

## UK request for an independent review of the scientific basis for a UK non-detriment finding (NDF) for the international trade in European eel, seen in relation to CITES legislation

### Review summary

ICES provides three independent reviews of the scientific basis (two papers provided with the request) for a UK non-detriment finding (NDF) for the international trade in European eel. Key findings are summarized below.

The request is not concerned with the relevancy of specific NDFs, but rather with determining the scientific thoroughness of the papers presented. The reviews all conclude that the scientific work is of a high standard, given the availability of data and knowledge gaps for this species. The systems examined are relatively data rich and rigorous analyses have been applied. Any potential positive NDF found for the fisheries and associated trade described here should not be viewed as a green light for all European eel fisheries across the stock range.

Recommendations for improvements/modifications are made, including some fundamental remarks, e.g. regarding the relation of the NDF proposal to the general ICES advice on eel.

### Request

*To provide an independent review of the scientific basis (i.e. analytical methods and interpretation described in two papers) of the proposed case for a Non-Detriment Finding (NDF) for international trade in European eel caught in some UK fisheries, and to make recommendations for improvements or modifications if appropriate. It is anticipated that the findings of this review, and any UK work to address any issues identified, will be included in the evidence supporting an NDF.*

*The UK has prepared two papers to support its proposal for a non-detriment finding for trade in European eel from some UK eel fisheries:*

- 1. Draft non-detriment finding for the export from the United Kingdom (UK) of European eel *Anguilla anguilla*. This draft discussion paper (about 71 pages including annexes) provides a science-based assessment of whether it might be possible to make a non-detriment finding (NDF) for trade in European eel from the UK following its exit from the EU. An earlier draft has been provided to the EU's CITES Scientific Review Group (SRG) for their information and to provide any comment and feedback on the science.*
- 2. Population Dynamics of Lough Neagh eel. This draft paper (57 pages plus references) describes the development of population dynamics models and their application for estimating the carrying capacity of the Lough in relation to recent inputs, the contribution of restocked glass eels to the fishery catches and escapement, and predictions of catches and escapement in coming years.*

## Basis of the review

### Background

Commercial fishing for European eel (*Anguilla anguilla*) is a long-standing practice throughout the coastal and inland waters of the United Kingdom (UK). The fisheries harvest eel at all of the life-history stages that occur in continental waters, as recruits (glass eel), as juveniles (yellow eel), and as out-migrating adults (silver). Europe is a traditional market both for eels and eel products originating from UK fisheries.

As a member state of the European Union (EU) the UK has managed eel within the framework defined in Regulation (EC) No 1100/2007 (EU, 2007), which came into effect to help ensure protection and sustainable use of the European eel stock during a period of pronounced decline in status. Furthermore, the European eel was listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which came into force on 13 March 2009. Article IV of the text of the Convention states that export of an Appendix II listed species '*will not be detrimental to the survival of that species*' and that a listing does not *per se* prevent trade but requires a positive 'Non-Detriment Finding' (NDF). An NDF should account not only for harvest and trade but also for management measures, life-history, policies, non-harvest threats to the species, and any other factors seen as relevant.

In December 2010, the EU's Scientific Review Group (SRG) concluded that it was not possible at the time to perform a non-detriment finding (NDF) for the export of European eel due to concern relating to the conservation status of eel, and subsequently a zero-import/export policy was set for the EU (Anon, 2010). On that basis, EU CITES Management Authorities were not able to allow export of European eel from the EU, and all commercial trade to and from the EU of European eel in any form was banned from 3 December 2010. This ban is still in place and the implementation of the CITES Appendix II listing of European eel was reviewed in 2018 at the request of the CITES parties (Musing *et al.*, 2018), which included a review of existing NDFs, or lack thereof.

Gaynor (2014) noted that European eel is one of the most challenging species to try to make an NDF for:

- It has a complex life-cycle with multiple life stages.
- It has an extensive range that encompasses three continents and multiple regional bodies and/or management regimes.
- There are fundamental knowledge gaps in the biology and management of the species.
- There are multiple threats to the species that may impact the species cumulatively and/or synergistically, and assessing the impact of exploitation and associated trade in isolation is very difficult.
- It is traded both live and processed in a number of different forms, all of which can be reported in multiple formats.
- There is evidence of significant illegal fishing and trade which confound attempts to assess existing legal fisheries and trade.
- As wild stock is used for seeding farms around the world (and often in non-range countries), monitoring of the input and output of farmed eels is challenging.

In 2015, ICES conducted an assessment of the scale that could be used to make a non-detriment finding (ICES, 2015a, 2015b), and found that:

*"...in the absence of decisive evidence on what part of the continental stock successfully contributes to reproduction, the precautionary approach is to assume that any or all parts of the continental stock might contribute to reproduction. Taking this point into account, it may be feasible to undertake an NDF-assessment at smaller spatial scales than the entire population (and there could be valid reasons for doing so) but the risks and benefits need to be considered."*

An NDF assessment on a finer spatial scale than the total area of distribution, or only on part of the life stages from glass eel to silver eel, requires that information on the contribution of the eel from the sub-area/life stage to the spawning stock is available and sufficient to assess the eel subpopulation in question applying the advised criteria. Until such information is available ICES has advised that the scale to be used to make an NDF assessment should cover the entire stock of the European eel.

The papers reviewed were submitted to assess whether an NDF can be carried out for some UK fisheries.

## Methods

A workshop was held by correspondence. The main review was conducted by three independent reviewers.

## Results and conclusions

An NDF for harvest of a species can be made when the sum of all harvests of the species is sustainable, i.e. when harvesting neither results in unplanned range reduction, long-term population decline, nor otherwise changes the population in a way that might be expected to lead to the species' decline (Musing *et. al.*, 2018). ICES has since 2003 advised that all anthropogenic mortality/impacts should be as close to zero as possible. On this basis, no catch is non-detrimental at the scale of the whole stock. Any positive NDF would thus need to apply to specific eel management units (EMUs) or river basin districts. An NDF is considered at a finer spatial scale when the criteria for a positive NDF could be fulfilled in certain subareas and the recruitment of eels in certain water systems may be higher than the carrying capacity of the system, hence providing a surplus of eel that could be harvested without negative impact on the development of the eel stock.

The reviewed papers appear to have followed ICES standards for data acceptance and approaches to analysis.

### *Paper 1: Draft non-detriment finding for the export from the United Kingdom (UK) of European eel (Anguilla anguilla)*

Paper 1 is a discussion paper providing a science-based assessment of whether it might be possible to make a non-detriment finding (NDF) for trade in European eel from the UK following its exit from the EU.

The science background for the NDF paper seems to be as good as can be expected, given the available data. Key knowledge gaps still exist and should be addressed as core to the aims of any implementation of stocking, exploitation, and trade as proposed, ensuring improved scientific basis and understanding of the conclusions drawn at present, as well as minimizing the impact of harvest in the context of other anthropogenic threats, as stated in the most recent ICES advice.

The focus is on calculation of the minimum glass eel production required to meet the silver eel carrying capacity, however the estimate of the current production is not sufficiently well described. An explicit account should be made of the estimated glass eel production in stocking rivers such as the Severn and Parrett.

The availability and demand of eel for stocking purposes has been carefully examined, and adaptive management outlined, which is essential for a positive NDF.

