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

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International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

H. C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

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Executive Summary

The Joint EIFAAC/ICES/GFCM Working Group on Eel [WGEEL] met in Antalya, Turkey from 24th November to 2nd December 2015. The group was chaired by Alan Walker (UK) and there were 36 participants representing 19 countries. Two representatives of the EU Commission DG MARE attended as observers. A full address list for the meeting participants is provided in Annex 3. Algeria was represented at the Working Group for the first time.

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 indices fell from 2014 levels, to 1.2% of the 1960–1979 reference level in the 'North Sea' series, and to 8.4% in the 'Elsewhere' series. The 'recruiting yellow eel' index has also fallen to 11% of the level during the reference period. 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.

Some potential statistical issues have arisen in relation to biases in the data due to factors relating to data at the low and high extremes. The consequence of this effect will need to be evaluated in a future meeting.

Following the 2015 progress reporting of the EU-assessed area and based on the stock indicators provided by EU Member States, it was concluded that the stock in most reporting countries/areas was not within the biomass limits of the Eel Regulation and in most management units, anthropogenic mortality is not at a level that can be expected to lead to recovery. The stock in the reporting areas as a whole remains outside the biomass limit, as defined in the Regulation, and average mortality over this area was not at a level that can be expected to lead to recovery.

A pilot study has been undertaken by the countries in the GFCM region which has included a comprehensive data gathering exercise and a preliminary standardised modelling assessment on all the tidal lagoons (123) and on the main rivers (12) and lakes (ten) in the region. The model needs to be validated and some data gaps need to be filled before this can be accepted as reliable information on levels of silver eel production and escapement. The assessment covers approximately 78% of the wetted area of eel habitat within the Mediterranean region.

The total landings from commercial fisheries in 2014, provided in Country Reports and other statistics, were about 4500 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 exist in environments, fishing gears, and 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 2014. Stocking is a component of many Eel Management Plans and in some cases the commitment could not be achieved in 2015 due to timing, market and other glass eel availability

issues. Aquaculture production has slightly decreased from 8000–9000 tonnes in 2004 to about 4000–6000 t in 2014. Some aquaculture production was subsequently used in stocking.

The working group further explored 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 (silver eel biomass relative to the best estimate of escapement that would have existed if no anthropogenic influences had impacted the stock).The management biomass reference limit of 40% of B_0 for eel, a Category 3 species in the Data-Limited Species approach, is in line with the 40% maximum spawning potential (at F=0) reference point (a common proxy for MSY) advised for category 3 and 4 species by ICES (2015a: WKLIFE V). Given the EU B_{lim} of 40% builds in a precautionary boundary above the standard 30% and is equivalent to the 40% maximum spawning potential, see above, the EU 40%, and its equivalent mortality limit may be used as the limit reference point for eel in the provision of advice with respect to management of the eel stock. Because current recruitment is far below its 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. The Eel Regulation indeed aims to achieve its objective "in the long term", but it does not specify this duration. This reference point for biomass must then be considered as a long-term objective and the need for a short-term mortality limit is advocated.

The overview of models and methods used to estimate national stock indicators was updated based on information provided in the national EMP Progress Reports 2015 and the 2015 Country Reports. The Working Group also developed a more efficient data reporting spreadsheet and accompanying Country Report template, and made recommendations for more efficient work based on an internal review.

The Working Group reviewed previous recommendations regarding data deficiencies, monitoring needs and research requirements, reiterating and refreshing those that remained outstanding. A synopsis of new and emerging threats and opportunities for the eel stock and its assessment was also prepared. This included climate change, invasive species, emerging contaminants and diseases, and renewable energy developments.

During the meeting, the Working Group made a first version of a Stock Annex for Eel using the standard template. The aim of the new stock annex was to summarise the common aspects of eel biology, mortality and management and provide a background to eel science and the management process. A chapter fully describes the analysis of the recruitment data used in the ICES advice. The next steps for the development of the annex are described.

1 Introduction

1.1 Main tasks

The Joint EIFAAC/ICES/GFCM Working Group on Eel [WGEEL] (chaired by: Alan Walker, UK) met in Antalya, Turkey between 24th November and 2nd December 2015 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 opened at 09:00 am on Monday 24th November (the meeting agenda is provided in Annex 4). The terms of reference were met.

The report chapters are linked to ToR, as indicated in the table below. ToR 1 (Assess the latest trends in glass and yellow eel indices and produce the first draft of the ICES annual eel advice) was addressed by the Working Group, by correspondence in order to meet the deadline of 2nd October, ahead of the annual Working Group meeting. The advice was published (ICES, 2015b). The scientific report supporting the advice is published on the www.ICES.dk website, but is also provided in this document in Annex 8.

ToR 2	Progress the development of the whole-stock assessment methods using the latest available data	Chapter 4
ToR 3	Progress an eel stock annex and make recommendations for further work	Annex 10
ToR 4	Review developments in the standardization of methods for data collection, analysis and assessment and make recommendations for further work	Chapter 6
ToR 5	Identify relevant data deficiencies, monitoring needs and research requirements	Chapter 7
ToR 6	Report on significant new or emerging threats to, or opportunities for, eel conservation and management	Chapters 8 & 9
ToR 7	Address the generic EG ToRs from ACOM	Annex 6

In response to the ToR, the Working Group considered ten Country Report Working Documents submitted by participants (Annex 13); 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 2.

1.2 Participants

Thirty-six experts attended the meeting, representing 19 countries. Two representatives of the EU Commission DG MARE attended as observers. A full address list for the meeting participants is provided in Annex 3. Algeria was 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 2 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 the planning and execution of measures to ensure the protection and sustainable use of the population of European eel.

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 restocking practices, hence only natural mortality operating on stock.
- Anthropogenic mortality (impacts):
    - 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. $\Sigma A = \Sigma F + \Sigma H$. 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. EU Member States again reported on progress with implementing their EMPs in 2015. A preliminary account of the stock indicators reported is provided in this document (Chapter 4).

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). Recent developments in this work of GFCM countries are reported in this document (Chapter 9).

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 currently banned (decision renewed by EU CITES Scientific Review Group SRG in October 2015), but trade from non-EU Range States to non-EU countries is still permitted. ICES (2015b) recently advised the EU CITES SRG on criteria and thresholds that might be used in forming a future application for a Non-Detriment Finding (NDF).

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 (2015). 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 WGEEL on the status of national eel production each year.

The status of eel production in EMUs is assessed by national or subnational fishery/environment management agencies. 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 2010a, 2011b) and WGEEL (ICES 2010b, 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, and has been applied again this year using the data reported in 2015 Progress Reports and Country Reports.

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 methodologies for giving scientific advice on management to effect a recovery in the international, panmictic stock.

2 ICES Stock advice

The ICES advice on the status of the stock and catch options for 2016 were prepared before the meeting. This Advice has been published on the ICES website, at European eel (*Anguilla anguilla*) throughout its natural range. The report describing the data and analysis supporting this advice have been published on the ICES website Analysis of Recruitment Trend and is provided as an annex to this report (Annex 8).

3 Recommendations from WGEEL 2015

Priority	Recommendations for intersessional work(shops)	To whom
	Developing the whole-stock assessment process	
High	In 2016, a workshop (workshop on eel assessment rationalisation and standardisation, WKEARS) is convened to review the substock-scale stock assessment approaches to identify where aspects could be merged, combined, or redundancies reduced in order to simplify the assessment approach across the distribution of the eel, to facilitate both inter-calibration and summing of sub-scale stock indicators to a robust whole-stock assessment.	SCICOM, ACOM
High	In 2016, a workshop is convened on ocean climate processes relevant to eel (WKOCRE). This workshop, in cooperation with the Working Group on Ocean Hydrography (WGOH) would compile time-series of indices that might relate to the migratory success of spawners and larvae in the ocean, and report on any significant explanatory relationships that could be used to reconstruct recruitment or spawning stock time-series.	SCICOM, WGOH
Medium, because 2017	In 2017, a new working group (WGESR) 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, and to define reference points. A new WG is proposed because this will be a multiyear program.	ACOM/SCICOM
	Developing stock assessment in the Mediterranean region	
High	In 2016, a workshop is convened to develop good practice guides and training protocols in eel data collection and analyses for assessment purposes (WKGPGEEL). This will be of particular value for those who are developing new programs of work. Links should be drawn to the EU data collection framework process.	GFCM
High	In 2016, a workshop is convened on good practice in developing and implementing Eel Management Plans (WKDIEMP). This will support GFCM countries that are developing EMPs.	GFCM
	Developments in management measures in support of stock recovery	
Low	A workshop is convened to update knowledge of the net benefit of stocking to the recovery of the eel stock, and to make proposals for research to fill any crucial knowledge gaps that prevent a definitive advice on stocking as a stock conservation measure (WKSTOCKEEL). The priority is Low because at this time it is not clear what new evidence is available to progress this topic. Should new infomation arise, priority will increase.	SCICOM

PRIORITY	RECOMMENDATIONS FOR OTHER EXPERT GROUPS	TO WHOM
High	In 2016, the workshop on WKBECEEL (January) should develop recommendations on the path towards incorporating eel quality indicators in stock assessments. This path will probably include further workshops to progress different aspects of the challenge. These workshops could include those to collate time-series of eel quality indices from 1950 onwards; on the potential effect of contaminants on eel quality; and on potential effects of eel quality to stock size.	WKBECEEL

PRIORITY	RECOMMENDATIONS FOR INTERNATIONAL–SCALE RESEARCH	TO WHOM
High	An international program of research be commenced to standardize and cross calibrate the assessment methods used to estimate silver eel escapement throughout the distribution of the European eel.	
High	An international program of research be commenced to address assessment of eel production from open waters throughout the distribution, including testing common methods and cross-calibrating different methods.	

PRIORITY	RECOMMENDATIONS FOR ACTIONS TO IMPROVE NATIONAL AND INTERNATIONAL ASSESSMENT AND REPORTING	TO WHOM
	Eel recruitment time-series identified by ICES as contributing to the annual inter-national stock assessment process are secured and time-series for eel recruitment in non-EU countries (e.g. Norway, Turkey, Egypt, Tunisia, and Morocco) are established as a matter of urgency.	
	Stocked eel should be marked in a way that identifies them as stocked, and in different countries.	
	Assessment reporting is done in full and using templates where available; additional templates are provided where required.	
	Application of and adherence to the requirements laid out in Articles 9 & 12 of the Eel Regulation in respect to reporting and development of a traceability system.	

4 ToR 2) Progress the development of the whole-stock assessment methods using the latest available data

4.1 Introduction

The Working Group has further considered and here reports on developments in the three available stock assessment approaches: (i) analytical developments in the recruitment time-series, (ii) update of stock indicators from 2015 EMP Progress Reports and Country Reports, and (iii) considerations for in future developing stock advice from the stock indicators and/or the stock recruitment relationship. The chapter also provides updates of the latest available data on time-series of eel exploitation, aquaculture production, eel stocking, etc., as these provide further information on the state of the stock and anthropogenic mortality impacts.

4.2 Analytical developments in the recruitment time-series

The objective of this section is to highlight some statistical anomalies that could occur in the model used to build the recruitment indices. These indices and the manner in which they are analysed in support of annual ICES advice are described in Annex 8 and in the Stock Annex (Annex 10).

The studentized residuals were calculated and compared to the predicted value. For each observation, the studentized (or jacknife deviance residual) were standardized against the residual mean square computed without that observation. They corresponded to the residuals that would have been obtained when fitting a model without that observation.

Overall, the WGEEL recruitment model overestimates the low and high observed values (Figure 4.1) with a stronger effect for the "North Sea" than for the "Elsewhere" zones (Figure 4.2). The overestimates of high values were mainly observed in the "trapping all" and "scientific survey" sampling protocols (Figure 4.3). Overestimates for the low values were found in commercial catch and, to a lesser extent, in "trapping all" and scientific survey protocols. However, there was no evident spatial structure in the residuals as illustrated by the maps for the last six seasons (Figure 4.4).

One possible explanation for why the model estimates a higher value than the observation when abundance is low, could be a decrease in the fishing efficiency, due to a motivation loss when abundances dropped. This might be true especially for those series of Tiber and Vidaa that finally stopped as a consequence of a lack of glass eel. Individually, those series, drop faster than the mean trend (Figure 4.5), and show consistently negative residuals in the years before the series ended. The fykenet fishery shows a varying effort with an increased fishing effort when abundance increases. As the distribution of glass eel catches are generally lognormal, a diminution in the fishing effort might lessen the chance to catch the "good run". This series shows negative residuals at the lowest abundance level. Note that this past drop in some of the series should not affect the recent analysis made on the trend. There might also be phenomena in model structure at low stock size.

The overestimation of high values could, especially for scientific surveys and trapping, be interpreted as a kind of saturation phenomena associated with gears not well adapted for high abundance. It is known that some traps are open during part of the day when abundance is very high to avoid mortality during counting process. There might also have been a consistent improvement of catching methods over time and this could have led to underestimated historical values.

Residuals, when plotted separately site per site, clearly show that the variance is different among series, and thus that the model violates the homoscedasticity assumptions. A box plot of residuals (Figure 4.6) shows for example that Vilaine has a low variance whereas Imsa has a larger one. No clear difference is observed between sampling types.

The consequence of the effect on possible bias in the recruitment indices should be evaluated. But the trend extracted from a very simple analysis of all series combined (yellow and glass), the separate geometric means for yellow and glass eel series, and the GLM estimate, all provide a consistent trend. However, if the interpretation of the trend is clear, the absolute value of the recruitment level, which has recently been put forward as a baseline for management decision (ICES, 2015d) could be affected by these bias.

In conclusion, overestimation of recruitment at very low and very high abundance and heteroscedasticity were detected. Application of a so-called mixed model is recommended, but time-pressure during this meeting did not allow the pursuit of this approach.

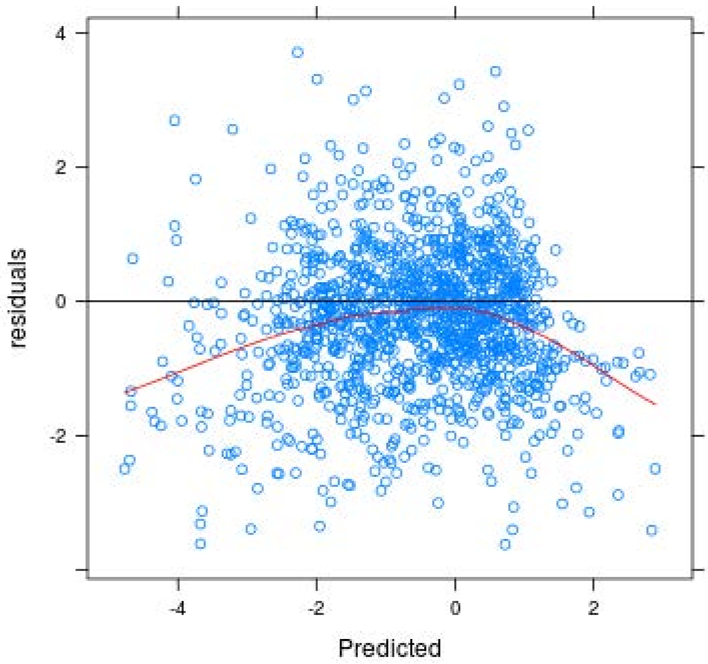


Figure 4.1. Relationship between predicted values and studentized deviance residuals in series used to build the recruitment indices (all glass and young yellow eel recruits data).

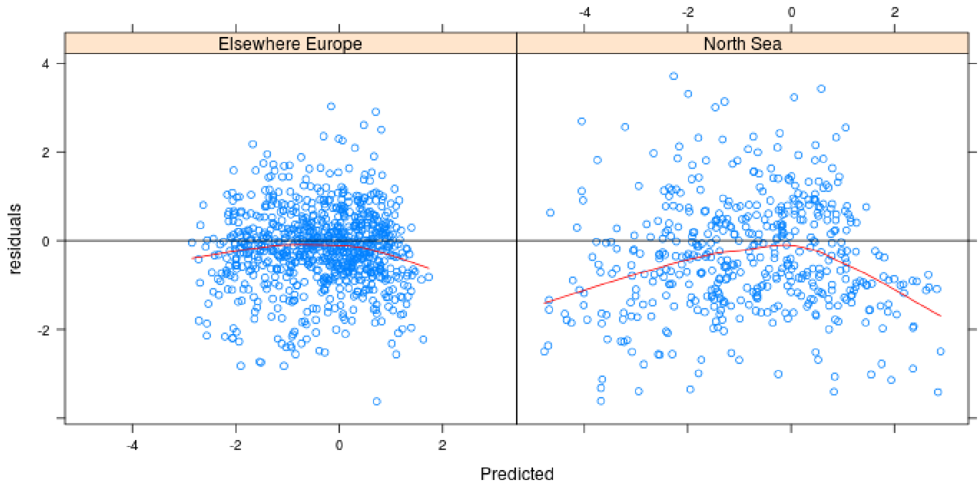


Figure 4.2. Relationship between predicted values and studentized deviance residuals according to recruitment area in series used to build the recruitment indices (all glass and young yellow eel recruits data).

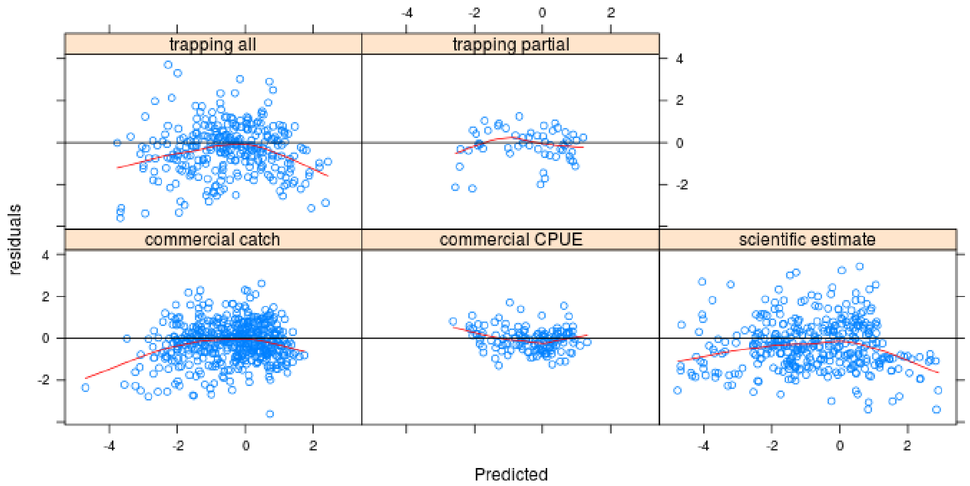


Figure 4.3. Relationship between predicted values and studentized deviance residuals according to types of sampling in series used to build the recruitment indices (all glass and young yellow eel recruits data).

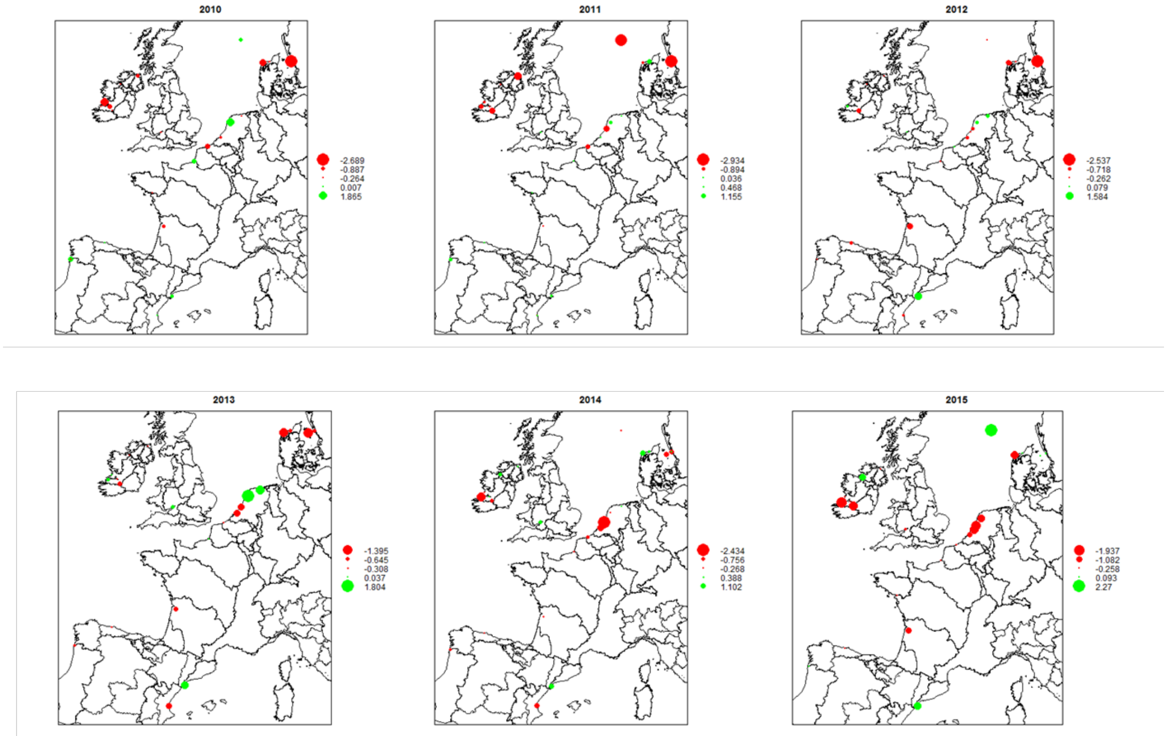


Figure 4.4. Map of the deviance residuals for the last six years. Red circles indicate where the WGEEL recruitment model predicts values larger than observed, green circles indicate where the WGEEL recruitment model predicts values lower than observed. Note that the outline for some non-EU countries producing eel is missing from the map.

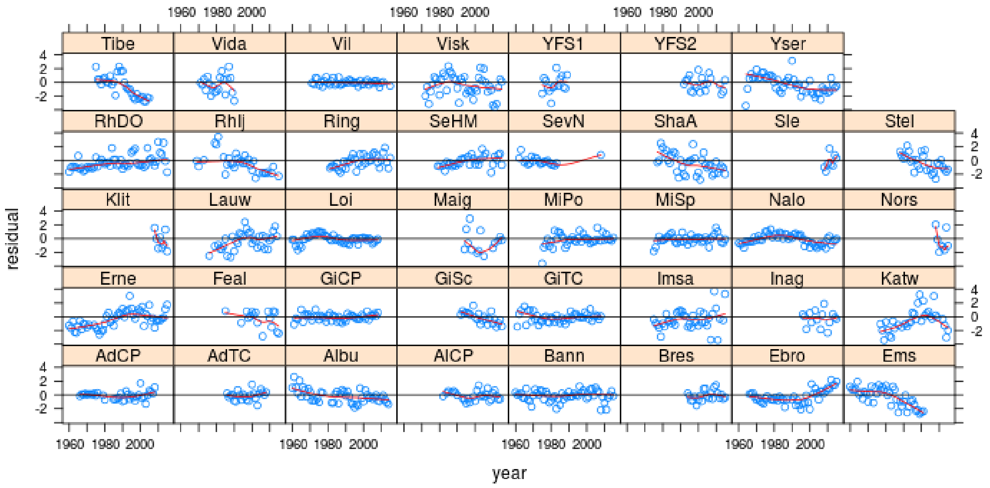


Figure 4.5. Evolution of the deviance residuals for the different recruitment series used to build the recruitment indices.

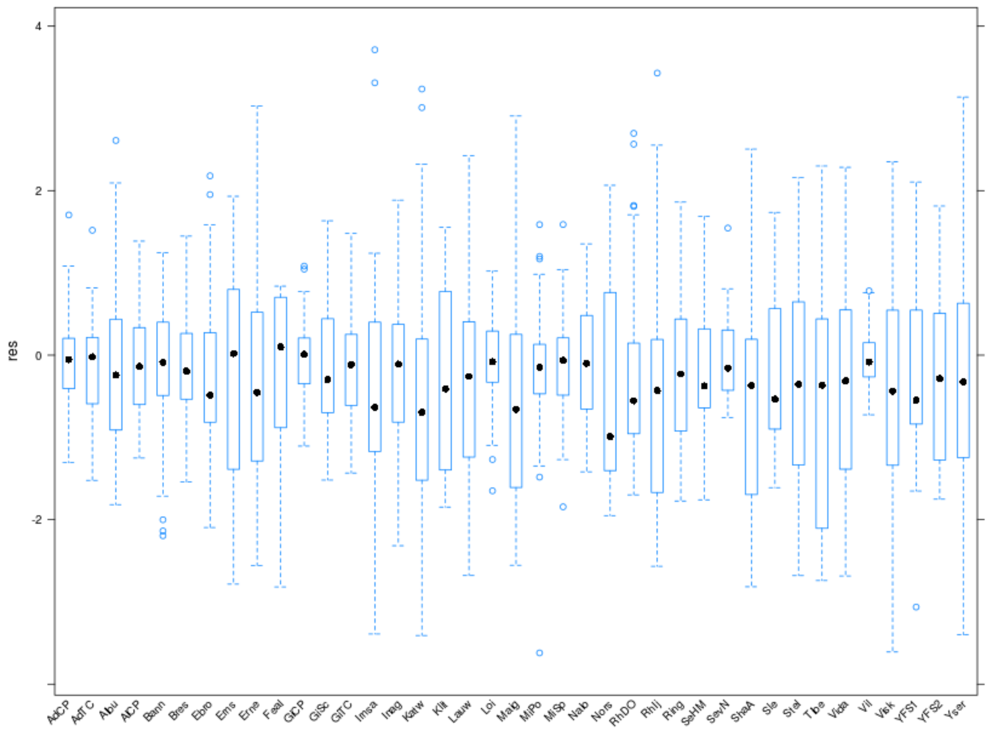


Figure 4.6. Histogram of the deviance residuals for the different recruitment series used to build the recruitment indices.

4.3 Update of stock indicators from 2015 EMP Progress Reports and Country Reports

In 2015, EU Member States post-evaluated the implementation of their Eel Management Plans, and provided estimates of national stock indicators 3Bs & ΣA. Results were made available to the Working Group by the European Commission, and were cross-checked with Country Reports and/or direct communication to authors and national authorities. The information in the 2015 Progress Reports is not always complete, and the quality of the national data and assessment are hard to evaluate. The Working Group conducted a first screening of the reported stock indicators and discussed some apparent anomalies with the relevant members of the group, but then accepted the remainder of the information in good faith.

4.3.1 Assessment results

The modified Precautionary Diagrams shown below plot the 3Bs & ΣA-indicators as provided by Member States in their progress reports against the background of the generic reference points according to the 40% biomass target of the EU Eel Regulation, the corresponding mortality limit of ΣA=0.92 (taking the 40% biomass limit as a trigger point below which the mortality is reduced to zero in proportion to the actual biomass of the escapement).

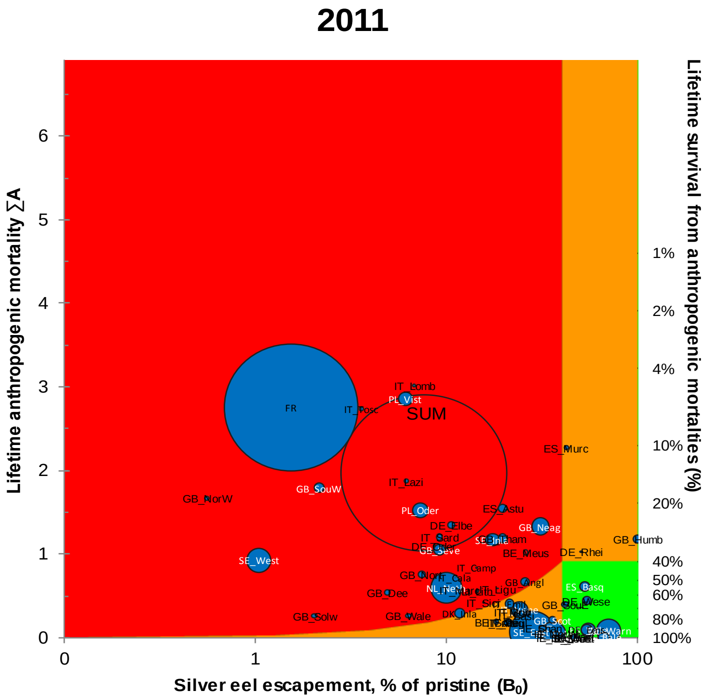
The modified Precautionary Diagrams evaluate the status, using national stock indicators provided by the Member States. Since not all Member States have reported (and not for all years from 2009 onwards), the presented stock-wide sum represents the reporting countries; not all countries within the distribution 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 is not directly comparable between the years. The Working Group decided to restrict the graphical presentation to the latest data years before the reporting, 2011 and 2014 (or the latest data year before that). In 2015, many countries had updated their methods, and therefore, the indicators reported in 2015 cannot be directly compared to the ones reported in 2012. However, in almost all cases where a change in methods occurred, an update of the 2012 indicators was provided too. Temporal comparisons presented below are based on the most recently reported stock indicator values.

The diagrams below present the indicators per Eel Management Unit (Figure 4.7), and per country (Figure 4.8), for 2011 and 2014 separately (or the latest data years); each plot also contains the Sum of the reported areas. Figure 4.9 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 ☹. Figure 4.10 presents the reported biomass indicators of each EMU.

Finally, Figure 4.11 compares the indicators for 2011 to those for 2014, for those areas that did report for both years. Where possible, the Working Group traced the major changes and removed reporting errors. Some of the reported changes could be traced directly to a major change in monitoring data, others remained unclear. Of the 50 EMUs that reported a value for the anthropogenic mortality both in 2012 and in 2015, 36 reported a reduction of $\sum A$, while 14 reported a rising anthropogenic mortality. Of the 59 EMUs that reported biomass indicators both in 2012 and 2015, 29 reported a rise in silver eel escapement ($B_{current}$), and 30 reported a decline. Note that the decline in recruitment about an eel generation ago is expected to lead to a declining silver eel production, on which the potential effects of management measures are superimposed.

