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Non-detriment finding assessment for the export from the United Kingdom of CITES-listed European eel *Anguilla anguilla* (2023–26)

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Summary

1. European eel (*Anguilla anguilla*) is listed in Appendix II of the Convention on International Trade in Endangered Species (CITES), and in Annex B of the Wildlife Trade Regulations which implement CITES in the UK, meaning that no international trade can be authorised unless it can be demonstrated that such trade is not detrimental to the survival of the species in the wild.

2. This document provides the over-arching non-detriment finding (NDF) assessment under CITES for trade in European eel (*Anguilla anguilla*) from the United Kingdom (UK) including, under the provisions of the Northern Ireland Protocol, between Great Britain and Northern Ireland. Any individual applications for trade will be assessed against this NDF to provide specific advice in each case. This over-arching NDF will be reviewed every three years. This over-arching NDF has been reviewed by the International Council for the Exploration of the Sea (ICES) and the CITES Animals Committee.

3. This NDF demonstrates that regulated trade from specified UK fisheries is not only sustainable but can also, in the case of Lough Neagh (see below), provide a conservation benefit by increasing production and associated escapement of silver eels above that which would have occurred without fishery-related interventions.

4. European eels constitute a single, panmictic and semelparous stock which breeds in the Sargasso Sea but whose continental life stages are shared by many countries over a wide and dispersed range across Europe and North Africa. The species is listed as **Critically Endangered** in the IUCN (International Union for Conservation of Nature) Red List due to a greater than 90% decline in recruitment of glass eels over the past 45 years with associated consequential declines also in yellow and silver eel life stages (IUCN criteria A2bd+4bd).

5. Whilst ICES (International Council for the Exploration of the Sea) recommends that any NDF is made at the level of the full stock, evidence provided here demonstrates that a positive NDF can be made at smaller spatial scales. Using this approach, the NDF justifies continued sustainable trade from two main fisheries:

   a) live glass eels from the rivers Severn and Parrett (South West England) and

   b) yellow and silver eels from Lough Neagh, Northern Ireland.

6. **Glass eel fisheries**, using hand nets only, operate in several estuaries on the west coast of Great Britain (GB). The average annual catch of glass eel in GB fisheries was about 4.5 tonnes or 7.9% of the 2018 total European glass eel catch (57 tonnes); recent harvests have been reduced due to the COVID-19 pandemic and the loss of access to former markets. Live specimens have been traded to Lough Neagh since 1984 for stocking; and were formerly traded for over 40 years to the European Union (EU) for both stocking and for aquaculture. Recently, some glass eels have been traded to a non-EU range State for stocking purposes only.

7. These glass eel fisheries have been assessed, using a **highly precautionary approach**, to identify if there were any whose recruitment levels exceed the estimated catchment carrying capacity. This analysis, using mean catch rates for 2015 to 2017, suggested that surpluses were available in eight rivers, but substantial weights of such surpluses were present in only two, the Severn and Parrett.

8. **Lough Neagh**, the largest lake by area in the UK, is shallow and extremely productive. Recruitment of eels to the lough is entirely dependent on assisted migration of glass eels up the river Bann and, additionally, on glass eels stocked predominantly from the GB donor catchments mentioned above.

9. Lough Neagh supports the largest wild eel fishery in Europe (13.8% of the total UK and EU catch), with a harvest of approximately 250 tonnes of yellow and silver eels valued at £3 million (GB) per year (p.a.) The fishery is managed through a cooperative; historically approximately 80% of its catch was traded to EU Member States with the remainder marketed in GB.

10. Models developed, using catch (greater than 100 years) and environmental data, to estimate eel production in Lough Neagh demonstrate a conservation **net benefit** of stocking sustainably sourced glass eels from identified GB fisheries (as above), leading to **more** silver eel production and associated escapement, even after fishery catches, than if the glass eels had been left *in situ* in donor rivers.

11. Lough Neagh achieves the UK Eel Regulation target of 40% escapement of silver eels, but this depends on stocking glass eels, a practice that is dependent on funding from a viable fishery and on having access to a non-detrimental source of supply from GB. Funding from the fishery towards stocking purchases has been supplemented by both the UK government and, formerly, the EU.

12. The UK will use safeguards to restrict levels and purpose of trade to ensure that non-detriment continues to be achieved. These will be complemented by measures for fisheries management and traceability of supply chains.

13. No evidence is currently available to demonstrate non-detriment of international trade derived from any other UK eel fisheries.

Contents

1. Introduction

This paper describes a science-based assessment of whether it is possible to make an over-arching non-detriment finding (NDF) for the export of the CITES-listed European eel (*Anguilla anguilla)* from the United Kingdom (UK).

1.1 What is an NDF?

Trade in specimens listed in the Appendices of the Convention on International Trade in Endangered Species (CITES) is governed by the provisions of the Convention as implemented through UK legislation; this is a form of the EU Wildlife Trade Regulations (338/97 & 865/06) retained and modified for use by the UK after its exit from the EU (see section 1.3 below).

European eel was listed in Appendix II of CITES (and Annex B of the EU Wildlife Trade Regulations) in March 2009 (Fleming 2011); Appendix II / Annex B includes species which may not necessarily be threatened now with extinction but may become so unless trade is strictly regulated to avoid utilisation incompatible with their survival. Accordingly, before any export permit can be issued for trade in any Appendix II specimens, such as European eel, the Scientific Authority of the state of export must determine that such export will '*not be detrimental to the survival of that species*' (Article IV.2.a) – this determination is referred to as a **non-detriment finding** or '**NDF**'. The UK also has stricter regulatory measures than those required by CITES; for instance, there is also a requirement for an NDF to be made upon imports of CITES specimens (in Appendices I & II / Annexes A & B). However, this NDF focuses only on exports.

Article IV.3 of CITES also requires that Scientific Authorities monitor permits issued and actual trade in Appendix II species to '*maintain that species throughout its range at a level consistent with its role in the ecosystems in which it occurs and well above the level at which that species might become eligible for inclusion in Appendix I*' and advise the Management Authority if trade needs to be limited to achieve that.

The implementation and effectiveness of the CITES-listing has been reviewed by the CITES Animals Committee (Musing *et al.* 2018).

1.2 Making an NDF for European eels

Guidance is available on the making of NDFs in Resolution Conf. 16.7 (rev. CoP17) which notes that an NDF is a '*science-based assessment*' to determine if any proposed trade will be detrimental to the survival of the species or not and for which '*data requirements should be proportionate to the vulnerability of the species concerned*'. An NDF is thus, essentially, a risk assessment.

An NDF is based, in part, on resource assessment methodologies which include management measures, threats, population structure, conservation status, harvests and trends, both nationally and internationally. An NDF for harvest of a species can be made when the sum of all harvests from a population of the species is sustainable, in that it does not result in unplanned range reduction, long-term population decline, or otherwise change the population in a way that might be expected to lead to the species' decline; it should also, where relevant, contribute to a species' recovery where its conservation status is unfavourable.