### *Paper 2: Population dynamics of Lough Neagh eel*

Paper 2 describes the development of population dynamics models and their application for estimating the carrying capacity of the Lough Neagh in relation to recent inputs, the contribution of restocked glass eels to the fishery catches and escapement, and predictions of catches and escapement in coming years.

The work done here seems to be fundamentally sound, with the model structure following the one established by the Joint EIFAAC/ICES/GFCM Working Group on Eels (WGEEL) and as such following the standard developed for eel research within the scientific community. The background was peer reviewed previously by Rosell *et al.* (2005) and their findings are still considered valid. Additional historical information has subsequently been uncovered and used in this work.

The analysis of the Lough Neagh eel population and its history involve significant hindcasting and reconstruction of data series. This inevitably involves uncertainty which should be better reflected in the conclusions, particularly with respect to management applications. When extrapolating the Lough Neagh carrying capacity to, e.g. Severn and Parrett river basins, more precaution is advisable and a buffer should be considered.

## Potential areas for modifications/improvements/suggestions

See specific comments in the three reviews attached (Annexes 1–3).

Two methods are used to estimate the carrying capacity of eel. Method 1 estimates the amount of glass eel required as a minimum to produce the amount of silver eels corresponding to the carrying capacity; and Method 2 uses the pristine silver eel production used in UK eel management plans (EMPs). Both methods are associated with considerable uncertainty. As such, the more conservative method (Method 2) would seem a sensible starting point, potentially including an additional buffer to as a precautionary measure.

Assessment of glass eel surplus potential was based upon estimates of habitat carrying capacity. It appears that only available freshwater habitat was included in the calculation. The focus is on quantity, and there is no assessment of quality and how this may impact on eel production in the donor and recipient catchments. Further, the fact that glass eel fisheries, or at least those associated with some potentially important glass eel donor rivers (e.g. Severn) occur in tidal waters, introduces uncertainty into the use of the commercial fishery data given that not all glass eel can be assumed to be destined to colonize non-tidal freshwater.

ICES (2015b) suggests criteria that may be applied to support CITES NDFs, but offers no specific guidance or advice on how assessments at scales smaller than the area of occupancy for the species could be conducted. The criteria proposed by ICES (2015b) were not used to evaluate a “sub-national ” NDF. In Annex 1 of Paper 1, the indicators were applied to the stock level (the title of the section erroneously mentions “UK” level; this should be corrected).

The latest ICES advice for eel (ICES, 2018a) specifically states that restocking should take place only where survival to silver eel escapement is high, and should not be used as an alternative to reducing anthropogenic mortality. The NDF is proposed for the trade of yellow and silver eels harvested from stocking activities. As a result the approach proposed here, transferring glass eel from an overall depleted stock to another area to try improve production, seems to be going against the ICES advice. The WGEEL (ICES, 2018b) recommends using restocking in the calculation of biomass indicators, but not when calculating mortality rates. Clarification is required whether restocking is included in the calculation of biomass and mortality in the two papers.

Escapement of any silver eel does not equal spawning success as stated in Paper 2. When the specific systems from which the surplus is taken and to where they are restocked are geographical neighbors probably constitutes a “best case” scenario for restocking. However, a key knowledge gap to examine would be the differences in spawning success between stocked eels from other systems and those produced within the receiving system. This is an ongoing issue that has previously been examined by ICES Workshop on Eel Stocking (WKSTOCKEEL – ICES, 2016).

The argument that the yellow/silver eel fishery in Lough Neagh/Bann River Basin is required to finance the stocking programme is not backed by data that may quantify the problem or the successfulness of the stocking programme. The restocking programme was initiated to support the fishery, as opposed to a conservation policy.

ICES notes that the 40% silver eel escapement criterion may not be relevant, as the NDF is directed at CITES and not at EU.

While eels from donor rivers may be “surplus” from a species perspective, it is important to acknowledge that their removal may affect the eel population structure (e.g. sex ratio) and the broader freshwater ecosystem. It is not clear how the surplus has been defined in the potential donor rivers. Given that pristine biomass ( $B_0$ ) is much higher than estimates of  $B_{best}$ , it is unclear how there could be surplus production. “Pristine biomass” in the UK was determined in the 1980s after most waterway barriers had been installed, leading to lack of access to suitable habitat and habitat degradation. This loss of habitat should not be used to justify the continuing fishery. Habitat loss, in general, is largely ignored in the documents even though there are management actions that could address this problem.

With regards to an NDF for a subarea of the whole stock, regionalized management only works if management of the whole stock is coordinated. The UK currently operates under the EU Eel regulation (EU, 2007; currently under review), but will no longer be party to this after UK leaves the EU. What is missing in the provided documents is an indication of

willingness to join future relevant international eel management programmes, e.g. an indication that the UK will remain involved in the entire eel stock management programme.

The papers presented appear to be the most comprehensive attempt to carry out a sub-national level NDF. There are limitations to the work, but generally they are well done. The systems examined are relatively data rich and rigorous analyses have been applied. This advice relates to a particular situation presented in the request, any potential positive NDFs found for the fisheries and associated trade described here should not be viewed as a green light for all European eel fisheries across the range.

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## Review 1

### Review of scientific basis for the background papers to the Proposed case for a Non-Detrimental Finding (NDF) for international trade in European Eel

#### Executive Summary

1. The science background for the NDF paper seems to be as good as can be expected given the available data;
2. Improvement of the monitoring programmes are not discussed;
3. The argument that the yellow/silver eel fishery in Lough Neagh /Bann River Basin is required to finance the stockings is not discussed;
4. When extrapolating the Lough Neagh carrying capacity e.g. to Severn and Parrett river Basins more precaution is advisable and a buffer should be considered;
5. The NDF paper is lacking with respect to a discussion of the exploitation rate of yellow and silver eels in Lough Neagh. Also, a discussion of the total harvest in relation to the production of silver eels at no anthropogenic impact should be explicit in the paper;
6. The analysis of Lough Neagh eel population and its history involves significant hindcasting and reconstruction of data series. This involves uncertainty and this should be better reflected in the conclusions particular of the management applications;
7. An account of the estimate of the glass eel production (Severn and Parrett) should be explicit in the NDF paper, the focus is on calculation of the minimum glass eel production required to meet the silver eel carrying capacity while the estimate of the current production is not sufficiently well described.

#### Background

European eel (*Anguilla anguilla*) are subject to EU management plans based on EC 1100/2007; this regulation is based on an escapement target “of at least 40% of the silver eel biomass relative to the best estimate of escapement that would exist if no anthropogenic influences had impacted on the stock”. The European eel is listed as ‘Critically Endangered’ in the IUCN Red List<sup>1</sup>. Further, the European eel is listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Accordingly, before any export permit can be issued for trade the Scientific Authority of the state of export has to determine that such export will ‘not be detrimental to the survival of that species’ - this finding is referred to as a non-detriment finding or ‘NDF’. An NDF is based, in part, on resource assessment methodologies which include management measures, threats and population structure, status, harvests and trends nationally and internationally. An NDF for harvest of a species can be made when the sum of all harvests of the species is sustainable, in that it does not result in unplanned range reduction, or long-term population decline, or otherwise change the population in a way that might be expected to lead to the species’ decline<sup>2</sup>.

