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Report of the Workshop for the Review of Eel Management Plan Progress Reports (WKEMP)

17–19 July and 13–16 November 2018

Copenhagen, Denmark

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

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Executive summary

The Workshop for the Review of Eel Management Plan Progress Reports (WKEMP) held two meetings in 2018, 17–19 July and 13–16 November, both in Copenhagen, Denmark. The chair of the Workshop also attended the first and last two days of WGEEL, 5–12 September in Gdańsk, Poland. WKEMP was chaired by Jean-Jacques Maguire, Canada. There was one participant from each of Canada and the UK (as chair of WGEEL) at the July meeting. These participants also attended the November meeting which an additional participant from the EU attended, see Annex 1 for list of participants.

WKEMP was convened to deliver solid estimates of stock parameters by Eel Management Unit that can be summed in terms of biomass and mortality, to reflect the state of the stock and exploitation status in Europe to answer a special request from the European Commission.

WKEMP approached this task by reviewing the national reports on implementation of Eel Management Plans which were requested by the EC in 2018 in line with Article 9 of the Eel Regulation 1100/2007. WKEMP also sought clarifications as necessary on these reports, and extracted and collated relevant biomass and mortality estimates. WKEMP also drew on information from WGEEL 2018 and previous technical and scientific reports to understand how estimates were calculated.

The report begins with an Introduction further elaborating on the mandate of WKEMP, the approach taken, and providing context. This is followed by sections on Methodology, Results, Discussion and WKEMP's Recommendations. Annex 1 lists the participants. Annex 2 summarises the methods used by countries to calculate biomass and mortality estimates. Annex 3 is WKEMP's comments and questions on EMPs. Annex 4 is the reporting schedule to the EC. Annexes 5 and 6 review two issues of importance in the evaluation of compliance with the Eel Regulation (eels in transitional and coastal waters; density-dependence effects on the estimation of B_0), evaluating possible shortcomings and bias in current assessments, and proposing avenues for future work. Annex 7 defines the Acronyms used and provides a glossary.

WKEMP found that, while several methods and data sources were used to estimate biomass and mortality, the results in terms of biomass per hectare fell within a relatively narrow range for most countries except B_0 for France and $B_{current}$ for Spain, whose values were much higher than those reported by other countries. It is also of note that reaching the target in several EMUs is based on stocking. It was not possible to provide mortality estimates that could be summed to reflect the state of impacts in Europe; available values for individual EMUs are presented and described.

1 Introduction

EC Regulation 1100/2007 (the Eel Regulation) imposes on Member States (MS) an obligation to prepare and implement eel management plans (EMPs) and regularly report to the Commission on the progress thus achieved. The reports should provide the best available estimates of the proportion of the silver eel biomass that escapes to the sea to spawn, the fishing effort that catches eel each year, and estimates of fishing mortality and mortality factors outside the fishery. Few MS reported fishing effort and the WKEMP did not analyse those data.

ICES was asked to organise an independent review and, where relevant, provide updated or new estimates of stock indicators to provide reliable estimation of total mortality and the status of the adult eel stock.

The main mandate of the review was to deliver solid estimates of stock parameters by EMU that can be summed in terms of biomass and mortality, to reflect the state of the stock and exploitation status in Europe. Experts were tasked to review data and methods provided by MS and to make new calculations where needed.

ICES contracted a core group of three experts to review data and methods, and make new calculations where needed. The group was comprised of an independent chair to oversee the process and assure independence and respect of the outcomes, the chair of WGEEL to ensure good linkages to relevant national experts, and another external eel expert.

Two meetings were held, WKEMPi 2018: Initial workshop (core experts), three days, Copenhagen in July and WKEMPii 2018; final workshop (core experts), four days, Copenhagen in November. WKEMP also held three WebExes to finalize its report. The chair also of WKEMP attended the first and last two days of WGEEL in Gdańsk, Poland, in September.

The WKEMP Terms of Reference were as follows:

a) Collate the Eel Management Unit biomass and mortality rates from EU Member State (MS) Eel Management Plan (EMP) Progress Reports as submitted to the European Commission by 30th June 2018;

b) Review EMP methods and results to confirm whether or not they appropriately reflect the (present and target) status of eel biomass and mortality rates across Europe;

c) Where there are gaps in results, or estimates are identified as not being appropriate, derive alternative estimates based on a standardized view of eel biomass and mortality;

d) Deliver an early draft advice and a report containing the full reviews of biomass and mortality rates from EMPs or replacements, and describe the methodology for standardizing the various results to determine overall estimates of biomass and mortality.

2 Methods

2.1 Sources of data used

WKEMP collated the data and information reported to EU as per the request from the Commission sent to MS on 5th April 2018. Reporting by MS was not 100% (see Annex 4): of those MS with EMPs; Croatia, Luxembourg and Portugal did not report at all, the Czech Republic, Finland and Ireland provided a description but no data tables, and France and Poland did not provide all seven data tables; the Czech Republic, Finland, Greece, Ireland, Latvia, Poland and Spain reported after the deadline. Austria, Bulgaria, Cyprus, Hungary, Malta, Romania, Slovakia and Slovenia have derogations from reporting. WKEMP also used data and information reported to the EU in 2015, to ICES in response to the 2018 data call, Country Reports provided to ICES for the annual meetings of the joint EIFAAC/ICES/GFCM Working Group on Eel (WGEEL), and data and information provided directly to WKEMP. WKEMP's gap analysis excludes those EU MS given derogations from implementing EMPs because natural recruitment was considered to be very low in the past, and those areas where MS implemented a 50% cut in fishing effort in lieu of an EMP.

2.2 The major players

WKEMP used FAO landing statistics starting in 1945 to identify which countries reported the largest eel catches, and could thus be considered as major players with respect to possible eel production. The FAO landings generally increased from 1945 to the mid-1960s (Figure 2.1 and Figure 2.2), followed by a steady decline which is consistent with the perception of stock trends based on recruitment series. Overall, according to FAO statistics, the landings of European eels decreased by a factor of six from close to 20 000 t in the late 1960s to slightly more than 3 000 t in 2014. Two anomalies were identified in FAO landings data: i) very large catches by Egypt since the late 1990s, and ii) relatively large catches by Hungary since about 2010. The large catches in Egypt, if they are indeed of European eel, could have a large influence on rebuilding possibilities.

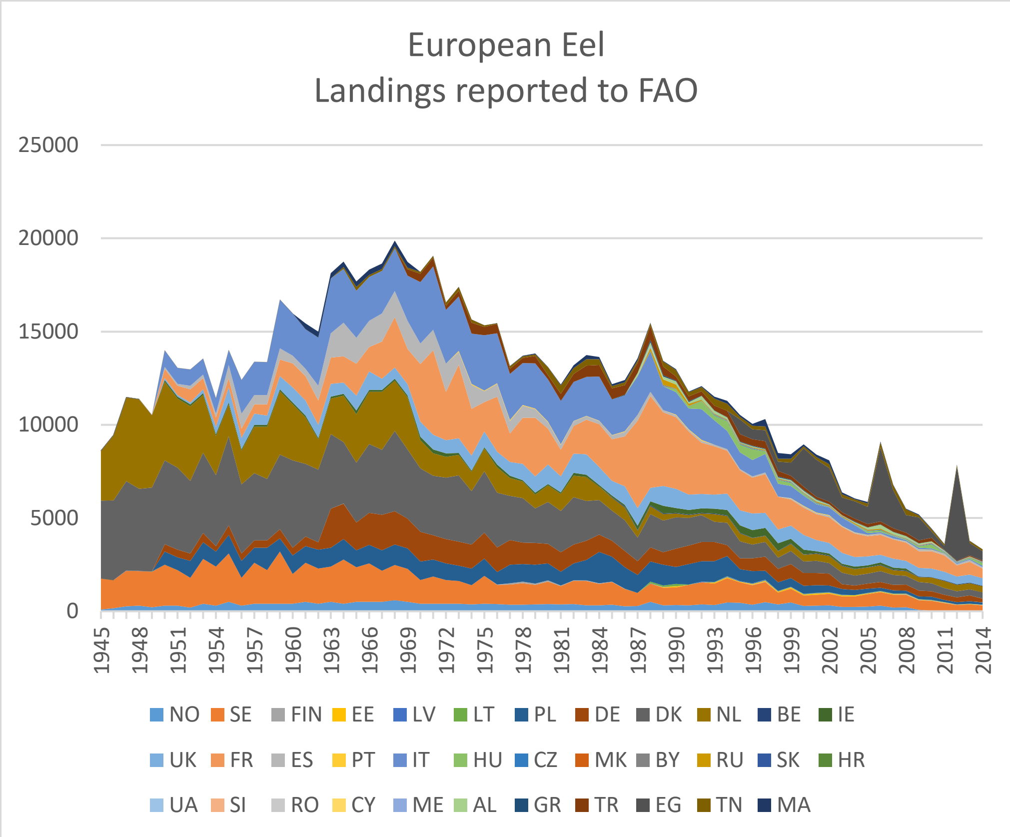

Figure 2.1. Landings of European eel (t) as compiled by FAO, by country.

Examining the FAO data country by country identified Sweden, Poland, Germany, Denmark, The Netherlands, the United Kingdom, France, Spain, Italy and Egypt as major players.

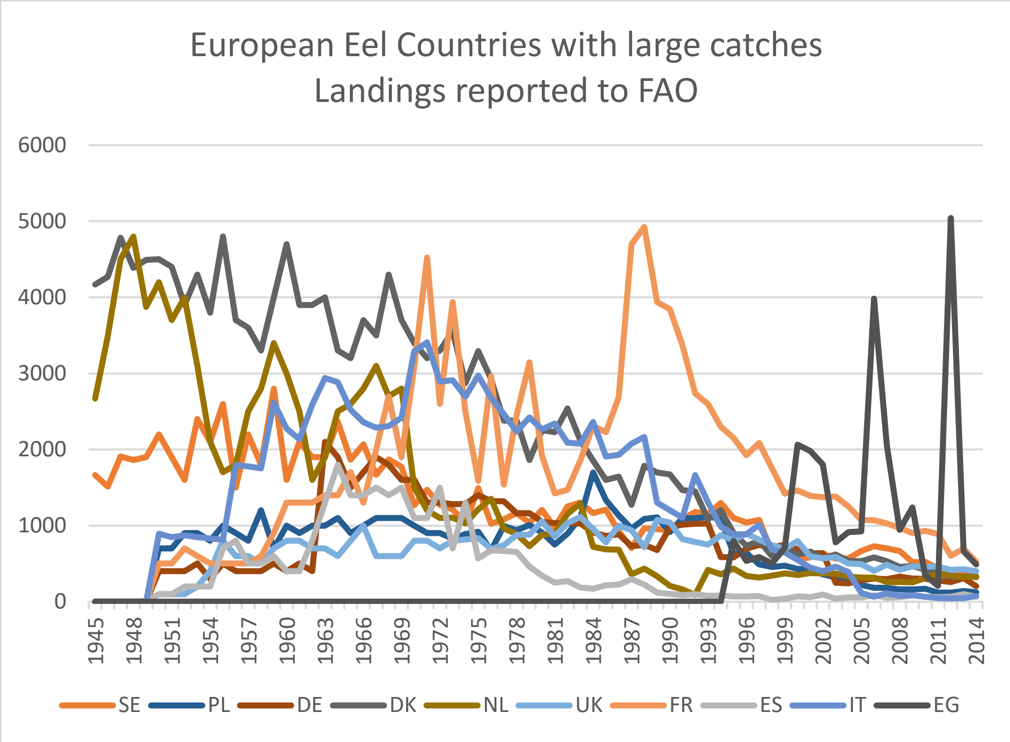

Figure 2.2. Landings of European eel (t) as compiled by FAO, by major eel fishing country.

2.3 Comments on EMPs submitted

As indicated above, the mandate of the WKEMP was to review biomass and mortality estimates, determine if they were appropriate and suggest alternatives if some were considered inappropriate or if there were gaps. While this relatively narrow mandate did not require reading the entirety of the reports, WKEMP choose to do so for context and completeness. Each WKEMP core member read a subset of the reports, taking notes and formulating questions where necessary. These questions were sent to the appropriate WGEEL member. WKEMP comments, questions and answers from WGEEL members are provided in Annex 3.

The mandate (ToR) referred specifically to the EU and Eel Management Plans but as the continental range of the European eel extends further than the EU, WKEMP also included information from Norway.

3 Results

3.1 Term of Reference a), Collate the Eel Management Unit biomass and mortality rates from EU Member State (MS) Eel Management Plan (EMP) Progress Reports as submitted to the European Commission by 30 June 2018

The reporting regime applied by the Commission in response to the reporting requirements of the EU Eel Regulation, specifies three biomass and three fishing mortality reference points:

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, hence only natural mortality operating on stock, i.e. excluding restocking practices;

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.

Table 3.1 is an Excel file where WKEMP (Silver Eel Table) presents the estimates of silver eel escapement biomass (B_0, B_{best}, $B_{current}$) and mortality rate (ΣA, ΣF, ΣH), collated by WKEMP for each EMU (codes from WGEEL), for the most recent year reported. This table also categorises each EMU according to the largest habitat type (freshwater, transitional water, coastal (marine) water) from which biological data on eel were used to estimate B_0, the largest habitat type used in the assessment of B_{best} and, $B_{current}$, and the drainage region (Baltic, North Sea, Atlantic, Mediterranean) and the reported year.

Wetted area (hectares, ha) was also collated, to standardise biomass estimates as weight per unit area (kg/ha) and facilitate comparisons among EMUs. Some countries report different wetted area for the B_0 vs. B_{best} and $B_{current}$ situation, so both types of area were collated and used in calculations, as appropriate.

3.2 Term of Reference b), Review the EMP methods and results to confirm whether or not they appropriately reflect (present and target) status of eel biomass and mortality rates across Europe

3.2.1 EMP Methods

Annex 2 collates the information from the data sources above on how countries calculated biomass and mortality estimates. Generally speaking, methods are consistently used in a given country, except for Spain and the UK, but vary considerably from one country to another. Two broad approaches are used, direct methods and indirect methods. Direct methods include mark–recapture tagging experiments, counts in traps, electrofishing or through other methods. Indirect methods are based on modelling and various models have been developed, e.g. EDA, ESAM, GEM-Il, and SMEP. Some models involve population dynamics approaches, e.g. CAGEAN in Poland, while other modelling involves standardising density estimates in sampling stations to account for factors such as time of sampling, temperature, distance from the mouth of the river, etc. and add those up to calculate a total for the EMU.

The EU Regulation Article 2, Establishment of Eel Management Plans, offers three approaches to the estimation of pristine escapement (B_0) i) using data collected in the most appropriate period prior to 1980, ii) habitat-based assessment of potential eel production, in the absence of anthropogenic mortality factors, and iii) with reference to the ecology and hydrography of similar river systems.

B_0 is a common concept in standard population dynamics models for marine fish where it refers to the unfished equilibrium spawning biomass, and it is rarely known. It is generally calculated from population models as the long-term average biomass in the absence of fishing. In production models, B_0 corresponds to the carrying capacity of the environment.

In practice, for most EMUs B_0 was calculated from data prior to the start of the observed decline in recruitment, i.e. between 1960 and 1980. Fisheries on eel and other anthropogenic mortality on eel have existed in most EMUs for a long time before those dates, so strictly speaking, estimates available correspond to the amount of silver eel biomass that would have existed prior to the recruitment decline, not the biomass that would have existed *if no anthropogenic influences had impacted the stock*. There are many challenges to estimating a true B_0 biomass, not least describing the available habitat in inland, transitional and marine waters under conditions unimpacted by the human race, and taking account of the influence of density-dependence on eel population dynamics. WKEMP examined B_0 estimates from Member States and Norway in relation to the approaches (a-c) set out in the Eel Regulation. However, WKEMP notes that even if all the EMUs were to reach 40% of their 'B_0', this will not guarantee recovery of the stock.

Table 3.2.1.1.

COUNTRY	BIOMASS ESTIMATE	SIGMA ESTIMATES
BE	$B_{current}$ is estimated from electrofishing densities of yellow eels, converted by a demographic model into escaping silver eels. B_0 and B_{best} are also estimated with the model.	Eels are not commercially fished in Belgium. Sigma F is based on recreational harvest estimated from a survey. Sigma H is based on mortality due to hydropower, pumping stations, and cooling stations
DE	B_0 is calculated from silver eel production measured prior to 1980. B_{best} and $B_{current}$ are calculated from a demographic model using data from freshwater.	Sigma F was calculated as -1*LN($B_{current}$_fishery/B_{best}+Stocking). Sigma H was calculated as total mortality - fishing mortality Sigma A was calculated as -1*LN($B_{current}$/B_{best}+Stocking)
DK	In Inland Waters, B_0 is estimated from historic yellow and silver eel abundance and fisheries. B_{best} is calculated from silver eel escapement in monitored rivers and fisheries data with estimated efficiencies. $B_{current}$ is calculated as B_{best} - mortalities in freshwater. In the marine waters, there has been a fishing effort reduction of 50% in lieu but no reporting of biomass estimates.	In Inland waters, sigma F is estimated from commercial and recreational fisheries landings. Sigma H is estimated for turbines, entrainment at trout farms, and predators, notably for cormorants by tag recoveries near roosts. No mortality rate estimates are reported for Marine waters.
EE	Based on mark–recapture up to 2015. In the absence of recapture in subsequent years, abundance was estimated from average abundance in fykenets. B_0 is based on commercial fisheries in the 1930s.	Sigma H is based on escapement studies in hydropower facilities. Sigma F is based on landings from commercial fisheries in lakes. Sigma A is greater than the sum of sigma F and sigma H, for reasons unknown.
ES	The method of estimating B_0 varies among EMUs. Methods include adjustment of current production rates by the change in glass eel recruitment and area production rates. B_{best} is estimated by various methods including mark–recapture, electrofishing and standard area production rate. $B_{current}$ is estimated by methods including subtraction of fishing mortality from B_{best} and calculation of silver eel production from electrofishing surveys.	Sigma F was calculated in various ways according to biomass estimation methods, including - Ln ($B_{current}$ /($B_{current}$+Catches in silver eel equivalents)). To calculate Sigma H, for the EMU ES_Gali, mortality is estimated as 8.7% for each hydro station.

COUNTRY	BIOMASS ESTIMATE	SIGMA ESTIMATES
FR	Yellow eel biomass is estimated from the Eel Density Analysis (EDA). Potential escapement (Bpotential) is calculated by converting yellow eel biomass into silver eel biomass estimate. Bcurrent is Bpotential minus known fishery catches. Bbest is the silver eel escapement that would be produced from the same recruitment but without any anthropogenic mortality. B0 is calculated by adjusting modern abundance by the observed decline in recruitment similar to how Bbest is calculated.	Sigma F, H, and A are from model outputs.
GR	A combination of data originating from the landings recorded by the fishing cooperatives and individual fishermen and (size of population), on-site recording of morphometric parameters (length classes), samples that are transferred in laboratories for further elaboration (sex ratio, age determination, etc.).	
IE	Biomass values are estimated from data gathered in index catchments.	Ireland has no commercial eel fishery. Sigma F = - ln(B_{best}-catch)/B_{best}. Sigma H = - ln (B_{best}-catch)-hydrokill/(B_{best}-catch)
IT	B_0 is derived from productivity differentiated by habitat type. B_{best} and $B_{current}$ are estimated a model that incorporates recruit settlement and vital rates.	Sigma H is a function of the number of hydro dams and the average survival rate. Sigma F is derived from the model and estimated catches. Sigma A is the sum of the two.
LV	Biomass values are estimated from fisheries catches and available habitat.	Mortality indicators were not assessed.
LT	B_0 is estimated from historical eel catches in the Curonian Lagoon. B_{best} and $B_{current}$ were estimated from stocking and a population dynamics model	Mortality estimates are calculated from the population estimates in the assessment model minus estimated catches and deaths in turbines.
NL	B_0 was estimated from carrying capacity. B_{best} and $B_{current}$ were estimated from a stock model that integrates outputs from submodels of population processes, standing stocks and densities, and barrier-induced mortality.	Sigma F, H, and A were estimated from the stock model

COUNTRY	BIOMASS ESTIMATE	SIGMA ESTIMATES
NO	The methods used to calculate the biomass indices will be available in early 2019 when we report to the Norwegian Fisheries Directorate.	Not reported.
PL	Biomass was estimated by a model that incorporated fishery harvest, restocking, weight and age structure, and cormorant predation.	Sigma F is from a catch-at-age model. Sigma H includes cormorant predation. Sigma A is the sum.
PT	A combination of methods including the commercial fishery and independent surveys are used as a proxy to estimate stock indicators. Wherever there is a fishery, it is monitored, but in the absence of a fishery, experimental fishing is carried out. B_0 = [[(YE densities 1988)*(silvering rate)]*mean SE weight] * wetted area $B_{current}$ = [[(YE densities 2017)*(silvering rate)]*mean SE weight] * wetted area B_{best} = $B_{current}$ + Anthropogenic mortality in Silver Eel Equivalents (SEE)	The only anthropogenic mortality considered was the mortality derived from the fisheries, which was estimated using the following expression: SumF= -ln ($B_{current}$/($B_{current}$+kg SEE)).
SE	In the east coastal waters B_0, $B_{current}$, and B_{best} refer to silver eels that have reared elsewhere in the Baltic region. In the Inland waters, B_0 is estimated with and without stocking. $B_{current}$ and B_{best} are estimated from a model relating recruiting eels to production. In the west coastal waters, the fishery closed in 2012.	In the east coastal waters, Sigma F of interceptory fisheries is estimated by mark–recapture. Sigma H is deemed to be zero. In the Inland waters, Sigma F is based on fisheries catches and Sigma H is based on hydro dam impacts. In the west coastal waters, mortality rates are reported as zero because fisheries were closed and no other human impacts are assessed.

COUNTRY	BIOMASS ESTIMATE	SIGMA ESTIMATES
UK	For England and Wales, B_0 is estimated from a population dynamics model using historic yellow eel records. B_{best} and $B_{current}$ were estimated from a population dynamics model using recent yellow eel records. For Scotland, B_0 is estimated from historic silver eel production in Scotland and Ireland. B_{best} and $B_{current}$ are estimated by data from river traps, according to altitudinal bands. For the NEAG EMU in Northern Ireland, $B_{current}$ and B_{best} are measured by mark–recapture at Lough Neagh, B_0 was estimated by historic extrapolation. In the North East EMU, B_0, B_{best} and $B_{current}$ are estimated from habitat proxies along with new data on eel abundance and densities.	For England and Wales, Sigma A is estimated from - ln()$B_{current}$ /B_{best}. Sigma F and H were estimated by models. For Scotland, there is no eel fishery so no sigma F, but sigma H (and A) are derived from the potential production lost upstream of hydropower barriers. In Northern Ireland, sigma A and F are estimated from NEAG according to landings reports from the commercial fishery and no mortalities are reported for the Northeast EMU

3.2.2 EMP Results

3.2.2.1 Biomass

WKEMP compared estimates of B_0 and $B_{current}$ among major catchment regions (i.e. Baltic, North Sea, Atlantic, Mediterranean), and among dominant habitat types (note that the dominant habitat type that provided eel data used in the estimates might not be the largest habitat type in the EMU.) within regions that provided the eel data used to estimate biomass, using the standardised kg/ha, to check for potential outliers. Local differences in the types and extent of anthropogenic mortalities between EMU mean that similar comparison of B_{best} estimates would complicate interpretation of comparisons, but estimates were tabulated and plotted for completeness.

Overall, B_0 ranged from <1 to 430 kg/ha (Table 3.1). Figure 3.2.2.1 shows B_0 estimates excluding France because some EMUs from France (FR_Loir, FR_Adou and FR_Garo in the Atlantic, FR_Cors and FR_Rhon in the Mediterranean) are conspicuously higher than others in each region and show up as outliers in Figure 3.2.2.1 upper right panel. France, in addition to the EMUs mentioned above for the Atlantic and the Mediterranean, also shows a much higher productivity than other countries in the North Sea (FR_Arto). $B_{current}$ ranged from <1 to 58 kg/ha: with values for some Spanish EMUs (ES_Basq in the Atlantic, ES_Vale and ES_Bale in the Mediterranean) noticeably higher than others in each region (Figure 3.2.2.1). WKEMP notes that ES_Vale uses biological parameters from FR_Rhon).

Figure 3.2.2.1 upper left panel shows some clusters of countries: i) Estonia, Greece, Ireland, Lithuania, Latvia, Poland and Sweden between less than 1 to 5 kg/ha, ii) Germany, Italy and the UK at around 10 kg/ha; iii) Belgium, Denmark, the Netherlands and Portugal at between 15 and 30 kg/ha, and iv) Spain above 30 kg/ha but with very large variability.

Average densities in Sweden and Ireland are low compared to other areas. WKEMP considers that low densities for Sweden are reasonable for EMUs in the Baltic. In Ireland, there are large wetted areas in lakes that are upstream of other large lakes, which may act as a natural barrier, or sink, resulting in low upstream migration to a large wetted area. Also almost half (47%) of the wetted area in Ireland is above hydropower barriers, and the provisions for assisting juveniles around those barriers may not be fully effective. More than 30% of the wetted area is in geology that is very acidic and eel production is naturally low. While estimates of $B_{current}$ may be robust as they are largely derived from field based assessments, historic B_0 maybe low, due to past underreporting of catches. Underreporting by 40% was assumed, but there is no way of knowing the real value.

Spain and Portugal have lost considerable eel habitat because of the construction of dams, but it appears that the two countries are not treating the lost habitat the same way: Spain includes it in its calculation of B_0 habitat while Portugal does not. WKEMP recommends that a standard approach should be taken for the Iberian Peninsula. If the intention is to agree targets that are reachable given current conditions, WKEMP suggests that if dams were constructed before the period for which average densities are calculated to estimate B_0, then the area above dams should not be included in calculating B_0. If the intention is to rebuild to pristine conditions before anthropogenic impacts, the area above dams should be included in calculating B_0.