4.3.2 Conclusions on stock status

Based on the stock indicators provided by EU Member States, it was concluded that the stock in most reporting countries/areas was not within the biomass limits of the Eel Regulation and in most management units, anthropogenic mortality is not at a level that can be expected to lead to recovery. The stock in the reporting areas as a whole remains outside biomass limit, as defined in the Regulation, and average mortality over this area was not at a level that can be expected to lead to recovery.



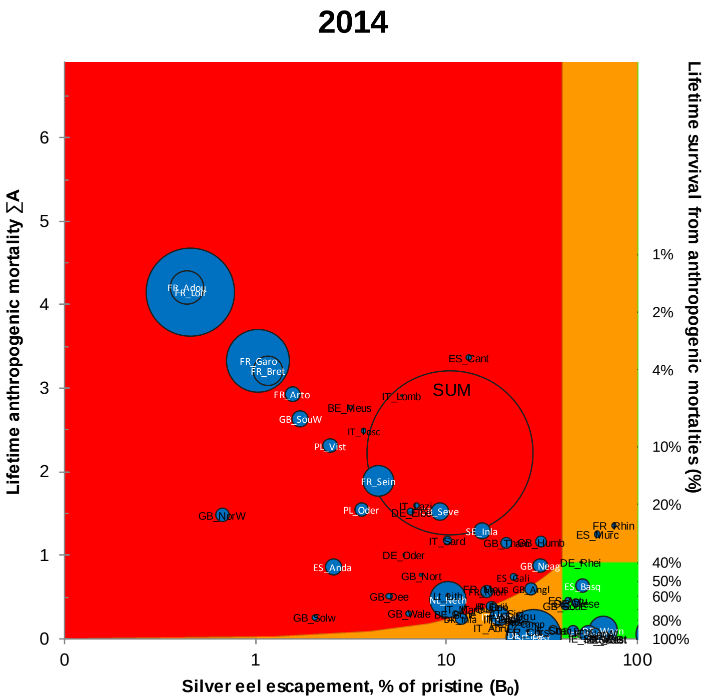


Figure 4.7. Modified Precautionary Diagram for <u>Eel Management Units</u>, presenting the status of the stock (horizontal, spawner escapement expressed as a percentage of the pristine (B_0) escapement) and the anthropogenic impacts (vertical, expressed as lifetime mortality ΣA). Data from the 2012 and 2015 progress reports or from Country Reports provided to WGEEL in 2015. Top: indicators for 2011 (or the latest data year before); bottom: indicators for 2014 (or the latest data year before).

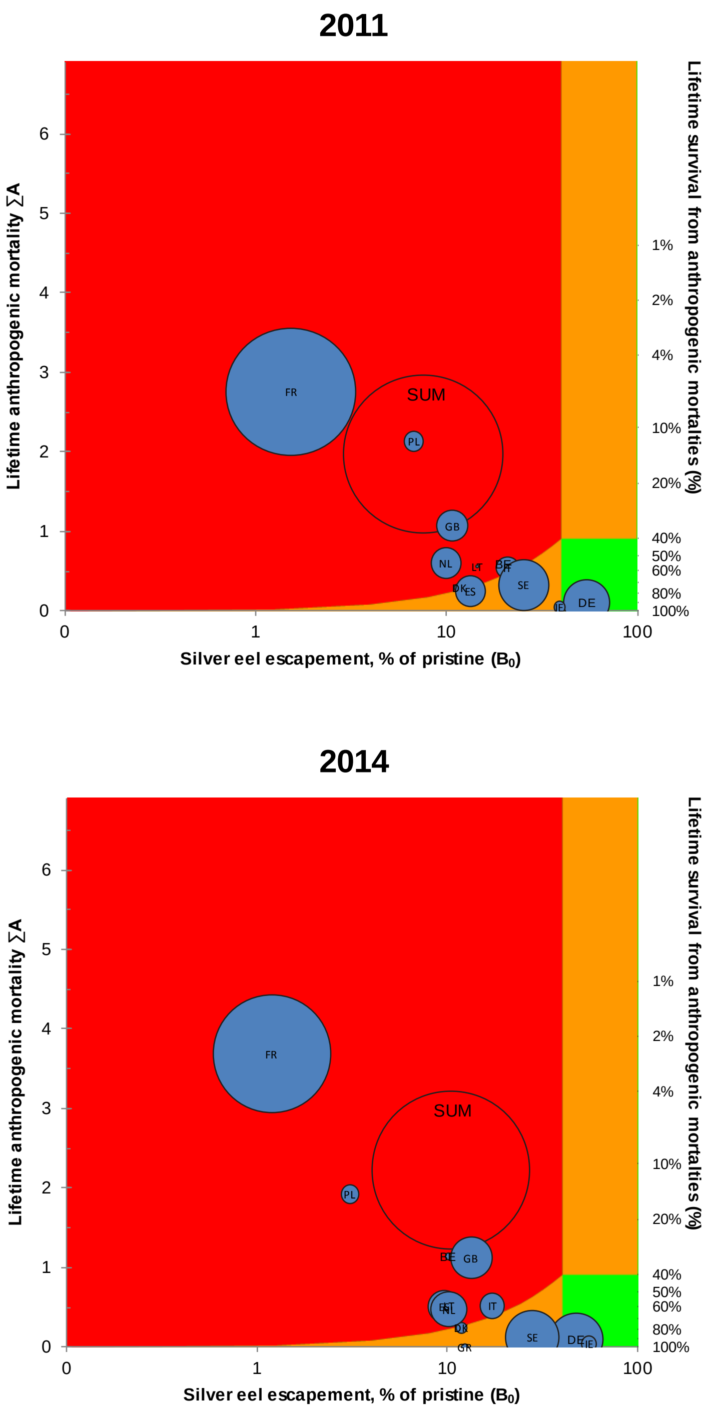
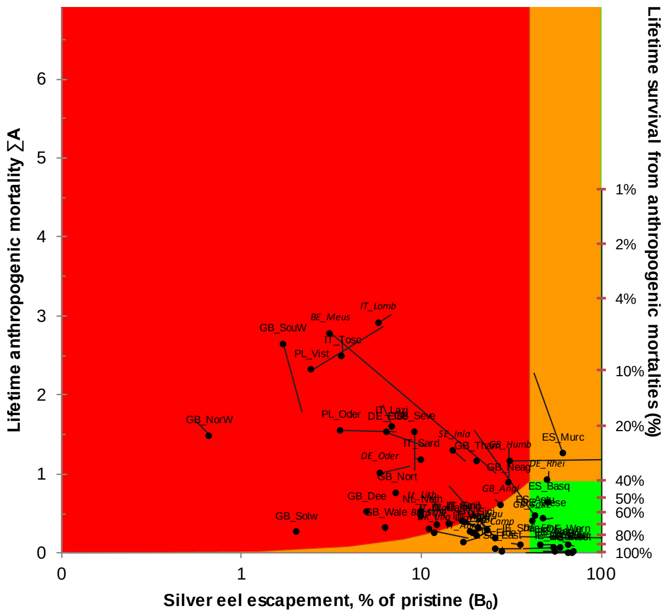


Figure 4.8. Modified Precautionary Diagram summed by <u>country</u>, presenting the status of the stock (horizontal, spawner escapement expressed as a percentage of the pristine escapement (B_0)) and the anthropogenic impacts (vertical, expressed as lifetime mortality ΣA). Data from the 2012 and 2015 progress reports or from Country Reports provided to WGEEL in 2015. Top: indicators for 2011 (or the latest data year before); bottom: indicators for 2014 (or the latest data year before).



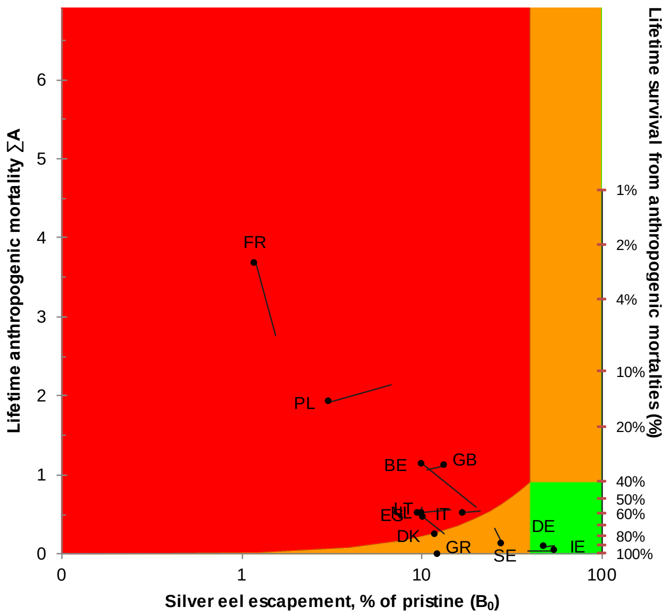
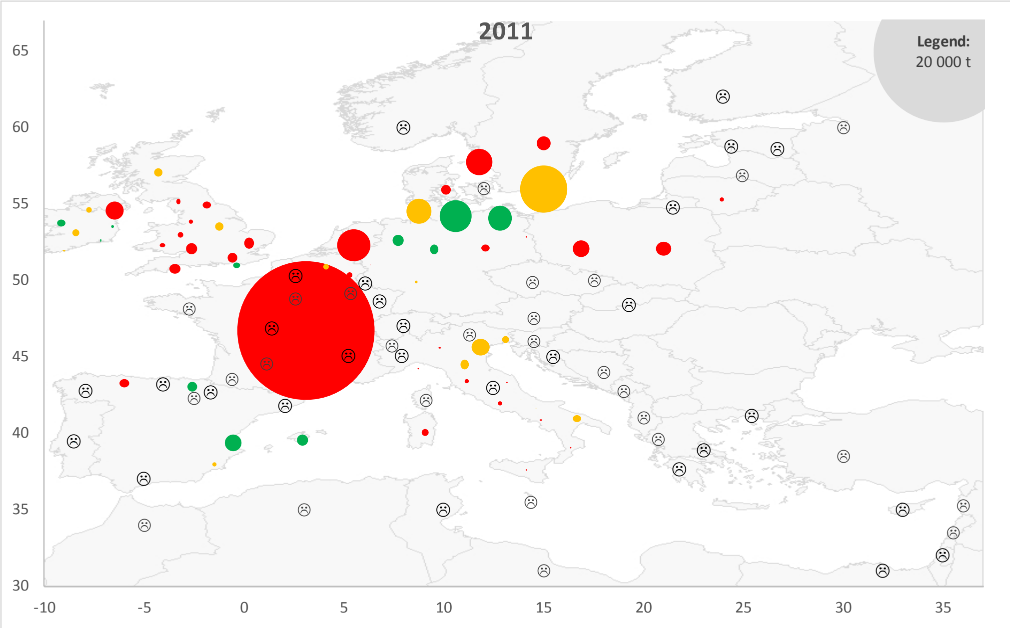


Figure 4.9. Modified Precautionary Diagrams showing the trajectory from 2011 (open) to 2014 (bullet), or the latest data year before; only those areas that did report indicators for both years are shown. Data from the 2012 and 2015 progress reports or from Country Reports provided to WGEEL in 2015. Top: indicators per Eel Management Unit; bottom: indicators per country. Note that this graph does not indicate the relative importance of each area, size of the stock in each area; while these can differ by over four orders of magnitude.



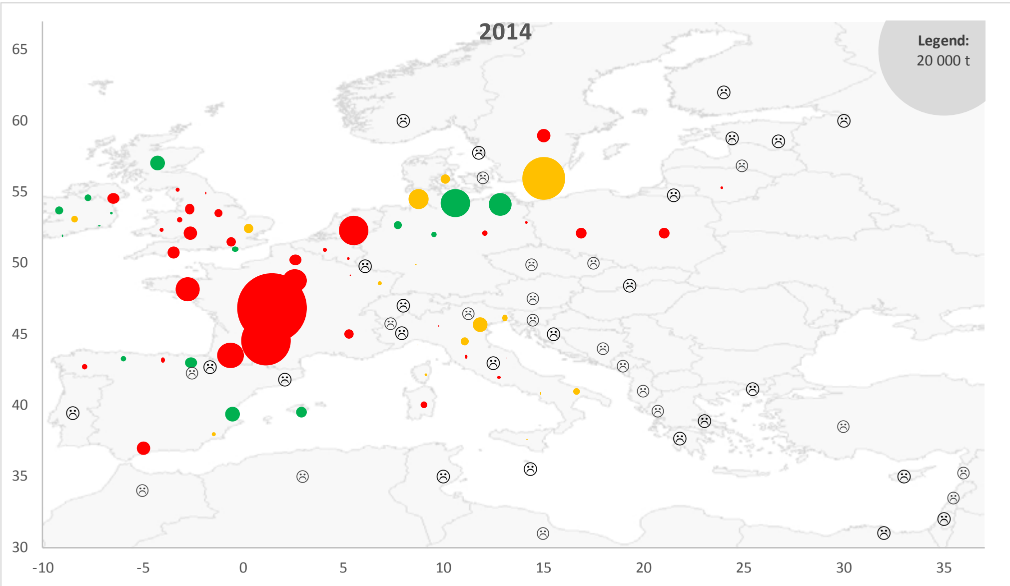


Figure 4.10. Anthropogenic <u>mortality indicators</u> from the Precautionary Diagram (Figure 4.7), plotted on the location of the EMU they refer to. The size of each bubble corresponds to B_{best}, the biomass of escaping silver eels if no anthropogenic impacts had affected the current stock. The colour of each bubble corresponds to the position of the indicators, relative to the reference limits of the Precautionary Diagram (the background colour in Figure 4.7, above). For non-reporting EMUs/countries, a ☹ of arbitrary size is shown.

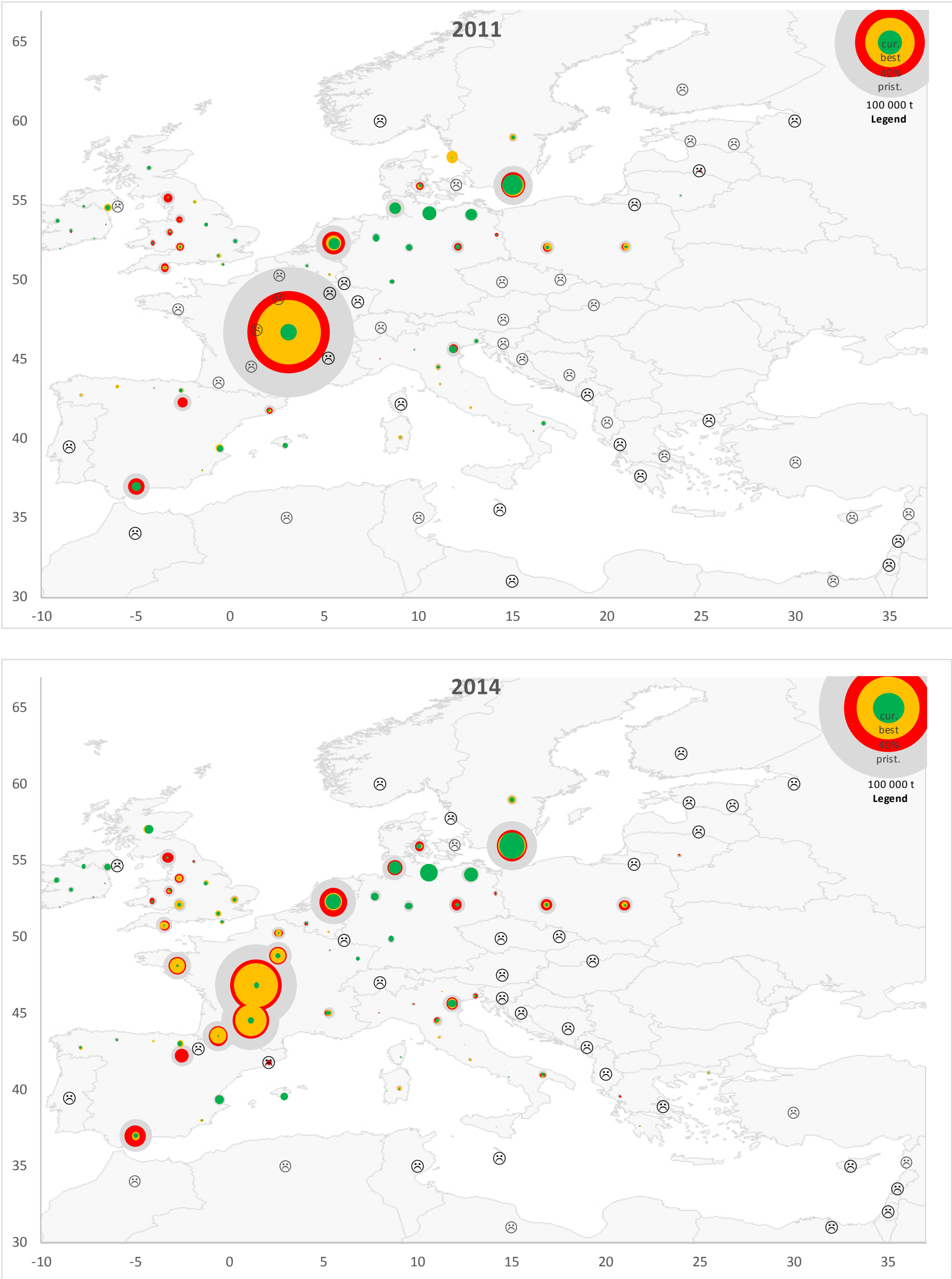


Figure 4.11. Stock <u>biomass indicators</u>, plotted on the location of the EMU they refer to. For each area/country, estimates of the current escapement ($B_{current}$), the potential escapement (B_{best}), the limit of the Eel Regulation (40% of B_0) and the pristine escapement (B_0) are shown. For non-reporting EMUs/countries, a ☹ of arbitrary size is plotted.

4.4 Considerations for developing future stock advice from the stock indicators and/or the stock-recruitment relationship

4.4.1 Introduction

The EU has requested that 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 (ICES, 2014).

ICES advice on the status of the European eel stock is an evaluation of the trend in eel recruitment. This approach is quite simple and relies on the most reliable series available. However, this kind of approach also has the disadvantages that (i) it cannot be used to make future predictions, (ii) it ignores the complex spatial structure of the stock, (iii) it is 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, and (iv) it does not provide information on the level of management action required or the evaluation of the implemented management actions. However, it is a good signal for stock status.

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

Since 2010 WGEEL has been working on the development of biomass and mortality indicators and management and scientific reference points to ultimately result in a scientific advice framework that might conform to the ICES precautionary approach. The progress, difficulties and remaining challenges to achieve the scientific advice framework will be briefly described.

4.5 Quality control of stock indicators of biomass and mortality

The biomass and mortality stock indicators (3Bs&ΣA) for assessment of European eel were developed by the Working Group in 2009–2011 and incorporated in the EU Reporting Template for 2012 (and unofficial template for 2015). While the stock indicators are widely used, the 2012 evaluation of the eel stock revealed serious issues regarding the quality assurance of the stock indicators reported by the Member States. Three areas of concern were raised regarding the quality of the indicators: 1) quality of data, methods and models used to derive the stock indicators, 2) lack of spatial coverage of indicators inside the EU, and 3) lack of spatial coverage of indicators outside the EU. Here we discuss each in turn.

1) Quality: data and models

ICES (2013a) demonstrated the urgent necessity to ensure the quality of data, assessment methods and models used by the different MS to derive the biomass and mortality stock indicators. The need for a review of data, methods and models was reiterated by European Commission in their report to the Council and the European Parliament in 2014. In this report the EC states that *"The Commission intends to request an external scientific review of the methodologies used by Member States, and, where relevant, an update* *or a new estimation of stock indicators regarding eel."* The review has not taken place to date.

There is complexity and significant regional differences in eel throughout its distribution range. This is reflected in the different assessment methods and models that have already been developed by MS in 2012 to derive the stock indicators. Although a single, central stock assessment as used for most marine species may be impractical for eel because of this complexity, being assured of the appropriateness of combining national/regional assessments would be facilitated by review and rationalisation of the methods. This would require:

1) Ensure the quality of the methodologies (input data, model structure, data and model uncertainties, etc.) used by the MS to derive the stock indicators,

2) Consider the level of redundancy in the currently applied suit of models, consider generalisations of existing models, and/or inter-calibrate the different models,

3) Evaluate the sensitivity of results towards input data, assumptions and estimates of model parameters, in the context of the precautionary approach.

This can only be achieved by an international steering and coordination process, not by uni-national initiatives.

2 Quality: spatial coverage inside EU

In 2012, many EU Member States did not completely report the obligatory biomass and mortality stock indicators; 59 of 93 (63%) of the EMUs reported biomass indicators, and 43 of 93 (46%) EMU reported mortality indicators. The lack of spatial coverage within the EU was indicated as a serious data quality issue and a major obstacle to progress from a trend-based assessment (eel recruitment) to an advice framework conforming to the precautionary approach.

However, in 2015 significant progress was made in the spatial coverage of stock indicators within the EU; 78 of 93 (83%) of the EMUs reported biomass indicators, and 74 of 93 (80%) EMUs reported mortality indicators. At present, stock indicators are available for over 80% of the total surface of the EMUs that fall under the reporting obligations of the Eel Regulations. However, the national progress reports of several countries do not fully cover all habitats within their countries. Not having detailed information available for those skipped habitats, it is difficult to judge the importance of this omission.

Because of the panmictic nature of the stock, biological advice should preferably be based on an assessment of the status of the whole stock. In practice, however, full coverage is highly desirable but not realistically achievable. On the one side, the Eel Regulation has a pragmatic approach to deal with incomplete coverage, setting management targets for each management unit. On the other side, understanding of the stock dynamics requires that full coverage of the assessment should still be pursued. However, management actions should not be held "hostage" by the last EMU to deliver the stock indicators no matter how insignificant this last EMU might be. The question then is, what coverage is representative for (changes in) the eel stock? At the same time, however, pressure will need to be applied to the non-reporting EMUs to deliver stock indicators as the ultimate long-term aim remains full coverage.

3) Quality: spatial coverage outside EU

The Eel Regulation 1100/2007 only applies to EC Member States but the European eel is a panmictic stock with widespread distribution extending much further than the territories of the Member States. The whole-stock (international) assessment requires data and information from both EU and non-EU countries producing eels. The 2013 stock assessment by WGEEL demonstrated a lack of required data from the non-EU countries.

The participation of General Fisheries Commission of the Mediterranean (GFCM) in the Joint EIFAAC/ICES/GFCM WGEEL since 2014 has contributed to strengthening collaboration with ICES and EIFAAC experts and significant progress has been made in the last two years. The GFCM has undertaking a series of case studies to develop regional multiannual 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 2015, 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). During WGEEL 2015, the GFCM participants used a model (ESAM) to provide rough estimates of some of the stock indicators for 13 Mediterranean countries.

While the spatial coverage inside the EU might be enough to evaluate the status of the stock within its boundaries, this point may not be reached for the non-EU countries in the near future. Since full coverage is not realistically achievable, a decision should be taken whether to initiate management actions and corresponding advice for the EU Member States, or to postpone actions until more full coverage has been achieved.

4.6 Biological reference point in biomass: long-term objective

ICES (2002) considered that the precautionary reference point for eel must be stricter than the generally considered provisional reference target of 30% and proposed a preliminary value at 50% of B_0. ICES (2007) added that an intermediate rebuilding target could be the pre-1970s average SSB level which has generated normal recruitments in the past.

The Eel Regulation 1100/2007 (European Council, 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). The management biomass reference limit of 40% of B_0 for eel, a Category 3 species in the Data-Limited Species approach, is in line with the 40% maximum spawning potential reference point advised for category 3 and 4 species by ICES (2015a, WKLIFE V).

So far, it was not possible to derive biological reference points from available eel data using a classical stock–recruitment relationship (non-depensatory) because (i) this relationship provides an unrealistic fit to the data and (ii) the estimated B_{lim} is actually above the range of observations, and the stock would thus have always been below that B_{lim} (the breakpoint of the hockey-stick relationship) since 1950 (ICES, 2014a).

Because of the misfit of classical stock–recruitment-relations, a default management reference point of 40% of B_0 management reference point was adopted for the Eel Regulation (European Council, 2007).

Because current recruitment is far below its 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 aims to achieve its objective "in the long term", but it does not specify an order of magnitude for that duration. This reference point for biomass must then be considered as a long-term objective.

4.7 Biological reference point in mortality: short-term objective

The general objective of the EU regulation is to protect and recover the European eel stock. A further deterioration of the status of the stock is to be avoided. This implicitly sets an upper limit on anthropogenic mortality.

A mortality limit of lifetime mortality $\Sigma A = 0.92$ can be shown to correspond to the 40% biomass limit in the long term (Dekker, 2010; ICES 2011a; 2011b). But establishing/maintaining mortality at that level in the current, depleted state will not allow the stock to recover.

Following standard ICES protocols for long-lived species (ICES, 2015a WKLIFE V), 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 $B_{current} = 0$) is recommended (ICES, 2011a).

4.8 Risk for requiring stricter reference points

The actual spawning–stock biomass (in the Sargasso Sea) for eel has never been observed. The best available proxy for the spawning biomass 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. As explained in ICES (2013b) this proxy can be approximated from the landing statistics and expert knowledge of the exploitation rate, the only information sources available for this period.

Although data on recruitment and especially on spawning biomass present weaknesses, analyses since 2004 (Dekker, 2004; ICES, 2014a) have indicated that the stock–recruit relation corroborated a recruitment declining faster than the spawner escapement. It might actually give signs of strong depensation (Hilborn and Walters, 1992) and/or overwhelming environmental drivers and/or spawner quality issues. Depensation can seriously accelerate population decline and drive a population to extinction, or at least heavily hinder its recovery (Walters and Kitchell, 2001). Although no firm conclusions can be drawn, 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 mortality (fisheries and other sources) to zero.

4.9 Application of the reference point to all management units

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).

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 would constitute a risk-averse approach (Dekker, 2010).

4.10 Further development of the advice

Implementation of the lines of reasoning spelled out in the previous paragraphs requires the following steps to be taken:

1) agreement on the biomass (40% B_0) and derived mortality ($\sum A=0.92$) **management** reference points of the Eel Regulation;

2) agreement on the (proportional) reduction in the mortality reference values below 40% of B_0

3) agreement on the reference points for individual EMUs (both biomass and mortality), in agreement with the stock-wide reference points.

4) agreement on a process to ensure the quality of the reported stock indicators by the Member States.

5) agreement on the spatial coverage of the assessment required to be representative for the EU part of the stock, and for the remainder of the distribution area.

4.11 Updates on time-series on exploitation, other anthropogenic mortalities, eel stocking, and aquaculture

4.11.1 Commercial fishery landings trends

FAO (2015) started collecting landings statistics over 60 years ago, but the incompleteness of the available information is manifest (Dekker, 2003b). FAO (2015) provides data up to and including 2011; during the Working Group meeting, an update of these database was received from FAO by personal communication, covering the years up to and including 2013. Figure 4.12 presents these dataseries. Care should be taken with the interpretation of this graph, since it is not based on consistently reported time-series.

Additional information on landings was made available in the Country Reports for 2014, and many countries had made an effort to complete or to reconstruct the dataseries for earlier decades. For the remaining missing information, a reconstruction was made on the basis of the common time-trend in the reported data and an estimate of the contribution from each country to the total landings, along the lines of Dekker (2003b) (a multiplicative model of country*year, gamma error, treating both country and year as a class variable). Combining the most recent update of the FAO data, with national information sources, and a reconstruction of the remaining missing data, constitutes the best available view on the trend in landings of eel (Figure 4.13).

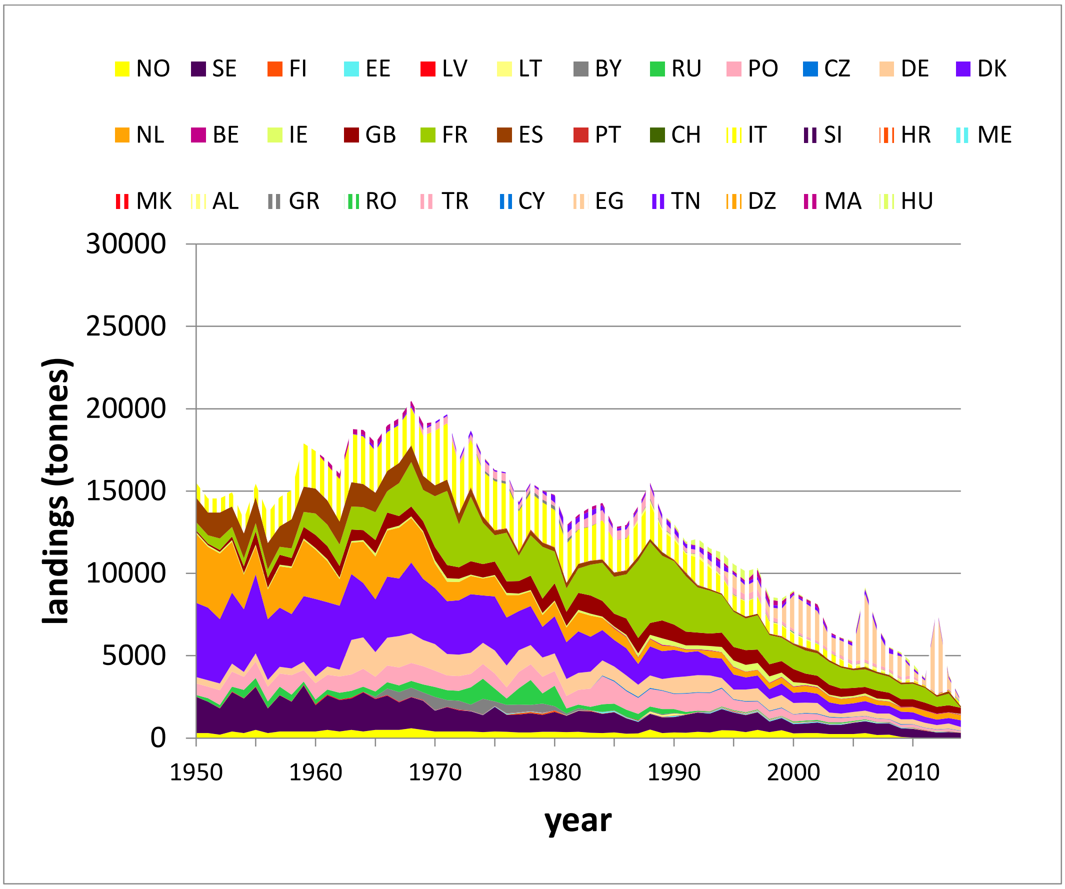


Figure 4.12. Time-series of commercial eel fishery landings, by country, as reported to FAO. Care should be taken with the interpretation of this graph, since it is not based on consistently reported time-series.