*ICES has since 2003 advised that “All anthropogenic mortality [impacts] as close to zero as possible, ...”<sup>3</sup> On this basis, no catch is Non-Detrimental at the scale of the population. The two papers that are presented for review<sup>4 5</sup> seek to determine whether an NDF could be made at smaller spatial-scales than at the full stock level; this option was considered that was considered by ICES (2015)<sup>6</sup>.*

<sup>1</sup> IUCN Redlist 2018 <https://www.iucnredlist.org/species/60344/45833138> accessed 13/12/2018

<sup>2</sup> Musing, L., Shiraishi, H., Crook, V., Gollock, M., Levy, E. and Kecse-Nagy, K. 2018. Implementation of the CITES Appendix II listing of European eel *Anguilla anguilla*. Report to the 30<sup>th</sup> meeting of the CITES Animals Committee. Available at: <https://cites.org/sites/default/files/eng/com/ac/30/E-AC30-18-01-A1.pdf>

<sup>3</sup> ICES. 2018. European eel (*Anguilla anguilla*) throughout its natural range. ICES Advice on fishing opportunities, catch, and effort Ecoregions in the Northeast Atlantic. Published 7 November 2018 ele.2737.nea <https://doi.org/10.17895/ices.pub.4601> ICES Advice 2018.

<sup>4</sup> Alan Walker, Derek Evans, Miran Aprahamian, Martin James, Samantha Watts, Grant Horsburgh, Kristopher Blake, Seamus Connor, Alison Littlewood & Vincent Fleming. 2018. Non-Detriment Finding for the export from the United Kingdom of European eel (*Anguilla anguilla*) - listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). DRAFT document for ICES peer review.

<sup>5</sup> M. W. Aprahamian, D. W. Evans, C. Briand, A. Walker, Y. Mc Elarney and M. Allen. 2018. Population Dynamics of Lough Neagh Eel (*Anguilla anguilla* L.).

<sup>6</sup> ICES. 2015. ICES Special Request Advice Northeast Atlantic. EU request on criteria for CITES non-detriment finding for European eel (*Anguilla anguilla*). In Report of the ICES Advisory Committee, 2015. ICES Book 9, section 9.2.3.2. Published 30th April 2015. 7 pp.

Annex 1 in Paper 1 (NDF Draft), addresses the possibility of an NDF at the stock level. This annex presents a precise analysis of the status of the European eel in relation to the ICES criteria.

The annex concludes:

*that a positive NDF for European eel exports cannot be made if considered at the level of the entire stock and so, under that approach, no international trade should be permitted under CITES*

An NDF is considered at a finer spatial scale on the basis that

- i. the European eel stock has a very wide distribution area and there may be sub-areas where the criteria for a positive NDF could be fulfilled, and
- ii. there may be water systems for which the recruitment of eels may be higher than the carrying capacity of the system, and any surplus of eel could thus be harvested without negative impact on the development of the eel stock.

The NDF draft considers the glass eel fisheries in UK and the yellow and silver eel fishery in Lough Neagh. The argument for a successful NDF is built on

- 1) There is surplus glass eel inflow to the Severn, Parrett and a few other UK river systems, i.e. glass eel densities beyond the production capacity of silver eel of these systems;
- 2) This surplus inflow can be removed from the systems without detrimental effects on their silver eel production;
- 3) The glass eel production to many River Basin systems is not sufficient to utilize fully their silver eel production capability and production may be enhanced through stocking of glass eel. Lough Neagh is in this category and stockings have taken place for several decades;
- 4) A yellow/silver eel fishery in the Lough Neagh may be allowed because Lough Neagh on its own meets the 40% criterion, provided appropriate stocking takes place. The natural production of silver eels in Lough Neagh is not at full capacity and without stockings the silver eel production is expected to be well below the 40% criterion.

The following argument is put forward: “transfer of glass eels is only possible if financed through a yellow/silver eel fishery in Lough Neagh” is found repeatedly in both papers although the argument is not backed by data to quantify the problem. Chapter 13 of paper 1 provides some insight into the socio economics of the Lough Neagh fisheries. This consideration is found to be outside this review.

**Request:** To provide an independent review of the scientific basis (i.e. analytical methods and interpretation described in two papers) of the proposed case for a Non-Detriment Finding (NDF) for international trade in European eel caught in some UK fisheries, and to make recommendations for improvements or modifications if appropriate. It is anticipated that the findings of this review, and any UK work to address any issues identified, will be included in the evidence supporting an NDF.

#### **Interpretation of the scope of the request**

Paper 1 (Walker *et al.*) is a draft for an NDF for the export from the United Kingdom of European eel (*Anguilla anguilla*). The analysis found in this paper includes elements that are beyond the scope of the request for a review whether the scientific basis (i.e. analytical methods and interpretation) are appropriate for an NDF. These chapters are required in a NDF document following the guidelines provided by CITES, see Annex I (at the end) of the present review. These elements are not considered in this review and include compliance, trade issues and management. In terms of chapters in the draft NDF paper:

Chapter	Title	Comment	Scientific Review
1	Introduction	Presenting the background for the paper	N/R
2	Biology and life history	These sections are summaries of the European Eel biology and life history. Furthermore, the summary covers a description of the fisheries and the statistics.  Issues such as compliance is outside the review, the material presented does not provide data that allow an evaluation of the claim that compliance is good.  The summaries are precise and cover the main issues.	N/R
3	Global and domestic Harvest		N/R
4	Threats and mortality		N/R
5	Fishery management measures		N/R
6	Compliance with fisheries measures		N/R
7	Monitoring of stock status		Monitoring of stock status is considered in relation to establishing the management plans
8	Conservation of the species	Background for the Eel management plans	N/R
9	Effects of illegal trade on the survival of the species	This topic is outside the realm of the scientific review	N/R
10	Products in trade	Back ground outside the scientific review	N/A
11	Socio importance of the trade	Background outside the scientific review. It is noted that an additional paper as part of the NDF package, A socio-economic appraisal has been prepared for the LNCFS (Steele, 2018).	N/A
12	Scientific background for the NDF	This is the core chapter for this evaluation	See chapters in this review below
13	Control measures	These are outside the scientific review	N/R
14	Conclusions	The Request explicitly ask that this section is not evaluated	N/R
Annex 1	Applying the ICES guidance for NDF for European eel to the UK	This section, addressing the possibility of an NDF at the stock level is well written and presents a precise analysis of the status of the European eel in relation to the ICES criteria.  The annex concludes:  <i>that a positive NDF for European eel exports cannot be made if considered at the level of the entire stock and so, under that approach, no international trade should be permitted under CITES.</i>	The reviewer finds that the analysis is well founded based on the material presented in Sections 2 and 12
Annex 2	Methods and data used in the 2014-2016 assessment of eel in England and Wales	Summary of the basis for the assessment	N/R
Annex 3		Lough Neagh eel production model	Reviewed in connection with paper 2
Annex 4		Review of circumstance for other UK eel fisheries	N/R

### Chapter 7 of paper 1: Monitoring of stock status

The approach taken in this chapter is monitoring the stock status of the yellow/silver eel production while the input – glass eel – is not accounted for in any detail.

The chapter summarises the UK monitoring programmes briefly and provides more details on the Lough Neagh programme. As a key part of the argument for an NDF finding is related to the existence of surplus glass eel production it



would be preferable if some more details on the glass eel monitoring would be provided. Apparently – based on Table 1 in paper 1 – there is a trap catching glass eel in several river basin systems. This might be described in this chapter.

