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Report of the Joint EIFAAC/ICES/GFCM Working Group on Eel

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Rome, Italy

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CIEM Conseil International pour l'Exploration de la Mer

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Executive summary

The Joint EIFAAC/ICES/GFCM Working Group on Eel [WGEEL] met at FAO HQ, Rome, Italy from 3–7 November 2014. The group was chaired by Alan Walker (UK) and there were 44 participants representing 20 countries, the General Fisheries Commission of the Mediterranean (GFCM) and the EU's DG MARE. Information was also provided by correspondence from Estonia and Finland for use by the Working Group.

WGEEL met to consider questions posed by ICES (in relation to the MoU between the EU and ICES), EIFAAC and GFCM and also generic questions for regional and species Working Groups posed by ICES. The terms of reference were addressed by reviewing working documents prepared ahead of the meeting as well as the development of documents and text for the report during the meeting. The work is summarised in the following points:

The WGEEL glass eel recruitment index has increased in the last three years, to 3.7% of the 1960–1979 reference level in the 'North Sea' series, and to 12.2% in the 'Elsewhere' series. The 'recruiting yellow eel' index has risen to 36% of the same reference period, from a low of 7% in 2013. The reference period for glass eel indices starts at 1960 because there is only one dataset meeting the index requirements before this year. The reference period for 'recruiting yellow eel' is set as the same years to be consistent with the glass eel indices.

Statistical analyses of recruitment indices using segmented regression ANOVA and Bayesian approaches detected a significant breakpoint (an upturn) in both North Sea and Elsewhere indices in 2011–2012. It was not possible to determine whether this upturn can be considered a trend shift, as this short positive trend could be the result of the time-series auto-correlation. However, if these positive trends are confirmed and continue in the future without any changes, the recruitment indices would be expected to exceed the reference level around 2030 in "North Sea" and 2045 in "Elsewhere" indices. Better understanding of the functioning of the population is required to make these analyses more robust. There is no statistical evidence of an upturn in the recruiting yellow eel time-series.

Following the 2012 reporting of the assessed area, the levels of silver eel escapement biomass were as follows: escaping silver eel ($B_{current}$ 12 000 t), present potential escapement in the absence of anthropogenic mortality (B_{best} 49 000 t), and 'pristine' potential escapement with no anthropogenic mortality (B_0 194 000 t). This indicates that current (2012) silver eel escapement biomass from the assessed area was at 6% of the 'pristine' state, or equal to 25% of the present potential if no anthropogenic impacts existed.

The total landings from commercial fisheries in 2013, provided in Country Reports, were 2470 t of eel. The current state of knowledge on level of underreporting, misreporting and illegal fisheries is insufficient to include these in the assessment. Catch and landings data for recreational fisheries are not consistently reported in the Country Reports: inconsistencies in environments, fishing gears, life stages sampled. Therefore, it was not possible to assess the most recent total landings and catches of recreational and non-commercial fisheries.

About 39 million glass eels and 15 million yellow eels were stocked in 2013. Aquaculture production has slowly decreased to about 5000 t in 2013. No new data on the impacts of non-fishing anthropogenic factors were available to WGEEL 2014: EU Member States will provide updates next year within their 2015 Eel Management Plan Progress Reports to the EU Commission.

The working group reviewed the life-history trait (LHT) information available in the Country Reports that would be required to conduct an eel stock assessment based on methods proposed for "Data-limited stocks" (DLS) by WKLIFE. Data were limited but large variations in LHTs were found, both for regional populations as a whole and for the sex (male, female) and eel stage (glass, yellow, silver) categories, leading the working group to tentatively conclude that DLS approaches based on LHT may not be suitable for eels. Furthermore, the working group noted that the presently adopted national and 'whole stock' spatial scales of eel assessment were more relevant than the standard ICES Ecoregions.

The data requirements for international stock assessment, the data available and the gaps in those data were reviewed by the working group. Reported commercial landings from countries that have not implemented Eel Management Plans (because they are not subject to the EC Eel Regulation) accounted for about 27 to 39% of the total reported eel catch in some years. Therefore, the addition of data from countries not covered by the stock assessment so far is urgently required, but so too are improvements in the spatial coverage and quality of data for the EU countries implementing and reporting on EMPs. The GFCM is working with the Mediterranean countries to provide their required data, with the support of the working group.

The working group reviewed the application of approaches used to estimate local or national silver eel escapement, categorised as methods based on catching and counting silver eels versus methods based on yellow eel proxies, with the latter including short descriptions of 'eel models' summarising model approach and processes, data requirements and model outputs. This review is intended as a starting point for those wishing to implement new local and national eel stock assessments.

The working group further developed the methods proposed to conduct the international, whole-stock assessment, noting that the Eel Regulation's limit for the escapement biomass of (maturing) silver eels at 40% of the natural escapement (in the absence of any anthropogenic impacts) is equivalent to the ICES B_{lim}. Given that the estimate of present silver eel escapement biomass from reporting EU countries is 6% of B_0, far below the 40% limit set by the EU Eel Regulation, the working group focussed attention on the shape of the line of the modified Precautionary Diagram below B_{lim} (i.e. 40%). The Review Group for ICES-WGEEL (2013) suggested the application of criteria for short-lived stocks (ICES 2013a), implying total anthropogenic mortality (ΣA) = 0 for $B_{current}$ <40% of B_0. The working group considered that because the spawning escapement comprises many year classes and annual perturbations in recruitment, production or spawning stock were buffered by up to 40+ year classes alive in any one year, the eel was 'long lived' in relation to ICES harvest control rules. Therefore, in the absence of indication on the required rate of stock recovery (the Eel Regulation terms it "in the long term"), and pending an improvement of the analysis of stock-and-recruit data, the working group proposed the basis of the harvest control rule for quantitative assessments (category 1), i.e. a proportional reduction in ΣA_{lim} below B_{lim} down to ΣA_{lim} = 0 at $B_{current}$ = 0. The working group noted, however, that the unusual form of the tentative stock–recruitment relationship might suggest that the mortality rate would have to reach zero at a spawning–stock biomass > 0, but the shape of the line is more important for setting advice in the immediate future than the point at which it intersects the x-axis.

A standardized assessment approach applied across the entire eel-producing countries would provide a means to address gaps in data reporting, and to examine the comparability of national estimates that are presently based on different data and analyses.

The working group reviewed and tabulated the eel- and anthropogenic-data available from eel-producing countries. The most common data available are yellow eel densities. However, these are not available from lakes, large/deep/wide river sections and transitional waters, and since these habitats can represent the majority of the wetted area in an EMU, this will require new methods to convert catch per unit effort data to density data. The working group proposed a coordinated research program to develop this standardised / cross-calibrating assessment method.

The working group recommended the creation of a digitised data reporting database, to make the preparation of assessments more efficient, to provide a readily accessible historical archive, and to facilitate national reporting to all international fora (e.g. ICES, EU, CITES, DCF). The long-term objective of such standardization is to facilitate the creation of an international database of eel stock parameters updated annually. The working group catalogued the existing eel databases (recruitment, POSE, eel quality) and developed a structured plan for storing data within the ICES Data Portal.

The working group catalogued the variety of management measures that are being implemented within the national and local Eel Management Plans. These actions were categorised as those relating to commercial fisheries; recreational fisheries; hydropower and obstacles; habitat improvement; stocking; and, others. This catalogue is intended as a starting reference for those wishing to implement new programs of management measures.

1 Introduction

1.1 Main tasks

The Joint EIFAAC/ICES/GFCM Working Group on Eel [WGEEL] (chaired by: Alan Walker, UK) met at FAO HQ in Rome, Italy between 3–7 November 2014 to consider (a) terms of reference (ToR) set by ICES, EIFAAC and GFCM in response to the request for Advice from the EU (through the MoU between the EU and ICES), EIFAAC and GFCM, and (b) relevant points in the Generic ToRs for Regional and Species Working Groups.

The meeting was preceded by a Task Leaders coordination meeting on Sunday 2 November and the full meeting was opened at 09:00 am on Monday 3 November (the meeting agenda is provided in Annex 7). The terms of reference were met. The report chapters are linked to ToR according to the following structure:

The report chapters are linked to ToR (as indicated in the table below) but the order that they are presented in the report is slightly different from the order of the ToR. The main body of the report is structured in three parts: description of the data and trends used in the present assessment of stock status (Chapter 2); development of the assessment method (Chapters 3 to 8); and, management options (Chapter 9).

ToR a)	Assess the latest trends in recruitment, stock and fisheries, including effort, and other anthropogenic factors indicative of the status of the stock, and report on the state of the international stock and its mortality	Chapter 2
ToR b)	Review the life-history traits and mortality factors by ecoregion	Chapter 6
ToR c)	Overview of available data and gaps for stock assessment	Chapter 4
ToR d)	Identification of suitable tools (models, reference points etc) in both data rich and data poor situations	Chapter 5
ToR e)	Further develop the stock–recruitment relationship and associated reference points, using the latest available data	Chapter 3
ToR f)	Explore the standardization of methods for data collection, analysis and assessment, and work with ICES DataCentre to develop a database appropriate to eel along ICES standards (and wider geography)	Chapter 7&8
ToR g)	Provide guidance on management measures that can be applied to both EU and non-EU waters	Chapter 9
ToT h)	Address the generic EG ToR from ACOM	Annex 3

The responses to the recommendations of the Review Group of the 2013 (the Technical Minutes, Annex 9 of the 2013 report) are provided in Annex 7.

In response to the ToR, the Working Group considered 18 Country Report Working Documents submitted by participants (Annex 10); other references cited in the Report are given in Annex 1. Additional information was supplied by correspondence, by those Working Group members unable to attend the meeting. A glossary of terms and list of acronyms used within this document is provided in Annex 9.

1.2 Participants

Forty-four experts attended the meeting, representing 20 countries, the EU DG MARE and the Secretariat of the General Fisheries Commission of the Mediterranean (GFCM). A full address list for the meeting participants is provided in Annex 2. Albania, Montenegro, Tunisia and Turkey were represented at the working group for the first time.

1.3 The European eel: life history and production

The European eel (*Anguilla anguilla*) is distributed across the majority of coastal countries in Europe and North Africa, with its southern limit in Mauritania (30°N) and its northern limit situated in the Barents Sea (72°N) and spanning all of the Mediterranean basin. Commission Decision 2008/292/EC of 4 April 2008 established that the Black Sea and the river systems connected to it did not constitute a natural eel habitat for European eel for the purposes of the Regulation establishing measures for the recovery of the stock of European eel (EC 1100/2007: European Council, 2007).

European eel life history is complex and atypical among aquatic species, being a long-lived semelparous and widely dispersed stock. The shared single stock is genetically panmictic and data indicate the spawning area is in the southwestern part of the Sargasso Sea and therefore outside Community Waters. 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 could exceed 50 years) prior to metamorphosis to the silver eel stage and maturation. Age-at-maturity varies according to temperature (latitude and longitude), ecosystem characteristics, and density-dependent processes. The European eel life cycle is shorter for populations in the southern part of their range compared to the north. Silver eels then migrate to the Sargasso Sea where they spawn and die after spawning, an act not yet witnessed in the wild.

The amount of glass eel arriving in continental waters declined dramatically in the early 1980s, with time-series indices (see below for further detail) reaching minima in 2011 of less than 1% in the continental North Sea and less than 5% elsewhere in Europe compared to the means for 1960–1979 levels (ICES, 2011a). The reasons for this decline are uncertain but may include overexploitation, pollution, non-native parasites and other diseases, migratory barriers and other habitat loss, mortality during passage through turbines or pumps, and/or oceanic-factors affecting migrations. These factors will have been more or less important on local production throughout the range of the eel, and therefore management has to take into account the diversity of conditions and impacts in Community Waters, in the planning and execution of measures to ensure the protection and sustainable use of the population of European eel. The recruitment indices have increased in the most recent three years, but only so far to about 4 and 12% of the mean levels of the 1960–1979 reference period.

1.4 Anthropogenic impacts on the stock

Anthropogenic mortality may be inflicted on eel by fisheries (including where catches supply aquaculture for consumption), hydropower turbines and pumps, pollution and indirectly by other forms of habitat modification and obstacles to migration.

Fisheries exploit the phase recruiting to continental waters (glass eel), the immature growth phase (yellow eel) and the maturing phase (silver eel). Fisheries are prosecuted by registered and non-registered vessels, or fisheries not linked to vessels, such as fixed traps, fixed net gears, mobile (bank-based) net gears, and rod and line. The exploited life stage and the gear types employed vary between local habitat, river, country and international regions.

1.5 The management framework of eel

1.5.1 EU and Member State waters

Given that the European eel is a panmictic stock with widespread distribution, the stock, fisheries and other anthropogenic impacts, within EU and Member State waters, are currently managed in accordance with the European Eel Regulation EC No 1100/2007, "*establishing measures for the recovery of the stock of European eel*" (European Council, 2007). This regulation sets a framework for the protection and sustainable use of the stock of European eel of the species *Anguilla anguilla* in Community Waters, in coastal lagoons, in estuaries, and in rivers and communicating inland waters of Member States that flow into the seas in ICES Areas III, IV, VI, VII, VIII, IX or into the Mediterranean Sea.

The Regulation sets the national management objectives for Eel Management Plans (EMPs) (Article 2.4) 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 EMP shall be prepared with the purpose of achieving this objective in the long term." Each EMP constitutes a management plan adopted at national level within the framework of a Community conservation measure as referred to in Article 24(1)(v) of Council Regulation (EC) No 1198/2006 of 27 July 2006 on the European Fisheries Fund, thereby meaning that the implementation of management measures for an EMP qualifies, in principal, for funding support from the EFF.

The Regulation sets reporting requirements (Article 9) such that Member States must report on the monitoring, effectiveness and outcomes of EMPs, including the proportion of silver eel biomass that escapes to the sea to spawn, or leaves the national territory, relative to the target level of escapement; the level of fishing effort that catches eel each year; the level of mortality factors outside the fishery; and the amount of eel less than 12 cm in length caught and the proportions utilized for different purposes. These reporting requirements were further developed by the Commission in 2011/2012 and published as guidance for the production of the 2012 reports. This guidance adds the requirement to report fishing catches (as well as effort), and provides explanations of the various biomass, mortality rates and stocking metrics, as follows:

- Silver eel production (biomass):
    - B_0 The amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the stock;
    - $B_{current}$ The amount of silver eel biomass that currently escapes to the sea to spawn;
    - 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.
- Anthropogenic mortality (impacts):
    - ΣF The fishing mortality rate, summed over the age-groups in the stock, and the reduction effected;

  - ΣH The anthropogenic mortality rate outside the fishery, summed over the age-groups in the stock, and the reduction effected (e.g. turbines, parasites, viruses, contaminants, predators, etc);
  - ΣA The sum of anthropogenic mortalities, i.e. ΣA = ΣF + ΣH. It refers to mortalities summed over the age-groups in the stock.
- Stocking requirements:
  - R(s) The amount of eel (<20 cm) restocked into national waters annually. The source of these eel should also be reported, at least to originating Member State, to ensure full accounting of catch vs stocked (i.e. avoid 'double banking'). Note that R(s) for stocking is a new symbol devised by the Workshop to differentiate from "R" which is usually considered to represent Recruitment of eel to continental waters.

In July 2012, Member States first reported on the actions taken, the reduction in anthropogenic mortalities achieved, and the state of their stock relative to their targets. In May 2013, ICES evaluated these progress reports in terms of the technical implementation of actions (ICES 2013a). In October 2014, the EU Commission reported to the European Parliament and the Council with a statistical and scientific evaluation of the outcome of the implementation of the Eel Management Plans. In 2015 and 2018, EU Member States will again report on progress with implementing their EMPs.

1.5.2 Non-EU states

The Eel Regulation 1100/2007 only applies to EC Member States but the eel distribution extends much further than this. The whole-stock (international) assessment (see Section 1.5) requires data and information from both EU and non-EU countries producing eels. Some non-EU countries provide such data to the WGEEL and more countries are being supported to achieve this through efforts of the General Fisheries Commission of the Mediterranean (GFCM).

The GFCM is currently undertaking a series of case studies to develop regional multi-annual management plans for shared stocks. Priority fisheries include the case of European eel which is shared by all countries in the region. A technical document was produced in 2014, with the assistance of national focal points on eel, which gathers the state of the art in terms of data availability, management measures in force, fishery description, biological parameters and stock status (where available). GFCM Member countries have requested the GFCM Secretariat to produce guidelines to improve the assessment and management of this important fishery. The participation of GFCM in the Joint EIFAAC/ICES/GFCM WGEEL has contributed to strengthen collaboration with ICES and EIFAAC experts whose availability and willingness to cooperate is very much appreciated. The next meeting of the GFCM Scientific Advisory Committee (SAC) in March 2015 will discuss and eventually approve the plan of action outlined during the 2014 WGEEL meeting. The inclusion of this action plan for eel in the work program of SAC for the next year will allow the search for supporting funds, if possible with the assistance of EU.

1.5.3 Other international legislative drivers

The European eel was listed in Appendix II of the Convention on International Trade in Endangered Species (CITES) in 2007, although it did not come into force until March 2009. Since then, any international trade in this species needs to be accompanied by a permit. All trade into and out of the EU is banned, but trade from non-EU range States to non-EU countries is still permitted.

The International Union for the Conservation of Nature (IUCN) has assessed the European eel as 'critically endangered' on its Red List, in 2009 and again in 2014 although recognising that " if the recently observed increase in recruitment continues, management actions relating to anthropogenic threats prove effective, and/or there are positive effects of natural influences on the various life stages of this species, a listing of Endangered would be achievable" and therefore "strongly recommend an update of the status in five years".

Most recently, the European eel has been added to Appendix II of the Convention on Migratory Species (CMS), whereby Parties (covering almost the entire distribution of European eel) to the Convention call for cooperative conservation actions to be developed among Range States.

1.6 Assessments to meet management needs

The EC obtains recurring scientific advice from ICES on the state of the eel stock and the management of the fisheries and other anthropogenic factors that impact it, as specified in the Memorandum of Understanding between EU and ICES. In support of this advice, ICES is asked to provide the EU with estimates of catches, fishing mortality, recruitment and spawning stock, relevant reference points for management, and 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 EU is required to arrange – through Member States or directly – for any data collected both through the Data Collection Framework (DCF) and legally disposable for scientific purposes to be available to ICES.

ICES requests information from national representatives to the joint EIFAAC/ICES/GFCM Working Group on Eel (WGEEL) on the status of national eel production each year, and ICES provides assessments at regional and whole-stock levels.

Complexities of the eel life history across the continental range of production, and limited knowledge and data of production and impacts for large parts of this distribution, make it very difficult to apply a classical fisheries stock assessment based on the principles of a stock–recruitment relationship (but see below) and the assumption that mortality due to fishing far outweighs other anthropogenic and natural mortalities. Therefore, the ICES advice has, to date, been based on a time-series of recruitment indices from fishery-dependent and -independent sources, comparing index levels in recent years with those of a historic reference period and expressing the former as a proportion of the latter.

Looking to the future, the regular provision by EU Member States of estimates of escapement biomass and rates of mortality associated with anthropogenic impacts as part of the process of EMP Review, and similar but voluntary reporting by non-EU countries producing eels, provides a means of international eel assessment.

The status of eel production in EMUs is assessed by national or sub-national fishery/environment management agencies to meet the terms of the national EMPs. The setting for data collection varies considerably between countries, depending on the management actions taken, the presence or absence of various anthropogenic impacts, but also on the type of assessment procedure applied. Additionally, the assessment framework varies from area to area, even within a single country. Accordingly, a range of methods may be employed to establish silver eel escapement limits (40% of B_0) and management targets for individual rivers, EMUs and nations, and for assessing compliance of current escapement ($B_{current}$) with these limits/targets. These methods require data on various combinations of catch, recruitment indices, length/age structure, recruitment, abundance (as biomass and/or density), length/age structure, maturity ogives, to estimate silver eel biomass, and fishing and other anthropogenic mortality rates.

The ICES Study Group on International Post-Evaluation of Eel (SGIPEE) (ICES 2010b, 2011b) and WGEEL (ICES 2010a, 2011b) derived a framework for *post hoc* summing up of EMU / national 'stock indicators' of silver eel escapement biomass and anthropogenic mortality rates. This approach was first applied by WGEEL in 2013 based on the national stock indicators reported by EU Member States in 2012 in their first EMP Progress Reports. However, not all countries with EMPs reported. The approach will be applied again in 2015, after the Member States provide their second EMP progress reports, and hopefully with the addition of data from non-EU countries as well to increase the spatial coverage of data for this assessment approach.

The working group is also developing the application of the 'traditional' Stock–Recruitment (S–R) relationship and associated reference points, as the S–R relationship remains a key function for the study of population dynamics in the perspective of management advice. The ultimate objective is a method to derive biological reference points adapted specifically to the European eel.

The actual spawning–stock biomass (in the Sargasso Sea) has never been quantified, so the best available proxy time-series is the quantity of silver eel that leaves continental waters to migrate to the spawning grounds; hereafter termed the 'escapement biomass'. As escapement biomass has only been reported by EU Member States once, in 2012, and not yet reported by non-EU states, WGEEL has attempted to derive historic time-series of stock-wide escapement from landing statistics. In the absence of stock-wide quantification of recruitment, the working group has applied an index of glass eel recruitment to continental waters, lagged by two years to account for the presumed transit time of eel 'larvae' between spawning area and continental waters. The classical Ricker and Beverton and Holt approaches to describe S–R relationships do not provide a good fit to these eel 'data'. The working group continues to explore ways to describe these data, most recently using data-driven General Additive Model (GAM) approach, and fit eel-specific reference points.

1.7 Conclusion

This report of the joint EIFAAC/ICES/GFCM Working Group on Eel is a further step in an ongoing process of documenting the stock of the European eel, and associated fisheries and other anthropogenic impacts, and developing methodology for giving scientific advice on management to effect a recovery in the international, panmictic stock.

The MoU between the EU and ICES requires an assessment of the status of the eel stock every year. As recruitment and landings data are reported to the working group every year, these form the basis of the annual assessment. New national biomass and anthropogenic mortality stock indicators are scheduled to be available in 2015, 2018 and every six years thereafter.

2 ToR a): Assess the latest trends in recruitment, stock and fisheries, including effort, and other anthropogenic factors indicative of the status of the stock, and report on the state of the international stock and its mortality

The purpose of this chapter is to provide the information for the international stock assessment in support of the ICES Advice. Sections 2.1 and 2.2 provide updates on trends in recruitment indices, and yellow and silver eel abundance information, respectively. Section 2.1 includes an examination of methods to test for significant changes in these trends. Sections 2.3, 2.4 and 2.5 provide information on commercial landings, recreational fisheries, and first attempts by the working group to summarise information on misreporting of catches and estimates of illegal catches. Section 2.6 updates information on eel stocking and 2.7 on eel aquaculture. The chapter concludes with a first attempt to collate information on the potential environmental drivers on the stock, followed by the tables for the chapter.

2.1 Recruitment trends

2.1.1 Time-series available

The recruitment 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 (Figure 2.1). The stages are categorized as glass eel, young small eel and larger yellow eel recruiting to continental habitats. The WGEEL is currently also building up data from yellow eel series, but these are related to standing stock. The yellow eel series used there all come from trapping ladders.

Figure 2.1. Location of the eel recruitment monitoring sites in Europe, circle = glass eel (white), glass eel and young yellow eels (blue), yellow diamond = yellow eel series. The lines show the different Eel Management Units in Europe.

The glass eel recruitment series have also been classified according to two areas: North Sea and Elsewhere Europe, as it cannot be ruled out that the recruitment to the two areas have different trends (ICES, 2010b). The Baltic area does not contain any pure glass eel series. The yellow eel recruitment series are either comprised of a mixture of glass eel and young yellow eel, or as in the Baltic, of young yellow eel only.

The WGEEL has collated information on recruitment in 52 time-series. The series code, name, comments about the data collection method, the international region, whether they are part of the North Sea or Elsewhere series, the country, EMU, river, location, sampling type, data units, life stages sampled, first and last year of data, whether they are active in the year of assessment, and whether or not there are missing data in the series, are all fully described in electronic Table E2.1 available on the working group web page.

Some series date back as far as 1920 (glass eel, Loire, France) and even to the beginning of 20th century (yellow eel, Gota Alv, Sweden). The status of the series can be described as following:

- 38 time-series were updated to 2014 (29 for glass eel or glass + yellow, and nine for yellow eel (Table 2.1).
- three series (one for glass eel and two for yellow eel) have been updated to 2013 only (Table 2.2).
- Some of the series have been stopped, as the consequence of a lack of recruits in the case of the fishery-based surveys (Ems in Germany, 2001; Vidaa in

Denmark, 1990), as a consequence of a lack of financial support (the Tiber in Italy, 2006), or from 2008 to 2011, as a consequence of the introduction of a new quota system and incomplete geographical reporting for the five fishery based French series (Table 2.3).

The number of available series has declined from a peak of 33 series in 2008 for the glass eel, and glass eel and young yellow eel series. The maximum number of yellow eel series increased to 12 in 2009 (Figure 2.2). Before 1960, the number of glass eel or glass eel + yellow eel series, which will be used to build the WGEEL recruitment index for glass eel, is quite small, with six series before 1959 (Figure 2.2). Those are Den Oever (scientific survey), the Loire (total catch), the Ems (mixture of catch and trap and transport), the Gironde (total catch), the Albufera de Valencia in the Mediterranean, and the Adour, which dates as far back as 1928, and is based on cpue. For the latter however, only the years 1928 to 1931 are available and the series only resumes in 1966.

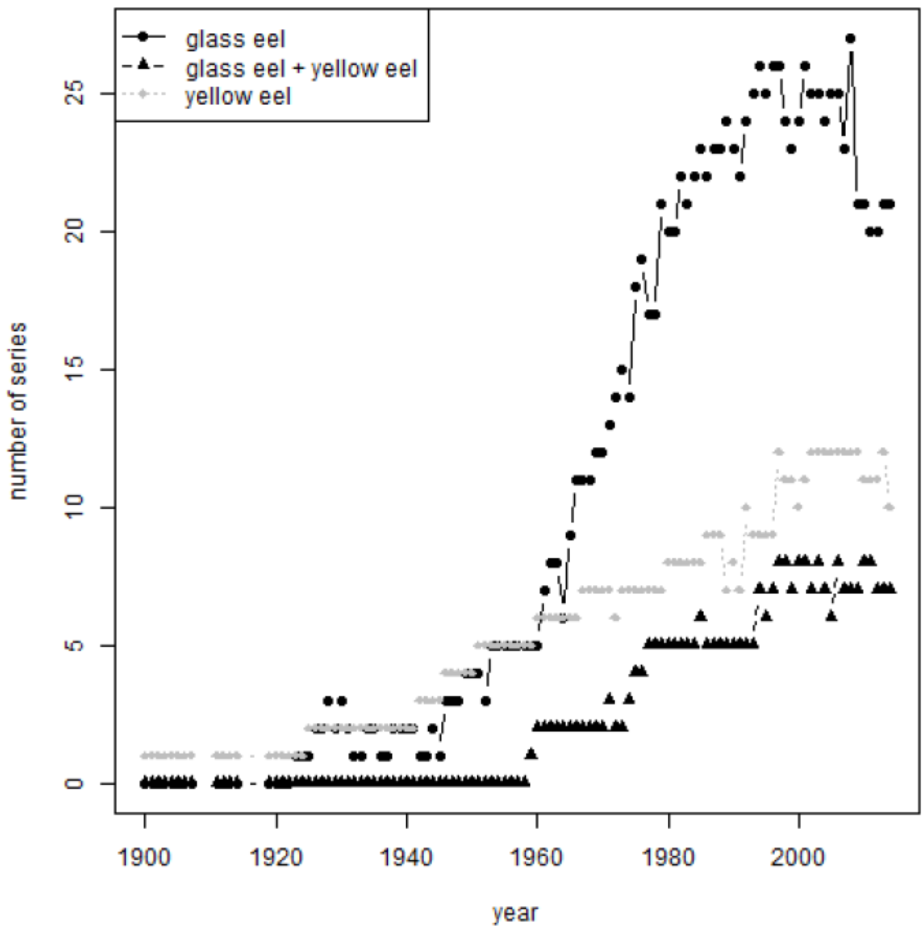

Figure 2.2. Trend in number of series giving a report any specific year, data split per life stage.

2.1.2 Simple geometric means

The calculation of the geometric mean of all series show that the recruitment is increasing in 2014 from a minimum in 2009 (Figures 2.3 and 2.4). Figure 2.3, although consistent with the trend provided by WGEEL since 2002, might be biased by the loss of most Bay of Biscay series from 2008 to 2012. The scaling is performed on the 1979–1994 average of each series, and seven series without data during that period are excluded from the analysis[1]. This scaling is simply to standardise the series so that they can all be presented on the same y-axis, and this period of years is not presented as a reference time period.

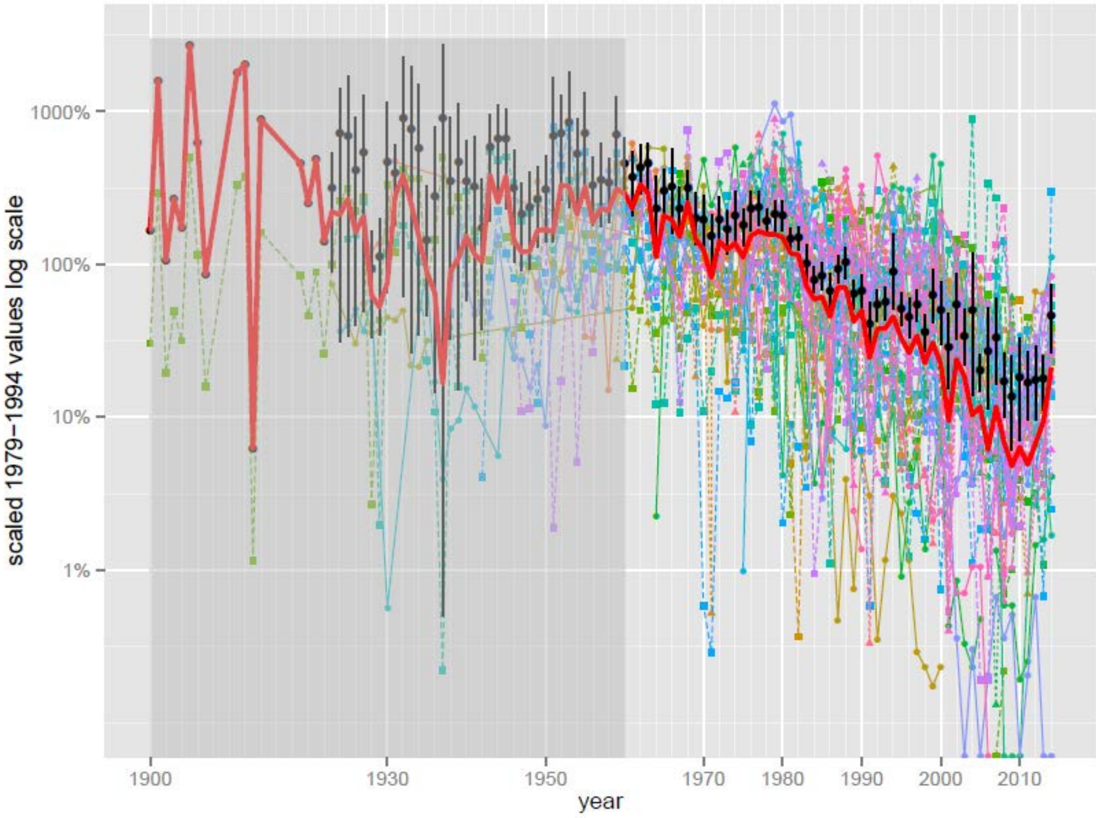

Figure 2.3. Time-series of glass eel and yellow eel recruitment in European rivers with dataseries having data for the 1979–1994 period (45 sites). Each series has been scaled to its 1979–1994 average, for illustrative purposes. Note the logarithmic scale on the y-axis. The mean values and their bootstrap confidence interval (95%) are represented as black dots and bars. Geometric means are presented in red. The shaded values correspond to pre-1960 where the number of glass eel dataseries available is lower and will not be included in the calculation of the reference period.

When looking at the separate trends for both glass eel and yellow eel series, as introduced by the WGEEL in 2006 (ICES, 2006), the increase seems mostly due to glass eel series which show a positive trend from 2011 while yellow eel series show a wider variation, and a large surge in 2014, that remains to be confirmed. Note that no lag was added to the yellow eel series but that the age of yellow eels might range from one to several years old (Figure 2.4).

Following the recommendation of RGEEL (ICES, 2013b: Minutes of the Technical Review), in 2014 the same figure is built from all series available, and a new scaling based on the 2000–2010 (included) was performed. This leaves out two series: Vida and YFS1. The scale from this graph shows an increase from the current level (1) to around a 100

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[1] [1]the series left out are : Bres, Fre, Inag, Klit, Maig, Nors, Sle.

times that value in the 1970s, and more than 100 times that level before the 1970s for the longest series (Figure 2.5).

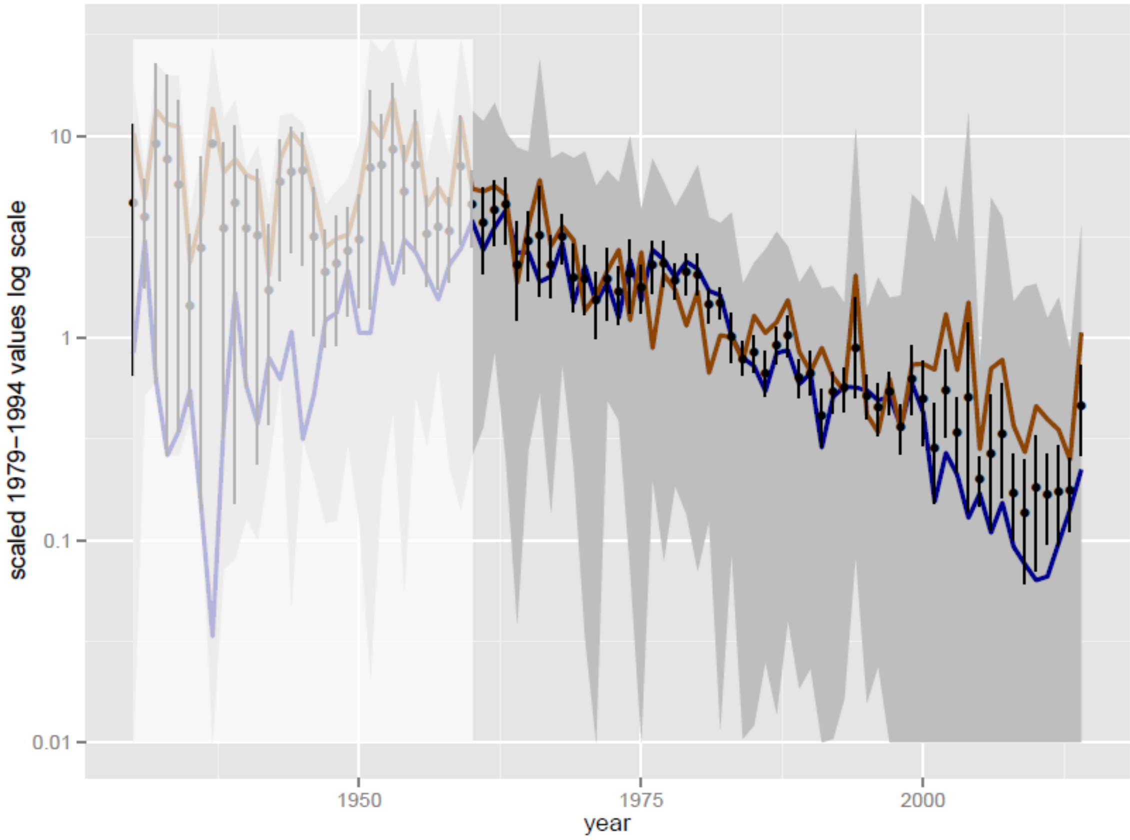

Figure 2.4. Time-series of glass eel and yellow eel recruitment in Europe with 45 series out of 52 available to the working group. Each series has been scaled to its 1979–1994 average. The mean values of combined yellow and glass eel series and their bootstrap confidence interval (95%) are represented as black dots and bars[2]. The brown line represents the mean value for yellow eel, the blue line represents the mean value for glass eel series. The range of the series is indicated by a grey shade. The time period 1900–1950 that will not be used to calculate the reference is shaded in white. Note that individual series from Figure 4.3 were removed for clarity. Note also the logarithmic scale on the y-axis.

[2] This is the same as in Figure 4.3.

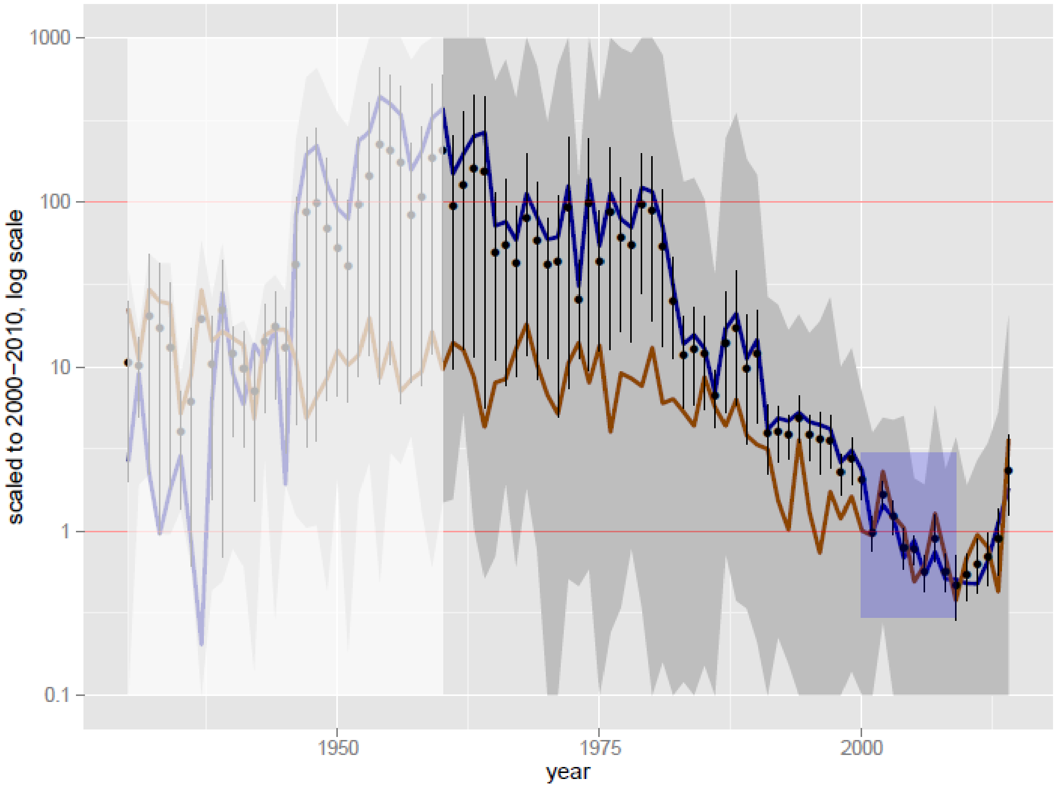

Figure 2.5. Time-series of glass eel and yellow eel recruitment in Europe. Same graph as Figure 4.4 but the series have been scaled to their 2000–2009 average (blue box). Two series[3] have been excluded from the initial number (52) that did not have data in the period 2000–2009. The mean values of combined yellow and glass eel series and their bootstrap confidence interval (95%) are represented as black dots and bars. The brown line represents the mean value for yellow eel, the blue line represents the mean value for glass eel series. The range of the series is indicated by a grey shade. Note the logarithmic scale on the y-axis.

2.1.3 GLM based trend

The WGEEL recruitment index is a reconstructed prediction using a simple GLM (Generalised Linear Model): *glass eel ~ year : area + site*, where glass eel is individual glass eel series, site is the site monitored for recruitment and area is either the North Sea or Elsewhere Europe. The GLM uses a gamma distribution and a log link. The dataseries comprising only glass eel, or a mixture of glass eel and what is mostly young of the year eel are grouped and later labelled glass eel series.

In the case of yellow eel series, only one estimate is provided: *yellow eel ~ year + site*.

The trend is reconstructed using the predictions from 1960 for 40 glass eel series and for 12 yellow eel series. This analysis rebuilds all the series by extrapolating the missing values. The series are then averaged. Some zero values have been excluded from the GLM analysis: 12 for the glass eel model and one for the yellow eel model (see Table E2-1).

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[3] Vidaa and YFS1.

The reference period for pre-1980 recruitment level is 1960–1979, as four series available from 1950 to 1960 are excluded because they were based on total catch of commercial glass eel, which are known to have been affected by changes in fishing practises, and the progressive shift from hand nets to push net fisheries from 1940 to 1960 (Briand *et al.*, 2008: see paragraph 24.1.1). After 1960, the number of available series increases rapidly (Figure 2.2). Though no such biases are known for the yellow series recruitment series, the same reference period has been chosen, to provide consistent results.

After high levels in the late 1970s, there has been a rapid decrease in the glass eel recruitment trends (Figures 2.6 and 2.7; note the logarithmic scales).

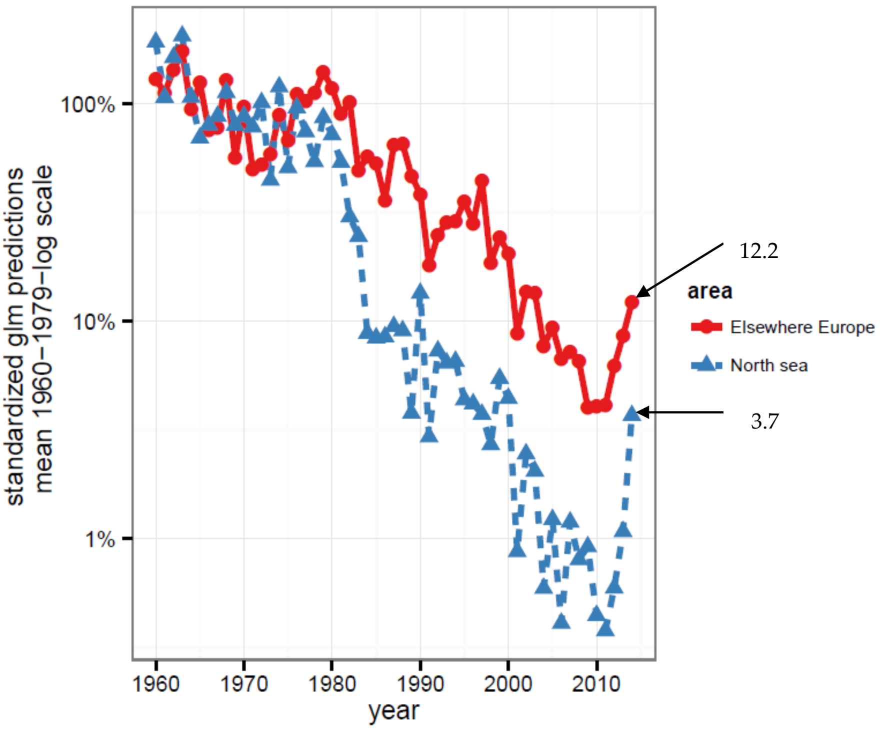


Figure 2.6. WGEEL recruitment index: mean of estimated (GLM) glass eel recruitment for the continental North Sea and elsewhere in Europe updated to 2014. The GLM (recruit = area: year + site) was fitted on 40 series comprising either pure glass eel or a mixture of glass eels and yellow eels and scaled to the 1960–1979 average. No series are available for glass eel in the Baltic area. Note the logarithmic scale on the y-axis.

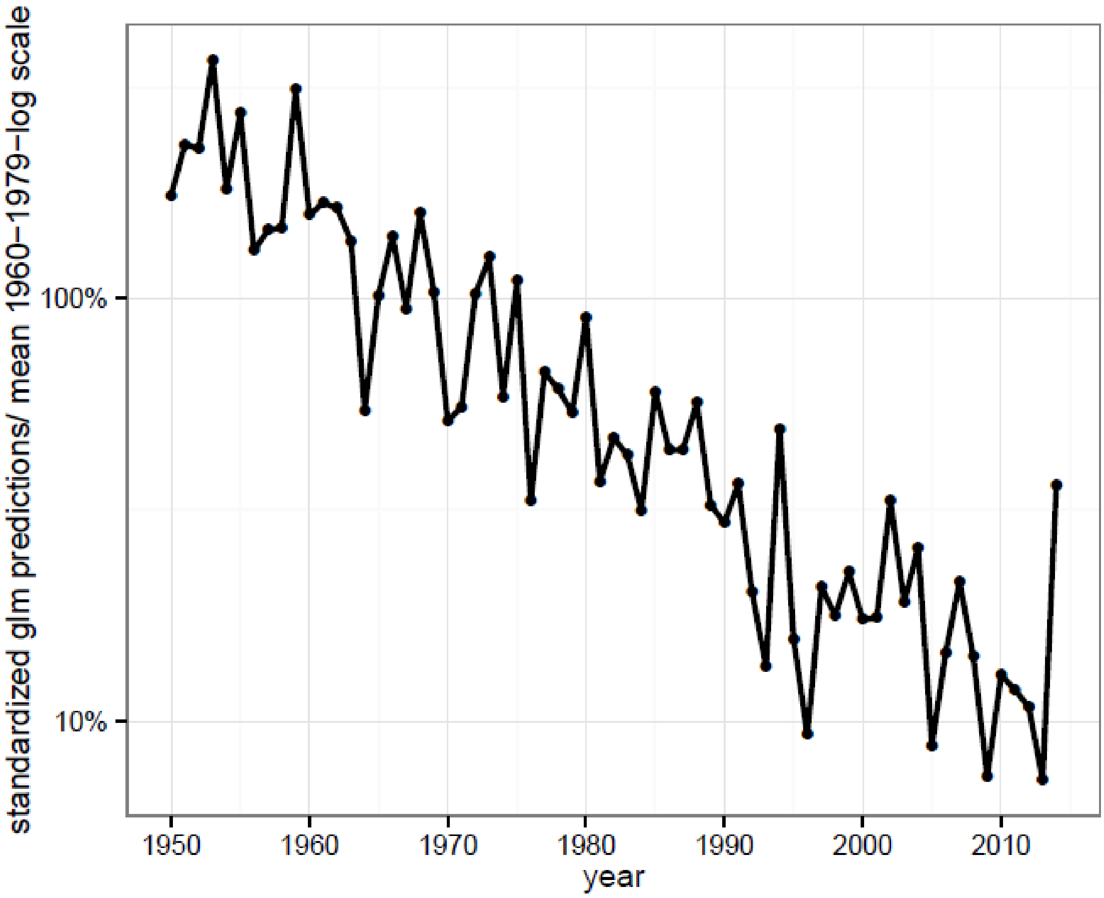


Figure 2.7. Mean of estimated (GLM) yellow eel recruitment and smoothed trends for Europe updated to 2014. The GLM (*recruit ~ year + site*) was fitted to 12 yellow eel series and scaled to the 1960–1979 average. Note the logarithmic scale on the y-axis.

In conclusion, the WGEEL recruitment index is currently low but increasing for both regional glass eel series: the current level with respect to 1960–1979 averages is 3.7% for the North Sea and 12.2% elsewhere in the distribution area (Tables 2.4 and 2.5). For yellow eel recruitment series, the recruitment has risen to 36% of the 1960–1979 period.

2.1.4 Are there significant changes in trend?

Given these recent increases in recruitment indices, the working group examined three statistical methods to test whether these were significant changes to the trends (i.e. break points, upturns). The objective of the first two methods, CUSUM and segmented regression, was to identify breakpoints in the whole time-series. The third method, the Bayesian approach, was used to detect a breakpoint in the last ten years and to simulate future recruitment to explore a trajectory of recruitment recovery

2.1.4.1 CUSUM

Trends were calculated using the cumulative sums method (CUSUM (Woodward and Goldsmith 1964; Ibanez *et al.*, 1993). A cumulative sum represents the running total of the deviations of the first observation from a mean based on the same interval. In general, the CUSUM approach to detect change points performs well, has been well-documented and is relatively easy to implement (Breaker, 2007). Breakpoints that may not be possible to detect in the original data often become easier to detect when the CUSUM is plotted. For a time-series with data sampled for each year (t), a reference value k is chosen (here we chose the standardized mean logarithmic of the glass and yellow eel time-series).

After subtracting k from each datapoint, the residuals are added successively to calculate the cumulative sums (CS_t):

$$CS_t = \sum_{i=1}^{t}(x_i - k)$$

The successive values of CS_t are plotted versus time (years) to produce the so-called CUSUM chart. The local mean between two breaking points is the slope of the cumulative sum curve between the two points, plus the reference value k. Changes in the average level of the process are reflected as changes in the slope of the CUSUM plot. For successive values equal to k, the slope will be horizontal; for successive values lower than k, the slope will be negative and proportional; and for successive values higher than k, the slope will be positive and proportional. The year of the change in the slope of the CUSUM is the year that a shift occurs. Breakpoints were visually identified on the CUSUM trajectories as abrupt changes (as opposed to a gradual change) in direction of slope.

CUSUM were first calculated on the whole time period (from 1960 to 2014) to define the main breakpoints (Table 2.6). Since two main periods were defined, CUSUM were then calculated on the second period, from 1980 onwards, to focus on the decline (Table 2.6).

All of the CUSUM calculated showed smooth trajectories with few breakpoints (Figures 2.8 and 2.9). This was due to the low amplitude in inter-annual fluctuations compared to the overall change around the total average of the time-series.

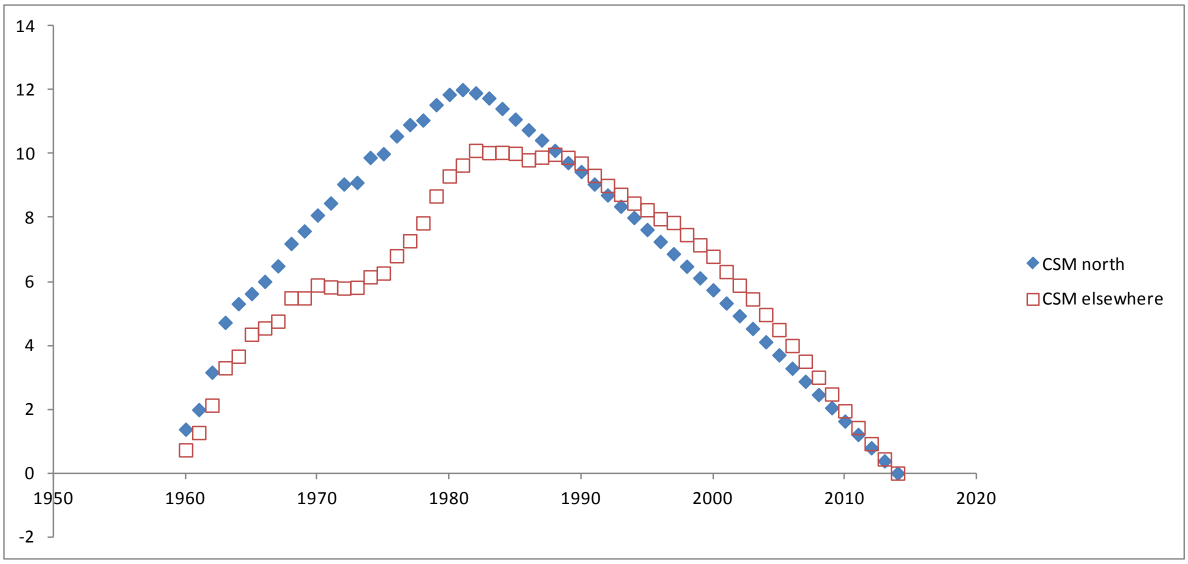


Figure 2.8. CUSUM calculated on the original glass eel time-series ('North Sea' and 'Elsewhere Europe'), with CUSUM values plotted against the y-axis and year shown on the x-axis.

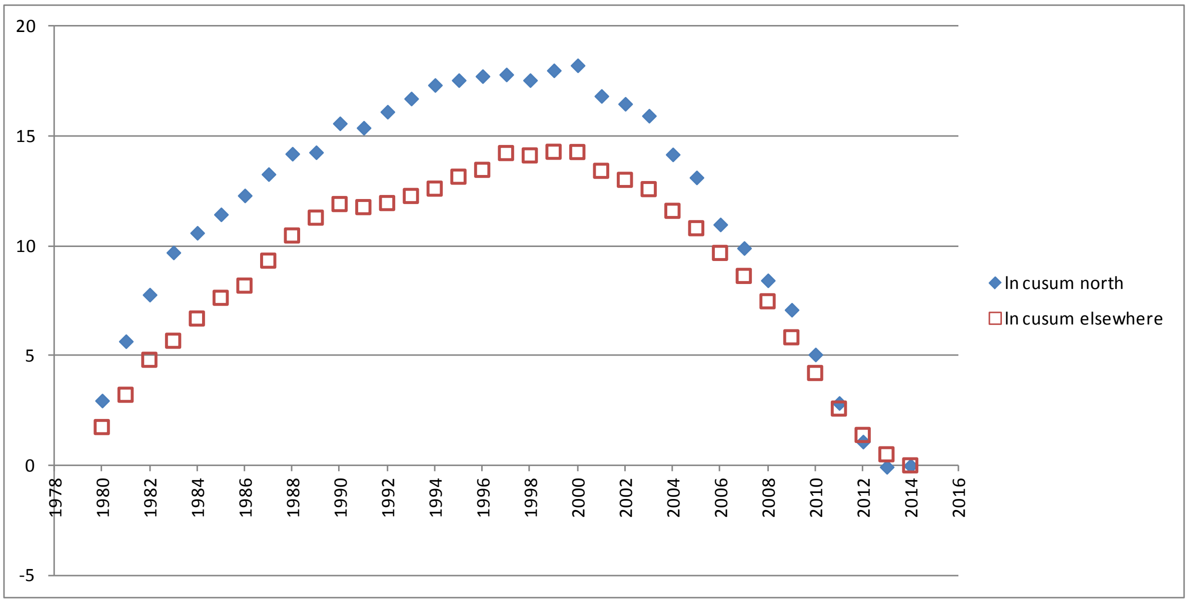


Figure 2.9. CUSUMS calculated on the natural logarithm of glass eel time-series ('North Sea' and 'Elsewhere Europe'), from 1980 to 2014, with CUSUM values plotted against the y-axis and year shown on the x-axis.

The blue lines on Figures 2.10 and 2.11 show two distinct periods with breakpoints in 1980 for the 'North Sea' time-series and two years later for the 'Elsewhere Europe' time-series. The slopes of the CUSUM become negative after these breakpoints. While the time trend for 'North Sea' time-series only shows one breakpoint, the trend for 'Elsewhere Europe' time-series displays three breakpoints with a relatively stable period between 1982 and 1990 (Figure 2.11). CUSUM calculated over the later period (starting in 1980) show two breakpoints for the 'North Sea' time-series and one for the 'Elsewhere Europe' time-series (Figures 2.10 and 2.11).