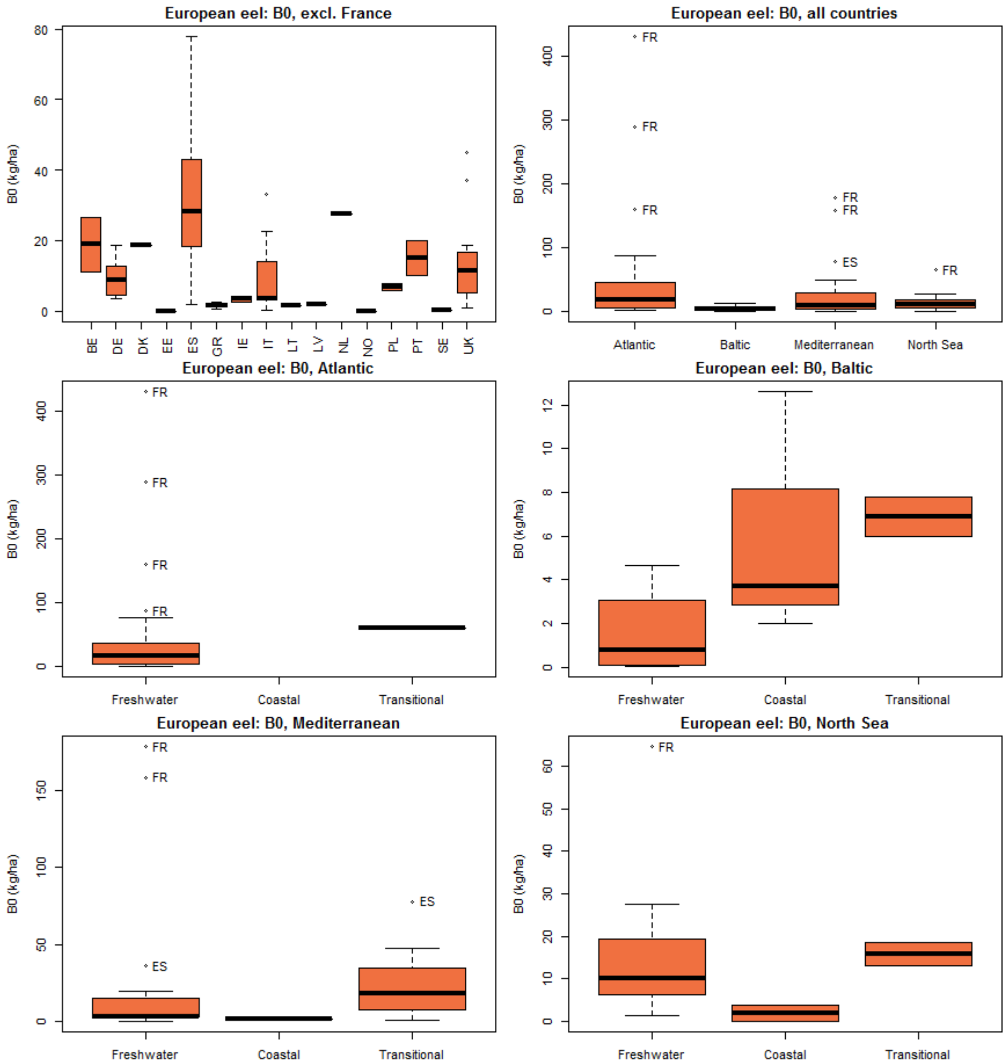

Figure 3.2.2.1. B_0 by country (excluding France, top left); by drainage region (top right) and by 'eel data' habitat for each drainage region (middle and bottom). The median (thick horizontal line), first and third quartiles (25% and 75%; box edges), 95% range (2.5%–97.5%; whiskers) and outliers (hollow points) are plotted.

B_{best} estimates are shown in Figure 3.2.2.2.

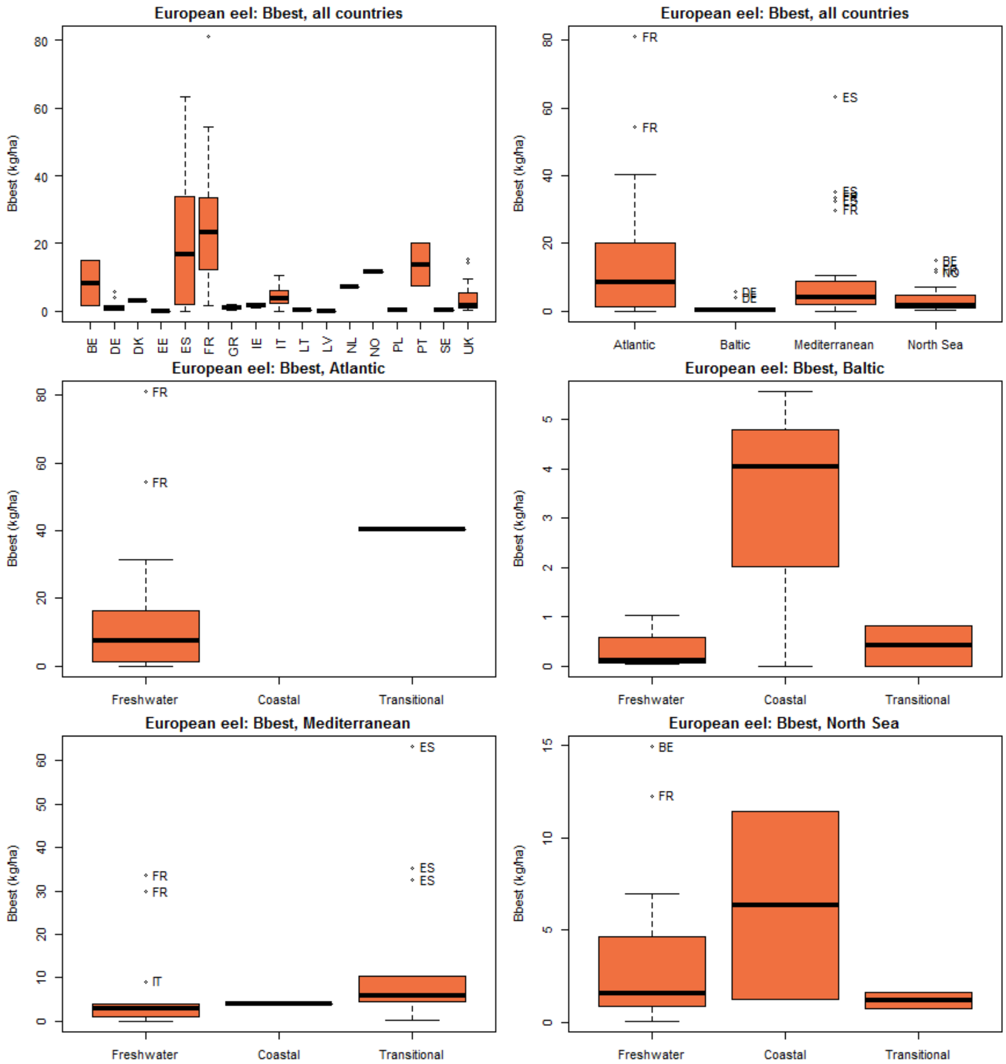

Figure 3.2.2.2. B_{best} by country (top left); by drainage region (top right) and by 'eel data' habitat for each drainage region (middle and bottom). The median (thick horizontal line), first and third quartiles (25% and 75%; box edges), 95% range (2.5%–97.5%; whiskers) and outliers (hollow points) are plotted.

When comparing $B_{current}$ (Figure 3.2.2.3), Spain shows large variability. While Norway did not report B_0 to WGEEL, B_{best} and $B_{current}$ are equal at 11 kg/ha.

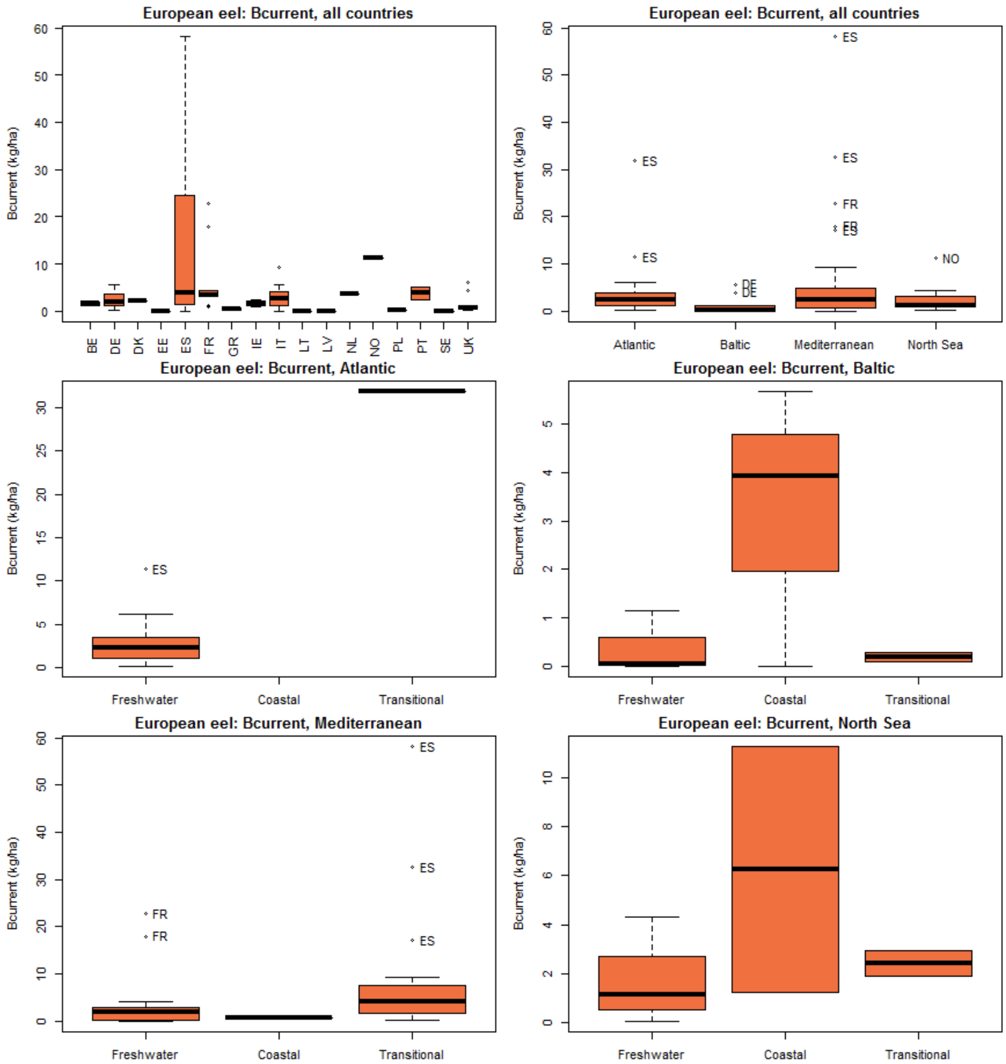

Figure 3.2.2.3. $B_{current}$ by country (top left); by drainage region (top right) and by 'eel data' habitat for each drainage region (middle and bottom). The median (thick horizontal line), first and third quartiles (25% and 75%; box edges), 95% range (2.5%–97.5%; whiskers) and outliers (hollow points) are plotted.

Plots of standardised (in kg/ha) estimates of B_0, B_{best} and $B_{current}$ in freshwater habitat (note the different vertical axis scale for the various biomass estimates) are shown in Figures 3.2.2.1, 3.2.2.2 and 3.2.2.3. The high values for France make it difficult to examine values for other countries, but excluding France, estimates for Ireland, Estonia, Latvia, Lithuania, Sweden and for some EMUs in Italy, appear low.

Most biomass estimates are derived mainly from eel data collected in freshwaters. Estimates based on eel in coastal habitats have been reported by three countries (one EMU in Spain and Norway, and three in Germany) while five countries reported production estimates based on eel data in WFD Transitional waters: Spain, Poland, Greece, Italy and Germany. In coastal habitats, $B_{current}$ is a quarter of B_{best} in Spain while the estimates are equal in Germany and Norway (different numerical values). For estimates based on eel data from transitional waters, Spain shows large variability and higher values than the other countries.

WKEMP also examined standardised production estimates by catchment region (Atlantic, Baltic, North Sea and Mediterranean (Figures 3.2.2.1, 3.2.2.2 and 3.2.2.3)) making similar observations: France has very high B_0 estimates, but its B_{best} and $B_{current}$ are more comparable to other countries. Production estimates are the highest in the Atlantic and in the Mediterranean. Median production estimates for Spain is higher in the Mediterranean than in the Atlantic, while the reverse is true for France. Production estimates for the Baltic are very low compared to the other regions while production estimates in the North Sea are intermediate and vary from country to country.

Figure 3.2.2.4 shows the ratio $B_{current}/B_{best}$. Germany was excluded from the figure because the ratio (in %) for one of the EMUs was close to 3000%. WKEMP notes that Germany makes extensive use of stocking. Ireland and Norway are at B_{best}, and Lithuania is at 0% of B_{best}. For other countries, status varies by EMU within countries with some very far from the target and others relatively close.

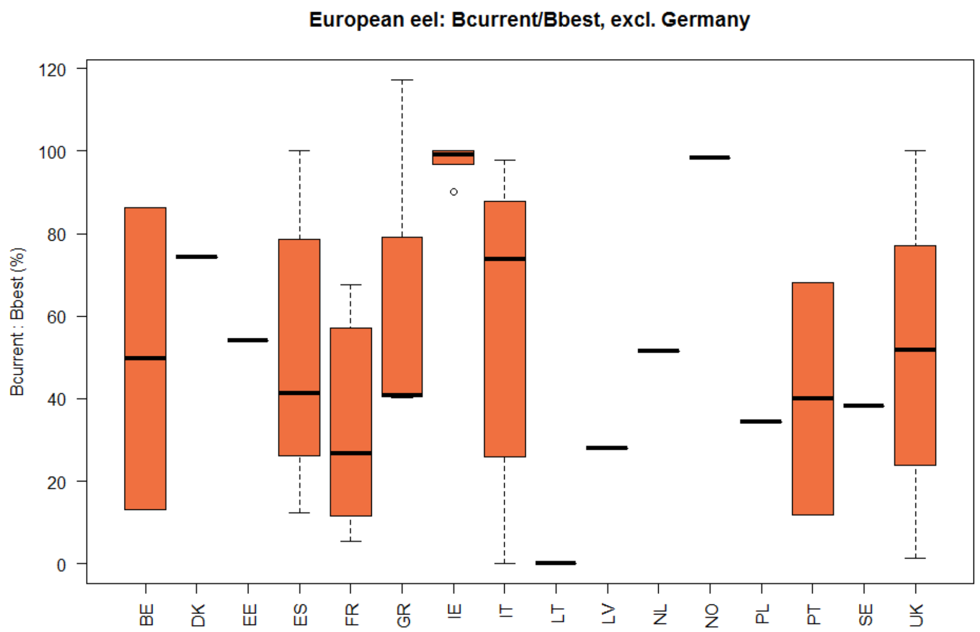

Figure 3.2.2.4. The ratio of $B_{current}$ to B_{best} by country. The median (thick horizontal line), first and third quartiles (25% and 75%; box edges), 95% range (2.5%–97.5%; whiskers) and outliers (hollow points) are plotted.

Why are France B_0 particularly high?

B_0 is back-calculated from B_{best}, assuming that the substantial decrease in recruitment compared to 1960s and 1970s (using the mean recruitment in that period) applies directly to silver eel, assuming no density-dependence, e.g. the possibility of higher natural mortality under higher densities or different sex ratio. Though there is limited direct evidence of density-dependence in the scientific literature, France may be taking a cautious approach in assuming it would not have occurred during periods of much higher recruitment.

On the other hand, WKEMP notes that France may have underestimated available habitat used in the EDA model, especially for lakes, ponds and marshes. Presumably this might mean B_0 is underestimated too.

Neighbouring countries

- England and Wales estimated B_0 based on observations of yellow eel abundance in the early 1980s, applying the same life-history model-based approach as for estimating B_{best}, so based on observations rather than extrapolations.
- Spain estimated separately for freshwaters and transitional waters (an extra layer of complexity which might be relevant to filling gaps in some cases).
  - For freshwater, applied the reverse of the recruitment decline to present productivity in Anda (akin to France); applied the 20 kg/ha estimate of ICES (2001) to Astu, Basq, Cast, Cata, Gali, Inne, Murc, Nava, Vale; applied a conversion factor in Cant but not clear what factor was applied to what; no freshwater habitats in Bale.
  - For transitional waters, applied the reverse of the recruitment decline to present productivity in Anda (akin to France); in Vale, in the absence of local information, applied the 80 kg/ha from the France Rhone EMP; used expert opinion in Astu; in Bale applied the decrease in CPUE before the 1980s (50%) to back-calculate from yield estimates in 2002, and applied this rate in Cata as a proxy; in Basq applied the highest production estimate from electrofishing surveys (but no years listed in Annex 2); applied a conversion factor in Murc but not clear what factor was applied to what; in Gali used surveys but no more information; in Cant no information for transitional waters approach; and in Cast, Inne and Nava there are no transitional waters.

In summary, the France approach differed from that applied to almost all EMUs in neighbouring countries. WKEMP cannot discount the possibility that the estimates for France are correct. However, assuming no density-dependence during periods of high recruitment might be over cautious, there is limited direct evidence from which to support or refute this.

What is clear is the substantial differences in the data, methods and assumptions used in estimating B_0. This makes it very difficult to compare and to explain differences in estimates.

Why are Spanish $B_{current}$ particularly high?

There is nothing obvious about the approach that Spain is applying in these EMUs that might explain why some $B_{current}$ estimates are high compared to others in the catchment regions (Spanish EMUs draining into the Atlantic and Mediterranean regions). Addressing the three EMUs with the highest $B_{current}$ estimates: the ES_Basq approach is based on electrofishing surveys of yellow eel, similar to that in England and Wales; the ES_Bale approach is an extrapolation from yield estimates of the early 2000s assuming production has since declined at the same rate as recruitment; and the ES_Vale estimate is based on the France Rhone EMU estimate as a proxy. It is noticeable that the ES_Bale and ES_Vale EMUs have little or no anthropogenic mortality factors and so this might be one explanation for their relatively high estimates.

3.2.2.2 Mortality rates

As indicated above in methods, mortality from fishing (ΣF) and from other causes, mostly turbines in hydropower stations (ΣH) are estimated and their sum calculated (ΣA = total anthropogenic mortality). Data are only available for a few countries and sometimes a limited number of years. WKEMP has tabulated and graphed the available data. Broadly speaking, the rebuilding target of 40% B_0 would be consistent with a total lifetime mortality of ΣA = 0.92. Available series are shown in Figures 3.2.2.5–3.2.2.8.

For Spain (Figure 3.2.2.5), mortality estimates are available for 2008, 2011, 2014 and 2017. Total mortality is around 1.0, mostly from fishing with ΣH being less than 0.02 or negative to account for stocking at hydropower facilities.

For the UK (Figure 3.2.2.5), estimates are available yearly for 2009–2016. Median total mortality increased from slightly above 0.5 in 2009 to slightly above 1 in 2014 and has slightly decreased since. Fishing and other causes of mortality contribute about equally to the total and remain above 0.92.

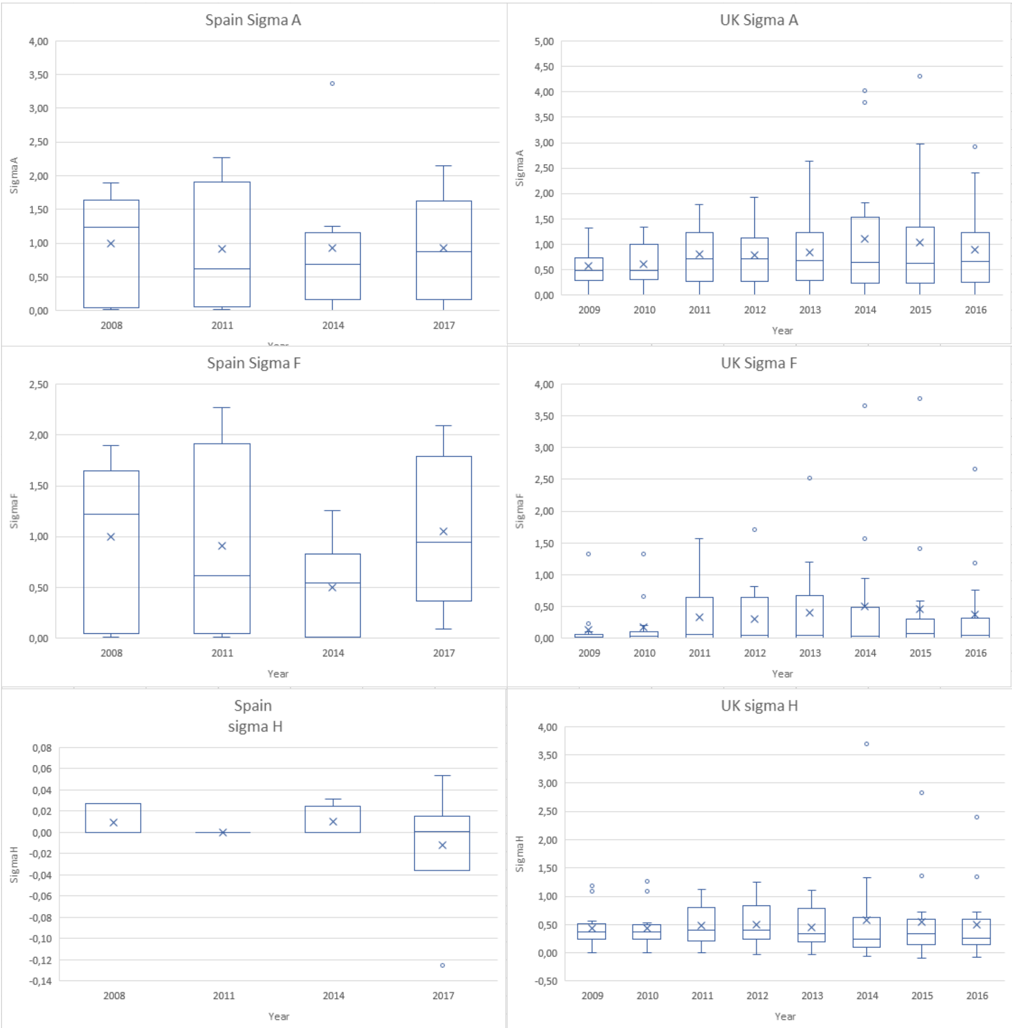

Figure 3.2.2.5. Box plots of mortality estimates for Spain and the UK. Sigma (Σ)F is from fishing, sigma (Σ)H is from other human causes and Sigma (Σ)A is the total.

For Italy (Figure 3.2.2.6), estimates are available for 2007 and yearly for 2009–2017 by habitat type. For freshwater, median total mortality has been less than ΣA = 0.92 since 2013 with ΣF very low since 2014 and near zero in recent years while ΣH also decreased but much less.

Figure 3.2.2.6. Box plots of mortality estimates for Italy. Sigma (Σ)F is from fishing, Sigma (Σ)H is from other human causes, and Sigma (Σ)A is the total.

For Ireland (Figure 3.2.2.7), estimates are available yearly for 2008–2017. Ireland choose to close its fisheries so median ΣA declined from slightly above 0.6 in 2008 to less than 0.1 in 2009. ΣA has remained low since then. Median ΣH is variable from year to year depending on environmental conditions (flooding vs. drought) at the time of the downstream migration.

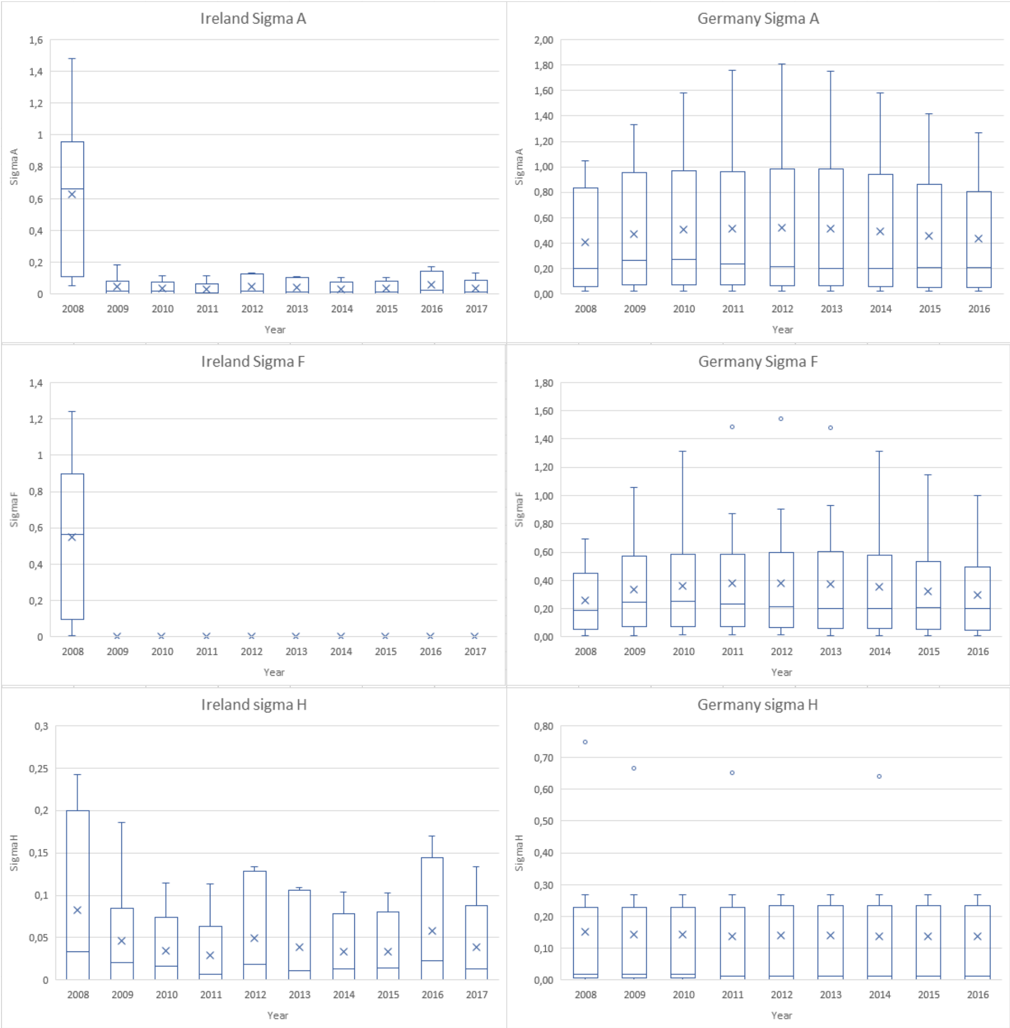

Figure 3.2.2.7. Box plots of mortality estimates for Ireland and Germany. Sigma (Σ)F is from fishing, Sigma (Σ)H is from other human causes, Sigma (Σ)A is the total.

For Germany (Figure 3.2.2.7), estimates are available yearly for 2008–2016. Median total mortality increased slightly from about 0.40 in 2008 to 0.55 in 2012–2013 before reverting back to about 0.40 in 2016. Fishing accounts for a larger proportion of the total mortality than do other causes.

Sweden (2000–2017), Poland (2011–2017), the Netherlands (by variable multiyear periods since 2005), Lithuania (2011–2017) and Denmark (2009–2017) have reported for single EMUs and therefore average values, rather than median are described (Figure 3.2.2.8).

