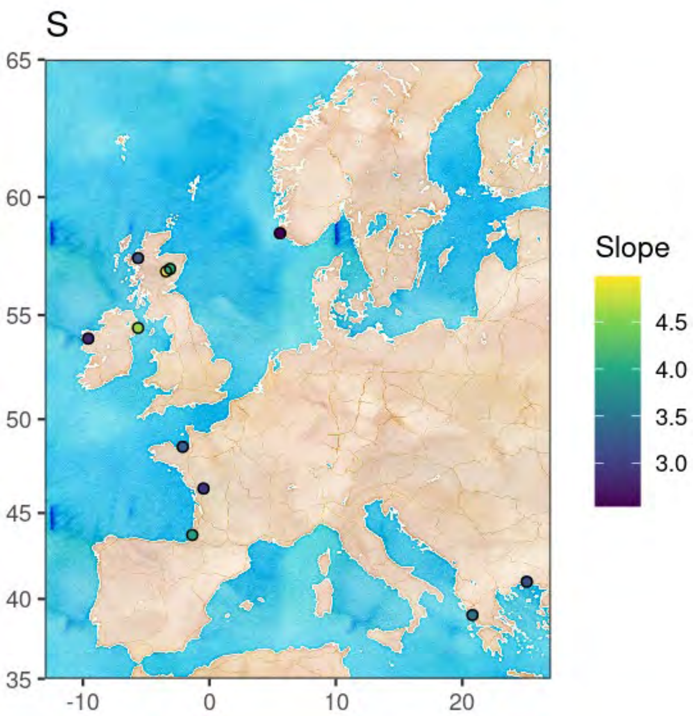

Figure 10. Slopes of length–weight regressions for different silver eel time-series in. A dot corresponds to a monitoring time-series.

9.2.2 Temporal trends in biometric parameters

In this section, the existence of temporal trends in biometry is explored.

9.2.2.1 Glass and glass/yellow recruitment series

Mean length of monitored eels has significantly increased over time in ImsaGY, BresGY and SousGY series (Table 6, Figure 11).

Table 6. Analysis of temporal trends (Mann Kendall) for glass and mixed glass/yellow series annual average length. Series with significant trends are shown in bold.

ser_nameshort	ser_hty_code	ser_lfs_code	first year	last year	tau	p.value
BannGY	F	GY	2003	2020	-0.06	0.76
BresGY	**F**	**GY**	**1994**	**2019**	**0.18**	**0.00**
ImsaGY	**F**	**GY**	**2012**	**2020**	**0.54**	**0.00**
ShiMG	T	G	2014	2020	0.33	0.37
SousGY	**F**	**GY**	**2013**	**2017**	**0.80**	**0.00**
StraGY	F	GY	2004	2015	-0.31	0.19