The International Council for the Exploration of the Sea (ICES) provides annual stock advice on the European eel throughout its natural range. ICES (2021, 2022) describe the status of the stock as remaining critical (see section 2.2.1). Indices of both glass and yellow eel recruitment strongly declined from 1980 to 2011 and remain low in 2022, with a 'North Sea' recruitment index of 0.5% of baseline (1960–79 geometric mean) and 9.7% in the 'Elsewhere Europe' index (provisional values). The yellow eel recruitment index in 2022 was 19% of the baseline. ICES now advises that when the precautionary approach is applied, there should be zero catches in all habitats in 2023. Furthermore, ICES advises all non-fisheries related anthropogenic mortalities should be zero, and the quantity and quality of eel habitats should be restored; this includes restoring connectivity and the physical, chemical, and biological properties of the habitats (ICES 2022). Previously, ICES only advised that "all anthropogenic impacts …. that decrease production and escapement of silver eels should be reduced to – or kept as close to – zero as possible" (ICES 2020).

The European eel was listed (in 2008, in 2014, and again in 2020) as Critically Endangered in the IUCN Red List (Jacoby & Gollock 2014; Pike *et al.* 2020). Illegal trade of European eel continues, particularly in live glass eels which are in demand for aquaculture in east Asia and for which high prices are paid, despite measures by range States and destination countries to prevent it (UNODC 2020).

All these factors suggest that trade in the species is of **high risk** and appropriate **precautionary measures** are required to mitigate or avoid such risk.

Although the EU currently has a negative opinion for imports of European eel (and zero export quotas), the EU previously asked ICES to consider what criteria and thresholds might be appropriate to enable an NDF to be made should the status of European eel improve. Based on a workshop in 2015, involving eel fishery experts and EU CITES Scientific Authorities (including from the UK), ICES provided their advice (ICES 2015a, b) as summarised in Appendix 1. An assessment by JNCC and Cefas of the **global state** of European eel against the ICES guidance (ICES 2015a, b), concluded that an NDF for European eel trade cannot be made at that spatial scale (Appendix 1).

However, the ICES report acknowledged the possibility of a positive NDF 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;

(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;

(iii) an NDF assessment on a finer spatial scale than the total area of distribution would require that information on the contribution of the eel from the sub-area to the spawning stock is available and sufficient to assess the eel sub-population in question.

These criteria, and their relevance as the cornerstone for this current overarching NDF assessment, are discussed at the finer spatial scale of the relevant Eel Management Units in Appendices 2 and 3. This overarching NDF assessment would be drawn on when determining NDF for specific proposed movements or permit applications received.

The ICES report did not provide any guidance or advice on how such sub-area assessments should be carried out. No binding technical criteria are available for undertaking NDFs, because the Scientific Authority of each CITES Party is responsible for making NDFs and determining how to do so. Therefore, this NDF has been guided in its development by:

- CITES Resolution Conf. 16.7 (Rev. CoP17) *Non-detriment findings*.

- CITES Non-Detriment Findings Guidance for Shark Species: A framework to assist Authorities in making non-detriment findings (NDFs) for species listed in CITES Appendix II, 2nd, revised version 1 October 2014 (Munday-Taylor *et al.* 2014).
- Guidance for CITES Scientific Authorities: Checklist to assist in making non-detriment findings for Appendix II exports.

Therefore, we examine the scientific evidence to determine whether an NDF might be possible for some eel fisheries in UK waters; this assessment addresses glass eels caught in selected river fisheries of England and Wales and yellow and silver eels caught in Lough Neagh and the River Bann in Northern Ireland (see Glossary for life stage definitions).

This overarching assessment is a collaborative effort between the Joint Nature Conservation Committee (JNCC), as the UK CITES Scientific Authority (Fauna), and relevant UK fisheries, science and regulatory bodies, namely the Centre for Environment, Fisheries & Aquaculture Science (Cefas), the Agri-Food & Biosciences Institute, Northern Ireland (AFBI), Department of Agriculture, Environment & Rural Affairs, Northern Ireland (DAERA), Department of Environment Food & Rural Affairs, UK (Defra) and the Environment Agency (EA). Defra is also the UK's CITES Management Authority; the Animal & Plant Health Agency (APHA), the UK's Management Authority responsible for CITES permit issue, have also been engaged in the preparation of this NDF.

The NDF was originally created as a working document in 2018 and has been subject to peer review (see section 1.4 below). This NDF was revised in the first half of 2023 following review meetings in autumn 2022 between the collaborators above, the outcomes from peer review, and input from stakeholder consultations. It is intended that it will be formally reviewed again in 2026.

Much of the background on eel distribution, status and anthropogenic impacts has been drawn from the ICES Stock Annex for European eel, co-authored by the Working Group on Eel (WGEEL), including UK participants (and co-authors of this NDF).

1.3 Implications of the UK leaving the European Union on trade in European eels

The UK left the European Union after a transition period on 1 January 2021. As a former member of the EU, the UK took part in EU decision making, was bound by EU Regulations and Directives (including those relating to CITES and European eels) and was able to trade freely in CITES specimens with the other 27 Member States without the need for CITES export or import permits.

After the transition period ended (31 December 2020), trade in CITES specimens between GB and NI, GB and the EU, and NI and the EU was initially conducted by the provisions of the Withdrawal Agreement and the Protocol on Ireland / Northern Ireland (NIP) and explanatory document. These provisions mean that, in practice, Northern Ireland will be able to continue to trade in CITES specimens with the 27 Member States of the EU without CITES permits; however, trade between Great Britain (GB) and Northern Ireland (NI), and GB and the EU, will require CITES permits for movements in either direction (permits for movements into or from NI will be issued by the UK CITES authorities in both cases). The NIP also means that the EU, rather than UK, Wildlife Trade Regulations apply in NI.

In December 2010, the EU effectively suspended trade to and from the Community in specimens of European eel because, in the opinion of the EU's CITES Scientific Review Group (SRG), a positive NDF could not be made when assessed at the full stock level (the UK agrees with this assessment when made at the full stock level – see Appendix 1). This decision has been reviewed annually ever since and remains in place. However, internal trade of European eel within the European Union is still permitted and does not require any CITES authorisation, permits or a finding of non-detriment.

This decision had implications post-exit for several UK fisheries which formerly had significant markets for European eel in the EU. These fisheries included Lough Neagh in Northern Ireland (Figure 1), the largest wild eel fishery in Europe (13.8% EU catch), with a harvest then of approximately 330 tonnes of yellow and silver eels with a value of £3 million (€ 3.36 million), falling to approximately 200 tonnes (less than £2.5 million) recently. Whilst the UK was in the EU, 86% of the Lough Neagh catch was traded with other Member States and 14% of the catch marketed within the UK, predominantly within GB. The UK also has significant glass eel fisheries, notably on the Severn estuary in south-west England and Wales (approximately 3 tonnes), and other yellow and silver eel fisheries elsewhere (approximately 35 tonnes), all with former significant markets in the EU (glass eels for aquaculture or stocking, others for direct human consumption); Lough Neagh in NI is also dependent on glass eels from GB to stock the Lough. The UK market (in both GB and NI) for eels (live or for human consumption) is limited.