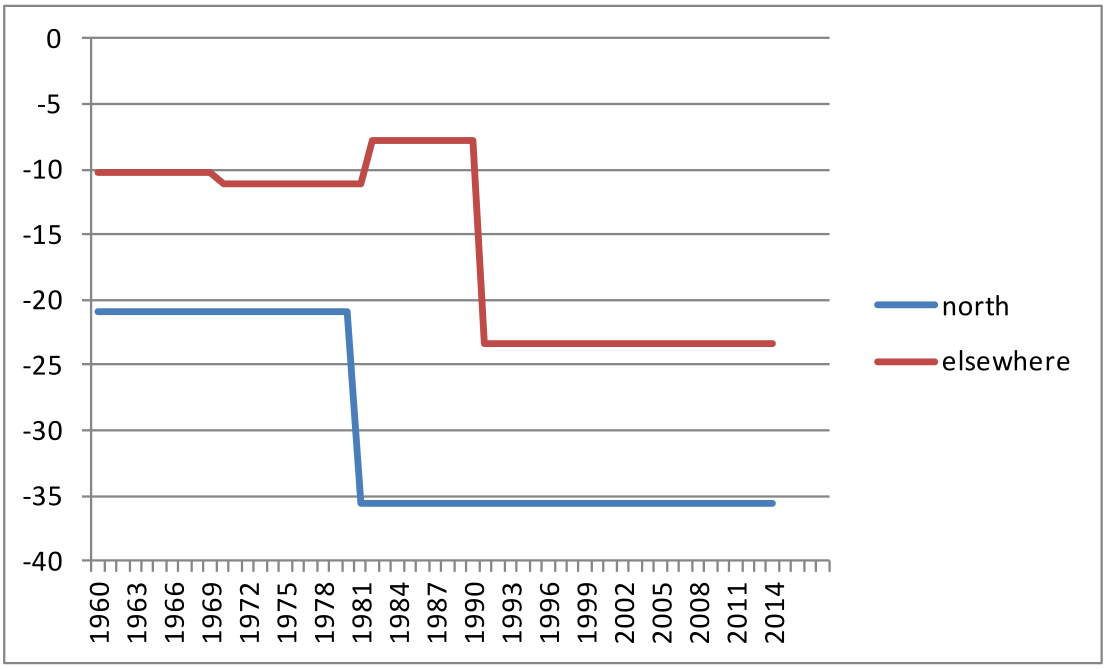


Figure 2.10. Step diagram representing the slopes calculated on the logarithm of the different time-series for 'North Sea' and 'Elsewhere Europe' time-series, (see Table 2.6 for details on k), with slope values plotted against the y-axis and year shown on the x-axis.

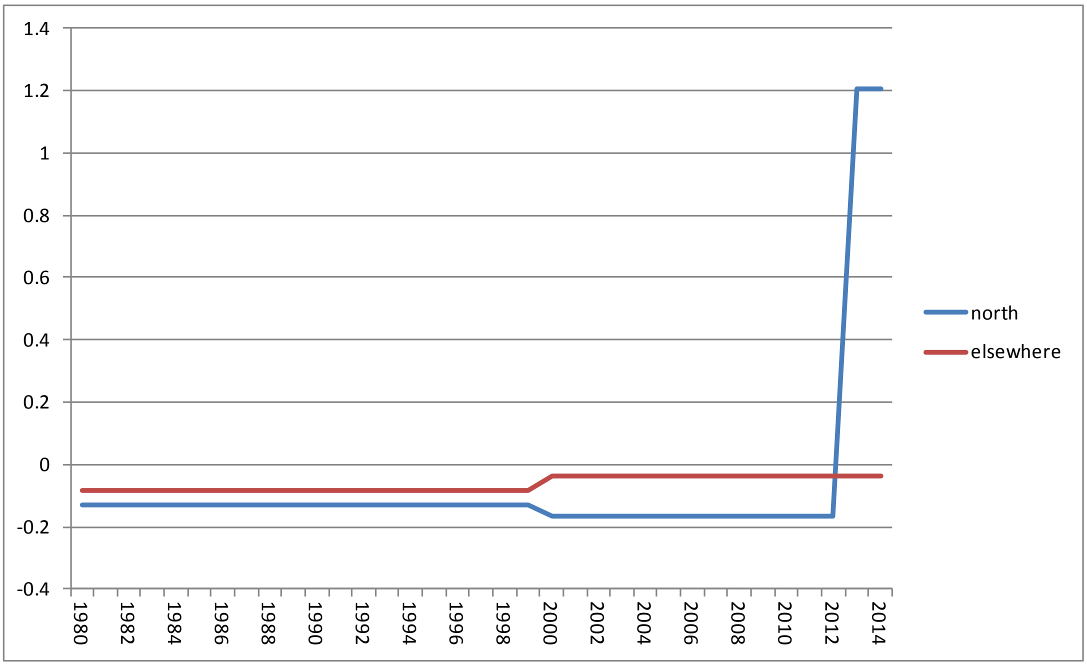


Figure 2.11. Step diagram representing the slopes calculated on the logarithm of the different time-series, for 'North Sea' and 'Elsewhere Europe' time-series, after the decline in recruitment (see Table 2.6 for details on k), with slope values plotted against the y-axis and year shown on the x-axis.

2.1.4.2 Segmented regression

The R package "segmented" was used to perform the segmented regression (Muggeo, 2003; 2008). This algorithm estimates the positions of a given number of breakpoints, starting from a user-defined initial condition (i.e. breakpoints locations), by iteratively fitting linear segmented models with the following predictor:

$$\beta_1 z_i + \beta_2 (z_i - \psi)_+$$

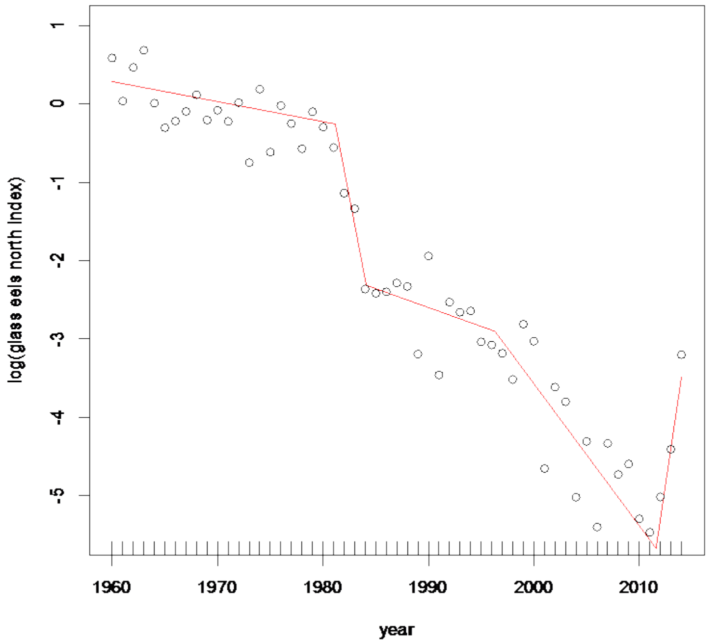
$$(z_i - \psi)_+ = (z_i - \psi) \times I(z_i > \psi)$$

where β_1 is the left slope, z_i is the independent variable, β_2 is the difference-in-slope before and after a breakpoint, ψ is the breakpoint and $I(\cdot)$ is the indicator function, equal to one when the argument is true, otherwise it is zero.

This model is strongly affected by the initial conditions for the breakpoints locations and it is not intended to determine the number of breakpoints in a time-series. Therefore, this algorithm is nested into a double loop: the first to compare the null model (i.e. the linear regression with no breakpoints) and different segmented models with *j* breakpoints (*j* = 1…4) and the second to compare several initial conditions, sampled randomly from all the combinations of *j* possible breakpoints locations (here the subsample is the 10% of all possible combinations). The Bayesian Information Criteria (BIC) is used to determine the performance of each resulting model. BIC was preferred to the Akaike Information Criteria (AIC) as it has a higher penalty on the number of parameters. The model associated with the lowest value of BIC is selected.

This method has been applied to the three time-series: the logarithm of glass eels recruiting in the 'North Sea' area (north), the logarithm of glass eels recruiting in the 'Elsewhere Europe' area (elsewhere) and the logarithm of yellow eels (yellow). The results are summarized in Table 2.7 and Figures 2.12 to 2.14.

a)



b)

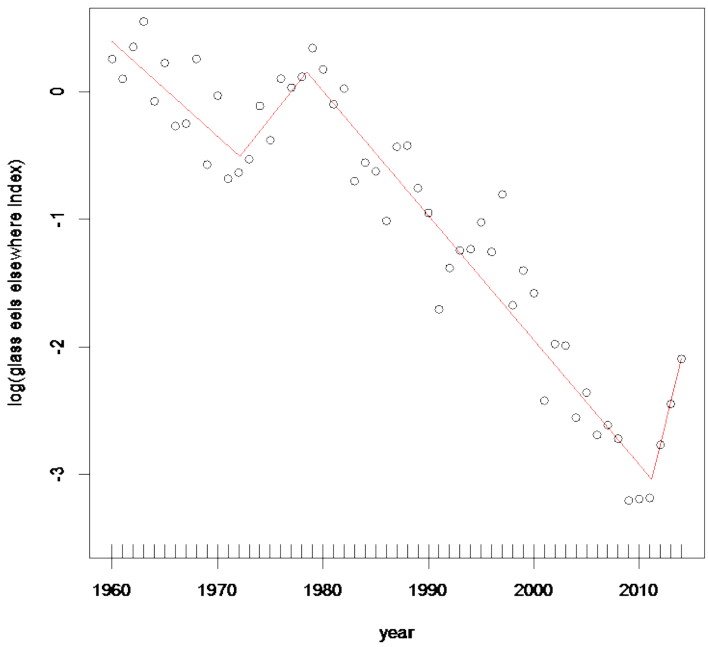


Figure 2.12. Segmented regression performed on the log of glass eel recruitment at the 'North Sea' (a) and on the log of glass eel recruitment 'Elsewhere Europe' time-series (b).

The calibration of the segmented regression model on the 'North Sea' time-series selected the model with four breakpoints (1981, 1984, 1996 and 2012) (Figure 2.12a). The 1981, 1984 and 1996 are breakpoints between regressions with negative slope, while the 2012 breakpoint identifies a change in the sign of the slope, from negative to positive (Figure 2.13).

The model selected in the 'Elsewhere Europe' time-series identified three breakpoints (1972, 1978 and 2011), subdividing the time-series into four different periods with different slopes (Figure 2.12b) that change sign at each breakpoint (Figure 2.13).

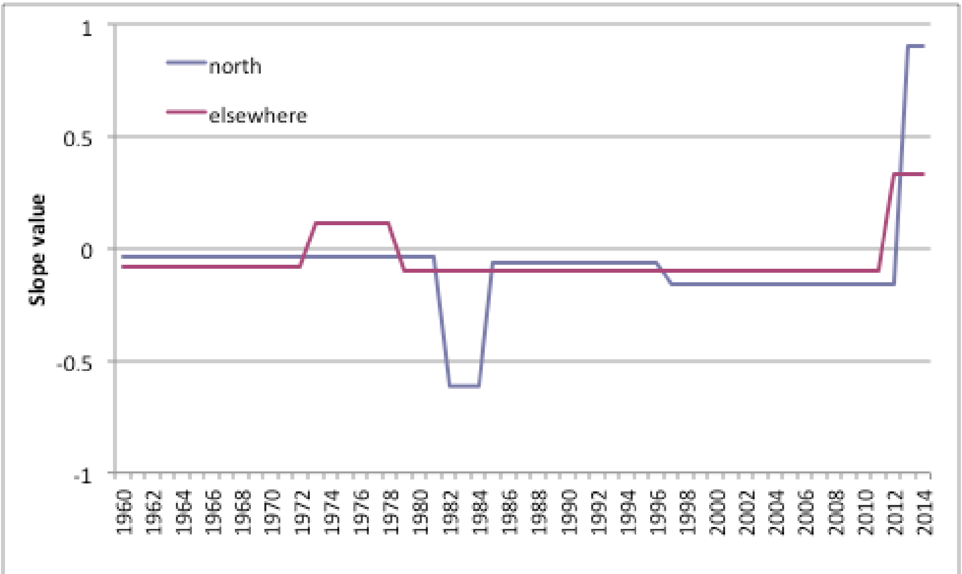


Figure 2.13. Step diagram representing the slopes calculated using the segmented regression model on the two recruitment time-series ('North Sea' and 'Elsewhere Europe').

No breakpoints were identified for the yellow eel time-series and the null model was selected (Figure 2.14). This regression showed a significant (p<0.001) negative slope (β=-0.049).

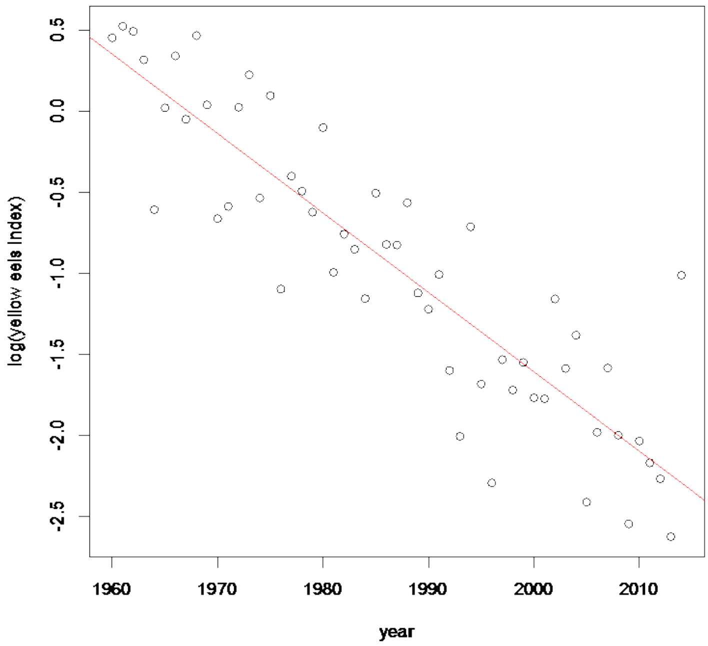


Figure 2.14. Segmented regression performed on the log of the yellow eel time-series.

The significance of using 2011 as a breakpoint in the recruitment time-series was tested using the model developed by SGIPEE (ICES, 2011b):

$$R \sim year + pmax(year, 2011)$$

Where $pmax$ is the maximum between the *year* and 2011. This model was calibrated on both recruitment time-series. An Analysis of Variance (ANOVA) revealed that the term *pmax(.)* was significantly different from zero (p<0.001 for both 'North Sea' and 'Elsewhere Europe').

2.1.4.3 Bayesian approach

The Bayesian Eel Recruitment Trend (BERT) model is based on exponential trends (a_1 and a_2) and auto-correlated perturbations ε_t. This type of perturbation structure simulates whether recruitment above the central trend in a particular year is more often followed by recruitment above or below the trend. This is the usual way to incorporate environmental fluctuations (e.g. climate, oceanic conditions) which are generally auto-correlated in time. This approach was adapted from that developed to set up the glass eel quota in France (Beaulaton *et al.*, in press.)

The possibility of a single regime shift was introduced with an indicator random variable I to test the credibility of this break point (Kuo and Mallick, 1998). The posterior distribution of I can be interpreted as the probability that a shift in the trend should be included in the model. The shift occurs at t_{shift} which was chosen between 2003 and 2014, according to categorical distribution.

The model is writte as:

$$R_t = \begin{cases} R_{t-1} \cdot e^{a_1+\varepsilon_t} & \text{for } t \le t_{shift} \\ R_{t-1} \cdot e^{a_1+I\cdot a_2+\varepsilon_t} & \text{for } t < t_{shift} \end{cases}$$

$$\varepsilon_t = \rho \cdot \varepsilon_{t-1} + \eta_t$$

$$\eta_t \overset{iid}{\sim} Norm(0,\sigma)$$

$$I \sim Bernoulli(p_I)$$

$$t_{shift} \sim \text{dcat}(\text{rep}(0.1,10))$$

where R_t the recruitment index the year t, t_{shift} the year of the regime shift, a_1 the slope before the regime shift, $a_1 + a_2$ the slope after the regime shift, I the indicator random variable to select or not the regime shift, ε_t the auto-correlated perturbations, ρ the auto correlation coefficient and η_t the independent and identically distributed residuals of mean 0 and standard deviation σ. I is drawn from a Bernoulli distribution of probability p_I. t_{shift} is drawn from a categorical distribution with a 10 values probability vector of 0.1.

The *a priori* distributions are chosen as least informative.

$$\rho \sim \text{dunif}(-1,1)$$

$$\sigma \sim \text{dgamma}(0.01,0.01)$$

$$a_1, a_2 \sim \text{dnorm}(0, 0.01)$$

$$\log(R_0) \sim \text{dnorm}(0, 0.01) + \text{dnorm}(0, 1)$$

$$\text{p}_I \sim \text{dbeta}(0.5, 0.5)$$

where dunif, dgamma, dnorm and dbata are the density functions respectively for uniform, gamma normal and beta distributions in jags.

Bayesian inferences were performed by Markov Chain Monte Carlo from the R package ‘rjags’ (Plummer, 2013).

The recruitment time-series ‘Elsewhere Europe’ and ‘North Sea’ over the period 1980 to 2013 were used to target the analysis on breakpoints in the recent period. The reference recruitment corresponds to the average recruitment during the reference period 1960–1973 (Chapter 2.1). This reference recruitment was used as a proxy for the stock recovery.

For the ‘Elsewhere Europe’ series, the BERT model gives a credibility of 35.1% for a trend shift between 2004 and 2013. The distribution of years with breakpoints is presented in Figure 2.15. Note that the special case with $\rho = 0$ and $t_{shift} = 2011$ is the equivalent Bayesian approach of the test proposed by SGIPEE (ICES, 2011b). In that case, the credibility of a trend shift in 2011 is 72.3%. This result shows the importance of taking account of autocorrelation in the analysis for such trends.

For the 'North Sea' series, with the full model, the credibility of a regime shift increased to 73.7% with the more likely breakpoint in 2013 (Figure 2.16).

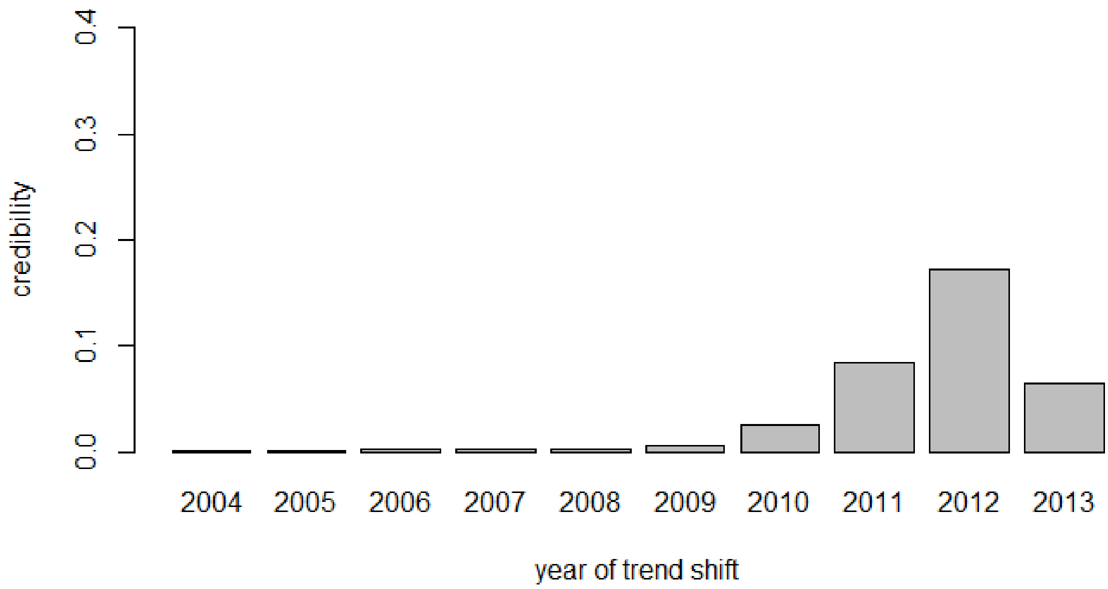


Figure 2.15. Credibility of (equivalent in classical statistics to "the probability to have") a trend shift according to year for the "Elsewhere Europe" time-series.

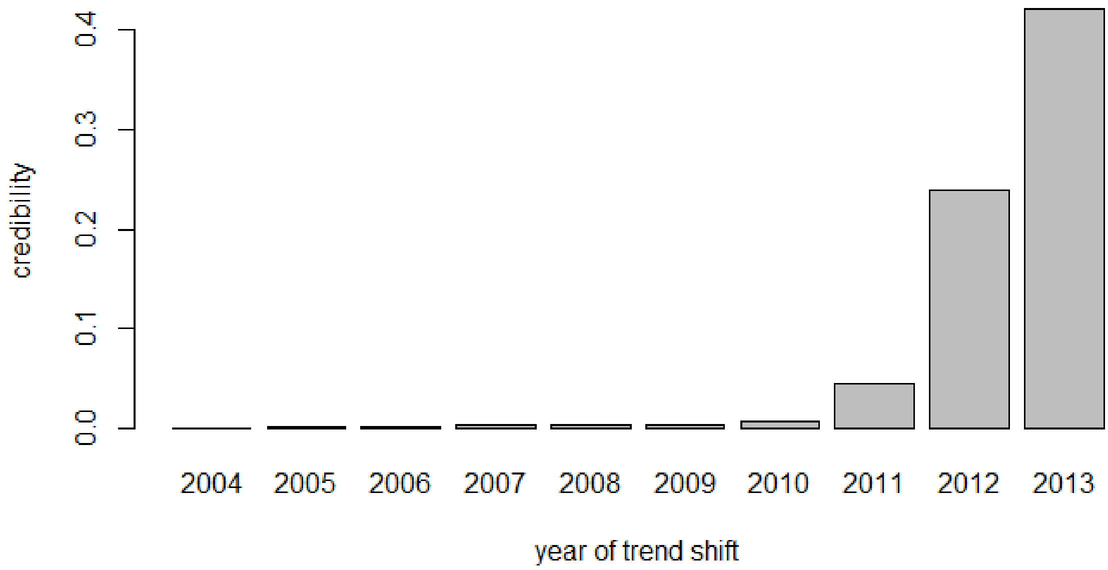


Figure 2.16. Credibility of (equivalent in classical statistics to "the probability to have") a trend shift according to year for the "North Sea" series.

2.1.4.4 Conclusion on the break points detected

All methods applied on the complete time-series (1960–2014) detected a breakpoint around 1980, indicating a change in the slope sign from positive to negative, except the segmented regression on the glass eel recruitment in the 'North Sea' for which the breakpoint corresponded to an increased negative slope. This result confirms the shift in trend observed in the recruitment series during the 1980s and the consequent decline of the recruitment until the most recent years.

The models detected several other breakpoints that occurred before 2010. These breakpoints were not related to a change in the trend but to steeper declines in recruitment.

Most models (except the CUSUM applied to the glass eel recruitment in the 'Elsewhere Europe' series) detected a breakpoint in 2011–2012 with a change of slope sign. The significance of this breakpoint was confirmed by the ANOVA and by the Bayesian approach, but it was not possible to determine whether this breakpoint can be considered a trend shift yet, as this short positive trend could be the result of the time–series autocorrelation. Moreover, there is no evidence of a trend change in the yellow eel time–series.

2.1.4.5 Evaluation of recruitment recovery based on trend analysis

This objective of this section is to determine whether or not trends in recruitment are moving towards recovery.

It is obvious that a decreasing trend in recruitment is not compatible with recovery of the stock. An increase in recruitment, confirmed by lagged increases of the standing stock and silver eel escapement (when data will be available) is a necessary condition to consider a recovery. However a short-term increase will not necessarily certify recovery. At least, an increase over a period that corresponds to the average lifespan should be recorded before giving a positive answer to recovery. Since life traits and contributions to spawning stock vary geographically, the definition of the average lifespan for eel is not simple and more work is needed.

Another way to evaluate whether the trend is moving towards recovery is to calculate how long it will take, given the present trend, to reach recruitment reference. In this analysis the recruitment reference is defined as the average recruitment observed during the period from 1960 to 1979.

The projections of the recruitment are presented in Figures 2.17 and 2.18 for 'Elsewhere Europe' and 'North Sea' respectively. Since a trend shift is considered in only 35.1% of the cases for the 'Elsewhere Europe' series, the trend of recruitment is predicted to slightly decrease in the next years and the credibility (akin to statistical 'probability') to be above the reference recruitment does not exceed 35% in the next 30 years (Figure 2.19). For the "North Sea" series, the trend is increasing (Figure 2.18) but will only reach the reference recruitment in the long term (Figure 2.20).

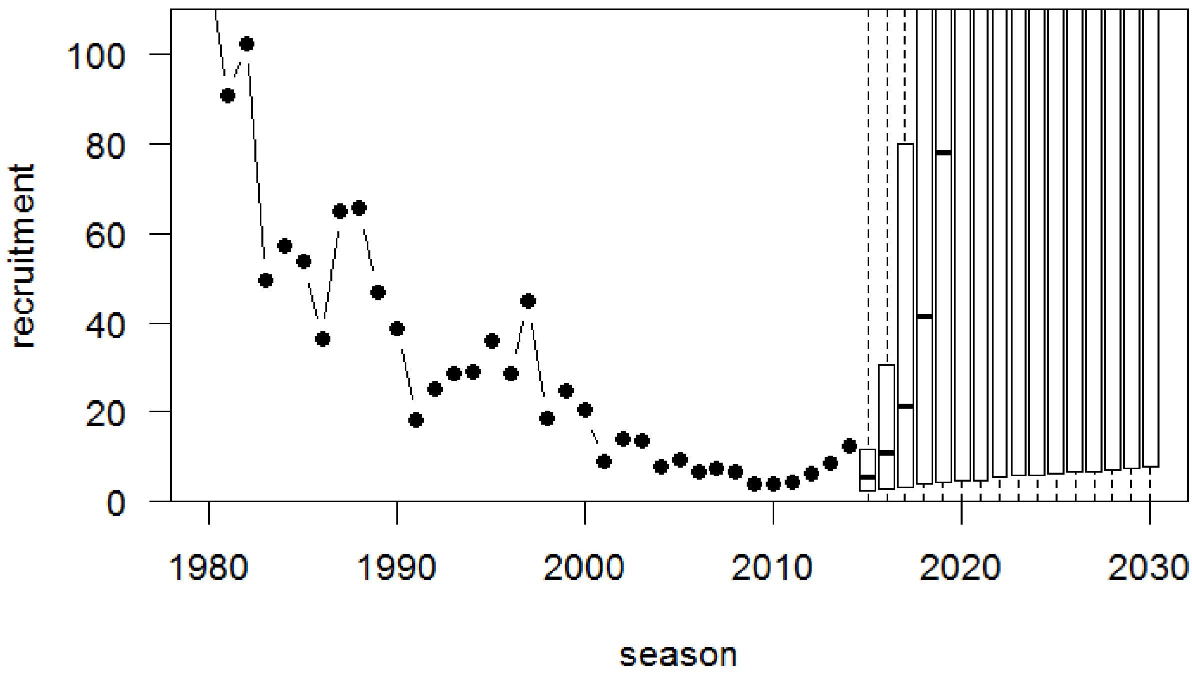


Figure 2.17. Evolution from 1980 to 2014 (point) and projection from 2015 to 2030 (box and whiskers plot) of recruitment for 'Elsewhere Europe' time-series. In the box and whiskers plot, the horizontal segment in bold represents the median, the box represents the inter-quartile range, and the whiskers represent the extreme values.

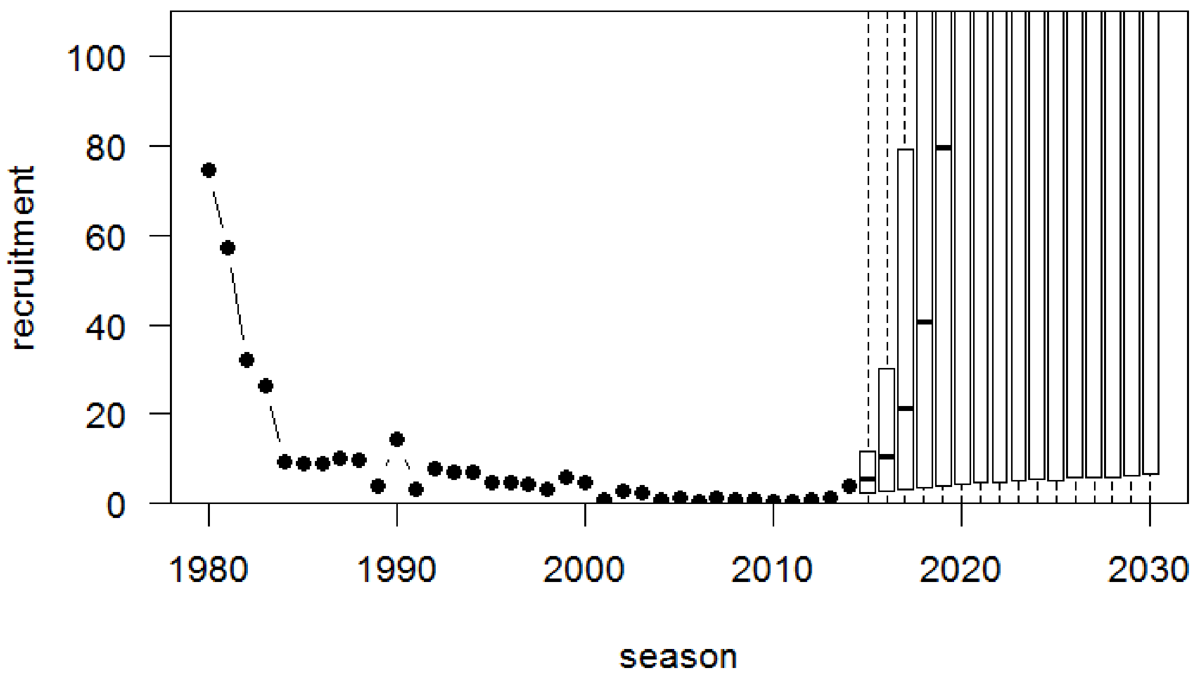


Figure 2.18. Evolution from 1980 to 2014 (point) and projection from 2015 to 2030 (box and whiskers plot) of recruitment for the 'North Sea' time-series. In the box and whiskers plot, the horizontal segment in bold represents the median, the box represents the inter-quartile range, and the whiskers represent the extreme values.

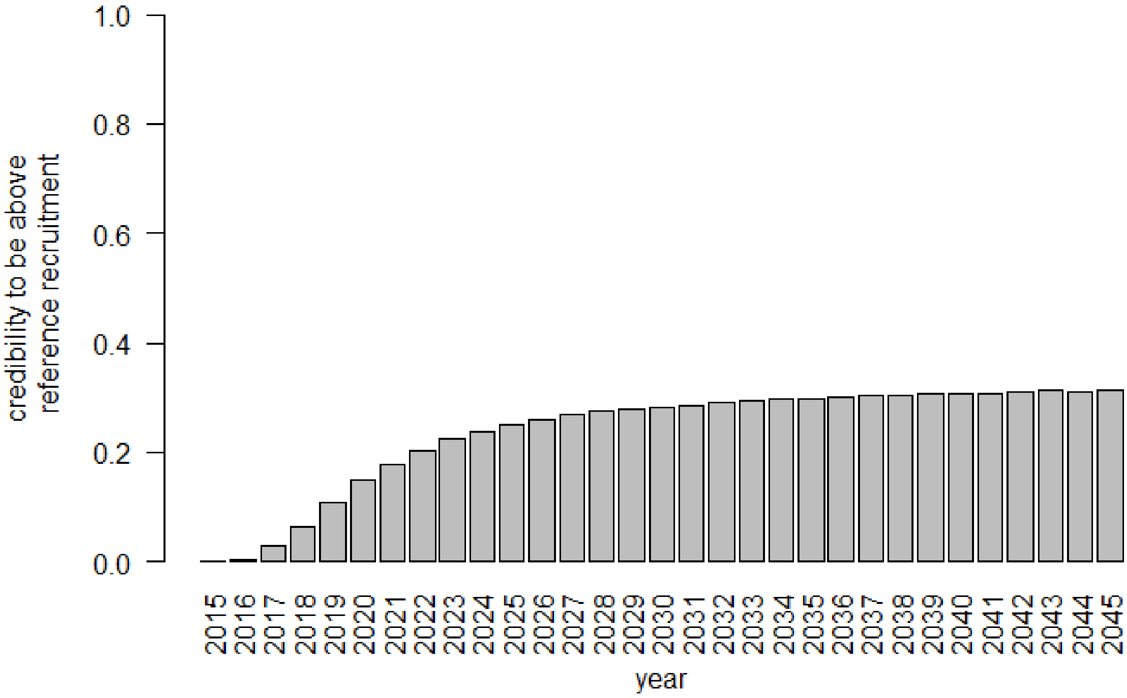


Figure 2.19. Evolution of the credibility (equivalent in classical statistics to the 'probability') to be above the reference recruitment (1960–1979 average recruitment) for the 'Elsewhere Europe' time-series.

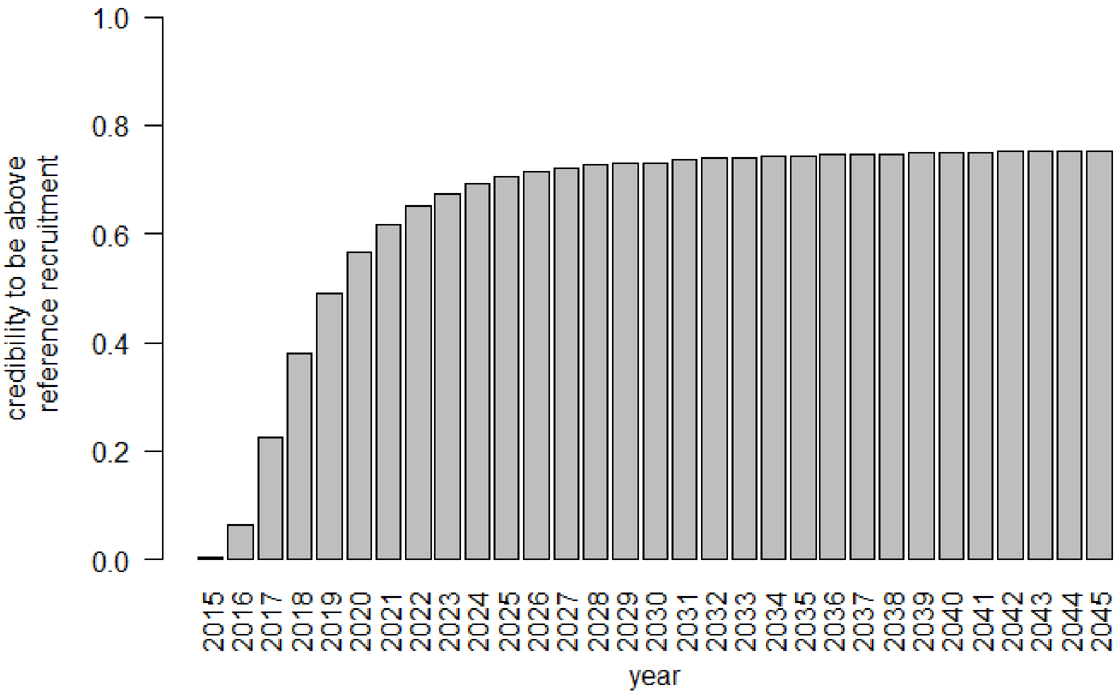


Figure 2.20. Evolution of the credibility (equivalent in classical statistics to the 'probability') to be above the reference recruitment (1960–1979 average recruitment) for the 'North Sea' time-series.

If a trend shift is set between 2004 and 2013 (i.e. assuming that the recent increases in recruitment trend continue in the future), the credibility to exceed the reference recruitment will be around 50% for 'Elsewhere Europe' in 2021, and for 'North Sea' in 2018, and higher than 95% after 2045 for 'Elsewhere Europe' and after 2029 for 'North Sea' recruitment (Figures 2.21 and 2.22).

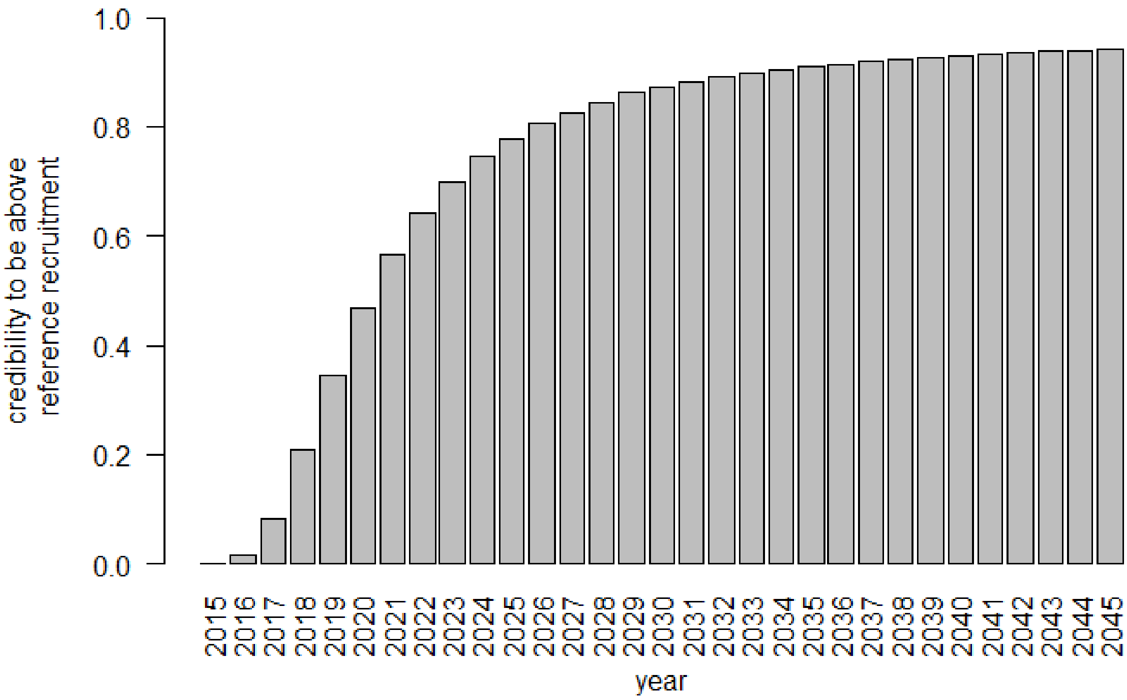


Figure 2.21. Evolution of the credibility (equivalent in classical statistics to the 'probability') to be above the reference recruitment (1960–1979 average recruitment) for 'Elsewhere Europe' assuming a trend shift set between 2004 and 2013.

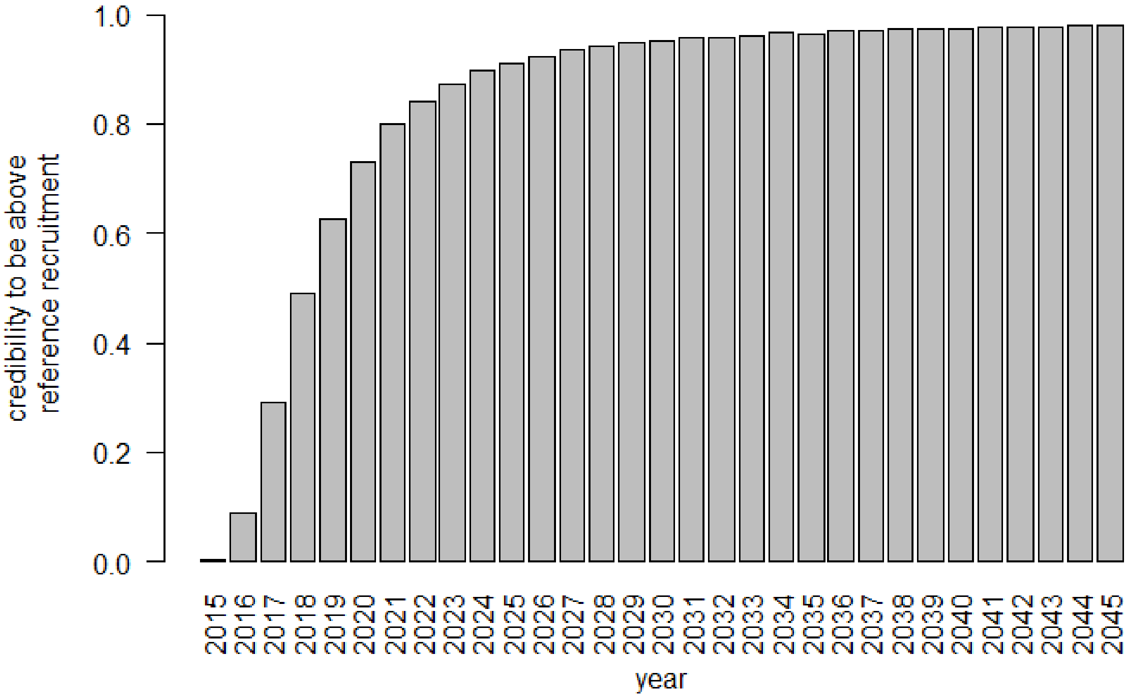


Figure 2.22. Evolution of the credibility (equivalent in classical statistics to the 'probability') to be above the reference recruitment (1960–1979 average recruitment) for the 'North Sea' time-series assuming a trend shift set between 2004 and 2013.

In conclusion, the recent increases in recruitment time-series observed over the last three years are not sufficient to be sure that the stock is moving towards a recovery. If these positive trends are confirmed and continue in the future without any changes, the recruitment might be expected to exceed the average 1960–1979 level around the year 2030 in 'North Sea' and around the year 2045 in the 'Elsewhere Europe' times-series. However, much improved understanding of the functioning of the stock is required to make these trend analyses more robust.

2.1.4.6 Indicators that might trigger an update assessment

The working group considered the question posed by the ICES Generic ToRs, to define or propose indicators that could be used to decide when an update assessment is required.

First and foremost, the working group reiterated that the '3B and ΣA' stock indicators should be estimated on an annual basis, and for each individual EMU, in order to update the precautionary diagram approach. It is also essential that the glass eel and yellow eel data used to build recruitment and standing stock indices are collected annually.

Regarding indicators to trigger an update assessment, the working group proposed that a regime shift (change of sign in the trend) in recruitment time-series that was detected with a high probability in the recent past might be a suitable trigger for an update assessment. It that case, explanations of this regime shift should be explored. Biological processes of the population dynamics and possibly the biological reference points should be re-evaluated in consequence. Specific work is clearly required to define more precisely such quantitative indicators for an update assessment.

2.2 Time-series of yellow and silver eel abundance

In addition to the glass eel and (young) yellow eel recruitment series, yellow eel and silver eel indices may be used in the future, though data are scarce, and may be uncertain. Moreover, yellow and silver eel data may be more representative for the local area where they are collected than for the global stock status because of the contrasts in population dynamics and anthropogenic pressures at the distribution area scale.

Several Country Reports present information on long-term monitoring of yellow eel abundance in various habitats, and these values have been updated in the WGEEL database. Descriptions of the time-series are presented in Table 2.8. Methodologies vary from electrofishing and traps in rivers to beach-seines, fykenets and trawls in larger waterbodies.

Information on long-term changes in yellow eel abundance in many cases is the only way to assess the status of eel production in the absence of a significant fishery. A development towards standardized methods was suggested by WKESDCF to be included in the revisions to the DCF (ICES 2012a).

2.3 Commercial fishery landings trends

At the present 2014 status, dataseries presented in this report contains information obtained from the Country Reports, FAO capture database and by personal communication from WGEEL participants (Table E2-2).

A review of the catches and landing reports in the Country Reports showed a great heterogeneity in landings data. Some countries make reference to an official system, which then reports either total landings or landings split by Management Unit or Region. Some countries do not have any centralized system. Furthermore, some countries have revised their dataseries, with extrapolations to the whole time-series, during the process of compiling their Eel Management Plan (i.e. Poland, Portugal).

Landings data sourced from the FAO database are presented for countries not reporting to WGEEL. These are the Mediterranean countries: Egypt, Tunisia, Morocco, Turkey and Albania. The quality of some of the Mediterranean data should be reviewed, as some figures seems to be unreliable, e.g. 2012 Egypt data show large variations that were of uncertain provenance given that there was uncertainties about the presence of a catch reporting system.

2.3.1.1 Collection of landings statistics by country (from CRs)

Changes in following the descriptions of the landing statistics per country compared to 2013 WGEEL are highlighted in *italics*.

Norway: Provided official landing statistics (Fisheries Directorate) calculated according to the number of licences. Fishing for eel has been banned in Norway since January 1, 2010.

Sweden: Data on eel landings in coastal areas are based on sales notes sent to the appropriate agency and in recent years also from a logbook system. There is a discrepancy between the data derived from the traditional sales notes system and the more recent logbook system. During the most recent years this difference was considerable, e.g. in 2011 sales notes reported 238 tonnes, whereas the logbooks system registered 355 tonnes (all from the marine areas). Landings data from freshwaters come from a system with monthly or yearly journals. Fishing for eels in private waters was not reported before 2005. Data from logbooks and journals are stored at the Swedish Agency for Marine and Water Management.

Finland: The statistical data are collected by the FGFRI. Data from professional fishers are collected by logbooks and recreational questionnaires. *Data are available for 1976–1988 and from 2003 onwards.*

Estonia: The catch statistics are based on logbooks from inland and coastal fisheries. Data are available for 1964 to 1992 (Lake Võrtsjärv) and from 1993 onwards for all areas.

Latvia: Eel landings are reported in monthly logbooks detailing date, number and type of gear, and fishing time. Logbooks from coastal and inland fisheries were collected by local Boards of MIWA and transmitted to BIOR for data summarization and storage.

Lithuania: Fisheries companies provide information according to their logbooks about catch on a monthly basis to the authority issuing permits: a Regional environmental protection department under the Ministry of Environment of the Republic of Lithuania if a company is engaged in inland fisheries (including the Curonian Lagoon), or the Fisheries Service of the Ministry of Agriculture of the Republic of Lithuania if a company is engaged in maritime fisheries. Data on recreational fisheries are collected using questionnaires.

Poland: The (approximate) data on inland catches were obtained by surveying selected fisheries facilities, and then extrapolating the results for the entire river basin. The data from the lagoons and coastal waters were drawn from official catch statistics (logbooks).

Germany: Eel landings statistics from coastal fishery are based on logbooks. The obligation to deliver the inland catch statistics separate for both stages has only recently been established in most states. Fishers have to deliver the information to the authorities at least on a monthly basis. Data are missing for the some states for inland landings in 2013.

Denmark: From 1st July 2009, professional fishing operations are based on licences and landings and number and type of gear must be registered with the Danish AgriFish Agency. The professional fishermen in saline areas are given a licence to use a limited number of gears in order to meet the 50% reduction within five years following the EU eel regulation.

Netherlands: For Lake IJsselmeer, statistics from the auctions around Lake IJsselmeer are now kept by the Fish Board. For the inland areas outside Lake IJsselmeer, no detailed records of catches and landings were available until 2010. In January 2010, the Ministry of Economic Affairs, Agriculture and Innovation introduced an obligatory catch recording system for inland eel fishers. Since 2012, eel fishers are required to also report effort (type of gear and number of gear) within the obligatory catch recording system. Catches and landings in marine waters are registered in EU logbooks.

Belgium: There is no commercial fishery for eel in inland waters in Belgium. Commercial fisheries for silver eel in coastal waters or the sea are negligible.

Ireland: Until 2008, eel landing statistics in Ireland were collected from voluntary declarations. From 2005 to 2008 this was improved by issuing catch declaration forms with the licence. From 2009, commercial fishing of eel has been closed.

United Kingdom: In England and Wales, the Environment Agency authorizes commercial eel fishing. It is a legal requirement that all eel fishers submit a catch return, giving details of the number of days fished, the location and type of water fished, and the total weight of eel caught and retained, or a statement that no eel have been caught. Annual eel and glass eel net authorizations and catches are summarized by gear type and Environment Agency region (soon to be RBDs) and reported in their "Salmonid and Freshwater Fisheries Statistics for England and Wales" series (www.environment-agency.gov.uk/research/library/publications/33945.aspx). The yellow and silver eel catches reported to the Environment Agency have historically been reported to the WG as a single catch for England and Wales. Since 2005, catches have been recorded according to the "nearest waterbody" and reported separately for yellow and silver eels.

In Northern Ireland, overall policy responsibility for the supervision and protection of eel fisheries, and for the establishment and development of those fisheries, rests with the Department of Culture, Arts and Leisure (DCAL). Catch returns from the one remaining commercial fishery are collated at a single point of collection and marketing, and reported to DCAL.

There have been no large-scale commercial fisheries for eel in Scotland for many years, and no catch data are available. Fishing for eel has been effectively banned for a number of years.

France: The marine commercial fisheries in Atlantic coastal areas, estuaries and tidal part of rivers in France have been monitored by the "Direction des Pêches Maritimes et de l'Aquaculture" (DPMA) of the Ministry of Agriculture and fisheries through the Centre National de Traitement Statistiques (CNTS, ex-CRTS) from 1993 to 2008, and now by France-Agrimer. This system is evolving and is supposed to include marine commercial fishermen from Mediterranean lagoons. In this system, glass eels are distinguished from sub-adult eel, but yellow and silver eels are only recently separated. The commercial and recreational fishermen in rivers (and in lakes) have been monitored since 1999 by the ONEMA (Office National de l'Eau et des Milieux Aquatiques, ex-CSP) in the frame of the « Suivi National de la Pêche aux Engins et aux filets » (SNPE). These two monitoring systems are based on mandatory reports of captures and effort (logbooks) using similar fishing forms collected monthly (or daily for glass eel) with the help of some local data collectors. Information for 2013 is not fully provided.

Spain: Data on eel landings in the Country Report are mostly collected from fishers' guild reports and fish markets (auctions). The precision of the information of the catches and landings differs greatly among Spanish Autonomies (regions). No data available for marine fishery.

Portugal: The eel fishery is managed by DGPA (General Directorate of Fisheries and Aquaculture) with responsibility in coastal waters, and AFN (National Forestry Authority) with responsibility in inland waters. Fisheries managed by DGPA have obligatory landing reports, while in inland waters, landing reports are obligatory in some fishing areas but in other areas only if requested by the Authorities.

Italy: The management framework for the Data Collection Framework (DCF) is the same as has been set up for the eel management under EC Regulation 1100/2007. In the eleven Regions that preferred to delegate eel management to central government (Directorate-General for Sea Fishing and Aquaculture of the Ministry of Agricultural, Food and Forestry Policy) where commercial eel fishing has been stopped completely since the year 2009, no data collection is carried out. In the remaining nine regions, where eel fisheries are ongoing, eel fishery data are collected with a standard methodology, as foreseen by the Italian National Plan for the Data Collection Framework. Detailed data on catches and landings (by life stage, by type of fishing gear, by EMU, commercial and recreational, etc.) are available from 2009.

Montenegro: No data on catch are available. Scientific estimation of total catch in recent year shows that about 60 tons of eel are landed, of which about 50% is taken by illegal fisheries.

Algeria: Data are available in the FAO database, but the quality of this information is not confirmed.

Greece: Fishing in the lagoons is based on the use of fixed barrier traps, which catch fishes during their seasonal or ontogenic offshore migration every year from September to January. Barrier traps (V-shape traps) are passive, fixed gears and are part of the fence installed at the interface between the lagoon and the sea (for more details see Ardizzone *et al*., 1988). The fishermen cooperatives usually have the adequate infrastructure to store live eels up to their sale (the largest quantity of these are exported to other European countries, such as Italy and Germany). The total fishery of the eels and the total fishery of the rest species must be declared every month to the regional authorities.

Turkey: Data are available in the FAO database, but the quality of this information is not confirmed.

Egypt: Data are available in the FAO database, but the quality of this information is not confirmed. Reported figure 5000 tons for 2012 is unreliable.

Tunisia: Data are available in the FAO database, the level of catch was confirmed by the Tunisian participants to WGEEL.

Morocco: Data are available in the FAO database, but the quality of this information is not confirmed.

2.4 Recreational and non-commercial fisheries

More data for recreational catch and non-commercial landings were available in 2014 compared with previous WGEEL reports. For the purpose of compilation and cross-checking, two sources of data were used; Country Reports and the (draft) ICES WGRFS 2014 report (Table 2.9). This analysis showed some discrepancies between sources and not reporting, even if required by the EU Data Collection Framework (Council Regulation (EC) No 199/2008 and Council Decision 2008/949/EC). Recreational fishery data on eels are to be collected, where appropriate, in the following areas:

- Baltic (ICES Subdivisions 22–32);
- North Sea (ICES Division IV and VIId) and Eastern Arctic (ICES Division I and II);
- North Atlantic (ICES Division V–XIV);
- Mediterranean and Black Sea.

The EC (DG-MARE) has indicated some general principles in the forthcoming modifications to the DCF (anticipated 2018 onwards) which are relevant to diadromous species, including improvement in the quality of data and coverage of recreational fisheries. The ICES workshop about eel and salmon data collection (ICES, 2012a) recommended the collection of data on all recreational and commercial eel and salmon fisheries regardless of how the catches are made.

The data reported in the Country Reports were incomplete in some cases because they omitted marine or inland waters, reported only passive gears catches while angling is not prohibited, or because some of the countries are not fully sampling recreational catches, focusing only on a selected life stage. These facts make it impossible in 2014 to assess the most recent total landings and catches of recreational and non-commercial fisheries.

Another data gap is the amount of eels released by recreational fishermen and the associated catch & release (C&R) mortality. An estimate of the amount of released eels was only provided by the Netherlands and partially (marine angling only) for the UK (England) and Denmark. In most countries it is prohibited for recreational anglers to retain eels but catch & release fisheries on eel area allowed in all countries. The amount of fish released by recreational anglers can be substantial (Ferter *et al.*, 2013) and catch and release mortality can be high (median 11%, mean 18%, range 0–95%, n = 274 studies; Bartholomew and Bohnsack, 2005) depending on species and factors like hooking location, temperature and handling time. Unfortunately, no studies have been conducted to estimate catch and release mortality in eel. During the 2012 evaluation of the EMPs, most countries did not report recreational catches (landed and/or released) and if an estimate of the amount of released eel was presented, C&R mortality was assumed to be "zero".

2.5 Misreporting of data, and illegal fisheries

Most countries did not report the level of underreporting, misreporting and illegal fisheries in their Country Reports. The limited data that were presented judged insufficient to draw conclusions on the level of misreporting or illegal fishing. Some countries reported the existence of illegal practices but those were not quantified. It can be considered that the current state of knowledge is insufficient to give an idea of the level of misreporting of data and illegal fisheries at the stock level (Table 2.10).