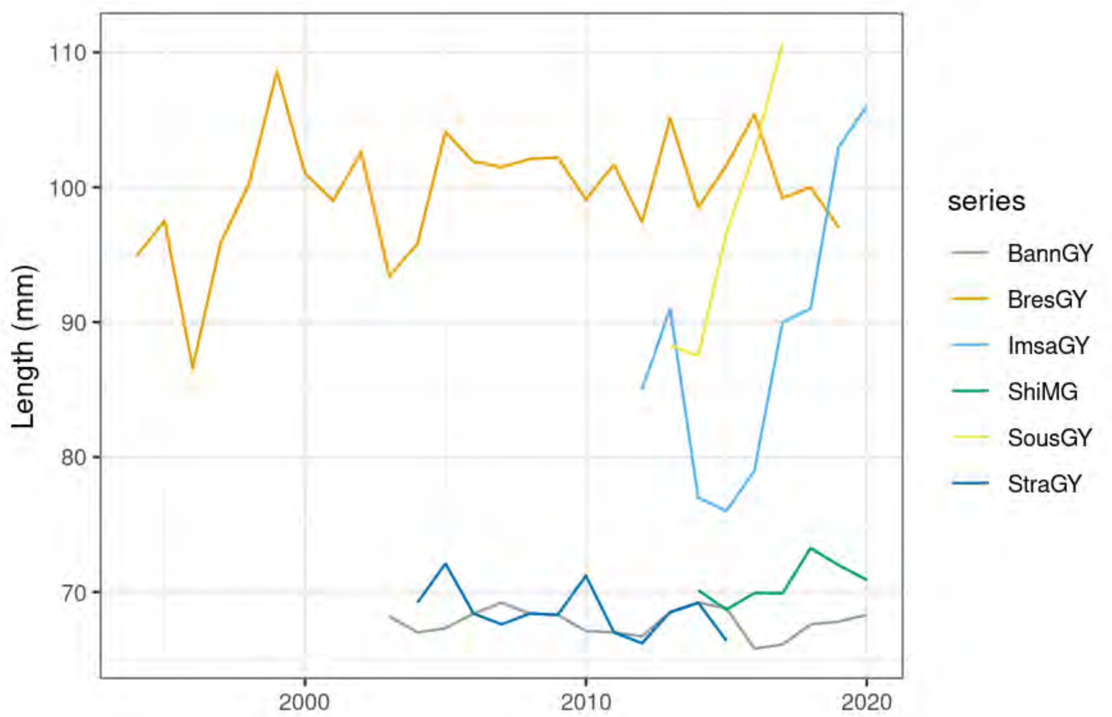

Figure 11. Glass and glass/yellow mixed series temporal trends in annual average length.

9.2.2.2 Yellow Eel

Significant trends are detected for eight EMUs over 22 (Table 7, Figure 12), with a decrease of mean length in six EMUs (ES_Basq, GB_Humb, GB_Nort, GB_Seve, GB_SouE, IE_West) and an increase in two (GB_SouW and NL_Neth).

Table 7. Analysis of temporal trends (Mann Kendall) for yellow series annual average length. Series with significant trends are shown in bold.

ser_emu_nameshort	ser_hty_code	first year	last year	tau	p.value	signif
ES_Basq	**F**	**2004**	**2019**	**-0.50**	**0.01**	**
FR_Adou	F	2010	2019	-0.16	0.59	ns
FR_Bret	F	1995	2019	0.24	0.10	ns
FR_Garo	F	2010	2018	-0.39	0.18	ns
FR_Loir	F	2002	2019	0.14	0.45	ns
FR_Sein	F	2010	2019	-0.29	0.28	ns
GB_Angl	F	1986	2019	-0.24	0.09	ns
GB_Dee	F	2002	2019	-0.03	0.95	ns
GB_Humb	**F**	**1990**	**2019**	**-0.56**	**0.00**	***
GB_Nort	**F**	**2005**	**2019**	**-0.45**	**0.03**	*
GB_NorW	F	1991	2019	-0.23	0.09	ns
GB_Scot	F	2008	2019	0.33	0.15	ns
GB_Seve	**F**	**1976**	**2019**	**-0.46**	**0.00**	***
GB_Solw	F	1995	2019	0.00	1.00	ns
GB_SouE	**F**	**2001**	**2019**	**-0.46**	**0.01**	**
GB_SouW	**F**	**1977**	**2019**	**0.32**	**0.01**	**
GB_Tham	F	1985	2019	0.01	0.95	ns
GB_Wale	F	2010	2019	0.07	0.86	ns
IE_West	F	1973	2019	-0.08	0.68	ns
IE_West	**T**	**1987**	**2019**	**-0.52**	**0.01**	**
NL_Neth	**F**	**1989**	**2019**	**0.64**	**0.00**	***
NO_total	C	1993	2018	0.26	0.11	ns