## **Chapter 12 of paper 1 Scientific background for NDF of UK European Eel Fisheries**

This includes the following subchapters:

### **12.1 Identifying glass eel fisheries exploiting a surplus of recruitment**

This subchapter presents two methods to estimate the glass eel inflow that is required to fully utilize the carry capacity of the system for production of silver eels-. Both methods are based on an estimate of the wetted areas, i.e. the area in which eel may live and grow.

The approach is

*The wetted area for each river was estimated using ArcGIS analysis of the EA's Detailed River Network (DRN), with stream widths estimated according to the Ordnance Survey polygons for stream orders 2 and above, and a standard mean width of 1.5 m for stream order 1 applied. As glass eel fisheries exploit eel during their immigration through the estuary, the wetted area was estimated from the tidal limit using the Accumulated Area of water upstream calculated using the Network Analyst package.*

This approach is critically dependent on available data (EA's Detailed River Network and UK Ordnance Survey), these data are considered to be reliable and the approach seems sound.

**Method 1:** Extrapolation of the estimate for the carrying capacity from Lough Neagh where detailed data are available. The upper level for glass input is found to be 300 glass eels per hectare. The Lough Neagh model is discussed further below under the review of paper 2.

**Method 2:** The pristine silver eel production ( $B_0$ ) for the river supporting a fishery was estimated as  $B_0$  (kg) \* wetted area (ha), and this was expressed as a weight of recruits on the basis that 1 kg of glass eel was considered equivalent to 59.4 kg of silver eel.

The conversion of glass eel to silver eel 1:59.4 is based on a population model including growth and mortality. The mortality is split into a settlement period (50 days) and a subsequent growth period until maturing as silver eel at 11.9 yr (males) and 17.8 yr (female). This method estimates the amount of glass eel (weight) required as a minimum to produce the amount of silver eels corresponding to the carrying capacity.

Both methods are acceptable. Extrapolating from the Lough Neagh that is a somewhat outstanding system (the largest) to smaller systems is risky and as the productivity of the systems depends on their environment caution is advised with this approach. An argument for using the Lough Neagh approach is that this system is the better understood among the river basins.

Both methods are associated with considerable uncertainty and an uncertainty buffer may be appropriate for the application to EMPs as a precautionary measure. As an example of the uncertainty one may mention that the conversion from number of glass eel to weight is based on a fixed weight per individual which combined with the discussion found in paper 2 on the changes in the productivity of the systems over the time-series.

These two approaches were applied to the 25 rivers for which commercial glass eel fisheries reported catches to the EA for 2015 to 2017. Those that have the potential to yield a surplus under one or both methods are shown in Table 1. The "300 glass eel per hectare" method suggested 13 fisheries with the potential to yield a surplus, totalling about 2378 kg glass eel. The " $B_0$  silver eel escapement" method was more cautious, suggesting 6 fisheries with a total of about 1391 kg. A buffer to account for uncertainty – a precautionary approach – would revise the list down to only two River Basins (Severn and Parrett) with a surplus production – based on method 2 – of about 1350 kg glass eel pa less whatever a precautionary buffer may dictate.

## 12.2 Lough Neagh eel production

Lough Neagh production is considered in detail in paper 2 (Arahamian *et al* <sup>7</sup>). This paper is aiming “...to develop an input-output model(s), ..., that describes the dynamics of the eel population in Lough Neagh, which [model] could then be used; 1) for the sustainable management of the stock, 2) to set reference points, 3) to quantify the levels of anthropogenic (fishing) mortality and 4) to assess compliance with the EC 40% escapement target.

The paper establishes a comprehensive database for the subsequent analysis including reconstruction of recruitment and catch series. The process is described in Section 2.3 and is based on a simplified version of the GLM approach established by WGEEL which is a standard approach to such problems. The construction of silver eel equivalents of the yellow eel catch is based on application of one peer reviewed paper <sup>8</sup> and the application of this paper in an EU project <sup>9</sup>.

This work seems to be done with care but is of course linked with a certain degree of uncertainty as a series of assumptions are required to the reconstruction. These uncertainties will return when the results are applied e.g. for management decisions and should be taken into account at this stage. This link seems to be less considered than what might be advisable although the Discussion section provides an adequate basis for the analysis.

To support the analysis the paper also considers environmental parameters in particular the flow and the authors should be commended to include this analysis.

The work seems to be fundamentally sound, the model structure follows the structure laid down through ICES WGEEL group work and as such follows the standard that has been developed within the eel research community. The background has been previously peer reviewed and the findings are still considered valid.

### Does the Lough Neagh – Bann system meet the EU 40% criterion? Is this question relevant?

The production of silver eels from Lough Neagh has not been addressed by its own chapter e.g. as an additional chapter 12.3 or elsewhere in the paper. Information can be found in paper 2. The executive summary of paper 2 promises “The findings are discussed in relation to 1) the European Eel Regulation 40% escapement biomass target and ...”

This point may not be relevant as the NDF is directed at CITES and not EU (after Brexit). Even so, the level of the catch relative to production should have its own chapter in the NDF paper. One may note that the original ICES advice pointed to a range (30–50%) rather than a fixed number and the 40% criterion was a EC decision found necessary in a management context.

### Annex I CITES Resolution Conf. 16.7 (Rev. CoP17) [Extract]

a) Scientific Authorities take into account the following concepts and non-binding guiding principles in considering whether trade would be detrimental to the survival of a species:

- i) a non-detriment finding for an Appendix-I or -II species is the result of a science-based assessment that verifies whether a proposed export is detrimental to the survival of that species or not;
- ii) Scientific Authorities should consider whether the species would be maintained throughout its range at a level consistent with its role in the ecosystems in which it occurs;
- iii) in making a non-detriment finding, Scientific Authorities should consider the volume of legal and illegal trade (known, inferred, projected, estimated) relative to the vulnerability of the species (intrinsic and extrinsic factors that increase the risk of extinction of the species);

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<sup>7</sup> M. W. Aprahamian, D. W. Evans, C. Briand, A. Walker, Y. Mc Elarney and M. Allen. 2018. Population Dynamics of Lough Neagh Eel (*Anguilla Anguilla* L.).

<sup>8</sup> Aprahamian, M. W., Walker, A. M., Williams, B., Bark, A., & Knights, B. (2007). On the application of models of European eel *Anguilla anguilla* production and escapement to the development of Eel Management Plans: the River Severn. ICES Journal of Marine Science, 64: 1472–1482.

<sup>9</sup> Walker, A. M., Andonegi, E., Apostolaki, P., Aprahamian, M., Beaulaton, L., Bevacqua, P., Briand, C., Cannas, A., De Eyto, E., Dekker, W., De Leo, G., Diaz, E., Doering-Arjes, P., Fladung, E., Jouanin, C., Lambert, P., Poole, R., Oeberst, R. & Schiavina, M. (2013). Lot 2: Pilot project to estimate potential and actual escapement of silver eel. Final project report, Service Contract S12.539598, Studies and Pilot Projects for Carrying out the Common Fisheries Policy, European Commission Directorate-General for Maritime Affairs and Fisheries (DG MARE), 358 pp.  
[http://ec.europa.eu/fisheries/documentation/studies/silver-eel/index\\_en.htm](http://ec.europa.eu/fisheries/documentation/studies/silver-eel/index_en.htm)