For the east coast of Sweden, ΣH is zero for the whole period while ΣF decreased from 0.10 during 2000–2008 to 0.02 since. For inland waters in Sweden, ΣA decreased from above 1.0 in 2000 to 0.60 in 2005–2007 before increasing to around 1.0 in 2012 due to increases in ΣH and oscillating around 1.0 since then. ΣH nearly quadrupled from slightly above 0.20 in 2006 to 0.80 in 2016–2017. ΣF was relatively high on the West coast of Sweden during 2000–2006. ΣF decreased steadily subsequently to zero in 2012 when fisheries were closed.

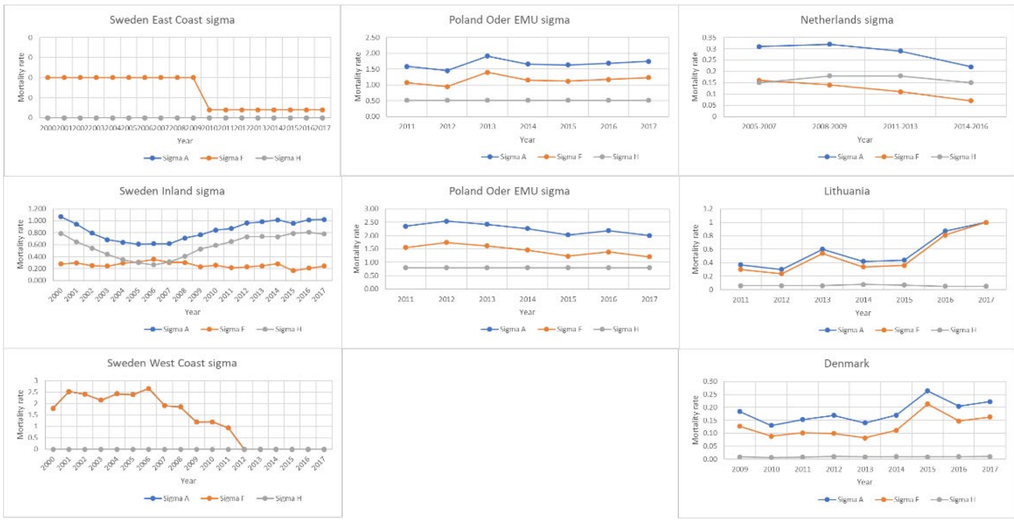

Figure 3.2.2.8. Mortality estimates for Sweden, Poland, the Netherlands, Lithuania and Denmark. Those countries reported only for one or a few EMUs and line graphs are presented rather than Box Plots.

In Poland, fishing is the main cause of mortality with ΣF above 1.0 and increasing slightly in EMU Oder and declining in EMU Vist from above 1.5 in 2011 to about 1.2 in 2017.

In the Netherlands, ΣA decreased from 0.3 in 2005–2007 to 0.21 in 2014–2016 mostly because of decreases in fishing.

In Lithuania ΣA is increasing irregularly from 0.4 in 2011 to 1.0 in 2017 mostly due to fishing except in 2016 and 2017 when ΣH increases markedly and ΣF declines to zero in 2017.

For Denmark, ΣH is very low. ΣA increased from 0.14 in 2010 to 0.22 in 2017.

3.3 Term of Reference c), Where there are gaps in results, or estimates are identified as not being appropriate, derive alternative estimates based on a standardized view of eel biomass and mortality

Table 3.3.1 shows where estimates of escapement biomass and mortality rates are not available - the gaps. Table 3.3.2 summarises this for EU Member States: biomass reporting was 82 to 84 of 95, mortality rates 74 to 79 of 95.

Table 3.3.2. Summary of biomass and mortality rate reporting by EU MS for eel management units. Where MS do not have eel management plans, the entire country is designated as a single eel management unit.

METRIC	REPORTED	MISSING	TOTAL
B_0	87	8	95
B_{best}	86	9	95
B_{curr}	88	7	95
ΣA	80	15	95
ΣF	83	12	95
ΣH	78	17	95

3.3.1 Gaps or inappropriate Biomass estimates

Austria, Bulgaria, Cyprus, Hungary, Malta, Romania, Slovakia and Slovenia are excluded because they have a derogation from implementing EMPs.

Denmark for the Baltic fishery area and Estonia for their WEST EMU implemented the 50% cut in fishing effort but did not report biomass or mortality estimates.

Croatia has not reported but ought to have eel recruitment from the Adriatic Sea so is included as a gap.

Within the EU, gaps in biomass were apparent for the following EMUs:

> B_0 - Croatia, Czech Republic, Danish marine waters, Estonia West, Finland, Greece Central and Aegean, Luxembourg, and Sweden East;
>
> B_{best} - Croatia, Czech Republic, Danish marine waters, Estonia West, Finland, Greece Central and Aegean, Luxembourg, Spain Navarra, Sweden East;
>
> $B_{current}$ - Croatia, Czech Republic, Danish marine waters, Estonia West, Finland, Greece Central and Aegean, and Luxembourg.

WKEMP proposes filling these gaps by referring to nearest neighbour or the catchment region average values; see Table 3.3.1 below. There are no estimates of B_0 for the Danish marine, Estonia West or Sweden East, because there are no B_0 available for other Baltic coastal waters, nor for the Baltic drainage region, so there are no values to apply.

Table 3.3.1. EMUs with gaps in reported B_0 and $B_{current}$, and potential values (kg/ha) to fill these gaps, based on nearest neighbour or average from the drainage region.

EMU			B0 (KG/HA)		BCURRENT (KG/HA)	
	Nearest neighbour	Drainage region	Nearest neighbour	Drainage region mean+-SD	Nearest neighbour	Drainage region mean+-SD
Croatia	Italy Vene	Med'n	18.73	24.0+-42.3	4.20	4.9+-7.6
Finland	Sweden Inland	Baltic	0.09	4.8 +- 4.0	0.01	1.4+-2.2
Greece	Greece	Med'n	1.70	24.0+-42.3	0.36	4.9+-7.6

CeAe	NorW					
Czech Republic	Polish Oder / German Elbe	Baltic / North Sea	7.76	11.1+-12.9	0.43	1.5+-1.6
Luxembourg	De-Rhine	North Sea	8.72	14.3 +-14.4	3.50	1.7+-1.3

For the nearest neighbour approach, the Italy Venezia-Giulia (IT_Vene) EMU is the nearest neighbour to Croatia. The German Elbe (DE_Elbe) and Polish Oder (PL_Oder) EMUs border the Czech Republic and so the average biomass estimates of these two EMUs were selected as the nearest neighbour estimates. Sweden Inland (SE_Inla) waters is selected as the nearest neighbour to Finland. The Greece North Western (GR_NorW) EMU is selected as the nearest neighbour to the Central and Aegean Islands (GR_CeAe) EMU because the Greece EMP presented eel landings from lakes in both these EMUs, but not in the other Greek EMUs. The German Rhine (DE_Rhei) was selected as the nearest neighbour to Luxembourg because a tributary (the river Mosel) flows along the border between the two countries.

The average B_0 and $B_{current}$ values for the Mediterranean are similar to the nearest neighbour of Croatia but much higher than that for the Greece CeAe EMU. The values for this drainage region are dominated by those for France and Spain which at the other end of the Sea from Greece and likely not representative of conditions in Greece.

The average B_0 and $B_{current}$ values for the Baltic are far higher than those for the Finnish nearest neighbour of Sweden. The regional values are dominated by high values from Germany and Poland but these might have been influenced by significant quantities of restocking. The report for Finland indicates that eel are rare in their country.

The large standard deviations around the means for drainage regions highlight the extent of variation between EMUs within a region, and suggest that the nearest neighbour approach may be more informative.

Within the EU but outside EMUs, gaps were apparent for some saline waters. There is insufficient knowledge of eel abundance and production in saline waters to fill these gaps at present, but this topic and options are discussed later; see Annex 5.

3.3.2 Gaps or inappropriate Mortality rate estimates

Within the EU, gaps in mortality rates were apparent for the following EMUs:

ΣA - Croatia, Czech Republic, Danish marine, Estonia West, Finland, Greece Central and Aegean, Greece East Macedonia - Thrace, Greece North Western, Greece Western Peloponnesus, Italy Umbria, Italy Valencia, Latvia, Luxembourg, Portugal exMinho, Spain Navarra;

ΣF - Croatia, Czech Republic, Danish marine, Estonia West, Finland, Greece Central and Aegean, Greece East Macedonia - Thrace, Greece North Western, Greece Western Peloponnesus, Latvia, Luxembourg, Spain Navarra,;

ΣH - Croatia, Czech Republic, Danish marine, Estonia West, Finland, Greece Central and Aegean, Greece East Macedonia - Thrace, Greece North Western, Greece Western Peloponnesus, Italy Umbria, Italy Valencia, Latvia, Luxembourg, Portugal exMinho, Spain Basque, Spain Catalonia, Spain Navarra.

WKEMP could not fill gaps in mortality rates for the EU MS as it would not be appropriate to assume that values for other EMUs in the same country or from other countries applies; conditions are expected to vary by EMU. WKEMP did not attempt to ascertain whether or not MS have quantified the effects of all anthropogenic impacts that have a significant effect on silver eel escapement in their territories.

4 Discussion

As discussed in Section 3.5.1 of WGEEL 2018, because of recent and current low recruitment, the biomass targets in several EMUs are unlikely to be met in the foreseeable future even if all anthropogenic mortality were removed. Rebuilding may take decades or centuries rather than years. If the Eel Regulation biomass targets are not achievable in the near future in several EMUs, deriving an explicit mortality target, corresponding to the time schedule requirement and/or the biomass target of the EU Eel Regulation might prove more useful.

4.1 ToR a) Collate the Eel Management Unit biomass and mortality rates from EU Member State (MS) Eel Management Plan (EMP) Progress Reports as submitted to the European Commission by 30th June 2018

WKEMP found that reporting to the EC was incomplete with several countries not reporting or reporting late. While submitting the information in Excel spreadsheets is an improvement over submitting in paper form or in Word files, data verification, compilation and analysis would be greatly facilitated if the data were input in a database by MS and verified by knowledgeable personnel before being added to the database. WKEMP understands that WGEEL is developing this approach.

4.2 ToR b) Review EMP methods and results to confirm whether or not they appropriately reflect the (present and target) status of eel biomass and mortality rates across Europe

WKEMP found that a limited number of approaches have been used to estimate biomass reference points, consistent with the Eel Regulation. Few reports provided detailed information on exactly how biomass and mortality estimates were derived. Most referred to other documents or primary publication where details were provided. MS were asked to provide the information in a summary table, but the information provided was highly variable by country and very rarely complete. Here again, submitting the information in a database and verifying the information submitted before loading it in the database would greatly facilitate subsequent analyses.

4.2.1 Eels in transitional and coastal waters

While eel management plans recognize three habitat types: fresh, transitional, and coastal, and the EMP overview template provided to MS by DG MARE also recognized marine open waters as a Habitat Assessed category, most of the information provided was for freshwater habitat (82 of 87 EMU reports), some for transitional waters (59/87) and very few MS reported information on coastal habitat (22/87) or marine open waters (4/87). WKEMP notes that not every EMU covers all four habitat types, but most do, and as it was not always obvious in the overview template whether a habitat type was pertinent or not, it is assumed here that all EMUs cover all habitat types.

Information on coastal habitat is important because eels commonly use saline waters as rearing areas and eel demographic parameters in saline waters may differ from those in freshwater, in particular, growth may be substantially more rapid in saline water than in freshwater (Cairns *et al.*, 2009; Daverat *et al.*, 2012). Eel fisheries occur in marine waters of at least Denmark, Estonia and Sweden.

ICES (2009) reviewed published and unpublished information on the biology of *Anguilla* eels, especially *A. anguilla* and *A. rostrata*, in saline (brackish and salt) water. A broad range of scientific studies and reports of fishery locations indicate that yellow phase European eels are widespread and common in estuaries and sheltered bays. On Europe's Mediterranean coast, eels are common in coastal lagoons. Overall, it can be inferred with reasonable confidence that yellow eels occupy estuaries and sheltered coastal waters throughout their continental range. Eels occupy or occupied unsheltered waters in the southern North Sea, but it is not known if eels use or used similar habitat in the Baltic Sea, Atlantic Ocean, and Mediterranean Sea.

There is a large deficit of knowledge of eel use and biology in coastal and transitional water, relative to knowledge in freshwater. Obtaining the information that is needed for a robust assessment of compliance with the Eel Regulation in coastal and transitional habitat is a long-term task. The following steps will assist.

i) Member States should map the transitional, coastal, and freshwater zones that are used in present assessments, and make these maps available in GIS format. Wetted areas of EMUs should be tallied according to these habitat types.

ii) Available datasets should be mined to help determine eel distribution in saline waters. DATRAS (datras.ices.dk) provides databases of bottom-trawl surveys between the Baltic Sea and Gibraltar which may help define the seaward distributional boundary of eels. In estuaries and sheltered coastal waters, biological research and monitoring is conducted with a large variety of collection methods, including beach-seines, underwater visual counts, dredging/trawling, suction sampling, and poisoning (Baker *et al*., 2016). Many of these methods are capable of capturing or detecting eels. Mining such studies for eel data is likely to shed light on eel distribution in estuaries and sheltered coastal waters.

iii) Prepare revised maps of transitional and coastal habitat using information collected in ii) above.

iv) Apply quantitative methods of estimating eel density in saline waters e.g. using night-time glass bottom boat surveys (Cairns *et al*., 2009) and by the corral (enclosure) method (Ubl and Dorow, 2014). Use of these methods should be expanded, and novel methods should be developed and tested. The use of environmental DNA (eDNA) (Sigsgaard *et al*., 2017) to determine seaward boundaries of eel distribution should be tested.

v) Expand eel population dynamics research in saline waters. With major demographic traits differing substantially with salinity, it is unwise to apply data collected in freshwater to eels living in saline waters (ICES, 2009).

4.3 ToR c) Where there are gaps in results, or estimates are identified as not being appropriate, derive alternative estimates based on a standardized view of eel biomass and mortality

WKEMP found that there were few gaps for biomass. Two approaches to fill these gaps were tested, nearest neighbour or average for a drainage basin. The nearest neighbour provided more reasonable values.

4.3.1 Density-dependence and B_0 estimation

The Eel Regulation mandates a management regime that is oriented towards targets of escaping silver eel biomass, relative to the escapement that would have occurred in the absence of anthropogenic impacts (EU 2007). Pertinent wording from the Regulation is "*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*." and "*The target level of escapement shall be determined, taking into account the data available for each eel river basin, in one or more of the following three ways: (a) use of data collected in the most appropriate period prior to 1980, provided these are available in sufficient quantity and quality; (b) habitat-based assessment of potential eel production, in the absence of anthropogenic mortality factors; (c) with reference to the ecology and hydrography of similar river systems*."

Estimated silver eel biomass in the absence of anthropogenic impact is referred to as B_0. The method of estimating B_0 varies among MS and among EMUs. B_0 is most often calculated by some form of method (a), in reference to the relative abundance of eels prior to 1980, at the yellow and silver stages (Denmark, France, Germany, UK), or at the glass eel stage (Italy, Poland, Spain). B_0 has also been estimated from habitat carrying capacity (method (b)), (Netherlands, Spain) and with reference to similar systems (method (c) Spain - Valencia).

Under Method (a), B_0 can be calculated from a measure of silver eel biomass made prior to 1980. If such a measure is not available, B_0 could be calculated from a measure of yellow eel abundance made prior to 1980, and converted to silver eel equivalents by application of vital rates (growth, mortality). If neither silver nor yellow eel abundance was measured prior to 1980, B_0 could be estimated from glass eel recruitment measured prior to 1980, again converted to silver eel equivalents using vital rates. Calculation of silver eel equivalents from historic yellow eel abundance entails an error due to random variation in, and inexact knowledge of, vital rates. Calculation of silver eel equivalents from historic glass eel abundance entails a greater error, because of the longer time period between the glass and silver stages.

Density-dependent effects could introduce systematic errors in the estimation of silver eel equivalents from historic measures of the abundance of earlier stages. Bevacqua *et al*. (2011) found that the mortality rate of high-density eel populations was about three times greater than the mortality rate of low-density populations. Under a scenario of density-dependence and declining recruitment, silver eel abundance is therefore likely to decrease less rapidly than glass eel abundance, and by an even greater margin less rapidly than glass eel recruitment. It is therefore possible that B_0 estimated from decreases in glass eel abundance/recruitment would be overestimated.

Density also influences eel sex ratio, with high densities associated with large proportions of males and low densities associated with large proportions of females (Geffroy and Bardonnet, 2016). Domination of a population by males will depress silver eel biomass because male silver eels are much smaller than female silver eels (Durif *et al*., 2005).

Density-dependence of sex-ratio and of natural mortality have the same directional effect in a scenario of declining eel recruitment: both types of dependence will cause yellow and silver abundance to decline less rapidly than glass eel abundance.

It is plausible that density-dependence affects eel natural mortally and sex-ratio in a way that decreases the decline rate of silver eels, relative to yellow and glass eels. If density-dependence causes the silver eel index to decline less steeply than the glass eel index, the raising factor to calculate silver eel from glass eel abundance will change over time. Switching between assumption and non-assumption of density-dependence in the estimation of eel decline could substantially change B_0.

WKEMP notes that there is literature evidence of density effects on natural mortality (Bevacqua *et al.*, 2011), sex ratio (Geffroy and Bardonnet, 2016), and growth (Boulenger *et al.*, 2016), but reported relations are variable and sometimes contradictory. Further research should be conducted on density-dependence in eels, with emphasis on studies that simultaneously measure different types of effects. In addition, recently developed life-history optimization models (e.g. Mateo *et al.*, 2017) should be used to examine the potential effects of density-dependence on stage-specific abundance trends in declining eel populations, and on their impact on estimations of B_0 from glass and yellow eel abundance series.

4.4 ToR d) Deliver an early draft advice and a report containing the full reviews of biomass and mortality rates from EMPs or replacements, and describe the methodology for standardizing the various results to determine overall estimates of biomass and mortality

A draft was uploaded to the WKEMP SharePoint and to the ADGEELMAN site.

4.4.1 Stocking

WKEMP noted that some MS use stocking to help achieve biomass targets. This remains a topic of considerable debate. The WKSTOCKEEL (ICES, 2016) report summarises the recent state of understanding for the European eel, but recent reports from North America on stocking of American eel (*A. rostrata*) provide further examples of the complexities, as summarised below.

Following the collapse of the recruitment of juvenile American eels to Lake Ontario in the 1980s and the subsequent lack of recovery following closures and fishery restrictions, large-scale stocking of the St Lawrence system began in 2005, with the objective of recreating an eel population with the characteristics of eels that naturally recruit to the area, i.e. exclusively female with very large size at maturity. Between 2005 and 2010, 6.8 million elvers, caught at the heads of estuaries on the Atlantic and Fundy coasts of Nova Scotia and New Brunswick, were translocated to the upper St Lawrence River, Lake Ontario, and the Richelieu River. Stocked eels flourished in receiving waters and soon produced silver eels that migrated to the estuary (Verreault *et al.*, 2010; Lloyst *et al.*, 2015). Long-term captive experiments showed a complex picture, where translocated eels showed a high fraction of males with unimodal growth rates, and a female component which split into slow-growing and fast-growing individuals (Cote *et al.*, 2015). In contrast, natural recruits to the area were exclusively female and slow-growing. Substantial numbers of stocked eels are currently silvering at a small size (Beguer-Pon *et al.*, 2018). Eel stocking to the upper St Lawrence Basin terminated in 2010 because of concerns that further stocking would risk additional import of *A. crassus*, and because the stocking programme failed to meet the objective of producing eels with the same characteristics as naturally recruited eels. There is currently no discussion in American eel conservation circles of resuming eel stocking in the upper St Lawrence.

5 Recommendations

5.1 Reporting

1) Reporting format and content should be obligatory rather than voluntary as it is now, to ensure consistent and comparable information is available from which to judge the state of biomass and mortality rates.

2) It would reduce the burden on MS if the reporting requests from DG MARE, ICES and others could be coordinated and combined.

3) While submitting the information in Excel spreadsheets is an improvement over submitting in paper form or in Word files, data verification, compilation and analysis would be greatly facilitated if the data were input in a database by MS and verified by knowledgeable personnel before being added to the database. WKEMP understands that WGEEL is developing this approach, and recommends that all support is provided to make this happen.

4) All data and methods used to estimate all biomass and mortality rates should be fully documented and available in a single location. Perhaps ICES could act as a depository with a link provided from the WGEEL page.

5) The treatment of restocking in all estimates of biomass and mortality must be clearly described.

6) The Habitats Assessed part of the Overview Table should include the option to record Not Applicable for when a habitat type is not assessed because it does not exist in the EMU.

5.2 Estimating biomass and mortality rates

1) Biomass and mortality rates should be regularly estimated for all waters producing European eel. This means that MS should be required to estimate biomass and mortality rates for all eel-producing waters in their territories, and not just those with EMUs as present. Also, estimates should be made for international or EU waters, and the EU should continue to work with non-EU countries to deliver similar reporting.

2) There is a large deficit of knowledge of eel biology in coastal and transitional water. Obtaining the information that is needed for a robust assessment of compliance with the Eel Regulation in coastal and transitional habitat is a long-term task, but requires the following:

   2.1) MS should map the transitional, coastal, and freshwater zones that are used in assessments, revised based on knowledge of eel distribution in saline waters, and make these maps available in GIS format. Wetted areas of EMUs should be tallied according to these habitat types.

   2.2) Eel distribution, abundance and life-history characteristics in saline waters should be quantified. Mining of available datasets, deployment of quantitative surveys and new research are required.

3) The B_0 in the Regulation is ambiguous because it first refers to a situation without human impact, but then refers to a time period before 1980 when human impacts existed. The time period and other aspects of B_0 must be clarified. For example, should potential eel habitat upstream of hydropower barriers constructed before the 1980s be included or excluded from estimates of B_0? MS may be required to re-estimate B_0 as a consequence of this.

4) Where B_0 is estimated from measures of glass or yellow eel abundance, reports should note the potential that density-dependence bias results.

5) B_0 should be estimated, in order of preference, from historic data on the abundance of silver eels, of yellow eels, or of glass eels. Time-specific sex ratios should be incorporated in calculations if available.

5.3 Further Research

1) Further research should be conducted on density-dependence in eels, with emphasis on studies that simultaneously measure different types of effects. And, life-history optimization models should be used to examine the potential effects of density-dependence on stage-specific abundance trends in declining eel populations, and on their impact on estimations of B_0 from glass and yellow eel abundance series.

2) Although there are good reasons for MS to apply different approaches to estimate biomass and mortality rates, these differences make it very difficult to determine whether the methods create a 'level playing field'. Cross-calibration between methods is therefore required.

5.4 Others

1) Those countries where eel production from natural recruitment was low but supplemented by significant restocking should not be setting targets based on this artificially elevated eel production.

2) The uncertainties about some of the eel landings data in the FAO statistics should be addressed, so that a complete and accurate landings dataset would be available.

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Annex 2: Methods used to calculate biomass and mortality estimates

Various sources of information were consulted to obtain a reasonably good idea of what methods Member States used to estimate biomass and mortality. In particular, information was sought for countries with relatively large proportions of total European catches according to FAO statistics, and those having large wetted areas. Notes on these inquiries are below.

Belgium

$B_{current}$ is estimated from electrofishing densities of yellow eels, converted by a demographic model into escaping silver eels. B_0 and B_{best} are also estimated with the model. Eels are not commercially fished in Belgium. Sigma F is based on recreational harvest estimated from a survey. Sigma H is based on mortality due to hydropower, pumping stations, and cooling stations.

Denmark

No explanation in the report on how rates are calculated, but losses estimated in biomass and subtracted from B_{best}.

Main management measure has been to reduce fishing effort in commercial and recreational fisheries. Have removed dams and other obstacles so reducing mortality and opening up habitats, restocking.

For North Sea and the Baltic

B_0 for before 1980 was estimated as 50 kg/ha from running waters and 8 kg/ha from lakes. For rivers there were two studies of yellow eel densities extrapolated to silver eel (1965–1968, 105 kg/ha; 1988, 9 kg/ha) and one of silver eel trapping (1965–1975, 49 kg/ha). For lakes, silver eel escapement was estimated based on fisheries yield prior to 1980, and assuming a fisheries mortality of F = 0.5 the production was roughly in the range of 6–10 kg/ha.

"Silver eel escapement is monitored in three (maybe only one now) out of 887 river systems. The results from these river systems are converted into production per area (kg/ha) values and then up-scaled to national level to estimate B_{best}. The current best estimate of silver eel production in freshwater is 169 ton. Mortalities in freshwater is 43.7 ton and subtracted from B_{best} to give a $B_{current}$ escapement is 125.3 ton. The silver eel production in River Ribe Å is used as indicator of silver eel production for Danish Running Water - but then Section 2 describes two rivers? River Ribe Å is a medium size lowland river with a catchment area of 1723 km² with a commercial fishery situated in the lower part of the river. Escapement is estimated from catch times fisheries efficiency measured by tag recapture experiments in the autumn 2010, 2014 and 2017: 17.7, 28, 21%, respectively. Fishing effort is constant between years, but environmental conditions affect gear effectiveness.

In the River Gudenå, at Vestbirk Hydropower station silver eel escapement is trapped from August to December, with a 65% catch efficiency, from river area (66.6 ha) and lake area (121.3) total 188 ha. The trap, however, is 100 km from the sea, so doesn't reflect system-wide escapement.

Silver eel escapement from Lake Vester Vandet in northern Jutland (479 ha) area trapped during September to December. Silver eel production in 2017 was 0.1 kg/ha, but this doesn't account for losses due to a yellow eel fishery in the lake or spring migrants. Commercial fisheries in a number of other lakes suggest a potential silver eel production in these lakes to be 1–2 kg/ha but these are not used in estimating B_{best}."

Mortalities in biomass subtracted from potential silver eel escapement to estimate $B_{current}$.

Total loss from freshwater estimated as 43.7 t: commercial fisheries 16.4, recreational fisheries 8.3 t.

Total loss from freshwater estimated as 43.7 t: predators ten, trout farms four, hydro turbines five. Some mortality has been documented due to hydropower turbines especially from Tange Hydropower plant; about 77% of migrating silver eel are lost. An estimate from all (46 in 2006, but now only three large stations) hydropower plants may be approximately 5 ton, but not clear how this is derived. At flow-through trout farms located at the bank of rivers, the mortality is estimated to approximately 4 ton, but the method and cause are not clear, only describing entrainment through a faulty screen or migratory delay. Predators are mostly herons, cormorants, otters and mink; mortality rates from cormorants estimated from tag recoveries near roosts.

For the Baltic

Main management measure: Reduced fishing effort by ~50% relative to 2004–2006, with reported 55% reduction in landings. Recreational eel fishing effort in marine waters was estimated to be reduced by 50 % by implementing closed seasons for fykenets and hook lines. In accordance with Article 11 (2) of the Regulation, the catches of recreational fishermen have been estimated at approximately 100 ton in 2009 and estimated to have been reduced to approximately 55 ton in 2014 but have raised to 117 ton in 2017 (Table 2.B3).