2.6 Non-fishery anthropogenic mortalities

ICES derived a framework for international assessment based on national/regional biomass and mortality stock indicators. ΣA, the lifetime anthropogenic mortality rate, is the addition of ΣF the fishery mortality and ΣH all other anthropogenic mortalities (e.g. hydropower, barriers, etc.). Member States are required to report their estimates of the indicators in 2012, 2015, 2018 and every six years thereafter. In 2012, $\sum H$ and $\sum F$ mortality estimates were not reported for almost half of the EMUs. Furthermore, for the EMUs for which mortality estimates were reported data were only available for 1–4 years. In 24 of 43 EMUs for which both mortality estimates were reported for at least one year, the rate due to F was greater than that due to H in the most recent year reported. H was greater than F in 15 EMUs, and the two rates were equal in the other four EMUs.

In time, these mortality stock indicators will provide a suitable series to analyse trends in mortality for both fisheries and other anthropogenic mortalities. At this point in time little can be said with regard to trends in anthropogenic mortalities due to the short time-series (1–4 years).

2.7 Eel stocking

2.7.1 Trends in stocking

Data on the amount of stocked glass eel and young yellow eel were obtained from Country Reports and are provided in Electronic Tables E2.3 and E2.4, respectively. Note that various countries use different size and weight classes of young yellow eels for stocking purposes.

Stocking of glass eel peaked in the late 1970s and early 1980s, followed by steep declined to a low in 2009 (Figure 2.23). The decline is most likely due to the increase in price of glass eel from ~€50 kg in the early 1980s to more than €400 kg in the late 2000s (see Figure 10-6 in WGEEL, 2013). The increase after 2009 is presumably caused by the implementation of EMPs, because stocking of glass eel is one of the management measures in many EMPs. The impact of the price on the amount of stocked glass eel was particularly clear in 2014, when a strong supply of glass eels meant the price dropped sharply to around €100 kg and a sharp increase in stocked glass eels was observed.

French stocking data are only available since 2010. Before 2010 stocking occurred in France but the data are not reported in the Country Report. The time-series only shows the *reported* amount of stocking and may underestimate the true amount of stocking that has occurred.

The stocking of young yellow eels has been increasing since the late 1980s (Figure 2.24). The explanation for this increase is, however, less obvious but may also have to do with the increased price for glass eel.

The proportion of glass eel amongst stocked eel has increased in the recent years (Figure 2.25).

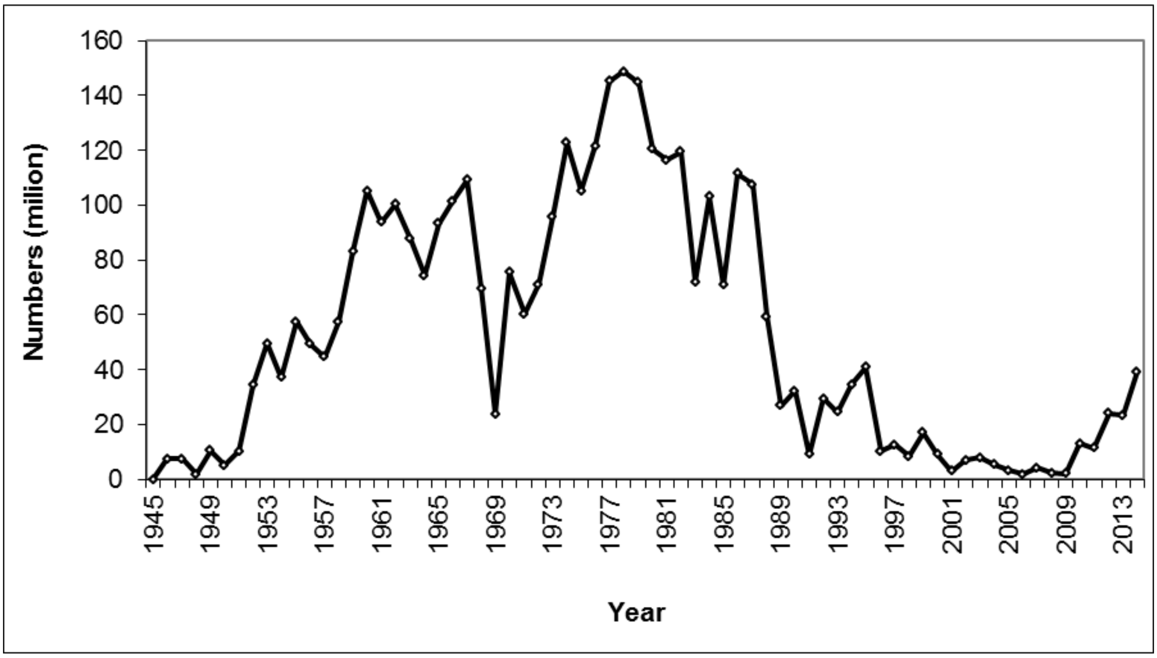


Figure 2.23. Reported stocking of glass eel in Europe (Sweden, Finland, Estonia, Latvia, Lithuania, Poland, Germany, the Netherlands, Belgium, Northern Ireland, Spain, Greece, France (no data before 2010)) in millions stocked. 2013–2014 data not fully available.

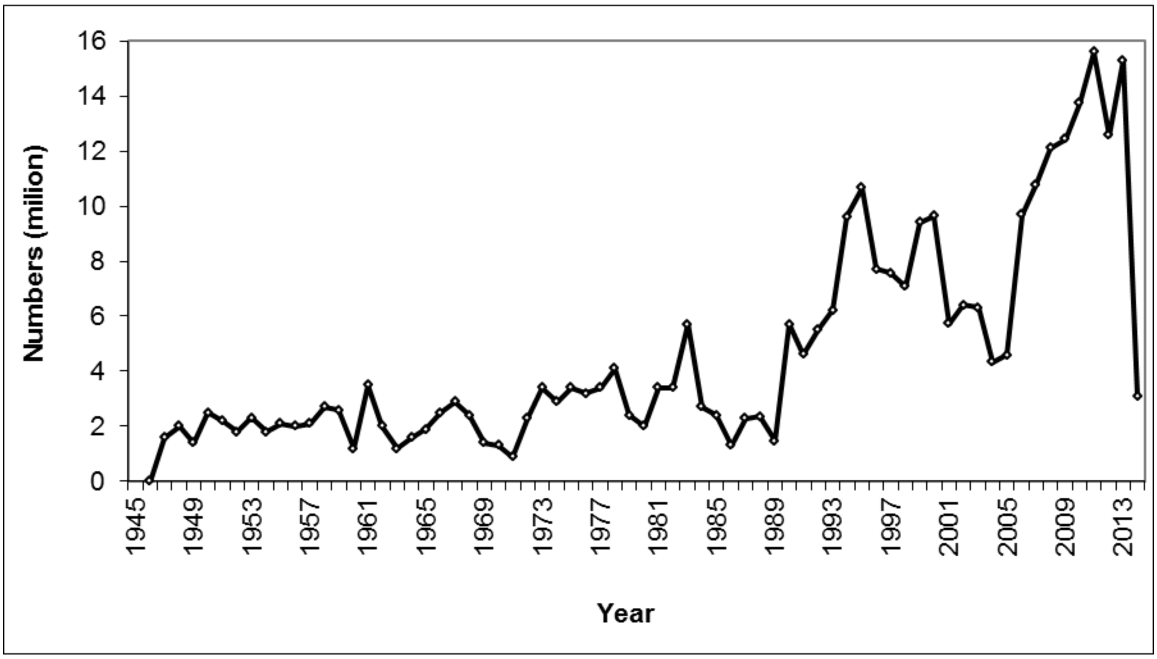


Figure 2.24. Reported stocking of young yellow eel in Europe (Sweden, Finland, Estonia, Latvia, Lithuania, Poland, Germany, Denmark, the Netherlands, Belgium, and Spain), in millions stocked. 2013–2014 data not fully available.

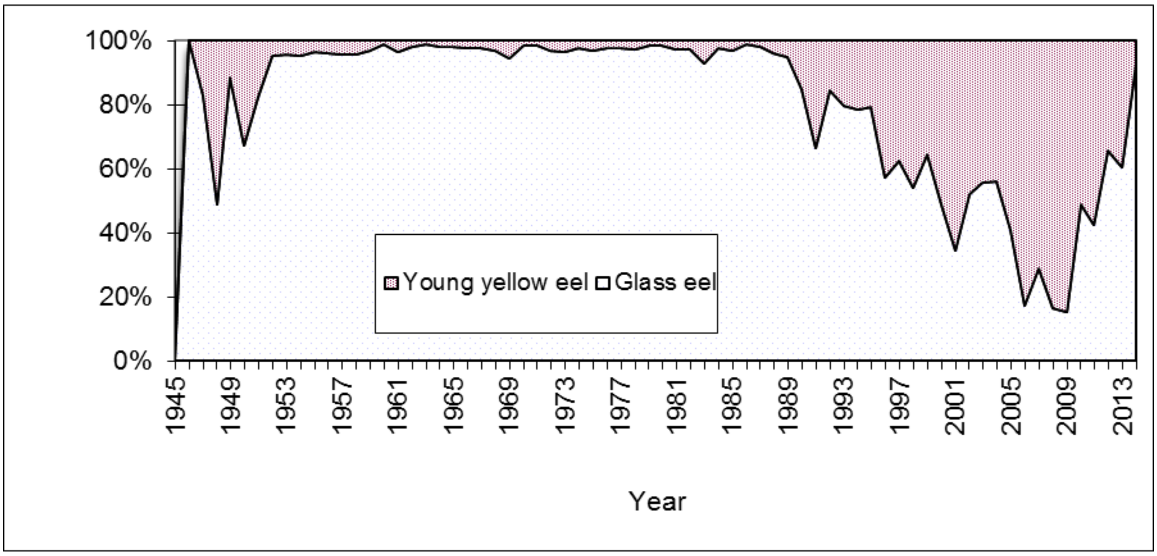


Figure 2.25. Stocking proportion in numbers stocked between on-grown and glass eel in Europe.

The following present an overview of stocking practices in various countries. Where information is new or different from that presented in WGEEL 2013, this is highlighted in *italics*.

Norway: No stocking on a national level.

Sweden: Until the 1990s, the transport of medium sized yellow eels from the west coast to the east coast (Sättål) dominated the stocking programmes. Recently, however, quarantined glass eel (i.e. ongrown) stocking is the only action left. Trollhättan eel (from Göta Älv) has always been a small quantity, and this transport ended in 2005. In 2013, catches at Trollhättan were transported upstream past three hydropower plants and released in Lake Vänern, i.e. "assisted migration". In 2012 and 2013, glass eels were again imported from River Severn (UK), after a few years when they had been supplied by French glass eels. According to the Swedish EMP, about 2.5 million glass eels (in practice ongrown cultured eels) will be stocked annually. All stocked eel have been chemically marked since 2009.

Finland: In 1989, it was decided to carry on stocking only with glass eels reared in a careful quarantine. Since then, glass eels originating in River Severn in the UK have been imported through a Swedish quarantine and restocked in almost one hundred lakes in Southern Finland and in the Baltic along the south coast of Finland. All stocked eel have been chemically marked since 2009.

Estonia: A historical database is available on stocking of glass eel/young yellow eel in Estonia, with records back to 1950. In 1956 stocking of glass eels into L. Võrtsjärv was started. However, stocking has been irregular. The stocking rate with glass eels in L. Võrtsjärv has been relatively low: annual average in 1956–2000 was about 37 ind.ha^{-1} with a maximum of 80 ind.ha^{-1} in 1976-1984. Estonia had a state stocking programme of fish, including eel, for 2002–2010. During the period 2011–2014, the stocking of eel into the Lake Peipsi basin is supported by the European Fisheries Fund (EFF) up to a limit of 255 000 euros (co-financing up to one third of total annual financing). In 2011, 680 000 glass eels were stocked; in 2012, 910 000 glass eels and 120 000 ongrown cultured eels were stocked; and in 2013, 810 000 glass eels were stocked. As the market price of glass eel in 2014 was extremely low, 900 kg or 3 million of glass eels and 193 000 of ongrown cultured eels were stocked into Estonian lakes.

Latvia: Data on stocking from 1945–1992 were obtained from archives of USSR institution Balribvod that was responsible for fish stocking and fisheries control in the former USSR. Since 1992, every stocking of fish in natural waterbodies in Latvia must be reported to Ministry of Agriculture (BIOR) by special documents. In 2011, Latvia started stocking again. Glass eel were imported from UK Glass Eel by a supplier from Czech Republic. Generally, few people ("commission") representing the local municipality and the fish supplier actually participate in stocking to certify the fact.

Lithuania: Stocking of Lithuanian inland waterbodies with glass eel originating in France or the United Kingdom began in 1956. During 1956–2007, a total of 148 lakes and reservoirs covering an area of 95 618 ha was stocked. About 50 million glass and juvenile eels were stocked in total. Stocking activities started again in 2011 within EMP framework. In 2011–2014, Fisheries Service under Ministry of Agriculture used support of European Fisheries Fund and stocked lakes releasing 1 million glass eels and 1 million ongrown cultured eels.

Poland: Eel stocking was initiated in regions within current Polish borders around the beginning of the 20th century. This was done mainly in rivers in the Vistula River basin and in the Vistula Lagoon. The stocking material of the day originated from the coasts of the United Kingdom (glass eel), although the Vistula Lagoon was also stocked with eel (20–30 cm total length) from the River Elbe. In 2011, Poland started stocking within the EMP framework. Data on stocking by private stakeholders comes from eel importers. All eels are foreign source: glass eels from France and England, and ongrown/cultured yellow eels from Denmark, Germany and Sweden.

Germany: There is no central database on stocking, but some data are available. Data provided for 2011–2013 not yet complete and have to be considered as the minimum numbers.

Denmark: Stocking by fishers in inland waters has taken place for decades, in places where recruitment of young eel was limited or absent because of migration barriers or distance to the ocean. Glass eels are imported mostly from France and are grown in heated culture to a weight of 2–5 g before they are stocked. Stocking is done as a management measure. In 2014 a total of 1.6 million 2–5 gram eels were stocked. In freshwater 1.34 million eel of size 2–5 gram were stocked in lakes and rivers as a management measure and 0.26 million were stocked in marine waters.

Netherlands*:* Glass eel and young yellow eel are used for stocking inland waters for as long as anyone can remember, mostly by local action of stakeholders. Future stocking of 1–1.6 t of glass eel is foreseen. All stocked glass eel are sourced outside the Netherlands. The main stocking material is glass eels in the Netherlands. However, the average weight of stocked young yellow eel decreased from ~30g to ~3 g between 1920 and 2014.

Belgium: Glass eel stocking in Belgium, both in Flanders and in Wallonia, has been carried out from 1964 onwards, with glass eel from the catching station at Nieuwpoort (River Yser). However, due to the low catches after 1980 and the shortage of glass eel, together with regionalisation of the fisheries, this stocking was stopped in Wallonia. In Flanders, stocking was continued after 1980 with foreign glass eel imported mostly from the UK or France. Also, yellow eels were restocked, mostly from the Netherlands, but this was ceased after 2000 as yellow eels used for stocking contained high levels of contaminants. In Wallonia, glass eel stocking was again initiated in 2011, in the framework of the Belgian EMP. Quantities of glass eel stocked amount to 40 and 50 kg for Wallonia in 2011 and 2012 respectively. In Flanders 156 kg, 140 kg and 500 kg were stocked respectively in 2012, 2013 and 2014. The glass eel were supplied from the Netherlands but originated from France. In 2013, 140 kg was stocked in Flemish waters using glass eel supplied by a French company (SAS *Anguilla*, Charron, France).

Ireland: Purchase of glass eel for stocking from outside the state does not currently take place. The only stocking that takes place is an assisted upstream migration around the barriers on the Shannon, Erne and Lee. Assisted migration of upstream migrating pigmented small eel takes place in the Shannon (Ardnacrusha) and Erne (Cathaleen's Fall), and of pigmented young eel (bootlace) on the Shannon (Parteen Regulating Weir). Prior to 2009, small amounts of glass eel and pigmented small eels were taken in the Shannon Estuary and in neighbouring catchments and these were stocked into the Shannon above Ardnacrusha and Parteen Hydropower Stations.

UK: There is no stocking of ongrown eel anywhere in UK. Glass eel from the England and Wales fishery are stocked into river systems of England and Wales: 53.6 kg in 2010, 50.1 kg in 2011, 41.5 kg in 2012, 65.7 kg in 2013, 55.6 kg in 2014. No eel stocking takes place in Scotland. In Northern Ireland, recruitment of glass eel and pigmented small eel to Lough Neagh has been supplemented by stocking of purchased glass eel since 1984, and these eel have been sourced from the glass eel fishery in England and Wales. However, in 2010, the 996 kg of glass eel purchased from UK Glass Eel Ltd originated from fisheries in San Sebastian, Spain and the west coast of France: no glass eels from UK waters were purchased. In 2011 and 2012, glass eel from UK and French sources were stocked into Lough Neagh though all were purchased from UK Glass Eels Ltd. In 2013 and 2014, 1866 kg and 2680 kg respectively of entirely UK sourced glass eels were stocked into L. Neagh. 2014 was also the first time that glass eel going into Lough Neagh (and the River Lagan) were marked using Strontium Chloride.

France: A public tender of 2 million Euros for stocking (and stocking monitoring) has been made each year since 2010. In 2014 this public tender was made twice. Glass eels are all stocked in the EMU in which they are caught. Thus, there is no stocking in EMU where there isn't a glass eel fishery. Glass eels have been quarantined in fish sellers' tanks for the duration of sanitary analyses. All stocking sites are monitored to assess the efficiency of stocking. The first nationally organized stocking action started in 2010. In 2010, two projects representing 150 k € (including monitoring) for 200 kg restocked were selected. However, no glass eel were restocked because of the end of the glass eel season. However, 209 kg (glass eel mean weight 0.233 g and thus 900 000 glass eels) were restocked in the Loire River in July 2010 after these glass eel were collected from a CITES seizure. In 2011, eleven projects were selected for a total amount of 4024 kg. However, only 747.5 kg were really restocked, partly because of late selection process and partly because of lack of supply. In 2012, eleven projects were selected for a total amount of 3475 kg, and 3086 kg were really restocked. In 2013, eleven projects were selected for a total amount of 3400 kg, and 2940 kg have really been restocked. In 2014, eleven projects were selected for a total amount of 6307 kg, and 5656 kg have really been restocked. Apart from this national restocking programme, some local restocking may have taken place but the quantity, quality (glass eel or yellow eel), origins and objectives are unknown. For example: there has been a long history of stocking in Lake Grand Lieu (Adam, 1997) to enhance a fishery with a maximum of more than 2 t of glass eels in the 1960s and more than 1.5 t of elvers in the 1990s.

Spain: No stocking is managed on a national level. Each Autonomy has its own rules and experience concerning stocking. In Spain, different stocking experiences have been carried out:

- In Navarra stocking is carried out in the Ebro River but only as a measure of artificial maintenance of the presence of eel in the rivers.
- Since 1988, C. Valenciana fishermen from the Albufera and from the Bullent and Molinell Rivers must give a percentage of their glass eels catches for restocking. These glass eels are raised in the public Centre for the Production and Experimentation of Warm Water Fishes until they reach a weight of 8–10 g. Fattened eels are released up in the river waters and wetlands of C. Valenciana and other autonomous regions. The EMP of C. Valenciana contains a detailed stocking plan.
- In Asturias, the Head Office of Fishery purchased 6 kg and 8 kg of glass eel that were released in Sella and Nalón Rivers in 2010 and 2011 respectively. The price per kg of glass eel was 531.8 € in 2010 and 577.8 € in 2011. No stocking was performed during 2012–2014.
- In Catalonia Inner River Basins and the Ebro RBD, different stocking experiences have been carried out since 1996. During 1998–2007, fishermen gave 5% of their seasonal glass eel catches approximately for stocking in the Fluvia, Muga, Ter and Ebro Rivers. No stocking was performed during 2012–2014.
- In Cantabria, 40% of the total glass eel landings of the 2010–2011 fishing season were used for restocking. Some of the catches were kept alive in tanks by the Council and stocked weekly along the fishing period in different river basins depending on the source of landings. The rest of the glass eels were cultured and stocked at different stages of their life cycle, aiming to assess the efficiency of each of the methods. No data available for the 2012–2014.
- In the Basque Country, a new pilot study started in the Oria River in 2011. In a first phase, 2400 young eels trapped in the Orbeldi trap (in Usurbil,

Gipuzkoa) were translocated up to the Ursuaran River (in Idiazabal, Gipuzkoa). Both rivers belong to the same river basin (Oria River basin). During 2012, and within the same project, 2.8 kg of glass eels from the fishery were stocked directly in the Oria River and another amount was kept for fattening in an eel farm: 1.7 kg of on-grown glass eel was stocked after. In 2013, 6250 glass eels from the fishery in the Urola River were stocked directly upstream. During the summer 2011, 2012, 2013 and 2014, different electric fishing operations have been carried out aiming to monitor the restocked individuals.

Portugal: No stocking on a national level.

Italy: The new glass eel regulation foresees that glass eel fisheries can continue on a local scale, provided that 60% is used for stocking in national inland waters open to the sea, and provided that fishers compile specific and detailed logbooks of catches and sales. This new system, together with reinforced controls by the *Corpo Forestale dello Stato*, shall ensure that information on recruitment in Italy is available from year to year, that most glass eel is conveyed to stocking and that illegal fishing is definitively prevented. Up to 2010, the new regulation was not in force, its definite approval being achieved in 2011. From 2011, the new regulation being in force, fishing has started again and catches are declared to the Ministry on a weekly basis. In 2013, 67 kg glass eel, 126 kg ongrown eel and 9.4 kg bootlace eels were stocked. At present, it is not possible to document where exactly restocking were performed, as provinces and regions have not provided this information. Overall, the two first years of implementation of the new regulatory framework for glass eel fisheries (2011 and 2012) must be considered as a pilot period, accounting for the setting up of the declaration system. At present (2013 and 2014), filling of the forms is still lacking, and the details of the documents of purchase and sale are also deficient. This does not allow complete traceability of movements on the Italian territory. To overcome this problem, a full traceability system is currently being studied, developed in collaboration with the Corpo Forestale dello Stato - Unit CITES. This system should ensure the full traceability of all glass eel movements, either from national waters or imported, also aiming to definitively eradicate illegal fishing of glass eels.

Greece: In the past some scarce, empirical and small scale attempts were undertaken with the aim of improving local fisheries. Glass eel stocking was performed in the Lake Pamvotis (EMU-1) and the Kalama's delta (EMU-1), while young reared eels were introduced in the Lake Pamvotis and at the estuaries of Western Greece rivers (Economidis, 1991; Economidis *et al*., 2000). There is no information concerning the number of eels or their characteristics, and no data exists about the results of these experiments. Then in 2010 and 2012, two more stockings took place in Messolonghi -Aitoliko lagoons (EMU 1) and in River Acherondas (EMU 1) according to the protocol suggested by the HEMP. In 2013, eel stocking was performed in River Acherondas (EMU 1), with eels provided by a private company in Epirus. The agency responsible for the eel releases in 2013 was the Regional Fisheries Authorities of Epirus-Western Macedonia. According to a decision (ΑΔΑ: ΒΛ10ΟΡ1Γ Ν02) in 2013, they have proceeded to the release of 10% of glass eels, imported by the aquaculture units in Epirus.

2.8 Aquaculture production of European eel

Aquaculture production data for European eel limited to European countries from 2004 to 2013 are compiled from different sources: Country Reports to WGEEL 2014

(Table 2.11), FAO (Table 2.12) and FEAP (Federation of National Aquaculture associations) (Table 2.13). Some discrepancies exist between FAO and FEAP databases and the Country Reports, but overall the trend in aquaculture production is decreasing from 8000–9000 tonnes in 2004 to approximately 5000 tonnes in 2013 (Figure 2.26). Some of the discrepancies between FAO and the Country Report data may result from the possibility that eel that is used for stocking is not being reported to the FAO.

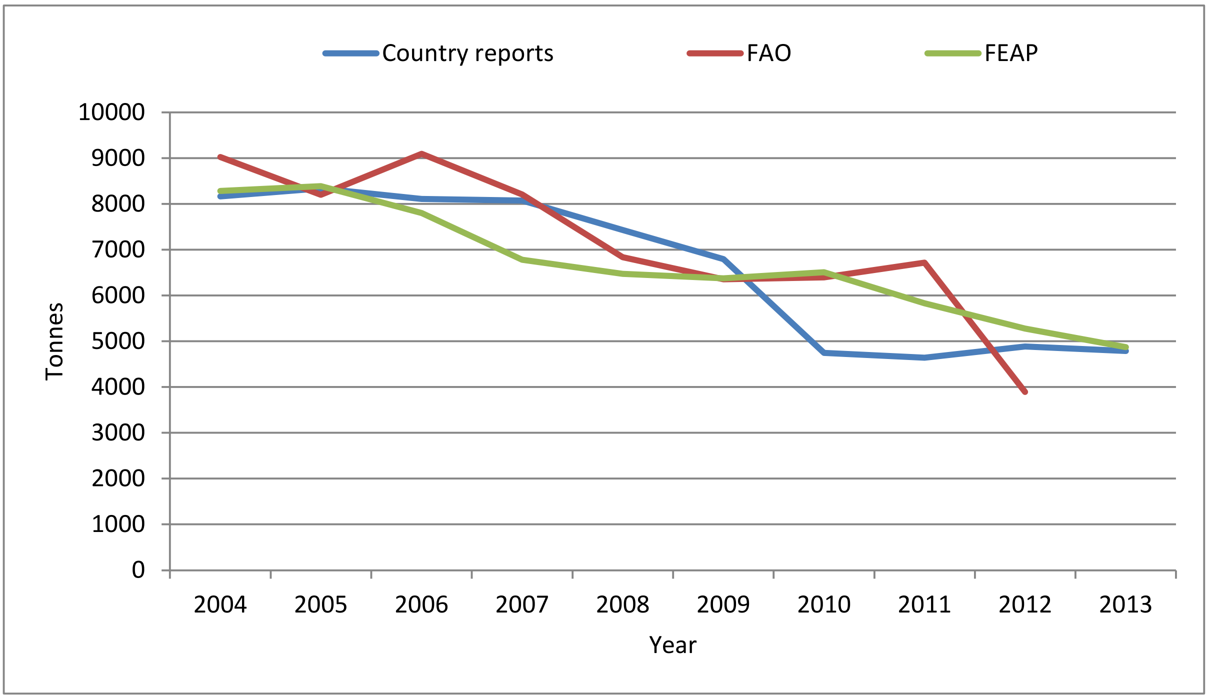


Figure 2.26. Different sources of data for aquaculture production of European eel in Europe from 2005 to 2013, in tons.

2.9 Environmental drivers

This year, the working group members were asked to include in their country reports any information that they thought was relevant to consideration of the potential environmental drivers influencing the stock. This information has been compiled and is presented in Table 2.14. Though those were not always reported in the country reports, they have been often assessed as having large effect in continental water, either as possibly continental wide change (e.g. temperature, eutrophication) or on a more local scale (unlike the oceanic factors).

2.10 Tables

Table 2.1. European eel recruitment time-series updated to 2014.

CODE	NAME	COUNTRY	AREA	STAGE
Ring	Ringhals scientific survey	Sweden	North sea	gls.
Stel	Stellendam scientific estimate	Netherlands	North sea	gls.
Kavl	K¨avlingeân trapping all	Sweden	Baltic	ylw.
Yser	Ijzer Nieuwpoort scientific	Belgium	North sea	gls.
YFS2	IYFS2 scientific estimate	Sweden	North sea	gls.
Dala	Dal¨alven trapping all	Sweden	Baltic	ylw.
SeEA	Severn EA commercial catch	UK	British Isle	gls.
SeHM	Severn HMRC commercial catch	UK	British Isle	gls.
Imsa	Imsa Near Sandnes trapping all	Norway	North sea	gls.
MiSp	Minho Spanish part commercial catch	Spain	Atlantic Ocean	gls.
Fre	Frémur	France	North sea	gls. +
ShaA	Shannon Ardnacrusha trapping	Ireland	British Isle	gls. +
Albu	Albufera de Valencia commercial catch	Spain	Mediterannean Sea	gls.
Nalo	Nalon Estuary commercial catch	Spain	Atlantic Ocean	gls.
Feal	River Feale	Ireland	Atlantic Ocean	gls. +
RhDO	Rhine DenOever scientific	Netherlands	North sea	gls.
RhIj	Rhine Ijmuiden scientific	Netherlands	North sea	gls.
Ronn	R¨onne A ˚ trapping all	Sweden	North sea	ylw.
Katw	Katwijk scientific estimate	Netherlands	North sea	gls.
Laga	Lagan trapping all	Sweden	North sea	ylw.
MiPo	Minho Portugese part commercial catch	Portugal	Atlantic Ocean	gls.
GiSc	Gironde scientific estimate	France	Atlantic Ocean	gls.
Lauw	Lauwersoog scientific estimate	Netherlands	North sea	gls.
Ebro	Ebro delta lagoons	Spain	Mediterannean Sea	gls.
Meus	Meuse Lixhe dam trapping	Belgium	North sea	ylw.
Gota	Gâta Àlv trapping all	Sweden	North sea	ylw.
Morr	M¨orrumsân trapping all	Sweden	Baltic	ylw.
Mota	Motala Str¨om trapping all	Sweden	Baltic	ylw.
ShaP	Shannon Parteen trapping partial	Ireland	British Isle	ylw.
Bann	Bann Coleraine trapping partial	Northern Ireland	British Isle	gls. + ylw.
Maig	River Maigue	Ireland	Atlantic Ocean	gls.
Inag	River Inagh	Ireland	Atlantic Ocean	gls. +
Visk	Viskan Sluices trapping all	Sweden	North sea	gls. +
Erne	Erne Ballyshannon trapping all	Ireland	British Isle	gls. +
Sle	Slette A	Denmark	North sea	gls. +
Klit	Klitmoeller A	Denmark	North sea	gls. +
AlCP	Albufera de Valencia commercial cpue	Spain	Mediterannean Sea	gls.
Nors	Nors A	Denmark	North sea	gls. +

Table 2.2. European eel recruitment time-series; those only updated to 2013.

CODE	NAME	COUNTRY	AREA	STAGE
Gude	Guden Å trapping all	Denmark	North Sea	Ylw.
Bres	Bresle	France	Atlantic Ocean	Gls + ylw.
Hart	Harte trapping all	Denmark	Baltic Sea	Ylw.

Table 2.3. European eel recruitment time-series; those stopped or not updated to 2013 at least.

CODE	NAME	COUNTRY	AREA	STAGE	LAST YEAR
YFS1	IYFS scientific estimate	Sweden	North sea	gls.	1989
Vida	Vidaa Højer sluice commercial catch	Denmark	North sea	gls.	1990
Ems	Ems Herbrum commercial catch	Germany	North sea	gls.	2001
Tibe	Tiber Fiumara Grande commercial catch	Italy	Mediterannean Sea	gls.	2006
AdCP	Adour Estuary (cpue) commercial cpue	France	Atlantic Ocean	gls.	2008
AdTC	Adour Estuary (catch) commercial catch	France	Atlantic Ocean	gls.	2008
GiCP	Gironde Estuary (cpue) commercial cpue	France	Atlantic Ocean	gls.	2008
GiTC	Gironde Estuary (catch) commercial catch	France	Atlantic Ocean	gls.	2008
Loi	Loire Estuary commercial catch	France	Atlantic Ocean	gls.	2008
SevN	Sèvres Niortaise Estuary commercial cpue	France	Atlantic Ocean	gls.	2008
Vil	Vilaine Arzal trapping all	France	Atlantic Ocean	gls.	2011

Table 2.4. GLM *glass eel ~ year : area + site* average of predicted values for 40 glass eel series, values given in percentage of the 1960–1979 period.

	1960		1970		1980		1990		2000		2010	
	EE	NS	EE	NS	EE	NS	EE	NS	EE	NS	EE	NS
0	130	192	97	87	119	72	39	13	20	4	4.5	0.4
1	112	107	50	78	90	54	18	3	9	1	4.2	0.4
2	143	164	53	101	102	30	25	7	13	2	6.1	0.6
3	174	205	59	45	49	25	29	6	14	2	8.6	1.1
4	95	107	89	120	57	9	29	7	8	1	12.2	3.7
5	125	70	68	51	54	8	35	4	9	1		
6	76	80	111	96	36	8	28	4	7	0		
7	78	88	103	75	65	9	44	4	7	1		
8	129	113	112	54	65	9	18	3	6	1		
9	57	80	140	86	47	4	23	5	4	1		

Table 2.5. GLM *yellow eel ~ year + site* average of predicted values for 12 yellow eel series, values given in percentage of the 1960–1979 period.

	1950	1960	1970	1980	1990	2000	2010
0	175	158	51	90	29	17	13
1	232	169	55	37	36	18	12
2	227	164	103	47	20	33	11
3	367	137	125	42	13	19	7
4	181	54	59	31	49	26	36
5	275	102	110	60	16	9	
6	130	141	33	44	9	15	
7	145	95	67	44	21	21	
8	147	159	61	57	18	14	
9	313	104	54	33	23	7	

Table 2.6. Summary of the breakpoints identified in the glass eel time-series using the CUSUM method.

K	Time period	Time-series	Breakpoints
$k1_{GENorth}$	1960–2014	Glass eels 'North Sea'	1981
$k1_{GEElsewhere}$	1960–2014	Glass eels 'Elsewhere Europe'	1970, 1982, 1990
$k2_{GENorth}$	1980–2014	Glass eels 'North Sea'	1983
$k2_{GEElsewhere}$	1980–2014	Glass eels 'Elsewhere Europe'	1990, 1997
$k3_{GENorth}$	1980–2014	Ln(glass eels 'North Sea')	2000, 2013
$k3_{GEElsewhere}$	1980–2014	Ln(glass eels 'Elsewhere Europe')	2000

Table 2.7. Breakpoints estimation for each time-series using the segmented regression method.

Time period	Time-series	Breakpoints
1960–2014	Glass eels 'North Sea'	1981, 1984, 1996, 2012
1960–2014	Glass eels 'Elsewhere Europe'	1972, 1978, 2011
1960–2014	Yellow eels	--

Table 2.8. Time-series of yellow and silver eel described in the country reports for 2014.

Gear	Start	End	Missing Years	Unit	Stage	Code	Location	Name	Country
fykenet survey	1960	2013	0	Index	yellow eel	DenB	Den Burg, Texel	Den Burg fykenet survey	Netherlands
electro fishing	1979	2013	13	eel.m-2	yellow eel	VesV	Vester Vedsted brook	Vester Vested elecrofishing	Denmark
beach seine survey	1925	2013	4	eel.haul-1	yellow + silver eel	ska	Skagerrak	Skagerrak Beach Seine Survey	Norway
fykenet survey	1977	2013	2	eel. net-1	yellow eel		Barsebäck	Swedish west coast monitoring	Sweden
fykenet survey	2002	2013	1	eel. net-1	yellow eel		Kullen	Swedish west coast monitoring	Sweden
fykenet survey	1976	2013	2	eel. net-1	yellow eel		Vendelsö	Swedish west coast monitoring	Sweden
fykenet survey	2002	2013	0	eel. net-1	yellow eel		Hakefjorden	Swedish west coast monitoring	Sweden
fykenet survey	1998	2013	1	eel. net-1	yellow eel		Fjällbacka	Swedish west coast monitoring	Sweden
Elecrified trawl	1988	2013	0	n/ha	yellow eel		Ijsselmeer Northern	Ijsselmeer trawl survey	Netherlands
Elecrified trawl	1988	2013	0	n/ha	yellow eel		Ijsselmeer Southern	Ijsselmeer trawl survey	Netherlands
fykenet survey	1995	2013	2	kg/fyke/day (?)	yellow eel			Zandvliet	Belgium
fykenet survey	1995	2013	3	kg/fyke/day (?)	yellow eel			Antwerpen	Belgium
fykenet survey	1997	2013	2	kg/fyke/day (?)	yellow eel			Steendorp	Belgium
fykenet survey	1997	2013	4	kg/fyke/day (?)	yellow eel			Kastel	Belgium
	2006	2013	0	kg/ha	silver eel	BadB	Baddoch Burn	Baddoch Burn	Scoltland
	1966	2013	24	kg/ha	silver reel	GirB	Girnoch Burn	Girnoch Brun	Scoltland
	1999	2013	4	kg/ha	silver eel	Shie	Shieldaig	Shiledaig	Scoltland
	1991	2011	5	cpue	silver eel	BIT1		BITS-1	
	1991	2010	0	cpue	silver eel	BIT4		BITS-4	
	1988	2011	2	cpue	silver eel	NSIB		NS-IBTS	
	1988	2005	6	cpue	silver eel	Pand		Pandalus	
	1975	2013	0	number	silver eel	ImsS	Imsa	Imsa Siver	Norway
	1996	2013	0	number	silver eel	Frem	Frémur	Frémur	France

Table 2.9. Recreational fisheries data for European eels.

	Retained							Released						
	Inland			Marine				Inland			Marine			
Country/ Year	Angling	passive gears	total inland	Angling	passive gears	total marine	Total retained	angling	passive gears	total inland	angling	passive gears	total marine	Total released
Norway														
2013	NP	NP		NP	NP			NC	NC		NC	NC		
Sweden														
2013	NP	NP		NP	NP			NC	NP		NC	NP		
Finland														
2010		9	9		1	1	10							
Estonia														
2012	0.02		0.02				0.02							
Latvia														
2012	NC	NP			0.102	0.102	0.102	NC	NP		NC	NC		
Lithuania														
2013	3	NP	3	NC	NP		3	NC	NP		NC	NP		
Poland														
2013	26.7	NP	26.7	<1	NP	<1	27	NC	NP		NC	NP		
Germany														
2013	NC	NC		NC	NC		240	NC	NC		NC	NC		
Denmark														
2013	NC	8	8		50	50	58	NC	NC		70000 (#)	NC		
Netherlands														

	Retained							Released						
	Inland			Marine				Inland			Marine			
Country/ year	Angling	passive gears	total inland	Angling	passive gears	total marine	Total retained	angling	passive gears	total inland	angling	passive gears	total marine	Total released
2010	53	NP	53	26	NP	26	79	143	NP	143	25	NP	25	168
Belgium														
2013 (Flanders)	NC	NP		NC	NP			NC	NP		NC	NP		
2013 (Wallonia)	NP	NP		NP	NP			NC	NP		NP	NP		
UK (England/ Wales)														
2012	NP	NP		5000 (#)	NP			NC	NP		32000 (#)	NP		
UK (Scotland)														
2013	NP	NP		NP	NP			NC	NP		NC	NP		
Ireland														
2013	NP	NP		NP	NP			NC	NP		NC	NP		
France														
2012	NC	5.3	5.3	NC	NP		5.3	NC	NC		NC	NP		
Portugal														
2013	NC	NP		NC	NP			NC	NP		NC	NP		
Spain														
2013	NC	NP		NC	2.4*	2.4*	2.4*	NC	NP		NC	NP		
Italy														
2013	82.6 ?													

	Retained							Released						
	Inland			Marine				Inland			Marine			
Country/ year	Angling	passive gears	total inland	Angling	passive gears	total marine	Total retained	angling	passive gears	total inland	angling	passive gears	total marine	Total released
Montenegro														
2013	NC	NP		NC	NC			NC	NP		NC	NC		
Albania														
2013	NC	NP		NC	NP			NC	NP		NC	NP		
Greece														
2013	NP	NP		NP	NP			NC	NP		NC	NP		
Turkey														
2013	NC	NC		NC	NC			NC	NC		NC	NC		
Tunisia														
2013	NC	NP		NC	NP			NC	NP		NC	NP		

Table 2.10. Estimation of underreported catches (in kg) of eel in 2013, by stage, as declared to the working group.

	Glass eel				Yellow eel				Silver Eel				Combined (Y + S)			
EMU	Reported catches (kg)	Underrept. %	Underrept. (kg)	Total catches (kg)	Reported catches (kg)	Underrept. %	Underrept. (kg)	Total catches (kg)	Reported catches (kg)	Underrept. %	Underrept. (kg)	Total catches (kg)	Reported catches (kg)	Underrept. %	Underrept. (kg)	Total catches (kg)
FI													3000	4-5	150	3150
LT													12 555	0.1	14.2	12 569
PL													48 631	56.5	27 500	76 131
NL															4.4	
FR	5525	11.7	647	6172	23 738	0.3	65	23 803	-	-	892	-	-	-	957	-
UK	344	0	0	344	321 000	0	0	321 000	72 000	0	0	72 000	393 000	0	0	0

Table 2.11. Aquaculture production of European eel in Europe from 2005 to 2013, in tons. Source: Country Reports. NR . = not reported.

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Denmark	1500	1700	1900	1617	1740	1707	1537	1156	1093	824
Estonia	26	19	27	52	45	30	20	25	35	NR
Germany	328	329	567	740	749	667	681	660	706	757
Netherlands	4500	4500	4200	4000	3700	3200	2000	2300	2600	2900
Portugal	1,5	1,4	1,1	0.5	0.4	1,1	NR	0,6	NR	NR
Sweden	158	222	191	175	172	139	91	94	93	92
Poland	1	1	1	1	1	1	1	1,5	1,5	1,5
Italy	1220	1131	807	1000	551	587	NR	NR	NR	NR
Spain	424	427	403	478	461	450	411	391	352	210
Total	8157	8329	8096	8063	7419	6781	4741	4602	4880,5	4784,5

Table 2.12. Aquaculture production of European eel in Europe from 2004 to 2012, in tons. Source: FAO FishStat.

	2004	2005	2006	2007	2008	2009	2010	2011	2012
Denmark	1823	1673	1699	1614	895	1659	1532	1154	1061
Estonia	7	40	40	45	47	30	22	10	NR
Germany	322	329	567	440	447	385	398	660	460
Netherlands	4500	4000	5000	4000	3700	2800	3000	3000	1800
Portugal	2	1	2	1	1	1	NR	1	NR
Sweden	158	222	191	175	172	0	0	90	93
Poland	NR	NR	NR	NR	NR	NR	NR	NR	NR
Italy	1220	1132	807	1000	551	567	647	1000	450
Spain	424	427	403	479	534	488	423	434	373
Greece	557	372	385	454	489	428	372	370	320
Hungary	11	5	NR	NR	NR	NR	NR	NR	NR
Total	9024	8201	9094	8208	6836	6358	6394	6719	4557

Table 2.13. Aquaculture production of European eel in Europe from 2004 to 2013, in tons. Source: FEAP.

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Denmark	1500	1610	1760	1870	1870	1500	1899	1154	1061	1061
Estonia	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Germany	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Netherlands	4500	4500	4200	3000	3000	3200	3000	2800	2300	2000
Portugal	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Sweden	158	222	191	175	172	170	170	NR	93	93
Poland	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Italy	1220	1132	808	1000	550	568	568	1100	1100	1100
Spain	390	405	440	280	390	510	446	402	350	315
Greece	500	500	385	454	489	428	428	372	304	304
Hungary	20	20	20	NR	NR	NR	NR	NR	NR	NR
Total	8288	8389	7804	6779	6471	6376	6511	5828	5208	4873

Table 2.14. Possible environmental drivers summarized from country reports.

Country code	Comment on environmental drivers
NO	Some rivers are still severely affected by chronic or episodic acid water. The areas affected by acidification have likely been among the most important areas for eel in Norway. Based on surveys in 13 rivers that are now limed, it seems that occurrence and density of eel was reduced due to acidification (Thorstad *et al*., 2011, Larsen *et al*., 2014). Densities of eel increased more than four-fold after liming when compared with pre-liming levels.
LV	Some research results related to climate change in Latvia and possible effects are published in: Climate change in Latvia and adaptation to it /eds. Maris Klavins and Agrita Briede. - Riga: University of Latvia press, 2012. -188 pp. Increase of water temperature and eutrophication would be factors improving eel living conditions in Latvia.
BE	Improvement of water quality by installing purification units is an on-going process (within the objectives of the Water Framework Directive). In summary following management measures are planned for restoration of eel habitat and accessibility of the rivers: • 90% of prior obstacles should be removed by 2015, other 10%- 2021; • resolving by migration barriers till 2027; • implementation of measures to attain the good quality class of prior rivers.
UK	The following impacts have been assessed for all RBDs in England and Wales; commercial fisheries, tidal gates, pumping stations, surface water abstractions and hydropower installations. The main impact that has not been assessed is the impact of manmade barriers, but work is ongoing to quantify the impact. The impact of the recreational fishery, predators and contaminants and parasites is treated as part of natural mortality.
FR	In France same impacts of climate change and water pollution effects has studied. Since 1960 the river Gironde discharge has been highly decreasing, lightly in the river Loire while the discharge remained stable in Seine. Moreover the summer temperature in the Gironde estuary has increased of 2.5 °C in 30 years. In France the concentration in nitrate has increased until the 1990s and has been stabilized since. Metallic and organic pollution is not well known and evolutions are site-specific (Le Treut ed. 2013)
ES	There is no information regarding how the environment in Spain has changed in the last 50 years that might have influenced eel production.
AL	Development of agriculture, construction of dams, development of industrial activities, have generated varies kind of impacts on ecological dynamics (physical and biological)
GR	In Greece national report was concluded that arrangement of facilities improving accessibility up from barriers are expensive and by doubtful results. Interventions in lowland ecosystems near the estuaries will be significantly more effective, as suggested in the Greek Management Plan for the Eel.

3 ToR e) Further develop the stock–recruitment relationship and associated reference points, using the latest available data

3.1 Introduction

This chapter will first summarise past ICES advice on eel with a focus on reference points, and discuss the objectives and targets of the Eel Regulation; then discuss options for providing advice, in particular focused on mortality reference points. Then, we present the derivation of reference points for the eel, using three different approaches; this part is essentially a rewriting of the preliminary results of WGEEL (2013). Future improvement of the analysis of the stock-recruit-relation will require additional data, for which we supply recommendations. Finally, the recent upturn in recruitment is put into perspective, contrasting the observed upturn to the change in spawner escapement assessed in 2012.

3.2 Reference points used or implicated in previous ICES Advice

Since 1998 (ICES, 1999 through to ICES, 2010), ICES has given advice[4] that the stock has shown a long-term decline; that fishing and other anthropogenic impacts should

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[4] ICES 1999 (advice) advised "The eel stock is outside safe biological limits and the current fishery is not sustainable. (…) Actions that would lead to a recovery of the recruitment are needed. The possible actions are 1) restricting the fishery and/or 2) stocking of glass eel."

ICES (2000) (advice) recommended "that a recovery plan should be implemented for the eel stock and that the fishing mortality be reduced to the lowest possible level until such a plan is agreed upon and implemented."

ICES (2001) (advice) recommended "that an international rebuilding plan is developed for the whole stock. Such a rebuilding plan should include measures to reduce exploitation of all life stages and restore habitats. Until such a plan is agreed upon and implemented, ICES recommends that exploitation be reduced to the lowest possible level."

ICES (2002) (advice) recommended "that an international recovery plan be developed for the whole stock on an urgent basis and that exploitation and other anthropogenic mortalities be reduced to as close to zero as possible, until such a plan is agreed upon and implemented. […] Exploitation, which provides 30% of the virgin (F=0) spawning stock biomass is generally considered […] a reasonable provisional reference target. However, for eel a preliminary value could be 50%."

ICES (2006) (advice) advice read: "An important element of such a recovery plan should be a ban on all exploitation (including eel harvesting for aquaculture) until clear signs of recovery can be established. Other anthropogenic impacts should be reduced to a level as close to zero as possible."

ICES (2008a) (advice) concluded "There is no change in the perception of the status of the stock. The advice remains that urgent actions are needed to avoid further depletion of the eel stock and to bring about a recovery."

ICES (2009) (advice) reiterated its previous advice that "all anthropogenic impacts on production and escapement of eels should be reduced to as close to zero as possible until stock recovery is achieved".

be reduced; that a recovery plan should be compiled and implemented; that preliminary reductions in mortality to as close to zero as possible are required until such a plan is implemented, until stock recovery has been achieved, until there is clear evidence that the stock is increasing, that both the recruitment and adult stock are increasing, , and of sustained increase in both recruitment and the adult stock.

ICES (2002) discussed a potential reference value for spawning–stock biomass: "a precautionary reference point for eel must be stricter than universal provisional reference targets. Exploitation, which provides 30% of the virgin (F = 0) spawning–stock biomass is generally considered to be such a reasonable provisional reference target. However, for eel a preliminary value could be 50%." That is: ICES advised to set a spawning stock biomass limit above the universal value of 30%, at a value of 50% of B_0. ICES (2007) added: "an intermediate rebuilding target could be the pre-1970s average SSB level which has generated normal recruitments in the past."

ICES has not advised on specific values for mortality-based reference points, but the wordings "the lowest possible level" and "as close to zero as possible" imply that the mortality limit should be set close to zero. Over the years, the implied time frame for this advice has changed from "until a plan is agreed upon and implemented", to "until stock recovery is achieved" and "until there is clear evidence that the stock is increasing". The first and third phrases are more interim precautionary mortality advice than clear reference points.

3.3 Objectives and targets/limits of the Eel Regulation

The Eel Regulation (Council Regulation 1100/2007) sets a limit for the escapement of (maturing) silver eels at 40% of the natural escapement (in the absence of any anthropogenic impacts and at historic recruitment). That is: a limit is set at 40% of B_0, in-between the universal level and the more precautious level advised. ICES (2008) noted that its 2002 advice was "higher than the escapement level of at least 40% set by the EU Regulation."

Because current recruitment is generally far below the historical level, a return to the limit level is not to be expected within a short range of years, even if all anthropogenic impacts are removed (Åström and Dekker, 2007). The Eel Regulation indeed expects to achieve its objective "in the long term", but it does not specify an order of magnitude for that duration. Noting the general objective to protect and recover the European eel

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ICES (2010c) (advice) reiterated its previous advice that "all anthropogenic mortality (e.g. recreational and commercial fishing, barriers to passage, habitat alteration, pollution, etc.) affecting production and escapement of eels should be reduced to as close to zero as possible until there is clear evidence that the stock is increasing."

ICES (2011 advice) and ICES (2012 advice) reiterated its previous advice that "all anthropogenic mortality (e.g. recreational and commercial fishing, hydropower, pollution) affecting production and escapement of eels should be reduced to as close to zero as possible until there is clear evidence that both recruitment and the adult stock are increasing."

ICES (2013 advice) once more advised "that all anthropogenic mortality (e.g. recreational and commercial fishing, hydropower, pollution) affecting production and escapement of silver eels should be reduced to as close to zero as possible, until there is clear evidence of sustained increase in both recruitment and the adult stock."

stock, we conclude that a further deterioration of the status of the stock is to be avoided, which implicitly sets an upper limit on anthropogenic mortality (in the order of magnitude of $\Sigma A = 0.92$, see below.

The 40% biomass limit of the Eel Regulation applies to all management units, without differentiation between the units. Whether or not that implies that the corresponding mortality limit ($\Sigma A = 0.92$) also applies to all units or not, is unclear. However, since it is unknown whether or not all areas contribute to successful spawning, a uniform mortality limit for all areas will constitute a risk-averse approach (Dekker, 2010).

3.4 Multiple criteria

The Eel Regulation set a biomass limit at 40% of B_0. The current silver eel escapement $B_{current}$, however, is estimated to be below that limit, at 6–18% (depending on the data source used; ICES, 2013b), and $B_{current}$ is unlikely to restore to 40% of B_0 in the near future; it is even more likely to decline for several years, due to the downward trend in recruitment observed in the past decade. A mortality limit of $\Sigma A = 0.92$ will correspond to the 40% biomass limit in the long run, but establishing/maintaining mortality at that level in the current, depleted state will not allow the stock to recover. The question arises what mortality limit to apply for the current, depleted state. WGEEL (ICES, 2010b) only considered an ultimate mortality limit ($\Sigma A = 0.92$). WGEEL (ICES, 2011a) followed standard ICES protocols and applied a reduction in the limit mortality in proportion to the biomass of the spawner escapement (setting the limit for $\Sigma A = 0.92$ at $B_{current}$ = 40% of B_0 and at $\Sigma A = 0$ for $B_{current} = 0$). The Review Group for WGEEL suggested the application of criteria for short-lived stocks (ICES, 2013b), implying $\Sigma A = 0$ for $B_{current}$ < 40% of B_0. The discussion of WKLIFE for short-lived species is not yet being available (WKLIFE-4, November 2014), while ICES (2014) specifies a harvest control rule for short-lived species but does not elaborate on its background. We therefore discuss the rationale for specific short-lived-species criteria, and their relevance for eel.

3.4.1 Knock-on effects of spawning stock depletion

In short-lived species, the number of age groups in the spawning stock is low; at the extreme, for an annual species (spawning at age 1), there is just a single year class in the spawning stock. A depletion of the spawning stock in one year will have consequences for the next year class, and because of the presence of just a single year class, knock-on effects are to be expected for several more generations. Or conversely, an effort to restore the stock will rapidly translate into a recovery of the whole stock. In case the stock is depleted, an immediate action to reduce the anthropogenic mortality to the lowest possible level will be required, to avoid knock-on effects for the coming generations.

For eel, the spawning escapement comprises many year classes (see Section 3.6, below); knock-on effects of current depletion/protection do not result in proportional decline/recovery of the spawning stock. Instead, prolonged protection is required to increase the size of the spawning stock in the long run. Section 3.7.2.2.2 (below) indicates that, despite the increased level of protection in recent years, the spawner escapement reported in 2012 actually went down by 4%. Knock-on effects are dampened, are smoothed out, by the many year classes in the silver eel run.

3.4.2 Sensitivity to external or random perturbations

In addition to the effects of management actions, the spawning stock size of short-lived species is sensitive to unpredictable external pertubations (e.g. environmental conditions). A single year of unfavourable conditions will have a large effect on the spawning stock in the year(s) after. The fewer year classes in the spawning stock, the larger the effect of an incidental low year class (though, on the other hand, the lower the number of years affected).

For eel, the spawner escapement comprises many year classes. Additionally, recruitment monitoring has shown a multi-decadal decline at a rather constant rate, perturbed by relatively small year-to-year variation. The causing factors for the decline are not well known; both, a depletion of spawner escapement from the continent and unfavourable oceanic conditions have been suggested. Whatever the ultimate cause, the long-lasting decline in recruit series indicates that short-term perturbations have had relatively small impact.