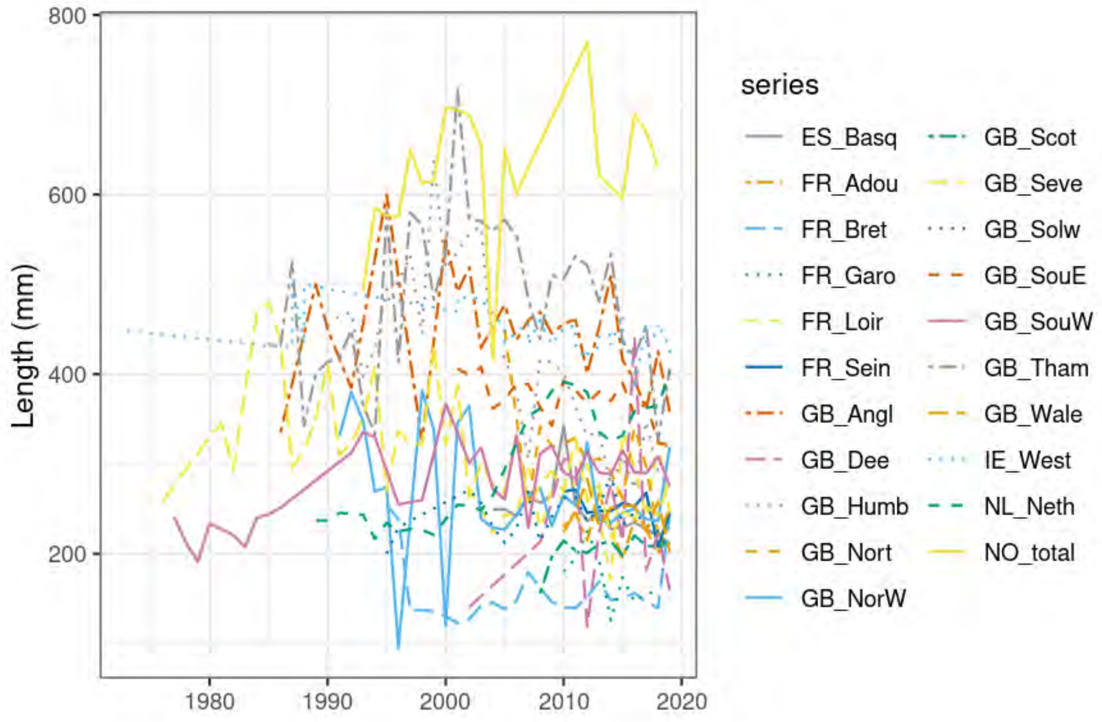

Figure 12. Yellow series temporal trends in average annual length.

For weight, significant trends are detected for seven EMUs over 20 (Table 8, Figure 13), with a decrease of mean weight in five EMUs (Es_Basq, GB_Humb, GB_Nort, GB_Seve, GB_SouE) and an increase in two (FR_Bret, GB_SouW).

Table 8. Analysis of temporal trends (Mann Kendall) for yellow series annual average weight. Series with significant trends are shown in bold.

ser_emu_nameshort	ser_hty_code	first year	last year	tau	p.value	signif
ES_Basq	**F**	**2004**	**2019**	**-0.50**	**0.01**	**
FR_Adou	F	2010	2019	-0.16	0.59	ns
FR_Bret	**F**	**1996**	**2019**	**0.41**	**0.01**	**
FR_Garo	F	2010	2018	-0.39	0.18	ns
FR_Loir	F	2002	2019	0.14	0.45	ns
FR_Sein	F	2010	2019	-0.29	0.28	ns
GB_Angl	F	1986	2019	-0.24	0.09	ns
GB_Dee	F	2002	2019	-0.03	0.95	ns
GB_Humb	**F**	**1990**	**2019**	**-0.56**	**0.00**	***
GB_Nort	**F**	**2005**	**2019**	**-0.45**	**0.03**	*
GB_NorW	F	1991	2019	-0.23	0.09	ns
GB_Scot	F	2008	2019	0.33	0.15	ns
GB_Seve	**F**	**1976**	**2019**	**-0.46**	**0.00**	***
GB_Solw	F	1995	2019	0.00	1.00	ns
GB_SouE	**F**	**2001**	**2019**	**-0.46**	**0.01**	**
GB_SouW	**F**	**1977**	**2019**	**0.32**	**0.01**	**
GB_Tham	F	1985	2019	0.01	0.95	ns
GB_Wale	F	2010	2019	0.07	0.86	ns
IE_West	F	1987	2019	0.10	0.67	ns
IE_West	T	1987	2019	-0.31	0.21	ns