B_0 Not estimated - no EMP implemented. Instead, a 50% cut in fishing effort.

No data to calculate B_{best} or $B_{current}$.

There is only mortality from fishing, no other impacts.

Estonia

Based on mark–recapture up to 2015. In the absence of recapture in subsequent years, abundance was estimated from average abundance in fykenets. B_0 is based on commercial fisheries in the 1930s. Sigma H is based on escapement studies in hydropower facilities. Sigma F is based on landings from commercial fisheries in lakes. Sigma A is greater than the sum of sigma F and sigma H, for reasons unknown.

Finland

France

B_0 is calculated on an EMU basis by multiplying the modelled average recruitment during 1960–1979 by the inverse of the observed decline in recruitment since 1980?

$B_{potential}$ is first calculated using a model, Eel Density Analysis (EDA) to calculate eel densities in a relatively large number of monitoring stations. In the current model, yellow eel density by size classes for several sections in each river monitored is related to the fishing method, year, month and EMU, altitude, distance from the sea, mean July temperature, and the sum of the height of migration obstacles from the mouth of the river. In a second step, eel densities are expanded to the habitat of the river section and summed for the whole river. Estimated numbers in each yellow eel size class are multiplied by probability of silvering and the mean weight of silver eel. The probability of silvering and the mean vary by river portion. This is done on an EMU basis. A Glass-Eel Recruitment Model (GEREM) is used to predict recruitment by EMU. These are scaled to the Eel Density Analysis results and adjusted for glass eel mortality of 80% and annual mortality of 0,1386 for subsequent years.

$B_{current}$ is calculated from $B_{potential}$ (see cell on the left) by subtracting known or estimated silver mortalities. Note that $B_{potential}$ and Bbest are consistently lower than actual counts on monitored rivers because the available habitat used in the EDA model are underestimated, especially for lakes, ponds and marshes.

Germany

German eel populations are modelled with the German Eel Model (GEM III), which tracks populations according to demographic parameters including growth rates, mortality rates, sex ratios, and maturation schedules). In many cases EMU-specific parameters are used; otherwise parameters are borrowed from studies elsewhere. Field methods used to generate these data are not indicated. Stream electrofishing and silver eel trapping are plausible field techniques, but the report sheds no light on this.

B_0 is taken as the mean of silver eel production estimates, i.e. 7 kg of silver eel/ha. B_0 is calculated from data obtained before 1980 in rivers draining into the North and Baltic Seas.

For the coastal area of EMU Warnow/Peene, B_0 is based on commercial fishery yields using a predetermined conversion factor, as per special ICES recommendation.

B_{best} is calculated by GEM, with all anthropogenic mortalities set at zero, and under the assumption that there is no stocking and no artificial transport of eels around hydro dams.

$B_{current}$ was calculated with GEM, incorporating the various anthropogenic mortality factors, stocking, and artificial transport of eels around hydro dams.

Total anthropogenic mortality was calculated as -1*LN($B_{current}$/B_{best}+Stocking).

Fishing mortality was calculated as -1*LN($B_{current}$_fishery/B_{best}+Stocking).

Other mortality was calculated as total mortality - fishing mortality.

Greece

A combination of data originating from the landings recorded by the fishing cooperatives and individual fishermen and (size of population), on-site recording of morphometric parameters (length classes), samples that are transferred in laboratories for further elaboration (sex ratio, age determination, etc.).

Hungary

Ireland

The Irish assessment is built around the use of index catchments, where the silver eel escapement and mortality is assessed directly using mark–recapture (Shannon, Erne, Fane), DIDSON (Erne, Shannon), acoustic tracking for mortality assessment (Shannon, Erne) or by total trap (Burrishoole). A comprehensive wetted area database of habitat is used along with the index catchments and eel growth data from 18 catchments to extrapolate to other catchments where there are no eel data. Production and escapement is estimated in data-poor rivers using extrapolation based on eel growth and geology. In future, it is hoped to use a combination of EDA and the extrapolation method for estimation silver eel production.

Italy

B_0 is derived from historical data or from the literature for each EMU. For EMU with no information, data from similar or neighbouring habitat is used. The model estimates the pristine recruitment (R_0) necessary to produce the assumed B_0. $R_{current}$ is estimated as a fraction of R_0 based on the decline in recruitment (ICES, 2012). Using $R_{current}$ and R_0 and the trend estimated for Elsewhere Europe (ICES, 2017) yearly recruitment are estimated starting in 1950. Data are available from surveys starting in 2007 for stocking, fishing, electric dams, etc. For years prior to 2007, the 2007 values are used.

The model is used turning off actual catches and mortality to obtain B_{best} for each year of the model.

The model is used with actual data of catches and mortality to estimate $B_{current}$ in each year of the model.

"In Italy, the stock is assessed using the ESAM model. The model can take into account i) density-dependent settlement of recruits, ii) sexual dimorphism with different growth rates, iii) sexual maturity by size and sex, iv) natural mortality by size, sex and temperature, v) fishing mortality for yellow and silver eel as a function of fishing effort, mesh size and minimum size, and vi) migration mortality. Biomass and mortalities are estimated using a deterministic model based on most recent scientific knowledge of eel dynamics.

Model parameters are systematically calibrated on actual catches data to reproduce patterns and biomasses.

The model is able to produce abundances and biomasses in pristine conditions and in current condition, turning on and off all anthropogenic mortalities to evaluate the effect of each one."

Sigma H is a function of the number of electric dams (N) and the average survival rate (S = 0,682. ICES, 2011). The probability of reaching the sea is SexpN.

Latvia

Biomass values are estimated from fisheries catches and available habitat. Mortality indicators were not assessed.

Lithuania

B_0 is estimated from historical eel catches in the Curonian Lagoon. B_{best} and $B_{current}$ were estimated from stocking and a population dynamics model. Mortality estimates are calculated from the population estimates in the assessment model minus estimated catches and deaths in turbines.

Netherlands

B_0 is taken as 10 400 t for inland waters and 2600 for marine waters. The inland value appears to be based on carrying capacity considerations (ICES, 2009. Review service:

evaluation of eel management plans. Report of the ICES Secretariat.). A detailed methodology is not available in English. There is no information on the derivation of the marine B_0.

Dutch eel populations are assessed with a demographic model that emphasizes dynamic processes (fishing, growth, natural and anthropogenic mortality), a static model that emphasizes standing stock densities and quantities of wetted areas, and a model of mortality due to migration barriers, that is based on hierarchical classification of water types. Output of these models are integrated in a stock model. %SPR (percent Spawner Per Recruit) is defined as the current escapement of silver eel as a percentage of the best possible escapement if all anthropogenic mortalities were mitigated. B_{best} is calculated as ($B_{current}$ x 100)/%SPR.

$B_{current}$ is the current escapement of silver eel, the surviving part of the silver eel stock after all silver eel anthropogenic mortality.

Sum of Sigma F and Sigma H.

Summed fishing mortality is calculated in the stock model.

Summed non-fishing anthropogenic mortality is calculated in the stock model.

Norway

The methods used to calculate the biomass indices will be available in early 2019 when we report to the Norwegian Fisheries Directorate.

Poland

Main management controls seem to be reducing fishing mortality rate closed season for all fisheries, but also minimum landing size. Stocking is an important management measure, but limited by price of eel for stocking so only achieved target in 1 RBD in 1 year.

Fishing: recreational catch was about 30 t pa before EMPs; recent catches not reported. Illegal fishing - not well known and no longer modelled, but inland fisheries might lose 20% or 70 t pa. Numerous (15 000+) obstructions in most rivers of the Oder and Vistula basins noted but not apparent that these impacts are addressed in estimates. Impact of hydropower turbines included - the 2015 report suggests about 600 exist, and only 24% of inland wetted area is not subject to hydropower facilities.

Assessment covers freshwater, transitional and marine coastal waters. The stock dynamics of eel for both EMUs is estimated using a version of CAGEAN model (Deriso *et al*., 1985), described in the Polish Eel Management Plan, modelled over 1960 to 2017, and using the WGEEL recruitment index in absence of observations in Polish waters. Models fishing mortality (catch-at-age) and cormorant predation, stocking rates, and recruitment (index of WGEEL), giving annual estimates of biomass and mortality rates. Biomass targets set according to the modelled predictions of the 1960–1979 period, with WGEEL recruitment index at that time. The waters were stocked during the B_0 reference period of 1960–1979, but this has been accounted for.

B_{best} based on average recruitment 2015–2017. Not clear how they estimate B_{best} but looks like they back-calculate from $B_{current}$ using SumF (or SumA).

Fishing mortality rates estimated using the catch-at-age model. No explanation of how the non-fishing rates are estimated, except that cormorant predation is included in the Cagean model.

Mortality at turbines is included, as described in the Polish EMP.

Portugal

A combination of methods including the commercial fishery and independent surveys are used as a proxy to estimate stock indicators. Wherever there is a fishery, it is monitored, but in the absence of a fishery, experimental fishing is carried out. B_0 = [[(YE densities 1988)*(silvering rate)]*mean SE weight] * wetted area.

$B_{current}$ = [[(YE densities 2017)*(silvering rate)]*mean SE weight] * wetted area

B_{best} = $B_{current}$ + Anthropogenic mortality in Silver Eel Equivalents (SEE). The only anthropogenic mortality considered was the mortality derived from the fisheries, which was estimated using the following expression:

$$SumF = -\ln (B_{current}/(B_{current}+kg\ SEE)).$$

Slovakia

Slovenia

Spain

Several different methods are used in Spain. A description for each EMU is therefore provided.

ES_Anda

For freshwater: Area production rate (16.4 kg/ha). To obtain the pristine productivity the decrease in the recruitment index before the 1980s (10%) has been applied to the B_{best}. For transitional waters: Area production rate (wetlands: 55.8 kg/ha). To obtain the pristine productivity the decrease in the recruitment index before the 1980s (10%) has been applied to the B_{best}.

B_{best} is obtained by mark–recapture.

$B_{current}$ for freshwater and transitional waters: Subtraction of fishing mortality to B_{best} and addition of stocking mortality.

ES_Astu

B_0 for freshwater: Area production rate (20 kg/ha) (ICES, 2001) for "big" rivers. Area production rate applied as conversion factor between "big/small" rivers. For transitional waters: Area production rate (14.3 kg/ha) (Expert criteria).

B_{best} is obtained by Electrofishing.

$B_{Current}$ For freshwater: Extrapolation of the Silver eel productivity obtained each year in electrofishing surveys in each river basin. For transitional waters: Extrapolation of area production rate (surveys).

ES_Bale

B_0 For freshwater: Not relevant. For transitional waters: Area production rate: lagoons 77.8 kg/Ha. Obtained by the application of the decrease in the CPUE (50%) before the 1980s to $B_{current}$.

B_{best}: Landings converted in silver eel equivalent using annual mortality of 0.138.

$B_{current}$: For freshwater: Not relevant. For transitional waters: Based on yield fishery data and surveys in Es Grau Lagoon (Cardona *et al.*, 2002). For 2017 the decrease in the recruitment index since 2002 has been applied (60.4% decrease since 2002).

ES_Basq

B_0: For freshwater: Area production rate (20 kg/ha) (ICES, 2001). For transitional waters: Area production rate. A value of 82.7 kg/ha has been assumed, which corresponds to the highest production obtained in the downstream sampling points through the periodic sampling using electrofishing surveys.

B_{best}: landings converted in silver eel equivalent using settlement mortality of 80%.

$B_{current}$: For freshwater: Extrapolation of the Silver eel productivity obtained each year in electrofishing surveys. For those rivers with no sampling, extrapolation of area production rate obtained in electrofishing surveys to similar habitats. For transitional waters: Extrapolation of the productivity values obtained in the samplings points which are located closer to the transitional waters.

ES_Cant

B_0: For freshwater: Apply a conversion factor to $B_{current}$. For transitional waters: no data.

B_{best}: To transform the catches into SEE a settlement mortality of %80 (Briand, 2009) and an annual mortality of 0.138 was considered (Dekker, 2000). It was considered that eel silvering age is 6. Fishery life mortality was estimated as = - Ln ($B_{current}$/ ($B_{current}$ + Catches in SEE)).

$B_{current}$: For freshwater: Extrapolation of the Silver eel productivity obtained each year in electrofishing surveys in each river basin. For transitional waters: no data.

ES_Cast

B_0: For freshwater: Area production rate (20 kg/ha) (ICES, 2001). For transitional waters: not relevant.

B_{best}: For freshwater: No current production, inaccessible habitat. For transitional waters: not relevant.

$B_{current}$: $B_{current}$ = 0, since there is not current population because obstacles.

ES_Cata

B_0: For freshwater: Area production rate (20 kg/ha) (ICES, 2001). For transitional waters: Area production rate (77,8 kg/ha) (EMP ES_Bale).

B_{best}: Transform landings into silver eel equivalent with a settlement mortality of 80% (Briand, 2009) and an annual mortality of 0.138 was considered (Dekker, 2000). It was considered that 65% of the eel landings corresponded to yellow eel. An average weight of 107 g for yellow and 216 for silver was used.

$B_{current}$: For freshwater: Extrapolation of the Silver eel productivity obtained in electrofishing surveys to areas of similar habitats within the same river. For rivers where no sampling has taken place the % population decrease since 2008 observed in similar rivers has been applied. For transitional waters: Extrapolation of area production rate (surveys); population decrease since 2008 where no sampling.

Sigma F: Fishery life mortality was estimated as = - Ln ($B_{current}$/ ($B_{current}$ + Catches in SEE)).

ES_Gali

B_0: For freshwater: Area production rate (20 kg/ha) (ICES, 2001). For transitional waters: surveys.

B_{best}: Transform landings into silver eel equivalent with an annual mortality of 0.138 was considered (Dekker, 2000).

$B_{current}$: For freshwater: Extrapolation of the Silver eel productivity obtained in electrofishing surveys to areas of similar habitats where no information is available. For transitional waters: Extrapolation of area production rate (surveys).

Sigma F: Fishery life mortality was estimated as = - Ln ($B_{current}$/ ($B_{current}$ + Catches in SEE)).

ES_Inne

B_0: For freshwater: Area production rate (20 kg/ha) (ICES, 2001). For transitional waters: not relevant.

B_{best}: No information.

$B_{current}$: For freshwater: No current production, inaccessible habitat. For transitional waters: not relevant.

Sigma F: no information.

ES_Murc

B_0: For freshwater: Area production rate (20 kg/ha) (ICES, 2001). For transitional waters: Apply a conversion factor to B_{curr}.

B_{best}: Mar Menor lagoon: $B_{current}$ == Based on fishery data and surveys (Martinez Baños, 2010) for the 2007–2009 period and updated each year assuming that the evolution of the CPUE is similar to that of the escapement. B_0 == Using the estimations for the 2007–2009 period as a reference and assuming that the evolution of the catches before the 1980s is similar to that of the escapement. Catches for the period prior to the recovery plan (1990–2009) were 51.7% lower than those for the period prior to 1980 (1960–1980). B_{best} == B_{cur}r+ SEE of the Fishery Segura River: Bo == An average area production rate (20kg /ha) (ICES, 2001) has been applied to the pristine habitat. The pristine habitat has been estimated using GIS and taking into account the surface water of watercourses from the river mouth to a height of 800 m in basins with little slopes and to 600 m in those of greater slopes, assuming that there were no natural obstacles in levels below these heights. $B_{current}$ == There is not enough data to provide B_{curr}. However, between October 2016 and September 2017, 20 points were sampled seasonally. In the Segura River, the species was detected in 100% of the locations sampled (three), while in the Randombes it was reduced to 45% (9 points) and in the ditches to 38% (8 points). The intricate network of canals that irrigate the Huerta de Murcia (over 500 km long) forms a network of aquatic environments ideal for the eel. The maximum values of density were detected in the random and ditches: of the order of four specimens per each thousand square meters, as opposed to one specimen per each thousand square meters in the river. These levels are therefore low and we can establish that the eel is still in a precarious state of conservation. (Vendrell *et al*., 2018; Quercus 384:22–29).

$B_{current}$: For freshwater: No data. For transitional waters: Based on fishery data and surveys (Martinez Baños, 2010).

Sigma F: To transform the catches in to SEE an annual mortality of 0.138 was considered (Dekker, 2000). It has been considered that eel become silver at an age of six years. Then, : Fishery life mortality was estimated as = - Ln ($B_{current}$/ ($B_{current}$ + Catches in SEE)).

ES_Nava

B_0: For freshwater: Area production rate (20 kg/ha) (ICES, 2001) has been applied to the pristine habitat. The pristine habitat has been estimated using GIS and taking into account the surface water of watercourses from the river mouth to a height of 800 m in basins with little slopes and to 600 m in those of greater slopes, assuming that there were no natural obstacles in levels below these heights. ES_Nava only includes freshwater habitat. For transitional waters: not relevant.

B_{best}: B_{curr}+ Anthropogenic mortality in silver eel equivalent. There is no fishery in the Navarra EMU. There is no information to estimate hydropower mortality, thus B_{best} is underestimated.

$B_{current}$: For freshwater: Extrapolation of the Silver eel productivity obtained in electrofishing surveys to areas of similar habitats where no information is available. For transitional waters: not relevant.

Sigma F:

ES_Vale

B_0: For freshwater: An average area production rate. Freshwater: 20 kg /ha (ICES, 2001), lagoon: 77,8 kg/ha (EMP_ES_Bale, 2010), Transitional: 80 kg/ha (Rhone, French EMP)

Best: B_{best} == $B_{current}$ + Anthropogenic mortality in SEE (SEE_com + SEE_rec). To transform the stocked eel into silver eel equivalent, an annual mortality of 0.138 was considered (Dekker, 2000). It was considered that eel silvering age is 6.

$B_{current}$: For freshwater: Extrapolation of area production rate ((Rhone, French EMP)

Sigma F: Stocking life mortality was estimated as = - Ln ($B_{current}$/ ($B_{current}$ + Stocking in SEE)). B_{best} = B_{curr}+ Fishing mortality in silver eel equivalent.

Sweden

Not reported but in our table have applied the Sigma F. Noting that this is mortality in the fishery alone and so not taking account of earlier mortality on the population before it recruits to Swedish coastal waters, from Baltic Sea and countries. So not a lifetime rate.

Sweden has three EMUs with slightly different approaches.

SE_East

Main management controls are fishery controls, stocking and trap-and-transport of silver eel; the contribution of stocking is assessed, but not those of fishing control (except F now 0 in closed fishery) or trap-and-transport.

B_0: Swedish fishery on silver eel that lived as yellow eel anywhere in the Baltic. No assessment undertaken.

B_{best}: Swedish fishery on silver eel that lived as yellow eel anywhere in the Baltic. No assessment undertaken.

$B_{current}$: Escapement from Swedish fishery, comprising yellow eel from whole Baltic mark–release–recapture in the coastal fishery.

Sigma F: Baltic Coast fishery assessed using mark–recapture, modelled across counties. But this fishery exploits eel from other Baltic States and with no knowledge of state or impacts on these eel before they reach the Swedish fishery, only silver eel fishing mortality rate is estimated. Since this assessment covers the silver eel stage only, the reported fishing mortality does not represent a lifetime mortality, only a partial mortality (F in Swedish waters, say: FSE - not ΣF). Other impacts on the same eels (in earlier life stages, often residing in other countries around the Baltic) have not been included.

Sigma H: No non-fishery mortality declared.

SE_Inla

Main management controls are fishery controls, stocking and trap-and-transport of silver eel; the contribution of stocking is assessed, but not those of fishing control (except F now 0 in closed fishery) or trap-and-transport.

B_0: Biomass is reported both with, and without, the contribution of stocking. For WKEMP purposes, B_0 in absence of stocking is relevant to comparisons with other countries.

B_{best}: The assessment for the inland waters relies on a reconstruction of the stock from information on the youngest eels in our waters (natural recruits, assisted migration, restocking). Based on 75 years of data on natural recruitment into 22 rivers, a statistical model is applied relating the number of immigrating young eel caught in traps to the location and size of each river, the distance from the trap to the river mouth, the mean age/size of the immigrating eel, and the year in which those eels recruited to continental waters as a glass eel (year class). From this, the production of fully grown, silver eel is estimated for every lake and year separately.

$B_{current}$: As B_{best} but then subtracting the catch made by the fishery (as recorded) and down-sizing for the mortality incurred when passing hydropower stations (percentwise, as recorded or using a default percentage), an estimate of the biomass of silver eel escaping from each river towards the sea is derived.

Sigma F: Fisheries - commercial, including the catch for silver eel Trap-and-transport. The trapping is included within the fishery statistics and therefore, it appears, within mortality rates. And so the F from this EMU is overestimated in this way.

Sigma H: Hydropower is the only non-fisheries impact quantified; other impacts considered minor so not quantified.

SE_West

Main management controls are fishery controls, stocking and trap-and-transport of silver eel; the contribution of stocking is assessed, but not those of fishing control (except F now 0 in closed fishery) or trap-and-transport.

B_0: No biomass estimates reported for either marine waters area because of insufficient data.

B_{best}: The West Coast fishery closed in 2012 so this EMU has no stock indicators (biomass and mortality), only trends from fishery-independent surveys

$B_{current}$:

Sigma F: Fisheries closed.

Sigma H:

UK England and Wales

For England and Wales, silver eel production was modelled (SMEP II) from yellow eel records collected in wading electrofishing surveys, using assumed or measured growth and mortality rates, sex ratios, length-weight relations, and silvering schedules. Production per ha modelled for river habitat was extended to all other habitat types. The method for mapping the seaward boundary of coastal habitat is not defined.

B_0 was estimated by SMEP II from electrofishing surveys in three rivers conducted in 1983, 1984, and 1992–1994.

B_{best} was calculated by SMEP for four periods between 2005 and 2016.

Fisheries removals were converted into silver eel equivalents using growth, mortality, and silvering schedules, and assuming that glass eels will become males and females in equal proportions. Reduction in silver eel production due to water installations (including hydro turbines, cooling water intakes, and water abstractions) was calculated on the basis of installation type and local circumstances. If the installation blocked upstream passage, then silver eel production was reduced in proportion to the amount of habitat rendered inaccessible. Impact of dams and other water barriers was estimated by a model that estimates eel density on the basis of number of downstream barriers, distance from the tidal limit, and gradient. The estimated depression of density due to barriers was converted to silver eel equivalents by SMEP. Stocking inputs were treated as a negative mortality, with number of stocked glass eels converted to silver eel equivalents by SMEP. $B_{current}$ was calculated as B_{best} - losses due to fishing - losses due to water installations - minus losses due to barriers + gains due to stocking.

The sum of Sigma F and Sigma H.

Silver eel biomass losses due to fishing divided by B_{best}.

Silver eel biomass losses due to water installations and barrier-induced habitat losses, divided by B_{best}.

UK Scotland

B_0 was estimated as silver eel production/ha averaged from three sources: a Scottish site, 1967–1981; Burrishoole, Ireland, 1971–1979; and an Irish model of five catchments. Production was scaled to the total EMU on the basis of wetted area that included waters above artificial barriers, but not natural barriers.

B_{best} is estimated the same way as B_{curr}, except it is assumed that water above barriers is available to eels.

$B_{current}$ is estimated at three whole river trap sites which measure production at three altitude bands: 0–240 m, 240–415 m, and >415 m. Production measured at these sites is scaled to the total EMU by the wetted area of the altitude band, with the production rate of the lowest band also applied to transitional waters. It is assumed that all river barriers completely block upstream migration and that eels that ascend hydro dams suffer 100% turbine mortality during their downstream migration.

UK Northern Ireland

The GB_Neag EMU is dominated by Lough Neagh. Since 2003, silver eel escapement from this lake has been estimated by the mark–recapture method. The report does not explain how B_0, B_{best}, and $B_{current}$ are calculated.

The e GB_NorE EMU has no fisheries and no or minimal barriers to migration; hence the EMU should be able to reach the 40% target without additional management measures. The report does not explain how B_0, B_{best}, and $B_{current}$ are calculated.

Annex 3: WKEMP comments on the EMP, questions sent to WGEEL participants and their answers

WKEMP Approach

Each core member examined a number the 2018 report and tables supplied via the Commission identifying information gaps and listing questions. When appropriate, the 2015 reports were examined to answer questions and fill gaps. The remaining questions were sent to WGEEL members during the WGEEL2018 meeting who responded promptly.

Belgium

Information reported for which areas.

Information is reported for the eel management units (EMUs) of Meuse and Scheldt.

Calculation of wetted area were updated on the basis of a GIS analysis. The results were very similar and totals per main basin remained virtually unchanged:

- **18 591 ha** for the Scheldt basin;
- **1204 ha** for the Maas basin;
- Total: **19 796 ha.**

Estimates of silver eel biomass (B_0, B_{best} & B_{curr}) are reported and adequate. Tables 12–14 of the Belgian report contain the results for 2018, 2015 and 2012.

B_0

B_0 = (surface area * 10 kg/ha) – predation from cormorants. Neither surface nor predation has changed from 2015, so B_0 is unchanged.

Scheldebekken	184 323 kg
Maasbekken	11 947 kg

$B_{current}$

Scheldebekken	21 354 kg
Maasbekken	2201 kg

B_{best}

$B_{best} = B_{current}$ + sum(anthro mort)

Scheldebekken	24 809 kg
Maasbekken	2659 kg

Estimates of mortality rates reported for Fishing (F), other anthropogenic factors (H) and summed together (A), for the subcategories of F or H requested in the Table 4.

The annual mortality of silver eel from pumps and turbines was:

- 1270 kg in Scheldebekken (the Scheldt basin)
- 240 kg in Maasbekken

ΣF

Scheldebekken	2185 kg
Maasbekken	218 kg

ΣH

Scheldebekken	1270 kg
Maasbekken	240 kg

Total

ΣA

Scheldebekken	3455 kg
Maasbekken	458 kg

Methods used to estimate biomass and mortality rates described in the report.

The method for calculating the silver eel escapement rate was adjusted from the calculation models used in the previous reports; the changes in the calculation model are considered to have a significant influence on the results. In the new model:

- conversion of catch data to expected number per ha have been optimized;
- mortality figures from recreational fisheries and cormorants have been calculated in a different way.
- Mortalities due to pumps and turbines are now integrated over the stratum *River Basin* on the basis of a different allocation key (in casu the proportion of the basin drained by pumps);
- For cases without CPUE data within the stratum *River Type * River Basin*, a zero-inflated negative binomial model was used to estimate the number of eels per hectare.

The model suffers from insufficient data and for some strata data with insufficient representativeness.

2018 report Authored by compared to 2015?

2018: Claude Belpaire, Pieter Verschelde, Yves Maes, Gerlinde Van Thuyne, Jeroen Van Wichelen, David Buysse, Jan Breine and Hugo Verreycken.

The fresh, brackish and salt tidal waters (types Mlz and O1) were considered together as one river type.

There is a concern that there was no new assessment for the parts of BE EMU Scheldt and part of BE EMU Meuse that are in Wallonia and that the old data (from the previous reporting period) were used.