3.4.3 Speed of recovery

The current silver eel run $B_{current}$ is estimated to be below the 40% limit of the Eel Regulation, at 6–18% (depending on the data source used; ICES, 2013b), and $B_{current}$ is unlikely to restore to 40% in the short run. Depending on the protocol applied, advised mortality levels may range from $\Sigma A = 0.92$ to $\Sigma A = 0$. Clearly, the lower the mortality level achieved, the faster recovery of the stock can be expected and the lower the risk of a continued decline or worse (Figure 8.1) (though multiple generation times might be required to achieve full recovery; Åström and Dekker, 2007). The previous Sections (3.4.1 and 3.4.2) did not indicate biological arguments for either a low or a high mortality advice. There appears to be no biological ground for a mortality advice at low spawning stock biomass (SSB < B_{lim}), other than the ultimate limit $\Sigma A \leq 0.92$. A high or a low mortality reference point probably is more a reflection of a low or high ambition level. WGEEL considers that to be outside its remit.

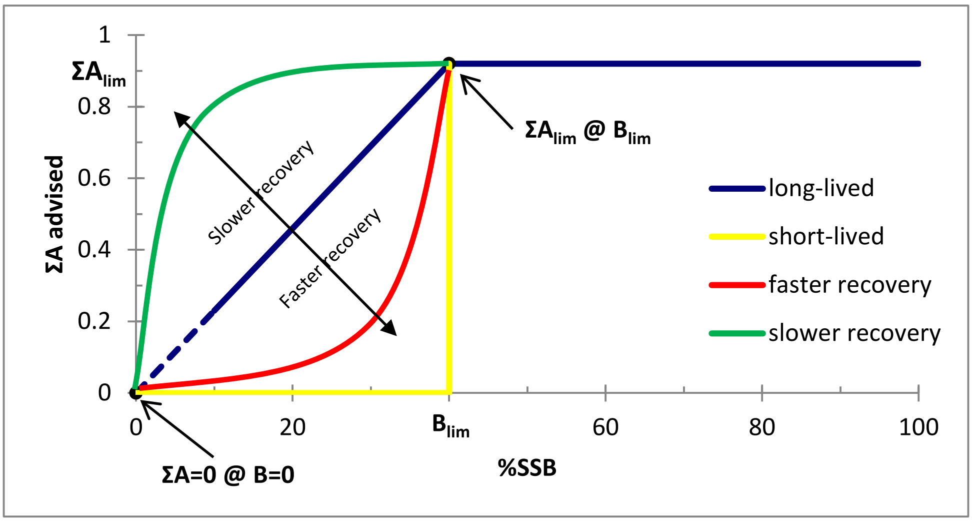


Figure 3.1. Schematic overview of different harvest control rules.

3.5 General stock–recruit relation, short-lived species protocol

ICES in 2002 advised "Exploitation, which provides 30% of the virgin (F = 0) spawning–stock biomass is generally considered to be … a reasonable provisional reference target. However, for eel a preliminary value could be 50%". This advice was based on comparison of the eel to fish stocks in general and a tentative estimate based on life-history parameters (Dekker, 2003). Subsequent analyses (Dekker, 2004; ICES, 2013b) have indicated that the stock–recruit relation might actually show signs of strong depensation and/or overwhelming environmental drivers, in particular evidenced by recruitment declining faster than the spawner escapement. Though neither the depensation nor the effect of environmental drivers has been proven beyond doubt, it is clear that reference points based on the data will be more strict than the standard advice (30% of B_0), or even the extra precautious level (50% of B_0).

The eel is a long-lived semelparous species. The suggestion made by the Review Group 2013 (ICES, 2013b, Annex 9) to apply a protocol for short-lived species actually contradicts the real life history parameters of the eel. Stacking a non-fitting protocol, on top of an assumed (standard) stock–recruit relation that is contradicted by the data would, in the view of WGEEL, be unwise and would undermine the credibility of the resulting reference point.

3.6 The age composition of the silver eel run escaping to the ocean

In countries where silver eel fisheries exist, catches are regularly sampled; at other places, incidental samples have been analysed, or age distributions have been derived from research traps. Results vary from region to region, from river to river, within and between the seasons, but overall, a wide range of ages is found (Figure 3.2). In southern regions, female silver eels tend to be relatively young (e.g. six years in Mediterranean lagoons; Figure 3.2), with only ten different year classes in the silver eel run. In northern regions, female silver eels are usually much older (e.g. 17 years in inland waters in Sweden; Figure 3.2) with up to 20 different year classes in the catch. Overall, some thirty age groups are regularly represented in the silver eel run from all over the continent. In addition, there are sites showing an uncommon age composition, such as Burrishoole in western Ireland, and sites in Scotland, where growth under oligotrophic conditions is extremely slow, mean age of the silver eel is about 31 years, adding at least ten extra age groups to the continental run. Though these exceptional sites are uncommon, their unusual age composition can be of crucial importance, when considering the population dynamics of the eel stock.

It is unknown what areas contribute to successful spawning to what degree. Hence, we are not able to provide an estimate of the number of age groups actually contributing to the spawning successfully, but it seems highly likely that a considerable number of year classes contribute each year.

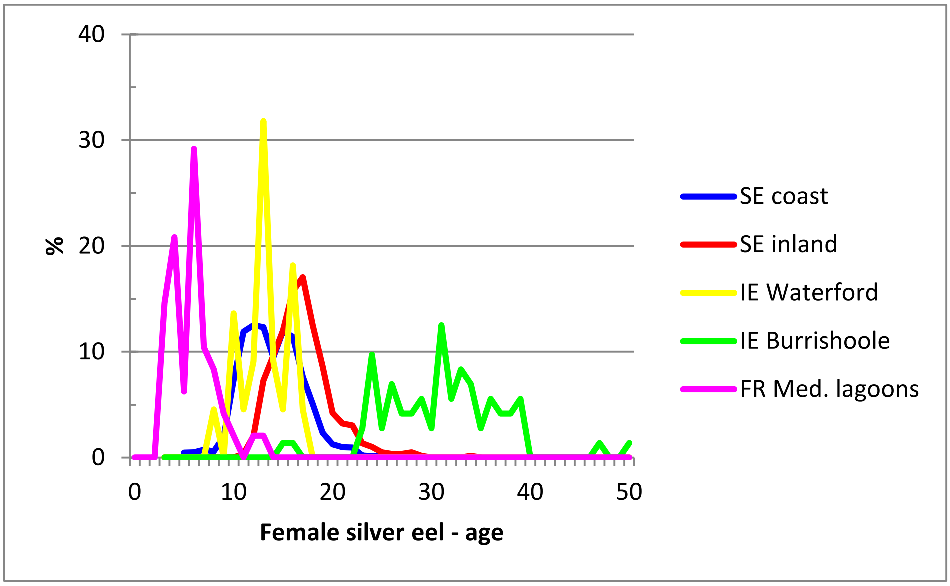


Figure 3.2. Age composition of the silver eel run from a number of selected sites.

3.7 Assessment methods

3.7.1 Trend-based assessment

3.7.1.1 Introduction and objectives for Trend-based assessment

Glass eel recruitment series are the most used to describe the status of the European eel stock as they are well-known and certainly the most reliable (see for example Jacoby and Gollock, 2014).

Trend-based assessment is a valuable and robust tool to assess stock status, especially in data-poor situations. This kind of method has several advantages: it requires few kinds of data, it relies on few assumptions and consequently it is quite robust, simple and easy to understand, and harvest control rules may be easily defined. This kind of approach has been implemented for various European stocks and has been widely implemented by Fisheries and Oceans, Canada (DFO, 2006) for the development of the precautionary approach, and is generally recommended by ICES for data-poor situations (ICES, 2012c).

The objective of the following text is to derive stock indicators only based on the value and trend of abundance index (here recruitment) of the stock.

3.7.1.2 Method for Trend-based assessment

The recruitment series contains two important pieces of information about the status of the stock:

- the absolute value can inform on how close or far recruitment is from a 'normal' level;
- the trend of the recruitment can inform on an improvement or deterioration of the status of the stock.

The principle of the analysis is thus to establish a reference level for the absolute value and the trend of recruitment. For the reference value of the recruitment ($R_{reference}$) the mean recruitment of the baseline period 1960–1979 (= 1) is the most logical (see Chapter 2).

The trend is computed as the exponential trend observed during the most recent years (0 indicates stable, positive value indicates an increase in recruitment, while a negative value indicates a decrease). A range of periods over which the trend was calculated was explored and a five year period appeared to be an appropriate compromise, reflecting the recent evolution in recruitment while smoothing interannual variability.

Combining both pieces of information in a status-and-trend diagram, four zones are defined:

- green zone: if recruitment is above $R_{reference}$ and the trend is positive (i.e. recruitment status is good and no deterioration is expected);
- yellow zone: if recruitment is above $R_{reference}$ but the trend is negative (i.e. recruitment status is good but may deteriorate in future);
- orange zone: if recruitment is below $R_{reference}$ but the trend is positive (i.e. recruitment status is bad but signs of possible improvements are observed);
- red zone: if recruitment is below $R_{reference}$ and the trend is negative (i.e. recruitment status is bad and may deteriorate in future).

This approach is illustrated using the 'Elsewhere Europe' and 'North Sea' glass eel recruitment series (Chapter 2).

3.7.1.3 Results on Trend-based assessment

Figure 3.3 shows the two recruitment series compared to the reference level defined above. Both recruitment series had oscillated between the four zones during the 1960s and the 1970s, before entering the critical zone (red) during the 1980s. Both series enter the cautious zone (orange) in the mid-1990s. The most recent years have entered into the cautious zone (orange), with an increasing trend in 2014 but a level of recruitment still low compared to the reference.

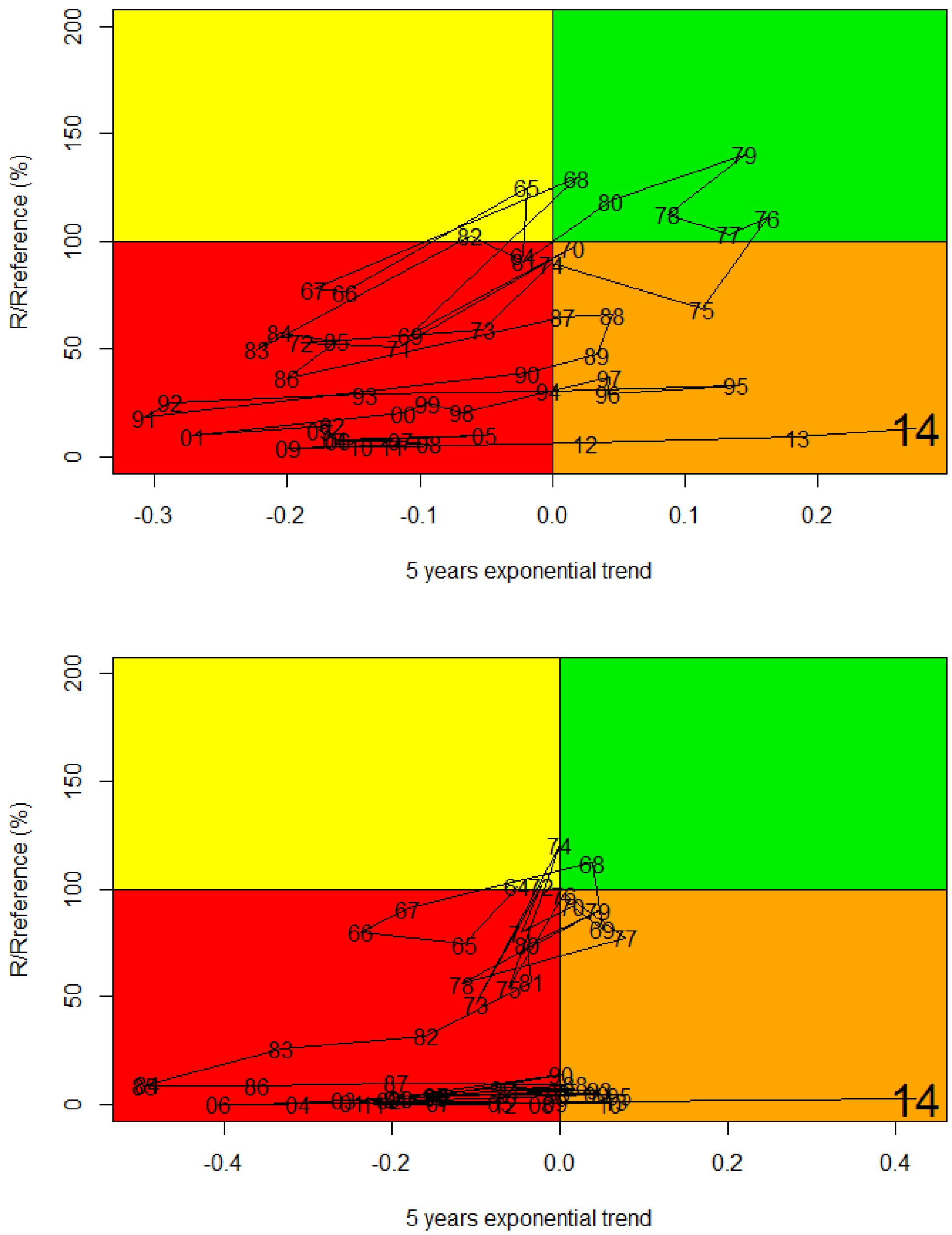


Figure 3.3. Recruitment status-and-trend with respect to the four zones (green=healthy zone, yellow=cautious zone, orange=other cautious zone, red=critical zone) for 'Elsewhere Europe' (upper panel) and 'North Sea' (lower panel) glass eel recruitment time-series

3.7.1.4 Discussion on, and management consequences of, Trend-based assessment

The recruitment is used here as a proxy of the status of the stock. To have a more complete approach this method should also be applied to other life stages (yellow and silver) of the eel as soon as robust indices for these life stages become available.

This approach is quite simple and relies on the most reliable series available. However, this kind of approach also has the disadvantages of simplicity in that (i) it cannot be used to make future predictions, (ii) it ignores the complex spatial structure of the stock, and (iii) it is very difficult to explain changes using the method alone, e.g. a positive increase may be the result of appropriate management measures but may also result from favourable environmental conditions. However, it is a good signal for stock status.

In period of stability at a 'normal' recruitment (around R_{target}) the recruitment oscillated between the four zones. This may not be a desired feature. A margin around R_{target} and the 0 trend may solve the problem but needs to be developed.

The status-and-trend diagrams provide a comprehensive and consistent view on the current recruitment status and evolution. Despite an increase in recent years, the recruitment appears to be in critical status and far from recovery to the healthy zone. Management actions should thus be continued as long as the recruitment is not in the healthy zone.

3.7.2 Eel specific reference points based on stock recruitment relationship

3.7.2.1 Introduction and objectives

ICES provides fisheries advice that is consistent with the broad international policy norms of the Maximum Sustainable Yield (MSY) approach, the precautionary approach, and an ecosystem approach, while at the same time responding to the specific needs of the management bodies requesting advice (ICES, 2014). For long-lived stocks with population size estimates, ICES bases its advice on attaining an anthropogenic mortality rate at or below the mortality that corresponds to long-term biomass targets (B_{MSY}). $B_{MSY\text{-}trigger}$ is a biomass level triggering a more cautious response. Below $B_{MSY\text{-}trigger}$, the anthropogenic mortality advised is reduced, to reinforce the tendency for stocks to rebuild. Below $B_{MSY\text{-}trigger}$, ICES applies a proportional reduction in mortality reference values (i.e. a linear relation between the mortality rate advised and biomass).

The objective of this chapter is to derive from information available the stock indicators required to manage eel fully in the general framework setup by ICES (ICES, 2014).

3.7.2.2 Deriving biological reference point

3.7.2.2.1 Classical method for deriving biological reference point

B_{MSY} is the biomass level for which the stock can be on average exploited with a maximum production (MSY) providing it is exploited at F_{MSY} (ICES, 2014; Figure 3.4). To determine this level the production (yield) should be related to the stock size (B) through fisheries mortalities (F) through the production function.

In the case of eel, fisheries are scattered throughout Europe in small scale fisheries targeting glass eel and/or yellow eel and/or silver eel (Dekker, 2000; 2003). Moreover, unlike other marine species, eel is suffering the impact of many other anthropogenic mortalities (pollution, obstacle to migration, etc.). For these reasons, and given the current knowledge, it is impossible to simply and reliably determine the production function and thus derive MSY, B_{MSY} and F_{MSY}.

ICES (2014) also define biological reference points based on the precautionary approach to avoid a significant risk of impaired reproduction. B_{lim} is defined as "the stock size below which there may be reduced reproduction resulting in reduced recruitment". B_{pa} is the precautionary reference point derived from B_{lim} by adding a safety margin to take into account the uncertainty in stock estimates and to avoid reaching B_{lim}.

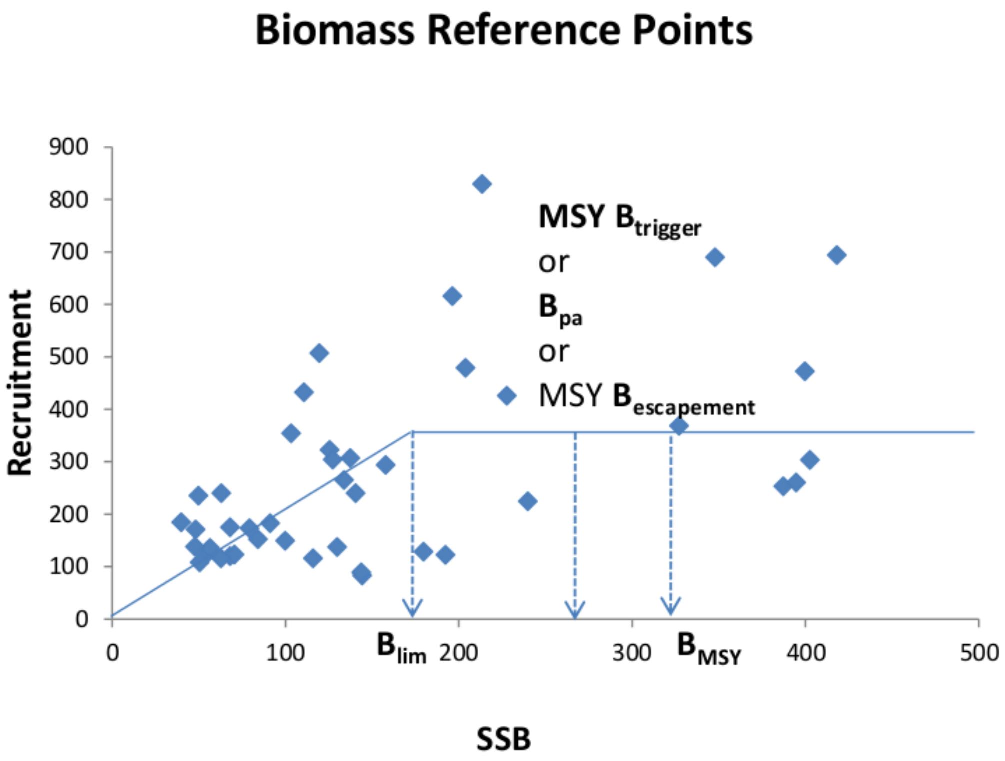


Figure 3.4. Illustration of biomass-based biological reference points. B_{lim} and B_{pa} are precautionary reference points related to the risk of impaired reproductive capacity, while MSY $B_{escapement}$ often equal to B_{pa} is used in the advice framework for short-lived species. MSY $B_{trigger}$ is the parameter in the ICES MSY framework which triggers advice on a reduced fishing mortality relative to F_{MSY}. B_{MSY} is the average biomass expected if the stock is exploited at F_{MSY}. Diamonds show the variable recruitment versus SSB that have been observed over the years. Recruitment can be seen to be generally lower below B_{lim}. (ICES, 2014).

B_{lim} can be determined by the examination of the stock–recruitment relationship.

The recruitment used here for illustrative purposes is the ‘Elsewhere Europe’ series of glass eel recruitment (Chapter 2), pending the combination of this and the ‘North Sea’ series.

The actual spawning–stock biomass (in the Sargasso Sea) has never been observed. The best available proxy is the silver eel escapement that exists after all of the fisheries and other mortalities (both natural and anthropogenic) in the continental and littoral waters have occurred. This can be derived from the landing statistics as explained in ICES (2013b), and used here again in the absence of new data.

The Ricker model presents an overcompensation that leads to a maximum production at an intermediate level of SSB (Ricker, 1954). The Beverton and Holt model presents a compensation for high recruitment. In that case, for high SSB, the recruitment does not increase as fast as the SSB (Beverton and Holt, 1957). Both Ricker and Beverton–Holt have maximum recruits per spawner at the origin, declining monotonically with increasing spawner abundance, and recruitment increases faster than SSB for SSB less than the value for maximum gain.

The hockey-stick model is a simplification of these models corresponding to a one-breakpoint segmented regression with the first segment passing through the origin and the second being horizontal and corresponding to a plateau. This last model assumes that recruitment is independent of SSB above some change point, below which recruitment declines linearly towards the origin at lower values of SSB.

The fitting of these three models of stock–recruitment relationship to the 'Elsewhere Europe' glass eel recruitment index was tested using the Akaike Information Criterion (AIC) (Akaike, 1974).

The AIC for each model (Table 3.1) show no strong preference for one or the other model. Figure 3.5 shows the result of the hockey-stick model. The breakpoint is at the very high biomass (> 40 000 tonnes).

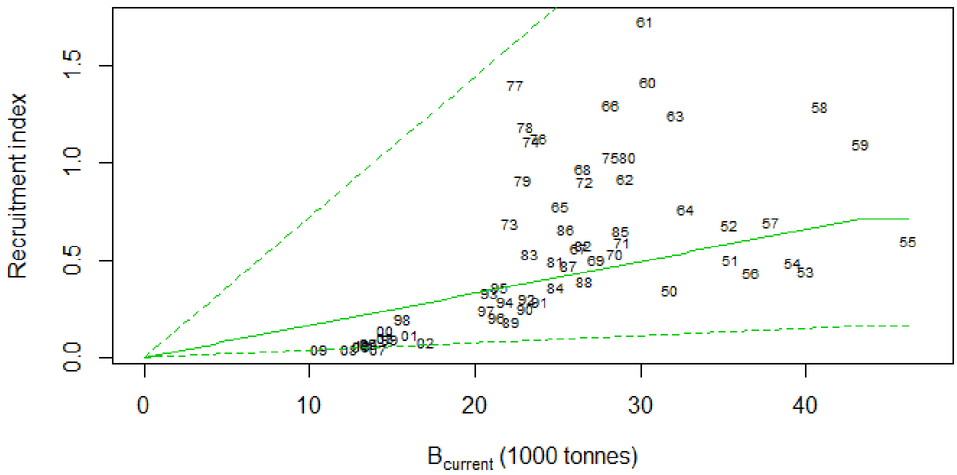


Figure 3.5. Hockey-stick regression between proxy for European eel spawning–stock biomass (proxy silver eel escapement: estimated $B_{current}$) and recruitment index between 1950 and 2010. Two-digit labels indicate the years of silver eel escapement, recruitment occurs two years later; the dashed lines indicate 95% confidence interval. Note the breakpoint in the regression line at the far right, at B = 43 000 tonnes.

According to the hockey-stick model, the stock has virtually never been above the B_{lim} (the breakpoint) since 1950. However, such a relationship provides an unrealistic fit to the data: observed recruitment has been below that predicted by the model ever since 1995 but nearly always above in the 1960s and 1970s. These difficulties may also be due to unreliable SSB (or R) data. They are derived from landings data and expert knowledge about the exploitation rate (ICES, 2013b). There are many gaps and uncertainties in these data.

3.7.2.2.2 Method for deriving eel-specific biological reference points

Given these limitations, it is difficult to derive any biological reference points using classical approach, but the S–R relationship remains a key function for the study of population dynamics in a perspective of management advice. It was thus decided to design an eel specific analysis to better take into account of the existing data.

Instead of fitting an imposed form of stock–recruitment, a data-driven method is designed following Dekker (2004) and ICES (2012b). A GAM (General Additive Model: Hastie and Tibshirani, 1990) is fitted on the same data used for the classical approach, using a cubic spline smoother of order 3 for the SSB.

This kind of model allows the incorporation of factors that may directly affect this S–R relationship. To illustrate this possibility, a GAM is fitted with a linear effect of the year, to test for a progressive change in S–R relationship like a degradation of the reproductive efficiency, and a smoothed effect of North Atlantic Oscillation (NAO) (average of monthly mean NAO indices (http://www.noaa.gov/) during the two years between escapement and recruitment); as a proxy of oceanic condition.

Figure 3.6 illustrates the result of this GAM (AIC -25.73) and Figure 3.7 shows the GAM that included the year and NAO effects (AIC -31.66). These curves show two points of inflexion, the first for low value of biomass (about 15 000 tonnes) and a second at intermediate value (about 30 000 tonnes).

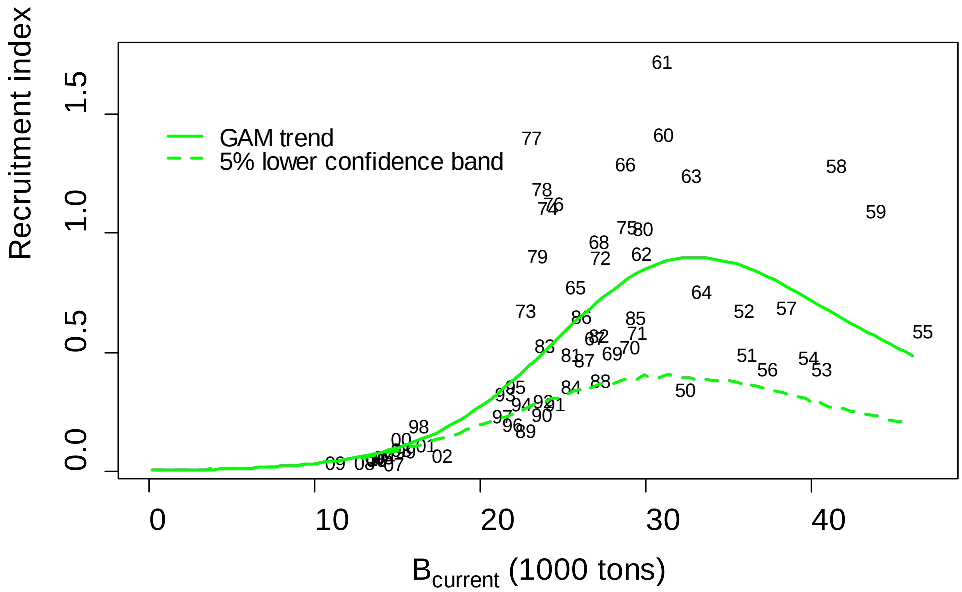


Figure 3.6. Illustration of European eel stock–recruitment relationship fitted by a GAM.

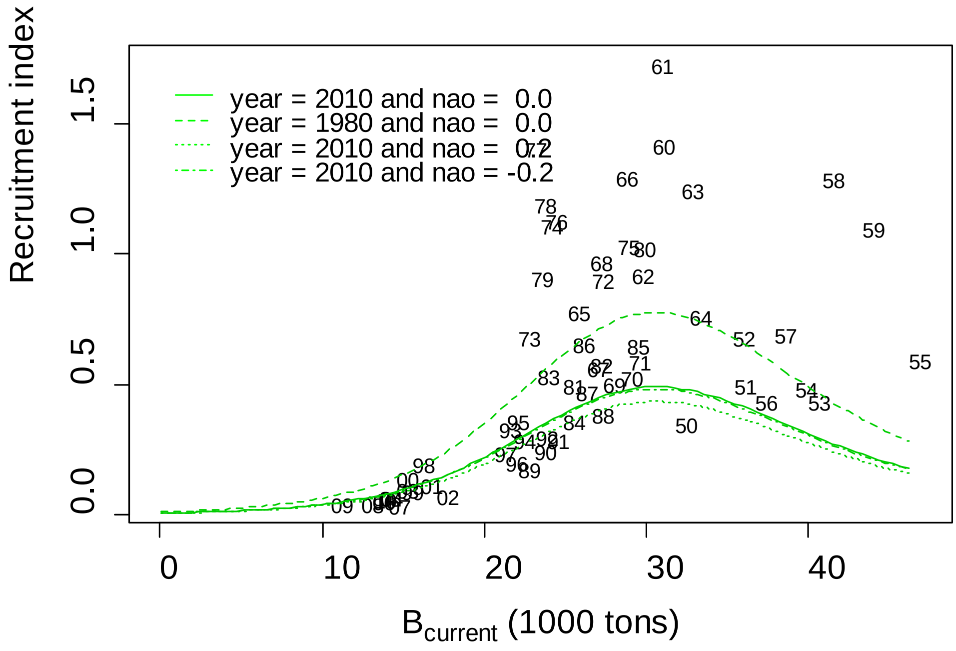


Figure 3.7. Illustration of the GAM fitting for recruitment with a year effect and smoothed effect of spawning–stock biomass and NAO index. Since the stock–recruit relationship depends not only on the current biomass $B_{current}$, but also on external covariates (i.e. NAO), predictions (regression lines) can be generated for the whole range of biomasses, for different values of the NAO-index. The graph provides predicted regression lines, spanning the data range in recruitment indices and the range in NAO values.

Comparison of AIC values suggests that curves fitted with GAM perform better than classical S–R relationship.

The right-hand part of the GAM fit is very similar to a Ricker curve. If we mimic the GAM fitting with a two-breakpoint curve (AIC = -24.28), the limit biomass is found at 27 800 tonnes (95% confidence interval: 23 100–33 500 tonnes) that is 14% B_0 (as estimate by summing estimates delivered by each EMU, resulting in a value of 193 000 tonnes).

However, the left-hand part of the GAM fit is unusual: it would suggest that when the spawning biomass decreases, the recruitment is lower than would be expected with a classical relationship. This effect is known as an Allee effect (Allee, 1931) and in the fisheries literature as depensation (Hilborn and Walters, 1992). It can seriously accelerate population decline and drive a population to extinction, or at least heavily hinder its recovery (Walters and Kitchell, 2001).

This notion can be further developed by plotting in the same figure the 'pristine' replacement line for $\Sigma A = 0$, as determined by the line crossing the origin and the point of coordinates B_0, pristine recruitment (R_0). In our example, the R_0 is approximated by the mean recruitment of 1960–1979 (1 by definition). In this case, the pristine replacement line is above the stock–recruitment relationship at low values of recruitment (Figure 3.8). In such circumstances, recruitment would produce fewer spawners than the previous generation, even in the absence of any anthropogenic mortalities.

By definition, where the lower confidence bound of the S–R relationship crosses the replacement line, the probability of a recruitment that cannot replace the current biomass is α = 5%. Where the mean predicted recruitment crosses the replacement line, there is a 50% chance of further deterioration. We label the biomass resulting in a mean predicted recruitment equal to the replacement line as B_{stop}, and the biomass at which the 5% lower bound crosses the replacement line as B_{stoppa}.

In our example, B_{stoppa} would be at 18 900 tonnes and B_{stop} would be 13 200 tonnes. (Figure 3.8), biomass would have been below B_{stoppa} since 1998, and current escapement has remained close to B_{stop} since 2005.

Taken at face value (see below) the B_{stoppa} reference point would have suggested a minimizing of all anthropogenic mortality to zero, 15 years ago, and a high risk that the stock was in the depensatory trap from 2005.

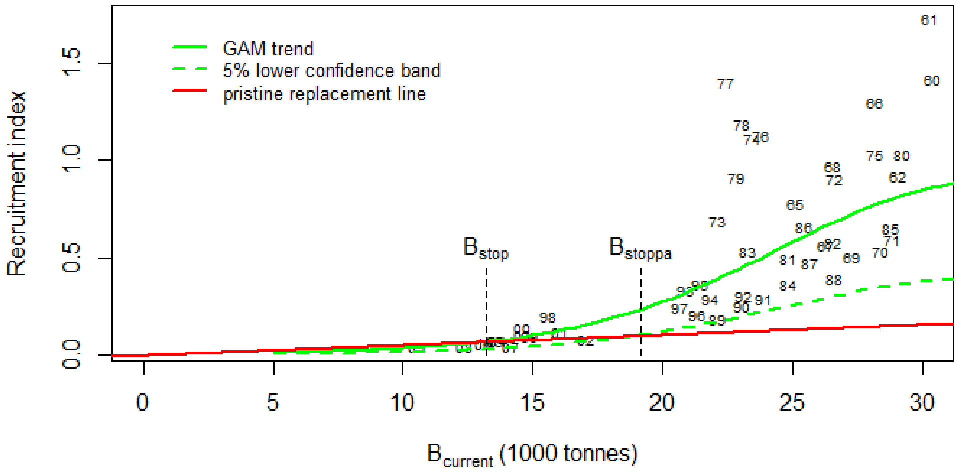


Figure 3.8. Stock–recruitment relationship fitted by a GAM and 'pristine' replacement line. For B_{stop} and B_{stoppa} explanation, see text.

The recent increase of recruitment may appear contradictory with a stock in a depensation trap. Our analyses are based on estimate of SSB derived from landings data and expert knowledge about the exploitation rate (ICES, 2013b). Moreover B_0 is the sum of data provided by countries and taken at face value. They are many gaps and uncertainties in these data, and any change in these may produce different curve and lead to different conclusion.

At this time, however, it is difficult to link this increase to a change in silver eel escapement (our proxy for spawner biomass). Based on the data provided by the Member States in their first EMP progress reports in 2012, no improvement of silver eel escapement could be detected shortly after the implementation of the EMPs (Table 3.2). In fact, a comparison of the available data on silver eel escapement of 2010 (after implementation of the EMPs) and 2008 (before the implementation) suggests a decrease of 4.3% (-544 tonnes). Noting the many uncertainties in the assessments (ICES, 2013a), it is unclear whether this is within confidence limits of the estimates or not. However, the recent increase in recruitment does not correspond to the reported trend in silver eel escapement, whether assuming a three or four year- interval between silver eel escapement and corresponding glass eel arrival.

An improvement in environmental condition may produce, temporarily, higher recruitment than expected. Besides, this increase is not yet fully consider as a trend shift. Note also that the last recruitment data are not yet place in these figures. Finally the observed data may be explained by other phenomenon like regime shift due to ocean change, decrease of recruitment efficiency due to spawner quality, etc.

However, these are the best data available to the working group at this time. Even though no firm conclusions can be drawn on the existence of a depensatory stock-recruitment relationship, due to flaws underlined above, the managers should consider this phenomenon as being possible for eel and even that eel is already in the depensation trap. This latter hypothesis would urge an immediate and complete reduction of all anthropogenic impacts (fisheries and other impacts) to zero.

3.7.3 Quantitative assessment applying generic reference points

3.7.3.1 Method

"The ICES approach uses both fishing mortality rates and biomass reference points" (ICES, 2014).

The Eel Regulation specifies a limit reference point (40% B_0) for the biomass of the escaping silver eel, but does not specify a mortality limit. That is: the endpoint of the recovery process is specified, but not the route (the time required, the speed of recovery) towards that point. However, a mortality limit (above the 40% B_0) of lifetime mortality $\Sigma A = 0.92$ can be shown to correspond to the 40% biomass limit (Dekker 2010; ICES 2011a; 2011b). The Eel Regulation, however, does not indicate what approach should be made to rebuild the stock (or correspondingly, what time-scale for rebuilding the stock is acceptable). For ICES, it will be in-line with its existing advice policy to recommend a linear reduction in mortality below the 40% limit adopted by the EU.

Since it is very difficult to derive biological reference points (BRP) from eel data using classical methods (see above), we here consider using these reference points derived from the EU eel regulation.

In the 2010 Report of ICES Study Group on International Post-Evaluation of Eel (SGIPEE) (ICES, 2010a), a pragmatic framework to post-evaluate the status of the eel stock and the effect of management measures was designed and presented, including an overview of potential post-evaluation tests and an adaptation of the classical ICES precautionary diagram to the eel case. In the 'classical' Precautionary Diagram, annual fishing mortality (averaged over the dominating age groups) is plotted vs. the spawning–stock biomass. In the 'modified' Precautionary diagram, lifetime anthropogenic mortality ΣA (or the spawner potential ratio %SPR on a logarithmic scale) is plotted against silver eel escapement (in percentage of B_0). This 'modified' diagram allows for comparisons between EMUs (%-wise SSB; lifetime summation of anthropogenic mortality) and comparisons of the status to limit/target values, while at the same time allowing for the integration of local stock status estimates (by region, EMU or country) into status indicators for larger geographical areas (ultimately: stock wide).

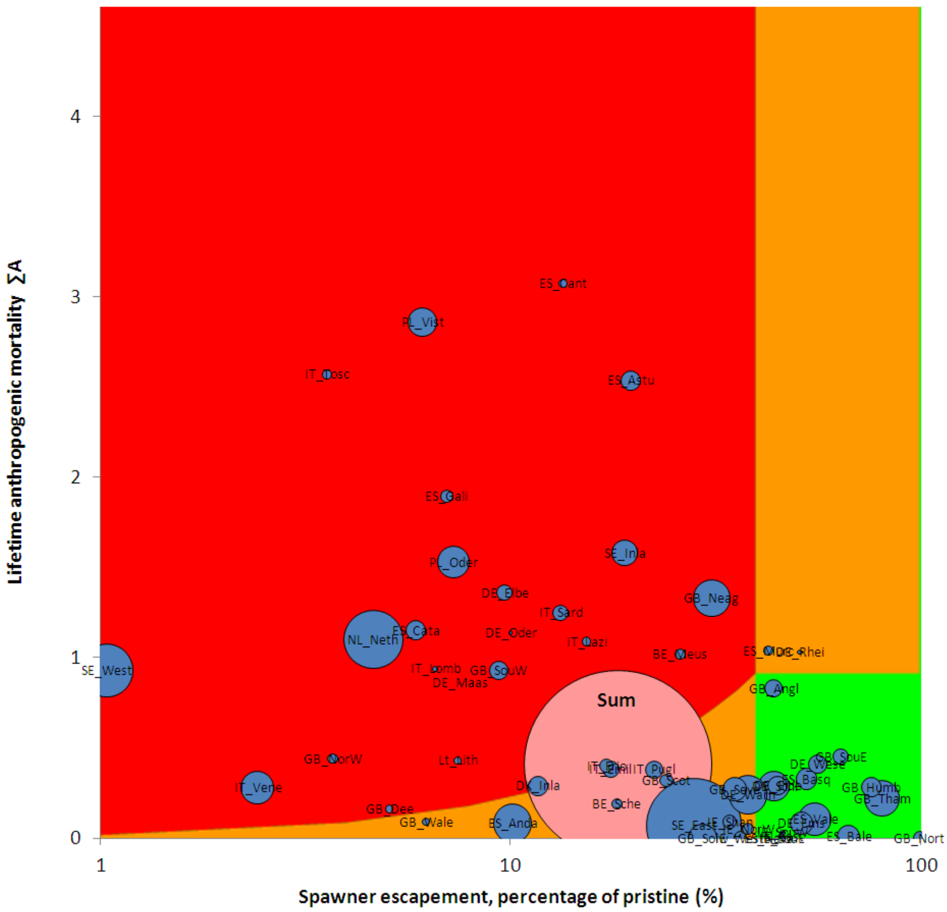
In 2012, EU Member States post-evaluated the implementation of their Eel Management Plans, and provided estimates of national stock indicators; the '3Bs & ΣA' ($B_{current}$, B_{best}, B_0 & ΣA) for before, and since implementation of their EMPs (putatively 2008–2012). ICES (2013a) reviewed those progress reports, concluding that information was not always completely reported or available, and the quality of the national data and assessment were hard to evaluate. Subsequently, the WGEEL decided to use the reported stock indicators in good faith, but recognising that their quality needs to be assured in the future.

3.7.3.2 Results

Since not all countries have reported (and not for all years from 2009 onwards), the presented stock-wide sum represents the reporting countries; not all countries within the distribution area, and not even all countries within the EU. Moreover, the set of countries reporting indicators has changed over the years; therefore, the sum of reporting countries cannot be compared between the years. WGEEL decided to restrict the graphical presentation to the latest data year, 2011. In some countries, additional management measures have been taken in 2012 (e.g. Sweden closing the fishery in SE-west), but these have not been considered in this report.

The diagrams present the indicators per EMU (Figure 3.9; top), and per country (Figure 3.9; bottom); each plot also contains the Sum of the reported areas. Some countries (notably France) did not report all stock indicators for each EMU (in particular B_0), but did so for the country as a whole. Thus, France is not represented in the top plot, but it is in the bottom, and continent-wide sums differ between the plots. The difference in outcomes between the plots emphasizes the importance of a consistent and full-coverage set of stock indicators.

Finally, Figure 3.10 presents the status of each EMU in relation to the modified Precautionary Diagram (i.e. the background colour that applies to the zone where the EMU bubble sits in the modified Precautionary Diagram) in a map, where data-deficient areas have been shown by a ☹. This map indicates that major areas have not assessed their part of the stock; while the sum of the reporting countries is far away from the required stock-wide total.


Lifetime anthropogenic mortality ∑A
Spawner escapement, percentage of pristine (%)
0
1
2
3
4
1
10
100
Sum
ES_Cant
PL_Vist
IT_Tosc
ES_Astu
ES_Gali
SE_Inla
PL_Oder
GB_Neag
DE_Elbe
IT_Sard
NL_Neth
ES_Cata
DE_Oder
IT_Lazi
SE_West
IT_Lomb
GB_SouW
DE_Maas
BE_Meus
DE_Rhei
GB_Angl
GB_NorW
Lt_Lith
IT_Vene
GB_SouE
IT_Pugl
GB_Scot
DK_Inla
ES_Basq
GB_Humb
GB_Tham
GB_Dee
BE_Sche
GB_Wale
ES_Anda
ES_Bale
GB_Nort

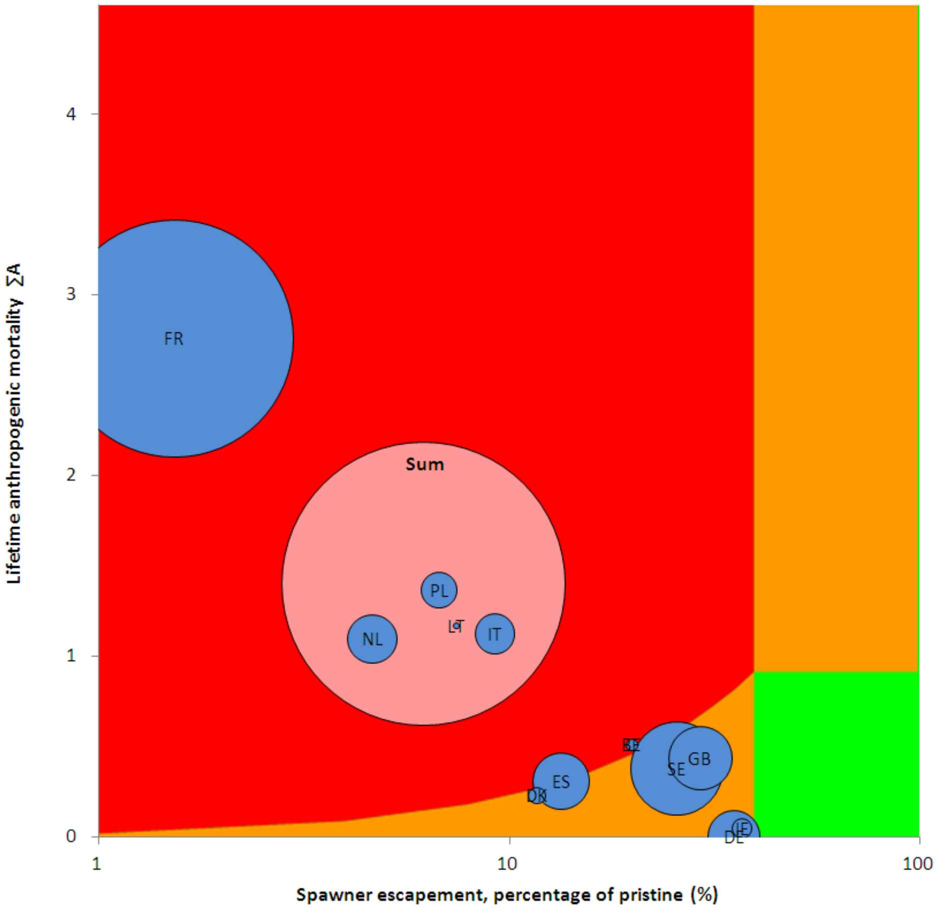


Figure 3.9. Modified Precautionary Diagram, illustrating the method to examine the status of the European eel stock (horizontal, spawner escapement expressed as a percentage of the pristine escapement) and the anthropogenic impacts (vertical, expressed as lifetime mortality ΣA). Data are those reported in the 2012 progress reports (ICES 2013a). The size of the points (bubbles) indicates the size of B_{best}, while their location indicates the status of eel in the EMU in terms of spawning biomass against the 40% target, and anthropogenic mortality against the rate equivalent to that biomass target (i.e. ΣA = 0.92 if $B_{current}$ >40% B_0 or ΣA = 0.92 * $B_{current}$/(40% B_0) if $B_{current}$ <40% B_0). Green indicates the local stock is fully compliant, amber indicates that one target is reached but not the other, and red indicates that neither target is reached. In most cases, the 2011 indicators are shown; when these were missing, the 2010 indicators are used. Top: stock indicators by EMU and for the sum of the reported EMUs (59 EU-EMUs are missing); bottom: stock indicators by country and for the sum of the reported countries (26 EU and no-EU countries are missing). Note that non-reporting EMUs/countries do not show up in these plots.

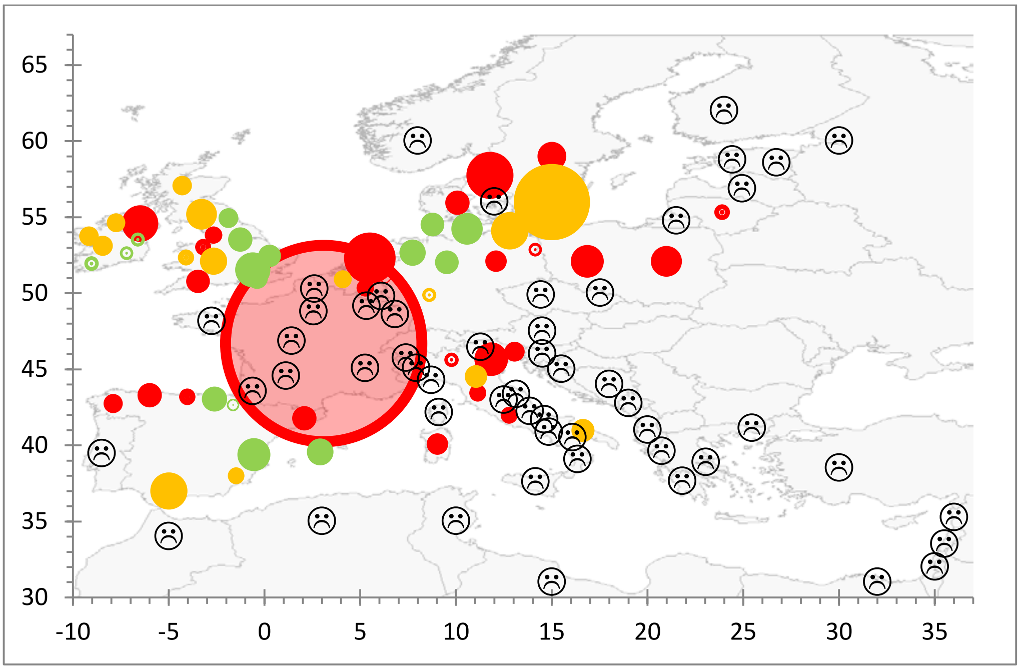


Figure 3.10. Stock indicators from the modified Precautionary Diagram (Figure 3.6), plotted on the location of their EMU. The size of each bubble corresponds to B_{best}, the biomass of escaping silver eels if no anthropogenic impacts had affected the current stock. The colour of each bubble corresponds to the position of the indicators, relative to the reference limits of the modified Precautionary Diagram (the background colour in Figure 3.9, above). For EMUs/countries that did not report their stock indicators (or incompletely), a ☹ of arbitrary size is shown. Data from the 2012 progress reports (ICES 2013a). In most cases, the 2011 indicators are shown; when these were missing, the 2010 indicators are used. For France, indicators have only been reported for the country as a whole, not for the constituting EMUs; that country-total is shown (shaded red), along with the EMUs (☹).

3.7.3.3 Discussion on and consequences for management

The reference points taken here are those derived from the EU eel regulation, data are those reported by country and taken at face value and some country/EMU have not fully provided data. Among non-reporting countries, some have not involved in a stock recovery process. Keeping these limitations in mind, the stocks can be assessed as not within sustainable limits conforming to the Eel Regulation and ICES policies. For those EMUs that reported, the overall escaping biomass is 18% of B_0 (cf EU limit 40% B_0) and the anthropogenic mortality (ΣA) is 0.41 compared to the limit of 0.42. For countries that reported (so including those that reported at country but not EMU levels), the overall escaping biomass is 6% B_0, and the anthropogenic mortality (ΣA) is 1.40 compared to the limit of 0.14.

Management actions should thus be continued and even amplified for some EMUs/countries until their mortality is decreased below the reference point and ultimately that their biomass increases above the limit biomass.

3.8 A provisional harvest control rule for eel

Assessment of the eel stock is not an easy task: because crucial knowledge of basic biological characteristics is incomplete; because the stock is scattered over an extremely large area, in typically small-scaled habitats; because the impacts vary from area to area; and because the stock has experienced a multidecadal decline and is now at a very low level.

Three complementary approaches to the eel assessment are presented having their own advantage and flaws. They all underline the bad status of the eel stock (recruitment and biomass), despite the encouraging recent increase in recruitment. The trend-based approach would lead to the conclusion that management actions should be continued as long as the recruitment is not in the healthy zone. The classical approach would lead to the conclusion that already taken action are not sufficient at least in some EMUs/countries. The eel specific approach would lead to an eel stock possibly in a depensatory trap that required an immediate and complete reduction of all anthropogenic impacts (fisheries and other impacts) to zero. It can thus be concluded that *a minima* management actions should be continued if not amplified.

In 2012, ICES convened WKLIFE (ICES, 2012d), to investigate the feasibility of developing methodology for providing assessments and advice on data-deficient stocks. WKLIFE, however, did not include the assessment of the European eel in its considerations, because "ICES does not have an accepted time-series of stock-wide catch for eel". In 2013, the Review Group for WGEEL (ICES, 2013a) nevertheless suggested the application of WKLIFE's criteria for short-lived stocks. In Section 3.4, the rationale for applying those criteria have been discussed, concluding that there is no biological argument for applying those criteria.

WKLIFE considers seven types of stocks (Table 3.3), none of which strictly applies to eel. Rather than enforcing one of these categories on the eel, WGEEL recommends developing a category for eel on its own. Unlike all other stocks, there is no realistic option to develop a single, stock-wide assessment based on primary data. Instead, WGEEL has developed an approach for an international assessment, in which only national stock indicators are used (Dekker, 2010; ICES 2010a,b; 2011a,b; 2012b; 2013b). Hence, the international stock assessment is based on national data only through the national stock indicators, not directly on the data themselves. This cascaded approach enables the assessment of the state of the stock in individual EMUs, allows to contrast indices of spawner escapement and total anthropogenic mortality to agreed reference points for these EMUs, and provides the information for the analysis of the stock–recruitment-relation and environmental drivers. Until complete spatial coverage has been achieved, the stock–recruit analysis is hampered by incomplete data.

ICES in 2002 provided advice on a minimum limit to the spawning stock ("Exploitation, which provides 30% of the virgin (F=0) spawning–stock biomass is generally considered to be […] a reasonable provisional reference target. However, for eel a preliminary value could be 50%.").

In the Eel Regulation, EU decided to adopt a limit of 40%, that corresponds to a mortality limit $\Sigma A_{lim} = 0.92$ when $B_{current} \geq B_{lim}$. According to the Regulation, this reference point applies to all Eel Management Units, irrespective of the achievements in other Eel Management Units or the status of the stock as a whole.

As indicated above (Section 3.4.3), there is no biological argument to adopt a specific harvest control rule for ΣA when $B_{current} < B_{lim}$. Analysis (Section 3.7.2.2.2) of the available data, however, indicates that current recruitment might be insufficient to replace current spawner escapement, and severe management actions might be required immediately. However, the quality of the data and hence the reliability of the analysis are not beyond doubt, and the working group recommends substantial steps forward, improving the database as well as the comprehensiveness of the analysis (below).

As the WGEEL considers the European eel to be a long-lived species in relation to harvest control rules, and pending an improvement of the analysis of stock-and-recruit data, WGEEL recommends that ICES provides advice on the basis of the harvest control rule for quantitative assessments (category 1), i.e. a proportional reduction in ΣA_{lim} below B_{lim} down to $\Sigma A_{lim} = 0$ at $B_{current} = 0$.

3.9 Future development priorities

In this chapter, the (potential) relation between the size of the spawning stock and the subsequent year-class strength has been analysed, extending the analyses in previous working group reports. To this end, an index of the spawning stock was derived (proportional to the landings (Dekker, 2004; ICES, 2012b); proportional to the landings taking into account an expert estimate of the relative fishing pressure over the decades (ICES, 2013b)). It is well acknowledged that other factors - including spawner quality, ocean climate and conditions in the spawning area - might have an influence too (ICES, 2008). However, few studies have attempted to analyse more than one factor at a time (Dekker 2004; ICES, 2013b). Hence, different views on the causes of the recruitment decline exist, but no progress is actually made towards a comprehensive analysis. Looking forwards, therefore, the working group recommends:

- an existing or new workshop is requested to compile and make available time-series of indices of eel quality, preferably from 1950 forward;
- a workshop on ocean climate indices relevant to the eel (WKOCRE), in co-operation with the working group on oceanic hydrography (WGOH) is organized, to compiles and make available time-series of indices that might relate to the survival of spawners and/or larvae in the ocean;
- that WGEEL makes available time-series of (reconstructed) spawner escapement and documents how these time-series have been derived; consider silver eel run reconstructions to be based on either silver eel landings data, yellow eel landings data, or other historical sources of information;
- that a workshop/study group (i.e. one or 2–3 years?) is established to analyse the stock–recruitment relation for the European eel, taking into account the potential effects of spawner quality and ocean climate indices.

3.10 Tables

Table 3.1. AIC for attempts to fit three stock–recruitment models to 'Elsewhere Europe' glass eel recruitment index. Smaller values of AIC indicate a better fit.

	Parameter number	AIC
Ricker	2	28.68
Beverton	2	29.08
Hockey stick (one-breakpoint)	2	29.04
GAM	3	-25.73
GAM + year + NAO	5.8	-31.67

Table 3.2. A comparison of silver eel escapement of the years 2008 (prior to the implementation of EMPs) and 2010 (after implementation of the IMPs). In the case of Poland, the Netherlands, Belgium and Spain (marked in red), post-implementation data were only available for 2011, in the case of France (marked in blue) only for 2009.