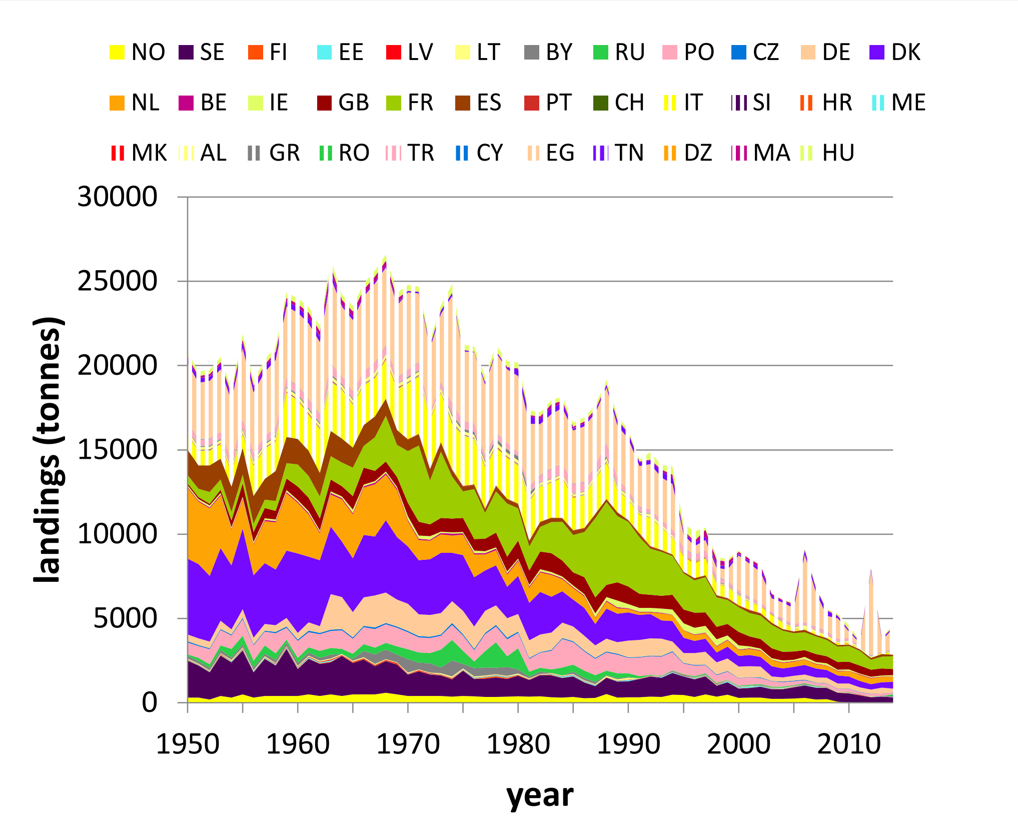


Figure 4.13. Time-series of commercial eel fishery landings, by country, combining information from the FAO database, national information sources (Country Reports) and a reconstruction of the non-reporting countries/years (see text).

A review of the catches and landing reports in the Country Reports showed a great heterogeneity in the manner in which landings data are reported. 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 for reporting. Furthermore, some countries have revised their dataseries, during the process of compiling their Eel Management Plan (i.e. Poland, Portugal) and, in some cases, added extrapolations back in time for unreported periods.

Landings data sourced from the FAO database are presented for all countries, including those 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 may be unreliable, e.g. 2006 and 2012 Egyptian data show large variations that were of uncertain provenance given that there were uncertainties about the presence of a catch reporting system.

In the years since the implementation of the Eel Regulation, fishing restrictions in many countries appear to have reduced the catches considerably. Care should be taken with the interpretation of the landings as indicators of the stock as such, since the catch statistics will now reflect the status of the stock as well as the effect of fishing restrictions.

4.11.2 Recreational and non-commercial fisheries

Recreational and non-commercial fishing is the capture or attempted capture of living aquatic resources mainly for leisure and/or personal consumption. This covers active fishing methods including line, spear, and hand–gathering and passive fishing methods including nets, traps, pots, and setlines.

The Working Group on Recreational Fisheries Surveys (WGRFS) discussed the use of recreational fishery data in the new European Union Multi-Annual Plan (EU MAP) (ICES, 2015c). Recreational fishing mortality of a stock may be as big or even exceed that of commercial landings. At present, recreational mortalities for most fish stocks are largely unquantified and/or lacking completely from some Member States and are thus not included in stock assessments (with the notable exception of Baltic cod, salmon and European sea bass). Current assessments may underestimate fishing mortality significantly and this may have an impact on the ability to sustainably manage fish stocks. Therefore WGRFS recommends that the need to include recreational fishery data in a stock assessment procedure should be evaluated on a case-by-case basis, according to the known magnitude of recreational catches compared with commercial catches based on previous surveys or pilot studies. This should be reviewed regularly as recreational catches can fluctuate significantly between years and recreational effort can remain high even where stocks are depleted.

It is an EU Data Collection Framework (Council Regulation (EC) No 199/2008) requirement that recreational catches of eel should be reported. In addition, the Eel Regulation (EC 1100/2007) includes statutory monitoring of recreational catches of eel. Hence, EU Member States (MS) are obliged to report their recreational catches (= catch ***and*** releases) of eel in inland waters and marine waters.

To address the recommendation of WGRFS the available recreational datasets were compiled from the 2015 Country Reports and the WGRFS 2015 report (ICES, 2015c).

Data deficiencies: The data reported in the Country Reports remained largely incomplete (Table 4.1) and little change was observed in the reporting of recreational catches compared to 2014. No MS completely covers all the different parts of its recreational fisheries (NC in Table 4.1); nearly all MS miss gears (angling, passive gears), areas (inland, marine) and/or life stages (glass eel, yellow eel, silver eel). A data gap is the nearly complete absence of MS reporting the amount of released eels and its associated release mortality. These facts make it difficult to assess the most recent total catches (catch and released) of recreational and non-commercial fisheries.

Overall, the impact of recreational fisheries on the eel stock remains largely unquantified.

Commercial vs. recreational: Summarizing the data from MS that did report recreational and commercial landings (Figures 4.14 to 4.15) demonstrated that recreational landings of yellow and silver eel may represent a significant part (7–32%) of the total landings. Furthermore these values are an underestimate of the true recreational landings in nearly all of the MS in Figures 1–3 data were lacking for gear (angling, passive gear) and/or area (inland, marine).

Released eel and associated mortality: There is little information on 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 United Kingdom (England) and Denmark. In most MS it is prohibited for recreational anglers to retain eels but a C&R fishery on eel is allowed in all these 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. In the Netherlands for example, 400 000 eels were retained but an additional 1 600 000 eels were caught and released in 2012. Unfortunately, to date no C&R mortality rates are available for eel. However, in 2015 several studies were conducted in Germany to estimate C&R mortality in eel. The results are currently being analysed and will be available for the WGEEL 2016 meeting. During the 2012 and 2015 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.

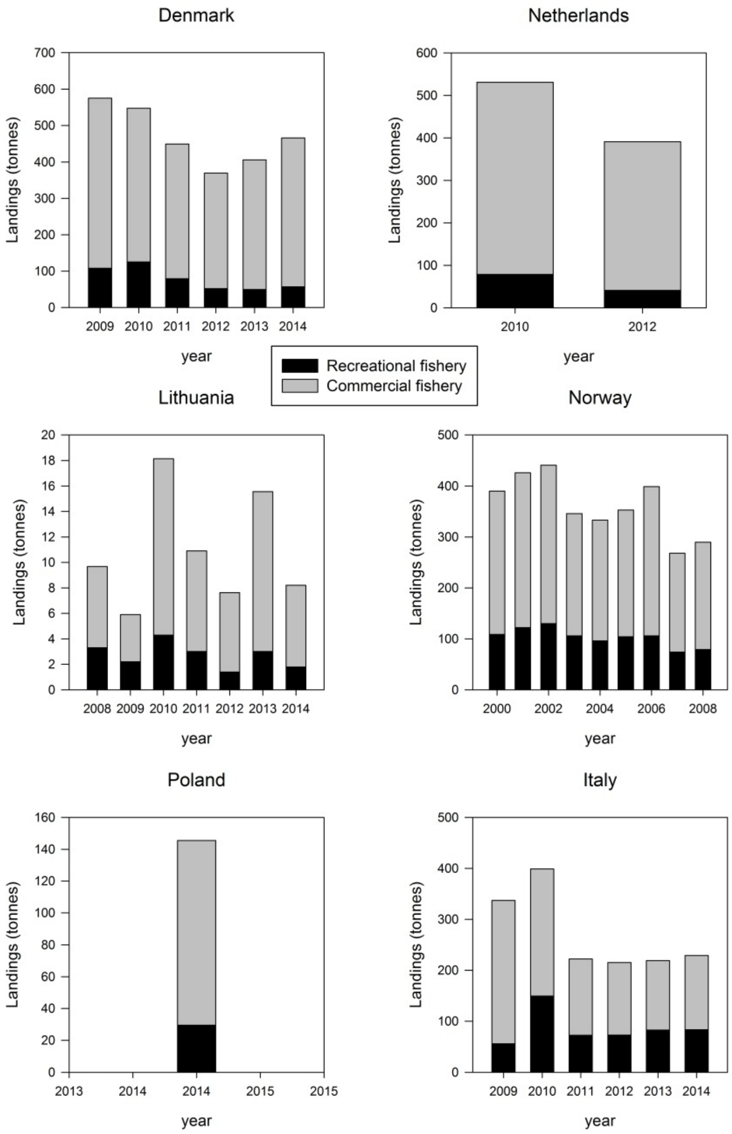


Figure 4.14. Comparison of recreational vs. commercial landings (retained eels only) of eel (yellow and silver eel combined) for some MS which provided data.

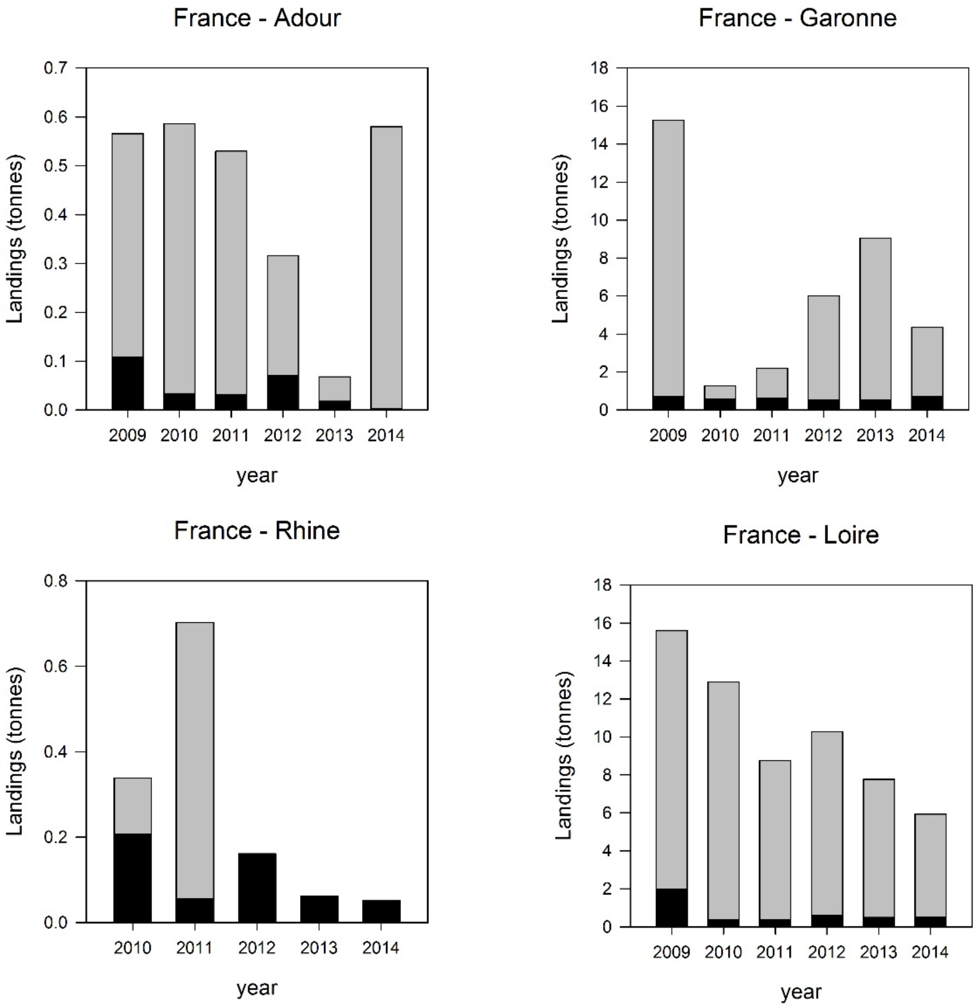


Figure 4.15. Comparison of recreational (passive gears, not angling) vs. commercial landings (tonnes) for some French catchment areas (retained fish only; yellow and silver eel combined). Note that these are only recreational landings of passive gears as no data are collected for recreational angling, hence underestimating the recreational landings.

4.11.3 Misreporting of data, and illegal fisheries

Most countries did not report the level of underreporting, misreporting and illegal (IUU) fisheries in their Country Reports. The limited data that were presented were judged insufficient to draw conclusions on the level of misreporting or illegal fishing. Some countries reported the existence of illegal practices but few were quantified. Only Poland provided quantified illegal eel fishing evaluations. Illegal glass eel trade was mentioned in the Spanish report. The current knowledge is insufficient to quantify misreporting of data and illegal fisheries at the stock level (Table 4.2).

4.11.4 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, ∑H 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. Stock indicators from the 2015 EMU evaluation reports could not be collated in time to investigate if enough data are available to start constructing time-series of $\sum$H.

In time, these mortality stock indicators will provide a suitable series to analyse trends in mortality for both fisheries and other anthropogenic mortalities.

4.11.5 Trends in stocking

Data on the amount of stocked glass eel and young yellow eel were obtained from Country Reports. Note that various countries use different size and weight classes of young yellow eels for stocking purposes. A country by country summary of stocking activities was provided in WGEEL 2014 but not updated this year, but the data are summarised in Tables 4.6 and 4.7.

Stocking of glass eel peaked in the late 1970s and early 1980s, followed by a steep decline to a low in 2009 (Figure 4.16). The increase after 2009 was presumably caused by the implementation of EMPs, because stocking of glass eel is one of the management measures in many EMPs. However, the planned restocking in 2015 with glass eel could not be performed in several countries (Belgium (Flanders and Walloon region), Poland), due to difficulties in obtaining glass eel as orders could not be fulfilled by glass eel suppliers. Issues relating to availability, timing, and price influenced the ability of some countries to fulfil the EMP obligations and also the time-series data on stocking. This is considered to jeopardize the fulfilment of the national restoration plans and hampers reaching restoration objectives as defined in the Eel Regulation. Issues regarding the difficulties to purchase glass eel for restocking should be considered on international scale. The geographic location of Poland makes it impossible to obtain glass eel during the period in which it occurs: January–March. This means that the Polish EMP is being implemented based exclusively on reared stocking material, the suitability of which has yet to be confirmed.

The stocking of young yellow eels has been increasing since the late 1980s, but shows a large reduction in 2014 and 2015 (Figure 4.17). The proportion of glass eel amongst stocked eel has increased in the recent years (Figure 4.18) but it is difficult to draw conclusions from this given the multiple factors affecting supply and demand of eel for stocking across different countries.

The Working Group was not able to conduct an analysis of glass eel trade this year, but will renew previous analysis in 2016.

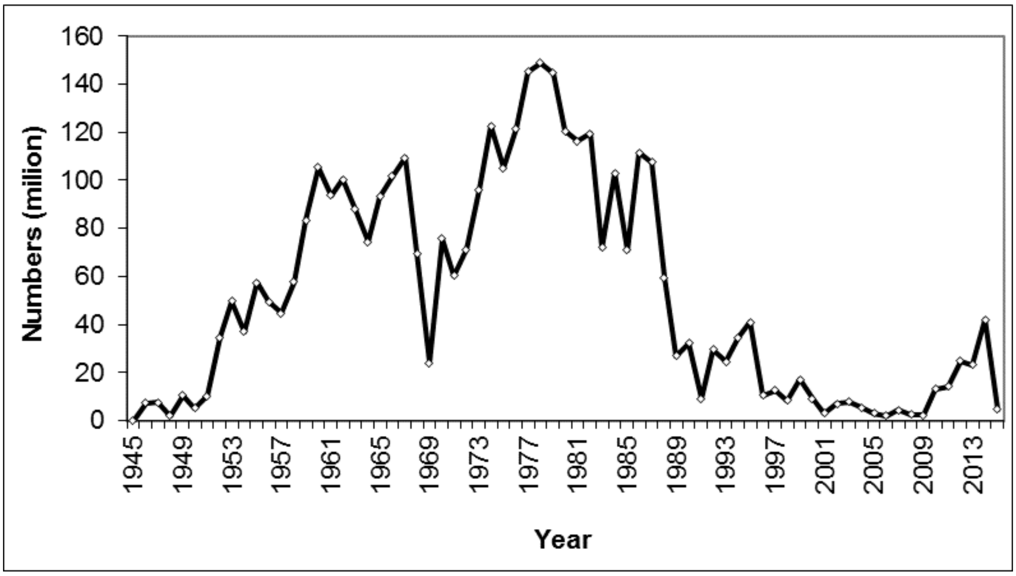


Figure 4.16. Reported stocking of glass eel in Europe (Sweden, Finland, Estonia, Latvia, Lithuania, Poland, Germany, the Netherlands, Belgium, United Kingdom, Spain, Greece, France (no data before 2010)) in millions stocked (1945–2014).

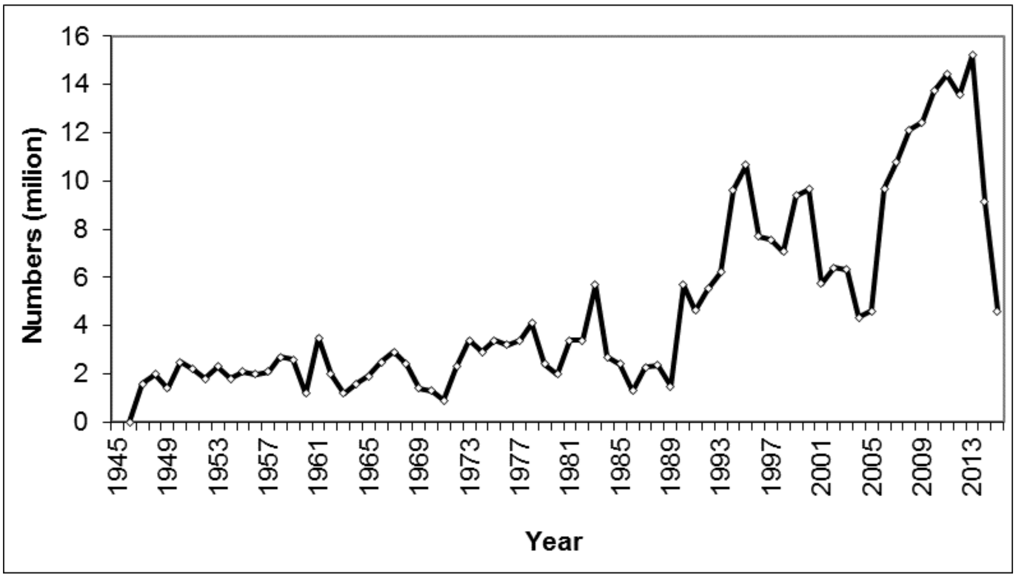


Figure 4.17. Reported stocking of young yellow eel in Europe (Sweden, Finland, Estonia, Latvia, Lithuania, Poland, Germany, Denmark, the Netherlands, Belgium, and Spain), in millions stocked (1945–2014).

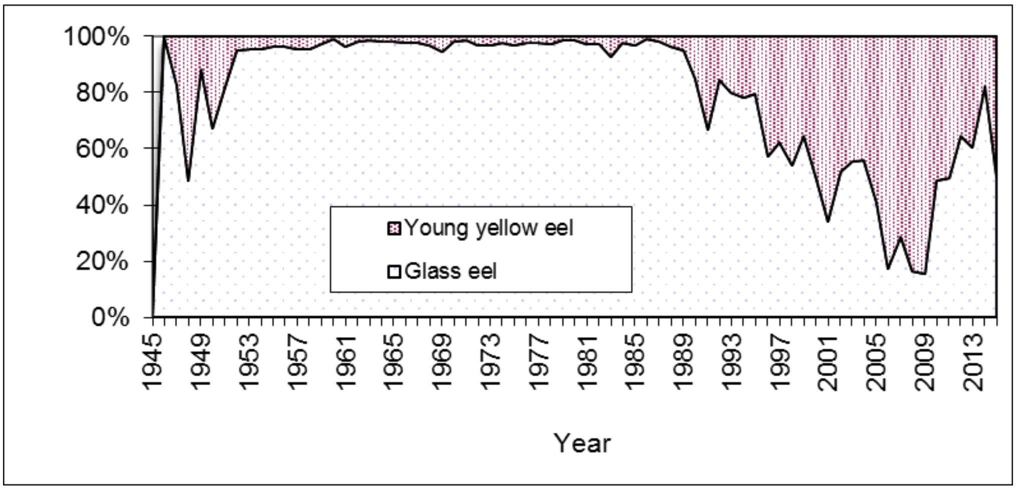


Figure 4.18. Stocking proportion in numbers stocked between on-grown and glass eel in Europe (1945–2014).

4.11.6 Aquaculture production of European eel

Aquaculture production data for European eel limited to European countries from 2004 to 2014 are compiled from different sources: Country Reports to WGEEL 2015 (Table 4.3), FAO (Table 4.4) and FEAP (Federation of European Aquaculture Producers) (Table 4.5). 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 4000–6000 tonnes in 2014 (Figure 4.19). 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.

It should be noted that eel aquaculture is based on wild recruits, and some aquaculture is subsequently released as ongrown eel for stocking, such as Germany (in 2015, of 926 t, 284 t were released) which complicates examination of the fate of these eels.

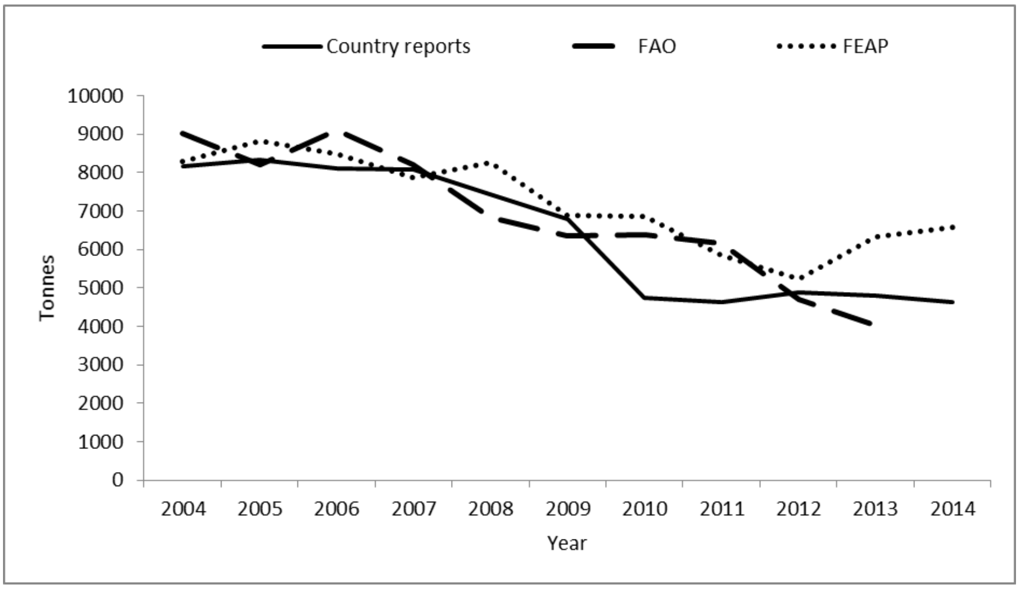


Figure 4.19. Different sources of data for aquaculture production of European eel in Europe from 2004 to 2014, in tonnes.

4.11.7 Environmental drivers

As in 2014, this year the working group members were asked again to include in their country reports any information that they thought was relevant to the consideration of the potential environmental drivers influencing the stock. In 2015, no additional information was reported compared to the information presented in the WGEEL 2014 report (ICES, 2014a).

Table 4.1. Latest reported recreational fisheries data for European eels (yellow and silver eel only). Codes to be used for circumstances of Nil Return in tables: 0: Reserve this designation for a measured data point with an actual zero value (for example when the catch is zero but the effort is >zero); NP: "Not Pertinent", where the question asked does not apply to the individual case; NR: "Not Reported", data or activity exist but numbers are not reported to authorities (for example for commercial confidentiality reasons); NC: "Not Collected", activity / habitat exists but data are not collected by authorities (for example where a fishery exists but the catch data are not collected at the relevant level or at all); ND: "No Data", where there are insufficient data to estimate a derived parameter.

	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														
2014	NP	NP		NP	NP			NC	NC		NC	NC		
Sweden														
2014	NP	NP		NP	NP			NC	NP		NC	NP		
Finland														
2014	?	?	11	?	?	9	20	?	?		?	?		
Estonia														
2012	0.02	?	0.02	?	?		0.02	?	?		?	?		
Latvia														
2012	NC	NP			0.102	0.102	0.102	NC	NP		NC	NC		
Lithuania														
2014	1.8	NP	1.8	NC	NP		3	NC	NP		NC	NP		
Poland														
2014	60.9	NP	60.9	<1	NP	<1	30	NC	NP		NC	NP		
Germany														
2013	NC	NC		NC	NC		240	NC	NC		NC	NC		
Denmark														
2014	NC	2		NC	55		57	NC	NC		70000 (#)	NC		
Netherlands														
2012	41	NP	41	18	NP	18	59	199	NP	199	13	NP	13	212
Belgium														
2013 (Flanders)	NC	NP		NC	NP			NC	NP		NC	NP		
2013 (Wallonia)	NP	NP		NP	NP			NC	NP		NP	NP		

	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
2014 (Flanders)	30	NP		NC	NP			NC	NP		NC	NP		
2014 (Walonia)	0	NP		NC	NP			NC	NP		NC	NP		
UK(England/Wales)														
2012	NP	NP		5000 (#)	NP			NC	NP		32 000(#)	NP		
UK (Scotland)														
2013	NP	NP		NP	NP			NC	NP		NC	NP		
Ireland														
2013	NP	NP		NP	NP			NC	NP		NC	NP		
France														
2014	NC	1319		NC	NP		1319	NC	NC		NC	NP		
Portugal														
2013	NC	NP		NC	NP			NC	NP		NC	NP		
Spain														
2013	NC	NP		NC	NP			NC	NP		NC	NP		
Italy														
2013	83.3	NC		NC	NC			NC	NP		NC	NC		
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		

	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
Turkey														
2013	NC	NC		NC	NC			NC	NC		NC	NC		
Tunisia														
2013	NC	NP		NC	NP			NC	NP		NC	NP		

Table 4.2. Estimation of underreported catches (in kg) of eel in 2013-2014, 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)
2013	FI													3000	5.00	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

2014		Glass eel				Yellow eel				Silver Eel				Combined (Y + S)			
	EMU	Reported catches (kg)	Underre pt. %	Underre pt. (kg)	Total catches (kg)	Reported catches (kg)	Underre pt. %	Underre pt. (kg)	Total catches (kg)	Reported catches (kg)	Underre pt. %	Underre pt. (kg)	Total catches (kg)	Reported catches (kg)	Underre pt. %	Underre pt. (kg)	Total catches (kg)
	FI													20 000	0.005	100	20 100
	LT													7700	10	770	8470
	PL													116 000	27.1	31 400	147 400
	FR	36 000	1.8	647	36 647	-	-	65	-	-	-	892	-	-	-	957	-
	ES	14 362	14.3	2049.2	16 411.2												

Table 4.3. Aquaculture production of European eel in Europe from 2004 to 2014, in tonnes. Source: Country Reports. NR. = not reported.

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Denmark	1500	1700	1900	1617	1740	1707	1537	1156	1093	824	842
Estonia	26	19	27	52	45	30	20	25	35	NR	80
Germany	328	329	567	740	749	667	681	660	706	757	926
Netherlands	4500	4500	4200	4000	3700	3200	2000	2300	2600	2900	2300
Portugal	1.5	1.4	1.1	0.5	0.4	1.1	NR	0.6	NR	NR	NR
Sweden	158	222	191	175	172	139	91	94	93	92	64
Poland	1	1	1	1	1	1	1	1.5	1.5	1.5	1.5
Italy	1220	1131	807	1000	551	587	NR	NR	NR	NR	NR
Spain	424	427	403	478	461	450	411	391	352	210	396
Total	8157	8329	8096	8063	7419	6781	4741	4641	4885	4788	4623

Table 4.4. Aquaculture production of European eel in Europe from 2004 to 2013, in tonnes. Source: FAO FishStat.