Despite improvements to the model and data input, serious concern remains on the reliability of the results, as data are few and for some strata data unrepresentative. The model generated production figures for the canals and tidal waters. However, it is very likely that the results for these two types are highly underestimated, due to insufficient and low-quality data. Instead, specific methods for the evaluation of the yellow eel stock or for the production and escapement ratio of silver eels in these waters (considering their large ratio in the total area of the eel management area) should be used. Electrofishing data for large water systems such as canals and large estuaries may be inappropriate. A well-chosen set of indicators coupled with direct monitoring of silver eels emigrating in experimental catchments could be a better alternative.

Czech Republic

- Information reported for the drainage basin of the river Elbe and river Oder. The 2015 report refers to the basins of the Labe and Odra. These may be the same rivers.
- There are no estimates of silver eel biomass (B_0, B_{best} & B_{curr}) reported.
- Fishing mortality is reported as estimated by the Ministry. No details provided.
- There is no description of the methods used to estimate biomass and mortality rates in the report.
- There are no stock and fishery trends.
- No biomass other than some catch biomass reported.
- Main management controls and expected effectiveness are described. The main problem seems to be Small Hydroelectric Plant Stations which cause high mortality.
- Stocking is used but no estimates of B_0, no report of $B_{current}$ either or their ratio.
- Mortality in turbines is taken into account.

Authorship of the 2015 report is not indicated but seems to have been prepared by the administration. The 2018 report was prepared by the Water Research Institute.

There are two EMU covering lakes and rivers.

Progress in meeting the targets is reported, but the target themselves are not reported.

No biomass or mortality estimates provided.

Downstream migration was monitored starting in 2012 with digital radio telemetry using automatic telemetric stations to detect the passage of tagged fish in combination with mobile telemetry to verify the position of tagged fish. The methodology is described in detail in Musil *et al*., 2012a,b, and 2014.

Methods to estimate biomass: None described.

Trends in biomass: None provided.

Mortalities assessed (according to the report): Reported from Ministry estimates as being very low.

Trends in mortality: None provided.

Methods to estimate mortalities: None provided.

Management measures

Listed and evaluated. Downstream migration is described as satisfactory in the basin of the river Oder, but very low in the basin of the river Elbe. The authors conclude that measures proposed in the Eel Management Plan are successfully implemented. The authors state that observed rates of turbine mortality in Small Hydroelectric Power Station are very low and require urgent risk assessment.

Other measures seem to have been implemented (catches reduced, but not clear if because of regulation or because of decreased abundance), stocking is according to guidelines, but there is no independent monitoring of downstream or upstream migration. Stocking (1.5 million per year) does not seem to have had a large effect.

The authors suggest that the EMP needs to be updated.

Report Tables: None available.

Denmark

- There is a single Danish Eel Management Plan for the whole country for freshwater habitat.
- Estimates of silver eel biomass (B_0, B_{best} and $B_{current}$) are reported and adequate
- Estimates of mortality rates reported for sumA, sumF and sumH.
- Glass eel monitoring takes place at a few selected sites. There is no yellow eel monitoring established and silver eel escapement is monitored in three out of 887 river systems. The results from these river systems are converted into production per area (kg/ha) values and then up-scaled to national level.
- Stock and fishery trends by life stage not available.
- There is no major difference in the overall production of silver eels since the last progress report (2015). The models of the National Institute of Aquatic Resources suggest that escapement of silver eels will decrease until years ~2030, from where it will start increasing again.
- Biomass reported in kg B_0, $B_{current}$ and B_{best}.
- The main management control is a reduction in fishing effort. This is considered successful.
- Recreational fishing effort reduced resulting in decreased catches, but DTU Aqua question the precision of the data collected from recreational fisheries and are currently running a project RECREA to get greater knowledge of the size of the recreational harvest on eel and other species (trout, salmon, cod).
- Stocking reported for 2009–2017 for inland and total.
- $B_{current}$ reported as a proportion B_0?
- Some mortality has been documented due to hydropower turbines, especially from Tange Hydropower plant but not from Vestbirk Hydropower plant (see chapter 2. C1). An estimate from all hydropower plants may be approximately 5 tons. At flow-through trout farms located at the bank of rivers, the mortality is estimated to be approximately 4 tons (see chapter 2. C2).
- Predation from cormorants and mammals in freshwater is difficult to estimate. An estimate is approximately 10 tons. Cormorants do eat eel from rivers and lakes, but they mainly forage in coastal waters, where results from Ringkøbing Fjord show a predation of 40% of stocked eel during the first year. Mortality outside the fishery adds up to 19 tons.

- Chapter 3 reports on the implementation of the plan. Measures seem to have been implemented as planned. Results of an experiment suggests that the farmed eel both survived and grew better than the wild eels and the National Institute of Aquatic Resources concludes that farmed eel a satisfactory stocking material.

Estonia

- The Estonian EMP (2008) sets separate goals for the two Eel Management Units (EMUs) i) Narva River Basin District (RBD based entirely on stocking) to ensure a 40% silver eel escapement to the sea relative to the best estimate of escapement that would have existed if no anthropogenic influences had impacted the stock, ii) West-Estonian RBD (mostly natural population of eel) to decrease the fishing effort of eel specific gear by 50% by year 2013.
- Estimates of silver eel biomass (B_0, B_{best} & B_{curr}) reported and adequate.
- Estimates of mortality rates reported for Fishing (F), other anthropogenic factors (H) and summed together (A), for the subcategories of F or H requested in the Table 4.
- Methods used to estimate biomass and mortality rates described in the report.
- Stock and fishery trends by life stage.
- Biomass units reported in kg.
- There are national programmes for restocking of glass eels all around the Baltic Sea including in Estonia. The biggest number of glass eels restocked (over 3 million sp.) were at the beginning of 1980s (data start in 1956) which resulted in the highest reported landings in history of L. Võrtsjärv some 7–8 years later.
- The pristine biomass indicator (B_0) is based on the earliest Estonian eel-related data available (commercial landings data from 1930s). The construction of the Narva Hydroelectric Station in the 1950s blocked all-natural recruitment upstream of River Narva making annual restocking programme necessary to conserve an eel population in Narva RBD. Both $B_{current}$ and B_{best} are calculated in annual restocking conditions while B^0 is the pristine indicator without restocking.
- Mortality in turbines: The Narva Hydroelectric Station makes migrating silver eels pass through the power station turbines on their way to the Baltic Sea. $\Sigma H=0.4$ relies on the results of a 2007 study. As these turbines are large with 3 m diameter and rotate slowly at 60 RPM there is a high possibility of the actual mortality being much lower than $\Sigma H=0.4$. A special tagging project will be carried out in autumn 2018 to solve this problem and update the mortality estimation.

2018 report prepared by the Estonian University of Life Sciences. Authorship of the 2015 is not mentioned. The format and content of the reports are similar.

One Estonian Eel Management Plan with two Eel Management Units, one dependent on stocking, the other having natural population. One covers freshwater and the other coastal waters.

Targets: 40% escapement of silver eel to the sea.

Biomass and mortality estimates provided for 2016 and 2017.

Methods to estimate biomass

Up to 2015 a mark–recapture approach was used on Lake Võrtsjärv and small lakes in the RBD to estimate the relative abundance of eel in fresh waterbodies. However as there was a lack of recapture data for 2015, a new approach in stock abundance estimation was introduced from 2016. Enclosure fykenet system (Ubl and Dorow, 2015) was used to determine approximate number of eels per hectare in the lake.

Trends in biomass for 2016–2017

Mortalities assessed (according to the report) SumA, sumF and sumH reported for 2016–2017.

Trends in mortality 2016–2017

Fishermen having the historical fishing rights purchase the licences (very low fee) to maintain their historical right, but never or very seldom use the gears for fishing because of low or non-existent eel catch.

Methods to estimate mortalities: Official records.

Management measures

The minimum legal size for the coastal area is total length (TL) = 35 cm and for inland waterbodies (excluding Lake Võrtsjärv, L. Peipus, and L. Pskov where the minimum size is 55 cm) the minimum landing size is TL = 50 cm. The freshwater eel fishery (10–20 t/year, 2006–2017) occurs in Narva RBD. All the eel caught is of restocked origin. Occasionally eel is also reported from Lake Ermistu which has a possible connection with the sea in the West-Estonian basin. The coastal area eel catch (0.6–10 t/year, 2006–2017 is mostly registered as bycatch in fykenets. Eels both of natural and restocked origin are being fished.

Report tables: Seven tables are provided but Table 6 is empty.

1) The report states in several places that fishing mortality has been F=0.05 in the last three years according to official records. How is F calculated?

We have estimated the abundance of eel in Lake Võrtsjärv by an enclosure fykenet system and coupled it with the data obtained from commercial fishery, so we know that our legal sized eel stock in Lake Võrtsjärv is a little more than 500 000 specimens. Official landings showed for these years 13 t of eels caught which accounts for 26 000 specimens (mean weight of caught specimen being 500 grammes) making up 5% of the fishable stock. I have added a description of our method to the attachment.

2) Table 1 has question marks (?) mostly. What habitat types have been considered? Freshwater, coastal and transitional?

I did not know what to put there; we have a fykenet monitoring survey in the coastal sea for the West-Estonian RBD, but is it coastal or transitional waters.

3) In Table 3, SEE_hydro is reported twice for EE_Narv for 2017 with different values. Presumably this is a typo and the first value is for 2016?

Yes a typo. The second value is for 2016.

4) Table 6 is provided but it is empty.

I added a correct table to this mail.

Finland

- Not clear that EMUs are defined.
- Separate tables for B_0, B_{best}, $B_{current}$ are not provided. Eel at the northern edge of its range. Seems like sporadic and limited natural production.
- Estimates of mortality not provided, no tables provided. Vague statement in the report that it is expected that 40% of the eel stocked do survive.
- Methods used to estimate biomass and mortality rates are not described in the report.
- Stock and fishery trends by life stage not available.
- Biomass units not reported.
- The main management control is restocking which picked up after 2010 when the Finnish eel management plan was approved.
- Stocking is used, but no indication of B_0.
- $B_{current}$ not reported.
- Mortality in turbines is not specifically mentioned, but expected to have decreased in some areas with eel being captured above turbines and moved downstream.

Monitoring of bycatches in sea lamprey fisheries since 2007.

Eel included in EU data collection program from 2018.

Restocking from eel quarantined in Sweden, mostly of English origin but also sometimes from France.

Seem to consider only southern Finland, Figure 2 does not show northern Finland.

Believe that commercial fishing provides the "truest picture" of the development of eel (page 6). Table 3 provides commercial fishing info for 2003–2017.

Eels migrating from inland waters have slim chances of reaching the Baltic Sea and even less of reaching the Sargasso Sea unless they are transported downstream by humans.

Evo research suggest that of 2400 eel starting their migration, only about 800 survive to the lower power plant at Harjavalta, implying a rough estimate of mortality of 67%.

New fisheries act wants to increase stock size (all species) naturally. This implies that smaller quantities of eel may be stocked in future.

Finland may revise its EMP to decrease or stop restocking.

France

- There is a single French Eel Management Plan with ten Eel Management Units.
- Estimates of silver eel biomass (B_0, B_{best} & B_{curr}) are reported and adequate based on monitoring rivers and modelling.
- Estimates of mortality rates reported for Fishing (F), other anthropogenic factors (H) and summed together (A), for the subcategories of F or H requested in the Table 4, based on EDA modelling. Mortality rates provided is the average for 2010–2015 for each EMU.

- Methods used to estimate biomass and mortality rates are not described in detail in the report but there is a reference to such a description (http://www.eptb-vilaine.fr/site/telechargement/migrateurs/eda2.2.pdf).
- Stock and fishery trends by life stage: biomass reported only for silver eel. Table 3 missing.
- Biomass units reported in kg.
- Main management controls and expected effectiveness are described in detail.
- Stocking takes place, mostly from domestic catches of glass eel. B_0 is calculated from the EDA and GEREM models, presumably taking stocking into account.
- $B_{current}$ is reported as a proportion of B_0 on the PA graphs.
- Mortality in turbines: mortality due to obstacles to upstream migration is included.

Authorship of either report not indicated, but the format and content suggests the same authors for both. 2018 report is 200 pages long, the 2015 report was 124 pages long.

There is one national French Eel Management Plan with ten Eel Management Units, covering **f**reshwater, transitional and coastal. **Targets h**ave been identified.

Biomass and mortality rates have been provided. Table 3 is missing.

Monitoring methods

Modelling (EDA), river index for upstream and downstream migration, electric fishing.

Methods to estimate biomass

Modelling (EDA) and raising density estimates from monitoring.

Trends in biomass

For 2008–2015.

Mortalities assessed (according to the report)

Table 3 is missing.

Trends in mortality

Table 4 provides the average mortality rates by EMU for 2010–2015.

Methods to estimate mortalities

Modelling.

Management measures

Are described. Several measures to decrease fishing mortality. Monitoring control and surveillance seems to have been stepped up. Limited success in removing/mitigating obstacles to migration.

Report tables

Table 3 (Mortalities) and Table 7 (fishing effort) missing.

1) The second paragraph of the introduction states that reducing fishing is not sufficient to rebuild eel: improving water quality and allowing passage of migrating fish (continuité écologique des cours d'eau) will also be necessary. The French plan calls for 75% reduction of mortality other than fishing recognising that it will be difficult to monitor. Implementation of measures to make it easier for migrating fish to overcome obstacles seems to be considerably behind schedule. Where is the best place to get a synthetic view of the reduction in non-fishing mortality?

Chapter 3 "Diminution de la mortalité liée à des facteurs extérieurs à la pêche" [in English: "decrease in mortalities other than fisheries"] contains a description of what has been done for these non-fishing mortalities. Regarding obstacles a summary is provided in Table 39 p. 106 from this chapter.

2) Page 7 refers to a summary table of actions taken since the adoption of the Eel Management Plan. This does not seem to be in the report.

This summary table has been provided in the 2015 progress, for some reasons (that I don't know) we haven't done that this year but forgot to delete this in the intro.

3) B_{best} and $B_{potentielle}$ are defined in a box on page 8. What is the difference between the two?

EDA is based on electrofishing data, mainly collected before the actual migration of silver eel. Thus estimate from EDA is the number of silver eels just before they migrate ($B_{potential}$). Once they migrate, they can suffer from mortalities at that stage (silver eel fisheries, turbines, ...) that should be accounted for in the $B_{current}$. B_{best} is the standard ICES definition: no mortalities whatever the stage.

4) Section 1.1.2.2 suggests that EDA seriously underestimates population numbers because habitat for lakes, coastal marshes, etc. are underestimated. Why not correct those in EDA? In this context, what are "retenues et chevelu"?

To be included in EDA, this should be included in the GIS layer, which is not very easy (needs the precise location and surface of those lake and marshes). Moreover, doing so would assume that the production (#/ha, length distribution) of those habitat is the same as that for the river. For those reasons, we evaluate them separately (Table 7 p 31). "Retenue" means here, artificial lake created by dams and "chevelu" means the very beginning of the rivers (the first x km of any river). Both are not in our GIS system. For "chevelu" there is a low probability of having eel, or any other fish).

5) How are the quotas for elvers set in France? The information is supposed to be available on http://www.sandre.eaufrance.fr/atlas/srv/fre/catalog.search#/home but I could not find it.

The link you give is not related at all to quota. Answer to your question is in our talk during AFS 2014: https://afs.confex.com/afs/2014/webprogram/Paper14820.html if needed I can provide that talk.

6) Is the scientific advice for setting the elvers quota publicly available?

It is publicly available in the sense that it is given to anyone asking the Ministry for it. It is however not available through a website for example.

7) In the Conclusion section, the second paragraph states that B_{best} for 2015 is estimated at 1,72 million silver eel. The following paragraph mentions new assessments of the production in marshes and lagoons, highly productive areas resulting in $B_{current}$ = 13 million silver eel and B_0 = 295 million silver eel. Is this interpretation correct?

See point 3 for the explanation between B_{best} and $B_{potential}$. 1.72 million is the estimate of silver eels from EDA (rivers and estuary, see answer to question 4) before any silver eel mortalities (see question 3). $B_{current}$ for whole France (EDA + lagoons, lake, ... see Table 7) = 13 million and B_0 (for the same area is 295 millions). Note that Figure 10 and 11 have been mixed up: caption of Figure 10 is in Figure 11 ...If needed, you can request Briand *et al.*, 2018 the technical report about EDA (in English) and Beaulaton and Briand, 2018 the technical report (in French) deriving the 3Bs&A from EDA estimate and expert estimate for other habitats.

Germany

Review of Erik Fladung and Uwe Brämick, 2018. 2018 Implementation Report on the 2008 Eel Management Plans of the German Länder. Commissioned by Ministry of the Environment, Agriculture, Nature and Consumer Protection of the Land of North Rhine-Westphalia for the principal fisheries authorities of the German Länder.

- This report covers the nine Eel Management Units of Germany, which are primarily defined as river drainage areas.
- Estimates of silver eel biomass (B_0, B_{best} and $B_{current}$) are reported and adequate.
- Estimates of mortality rates are reported separately for fishing, and for hydro dams and other water installations.
- Methods used to estimate biomass and mortality rates are described in the report for freshwater habitat. Methods used in coastal waters are not fully described.
- Biomass units are reported.
- Main management methods are restocking, controls are restrictions in fishing, and improvements in river connectivity.
- $B_{current}$ was appropriately reported as a proportion.
- Mortality in turbines was estimated and incorporated into models.

Gaps/ questions to answer

- GEM IIIb uses the Bevacqua *et al.* (2011) formulation for natural mortality. This formula is size- and sex-dependent. But p. 10 states that losses due to anthropogenic mortality were modelled with a constant natural mortality of 13% (Dekker, 2000). It should be explained why a constant M was used in this situation but a variable M was used elsewhere.
- Section 3.1.4 reports validation of modelled estimates of silver eel escapement by three mark–recapture studies of silver eel escapement. The match between modelled escapement and escapement from mark–recapture estimates was characterized as "good" and "close to reality." Matches were also characterized as "orders of magnitude." The meaning of the reference to orders of magnitude is not clear. Most people would hope that differences between modelled and observed results would be less than an order of magnitude.

- Role of coastal waters: Table 8 (separate Excel file) indicates that 68.5% of German eel habitat is coastal, 9.0% is transitional, and 22.3% is freshwater. In the Warnow/Peene EMU (Baltic drainage), coastal waters are modelled separately, with the reference value calculated by multiplying commercial catches by an ICES-recommended conversion factor. It is unclear if this method is applied in coastal waters of other EMUs. It's unclear if GEM is part of the assessment process in coastal waters. The report states (p. 28) "Nevertheless, it remains unresolved how the data requirements under the Eel Regulation can be methodically implemented in the tidal coastal area of the North Sea." Given the dominance of coastal habitat in Germany, assessment issues in coastal habitat decrease the overall robustness of the German eel assessment. The problems of eel assessment in coastal waters are noted in the report's text, but not in its summary.

Additional review notes

Authors of this report are Erik Fladung and Uwe Brämick, who are also authors of the 2015 report (Fladung, E. and Brämick, U. 2015. Umsetzungsbericht 2015 zu den Aalbewirtschaftungsplänen der deutschen Länder 2008. Institut für Binnenfischerei e.V. Potsdam-Sacrow im Auftrag des Niedersächsischen Ministeriums für Ernährung, Landwirtschaft, Verbraucherschutz und Landesentwicklung, Potsdam, 48 p).

This report covers the nine EMUs of Germany. Most of Germany drains into the North Sea, including the Rhine, Weser, and Elbe EMUs. A sizable part of southern Germany drains into the Danube (Donau EMU). A relatively small part of northeast Germany drains into the Baltic Sea (Schlei/Trave, Warnow/Peene, and Oder). Most of the land area of Germany is drained by rivers which cross international boundaries. Only the Weser EMU, and three relatively small coastal EMUs in northern Germany, have drainage areas that are exclusive to Germany.

Table 3.1 shows two EMUs (Meuse, Rhine) as having Inland Waters habitat only. All other EMUs include transitional waters, coastal waters, or both transitional and coastal waters.

The target is mentioned as escapement being 40% of B_0.

Estimates of B_0, $B_{current}$, and B_{best} are provided in Excel Table 2 by EMU starting in 2009.

Estimates of anthropogenic mortality are provided in Excel Table 4.

Calculations were performed with the German Eel Model (GEM), version IIIb. Inputs of demographic data (sex ratio, length–frequency distributions of silver eels, growth rates, natural mortality) were in most cases EMU-specific, although in some cases the absence of local data obliged the authors to borrow data from other locations.

For coastal waters of the Warnow/Peene EMU, and possibly coastal waters elsewhere (the text is not clear), assessment calculations are made on the basis of a multiplication factor applied to commercial fishery landings. No further information is given on how this is done. Coastal waters appear to be a substantial fraction of total German eel habitat (see above), which means that full methodology details are not supplied for much of the German eel resource.

B_0, B_{best}, and $B_{current}$ for the EMUs are presented in Excel Table 2.

Fishing and non-fishing anthropogenic mortalities for the EMUs are presented in Excel Tables 3 and 4.

Fishing and non-fishing anthropogenic mortalities for the EMUs are presented in Excel Tables 3 and 4.

The main management measure is restocking. Additional restrictions have also been imposed on commercial and recreational fisheries, by such measures as increases in the minimum size, temporary and/or local fishing bans and further quota restrictions. There have been improvements in river continuity and reduction turbine losses to migrating silver eels by "catch and carry," i.e. capturing eels above the dam and transporting them to downstream release points.

Table 1, overview: complete for all EMUs.

Table 2, biomass complete for all EMUs.

Table 3, mortality quantities complete for all EMUs.

Table 4, mortality rates complete for all EMUs.

Table 5, stocking complete for all EMUs.

Table 6, management measures complete for all EMUs.

Table 7, effort complete for all EMUs.

Table 8, pristine habitat area, given for all EMUs, broken down by habitat type.

Table 9, aquaculture production complete.

Table 10, landings complete for all EMUs.

Greece

- Required parameters are listed in tables. However, the submission lacks a report, and the information in Table 1 is insufficient to allow an understanding of how parameters are calculated. Without this understanding, it is not possible to evaluate the reliability of the parameter estimates.
- According to Table 1, the assessment is conducted using landings data, morphometric data and biological data. It is unclear how such data are used to estimate the various parameters. Table 1 indicates interest in applying a modelling approach in the future, but there is no indication that this has been done.
- Table 1 has pages which correspond to three EMUs. Each page refers to the release of 30% of silver eel landings. There are three versions of Table 6, corresponding to three EMUs. All versions contain the following text: "authorized lagoon extensive aquaculture operators are obliged to give 30% of the eel they harvest, for restocking." Does the 30% rule apply to all silver eel harvest, or just harvest from certain aquaculture operations?
- Stocking or restocking usually refers to release of glass eels/elvers, or sometimes small juvenile eels. Some readers might be confused when the term is applied to silver eels.
- Table 5 indicates annual stocking of silver eels up to 18 000 kg. Are the silver eels mentioned in Table 5 the same eels that represent 30% of the harvest? What proportion of these eels are of aquaculture origin and what proportion are wild? (Table 6 refers only to the stocking of wild eels). The answer to this question has implications to the way silver eel equivalents are calculated. Eels raised in aquaculture may be less wary of predators and therefore more susceptible to predation during the spawning migration during the journey

to the Sargasso Sea. If so, their value as escaping eels would need to be downwardly adjusted in calculation of silver eel equivalents.

- Table 1 refers to CITES restrictions on exporting eels to other European countries. Most European countries are members of the EU, which operates as a single block with respect to CITES restrictions. Therefore the role of CITES in curtailing Greek eel exports to European countries would be limited.
- Page tr_emu_em in Table 2 appears to be the full list of Greek EMUs. It shows four EMUs. Elsewhere, there is variation in the number and nomenclature of EMUs. The tabs of pages in Table 1 refer to EMUs by number (1, 2, 3). The contents of these pages give abbreviations (e.g. GR_EaMT). The three versions of Table 6 give EMUs by number, and also by full name (e.g. Western Greece Lagoons). Regardless of the nomenclature, three EMUs are referred to. However, Table 2 also refers to a fourth EMU, GR_CeAe. This might mean Crete-Aegean (that's a guess). This EMU has a B_0 of zero, meaning no historic eel capacity. The map in Table 2 seems to contain four, possibly five, districts for Greece, but these are FAO districts and I don't know what relation these districts have with EMU boundaries.
- Table 7 reports a constant 120 days of fishing per year over the reported years. This seems like a small effort, in the context of the substantial landings reported in Table 2 (unless the traps are very large and capture many or most eels of a downstream run).
- Tables 3 and 4 indicate nil mortality from hydro dams and water intakes. According to Wikipedia, 12% of Greece's electrical energy comes from hydro power. It seems likely that Greek hydro dams would have some negative effects on eels.
- Although there is stocking of both glass and silver eels, Table 4 shows no mortality (or negative mortality) effect of stocking.

There is no report. There is a cover letter, machine-translated from Greek to English, which outlines what topics are covered. We examined this cover letter and attached tables.

The cover letter of the 2018 submission is signed by Marina Petrou of the Directorate-General for Fisheries.

Three EMPs are treated: Western Greece (GR_NorW), Western Peloponnesus (GR_WePe), and Eastern Macedonia Thrace (GR_EaMT). A fourth EMU (GR_CeAe) exists but is not covered.

For GR_NorW, Transitional and Coastal habitats are covered. For GR_WePe, Transitional habitats are covered. For the GR_EaMT, Freshwater and Transitional habitats are covered.

The target is not stated, although it is assumed to be the escapement to the sea of at least 40% of adult eels that would have existed in the absence of human influences.

Estimates of B_0, $B_{current}$, and B_{best} are provided in Excel Table 2 for 2015, 2016, and 2017, for each of three EMSs.

Excel Table 3 gives annual estimates of mortality due to commercial fishing, recreational fishing, hydro and water intakes, habitat issues, stocking, and other issues, in silver eel equivalents, for 2015–2017. Data are given as totals for the country. Positive values are given for commercial fishery and for stocking. Nil values are entered for all other parameters.

Excel Table 4 gives estimates of mortality summed over the age groups of the stock for fishing, for non-fishing anthropogenic mortality, and for all anthropogenic mortality for 2014–2017. Values are also given for commercial fisheries, recreational fisheries, and habitat, stocking, and other effects. Values for 2014 are shown as totals for the country. The geographic coverage of the data is not indicated for 2015–2017.

Landings records were obtained and used. Other monitoring methods are not described.

The method to estimate biomass is not described.

Estimates of B_0, $B_{current}$, and B_{best} are provided in Excel Table 2 annually for 2015–2017. Estimates are provided for each of three EMUs.

Excel Table 3 gives annual estimates of mortality due to commercial fishing for 2015–2017 in silver eel equivalents, for the whole country. Mortality due to other factors is not reported.