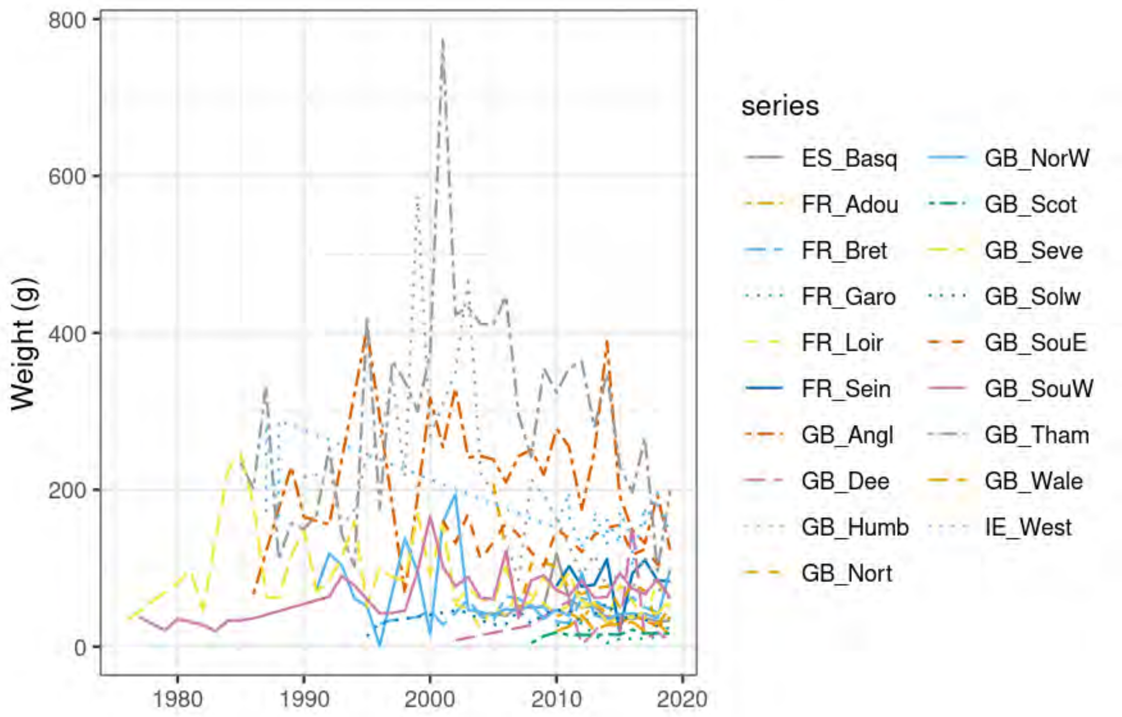

Figure 13. Yellow series temporal trends in average annual weight.

9.2.3 Silver Eel

Only those series for which information was available for both sexes have been included in this analysis.

Silver eel length has significantly increased in the FR_Bret, FR_Sein, NO_total and GB_Scot and decreased in FR_Loir FR_Adou, IE_West (Table 9, Figure 14). The trends remained significant for FR_Bret, GB_Scot, NO_total, FR_Loir and IE_West if only females where considered. All the series in which male biometrics are collected showed a significant temporal trend and those trends were the same as those for female: increased in the FR_Bret and GB_Scot and decreased in the FR_Loire and, IE_West and EMUs.

Table 9. Analysis of temporal trends (Mann Kendall) for silver annual average length per EMU. EMUs with significant trends are shown in bold

ser_emu_nameshort	ser_hty_code	sex	first year	last year	tau	p.value
FR_Adou	**F**	**Both**	**2011**	**2017**	**-0.81**	**0.02**
FR_Bret	**F**	**Both**	**1996**	**2019**	**0.72**	**0.00**
FR_Loir	**F**	**Both**	**2013**	**2019**	**-0.81**	**0.02**
FR_Sein	**F**	**Both**	**1992**	**2019**	**0.56**	**0.00**
GB_Scot	**F**	**Both**	**1966**	**2019**	**0.67**	**0.00**
GR_EaMT	T	Both	2009	2019	-0.11	0.75
IE_Shan	F	Both	2009	2019	0.60	0.22
IE_West	**F**	**Both**	**1976**	**2019**	**-0.27**	**0.03**
NO_total	**F**	**Both**	**2012**	**2019**	**0.64**	**0.04**
SE_East	C	Both	2000	2017	0.16	0.36
FR_Bret	**F**	♀	**1996**	**2019**	**0.72**	**0.00**
FR_Loir	**F**	♀	**2013**	**2019**	**-0.81**	**0.02**
GB_Scot	F	♀	**1966**	**2019**	**0.67**	**0.00**
GR_EaMT	T	♀	2009	2019	-0.11	0.75
IE_West	**F**	♀	**1976**	**2019**	**-0.27**	**0.03**
FR_Bret	**F**	♂	**1996**	**2019**	**0.72**	**0.00**
FR_Loir	**F**	♂	**2013**	**2019**	**-0.81**	**0.02**
GB_Scot	**F**	♂	**1966**	**2019**	**0.67**	**0.00**
IE_West	**F**	♂	**1976**	**2019**	**-0.27**	**0.03**