Figure 1. The Neagh Bann River Basin District in Northern Ireland (left); and the location of the yellow eel fishery in Lough Neagh (yellow circle) and silver eel fisheries on the outflowing River Bann (red circles) (right) (Source: Neagh Bann Eel Management Plan 2009).

Following the UK's exit from the EU, and under the provisions of the NIP, a new system of trading evolved:

- Lough Neagh retains the ability to trade (without CITES permits) with the 27 Member States of the EU.
- The UK has issued CITES permits, under the provisions of both the NIP and this NDF, for trade between NI and GB to continue; this has enabled glass eels to be moved to NI for the purpose of stocking Lough Neagh only and for silver and yellow eels to be imported from Lough Neagh to GB for human consumption.
- The other markets in the EU for eels derived from the UK, notably for glass eels, have been lost. This loss has remained despite repeated UK attempts (see section 1.2) to persuade the EU SRG to accept this assessment as evidence of non-detriment and to

make an exemption from their negative opinion for glass eels of demonstrably sustainable GB origin. The EU continues their internal trade in glass eels, sourced from France and Spain, which does not require an assessment of non-detriment. At recent annual ICES WGEEL meetings concerns have been raised by Sweden and Finland regarding the unavailability of UK glass eels for their national restocking after EU exit and that this may have adverse impacts on inland silver eel production. Sweden reported a significant reduction in the number of imported glass eels sourced from France in 2021 and 2022 compared to earlier years from England.

1.4 Transparency and peer review

The UK is committed to transparency in the development of this NDF and has sought external review of the NDF and the evidence that underpins it. Earlier drafts of this NDF, and UK responses to their EU questions, have been provided to the 84th, 86th, 89th, 91st and 92nd meetings (over the period 2018 to 2020 inclusive) of the EU's CITES Scientific Review Group for their comment and feedback.

An earlier version of the NDF, and the evidence and analyses upon which it is based, has also been reviewed by the International Council for the Exploration of the Sea (ICES 2019a), the UK's response to which is contained in Appendix 4. An earlier version of this NDF was also shared in September 2021 with the CITES Animals Committee for their review and advice under Decision 18.197.a (now superseded by Decision 19.218.b); their feedback and comments are contained in Appendix 5. They concluded '*The current system as described by the UK in the NDF document gives the Committee sufficient assurance that the export of the surplus of glass eels is not detrimental to the survival of the species in the UK*'.

The responses by all these external bodies have been used to revise and strengthen this NDF.

2 Biology and life history

European eel life history is complex and atypical among aquatic species, being a long-lived semelparous and widely dispersed stock (see Glossary of Terms and life cycle, Figure 2). The shared single stock is panmictic (Palm *et al.* 2009) and data indicate the spawning area is in the south-western part of the Sargasso Sea in areas beyond national jurisdiction (McCleave *et al.* 1987; Tesch & Wegner 1990). Satellite-tagging of eels in the Azores has recently tracked adult European eels, for the first time, to their putative spawning areas in the Sargasso (Wright *et al.* 2022).

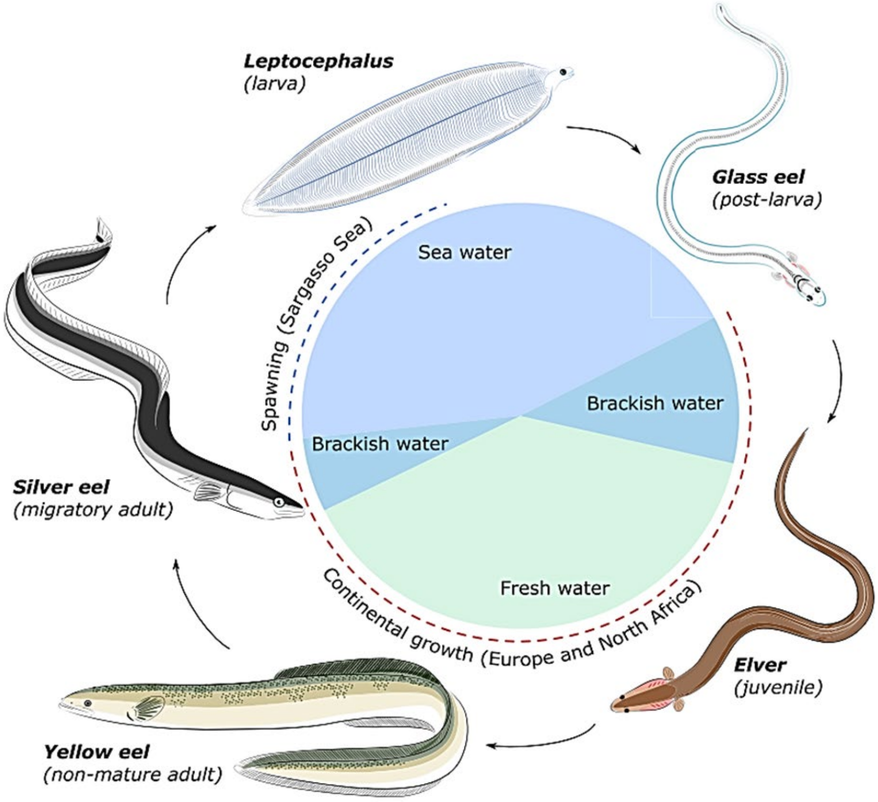

Figure 2. Life cycle of the European eel (*Anguilla anguilla* L.) (Source: Cresci 2020).

The newly hatched leptocephalus larvae drift with the ocean currents to the continental shelf of Europe and North Africa where they metamorphose into glass eels and enter continental waters. (Note for the purposes of this assessment, glass eels are defined as eels less than 12 cm in length (and, if live, traded and reported under the code for fingerling FIG) as recommended at the 30th meeting of the CITES Animals Committee (see AC30 Com. 5)). The growth stage, known as yellow eel, may take place in marine, brackish (transitional), or fresh waters. This stage may last typically from two to 25 years (and could exceed 50 years) prior to metamorphosis to the silver eel stage and maturation. Age-at-maturity varies according to temperature (latitude and longitude), ecosystem characteristics, and density-dependent processes. The European eel life cycle is shorter for populations in the southern part of their range compared to the north due to some of the above factors. Silver eels then migrate to the Sargasso Sea where they spawn, subsequently dying after spawning, an act not yet witnessed in the wild.

Eels are a long-lived species with the yellow eel stage lasting 2–20 years for males or 5–50 years for females (Dekker 2002). According to Vøllestad (1992), mean length and age at silvering differs significantly between males (405 mm; 5.99 years respectively) and females (623 mm; 8.73 years). When compared to other fish, growth is slower, usually 3–4 cm a year

(Dekker 2002). Annual growth can be as low as 1 cm a year or less in the northern areas (e.g. Poole *et al.* 1992, 1996a, b; J.D. Godfrey, personal communication) but up to 15 cm a year in the more southern areas (Dekker 2002). Mean length of the female silver eel increases with latitude but the same relationship for males is absent; there is also an increase in age with latitude (ICES 2010).