Excel Table 4 gives estimates of mortality summed over the age groups of the stock for fishing, for non-fishing anthropogenic mortality, and for all anthropogenic mortality for 2015–2017.

Excel Table 3 gives annual estimates of mortality due to commercial fishing for 2015–2017 in silver eel equivalents, for the whole country. Mortality due to other factors is not reported.

Excel Table 4 gives estimates of mortality summed over the age groups of the stock for fishing, for non-fishing anthropogenic mortality, and for all anthropogenic mortality for 2015–2017.

Methods to estimate mortality are not described.

The main management measures that have been implemented are bans on fykenets and the requirement that a portion of imported glass eels and harvested eels are used for stocking.

Table 1, overview: complete; separate overviews are given for three EMUs.

Table 2, biomass: complete, for three EMUs.

Table 3, mortality quantities: complete, given as totals for the country.

Table 4, mortality rates: complete.

Table 5, stocking is given as total values for the country for 2013–2017. Both silver eels and glass eels are reported to be stocked.

Table 6, management measures: Changes in management measures are given. Separate tables are given for three EMUs.

Table 7, effort is reported for 2014–2017 for the whole country. Effort is constant across these years.

1) According to Table 1, the assessment is conducted using landings data, morphometric data and biological data. It is unclear how such data are used to estimate the various parameters. Table 1 indicates interest in applying a modelling approach in the future, but is the current assessment based on modelling?

It is mainly based on assumptions, which were tested with the Italian model during the WGEEL meeting in Antalya in 2015 and the results were the same. For more information we can discuss it tomorrow.

2) Table 1 has pages which correspond to three EMUs. Each page refers to the release of 30% of silver eel landings. There are three versions of Table 6, corresponding to three EMUs. All versions contain the following text: "authorized lagoon extensive aquaculture operators are obliged to give 30% of the eel they harvest, for restocking." Does the 30% rule apply to all silver eel harvest, or just harvest from certain aquaculture operations?

This is a misunderstanding of the Ministry, which insists in characterizing the fish exploitation in lagoons as an aquaculture activity. Anyway, the fishing cooperatives that lease the lagoons, release the 30% of the annual landings. Thus, the eels released originate in the wild population.

3) Stocking or restocking usually refers to release of glass eels/elvers, or sometimes small juvenile eels. Some readers might be confused when the term is applied to silver eels.

Yes you are correct.

4) Table 5 indicates annual stocking of silver eels up to 18 000 kg. Are the silver eels mentioned in Table 5 the same eels that represent 30% of the harvest? What proportion of these eels are of aquaculture origin and what proportion are wild? (Table 6 refers only to the stocking of wild eels). The answer to this question has implications to the way silver eel equivalents are calculated. Eels raised in aquaculture may be less wary of predators and therefore more susceptible to predation during the spawning migration during the journey to the Sargasso Sea. If so, their value as escaping eels would need to be downwardly adjusted in calculation of silver eel equivalents.

As I mentioned in Question 2, all the eels released from the lagoons are originated from the wild population and not from reared eels.

5) Table 1 refers to CITES restrictions on exporting eels to other European countries. Most European countries are members of the EU, which operates as a single block with respect to CITES restrictions. Therefore, the role of CITES in curtailing Greek eel exports to European countries would be limited.

This is a wrong statement. What was meant to be written is that: "… the limitations imposed by CITES for the exports to other countries outside EU."

6) Page tr_emu_em in Table 2 appears to be the full list of Greek EMUs. It shows four EMUs. Elsewhere, there is variation in the number and nomenclature of EMUs. The tabs of pages in Table 1 refer to EMUs by number (1, 2, 3). The contents of these pages give abbreviations (e.g. GR_EaMT). The three versions of Table 6 give EMUs by number, and also by full name (e.g. Western Greece Lagoons). Regardless of the nomenclature, three EMUs are referred to. However, Table 2 also refers to a fourth EMU, GR_CeAe. This might mean Crete-Aegean (that's a guess). This EMU has a B_0 of zero, meaning no historic eel capacity. The map in Table 2 seems to contain four, possibly five, districts for Greece, but these are FAO districts and I don't know what relation these districts have with EMU boundaries.

There are four EMUs, i.e.:

EMU1 - GR_NorW

EMU2 - GR_WePe

EMU3 - GR_EaMT

EMU4 - GR_CeAe

EMU4 - GR_CeAe has a B_0 of zero because there aren't any historic data for the area and furthermore, there isn't any fishing activity until today and no eel landings exist there.

7) Table 7 reports a constant 120 days of fishing per year over the reported years. This seems like a small effort, in the context of the substantial landings reported in Table 2 (unless the traps are very large and capture many or most eels of a downstream run).

I have attached a photo of the traps that are used to capture eels. These traps block the entrance to the lagoon completely, and thus the migration of the eels towards the sea. The fishermen close the grids of the traps in November until the end of February. That's why the effort remains stable all the years. But they capture the total number of migrating eels.

8) Tables 3 and 4 indicate nil mortality from hydro dams and water intakes. According to Wikipedia, 12% of Greece's electrical energy comes from hydro power. It seems likely that Greek hydro dams would have some negative effects on eels.

The majority of the hydro power plants (big and small-scale) are constructed in the mountainous part of the rivers, and because of the general morphology of the area it is not possible for the glass eel to reach these places. Moreover, normally in the lowland part of the river, you will find irrigation dams that will not allow the upstream migration of them.

9) Although there is stocking of both glass and silver eels, Table 4 shows no mortality (or negative mortality) effect of stocking.

Yes because it hasn't been assessed yet.

Italy

- Information reported for 20 regions, nine with regional management plans, eleven where eel fisheries have been closed. The Italian National Eel Management Plan includes the 20 regions.
- Estimates of silver eel biomass (B_0, B_{best} & B_{curr}) are reported based on modelling with ESAM.
- Estimates of mortality rates reported sumA, sumF and sumH for some regions.
- Methods used to estimate biomass and mortality rates are described in the report, but not in sufficient details. The model is described in https://www.researchgate.net/publication/268685873_A_user-friendly_tool_to_assess_management_plans_for_European_eel_fishery_and_conservation
- Stocking trends for silver eel
- Biomass in kilograms.

- Main management measures are reported by EMU. Most of the measures implemented until now have been to reduce fishing effort. It may be necessary in future to improve habitats and remove/mitigate barriers to migration.
- Each region reports whether stocking is used and if it was taken into account in setting benchmarks.
- $B_{current}$ and B_0 are reported, but I did not find the ratio.
- Mortality in turbines is reported.

The entire dataset used for the evaluation of individual EMUs has been prepared and monitored by researchers, based on the most complete and best information available, retrieved from all possible sources. The entire dataset was verified during a Consultation Table with the Heads of the Fishing Offices (or other responsible units) of the Regions (Administrations of the EMU) and of the Ministry of Agricultural, Food and Forestry Policies, as part of a coordinated action by the Ministry itself. The results of the evaluations were presented to the same Managers for agreement and approval by all before preparing this Report and its Attachments.

Authorship of the 2015 report was not stated. The 2018 report, Section 5 gives the membership of the working group that has prepared the report. The report states that results have been submitted to local managers and agreed by all before preparing the report.

The nine regional plans with specific management measures together with the eleven regions that have decided to close all eel fisheries constitute the Italian National Eel Management plan. Umbria has a regional plan, but no connection to the sea.

Lagoons (coastal areas), lakes and rivers. The coastal areas are separated into managed lagoons and lagoons where simple fishing takes place. There are also private fishing basins in Emilia Romagna, Veneto and Friuli Venezia Giulia. Historically, eel fishing took place based on stocking, but these zones are now used more as hunting reserves and fishing for eel has decreased considerably. It has not been possible to obtain data for these zones on an annual basis.

The surface area of eel habitat was calculated from satellite images for each habitat.

B_0 is provided.

Biomass and mortality estimates are provided.

At present, monitoring is conducted in almost all regions, according to a standardized protocol, but with variable results.

The datasets were reviewed and estimates were calculated using the same model but also revised and improved. In this Report, parameters were estimated for individual Eel Management Units by habitat type assuming a homogeneous management unit.

Previously, used DemCam which evolved into ESAM (Eel Stock Assessment Model). The model was compared to EDA, GEM and SMEPII in the project POSE/MARE and found to be a good compromise between complexity and flexibility. The model takes into account i) density-dependence of recruit settlement, ii) sexual dimorphism, iii) maturity by size and sex, iv) natural mortality dependent on size, sex and temperature, v) differential fishing mortality for yellow and silver eel, vi) mortality during migration. The model also allows to calculate pristine conditions. Using $R_{current}$ and R_0 for "Elsewhere Europe", the model uses data on i) glass eel fishery in the sea, ii) stocking, iii) fishing effort, and the presence of barriers to calculate $B_{current}$ and B_{best} for each year. Confidence in the results of the model are limited by the availability of information for some time/area strata. Confidence will improve as data are improved. Recreational catches are not used (catch and release).

Trends in biomass are provided.

Mortality by habitat type, mortality rates sumA, sumF, and sumH. SumH is calculated only as a total.

Trends in mortality are not provided.

Mortalities are estimated in the ESAM model.

Management measures to reduce fishing mortality have been implemented in all 20 regions. Some regions have implemented stocking, but not as much as originally planned because of the limited supply and high price of glass eel. Stocking has also been done with eel larger than 12 cm, but there are concerns about the quality of eel stocked.

There are tables for all available by EMU which makes it difficult to compile.

1) What is the difference between managed lagoons and lagoons where simple fishing takes place?

The habitat categories that were identified are as follows: coastal lagoons, lakes, rivers. In the case of coastal lagoons, for those regions that follow different management strategies an explicit distinction has been introduced, within the lagoons specifically managed (fish stockings, presence of fish barrier) from the lagoons where only artisanal fisheries are present. However, in both Ices Data Call and Art. 9 Reg. 1100/2007 Data call data concerning managed lagoons and lagoons have been aggregated within the transitional water category.

Latvia

- Information is reported for the whole country. There is a single Eel Management unit.
- Estimates of silver eel biomass (B_0, B_{best} & B_{curr}) are reported for 2017 based on average production for rivers, lakes and coastal areas
- Tables 3 and 4 have been sent but there are no data reported. Catch data for 2016 are reported in Table 7.
- Biomass is estimated from production by habitat type multiplied by available habitat.
- Trend in yellow eel abundance from electrofishing is provided. Catch and effort by gear type are provide for 2016 in Table 7. There are no fisheries targeting specific life stages, all are mixed catches. Commercial fishing is only taking place in twelve lakes inaccessible for eel migration.
- Biomass is reported in kg.
- Main management controls and expected effectiveness are described in Section 3. Fishing effort has been reduced, but mortality in hydroelectric stations and barriers to migration remain a problem.
- Stocking is used in lakes that have no natural recruitment. Does not seem to be taken into account in setting B_0. There are eel in lakes with no access to the sea based on stocking prior to 1989.
- $B_{current}$ is reported as a proportion B_0.

- Mortality in turbines was reduced by not stocking glass eel upstream of hydroelectric dams. Only 14% of inland waters are available for eel migration.

2018 report authored by Institute of Food Safety, Animal Health and Environment "BIOR". Authors of the 2015 report not identified, but presumably is also BIOR as it was listed as the implementation institution for most of the actions.

There is one EMU for the country including rivers, lakes and coastal areas. B_0, $B_{current}$ and B_{best} estimated. Monitoring is by electrofishing. Biomass is estimated by multiplying **a**verage production by habitat time multiplied by available habitat.

Trends in biomass for yellow eel. No trend in mortality, catches reported only for 2016.

All seven tables provided, but no information in Tables 3 and 4.

Lithuania

Review of Gecys, V, and J. Poviliunas. 2018. Report from Lithuania under regulation (EC) No 1100/2007 (The "Eel Regulation").

- This report covers Lithuanian waters, with emphasis on inland freshwaters where eels are stocked.
- Estimates of silver eel biomass (B_0, B_{best} and $B_{current}$) are reported and adequate.
- Estimates of mortality rates are reported for Fishing (F), other anthropogenic factors (water intakes, hydro dams (H) and summed together (A), for the subcategories of F or H requested in Table 4.
- Methods used to estimate biomass and mortality rates are described in the report.
- Biomass units are reported.
- The chief management measure is stocking in those inland waters whose routes to the sea pose few or no risks to outmigrating silver eels. Fishing has become more restrictive. Screens must be installed on small hydro plants; however the screens are too coarse to protect eels.
- $B_{current}$ was appropriately reported as a proportion.
- Mortality in turbines was estimated and incorporated into models.
- Naturally recruited eels occur in Baltic coastal waters and in the brackish Curonian Lagoon. However, such eels have declined with the overall decline of the eel stock. Understanding the eel situation in Lithuania is primarily an exercise in understanding the dynamics of stocked eels.
- B_0 is calculated on the basis of production from natural recruits prior to the stock decline. The orientation of the eel programme is to stock in sufficient numbers, and keep fishing and hydro mortality low enough, that production from stocked eels will be at least 40% of B_0.

Gaps/ questions to answer

- Figure 6.8 is printed twice (pp. 31 and 32).
- Silver eels produced in the Baltic area are subject to Danish and Swedish fisheries at the Baltic exit. Baltic silver eels have not truly escaped until they pass these fisheries. Pan-Baltic collaboration is needed to measure and integrate the effects of these fisheries into eel assessments of Baltic nations.

- The report states that escapement is modelled by the method of Dekker *et al*., 2008. Dekker *et al*., 2008 is not in the Literature Cited. It appears that the intention is to cite Dekker *et al*., 2018.
- Figure 6.1 gives stocking numbers for inland waters starting in 1950. Excel Table 5 gives country-wide stocking data starting in 2011. It appears that the Curonian Lagoon has never been stocked. This should be stated explicitly, referring to both Lithuanian and non-Lithuanian segments of the Curonian Lagoon.
- Consistent sampling of eels in Lithuanian waters started in 2017 (p. 24). It appears that most biological characteristics are based on Swedish data used in Dekker *et al*. reports, except for growth rate. Is this correct?
- One third of eels descending through a hydro dam equipped with a fish pass will use the pass (p. 21). P. 23 gives mortality rates for hydro dam descent. Small Kaplan turbines have a mortality rate of 50%. Small Kaplan turbines with a fish ladder have a mortality rate of 30%. For Kaplan turbines with a fish ladder, considering 1000 descending eels, 667 will go through the turbines, of which 333 will be killed. 333 will go through the ladder, of which 0 will be killed. So it would appear that the mortality rate for small Kaplans with a fish ladder is 33.3% rather than 30%.
- Section 6.2 appears to deal only with inland eels and stocked eels. This should be stated explicitly, including in captions for Figures 6.8 and 6.9.

The 2018 report authors are Valdas Gecys and Justas Poviliunas, both of the Fisheries Service of the Ministry of Agriculture. Analysis is performed by Nature Research Centre staff: Linas Lozys (Head of Laboratory), Justas Dainys, and Zilvinas Putys. The 2015 report does not list authors, although there are some signatures on the front; not sure what that means.

There is one EMP in Lithuania, which also includes the country's Baltic Sea coastal zone. There are four River Basin Districts (RBDs): the Nemunas with 81% of eel habitat, and three smaller river basins. All of these RBDs are shared with neighbouring countries (Belarus, Poland, Russia, Latvia). There has have been preliminary discussions between Lithuania and some of its neighbours on the possibility of collaboration in eel management planning, but such collaboration has not taken place.

All of the calculations and modelling concern inland freshwaters. The Curonian Lagoon, which is brackish (according to Wikipedia) is referred to for fisheries, mostly in the past. Table 1 indicates that coverage is freshwater only. Coastal waters of the Baltic Sea are mentioned as eel habitat, but there is no treatment of eels in these waters.

The target of the Lithuanian EMP is to ensure escapement to the sea of at least 40% of adult eels that would have existed in the absence of human influences.

Estimates of B_0, $B_{current}$, and B_{best} are provided in Excel Table 2 annually for 2011–2017.

Excel Table 3 gives annual estimates of mortality due to commercial fishing, recreational fishing, and hydro and water intakes for 2011–2017 in silver eel equivalents.

Excel Table 4 gives estimates of mortality summed over the age groups of the stock for fishing, for non-fishing anthropogenic mortality, and for all anthropogenic mortality for 2011–2017.

Consistent sampling for biological characteristics began in 2017. There are limited data on maturity schedules, which were used in this assessment.

B_0 is 87 t, which is the estimated silver eel production of the Lithuanian part of the Curonian Lagoon when the stock was in a good state in 1954–1978.

The model used by Sweden for their 2015 and 2018 post-evaluations (Dekker *et al.*, 2015; 2018) was used in this analysis. The starting point was eels stocked in inland waters. The model grew these eels, subjected them to natural mortality (based on Swedish data), fishing mortality based on fishing records, and hydro mortality based on the number and type of hydro dams encountered by down-migrating silver eels.

Estimates of B_0, $B_{current}$, and B_{best} are provided in Excel Table 2 annually for 2011–2017.

Excel Table 3 gives annual estimates of mortality due to commercial fishing, recreational fishing, and hydro and water intakes for 2011–2017 in silver eel equivalents.

Excel Table 4 gives estimates of mortality summed over the age groups of the stock for fishing, for non-fishing anthropogenic mortality, and for all anthropogenic mortality for 2011–2017.

Excel Table 3 gives annual estimates of mortality due to commercial fishing, recreational fishing, and hydro and water intakes for 2011–2017 in silver eel equivalents.

Excel Table 4 gives estimates of mortality summed over the age groups of the stock for fishing, for non-fishing anthropogenic mortality, and for all anthropogenic mortality for 2011–2017.

A large number of control measures have been put in place for the commercial fishery under the Lithuanian EMP, including gear, season, and location restrictions. Specialized eel fishing has been banned in the Baltic Sea. Recreational bag limits have been reduced from five to three.

Mortality of eels passing through hydro turbines ranges from 24% to 100% depending on type and size the turbine. Screens on dams are too course to prevent eel passage. Some hydro dams have fish passes. The main dam-related conservation measure is to avoid stocking upstream of hydro dams that lack fish passes.

Table 1, overview: complete.

Table 2, biomass: complete.

Table 3, mortality quantities: complete.

Table 4, mortality rates: complete.

Table 5, stocking is given as total values for the country for 2011–2017.

Table 6, management measures: Changes in management measures are given.

Table 7, effort, number of nets or traps for 2011–2017 is given. No other information on effort is given.

1) Consistent sampling of eels in Lithuanian waters started in 2017 (p. 24). It appears that most biological characteristics are based on Swedish data used in Dekker *et al*. reports, except for growth rate. Is this correct?

Simple answer is “Yes“. Actually LT was doing some sampling before, however sample size is not large and most essential - we do not trust ageing done by guy who was responsible before (he was declaring that ageing is done using the whole otolith, i.e. without cutting it). As parts of Sweden are at the same latitude and climate we used Swedish data for age at silvering (15 years as an average age). Let me know if you get any other questions.

Netherlands

- Eels in the Netherlands occupy a complex network of fresh waterbodies with a very large number of barriers (water pumping stations, hydro dams). This assessment attempts to cover eels using all of these habitats. There is no analysis of eel status in coastal or marine habitats.
- Estimates of silver eel biomass (B_0, B_{best} & B_{curr}) are reported and adequate.
- Estimates of mortality rates are reported for Fishing (F), other anthropogenic factors (pumping stations, hydro dams (H) and summed together (A), for the subcategories of F or H requested in the Table 4.
- Methods used to estimate biomass and mortality rates are described in the report.
- Stock and fishery trends are given by life stage.
- Biomass units are reported.
- Main management controls are restrictions in fishing and measures to reduce mortality at pumping stations and hydro dams. However, the effect of restrictions on actual fishing effort is not known.
- $B_{current}$ was appropriately reported as a proportion.
- Mortality in turbines was estimated and incorporated into models.

The 2018 report was authored by K.E. van de Wolfshaar, A.B. Griffioen, H.V. Winter, N.S.H. Tien, D. Gerla, O. van Keeken and T. van der Hammen. Author affiliation is not given. The report was commissioned by the Ministerie van Lanbouw, Natuur en Voedselkwaliteit. The 2015 report was authored by K.E. van de Wolfshaar, N.S.H. Tien, A.B. Griffioen, H.V. Winter, and M. de Graaf.

There is a single Eel Management Plan for the Netherlands, NL_Neth, covering exclusively with freshwaters. "Coastal waters" are mentioned as having a B_0 of 2600 t but no further information is supplied. Targets are mentioned only as 40% of B_0. No other targets are proposed. For 2014–2016, biomass ($B_{current}$) is estimated as 1365 t and lifetime anthropogenic mortality is estimated as 48%.

Major elements of the monitoring program are:

- sampling for biological characteristics (length, weight, sex, maturity, age);
- fisheries landings;
- recruitment monitoring; den Oever glass eel index; and
- electrofishing to support density estimations.

Demographic model - This model carries eel cohorts between the glass and silver stages in Dutch freshwaters, calculating their age, size, sex, maturity status and density. A constant natural mortality of 0.138 is assumed. Model output is used to generate length–frequency distributions, which are compared to observed length–frequencies in Lake IJsselmeer. Details of model fitting are not given, but it appears that fishing mortality is adjusted until modelled and observed length–frequency distributions match. Model outputs include fishing mortality and eel density.

Static yellow eel model - The Netherlands includes a great variety of types of waterbodies. A static model was developed that used densities of yellow eels from field electrofishing surveys and measurements of wetted areas. Both electrofishing catch efficiency and eel habitat preference are poorly known. Therefore modelling covered various scenarios of efficiency and preference in relation to distance from the shore. Biomass of both yellow and silver eels was estimated from the model.

Barrier mortality modelling - Mortality of silver eels when migrating through hydro dams, pumping stations, and other barriers was estimated in a model that classed the various routes that silver eels take from their rearing sites to the sea, and accounted for the mortality rates imposed by the barriers that they would encounter.

Outputs of these models are integrated to produce estimates of stock parameters (biomass, mortality) at a national level. Estimates are provided for four time blocks: 2005–2007, 2008–2010, 2011–2013, and 2014–2016.

Estimates of silver eel biomass (t) in the four time blocks, respectively:

B_0: 10 400, 10 400, 10 400, 10 400

$B_{current}$: 1049, 816, 867, 1365

B_{best}: 5619, 2445, 2123, 2547

% $B_{current}/B_0$: 10, 8, 8, 13

% Spawner per recruit: 19, 33, 41, 52

Annual commercial and retained recreational catches (t) for the four time blocks, respectively:

Yellow: 852, 369, 277, 229

Silver 280, 194, 151, 133

Fishing mortality (f) for the four time blocks, respectively (under Scenario 2)

Yellow: 0.17, 0.09, 0.07, 0.04

Silver: 0.16, 0.14, 0.11, 0.07

Percentage of silver eel biomass lost to anthropogenic mortality (fishing and barriers) for the four time blocks, respectively (Scenario 2)

33.8, 34.9, 31.0, 24.0

Lifetime anthropogenic mortality (%) for the four time blocks, respectively (Scenario 2)

81.3, 66.6, 59.1, 48.5

There are management measures to reduce mortality and hydro dams and pumping stations. There is a fishing ban in areas that are important for migration, closed season from 1 September to 1 December. For recreational fisheries there is compulsory release of eels, ban of recreational fisheries in coastal fisheries using professional gear; licences no longer issued for sniggling in state waters.

Stocking: stocking of glass eels.

There is no information on the extent to which the above measures have reduce actual, vs. potential, fishing effort.

Report tables

Table 1, overview: complete.

Table 2, biomass: complete.

Table 3, mortality quantities: complete.

Table 4, mortality rates: mortality rates due to poaching, habitat issues, barriers (yellow eels), and stocking (negative mortality rate) are not available and not presented. Other mortality rates are presented.

Table 5, stocking: Stocking data are provided for glass and yellow eels, by year. Release locations are not given.

Table 6, management measures: Changes in management measures are given. Management measures that have not changed are not given.

Table 7, effort: fishing effort is unknown and not given.

The pristine biomass estimate has been questioned by stakeholders and scientists alike who believe the target is unlikely to ever be met, even if there were no barriers or fishing at all, mainly because the carrying capacity (in terms of food conditions) is very different from the reference period and the local population depends on the glass eel index and thus on other countries. Also, there is the opinion that the value (B_0) is not reasonable compared to the ones estimated for other countries/EMUs.

1) Excel Table 5 indicates that a mean of 1 752 208 glass eels and 420 298 yellow eels were stocked annually between 2005 and 2016. However, according to Excel Table 1, stocking data were not used in estimating biomass and mortality. Is this correct?

Biomass and mortality are estimated using survey data and landings. So indirectly stocked eel are used, if they indeed survive and contribute to the stock.

2) Over the reporting period (2005–2007 to 2014–2016) estimated lifetime anthropogenic mortality has decreased by nearly half, but $B_{current}$ as a percentage of B_0 has improved only by a small amount. Why has $B_{current}/B_0$ shown so little progress, and what management measures would be required to be made to improve it toward the 40% target?

LAM has decreased mainly due to a decrease in fishing mortality, which is relatively easy to achieve because of a decrease in landings. An increase in $B_{current}$ depends on recruitment, and LAM and has a time-lag because it takes 5–15 years before glass-eel becomes silver eel. This will also depend on other countries, because part of the Dutch Silver Eel migrate from other countries. Improving $B_{current}$ would mainly depend on recruitment, which is depending on the total stock and not just the Netherlands. The Netherlands could decrease fishing mortality, barrier mortality and pollution.

3) Table 1 indicates that parameters other than B_0 are estimated by minimizing log-likelihood. Does this refer to model fitting of length–frequency distributions? How is this done? Is fishing mortality the only variable that is varied in the fitting process?

Methods are described in the Eel evaluation report. In short, we estimate F in Lake IJsselmeer by fitting length–frequency distributions and following year classes. Absolute biomass is then estimated using landings and F. For some other lakes, the same F as in Lake IJsselmeer is assumed, and biomass is estimated using the landings from these lakes. In other waters, biomass is estimated using swept-area estimates from electric dipping net.

4) Electrofishing with an electric dipping net is a key data-gathering method. Table 1 refers to "swept estimates." Is this based on electrofishing? Is it by backpack or by boat?

Yes, the swept estimate is based on electrofishing. This is by backpack in smaller waters and by boat in broader waters.

5) Biomass values are given in report Table 8-2 and in Excel Table 2, page biomass_indicators. For B_{best} 2014–2016, the report gives 2547 t but the Excel sheet gives 2 657 000 kg. All other values match between the two tables.

The report gives 2647 tonnes, which is correct. In the ICES data call, the value was already corrected.

6) Both the report (Table 1-1) and Excel Table 6 say "Reduction of eel mortality at hydroelectric stations with at least 35%." Should this read "by at least 35%"?

Yes.