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Denmark	1823	1673	1699	1614	895	1659	1532	1154	1061	498
Estonia	7	40	40	45	47	30	22	10	NR	NR
Germany	322	329	567	440	447	385	398	660	460	471
Netherlands	4500	4000	5000	4000	3700	2800	3000	3000	1800	1800
Portugal	2	1	2	1	1	1	NR	1	NR	1
Sweden	158	222	191	175	172	0	0	90	93	92
Poland	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Italy	1220	1132	807	1000	551	567	647	1000	450	500
Spain	424	427	403	479	534	488	423	434	373	305
Greece	557	372	385	454	489	428	372	370	320	350
Hungary	11	5	NR	NR	NR	NR	NR	NR	NR	NR
Total	9024	8201	9094	8208	6836	6358	6394	6719	4557	4017

Table 4.5. Aquaculture production of European eel in Europe from 2004 to 2014, in tonnes. Source: FEAP.

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Denmark	1500	1610	1760	1870	1870	1500	1899	1154	1061	1079	1079
Estonia	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Germany	NR	NR	NR	NR	NR	NR	NR	NR	NR	700	927
Nether-lands	4500	4500	4200	3000	3000	3200	3000	2800	2300	2885	2885
Portugal	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Sweden	158	222	191	175	172	170	170	NR	93	93	64
Poland	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Italy	1220	1132	808	1000	550	568	568	1100	1100	1000	1000
Spain	390	405	440	280	390	510	446	402	350	315	366
Greece	500	500	385	454	489	428	428	372	304	250	250
Hungary	20	20	20	NR	NR	NR	NR	NR	NR	NR	NR
Total	8288	8389	7804	6779	6471	6376	6511	5828	5208	6321	6571

Table 4.6. Stocking of glass eel. Numbers of glass eels (in millions) stocked in Sweden (SE), Finland (FI), Estonia (EE), Latvia (LV), Lithuania (LT), Poland (PL), Germany (DE), the United Kingdom (GB), Belgium (BE), France (FR), Spain (ES) and Greece (GR).

	SE	FI	EE	LV	LT	PL	DE	NL	BE	GB	FR	ES	IT	GR	TOTAL
1946								7.3							7.3
1947								7.6							7.6
1948								1.9							1.9
1949								11							10.5
1950								5.1							5.1
1951								10							10.2
1952						18		17							34.5
1953						26	2.2	22							49.6
1954						27	0	11							37.1
1955						31	10	17							57.5
1956			0		0.3	21	4.8	23							49.4
1957						25	1.1	19							44.8
1958						35	5.7	17							57.6
1959						53	11	20							83.3
1960			1	3.2	2.3	64	14	21							105.3
1961						65	7.6	21							93.7
1962			1	1.9	2	62	14	20							100.3
1963				1.5	1	42	20	23							87.8
1964			0	0.9	2.4	39	12	20							74.4
1965			1	0.4	2.1	40	28	23							93.3
1966		1.1			0.7	69	22	8.9							101.6
1967		3.9		1	0.5	74	23	6.9							109.3
1968		2.8	1	3.7	3	17	25	17							69.7
1969					0	2	19	2.7							23.9
1970			1	1.8	2.8	24	28	19							75.6

	SE	FI	EE	LV	LT	PL	DE	NL	BE	GB	FR	ES	IT	GR	TOTAL
1971					1.6	17	24	17							60.3
1972			0	1.6	0.3	22	32	16							71.1
1973					1.4	62	19	14							96
1974			2		1.8	71	24	24							122.7
1975					2.2	70	19	14							105.2
1976			3	0.6	1	68	32	18							121.7
1977			2	0.5	1.4	77	38	26							145.2
1978		3.7	3		2.7	73	39	28							148.8
1979					0.8	74	39	31							144.65
1980			1		1.8	53	40	25							120.5
1981			3	1.8	3	61	26	22							116.4
1982			3		4.6	64	31	17							119.4
1983			3	1.5	3.7	25	25	14							72.1
1984			2			49	32	17		4					103.1
1985			2	1.5	1.6	36	6	12		10.9					70.52
1986			3		2.6	54	24	11		17.8					111.61
1987			3	0.3		57	26	7.9		13.8					107.55
1988				2.2		16	27	8.4		6.32					59.42
1989						5.9	14	6.8							27
1990	0.8	0.1				8.6	17	6.1							32.2
1991	0.9	0.1	2			1.7	3.2	1.9							9.2
1992	1.1	0.1	3			14	6.5	3.5		2.36					29.06
1993	1	0.1				11	8.6	3.8	0.8						24.5
1994	1	0.1	2		0.1	12	9.5	6.2	0.5	2.32					34.52
1995	0.9	0.2		0.6	1	24	6.6	4.8	0.5	2.06					40.96
1996	1.1	0.1	1		0.4	2.8	0.8	1.8	0.5	0.1		0.1			10.37
1997	1.1	0.1	1			5.1	1	2.3	0.4	0.21		0.1			12.58
1998	0.9	0.1	1		0.1	2.5	0.4	2.5		0.05		0.1			8.36

	SE	FI	EE	LV	LT	PL	DE	NL	BE	GB	FR	ES	IT	GR	TOTAL
1999	1	0.1	2	0.3		4	0.6	2.9	0.8	3.6		0.2			17.02
2000	0.67	0.1	1			3.1	0.3	2.8		0.45		0.1			9.23
2001	0.44	0.1				0.7	0.3	0.9	0.2			0			3
2002	0.26	0.1		0.2			0.3	1.6		3.02		0			6.94
2003	0.27	0			0.4	0.5	0.1	1.6	0.3	4.1		0.1			7.89
2004	0.18	0.1				2.3	0.2	0.3		1.28		0.1			5.5
2005	0.07	0.1		0.1			0.6	0.1		2.16				0.06	3.19
2006	0.003	0.1		0				0.6	0.3	0.99				0.02	2.013
2007	0.03	0.1		0			1	0.2	0	3		0		0.02	4.35
2008	0.12	0.2					0.5		0.3	1.28				0.01	2.41
2009	0.02	0.1					0.76	0.3	0.4	0.65				0.02	2.25
2010	0.8	0.2					4.8	2.7	0.4	3	1	0		0.11	13.01
2011	0.9	0.31	0.7	0.4			4.8	0.8	0.5	3.3	2.2	0	0.2		14.11
2012	0	0.18	0.9	1.0	1.0		4.0	2.4	0.6	4.0	9.3	0.2	1.3	0.01	24.89
2013	0	0.2	0.8	0	1.2	0	4.7	1.8	0.4	5.8	8.8	0.1	0.6	0.01	23.31
2014	0	0.15	3.0	1.4	0	0		7.95	1.62	8.2	17.00	0.02	1.5	0.21	42.00
2015	0	0.1	1.87	0	0	0	0	0.86	0	1.8	0	0	0	0	4.60

Table 4.7. Stocking of young yellow eel. Numbers of young yellow eels (in millions) stocked in Sweden (SE), Finland (FI), Estonia (EE), Latvia (LV), Lithuania (LT), Poland (PL), Germany (DE), Denmark (DK) the Netherlands (NL), Belgium (BE), Spain (ES) and Italy (IT).

	SE	FI	EE	LV	LT	PL	DE	DK	NL	BE	ES	IT	TOTAL
1947									1.6				1.6
1948									2				2
1949									1.4				1.4
1950							0.9		1.6				2.5
1951							0.9		1.3				2.2
1952							0.6		1.2				1.8
1953							1.5		0.8				2.3
1954							1.1		0.7				1.8
1955							1.2		0.9				2.1
1956							1.3		0.7				2
1957							1.3		0.8				2.1
1958							1.9		0.8				2.7
1959							1.9		0.7				2.6
1960							0.8		0.4				1.2
1961		0		1			1.8		0.6				3.5
1962		0		0.7			0.8		0.4				2
1963				0.4			0.7		0.1				1.2
1964		0		0.4			0.8		0.3				1.6
1965		0		0.3			1		0.5				1.9
1966		0					1.3		1.1				2.5
1967				0.8			0.9		1.2				2.9
1968							1.4		1				2.4
1969							1.4						1.4
1970				0.4			0.7		0.2				1.3
1971							0.6		0.3				0.9

	SE	FI	EE	LV	LT	PL	DE	DK	NL	BE	ES	IT	Total
1972							1.9		0.4				2.3
1973						0.2	2.7		0.5				3.4
1974							2.4		0.5				2.9
1975							2.9		0.5				3.4
1976				0.3			2.4		0.5				3.2
1977						0.1	2.7		0.6				3.4
1978							3.3		0.8				4.1
1979		0					1.5		0.8				2.4
1980							1		1				2
1981							2.7		0.7				3.4
1982				0.3		0.1	2.3		0.7				3.4
1983				0.4		2.3	2.3		0.7				5.7
1984						0.3	1.7		0.7				2.7
1985						0.5	1.1		0.8				2.4
1986						0.2	0.4		0.7				1.3
1987							0.3	1.58	0.4				2.28
1988			0.2	0.8		0.1	0.2	0.75	0.3				2.35
1989						0.7	0.2	0.42	0.1		0.06		1.48
1990	0.7					1	0.4	3.47			0.03		5.7
1991	0.3					0.1	0.5	3.06			0.06		4.62
1992	0.3					0.1	0.4	3.86			0.06		5.52
1993	0.6						0.7	3.96	0.2	0.2	0.17		6.23
1994	1.7				0.1	0.1	0.8	7.4		0.1	0.12		9.62
1995	1.5		0.2				0.8	8.44		0.1	0.22		10.66
1996	2.4					0.5	1.1	4.6	0.2	0.1	0.1		7.7
1997	2.5					1.1	2.2	2.53	0.4	0.1	0.14		7.57
1998	2.1				0.1	0.6	1.7	2.98	0.6	0.1	0.09		7.07
1999	2.3				0.1	0.5	2.4	4.12	1.2	0.04	0.04		9.4

	SE	FI	EE	LV	LT	PL	DE	DK	NL	BE	ES	IT	TOTAL
2000	1.4					0.8	3.3	3.83	1		0.05		9.65
2001	0.8		0.44			0.6	2.4	1.7	0.1		0.06		5.74
2002	1.7		0.36	0.2		0.6	2.4	2.43	0.1	0.01	0.04		6.4
2003	0.8		0.54			0.50	2.60	2.24	0.10	0.01	0.06		6.32
2004	1.3		0.44		0.10	0.50	2.20	0.75	0.10	0.01	0.06		4.34
2005	1		0.37			0.70	2.10	0.30		0.01	0.12		4.6
2006	1.1		0.38			1.10	5.50	1.60					9.68
2007	1		0.33			0.90	8.7	0.83			0.02		10.78
2008	1.4		0.19			1.00	8.5	0.75	0.23		0.04		12.11
2009	0.8		0.42			1.40	8.3	0.81	0.30		0.02	0.38	12.43
2010	1.9		0.21			1.40	8.2	1.55	0.10		0.01	0.36	13.73
2011	2.6		0.20	0.004	0.13	2.70	5.5	1.56	1.0		0.02	0.69	14.404
2012	2.6	0.17	0.10		0.5	1.70	6.1	1.53	0.5		0.16	0.2	13.580
2013	2.7	0.19		0.006	0.2	3.5	6.6	1.53	0.5		0.10	0.37	15.196
2014	3.0		0.19		0.4	2.3		1.6	1.085		0.16	0.38	9.115
2015	1.83				0.45			1.53	0.8				4.61

5 ToR 3) Progress an eel stock annex and make recommendations for further work

The working group developed a first draft of the stock annex, basing this on those parts of the assessment that are used in supporting the ICES Advice at this time, and using the Stock Annexes of the Atlantic Salmon, Brill and Cod as templates.

As the Stock Annex is intended to be a stand-alone document, it is provided here as a link in this report in Annex 10.

6 ToR 4) Review developments in the standardization of methods for data collection, analysis and assessment, and make recommendations for further work

6.1 Introduction

WGEEL noted a critical need for improvement in the quality and consistency of data reporting at the national and EMU level (ICES, 2013b), because variability of reporting standards, level of detail and coverage restricted the scope and value of international evaluation of the eel stock, and hampered the provision of management advice for the eel stock.

6.2 Use of models

ICES (2013b) gives an overview over the range of eel models which are/were in use in the Member States to process data towards biological reference points. Some of these models were improved. These changes are described in more detail in the corresponding 2015 EMP progress reports within this report, and are only briefly addressed here.

There have been considerable changes within the Belgian, German, Dutch, Polish, United Kingdom, and France approaches, as well as Italy and other Mediterranean countries.

In Belgian Flanders, model calculations are based on the electrofishing assessments for the Water Framework Directive. Within each stratum River Basin * River Type, the total number of yellow eels was estimated based on the recorded density of yellow eel, and adjusted for various factors of natural and anthropogenic mortality. The method for calculating the level of escapement for the 2015 report (Belpaire *et al.*, 2015c) was modified compared with the method used in the 2012 report (Stevens and Coeck, 2013). It may not be excluded that the results were influenced by differences in measurement strategy, data quality and calculation method.

In Germany, the existing "unisex" model (GEM II, Oeberst and Fladung, 2012) has been extended in 2014 and has also been tested in the frame of the POSE project (Walker *et al.*, 2013). With the third generation model (GEM III) it is now possible to take eel gender into account, in terms of growth, influence of mortality factors and survival rates. Furthermore, a tool for integrating catches from trap & transport actions has been added.

In the Netherlands, various methods (Estimating lifetime anthropogenic mortalities, LAM, evaluation of the EMP using stock indicators, and (Demographic, static spatial, silver eel migration) models are used, and further developed. Van de Wolfshaar *et al.* (2014) described the details of each method and models and explain and discuss purposes of the usage of different methods and models, and put the advantage and disadvantages of each model in that report. Some other European countries (FR, GB, IE) are using similar spatial models (i.e. EDA, SMEP II) to estimate yellow eel standing stock and silver eel production. The report focuses on crucial importance of standardization of assessment methods to ensure the recovery of the European eel stock and its sustainable exploitation.

In Poland, the CAGEAN model (Deriso *et al.*, 1985) fitted to data covering period 1960–2011 is used to assess stock dynamics of eel in two river basins. The model uses data such as fishery, age structure, weight-at-age, and cormorant predation, and has improved with respect to the availability of data in 2005, 2006 and 2008. Some explanations about differences between the model in 2014 and the model in 2008 are given in the report of the Polish Eel Management Plan 2012–2014.

In the United Kingdom, the data used in the Scenario-based Model of Eel Production II (SMEP II) were updated for the 2015 assessment for England and Wales, as were some of the methods to estimate anthropogenic impacts (UK EMP Progress Report 2015). Due to continued developments (summarised below) the 2015 stock indicators have been recalculated for the reference period (pre-1980s), immediately before, and after implementation of the EMPs. The estimates of B_{best} have been revised by the addition of more index rivers across the eleven RBDs (using eleven rivers for the 2012 report compared to 44 rivers for the 2015 report). Estimates of anthropogenic impacts and hence derivation of $B_{current}$ from B_{best} have been revised by the application of a new analysis quantifying the losses due to barriers to eel migration. These losses were not accounted for in the 2012 or 2013 reports, because the method had not been developed at that time. The B_0 estimates have also been revised by using this method to take account of the impact of barriers during the reference period.

In the Scotland EMP (United Kingdom), silver eel escapement is measured directly at three catchments, and scaled up to the entire EMU based on altitude and wetted area. From 2013, and following the methods used in England and Wales, Scotland has adopted the inclusion of a silver eel production estimate for transitional waters based on the simplistic assumption that this is equivalent to silver eel production in the lower lying rivers and lochs of Scotland.

The French EDA (Eel Density Analysis) is a modelling tool which allows the prediction of yellow eel densities and silver eel escapement from electrofishing survey networks (French EMP Progress Report 2015). The 2015 version of EDA (2.2) is based on a dataset of 24 541 electrofishing operations (increased from the 9556 operations used in the 2012 version). The larger dataset is explained by the inclusion of deep-water electrofishing operations and eel-specific surveys. The model distinguishes from its 2012 (2.1) version by the prediction of eel abundance per size class, separated with boundaries 150, 300, 450, 600 and 750 mm (Briand *et al.*, 2015).

In Ireland, the French EDA model was run for the period up to and including 2011, and compared to the 2012 reported values derived using the Irish analysis (IMESE) (de Eyto, Briand, Poole, and O'Leary, in press; Irish Progress Report to the EU 2015). The EDA model produced biomass estimates which were in line with those previously calculated using the Irish model, giving confidence that the two methods (IMESE & EDA) are successfully estimating total eel production for the country. For the Progress Report 2018, it is hoped to bring the EDA modelling up to date (for years 2012–2017).

In Italy, until 2013, the stock assessment was conducted using the model DEMCAM (Demographic Camargue Model) updated and improved year by year. Up to this time, DEMCAM appeared to be the best compromise between estimate and modelling (IT EMP Progress report 2015). Tests in the frame of the POSE project (Walker *et al.*, 2013) resulted in a good tool for assessment in transitional waters. Since 2014, the ESAM (Eel Stock Assessment Model) model has been applied, being an evolution and generalization of the DEMCAM model. ESAM is proposed for all Mediterranean countries (Schiavina *et al.*, in prep). Italy will use the ESAM model from 2015 onwards.

Given the range of models and methods used in different countries to conduct national assessments for EMPs, WGEEL 2014 created a spreadsheet to capture all of the information in one place. This is intended to act as a resource for anyone wishing to apply an approach to a new situation, so that they can choose from, or adapt, existing approaches. This approach was refined in the WGEEL 2015. This file is stored on the Working Group SharePoint for future use of the WG.

6.3 Data collection

Picking up earlier recommendations (ICES, 2013b), new tables for use in country reports were developed in order to facilitate national reporting to all international fora requiring eel data. The tables are arranged in a way to also facilitate the creation of an international database of eel stock parameters that could be updated annually.

6.3.1 Country report templates

To facilitate data analyses during Working Group meetings, the existing method of providing national data and results in the format of a country report in Word/PDF format was revised. The first step was to create an Excel file with standardized spreadsheets to report and store all national data in a harmonized way (stored on the SharePoint but not produced here). The spreadsheets are arranged to facilitate merging data from all countries and as a first step towards an international database. The data stored in most tables are not raw data but data aggregated on different levels.

The second step was to adapt a new template for a Microsoft Word version of the country reports. Having all data reported in tables as described above, it is suggested that the new version of the report should be more simple, giving a summary of national results and data and a brief description of background, methods and important changes in the analyses and data. It is also suggested that the most important results on national assessments are given early in the report and that data supporting these results are reported thereafter.

6.4 Recommendations

It is recommended that the new reporting scheme for the country reports including explanatory texts and spreadsheet templates is adopted to improve the availability and quality of data aiming at enhanced efficiency in analysis and assessment during Working Group meetings. The electronic files could be enhanced by including data links between tables used for the data collection suggested here and the progress report tables proposed in the 2015 EMP evaluation (Walker, pers. comm.).

An internal review of the operating of the WGEEL identified the following adjustments that could make the work of the meetings more efficient:

1) Identify ongoing tasks (or typical working areas) and define task leader and people interested in these tasks one year in advance (i.e. at end of the working group meeting);
2) Keep track of who is doing which task, and enable communication between task groups working on the same topic in consecutive years;
3) For more consistency, participants should not switch tasks from year to year;
4) For more effectiveness, participants/groups might previously work on aspects of their tasks that can more easily be prepared from home (i.e. maps);
5) If you do work on a task, always place the latest version of the results of your work on the SharePoint (i.e. Excel tables, graphs, figures, etc.);
6) Use standardised spreadsheet templates for data collection;

7) Hand in your country report files and spreadsheet templates *before* the Working Group meeting.

7 ToR 5) Identify relevant data deficiencies, monitoring needs and research requirements

7.1 Introduction

For a full international eel stock assessment to be achieved, against which a post- evaluation of the implementation of the EU Regulation can be measured, there is a need for the establishment of nationally maintained eel stock databases of key stock descriptors (see Chapter 6 above), including fishing effort, which is made available for international compilation and analysis. Only when such data exist in a standardized format will it be possible to bring eel population and stock–recruitment assessments to the level given to most other major internationally exploited fish species.

7.2 Data deficiencies

WGEEL (ICES, 2014a) reviewed the data requirements for international stock assessment, the data available and the gaps in those data. The Working Group considered these again at the 2015 meeting, in light of developments in the past year. Those that remain outstanding are summarised below.

7.2.1 Recruitment

The Working Group has over recent years repeatedly raised its concern about the constancy and coverage of recruitment data. WGEEL (2011a, 2012b, 2013b) noted that some of the glass eel recruitment series have been stopped (Ems in Germany, 2001; Vidaa in Denmark, 1990; Tiber in Italy, 2006). For example, in France in 2012, four out of the six series were discontinued, and 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. WGEEL (2013) encouraged the development of additional recruitment monitoring time-series, especially in the Mediterranean basin, preferable by methods that were not dependent on commercial fisheries.

7.2.2 Landings

The Working Group has repeatedly requested improvements concerning the quality of eel landings data. Even basic data of catch "C" and effort "f" and the main fishery indicators: C total (landings/ fishing mortality), f total, and abundance index (generally cpue) for eel are very often under-evaluated, or even missing in the Country Reports. Moreover, they are not clearly reported by biological stages (glass eel, yellow, silver), by fishing categories or by appropriate management unit, also omitting marine or inland waters.

The inaccuracy and poor representativeness of these indicators have so far made it impossible to assess stock-wide plausible total commercial landings as well as catches of recreational and non-commercial fisheries.

7.2.3 Reporting of indicators for stock assessment

WGEEL (ICES, 2014a) reviewed the data requirements for international stock assessment, the data available and the gaps in those data. 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. A complete reporting of indicators is ideal for a proper stock assessment (but see chapter 4). However, despite the fact the Eel Regulation puts upon

Member States clear and significant reporting obligations, progress reports are still incomplete and inconsistent (see chapter 4). Some stock and mortality indicators are lacking from many countries. Standardization of data table formats and calculation methods would facilitate reporting, while enabling a better evaluation of the effectiveness of individual management measures at EMU level (see Chapter 6, and 2015 Progress Report draft templates, Walker pers. comm.).

7.2.4 Traceability

There is still an urgent need for a traceability system to meet the requirements of Article 12 of the EU Eel Regulation, as identified in the WGEEL Reports from 2009, 2011 and 2012 regarding specifically both trade and the actual use of glass eels. Concerning trade there is an obvious mismatch between "export" and "import" in the trade of glass eels within (and outside EU).

It has been recommended that all countries put in place a system which will:

1) permit cross-checking of imports and exports between countries for each batch of glass eel exported;

2) be able to identify the quantity of glass eel which is supplied to aquaculture but subsequently stocked;

3) allow for each batch of glass eel exported, the date, the amount, the price, the destination EMU and final fate (stocking/aquaculture/consumption), and the EMU of origin to be recorded and made available to the appropriate regulatory authority.

7.2.5 Evaluation of stocking measure and life cycle mortality

To be able to distinguish stocked eels from natural recruits and to facilitate the evaluation of stocking measures, it is recommended that all stocked eels be marked, for example by chemical methods. This was also mentioned by the Commission in their report to the Council in 2014 (COM(2014) 640 final)*. Preferably this would be done in a way that allows the separation between eels stocked within different countries' management plans. This implies the need for an internationally coordinated program. The effects of stocking measures at all steps of the chain from the catch of glass eels at one place until the eventual escapement of silver eels at another place have to be known and the mortality at each step estimated. Those summed mortalities have then to be considered when deciding if stocking results in a net benefit to the stock or not. As American eels have been stocked in Europe, intentionally or not, there is an obvious need to distinguish the two species from each other (cf Marohn *et al*., 2014). Several molecular methods suitable for this discrimination have been described in recent years, (cf Espiñeira and Vieites, 2015)[1].

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[1] * REPORT FROM THE COMMISSION TO THE COUNCIL AND THE EUROPEAN PARLIAMENT On the outcome of the implementation of the Eel Management Plans, including an evaluation of the measures concerning restocking and of the evolution of market prices for eels less than 12 cm in length. 9 p.

7.2.6 Most up to date advice/recommendations in relation to the required metrics gathered

Member States report stock and mortality indicators incompletely and inconsistently, despite the fact that these indicators are essential to the whole stock assessment. Standardisation of data table formats and calculation methods is needed to improve the reporting (see Chapter 6 and draft templates for 2015 EMP Progress reporting (Walker, pers. comm.)).

ICES 2016 Advice states:

- Total landings and effort data are incomplete;
- There is a great heterogeneity among the time-series of landings;
- Inconsistencies in reporting by, and between, countries;
- Incomplete reporting;
- Changes in management practices have also affected the reporting of non-commercial and recreational fisheries.

As a consequence it was concluded that landings data were too incomplete to be used in the Advice. Therefore the Working Group reiterates the request that Member States provide sound data on recruitment, catch, effort and total landings (and catches). In addition, a complete reporting of verified indicators covering the distribution area of the European eel is required for a full assessment of the stock (but see Chapter 4).

7.3 Monitoring deficiencies and needs

7.3.1 Stocking

There is evidence that translocated and stocked eel can contribute to yellow and silver European eel production in recipient waters, but evidence of contribution to actual spawning biomass is missing due to the general lack of knowledge of the spawning biology of eels. Internationally coordinated research is required to determine the net benefit of restocking on the overall population, including carrying capacity estimates of glass eel source estuaries as well as detailed mortality estimates at each step of the stocking process. Prior to stocking, or for continuing existing stocking, a risk assessment should be conducted, taking into account fishing, holding, transport, post-stocking mortalities, and other factors such as disease and parasite transfers (ICES, 2011a). Where eel are translocated and stocked, measures should be taken to evaluate their fate and their contribution to silver eel escapement. This requires batch marking of eel to distinguish groups recovered in later surveys (e.g. recent Swedish, French, and GB marking programmes), or implementing tracking studies of eel of known origin. Marking programmes should be regionally coordinated.

7.3.2 Mortality assessment

The stock response to management actions, in terms of silver eel escapement, will be slow and difficult to monitor. There is a need for methods to quantify anthropogenic mortalities and their sum ‘lifetime mortality’ across Europe. WKESDCF (ICES, 2012a) recommended that the new EU-MAP should include support for the collection of data necessary to establish the mortality caused by non-fisheries anthropogenic factors. Data regarding Natural Mortality (M) are lacking in most cases of stock assessment (ICES, 2014a) and it been recommended that research to investigate factors that cause M to vary in space and time be given high priority. Thus further data collection and research should be encouraged to support and improve the knowledge in order to obtain more reliable stock assessments.

7.3.3 Regional coordination of monitoring

The Workshop on the Baltic Eel (2010c) recommended the coordination, standardisation, integration and joint organization of eel stock monitoring in the Baltic Sea in order to develop pan-Baltic management advice, although to date this has not been implemented. Similar coordinated activity would be relevant to the Mediterranean Sea and other regions.

7.3.4 Ground-truthing models

Models and their outputs need ground-truthing. As far back as 2010, the Working Group advised to only use models independent of the applied actions for careful post-evaluation of implemented management actions.

7.3.5 Eel quality

Most data on eel quality (with respect to contaminants) have been collected for human health considerations and the assessment of habitat quality. These have largely focused on yellow eels. Sampling of silver eel and the assessment of their quality are considered a priority for eel stock restoration, but spatial coverage is poor. However, there is no comprehensive and long-term monitoring of eel quality in silver eels under the framework for eel population recovery. The Working Group therefore recommended that monitoring of silver eel quality should be introduced as part of new or existing programmes (WGEEL, 2013b).

Parasites: Disease monitoring is still only carried out in a few countries and is focused mainly on parasites, such as *Anguillicola crassus*, and in some cases also eel viruses, such as EVEX and AngHV-1.

Establish eel quality database: International assessment of the quality of eel stocks is only possible if raw data are accessible. Most of such data are not made available for international assessment (ICES, 2015f (WKPGMEQ)). The long-term management of the Eel Quality Database (EQD) needs a structural basis and is currently hampered by insufficient resources. WGEEL (ICES, 2009a) suggested that the EQD should be managed at an international level, e.g. by ICES (ICES DataCentre) or a European agency, with long-term funding options and database management expertise (reiterated by ICES, 2015d WKPGMEQ).

7.3.6 Recruitment

It is vital that the recruitment time-series are further improved and expanded in order to provide consistent baseline international assessments. It is therefore recommended (ICES, 2012a) 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 EU-MAP. Loss of monitoring sites was highlighted by SGIPEE (ICES, 2010a). Several fishery-dependent time-series were lost due to restrictions of the fishery or for other reasons (ICES 2014a).

In addition to the stock assessment efforts on the continental life stages of eel, standardized larval surveys as carried out by Germany in 2011, 2014 and 2015 (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.

7.4 Research requirements

In this section the Working Group reviewed the research requirements as identified in previous reports: many are still outstanding. These research issues have been classified as research needs which are considered crucial to future stock management, and research issues contributing to a better understanding aspects of eel biology. They are first summarised (in no particular order) and then some are expanded.

Research requirements crucial to stock management

- eel quality, its impact on stock dynamics and its integration into quantitative assessments,
- hydropower impacts, pumps and mitigation measures,
- stocking, the subsequent production of silver eel and ultimately their contribution to the spawning stock,
- Estimating silver eel escapement,
- Standardization of assessment approaches.