There are limited empirical data on natural eel mortality. A value of M = 0.1386 $year^{-1}$ is frequently applied (Dekker 2000). Bevacqua *et al.* (2011) calibrated a general model for natural mortality for the post-settlement yellow eel stage, considering the effects of body mass, temperature, stock density and gender. Their analyses suggested that eel natural mortality of a body mass of 100 g varied between 0.02 $year^{-1}$ at 8°C-low density and 0.47 $year^{-1}$ at 18°C-high density, indicating appreciably lower values than those of most fish, most likely due to their exceptionally low energy consuming metabolism. Similarly, a study in Lough Neagh indicated density-dependent instantaneous natural mortality of eels, ranging from 0.02 $year^{-1}$ when stocked at low densities (100 to 200 glass eel per hectare) to 0.12–0.14 $year^{-1}$ when stocked at high densities (700 glass eel per hectare) (Aprahamian *et al.* 2021). Dekker (2012) concluded recently that natural mortality on Swedish stocked eels must be lower than the usual estimate, with 0.10 yr^{-1} selected as the most likely value given eel escapement predictions and reported catch in Sweden (ICES 2012b).

2.1 Distribution of European eel

The European eel stock consists of a single genetic population throughout its natural range (Palm *et al.* 2009). The species is distributed across most coastal countries in Europe and North Africa, with its southern limit in Mauritania (20°N) and its northern limit situated in the Barents Sea (72°N) and spanning all of the Mediterranean and Baltic basins (ICES 2014). The spawning area in the Sargasso Sea is thought to be situated quite narrowly between latitudes 23° and 29.5°N but on a wider longitudinal range from 48° to 78°W (McCleave *et al.* 1987; Tesch & Wegner 1990). At the continental scale, eels have a wide and scattered distribution and are found in virtually all types of water bodies from rivers and lakes to estuaries and coastal waters. Its distribution area is estimated to be at approximately 90,000 km^2 (Moriarty & Dekker 1997; Dekker 2009).

Eels are widespread throughout estuaries, rivers, and lakes of the UK with the possible exception of the upper reaches of some rivers, particularly in Scotland, due to geographical difficulties of access.

2.2 Stock status and trends

2.2.1 Status and trends

ICES provides annual stock advice on the European eel throughout its natural range as requested by the EU, Iceland, North Atlantic Salmon Conservation Organisation, North-East Atlantic Fisheries Commission, Norway, and the United Kingdom. The latest ICES advice (2022) describes the status of the global stock as remaining critical, on the basis that the annual recruitment to European waters in 2022 remained low, at 0.5% of the 1960 to 1979 level in the “North Sea” series and 9.7% in the “Elsewhere Europe” series (provisional values).

ICES (2022, 2021) now advise that ‘*when the precautionary approach is applied, there should be zero catches in all habitats in 2023. This applies to both recreational and commercial catches and includes catches of glass eels for restocking and aquaculture*’.

The advice from ICES (2022) specifically regarding stocking states “*ICES notes that the restocking of eels (the practice of adding eels to a waterbody from another source) is* *considered a "conservation measure" in the EU Council Regulation (EU Council 2007) and in many eel management plans is implemented for achieving the 40% escapement target on all Eel Management Units (EMUs). Restocking is reliant on a glass eel fishery catch, which is in contradiction with the current advice. The net benefit of the restocking of eels to the reproductive potential of the stock is unknown. It requires information on, e.g. carrying capacity estimates of glass eel source estuaries, detailed mortality estimates at each step of the restocking process, and the spawning potential of stocked vs. non-stocked eels. ICES (2016b) found that while a local increase in eel production may be apparent, an assessment of net benefit to the spawning stock was unquantifiable. ICES advises that when constrained by the above-mentioned uncertainties and potential harmful effects (ICES 2016b), while following the precautionary approach, no catch for restocking should be allowed*." However, ICES (2022) further notes that this advice does not apply to assisted migration where the future escapement of silver eels is ensured.

Previously (e.g. ICES 2020), ICES advised that '*when the precautionary approach is applied for European eel, all anthropogenic impacts (e.g. recreational and commercial fishing on all stages, hydropower, pumping stations, and pollution) that decrease production and escapement of silver eels should be reduced to – or kept as close to – zero as possible*.'

The European eel global stock was listed (in 2008, in 2014, and again in 2020) as Critically Endangered in the IUCN Red List (Pike *et al.* 2020; Jacoby & Gollock 2014). Regional and national red listings are either Critically Endangered (HELCOM Baltic region, Sweden, and Denmark) or Endangered (Finland, northern Africa) (Azeroual 2010). There is no separate Red List assessment for European eel in UK waters.

The overall intrinsic vulnerability of the species, as determined using the Worksheet in Mundy-Taylor *et al.* (2014), has been assessed as 'Medium to High'. The individual biological factors were graded as 2 'Low' vulnerability, 6 'Medium', 1 'High' and 2 'Unknown'. The 'High' was for the current stock size being less than 25% of baseline abundance, and this was given a higher weighting on the overall score.

However, the European eel is also assessed at finer regional, national, and sub-national scales below the spatial scale of the full stock.

2.2.2 UK stock assessments

As required by EU Eel Regulation (EC 1100/2007), now retained as UK law, the UK developed 14 Eel Management Plans (EMPs), set at the River Basin District (RBD) level, as defined under the Water Framework Directive (WFD: 2000/60/EC), covering England, Wales, Scotland, and Northern Ireland (Figure 3). The RBDs in Northern Ireland deviate slightly from those defined for the WFD, owing to their transboundary nature with the Republic of Ireland.

In the EMPs, approved by the European Commission following peer review by ICES, the UK listed a range of management and conservation measures currently in place or to be enacted, including the closure of the commercial eel fisheries on the Erne system, Northern Ireland (NWIRBD Transboundary EMP; Figure 3) and those in the North Eastern RBD. Most of the UK EMPs included eel fisheries (e.g. Severn and Lough Neagh) and these had been subject to the same restrictions on international trade as other Member States when the UK was in the EU.

The main thrust of the Eel Regulation is aimed at increasing the production and escapement of silver eels against a conservation target; the retained Council Regulation (EC) No. 1100/2007 states in Article 2 section 4:

“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. The Eel Management Plan shall be prepared with the purpose of achieving this objective in the long term.