- iv) the data requirements for a determination that trade is not detrimental to the survival of the species should be proportionate to the vulnerability of the species concerned;
- v) the making of an effective non-detriment finding relies upon a correct identification of the species concerned and verification that it is specimens of this species that are to be exported;
- vi) the methodology used to make a non-detriment finding should reflect the origin and type of specimen, such that the method used to make a non-detriment finding for a specimen known to be of non-wild origin may be less rigorous than that for a specimen of wild origin for example;
- vii) the methodology used should be flexible enough to allow for consideration of the specific and individual characteristics of different taxa;
- viii) the implementation of adaptive management, including monitoring, is an important consideration in the making of a non-detriment finding;
- ix) the non-detriment finding is based on resource assessment methodologies which may include, but are not limited to, consideration of:
  - a. species biology and life-history characteristics;
  - b. species range (historical and current);
  - c. population structure, status and trends (in the harvested area, nationally and internationally);
  - d. threats;
  - e. historical and current species-specific levels and patterns of harvest and mortality (e.g. age, sex) from all sources combined;
  - f. management measures currently in place and proposed, including adaptive management strategies and consideration of levels of compliance;
  - g. population monitoring; and
  - h. conservation status; and
- x) the sources of information that may be considered when making a non-detriment finding include but are not limited to:
  - a. relevant scientific literature concerning species biology, life history, distribution and population trends;
  - b. details of any ecological risk assessments conducted;
  - c. scientific surveys conducted at harvest locations and at sites protected from harvest and other impacts; and
  - d. relevant knowledge and expertise of local and indigenous communities;
  - e. consultations with relevant local, regional and international experts; and Resolution Conf. 16.7 (Rev. CoP17)-3
  - f. national and international trade information such as that available via the CITES trade database maintained by UNEP World Conservation Monitoring Centre (UNEP-WCMC), publications on trade, local knowledge on trade and investigations of sales at markets or through the Internet, for example;

## Review 2

### Review of papers relating to Non-Detriment Finding for the export from the United Kingdom of European eel (*Anguilla anguilla*)

#### Preamble

The European eel (*Anguilla anguilla*) was listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which came into force on 13 March 2009. Article IV of the text of the Convention, states that export of an Appendix II listed species 'will not be detrimental to the survival of that species' and a listing per se does not prevent trade but requires a positive 'Non-Detriment Finding' (NDF). A NDF should account for not just harvest and trade but also management measures, life-history, policies, non-harvest threats to the species and other factors felt to be relevant.

In December 2010, the EU's Scientific Review Group (SRG) concluded that at the time it was not possible to perform a Non-Detriment Finding (NDF) for the export of *A. anguilla* due to concern relating to its conservation status and subsequently a zero-import/export policy was set for the EU<sup>10</sup>. On that basis, EU CITES Management Authorities were not able to allow export of *A. anguilla* from the EU and commercial trade in all commodities of *A. anguilla* to and from the EU was banned from 3 December 2010. At the time of writing this ban is still in place and the implementation of the listing was reviewed in 2018 at the request of the CITES parties<sup>11</sup>, which included reviewing existing NDFs, or lack thereof.

This review stated:

Gaynor (2014)<sup>12</sup> noted that *A. anguilla* is one of the most challenging species to try to make a NDF for. There are a number of reasons why this is particularly difficult for *A. anguilla*, including:

- It is considered to be panmictic i.e. from a single population.
- It has a complex life cycle with multiple life stages (see Figure 1).
- It has an extensive range crossing three continents and multiple regional bodies and/or management regimes.
- There are fundamental knowledge gaps in the biology and management of the species that hinder stock assessments, such as:
  - An estimate of spawning biomass
  - The scale of density dependant mortality
  - Sex ratios
  - The relationship between recruitment and spawning stock
  - The effectiveness of management interventions e.g. EU Council Regulation (EC) No 1100/2007
  - The effectiveness of re-stocking on the replenishment of the spawning stock
- There are multiple threats to the species that may impact the species cumulatively and/or synergistically and assessing the impact of exploitation and associated trade in isolation is very difficult.
- It is traded both live and processed in a number of different forms all of which can be reported in multiple formats (see Sections 3–5).
- There is evidence of significant illegal fishing and trade which confound attempts to assess existing legal fisheries and trade (see Section 7)
- As wild stock has to be used to seed farms around the world (and often in non-range States), monitoring of the input and output of farmed eels is challenging.

<sup>10</sup> Summary of Conclusions. 54<sup>th</sup> Meeting of The Scientific Review Group on Trade in Wild Fauna and Flora. Brussels 3<sup>rd</sup> December 2010. [https://circabc.europa.eu/sd/a/49ab3fc9-646b-4b35-ac42-f0333479ce24/54\\_summary\\_srg.pdf](https://circabc.europa.eu/sd/a/49ab3fc9-646b-4b35-ac42-f0333479ce24/54_summary_srg.pdf).

<sup>11</sup> Musing, L., Shiraishi, H., Crook, V., Gollock, M., Levy, E. and Kecse-Nagy, K. 2018. Implementation of the CITES Appendix II listing of European eel *Anguilla anguilla*. <https://cites.org/sites/default/files/eng/com/ac/30/E-AC30-18-01-A1.pdf>

<sup>12</sup> Gaynor, K. (2014). An assessment of the challenges faced in making a Non-Detriment Finding (NDF) for *Anguilla anguilla* (European eel). Master's thesis, Universidad Internacional de Andalucía.

In 2015<sup>13</sup>, ICES were requested to:

...provide scientific information and advice on the following issues:

- 1) What criteria (and if possible, what thresholds) that could be used to make a Non-Detriment Finding in the future.
- 2) An assessment of the scale that could be used to make a Non-Detriment Finding.
- 3) An assessment of possible conditions that could be used in association with a Non-Detriment Finding (e.g. quota, or size of specimens, or any other condition).

With regard to point 2, which relates to the present paper, it was stated:

*With respect to the spatial scale on which an NDF might be assessed, in the absence of decisive evidence on what part of the continental stock successfully contributes to reproduction, the precautionary approach is to assume that any or all parts of the continental stock might contribute to reproduction. Taking this point into account, it may be feasible to undertake an NDF-assessment at smaller spatial scales than the entire population (and there could be valid reasons for doing so) but the risks and benefits need to be considered.*

The recent review by Musing *et al.* (2018) highlighted that some attempt to carry out, national-level NDFs had already occurred in Norway, Turkey and countries in North Africa. The papers reviewed below have been submitted in the context of assessing whether a NDF can be carried out at a national scale for/within the UK. The first paper<sup>14</sup> (paper 1) relates to carrying out a NDF for European eels in the UK; the second<sup>15</sup> (paper 2) analyses the population dynamics of Lough Neagh.

### Summary findings

The core of an NDF is that trade will '*not be detrimental to the survival of that species*', which, by association also means harvest that contributes to this trade, either for consumption, aquaculture or stocking, should not be detrimental. As stated above, determining non-detriment for the European eel, is potentially very challenging, but the two papers have presented a comprehensive case, using the best available data for how a positive NDF could be achieved for certain UK waterbodies. However, there are still key knowledge gaps that should be addressed as core to the aims of any implementation of stocking, exploitation and trade proposed, to ensure there is improved understanding of the conclusions drawn at present, and that the impact of harvest, in the context of other anthropogenic threats, is minimised, as per the most recent ICES Advice<sup>16</sup>.