Research requirements for understanding the biology of eel

- eel natural and artificial reproduction,
- effects of predators on the stock,
- tracking methodology developments to monitor silver eel escapement,

7.4.1 Research requirements crucial to stock management: Eel Quality

Specific research needs related to eel quality:

- The role of fat content in eel quality (WGEEL, 2008),
- The effects of specific contaminants and parasites on fat metabolism and a possible relationship between eel fat content and environmental variables (changing temperature, changing trophic status, and food availability; WGEEL, 2008),
- The contaminant and infection levels of diseases and parasites from large parts of the distribution area (WGEEL, 2010b),
- WGEEL recommended the initiation of an internationally coordinated research project, in order to improve the understanding and quantification of the effects of contaminants on the reproductive success of the European eel, for integration in stock wide assessments (WGEEL, 2013b).

7.4.2 Research requirements crucial to stock management: Hydropower & Predators

Specific research needs related to hydropower and predator-driven mortalities:

- Identify measures that mitigate against the impact of hydropower on silver eel migration (ICES, 2010b), and their net benefit as mitigations.
- Quantifying predator–prey relationships (e.g. cormorants; ICES, 2008) in order to inform application of predation mortalities in assessments where desired, and to put losses from predation in context of other losses.

7.4.3 Research requirements crucial to stock management: Stocking

- An assessment of the success of stocking measures (ICES, 2008, 2010b),
- Comparing the reproductive fitness of silver eels originating in stocking programs vs. that of native-origin eels (ICES, 2010b, 2013b),
- Investigating the impact of holding and maintenance feeding of elvers in aquaculture with regard to a possible adaptation to culture conditions and their subsequent suitability for conservation stocking (ICES, 2013b),
- 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* (ICES, 2008, 2012b, 2013b, 2014a).

7.4.4 Research requirements crucial to stock management: Standardization of methods

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, or both. To undertake the International Stock Assessment there are a number of essential components, as outlined below. These are all interrelated and need to be addressed in a systematic manner to maximise standardization across countries.

The suggested programme has two main objectives:

a) estimation of spawning–stock biomass, and

b) estimation of mortality, (this has been separated into an assessment of anthropogenic and natural mortality).

a) 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 of effort in lakes, estuaries, and other large waterbodies; validation, and intercalibration between methods as continually recommended by WGEEL (ICES, 2008, 2011a, 2012b, 2013b & 2014a).
- 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 (ICES 2011a, 2012b 2013b, 2014a). This should include a cross-calibration of yellow eel catch per unit of effort with density data across a variety of habitats.
- Spatially model/describe 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 (ICES, 2014a);
- International surveys at sea of eel in the spawning area in the Sargasso Sea (ICES, 2008, 2012b, 2013b, 2014a).

b) Mortality assessment

- The stock response to implemented management actions, in terms of silver eel biomass, will be slow and difficult to monitor. There is a need for developing standardized methods of quantifying anthropogenic mortalities and their sum 'lifetime mortality' and estimating the same across the entire distribution of the eel, (ICES, 2012b, 2013b, 2014a).
- A whole eel distribution approach to assessing stocking and determining net benefit to the stock (ICES 2011a, 2012b, 2013b, 2014a) including an evaluation of the mortality of the stocked fish in relation to the mortality the fish would have experienced if left *in situ (*ICES 2008, 2012b, 2013b, 2014a).
- 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 (ICES 2012b, 2013b, 2014a). This will need to include an assessment of density-dependent influences (DD) on eel population dynamics that occur at the local level and investigate whether DD has/will play a role at the continental scale in the decline/recovery of the eel stock. (ICES 2011a, 2012b, 2013b, 2014a).

7.4.5 Research requirements for understanding the biology of eel: reproduction

Specific research needs related to early eel stages and to natural and artificial reproduction:

- Determine the oceanic effects on leptocephali survival and migrations, and metamorphosis to glass eel (ICES, 2008);
- Natural reproduction of eels, including their migration routes and spawning grounds (ICES, 2010b);
- The improvement of early larval survival in culture (ICES 2009, 2010b).

7.4.6 Research requirements crucial to stock management: Tracking to validate/estimate Silver eel Escapement

- The development of methodologies to obtain estimates of escapement as direct (*e.g.* mark-recapture or acoustic counting) or indirect methods (*e.g.* yellow eel proxies to determine silver eel production and eel habitat modelling production). Validation of indirect methodologies is required (ICES, 2008).

8 ToR 6) Report on significant new or emerging threats to, or opportunities for, eel conservation and management

As for other Working Groups (e.g. Salmon), WGEEL should comment on emerging threats and/or opportunities to the stock. Due to its complex life history as a diadromous species, the eel is exposed to a multitude of risks. For many of them the impact on the stock is difficult to assess and largely unknown. However, based on a literature review of recent publications (publication years 2014, 2015), some emerging potential threats are discussed.

8.1 New threats

8.1.1 Changing environment, further ongoing climate change

The effects of environmental changes on the eel stock are difficult to assess and quantify. Changes in ocean currents and productivity in the Sargasso Sea and the larval migration routes are likely to impact the early life stages of eels. Given that we have little access to the leptocephalus life stage, we can only speculate on the magnitude of their impact but there have been studies which have correlated numbers of glass and yellow eels abundance to oceanic factors in the Sargasso Sea and in the Atlantic more generally (Friedland *et al.*, 2007; Bonhommeau *et al.*, 2008 a,b; Kettle *et al.*, 2008). High abundance of eel was cross-correlated with low temperatures in the Sargasso Sea (12-year lag) and also the NAO index (11-year lag) (Durif *et al.*, 2011). High temperatures at the spawning grounds can also prevent the spring thermocline mixing and hence decrease primary and secondary productions (Friedland *et al.*, 2007; Bonhommeau *et al.*, 2008a, b). However, Hanel *et al.* (2014) demonstrated low larval abundance in the Sargasso Sea as compared to investigations before the onset of the decline of the eel population, questioning the hypothesis of changes of ocean currents as a major driver for low glass eel recruitment. Climate change might also impact the continental eel stages through shifts in biotic communities of aquatic ecosystems.

8.1.2 New invasive species, threats or opportunities for the eel

Several Ponto-Caspian gobies are spreading over Western Europe and are suspected to cause considerable ecological damage. After colonisation of the Baltic and central European regions, these gobies are now occurring in parts of Western Europe (the Netherlands, Germany, France). Some of these countries reported severe adverse impacts to native biodiversity, e.g. a sharp decline or near disappearance of endangered bullhead *Cottus perifretum* in the Netherlands due to competition from round goby *Neogobius melanostomus* (van Kessel *et al.*, 2014). In Belgium, both the round goby and the tubenose goby *Proterorhinus semilunairs* were caught for the first time in 2010 (Verreycken *et al.*, 2011, Cammaerts *et al.*, 2012) and have since extended their range vastly whilst densities are increasing exponentially. The most recent arrival in Belgium is the bighead goby *Ponticola kessleri* which was first reported from a canal in 2012 and has since been recorded in at least ten other sites at densities up to 30 specimens per 100 m electrofishing. These expanding gobiid populations are expected to have a drastic impact on the local fish assemblages, affecting the diversity of the fish community and the densities of several (rare/endangered) species. Also economic impacts on fisheries and angling have been described (Verreycken, 2013). The possible impact on local eel populations is not known (H. Verreycken, pers. comm.). Nevertheless, the results of the work reported by Rolbiecki (2006) in the Vistula lagoon (Poland) suggested that these gobiids may contribute to the further spreading of eel parasites including *Anguillicola*.

There are observations of new colonization and spreading by the European catfish *Silurus glanis*, which is considered as a non-native species, e.g. in France (Poulet *et al.*, 2011) and Spain (Clavero and Garcí-Berthou, 2006). Catfish abundance is negatively correlated with eel settlement in Southern France, which could be explained by the possible predation of catfish upon eels and/or interspecific competition between the two species (Bevacqua *et al.*, 2011). However, the overall impact of the spreading of European catfish on eel has not been quantified.

8.1.3 New emerging contaminants

Apart from numerous reports being published on the presence of a wide variety of 'old' contaminants in local eel populations (see for overviews e.g. ICES 2009, 2010b, 2011a, 2012b, 2013b; WKPGMEQ report ICES 2015f, Freese *et al.*, 2015), there are an increasing number of cases of new chemical substances reported in the tissues of the eel. These include contaminants, fluorinated compounds (such as PFOS) and brominated flame retardants found in eel muscle tissue (Sühring *et al.*, 2013; Sühring *et al.*, 2014; Roland *et al.*, 2014; Roosens *et al.*, 2010). Belpaire *et al.* (2015a) found textile dyes in eel in 77% of the studied Belgian sites, the carcinogenic malachite green being present in eel in 25% of the sites. Malarvannan *et al.* (2015) reported on the presence and levels of organophosphorus flame retardants and plasticizers in wild European eels from freshwater sites in Flanders region (Belgium). Kammann *et al.* (2014) measured PAH metabolites, GST and EROD in European eel as possible indicators for eel habitat quality in German rivers. While many of those substances have toxic properties, it is not known if or how these new substances and the levels at which they are found in eel may present an additional threat to the population.

There has been recent concern about pollutants impacting organisms via changes in gene expression. The presence of pollutants may lead to an increase in the transcription of genes involved in detoxification, but at a cost of the reduced expression of genes involved in vital organism processes, such as respiratory and lipid metabolism. (ICES 2013b; Pujolar *et al.*, 2013; Marohn *et al.*, 2008). This may have implications for eels.

Microplastics are a potential problem for aquatic species as they are incorporated at the base of the food chain (Andrady, 2011). They can have a mechanical effect (on digestion and buoyancy of autotrophs) but are also loaded with heavy metals which accumulate in organisms (Cole *et al.*, 2011). We have currently no idea how this might affect the early life stages of eels, and there are no microplastics data for freshwater systems so this remains an area to be investigated.

8.1.4 New diseases

In recent years a substantial amount of literature has documented the presence and spread of viruses in eel stocks (e.g. Belgian country report). The three primary viral diseases of eel are Anguillid herpesvirus 1 (AngHV-1), Eel Virus European (EVE), and other aquabirnaviruses (IPNV), and Eel Virus European X (EVEX), however, new viruses, like betanodavirus (Bandín *et al.*, 2014) and picornavirus (Fichtner *et al.*, 2013) have been reported in eel. In some cases the detection of Herpesvirus in eel was associated with eel mortalities (Armitage *et al.*, 2013). Although some reports consider the potential impact of viruses (e.g. Haenen *et al.*, 2009; van Ginneken *et al.*, 2005), the impact on the eel and the potential role in the decline of the stock have not been fully assessed. Restocking practices with ongrown eels may facilitate the spread of viruses (EFSA, 2008).

8.1.5 Renewable marine energy

Several countries have plans for renewable energy production, including offshore tidal turbines. The likelihood of any impacts on European eels will depend on interactions between (1) migratory routes and behaviour (2) the distribution of offshore developments (3) the technologies deployed. (Malcolm *et al*., 2010).

8.1.6 New hydropower initiatives

Some Member States reported on new plans for the construction or further developments of hydropower stations, which are likely to put additional threats on the local stocks. For example, in Turkey 575 hydropower projects are under construction (*http://www.invest.gov.tr/en-US/infocenter/news/Pages/031011-600-hydro-electric-power-plant-projects-turkey.aspx) <http://www.invest.gov.tr/en-US/infocenter/news/Pages/031011-600-hydro-electric-power-plant-projects-turkey.aspx)>*. In the Balkan area, a larger number of dams and hydropower stations are planned or under construction, an interactive map of their location can be downloaded from http://riverwatch.eu/en/interactive-map. In Belgium, there are existing projects to exploit new hydropower stations on the River Meuse and on the lower Sambre river, which may put additional pressure on the silver eels of the Meuse EMU (Vlietinck and Rollin, 2015).

8.1.7 Predators

The Eurasian otter (*Lutra lutra* L) is a top predator in aquatic systems, and in many waterbodies eel constitutes a substantial part of their diet (Almeida *et al*., 2012; Reid *et al*., 2013). Environmental degradation, the presence of toxic compounds and eradication by fishermen resulted in a dramatic decline of the otter populations. In recent years, otter populations seem to be increasing in many countries. It may reasonably be expected that restoration of the otter populations might increase predation pressure on eel in certain localities.

8.2 New opportunities

8.2.1 Invasive species as new opportunities for the stock?

The expansion of new invasive alien species has also been reported to have positive impact on the eel, and may hold new opportunities for the eel stock.

The Asian clam *Corbicula fluminea* is a widespread invasive alien species. Being imported into the Rhine in the 1980s, this freshwater bivalve reached Ireland in 2010 and is now also present in Portugal. The species is known to cause large-scale changes in macrozoobenthic assemblages. Research in the River Minho (Portugal) indicated that some fish species, among them the European eel, may be positively impacted by this invasive clam. The results suggest that the physical structure provided by the shells is likely to be one of the main factors responsible for the differences observed (through influence on the epibenthic associated fauna) (Ilari *et al*., 2014).

8.3 New literature findings with potential management implications

In the following section some more recent papers with a possible relevance to eel stock management were reviewed.

8.3.1 Advances in telemetry technology

The development of animal electronic tracking technology (telemetry) has provided unique tools to reveal novel information on animal behaviour in aquatic habitats: knowledge that a few decades ago was impossible to achieve (e.g. Lucas and Baras, 2000; Thorstad *et al*., 2013). Using electronic tracking techniques, extensive long-term data on individual fish movements, physiology and/or environmental parameters can be collected. This new tracking technology has also opened opportunities for collecting new information on the biology of European eel, and of impacts of anthropogenic activities (e.g. Wysujack *et al*., 2014; Aarestrup *et al*., 2009; Calles *et al*., 2010; Davidsen *et al*., 2011).

8.3.2 New application using environmental DNA

The Working Group acknowledged the presence of numerous reports showing potential applications of using environmental DNA methods (e-DNA) in assessing natural fish populations. As an example, Thomsen *et al*. (2012) demonstrated the possibilities of detecting the presence of European eel in the marine environment through e-DNA analysis in seawater samples, while Ray (2014) reported on the use of e-DNA to detect the absence/presence of American eels (*Anguilla rostrata*) in stream water in tributaries of the Hudson River.

8.3.3 Advances in techniques for reproducing eel, and its value for research (e.g. assessing the effects of reprotoxic substances on eel reproduction)

Significant advances have been made in recent years in the artificial reproduction of anguillids (see e.g. Masuda *et al*. (2012) for *A. japonica* and Butts *et al*. (2014) for *A. anguilla*). Future developments in the production of eel larvae in captivity hold new possibilities for experimental work in many areas, including toxicology, as researchers may be able to test the effect of pollutants in reproduction experiments (Brinkmann *et al*., 2015; Sühring *et al*., 2015; Belpaire *et al*., in press).

8.3.4 Advances in application of biomarkers and genetic work

The eel genome was recently sequenced and published (Henkel *et al*., 2012), providing opportunities in diverse applications for a better understanding in eel biology.

Understanding the real and long-term effects of contaminants on the reproductive potential of eels is one of the fundamental goals of biomarker development for eel. The WKPGMEQ workshop (ICES, 2015) and Belpaire *et al*. (in press) reviewed the advances in this topic. A new paper using transcriptomic methods (Baillon *et al*., 2015a) investigated the effects of organic and inorganic contaminants on the gonad development of wild female silver eels, and suggested an impairment of gonad development in eels from the polluted waters. Detecting and separating specific effects of contaminants in a multi-stress field context remain a major challenge in ecotoxicology. However, new transcriptomic methods may have promising applications. Baillon *et al*. (2015b) demonstrated the applicability and usefulness of performing gene transcription assays on non-invasive tissue sampling in order to detect the *in situ* exposure to Cd and PCBs in eel. Other examples of studies relate to PCBs (Marohn *et al*., 2008) and heavy metals (Nunes *et al*., 2014).

8.3.5 New findings in relation to stocking

Several papers have recently reported unexpected results from stocking American glass eels (*Anguilla rostrata*) in lakes within the Saint Lawrence drainage. Silver eels originating in glass eels taken from coastal waters in Canada were much smaller and younger than silver eels that had naturally recruited to the area. Also, while the natural system normally produced female silver eels only, males occurred among the eels with a stocked origin. The phenotypic variation observed among regions and between individuals of the same region is explained with a spatially varying selection and such factors must be considered for any successful management strategies, including stocking. The results are also consistent with divergent natural selection of phenotypes and/or genotype-dependent habitat choice by individuals that results in genetic differences between those in different habitats, occurring every generation anew. (Côté *et al.*, 2015; Pavey *et al.*, 2015; Stacey *et al.*, 2015). Whether these findings are also valid for the European eel remains to be seen. However, the unexpected results from Canada may be more of a temporary phenomenon related to the very first age classes dominated by fast growers silvering at low age and size. Stocking of European eel has been practised across Europe for many decades and such unusual results have not been reported.

There are also several papers published on the performance of European eels stocked in the wild. Among the most recent ones, Ovidio *et al*. (2015) reported on stocking with imported glass eels in three small streams of different typology. They found, as in many earlier studies, that the stocked eels survived, grew, dispersed upstream and downstream. Another recent paper (Pedersen and Rasmussen, 2015) shows that in contrast to common belief there was no advantage in using larger eels compared with small ones (9 g vs. 3 g eels) for stocking in a Danish fjord. The comparison was made on the basis of yield-per-recruit in the two groups, respectively.

8.3.6 New findings indirectly related to possible threats and opportunities

The seaward migration in Australian short-finned eel, *Anguilla australis*, was studied using acoustic transmitters. This migration was assumed to be rapid and direct once initiated. However, it was found that this migration was much more complex and varying than expected. Most eels that left freshwater stayed in the estuary for one to 305 days before leaving for the sea. This may lead to a higher exposure to exploitation or predation than earlier realized (Crook *et al*., 2015). Similar findings were presented by Aarestrup *et al*. (2010), where tagged eels were tracked along their route towards the sea. Mortality in freshwater reaches were low, while in the fjord parts close to the sea mortality was high, mainly from fishing.

Tide gates form a temporal barrier to migrating eels and their impact on downstream migrating eels are unknown. Wright *et al*. (2015) studied the passage of silver eels arriving at such gates using passive integrated transmitters (PIT tags). Though almost all eels tracked actually passed the gates, there was a delay in passage compared to undisturbed areas. This delay may impose an increased mortality from predation. However, a changed operation of the gates could speed up the passage.

8.4 Conclusions

As noted throughout the variety of sources assessed for this task there are severe 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 coordination 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 (2011a) 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.

Ongoing environmental changes and continued habitat deterioration are considered to further increase the pressure on the eel stock also in future. However, WGEEL also acknowledges the further development of new technologies as opportunities towards a better understanding the biology of the eel, with potential implications for stock management.

8.5 Recommendations

- WGEEL reiterates the request and recommends that Member States provide sound data on recruitment, catch effort and total landings. In addition a complete reporting of verified indicators covering the distribution area of the European eel is required for a full assessment of the stock.
- Application of and adherence to the requirements laid out in Articles 9 & 12 of the Eel Regulation in respect to reporting and development of a traceability system.
- Establish time-series for glass eel recruitment in non-EU countries (e.g. Norway, Turkey, Egypt, Tunisia, and Morocco) as a matter of urgency.
- WGEEL reiterates the need for urgent clarification of research issues crucial to stock management as outlined in previous reports but also urges the scientific community to consider new emerging threats, like the spread of invasive species, to eels and their habitats.

9 Report on developments from the GFCM

9.1 Reference framework and roadmap that led to the planning of the Pilot Action towards the Assessment of the European Eel, in the GFCM region

The need to include the Mediterranean countries in the stock assessment of the European eel became evermore apparent after the issue of Regulation 1100/2007. In 2011, within the Study Group on International Ex-post Evaluation on Eel, SGIPEE, held in London, it was stated that *"The European Eel Regulation recognizes that cooperation between countries within and outside EU is desired, especially where management measures taken in one country might interact with measures taken in other countries. This has brought attention to the fact that the "missing" countries that are most relevant to the production assessment are the Mediterranean countries. The Mediterranean area has been neglected up to now regarding its role in the stock-wide assessment. A distinctive contribution regarding potential and actual escapement for Mediterranean areas might be envisaged, on the basis of specific growth patterns, silvering rates and sex-ratios".* Following this, the need to coordinate actions and stimulate coordination has been raised, both within GFCM meetings and EIFAAC/ICES Working Group on Eel.

At the GFCM level, a Transversal Workshop on European Eels, was held in Salammbô, Tunisia, 23–25 September 2010, and it was recommended to develop management plans for the European eel covering all subregions of the Mediterranean. The workshop also recommended the engagement of GFCM in the Joint EIFAAC/ICES Working Group on Eels. The creation of a Joint EIFAAC/ICES/GFCM Working Group on European Eel was subsequently approved by the 14th session of SAC (the GFCM Scientific and Advisory Committee on Fisheries) and the 36th Session of the Commission in 2012. At its 37th session, the Commission agreed to convene a workshop on European eel with ToRs to be developed. It was also recommended that a case study on European eel should be discussed during the Subregional Workshop to Test the Feasibility of Implementing Multiannual Management Plans (Western, Central and Eastern Med.) held in Tunisia, 7–10 October 2013. On this occasion, the European eel was selected as one of the seven case studies for the development of GFCM multiannual management plans.

In this respect, SAC was asked to assess the status of the eel stock within the GFCM area and to build the foundation for an adaptive regional management plan that considers existing national measures. In line with this, the FAO hosted the first meeting of the Joint EIFAAC/ICES/GFCM Working Group on Eel (WGEEL) in Rome, November 2014. At that meeting, a plan for a one-year **pilot action,** starting in November 2014, was drafted. The aim of this pilot action was to assist the relevant countries in collecting basic data for a preliminary assessment of the reference points (biomass and mortality parameters) for Mediterranean eel, in time for the upcoming international assessment, foreseen for 2015–2016. Thus, this pilot action is a first step in collaboration between the Mediterranean countries (both EU states and non-EU states) in collecting, for the first time, data on eel landings and their suitable habitats in order to obtain a total assessment of the eel stock in the Mediterranean basin.

9.2 Working schedule and specific Terms of Reference of the Pilot Action towards the Assessment of the European Eel, in the GFCM area

The following actions were considered essential to the successful implementation of this plan:

1) Designation of a national focal point for eel, who will be in charge of coordinating the collection of basic data on eel habitats, eel fisheries and eel local stocks.
2) Submission of data through an online survey.

The information collected were compiled, discussed and subsequently integrated with the EIFAAC/ICES/GFCM Eel Working Group in 2015 (this report).

The experts participating at the EIFAAC/ICES/GFCM WGEEL (Rome, Italy, 3–7 November 2014) agreed on the following working schedule of the Pilot action towards the assessment of European eel:

First phase (launched by the Secretariat in 2014, and developed by experts through 2015)

- Creation of a SharePoint site for the GFCM Expert Group on Eel.
- Provision of basic documents and relevant articles.
- Site selection for data collection at national level.
- Dissemination of a concept note on the pilot action to all GFCM countries.
- Definition of the minimum set of data for the application of models well-suited to coastal fisheries.
- Development and distribution of an online template for a survey on eel sites and catches.
- Data collection at the national level: information on wetted areas (i.e. areas that are suitable or potentially suitable for eel), historical data on sites, biology and fisheries from literature (or other sources) as well as any surveys of selected sites.
- Overview of suitable models for coastal lagoons and inland fisheries.

Second phase (to be carried out by GFCM Expert Group on Eel with the support of the Secretariat, in collaboration with the National Focal Points and experts within the EIFAAC/ICES/GFCM WGEEL)

- First attempts at running a model to obtain an assessment of the reference points for eel in the Mediterranean countries and for the Mediterranean Region.
- If deemed necessary, arrange a meeting in order to collate all data and run the models at the regional (Mediterranean) scale.
- Submit the results of the modelling exercise to the WGEEL in order to discuss and evaluate it, and integrate it in the international assessment.

The final ***Terms of Reference*** of the Pilot Action towards the Assessment of the European Eel agreed by the GFCM Expert Group on Eel were to:

1) Collect the basic necessary data (in some countries, for the first time) and setting up of the methodology (modelling approach, targets and reference points) to participate to the international assessment of the European eel (as discussed in Rome, October 2014).

2) Perform the first assessment of reference points based on the three Bs (B_0, B_{curr}, B_{best}), and on the anthropogenic mortality rates, consistent with the ongoing approach in Europe based on the EIFAAC/ICES Eel WG and the requirements of Regulation 1100/2007.

3) Have a first outline of a management strategy specific for the Mediterranean.

9.3 Methodology I: online survey, data collection, data validation

Online surveys were performed with the aim to collect basic data needed for a preliminary Mediterranean eel stock assessment using a demographic model approach (based on Aalto *et al*., 2015; Bevacqua *et al*., 2015; Schiavina *et al*., 2015). Having been tested against other models (e.g. Walker *et al*., 2011), this model was found to be one of the most reliable, particularly for transitional water environments that are typical of the Mediterranean area.

The online procedure consisted of two surveys that were made available online, in English and French. An e-mail contact was available in case National Focal Points needed any assistance.

The data requested were as follows:

1) Locations where eel is present (rivers, lakes and coastal lagoons) and basic geophysical information:
   - 1.1) Site name.
   - 1.2) Geographic coordinates.
   - 1.3) For lake only: typology, mean depth (m), wetted surface (ha) and outflowing stream.
   - 1.4) For river only: river mouth typology (estuary or delta), delta surface (only for river with delta mouth) (ha), wetted area (h), approximate total length below 600 m (km), approximate average width (m), approximate distance from the mouth to the first impassable dam (km), approximate average width from mouth to the first impassable dam (m).
   - 1.5) Surface (ha) for lagoons.

2) Information on eel biology and catches for each location:
   - 2.1) Eel biological traits:
     - 2.1.1) Silver eel male and female mean length (cm).
     - 2.1.2) Silver eel male and female mean age (year).
     - 2.1.3) Von Bertalanffy growth curve parameters (k, l_∞, t_0).
   - 2.2) Fishery information:
     - 2.2.1) Fishing gears.
     - 2.2.2) Sex ratio.
     - 2.2.3) Annual yellow and silver yields (tonnes).
     - 2.2.4) If total yield, yellow/silver ratio.
     - 2.2.5) Restocking practices (glass eels or bootlaces biomasses).
     - 2.2.6) Qualitative (or quantitative when possible) description of effort (i.e. annual number of boat fleet, licenses, nets abundance…).

Consultants hired by the GFCM Secretariat also contributed to partially complete the two surveys using:

- Scientific papers coming from ISI web of knowledge, Google scholar and CAB Direct and direct requests to authors (www.researchgate.net).
- International reports from FAO (GFCM studies and Review and Technical meetings), LaMed-2 Project National reports and ppt presentation, and ICES (WGEEL reports and National Country reports.
- National Fishery (http://archimer.ifremer.fr/; http://www.gafrd.org/; http://www.chioggia.org/; etc.) and Research project reports (Phare project, ZOUMgest project, ENEA "Parchi in Qualità", UNESCO, etc.).

The national focal points were requested to complete the survey to the greatest extent possible, by providing information on historical and present data (the survey allowed users to provide catch data since the 1950s), that were available in national reports, grey literature and national statistics. All data gathered are thus available as published papers or on the Internet or are national statistics provided by the ministries (see References). A first database was prepared and a preliminary assessment was run during the weeks prior to the meeting. The first day of the meeting within the GFCM Med subgroup at WGEEL 2015 was dedicated to verify the dataset and to fix inconsistencies, errors and gaps. The assessment work was then carried out on the second day using the corrected definitive Database.

9.4 Methodology II: Assessment, modelling approach

Local stock assessments were performed at the site level taking into account specific habitat typologies (lakes, lagoons, rivers and river estuaries), by means of a demographic model tuned on available annual data of catches. The ESAM (Eel Stock Assessment Model) was selected for this purpose as it is flexible and easily adapted to data-poor case studies, and it has been developed specifically for lagoons that represent important habitats for eel in the Mediterranean area.

The ESAM is a generalization and evolution of two models: the DEMCAM model (Aalto *et al.*, 2015; Bevacqua *et al.*, 2015), developed by Bevacqua *et al.* (2007) from University of Parma and Politecnico di Milano and evaluated in the ICES working group SGIPEE and POSE project (Walker *et al.*, 2011) and EMS models (Schiavina *et al.*, 2015), which has been specifically improved for eel stock assessment.

DEMCAM was developed specifically for the assessment of the eel stock and catches in spatially implicit environments such as lagoons, lower water systems or uniform stretches of rivers. A general formulation, ESAM, makes it suitable to describe the demography of different eel stocks, provided that a sufficient number of data are available for parameter calibration. The model covers the whole continental phase of the European eel's life cycle, from the recruitment at the glass eel stage up to the escapement of migrating silver eels. It defines the eel stock and the harvest structured by age, length, sex and maturation stage (yellow or silver) on an annual basis. The model also allows considering the system in pristine conditions by using the extension of pristine habitat in the absence of human pressure (fishing mortality and presence of dams) and the abundance of recruitment to the maximum settlement potential (Bevacqua *et al.*, 2015; Schiavina *et al.*, 2015).

The ESAM requires data on pristine and current wetted areas, habitat quality loss, connection with the sea (both for recruitment and escapement), silver eels characteristics, morphometric relationship, stocking abundances, exploitation characteristics (of all stages: glass eels, yellow eels, silver eels and migrating silver eels) and observed catches. For many of these data, default values (literature average on European population) are proposed and can be used in data poor case studies.

Body growth curves are described by the model proposed by Melià *et al*. (2014), which derives von Bertalanffy parameters from migrating silver eels characteristics. The probability of reaching sexual maturity, and natural mortality were estimated with the model proposed by Bevacqua *et al*. (2006; 2011) with parameters adapted accordingly with growth curves (Andrello *et al*., 2011)

Fishing mortality rate (F) was calculated as the result of the effort, the selectivity of the nets used (depending on the length and the mesh size of the gears) and the catchability (Bevacqua *et al*., 2009), specifically calibrated for each site. The model also considered a trapping fraction, calibrated on data, for those sites that are fished using fixed barriers along the escapement way. Calibrations are carried on by minimizing the sum of square errors between predicted and observed catches in each class (yellow, silver and silver from fishing barriers).