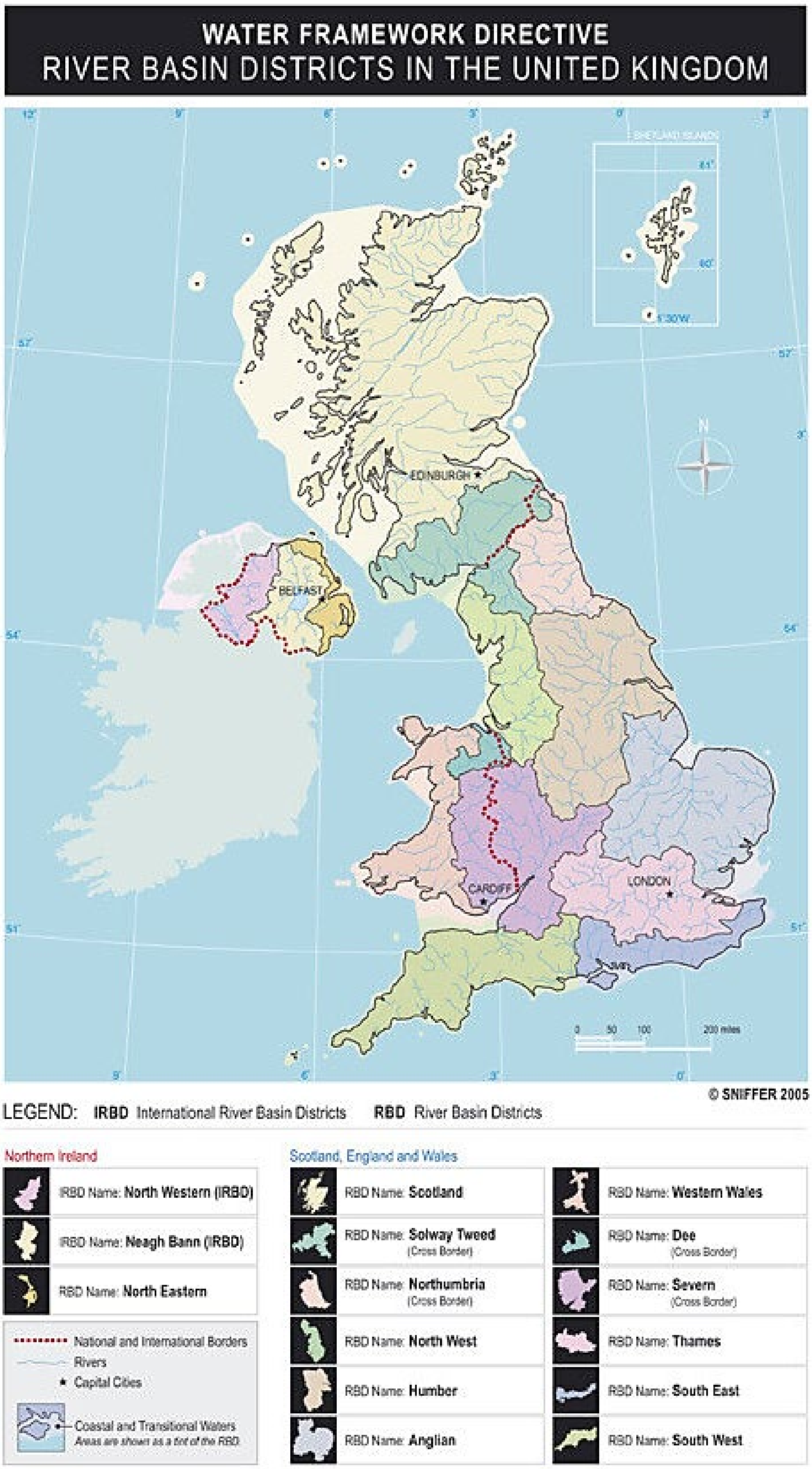

Figure 3. Schematic map of the River Basin District (RBD) layout across the UK, which forms the basis of the associated Eel Management Plans (EMPs) (Source: UK EMP Progress Report 2015).

Fisheries' management is a devolved policy area in the UK and, as such, EMPs were drawn up by the relevant UK authorities within each of the devolved administrations. Assessment methods differ between England and Wales, Scotland and Northern Ireland (see Annexes A to C of Cefas *et al.* 2021), but every three years the UK reports the same stock indicators for each EMP, as follows:

- $B_{current}$: the amount of silver eel biomass that currently escapes to the sea to spawn;
- B_0: the amount of silver eel biomass that would have existed historically if no anthropogenic influences had impacted the stock;
- B_{best}: the amount of silver eel biomass that would exist if no anthropogenic influences impacted the current stock;
- $\sum F$: the fishing mortality rate, summed over the age-groups in the stock;
- $\sum H$: the anthropogenic mortality rate for the combined non-fishery factors impacting on eel;
- $\sum A$: the sum of anthropogenic mortalities (i.e. $\sum A = \sum F + \sum H$).

UK escapement biomass and mortality rates cannot be measured directly at the River Basin District scale, so are modelled using a range of input data (Table 1). The analytical approaches require several assumptions about the life history and production of eel and there is natural variation (spatial and temporal) inherent within the input data used in the analyses. Hence, the assessments are described as 'best available estimates' and should be treated as such.

It is useful to place the production of eel from UK waters in the context of the species globally. Estimates from outside the EU are scarce and those from EU Member States are derived from a range of methods and assumptions, so any comparisons must bear these caveats in mind. However, national estimates of pristine and current silver eel escapement were reported by Member States to the EU in 2015, 2018 and 2021. According to the data compiled by ICES (ICES 2018b), the pristine production of silver eel from the EU might have been about 151,903 tonnes to which the UK contributed about 7,317 tonnes or 4.8% of the total. The estimated silver eel escapement from the EU in 2017 was estimated at 17,587 tonnes and that from the UK was about 794 tonnes or 4.5%.

2.2.2.1 Rivers supporting glass eel fisheries

The South West, Severn, West Wales, Dee and North West RBDs support or supported glass eel fisheries, though catches are very small outside of the South West and Severn RBDs. EMP assessments are at the RBD level, not that of specific rivers supporting glass eel fisheries. The latest assessments (see Annex A of Cefas *et al.* 2021 for a description of the methods) place 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 section 2.2.2 above). However, the potential recruitment surplus for specific rivers was also assessed and will be described later in this paper.

2.2.2.2 Neagh Bann

The estimation of silver eel escapement from the Neagh Bann RBD is based on monitoring of silver eel migration. An annual mark-recapture programme has been implemented in the River Bann outflow since 2003, with the objective of estimating escapement of silver eels from Lough Neagh based on the non-recaptured proportion of those tagged silver eels taken back upstream and released. This work was further enhanced and corroborated by implementing a hydro-acoustic tracking study in 2011. To date, 13,154 eels have been tagged with FloyTags™ and recaptures have been recorded at both silver eel sites in the RBD. Specific details of this mark recapture escapement assessment are outlined in Section 11.1 of the Neagh/Bann EMP.

Whilst the long-term trend from 2003 to 2022 is of decreasing escapement, the Neagh Bann is currently compliant within the range of its escapement conservation target at 229 tonnes for the most recent five-year period, and 178 tonnes for the EMP Review three-year period (Section 12.3).