Analysis included in Paper 1 indicated that a NDF was not possible across the species range using the criteria proposed by ICES (2015). It has already been highlighted that biologically (ICES, 2015), there are questions over whether a national-level NDF can be carried out for a panmictic species. However, the data presented proposes, that Lough Neagh's unique circumstances, which utilise 'surplus' glass eels from English rivers to supplement natural recruitment in a very controlled environment with tightly-managed fisheries, can meet present EU Eel Management Plan targets for escapement<sup>17</sup>. That said, escapement of any silver eel does not equal spawning success and as stated in Paper 2, the use of stocked eels from other systems may influence this success. This should be a key knowledge gap to examine. Further, while eels from donor rivers may be 'surplus' from a species perspective, it is important to acknowledge that their removal may affect the broader freshwater ecosystem.

<sup>13</sup> ICES. 2015. Report of the Workshop on Eel and CITES (WKEELCITES), 10–12 March 2015, Copenhagen, Denmark. ICES CM 2015/ACOM:44. 57 pp.

<sup>14</sup> Alan Walker, Derek Evans, Miran Aprahamian, Martin James, Samantha Watts, Grant Horsburgh, Kristopher Blake, Seamus Connor, Alison Littlewood & Vincent Fleming. 2018. Non-Detriment Finding for the export from the United Kingdom of European eel (*Anguilla anguilla*) - listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). DRAFT document for ICES peer review

<sup>15</sup> M. W. Aprahamian, D. W. Evans, C. Briand, A. Walker, Y. Mc Elarney and M. Allen. 2018. Population Dynamics of Lough Neagh Eel (*Anguilla anguilla* L.).

<sup>16</sup> <http://ices.dk/sites/pub/Publication%20Reports/Advice/2018/2018/ele.2737.nea.pdf>

<sup>17</sup> "The objective of each Eel Management Plan shall be to reduce anthropogenic mortalities so as to permit with a high probability the escapement to sea of at least 40% of the silver eel biomass relative to the best estimate of escapement that would exist if no anthropogenic influences had impacted on the stock."

Should the proposed positive NDF allow fisheries and trade to develop in a manner outside of present limitations implemented by the EU, the Severn/Parrett/Lough Neagh axis potentially provides, with appropriate monitoring, research and enforcement, a highly controlled opportunity to more fully examine the impacts and effectiveness of stocking and whether sub-national NDFs are possible. However, it is essential to recognise that Lough Neagh is a very unique system and there is more data available than most, if not all, fisheries for this species. Further, a precautionary approach has been taken in this assessment e.g. assuming 100% catch in the glass eel fisheries used to stock Lough Neagh and using a range of relevant models to assess these waterbodies. As such, the positive NDF for the fisheries and associated trade described, should not be viewed as a green light for all European eel fisheries across the range. The supply and demand has been carefully examined, and adaptive management outlined, which is essential for a positive NDF.

## Specific Comments

### Paper 1

#### Page 16:

*'...silver eel escapement in all RBD supporting glass eel fisheries below the long-term objectives set by the principle of the EC Eel Regulation (EC 1100/2007) (see 2.2.2 above). However, the potential recruitment surplus for specific rivers was also assessed and will be described later in this paper.'*

Fisheries are identified as the major impact on these RBDs, and while there may be 'surplus' in rivers within them, if the fishery is to continue to provide seed for Lough Neagh, and the 40% target is being used as relevant metric in the justification for a positive NDF, it would be useful to outline what management measures might be implemented outside of fisheries across the donor RBDs to achieve this target.

#### Page 25:

*'A surplus is defined as the part of the recruitment exceeding that required to achieve carrying capacity within the relevant system.'*

It appears that only habitat availability is included in the calculation and no assessment of quality, which would undoubtedly have the potential to influence this calculation. Also, any mortality of 'surplus' will play a role in the broader freshwater ecosystem.

#### Page 26:

*'These two approaches were applied to the 25 rivers for which commercial glass eel fisheries reported catches to the EA for 2015 to 2017. Those that have the potential to yield a surplus under one or both methods are shown in Table 1. The "300 glass eel per hectare" method suggested 13 fisheries with the potential to yield a surplus, totalling about 2378 kg. The "B<sub>0</sub> silver eel escapement" method was more cautious, suggesting 6 fisheries with a total of about 1391 kg.'*

Considering the status of the species, the more conservative model would seem a sensible starting point.

#### Page 28:

*'Natural recruitment to this fishery is dependent upon assisted migration up the River Bann into Lough Neagh and by stocking of glass eels from other catchments (predominantly the UK fisheries). Even with the commercial fishery for yellow and silver eels, the Lough Neagh silver eel escapement, (as an average from 2003 to 2017), is estimated at 43.7% of pristine - exceeding the '40%' long term objective (Defra, 2018). If future international trade was not possible, this is likely to lead to the closure of the fishery and, in turn, the cessation of stocking, assisted migration trucking and year-round enforcement patrols by the LNFCs as a direct consequence of revenue loss. This might result in a perverse outcome if that course of action was to result in a reduced biomass of silver eels escaping to the sea. The reduction in policing by the LNFCs could also increase the potential for illegal activity in the area.'*

While we have been asked to review the science, it is important to recognise pragmatic matters and this clearly highlights how the fishery has added-value.

**Page 31:**

*'Being above carrying capacity, these glass eels, if left in situ in the donor catchment, would not have otherwise contributed to silver eel escapement.'*

As carrying capacity has only been assessed using available habitat and not quality, this feels like a rather definitive statement.

**Page 35:**

*'Stocking of Lough Neagh is necessary to support the fishery, to achieve / exceed the long-term silver eel escapement objective, and to ensure the Lough provides a net benefit to silver eel escapement by using glass eels that would, if left in donor catchments, be unlikely to mature into silver eels due to density dependent mortality (i.e. a recruitment surplus).'*

Solely considering density-dependent mortality rules out the impacts of one-off events e.g. pollution incidents and removing the full recruitment buffer for stocking could be a risky strategy.

**Page 36:**

*'...as part of the NDF, the LNFCs will, as an additional conservation measure, stock glass eels whenever possible into other river and lake systems in Northern Ireland which are not fished and which have been assessed as suitable habitat for silver eel production and escapement.'*

Simply stocking glass eels in to unfished rivers is not conservation; there needs to be a follow-up monitoring on the benefits and impacts of this activity.

**Page 38:**

*'The estimate of surplus glass eel from some glass eel fisheries in England and Wales takes a very precautionary approach of assuming that the fishery exploits 100% of the recruitment to the relevant river.'*

This precautionary approach should be applauded.

*'This approach will be reviewed when more accurate estimates of exploitation rate become available.'*

One would assume that developing these improved estimates will be part of the programme of research and adaptive management.

*'If further or new information on species abundance, distribution and harvest becomes available, harvest (and trade) levels can be reassessed.'*

This is fundamental to the NDF and associated adaptive management.

**Annex 1:**

Should the title of this not be for 'the stock across it's range' and not 'the UK'?

**Paper 2**

I am not a modeller or mathematician, and so while my grasp of the content is limited, I have made a few cursory points below. However, it is clear that the data available to input to them, the limitations of which are acknowledged by the authors (page 43), is comprehensive compared to most, if not all, other datasets relating to the species. This gives

confidence in the conclusions drawn from the population model, and the associated metrics relating to mortality, the contribution of stocking to escapement and total escapement.

**Page 33:**

*'Given the assumption that there is no difference in survival between wild and stocked glass eel...'*

This seems to contradict statements and analysis later in the document relating to how well stocked eels might contribute to escapement:

*'There is some evidence to suggest that stocked glass eel do not perform as well as wild / translocated glass eel from the Lower River Bann.'* (Page 53).