The model allows to consider other anthropogenic mortalities, such as silver eel mortality during downstream migration, by considering the number of dams with hydroelectric turbines and their correspondent probability of survival of each plant ($\varsigma = 0.682$, ICES 2011a), cormorant impacts (when available data on cormorant populations are available) and habitat loss mortality.

On the basis of the escapement pristine data, B_0, and the pristine available wetted areas (in hectares), the model estimates the pristine level of recruitment R_0. Considering the current recruitment $R_{current}$ as a fraction of the pristine one (10%, ICES, 2013b), the model calibrates a negative exponential function for recruitment time-series (1950–2009) (ICES, 2013b) imposing $R_{1980} = R_0$ and $R_{2009} = R_{current}$, with an increment in the subsequent years (2010–2014) following the analysis reported by ICES (2014a). With this series and considering the current actual available wetted areas, the model simulates the system in the absence of human pressure, to obtain an estimate of the potential silver eel biomass (B_{best}), and in actual conditions, assess the annual escapement of silver eels (B_{curr}).

The limits to the application of this model are largely due to the lack of specific data for each site. The generalization process for a particular site may lead to overestimates or underestimates of the biomass of spawners. In particular, the value of recruitment, both pristine and actual, and the possible density effects in settlement process has a strong influence on model predictions and the lack of specific data for the estimation of this parameter makes assessments less reliable. When enough data are available (at least five years before 1990) the model tries to estimate a value of B_0 by minimizing the sum of square error only of catch data before 1990. This estimation usually finds the minimum necessary value to predict the observed catches, and thus should be considered as a minimum reference value. This means that a lower value would not have allowed the observed historical catches, but could be an underestimation of reality.

9.5 Results I: data survey, database

A large amount of data was acquired through the online survey. The bibliographic search identified a total of 296 scientific papers and more than 60 of documents from grey literature.

More specifically:

1) Eel focal points from some countries (Italy, Spain, France, Albania, Montenegro, Greece, Turkey, Tunisia, Algeria and Libya) fulfilled the online questionnaire and/or were present at the meeting to fix problems.

2) For some of the counties (Morocco, Egypt) that did not send any information it was possible to find some data using reports and publications.

3) Finally, it was not possible to record any information from Syria, Israel, Bosnia, Croatia, Slovenia, Monaco, Lebanon, Malta and Cyprus).

In total, 12 Mediterranean Countries were covered, with data from 123 Mediterranean coastal lagoons (457 284 ha, 77.7% of total surface of Mediterranean lagoons) (Figure 9.1 and Table 9.1), twelve main rivers (Figure 9.2) (Table 9.2) and ten lakes (±91 265 ha) (Figure 9.1 and Table 9.3). For yields, more than 2650 annual eel catch datapoints were collected.

Table 9.1. Results of the GFCM data collection for eel fisheries in Mediterranean coastal lagoons.

Country	Number of lagoons with fishery data	Wetted area with fishery data (ha)	Representativeness	Total wetted area (ha)
Albania	9/10	10 944	97.7%	11 204
Algeria	1/1	865	100%	865
Egypt	5/6	170 000	96.6%	176 000
France	27/29	66 998	99.0%	67 659
Greece	41/76	31 695	91.0%	34 822
Italy	24/198	112 749	82.1%	137 352
Lybia	0/4	0	0%	3680
Montenegro	0/2	0	0%	1642
Morocco	1/1	11 500	100%	11 500
Spain	8/10	21 288	99.1%	21 475
Tunisia	4/6	15 319	35.6%	90 910
Turkey	11/44	15 927	50.6%	31 473
Total	125/373	457 284	77.7%	588 583

Many Mediterranean rivers, and in particular in the south and eastern part of the basin, are short and run through steep gorges with fast water flow in winter and spring, while in the dry season the water discharge is lower and much water even do not reach the sea. For this reason, and also due to the lack of basic information (length, width, wetted area, et.) on the majority of rivers in the Mediterranean countries, the GFCM survey only took into account rivers with the highest annual river discharge (Struglia *et al.*, 2004; Ludwig *et al.*, 2009) (Figures 9.1 and 9.2).

The "pristine" river surface area refers to habitats available to eel at a time prior to the building of dams and barriers. This area was estimated by multiplying the length of each stream from the mouth with the average width resulting from several width measurements taken along the river axis. The "current" river surface refers to the wetted area between the mouth and the first impassable dam. The first impassable dam on each river was identified analysing satellite and aerial images (Google Earth®). The impassability of the barriers was verified by using photographs of the barriers and other information obtained from scientific literature. When impassable weirs were not identified, the area was measured up to the source. Furthermore, the lower reaches of each river (the lowermost 30 km) was considered separately, due to being a more productive transitional area for eel. Therefore, in the model, the pristine value of B_0 in this section was set by averaging production between the lagoon and the upper river.

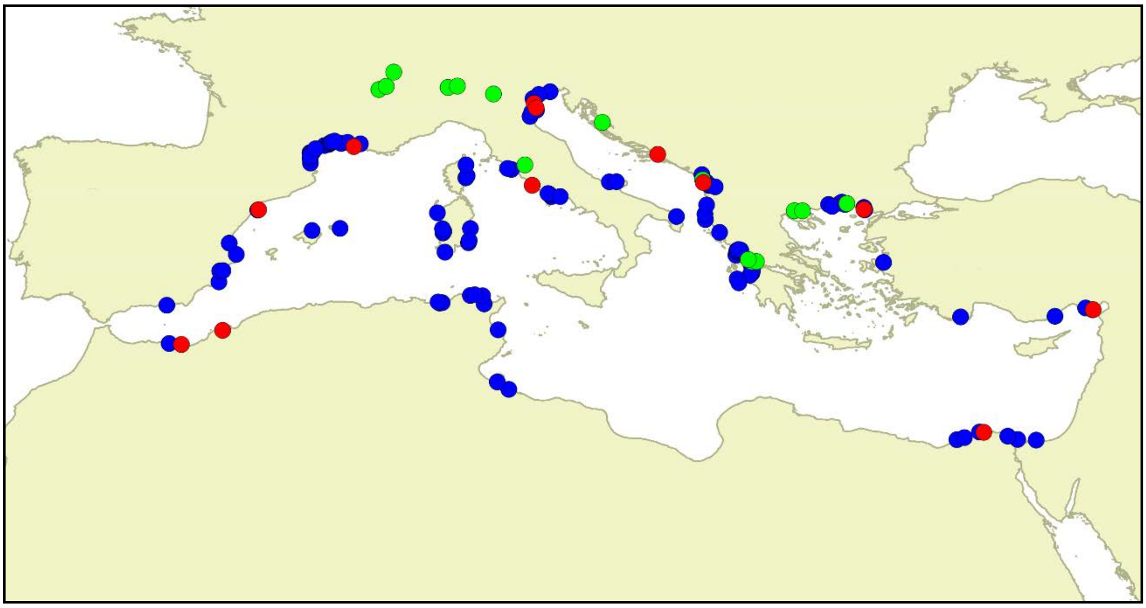

Figure 9.1. The total sites that were evaluated for the Mediterranean eel assessment. The blue dots represents the coastal lagoons, green dots are the lakes and the red dots represents the river estuaries.

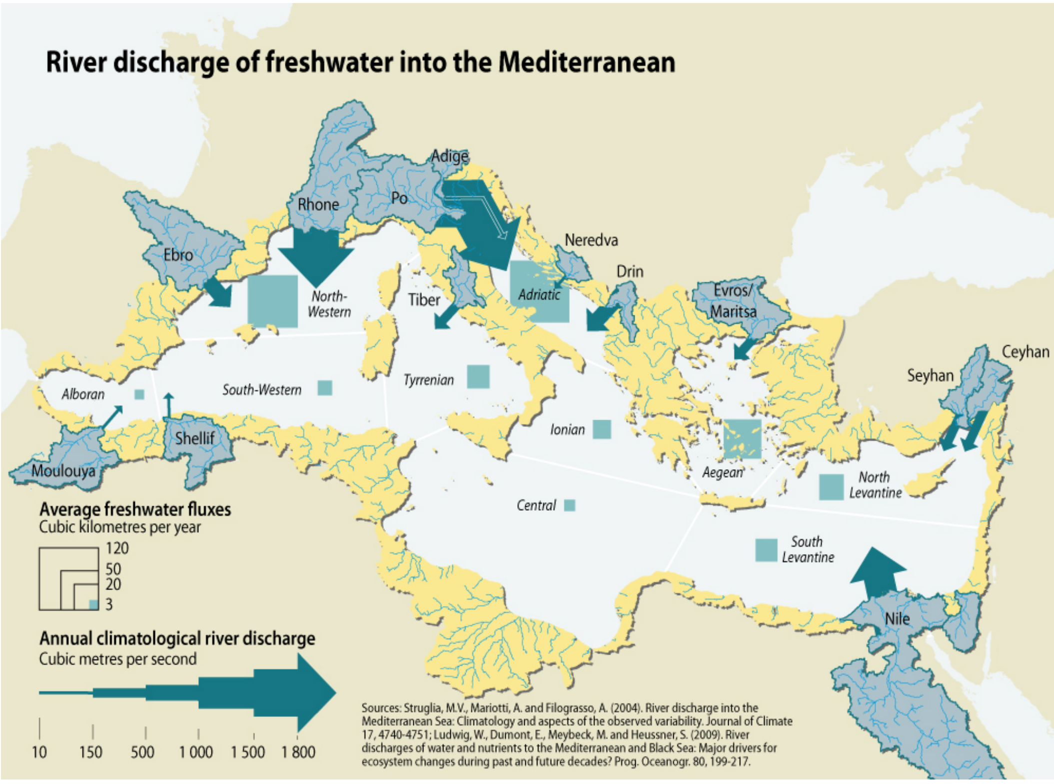

Figure 9.2. The basins of the rivers (shaded blue) that were evaluated for the Mediterranean eel assessment. Only the rivers with annual discharge above a threshold of 10 cubic metres per second were considered (source: Struglia *et al.*, 2004; Ludwig *et al.*, 2009).

Table 9.2. Results of the GFCM data collection for eel fisheries in main Mediterranean rivers considering an annual river discharge threshold of 10 cubic meters per second (source: Struglia *et al.*, 2004; Ludwig *et al.*, 2009)

Country	Rivers	Mouth Type	Lower stretch area (ha)	Available riverine area (ha)	Pristine Riverine area (ha)	Fishery data
Egypt	Nile	Delta	8144	44 900	100 130	V
Spain	Ebro	Delta	250	689	27 654	
France	Rhone	Delta	639	2171	10 142	V
Italy	Po	Delta	2060	6456	13 408	
Italy	Adige	Estuary	305	1440	3082	
Italy	Tiber	Estuary	141	373	2629	V
Turkey	Ceyhan Nehri	Estuary	101	140	2535	
Morocco	Moulouya	Estuary	595	40	775	
Croatia	Neretva+Buna	Estuary	126	320	980	
Albania	Drin	Estuary	144	240	2680	
Greece	Evros	Delta	89	2.336	2336	V
Algeria	Cheliff	Estuary	12	11	346	
			12 071	59 116	166 697	

For those lakes with an average depth of more than 30 m, the area considered suitable for eel was calculated as 10% of the total lake surface. This approach is justified by observations in lentic systems (Ciccotti *et al*., 2012; Schulze *et al*., 2004; Yokouchi *et al*., 2009).

Table 9.3. Results of the GFCM data collection for eel fisheries in Mediterranean freshwater lakes.

Country	Lake	Area (ha)	Fishery data
Albania	Shkopeti	130	
Albania*	Skadar	45 000	
Algeria	Oubeira	2200	V
Algeria	Tonga	2300	V
France	Lac du Bourget**	445	
France	Lac d'Annecy**	276	
France	Lac Léman**	5580	
Greece	Koroneia	3000	V
Greece	Volvi	6700	V
Greece	Lysimachia	1304	V
Greece	Trichonida	9651	V
Greece	Ismarida	340	V
Greece	Vulkaria	912	V
Greece	Ozeros	990	V
Italy	Garda**	3700	
Italy	Varese**	1456	
Italy	Como**	1455	
Italy	Bolsena**	1145	
Italy	Maggiore**	2122	V
Montenegro	Veliko Blato	500	
Montenegro	Sasko	350	
Tunisia	Ichkeul	9000	V
		98 556	

*** Skadar Lake is a basin shared by Albania and Montenegro.**

**** 10% of the total surface.**

9.6 Results II: assessment by Country, assessment at Regional level

As mentioned above, not all the habitats have been considered and the Mediterranean wetted area has only been considered partially. Also, some problems regarding data availability should be solved and model performance should be improved. Therefore, **the results of the implementation of the ESAM model presented in the present section do not constitute an assessment of the Mediterranean production but a first approach towards achieving this overall assessment.**

Assessment within the Pilot Action was on on-site basis, and site performance was variable depending on the data input for each site. According to the model results, more than half of the sites showed good performance, with a determination coefficient R^2 >0.2 (80 of 149 sites, 54%), for 36% of them with an R^2 >0.5. On the other hand only 15% showed a poorer performance (R^2 was <0.2), while the rest 30% of the sites have no R^2, as they are sites with zero or only one year data, or they are not fished at all.

A preliminary estimate of escapement from the overall Mediterranean area from 1951 to 2014 and its pristine value were calculated (Figure 9.3; Table 9.4). Current escapement was compared to the pristine escapement with no anthropogenic mortality, and pristine area available to eel colonization. The estimate given by the model would suggest a reduction of escapement to 11% of the pristine value, and a decline from 10 602 t in 1951 (escapement 54.9%), to 2199 t (11%). The pristine escapement estimate of 19 319 t is much higher (almost double, Aalto *et al.*, 2015) than all previous estimates from other studies.

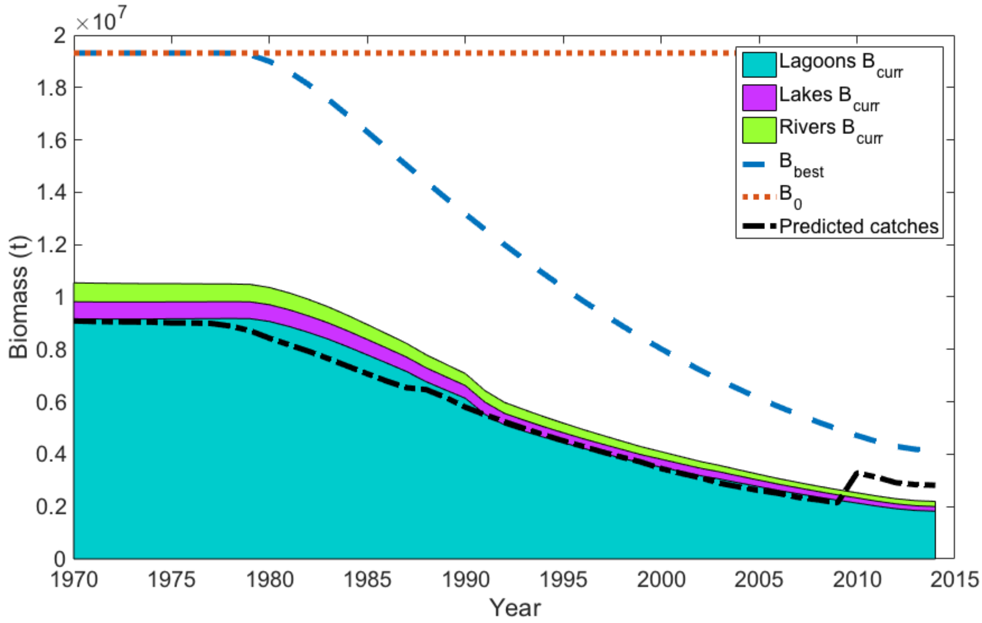

Figure 9.3. Trend (1970–2014) of B_{curr} for the three habitat types; lagoons lakes and rivers. Predicted catches (black dotted line), B_{best} and B_0 are also plotted.

Table 9.4. Results of the assessment: B_0, B_{curr} and B_{best} for the overall Mediterranean area in selected years, stock status as percentage of the pristine escaping biomass (% pristine) and potential escaping biomass (% potential), and lifetime anthropogenic (As with stocking, A without stocking) and fishing mortalities.

MEDITERRANEAN ASSESSMENT			REFERENCE POINTS			STOCK STATUS		MORTALITIES		
YEAR	Pristine Surface (ha)	Current Surface (ha)	B_0 (t)	B_{best} (t)	B_{curr} (t)	% Pristine	% Potential	Σ As (lt-1)	Σ A (lt-1)	F (lt-1)
1951	696,361	696,361	19,319	19,319	10,602	54.9%	54.9%	0.58	0.58	0.58
1952	696,361	696,361	19,319	19,319	10,599	54.9%	54.9%	0.50	0.50	0.50
…										
1964	696,361	696,361	19,319	19,319	10,589	54.8%	54.8%	0.51	0.51	0.51
1965	696,361	696,361	19,319	19,319	10,561	54.7%	54.7%	0.51	0.51	0.50
…										
1977	696,361	696,361	19,319	19,319	10,503	54.4%	54.4%	0.48	0.48	0.47
1978	696,361	696,361	19,319	19,311	10,500	54.4%	54.4%	0.49	0.49	0.48
1979	696,361	696,361	19,319	19,249	10,484	54.3%	54.5%	0.49	0.49	0.48
…										
1989	696,361	599,761	19,319	13,781	7,436	38.5%	54.0%	0.51	0.51	0.49
1990	696,361	599,761	19,319	13,172	7,079	36.6%	53.7%	0.52	0.52	0.50
1991	696,361	599,761	19,319	12,577	6,428	33.3%	51.1%	0.60	0.60	0.54
1992	696,361	599,761	19,319	11,998	5,978	30.9%	49.8%	0.63	0.63	0.56
…										
2001	696,361	599,761	19,319	7,605	3,908	20.2%	51.4%	0.60	0.60	0.55
2002	696,361	599,761	19,319	7,207	3,724	19.3%	51.7%	0.60	0.60	0.54
2003	696,361	599,761	19,319	6,829	3,569	18.5%	52.3%	0.59	0.59	0.53
2004	696,361	599,761	19,319	6,472	3,397	17.6%	52.5%	0.59	0.59	0.53
…										
2011	696,361	599,761	19,319	4,487	2,405	12.5%	53.6%	0.51	0.52	0.47
2012	696,361	599,761	19,319	4,298	2,299	11.9%	53.5%	0.52	0.53	0.48
2013	696,361	599,761	19,319	4,184	2,228	11.5%	53.2%	0.53	0.53	0.48
2014	696,361	599,761	19,319	4,129	2,199	11.4%	53.3%	0.52	0.53	0.48

Assessment results relative to year 2014 are given for the thirteen countries for which it was possible to carry out the assessment (Table 9.5). B_0, B_{curr} and B_{best} as estimated by the ESAM model are also given, as well as the stock status as percentage of the pristine escaping biomass, and estimates of anthropogenic (overall and without stocking) and fishing mortalities.

The results can be discussed in different ways for different countries. For countries that are facing evaluation of their local eel stocks for the first time, this evaluation provided first results and a starting point for future work. The work done within this task represents development of an assessment procedure that can be followed in the coming years.

Countries that are included in the evaluation process under obligation by Regulation 1100/2007 have provided a more detailed database, and they have assessment procedures already established and official estimates made by management plans and reports made to article 9. A comparison can be made between the different approaches and results.

Table 9.5. Results of the assessment for year 2014 for 13 countries in the Mediterranean area: pristine and current wetted area, B_0, B_{curr} and B_{best}, stock status as percentage of the pristine escaping biomass (% pristine) and potential escaping biomass (% potential), and lifetime anthropogenic (As with stocking, A without stocking) and fishing mortalities.

MEDITERRANEAN ASSESSMENT 2014			REFERENCE POINTS			STOCK STATUS		MORTALITIES		
COUNTRY	Pristine Surface (ha)	Current Surface (ha)	B0 (t)	Bbest (t)	Bcurr (t)	% Pristine	% Potential	Σ As (lt-1)	Σ A (lt-1)	F (lt-1)
Italy	145,852	133,402	4,080.9	891.5	619.2	15.2%	69.5%	0.34	0.37	0.32
Spain	49,099	22,134	711.3	166.7	81.7	11.5%	49.0%	0.81	0.83	0.36
France	77,304	69,333	3,596.9	712.5	158.0	4.4%	22.2%	1.85	1.85	1.80
Algeria	5,723	5,388	156.8	54.0	22.9	14.6%	42.5%	0.71	0.71	0.70
Albania	58,898	56,458	487.5	221.2	125.6	25.8%	56.8%	0.55	0.55	0.53
Tunisia	52,073	52,073	1,714.7	337.3	276.2	16.1%	81.9%	0.18	0.18	0.18
Morocco	12,335	11,600	231.1	138.0	51.5	22.3%	37.3%	1.26	1.26	1.25
Lybia	3,680	3,680	72.1	22.8	22.7	31.5%	99.7%	0.00	0.00	0.00
Egypt	379,274	229,044	7,552.0	1,487.0	769.3	10.2%	51.7%	0.83	0.83	0.71
Turkey	18,205	15,810	322.8	69.6	52.3	16.2%	75.1%	0.28	0.28	0.20
Greece	57,017	57,017	869.1	187.5	111.3	12.8%	59.4%	0.56	0.56	0.56
Croatia	1,106	446	7.9	2.5	2.0	25.2%	80.0%	0.20	0.20	0.00
Montenegro	2,492	2,492	48.8	15.4	15.4	31.4%	99.6%	0.00	0.00	0.00
TOTAL	696,361	599,761	19,319	4,129	2,199	11.4%	53.3%	0.68	0.69	0.62

For Italy, for instance, assessment for the EMP was done using the Eel Management Units, i.e. the Regions, as the unit, while here the assessment was carried out for single sites. The results are similar, despite the database used in the present assessment (site-based) being more detailed than the assessment based on the EMUs. This is because the modelling approach is similar, with ESAM being a modified and updated version of the DEMCAM model used in the Italian Eel Management Plan assessment. The assessment approaches provided similar assessments of both B_0 and B_{curr}, meaning that the high catches pre-1980s could be easily predicted.

Assessment carried out for the Mediterranean part of France provided a good estimate for B_0, with the highest average values in the Mediterranean area, with a good fitting of catches in the period before 1990, because of the longest time-series of catches provided for some lagoons. Unfortunately, the lack of data and trend series in the effort (that imposed the use of a constant effort) leads to systematically overestimated catches in recent years, from two to six times higher than the observed values. This leads to an underestimation of the current escapement, whose estimates for the Mediterranean part of France therefore cannot be considered reliable.

Therefore, to improve the model performance for the Mediterranean part of France, progress should be made on the record of catches and effort. Professional fishermen from Mediterranean lagoons are required to record their daily catches on personal logbooks. These data are then transferred to France-Agrimer to be computerized. However, this system is not working efficiently and the database currently available from France-Agrimer is unreliable. When possible, data are also recorded at the DPMA level, or/and other local fishing organization in some places. These data are currently used for Mediterranean figures. Another issue concerns the record of the fishing site. Fishermen are asked to record the area ("Mediterranean zone" or the name of the fishing co-operative that can gather several lagoons together). However, because lagoons can be very different (ecological and physical characteristics), the model is run for each site separately. Therefore, effort should be done to record the catches and effort at site level on the logbooks.

Also for the Mediterranean part of Spain, there are big differences between the model results and those estimated in the post evaluation report. The comparison of the results of the ESAM model with those of the post-evaluation report is hampered by the different level of aggregation of data used for the analysis and in addition, for rivers, only one of the four RBDs flowing into the Mediterranean has been considered. However, some general conclusions can be drawn. Firstly, catches were correctly estimated in those sites with low catches but not in those with high ones: the model underestimated catches in Mar Menor and overestimated catches in Albufera de Valencia and Ebro lagoons. Regarding biomass indicators, B_{curr} estimated from the model is much lower than that reported in the Spanish 2015 post-evaluation report. This is because the model estimated higher B_0 and lower B_{curr} than those of the report. Probably those lower B_{curr} are mainly driven by the assumption of a lower recruitment (10% of historic) than the one really happening in the Mediterranean and more specifically in the Mediterranean part of Spain. Further analyses should be carried out to verify if this assumption is reliable and verify the actual level of recruitment in Mediterranean area. Also, a constant effort has been assumed in many cases where effort data were not available. However, even if exact information has not been compiled, there is an overall effort decrease everywhere in Spain, and if this is not taken into account the population decrease would be overestimated.

Another fact that should be taken into account is that, except from the Mar Menor, which is a hypersaline lagoon, and therefore less productive than the rest of the Spanish lagoons, the pristine productivity of all the Spanish Mediterranean lagoons should be similar. But, habitat suitability, and therefore eel productivity, currently varies greatly among these lagoons. However, the model does not take that into account, and this, together with the fact that effort is not currently documented, could have caused the differences among the different places in the Mediterranean part of Spain being not correctly reflected by the model. For example, Es Grau Albufera, a perfectly conserved lagoon, with only one fishermen, had the second lowest B_{curr}/B_0 relation in Spain.

Therefore, to improve the model performance for Spain, the glass eel fishery effect, an effort assessment, and the different current habitat quality and its variation in last decades, should be taken into account. In future, it is to be hoped that the assessment can be done for all Mediterranean RBDs, also including site-specific biological parameters, to improve the model estimations.

Greece gets assessment results definitely different from those presented in the post-evaluation report 2015. The ratio B_{curr}/B_0 does not change, and is around 12% in both assessments, but absolute values of both reference points are different: the ones attained by the ESAM assessment being almost one order of magnitude higher, for B_0 and for B_{curr} as well.

The estimations of escapement in all conditions (B_0, B_{curr} and B_{best}) in the three habitat types considered for the ESAM assessment (Table 9.6) show that production in lagoons represents 80% of the overall escapement, with a pristine value of about 16 000 t. Rivers contribute 14% and lakes 6% to the overall escapement. These estimates, however, must be taken with precaution, because for those habitats the coverage of the dataset was not entirely satisfactory (see previous section), and therefore the contribution to the escapement has been underestimated. Rivers show the lowest B_0/B_{curr} relation, probably related to the severe reduction of suitable habitat due to dam constructions, resulting in current surface of eel habitat being less than 40% of the pristine. Lakes are the habitat least impacted by fishing mortality, because many of them are no more fished, or are not reachable by juveniles recruitment as their colonization is impaired by obstacles along emissaries (dams, barriers…).

The ESAM model and the resulting assessment and stock indices are less suitable for lakes and rivers, than for transitional waters, both coastal lagoons and estuaries. The French EDA model is probably better suited for those habitats and, hence, should be tried on the dataset available for the Med-countries. Therefore, a complementary approach using different assessment models, dependent on the habitat type and data availability, is suggested for future developments of eel stock evaluation in the Mediterranean area.

Table 9.6. Results of the assessment for year 2014 for the three habitat typologies for the overall Mediterranean area: pristine and current wetted area, B_0, B_{curr} and B_{best}, stock status as percentage of the pristine escaping biomass (% pristine) and potential escaping biomass (% potential), and lifetime anthropogenic (As with stocking, A without stocking) and fishing mortalities.

MEDITERRANEAN ASSESSMENT 2014			REFERENCE POINTS			STOCK STATUS		MORTALITIES		
HABITAT	Pristine Surface (ha)	Current Surface (ha)	B_0 (t)	B_{best} (t)	B_{curr} (t)	% Pristine	% Potential	Σ As (lt-1)	Σ A (lt-1)	F (lt-1)
LAGOON	585,734	489,134	15,720	3,219	1,825	11.6%	56.7%	0.49	0.49	0.45
RIVER	178,768	71,187	2,710	663	196	7.2%	29.6%	0.83	0.83	0.72
LAKE	98,556	98,556	889	247	178	20.0%	72.0%	0.19	0.19	0.19

9.7 Key issues for a management strategy at the Regional level

One of the priorities of GFCM in sustaining the Pilot Action towards the Assessment of the European Eel, was to build the foundation of an adaptive regional management plan for this species. EU Regulation 1100/2007 has force in only some Mediterranean countries (Spain, France, Italy and Greece), however the inclusion of eel in Annex II of CITES has made non-EU countries aware of the need for an international framework for management and stock restoration.

The distinctive features of exploitation in coastal lagoons may provide a key to the setting up of the whole Mediterranean area as a single geographical management unit. In these environments, traditional management practices were honed to sustain local eel stocks, and environmental characteristics are such that very high production can be attained if recruitment is consistent. Furthermore, silver eel fishing at the fish barrier, typical of Mediterranean areas, allows direct control of escapement. Thus the coastal lagoon management model has potential as an instrument for eel conservation: the sustainable implementation of these traditional enhanced fisheries, based on the prudent use of glass eel to maintain lagoon recruitment and managing local escapement targets by scheduled opening of barriers during the migration season. This could allow an important contribution to overall escapement at the Regional scale (Ciccotti, 2005).

Some differences will exist in developing management structures between those countries that are involved in Eel Management Plans under Regulation 1100/2007 and those that are not. Among the former, Spain and France have both Atlantic and the Mediterranean coasts, and hence within the country coordination is required between EMUs. For countries, such as Spain and France, where local management for eel is delegated to regions and autonomous regional eel management plans are in place, each of these Mediterranean regions should adopt the "Mediterranean approach" and be involved directly in a Mediterranean Management Strategy.