Table 1. Best estimates of silver eel biomass (kg) across England and Wales RBDs during 2017–2020, and across Scotland and Northern Ireland during 2018–2020. Note these estimates are based on period means for some data inputs. Key for terms provided below. (Data from Cefas *et al.* 2021)

RBD code	B_0	$B_{current}$				B_{best}				Mean compliance (%) in most recent 3 years
	Pre-1980	2017	2018	2019	2020	2017	2018	2019	2020	
Northumbria	60,876	7,628	7,690	7,667	ND	14,074	14,074	14,074	ND	12.6
Humber	137,859	3,838	4,545	5,305	ND	43,534	43,534	43,534	ND	3.3
Anglian	341,084	25,580	19,797	23,628	ND	58,385	58,385	58,385	ND	6.7
Thames	251,699	56,034	56,196	56,760	ND	161,730	161,730	161,730	ND	22.4
South East	121,340	23,807	23,969	23,989	ND	36,575	36,575	36,575	ND	19.7
South West	1,327,684	15,630	13,198	13,426	ND	145,072	155,588	213,997	ND	1.1
Severn	899,687	21,233	21,227	20,237	ND	138,538	189,225	265,071	ND	2.3
Western Wales	429,944	11,169	11,070	11,769	ND	15,360	16,386	16,405	ND	2.6
Dee	636,166	9,478	10,390	9,752	ND	17,832	20,812	20,222	ND	1.6
North West	865,449	19,859	20,065	19,915	ND	42,003	43,915	46,258	ND	2.3
Solway Tweed	1,473,755	85,611	85,611	85,611	ND	110,991	110,991	110,991	ND	5.8
Scotland	267,717	194,955	171,501	144,052	164,395	244,780	212,134	177,145	201,519	59.8
North Eastern	4,000	989	1,453	539	ND*	989	1,453	539	ND*	24.8
Neagh Bann	500,000	247,000	388,000	225,310	136,900	542,000	717,000	492,310	356,700	54.1

Key:

- 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.
- ND No Data – where there are insufficient data to estimate a derived parameter (for example where there are insufficient data to estimate the stock indicators, or where data were collected but not available in time to be used in this report).
- ND* No Data – due to COVID-19 impacts.

The overall intrinsic vulnerability of the eel in Lough Neagh was assessed as Medium. The only factor scoring differently from the global assessment was ‘current stock size’ which was scored at Medium for Lough Neagh because the current silver eel escapement is between 25 to 50% of baseline abundance.

Given the overall decline and low state of eel recruitment to European waters (ICES 2020, 2021, 2022), the continued high production of eel from Lough Neagh is wholly dependent on annual stocking to enhance recruitment. ICES (2019b, 2020) recommended that, “when stocking to increase silver eel escapement and thus aid stock recovery, an estimation of the prospective net benefit should be made prior to any stocking activity. Where eels are translocated and stocked, measures should be taken to evaluate their fate and their contribution to silver eel escapement”. A recently revised analysis of Lough Neagh eel production dynamics (Aprahamian *et al.* 2021; Appendix 2) addresses these recommendations.

The **principle** of this NDF is that Lough Neagh should be stocked with glass eels only from fisheries exploiting a surplus to the local recruitment requirements in the donor catchments (that is the *carrying capacity*) and, in doing so, provides a conservation net benefit by way of the production and associated escapement of silver eels.

3 Global and domestic harvest

Fisheries have taken place over the whole geographic range of European eel and most often occur as scattered small-scale rural enterprises (Dekker 2004). Eel are traded both locally and internationally. Total landings and effort data are incomplete. There is a great heterogeneity among the time-series of landings because of inconsistencies in reporting by, and between, countries, as well as incomplete reporting. Changes in management practices have also affected the reporting of non-commercial and recreational fisheries.

3.1 Commercial harvest

3.1.1 Europe & North Africa

The glass eel fisheries are mainly concentrated around South-west England, the Bay of Biscay area (Dekker 2003) and along the Mediterranean coasts of Spain and Italy (ICES 2012). Situated in estuaries and river mouths, these fisheries capitalise on the natural concentration of glass eels in the area (Dekker 2003). The exploitation of glass eels takes place in winter and early spring when they arrive on the European coast. The glass eel fishing gear varies across Europe but consists of both active and passive gears. The active gear includes different hand-held or ship-borne nets while passive gear is composed of traps and fyke nets kept fixed in a stream (Dekker 2002). The glass eels caught are used for stocking, aquaculture, or local consumption (ICES 2013b).

Yellow and silver eel fisheries have been located all over the distribution area of the species, from the Mediterranean basin to northern Scandinavia (Dekker 2003), with some countries having reduced or closed their fisheries in response to the EU Regulation. Historically, the biggest landings have been reported from the northern part of the distribution area except for Spain and Italy in the Mediterranean. Various types of gear are used in the yellow and/or silver eel fisheries, including different nets, traps, hooks, etc., in both salt- and fresh water (Dekker 2003). The eel fisheries located in the coastal and rural areas all over Europe are rather small-scale making up less than 5% of the total European catch (Dekker 2002). According to Moriarty and Dekker (1997) these fisheries employed thousands of people across Europe in the 1990s, but the number has subsequently declined. In many European countries, yellow and silver eels are not distinguished in the reported catch (ICES 2014). Directed fisheries for silver eel in coastal waters are specific to the Baltic/Kattegat, where pound nets are used (Dekker 2003). As the eel densities are low in the northern areas (25 eels/km^2 of land surface), the fishery is concentrated on the emigration period in the late summer and autumn when most of the silver eel is exploited. In contrast, yellow eel fisheries are established in central Europe where eel densities per km^2 of land surface are much higher (400 eels/km^2; Dekker 2003). Yellow and silver eel caught are mainly sold for consumption, either locally or after export to neighbouring countries, mostly within the EU (ICES 2015a).

3.1.2 UK

In the UK, a number of fisheries operate within the context of the EMPs, and measures brought in to comply with the Eel Regulation (EC Reg 1100/2007). The most significant wild eel fishery in the UK, and indeed in Europe, is the Lough Neagh fishery for yellow and silver eels. This fishery had a pre-EU exit average catch of about 330 tonnes per year (p.a.), accounting then for 13.8% of Europe's catch (ICES 2018a), has recognised EU-protected food name status (Protected Geographical Indication or PGI) and is a significant employer and contributor to the Northern Ireland economy (see section 11 and Appendix 3); recently greater than 86% of their catch has been exported to the EU with only 14% marketed within the UK.

A glass eel fishery, using hand nets only, operates in estuaries draining into the Bristol Channel, especially in the Rivers Severn and Wye (Severn EMP) and the Parrett (South West EMP), and had a recent, pre-2020 catch of about 4.5 tonnes p.a. (much reduced from previous years and disrupted by the Covid pandemic and restricted access to former markets). The season for the glass eel fishery is later than in France and Spain, extending typically from the 15 of February to the 25 of May (see section 13.1). The annual catch of glass eel in UK fisheries was thus about 7.9 % of the total glass eel catch (57 tonnes) reported to ICES (ICES 2018a), and 1.0 % of the total recruitment (440 tonnes) estimated by Bornarel *et al.* (2018).

Glass eels from the UK fishery are purchased by Lough Neagh for stocking their yellow and silver eel fisheries, but they were also formerly exported to the EU for stocking, aquaculture, or direct consumption (note section 1.1) (Defra 2018).