*'There is some evidence to suggest that stocked glass eel do not survive as well as wild glass eel.'* (Page 39).

**Page 44:**

Table 8 highlights the relative strength of Lough Neagh's long-term dataset compared to similar systems across the species' range.

**Recommendations**

Some suggestions have been made in the above text, but below are some top-line recommendations:

- As per the suggestion of the ICES WKEELSTOCK report<sup>18</sup> marking of fish to look at the benefits and limitations of stocking would have value:

*'Where eel are translocated and stocked, batch marking to distinguish between groups recovered in later surveys should be undertaken to evaluate their fate and their contribution to silver eel escapement.'*

- It would be very valuable to carry out satellite tagging studies of escaping stocked silver eels to understand if they migrate similar to other eels, however, the logistical challenges of keeping a proportion of stocked eels separate from wild eels may prohibit this.
- The use of more conservative models and metrics where possible should be encouraged in the first instance, while the national-level NDF is tested.
- Within the documents there were a number of references to how any new data might help to adapt any future exploitation, trade and management. I would see the fisheries described in the two documents as having the potential provide opportunities to collect this data through on-going collection of data and/or novel research to fill identified knowledge gaps.
- Any future attempts to carry out national-level NDFs by other range states should aim to use a similar level of rigour as the present documents.

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<sup>18</sup> ICES. 2016. Report of the Workshop on Eel Stocking (WKSTOCKEEL), 20–24 June 2016, Toomebridge, Northern Ireland, UK. ICES CM 2016/SSGEPD:21. 75pp. <http://ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/SSGEPD/2016/01%20WKSTOCKEEL%20-%20Report%20of%20the%20Workshop%20on%20Eel%20Stocking.pdf>



## Review 3

### Review of the Scientific Basis for a UK Non-Detriment Finding (NDF) for the International Trade in European Eel, in Relation to CITES Legislation

#### Context of Review

Commercial fishing for European eel (*Anguilla anguilla*) is a long-standing practice throughout the coastal and inland waters of the United Kingdom (UK). The fisheries prosecute eel at all of the life-history stages that occur in continental waters, as recruits (glass eel), as juveniles (yellow eel) and as out-migrating adults (silver). Europe is a traditional market both for eels and eel products originating from UK fisheries. As a Member State of the European Union (EU) the UK has managed eel within the framework defined in Regulation (EC) No 1100/2007 which came into effect to help ensure protection and sustainable use of the European eel stock during a period of pronounced decline in status. The regulation requires management within plans that establish escapement targets based upon potential silver eel production under conditions of no human-induced mortality and high, healthy levels of recruitment. Within the UK Eel Management Plans (EMP) have been developed for River Basin Districts. Monitoring occurs to support assessment of current silver eel escapement relative to the target escapement.

European eel were added concurrently to Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) to Annex B of the EU Wildlife Trade Regulations in March 2009. Imports and exports of European eels were suspended by the EU in December 2010 because it could not be shown that these were not detrimental to the survival of the species, the Non-Detriment Finding (NDF) under CITES. The EU maintained provisions for continued internal trade, UK fisheries accordingly continued to supply the European market for European eels after December 2010.

Change in the status of the UK to a Third Party Country will result in the loss of access to the internal EU market for European eel unless the designated UK Scientific Authority can make a NDF for European eel caught in the domestic fisheries. ICES (2015) has proposed that NDF's could be considered at spatial-scales smaller than the range of the species on the bases that (i) the European eel stock has a very wide distribution area and there may be sub-areas where the criteria for a positive NDF could be fulfilled, and (ii) there may be water systems for which the recruitment of eels may be higher than the carrying capacity of the system, and any surplus of eel could thus be harvested without negative impact on the development of the eel stock.

An independent review of the scientific basis of the case for a NDF, as proposed by the UK Scientific Authority, for international trade in European eel caught in UK fisheries has been requested, with particular emphasis on 1) glass eels from English and Welsh rivers that represent potential donor populations to support stocking and 2) yellow and silver eels in the River Bann in Northern Ireland, including Lough Neagh. The Lough Neagh eel fisheries are supported by supplemental stocking of glass eels sourced either from the lower River Bann or from elsewhere in the UK.

The review is to focus on analytical methods and interpretation of resultant analyses and to make recommendations for improvements or modifications if appropriate.

The materials to be reviewed are:

Paper 1. Draft non-detriment finding for the export from the United Kingdom (UK) of European eel *Anguilla Anguilla*, and

Paper 2. Population Dynamics of Lough Neagh eel.

#### General Comments

ICES (2015) suggests criteria that may be applied to support CITES NDF's but no specific guidance or advice on how assessments at scales smaller than the area of occupancy for the species could be conducted. Paper 1 (the draft NDF) draws upon several authoritative CITES sources to help develop a structure and then applies the criteria suggested by ICES (2015). Thus, the authors have made good use of available advice regarding the preparation of a

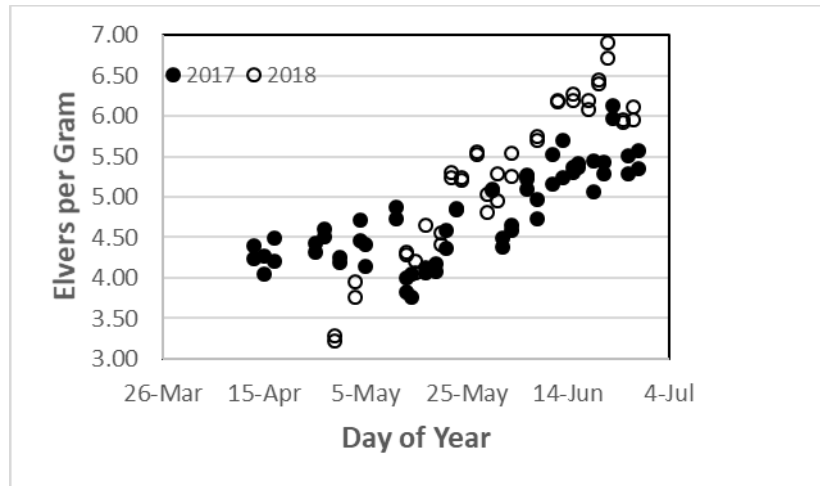
NDF. As well, the authors appear to have limited their sources of input data and models to those that have been accepted for use by UK regulatory agencies responsible for managing domestic eel fisheries and those that contribute to ICES stock assessments. I have not had the benefit of having contributed to an ICES-led eel stock assessment cycle but from what I can gather from a gleaning of recent published reports the authors of Papers 1 and 2 appear to have followed ICES standards for data acceptance and approaches to analysis.

Overall the authors have demonstrated that on the basis of the CITES criteria related to species status that a positive NDF could not be found at the spatial scale of the UK, recruitment indices are below the 15% 1960–1979 baseline. Thus any positive NDF would need to apply to specific Eel Management Units (EMU) or River Basin Districts.