Spain and Italy are the only countries in the Mediterranean having glass eel fisheries in the Mediterranean, although Greece may issue special licences for glass eel fishing for stocking and aquaculture. This resource is of significant economic value, and has potential for driving sustainable models of management via stocking. Hence, a harmonization of glass eel fishing regulations between those two countries and among their management units is an important goal. Therefore, a common strategy for the rational use of glass eels among the Mediterranean countries should be drawn up, giving priorities and guidelines for restocking (within/across countries, management units, lagoons, catchments; with/without on-growing, etc.), in agreement also with the Eel Regulation (art. 12) and other reference frameworks. Data on glass eel recruitment and its variation between years and across the Mediterranean could also help in understanding its current level with respect to pristine levels, and the possible density effect on settlement and its distribution among all sites.

Discussion has highlighted the fact that experience undergone by countries that have already faced the process of preparing and implementing an Eel Management Plan might prove to be very useful, and the path these countries have already traced might be a model for other Mediterranean countries to follow.

A requirement that is shared by all GFCM countries, which is the prerequisite to any shared management strategy, is the possibility to share a common methodology in the *data gathering*, both for *fisheries* and for *biological monitoring*. Again, there are some differences in EU/non EU member countries, the former being involved in the Fisheries Data Collection Framework (DCF) under Regulation 199/2008. The DCF, despite limitations for eel, a species for which specific monitoring and samplings are required, has allowed the establishment of a reference framework for eel data gathering that differentiates catches in stages (glass eels/yellow eels/silver eels), requires detailed data on fishing effort and introduces also the requirement to census recreational fishing. In addition, the DCF establishes a common framework for biological monitoring, notwithstanding the fact that the common scheme shows some peculiarities for eel (ICES, 2012a). Hence, the establishment of a common framework for fishery data collection seems strongly required for Mediterranean countries, involving guidelines for sampling site selection for biological monitoring. Participants at WGEEL have shown willingness to stimulate their National Administrations in this direction. Also, common guidelines for biological monitoring to collect necessary information on biological parameters of local stocks will be required.

It has been noted that *recreational fisheries* must be considered because this represents an important source of exploitation in many countries. Efforts will be required also towards the gathering of information on *illegal and underreported eel fisheries*, that may be an important part of the total of eel catch in the Mediterranean area.

The achievement of a comprehensive, coordinated, framework for the eel data collection in the Mediterranean would create a common baseline for all countries for databases, quality and reporting, and therefore also allow a resource assessment on a reliable basis for all the Mediterranean region. This data collection, should be coordinated with the databases already existing or planned in the future within the EIFAAC/ICES/GFCM group.

It would be important to make some calibration exercises among the different modelling approaches to compare results and check the weaknesses and strengthens of each of them.

The best approach for the assessment is to do it separately for each of the different habitats (rivers, transitional waters, lakes and coastal lagoons). This approach reflects both differences in environmental conditions and also in eel exploitation patterns. This has been already followed on 2014–2015 in the present task; but it also will give the opportunity to the countries in the following assessments to choose among one or another different modelling approaches that fits better to each of their habitats.

Finally, *transborder issues* such as shared river catchments or lakes must be dealt with specifically.

The discussion among the GFCM representatives has not yet dealt in detail with specific measures to be contemplated within local, national or supra-national management plans. These should follow from a discussion to be carried out with the various *stakeholders* directly involved in eel exploitation and management at the local levels. Also cooperation between the regional authorities and the local fishing cooperatives, is needed in order to apply measures tailored to the local conditions. An example of good management practice is that achieved at the local level within European Fisheries Funds Projects in Italy (Measures 3.2 within Reg. (CE) n. 498/2007 in application of Reg. (CE) n. 1198/206), that have brought about the implementation of local Management Plans, specifically tailored for single coastal lagoons or catchments.

9.8 Discussion: strengths and weaknesses

Considering the ToR of the Pilot Action towards the Assessment of the European Eel, the proposed objectives were achieved, including the establishment of a first eel database for Mediterranean countries. This concerns in particular some countries for which eel data have previously not been compiled in a coordinated framework, and includes the establishment of a methodology to perform the stock assessment.

A preliminary assessment for Mediterranean eel stocks was carried out during the meeting, pursuing specific reference points consistent with an already established and ongoing approach (biomass and mortality parameters). This exercise can thus provide a first base and reference for the countries that for the first time are involved in the eel stock assessment on a coordinated basis. At the same time it has provided the possibility to compare the assessment results of those countries that are already involved in the eel evaluation and management process under Regulation 1100/2007 with those obtained with the ESAM approach.

During the discussion on results, some weaknesses and also a number of strengths have been pointed out. Some main strengths that were evidenced during the discussion:

- In those countries facing Atlantic and Mediterranean, i.e. France and Spain, and already involved in the stock assessment, lagoon environments might not have been sufficiently or correctly assessed within national frameworks.
- The assessment methodology based on the use of the ESAM model proved to be successful in estimating reference points for the Mediterranean area, especially for transitional environments. For example in France, the models currently used to estimate the stock indices (such as EDA) have not been specifically built to assess transitional waters such as coastal lakes, canals, estuaries, bays, marshes and lagoons. These habitats represent an important part of the total habitat area for eels (particularly in the Mediterranean countries i.e.: 60% in the case of France), and are often rich and productive habitats with eels with rapid growth and short generation time. Hence, from a methodological point of view, the participants felt that it is a main achievement that the ESAM model, which is adapted for the transitional waters, allowed biomass estimations for areas that are not covered by other models.
- This has provided an overview for the stock assessment for the Mediterranean region for the first time.

- The assessment indicated the need for calibrating the model for the data-poor sites in order to obtain an improved eel assessment for the Mediterranean area.

Some weaknesses related to the available data for the Mediterranean area, to the stock assessment method, and to the approach to eel management in the Mediterranean area were also identified:

- The establishment of this first database the Mediterranean area can be considered highly important for the assessment. However, there are some shortcomings since not all the Mediterranean countries participated fully in the online survey and/or were present in the meeting to fill gaps and correct errors. The consequence is that estimates of reference points for these countries and their habitats, and hence global estimate for the Mediterranean, can be biased.
- Another weakness is the inconsistency of catch composition and effort data. For most countries (both those that provided a small amount of data and those that contributed with a large amount of data and long-time catches series), dataseries did not include composition of yellow and silver eel of catches, and for some countries, biological information such as sex ratio of silver eel fraction was also missing. Some indication of the fishing effort (in terms of number of fishers, boats or gears) was also missing. However, the majority of Mediterranean lagoons have been managed for decades by traditional fisheries in a similar and consistent way (Pérez-Ruzafa and Marcos, 2012; Ciccotti, 2014; Aalto *et al*., 2015), and this applies especially to lagoons managed through fixed barriers that are gears independent of personnel involved and dimensions from year to year. Therefore, the use of a constant effort in those cases seemed justified. However, the assumption of a constant effort in places where effort seems to have decrease might have underestimated B_{curr} (e.g. the Mediterranean part of Spain and France).
- Trends in recruitment modelled are simplistic, with the assumption of constant recruitment before the 1980s and a continuous exponential drop thereafter until a fixed value of 10% of the 1980s level. This approach will thus not consider: i.) the interannual variability of recruitment that is reflected in the catches and possible different figures of trends within the Mediterranean area (Schiavina *et al*., 2013). ii.) that the effect of glass eel decline in the Mediterranean might have been different in regions close to and far away from Gibraltar (i.e. Spain and Morocco).
- The results of the assessment might be biased because of the possible density effect on settlement process and differences in settlement potential among sites due to their heterogeneity, and lack of information did not allow for a proper implementation. Moreover, the model uses a fixed relationship between pristine recruitment and settlement potential (pristine recruitment at saturation level) for the entire Mediterranean area, while probably some places receive higher recruitment than the settlement potential in pristine years and vice versa.
- Habitat suitability has not been taken into account, and for that reason the model has not correctly detected differences among areas with different current habitat quality.

- River wetted area in the Mediterranean has only been partially covered and the model performance in this habitat is lower than in transitional waters and lagoons. It is well known that Mediterranean rivers present high variability in terms of hydrological "behaviour" throughout the year, and this variability is not been taken into consideration, at this point, during the simulation. The insertion of more data regarding the river wetted area could possible revise the estimation of the reference point for the European Mediterranean countries and hence the global estimate for the Mediterranean.
- Other models better suited to river environments, should be tested in future in the Mediterranean area if data availability permits.

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Annex 2: Acronyms and Glossary

ACRONYMS	DEFINITION
ACFM (ICES)	Advisory Committee on Fisheries Managment
ACOM (ICES)	Advisory Committee on Management
ADGEEL (ICES)	Advice drafting group on eel, for ICES
AngHV-1	Anguillid herpesvirus 1
BERT	Bayesian Eel Recruitment Trend model
CAGEAN	The Catch-at-Age Analysis Model
CITES	Convention on International Trade in Endangered Species
CMS	Convention on Migratory Species
Cpue	Catch per unit of effort
C&R	Catch and release mortality
DD	density-dependent
DCF	Data Collection Framework
DEMCAM	Demographic Camargue Model
DG MARE	Directorate-General for Maritime Affairs and Fisheries, EU Commission
DNA	deoxyribonucleic acid
DPMA	Direction des Pêches Maritimes et de l'Aquaculture, France
e-DNA	Environmental DNA
EC	European Commission
EDA	Eel Density Analysis (modelling tool)
EIFAAC	European Inland Fisheries & Aquaculture Advisory Commission
EIFAC	European Inland Fisheries Advisory Commission
EMP	Eel Managment Plan
EMU	Eel Management Unit
EFF	European Fisheries Fund
EQD	Eel Quality Database
EROD	Ethoxyresorufin-O-deethylase
ESAM	Eel Stock Assessment Model
EU	European Union
EU MAP	the European Union Multi Annual Plan (EU MAP).
EVEX	Eel Virus European X
FAO	Food and Agriculture Organisation
FEAP	The Federation of European Aquaculture Producers
GEM	German Eel Model
GFCM	General Fisheries Commission of the Mediterranean
GIS	Geographic Information Systems
GLM	Generalised Linear Model
HPS	Hydropower Station
ICES	International Council for the Exploration of the Sea
IMESE	Irish model for estimating silver eel escapement
IUCN	The International Union for the Conservation of Nature
GST	Glutathione-S-transferase
LAM	Lifetime anthropogenic mortalities
MS	Member State

Acronyms	Definition
MSY	Maximum Sustainable Yield
MoU	Memorandum of Understanding
NAO	North Atlantic Oscillation
NC	"Not Collected", activity / habitat exists but data are not collected by authorities (for example where a fishery exists but the catch data are not collected at the relevant level or at all).
NDF	Non-Detriment Finding
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).
ONEMA	Office National de l'Eau et des Milieux Aquatiques, France (ex-CSP)
PAH	Poly aromatic hydrocarbons
PBDE	polybrominated diphenyl ether
PCB	Polychlorinated biphenyl
PFOS	Perfluorooctane Sulfonate
POSE	Pilot projects to estimate potential and actual escapement of silver eel
RBD	River Basin District
RGEEL	Review Group on Eel (ICES)
SAC	The GFCM Scientific and Advisory Committee on Fisheries
SCICOM	The Science Committee of 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
SMEP II	Scenario-based Model for Eel Populations, vII
SPR	Estimate of spawner production per recruiting individual.
SRG	Scientific Review Group
SSB	Spawning–Stock Biomass
ToR	Terms of Reference
WG	Working Group
WGEEL	Joint EIFAAC/ICES/GFCM Working Group on Eel
WGRFS	The Working Group on Recreational Fisheries Surveys
WKAREA	Workshop on Age Reading of European and American Eel
WKBECEEL	Working Group on Biological Effects of Contaminants in Eel
WKEPEMP	The Workshop on Evaluating Progress with Eel Management Plans
WKESDCF	Workshop on Eels and Salmon in the Data Collection Framework
WKPGMEQ	The Workshop of a Planning Group on the Monitoring of Eel Quality
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
IYFS	International Young Fish Survey

Glossary

Bootlace	Intermediate sized eels, approx. 10–25 cm in length (fingerlings). 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.
Depensation	
Eel Management Unit (Eel River Basin)	"Member States shall identify and define the individual river basins lying within their national territory that constitute natural habitats for the European eel (eel river basins) which may include maritime waters. If appropriate justification is provided, a Member State may designate the whole of its national territory or an existing regional administrative unit as one eel river basin. In defining eel river basins, Member States shall have the maximum possible regard for the administrative arrangements referred to in Article 3 of Directive 2000/60/EC [i.e. River Basin Districts of the Water Framework Directive]." EC No. 1100/2007.
Elver	Young eel, in its first year following recruitment from the ocean. The elver stage is sometimes considered to exclude the glass eel stage, but not by everyone. To avoid confusion, pigmented 0+cohort age eel are included in the glass eel term.
Escapement (silver eel)	The amount of silver eel that leaves (escapes) a water body, after taking account of all natural and anthropogenic losses.
Glass eel	Young, unpigmented eel, recruiting from the sea into continental waters. WGEEL consider the glass eel term to include all recruits of the 0+ cohort age. In some cases, however, also includes the early pigmented stages.
Non-detriment finding (NDF)	the competent scientific authority has advised in writing that the capture or collection of the specimens in the wild or their export will not have a harmful effect on the conservation status of the species or on the extent of the territory occupied by the relevant population of the species
Ongrown eels	Eels that are grown in culture facilities for some time before being stocked.
Silver eel production	The amount of silver eel produced from a water body. Sometimes referred to as escapement + anthropogenic losses, or production-anthropogenic losses = escapement.
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 (restocking)	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). Sometimes is also called Brown eel.

Eel reference points/population dynamics	
$B_{current}$ or B_{curr} (Current escapement biomass)	The amount of silver eel biomass that currently escapes to the sea to spawn, corressponding to the assessment year.
B_{best} (Best achievable biomass)	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.
B_0 (Pristine biomass)	Spawner escapement biomass in absence of any anthropogenic impacts.
B_{lim} (Limit spawner escapement biomass)	Spawner escapement biomass, below which the capacity of self-renewal of the stock is considered to be endangered and conservation measures are requested (Cadima, 2003).
B_{MSY}	Spawning–stock biomass (SSB) that is associated with Maximum Sustainable Yield (MSY)
B_{pa} (Precautionary spawner escapement biomass)	The spawner escapement biomass, below which the capacity of self-renewal of the stock is considered to be endangered, taking into consideration the uncertainty in the estimate of the current stock status.
F	Fishing mortality rate
F_{lim}	F_{lim} is the fishing mortality which in the long term will result in an average stock size at Blim.
F_{pa}	ICES applies a precautionary buffer F_{pa} to avoid that true fishing mortality is above F_{lim}.
F_{MSY}	F_{MSY} is estimated as the fishing mortality with a given fishing pattern and current environmental conditions that gives the long-term maximum yield.
M	Natural mortality
MSY	Maximum Sustainable Yield
MSY $B_{trigger}$	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.
Precautionary spawner escapement biomass (Bpa)	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.
Pristine	Conditions not affected by humans
R(s)	The amount of eel (<20 cm) restocked into national waters annually
R2	Determination coefficient
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

Eel reference points/population dynamics	
ΣA	The sum of anthropogenic mortalities, i.e. ΣA = ΣF + ΣH, It refers to mortalities summed over the age-groups in the stock.
three Bs & ΣA	Refers to the three 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.

Annex 3: Participants list

NAME	ADDRESS	TELEPHONE/FAX	E-MAIL
Elsa Amilhat	Université de Perpignan - Centre de Formation et de Recherche sur l'Environnement Marin 58 Avenue Paul Alduy 66860 Perpignan Cedex France	+33 468662186	elsa.amilhat@univ-perp.fr
Jan Andersson	Institute of Coastal Research Simpevarp 100 572 95 Figeholm Sweden	phone +46 10 4784112 mobile +46 70 6205705	jan.andersson@slu.se
Claude Belpaire	Instituut voor Natuur- en Bosonderzoek Duboislaan 14 1560 Groenendaal-Hoeilaart Belgium	+3226580411 mobile: +32 475 678992	Claude.Belpaire@inbo.be
Lamia Bendjedid	National Center for Research and Development of Fisheries and Aquaculture 11 boulevard Colonel Amirouche Bousmain Tipaza Algeria	mobile: +213 661 23 84 16	lamiabendjedid@gmail.com
Pritt Bernotas	Estonian University of Life Sciences Kreutzwaldi 64 Tartu 51014 Estonia	+372 56501622	pbernotas@emu.ee
Cedric Briand	Institution d'Amenagement de la Viliane Boulevard de Bretagne BP 11 56130 La Roche France		cedric.briand@eptb-vilaine.fr
Karin Camara	North Rhine-Westphalia State Agency for Nature, Environment and Consumer Protection Department 26 - Fishery Ecology Heinsberger Str. 53 57399 Kirchhundem-Albaum Germany	+49 2723 779-40	Karin.Camara@lanuv.nrw.de
Fabrizio Capoccioni	Consiglio per la Ricerca e la sperimentazione in Agricoltura (CRA) Via Salaria 31 00016 Monterotondo Roma Italy		fabrizio.capoccioni@entecra.it

NAME	ADDRESS	TELEPHONE/FAX	E-MAIL
Eleonora Ciccotti	Universitá di Roma Tor Vergata Dept of Biology Via della Ricerca Scientifica 00133 Rome Italy		ciccotti@uniroma2.it
Willem Dekker	Institute of Freshwater Research Stångholmsvägen 2 Dept. of Aquatic Resources 17893 Drottningholm Sweden	phone +46 10-478 4248 Mobile: +46 76-12 68 136	willem.dekker@slu.se
Estibaliz Diaz	AZTI Sukarrieta Txatxarramendi ugartea z/g 48395 Sukarrieta (Bizkaia) Spain	phone +34 946 029 400 fax +34 946 870 006	ediaz@azti.es
Caroline Durif	IMR Austevoll Aquaculture Research Station 5392 Storebø Norway	+47 468 47 514	caroline.durif@imr.no
Yiorgos Emfietzis	Fisheries Research Institute (F.R.I) Hellenic Agricultural Organisation – Demetra N. Peramos 64 007 Kavala Greece	Tel. +30 25940 22691-3 Fax. +3025940 22222	gemfietzis@inale.gr
Derek Evans	Agri-food and Biosciences Institute AFBI HQ Newforge Lane Belfast BT9 5QX UK	+44 28 9025 5551	derek.evans@afbini.gov.uk
Deniz Frljuckic	Ministry of Agriculture and Rural Development Directorat for Agriculture and Fishery Rimski Trg 46 81000 Podgorica Montenegro	Office: 00 382 20 234 305 Mobile: 00 382 67 263 531	deniz.frljuckic@mpr.gov.me
Evangelia Georgitsi Observer	DGMare 200 rue de la Loi 1049 Brussels Belgium	+32485 83 73 22	Evangelia.georgitsis@ec.europa.eu
Lukasz Geidrojć	National Marine Fisheries Research Institute ul. Kollataja 1 81-332 Gdynia Poland	+48 587 356 211 Mobile: +48 515 920 711	lgiedrojc@mir.gdynia.pl
Jason Godfrey	Freshwater Laboratory Faskally Pitlochry PH16 5LB UK		J.D.Godfrey@marlab.ac.uk

NAME	ADDRESS	TELEPHONE/FAX	E-MAIL
Martin de Graaf	Wageningen Imares PO Box 68 1970 AB IJmuiden Netherlands		martin.degraaf@wur.nl
Reinhold Hanel	Institute of Fisheries Ecology Palmaille 9 22767 Hamburg Germany	+49 40 38905290	reinhold.hanel@ti.bund.de
Michael Ingemann Pedersen	DTU Aqua Danish Technical University Section for Freshwater Fisheries Ecology Vejlsoevej 39 8600 Silkeborg Denmark	Phone +45 35883128 Private mobile: +45 61339030	mip@aqua.dtu.dk
Stanislovas Jonusas Observer	DGMare 200 rue de la Loi 1049 Brussels Belgium		Stanislovas.Jonusas@ec.europa.eu
Tagried Kurwie	Mahurangi Technical Institute PO Box 414 11 Glenmore Drive Warkworth New Zealand	+64 94258934 fax +64 94258926	tagriedkurwie@gmail.com
Patrick Lambert	Irstea – UR EABX Unité Ecosystèmes aquatiques et changements globaux Pôle Etudes et Recherches Ecohydrauliques ONEMA-IMFT-Irstea 50, avenue de Verdun 33612 CESTAS cedex France	phone +33 5 57 89 08 09	patrick.lambert@irstea.fr
Linas Lozys	Nature Research Center Laboratory of Marine Ecology Akademijos st. 2 08412 Vilnius-21 Lithuania	Mobile: +370 61006873 Tel: +370 52729284 Fax: +370 52729352	lozys@ekoi.lt
Danilo Mrdak	University of Montenegro PO Box 5455 G. Washington Street Faculty of Natural Sciences and Mathematics 81 000 Podgorica Montenegro		danilomrdak@gmail.com
Sukran Ozdilek Yalcin	Canakkale Onsekiz Mart University Faculty of Science and Arts Dept. of Biology Canakkale 17100 Turkey	+90 286 2180018-1796	syalcinozdilek@gmail.com

NAME	ADDRESS	TELEPHONE/FAX	E-MAIL
Wojciech Pelczarski	National Marine Fisheries Research Institute ul. Kollataja 1 81-332 Gdynia Poland	phone +48 58 7356219 fax +48 58 7356110	wpelczarski@mir.gdynia.pl
Russell Poole	Fisheries Ecosystem Advisory Services Funace Newport, Co Mayo Ireland	+ 353 98 42300	Russell.poole@marine.ie
Argyrios Sapounidis	Fisheries Research Institute (F.R.I) Hellenic Agricultural Organization N. Peramos 64 007 Kavala Greece	Tel +30 25940 22691-3 Fax +30 25940 22222	asapoun@inale.gr fri@inale.gr
Marcello Schiavina	Politecnico di Milano Dipartimento di Elettronica Informazione e Bioingegneria Via Ponzio 34/5 20133 Milano Italy	+39 02 2399 4030	m.schiavina@gmail.com
Arvydas Svagzdys	FRL PO Box 108 J.Lelevelio str. 6 Vilnius 01102 Lithuania	phone +37060336551	arvydasrusne@gmail.com
Eva Thorstad	Norwegian Institute for Nature Research PO Box 5685 Sluppen 7485 Trondheim Norway	~~+47~~	eva.thorstad@nina.no
Rachid Toujani	National Institute of Marine Sciences and Technologies-INSTM 28 rue du 2 Mars 1924 2025 Salammbô Tunisia	Office: 216 71 730 420 Mobile: 216 97 496 085 on SP	toujani.rachid@instm.rnrt.tn
Alan Walker Chair (ICES)	Cefas Lowestoft Laboratory Pakefield Road Lowestoft Suffolk NR33 0HT United Kingdom	phone +44 (0) 1502 562244 mobile +44 (0) 7766 475301	alan.walker@cefas.co.uk
Håkan Wickström	Swedish University of Agricultural Sciences Dept. of Aquatic Resources Institute of Freshwater Research Stångholmsvägen 2 178 93 Drottningholm Sweden	phone +46 76-126 81 34 fax +46 10-478 42 69	hakan.wickstrom@slu.se

NAME	ADDRESS	TELEPHONE/FAX	E-MAIL
Klaus Wysujack	Thünen Institute of Fisheries Ecology Wulfsdorfer Weg 204 22926 Ahrensburg Germany	Phone: ++49-4102-70860-13	klaus.wysujack@ti.bund.de
Tomas Zolubas	FRL PO Box 108 J.Lelevelio str. 6 Vilnius 01102 Lithuania	phone +370 46 310-660 fax +370 46 257-745	tomas.zolubas@zuv.lt

Annex 4: Meeting agenda

Tuesday 24th November

09.30–10:00	Welcome, Intro to Working Group, ToR, adopting the agenda.
10:00–18.00	Country Reports; EMP Progress Reports

Wednesday 25th November

09:00–13:00	Country presentations, Updates from WKEELCITES, WKPGMEQ, WGRECORDS
14:00–15:00	Presentations on new and emerging threats & opportunities
15:00–17:00	Introduce tasks, decide who does what, short brainstorm on tasks
17:00–18:00	Plenary for tasks to report plans and requirements

Thursday 26th November

09:00–16:00	All Task Groups breakout
16:00–18:00	Plenary for tasks to report progress

Friday 27th November

09:00–16:00	All Task Groups breakout
16:00–18:00	Plenary presentation by the GFCM Mediterranean subgroup

Saturday 28th November

09:00–16:00	All Task Groups breakout
16:00–18:00	Plenary

Sunday 29th November

09:00–17:00	All Task Groups breakout
17:00	Deadline draft report to Chair
18:00	Chair circulates draft report for comments

Monday 30th November

09:00–17:00	Reading the report, preparing for review

Tuesday 1st December

09:00–16:00	Review report and identify revisions
18:00–18:00	Revise Report

Wednesday 2nd December

09:00–13:00	Revise Report
14:00–15:00	Read changes
15:00–16:00	Review and agree changes to Report

16:00–16:30	Outstanding Issues
16:30	Close Working Group

Annex 5: WGEEL responses to recommendations from other Expert Groups

Recommendations from WKPGMEQ: Raw data should be made available to the International community through WGEel for inclusion in the Eel Quality Database.

WGEEL response: This request will be addressed during the WKBECEEL (January 2016). Therefore, this recommendation should be forwarded to WKBECEEL. Note, however, that the ultimate recipients of the recommendation should be countries producing eel.

Recommendations from WGRFS: The need to include recreational fishery data in a stock assessment procedure should be evaluated on a case-by-case basis, according to the known magnitude of recreational catches compared with commercial catches based on previous surveys or pilot studies. This should be reviewed regularly as recreational catches can fluctuate significantly between years and recreational effort can remain high even where stock are depleted.

WGEEL response: To address this recommendation the WGEEL compiled the available recreational datasets from the Country Reports to compare the recreational catches against the commercial catches and to identify the major gaps in data collection.

Annex 6: 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. WGEEL responses to the generic ToR are given in the table below.

GENERIC TOR QUESTIONS	WGEEL RESPONSE
a) Consider and comment on ecosystem overviews where available.	*Anguilla anguilla* is a catadromous species and therefore occupies marine, transitional and freshwater environments during its life cycle. The ecosystem function (role) of *Anguilla anguilla* in each of these environments is not well understood. A brief ecosystem overview is provided in the initial WGEEL stock annex developed in this report (Annex 11). 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 fisheries considered by the working group consider and comment on: i) Descriptions of ecosystem impacts of fisheries where available ii) Descriptions of developments and recent changes to the fisheries iii) Mixed fisheries overview, and iv) Emerging issues of relevance for the management of the fisheries.	i) The current commercial fishery is prosecuted with fixed and mobile traps, longlines, fine mesh trawls and handnets, and the recreational fishery is mostly rod-and-line, small traps and nets. The operation of these gears probably has little direct impact 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 of the magnitude of these effects. ii) There have probably not been any substantial changes in fishing gears and their operation 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. iii) Most eels are caught in targeted fisheries in coastal waters, transitional (brackish) and freshwater. Some mixed fisheries do occur (e.g. German freshwater fykenet fisheries). Eels may be captured as bycatch in commercial and recreational fisheries (see Chapter 4). There is limited information on number of eels captured as bycatch, or on their survival when there are regulations requiring the 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. iv) See Chapter 8 of this report for more details.

GENERIC TOR QUESTIONS	WGEEL RESPONSE
c) Conduct an assessment to update advice on the stock(s) using the method (analytical, forecast or trends indicators) as described in the stock annex and produce a brief report of the work carried out regarding the stock, summarising where the item is relevant: i) Input data (including information from the fishing industry and NGO that is pertinent to the assessments and projections); ii) Where misreporting of catches is significant, provide qualitative and where possible quantitative information and describe the methods used to obtain the information; iii) For relevant stocks estimate the percentage of the total catch that has been taken in the NEAFC regulatory area by year in the recent three years. iv) The developments in spawning-stock biomass, total-stock biomass, fishing mortality, catches (wanted and unwanted landings and discards) using the method described in the stock annex; v) The state of the stocks against relevant reference points; vi) Catch options for next year; vii) Historical performance of the assessment and catch options and brief description of quality issues with these;	Most of the questions posed in this section of the generic ToR are addressed routinely in the WGEEL report, See Annex 5. However, iii) and iv) are not applicale to eel. A benchmark type stock annex has not yet been developed for eel. Work on an initial stock annex describing the assessment methods was started in 2015 (Annex 11). See annual advice. Knowledge of misreporting of catches is poor. The WG 2015 was not aware of any methods used to obtain this information. Not applicable. Described in the main report. See annual advice. The annual advice provides no catch options because total landings and effort data are incomplete and therefore ICES does not have the information needed to provide a reliable estimate of total catches of eel. Furthermore, the understanding of the stock dynamic relationship is not sufficient to determine/estimate the impact of any catch above zero (at glass, yellow, or silver eel stage) on the reproductive capacity of the stock.). There is no historical assessment of the assessment and catch options.
d) Produce a first draft of the advice on the fish stocks and fisheries under considerations according to ACOM guidelines.	Advice is drafted annually by the WG and redefined by the ADGEEL. A draft advice was delivered to ICES from the WG in October 2015.

GENERIC TOR QUESTIONS	WGEEL RESPONSE
e) Produce a first draft of the advice on the fish stocks and fisheries under considerations according to ACOM guidelines.	For improvements to data quality, see Chapter 7 of this report. For improvements to data transmission, see Chapter 6 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. Some EU Member States have not completely reported stock indicators (15 of 93 EMPs did not report all biomass indicators and 19 did not report all mortality indicators in 2015), 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) Prepare the data calls for the next year update assessment and for the planned data compilation workshops	This will be done in discussion with ICES, EIFAAC, GFCM and DG MARE in the first quarter of 2016.
g) Update, quality check and report relevant data for the stock: i) Load fisheries data on effort and catches into the INTERCATCH database by fisheries/fleets; ii) Abundance survey results; iii) Environmental drivers.	See Chapter 4 and Annex 9 of this report. Eel data are not currently in ICES Databases, because these databases are not structured in a way that is appropriate to European eel. Data are 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. Abundance survey results are provided in some Country Reports, but at present the WG does not collate and analyse these data. 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.
h) 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 (see above). For database and recommendations for future data management, see Chapter 6 of this report.
i) Identify research needs of relevance for the working group	See Chapter 7 of this report.