Across England and Wales, commercial fisheries are undertaken for yellow eels using fyke nets (five year average 33 tonnes) and for silver eels using fyke nets and fixed weir traps (five year average 6 tonnes).

3.2 Recreational harvest

In many EU countries, recreational fisheries contribute significantly to the total catch. The gear might consist of rod-and-line as well as longlines and nets or traps. Usually, a licence or permit is required to be able to fish recreationally, however there are countries where the access to the fisheries is free or based on private ownership (Dekker 2005). Data on recreational fisheries are collected but the inconsistencies in reporting make assessment unreliable (ICES 2014).

There are no recreational landings of eel across the UK, and any eel that are caught by recreational fisheries must be returned alive to the water where they were caught. No information is collected on these catch rates nor on post-release survival rates.

4 Threats and Mortality

4.1 Global summary

ICES (2022) provides a summary of the threats and mortality to the whole European eel stock. Fisheries take place on all available continental life stages throughout the distribution area, although fishing pressure varies from area to area, from almost nil to heavy overexploitation. Illegal, unreported, and unregulated (IUU) fishing is known to occur. The non-fishing anthropogenic mortality factors can also have an impact on all continental life stages and can be grouped as those due to:

(a) hydropower, pumping stations, and other water intakes;

(b) habitat loss or degradation; and

(c) pollution, diseases, and parasites.

In addition, anthropogenic actions may affect predation mortality (e.g. conservation or culling of predators).

Eels tend to have considerably greater mortality rates from downstream passage at hydropower stations than other fish species (Hadderingh & Bakker 1998). Similarly, pumping stations can cause damage and direct or delayed mortality in fish when passing through a pump, or delays in fish passage may increase rates of fishing pressure, predation, and disease. Eels can get caught up in cooling water intake flows and screens at any stage of their life. However, they are most at risk during their upstream and downstream migrations within fresh waters (Environment Agency UK 2011). Environmental impacts in transitional and fresh waters, which include habitat alteration, barriers to eel passage, deterioration in water quality, and presence of non-native diseases and parasites, all contribute to the anthropogenic stresses and mortality on eels and affect their reproductive success.

4.2 Assessments for the areas considered by this NDF

In addition to commercial eel fisheries in the four English and Welsh RBDs (see below) considered by this NDF, other anthropogenic impacts on eel are caused by entrainment and mortality at water intakes (including abstraction sites, pumping stations, power stations and hydropower facilities), barriers to migration and areas of reduced habitat quality and quantity (data are available on these if required). The assessment approach (see Annex A of Cefas *et al.* 2021) means that the effects of these impacts are quantified at RBD scale rather than directly for those rivers supporting glass eel fisheries. Commercial fishing has been assessed as the main anthropogenic impact in the South West and Severn RBDs (90% on average of the total impact rate for 2017–2019 in both RBDs) whereas non-fishing impacts dominate in the North West and Western Wales RBDs (69% and 72% on average of the total impact rate for 2017–2019, respectively; Cefas *et al.* 2021).

Commercial fishing targeting eel is the only anthropogenic impact on eel in the Neagh Bann RBD. The instantaneous mortality rate for commercial fishing in 2020 was estimated at 0.6 (Cefas *et al.* 2021). The outflowing River Bann is free of any turbine, power generation system or major water abstraction which might impede the escapement of silver eels to the sea, and there is a minimum 10% river width free gap past the two active silver eel fisheries.

5 Fishery management measures

Fisheries management is a devolved policy area in the UK and responsibility for the management of eel, including human impacts and the delivery of eel management plans (EMPs) is managed by different regional agencies: the Environment Agency (EA) for England; Natural Resources Wales (NRW) for Wales; Marine Directorate for Scotland; and the Department for Agriculture, Environment and Rural Affairs (DAERA) for Northern Ireland.

5.1 England and Wales

Fisheries management for freshwater and diadromous stocks in England and Wales is governed by the Salmon and Freshwater Fisheries Act (1975), as amended by the Marine and Coastal Access Act (2009). In addition, The Eels (England and Wales) Regulations (2009) Statutory Instrument came into force in January 2010. This legislation was specifically developed to facilitate the implementation of Council Regulation (EC) No. 1100/2007 in England and Wales. The legislation makes provisions to monitor exploitation, imposed a temporary close season on fishing for eels, enabled some control on the fishery and makes provision to protect the passage of eels.

All commercial fishing for eels in England and Wales requires authorisation, which is subject to standard national conditions that control seasons, methods, minimum landing size (300 mm except glass eel fisheries), apply geographic restrictions and other measures to protect bycatch species. Since 2010, the yellow and silver eel fisheries have been limited to those individuals who were already licensed, and these individuals are limited to the number of nets that they can apply for based on previous effort. The glass eel fishery is restricted to two zones; in parts of South-west and North-west England. The EA, under formal agreement, formerly issued authorisations on behalf of NRW for those fisheries operating in Wales. However, in 2021 NRW, decided to not to issue further authorisations for commercial fishing for glass or other eel fisheries; this position will be kept under review, but these fisheries are currently closed.

Every authorized instrument must carry an identity tag issued by the EA and it is a legal requirement that all eel and glass eel/elver fishermen submit a catch return; these catch returns also require the fisher to state the destination of the harvest, that is the person or business to whom they sold their catch. In turn, traders must also record the quantity of eels they purchased and from whom, thus enabling cross-checking and traceability. The EA, under formal agreement, collates catch return information on behalf of NRW. Eel fishers are required to give details of the number of days they have fished, the location and type of water fished, the total weight of eel caught and retained or a statement that no eel have been caught. Annual eel and glass eel/elver net authorization sales and catches are summarized by instrument type for England and Wales and reported in the "Salmonid and Freshwater Fisheries Statistics for England and Wales" series.

5.2 Northern Ireland (Lough Neagh)

Lough Neagh in Northern Ireland is the largest freshwater lake in the UK. Productivity is such that the Lough sustains a large population of yellow eels and produces many silver eels that migrate 38 km via the outflowing Lower River Bann to the sea. Fishing rights to all eel life stages are owned by the Lough Neagh Fishermen's Co-operative Society (LNFCS), essentially placing Lough Neagh fisheries under Community Based Natural Resource Management (Steele 2018).

The legal minimum landing size for yellow eel was increased from 300–400 mm in 2010 to match that of the LNFCS' self-imposed 400 mm limit since the mid-1970s. The yellow eel fishery (May to September, five days a week) supports a peak season average of 85–95 boats (declining from about 200 in 1990) each with a crew of two men using draft nets and/or baited longlines. The fishery is run on a quota-based system driven by management decisions in consideration of conservation target compliance and commercial needs (usually 50 kg per boat per day). Eels are collected and marketed centrally by the Cooperative with fishermen paid the entire value of their catch.

Prior to 2012 there were three weirs where silver eels were caught using Coghill nets, however, the LNFCS has voluntarily stopped fishing one weir to ensure the fishery meets the EU escapement target thus leaving just two weirs which are fished in the lower River Bann. The LNFCS also voluntarily reduced their silver eel fishing season by two months, closing all fisheries at the end of December each year. Profit from the less labour-intensive (five to six men) silver eel fishery sustains the management of the whole cooperative venture, providing working capital for:

- year-round enforcement/policing: £185,000 (€219,430)
- marketing: £547,000 (€648,790)
- purchase of glass eel for stocking: £246 667 (€292 570)
- assisted migration of glass eel: £25 000 (€29 650).