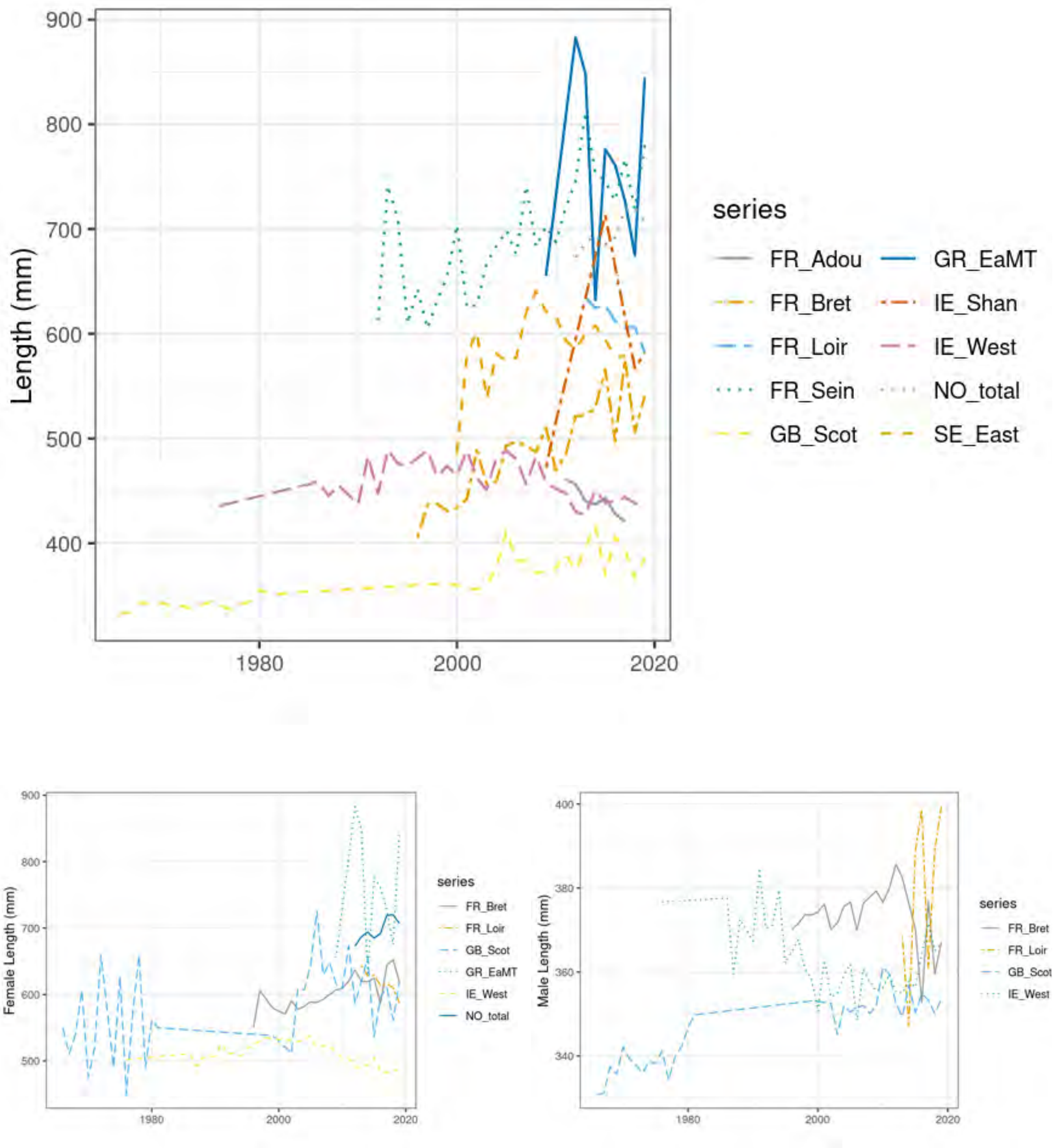

Figure 14. Silver series temporal trends in annual average annual length (above both sexes included, below per sex).

Results for weight are very similar than for length (Table 10, Figure 15). Silver eel weight has significantly increased for the last years FR_Bret and NO_total, and significantly decreased in FR_Adou and FR_Loir and IE_West series. These trends are maintained in the FR_Bret, NO_total, FR_Loir and IE_West series if female and male are considered separately. No sex-disaggregated are available for the Adour.