	$B_{current}$ 2008 (t)	$B_{current}$ 2010 (t)	Diff (t) 2010/2008	%Diff 2010/2008
SE	3463	3533	70	2.0
FI				
EE				
LV	1.7	1.7	0	0.0
LI	7.1	14.6	7.5	105.6
PL	469	199	-270	-57.6
CZ				
DE	2192	1919.2	-272.8	-12.4
DK	129.5	129.5	0	0.0
NL	439	482	43	9.8
BE	49	48	-1	-2.0
LU				
IE	142.6	216.4	73.8	51.8
GB	1707	1588.2	-118.8	-7.0
FR	2574.4	2234.6	-339.8	-13.2
ES	1173.7	1421.3	247.6	21.1
PT				
IT	269	285.5	16.5	6.1
GR				
Total	12 617	12 073	-544	-4.3

Table 3.3. Generic categorization of stocks by WKLIFE and its applicability for eel assessments.

WKLIFE CATEGORY	QUALIFYING CRITERIA	APPLICATION TO EEL
Category 1 – data rich stocks (quantitative assessments)	full analytical assessments and forecasts	Partial spatial coverage; assessments for some areas incomplete
Category 2 – negligible landings stocks	landings are negligible in comparison to discards	In cases where eel is caught as a bycatch, it is most often retained; when returned to the water, survival is usually high.
Category 3 – stocks with analytical assessments and forecasts that are only treated qualitatively	assessments and forecasts which for a variety of reasons are merely indicative of trends in fishing mortality, recruitment and biomass	Partial spatial coverage, known trends in mortality and biomass need not be indicative for un-assessed areas.
Category 4 – stocks for which survey-based assessments indicate trends	survey indices are available that provide reliable indications of trends in total mortality, recruitment and biomass	No such stock-wide surveys exist, other than the recruitment surveys, which are considered to be representative for larger regions.
Category 5 – stocks for which reliable catch data are available for short time-series	catch curve analyses can be undertaken and an estimate of exploitation provided	Catch-curve analyses are not wide-spread, and need not at all be indicative for other areas.
Category 6 – data-limited stocks	only landings data are available;	Following the implementation of the Eel Regulation, much more detailed data have become available. Life-history-parameter-based assessments for the eel vary from region to region.
Category 7 – stocks caught in minor amounts as by-catch	primarily caught as by-catch species in other targeted fisheries	Eel is most often the target species of its fisheries

4 ToR c) Overview of available data and gaps for stock assessment

4.1 Introduction

Chapter 3 highlights the range of data (at various geographic scales) required for the various stock assessment methods, and the fact that much of these data are not yet available to the working group and therefore elements of the assessment of whole-stock status remain uncertain. To facilitate the collection and reporting of these data, the following chapters of this report summarise the required, available and missing data (with reference to the methods discussed in chapter 3), consider a range of methods available for the provision of such data, and means by which this provision can be improved.

4.2 Consideration of data required

4.2.1 Stock assessment

The data requirements for eel stock assessment at national and international have been previously discussed and summarized by the ICES Workshop on Eel and Salmon DCF Data (ICES, 2012a). Generally, the data required for the assessment and management of European eel fall into three broad categories:

- Data requested by ICES to undertake annually recurring international assessment;
- Data requested by ICES or another scientific/ technical review group to periodically (2012, 2015, 2018, 2024, and every six years thereafter) establish stock reference points, post-evaluate the Eel Regulation and implementation of EMPs; and
- Data required by Member States to determine silver eel escapement levels relative to the target set out in the national EMPs and undertake river-specific stock assessments according to EMPs. (Even though these data are used for the local stock assessment, they form the basis for the next level, the international stock assessment. Therefore they are included here.)

The general framework for international stock assessment and post-evaluation in European eel has been established and discussed in previous reports, and further developed here in Chapter 3. In principal, the approach of the international assessment consists of the *post hoc* summing up of stock indicators, based on estimates for:

- $B_{current}$, the amount of silver eel biomass that currently escapes to the sea to spawn, corresponding to the assessment year;
- B_0, spawner escapement biomass in absence of any anthropogenic impacts ('pristine');
- B_{best}, spawner escapement biomass corresponding to recent natural recruitment that would have survived if there was only natural mortality and no stocking, corresponding to the assessment year;
- ΣA, the sum of anthropogenic mortality rates, i.e. $\Sigma A = \Sigma F$ (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) or %SPR, the ratio of actual escapement $B_{current}$ to best achievable spawner escapement B_{best}. SGIPEE (ICES, 2011b) indicated that estimates of either ΣA or %SPR usually refer to anthropogenic impacts in the most recent

year, not to impacts summed over the life history of any individual or cohort in the current stock.

At present, the international stock assessment is based on national data only through the national stock indicators, not directly on the data themselves. The approach of regional stock assessment and *post-hoc* summing up of indicators for total stock assessment appears to be more pragmatic then a "central assessment". Most of the necessary monitoring structures and data should be available at the EMU level, and the interpretation of the results is easier. Additionally, the local assessments at EMU level are required for post-evaluation of EMPs. Member States have been and are requested to report the indicators in their EMP reviews, along with data on the amount of glass eel recruiting to continental waters. The associated country data currently requested by ICES through the annual stock 'assessment' report to WGEEL are, where appropriate:

- Quantity of glass or yellow eel recruitment, derived from commercial or recreational fisheries, or fisheries-independent surveys (further explained below);
- Catches and landings by EMU, stage (yellow, silver eels), gear, commercial and recreational, and marine fisheries, and length frequency;
- Catches and landings of eel <12 cm by EMU, with proportion retained for restocking and destination;
- Quantity and origin of eel restocked, by glass eel, bootlace or ongrown;
- Aquaculture production weight of eel, distinguishing between that sold for stocking versus sold for consumption, quantity and source of seed;
- Fishing capacity by EMU, e.g. number companies, boats, fishermen, by stage (glass, yellow, silver) and by marine fisheries;
- Fishing effort by EMU, e.g. number licences fished, number of net nights, by stage (glass, yellow and silver) and by marine fisheries;
- Catch per unit of effort (cpue) for commercial and recreational fisheries, by EMU, stage (glass, yellow, silver) and for marine fisheries;
- Other anthropogenic impacts (non-fisheries), including type and quantity of impact, e.g. turbines - mortality rate and amount of silver eel killed in tonnes;
- Scientific surveys of the stock: abundance of recruitment, yellow eel standing stock, silver eel, by sampling method;
- Catch composition by age and length, for commercial catches and scientific surveys, by sub-catchments, catchments or EMU;
- Other biological sampling to inform biological characteristics, e.g. length, weight and growth, parasites and pathogens, contaminants and predators, by sub-catchments, catchments or EMU.

In addition to the aforementioned stock indicators, ICES (2012b) requested the following data by EMU:

- Wetted area habitat, by water type (lacustrine, riverine, transitional and lagoon, coastal);
- Production values per unit area, e.g. kg/ha.
- R(s*) The amount of eel (<20 cm) restocked into national waters annually. The source of these eel should also be reported, at least to originating Member State, to ensure full accounting of catch vs restocked (i.e. avoid 'double banking').

(Note that R(s*) for restocking is a new symbol devised by the WKESDCF to differentiate from "R" which is usually considered to represent Recruitment of eel to continental waters.)

4.2.2 Data needs for stock–recruitment relationship

4.2.2.1 Recruitment

Information on recruitment is essential to follow up natural variations and results of management actions over the area of distribution of the European eel. Recruit surveys (glass eel, young yellow eel) are the prime source of information on the status of the oceanic reproduction. Even though they play a minor role in the national assessments, these are essential to the overall evaluation of the Eel Regulation. Before the 3B and ΣA approach had been established, the ICES stock assessments of European eel has been based largely on examining trends in glass eel and yellow eel recruitment time-series. These time-series have consisted of a combination of fisheries-dependent and fisheries-independent data on both glass eel and young yellow eel stages. It was cautioned already by the WGEEL (ICES, 2008) that data discontinuities, particularly related to data from commercial fisheries, can be expected following implementation of EMPs (e.g. management measures affecting fishing effort, season quota, size limits), and CITES restrictions, although at that time it was unknown to what extent this might impact on the dataseries. Loss of monitoring sites was highlighted already by SGIPEE (ICES, 2010a). Several fishery dependent time-series were lost due to restrictions of the fishery and for other reasons. The present availability of recruitment series for the calculation of the recruitment index series is also given in Chapter 2.

It is vital that the existing recruitment time-series are maintained in order to provide consistent baseline international assessments. ICES (2012a) therefore recommended that eel recruitment time-series identified by ICES as contributing to the annual international stock assessment process should be included in the new version of the Data Collection Framework (DCF, formally going to be known as DC-MAP). SGIPEE (ICES, 2010a) pointed out that the absence of any internationally driven requirement to maintain a recruitment dataseries needed to be corrected and highlighted the recommendations of WGEEL (ICES, 2008) and EU Contract 98/076: Establishment of an international recruitment monitoring system for glass eel. Furthermore, SGIPEE (ICES, 2010a) recommended that efforts to establish time-series for glass eel in non-EU countries (e.g. Norway, Turkey, Egypt, Tunisia, and Morocco) should be continued.

Recruitment data required

- Location of data collection
- Stage and size of eel
- Indicator data collected (numbers, biomass)
- Capture and sampling method
- Time-series
- Capture effort

In addition to the typical stock assessment efforts on the continental life stages of eel, standardized larval surveys as carried out by Germany in 2011 and Germany and Denmark in 2014 (Hanel, pers. comm.; Hanel *et al*., 2014) with a clear target on monitoring and evaluating eel leptocephali (or egg) densities in the Sargasso Sea need to be continued on a regular basis to enable more immediate detection of changes in reproductive success and possible spawning–stock biomass than can be achieved by monitoring medium- and longer-term trends in continental recruitment. In the long run, such data may also help to explain variations or apparent inconsistencies in the stock–recruitment relationship. Therefore, ICES (2012a) recommended that the new DCF (-MAP) supported the need for international surveys at sea of eel in the spawning area in the Sargasso Sea.

4.2.2.2 Spawning stock

Whereas a rather well accepted recruitment series exists for the European part of the eel distribution area, information on spawner stock biomass is limited. The actual spawning–stock biomass (in the Sargasso Sea) has never been observed. The best available proxy is the escapement of silver eels that exists after all of the fisheries and other mortalities (both natural and anthropogenic) in the continental and coastal waters have occurred.

For present and future reports according to EU Regulation 1100/2007, Member States will provide the best estimate of silver eel escapement for each EMU. However, no direct estimate of historical escapement at the stock scale is available. Therefore, WGEEL (ICES, 2013b) attempted to reconstruct a time-series of escapement for the past 60 years from proxy data. The idea is to use the landings, prioritizing the silver eel fishery since they are the closest to the escapement. If it is not possible to use silver eel data, information from the yellow eel fishery may be used, although it will complicate the procedure. The methodology for the estimation of silver eel escapement from landings data has been discussed in ICES (2012b; 2013b).

In the previous attempts to reconstruct historic silver eel escapement for the whole stock, several shortcomings were noted.

So far, only EMUs or countries could be considered that provided both catches and $B_{current}$. If either of these data had not been available, the EMU/country was not taken into account in our estimate. One should notice that some EMU/countries with high stock and/or catches have thus been left out (e.g. Norway, marine part of Denmark, Portugal and North Africa).

Of further considerable concern for predicting this relationship is whether significant changes in effort or gear have occurred. Such changes would affect the relation between landings and escapement if the expert-supplied exploitation rate estimates do not account for this.

WGEEL (ICES, 2012b) still noted, despite some improvements, a considerable degree of heterogeneity and unreliability in the landings dataseries. It has hence to be concluded that if the WGEEL continues to develop the stock–recruitment relationship using these methods, it is of utmost importance that catch series are improved and that the splitting of these data by stage is also improved. The work on estimates of yellow eel landings should be continued as well because these may provide proxies for silver eel from missing ecoregions.

The data requirements for (improved) establishing of the stock–recruitment relationship can thus be summarized as follows:

- Increase the amount of information available (all countries constituting eel habitats should deliver the stock indicators and landings data).
- Provide data for all relevant habitats. If necessary develop habitat-specific assessment methods.
- Increase reliability and homogeneity of landings data, including a standardization of methods at least to some degree (e. g. regional standardization or standardization within a subset of methods).
- Improve the separate reporting for glass, yellow and silver eels.
- Provide information on fishing effort.
- Provide information on exploitation rates (all anthropogenic impacts, including non-fisheries factors).
- Achieve better geographical coverage, including the countries outside the EU but within the eel distribution area. This includes recruitment and silver eel escapement data.
- Establish regular larval surveys in the ocean (Sargasso Sea).

4.3 Data quality issues

During establishing the framework for international stock assessment in European eel, ICES (2012b) discussed the need for quality control on the national assessments, because the quality of the international stock assessment depends on the quality of national assessments and the consistency (and completeness) of these local and national assessments. SGIPEE (ICES, 2011a) started to develop quality criteria for the data and models underpinning the estimates of the "3Bs& ΣA". These quality criteria could be used initially by the member states as a check list when preparing their progress reports for the EU. At a later stage the quality criteria may be used as a tool (to assess quality of the estimates and identify over- and underestimates) during the post-evaluation of European eel stocks. The following recommendations on international stock assessment were formulated during ICES (2010b):

- the reporting on stock status by countries is standardized;
- the minimal information on stock status required is $B_{currrent}$, B_{best} and B_0 (or equivalent trios, e.g. $B_{current}$, ΣA and B_0);
- quality criteria for national stock assessments are considered, and implemented;
- intercalibration between assessment methods be executed to standardize results.

As a first step, SGIPEE (ICES, 2011a) and WGEEL (ICES, 2012b) developed a scorecard, which could be used for a basic check for bias in the data (Annex 9 in ICES, 2012b). This scorecard is an attempt to summarize some of the important criteria that, however, needs further development: the list of criteria should be reviewed and realistic standards for these criteria should be formulated. Another important step during the evaluation of the "3Bs& ΣA" is to predict if certain biases will produce an overestimate or underestimate. Finally a decision needs to be made on which "rule of aggregation" to apply when moving from the individual criteria, to the three estimates and to the overall quantification of the status of an EMUs "3Bs& ΣA" estimate.

4.4 Data available vs gaps

Given all of these data requirements, the working group has reviewed the available information provided in the Country Reports about the stock indicators and the habitat coverage achieved by the countries. The electronic table "Chapter 4 Table E4-1" accompanying this report reveals considerable gaps of such information.

The stock indicator, B_0, pristine biomass, is reported from 71 EMUs out of the 129 EMUs/countries in the area of European eel distribution. Stock and mortality indicators are lacking from many countries, especially from the eastern and southern parts of the Mediterranean Sea. The indicator B_{best} is reported by 80 EMUs and the current escapement, $B_{current}$, by 69 EMUs. Data on total mortality exist from 63 EMUs. In many countries riverine and lake habitats were assessed based on estimates of habitat specific productivity. Coastal and estuarine habitats have considerable data gaps.

Table E4-1 also summarizes the existence of recruitment time-series as reported in the 2014 country reports to the WGEEL. Most monitoring sites are located in the North Sea region, several of them fishery independent. In the Biscay region only two sites for glass eel monitoring are still in operation. In the Mediterranean Sea only Italy reports data from one site in the Lazio eel management unit. For further information on recruitment series see also Chapter 2.

4.5 Prioritization for future work (based on identified gaps)

The prioritization of the gaps in terms of impact on the quality of the international stock assessment for eel has to be based on the discussion on shortcomings and limitations in the present assessment. Two major aspects can be extracted:

1) Improve the amount and the quality of the data (stock indicators, landings etc.) delivered by the countries already contributing somehow to the stock assessment. This also includes information on habitats, which so far are not sufficiently covered by the assessment, e.g. coastal and transitional waters. It is known that these may form important habitats for eel but there are considerable gaps in data on eel stocks in these habitats.

2) Include data from countries in the distribution area of European eel, from which information is lacking more or less completely (or for certain stages, e. g. glass eel recruitment), but which may be of considerable relevance due to the size of their local stocks.

Whereas the first aspect has been discussed before, the second aspect will be explained shortly here. Stock assessment on a total population scale sets demands for stock indicators from a representative majority of habitats producing eel all over the area of distribution. So far, information is missing for a considerable part of the distribution area.

A total of 38 countries are considered to produce eel across Europe, Africa and Asia and have presently (or have had in the past) eel capture fisheries production according to FAO (2011). Of these, 19 countries are in the EU and have produced EMPs.

The relative role these countries play in eel exploitation can be roughly derived by examining eel capture fisheries statistics. The annual catches of eel reported to FAO statistics for 2007–2009 have been summarized in ICES (2011a, Table 3.2). Note that ICES (2008) has previously identified some inconsistencies in the FAO eel statistics, so the data should be viewed with caution, but they may be used here for illustrative purposes. In each year, European countries that have implemented EMPs account for most of the eel exploitation, but non-EU EMP countries account for considerable productions in the region of 27 to 39% of the total catch (Figure 3.1 in ICES 2011a). In the latter group, Egypt accounts for most of the eel yields, but Albania, Tunisia and Turkey also contribute. For further information see also Chapter 2.

These figures clearly indicate that even rough information from these countries outside of the EU will increase the quality and plausibility of the international stock assessment. However, in the absence of information on relative catches of yellow and silver eel in these statistics, and in silver eel characteristics of these countries, it is difficult to provide any greater understanding of the relative contribution (potential) of these other countries to the spawning stock and therefore future recruitments.

Whereas the inclusion of data from countries not covered by the stock assessment so far is urgently needed, improvements in amount and quality (homogeneity, reliability etc.) of data have to be achieved as well for the EU countries during the implementation of the Eel Management Plans. These two approaches to data enhancement and improvement should not be viewed as mutually exclusive as both need to be pursued to improve the collective ability to assess and to manage the eel stock. Furthermore, if, when and in which quality data from the so far missing countries can be provided is unclear. Meanwhile, the EU / European countries have the ongoing responsibility to ensure that their own contributions as good as possible.

4.6 Recommendation from this chapter

RECOMMENDATION	ADRESSED TO
International coordination with countries outside the EU to achieve adequate spatial coverage of eel stock assessment.	ACOM / ICES Secretariat / EU / GFCM / EIFAAC

5 ToR d) Identification of suitable tools (models, reference points etc.) in both data rich and data poor situations

5.1 Introduction

The purpose of this chapter is to provide a source of reference for those wishing to implement eel stock assessments in their countries. The chapter draws on reports previous Working Group, Study Group and Workshop reports, Country Reports and other publications (e.g. EMPs, EMP Progress Reports, EU-POSE and EU-SLIME project reports), and summarises the application of approaches to assess eel at various geographic scales and under various data situations.

The methods applied in various EU and other countries, their data requirements and outputs, are summarised in the accompanying electronic table, Table E5-1.

5.2 Methods available to assess silver eel production and escapement

The methods available to determine the potential escapement, in the absence of anthropogenic impacts, and actual escapement of silver eel are outlined below. Silver eel escapement is the amount of eel that have successfully passed and survived all of the potential anthropogenic and natural mortality impacts in continental freshwaters, estuaries and coastal waters (or fresh and saline waters) on their emigration to the oceanic spawning ground.

5.2.1 Methods based on catching or counting silver eels

There are several means by which silver eel escapement can be estimated (at least) directly from catching or counting eels. The EIFAC/ICES Working Group on Eels reviewed these methods in 2008 (ICES, 2008). The following develops from this review, and adds consideration of the major practical issues associated with deploying these methods at geographical scales appropriate for basin district or national assessments.

5.2.1.1 Whole River or total traps; "index" sites

Wolf traps, or related systems, or use of winged nets deployed for research purposes can provide precise estimates of migrating eel population dynamics and under some circumstances all silver eels can be counted and weighed. However, this is usually only possible in smaller river systems where discharge patterns allow for silver eel trapping throughout the migration season. Examples of this type of silver eel escapement estimation include the studies undertaken on the Norwegian River Imsa (Vollestad and Jonsson, 1988), the French Rivers Frémur (Feunteun *et al.*, 2000) and Oir (Acou *et al.*, 2009), and the Irish Burrishoole river basin (Poole *et al.*, 1990).

There are several issues with applying this method for eel stock assessment that mean it is not widely suitable. There are exceptionally high resource requirements associated with installing and maintaining the traps. Given that the trap is required to fish the entire river width, there are likely to be relatively few suitable sites within EMUs. It is worth noting in this context that WKESDCF (ICES, 2012a) recommends the adoption of one index site per EMU, not specifying full detail of what constitutes an index site. Full and accurate measures of silver eel escapement require that traps operate throughout the entire period when emigrating fish are passing the site, and that they are all captured. However, the capture efficiency of the trap can be reduced by varying flow conditions. Given the considerable size range of silver eels (e.g. 35 to 100+ cm length) in some basins, the trap design may not be suitable to catch eels across the whole size range; i.e. is size selective. This is often the case with commercial gears (see below), especially where the fishery is controlled by a minimum size limit for the catch. In such circumstances, the catch may not accurately represent the full run.

5.2.1.2 Partial research traps and partial commercial fisheries

Where trap efficiency is not 100%, mark–recapture methods (e.g. using passive integrated transmitters (PIT) or externally attached high visibility tags) can be employed to estimate capture efficiency of the trap. The proportion of marked eels recaptured provides an estimate of the capture efficiency of the fishery. The catch is then raised by this efficiency to estimate the size of the run. A comprehensive measure of capture efficiency would incorporate the varying effects of river condition and fish size. Note therefore that mark–recapture methods require a model-based approach to raise the catch to the whole population based on estimates of capture efficiencies: all the methods require some form of model-based approach to raise catches in account of fishery selectivity/efficiency and/or accounting for downstream parts of the basin.

5.2.1.3 Fisheries-based assessments; mark-recapture

Commercial silver eel fisheries can, depending on their location and scale, provide good opportunities for direct estimation of the numbers and biomass of silver eels escaping from eel producing systems. The approach of using tagging with mark–recapture can be used to estimate passage at commercial fisheries, in just the same way as a research trap. Provided that scientists have full access to the fishery and that the commercial operation permits the time and intervention to check the whole catch for tags, it is possible to determine the efficiency (proportion of run or local stock that is captured) of the eel capture systems involved (see above). Examples of such investigations, of population dynamics and seasonal patterns of seaward migrating eels, include those undertaken on the River Loire, Rivers Shannon and Corrib, River Bann (Lough Neagh outlet), the River Imsa, the Baltic Basin and the St Lawrence River. Catch and effort data from closely monitored fisheries in enclosed waterbodies such as Lough Neagh (Northern Ireland) allow detailed assessments of eel production. However, such large and discrete eel fisheries constitute only about 5% of the continental fisheries, with the remainder consisting of very small and disparate fisheries.

As with scientific monitoring studies, difficulties can occur when the fishing season does not cover the full migration period or when there is significant eel production downstream of the fishery area. Use of mark-recapture methods for estimating fishery capture efficiency allows for estimation of the numbers and biomass of migrating eels at the fishing sites. This can involve use of a variety of tags and marks (see Concerted Action for Tagging of Fish: www.hafro.is/catag). Experimental fisheries could be established in data poor areas and used to improve fishery monitoring methodologies.

5.2.1.4 Fish Counters and sonar

Counters and various acoustic technologies can allow for the estimation of silver eel escapement in locations where eel capture is not possible. McCarthy *et al*. (2008) used hydroacoustic methods to investigate variations in numbers of silver eels migrating downstream in the headrace canal of the Ardnacrusha hydropower plant in the River Shannon, Ireland. Resistivity counters have been trialled successfully for counting emigrating silver eel in the UK (J. Hateley, pers. comm.), as have high-frequency multibeam sonar (DIDSON®) in the UK, Ireland and the Netherlands (J. Hateley and W. Dekker*.* http://www.imares.wur.nl/NL/onderzoek/faciliteiten/didson/). The Didson may not be suitable for deployment in rivers >15 m width if a full width count is required, and the main constraint at sites of appropriate dimensions is that the site must have a suitable profile with minimum or little shadowing of the beam (Briand *et al.*, 2014; Bilotta *et al.*, 2011; Keeken *et al.*, 2011). Such eel counts, and linked data on size frequencies of the migrating eels, are only possible in locations where other fish species with target strengths in the same range as the silver eels are not also migrating downstream at the same time as eels. Work is in progress in Ireland, UK, Poland, Sweden and other European countries that should lead to improved sampling protocols and to more widespread use of this method for estimation of eel escapement rates.

5.2.1.5 Acoustic or radio tracking of individual fish

Where resources permit, mark–recapture escapement estimation at a partial fishery or trap (generally for silver eel) can be usefully supplemented for verification, or in some cases substituted, by acoustic (or radio) tracking with upstream and downstream recording receivers. This has the distinct advantage of observing the fish that pass an obstacle or fishery rather than estimating them from numbers not recaptured. This work is expensive and generally carried out at a research scale with small numbers of tags (rarely more than 100 individuals in any one study, and usually only tens). Telemetric tracking can be an alternative means of eel passage estimation at sites where there is no possibility of a mark–recapture set-up, such as at large river hydropower sites, or used as a verification method for DIDSON® or similar hydroacoustic escapement assessments (McCarthy *et al.*, 2013). Where there is no tagged eel recovery, care needs to be taken to ensure that tracked tagged fish are still viable having passed through the tagged area, for example that the tagged fish have not been taken by mobile predators, or are not simply moving downstream in a moribund state.

5.2.1.6 General issues with catch, count and proxy approaches

Few fisheries or in-river traps are operated at the very downstream extreme of the study basin, and therefore they miss any silver eel produced from the habitats further downstream. This is especially a problem when the study basin includes the estuary or even coastal waters. Given the practical and logistical difficulties associated with methods relying solely on capture of silver eels, not least the ability to catch the eels in a manner that is representative of the entire run, there are relatively few places across Europe where this method can be adopted.

A further limitation of these direct approaches, as it relates to European assessment and management of eel, is their inability to provide a measure of potential 'pristine' silver eel production in the absence of data from the appropriate historic period. Although such historic data exist and have been used for a small number of river basins, e.g. Burrishoole (Ireland), Neagh/Bann (UK N. Ireland), the approach cannot be used to back-calculate from present to historic production. Thus, while a new direct approach might be deployed in a river basin, it can only provide an estimate of silver eel production from now onwards, assuming constant conditions. In the absence of historic data, therefore, we are reliant on models of eel production to estimate pristine levels.

5.2.2 Methods based on yellow eel proxies

The use of proxy indicators from sedentary eels and habitat population models is another approach that has been applied to estimate silver eel escapement (e.g. Feunteun *et al.*, 2000; Aprahamian *et al.*, 2007; Lobon-Cervia and Iglesias, 2008). In many river systems, surveys are commonly conducted to characterize the sedentary 'yellow eel' component of the local stock. Mark-recapture or other more locally adequate methods could be used to estimate density of yellow and pre-migrant silver eels. A number of morphological characteristics have been identified that indicate pre-migrant status of eel, i.e. that they should be expected to emigrate as silver eels in the next migrant season (Feunteun *et al.*, 2000; Durif *et al.*, 2005). It is possible therefore to estimate silver eel production from a water course based on the numbers of such 'pre-migrant' eels (Feunteun *et al*., 2000; Acou *et al.*, 2009).

The approach introduces two main sources of uncertainty in any estimate of silver eel production. First, if it is conducted in only one year it assumes that all eels classed as pre-migrants will actually become silver eels in the following migration season. Rather, evidence suggests that some pre-migrants may not emigrate in the year of marking (E. Feunteun, pers. comm.), and that studies using this method should be conducted over a number of years.

The second assumption is that the eels sampled during the surveys are representative of the eel population across the river basin, such that the survey results can be raised to the system, typically according to the relative wetted areas. These procedures should nevertheless be standardized so that methodologies used can provide representative estimates of silver eel production, e.g. sampling at the beginning of the migratory season (late summer in southern latitudes and middle summer in northern latitudes). Several habitat types representative of each catchment should be evaluated in order to be able to extrapolate for the whole catchment and include it in habitat population models. Eel mortality rates need to be determined throughout the river basin including the estuary as well as fresh-water habitat.

Acou *et al.* (2009) estimated silver eel production from two coastal river systems of western France, the Frémur and Oir. In the Frémur, 29 surveys covered about 2.3% of the wetted area of fluvial habitat, and four sites each in two still waters, and up to 32 sections of the Oir, accounting for 8% of fluvial habitat but only along a 7.5 km length of river.

Obtaining population density estimates for yellow eels in large water bodies including still waters is often difficult or impossible. Studies suggest that eels are often confined to shoreline margins of still waters because of the presence of cover and food (Jellyman and Chisnall, 1999; Schulze *et al.*, 2004), though this is a topic that has received relatively little study. Whilst that presence of eels has also been recorded along the shoreline margins of many lake systems throughout Ireland (Poole, 1994; Moriarty, 1996; Rosell *et al.*, 2005), these findings are commonly associated with seasonality, given that the shallow waters warm up quickest thereby promoting eel feeding behaviour in these regions. However, commercial fishing experience and scientific survey data have revealed that as water temperatures begin to rise throughout the summer months, eels are more commonly found in the deeper (>9 m) waters (Matthews *et al.*, 2003; Allen *et al.*, 2006; R. Poole, pers. comm.). Nevertheless, extrapolation of fluvial densities across the entire surface area of still waters may overestimate eel production from some still waters. In the Frémur, France, (Acou *et al.*, 2009), only a 2.5 m wide shoreline strip of fluvial habitats produced eel and thus eels were absent from about 95% of the fluvial wetted area. It is clear that the proportion of water surface area occupied by eel can be a highly individual calculation and care needs to be taken in extrapolating between areas, to avoid grossly underestimating or over-estimating eel production in many waters.

The surveys have a significant resource requirement and therefore numbers and distribution of surveys is often limited. To date we are unaware of any study testing the number and distribution of surveys against the accuracy of their representation of the actual yellow eel population in a river system. Statistical methods are available to aid sampling design (e.g. power analysis), but these must be incorporated with spatial information on habitat diversity and distributions in order to develop statistically robust stratified sampling programmes.

5.2.3 Model-based approaches to estimate potential and actual silver eel escapement

The level of complexity that characterizes the life cycle of eel populations makes the simulation of its dynamics particularly challenging. Studies have already focused on the development of population dynamics models for several eel species including the American eel (*Anguilla rostrata*) (Reid, 2001), shortfin (*A. australis*) and longfin eel (*A. dieffenbachia*) (Francis and Jellyman, 1999), and European eel (*A. anguilla*). The European SLIME (Dekker *et al.,* 2006) and POSE Projects (Walker *et al.,* 2013) reviewed developments in quantitative modelling of European eel populations and tested different models in light of the management target proposed by the EC.

The number and diversity of models developed for Anguillid species is considerable, starting with the age-structured and life table models of Sparre (1979) and Rossi (1979), respectively, and to date including input–output, stochastic and/or spatially distributed demographic, VPA-like, and multi-stage stock-recruitment models, and covering a single life stage (glass eel) to the global stock. De Leo *et al*. (2009) provided a representative summary of the features of many of the models that have been used over the years to describe the dynamics of eels and predict the status of the stock. Because of the complex life cycle of eels the range of information needed to describe this and the complexity of the model that could be used, is high. Similarly, the range of information needed to estimate unexploited and current stock sizes and escapement is considerable. This includes standard type of stock assessment inputs/estimates such as recruitment levels, catch data but also less common factors such as stage-specific stock estimates and indices of habitat quality.

This discussion focussed only on those models that have been applied in EMPs and/or are under continuing development, compared to those models that are not, as far as we can establish, being used in EMPs or subject to further developments. These models, listed in alphabetical order, are as follows:

- Demographic model of the Camargue (DemCam)
- Eel Density Analysis 2.0 (EDA)
- German Eel Model (GEM)
- Scenario-based Model of Eel Production II (SMEP II)
- Swedish analytical model (SWAM)
- Model of eel population within a Hydrographic network (GloBang)
- Length-Based Virtual Population Analyses (LVPA)
- Dutch eel models
- version of CAGEAN model (Deriso *et al.,* 1980)

A further model, GEMAC (glass eel model to assess compliance) exists as a glass eel-specific model used in France to determine actual glass eel settlement after fishing, glass eel fisheries mortality and other anthropogenic factors at that stage, and natural mortality from the glass eel arriving at the coast/estuary. It has been described in the

SLIME report, but it is not yet used in producing recruitment time-series data but could, given expert time and data, be used to improve estimates of recruitment of glass eel or give absolute recruitment estimate. However, as it is not designed to produce silver eel biomass and anthropogenic mortality reference points, it is not considered here.

There are considerable differences between these models in terms of their level of complexity, data requirements, real cases in which they can be applied, etc. Knowledge of these differences is very important in order to identify the right model to apply to quantify potential and actual eel production and silver escapement, depending on eel population characteristics and data situations. The following descriptions are summarised from the reports of the SLIME (Dekker *et al.*, 2006) and POSE (Walker *et al.*, 2013) reports.

5.2.3.1 Demographic model of the Camargue (DemCam)

Model approach and processes

DemCam is a stage-, age-, and length-structured model that provides a detailed description of the status of the eel stock in a homogeneous water body, considering the main aspects (both natural and anthropogenic) that affect eel population dynamics. A general formulation makes it suitable to describe the demography of other different eel stocks, providing that a sufficient number of data are available for parameter calibration. The model is designed to simulate the condition of the stock in actual, pristine and future conditions under different scenarios.

The model is deterministic with an annual time step, using density-dependent juvenile mortality, growth of undifferentiated, male and female eels, fishing mortality and length-dependent maturation.

The model evaluates the consequences of fisheries, restocking, maturation, growth and natural mortality on the yellow and silver eel population and it explicitly account for the dynamics of glass eels to capture the effects of anthropogenic and other factors on this part of the population.

Data requirements

The model requires annual indicators of recruitment and fishing effort, and biological parameters, either directly assessed for the studied population (when data are available) or taken from literature. These required parameters are: Annual recruitment (time-series or index); Sex ratio (at silver stage or at 30 cm); Density-dependent juvenile mortality (back calculated from historical maximum); Sex-specific body growth (otolith, age at silvering); Sexual maturation (silver size); adult mortality (literature, or know); Fishing mortality (know, estimated).

Further model developments foreseen but not planned at this time, can focus on improving the description of sex differentiation in small yellow eels and producing mark–recapture estimates of yellow and silver eel abundance. The model also needs to be calibrated against length distributions of yellow and silver eel catches, to allow the ability to carry out sensitivity analyses on parameters and outputs, and to bootstrap input data.

Model outputs

The output of the model is number of eels in a given time at a given age, size, sex and maturation stage. Based on this information, the user can estimate the number of migrating silver eels for any given time.

The model defines the eel stock and the harvest structured by age, length, sex and maturation stage (yellow or silver) on an annual basis. The output consists of biomass and number of eels in catches, and yellow and silver eel stock by age, length, sex and maturation structure under different management scenarios, such as stocking, fishing regulations, and/or different environmental conditions.

5.2.3.2 Eel Density Analysis (EDA 2.0): A statistic model to assess European eel (*Anguilla anguilla*) escapement in a river network

Model approach and processes

This is a framework of eel density analyses rather than a fixed, end-user model. It relates yellow eel densities to environmental variables, including anthropogenic impacts, and is extrapolated from survey sites to the river basin. The predicted yellow eel stock is then converted to a silver eel escapement, using a conversion rate.

The modelling tool is based on a geolocalized river network database to predict yellow eel densities and silver eel escapement. There are six main steps in the model application:

1) Relate observed yellow eel presence/absence and densities to descriptor parameters: sampling methods, environmental conditions (distance to the sea, relative distance, temperature, Strahler stream order, elevation and slope, etc.), anthropogenic conditions (obstacles, fisheries, etc.) and time (year trends);

2) Extrapolate yellow eel density in each river stretch by applying the statistical model calibrated in step 1;

3) Calculate the overall yellow eel stock abundance by multiplying these densities by the surface of each stretch and summing them;

4) Estimate a potential silver eel escapement of each stretch by converting yellow to silver eel abundance using a fixed conversion rate;

5) Calculate effective escapement by reducing potential escapement with silver eel mortalities during downstream migration;

6) Sum the effective escapement from all the stretches to give estimate at EMU scale.

It is also possible to give an estimate of the pristine escapement by running the EDA model with anthropogenic conditions artificially set to zero and time variable datasets before 1980.

Data requirements

The model needs information on the yellow eel population, environmental characteristics, and anthropogenic impacts on eel production. The data required on the eel population are the presence/absence and densities of yellow eel, typically derived from scientific surveys (e.g. electro-fishing surveys).

The environmental data are the distances to the sea and source, and the relative distance (between sea limit and the more upstream source), the temperature in each segment of the river network, the mean rainfall, the elevation, slope and stream order (Strahler and Shreve). EDA is designed to be applied at the EMU or larger scale. It uses the CCM v2.1 (Catchment characterisation and Modelling) a European hydrographical databases (Vogt *et al.*, 2007, http://ccm.jrc.ec.europa.eu/) to derive the environmental descriptors. The CCM2 database includes a hierarchical set of river stretches and catchments based on the Strahler order, a lake layer and structured hydrological feature codes based on the Pfafstetter system (De Jager *et al.*, 2010). The primary catchment referred to is the drainage area; this is the smallest entity in this hierarchy and is drained by CCM river stretch.

The anthropogenic impacts are described by the obstacle pressure (cumulative number of dams and their pass-ability), the land use, and fisheries.

Model outputs

The outputs of the model are the yellow eel density in each reach of river network, and the overall yellow eel stock abundance and a potential silver eel escapement at pristine and actual conditions. The biomass and number of yellow eel and eel escapement are optional.

5.2.3.3 German Eel Model (GEM)

Model approach and processes

The German eel model was developed specifically for describing the dynamics of the eel population of the River Elbe system, especially for estimating the escapement of silver eel between 2005 and 2007. The age-based model is data driven and was adapted to the available dataseries estimated relationships. The model treats the productive area as a single unit, so does not take into account spatial aspects like different habitat patterns, area dependent growth, etc. Nor does it account for the potential effects of density on eel production processes such as growth and mortality rates.

The model is based on the structure of the Virtual Population Analysis (VPA), but the GEM works in the opposite direction. The initial population in number, by age group, at the beginning of year one is estimated. Then the model estimates the number of eels of each age group which leave the system for various reasons (natural mortality, fisheries, predation, turbines, etc.) in the same year. The population at the beginning of the following year is then estimated based on the remaining population, and the numbers of immigrating elvers and restocked eels.

The following parameters are assumed to be stable during the total model period:

- Growth and weight–length relationship;
- Relative age distribution of eel eaten by cormorants;
- Relative age distribution of silvering eel;
- Mean weight of eel in the stomach of cormorants;
- Relative age distribution of immigrating eels.

The natural mortality is split into two components: the effect of cormorants and the remaining natural mortality. It is assumed that the age distributions of eel caught in fisheries and those eaten by predators are similar to the age distribution of the stock. Also, that turbines and pumping stations only impact silver eels.

Note that for the Elbe dataset at least, analyses have shown that the size and the relative age distribution of the initial year has relative low effects concerning the year t_x if the period between the initial year and the year t_x is more than 18 years. Thus, GEM requires a 'training' dataset of at least 18 years.

Data requirements

The following input data are required for the model:

- Catch in kg by fishermen and angler per year;
- Number of restocked eel by age group and year;
- Number of immigrating elvers by age group and year (if data are not available for each year, estimates based on international time-series can be used);
- Catch in kg by cormorants per year;
- Mortality of silver eels due to hydropower plants and water removals in % per year.

Input data are provided as numbers per cohort, with various counts or length distributions converted to age profiles based on survey data. The model requires descriptions concerning the weight–length relationship and the growth of eel to estimate the mean weight of eel by age group and to transform length-based estimates into age-based estimates.

The relative age distribution of eel captured by cormorants is required for estimating the total number of eel consumed by cormorants. It is assumed that the proportion of eel in the food of cormorants is dependent on the density of eel.

The model also contains the option to add stochastic noise to the input data which are normally distributed with a mean of zero and a given variance. If the variance is realistic this option can be used for estimating the confidence intervals of the escaping silver eels by means of bootstrap methods.

Outputs

Model outputs are population size, catch by fishermen, catch by anglers, catch by cormorants, mortality by other natural reasons, and silver eel escapement, all expressed as numbers per cohort.

5.2.3.4 Scenario-based Model of Eel Populations (SMEP II)

Model approach and processes

SMEP II is a software package developed to model the dynamics and exploitation of eel populations (Aprahamian *et al.*, 2007). It is based on the scale of a river basin, and simulates the freshwater phase of eel production. It is a population dynamics model that simulates both the biological characteristics of the eel population and a number of potential anthropogenic influences on that population. Biological processes modelled include growth, natural mortality, sexual differentiation, maturation (silvering) and migration within the basin. Anthropogenic influences include environmental and habitat quality, fishing practices, barriers to migration and stocking.

The population dynamics model used is a length-based model that describes the dynamics of a population of eels for the duration of its stay in the river basin. The model is also sex-, stage-, and area-specific and accounts for density dependent effects, and habitat structure and quality. Therefore, it tracks changes in undifferentiated, yellow (male and female) and silver (male and female) eels within four seasons and for each reach in the basin. The model does not make any assumptions about the dynamics of eels that have migrated from the river back to the sea (i.e. on silver eels once they exit the basin). Since only partial simulation of the population dynamics is possible (the salt water phase of population's life is not simulated), processes such as recruitment cannot be modelled explicitly and therefore, information about them needs to be provided externally (or estimated).

Model outputs are provided both as numbers and biomass of eel, per sex and life stage, river reach and year; and length–frequency distributions. SMEP II is designed to provide time-series or equilibrium outputs for each reach and summarised for the catchment for: undifferentiated eels, male and female yellow and silver eels: in terms of numbers, density and biomass, length–frequency distributions, sex ratios, and predicted catch numbers and biomass. The model can be used to project the population forward from a predetermined starting condition or estimate the starting conditions that could lead to a given population size or structure. As a projection tool, the user may vary anthropogenic influences and levels of recruitment in order to create 'what-if' management scenarios, relative to the given reference point.

Data requirements

SMEP II must at least have information describing the eel life-history processes, and the size and structure of the river basin and the level of annual recruitment, in order to predict potential production under 'pristine', constant conditions. Where data are available, either for historic or present conditions, these can also be applied to characterise the yellow eel population (in the past or present), impacts on escapement (e.g. fishing or turbines), inputs such as stocking events, and changes in the available area and quality of habitat. These additional data allow the user to set the model to simulate escapement under various conditions (past, present and future), and to alter the effects of impacts and inputs in order to examine their relative influence on escapement.

The biological processes that apply to the life cycle of eels in the study river are defined by the user from river-specific information, or can be parameterised according to values from neighbouring rivers or from the scientific literature.

Recruitment of eel is described according to the length of recruits (mean and standard deviation), the maximum number of recruits in any year, and a time-series of recruitment as an index of that maximum.

The model also needs information to describe the effect of density on the dynamics of eels if such effects are to be taken into account in the calculations. This is characterised according to the level of eel density biomass at or above which the density-dependent variations in biological processes take a strong effect.

In terms of the spatial component of the model, the user defines the number and topography of the reaches, their length and wetted area, as well as information about obstacles that might constrain the movements of eels between the reaches. The user also sets the speed at which eels move between reaches.

Where anthropogenic impacts are to be included in the model, fishing is described as catch weight by stage (glass, yellow, silver eels) and assigned to specific reaches seasons and years, and turbine mortality is described as the proportion of eel that are killed when passing a turbine.

If stocking is to be simulated, this is described in terms of the number and length distribution (mean length and range) of stocked eels, the reach where they are stocked, and the season and year when the stocking takes place.

Model output

SMEP II reports the results of simulations in a series of .csv files that provide, for each reach in every year: the density and biomass of undifferentiated, male and female yellow eels; numbers and weight of emigrating male and female silver eels; the proportion of females; and the numbers and weight of 'catch'.

End-of-run files provides summaries of density and biomass of undifferentiated, males and female yellow eels, biomass of male and female silver eels, and 'catch' (numbers and biomass) of undifferentiated, yellow and silver eels, and the length frequency of eels, stages and sexes in each reach.

5.2.3.5 GlobAng, a model of eel population dynamics within a hydrographical network

GlobAng is designed to perform simulations of eel population dynamics within a hydrographical network. After calibration with real field data, the model is able to evaluate the putative pristine silver eel escapement in response to a variety of management scenarios, especially when the spatial (reach) dimension is important. The main strengths of GlobAng are that it takes the river system into account, permits testing of spatial management scenarios and can be used to analyse impacts of barriers. It also takes into account density dependent processes and non-linearity in the relationship between recruitment and silver eel escapement.

Data requirements

GlobAng requires a description of the connectivity and carrying capacities of river system reaches and a recruitment time-series. Additional data, such as time-series of age structure of yellow or silver eels or eel population distribution throughout the catchment, are required for calibration and validation procedures.

Model approach and processes

GloBang integrates growth, recruitment, sexual differentiation, maturation, natural mortality and migration within a watershed. Impacts of fishing and migration barriers can also be simulated. The time step is the week. Sex determinism, natural mortality and movement depend on density.

Model output

The main outputs are sex and age structure of yellow eels in each reach and silver eel escapements either for long run (equilibrium) or over time.

5.2.3.6 Swedish analytical models (SWAM)

SWAM was originally developed for the Swedish (coastal) fisheries (west and east coast), to investigate how yellow and silver eel fisheries, fishery restrictions and glass eel restocking affect present and future spawner escapement (and catch) in a specified homogenous water body. Estimated present and potential spawner escapements can also be related to estimated escapement at some earlier time representing a more pristine stock. The main strengths of SWAM are its simplicity, transparency and flexibility (it can be applied to many different types of systems, using little data), and that it gives analytical solutions that are well defined and do not depend on simulations, and allow for changes between what is used as an input or an output (e.g. either using data on either recruitment or catch). Its main weakness is that it is dependent on parameter estimates from other sources, and that it omits many (possibly important) biological processes (e.g. using one size where all eels of one sex silver or migrate, or for sexual differentiation).

Data requirements

In general, only externally determined parameter estimates are used as input, but recruitment time-series can also be incorporated. No tuning or calibration process is incorporated in the models. The input must be a continuous series of annual length frequencies of commercial landings.

Model approach and processes

Following classic fishery modelling, only recruitment, mortality (natural and fishing) and average growth are considered annually.

Model output

Both equilibrium and time-dependent deterministic solutions can be derived. The main output is proportional spawner escapement, either as equilibrium solutions or over time since management actions have been applied. Depending on available input, estimates can be made of silver and yellow eel catch and spawner escapement in numbers (or biomass) or recruitment into the yellow eel fishery (in numbers) for a specific year (based on data on yellow eel catch).

5.2.3.7 Length-Based Virtual population analysis

Data requirements

Fishery modelling, only recruitment, mortality (natural and fishery induced), growth and maturation by size class to the silver eel stage and subsequent escapement each year are considered. The model requires data on total number of eels landed per size class per year, derived from landings statistics and catch composition sampling. A breakdown of catches by gear type results in gear-specific outputs. Additionally, parameter values are required for growth, and for natural (non-fishery) mortality.

Model approach and processes

The LVPA model quantifies the population state and the impact of fishing, based on total landings in numbers by length class in recent years.

Model output

The model aims to provide a critical post-evaluation of management measures implemented during the data years. A minimum of assumptions and a maximum of data ensure a close tracking of the true population. Derivation of reference points is straight forward, but has not yet been elaborated. The outputs are population numbers, partial fishing mortality for each gear type, and silver eel.

5.2.3.8 Dutch eel models

The Dutch EMP reporting relies on models in three components to produce data for reporting (Bierman *et al.*, 2012; Van de Wolfshaar, 2014). These consist of three interacting processes: a dynamic population model for yellow eel for estimating %SPR, an extended yellow eel model for estimating mortality rates, and a static spatial model for yellow and silver eel. Their use and interaction is described in Bierman *et al.* (2012).

The population model starts with recruitment data and applies growth, natural mortality, fishing mortality, and maturation parameters on a rate basis to follow cohorts through to silver eel. The extended yellow eel model uses fitting the data on catches per unit of effort from stock surveys, or length-frequency distributions from retained catches, to assess yellow eel stock trends and compare fishing mortality estimates with actual measurements derived from stock biomass surveys. The static spatial population model estimates standing stock biomass of yellow and silver eel to further derive biomass of silver eel escapement using geographic data of fresh water bodies with spatially-structured eel density data.

Data requirements/ Model approach and processes

The method uses a mix of rate-based process with actual survey and fisheries data, and geographic information.

Model output

The Dutch method produces the three biomass and summed anthropogenic mortality rate reference points required for local EMP and international reporting.

5.2.3.9 CAGEAN model (Deriso, 1980) and Simplified eel population model (Dekker, 2008)

Model approach and processes; summary

These two models, based on classical fisheries rate based processes, each feature once in use by WGEEL reporting countries (Poland and Lithuania) to supply $B_{current}$ and B_{best} B from basic fishery data.

5.2.4 Use of other methods and extrapolations to calculate or estimate biomass reference points

5.2.4.1 Wetted area based estimations

Many countries or EMU assessors use some means of extrapolating from habitat area data to derive the biomass reference points, particularly B_0, but also combining with knowledge of eel specific parameters to aid calculation of B_{best}. There are variable degrees of sophistication applied, ranging from simple map-based water area measurement combined with application of literature-derived eel carrying capacities, to detailed reach-based modelling approaches verified with field survey data. The most robust of these approaches use GIS-determined wetted area, with natural and man-made barriers defined and field verification to give reach-based accessibility parameters. This approach can often interlink with WFD assessments of river continuity and/or estimates of population level targets for other species (e.g. migratory salmonids in Northern European countries). A good example is that used for the Irish EMPs based on a wetted area model originally designed for defining Atlantic salmon habitat-based stock reference points (McGinnity *et al.*, 2011).

6 ToR b) Review the life-history traits and mortality factors by ecoregion

6.1 Introduction

The working group explored whether the ICES approach to assessing Data-Limited Stocks (DLS) might offer an alternative approach for assessing the stock status of the European eel. This DLS approach has been developed within the WKLIFE I, II, III reports (WKLIFE IV met the week before WGEEL 2014 but the report was not available for WGEEL to consider). As the new ICES model for providing advice aims to deliver this at the ecoregion scales (Figure 6.1), the working group explored these eel life-history traits at this scale, compared to other geographic scales typically applied to eel assessment.

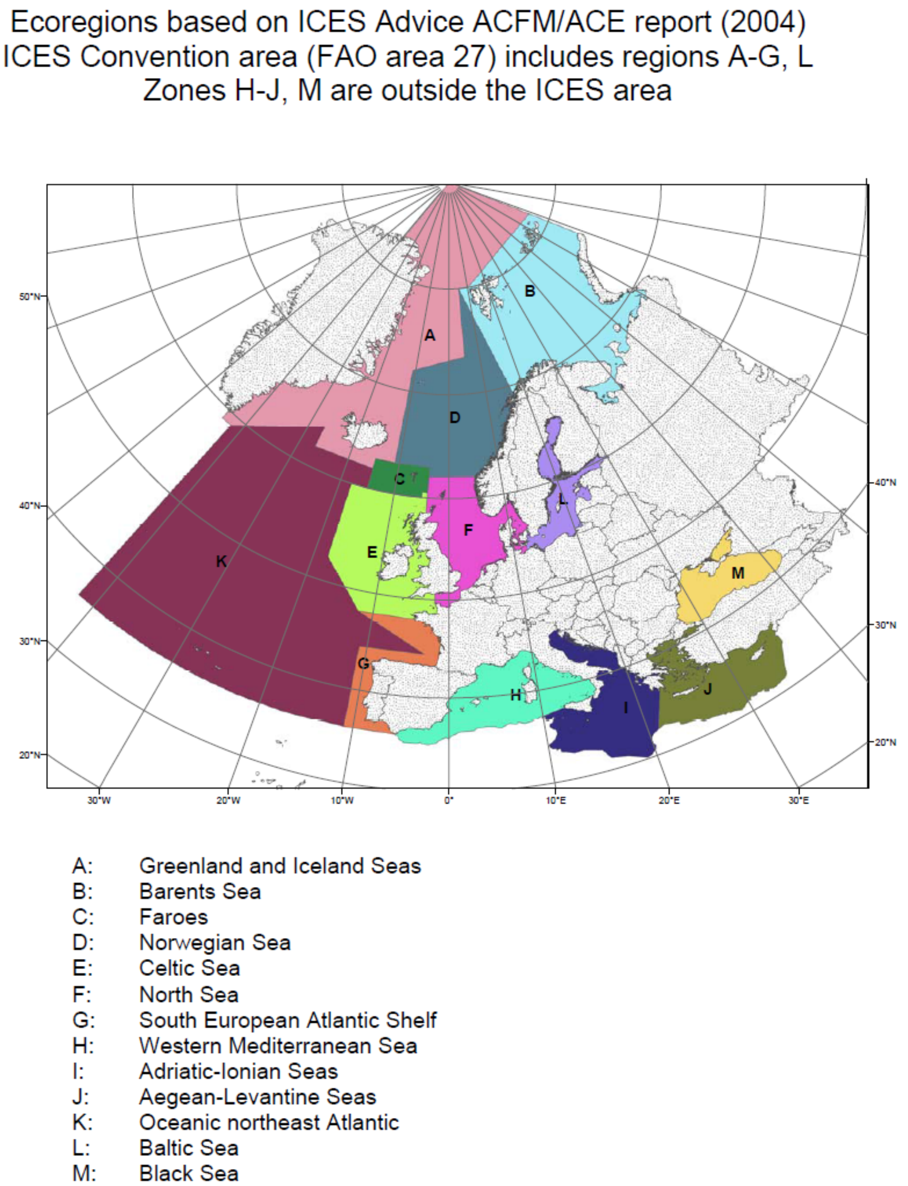


Figure 6.1. ICES ecoregions.

6.2 Life-history traits relevant to eel assessment

The work of WKLIFE suggests that in the absence of quantitative data, life-history traits may be used to assess stocks. The life-history traits used by some of the DLS approaches to define reference points for sustainable exploitation, that appear potentially relevant to eel are: growth parameters using the von Bertalanffy function; various L50 matured, where 50% of the population by length has silvered; Length and age; Fecundity; Weight-at-age and Length–weight relationship.

Due to their outstanding complexity in life cycle, with oceanic reproduction and larval transport, ascending as glass eels in rivers, growing as yellow eels in a diversity of marine, brackish, or freshwater habitats, and - after metamorphosis - leaving the freshwater habitat for a period of oceanic migration to distant spawning grounds, the eel is not assessable or manageable in the same way as most other marine exploited fish species. The presence of different life stages and metamorphoses, its longevity and semelparity and the exceptional migration advocates the need to use specific eel-oriented life-history traits, different from the ones used in other fish stock assessments.