Poland

- Information reported for the two areas - Oder and Vistula - and for fresh, brackish and marine waters. This appears to cover almost all of the eel habitat.
- Estimates of silver eel biomass (B_0, B_{best} & B_{curr}) are reported, though B_{best} is fixed for the period 2011–2017.
- Estimates of mortality rates reported for Fishing (F), other anthropogenic factors (H) and summed together (A), but not for the subcategories of F or H requested in the Table 4.
- Methods used to estimate biomass and mortality rates are not well described in the report. More information was supplied with the 2015 report, and more still is probably contained in the original EMPs though these have not been examined yet.
- Silver eel biomass is reducing while anthropogenic mortalities are increasing, so both going in the 'wrong' direction.
- Biomass reported as total weight - we used wetted areas from the 2015 report to standardize according to area.
- Main management controls seem to be reducing fishing mortality rate by a 15 June–15 July closed season for all fisheries, but no evidence presented to explain how this will be effective. Especially given that $B_{current}$ so low compared to target at this time - 1 and 4% vs. 40%. Choosing the dates for the closure was based on running the model with varying human and environmental pressures.
- Stocking is an important management measure, but limited by price of eel for stocking so only achieved target in one RBD in one year. Stocking occurred during 1960–1979 the period during which B_0 was estimated but this has been taken into account in setting the B_0 and stocked eel are not included.
- $B_{current}$ is reported as a proportion of B_{best}, but the pertinent proportion is B_{curr}/B_0.
- Mortality in turbines is included, but estimates are expected to be updated with more recent research results.

It appears that the Polish model needs to be updated with recent research results, updating the mortality rates in hydropower facilities that significantly affect the estimation of silver eel escapement, as well as specific assumptions on age of silvering and data from cross-border river basins. It is expected that estimates in future (perhaps as soon as next year) may differ from those in this year's report. Historical values for input data are in many cases scientific estimation or extrapolation, but trends are considered reasonable. There is no expectation that it will be possible to estimate poaching or IUU nor of its impact.

1) Why is Table 3 annex of mortality quantities missing?

It is enough to provide final mortality estimates and biomass indicators instead of reporting silver eel equivalents. During the last WGEE, it was decided to drop the silver eel equivalents due to the difficulties in accurately calculating these values.

2) WKEMP requires more detailed descriptions of the methods used to estimate biomass and mortalities, and the selection of management measures. The annex to the 2015 report provides some of this detail but the EMPs may provide more.

The full description of methods is available in the Polish EMP.

3) What is the basis of the 'expert opinion' deciding that a 25% reduction in fishing mortality is enough to achieve (what?), and that the one month's closed season will achieve this?

See the Polish EMP. We made the Model for forecasting eel resources with different variants of anthropogenic and environmental pressure. Based on the predictions and fishery (commercial and rec fish) statistics 25% of reduction had to lead to the target. On the basis of monthly statistics, we selected 15th of June to 15th of July.

4) Has the impact of migratory obstacles and turbines been incorporated in the mortality estimates, and if so, how?

Yes, the impact has been incorporated. The evaluation on hydropower mortality is described in the Polish EMP. Next year we're going to revise this issue based on the newest findings.

5) Has illegal fishing been included in the assessment?

Illegal fishing has been included up to 2010. From 2011 onwards we decided not to incorporate illegal and unreported catches into the model due the data unreliability.

6) Why is B_{best} fixed 2011 to 2017 when catches and mortality rates vary? In the 2015 report they varied from year to year.

Calculation of B_{best} is based on the average natural recruitment from 2015–2017 reduced in subsequent years only by a natural mortality and corresponds to the current state (in our model it is the so-called "forward estimation.") Catches and mortality rates are needed to "backward estimation" of B_{best}: If historical B_{best} should be based on recruitment from previous years, it will be different.

7) As fishing effort is reported separately for marine waters vs. the Oder and Vistula basins, please confirm that these marine waters are included in estimates of biomass and mortality rates for these two basins?

All areas and habitats are included in the estimates.

8) Did stocking occur during the reference period 1960–1979, and if so, do the B_0 estimates include the contribution of stocked eel?

Yes, we had stocking, but B_0 estimates do not include the contribution of stocked eels.

Portugal

No information provided.

Because of the construction of large dams, a large portion eel habitat is no longer available for eel in Portugal. Apparently, this previously available habitat had not been included in the calculations of the pristine biomass.

Spain

Provided tables, but no text.

The EMUs use different approaches to calculate the indicators; differences between the different EMUs should therefore be interpreted with caution. Non-fishery impacts, entrainment and mortality at water intakes, habitat quantity and quality decrease are considered to be underestimated because there are insufficient data for their estimation.

Similar to Portugal, the construction of large dams in Spain have made a large proportion of the eel habitat disappear to eel. Spain has included this pristine habitat in the calculations of the pristine biomass, assuming that the habitat that currently does not produce eel would produce 20 kg/ha. This results in a high target with current biomass very far from the target. Current productivity above the dams is likely to be lower, and it is not possible to know how eel produced above the dams would affect downstream population. Habitat losses should be taken into account consistently when calculating B_0.

The average pristine freshwater production rate in the Mediterranean should be higher than in the Atlantic (20 kg/ha) which is not currently the case.

For EMUs with fishery data and surveys in lagoons, specific studies are used (Murcia and Balearic Islands) and then apply the change in recruitment or CPUE to estimate pristine and yearly biomass. The indicators should be updated with real surveys. In the Mar Menor lagoon from Murcia, B_{best} is higher than B_0 because the lagoon is more productive now than it was before. This is because it was a closed hypersaline lagoon that has been opened to the Mediterranean. Based on catches before the system was opened, B_0 appears too low.

In Valencia reference values from the Rhone (French management plan) are used. This was reasonable to do that when the EMP was developed and indicators had to be used. However, ten years later, these should have been improved. Reference points for this region may no longer be acceptable.

Sweden

- Assessments are provided for three areas: the west coast marine, inland waters, and the Baltic coast marine.
- Estimates of silver eel biomass (B_0, B_{best} & B_{curr}) are reported for Inland waters only, but adequate for that region. No biomass estimates reported for either marine waters area because of insufficient data. Biomass is reported both with, and without, the contribution of stocking. Biomass is declining.

- Estimates of mortality rates are reported for Fishing (F), other anthropogenic factors (H) and summed together (A), for the hydropower, the only subcategory of F or H requested in the Table 4, this is assessed. Other categories are not assessed because they are considered very minor. However, habitat loss is not mentioned. A has increased in recent years, partly because stocking is now more in waters upstream of hydropower so H has increased.
- Methods used to estimate biomass and mortality rates described in the report.
- Stock and fishery trends reported for inland waters, and fishery trends for marine silver eel reported (yellow eel a minor component).
- Biomass units reported for Inland waters, but not the wetted area so not possible to report kg/ha.
- Main management controls are fishery controls, stocking and trap-and-transport of silver eel; the contribution of stocking is assessed, but not those of fishing control (except F now 0 in closed fishery) or trap-and-transport.
- Stocking is used and contributes about 90% of silver eel escapement from Inland waters, compared to <5% from marine waters. B_0 reported with and without stocking, but WKEMP uses the 'without'.
- $B_{current}$ reported as a proportion B_0, though Swedish report with and without effects of stocking whereas WKEMP focus on $B_{current}$ (with) compared to B_0 (without) as being the 'actual' situation today.
- Mortality in turbines is assessed, about 519 stations relevant to the eel assessment, applying rates of observed, 30 or 70% mortality.

There is no report document, only the excel tables were sent to the Commission. However, Willem Dekker provided the "Assessment of the eel stock in Sweden, spring 2018: Third post-evaluation of the Swedish Eel Management Plan" to WKEMP.

There are regional EMPs. Eel in Sweden occurs from the Norwegian border in the Skagerrak on the west side, all along the coast, north to about Hälsingland (61°N) in the Baltic Sea, and in most lakes and rivers draining there. Further north, the density declines to very low levels, and these northern areas are therefore excluded from most of the discussions here. Is this consistent with Finland?

Assessments are provided for three areas separately (west coast marine, inland waters, Baltic coast marine). The West coast has no stock indicators (biomass and mortality), only trends from fishery-independent surveys; the Inland has all indicators; the Baltic coast has estimates of Swedish fishing impact only.

All habitats are considered, but using different approaches.

All inland waters assessed with one method.

Marine areas split into the West Coast and the Baltic.

The West Coast fishery was closed in 2012, so there are no recent data from which to develop stock indicators, but a small number of fishery-independent surveys used to examine trends in eel stock.

Baltic Coast fishery assessed using mark–recapture, modelled across counties. But this fishery exploits eel from other Baltic States, and with no knowledge of state or impacts on these eels before they reach the Swedish fishery, only silver eel fishing mortality rate is estimated. Presumably if there had still been a fishery on the West coast they'd have had to consider other Baltic production there too.

Targets are as per the EU Regulation for biomass and mortality rates.

Biomass and Mortality rates reported both with and without the effects of stocking.

Biomass for Inland waters only. B_0 300 t plus contributions from stocking - reasons for reporting escapement with and without stocking understood, but B_0 should be without any human effects.

Mortality rates for Inland waters, and F for Baltic coastal waters but only for this Swedish fishery whereas the eels could have originated from other countries.

Fisheries landings, size and tag returns; recruitment with modelling to extrapolate; stocking inputs; trap-and-transport of silver eel.

Biomass estimates reported with, and without, the contribution of stocking.

The assessment for the inland waters relies on a reconstruction of the stock from information on the youngest eels in Swedish waters (natural recruits, assisted migration, restocking). Based on 75 years of data on natural recruitment into 22 rivers, a statistical model is applied relating the number of immigrating young eel caught in traps to the location and size of each river, the distance from the trap to the river mouth, the mean age/size of the immigrating eel, and the year in which those eels recruited to continental waters as a glass eel (year class). From this, the production of fully grown, silver eel is estimated for every lake and year separately. Subtracting the catch made by the fishery (as recorded), and down-sizing for the mortality incurred when passing hydropower stations (percentwise, as recorded or using a default percentage), an estimate of the biomass of silver eel escaping from each river towards the sea is derived.

Biomass only reported for inland waters.

Since 1960, the production of silver eel in inland waters has declined from over 500 to below 300 tonnes per annum, and is still falling - but this includes the contribution of stocking. Natural recruitment (assisted and fully natural) has gradually been replaced by restocking for 90%. Fisheries have taken 20–30% of the silver eel, while the impact of hydropower has ranged from 20% to 60%. Escapement is estimated to have varied from 100 t in the late 1990s, to 200 t in the early 2000s.

Stocking elevates B_{best} above B_0 in the reported 2000–2017. The trend is declining $B_{current}$ throughout this period. $B_{current}$ (including stocking) is 40% of B_0 in 2017 (120 t vs. 300 t). Excluding the effects of stocking, the biomass from inland waters would be about 6% of B_0 in 2017.

Fisheries - commercial, including the catch for silver eel Trap-and-transport. Recreational fishing is rare, only being allowed in lakes above three hydropower dams, so these do not appear to have been included in the assessment.

In Inland waters, anthropogenic mortality (fishing and hydropower) (excluding effects of stocking) increased from 2000s to 2010s but similar since then at about 1.0.

Because stocking is more now in waters upstream of hydropower vs. other waters, mortality rate due to hydropower is increasing, and hence overall mortality rate increasing.

Presumably therefore, Trap and transport not sufficient to compensate.

Baltic coastal fisheries mortality rate estimated as about 2% from 2010–2017: average catch 223 t/a, run size 800–4000 t/a depending on county.

Methods to estimate mortalities

Fish model (landings, size, tag returns).

Hydropower uses loss rates from observed, x and average, in that order.

IUU - limited information suggests total catch could be similar to commercial catch, but this is not included in the mortality rate estimates because of the uncertainties.

The effect of stocking is not included in estimates of Sum(Mortality rates) because of the risk Stocking as a compensation for other anthropogenic mortalities, when included in the overall rate, underestimates the actual human impact.

Trap and transport of silver eel - the trapping is included within the fishery statistics and therefore, it appears, within mortality rates. However, the release of these eel in coastal waters is not included as a negative mortality, to balance the equation, because they are moved from one management area to another.

Predation by cormorants acknowledged but insufficient information to address this in mortality rates for coastal waters.

Management measures

Stocking: in recent years (since 2010) stocking is estimated to contribute about 5–10% to B_{best} silver eel escapement from West coast marine (the report states 50 t and 'considerably less than' 100 t), about 0.3% to B_{best} from the Baltic coastal zone, but about 90% of the B_{best} in Inland waters.

In Inland waters, prior to 2009 stocking mostly to waters with free access to sea, whereas since 2010 more stocking into waters upstream of hydropower (because hydropower paid for the stocking?).

Trap and transport - bypassing hydropower. About 13 t/a on West Coast and 6 t/a on Baltic in last four years. Adds about 1–5% to silver eel escapement, but what % of the potential is protected in this way?

Fishery controls - closed fishery on west coast since 2012.

All Tables provided but note that Table 5_Stocking reports only numbers of eel, not the required weights.

1) Why is Table 5_Stocking reports only numbers of eel, not the required weights?

Data are available to us but the responsible agency created their own file where weight for some reason was cut out, and the range in time was reduced. However, the data in the ICES data call should be complete.

2) Is there an assessment of the impact of habitat loss?

As noted in section C.1.4, in the Aqua report, increasing quantities of restocking always resulted in increasing fishing yield. We therefore concluded that habitat is not a limiting factor for eel production. So, habitat loss is not an issue in Sweden (of today).

3) "The original natural (not assisted) recruits were far less impacted by hydropower, since they could not climb the hydropower dams when immigrating." - does this imply that natural potential production above hydropower was ignored?

Not ignored, as there are almost no naturally recruited eels above hydropower stations.

4) What are the wetted areas for each of the assessed areas?

Table 2. Vattenareal i sötvatten in freshwater fördelat på vattendistrikt (SCB 2005)

Vattendistrikt

Areal (km^2)

Bottenviken (1)

10 880

Bottenhavet (2)

10 388

Norra Östersjön (3)

3263

Södra Östersjön (4)

4872

Västerhavet (5)

9857

Total

39 260

Den totala arealen potentiella ålproduktionsområden i kustvatten (in coastal water) ut till djupzon 20 meter är ca 16 000 km^2 (Table 3). Fördelningen framgår av bilaga 3.

Table 3. Vattenarealer i kustområdet fördelat på vattendistrikt.

Vattendistrikt

Areal (km^2) along the Baltic Coasts

Bottenviken (1)

4581

Bottenhavet (2)

1521

Norra Östersjön (3)

2190

Södra Östersjön (4)

5403

Västerhavet (5)

2104 West coast

Total t

15 799

5) Sweden to clarify whether these earlier estimates of coastal production of silver eel include contributions from neighbouring inland waters.

The SLU Aqua reports assesses the coastal stock on the basis of landings that includes silver eels of whatever origin, including Swedish inland waters and from other countries. (This is a major reason why a Pan-Baltic collaboration/cooperation and a common Baltic EMP is urgently needed).

6) Sweden to clarify whether the Inland waters assessment is for all waters or only lakes - texts imply either.

The occurrence of landings indicate all fishing in done in lakes, but the silver eel run includes also eels coming from upstream the lake where the fishing data come from.

United Kingdom

- This report covers England, Wales, Scotland, and Northern Ireland, which have separate eel management authorities under government devolution, and different availability of field datasets. Fourteen Eel Management Units, each representing a River Basin District, are treated.
- Estimates of silver eel biomass (B_0, B_{best} and $B_{current}$) are reported and adequate.
- Estimates of mortality rates are reported for Fishing (F), other anthropogenic factors (water intakes, hydro dams (H) and summed together (A), for the subcategories of F or H requested in Table 4.
- Methods used to estimate biomass and mortality rates are described in the report.
- Biomass units are reported.
- Main management controls are restrictions in fishing and the installation of passes to allow access to upstream waters and screens at water intakes. The effect of restrictions on actual fishing effort is not known.
- $B_{current}$ was appropriately reported as a proportion.
- Mortality in turbines was estimated and incorporated into models.

Authors of this report are not credited. The author of the 2015 report was listed as Defra (Department for Environment, Food, and Rural Affairs).

This report presents data on 14 Eel Management Plans (EMP)s, corresponding to 14 River Basin Districts (RBD). Thirteen of these RBDs lie entirely within the UK. The Neagh Bann RBD is shared with the Republic of Ireland, but is included in this report. The North Western International RBD is shared with the Republic of Ireland, and is included in the report for Ireland.

Table 1 lists four habitat categories (Freshwater, Transitional, Coastal, Marine Open).

Two RBDs (NorE, Neag, both on the island of Ireland) are shown as covering Freshwater only. One RBD (Scot) covers Freshwater, Transitional, and Coastal. All other RBDs cover Freshwater and Transitional water. However, it is unclear how Transitional habitats are dealt with in England and Wales, and how Coastal habitats are dealt with in the Scotland RBD.

Targets are mentioned only as 40% of B_0, and targets for glass eel stocking, both in Northern Ireland.

Estimates of B_0, $B_{current}$, and B_{best} are provided in Report Table 1 by RBD and year (2014–2017) and in Excel Table 2 starting in 2009.

Estimates of fishing, non-fishing, and total anthropogenic mortality are provided in Report Table 2 by RDB and year (2014–2017) and in Excel Table 4, starting in 2009.

Monitoring in England and Wales: index river, method not stated (probably electrofishing); resistivity counter for silver eels in the Severn (not clear if this is used for monitoring or for model testing only).In Scotland: silver eel counts, upstream river counts. In Northern Ireland: silver eel mark-recapture and netting, glass eel monitoring.

For England and Wales, the Scenario-based Model of Eel Production II (SMEP II) was used to extrapolate yellow eel density data from surveys in a river basin to whole-river numbers-at-length, and then converted to silver eels. Rate of silver eel production from the wetted area of modelled rivers was applied to the RBD as B_{best}. $B_{current}$ was estimated from B_{best} after adjustment for anthropogenic mortality factors. Anthropogenic mortalities were due to fishing, entrainment at water intakes, including pumping stations and hydroelectric facilities, and loss of habitat due to dams. Stocking was modelled as a negative mortality.

The biomass of yellow eels caught was considered equivalent to potential silver eel escapement on the grounds that assumed yellow eel mortality (0.14 yr^{-1}) approximates instantaneous growth rate (0.2 yr^{-1}). For glass eels, silver eel equivalencies were calculated assuming an instantaneous settlement mortality of 0.00915 day^{-1} and a settlement period of 50 days (total of 0.4575), and a subsequent mortality of 0.14 yr^{-1}. The model was run with a 50:50 sex ratio, and a schedule of male and female maturities according to weight.

In the Scotland RBD, modelling is based on silver eel counts on rivers which reflect production in three altitudinal bands. Transitional waters are considered to have the same production per wetted area as the lower altitudinal band. In the absence of fishing, modelled anthropogenic mortality was due to barriers, which were assumed to totally block upstream passage unless fish passage is provided; in which case turbine mortality is assumed to be 100%.

In Northern Ireland, silver eel escapement from the Neagh Bann RBD was estimated by mark–recapture analysis of downstream migrants. In the North Eastern RBD, fisheries are absent and barriers are assumed to be minimal or absent.

Trends in B_0, B_{best}, and $B_{current}$ for the 14 EMUs are presented in Excel Table 2.

Trends in fishing and non-fishing anthropogenic mortalities for the 14 EMUs are presented in Excel Tables 3 and 4.

Fishing and non-fishing anthropogenic mortalities for the 14 EMUs are presented in Excel Tables 3 and 4.

The main management measures introduced since 2009 in England and Wales are compulsory release of eels by anglers, seasonal, geographic, and gear restrictions for commercial fisheries, new eel passes, and screens at water intakes. In Scotland, commercial and recreational fishing for eels has not been permitted since 2009 [not clear if this is Scotland the country or Scotland the RDB]. In Northern Ireland, measures implemented since 2010 include commercial gear restrictions, an increase in the legal size, a ban on eel retention by recreational fishers, closure of a silver eel weir on the River Bann, and an increase in longline hook size.

In the Neagh Bann in Northern Ireland, 2690, 604, 0, and 810 kg of glass eels were stocked in 2014–2017, respectively, using mostly glass eels from the UK. In other RBDs, only minor quantities of glass eels were stocked in 2014–2017 (range 0–21.5 kg per RBD per year).

There is no information on the extent to which fishing restrictions have reduced actual, vs. potential, fishing effort.

Table 1, overview: complete.

Table 2, biomass: complete for all RBDs.

Table 3, mortality quantities: complete for all RBDs.

Table 4, mortality rates: complete for all RBDs.

Table 5, stocking: complete for all RBDs.

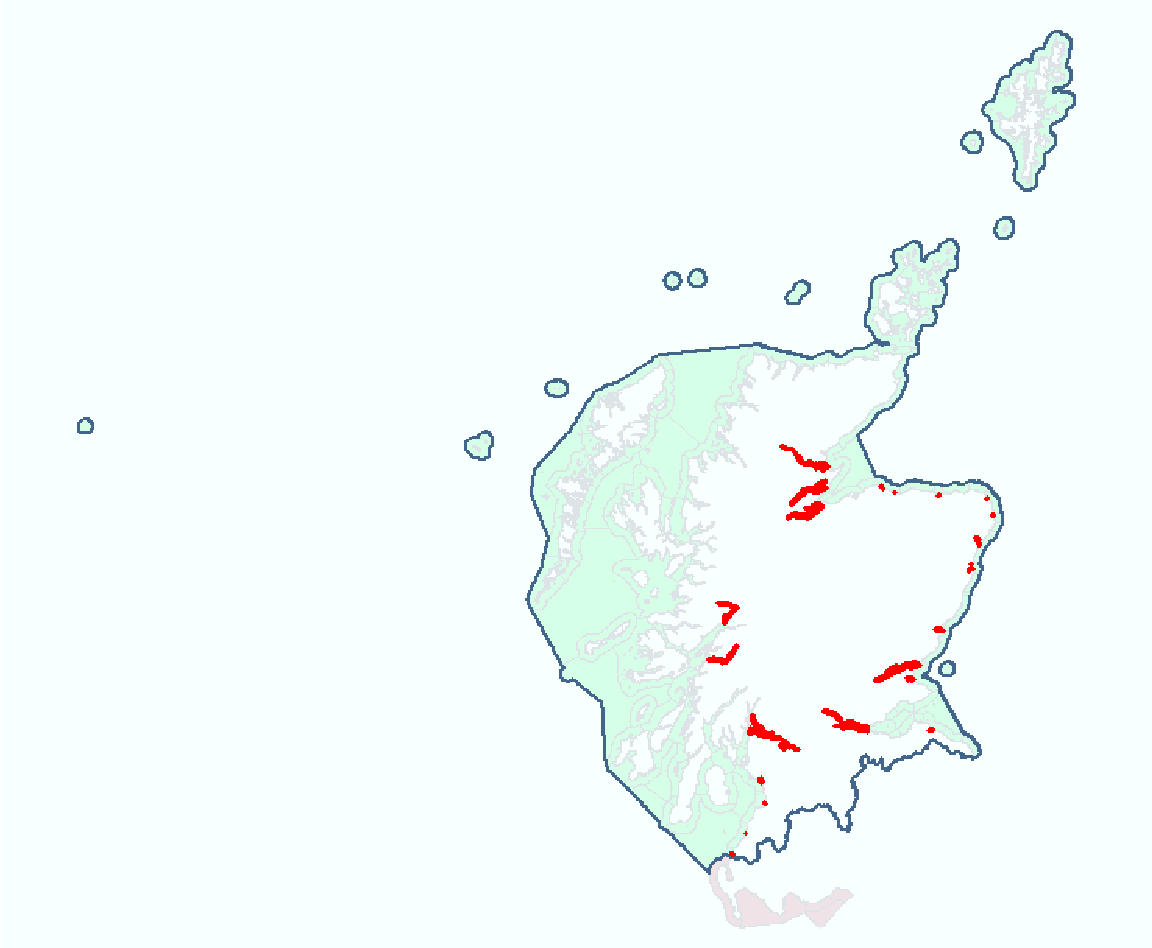
Table 6, management measures: Changes in management measures are given. Management measures that have not changed are not given.

Table 7, effort, complete; data given for all RDBs.

United Kingdom

1) The report indicates that Scotland, since 2013, includes transitional waters in its production estimates, following the method of England and Wales. However, the sections on England and Wales don't mention transitional waters. "Transitional waters" should be defined, and it should be explained how their area has been measured and how they are dealt with in models. Excel Table 1 says that the Scot RBD covers coastal habitat. The word "coastal" does not appear in the report. What is the nature of "coastal" coverage in the Scot RBD? Non-freshwaters are an important part of eel growth range. It's important to know to what extent such habitat is already covered in this study, and at least in rough terms, how much habitat is not covered.

The transitional waters “assessed” in Scotland RBD are those defined as Transitional Waters in the WFD, amounting to 60 502 ha. Any reference to coastal water for Scotland means these Transitional Waters.



Scotland RBD transitional waters.

2) The title of Annex B refers to the Scotland RBD. However, the text refers in several places to Scotland without qualification, which implies the whole country. Annex B states that there have been no eel fisheries in Scotland since 2013. Most (about 3/4, judging from Figure 1) of the Solway Tweed RBD is in Scotland. Is the information in Annex B exclusively applicable to the Scotland RBD, or does some of it also apply to the Scottish segment of the Solway Tweed RBD? In particular, has eel fishing been prohibited in the Scottish segment of Solway Tweed since 2013? Solway-Tweed appears to be analysed by the method used for England and Wales. Does this mean that the analysis is based only on index river data on the English side of the border?

In the specific cases you mention, Scotland means the territory of Scotland, i.e. Scotland RBD plus the Scottish section of the Solway-Tweed RBD. Eel fishing has indeed been prohibited in the Scottish section of the Solway-Tweed RBD since 2009.

The Solway-Tweed RBD is assessed using the England-Wales method. In the 2015 assessment both Scottish data (one river) and English data (three rivers) contributed to the report, but in 2018 only English data (three rivers) were used.

3) The caption of Report Table 1 indicates that data are given for England and Wales, but the table gives data for all UK RBDs.

Simply change it to UK rather than England & Wales.

4) Use of similar names for a Northern Irish/Irish RBD (North Western) and an English RBD (North West) leaves room for confusion. (Probably too late to change this).

The names of the EMU are fixed - cannot change them now.

5) The report's Table of Contents lists Item 4 as "Amount of Glass eel caught and proportions used for different purposes." In the text, this heading seems to have been sucked back to the previous paragraph where it lost its large and coloured font. See the bottom of the 3rd last paragraph on p. 24.

Reformat?

6) For Excel Table 1, Item 6, Stocking, the Method Description box for eleven English and Welsh RBDs says "Catch is subtracted from B_{best} to make B_{curr}. None of the catch is restocked in the EMU so this approach is appropriate." This implies that glass eels have been caught in the RBD and have been used or sold elsewhere. Is it correct that glass eel fisheries have occurred in eleven English/Welsh RBDs? Table 4 shows glass eel fishing effort in only six RBDs.