Table 10. Analysis of temporal trends (Mann Kendall) for annual average silver weight per EMU. EMUs with significant trends are shown in bold.

ser_emu_nameshort	ser_hty_code	sex	First year	last year	tau	p.value
FR_Adou	**F**	**Both**	**2011**	**2017**	**-0.81**	**0.02**
FR_Bret	**F**	**Both**	**1996**	**2019**	**0.72**	**0.00**
FR_Loir	**F**	**Both**	**2013**	**2019**	**-0.81**	**0.02**
GB_Scot	F	Both	2002	2019	0.22	0.23
GR_EaMT	T	Both	2009	2019	-0.11	0.75
IE_West	**F**	**Both**	**1976**	**2019**	**-0.27**	**0.03**
NO_total	**F**	**Both**	**2012**	**2019**	**0.64**	**0.04**
FR_Bret	**F**	♀	**1996**	**2019**	**0.72**	**0.00**
FR_Loir	**F**	♀	**2013**	**2019**	**-0.87**	**0.02**
GB_Scot	F	♀	2003	2019	0.12	0.54
GR_EaMT	T	♀	2009	2019	-0.11	0.75
IE_West	**F**	♀	**1976**	**2019**	**-0.27**	**0.03**
NO_total	**F**	♀	**2012**	**2019**	**0.64**	**0.04**
FR_Bret	**F**	♂	**1996**	**2019**	**0.72**	**0.00**
FR_Loir	**F**	♂	**0013**	**2019**	**-0.87**	**0.02**
GB_Scot	F	♂	2002	2019	0.22	0.23
IE_West	**F**	♂	**1976**	**2019**	**-0.27**	**0.03**

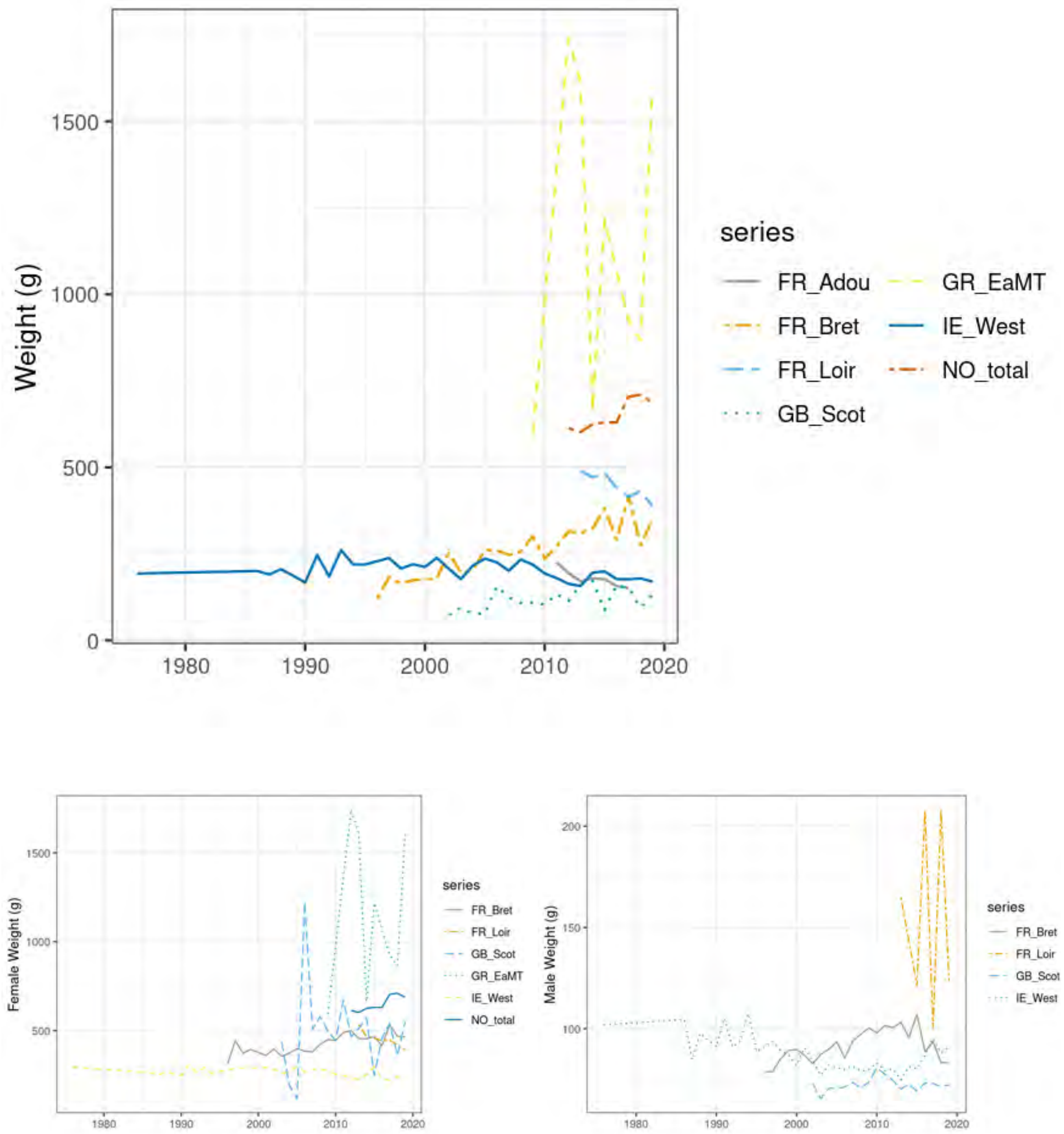

Figure 15. Silver series temporal trends in annual average weight above both sexes included, below per sex).