Moreover, eels are eurytopic and have a widespread geographic range from the warm waters of the North African continent to cold Scandinavian river systems. The high natural variability in habitats where they live, added to the variety of anthropogenic pressures in these different habitats, provokes an exceptional plasticity in traits over the local stocks. Probably the most striking examples of this are the extreme differences in *sex ratio* and *size* and *age at silvering* over a latitudinal gradient.

Furthermore, while in most marine species mainly the adult sized fish is exploited, in eel, immature life stage are targeted by fisheries, from recruiting glass eel, resident yellow eels and migrating potential spawners in the silver stage.

In European eel, in contrast to other marine species where detailed and comprehensive monitoring data e.g. fecundity and reproduction potential, allow "finger on the pulse" management, uncertainties and gaps in knowledge about essential phases in eel's life history (especially concerning reproduction, fecundity and migration success) hamper stock assessment and management.

All the above illustrates why assessment based on a classical set of life-history traits, as used by most exploited marine species, is not feasible for eel, and advocates the need for a specific eel-based approach with an expanded set of eel-specific life-history traits.

An overview of the potential eel-specific life-history traits is given in Table 6.1. These may be classified as traits related to silvering process, population, quality and growth. As both sex and stage (yellow or silver) are crucial factors when describing an eel population, most parameters have to be split into those categories.

Males at silvering are smaller than females at silvering and most often also younger. The size at silvering is used both as a quality factor (condition) but also for the conversion between length and weight (and vice versa) when calculating the production in biomass. Other, population-related traits include *sex ratio* and mean *age*. *Age* is of outmost importance in all models as this affects the lifetime mortalities.

Quality-related traits such as good *condition* and sufficient energy accumulated through lipid stores is required for fuelling the migration and production of gametes. *Fecundity* and *lipid content* are parameters not yet used in any eel quantitative model to our knowledge. However, as quality/fitness in this long-migrating species probably is a determining factor for a successful reproduction, those parameters may be considered in the future in more complex models. Also *growth rate* and *von Bertalanffy parameters* are relevant descriptors for growth.

The working group examined the information provided in Country Reports to ascertain what life-history trait data were available by country. Data on the various life-history traits are available, and a summary of their availability is provided in the electronic Table E6-1 accompanying this report. Time constraints within the meeting precluded a more detailed compilation and analysis but this is recommended in the future (see below). Previous working group reports (ICES 2010; 2011) and scientific papers (e.g. Vollestad, 1992; Tesch, 1977) provide further details.

6.3 ICES ecoregion vs other geographic scales

Available data show large and progressively increasing levels of variation in the eel life-history traits at basin, country and ecoregion scales. For example, *length at silvering* for females is 471–675 mm within the ecoregion Western Mediterranean Sea and 420–1120 in Celtic Sea Ecoregion. *Age at silvering* for females in Celtic Sea Ecoregion ranges from 8–28 years but for Western Mediterranean Sea the range in age at silvering is 7–12 years. In marine species the degree of variability of LHTs within an ecoregion is considerable lower than the degree of variability of LHTs in eels even in the same EMU. Marine fish stocks may inhabit large sea areas and the management unit may with good reason be an ecoregion. However, the use of life-history traits in assessment on an ICES ecoregion scale is considered not appropriate for assessment of the eel stock. The WGEEL proposes that the Eel Management Unit is the most appropriate geographic scale for the assessment of data-limited eel stocks in alignment of the EU's Eel Regulation (EC 1100/2007), and that data on life-history characteristics be collated at the spatial scale of the eel management unit (EMU) as part of the development of the European Eel Stock Annex (see Annex 4).

Table 6.1. Overview of eel life-history traits information available, as reported in the country reports to the WGEEL 2014. *L50 = the length at which 50% of the population has silvered, as defined by WKLIFE.

Life-History traits	Yellow eels males	Yellow eels females	Silver eels males	Silver eels females	Population
Silvering related traits					
Length at silvering (average, range, L50*)	N/A	N/A	X	X	
Weight at silvering (average, range)	N/A	N/A	X	X	
Age at silvering (average, range)	N/A	N/A	X	X	
Population related traits					
Sex ratio (100* F/(F+M))	X	X	X	X	
Condition/quality related traits					
Fecundity (average, range)	N/A	N/A		X	
Lipid level (average, range)			X	X	
Condition factor (average, range)			X	X	X
Length/weight relationship	X	X	X	X	X
Growth related traits					
Von Bertalanffy parameters: L_{inf}, K, t_0	X	X	X	X	X
Growth (cm/year)	X	X	X	X	X

7 ToR f (i)) Explore the standardization of methods for data collection, analysis and assessment

7.1 Introduction

Eel is thought to be one (panmictic) population spread over Europe, (including the Mediterranean) and parts of North Africa, but local conditions vary so much that uniform stock-wide management is impractical. For those countries with the EU, the development and implementation of protection measures has therefore been delegated to the national / regional levels and management / assessment is at the national, EMU or individual river level as set out in the Eel Management Plans.

The EU Member States (MS) have used an extensive variety of methods to determine stock indicators to meet both national and international obligations, with only little coordination or standardization among MS. This means that full international standardization (facilitating Community support) may need to be more flexible than for traditional marine fisheries, although there might be scope for a general move to more standardized approaches, which might aid quality control in the future. The standardization and coordination of the data collection, analysis and reporting would unequivocally facilitate post-evaluation of the EMUs, and will provide for more cost-effective data collection and analysis (ICES, 2013a). In addition, an appropriate eel whole-stock assessment, could only be achieved if all the eel-producing habitats (rivers, lakes, transitional and coastal waters) are taking into account. Thus, to achieve a population-wide, international assessment it is necessary to try to standardize the assessment method as much as possible, taking into account the data available in the various countries, such an approach is outlined in Section 7.3. The first step is to analyse what information is available in each of the eel producing countries and based on this compilation we can explore the options for a common methodology for assessment.

7.2 Available information in eel producing countries

Four tables have been designed to analyse the available information in eel producing countries: two of them dealing with commercial and recreational fisheries respectively, one regarding the information compiled in the EU surveys, and one referring to national surveys. The aim of these tables was to have a general idea of the available information, so the parameters have been grouped in general categories and are much less detailed than in other sections of the present report. A colour code has been established to determine the level of data available per EMU at the country level in those countries having a management plan, or per Country in those not having a plan (Table 7.1). The table has been fulfilled taking into account the expert knowledge of the country representatives in the meeting in the case of Norway, Sweden, Latvia, Lithuania, Poland, Germany, Denmark, Netherlands, Belgium, Ireland, United Kingdom, France, Spain, Portugal, Italy, Montenegro, Albania, Greece, Turkey, Tunisia. Information from Malta, Slovenia, Croatia, Egypt and Algeria has been recorded from the GFCM Background technical document on eel fisheries and aquaculture in the Mediterranean Sea (under revision). No information has been obtained for Finland, Estonia, Russia, Luxemburg, Slovenia, Bosnia-Herzegovina, Cyprus, Lebanon, Israel, Libya and Morocco.

The exploited stages change depending on the Country, and fisheries has been forbidden in some Countries following implementation of EMPs (Table 7.2). Among glass eel fishing countries, data regarding capacity, effort and landings exists in France, Portugal, United Kingdom and Italy, whereas in Spain only catch information is collected in all the EMUs. In those countries with an existing EMP, within the EC Eel Regulation, yellow and silver eel fisheries are widely distributed. In the rest of the Mediterranean countries, except from Tunisia which compiles data regarding effort and catches and landings, the only available fishery data relate to catches and landings.

In European countries with an existing EMP, recreational fishery capacity and catches and landings data are documented, except from United Kingdom and Spain (Table 7.3). But among the countries reporting data, Denmark, Germany and Belgium do not collect effort data. Only Lebanon records fishery data in the case of the Mediterranean countries without an existing EMP within the remit of the EC Eel Regulation (European Commission, 2007).

Most of the EU countries record WFD data and are able to determine eel abundance using these surveys (Table 7.4) even if this abundance might be underestimated in most of the cases because few of them have eel specific surveys. In the same way, except from Spain, all the countries having commercial fisheries have implemented DCF and record biological data within this framework. However, most of the countries where recreational fishery is performed have not implemented DCF. Though most countries have collected DCF data for commercial fishery, there are concerns that it does not meet the requirements for eel. Conventional marine fisheries management is built upon regionally coordinated data collection programmes feeding into a stock-specific assessment. Given the substantial convergence in methodologies across the ICES assessed stocks (mostly age-based cohort assessments to reconstruct populations based on catches, with a subordinate role for standing stock surveys of juveniles for assessment tuning only), this allows for a substantial standardization in data collection programmes, as in the current DCF Regulation. For eel the situation is much more complex, and the standardized approach applied to marine species is inappropriate.

The WKESDCF Workshop (ICES, 2012a) reviewed brief overviews of the data collection programmes for eel currently implemented under the DCF and the problems and concerns identified by those Member States represented at the meeting. It was evident that Member States had adopted very different approaches to meeting the requirements of the DCF, further highlighting the ambiguities in the current measures relating to diadromous species. Some Member States had collected no information because they believed (rightly or wrongly) that the measures did not apply to diadromous species in their waters; others had collected only the data specified in Commission Decision 2010/93, using data in assessments, but not all equally efficient or not on an annual basis; and others had developed pilot studies to cover a wide range of sampling required to address national and international obligations for assessments. Workshop participants identified examples of the problems that they had encountered with the current data collection requirements for diadromous species; these included:

- Inadequate geographical coverage;
- Incompatibility of the requirements with the wide range of fishing methods employed;
- Requirements are based on fisheries and not local river conditions (i.e. each river basin, and part, is subject to different recruitment patterns and human pressures leasing to localised differences in stock structures);
- Reduction or closure of fisheries removes the requirement to collect data;
- No fisheries-independent data collection requirement, especially in the absence of fisheries;
- No requirement to collect recruitment data;

- Inappropriate requirements for age analysis;
- No data collection on non-fisheries anthropogenic factors affecting stocks;
- Bycatch sampling is of limited use and value;
- Maturity data are not required for assessment.

It is hoped that some of these concerns can be addressed as part of the next revision of the DCF (formerly known as EU-MAP).

There are large differences in the information recorded in national surveys among the eel producing countries (Table 7.5). Those countries without an EMP don´t compile data regarding recruitment or anthropogenic mortality but, they do have some population surveys and data regarding some biological parameters.

Even the countries that already have an EMP (those in the EU), have a very different level of information. Recruitment data are mainly collected in southern EU countries, and these countries also have some information on populations, but some of them use Eel specific electrofishing surveys, while others use other kinds of passive sampling methods. Most of the EU countries collect some information that allows them to estimate escapement. Even if it is not collected routinely, almost all the EU countries have some information regarding biological parameters; but data regarding natural mortality are lacking in most cases. Some non-fishery anthropogenic mortality data are collected, many countries have data on hydropower mortality; some of them have data concerning barriers, intakes (water diversion structures) and predation. However, in the case of predation many countries consider this mortality as natural.

In summary, most of the countries within the eel distribution range have some data regarding fisheries, but many of them, especially the non-EU Mediterranean countries, lack scientific (fishery-independent) eel specific surveys. The EU countries compile information within the WFD and DCF directives, but these data are 1) not available in the non-EU countries, though some operate a similar programme, and 2) the data recorded in the DCF have been shown not to be useful for stock assessment purposes. Therefore, taking into account the common available information, a standardized approach should be based on yellow eel density; preferable from surveys, such as those within the WFD, and if this is not available, from fisheries data (though these data are generally in the form of cpue and will need to be converted to density estimates).

7.3 Standardized approach

One set of data that is common among most countries within the eel's natural range is that collected as part of the Water Framework Directive (WFD) program (Table 7.4). It consists in most cases of multispecies electric fishing assessments, distributed over a catchment. These data have the potential to be converted into yellow eel standing stock estimates for a catchment / RBD / EMU, using current models (EDA, SMEP II: see Chapter 5). From the yellow eel standing stock estimate, it is possible to estimate silver eel escapement based on maturation schedule (Bevacqua *et al.*, 2006), eye index (Pankhurst, 1982), colour measurements using a spectrophotometer (Durif *et al.*, 2009a) and /or a combination of methods (Acou *et al.*, 2005; Durif *et al.*, 2009b) (reviewed in Section 4.4 of WGEEL, 2010).

WFD is focused on assessing the status if fish populations in fresh and transitional water, it has the advantage in that it is collected throughout the EU countries and the disadvantage that similar data are not collected (currently) in the non-EU countries.

In relation to eel there are also some limitations of the data:

1) In some countries eel does not contribute to the metric for assessing good ecological status (GES) for fish and thus eel are not assessed quantitatively as part of the program.
2) Sampling is undertaken on a 3- and sometime 6-year rolling program so annual assessments would not be available.
3) It is a multispecies method and so may underestimate the eel component in the population, but can be address through calibration of the technique (Baldwin and Aprahamian, 2012).
4) Quantitative assessments for eel are mainly confined to rivers that can be sampled using electric fishing, in most cases this means that the eel populations in lakes, large rivers, transitional and coastal waters have not been quantitatively assessed and for these habitats the riverine estimates of silver eel production are used as proxies for these water bodies. However, these habitats are most effectively sampled using passive gears with catches expressed in terms of catch per unit of effort (cpue). In order to use such data in the assessment there is a need to be able to convert the cpue estimate into a density estimate, this would then allow the data to be integrated with that collected using electric fishing and analysed in a similar way to that collected for WFD for non-riverine habitats or non EU countries (Figure 7.1).

Though there are limitations to the dataset, it is a near universal set of data collected in a near standard way available throughout much of the eel's distribution range. Its spatial coverage may be limited as in most cases it is confined to those areas which can be effectively sampled using electric fishing and would need to be expanded to cover lakes, large section of river and transitional waters, especially as the latter habitats represent the majority of the wetted area in an EMU. There is the limitation that a complete assessment, using all the data, for an EMU would only be possible on a three year (possibly six year) basis, this does not prevent partial annual assessments within the EMU, and may be just as valid. For those countries where eel does not contribute to the metric for the assessment of GES and therefore may not be quantitatively sampled, it may be possible to alter protocols to include eel. It is important to note that the suggestion for a standardized approach is based on the yellow eel component of the stock, the WFD database is one source of such data, there may be others, but to convert yellow eel density data into silver eel escapement the same procedure, outlined in Figure 7.1, would still need to be followed.

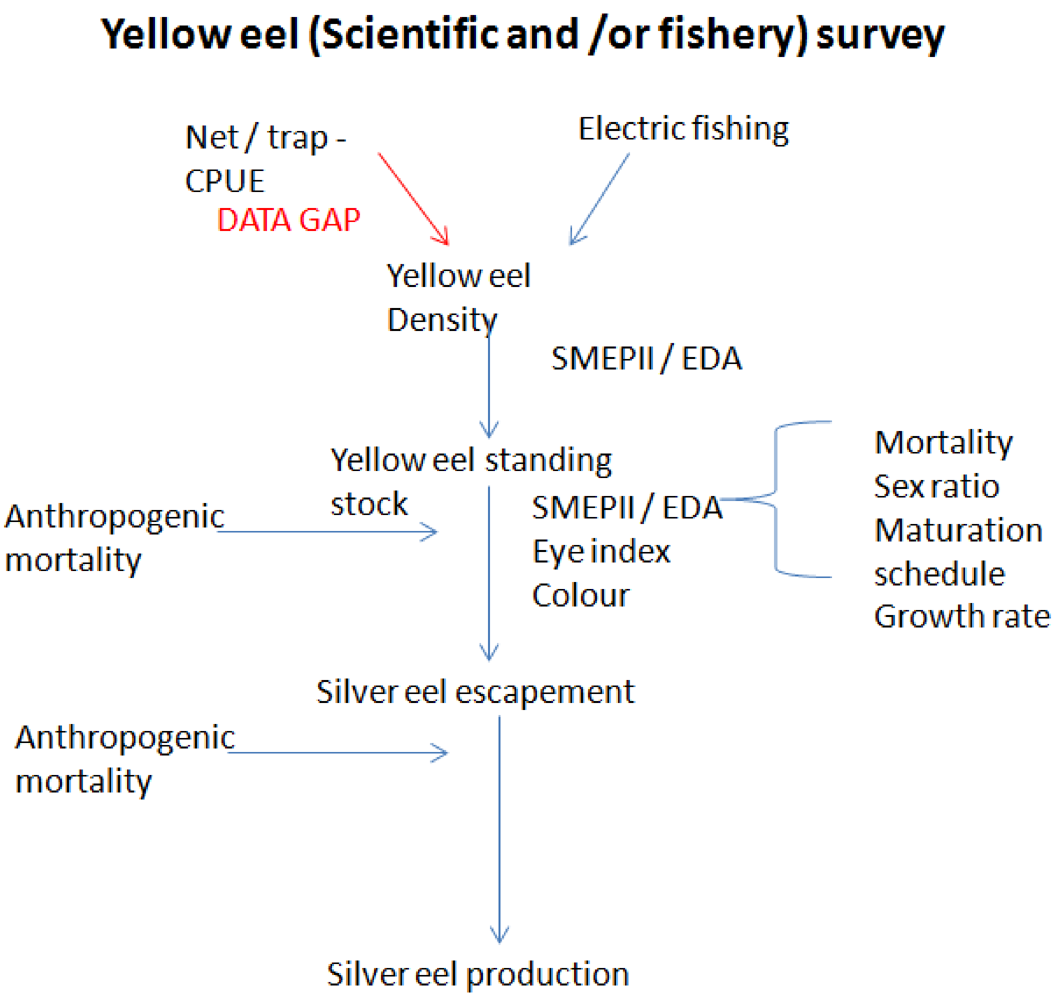


Figure 7.1. Flow diagram showing how yellow eel data collected as part of the WFD program and from other sources can be used to estimate silver eel escapement.

For such an approach there is a need to:

1) Undertake a study to convert cpue data to density data across a variety of habitats, some work in this area, is currently underway in Ireland and, will start in France in 2015, but is needed to be undertaken in a wider range of habitats and countries. Associated with this is a need to standardize on the measurement of wetted area. Analysis in 2010 of the use of wetted area models for estimating silver eel production revealed a lack of consistency within and between countries on how production area is determined and reported. The types of habitat considered in these estimates varied between EMUs and countries and differences were found in the estimates areas and these created uncertainty for stock assessment at the international level. A consistent approach, including all types of natural eel habitat is necessary, and may require more data collection to inform this process (ICES, 2010b).

2) Validate the models (EDA, SMEP II) and other approaches outlined in WGEEL (ICES, 2010b) to estimate silver eel escapement. A preliminary comparison has been made between the predictions by the silvering model (Bevacqua *et al.*, 2006) and the number of silver eels as determined by the

silver index (Durif *et al.*, 2009b). The dataset used for the validation was different from that used to develop the model. The test data consisted of lengths of 1102 eels (male and female at different stages) collected in France in different types of water habitats. The predicted number of silver eels was very close to what the silver index determined (Figure 7.2). In the dataset 13% of the eels at were the pre-silver stage and 35% at the silver stage; the model predicted that 41% of the eels were silver. This value is intermediate between the estimate of strictly silver eels and a broader estimate which would encompass pre-silver eels. Figure 7.3 shows that the model behaves very well in the >600 mm, length classes with less than 3% difference with the index estimations. The main difference occurs in the 500 mm length class (6% difference).

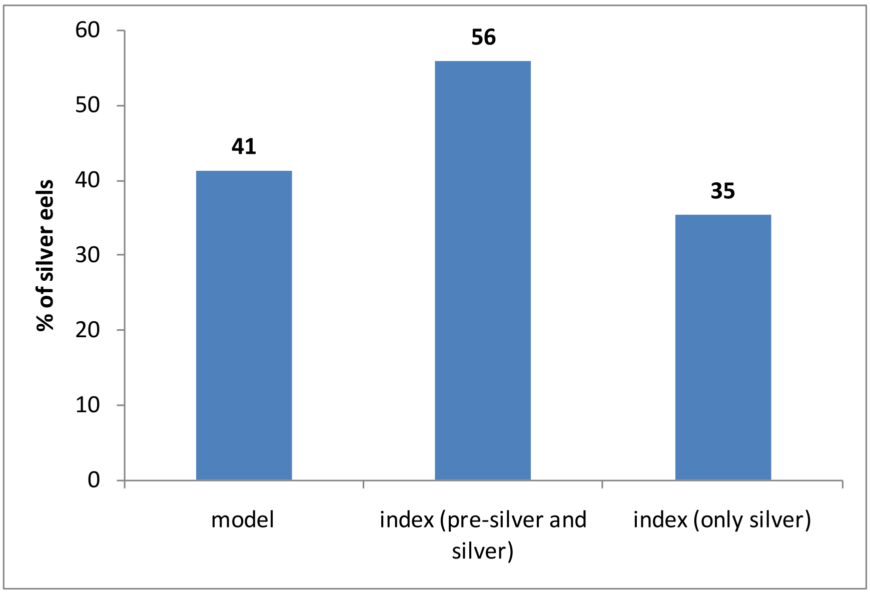


Figure 7.2. Percentages of silver eels (blue: as determined using the silver index; green: as predicted according to the silvering rate model) according to each size class.

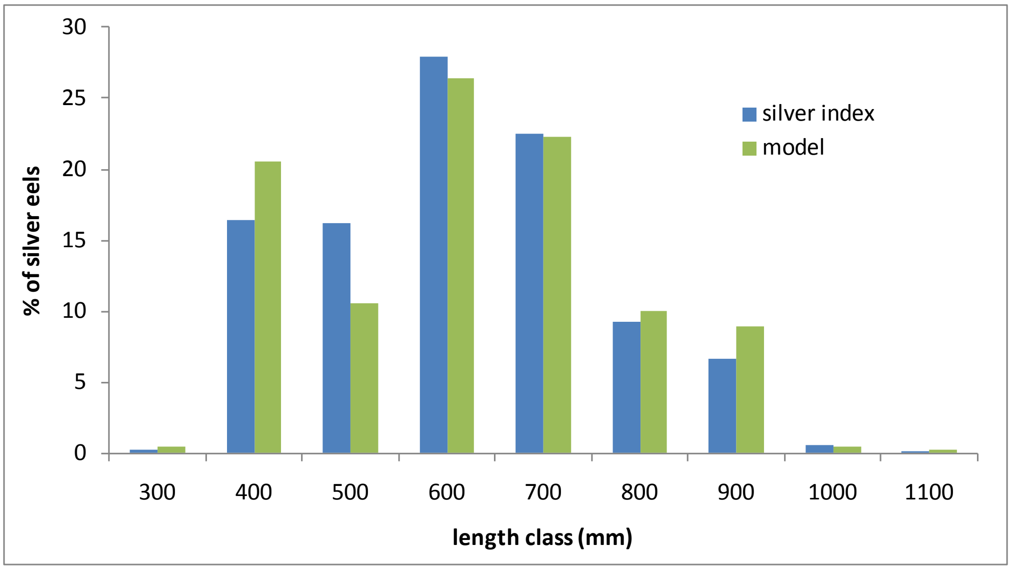


Figure 7.3. Percentages of silver eels (blue: as determined using the silver index; green: as predicted according to the silvering rate model) according to each size class.

3) Spatially model life-history traits (growth, mortality, maturation schedule, sex ratio) in order to transport parameters from data-rich to data-poor EMUs. As an example data have been collected on the age and size of silver eel across their natural range. The mean length of female eel increased significantly with latitude ($p < 0.01$), from 575 to 697 mm between 37–70° latitude, explaining 4% of the variability (Figure 7.4). There was no relationship between male size and latitude remaining constant at between 290–470 mm (Figure 7.4).

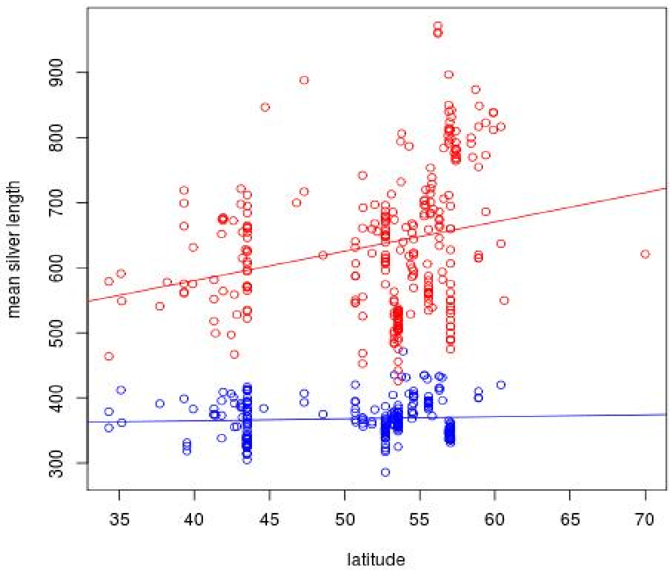


Figure 7.4. Mean length of silver eel in relation to latitude; female (red), male (blue).

Age at silvering, increased significantly with latitude for males and females (Figure 7.5). Average growth rate decreased significantly with latitude for female and male eel (Figure 7.6).

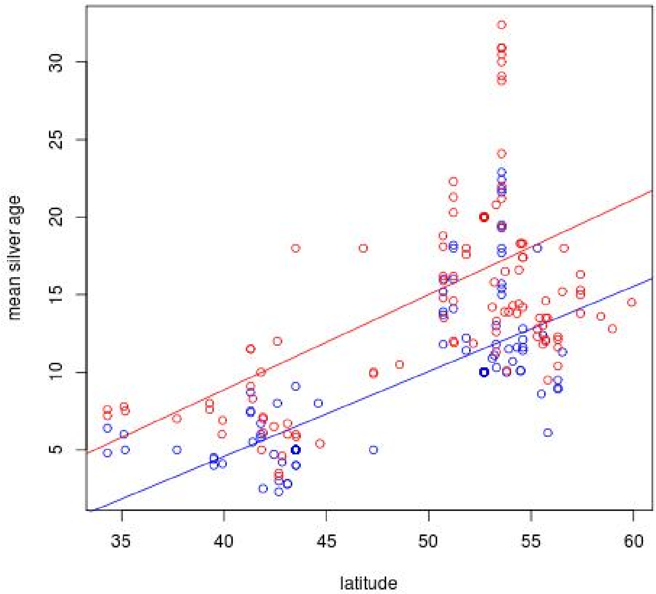


Figure 7.5. Mean age of silver eel in relation to latitude; female (red), male (blue).

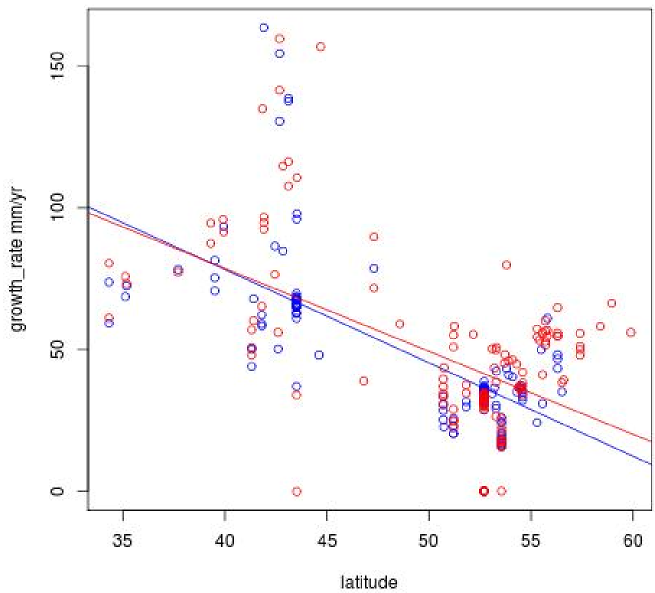


Figure 7.6. Mean growth rate of eel in relation to latitude; female (red), male (blue).

An Analysis of Covariance (ANCOVA) model incorporating latitude, longitude, year and habitat explained 35% and 62% of the variability in length and age of males at silvering, respectively, and 33% and 65% of the variability in length and age of females at silvering, respectively ($p < 0.01$).

4) Combine the impacts of anthropogenic (fisheries, hydropower, water diversion structures, barriers, predation etc.) mortality together with the assessment of silver eel escapement to estimate overall silver eel production.

7.4 Recommendations

It is recommended that a program of research be undertaken with the aim of standardising/ cross calibrating the assessment methods used to estimate silver eel escapement from yellow eel abundance data, with the following objectives:

1) Validate the models (EDA, SMEPII and others) and other approaches outlined in WGEEL (2010) that are used to estimate silver eel escapement from yellow eel abundance data.

2) Cross calibrate yellow eel catch per unit of effort (cpue) with density data across a variety of habitats (rivers, lakes, transitional water and coastal waters).

3) Develop a consistent approach to measuring wetted area across all types of natural eel habitat.

4) Spatially model the life-history traits currently used in the models (growth, mortality, maturation schedule, sex ratio) in order to transport parameters from data-rich to data-poor EMUs.

5) Combine the impacts of anthropogenic (fisheries, hydropower, water diversion structures, barriers, predation etc.) mortality into the overall assessment of silver eel escapement.

7.5 Tables

Table 7.1: Coding used to classify data availability.

NP	NP: “Not Pertinent”, where the question asked does not apply to the individual case (for example where catch data are absent as there is no fishery or where a habitat type does not exist in an EMU).
(green)	Parameter compiled in 100% of the EMUs or country area
(yellow)	Parameter compiled in >50% of the EMUs or country area
(orange)	Parameter compiled in <50% of the EMUs or country area
(red)	This parameter is not compiled

Table 7.2. Available commercial fishery data by country (blanks mean no information was available).

	Capacity			Effort			Catches & Landings		
	Glass	Yellow	Silver	Glass	Yellow	Silver	Glass	Yellow	Silver
NO	NP	NP	NP	NP	NP	NP	NP	NP	NP
SE	NP			NP			NP		
FI									
EE									
LV	NP			NP			NP		
LT	NP			NP			NP		
RU									
PL	NP			NP			NP		
DE	NP			NP			NP		
DK	NP			NP			NP		
NL	NP			NP			NP		
BE	NP	NP	NP	NP	NP	NP	NP	NP	NP
LU	NP								
IE	NP	NP	NP	NP	NP	NP	NP	NP	NP
UK									
FR									
ES									
PT			NP			NP			NP
IT									
MT	NP	NP	NP	NP	NP	NP	NP	NP	NP
SI	NP	NP	NP	NP	NP	NP	NP	NP	NP
HR	NP			NP			NP		
BA									
ME	NP			NP			NP		
AL	NP	NP		NP	NP		NP	NP	
GR	NP	NP		NP	NP		NP	NP	
TR	NP			NP			NP		
CY	NP	NP	NP	NP	NP	NP	NP	NP	NP
SY									
LB	NP			NP			NP		NP

	Capacity			Effort			Catches & Land-ings		
	Glass	Yellow	Silver	Glass	Yellow	Silver	Glass	Yellow	Silver
IL									
EG	NP			NP			NP		
LY									
TN	NP			NP			NP		
DZ	NP			NP			NP		
MA									

Table 7.3. Available recreational fishery data per by Country (blanks mean no information was available).

	Capacity			Effort			Catches & Landings		
	Glass	Yellow	Silver	Glass	Yellow	Silver	Glass	Yellow	Silver
NO	NP	NP	NP	NP	NP	NP	NP	NP	NP
SE	NP	NP	NP	NP	NP	NP	NP	NP	NP
FI									
EE									
LV	NP			NP			NP		
LT	NP			NP			NP		
RU									
PL	NP		NP	NP		NP	NP		NP
DE	NP			NP			NP		
DK	NP			NP			NP		
NL	NP			NP			NP		
BE	NP			NP			NP		
LU									
IE	NP	NP	NP	NP	NP	NP	NP	NP	NP
UK	NP			NP			NP		
FR	NP		NP	NP		NP	NP		NP
ES									
PT	NP	NP	NP	NP	NP	NP	NP	NP	NP
IT									

	Capacity			Effort			Catches & Landings		
	Glass	Yellow	Silver	Glass	Yellow	Silver	Glass	Yellow	Silver
MT									
SI									
HR									
BA									
ME	NP			NP			NP		
AL	NP	NP	NP	NP	NP	NP	NP	NP	NP
GR	NP	NP	NP	NP	NP	NP	NP	NP	NP
TR	NP			NP			NP		
CY	NP	NP	NP	NP	NP	NP	NP	NP	NP
SY									
LB	NP			NP			NP		
IL									
EG									
LY									
TN	NP	NP	NP	NP	NP	NP	NP	NP	NP
DZ									
MA									

Table 7.4. Information recorded in the EU monitoring programs by Country.

	WFD					DCF Commercial									DCF Recreational								
	Y/N	Multiple passes	Eel specific	Abundance	Biometrics	Y/N	Glass eel surveys	Yellow surveys	Silver surveys	Length	Weight	Age	Parasites	Sex	Y/N	Glass eel surveys	Yellow surveys	Silver surveys	Length	Weight	Age	Parasites	Sex
NO	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP
SE							NP									NP							
FI																							
EE																							
LV																NP							
LT																NP							
RU																							
PL															NP	NP	NP	NP	NP	NP	NP	NP	NP
DE							NP									NP							
DK																							
NL																NP							
BE						NP	NP	NP	NP	NP	NP	NP	NP	NP									
LU																							

	WFD					DCF Commercial									DCF Recreational								
	Y/N	Multiple passes	Eel specific	Abundance	Biometrics	Y/N	Glass eel surveys	Yellow surveys	Silver surveys	Length	Weight	Age	Parasites	Sex	Y/N	Glass eel surveys	Yellow surveys	Silver surveys	Length	Weight	Age	Parasites	Sex
IE						NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP
UK																							
FR																							
ES																							
PT																							
IT																							
MT																							
SI	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP
HR	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP
BA	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP
ME	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP
AL	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP
GR							NP	NP							NP	NP	NP	NP	NP	NP	NP	NP	NP
TR	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP

	WFD					DCF Commercial									DCF Recreational								
	Y/N	Multiple passes	Eel specific	Abundance	Biometrics	Y/N	Glass eel surveys	Yellow surveys	Silver surveys	Length	Weight	Age	Parasites	Sex	Y/N	Glass eel surveys	Yellow surveys	Silver surveys	Length	Weight	Age	Parasites	Sex
CY																							
SY	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP
LB	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP
IL	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP
EG	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP
LY	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP
TN	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP
DZ	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP
MA	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP

Table 7.5. Information recorded in national surveys per eel producing Country.

	Recruitment data								Population		Escapement				Biological parameters				Non fishery mortality			
	Glass eel				Young yellow eel																	
	Catches	CPUE	Survey	Trap	Catches	CPUE	Survey	Trap	Eel specific electrofishing surveys	Other eel specific surveys	Silver production	DIDSON	Trap	Mark-recpature	Ageing	Sex	Natural Mortality	Growth rate	Hydropower	Barriers	Intakes	Predation
NO	NP	NP			NP	NP																
SE	NP	NP			NP	NP																
FI																						
EE																						
LV																						
LT																						
RU																						
PL																						
DE	NP	NP																				
DK																						
NL	NP	NP																				NP
BE																						
Lu																						

	Recruitment data								Population		Escapement				Biological parameters				Non fishery mortality			
	Glass eel				Young yellow eel																	
	Catches	CPUE	Survey	Trap	Catches	CPUE	Survey	Trap	Eel specific electrofishing surveys	Other eel specific surveys	Silver production	DIDSON	Trap	Mark-recpature	Ageing	Sex	Natural Mortality	Growth rate	Hydropower	Barriers	Intakes	Predation
IE	NP	NP																			NP	NP
UK																						NP
FR																						
ES																						
PT																			NP	NP	NP	
IT																						
MT																						
SI																						
HR																						
BA																						
ME																						
AL																						
GR	NP	NP																	NP		NP	NP
TR	NP	NP																				

	Recruitment data								Population		Escapement				Biological parameters				Non fishery mortality			
	Glass eel				Young yellow eel																	
	Catches	CPUE	Survey	Trap	Catches	CPUE	Survey	Trap	Eel specific electrofishing surveys	Other eel specific surveys	Silver production	DIDSON	Trap	Mark-recpature	Ageing	Sex	Natural Mortality	Growth rate	Hydropower	Barriers	Intakes	Predation
CY																						
SY																						
LB																						
IL																						
EG																						
LY																						
TN																						
DZ																						
MA																						

8 ToR f (ii)) ... and work with ICES DataCentre to develop a database appropriate to eel along ICES standards (and wider geography)

8.1 Introduction

Chapter 4 of this report outlines the data requirements and gaps for the different stock assessments undertaken by the working group, and at the workshop on evaluating progress of eel management plans (WKEPEMP) in 2012 (ICES, 2012a). Chapter 5 refers to the different models created by different countries to estimate production and silver eel escapement and their data requirements. The overall conclusion of these chapters is the need for the collection of eel-specific data and the efficient availability of these data to the working group from countries within the distribution range of the eel.

WGEEL 2013 (ICES, 2013) noted a critical need for the improvement in the quality and consistency of data reporting at the national and EMU level. This inconsistency in reporting affects the international stock assessments and limits our ability to provide management advice for the eel stock. Currently the working group members need to trawl through all country reports and manually extract the relevant data. This is time consuming - a digitised reporting database would ensure a more efficient use of time at the working group session. The recommendation from the WGEEL in 2013 was a standardization of data table formats for use in the country reports. The standardization tables are offered as a format which will facilitate national reporting to all international *fora* requiring eel data. The long-term objective of such standardization is to facilitate the creation of an international database of eel stock parameters.

The next step in digitising and standardising the data used by the working group is to address the storage issues for the data required annually for the stock assessments. Currently, data are stored in various spreadsheet files and databases created by members but using their institute facilities such as computer software and servers. The time taken to update and maintain these databases is done on a voluntary basis. This is not a good long-term strategy however and therefore a structured plan for storing data needs to be created, not least because of the importance of the stock assessments in the ICES advice and evaluation of the Eel Regulation.

8.2 WGEEL Stock Assessment database

There is a requirement for a reporting template and database to facilitate the ease of extracting data from the Country Reports for use in the stock assessment and data analyses undertaken by the working group.

Action plan for developing the database

- Digitise Country Reports
    - Facilitate a streamlined, standardised reporting process in EXCEL for the immediate future using the template from WGEEL 2013; with the prospect of creating a SQL or ACCESS database with remote access for data providers in the future.
    - Circulate EXCEL template to Country Report lead authors
- Facilitate Stock Assessment with a stock assessment database containing:
    - Recruitment time-series

- Research data - (to be decided in the future)
  - yellow eel / standing stock data (see Chapter 7)
  - silver eel data
- Encourage participation of all countries within the eel distribution area and ensure all databases can capture data from different regions. Use WGS1984 (latitude/longitude) geoereferencing.
  - Countries outside EU
  - ICES countries
  - GFCM countries
  - EIFAAC countries

8.3 Existing databases

It is not the aim of the task group to reinvent the wheel. There are a number of databases that have been created in the past, both within the working group and during various international projects. A discussion is required to determine how useful the data held in these databases are to the stock assessments carried out by the working group, and how to adopt those that can be used. In the following text we provide a preliminary consideration of some example databases.

8.3.1 Recruitment Index database

The recruitment index database was created at the WGEEL meeting in Rome in 2006 (ICES, 2006) and is stored on a postgres (postgis) server accessible to the members of the WGEEL. The database was initially designed to store a range of data from catches to effort. To date it has only been used to maintain the recruitment time-series. However, it has the capacity to include yellow and silver eel series. The design links a location table with three tables describing either the recruitment series or the yellow or the silver eel series, and finally to use a final table to store data (Figure 8.1).

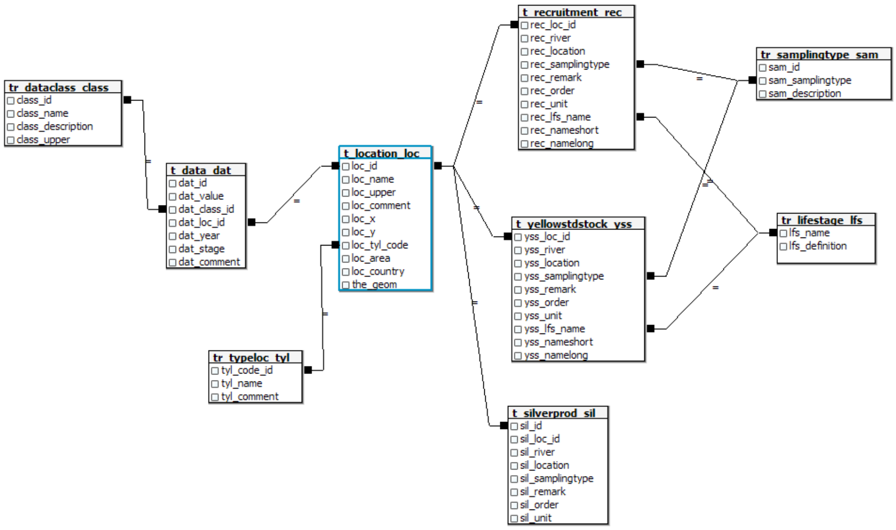


Figure 8.1. Schematic design of the eel recruitment index database.

8.3.2 EU-POSE Project-DBEEL database

The aim of the EU-POSE project (Walker *et al.*, 2013) was to provide EU eel scientists and managers with a comprehensive knowledge of the techniques most suitable for the assessment of their local eel stocks, and thereby to support the conservation and management of eel through the Eel Management Plan process. POSE developed a database structure for eel (DBEEL) in order to facilitate the collation and dissemination of data for analysis by different models (see Chapter 5).

This structure (Figure 8.2) could be adopted at the international level to support the coordinated assessment and management of eel, and the intercalibrations requiring exchanges of eel data. However, management of the database is a substantial task requiring resources, funding and quality control measures.

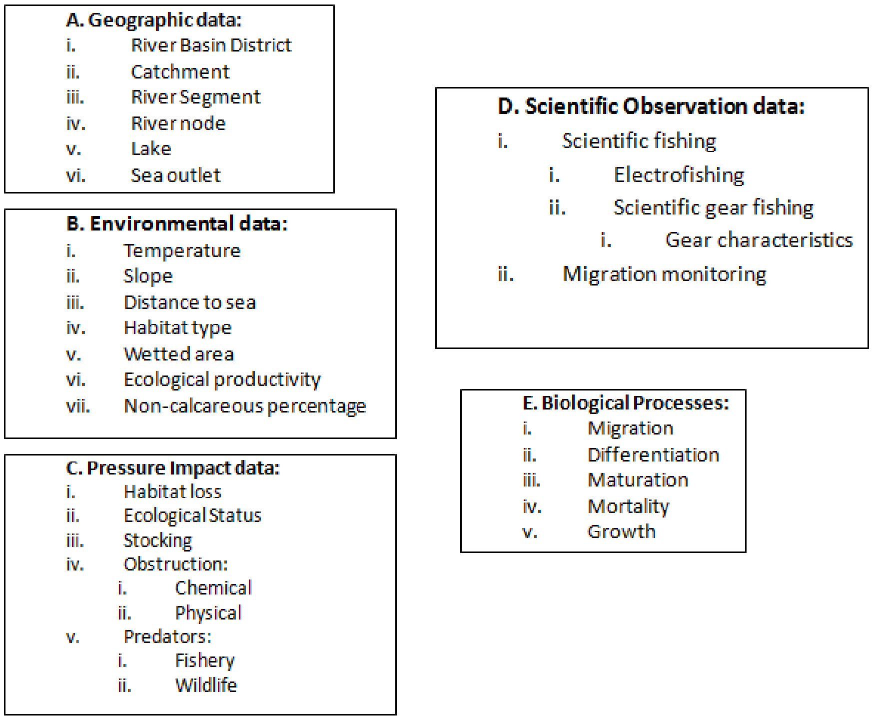


Figure 8.2. Database structure for the EU-POSE DBEEL.

8.3.3 International Eel Quality Database

In recent years WGEEL has considered the risks of reduced biological quality of (silver) eels. The reduction of the fitness of potential spawners, as a consequence of (specific) contaminants and diseases, and the potential mobilization of high loads of reprotoxic chemicals during migration, might be key factors that decrease the probability of successful migration and reproduction. An increasing amount of evidence indicates that eel quality might be an important issue in understanding the reasons for the decline of the species. An international Eel Quality Database already exists and is stored at Instituut voor Natuur- en Bosonderzoek (INBO) in Belgium. It is updated on an annual basis by the institute with the relevant data, and a new application is currently under development. The database is a compilation of eel quality data over the world, including contaminants and diseases. The new application will be a more efficient system (migrating from Excel worksheets to an Access database) and will include opportunities to include more data fields and validation mechanisms. The database has been expanded now to include all anguillid species and hence will be renamed (from EEQD (European Eel Quality Database) to EQD (Eel Quality Database)). Further development of the database is foreseen in the future.

8.3.4 Data Collection Framework

Since 2000, an EU framework for the collection and management of fisheries data has been in place. This framework was reformed last in 2008 resulting in the Data Collection Framework (DCF). Under this framework the Member States (MS) collect, manage and make available a wide range of fisheries data needed for scientific advice. The data are collected on the basis of National Programmes in which the MS indicate which data are collected, the resources they allocate for the collection and how data are collected. Member States must report annually on the implementation of their National Programmes and the Scientific, Technical and Economic Committee for Fisheries

(STECF) evaluates these Annual Reports. Part of these data collected by the MS is uploaded in databases managed by the Joint Research Centre (JRC) in response to data calls issued by DG MARE. These data are analysed by experts of the STECF and form the basis for scientific opinions and recommendations formulated in STECF reports. The resulting scientific advice is used to inform the decision making process for the Common Fisheries Policy (CFP).

If the recommendations of WKESDCF (ICES, 2012a) and various STECF meeting reports are accepted, the new DCF (formerly to be called EU-MAP) programme, when agreed, will result in the collection of biological commercial and fishery-independent data on eels that would prove useful for stock assessments by the working group in the future. The WGEEL needs to consider a data call to use these data at future working groups and a discussion should be had with STECF to create a platform for this to happen on a rolling basis.

8.4 Pros and cons for ICES DataCentre hosting an eel database

If the working group are successful in applying to the ICES DataCentre to host the database, a number of issues must be addressed:

- Can ICES DataCentre hold data from countries outside the ICES area? The working group works in collaboration with countries from ICES, GFCM and EIFAAC. The Italian Beam Trawl Survey is carried out in areas outside ICES countries but is hosted by the DataCentre so this is not anticipated to be a problem for eel data.
- The data supplied to the DataCentre are public data in agreement with the ICES data policy (http://www.ices.dk/marine-data/guidelines-and-policy/Pages/ICES-data-policy.aspx). The only exception is commercial fisheries data that is commercially sensitive information and therefore commercial data policy applies. The working group would need to get a data agreement from all data providers in relation to data publication.
    - Is there another alternative host organisation where the data remains private but has the funds and expertise required?
- Who has access to the database?
    - It is very important that the working group can easily access the data remotely, so that work can progress outside the dates of annual meetings, and when meetings occur in different countries. It has yet to be established in DataCentre access would only be available at the ICES headquarters in Copenhagen. Currently a copy of the recruitment database is stored on one of the WGEEL member's computer, and R<-> postgres interaction is easy to set up.

It is the conclusion of the working group that the best option is to work with ICES DataCentre to address the issues outlined above but that a solution may not be possible without needing an alternative host centre.

8.5 Work Plan for developing a working group database

The task of creating a standardised database for the WGEEL stock assessment cannot be done within the short time frame of the annual meeting. A work plan with tasks has been outlined below and it is the intention of the group to work on these topics over the coming year.

- Finalise additions and improvements to the stock assessment recruitment tables.
- Create Stock Assessment (Recruitment) Database Fact Sheet outlining (draft template available):
  - Role of database
  - Outline what is captured in the relational database
    - Tables
    - Fields (units)
    - Code requirements (EMU)
  - Output from database
    - Reporting requirements for WGEEL and structure, raw data/ summary data
    - Creation of output queries
    - Access to export data from database
      - Export to R.
- Create and fill metadata document for database (draft template available)
  - ICES DataCentre requires compliance with the ISO19115.
  - The metadata describes the data captured in the database, listing the owners of the data with relevant contact details. The Metadata will make it easier to retrieve, use and manage the information resource.
- Complete DataCentre Request Form.
- Liaise with datacentre in the creation of:
  - SQL database
  - User friendly interface for adding data remotely
  - Suitable/relevant output queries to assist stock assessment process at WGEEL
  - Remote access to raw data for stock assessment at WGEEL and other eel workshops created in the future
  - Maintenance programme
    - Request forms for changes/additions to columns in tables
    - Request forms for additional fields within a column
    - Arrangement in place to add tables to database for other life stages should additional stock assessment analysis be created.
- Once a database template and interface have been designed by ICES. The working group will need to create a document for users on how to fill in the form.
- Other: liaise with ICES over the long-term storage of data files created at working groups.
  - What happens to files on SharePoint after a number of years; are they archived or deleted?

8.6 Conclusion

It is proposed that all country report authors will adopt the digital template created in WGEEL 2013, to ensure the efficient operation of the working group. This efficient handling and processing of data has been recommended in several previous reports (including ICES, 2001; ICES, 2010a, ICES, 2013b). Concerted action is required in 2015 by key members of the working group in cooperation with the ICES DataCentre, to ensure these recommendations are not reiterated next year.

9 ToR g) Provide guidance on management measures that can be applied to both EU and non-EU waters

9.1 Introduction

The information in this chapter will be important in guiding new participants to WGEEL and non-EU countries as to the possible management options that could be applied in their regions and to considerations of future post-evaluations of EU eel management plans, and of other management plans outside of the EU.

It should be noted that there is some disparity among Member States regarding the degree of realisation of these measures: some Members States appear to be implementing the foreseen measures according to their schedule, while others are lagging behind. However in the following analysis, the apparent absence of management measures of a particular type does not necessarily indicate a lack of appropriate action, since, for example, a country that has never had a commercial fishery could not be expected to take management measures to control one.

During the creation of the Eel Regulation in 2007 the Council of the European Union noted that in relation to eel there are diverse conditions and needs throughout the Community which will require different specific solutions. That diversity should be taken into account in the planning and execution of management measures to ensure protection and sustainable use of the eel population. In order to ensure that their eel recovery measures were effective and equitable, it was necessary that Member States identified the measures they intended to take and the areas to be covered, that this information be communicated widely and that the effectiveness of the measures be evaluated.

To that effect Articles 2(8) & 2(10) of the 2007 Eel Regulation 1100/2007 state that:

(8) An Eel Management Plan may contain but is not limited to, the following measures:

- Reducing commercial fishing activity.
- Restricting recreational fishing.
- Restocking measures.
- Structural measures to make rivers passable and improve river habitats, together with other environmental measures.
- Transportation of silver eel from inland waters to waters from which they can escape freely to the Sargasso Sea.
- Combating predators.*
- Temporary switching off hydro-electric power turbines.
- Measures related to aquaculture.

(10) In the Eel Management Plan, each Member State shall implement appropriate measures as soon as possible to reduce the eel mortality caused by factors outside the fishery, including hydroelectric turbines, pumps or predators, unless this is not necessary to attain the objective of the plan.

*Given that the ToR for this section related only to anthropogenic impacts, management actions undertaken or proposed in relation to *Combating Predators* were not included.

9.2 Analysis of Management Measures reported

Differing management structures within the EU mean that EMPs and assessment procedures vary between Member States. Information and data relating to management measures were obtained from ICES WKEPEMP report (ICES, 2013a), previous ICES Reports and the Country Reports to the WGEEL from 2013 & 2014, with the list of Countries included in the analysis derived from Table 10.3 of the WGEEL 2013 report (ICES, 2013b).

A total of 1362 individual management actions were reported from the 81 EMUs established by Member States for the implementation of their EMPs, the precise details of which can be found in ICES (2013a).

Given the volume of management measures adopted across the EU, it was decided for the purposes of this report to filter the available data under the classification of management actions listed in ICES WKEPEMP (ICES, 2013a), which were:

- Commercial fishery
- Recreational fishery
- Hydropower and obstacles
- Habitat improvement
- Stocking
- Others

Management actions aimed at control of commercial and/or recreational fisheries were the most commonly adopted, with slightly fewer measures addressing hydropower and obstacles to eel movements, and fewer still implementing habitat improvement or stocking measures (Figure 9.1).

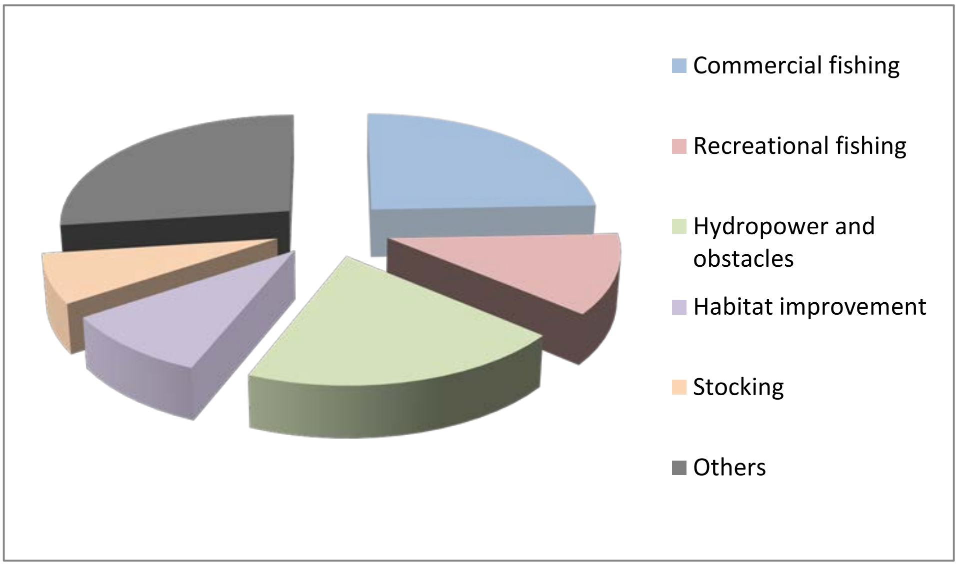


Figure 9.1. The proportion of management actions of various categories implemented in EMPs across the EU.

9.2.1 Aquaculture

Though listed in the Eel Regulation as a possible feature of management measures no Member States reported any direct actions related to aquaculture.

9.2.2 Fisheries

9.2.2.1 Commercial fishery

Across the EU, 17 countries have adopted management measures to reduce the impact of commercial and recreational fishing on the eel stock (Figures 9.2 and 9.3). Despite the large variety of measures proposed by each country, they are in general devoted to reducing fishing effort, size limit, and to implementing national registers for catches. In the majority of cases such actions were driven by:

- improvements in fishery administration systems;
- the introduction or extension of closed seasons;
- a reduction in fishing effort..

The diversity of commercial fishery management measures was large but the variation within these different categories was even larger, ranging from the prohibition of specific fishing gears such as fykenets in a particular fishing area, to a total ban of commercial eel fisheries (e.g. Norway and Ireland).