The table is correct, not all of the eleven English and Welsh RBD have glass eel fisheries.

7) In conformity with instructions, the report describes conservation measures that have been implemented since the EMP was issued. To understand the likely conservation impact of these changes, we need to know the fishing regime before changes were made, and the fishing regime now. This information would be useful, although the Commission did not ask for it.

8) Tables in the report present data by RBD. It would be useful to have national summations that give overall UK results. For example, Table 5 presents eel fishing effort by RBD, but it is difficult to see if there is any UK-wide change in fishing effort by scanning 11 columns of data.

We could add new line in table for UK total, but should we exclude the crossed border EMU with ROI?

Annex 4: Reporting schedule to the Commission

Summary of Member States reporting in their 2018 EMP Progress Reports supplied to the European Commission, noting those Member States with derogations from reporting, and those that reported after the 30 June 2018 deadline. Note that the Description of the Methodology was requested in **Ares(2018)504014-29/01/2018** (with templates and guidance) but not in **Ares(2018)1830726-05/04/2018** (cover letter and excel templates).

Letter to Member States 2018 report.p

Member State	Data Tables 1–7	Description of the Methodology	Comment
Austria			Derogation 2/4/09
Belgium	Y	Y	
Bulgaria			Derogation 4/4/08
Croatia	N	N	Did not report
Cyprus			Derogation 2/4/09
Czech Republic	N	Y	Reported late 4/7/18
Denmark	Y	Y	
Estonia	Y	Y	
Finland	N	Y	Reported late 5/7/18
France	Y, missing Tables 3, 7	Y	
Germany	Y	Y	
Greece	Y	Y	Reported late 11/7/18
Hungary			Derogation 4/4/08
Ireland	N	Y	Reported late 13/11/18

Italy	Y	Y	
Latvia	Y	Y	Reported late 2/7/18
Lithuania	Y	Y	
Luxembourg	N	N	Did not report
Malta			Derogation 2/4/09
Netherlands	Y	Y	
Poland	Y, missing Table 3	Y	Reported late 2/7/18
Portugal	N	N	Did not report
Romania			Derogation 2/4/09
Slovakia			Derogation 2/4/09
Slovenia			Derogation 24/9/09
Spain	Y	N	Reported late 17/8/18
Sweden	Y	N	
United Kingdom	Y	Y	

Annex 5: Eels in transitional and coastal waters

Context

This section deals with issues in identifying two of the three habitat types recognized in EMUs (transitional waters, coastal waters) and properly treating the eels they contain. This needs attention because:

i) Eels commonly use saline (i.e. either brackish or salt) waters as rearing areas. The proportion of eels that do so is unknown, but appears to be substantial (ICES, 2009).

ii) Eel demographic parameters may differ between salinity zones (particularly growth, Daverat *et al*., 2012). Application of parameters measured in freshwater to saline habitats may skew results.

iii) Transitional and coastal waters are not identified in any consistent way. In some MS, the outer limit of coastal waters may be set as the shoreward boundary of EU waters. However, EU waters are not defined in any consistent way. Tidal limits or the limit of salt penetration could serve as the boundary between transitional water and freshwater, but this is not defined. National reports to WGEEL and to the EU generally do not contain maps of transitional and coastal waters, do not explain how their boundaries are set, and do not report quantities of transitional and coastal habitat.

The absence of established and reviewed methods leads to the possibility that wetted areas used in population analysis will include large amounts of habitat that eels do not occupy or exclude large amounts of habitat that they do occupy. Evaluation of conservation compliance under the EU Eel Regulation is generally area-based, i.e. based on scaling silver eel production per ha of wetted habitat to wetted area of the whole EMU. If wetted area is subject to large error, compliance evaluation will be subject to large error.

iv) In at least one case (near Denmark), eel fisheries occur in EU waters that are outside any EMU. Article 8 of the Eel Regulation specifies fishing reductions to be applied to such waters between 2009 and 2014. After 2014, these waters are not subject to ongoing EU management oversight and to reporting requirements for biomass and mortality rates.

The distribution of eels in transitional and coastal waters

A broad range of scientific studies and reports of fishery locations indicate that yellow phase European eels are widespread, and common in estuaries and sheltered bays (ICES, 2009). On Europe's Mediterranean coast, eels are common in coastal lagoons. In the southern North Sea, data for 1978–2008 from an ICES-coordinated beam trawl survey showed that eels were present in a coastal fringe up to 20 km wide (ICES, 2009). In 1964 to the 1980s, up to 300 t of eels, primarily yellow eels, were commercially trawled in the open waters of the southeast North Sea, generally at 10–50 m depth. It is not known if eels use or used similar habitat in the Baltic Sea, Atlantic Ocean, and Mediterranean Sea.

Fresh–saline habitat choice and its consequences

Studies of eel movements, most often conducted using otolith strontium as an indicator of marine occupancy, show that some eels are freshwater residents, some are saline water residents, and others shift salinity zones at irregular intervals or according to seasonal cycles. Choice of habitat at the glass eel stage is influenced by both intrinsic and environmental factors. Eels that occupy saline water reach silvering size sooner than eels that grow in freshwater, but it is not clear if fresh-reared eels have higher annual survivorship that compensates for their longer time to maturity (Cairns *et al*., 2009).

Anthropogenic impact on eels is often greater in fresh than saline habitat, especially due to the effects of dams. Secor (2015) argued that the availability and use of both salinity categories is essential to long-term eel conservation, and that saline waters should not be considered as a satisfactory alternative habitat for eels that have been diminished in freshwaters.

Ways forward

There is a large deficit of knowledge of eel biology in coastal and transitional water. Obtaining the information that is needed for a robust assessment of compliance with the Eel Regulation in coastal and transitional habitat is a long-term task. The following steps will assist.

i) Member States should map the transitional, coastal, and freshwater zones that are used in present assessments and make these maps available in GIS format. Wetted areas of EMUs should be tallied according to these habitat types.

ii) Available datasets should be mined to help determine eel distribution in saline waters. This approach has been successfully applied to the American eel, where data from 26 trawl and beach-seine surveys produced the first continent-scale picture of the marine distribution of an *Anguilla* eel (Cairns *et al*., 2017). In Europe, DATRAS (datras.ices.dk) provides databases of bottom-trawl surveys between the Baltic Sea and Gibraltar. Such surveys may help define the seaward distributional boundary of eels. In estuaries and sheltered coastal waters, biological research is conducted with a variety of collection methods including beach-seines, underwater visual counts, dredging/trawling, suction sampling, and poisoning (Baker *et al*., 2016). Many of these methods are capable of capturing or detecting eels. Mining such studies for eel data will shed light on eel distribution in saline waters.

iii) Revised maps of transitional and coastal habitat should be prepared, that are based on knowledge of eel distribution in saline waters. It is likely that thorough knowledge of eel distribution will be confined to a small number of locations. Elsewhere, maps of transitional and coastal habitat should be prepared on the basis of habitat use patterns found in well-studied areas. Water depth is a possible criterion for setting boundaries of eel habitat. Trawl results for the American eel indicate strong abundance-depth relations, but depth appears to be unsuitable for broad-scale habitat mapping because abundance-depth patterns differ markedly among locations (Figure A5.1).

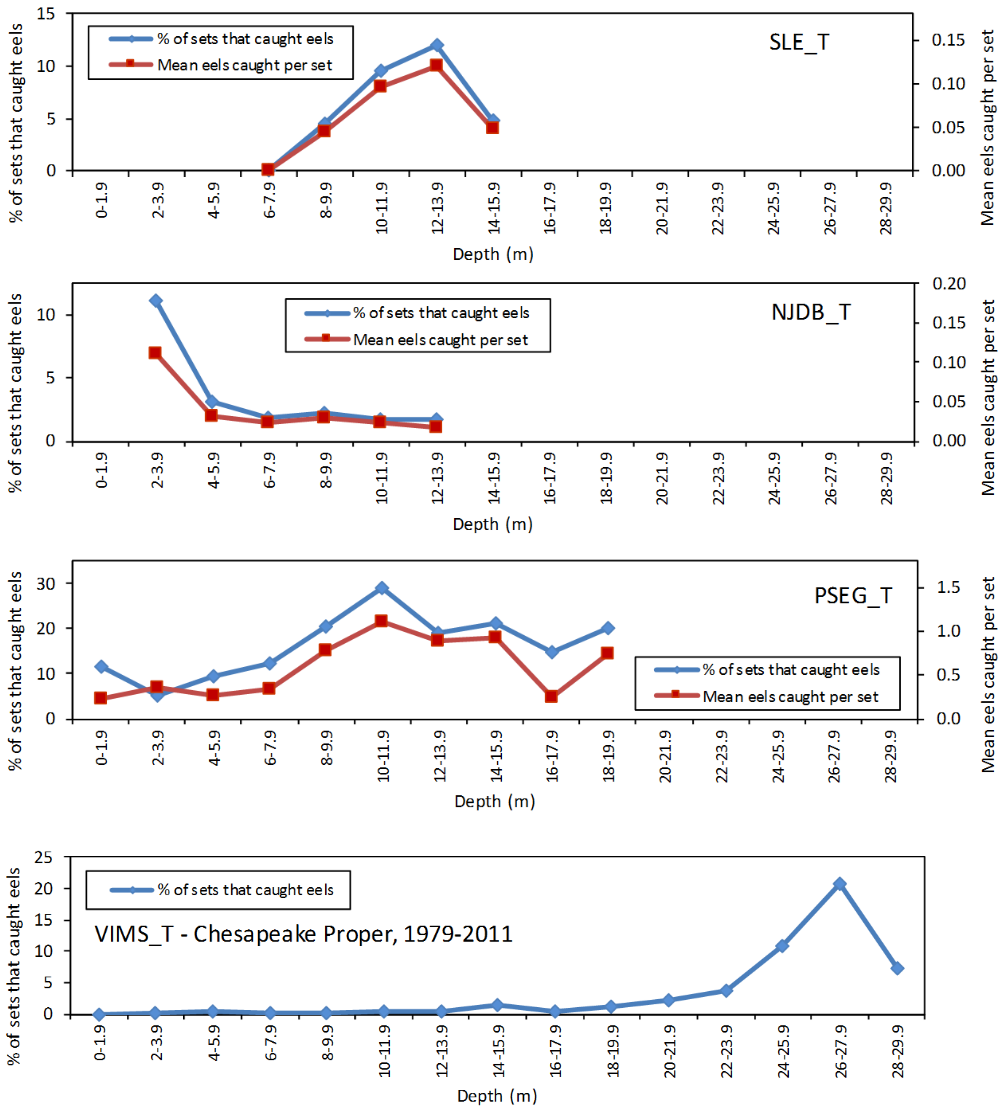


Figure A5.1. Relation of American eel catch rate in trawl surveys to water depth in four estuaries and bays in eastern North America (SLE_T: St Lawrence estuary trawl survey, NJDB_T: New Jersey Delaware Bay trawl survey, PSET_T: Delaware River and Bay trawl survey, VIMS_T: Chesapeake Bay trawl survey). Data assembled by Cairns *et al.*, 2017.

Qualitative habitat descriptions indicate that that European eels are commonly found in sheltered waters. Degree of shelter from the open sea can be quantified as mean wind-adjusted fetch, which is often a strong predictor of the distribution of marine organisms (e.g. Jacinto *et al.*, 2016). In North American trawl surveys, nearly all eel records were located in waters with a mean fetch of less than 60 km (Figure A5.2). Fetch-based ecological studies commonly calculate mean fetch from 22 to 48 distance measurements. This sampling intensity produces large errors in fetch maps (D. Cairns and D. Mills, Department of Fisheries and Oceans, unpublished). Mean fetches that are calculated with greater sampling intensity have a better chance of showing good correspondence with eel habitat.

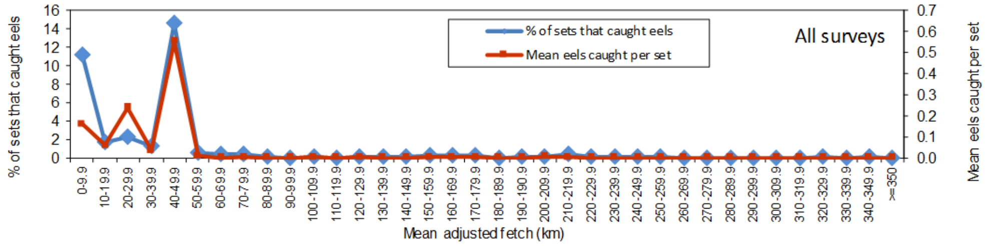


Figure A5.2. Relation of American eel catch rates in trawl surveys to mean wind-adjusted fetch in eastern North America. Data from Cairns *et al.*, 2017.

The only data input requirement for mean fetch mapping is coastal maps that have a reasonably high resolution. Such maps are available Europe-wide from public sources (Figure A5.3).

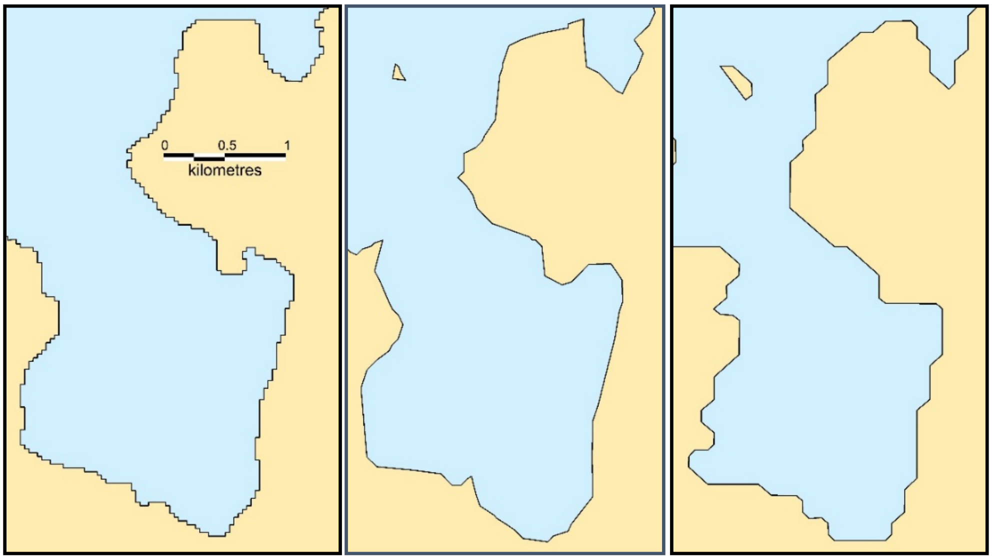


Figure A5.3. The southeast corner of Roskilde Fjord, Zealand, Denmark, as depicted by maps that might be used for mean wind fetch mapping across the European eel range. Left panel from diva-gis.org, middle panel from the European Environment Agency (EEA) (https://www.eea.europa.eu/data-and-maps/data/eea-coastline-for-analysis-1), and right panel from a Global, Self-Consistent, Hierarchical, High-resolution Geography Database (GSHHG) (http://www.soest.hawaii.edu/wessel/gshhg/).

iv) Apply quantitative methods of estimating eel density in saline waters. Core field methods used in freshwater (electrofishing to estimate densities, fish trapping at choke points to measure ingress and egress) cannot be readily applied in transitional and coastal waters (although ingress/egress can be measured in coastal lagoons with narrow entrances). Eel density in fresh or saline shallow lentic (non-flowing) water can be estimated by night-time glass bottom boat surveys (Cairns *et al.*, 2009) and by the corral (enclosure) method (Ubl and Dorow, 2014). Use of these methods should be expanded, and novel methods should be developed and tested. The use of environmental DNA (eDNA) (Sigsgaard *et al.*, 2017) to determine seaward boundaries of eel distribution should be tested.

v) Expand eel demographic research in saline waters. With major vital rates differing with habitat salinity, models of eels living in saline water should use input data collected in saline water.

Annex 6: Density-dependence and B_0 estimation

Context

The Eel Regulation mandates a management regime that is oriented towards targets of escaping silver eel biomass, relative to the escapement that would have occurred in the absence of anthropogenic impacts (EU, 2007). Pertinent wording from the Regulation is "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." and "The target level of escapement shall be determined, taking into account the data available for each eel river basin, in one or more of the following three ways: (a) use of data collected in the most appropriate period prior to 1980, provided these are available in sufficient quantity and quality; (b) habitat-based assessment of potential eel production, in the absence of anthropogenic mortality factors; (c) with reference to the ecology and hydrography of similar river systems."

Estimated silver eel biomass in the absence of anthropogenic impact (B_0) is estimated most often by Method (a), in reference to the relative abundance of eels prior to 1980, at the yellow and silver stages (Denmark, Germany, UK), or at the glass eel stage (France, Italy, Poland, Spain). Since compliance with the Eel Regulation is based on silver eel biomass, the ideal way to calculate B_0 under Method (a) is from a measure of silver eel biomass prior to 1980. B_0 can also be calculated from measures of yellow or glass eel abundance made before 1980, and converted to silver eel equivalents by application of vital rates (growth, sex ratio, mortality etc.). ICES (2018a) has compiled composite indices of glass and yellow eel recruitment (Figure A6.1). Between a baseline calculated as the mean of 1960–1979 values and 2017, composite recruitment indices declined by 98.6% for North Sea glass eels, by 90.4% for Elsewhere Europe glass eels, and by 85% for yellow eels. Note that the yellow eel recruitment series shown in Figure A6.1 is based on trap counts of upward-migrating yellow eels. Yellow eel series used in estimating B_0 are based on electrofishing data.

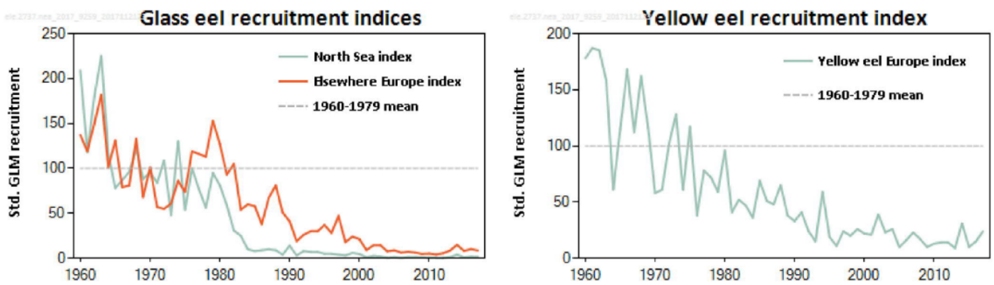


Figure A6.1. Geometric means of GLM recruitment of glass eels (left panel) and yellow eels (right panel). From ICES, 2018b.

Density effects on natural mortality

Bevacqua *et al*. (2011) examined factors influencing natural mortality in 15 eel stocks. At a given temperature, the modelled mortality rate of a high-density eel population was about triple the mortality rate of a low-density population. In a scenario where eel recruitment is declining from high to low, and under density-dependent mortality, density decreases over time, which leads to improving survivorship over time. Improving survivorship would cause yellow eel abundance to shrink less rapidly than glass eel recruitment, and silver eel abundance to shrink less rapidly than yellow eel abundance (Figure A6.2).

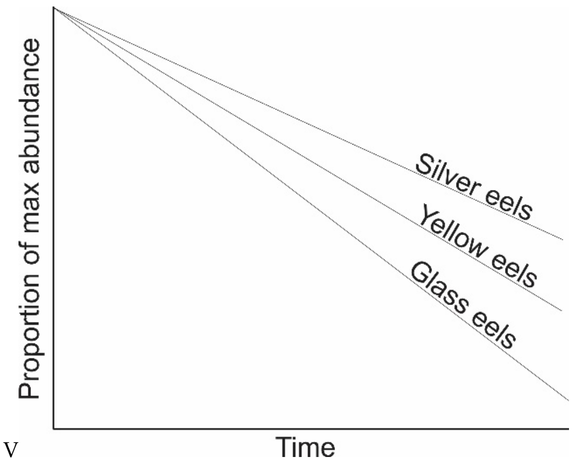


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Figure A6.2. Conceptual model of abundance trends of silver, yellow, and glass eels in a declining eel population under the assumption of density-dependent natural mortality.

Density effects on sex ratio

Male eels silver and leave continental habitats at a smaller mean age (6.0 years) and length (406 mm) than females (8.7 years, 623 mm) (Vollestad, 1992). The proportion of males in eel populations tends to be greater at high density (Geffroy and Bardonnet, 2016). Consider a yellow eel population that is declining because of declining glass eel recruitment. With the density-dependent shift from early leaving males to late-leaving females, the average duration of continental residency increases, which causes yellow eel abundance to decline less rapidly than glass eel recruitment. This reinforces the effect of density-dependent mortality; both factors cause yellow eel abundance to decline less rapidly than glass eel abundance.

Impact of density-dependence on estimates of B_0

Table A6.1 explores the potential impact of density-dependence on a hypothetical declining eel population. If density-dependence does not occur, the ratio of the silver eel index to the glass eel index (raising factor) will be constant across time. When density-dependence causes the silver eel index to decline less steeply than the glass eel index, the raising factor changes over time. To estimate the historic silver eel index (a proxy for B_0), we apply the raising factor from current data to the historic glass eel index. In the scenario shown in Table A6.1, where the silver index declines by 90% under the assumption of series linearity and by 80% under the assumption of density-dependence, this method estimates the historic silver eel index at 1000, which is double its true value. If this scenario reflects patterns found in nature, then B_0 derived from measures of yellow eel abundance would be systematically overestimated. B_0 derived from measures of glass eel abundance would also be systematically overestimated, by a greater degree.

Table A6.1. Changes in glass eel index values (millions of individuals) and in silver eel index values (thousands of individuals) in a hypothetical declining eel population, under scenarios of a linear relation between the two series, and under the assumption that the silver eel index declines less steeply than the glass eel index.

Period	Glass eel index		Silver eel index		Raising factor to calculate the silver eel index from the glass eel index
	Value	Percent decline	Value	Percent decline	
Assuming a linear relation between the silver eel index and the glass eel index					
Historic period	100		1000		10
Current	10	90	100	90	10
Assuming that density-dependent mortality causes the silver eel index to decline less steeply than the glass eel index					
Historic period	100		500		5
Current	10	90	100	80	10
Estimation of the historic silver eel index from the current glass eel index, assuming density-dependent mortality, but using a raising factor that assumes a linear relation between the series					
			1000		

The above considerations are based on abundance expressed in numbers of individuals. However, the target specified by the Eel Regulation is silver eel escapement expressed in mass. Use of changes in glass or yellow eel abundance to estimate B_0 involves application of vital rates, including sex ratios, to convert numbers of pre-silver eels to silver biomass. The proportion of males prior to 1980 may have been higher than it is currently, due to high densities then. Male silver eels are smaller than female silver eels, so a given number of male silver eels will have a smaller biomass than the same number of female silver eels. Bias can be avoided if time-specific sex ratios are used in the conversion of glass or yellow numbers to silver biomass. However, sex ratios were not widely measured prior to 1980. If current sex ratios are used in the conversion of glass and yellow eel numbers, there is a risk that B_0 will be overestimated.

Ways forward

i) National reports to the EU and to WGEEL should provide detail on the methods used to estimate B_0. In particular, the source and values of sex ratios that are used in calculations should be reported. Where B_0 is estimated from measures of glass or yellow eel abundance, reports should note the potential for density-dependence to bias results.

ii) B_0 should be estimated, in order of preference, from historic data on the abundance of silver eels, of yellow eels, or of glass eels. Time-specific sex ratios should be incorporated in calculations if available.

iii) There is literature evidence of density effects on natural mortality (Bevacqua *et al.*, 2011), sex ratio (Geffroy and Bardonnet, 2016), and growth (Boulenger *et al.*, 2016). However, reported relations are often variable and sometimes contradictory. Further research should be conducted on density-dependence in eels, with emphasis on studies that simultaneously measure different types of effects.

iv) Life-history optimization models (e.g. Mateo et al., 2017) should be used to examine the potential effects of density-dependence on stage-specific abundance trends in declining eel populations, and on their impact on estimations of B0 from glass and yellow eel abundance series.

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Annex 7: Acronyms and Glossary

ACRONYMS	DEFINITION
ACFM (ICES)	Advisory Committee on Fisheries Management
ACOM (ICES)	Advisory Committee on Management
ADGEEL	Advice drafting group on eel, for ICES
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
EC	European Commission
EDA	Eel Density Analysis (modelling tool)
EIFAAC	European Inland Fisheries & Aquaculture Advisory Commission
EIFAC	European Inland Fisheries Advisory Commission
EMP	Eel Management Plan
EMU	Eel Management Unit
ESAM	Eel Stock Assessment Model
EU	European Union
EU MAP	The European Union Multi Annual Plan
FAO	Food and Agriculture Organisation
GEM	German Eel Model
GFCM	General Fisheries Commission of the Mediterranean
GIS	Geographic Information Systems
GLM	Generalised Linear Model
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
LAM	Lifetime anthropogenic mortalities
MS	Member State
MSY	Maximum Sustainable Yield
MoU	Memorandum of Understanding
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)
POSE	Pilot projects to estimate potential and actual escapement of silver eel
RBD	River Basin District
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
WKEPEMP	The Workshop on Evaluating Progress with Eel Management Plans
WFD	Water Framework Directive
WGRFS	Working Group on Recreational Fisheries Surveys

Glossary

Bootlace	Intermediate sized eels, approx. 10–25 cm in length (fingerlings). These terms are most often used in relation to restocking. The exact size of the eels may vary considerably. Thus, it is a confusing term.
Depensation	The effect on a population when a decrease in spawners leads to a faster decline in the number of offspring than in the number of adults.
Eel 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 waterbody, 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.
On-grown eels	Eels that are grown in culture facilities for some time before being restocked.
Silver eel production	The amount of silver eel produced from a waterbody. 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.
Restocking	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 yellow eel is also called ‘brown eel’.
EEL REFERENCE POINTS/POPULATION DYNAMICS	
$B_{current}$ (Current escapement biomass)	The amount of silver eel biomass that currently escapes to the sea to spawn, corresponding 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 restocking, corresponding to the assessment year.
B_0 (biomass)	Spawner escapement biomass in absence of any anthropogenic impacts.
F	Fishing mortality rate
M	Natural mortality

MSY	Maximum Sustainable Yield
Pristine	Conditions not affected by humans
R(s)	The amount of eel (<20 cm) restocked into national waters annually
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.
3 Bs & ΣA	Refers to the three biomass indicators (B_0, B_{best} and $B_{current}$) and anthropogenic mortality rate (ΣA)

Definition: 40% EU Target from EC 1100/2007: "The objective of each Eel Management Plan shall be to reduce anthropogenic mortalities so as to permit with high probability the escapement to the sea of at least 40% of the silver eel biomass relative to the best estimate of escapement that would have existed if no anthropogenic influences had impacted the stock". The WGEEL takes the EU target to be equivalent to a reference limit, rather than a target.