Four of the five analysed series showed a significant trend in sex ratio; an increasing one in FR-Bret and GB_Scot and a decreasing trend in FR_Loir and IE.West. (Table 11, Figure 16). Thus, the proportion and size of females have increased in Fr_Bret and GB_Scott while an opposite trend have occurred in FR_Loir and IE_West.

Table 11. Analysis of temporal trends (Mann Kendall) for annual average silver sex ratio (%female) per EMU. EMUs with significant trends are shown in bold

ser_emu_nameshort	ser_hty_code	first year	last year	tau	p.value	signif
FR_Bret	**F**	**1996**	**2019**	**0.72**	**0.00**	***
FR_Loir	**F**	**2013**	**2019**	**-0.81**	**0.02**	*
GB_Scot	**F**	**1966**	**2019**	**0.67**	**0.00**	***
IE_Shan	F	2009	2019	0.60	0.22	ns
IE_West	**F**	**1976**	**2019**	**-0.27**	**0.03**	*

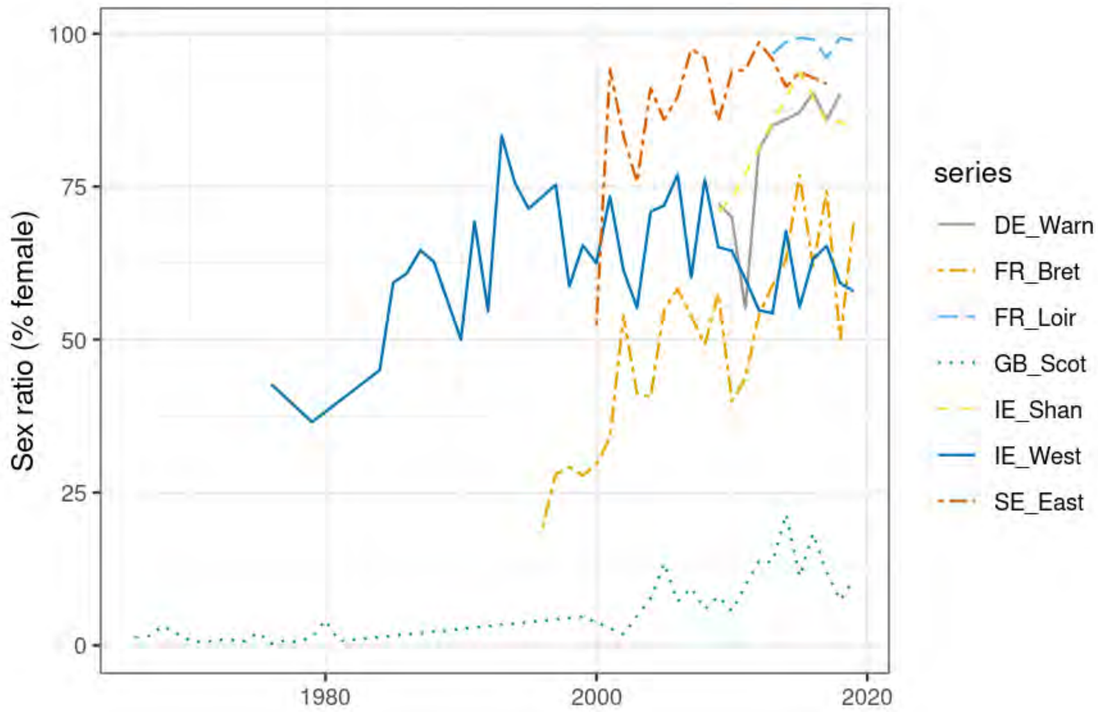

Figure 16. Analysis of temporal trends (Mann Kendall) for silver annual average sex ratio (%female) per EMU. EMUs with significant trends are shown in bold.