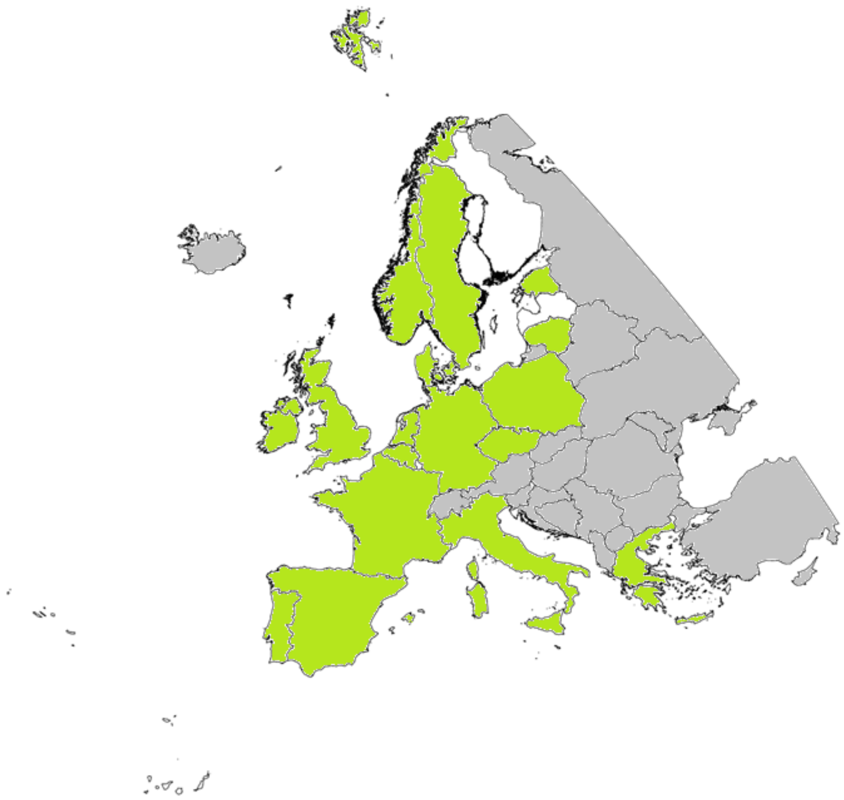


Figure 9.2. EU and non-EU countries adopting management measures affecting commercial eel fisheries: green = measures either in place or intended; white = no known measures; grey= no data. (Distribution of countries taking measures remains the same, for all life stages of eel).

9.2.2.2 Recreational fishery

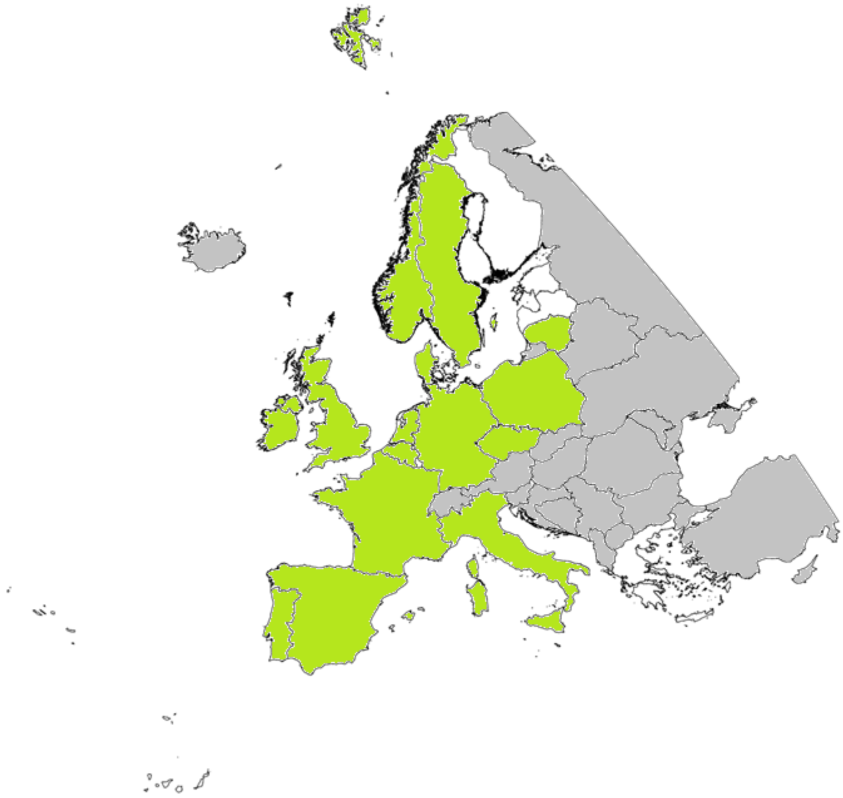


Figure 9.3. EU and non-EU countries adopting management measures affecting recreational fishing for eel: green = measures either in place or intended; white = no known measures; grey= no data.

The management measures adopted to reduce the impact of recreational fishing on eel populations covered a wide range of actions, similar in many ways to those used in the commercial fisheries, and included:

- a complete ban on targeting or capturing eel;
- restricting the fishery at certain periods or life stages (e.g. implementing closed seasons);
- introducing a quota to reduce the numbers caught;
- adjusting gears and hours of fishing thereby reducing their efficiency;
- regulating the fisheries by implementing systems to report catches;
- increase minimum size limit.

9.2.3 Hydroelectric turbines, pumps and obstacles

The impact of hydroelectric turbines and proposed mitigation measures to aid eel movements were the subject of previous reviews by WGEEL (ICES, 2004; 2008). Extensive reviews focusing on eel passage were produced by the UK Environment Agency as part of their *Eel Manual* in 2011;

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/297341/geho0411btqb-e-e.pdf eel passage

EMP measures that are intended to mitigate for the problems caused by hydropower, pumps and obstacles are detailed in Country Reports and their distribution across the EU is illustrated in Figure 9.4.

It should be noted that whilst coverage of these measures looks widespread across Member States, many of the measures proposed in national or EMU eel management plans have not yet been implemented or are only partially implemented. All continental life-history stages of eel can be adversely affected by these type of migratory impasses. Juvenile eels (glass eel and small yellow eels) may be obstructed in their upstream migrations. Silver eels, and large yellow eels in some locations, can be delayed in downstream migration due to river discharge regulation and they are likely to experience significant mortality rates associated with passage downstream through power generation facilities. Such mortalities, and non-fatal injuries, can result from either impingement at turbine intake screens or following entrainment and passage through turbines. Similar adverse effects on eels can occur at pumping stations, though generally EMP measures do not specifically address these. However, many of the hydropower mitigation measures are also relevant to problems associated with pumping stations and other anthropogenic obstacles impeding riverine eel migrations.

Facilitation of natural upstream migration in hydropower impacted eel populations has been proposed by eight countries in respect of glass eel and nine countries in respect of small yellow eel. This involves either removal of barriers or installation of appropriate eel pass structures. Likewise, removal of obstacles and/or provision of eel pass facilities has been proposed by nine countries for larger yellow eels and by five countries for silver eel migrating downstream.

Management measures involving hydropower plant operational protocols or design features are proposed measures in eleven Member States, though the specific details are unclear or are subject to future technology advances. A short to medium-term measure included in the EMPs for several countries is the trapping of silver eels upstream of hydropower dams for release downstream. This measure also provides income for eel fishermen affected by EMP restrictions on commercial eel capture as their skills are re-employed in such conservation fisheries. Research and surveys to document the impact of hydropower on eel populations of individual EMUs have been proposed by seven countries and a number of others listed a small number of "other" related measures that appear to be of limited applicability to EMPs elsewhere.

Figure 9.4. EU and non-EU countries adopting management measures relating to hydropower and obstacles: green = measures either in place or intended; white = no known measures; grey= no data.

9.2.4 Habitat improvement

Measures categorised as habitat improvement in the ICES WKEPEMP report (2013a) and the Country Reports to the WGEEL in 2014 (see Annex 10) were reported by only six Member States. The specific measures taken comprise a variety of actions that are often somewhat vague in nature, ranging from those broadly relating to increasing habitat connectivity, and water quality improvement, to the adoption of protected areas, and the benefit to the eel as a consequence of the application of the Water Framework Directive. Broad similarity of measures between countries cannot be assumed. The distribution of habitat improvement measures by country affecting all eel life stages is shown in Figure 9.5. Maps for individual life stages are identical, since habitat improvement measures generally have wide ranging impacts that affect all life stages.

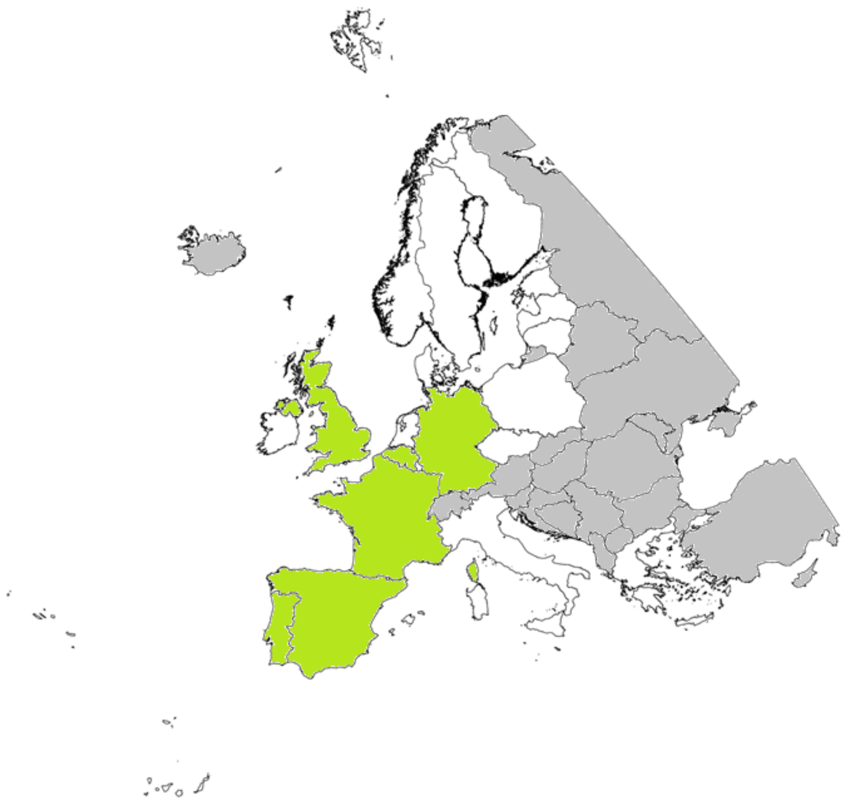


Figure 9.5. Management measures related to Habitat Improvement taken by country affecting all eel life stages: green = measures either in place or intended; white = no known measures; grey= no data.

9.2.5 Stocking

In 2008, prior to the inception of EMPs in 2009, twelve countries proposed the use of stocking in their management plans to enhance eel populations. In 2013, stocking of glass eel was undertaken in 16 Member States (Figure 9.6). Whilst stocking is a measure featuring in virtually all of the EMPs for which there are data, only six achieved their EMP stocking target. Most EMUs have partially reached their targets and a few have yet to implement the action (ICES, 2013a).

The most common reason given for a country being unable to achieve its stocking target was a lack of funding to buy glass eel. The impact of holding and maintenance-feeding of elvers in aquaculture needs to be addressed with regard to their potential adaptation to culture conditions which are subsequently deleterious when stocked out, as known from other fish species like salmon and trout.

Given the unknown nature of some of the eel pathogens in the wild, biosecurity must be of highest priority in any transport/translocation or eel culture system. All equipment, vehicles, tanks, personnel and clothing must be thoroughly disinfected before and after any contact with eels and critical control points should be established at all rearing/holding facilities. Stocking with on grown young yellow eel carries the risk of spreading disease, reduced genetic fitness and skewed sex ratios, while the stocking of wild-caught young yellow eels from clean donor sites may be deleterious if they are stocked in contaminated recipient sites (Walker *et al.*, 2009).

Concerns about current eel stocking practices have been expressed and its effective contribution to ensure increased silver eel production has been raised. It has been recommended that there should be a co-ordinated marking programme of stocked eel and thereby separable from wild eel in subsequent sampling.

The effects of stocking under EMPs cannot be demonstrated immediately because of the generational lag time but recent Swedish work indicates that stocked eels behave in the same way as natural recruits (ICES, 2013b).WGEEL reviewed the use of stocking as a management measure in their reports from 2010 and 2013 (ICES 2010 & 2013b).

There was almost no new evidence available to WGEEL in 2013 that was not considered by ICES WGEEL in its 2010 report and the conclusions of both are similar, i.e. that there is evidence that translocated and stocked eel can contribute to yellow and silver eel production in recipient waters, but that evidence of further contribution to actual spawning is limited (by the general lack of knowledge of the spawning of any eel).

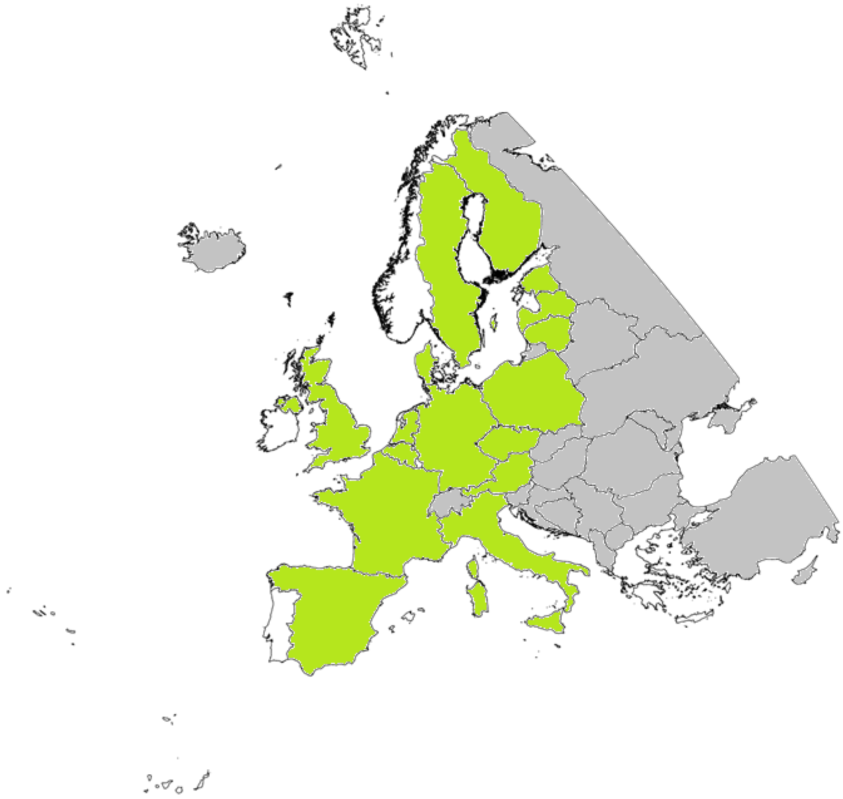


Figure 9.6. Management measures related to Stocking taken by country: green = measures either in place or intended; white = no known measures; grey= no data.

9.2.6 Other management options

Other management options listed by Member States in their EMPs and associated Reports, include a wide range of actions, none of which effectively refer strictly to managing an anthropogenic impact but mostly to other issues ranging from legal framework enhancement to monitoring and research.

Other management options essentially fall under eight main subgroups:

1) Strengthening of the framework, including:

 1.1) Reinforcement of legal framework;

- 1.2) Reinforcement of co-ordination among agencies and interested parties;
- 1.3) Dissemination, raising of awareness;
- 1.4) Stakeholders' involvement.

2) Reinforcement of fishery reporting structures, including

- 2.1) Setting up of fisheries reporting systems (other than DCF);
- 2.2) Use of import/export data to monitor commercial fisheries;
- 2.3) Use of catch/return logbooks to monitor commercial fisheries;
- 2.4) Improvement of fisheries control (enforcement);
- 2.5) Control and contrast of illegal fisheries (enforcement).

3) Reinforcement of monitoring frameworks, including

- 3.1) Catchment surveys, by fykenet or electrofishing (both multispecific or eel-specific) in defined catchments;
- 3.2) Establishment of new, or the continuation of existing recruitment monitoring, most specific for glass eel and many aiming at investigating potential new sites;
- 3.3) Assessment of sites for silver eel monitoring, the implementation of or continuation of escapement monitoring;
- 3.4) Continuation of monitoring of index rivers.

4) Assessment of efficacy of technical actions, to

- 4.1) Enhance accessibility and migration routes;
- 4.2) Reduce impacts and losses on eel populations.

5) Actions related to restocking, including

- 5.1) Identification of areas for restocking;
- 5.2) Implementation of restocking plans;
- 5.3) Investigations of contribution of stocking to the eel stock;
- 5.4) Pilot studies for restocking actions.

6) Actions related to eel quality issues and fish health, such as

- 6.1) Monitoring of *Anguillicola crassus*;
- 6.2) Investigations on pathogens and contamination;
- 6.3) Implementation of sanitary agreements specific for dealers;
- 6.4) Assurance of compliance to Fish Health Directive.

7) Inclusion of eel within specific conservation or species protection programmes.

8) Research actions, generic or specifically aimed at:

- 8.1) Development of models for the assessment of stock indicators;
- 8.2) Development of models to assess compliance with targets;

8.3) Development of indices for assessing management effectiveness;

8.4) Setting up of river or basin indexes for recruitment and escapement quantification;

8.5) Development of ecosystem-based models specific for eel;

8.6) Retrieving and analysing historical data.

Some of these actions refer specifically to eel stage, i.e. glass eel, yellow and silver eel: such is the case with specific monitoring targeting recruitment, yellow eel stock or escapement. Most of the management options listed here refer to all eel life stages because they are generic or aimed at enhancing the knowledge base or the general working framework.

9.3 Post-evaluation

In 2013, the European Commission stated that Member States have been progressively implementing more and more management measures as foreseen in their EMPs. These measures include fisheries restrictions, restocking, facilitation of upstream and downstream migration, etc. There is however some disparity among Member States regarding the degree of realisation of these measures: some Members States appear to be implementing the foreseen measures according to schedule, while others are lagging behind. Some of the most challenging measures to implement are the removal or modification of large obstacles, usually due to technical and financial constraints. The recovery plans have only been in place for several years with many having been submitted late (ranging from several months to almost two years after the deadline). Given that it will take at least 2–3 eel generations (i.e. at least ten years) before any significant trends in the stock status can be observed, it is too early to draw conclusions as to the effectiveness of these measures.

Of the 81 EMUs established by Member States for the implementation of their EMPs, progress was made in implementing management measures related to fisheries, but other anthropogenic management measures, such as improving habitats and passage, or achieving stocking targets have often been postponed or only partially implemented.

Following the 2012 EMP Reviews (ICES, 2013a) it remains difficult to assess the outcome of EMPs against the 40% escapement target set by the Eel Regulation. The scientific advice gleaned from the sources examined underlines that the effectiveness of individual management measures cannot always be demonstrated: necessary data are missing or the measures concerned are not expected to produce their effects immediately or in the short term. For instance, there is high probability that restrictions on fisheries for silver eel have contributed to increase in silver eel escapement. However, management measures targeting eels prior to the silver eel stage (e.g. stocking) are not expected to have yet contributed to increased silver eel escapement due to generational lag time (ranging from approximately five years in the Mediterranean lagoons to 25–30 years in Northern Europe). Non-fisheries measures related to hydropower, pumping stations and migration obstacles are also difficult to evaluate at this point in time, mainly due to the site specific nature of potential impacts and lack of post evaluation data.

The post-evaluation process commencing with the reporting by Member States in 2012 has been first and foremost a synchronized process of national post-evaluations. National reports have evaluated to what extent the implementation of the EMP(s) has been successful, and whether the targets have been achieved.

9.4 Conclusions

The stock in the whole distribution area is considered to constitute one single panmictic population (Palm *et al*., 2009; Als *et al*., 2011). This contrasts strongly with the scattered, small-scale pattern of the continental stock and the national/regional scale of management (Dekker, 2000; 2008). Management of the stock by uniform measures all over the EU (e.g. a common minimum legal size, a common closed season or a shared catch quotum, etc.) were not feasible or applied, since uniform measures cannot be designed in a way that would be effective all over the EU (or the wider range of the eel) due to large variations in eel life history over its natural range.

Regionalised management (a common objective and target, but local action planning, local measures and local implementation) is central to the EU Eel Regulation (Dekker, 2004; 2009) and on this basis Eel Management Plans have been developed per country/region. Few cross-boundary EMPs exist. Note, however, that the European eel range extends beyond the EU and that the management of the eel and anthropogenic impacts are necessary throughout its range. As such it is hoped that the information above will be an important and useful reference to new participants to WGEEL and non-EU countries, suggesting possible management options which could be applied in their regions and to considerations of future post-evaluations of implemented management actions.

9.5 Recommendations

We recommend a comprehensive evaluation of the effectiveness of various management measures across EU and non-EU waters facilitating the prioritisation of management actions.

Management guidelines have been produced on various topics; it is recommended that these are hosted on the EIFAAC web site, so that their specific details can be scrutinised.

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Annex 3: Meeting agenda

Sunday 2nd Nov

Meeting of task leaders in the afternoon - 15:00–18.00

Monday 3rd

08.30	Arrival
09.00–09.30	Introductions, ToR
09:30–10:00	GFCM presentation on status of eel fisheries and aquaculture in Mediterranean
10:00–10:15	Italian presentation on Eel escapement from Mediterranean la goons
	Country Report highlights (two slides, 5 minutes per Country)
10.45–11.00	Norway, Sweden, Latvia,
11.00–11.15	Lithuania, Poland, Denmark
11.15–11.30	Germany, Netherlands, Belgium
11.30–11.45	United Kingdom, Ireland, France
11.45–12.00	Spain, Portugal, Italy
12.00–12.15	Greece, Turkey, Albania
12.15–12.30	Montenegro, Bosnia & Herzegovina, Tunisia
12.30–13:30	**Lunch**
13:30–17:00	All Task Groups breakout
18:00–19:00	Sub-group/Task leaders co-ordination meeting

Tuesday 4th

08:30–09:00	Plenary
09:00–17:00	All Task Groups breakout
17:00–18:00	Sub-group/Task leaders co-ordination meeting
19.00	WGEEL dinner

Wednesday 5th

08:30–09:30	Introduction to WGEEL (Russell Poole, Ethiopia Room)
08:30–13:00	All Task Groups breakout
14.00–15.00	Plenary – Tasks to present key results
15:00–17:00	DEADLINE FOR DRAFT REPORT on SP
18:00	Circulate Report for comments

Thursday 6th

08:30–12:30	Reading draft chapters for content

13:30–17:00	Plenary - identify and discuss report issues

Friday 7th

08:30–11:00	Agree Advice drafts
11:00–17:00	Task groups Revise Chapters
17:00	Final documents on SharePoint\Report 2014\Friday 1700 Report
17:00	Close Working Group

Annex 4: WGEEL responses to the generic ToRs for Regional and Species Working Groups

The Working Group was asked, where relevant, to consider the questions posed by ICES under their generic ToRs for regional and species Working Groups. This was the first time that WGEEL had directly considered these ToRs. WGEEL responses to the generic ToR are given in the table below.

GENERIC TOR QUESTIONS	WGEEL RESPONSE
For the ecoregion:	
a) Consider ecosystem overviews where available, and propose and possibly implement incorporation of ecosystem drivers in the basis for advice.	*Anguilla anguilla* is a catadromous species and therefore occupies marine, transitional and freshwater environments during its lifecycle. The ecosystem function (role) of *Anguilla anguilla* in each of these environments is not well understood. A brief ecosystem overview will be provided in the initial WGEEL stock annex that should be developed in 2015 (see below) and environmental influences on the stock are incorporated in the annual advice and may address a wide range of factors affecting eels at different stages in their life cycle. Consideration has and will be been given to possible ecosystem drivers in both freshwater and the marine environment, but at present it is not possible to incorporate such drivers in the assessment process.
b) For the ecoregion or fisheries (suggest separate for glass, yellow, silver eel fisheries) considered by the Working Group, produce a brief report summarising for the stocks and fisheries where the item is relevant: • Mixed fisheries overview and considerations; • Species interaction effects and ecosystem drivers; • Ecosystem effects of fisheries; • Effects of regulatory changes in the assessment or projections;	i) Most eels are caught in targeted fisheries in coastal waters, transitional (brackish) and freshwater. Some mixed fisheries do occur (e.g. German freshwater fyke net fisheries). Eels may be captured as bycatch in commercial and recreational fisheries (see Chapter 2). There is limited information on number of eels captured as bycatch, or on their survival when there are regulations requiring obligatory release of eel captured in other fisheries (for instance by recreational angling). There are few data on bycatch of other species in targeted eel fisheries. ii) Species interaction effects and ecosystem drivers should be summarised in the initial stock annex proposed for 2015/2016 – see annex below. iii) The current fishery probably has little direct influence on aquatic ecosystems, with the possible exception of local bycatch issues. However, the eel is an important and frequently dominating species in the ecosystem, and its substantial reduction, whether due to fisheries or other causes may have had a more profound effect. There is limited knowledge on the magnitude of these effects. iv) In recent years, many eel fisheries have been subject to management controls and closures, with resulting reductions in exploitation rates. This has resulted in increasing sensitivity of assessment procedures to these values.

Generic ToR questions	WGEEL response
For all stocks:	
c) If no stock annex is available this should be prepared prior to the meeting, based on the previous year's assessment and forecast method used for the advice, including analytical and data-limited methods.	Countries prepare national reports annually for the working group. WGEEL has not yet drafted a stock annex to provide details of the assessment. A stock annex for WGEEL should be initiated in 2015, including a possible benchmark. WGEEL proposes to establish a benchmark-type study group in 2015 that will develop an initial stock annex. Based on this, a benchmark workshop could be held in 2016. The final output should be a benchmarked stock annex. A suggested Stock Annex template for WGEEL is given below.
d) Audit the assessments and forecasts carried out for each stock under consideration by the Working Group and write a short report.	The Working Group does not routinely audit assessments. Input data and outputs are checked by appropriate country/ region representatives during each meeting. Some model developments have been subject to review by the Working Group and the modelling approaches have been described either in the peer-reviewed literature and/or in the SLIME- and POSE-projects. A number of members of the Working Group have also been involved in collaborative efforts to explore further model developments. For example, close links have been established with the ECOKNOWS project. Stock annex and electronic reporting are planned to contribute to improve data quality in future.
e) Propose specific actions to be taken to improve the quality and transmission of the data (including improvements in data collection).	For improvements to data quality, see Chapter 7 of this report. For improvements to data transmission, see Chapter 8 of this report. Total landings and effort data are incomplete. There is a great heterogeneity among the time-series of landings because of inconsistencies in reporting by, and between, countries and incomplete reporting. Changes in management practices have also affected the reporting of non-commercial and recreational fisheries. Many EU Member States have not completely reported stock indicators (22 of 81 EMPs did not report all biomass indicators and 38 did not report all mortality indicators in 2012), and there are inconsistencies in the approaches used to calculate reported stock indicators. The distribution area of the eel extends considerably beyond the EU, and data from countries in these other regions were not available. A complete reporting of indicators covering the range of the European eel is required for a full assessment of the stock. To facilitate this, data collection and analysis should be internationally standardized.
f) Propose indicators of stock size (or of changes in stock size) that could be used to decide when an update assessment is required and suggest threshold % (or absolute) changes that the EG thinks should trigger an update assessment on a stock by stock basis.	See Chapter 2 of this report. Reporting to the EU takes place every three years, see EU Regulation (2007–1100). Biomass and mortality indicators are proposed for this process, 3Bs & A (F & H).
g) Prepare planning for benchmarks next year, and put forward proposals for benchmarks of integrated ecosystem, multi or single species for 2016.	A benchmark is not envisaged in 2015. See annex on proposal for a benchmark-type stock annex below.
h) Check the existing static parts of the popular advice and update as required.	See Chapter 2 of this report and it is also undertaken during the advice drafting process.

Generic ToR questions	WGEEL response
i) In the autumn, where appropriate, check for the need to reopen the advice based on the summer survey information and the guidelines in AGCREFA (2008 report). The relevant groups will report on the AGCREFA 2008 procedure on reopening of the advice before 13 October and will report on reopened advice before 29 October.	This is not relevant to WGEEL.
j) Take into account new guidance on giving catch advice (ACOM, December 2013).	This is addressed through the Advice Drafting Group that convenes after the WGEEL.
k) Update, quality check and report relevant data for the stock: i) Load fisheries data on effort and catches (landings, discards, bycatch, including estimates of misreporting when appropriate) in the INTERCATCH database by fisheries/fleets, either directly or, when relevant, through the regional database. Data should be provided to the data coordinators at deadlines specified in the ToRs of the individual groups. Data submitted after the deadlines can be incorporated in the assessments at the discretion of the Expert Group chair; ii) Abundance survey results; iii) Environmental drivers.	See Chapter 2 of this report. Eel data are not currently in ICES Databases. Data reported using annual Country Reports, and WGEEL maintains relevant databases used consistently in the advice, such as recruitment and silver eel time series and the Eel Quality Database. Environmental drivers are relevant at the local level for individual catchment assessments, but these are not relevant at the international scale, with the possible exception of oceanic environmental influences on spawning stock and larval migrations. Global environmental drivers are not currently incorporated, or maybe even relevant, to the international assessment.
l) Produce an overview of the sampling activities on a national basis based on the INTERCATCH database or, where relevant, the regional database.	The InterCatch database is not used by WGEEL. For database and recommendations for future data management, see Chapter 8 of this report.
For update advice stocks: m) Produce a first draft of the advice on the fish stocks and fisheries under considerations according to ACOM guidelines and implementing the generic introduction to the ICES advice (Section 1.2). If no change in the advice is needed, one page 'same advice as last year' should be drafted.	None of the questions posed in this section of the generic ToR imply a change in the procedures that WGEEL normally follows every year. The issues raised in ToR 'n' are addressed routinely in the WGEEL report. Advice is drafted annually by the WG and refined by the ADGEEL. An initial stock annex describing the assessment methods used should be developed in 2015 (see above and below).

GENERIC TOR QUESTIONS	WGEEL RESPONSE
n) For the eel stock, when possible prior to the meeting: i) Update the assessment using the method (analytical, forecast or trends indicators) as described in the stock annex. ii) Produce a brief report of the work carried out regarding the stock, summarising for the stocks and fisheries where the item is relevant: 1. Input data (including information from the fishing industry and NGO that is pertinent to the assessments and projections); 2. Where misreporting of catches is significant, provide qualitative and where possible quantitative information and describe the methods used to obtain the information; 3. Stock status and catch options for next year; 4. Historical performance of the assessment and brief description of quality issues with the assessment; 5. In cooperation with the Secretariat, update the description of major regulatory changes (technical measures, TACs, effort control and management plans) and comment on the potential effects of such changes including the effects of newly agreed management and recovery plans. Describe the fleets that are involved in the fishery.	See above and Chapter 2 of this report.
o) Review the outcomes of WKMSRREF2 for the specific stocks of the EG. Calculate reference points for stocks where the information exists but the calculations have not been done yet and resolve inconsistencies between MSY and precautionary reference points if possible.	See Chapter 3 of this report.

Benchmarking and development of a stock annex for European eel

The goal of a benchmark is consensus on an assessment methodology that is to be used in future update assessments, laid down in a stock annex. This assessment methodology can be an analytical assessment, but can also be non-analytical, for instance based on trends in an assessment or in a selected set of (survey) indicators, with or without forecasts. The result will be the 'best available' method that ICES advice can be based on. ICES benchmark workshops are the normal way of benchmarking stock assessment methodology. Hence, the term benchmark refers to methodology for assessing a fish stock that is the result of an intense process to decide on the most appropriate scientifically defensible way of interpreting or using biological knowledge, available data, and models to address management needs.

A Benchmark workshop is set up around a group of stocks with similar issues that need to be dealt with. Members consist of:

- Stock assessment experts;

- Data collection experts;
- Experts on ecosystem /environment /fisheries information;
- Stakeholders;
- External experts (invited by ICES on the basis of the issues at hand).

The preparation of the actual workshop should be guided by an ICES convener, a stock expert from the ICES community. The technical chair during the workshop should be one of the external experts. The external experts are invited by ICES and are responsible for guiding the meeting on a scientific level (also during the preparation) and in the end auditing the resulting stock annexes.

The stock annex describes the methodology agreed by the benchmark workshop and the assumptions on which this is based; specifically:

1) the data used as basis for advice and procedures to raised data and to handle missing data;
2) the methodology and standard settings of the assessment model;
3) the assumptions for which these settings are valid;
4) the diagnostics that should be checked to validate the assumptions;
5) reference points.

WGEEL has not yet drafted a stock annex to provide details of the assessment. As part of the international co-ordination and planning for a standardized assessment approach for eel, a stock annex for WGEEL should be initiated in 2015, including a possible benchmark, and WGEEL proposes to establish a benchmark-type study group in 2015 to undertake this task. Based on this, a benchmark workshop could be held in 2016.

A suggested Stock Annex template for WGEEL is given below.

Suggested Stock Annex template for WGEEL

(additions or changes to the general ICES stock annex template are suggested and marked with yellow).

A. General

A.1. Stock definition

A.2. Fishery

A.3. Ecosystem aspects

A.4. Non-fishery anthropogenic impacts

B. Data

B.1. Commercial catch

B.2 Recreational catch

B.3 Time -eries data (e.g. recruitment, silver eel)

B.4 Other data (e.g. stocking, aquaculture)

B.5 Local assessment data (e.g. WFD, DCF)

B.6. Biological

B.7. Other relevant data (e.g. habitat, eel contaminants and parasites and diseases)

C. Assessment: data and method

Definition of stock indicators and EU-regulation and stock recovery objectives

Description of local stock assessment models

Stock indicators (see below*)

Reference points

Development of stock indicator/management advice framework (including risk analysis)

D. Biological Reference Points

Biological reference points do not currently exist for eel, with the exception of the EU escapement target, and these are under development in the working group.

The following table is an example for other species' template.

	Type	*Value*	*Technical basis*
MSY Approach	**MSY $B_{trigger}$**	**xxx t**	**Explain**
	F_{MSY}	**Xxx**	**Explain**
Precautionary Approach	**B_{lim}**	**xxx t**	**Explain**
	B_{pa}	**xxx t**	**Explain**
	F_{lim}	**Xxx**	**Explain**
	F_{pa}	**Xxx**	**Explain**

(Only include latest reference points, add some text if necessary)

International stock assessment and quality control of local outputs.

E. Other Issues

H.1. Historical overview of previous assessment methods (optional subsection)

F. References

* Stock indicators

Silver eel production (biomass)

1) B_0 The amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the stock;

2) $B_{current}$ The amount of silver eel biomass that currently escapes to the sea to spawn. NB – listed in the ICES template as B_{post};

3) 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;

4) Wetted area habitat, by water type (lacustrine, riverine, transitional & lagoon, coastal);

5) Production values per unit area, e.g. kg/ha.

Anthropogenic mortality (impacts)

6) ΣF The fishing mortality rate, summed over the age groups in the stock, and the reduction effected;

7) ΣH The anthropogenic mortality rate outside the fishery, summed over the age-groups in the stock, and the reduction effected (e.g. turbines, parasites, viruses, contaminants, predators, barriers, pumping stations, etc);

8) ΣA The sum of anthropogenic mortalities, i.e. ΣA = ΣF + ΣH. It refers to mortalities summed over the age groups in the stock.

Restocking requirements:

9) R(s*) The amount of eel (<20 cm) restocked into national waters annually. The source of these eel should also be reported, at least to originating Member State, to ensure full accounting of catch vs restocked (i.e. avoid 'double banking').

Annex 5: Research needs

As noted throughout the WGEEL 2014 report, there are many data and knowledge deficiencies that hinder stock assessment (at local, national and international levels), identification and quantification of impacts (natural and anthropogenic), and the development and implementation of locally and internationally effective management measures. With the inclusion of the GFCM countries into the WGEEL, the need for international co-ordination and stock assessment now extends far beyond the EU and covers the whole range of eel.

Mortality based indicators and reference points routinely refer to mortality levels assessed in (the most) recent years. ICES (2011) noted that the actual spawner escapement will lag behind, because cohorts contributing to recent spawner escapement have experienced earlier mortality levels before. As a consequence, stock indicators based on assessed mortalities do not match with those based on measured spawner escapement. There is therefore, a need for both biomass and mortality reference points.

The diverse range of data collection and analysis methods used by countries to estimate their stock indicators, and the uncertainties associated with extrapolating from local to national stock assessments mean that there are inevitable but so far unquantifiable levels of uncertainty in the national and stock-wide assessments. These uncertainties need to be addressed at local, national and international levels, either through standardization of methods, setting minimum standards for data and methods (cf Data Collection Framework (DCF)), or both.

To undertake the International Stock Assessment there are a number of components, outlined below. These are all interrelated and will need to be addressed in a systematic manner to maximise standardization across countries. The programme has two main objectives; estimation of spawning–stock biomass and mortality, in the case of the latter this has been separated into an assessment of anthropogenic and natural mortality.

1. Spawning–Stock Biomass assessment

- An international calibration and standardization of the methods used to estimate silver eel escapement from eel standing stock estimates. Calibration between electro-fishing streams, catch per unit effort in lakes, estuaries, and other large waterbodies; validation, and intercalibration between methods. Links to DCF, WFD and EU Regulation.
- A coordinated programme of work should be undertaken to address the assessment of densities or standing stock of eels in large open waterbodies, such as lakes, deep rivers, transitional and coastal waters. This should include a cross-calibration of yellow eel catch per unit of effort with density data across a variety of habitats. Links to SGAESAW, DCF, WFD and EU Regulation;
- Spatially model the life-history traits used in the assessment models (growth, mortality, maturation schedule, sex ratio) to transport parameters from data-rich to data-poor EMUs;
- An international pilot study under the auspices of the new DCF is required to establish minimum standards for data collection on the basis of current expert judgement; to analyse achieved precision levels where adequate databases exist; and to stimulate further analysis when and where more data become available within the framework of the DCF.

- International surveys at sea of eel in the spawning area in the Sargasso Sea. Links to DCF.

2. Mortality assessment

- The stock response to implemented management actions, in terms of silver biomass, will be slow and difficult to monitor. There is a need for developing methods of quantifying anthropogenic mortalities and their sum 'lifetime mortality' and estimating the same across the entire distribution of the eel. WKESDCF recommends that the new DCF should include support for the collection of data necessary to establish the mortality caused by fisheries and non-fisheries anthropogenic factors. Links to DCF, WFD, EU Regulation.
- A whole eel distribution approach to assessing stocking and determining net benefit to the stock, including an evaluation of the mortality of the stocked fish in relation to the mortality the fish would have experienced if left *in situ*. Links to EU traceability, CITES, EU Regulation and ICES advice.
- It is recommended that research to investigate factors that cause Natural Mortality (M) to vary in space and time be given the high priority. Thus, further data collection and research should be encouraged to support and improve the knowledge of this difficult research topic in order to obtain more reliable stock assessments. This will need to include an assessment of density-dependent influences (DD) on eel population dynamics that occur at the local level and whether DD will play a role at the continental scale in the decline/recovery of the eel stock.

Annex 6: Forward Focus of the WGEEL

This report is a further step in an ongoing process of documenting stock and fisheries of the eel (*Anguilla anguilla*) and developing methodology for giving scientific advice on management to effect a recovery in the international, panmictic stock.

The focus of the WGEEL in the coming years will be on the following key areas:

1) Source the appropriate assessment data from across the range of the European eel, by working with the EU, EIFAAC, ICES and GFCM members;
2) Complete development of eel-specific stock assessment methods, working with ACOM;
3) Contribute to the development of a standardization and unification of the assessment process across the entire distribution of the European eel, working with EU, EIFAAC, ICES and GFCM members;
4) Develop the focus of management advice on the pragmatic use of mortality indicators (immediate impact) as intermediate or short-term goals, leaving biomass indicators (long-term impact) for the longer-term goals, working with ACOM and the EU Commission;
5) Develop an advice process for managing stock recovery and achieving sustainable anthropogenic impact, by working with ACOM.

6.1 Complete data coverage

6.1.1 The contribution of GFCM countries and the Secretariat to WGEEL 2014 and future work is welcomed and the WGEEL anticipates having new data covering a greater distribution of eel in the near future.

The GFCM has informed that a proposal to include eel in the list of priority species within the new GFCM Data Collection Reference Framework (DCRF) will be formulated to the Scientific Advisory Committee (SAC) and relevant bodies December 2014 and March 2015. The WGEEL will be informed regularly of the outcomes of these discussions and will be consulted on the frequency of collection of biological data so these can be aligned those in other EU countries.

The GFCM experts participating at the WGEEL 2014 agreed on a plan of action during 2014–2015 to fill some information gaps and to be in the position to provide the minimum necessary set of data to be incorporated to the 2015 full international stock assessment of European eel. The primary objective of this action plan is to collect current and historical data under the guidance of WGEEL experts. These data will be gathered by the GFCM in a standardised database. The Italian team who have some previous experience of eel data collection and assessment in coastal lagoons will lead these actions, in consultation with some other WGEEL experts. The French experience on Mediterranean rivers could be also taken into account for the inland systems. A first regional stock assessment exercise with the most suitable models could be carried out in a two day (back-to-back) Mediterranean workshop immediately preceding the 2015 meeting of WGEEL.

Details of the action plan will be proposed to the SAC and agreed actions will be executed in the 2014–2015 period in collaboration with ICES and EIFAAC.

All these actions are subject to the approval of the SAC and the Commission and to the allocation of funds to cover a consultant on a part-time basis and the travel expenses to the 2015 WGEEL including the two day regional workshops preceding WGEEL 2015.

6.1.2 The WGEEL will seek data and participation from other countries, e.g. the Russian Federation, where European eel is of interest.

6.1.3 New data from within the EU may also become available through national implementation of the EU – Multi-annual Plan (EU-MAP – the follow-on to the EU Data Collection Framework, DCF). However, this regulation may not be implemented until 2017 or 2018 at least. Most of the recommendations of the ICES WKESDCF for the better alignment of eel (and salmon) data collection with international and national stock assessment, have been accepted but it is uncertain whether and when these might be adopted into European fisheries legislation. The WGEEL will continue to monitor these developments and contribute scientific expertise wherever required.

6.2 Improved methods of whole-stock assessment

The WGEEL has developed three approaches (tiers) to the international stock assessment: an index based assessment (recruitment; possibly older yellow and/or silver eel in future); the modified Precautionary Diagram derived from EU limits (the 40% biomass 'target'); and, eel-specific reference points based on a tentative stock–recruitment relationship. All three approaches have been approved in principle by the RGEEL and ACOM in 2013, although some issues over the specifics of the stock indicator and S–R approaches meant that the ICES Advice 2013 was based on the recruitment trend stock assessment alone.

The data gaps in the EU limits approach remain to be filled, but it is anticipated that the next round of national EMP Progress Reports in 2015 along with the new data from GFCM countries will contribute substantial improvements in data coverage. There were also some questions about the form of management advice on mortality limits, both when eel biomass (escapement, a proxy for spawning stock) was below or above the EU's limit reference point of 40% B_0. These questions must be resolved as a matter of urgency.

The stock–recruitment relationship was (is) based on tentative data relationships and assumptions about historic exploitation rates. The use of these extra data allows the derivation of eel-specific reference points, but at the costs of uncertainties in data and processes. The working group was not able to improve upon these source data in 2014 but will continue to pursue this.

6.3 Standardization and quality assurance

There is an urgent requirement to test, and where necessary improve, the quality of data and analyses used in deriving these stock indicators (independent review).

A full international stock assessment should include data from all parts of the natural range of European eel. There is an urgent requirement, therefore, to support the development of suitable assessment data in the remainder of the productive range of the European eel.

This ICES standard approach could be developed for the European eel, adopting a standardized international data collection (e.g. based on WFD fish monitoring of fresh and transitional waters but modified to be eel-specific; see Chapter 7) and analysis to support the international stock assessment. Note this international data collection and analysis would not replace the local stock assessment (which is necessary to support local management). There is an urgent need for planning (data exchange and methodologies), and for tuning expectations and opportunities. The urgency of this requirement and the size of the task are such that it should be pursued outside the normal annual cycle of the WGEEL. WGEEL 2014 has made proposals for study groups and workshops to progress these actions.

6.4 Management advice based on interim mortality-based indicators

The Eel Regulation specifies a limit reference point (40% B_0) for the biomass of the escaping silver eel. Due to the long lifespan of eel, however, it will take at least 5–10 years before the first effect of a management measure impacting on the glass eel or yellow eel stage would be expected to be visible in estimates of escapement biomass. In contrast, the impact of management actions on mortality indicators should be apparent almost immediately. It will be in line with the conventional ICES procedure and the modified Precautionary Diagram to focus on immediate effects (mortality indicators A, F and H), ignoring the inherent time lag in spawner escapement (biomass indicator). Defining mortality targets and trajectories to reduce mortality to achieve standard ICES targets within a defined time period would improve the chance of recovering the eel stock.

6.5 Management advice for stock recovery

If the recent increase in recruitment indices continues, then everyone will face a new challenge of how to manage and sustain a recovery of the productive stock, and associated sustainable exploitation.

Annex 7: Formal recommendations of WGEEL 2014

Number	Recommendation	To
1	International coordination with countries outside the European Union pursued to achieve complete spatial coverage of data for eel stock assessment.	ICES Secretariat; EU; GFCM; EIFAAC
2	As WGEEL considers the eel a long-lived species in terms of harvest control rules, and pending an improvement of the analysis of stock-and-recruit data, WGEEL recommends that ICES provides advice on the basis of the harvest control rule for quantitative assessments (category 1), i.e. a proportional reduction in ΣA_{lim} below $B_{lim,}$ down to $\Sigma A_{lim} = 0$ at $B_{current} = 0$.	ACOM
3	An International programme of research be undertaken to standardize and cross calibrate the assessment methods used to estimate silver eel escapement throughout the distribution of the European eel.	SCICOM, GFCM, EU, EIFAAC (all working with WGEEL); see draft Resolution enclosed
4	An existing or new workshop is requested to compile and make available time-series of indices of eel quality, preferably from 1950 forward.	SCICOM
5	A workshop on ocean climate indices relevant to the eel (WKOCRE), in cooperation with WGOH compiles and makes available time-series of indices that might relate to the migratory success of spawners and/or larvae in the ocean.	SCICOM
6	A workshop/study group is established to analyse the stock–recruitment relation (WKESR) for the European eel, taking into account the potential effects of spawner quality and ocean climate indices.	ACOM, SCICOM
7	A Study Group on Establishing an Eel Stock Annex (SGEESA), chaired by *NN, country*, will be established and will meet in *Country A, xx–yy October* 2015 and in *Country B, xx–yy month* 2016 to develop an initial stock annex in two steps: a) define the stock, anthropogenic impacts and data available for assessments; b) describe the assessment method and required data, including biological reference points.	ICES Secretariat

Recommendations from WGEEL to itself

Number	Recommendation	ToR for future (letter code indicates ToR 2014)
1	In the interest of long-term planning and international co-ordination, we recommend data on life-history characteristics be collated at the spatial scale of the eel management unit (EMU) as part of the development of the European Eel Stock Annex.	b) Review the life-history traits and mortality factors by ecoregion
2	WGEEL makes available time-series of (reconstructed) spawner escapement and documents how this time-series have been derived; consider silver eel run reconstructions to be based on either silver eel landings data, yellow eel landings data, or other historical sources of information	e) Further develop the stock–recruitment relationship and associated reference points, using the latest available data
3	It is proposed that all country report authors will adopt the digital template created in WGEEL 2013, to ensure the efficient operation of the working group. This efficient handling and processing of data has been recommended in several previous reports (including ICES, 2001; ICES, 2010a, ICES, 2013b). Concerted action is required in 2015 by key members of the working group in cooperation with the ICES Datacentre, to ensure these recommendations are not reiterated next year.	f) (ii) work with ICES DataCentre to develop a database appropriate to eel along ICES standards (and wider geography)
4	An international programme of research be undertaken to standardize and cross calibrate the assessment methods used to estimate silver eel escapement throughout the distribution of the European eel.	f) (i) Explore the standardization of methods for data collection, analysis and assessment

Annex 8: WGEEL responses to the Technical Review Group minutes, 2013

The Working Group considered and responded to the Technical Review Group minutes on the 2013 WGEEL Report. Typographical and editorial changes were made in the 2013 report and indicated [DONE] in the Technical Minutes and won't be addressed here. Responses in this table will either indicate where the issue is addressed in the report or a response will be made directly on the table.

No.	Technical Minute GENERAL COMMENTS OVERVIEW	WGEEL response
1	The Working Group (p. 180) has asked ICES to advise on which of the three assessment approaches (analysis of recruitment trends, use of stock indicators by country or EMU, and single international assessment) should be pursued, although it gives no indication of its own views. The answer is all three.	The Review Group seems to refer to the sentence "A decision needs to be made as to whether ICES accepts any or all of the three assessment approaches presented". In our view, there is no doubt that all three methods have their pros and cons. The question raised, however, is which of the three is considered to be best for providing advice – noting that the methods differ considerably in detail, in credibility and in specificity to eel. So far, advice was essentially based on the recruitment trends, which does inform about the worrying status of the stock, but does not indicate whether the implementation of the Eel Regulation has resulted in adequate protection or not.
2	The Working Group should clarify what data need to be obtained in order to develop such an international species-wide assessment in the future.	These were developed by the Working Group in 2009–2011 and incorporated in the EU Reporting Template for 2012 reporting as follows: silver eel production (biomass): 1) B_0 The amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the stock; 2) $B_{current}$ The amount of silver eel biomass that currently escapes to the sea to spawn. NB – listed in the ICES template as B_{post}; 3) 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; 4) Wetted area habitat, by water type (lacustrine, riverine, transitional & lagoon, coastal); 5) Production values per unit area, e.g. kg/ha. anthropogenic mortality (impacts): 6) ΣF The fishing mortality rate, summed over the age-groups in the stock, and the reduction effected; 7) ΣH The anthropogenic mortality rate outside the fishery, summed over the age-groups in the stock, and the reduction effected (e.g. turbines, parasites, viruses, contaminants, predators, barriers, pumping stations, etc); 8) ΣA The sum of anthropogenic mortalities, i.e. $\Sigma A = \Sigma F + \Sigma H$. It refers to mortalities summed over the age-groups in the stock. restocking requirements: 7) R(s*) The amount of eel (<20 cm) restocked into national waters annually. The source of these eel should also be reported, at least to originating Member State, to ensure full accounting of catch vs restocked (i.e. avoid 'double banking').

3	The Working Group has also raised the issue of whether annual assessments, between those required for reporting under the Eel Regulation, are necessary; they are said to be useful for monitoring the trend in status, but no strong case is made for conducting them. While limiting the assessments to every third year might provide more time to develop new methods, consideration should be given to the difficulty of maintaining and populating the databases used to undertake the assessments if they are not undertaken annually.	Agreed. Coordination of data, their storage and application are now discussed in Chapters 7 and 8.
4	Since a rebuilding objective has already been defined for the European eel, there is no need to develop alternate reference points. The objective of exceeding 40% of pristine spawning biomass has been taken to correspond to the term used by the Working Group of $B_{MSYtrigger}$ (but see comments below). Alternate objectives, based on recruitment trend indicators (R_{target} and R_{down}) are not useful for informing management decisions as they cannot be measured directly against silver eel biomass or removal rate objectives.	This comment is dealt with in Chapter 3.
5	The development of the relationship between stock (proxy value for silver eel biomass) and recruitment (index of glass eels from Elsewhere Europe) is too preliminary to justify providing alternative, more precautionary, reference points (B_{stop} and B_{stoppa}) to the 40% of pristine biomass value.	This comment is dealt with in Chapter 3.
6	The Precautionary Diagram for eel shows $B_{current}$ on the x-axis, and it would be more appropriate to show B_{best} (the expected biomass in the absence of anthropogenic impacts).	This comment is dealt with in Chapter 3. B_{best} is actually shown in the diagrams, as the size of the bubbles. The relation to B_0 is relevant, in relation to the management target to restore spawner escapement to 40% of the pristine biomass.
7	In addition, the Precautionary Diagram shows the maximum removal rate, 60% (corresponding to $\Sigma A = 0.92$), being applied at $B_{MSYtrigger}$, but this removal rate can only be sustained at or above the pristine biomass (B_0) without reducing escapement below 40% of B_0.	Agreed.

8	We suggest that eel is actually more akin to a '*short lived stock with population size estimates*' (ICES 2013a) because the anthropogenic mortality is calculated as a single lifetime value (ΣA), and that mortality occurs before the fish spawn. For such stocks, the ICES MSY approach is aimed at achieving a target escapement (MSY $B_{escapement}$) which would accord with the 40% of B_0 reference point set by the EU.	This comment is dealt with in Chapter 3.
9	ICES (2013a) has also proposed that catches should be limited to the stock biomass in excess of the target escapement, and that no catch should be allowed unless the escapement can be achieved each year. On this basis, Figure 6-1 might take the form of Figure 1 (Tech Minutes).	This comment is dealt with in Chapter 3.
10	Depensation is again highlighted by the Working Group as a process which may be affecting European eel. The evidence put forward to support the depensation hypothesis is a stock and recruitment (S-R) relationship that is based on a partial index of silver eel spawning escapement and a relative index of glass eel recruitment. In the ICES review of the 2012 WGEEL report (ICES 2012, Annex 11), alternate hypotheses for the pattern in glass eel indices and silver eel indices were described. These alternative hypotheses are still worthy of consideration. Depensation is defined in S-R analysis as recruits per spawner that increase from the origin and then decline at an intermediate spawner abundance. The causal mechanisms of depensation are primarily associated with Allee effects, by which spawning success is compromised by low spawner abundance. To demonstrate depensation, the recruits and spawners must be in similar units. Production of glass eel that is low relative to historic abundance is not sufficient to demonstrate depensation.	This comment is dealt with in Chapter 3.The tentative stock-recruitment-relation based on the available data indicates that a much more precautious management approach is required to restore the stock, than would be expected for a non-depensatory relation. The Review Group appears to reverse the burden of proof.