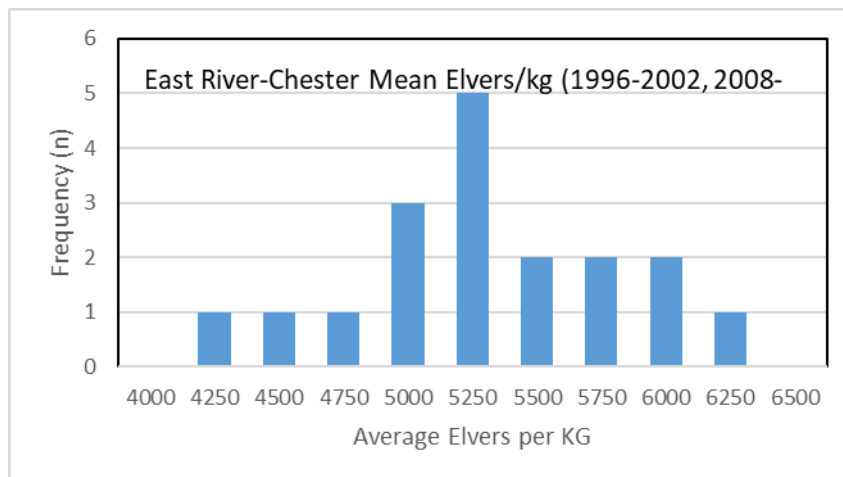
The Neagh Bann River Basin District River as a discrete management unit within which the River Bann-Lough Neagh catchment is the dominant feature such that the status of European eel within the catchment likely defines the status of glass eel recruitment, eel standing stock, silver eel production, and fishery-effects for this District. Evaluation of the status of eel life-stages in other EMU's is less straight-forward, particularly where numerous drainages with direct connections to tidal water are contained within the EMU boundary and/or where fishery-dependent information related to recruitment, yellow eel standing stock and silver eel production/exploitation/escapement is less robust than for Lough Neagh. In these instances index rivers represent the principle sources of information.

### Specific Comments

1. Identification of EMU's wherein the availability of glass eels in abundances that exceed local carrying capacity, and the potential benefit to overall silver eel production that might result from translocation of surplus glass eels to EMU's where production is presently depressed, are core elements of the draft NDF evaluation. Neither manuscript submitted for review is clear on availability of fishery-independent glass eel indices for EMU's other than for the Neagh Bann EMU. Glass eel index data for all other EMU's appears to be fishery-dependent and therefore would not likely represent complete counts. The authors assumed 100% capture efficiency to generate conservative and precautionary estimates of glass eel availability. Assessment of glass eel surplus potential was based upon estimates of freshwater habitat carrying capacity. The fact that glass eel fisheries, or at least those associated with some potentially important glass eel donor rivers (e.g. Severn) occur in tidal waters, introduces uncertainty into the use of the commercial fishery data given that not all glass eel can be assumed to be destined to colonize non-tidal freshwater (i.e., facultative processes in the determination of degree of catadromy are not considered). The documents are silent on facultative catadromy as a factor in estimation of glass eel availability to enhance freshwater productivity.
2. Glass eel are assumed to be "Young, unpigmented eel, recruiting from the sea into continental waters." It is unclear from the documents if all so-defined specimens, either previously translocated to Lough Neagh, or those removed by the capture fisheries that were used to estimate glass eel availability/surpluses meet this definition. Information that can substantiate that only glass eel have been stocked, or captured in commercially fisheries, should be presented, if available, to support use of the 3000 glass eel/kg conversion in all subsequent calculations for a number of reasons. For instance, elver number per unit weight can vary significantly with time, both within-year and between years. The following figure shows change with time for *A. rostrata* as measured at the head of tide on the East River-Chester, Nova Scotia, Canada (R.G. Bradford, unpublished data). Variability approaching a factor of two over the duration of runs can be anticipated within a year and overall variability between years can be expected.



The within-season timing of glass eel removals relative to the timing and duration of the natural run is therefore potentially important to understand. As well, the average 'count per kilogram' can vary significantly among years. The following figure shows the range in the average elvers/kg (total run size (n)/total run size (kg)) for the years 1996–2002, 2008–2017 on East River-Chester can exceeds 40%.



3. Potential variability in glass eel/elver number per unit weight and the development stage of stocked animals lends uncertainty to the appropriateness of the settlement instantaneous natural mortality rate of 0.00915 day<sup>-1</sup>, (95% CI ± 0.00149 day<sup>-1</sup>) which is based on back-casting to 80 cm from the relationship derived by Bisgaard and Pederson (1991) for ~15 cm–~60 cm yellow eels. Reporting of the sensitivity of the glass eel-silver eel equivalent (1 kg = 59.4 kg) to the instantaneous natural mortality rate may be warranted. As well I suspect that an 8 cm total body length would be more representative for river age 1+ year old or older eels rather than river age 0+ year old eels.
4. If verification that only unpigmented eels are being stocked/captured is not possible then it may be prudent to adopt the WGEEEL definition of glass eel, i.e. all recruits of the 0+ cohort age (including pigmented stages).
5. In the event that the actual number (n) of recruits and/or stocked animals are not known then it may be more factual to report and display (e.g. Figure 5, Paper 1; Figures 13 and 14, Paper 2) the relationship between eel recruitment and silver eel production in kilograms.
6. Reporting of the goodness of fit statistics for both the Beverton–Holt and Ricker models (Paper 2) would be helpful.
7. If existence of significant inter annual variability in number of glass eel per kg (Comment 2 above) were to be shown to be possible (and with that the possibility that instantaneous natural mortality might vary with physiological development of stocked animals) it may be relevant to ask if the Beverton-Holt model would continue to yield a better fit over the Ricker model.

8. Given the definition of  $B_{best}$  as the ‘the amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the current stock’ I find it difficult to accept that the recruitment of glass eels to proposed donor rivers (i.e., Severn) exceeds local production potential.  $B_{best}$  is estimated (Tables A2.1 and A2.2, Paper 1 see below) not to have exceeded 2.06 kg/ha in any time period. This value is significantly lower than the estimates of  $B_0$ , ‘the amount of (historic pre-1980s reference period) silver eel biomass that would have existed if no anthropogenic influences had impacted the stock’, of 6.84 kg/ha and 11.98 kg/ha in the presence and absence of barriers respectively.

9.

RBD	River	$B_{best}$ (kg ha <sup>-1</sup> ) 2005–2007	$B_{best}$ (kg ha <sup>-1</sup> ) 2008–2010	$B_{best}$ (kg ha <sup>-1</sup> ) 2011–2013	$B_{best}$ (kg ha <sup>-1</sup> ) 2014–2016
Severn(Table A2.1)	Severn	1.18	1.48	1.33	0.51
Severn(TableA2.2)		0.45	2.06	1.13	1.08

From Table A2.12

River Basin District	$B_0$ In the presence of barriers (kg ha <sup>-1</sup> )	$B_0$ In the absence of barriers (kg ha <sup>-1</sup> )	Comment
Severn	6.84	11.98	Severn 1983

10. Estimates of eel production, production potential and change with time rely extensively on electrofishing-based abundance estimates of yellow eel (Knights *et al.*, 2001) are key inputs for the Scenario-based Model of Eel Production II (SMEP II) (Aprahamian *et al.*, 2007) but the draft NDF contains no summary of the input data. Scatterplots of eel abundance estimates versus year of survey for at least the rivers recommended as having a surplus of glass eels would be helpful as a means to assess the usefulness of the data.
11. Paper 1 (page 26) states that Lough Neagh eel carrying capacity is reported as having been found to be 300 glass eels per hectare in a range of studies. None of the citations (Moriarty (1999); Moriarty and Dekker (1997) and Rosell *et al.* (2006)) provide empirical support for this statement. Moriarty and Dekker (1997) cite Knights and White (1997) when discussing glass eel stocking requirements.

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