9.3 Conclusions and recommendations

A first exploratory spatial and temporal analysis of the data has been made that has identified some spatio-temporal trends. However, the low number of series with biometric data in some stages and lack of information about the analysed stages and insufficient details on the monitoring protocols and sites, makes it currently impossible to clearly disentangle whether those patterns arise from methodological differences among series (e.g. sampling gear, monitoring season), local environmental (e.g. habitat type, distance to the sea) or anthropogenic (e.g. restocking) influences, or large-scale life-trait patterns. Still, it has been useful to identify complementary information that must be collected in order to make a complete analysis of the data.

As far as spatial analysis is concern, there are differences among series, but no clear spatial trend was found. In the case of the length of monitored standing stock yellow eel, a positive relation of length and weight with distance to Gibraltar was found. However, no definitive conclusion can be drawn as the analysis includes average lengths obtained by different sampling methods, some of which show a bias of catching certain sizes. Thus, until the series information is completed, it remains unclear whether there is a relationship between latitude and weight and length of eels.

As far as temporal trends is concerned (Table 12), trends in length and weight have been detected in many different time-series, for each stage and EMU/series. However, the sign of the trends was variable, even for a similar life stage and in a single country. Thus, it was not possible to detect any general pattern per stage or latitude in those parameters.

Table 12. Summary of the temporal trends analysis for length, weight and silver sex ratio per stage.

	Length		weight		sex ratio	
	trend	+ trend	trend	+ trend	trend	+ trend
Glass /yellow		ImsaGY, BresGY SousGY		Imsa, Sous		
Yellow	Es Basq GB_Humb GB_North GB_Seve GB_SouE IE_West	GB_SouW and NL_Neth	Es_Basq GB_Humb GB_North GB_Seve GB_SouE	FR_Bret GB_SouW GB_Scot	Not analysed	
Silver	FR_Adou (♀+♂) FR_Loi (♀+♂) IE_West (♀+♂) FR_Loi (♀) IE_West (♀) FR_Loi (♂) IE_West (♂)	FR_Bret (♀+♂) GB_Scot (♀+♂) FR_Sein (♀+♂) FR_Bret (♀) , GB_Scot (♀) FR_Bret (♂) GB_Scot (♂) NO_total (♀)	FR_Adou (♀+♂) FR_Loi (♀+♂) IE_West (♀+♂) FR_Loi (♀) IE_West (♀) FR_Loi (♂) IE_West (♂)	FR_Bret (♀+♂) FR_Bret (♀) FR_Bret (♂) NO_total (♀)	FR_Bret (%♀) GB_Scot (%♀)	FR_Loi (%♀) IE_West (%♀)

This analysis allows to issue some recommendations:

- For those series in which a mixture of stages is reported (e.g. mixed glass eel/yellow series), an approximate percentage of each stage should be indicated.
- In the series, it must be indicated if the sampling method is considered to be causing a bias in the captured sizes.
- It is recommended to include information about the sampling timing that might influence biometrics.
- It should be indicated whether there have been changes in the series that may lead to a change in the time trend (e.g. period or sampling method).

9.3.1 References

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Dekker, W. 1998. Long-term trend in the glass eels immigrating at Den Oever, the Netherlands. Bulletin Français de Pêche et de Pisciculture 349, 199–214.

Mateo, M., Lambert, P., Tétard, S., Drouineau, H. 2017. Impacts that cause the highest direct mortality of individuals do not necessarily have the greatest influence on temperate eel escapement. Fisheries Research 193, 51–59. https://doi.org/10.1016/j.fishres.2017.03.024.

Annex 10: Recommendations

Recommendations	**Addressed to**
A workshop is required early in 2021 to draft the data call for 2021. Aligned with the EMP progress reports of the countries, the ICES data call asks for additional information (e.g. stock indicators and mortalities) every three years and hence in 2021. The aim of this workshop is to address the issues experienced in 2018 and implement additional data needs (e.g. habitat loss). Furthermore, the workshop will identify potential data needs on the impacts of contaminants of the eel stock, which will be addressed by WGEEL in 2021.	ACOM
A workshop is required as an endpoint of the 2021 data call, with data providers of the reporting countries, to facilitate the integration of data in the database through an online interface. This workshop should include a general session as well as individual guidance for the data providers.	ACOM
WGEEL recommends that the newly designed eel database is hosted by ICES, which requires the provision of a shiny interface. The database compiles all data used by WGEEL and makes them available in the form of raw data, individualized tables and graphs and provides background information. Therefore, it is considered of broad interest to stakeholders and scientists.	ICES Data Center