11	It could be that the low values of the glass eel indices since the 1990s are the result of less favourable survival conditions of the early life stages (possibly due to a regime shift) perhaps exacerbated by reduced spawner quality associated with contaminants or other factors in freshwater. There may be subsequent compensatory responses in the spawner production in the continental phase of the life cycle that results in a spawner to spawner ratio which is greater than one, before potential spawners are killed in continental areas. Evidence is provided in the report of some of these, including increased size and proportion females among silver eels as abundance has declined (see Sections 9.11.1 and 9.11.2). It is notable that marine mortality of Atlantic salmon, which is most unlikely to demonstrate depensation during the marine phase, also shows signs of having been affected by a regime shift around 1990 (ICES 2013b)	As point 10.
12	The management advice is the same regardless of whether the S-R dynamic is due to non-stationarity (density independent or density dependent phenomenon associated with reduced resources) or depensation; to maintain and increase recruitment, the spawner biomass must be increased.	Agreed, and further dealt with in Chapter 3.
13	The combined report of the March and September meetings excludes any information on the work undertaken to address ToR ‘d’ to ‘g’. The WKEPEMP report (ICES 2013c) contains some of the information collated during the March meeting. The summary tables of the key stock indicators by EMU, referred to as the 3Bs&ΣA-approach, which are summarized later in the PA summary plots of status by EMU and country in Section 6.5 of this report, are provided in ICES (2013c) and a similar table should have been included in this report, as a response to ToR ‘e’ and ‘f’. Given that these stock indicators are proposed as key indicators of stock status and progress by states in achieving stock rebuilding objectives, readers of this report would have benefited if a section describing these stock indicators, their origin, and how they are used to assess stock status had been provided.	Agreed, but it was designed that way at the time to keep some role separation between the technical review of the EMPs (WKEPEMP) and the work of the WG. Comment noted for future reference.

14	The Working Group has a difficult task to pull together data from a large and diverse group of countries and to develop unified assessments of the eel stock. However, the report is not clearly structured, and sections neither fully address specific ToR (e.g. ToR 'j' is addressed in Sections 4, 5, 6, 9, 10 and 11) nor provide complete answers to specific advisory questions	Done – the report structure has been redesigned to largely follow the recommendations of the RGEEL 2013, and chapter titles and content largely organised to address individual ToRs.
15	Throughout the report, reference points are frequently referred to as 'targets' when they are actually 'limits'. This is an important distinction which has significant implications for management.	It is referred to as a 'target' in the Regulation; will be referred to as a 'limit' in WGEEL.
16	There are several sections in which figure numbers have been duplicated. This is difficult to avoid when compiling a large report quickly, but it could be reduced by employing the normal ICES convention for numbering figures and tables	Agreed.
	Sections 1–3, Opening, Agenda & Introduction	
17	The ToR would be easier to find if they were placed in a stand-alone section at the start of the report. It would also be helpful to indicate which management body(ies) are requesting the advice (See Technical Review 2012). It is helpful that some sections of the report are prefaced by the ToR which they address; it would also be helpful if the list of ToR at the beginning of the report showed the section in which each ToR is considered	Done - The ToR, the bodies requesting the Advice, and detail of which report chapter addresses which ToR, are all provided in the Introduction to the report (Chapter 1). The chapter titles include the ToR to which they are addressed.
18	Annex 3 appears to indicate that the ToR are proposed by the Working Group itself, but clarification is required on the customer(s) for the advice and the precise management needs. It might be helpful if future ToR reflect the ultimate advisory need (e.g. an assessment of the status of the eel stock across its range) rather than the process for achieving that need (e.g. compilation of data).	Done – the ToR for 2014 were designed to reflect the advisory need.
19	The Review Group recommends that in future the Working Group provides an Annex listing the Review Group's comments and either provides a response or indicates where in the report that response can be found.	Done

20	In the absence of a Stock Annex all data and methods used should (as far as practicable) be provided in the report; it is not reasonable to expect the reader to look through more than 15 Expert Group reports to find the relevant information. Where the volume of data is too great to be included in the report, the information should be summarized and sources given.	Stock Annex planned in Future Focus. See under response to Generic ToRs Annex
21	p. iii, Section B, Chapter 10, 1st para. Unclear what 'exports' means; is it exports out of the EU, or exports out of the fishing country?	Out of the fishing country
22	p.20: Implementation of the EMPs has now introduced discontinuities in data trends (e.g. fisheries dependent recruitment series); the Working Group should consider the implications and review the need to shift from fisheries-based to scientific survey-based assessments.	The need to shift to scientific series and the risk of losing the fishery based series has been addressed by the WGEEL before the implementation of the management plan. The WGEEL has repeatedly made recommendations to try to address this problem, See SGIPPEE '11, WGEEL, '09 & 10 & 11 & '12, and WKESDCF
	Section 4, Introduction to stock assessment, reference points and stock status	
23	In Section 4.2, the Working Group presents a narrow view of what are termed 'standard stock assessment techniques' and suggests that, if these techniques were applied to eel, the assessment would be meaningless. However, the problem is not with eel biology or ecology, it resides with the lack of adequate basic stock assessment data for European eel, including catch data, biological data including length and weight at age and stage (yellow *vs* silver eel) and estimates of exploitation rates across the species range. If these data were available, the European eel could very well lend itself to standard assessment approaches, such as statistical catch at age or cohort analyses. If such information was collated and integrated over all regions, this would constitute an international assessment to which WGEEL aspires. The references to previous WGEEL reports, which are the source of the text in this section, **do not provide scientific support for discounting standard assessment procedures.** In the meantime, there remains an urgent need to introduce further quality control into the separate regional assessments undertaken.	Section 4.2 actually indicated that a standard, centralised, age-based approach could indeed be followed; we do not disagree on that. The point made in Section 4.2 (highlighted by an example of age 5 year old eels, combining recruiting yellow eels from Scandinavia with escaping silver eel from the Mediterranean) is that the results (e.g. mortality at age 5) would be difficult to interpret, and would hardly relate to any management action. The assessment is feasible, but would have severely restricted application.

24	p.23, Sec 4.3: It would be helpful to clearly present the management objectives (e.g. the EU Regulation) against which the three assessment methods described in Section 4.3 are conducted	This comment is dealt with in Chapter 3. Done.
25	p.23, Sec 4.3, para 2: the references to DLS Guidance are unclear; the name should be spelt out in full the first time it is mentioned and the correct reference should be included. Furthermore the references to Methods 1.1.2 (*If estimated stock biomass in the intermediate year is less than MSY* $B_{trigger}$) and 5.3 (*If catches have declined significantly over a period of time and this is considered to be representative of a substantial reduction in biomass, a recovery plan and possibly zero catch is advised*) do not appear to match the text.	This comment is dealt with in Chapter 3.
26	p.24, para 1, line 3: the report refers to *'a discussion on how to deal with a (real or perceived) break in a hitherto consistent, multidecadal decline (for which DLS Guidance does not provide a method)'*; this statement is unclear; there is not a break, it is an upturn.	This comment is dealt with in Chapters 2 and 3.
27	p.24, para 1, line 5-6: the report states, *'Finally, the available data indicate that recruitment has declined more rapidly than the (reconstructed) spawner escapement, which may indicate a. an inappropriate reconstruction of the trend in spawner escapement, or b. a non-stable stock–recruit relationship (e.g. change in ocean conditions), or c. a depensatory stock–recruitment relationship.'*. However this is to be expected; in a compensatory S-R relationships, recruitment (R) will decline faster than spawner escapement (S) when S is less than the spawners required to achieve MSY (S_{MSY}). (R will decline less rapidly than S when S > S_{MSY})	This comment is dealt with in Chapter 3. Both a Beverton & Holt-type and Ricker-type relation are concave between MSY and the origin, that is: spawning stock decreases faster than the resulting recruitment. The eel data appear to indicate the opposite.
28	p.24, Sec 4.4, para 2: It is suggested, '*the net effect of the actions taken in 2009 on the total 2009 silver eel escapement is probably small, far below the targets of the EMPs and/or the ultimately sustainable level.'* These conclusions are not justified without a list of the actions taken and the life stages likely affected	ICES-WKEPEMP 2013 provided that list. Chapter 4 is intended to sketch the framework for stock assessment and reference points, while dedicated chapters provide full detail. DONE
	Section 5, Trend based assessment and reference points	

29	Little information is provided on the derivation of the recruitment indices used in this assessment; Table 5-1 refers to *'the two recruitment series presented in Chapter 9'*, but that section deals with three life stages (glass, yellow and glass+yellow) and two areas (North Sea and Elsewhere). (NB Comments on the time series analysis are presented for Section 9 below.)	Agreed, the tables 4.3 4.4 and 4.5 describe the current state of series used (which are updated, which are not). We now explain that the glass eel trend is based on both glass eel and glass eel + yellow eel (Chapter 2). The full description of the series available and their possible weaknesses is described in an E-table accompanying that chapter. This description comprises the first year, last year, duration, missing years, and the expertise of a possible change in the trend over the years. No selection was done this year on the series, but the wgeel acknowledges the need to work on the weighing of those series. There might be up to 3 series in the same place, and geographical, with respect to absolute recruitment, some series will have much more weight than others.
30	Choice of the baseline period is a key element of these analyses, and this is not explained either here or in the general discussion of data compilation (Chapter 9). The period 1960-1979 is chosen as a baseline because *'the stock was considered to be 'healthy' during this period'*, but elsewhere the report says that yellow eel recruits have been declining since the 1960s (p. i) Also p.26, Table 5-1: the caption refers to a reference period of 1960-80; should this be 1960-79 (or it is inconsistent with the reference period used elsewhere)?	This is now answered in Chapter 2. The WGEEL acknowledges that the period of reference leads to a difficulty in the interpretation, but choosing a different period might lead far fewer series available. Figure 4.2 and 4.3 presents the raw data in a way that is consistent with previous reports from 2002.
31	The report draws a firm conclusion from the trend analysis that *'the stock remains in the critical zone.'* This is based on the chosen baseline, and additional analyses should be presented to confirm whether the report's conclusion on trends is upheld using alternate baselines. The extent to which the recruitment index varies with baseline choice would also help in the evaluation of the robustness of this method.	The WGEEL has considered including data before 1960. The unbiased data before 1960 are not numerous enough to provide a trend that we could be confident in. As a result, the graphs were adapted with shading for data before 1950 and only the values after 1960 are presented in the WGEEL recruitment index. The yellow eel series is based on four unbiased series after 1946, and the reference period for those series has not been changed.
32	The concept of a 'baseline,' a period when the population was 'healthy', has a relevance that goes beyond Chapter 5. The analytical approach of Chapter 6 is based on a hypothetical population that is unaffected by anthropogenic activities, which is another way of saying a baseline population. These baselines should be consistent.	The baseline is chosen as following : 1980: breakpoint in recruitment 1960: before we don't have enough data.

33	It is not clear that the presentation of the recruitment trends in Figure 5-3 adds significantly to Figures 5-1 and 5-2, particularly given that the 5-year exponential trend appears to be quite sensitive to relatively small annual fluctuations in R and many of the data points are superimposed. The reference points used in these analyses are not reference points for management, and managers may be confused by the introduction of the new status terminology; the use of a 'high cautious' zone is confusing, and the distinction with the 'cautious' zones may also be misleading (for example, a strongly decreasing trend when R/R_{target} is marginally greater than 1.0 (cautious zone) would appear to pose much greater risk to the stock than a strongly positive trend with R/R_{target} marginally less than 1.0 (high cautious zone)).	Agreed. Addressed in Chapter 3. We now keep only the Figure 5.3. As said in the report, different period to calculate the trend haves been tested and 5 years seems to the best compromise. The figures has been enlarged The EU has agreed on a biomass limit reference point, but has not adopted any mortality reference point. ICES advice so far has essentially been based on the trend in recruitment only. That is: management and advice address different dimensions. The reference points discussed in this section can be applied for management, as exemplified by their application by DFO in Canada. In order to help to align ICES advice with EU policies on eel, Chapter 3 discusses the three different assessment approaches. Elaboration of the trend-based assessment and derivation of corresponding reference points is one option; advising EU on biomass and mortality reference points another.
34	For a panmictic species, a decline in recruitment to northern areas but not in southern areas is not consistent with depensation.	The decline happens everywhere. We note that it might not be consistent with other hypotheses either.
35	Overall, the trend analyses confirm the continuing severely depleted state of the recruitment, and this is clearly described. A number of comments are made about the recent upturn in the recruitment indices, and this raises the issue of determining when these changes should be considered significant.	This is now addressed in Chapter 2.
36	The Working Group might consider whether examination of previous year-to-year variation in the indices (e.g. annual changes, sequences of increase/decreases, etc) could be used to evaluate the significance of recent changes. As indicated, it would be desirable to be able to present similar trends in yellow and/or silver abundance, even if these trends may reflect local differences in population dynamics and anthropogenic impacts.	This is done for recruitment. No analysis was done this year on the yellow and silver eel trends, as it is felt that those might only reflect local change.
37	p. 26, Sec 5.2: R_{down} is based on the 5% quantile of recruitment. Since there are 20 years between 1960 and 1979, it appears that R_{down} should be the recruitment during the poorest recruitment year between 1960 and 1979. If this is correct, it should be stated in the text.	Figures 5.1 and 5.2 cancelled in this year's report

38	p.26, line 5: the reference to using trend analysis in the development of the PA by Fisheries and Oceans, Canada is unclear.	The reference is supplied a few lines further down the page, in the section that elaborates on this.
39	p. 29, Figure 5-3: The y-axis should indicate that R/R_{target} is expressed as a %. The reason for using a five year exponential change for the x-axis should be explained in the text.	Figure corrected.
	Section 6, Quantitative assessment applying generic reference points	
40	Section 6.2 provides an important description of the management objectives and should be the basis for the management advice. However, the EU's reference point of 40% of pristine biomass is referred to as a 'target' (lines 3 and 9) but also as a trigger point (line 9) and as a 'limit' reference point (line 15); it is important to be clear whether this is a target or a limit.	Acknowledged; corrected in this year's report.
41	Section 6.3 refers to 'stock indicators 3Bs&ΣA' but it is not immediately clear which biomass reference points are being referred to (the glossary defines seven biomass reference points).	Correct.
42	It would be helpful to provide a definition of the relevant indicators (B_0, $B_{current}$ B_{best} and ΣA?) in a text table and relate these to the ICES reference points (e.g. $B_{MSY-trigger}$).	B_0 The amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the stock. $B_{current}$ The amount of silver eel biomass that currently escapes to the sea to spawn. B_{best} The amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the current stock. ΣF The fishing mortality rate, summed over the age-groups in the stock, and the reduction effected. ΣH The anthropogenic mortality rate outside the fishery, summed over the age-groups in the stock, and the reduction effected. R The amount of glass eel used for restocking within the country. ΣA The sum of anthropogenic mortalities, i.e. ΣA = ΣF + ΣH.
	It appears that values are not provided for all EMUs and the reason for this needs to be discussed and solutions explored. [NB: However, in relation to this and following comments on Section 6, see the 'Overview - General comments' regarding the Precautionary Diagram.]	Done – the missing values for these stock indicators for EU countries have been highlighted again in Chapter 4. Solutions to fill these gaps have been considered through Chapters 4 and 7.

43	The assessment results presented appear to have been taken directly from Member States' 2012 progress reports on their EMPs, and no new analysis seems to have been undertaken by the Working Group. There is clearly a need for some degree of quality/consistency review. It is not possible to provide full details of these assessments within reasonable limits of space, but some key points need to be explained to allow readers to judge the strength of the approach and the limits to its interpretation. Plus bullet points……….	The WGEEL are well aware of this problem and the issue has been raised with ACOM and the EU. Discussed in March 2013 and in WKEPEMP. Being partly addressed in the 2014 WGEEL ToRs, but peer-review of the EMP assessments remains a technical and resources issue beyond the time resource available within the WGEEL.
44	The impact of these gaps on the overall assessment may vary with the type of gap. Data from Portugal are missing, but data from adjoining EMUs on the Iberian Peninsula may provide a valid proxy. Gaps in broad regions are more problematic. The Mediterranean basin may be as important as the Atlantic for European eel production, but there are no data for about 3/4 of the Mediterranean coastline. If we cannot assess eel status there, it leaves a large gap in the picture for the species as a whole. Can tentative or preliminary conclusions be drawn on the basis of reported landings for this region? Reported eel landings in non-EU Mediterranean countries (particularly Egypt) are very large, peaking at >4000 t in 2006 (Figure 9–10), which exceeded total reported European landings at that time.	Lack of data from large areas is a huge problem in eel assessment. However, the severity of the problem differs, depending on the focus. For evaluating local/national/regional/EU-wide management, biomass and mortality indices and their position relative to corresponding reference points provides meaningful and reliable information for the areas that do provide data. For analysing stock-wide relations, such as the stock-recruit-relation, lack of data from many areas is a serious problem. Note, however, that trends in recruitment and trends in landings have shown only little differentiation between areas in the past (Dekker 2004) – the landings-based analysis of the stock-recruit-relation would be valid, even on a subset of the data. Given the extreme variation between nearby habitats (e.g. rivers versus lagoons), but also between likewise habitats in nearby countries, we see little point in tentative filling in. Duplicating information from some areas to fill the gap for nearby areas would boil down to raising the statistical weighing factor for the known areas, while the quality of those data is often not beyond doubt.
45	Do many or most EMUs have substantial eel production areas in saline waters that are not fished and lack biological data? If saline areas are poorly covered or not covered in models, what is the effect on the assessments? Would inclusion of unfished saline waters in models boost silver eel production and raise the modelled $B_{current}$ for that EMU?	Eels do occur in many saline waters, and several countries have included their saline/coastal areas in their management plans and assessments. Other areas are uncovered, but these have mainly been identified in our results (e.g. weeping faces in Fig 6-2). The contrasts in life history characteristics between fresh and saline waters is not fundamentally different from the contrasts between other areas.
46	Eel growth is more rapid in saline than fresh water (ICES 2009); do models take this into account?	As indicated in the report, the international assessment takes as its prime inputs the 3B&ΣA indices from Eel Management Units, and the assessments for each of those units is considered to have used the appropriate parameters.
47	Incomplete reporting by EIFAAC/ICES members is clearly an ongoing problem, and the Working Group should clearly spell out in Tables the data/indicators that have been provided by EMU or country (distinguishing EU-MSs).	This was tabulated in the March meeting and report in the WKEPEMP 2013. It is also tabulated in Chapter 4, of this report including the countries outside of the EU.

48	p. 32, Sec 6.5, line 1 & Figure 6-1 states that the Precautionary Diagrams plot the 3Bs & ΣA. In fact they appear to plot $B_{current}/B_0$(%) against ΣA. The boundaries between the coloured zones in Figure 6-1 should be defined in the text and/or the figure caption.	In fact, lines 3-6 of that paragraph did that.
49	p.35 - 36, Figures 6.1 and 6-2: it is not clear how the overall sum for <u>ΣA</u> (from the EMU or country data) is derived. The overall ratio for the biomass indicator could be estimated as $\Sigma B_{current}$ / ΣB_0 for reporting jurisdictions. For ΣA, does the report calculate the overall value as: ($\Sigma B_{best} - \Sigma B_{current}$) / ΣB_{best}?	The functional relation between ΣA and %SPR was discussed in ICES-SGIPEE (2010), in the wider setting of developing the required methodology. The 2013 report explained methodology in common words, and referred back to the sources, in order to put prime focus on the results.
50	p.35: In Figure 6-1, scaling the bubbles by B_{best} confuses the productive capacity (large areas can produce lots of eels) with the realized production.	B_{best} not necessarily relates to production area; the major part of B_{best} is derived from a single country! Scaling the bubbles by $B_{currentt}$ would mix the information on the size/productivity with that on ΣA.
51	For communication to managers, it might be better to not use B_{best} to scale the bubbles but rather use similar sized symbols for all EMUs or countries but with two colours representing the following conditions: a white symbol to indicate $B_{best}/B_0 < 40\%B_0$ (i.e. failure to meet the target even in the absence of all anthropogenic mortality) and a solid symbol to indicate $B_{best}/B_0 >= 40\%B_0$ (potential to attain the target in the absence of mortality). This would show whether the failure of an EMU or country to achieve its objective ($B_{current}/B_0 < 40\%B_0$) is due to insufficient management intervention in the given year versus failure to meet the target due to low potential production in that year.	We disagree. The scaling of the bubbles does highlight the relative importance of different areas/countries, while the information on whether aims have or not been achieved is adequately represented in the background colour. The suggested change would reduce the information content of the plot, and would not simplify the interpretation.
52	The information that needs to be communicated to managers is where $B_{current}$ is relative to $40\%B_0$ and ΣA (the three colours) and where B_{best} would be relative to B_0. In this case, using the sad or happy face symbols could be used to communicate this information (sad face means B_{best} was below $40\%B_0$, happy face means $B_{best} >= 40\%B_0$) with the same colour scheme of red, yellow, and green to describe the current state of the stock, and the white symbols to indicate no information. This scheme would avoid placing the large red symbol for France as it currently appears in Figure 6.2.	The Review Group suggests replacing colours by sad/happy symbols, while losing the information on the relative importance of areas. The large red bubble for France dominates the plot, reflecting the dominating share of the total stock being located in France. We do not understand what the Review Group wants to achieve, by removing essential information.

53	p.36, Sec 6.6: the first paragraph states, '*The anthropogenic mortality ΣA is estimated to be just at (averaged over reporting EMUs) or far above (averaged over reporting countries) the precautionary level that would be in accordance with ICES general policies for recovering stocks (for EMU sums: ΣA=0.41 with target 0.42; for country sums: ΣA=1.40 with target 0.14).*' It is difficult to understand the values for the target ΣAs. In reference to Figure 6.1, the sum of the biomass indicator over all EMUs (top panel of Figure 6-1) shows the $B_{current}/B_0$ at a value of 18% which would give a maximum ΣA of 0.41 according to the rule (0.92 * $B_{current}/40\%B_0$ = 0.92 * 18%B_0 / 40%B_0). For the country sum, $B_{current}/B_0$ equals 6% which would give a maximum ΣA of 0.14 (0.92 * 0.06/0.40). Perhaps the following would be clearer to the reader: '*The biomass of escaping silver eel ($B_{current}$) estimated over all EMUs reporting was 18% of B_0. The maximum ΣA for that level of spawner production equals 0.41 (i.e. 0.92 * 0.18/0.40). The estimated realized ΣA was 0.42, at the maximum level. The biomass of escaping silver eel estimated over all reporting countries was 6% of B_0. The maximum ΣA for that level of spawner production equals 0.14 (i.e. 0.92 * 0.06/0.40). The estimated realized ΣA was 1.40, greatly above the ΣA limit.*' And But this comment should be considered in the light of what was mentioned above regarding ΣA = 0.92 for $B_{best} = B_0$ rather than for $B_{current} = 40\%B_0$.	This is editing.
	Section 7, Eel specific reference points based on the S-R relationship	
54	The development of the appropriate time series has proven to be challenging. Efforts of EU Member States to provide estimates of exploitation rates with which to derive estimates of total abundance and of spawners is an important step. However, the Working Group needs to document the input data, the methods for aggregating from local scales to ecoregion and eventually the species scale, and to be clearer on the limitations of the data and the models used. As presented, there remain major issues with how the catches are collected, collated and partitioned into life stage, and how missing data are	The WGEEL intends to develop a Stock Annex in the future to address this issue – see Annex 4: Response to Generic ToRs

	treated. The reconstruction of catches back in time for all countries is not currently acceptable based on the information provided by the Working Group. If this component of the reconstruction is flawed, then all subsequent analyses and discussions are premature.	
55	Ideally, one would want to undertake the S-R analysis with a biomass estimate for the entire panmictic stock, but there is clearly substantial silver eel production which is outside the scope covered in the analysis. For example, silver eel fisheries are generally directed at production from river systems, where silver eels can be readily caught by interceptory gear at predictable times of the year. Silver eels produced in saline areas cannot be readily caught by interceptory gear and are generally not subject to targeted fisheries (with the exception of the Baltic Sea). In addition, in the eastern and southern Mediterranean Sea, there are eel fisheries which may rival in size those of European countries (Fig. 9-10), but landings from these countries are not included in the analysis, perhaps because there are insufficient harvest data. **The question therefore arises as to how robust the approach is without these data.** If the biomass value used in the model underestimates the true stock biomass but is linearly related to it, it may be regarded as a biomass index rather than an estimate. However, there is a need to determine whether the index may be biased and whether the S-R analysis would be valid if this biomass index was 90%, 50%, 25% etc of the true biomass value.	Egypt data does not seem reliable (see catch data Chapter 2). We are working to obtain data for missing counties, but in the meantime some are still missing. Thus our SSB series are incomplete and take the assumption that missing data are proportional to documented data and thus that missing SSB are proportional to documented SSB. Underestimate of SSB translates the curve to the right, and does not challenge the B_{stoppa} concept. However deeper analysis is needed to tackle this point.
56	No evidence has been presented in this report to reinforce the depensation argument, and such a conclusion is premature. If true biomass is greater than calculated biomass, would the proposed conclusions regarding stock dynamics at low recruitment remain valid?	See Chapter 3 and comment 10

57	The management advice for European eel is the same whether the declines in indices of recruitment are due to depensation, declines in the survival of the early life stages at sea or declines in silver eel spawner quality associated with continental factors. Regardless of the mechanism, the only action that can be taken to increase recruitment is to increase spawning escapement by reducing anthropogenic mortality on the continental stages of European eel. There is no guarantee that reducing mortality at those stages will result in increased recruitment, but it is more likely that recruitment will continue to be low or decline further if anthropogenic mortality rates remain high, as estimated in this assessment.	Discussed in Chapter 3. And see #12 also
58	The detailed discussion in Section 7 is not essential for providing management advice. Higher priority for the Working Group is improving the catch data, biological sampling and the indices of abundance from this point forward.	Don't agree. Essential for addressing the management response to very low stock and recruitment. Were requested to follow up this line of thinking by ACOM.
59	Section 7.7 (p.53) considers the estimation of B_{lim}. However, if B_0 is 193 kt (not million tons - see editorial comments) then the limit reference point in the EU Eel Regulation (40% of B_0) is about 77 kt, which is >70% greater than any $B_{current}$ in the historical time series. This would imply that the stock has not been sustainably managed for more than 60 years, which then casts doubt on using the 1960-79 period as a baseline for assessment. There are clearly various possible explanations for these anomalies (incorrect estimation of B_0, β_{su}, etc) and they need to be explored.	See Chapter 3.
60	In the absence of a Stock Annex, all the parameters used in the equations and their suffixes need to be defined and parameter values used in this model (referred to in Sections 7.4 and 7.5) should be provided in the report. Data are provided for 67 of the 81 EMUs but more information should be provided on where the data have come from and flaws associated with them.	WGEEL intends to develop a Stock Annex in the future to address this issue – see Annex 4: Response to Generic ToRs

61	p.38. Sec 7.2, line 2: the text suggests that the best available proxy for SSB is the escapement that exists after all of the fisheries and other mortalities (both natural and anthropogenic) in continental and littoral waters have occurred. However this information is also unavailable, so the real proxy is reported landings.	Sec 7.4.1 from WGEEL 2013 explicitly explains how we assess escapement after anthropogenic mortalities in the continental phase. Moreover member states are required by the eel regulation to deliver escapement figure (article 9.1.a)
62	p.40, para 2: the report states that the catches were further divided by stage (yellow and silver eel) based on collected series made available to WGEEL or by expert knowledge. This information should be included in a table.	WGEEL intends to develop a Stock Annex in the future to address this issue – see Annex 4: Response to Generic ToRs
63	p.40, Sec 7.11.1: (NB Section number is incorrect.) All the parameters used in the equations and their suffixes need to be defined: s appears to refer to silver eels but is not really required; H appears to be the instantaneous rate of anthropogenic mortality but is later set at 0 so could be omitted; 't' is undefined but is shown to refer to year in Sec 7.5 and, as such, should be shown as a suffix (at present it appears to be a variable). For clarity, a symbol other than β should be used for exploitation rate, as it is easily confused with the biomass symbol.	Section deleted in this year's report
64	p.40, Sec 7.4: The use of expert opinion to derive starting values for exploitation rates is a good beginning in the effort to develop estimates of silver eel escapement. However, there is insufficient information to allow the reader to understand how the expert opinions on exploitation rate were developed, why the aggregation for ICES ecoregions at this stage, and how the exploitation rates for an ecoregion and time period were determined	WGEEL intends to develop a Stock Annex in the future to address this issue – see Annex 4: Response to Generic ToRs
65	p.47, below Figure 7.6, line 3: a reference is given to 'equation (0)', but only one equation is numbered (p.41) so this is not very helpful.	Section deleted in this year's report
66	p.49, Figure 7-8: there appears to be a leveling or upturn of escapement in the Baltic, North Sea and Celtic Sea but not Bay of Biscay and Mediterranean; can this be attributed to the management measures?	The figure 7-8 shows more variation from year to year and no clear upturn. See also Chapter 3.
67	p.51, Figure 7-10: need to make clear in caption that catches are silver eels only.	WGEEL intends to develop a Stock Annex in the future to address this issue – see Annex 4: Response to Generic ToRs

68	p.51, Sec 7.6, para 2: Lines 2–5 provide an awkward and incorrect description of S–R relationships. The Beverton–Holt function has maximum recruitment occurring at infinite spawner abundance, not compensation for high recruitment. Both Ricker and Beverton-Holt have maximum recruits per spawner at the origin, declining monotonically with increasing spawner abundance, and recruitment increases faster than SSB for SSB less than the value for maximum gain.	Description revised Chapter 3.
69	p.53, second Figure 7-9: y-axis label should be 'Biomass / B_0 (%)' and this should be reflected in the caption.	See # 59 Since we have concern about B_0 estimate, the biomass in the stock–recruitment graph are kept in tonnes
70	p.54, Section 7.8, para 5: This paragraph provides a confusing (or incorrect) explanation of the replacement line; in the absence of density-dependent processes the potential for spawning stock production should defined by the gradient of the S-R relationship not by the replacement line.	Paragraph removed in this year's report
71	Figure 9-9, showing '*Total landings (all life stages) from 2013 Country Reports (not all countries reported); the corrected trend has missing data filled by GLM.*' should be moved to this section of the report as this is the figure for modelled landings. Figure 9-9 should not appear in Section 9 as it gives the impression to the reader that landings are reported for all those countries back to 1945.	Since the chapter has been restructured, there is no more reason to move this figure
	Section 8, Discussion of assessment methods and results	None
	Section 9, Data and trends	
72	Section 9.1 describes the time-series of data on glass and yellow eel recruitment. The selection of time series and the method used to combine them need more explanation (see also editorial comments). The fact that some time series have been terminated because of lack of recruits (e.g. Ems and Vidaa) suggests that the use of time series starting and ending at different times may introduce biases. It is recognised that efforts must be made to make the best use of available data, but the data can be tested to see whether such biases exist. For example, if there were two groups of time series with group 1 spanning the period from 1980 to 2000 and group 2 the period from 1980 to the present, the groups could be compared over the initial period to see whether the loss of group 1 might	The WGEEL 2010 considered spatial structure of the recruitment. Table 2.1 p15, for the series discontinued in France, the clusters are different, groups1 (Adour 2 series, Gironde 2 series), 3 Loire, 5Vilaine. Please also look at figure 2.16 page 43: The Biscay series are in red on the right, they have the same trend as those in British Isles or the Mediterranean.

	introduce a bias in the later years.	
73	Limited information is provided on the time series that are excluded from the analysis and the reasons. It would be helpful to include in Tables 9-1 to 9-3 (Annex 7) the start and end date of the time series, the number of years for which estimates are available, and any comments about potential uncertainty in the data, e.g. if sampling is conducted upstream of a fishery. More explanation is required on the fluctuating nature of the recruitment series in Figures 9-3, 9-4 and 9-5.	None are excluded, series are now scaled to their average value before the GLM. The series that are excluded from scaled graphs are described now
74	Section 9.2 describes trends in yellow eel and silver eel abundance from a small number of monitoring programmes. The data are not presented in tabular form and are difficult to interpret from Figure 9-7. The data are limited but sufficient to suggest that the relationship between recruitment and yellow/silver abundance can be complex. These complexities provide another reason for suggesting non-stationarity in any S–R relationships.	The WGEEL has removed the yellow eel and silver eel trend series graph, those should not be considered as representative of the trend in stock size. The relation between recruits and subsequent yellow eel abundance has no relation to the stock-recruit-relation. Anthropogenic mortality on yellow and silver eel interfere.
75	The conversion of stocking numbers to glass eel equivalents should attempt to include all mortality between capture and release (p.104). It is not clear why this has not been modelled.	An assumed and reasonable M was applied and that mostly in order to facilitate comparisons between different sizes of eels used for stocking. The possible mortalities when using different methods to catch glass eels is a totally different issue that has nothing to do with this simple way of "equalisation", and has to be addressed in another context.
76	Stocking remains an important, and contentious, issue for eel management and so more should be made of these data. It may be possible, for example, to assess the proportional loss or gain of glass eel equivalents in different areas to assess the extent that stocking could be impacting stock abundance.	This is true and a net benefit is a prerequisite for stocking. This issue has been dealt with in recent WGEEL Reports, e.g. in the chapter on STOCKEEL in the WGEEL Report from 20111.
77	p.62, Sec 9.11.1 and Figure 9-1: It is unclear what the figure is showing; the number of available time series should never decrease, so is this the number of 'active' time-series? Does this ignore gaps in the time series?	Yes active series, corrected in the caption now.

78	p.62, final para: it appears that time series are only used in the analysis if they exceed a certain number of years, and it would be helpful if this was explained here rather than in Section 9.11.3; how large a gap is acceptable? The time series are scaled to the 1979-94 mean, but it is not clear whether data must be available for that full period or for a certain number of years within it; this is a potential source of bias. It appears that any time series spanning the 1979-94 period might be used; so how was the 35 year limit determined?	Yes in 2013 the series had to have data in the 1979-1994 period for the calculation of the WGEEL recruitment index, not in 2014. 35 years limit was only used to limit the number of series shown in graph 4.3 and 4.4 presenting the raw data. The only limitation now is of course having data in the baseline period.
79	p.64, para 2: to aid reading in future years, specific years should be referenced, i.e. 'In 2012, …', etc. rather than 'Last year, …'.	Noted
80	Is any lag (negative) applied to the yellow eel time series to compare them with the glass eels - or should it be? The y-axis caption indicates a ratio, but the data show %; this should be the same as Figure 9-4.	No, and no it would be difficult to have an idea of the age structure of the different series which include Baltic series and some other places in Europe. The scaling is done on the same period as the glass eel series, though it could have spanned a longer period as more than four reliable series were available after 1946. But we have chosen to be consistent between the two time trends. Note that figures 4.5 4.6 and the tables 4.1 4.2 consistently express the recruitment as a percentage of the baseline period 1960 -1980.
81	p.65: Figure 9-4 is not referred to in the text and has a confusing caption; the time series of glass and yellow eel are not shown in the figure as suggested; in addition the difference between the 'mean values' shown in Figures 9-2 and 9-4 is unclear (or are they the same?).	We do not understand this comment. The figure does show the average of the glass eel (in blue) and yellow eel (in brown) series. Some text has been added to clarify why this figure is drawn. The value is the same as in figure 4.3and this has been explained by a footnote reference.
82	p.66, para 4: the first two sentences say the same thing; no indication is given of the state of the recruitment indices between 2006 and 2012 (i.e. where the indices have increased.)	Noted
83	p.68, Figure 9-5: it should be possible to add confidence limits for the GLM estimates.	No. We would then have to do the average of the confidence intervals of the predictions of all sites. And this would not be meaningful.
84	p.69, Figure 9-6: indicates that there is a smoothed trend with confidence intervals but there is no description of how the smoothing was performed.	Point taken, smoothing removed
85	p. 69–70: It is difficult to conclude anything from the description of the yellow eel time series. There is no reference to Figure 9-7 in the text, and it is not clear what conclusion is drawn from these data.	No overall conclusions, figure deleted from the report Yellow eel abundance

86	Table 9-6 (Annex 7): It would be helpful to clarify the difference between years for which there are no data, years when the fishery was closed and years with a fishery but no catch (if this occurs).	Information is given in the main text (collection of landings statistics by country)
87	p.71 and Figure 9-8: the text refers to three Scottish data series but only one is shown in the figure. Additional data series from Sweden and France are described but are not presented in tables or figures. Why not?	Done, figure 9-8 deleted from the report, table moved to the accompanying electronic annex.
88	pp 72–76: Sections 9-3 and 9-4 both describe landings data from the Country Reports and it is unclear why there are two sections.	Section 9-3 describe commercial landings, section 9-4 is dedicated to recreational catches.
89	p.73, Sec 9.3: there is no specific description of the reported/estimated [WGEEL: WHAT IS MISSING HERE?] in this section and more information is provided elsewhere in the report; more information is required on how different parts of the fisheries have changed (i.e. glass, yellow. silver eel). How has the EU Regulation affected the data, i.e. national closures and other measures?	This section deals only with landing statistics and type of reporting
90	p.73, Figure 9-9: This figure should not be presented in Section 9 as it gives the impression that landings are reported for all those countries back to 1945. If such modelling results are presented, minimally, an accompanying panel should show the total reported landings, the modelled predicted landings, and the proportion of the predicted landings which are reported; Figure 2 shows an example developed using the data in Table 9.6. It is striking that the reported landings during 1945 to about 1992 totalled about 10 000 t annually.	Agreed; as was done in our previous reports. The remarkable level of underreporting has been analysed/discussed by Dekker (2003). The apparent stability from 1945 to 1992 is very misleading. Detailed information, comparable over time, from areas with consistent data, do show the decline. Graph deleted from the report.
91	p.73, para 3: (the reference to Figure 8-10 should be Figure 9-10.) It would be more helpful to compare the mean catch over a number of years in countries reporting to WGEEL and countries not reporting to WGEEL rather than highlighting 2006.	Noted
92	p.78, Table 9-7 and 9-8: It is unclear what can be drawn from Table 9-7 and no explanation is provided in the text. Similarly, no conclusions are drawn from Table 9-8.	Information fulfilled

93	p.81: Sections 9.5 deals with the compilation of data on stocking and Sections 9.6 evaluates the size and origin of stocked fish and the development of 'glass eel equivalents'. These Sections seem out of place in this sequence, as section 9.7 is about fishing effort. Section 9.5, 9.6, and 9.8 deserve their own main section, given the question and the amount of detail.	Section 9.6 deleted from the report.
94	p.81: it would be helpful to clarify that the data presented in Figures 9-11 and 9-12 are derived from Tables 9-9 and 9-10 respectively; while information is provided on the stocking programmes in each country, it would be helpful to provide a summary that explains the overall trends in the data. Are there differences in the regional trends? What caused the decline in glass eel stocking from around 1990 and the increase in yellow eel stocking around the same time? Figure 9-13 presents the ratio of yellow to glass eel stocking, but is not referred to in the text.	Note taken for future reports. The change in glass eel versus yellow eel stocking is mainly due to the increased use of larger, pre-grown eels for restocking. For some eastern European countries it is not possible to restock with glass eels in early spring due to ice cover.
95	p. 102, line 6: An annual mortality of 0.138 for glass eels seems unlikely. If the true mortality is higher than this, then the estimate of the number of 'glass eel equivalents' stocked will be underestimated.	If M = 0.138 is that unlikely, the numbers are underestimated. However, the idea behind the equivalents is mainly to make different stocking materials comparable and to simplify further calculations. Besides, the WGEEL made an extensive review on natural mortalities in the 2012Report (Chapter 7 in ICES CM 2012/ACOM:18)
96	p.106–107, Figures 9-13 & 9-14: The captions refer to United Kingdom (GB); Northern Ireland is part of UK but not part of GB, so either UK or GB should be referred to. NB: with reference to other sections, GB is not an EU Member State, UK is.	ICES vocabulary (ICES Reference Codes RECO Vocabulary v2.0 q) United Kingdom is abbreviated as GB (and N Ireland GB-NIR)
97	p.107: Section 9.7 deals with effort, which potentially provides a means for assessing trends in exploitation used in run-reconstruction approach, but no reference is made to these data in Section 7.	Effort section not updated this year
98	p.109: Section 9.8 presents data on aquaculture from three sources, which show essentially the same trends. No explanation is provided for the decline in eel aquaculture production, although this appears surprising at a time when availability of wild caught eel must be declining. Is this because of difficulties of obtaining juvenile eels for on-growing?	Cause of negative trend is a combination of glass eel availability and prices, and lower market demand.
	Section 10, Glass eel landings and trade	
99	Sections 10.2 to 10.4 deal with glass eel catches and trade, and thus cover much	Comment noted for future reference.

	of the same ground as Sections 9.1, 9.5 and 9.6. Sections 10.5 and 10.7 address stocking and aquaculture and therefore overlap with subsections 9.5, 9.6 and 9.8. Overall these sections are confusing, and it would be helpful to identify clear objectives for collating these data; the analysis could then be directed towards achieving those aims. These objectives might be to (reliably) quantify the anthropogenic losses to stocks from fishing and additions to stocks from stocking, and assess likely future trends.	
100	There is a requirement under EMPs that those MSs with glass eel fisheries must set aside 60% for stocking, but there is no requirement for MSs to purchase these eels. Section 10.8 concludes that the stocking target is not being achieved by all MSs. Why are the remaining countries not stocking and not reaching targets – funding? Is the Working Group able to comment on where traceability is working and why data presented in Country Reports, EuroStat, etc. differ?	This was addressed in Section 10.7 of the 2013 report. The time frame for WGEEL meeting is insufficient for a detailed trade data analysis to scrutinize possible sources for differences in source data
101	The information in Section 10.2 to 10.4 appears to be relevant to the EU-CITES Committee in relation to CITES discussions on the listing of eel, but it is not clear whether they are provided for or used by that committee.	SRG request ICES advice and sight of the data and report. This was complied with.
102	p.115, final para: it is stated, '*EuroStat can well describe glass eel exports in Europe*' despite a number of caveats being highlighted; does this comment apply to the raw or corrected EuroStat data?	Corrected Eurostat data.
	Section 11, Assessment of quality of eel stocks	
103	Section 11.2 provides a useful review of recent literature on contaminants, diseases and parasites on the quality of emigrating eels. An update is provided on incidence of *Anguillicola crassus* in different countries but much of the information is not quantitative. Section 11.3 provides preliminary results from a model estimating the reproductive potential of silver eels when they reach the Sargasso Sea, depending on origin, size, sex, and initial fat content. While the report indicates many uncertainties in the model, the results highlight some interesting and potentially important considerations concerning the reproductive potential of eel from different areas (particularly the effects	Comment noted for future reference.

	of distance to the spawning areas and size at emigration). The Working Group might consider incorporating uncertainties into the model, thus allowing an assessment, for example, of the proportion of eels that have a greater than X% probability of having a reproductive potential > Y.	
104	While the current results are very interesting, it is premature to state, '*The new figures show considerable variation in reproduction potential between countries/catchments*.' (Section 11.6), and the Working Group should be more cautious about their conclusions.	Comment noted. We still believe the figures show variation as indicated. The shortcomings of the model and uncertainties with respect to the data, used to elaborate the figures have been discussed.
105	More work is required on some of the model inputs (e.g. energy costs of migration under oceanic conditions (effects of currents and pressure at different depths), the influence of shoaling, etc).	Fully agreed.
106	Monitoring eel quality is an expensive undertaking, and at the moment no guidance is available to prioritize what assessments should be conducted that will give meaningful information. While this is potentially important work, it should be evaluated against other data deficiencies and research needs to ensure that it is the highest priority area for improving the assessment and management of eel; at present collecting adequate information on catches, biological characteristics, and abundance indices that can be used to deliver a stock wide assessment must be a higher priority. Any progress made on improving the knowledge about the effects of contaminants will be difficult to incorporate in a stock wide assessment that doesn't exist.	Comment noted.
	Section 12, Local stock assessment	
107	This section makes proposals for standardizing data collection to simplify and improve provision of reports to a range of customers/fora. Such efforts are to be commended, although the Working Group should be cautious about seeking excessive detail in the data reporting.	Agreed.
108	Other information requirements are to address commitments on monitoring activities or commitments to CITES and it is not clear that these should be led by Science, including ICES.	This is not an actionable recommendation.

109	The priorities for the assessment are probably: Catch-effort-cpue (Sec 12.2) Stock (*not stocking*) indicator table (Sec 12.6) Estimate of B_0 (Sec 12.11.2) Biological data (Sec 12.9) Management measures overview (for estimating changes in exp. rates) (Sec 12.8) Management measures details (including expected effect on the stock) (Sec 12.11.3) Other data tables listed are used for responding to other commitments unrelated to the assessment of the EU Eel Recovery Regulation.	Actioned to some extent in this report and noted for future reference and development.
	Sections 13 and 14, Forward focus and Research needs	
110	Section 13 provides a brief history of eel management over the past ~5 years and an evaluation of the assessments provided in Sections 4-8. It covers much of the same ground as Section 8 and might sensibly be combined with or replace that section. Section 14 addresses data deficiencies and research needs identified by the Working Group, although more detail on some research areas is provided in other sections and not all the proposals are for research. It would be helpful to have all the data deficiencies and research needs described in similar detail in one section. This needs to be accompanied by an evaluation of the priorities for the various proposals and a more systematic examination of what is feasible. Such an examination would assist in determining which analyses should be pursued and which dropped. At present it is difficult to determine whether eel quality, for example, is the most pressing research need or just has the most fervent advocate.	Agreed. Time constraints prevented this during the 2014 meeting but it is noted for 2015.
111	It would be helpful if future ToR clearly reflected (a) the specific advisory requirements (e.g. report on the status of the European eel stock by region), (b) methodological developments to meet those advisory needs (report on the further development a stock–recruitment relationship for European eel), (c) other issues requiring attention in order to provide the advice (e.g. research and data needs) (e.g. report on the development of methods to incorporate eel quality in current	Done – the 2014 ToR were designed with this recommendation in mind, and recommendations for ToR for 2015 are similarly designed.

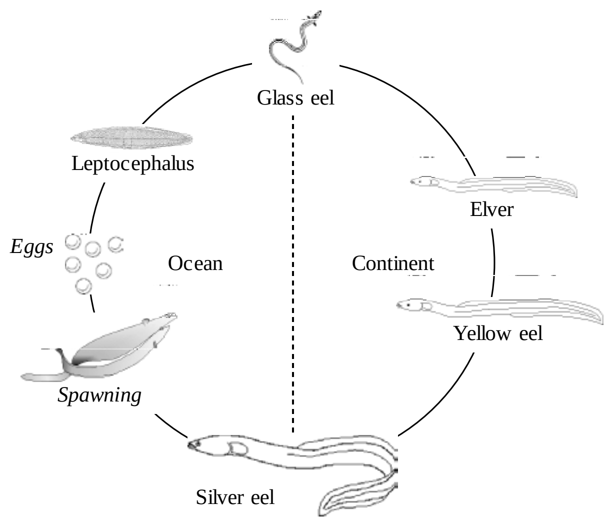
	assessments.)	
112	It is not clear where Recommendation 1 originates from in the report. The following recommendations are made in the report but not included in Annex 4: p.132: It is recommended that all countries adhere to the conditions laid out in the Eel Regulation of 2009 and establish the required international traceability system in line with Article 12. p.154: WGEEL 2013 recommended the development of standardized and harmonized protocols for the estimation of eel quality through the organization of a Workshop of a Planning Group on the Monitoring of Eel Quality). p.155, Sec 11.8: We recommend that monitoring of silver eel quality should be introduced as part of new or existing programmes (DCF/DCMAP). p.185: It is recommended that research to investigate factors that cause Natural Mortality (M) to vary in space and time be given the high priority. Thus further data collection and research should be encouraged to support and improve the knowledge of this difficult research topic in order to obtain more and more reliable stock assessments.	Recommendations are collated in Annex 7.
113	It is not clear why some tables are in this Annex while others are in the text. [NB Is there a standard ICES format; e.g. placing all tables and figures at the end of each section?]	Most tables are now placed at the end of relevant chapters, with the exception of some large tables that are provided as accompanying electronic tables.

Annex 9: Glossary

Eel life history

Eels are quite unlike other fish. Consequently, eel fisheries and eel biology come with a specialized jargon. This section provides a quick introduction. It is by no means intended to be exhaustive.

There are two species of eel in the North Atlantic, the European eel (*Anguilla anguilla*) and the American eel (*A. rostrata*).



The life cycle of the European eel. The names of the major life stages are indicated; spawning and eggs have never been observed in the wild and are therefore only tentatively included. **(Diagram: Willem Dekker).**

The European eel *Anguilla anguilla* (L.) is found and exploited in fresh, brackish and coastal waters in almost all of Europe and along the Mediterranean coasts of Africa and Asia. The life cycle has not been fully elucidated but current evidence supports the view that recruiting eel to European continental waters originate in a single spawning stock in the Atlantic Ocean, presumably in the Sargasso Sea area, where the smallest larvae have been found. Larvae (*Leptocephali*) of progressively larger size are found between the Sargasso Sea and European continental shelf waters. While approaching the continent, the laterally flattened *Leptocephalus* transforms into a rounded glass eel, which has the same shape as an adult eel, but is unpigmented. Glass eel migrate into coastal waters and estuaries mostly between October and March/April, before migrating, as pigmented elvers, on into rivers and eventually into lakes and streams between May and September. Following immigration into continental waters, the prolonged yellow eel stage (known as yellow eel) begins, which lasts for up to 20 or more years. During this stage, the eels may occupy freshwater or inshore marine and estuarine areas, where they grow, feeding on a wide range of insects, worms, molluscs, crustaceans and fish. Sexual differentiation occurs when the eels are partly grown, though the mechanism is not fully understood and probably depends on local stock density. At the end of the continental growing period, the eels mature and return from the coast to the Atlantic Ocean; this stage is known as the silver eel. Female silver eels are twice as large and may be twice as old as males.

Bootlace, fingerling	Intermediate sized eels, approx. 10–25 cm in length. These terms are most often used in relation to stocking. The exact size of the eels may vary considerably. Thus, it is a confusing term.
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.
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.
River Basin District	The area of land and sea, made up of one or more neighbouring river basins together with their associated surface and groundwaters, transitional and coastal waters, which is identified under Article 3(1) of the Water Framework Directive as the main unit for management of river basins. The term is used in relation to the EU Water Framework Directive.
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.
Stocking	Stocking (formerly called restocking) is the practice of adding fish [eels] to a waterbody from another source, to supplement existing populations or to create a population where none exists.
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: 35–46 cm) (Tesch, 2003).
Yellow eel (Brown 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).

Eel reference points/population dynamics	
Curent escapement biomass ($B_{current}$)	The amount of silver eel biomass that currently escapes to the sea to spawn, corressponding to the assessment year.
Best achievable biomass (B_{best})	Spawning biomass corresponding to recent natural recruitment that would have survived if there was only natural mortality and no stocking, corressponding to the assessment year.
Pristine biomass (B_0)	Spawner escapement biomass in absence of any anthropogenic impacts.
$B_{MSY\text{-}trigger}$	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_{stop}	Biomass of the spawning stock, at which recruitment is severely impaired, and the next generation is (on average) expected to produce an equally low spawning-stock biomass as the current.
B_{stoppa}	Biomass of the spawning stock at which recruitment is severely impaired, and the next generation has a 5% chance to produce an equally low spawning-stock biomass as the current.
Limit anthropogenic mortality (A_{lim})	Anthropogenic mortality, above which the capacity of self-renewal of the stock is considered to be endangered and conservation measures are requested (Cadima, 2003).
Limit spawner escapement biomass (B_{lim})	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).
Precautionary anthropogenic mortality (A_{pa})	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.
Precautionary spawner escapement biomass (B_{pa})	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.
R_{target}	The Geometric Mean of observed recruitment between 1960 and 1979, periods in which the stock was considered healthy.
Spawner per recruitment (SPR)	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.
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.
"3Bs & A"	Refers to the 3 biomass indicators (B_0, B_{best} and $B_{current}$) and anthropogenic mortality rate (ΣA).

Definition

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

Acronyms

ACRONYMS	DEFINITION
ACE	Advisory Committee on the Environment
ACFM (ICES)	Advisory Committee on Fisheries Managment
ACOM (ICES)	Advisory Committee on Management
AFN	National Forestry Authority
AIC	*Akaike Information Criterion*
ANCOVA	Analysis of Covariance
ANOVA	Analysis of Variance
BERT	Bayesian Eel Recruitment Trend model
BIC	*Bayesian Information Criterion*
BIOR	Institute of Food Safety, Animal Health and Environment "BIOR", Latvia
CCM	Catchment Characterisation and Modelling
CITES	Convention on International Trade in Endangered Species
CNTS	Centre National de Traitement Statistiques, France (ex CRTS)
COMM	EU Commission
CPUE	Catch per unit of effort
CR	Country Report
CUSUM	Cumulative Sum Control Chart
DBEEL	Database on Eel (EU POSE project)
DCAL	Department of Culture, Arts & Leisure, N. Ireland
DCF	Data Collection Framework
DFO	Department of Fisheries and Oceans
DG-MARE	Directorate-General for Maritime Affairs and Fisheries, EU Commission
DGPA	General Directorate of Fisheries and Aquaculture, Portugal
DLS	Data-Limited Stocks
DPMA	Direction des Pêches Maritimes et de l'Aquaculture, France
EIFAAC	European Inland Fisheries & Aquaculture Advisory Commission
EMP	Eel Managment Plan
EMU	Eel Management Unit
EFF	European Fisheries Fund
FAO	Food and Agriculture Organisation
FEAP	The Federation of European Aquaculture Producers
FGFRI	Finnish Game and Fisheries Research Institute
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
HPS	Hydropower Station
ICES	International Council for the Exploration of the Sea
LHT	Life History Trait
L50	L50 = the length (L) at which half (50%) of a fish species may be able to spawn
LVPA	Length-based Virtual Population Assessment

Acronyms	Definition
MIWA	Marine and Inland Waters Administration
MS	Member State
MSY	Maximum Sustainable Yield
NAO	North Atlantic Oscillation
ONEMA	Office National de l'Eau et des Milieux Aquatiques, France (ex-CSP)
POSE	Pilot projects to estimate potential and actual escapement of silver eel
RBD	River Basin District
RGEEL	Review Group on Eel (ICES)
SGIPEE	Study Group on International Post-Evaluation on Eels
SLIME	Restoration the European Eel population; pilot studies for a scientific framework in support of sustainable management
SMEPII	Scenario-based Model for Eel Populations, vII
SNPE	Suivi national de la pêche aux engins et aux filets
SPR	Estimate of spawner production per recruiting individual.
SQL	Special purpose programming language for managing data
SSB	Spawning–Stock Biomass
STECF	Scientific, Technical and Economic Committee for Fisheries, EU Commission
SWAM	Swedish Analytical Models
ToR	Terms of Reference
VPA	Virtual Population Analysis
WG	Working Group
WGEEL	Joint EIFAAC/ICES/GFCM Working Group on Eel
WKEPEMP	The Workshop on Evaluating Progress with Eel Management Plans
WKESDCF	Workshop on Eels and Salmon in the Data Collection Framework
WFD	Water Framework Directive
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”
WGRFS	Working Group on Recreational Fisheries Surveys
YFS1	Young Fish Survey: North Sea Survey location

Annex 10: Country Reports 2013–2014: 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 are presented. These Country Reports aim at presenting the best information which does not necessarily coincide with the official status.

Participants from the following countries provided an updated report to the 2014 meeting of the Working Group on Eels:

- Belgium
- Denmark
- Estonia
- Finland
- France
- Germany
- Greece
- Ireland
- Italy
- Latvia
- Lithuania
- Montenegro
- Netherlands
- Norway
- Poland
- Portugal
- Spain
- 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 2013/2014.