Annex 7: Forward Focus

This report is a further step in an ongoing process of documenting stock and fisheries of the European 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;

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 short-term goals, leaving biomass indicators (long-term impact) for the longer term goals.

1) Complete data coverage

1.1) The contribution of GFCM countries and the Secretariat in 2014 and 2015 has resulted in additional data from areas throughout the Mediterranean. It is anticipated that this work will continue to develop additional data in the coming years.

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

1.3) New data from within the EU may become available through national implementation of the latest iteration of the EU Data Collection Framework (DCF) – the EU Multi Annual Plan (EU MAP). The WGEEL will continue to monitor these developments and contribute scientific expertise wherever required.

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 were approved in principle by the RGEEL in 2013, although some issues over the specifics of the stock indicator and S-R approaches mean that they are not yet formally contributing to ICES Advice.

Data gaps in the EU limits approach remain, even after the national EMP Progress Reports in 2015 along with the new data from GFCM countries. Although efforts continue to fill these gaps, the Working Group will examine risks and benefits of basing stock assessment on a less-than complete data coverage. The methods used to develop these stock indicators need to be peer-reviewed. 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.

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 national stock indicators.

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, and for cross-calibration exercises.

4) WGEEL Meeting operation

In addition to these wider issues summarised above, the WGEEL conducted an internal process review to identify where its work could be made more efficient. The following are suggested:

- Identify ongoing tasks (or typical working areas) and define task leader and people interested in these tasks one year in advance (i.e. at end of the working group meeting);
- Keep track of who is doing which task, and enable communication between task groups working on the same topic in consecutive years;
- For more consistency, participants should not switch tasks from year to year;
- For more effectiveness, participants/groups might previously work on aspects of their tasks that can more easily be prepared from home (i.e. maps);
- If you do work on a task, always place the latest version of the results of your work on the SharePoint (i.e. Excel tables, graphs, figures, etc.);
- Use standardised spreadsheet templates for data collection;
- Hand in your country report files and spreadsheet templates *before* the working group meeting.

Annex 8: Recruitment analyses supporting the ICES Advice for European Eel for 2016

1 Data and trends in glass and yellow eel recruitment indices

This chapter addresses the latest trends in glass and yellow eel indices and produces the first draft of the ICES eel advice.

1.1 Recruitment

1.1.1 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 1.1). The stages are categorized as glass eel (gls.), mixture of glass eel and young yellow eel (gls.+ylw.) and older yellow eel (ylw.) recruiting to continental habitats (Dekker, 2002).

Figure 1.1. Location of the recruitment monitoring sites in Europe, white circle = glass eel, blue circle = glass eel and young yellow eels, yellow square=yellow eel series.

The glass eel recruitment time-series have also been classified according to two areas: 'continental North Sea' and 'Elsewhere Europe', as it cannot be ruled out that recruitment to the two areas has different trends (ICES, 2010). The glass eel recruitment series are either comprised of only glass eel or of a mixture of glass eel and young yellow eel. Yellow eel series are predominantly made of young yellow eel, or of yellow eel that might be several years old (in the Baltic).

The WGEEL has collated information on recruitment from 51 time-series. Some time-series date back to the beginning of 20th century (yellow eel, Gota Älv, Sweden) or 1920 (glass eel, Loire, France).

- 36 time-series were updated to 2015 (26 for glass eel and ten for yellow eel Table 1.3 in Appendix).
- Five time-series (three for glass eel and two for yellow eel) were updated to 2014 only (Table 1.4 in Appendix).

- Among the time-series based on trap indices, some have reported preliminary data for 2015 as the season is not yet finished (Lagan (SW), Kavlingean (SW), Göta Älv (SW), Motalä Stom (SW), Parteen (IR), Bann (GB), Frémur (FR), Bresle (FR)), while others have not yet reported (Guden Å (DK), Harte (DK)). Therefore, the indices given for 2015 must be considered as provisional especially those for the yellow eel.
- Ten time-series have been stopped (ten for glass eel and none for yellow eel, Table 1.5 in Appendix). They stopped reporting either because of a lack of recruits in the case of the fishery-based surveys (Ems in Germany, stopped in 2001; Vidaa in Denmark, stopped in 1990), a lack of financial support (the Tiber in Italy, 2006) or the introduction of quota from 2008 to 2011 that has disrupted the five fishery-based French time-series. Note the French Vilaine time-series could be used again in 2015 because the glass eel fishery never achieved its quota.

The number of glass eel and glass eel + young yellow eel time-series available has declined from a peak of 33 in 2008. The maximum number of older yellow eel time-series has increased to 12 in 2014 (Figure 1.2).

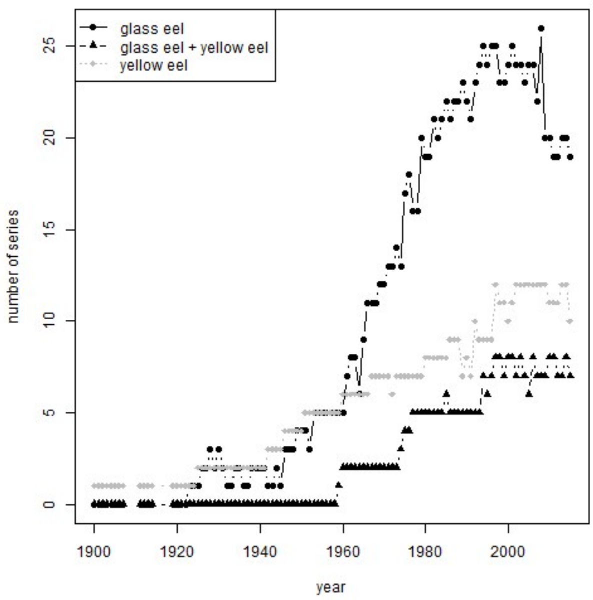

Figure 1.2. Trends in number of glass (black circle), glass+young yellow eel (grey triangle) and older yellow eel (black triangle) time-series giving a report in any specific year.

1.1.2 Raw data

Calculation of the geometric mean of all time-series is given in (Figures 1.3 and 1.4). [2].

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[2] This figure is given as it consistent with the trend provided by WGEEL from 2002 to 2006. The scaling is performed on the 1979–1994 average of each time-series, and seven time-series without data during that period are excluded from the analysis. The time-series left out are: Bres, Fre, Inag, Klit, Maig, Nors, Sle.

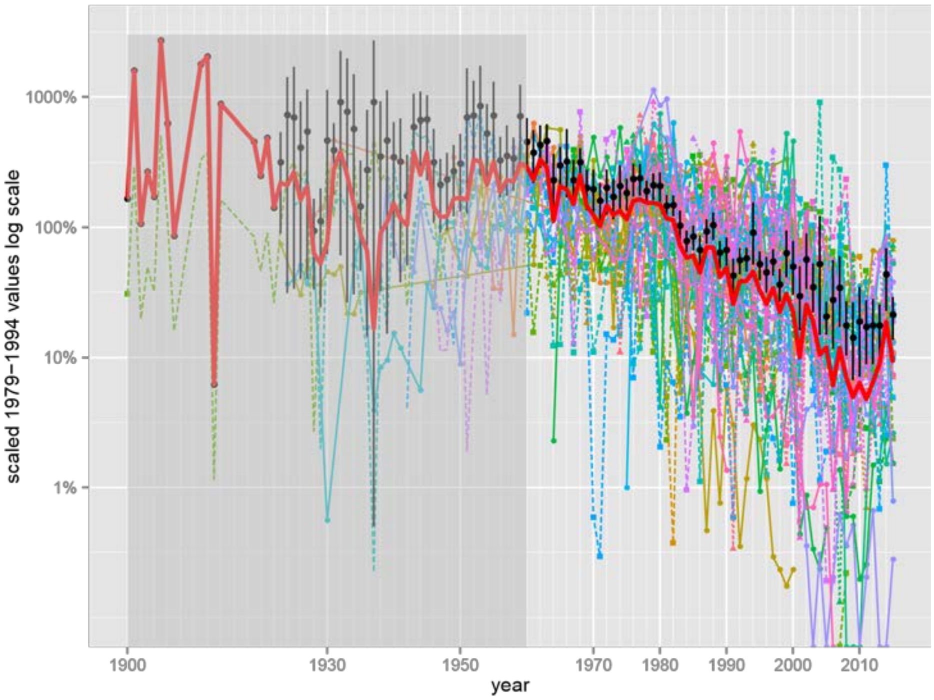

Figure 1.3. Time-series of glass eel and yellow eel recruitment in European rivers with time-series having data for the 1979–1994 period (44 sites). Each time-series has been scaled to its 1979–1994 average. Note the logarithmic scale on the y-axis. The mean values and their bootstrap confidence interval (95%) are represented as black dots and bars. Geometric means are presented in red.

Separate trends for both glass eel and yellow eel time-series were introduced by the WGEEL in 2006 (Figure 1.4).

1.1.3 Trends in recruitment

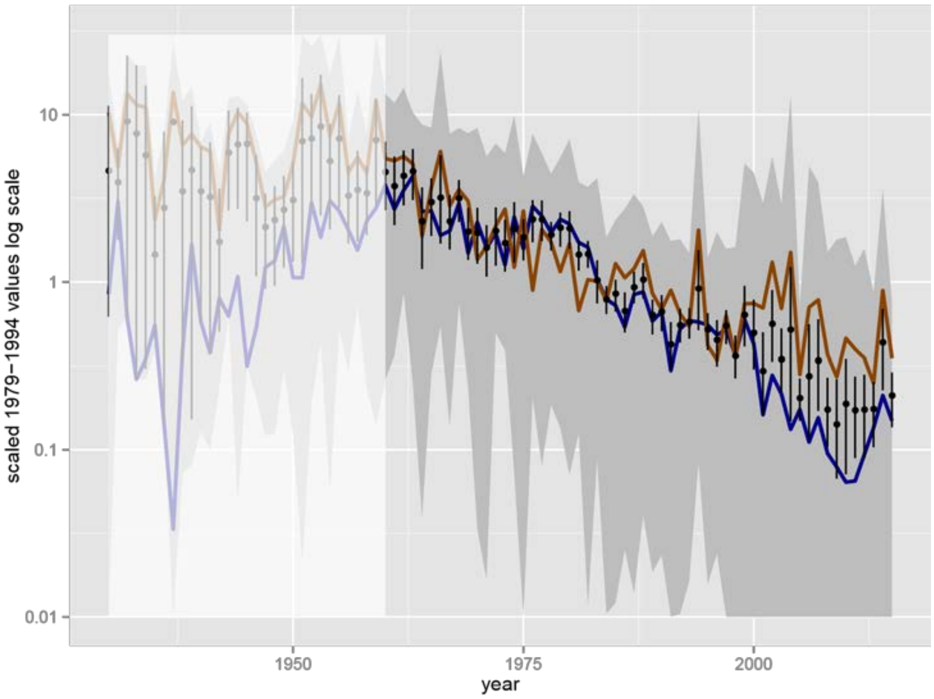

Figure 1.4. Time-series of glass eel and yellow eel recruitment in Europe with 44 time-series out of the 51 available to the working group. Each time-series has been scaled to its 1979–1994 average. The mean values of combined yellow and glass eel time-series and their bootstrap confidence interval (95%) 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 time-series. The range of these time-series is indicated by a grey shade. Note that individual time-series from Figure 1.3 were removed to make the mean value more clear. Note also the logarithmic scale on the y-axis.

1.1.3.1 GLM based trend

The WGEEL recruitment index is a reconstructed prediction using a GLM (Generalised Linear Model) with gamma distribution and a log link: *glass eel ~ year*: *area + site*, where *glass eel* is individual glass eel time-series, *site* is the site monitored for recruitment and area is either the continental North Sea or Elsewhere Europe. In the case of yellow eel time-series, only one estimate is provided: *yellow eel ~ year + site*.

The trend is reconstructed using the predictions from 1949 for 39 glass eel time-series and 12 yellow eel time-series. Some zero values have been excluded from the GLM analysis: 12 for the glass eel model and one for the yellow eel model.

The reconstructed values are then aggregated using geometric means of the two reference area (Elsewhere Europe EE, and North Sea NS). The predictions are given in reference to the geometric mean of the 1960–1979 period. Note that the shift from arithmetic to geometric means was done this year as the recruitment is usually assumed to be lognormally distributed (Drouineau *et al.*, 2016).

After high levels in the late 1970s, there has been a rapid decreasing trend for three decades to a minimum in 2009 (Figures 1.5–1.6).

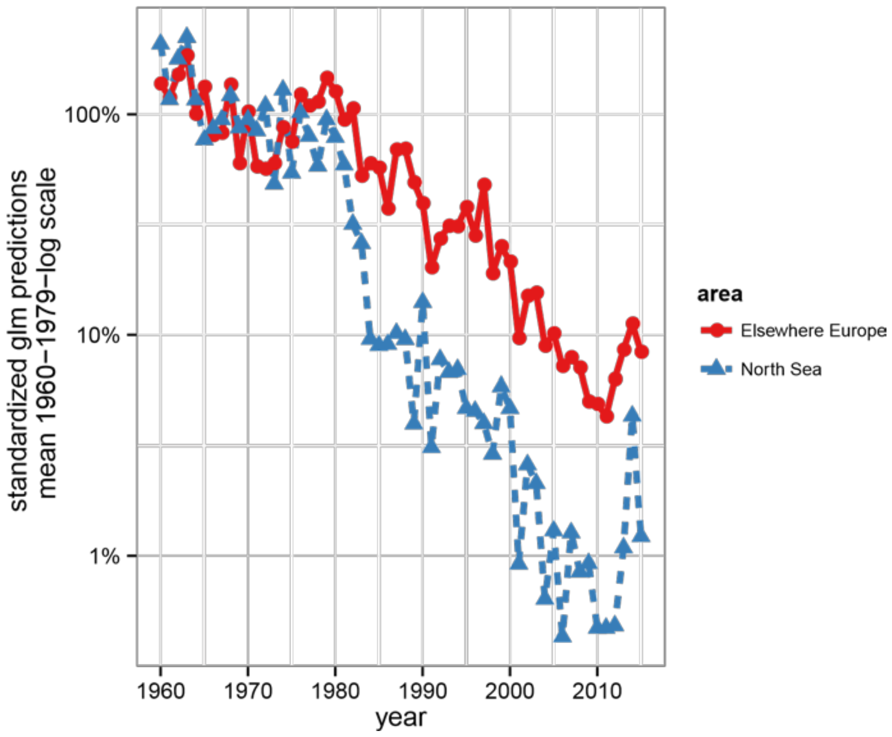

Figure 1.5. WGEEL recruitment index: geometric mean of estimated (GLM) glass eel recruitment for the continental North Sea and Elsewhere Europe series updated to 2015. The GLM (*recruit ~ area*: *year* + *site*) was fitted on 39 time-series comprising either pure glass eel or a mixture of glass eels and yellow eels and scaled to the 1960–1979 average. No time-series are available for glass eel in the Baltic area. Note the logarithmic scale on the y-axis.

Both WGEEL recruitment indices for 2015 are lower than 2014, but modelling a break-point around the minima of 2011 still gives significant results when using the lower value from 2015 (p=4*e* − 04 Elsewhere Europe and p=2*e* − 04 North Sea ICES SGIPEE(2011)). The 2015 level with respect to 1960–1979 averages is 1.2% for the North Sea and 8.4% elsewhere in the distribution area (Tables 1.1 and 1.2).

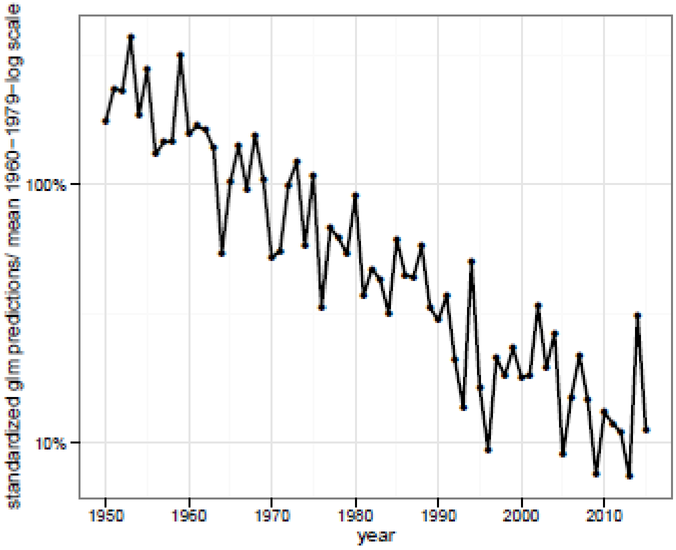

Figure 1.6. Geometric mean of estimated (GLM) yellow eel recruitment and smoothed trends for Europe updated to 2015. The GLM (*recruit ~ year + site*) was fitted to 12 yellow eel time-series and scaled to the 1960–1979 average. Note the logarithmic scale on the y-axis.

Table 1.1. GLM *glass eel ~ year*: *area + site* geometric means of predicted values for 39 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	138	209	103	95	127	79	40	14	21.4	4.7	4.9	0.5
1	119	117	58	84	95	59	20	3	9.7	0.9	4.3	0.5
2	152	178	57	109	106	32	27	8	15.0	2.6	6.3	0.5
3	185	224	60	48	53	26	31	7	15.5	2.1	8.6	1.1
4	100	117	87	129	60	10	31	7	8.9	0.6	11.2	4.3
5	133	77	75	54	57	9	38	5	10.1	1.3	8.4	1.2
6	81	86	123	102	37	9	28	5	7.2	0.4		
7	83	95	109	80	69	10	48	4	7.9	1.3		
8	136	122	114	58	70	10	19	3	7.1	0.8		
9	60	87	146	95	49	4	25	6	5.0	0.9		

Table 1.2. GLM *yellow eel ~ year + site* geometric means of predicted values for twelve yellow eel series, values given in percentage of the 1960–1979 period.

	1950	1960	1970	1980	1990	2000	2010
0	175	158	52	90	30	18	13
1	236	168	56	37	37	18	12
2	230	164	100	47	21	34	11
3	372	139	123	43	14	20	7
4	184	55	58	32	50	26	31
5	278	102	109	62	16	9	11
6	132	142	34	45	9	15	
7	146	97	68	44	21	22	
8	148	156	62	58	18	15	
9	316	104	54	33	23	8	

Appendix

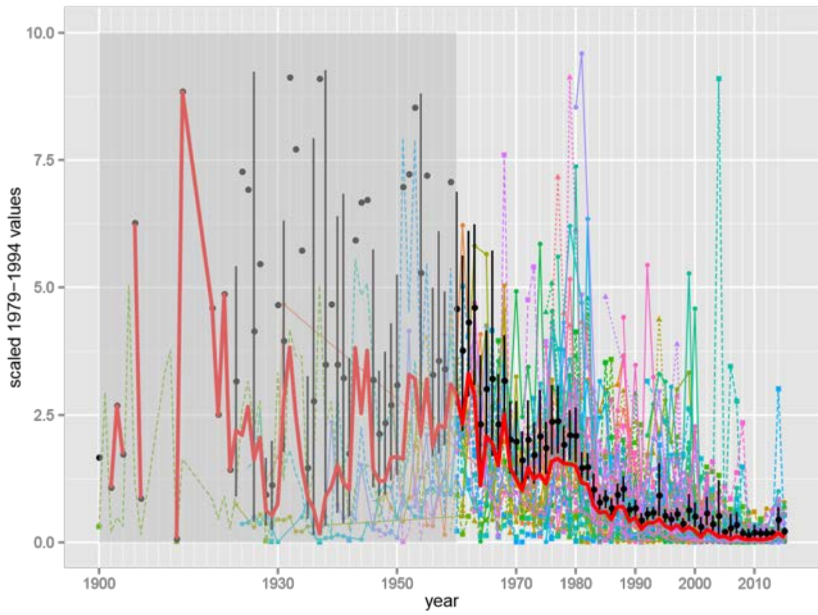

Figure 1.7. Same as Figure 1.3 but without log scale.

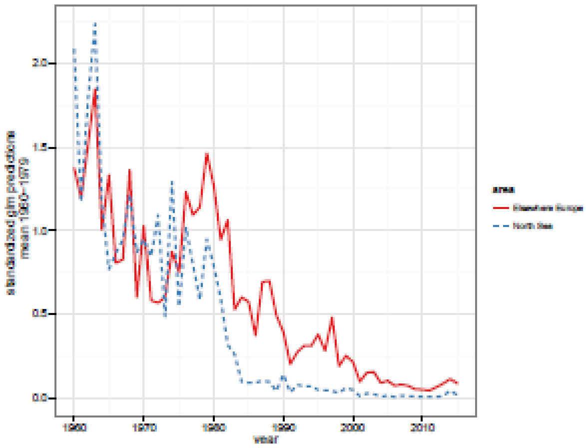

Figure 1.8. Same as Figure 1.5 but without a log scale.

Figure 1.9. Same graph as Figure 1.6 but without a log scale.

Table 1.3. Series updated to 2015.

Code	Name	Country	Area	Stage
Kavl	Kavlingeän trapping all¨	Sweden	Baltic	ylw.
Dala	Dalalven trapping all¨	Sweden	Baltic	ylw.
SeHM	Severn HMRC commercial catch	UK	British Isle	gls.
MiSp	Minho Spanish part commercial catch	Spain	Atlantic Ocean	gls.
Bres	Bresle	France	Atlantic Ocean	gls. + ylw.
Vil	Vilaine Arzal trapping all	France	Atlantic Ocean	gls.
ShaA	Shannon Ardnacrusha trapping all	Ireland	British Isle	gls. + ylw.
Nalo	Nalon Estuary commercial catch	Spain	Atlantic Ocean	gls.
Feal	River Feale	Ireland	Atlantic Ocean	gls. + ylw.
MiPo	Minho Portugese part commercial catch	Portugal	Atlantic Ocean	gls.
GiSc	Gironde scientific estimate	France	Atlantic Ocean	gls.
Ebro	Ebro delta lagoons	Spain	Mediterannean Sea	gls.
Morr	Morrumsän trapping all¨	Sweden	Baltic	ylw.
Mota	Motala Strom 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. + ylw.
Erne	Erne Ballyshannon trapping all	Ireland	British Isle	gls. + ylw.
Ring	Ringhals scientific survey	Sweden	North Sea	gls.
Stel	Stellendam scientific estimate	Netherlands	North Sea	gls.
Yser	Ijzer Nieuwpoort scientific estimate	Belgium	North Sea	gls.
YFS2	IYFS2 scientific estimate	Sweden	North Sea	gls.
Imsa	Imsa Near Sandnes trapping all	Norway	North Sea	gls.
Laga	Lagan trapping all	Sweden	North Sea	ylw.
Fre	Frémur	France	North Sea	ylw.
RhDO	Rhine DenOever scientific estimate	Netherlands	North Sea	gls.
RhIj	Rhine IJmuiden scientific estimate	Netherlands	North Sea	gls.
Ronn	Ronne Å trapping all	Sweden	North Sea	ylw.
Katw	Katwijk scientific estimate	Netherlands	North Sea	gls.
Meus	Meuse Lixhe dam trapping partial	Belgium	North Sea	ylw.
Gota	Gota Älv trapping all¨	Sweden	North Sea	ylw.
Visk	Viskan Sluices trapping all	Sweden	North Sea	gls. + ylw.
Sle	Slette A	Denmark	North Sea	gls. + ylw.
Klit	Klitmoeller A	Denmark	North Sea	gls. + ylw.
Nors	Nors A	Denmark	North Sea	gls. + ylw.

Table 1.4. Series updated to 2014.

Code	Name Country	Area	Stage
Albu	Albufera de Valencia commercial Spain catch	Mediterannean Sea	gls.
Hart	Harte trapping all Denmark	Baltic	ylw.
AlCP	Albufera de Valencia commercial Spain cpue	Mediterannean Sea	gls.
Gude	Guden Å Tange trapping all Denmark	North Sea	ylw.
Lauw	Lauwersoog scientific estimate Netherlands	North Sea	gls.

Table 1.5. Series stopped or not updated to 2014.

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

Table 1.6. Short description of the recruitment sites.

CODE	AREA	MIN	MAX	N+	N−	LIFE STAGE	RIVER	SAMPLING TYPE	UNIT
Imsa	NS	1975	2015	41	1	gls.	Imsa	trap	Number
YFS2	NS	1991	2015	25	0	gls.	.	sci. surv.	Index
Ring	NS	1981	2015	35	0	gls.	Kattegat-Skagerrak	sci. surv.	Index
Visk	NS	1972	2015	44	0	gls.+ylw.	Viskan	trap	Kg
Sle	NS	2008	2015	8	0	gls.+ylw.	Slette A	sci. surv.	eel/m2
Klit	NS	2008	2015	8	0	gls.+ylw.	Klitmoeller A	sci. surv.	eel/m2
Nors	NS	2008	2015	8	0	gls.+ylw.	Nors A	sci. surv.	eel/m2
Bann	EE	1960	2015	56	0	gls.+ylw.	Bann	trap	Kg
Erne	EE	1959	2015	57	2	gls.+ylw.	Erne	trap	Kg
Feal	EE	1985	2015	31	14	gls.+ylw.	Feale	trap	Kg
Maig	EE	1994	2015	22	4	gls.	Maigue	trap	Kg
Inag	EE	1996	2015	20	4	gls.+ylw.	Inagh	trap	Kg
ShaA	EE	1977	2015	39	0	gls.+ylw.	Shannon	trap	Kg
SeHM	EE	1979	2015	37	4	gls.	Severn	com. catch	t
Vida	NS	1971	1990	20	0	gls.	Vidaa	com. catch	Kg
Ems	NS	1946	2001	56	0	gls.	Ems	com. catch	Kg
Lauw	NS	1976	2015	40	4	gls.	.	sci. surv.	nb/h
RhDO	NS	1938	2015	78	1	gls.	Rhine	sci. surv.	Index
RhIj	NS	1969	2015	47	5	gls.	Rhine	sci. surv.	Index
Katw	NS	1977	2015	39	5	gls.	.	sci. surv.	Index

Table 1.7. Short description of the recruitment sites (continued).

CODE	AREA	MIN	MAX	N+	N−	LIFE STAGE	RIVER	SAMPLING TYPE	UNIT
Stel	NS	1971	2015	45	0	gls.	.	sci. surv.	Index
Yser	NS	1964	2015	52	1	gls.	Ijzer	sci. surv.	Kg
Bres	EE	1994	2015	22	0	gls.+ylw.	Bresle	trap	Number
Vil	EE	1971	2015	45	3	gls.	Vilaine	trap	t
Loi	EE	1924	2008	85	6	gls.	Loire	com. catch	Kg
SevN	EE	1962	2008	47	25	gls.	Sèvres Niortaise	com. cpue	cpue
GiSc	EE	1992	2015	24	1	gls.	Gironde	sci. surv.	Index
GiTC	EE	1923	2008	86	28	gls.	Gironde	com. catch	t
GiCP	EE	1961	2008	48	1	gls.	Gironde	com. cpue	cpue
AdTC	EE	1986	2008	23	0	gls.	Adour	com. catch	t
AdCP	EE	1928	2008	81	40	gls.	Adour	com. cpue	cpue
Nalo	EE	1953	2015	63	0	gls.	Nalon	com. catch	Kg
MiSp	EE	1975	2015	41	0	gls.	Minho	com. catch	Kg
MiPo	EE	1975	2015	41	0	gls.	Minho	com. catch	Kg
Albu	EE	1949	2014	66	5	gls.	Albufera lagoon	com. catch	Kg
Ebro	EE	1966	2015	50	3	gls.	Ebro delta lagoons	com. catch	Kg
AlCP	EE	1982	2014	33	5	gls.	Albufera lagoon	com. cpue	cpue
Tibe	EE	1975	2006	32	0	gls.	Tiber	com. catch	t
YFS1	NS	1975	1989	15	0	gls.	.	sci. surv.	Index

Table 1.8: Short description of the recruitment sites (continued-yellow eel series)

CODE	AREA	MIN	MAX	N+	N−	LIFE STAGE	RIVER	SAMPLING TYPE	UNIT
Dala	EE	1951	2015	65	3	ylw.	Dalalven	trap	Kg
Mota	EE	1942	2015	74	0	ylw.	Motala Strom	trap	Kg
Morr	EE	1960	2015	56	0	ylw.	Morrumsän	trap	Kg
Kavl	EE	1992	2015	24	0	ylw.	Kavlingeän	trap	Kg
Ronn	NS	1946	2015	70	9	ylw.	Ronne Å	trap	Kg
Laga	NS	1925	2015	91	0	ylw.	Lagan	trap	Kg
Gota	NS	1900	2015	116	12	ylw.	Gota Älv	trap	Kg
ShaP	EE	1985	2015	31	0	ylw.	Shannon	trap	Kg
Gude	NS	1980	2014	35	1	ylw.	Guden Å	trap	Kg
Hart	EE	1967	2014	48	1	ylw.	Harte	trap	Kg
Meus	NS	1992	2015	24	3	ylw.	Meuse	trap	Kg
Fre	NS	1997	2015	19	0	ylw.	Frèmur	trap	Number

Annex 9: Joint EIFAAC/ICES/GFCM WGEEL Stock Annex

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

Stock ID	Stock name	Last updated	Link
Anguilla anguilla	European eel	December 2016	*Anguilla anguilla*

Annex 10: Country Reports 2014–2015: 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 2015 meeting of the Working Group on Eels:

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

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

Country Reports 2014/2015