DAERA produces an annual Fish Digest online, containing statistics on all aspects of eel catches including both commercial trade and conservation trap and transport catches from the closed Erne system.

6 Compliance with management measures

Fisheries management compliance is closely monitored by the regulatory agencies.

For England and Wales there is little evidence of illegal, under-reported or unrecorded catches across the fisheries in question. Most offences detected are for minor infringements of permit conditions or fishing without appropriate authorisation.

For the Neagh Bann RBD, data are reported in the DAERA statistics digest about illegal, under reported catches (which are minimal, see Withdrawal Agreement and Political Declaration) targeting eel.

7 Monitoring of species status

7.1 Global

Recurring scientific advice is provided by ICES, at the request of several States and multi-lateral bodies (see section 2.2.1), on the state of the eel stock, the management of the fisheries and other anthropogenic factors that impact it. In support of this advice, ICES is asked to provide estimates of catches; fishing mortality; recruitment and spawning stock; and relevant reference points for management. The EU also arranges, through Member States or directly, for any data collected through their Data Collection Framework (DCF) and legally disclosable for scientific purposes to be available to ICES. On leaving the EU, the UK has established a separate governance framework, including a retained DCF, to support the coordination of UK fisheries data and evidence.

ICES requests information from all the countries within the geographic range of the European eel annually via a data call. National representatives to WGEEL are requested to provide this information within a series of spreadsheets and with an accompanying text (Country Report) explaining, for example, management structures, data collection programmes and national assessment methods. The UK signed a Memorandum of Understanding with ICES in January 2021 which, amongst other things, requires the UK to provide relevant data to ICES for them to undertake stock assessments and provide advice relating to the North Atlantic and its adjacent seas, including advice on European eels.

The setting for data collection varies considerably between countries, depending on the management actions taken, the presence or absence of various anthropogenic impacts, but also on the type of assessment procedure applied. The assessment framework varies from area to area, sometimes within a single country. Accordingly, a range of methods may be employed to establish silver eel escapement limits, management targets for individual rivers, river basins, RDBs, EMUs and nations, and for assessing compliance of current escapement with these limits/targets. These methods require data on various combinations of catch, recruitment indices, length/age structure, recruitment, abundance (as biomass and/or density) or maturity curve, to estimate silver eel biomass, fishing, and other anthropogenic mortality rates.

7.2 UK

The status of the European eel in the UK is monitored through statutory reporting of fishery catches and effort, and abundance and biological characteristics of the eel throughout the region (Cefas *et al.* 2021; see below). Monitoring programmes address local and national requirements plus those to support obligations set out in the EC 1100/2007, as retained in UK law, and the DCF. In England and Wales, the EA and NRW survey yellow eel abundance across EMUs using a six-year rolling programme of electrofishing surveys. These data are used to assess the biomass of silver eel escaping from each EMU, as required by the EU Eel Regulation (1100/2007) now retained in UK law, and ICES data request, using SMEP II + Impacts models. Eel recruitment is monitored at several sites around England and Wales, to assess trends in recruitment over time.

There is no commercial glass eel fishery in Northern Ireland. The relevant glass eel catches for the Neagh Bann EMU are transported into Lough Neagh as an assisted migration by the LNFCS who have provided the funding and manpower to undertake this since 1965.

In Lough Neagh, eels are sampled regularly as part of a long-term research programme, funded by DAERA and undertaken by AFBI, which investigates all life stages throughout the year. Yellow eel catches are sampled weekly over 20 weeks (from May to September). A sample of 20 eels each week is chosen to reflect all sizes caught and these are analysed for age and length. In addition, the entire, ungraded landing of two fishing crew on one day each month is sampled, usually comprising 400–600 eels captured by longline and a similar number by draft net, to enable comparison between methods. Every eel is measured for length and the total catch recorded.

Samples of ten silver eel, chosen to reflect all sizes in the catch, are removed every week over a 12-week period (from October to December inclusive) at Lough Neagh and analysed for age and length. At weekly intervals the previous night's haul is measured for length. The number analysed can vary widely but on average covers at least 400 fish within a night's catch of greater than 1 tonne. In addition, the weekly silver eel samples are also analysed for length, weight, fat content, sex, prevalence, and intensity of *Anguillicola crassus*, stomach contents, and gastrointestinal endohelminths. Sex ratio of the silver eel population is also examined by counting the numbers of individuals contained in the graded (depending upon size) 15 kg boxes. The fishery records the number of boxes of small (male) and large (female) eels sold, and from this the sex ratio and number of silver eels can be estimated.

8 Conservation of the species

8.1 Global

As a single stock shared between many countries, the conservation of the species requires international cooperation. In addition to the species being listed in the CITES Appendices in 2009, European eel was also included in 2015 in Appendix II of the Convention on Migratory Species (CMS). Appendix II of CMS includes animals with unfavourable conservation statuses, and which require international agreements for their conservation and management. Parties that are Range States of migratory species listed in Appendix II are encouraged to conclude agreements where these would benefit the species and to give priority to those species in an unfavourable conservation status.

In 2017, CMS adopted a concerted action plan for European eel which envisaged meetings of range States to identify and prioritise any gaps in conservation and management efforts and to discuss possible options for a future CMS instrument. The UK has participated in the 1st (Galway, Ireland, 2016), 2nd (Malmo, Sweden, 2018) and 3rd (Malmo, 2019) Meetings of Range States of the European Eel organised by the Secretariat of the CMS and the Sargasso Sea Commission, the latter meeting (in Malmo, Sweden, June 2019) considered future actions on European eels under the CMS. At their 13th Conference of the Parties (CoP) in February 2020, the Parties to CMS adopted Decisions 13.76-13.79 requiring, subject to resources, the development of a draft action plan for adoption at the 52nd or 53rd meetings of its Standing Committee or at CoP14 (August 2023).

CITES has retained an active interest in European eels with Decisions adopted at all their recent CoPs, most recently with the adoption of Decisions 19.218-19.221 at CITES CoP19 (November 2022). These, amongst other things, encourage Parties to strengthen coordination measures between them to improve traceability of eels in trade and effective enforcement measures, that NDFs are developed and shared, and that review and advice on these is sought from the CITES Animals Committee.

CITES has also, through its Review of Significant Trade, scrutinised trade in European eels and made recommendations to specific countries for measures to be implemented to ensure trade is sustainable. Failure to implement the recommendations can result in sanctions, including recommendations to suspend trade, being taken under this compliance mechanism. Currently, three countries, Algeria, Morocco, and Tunisia, are retained in this review. Trade from the UK might also be subject to such future scrutiny.

ICES requests information on eel stock parameters from countries within the geographic range of the European eel (North Atlantic, Baltic and Mediterranean Seas, and inland waters) via the Working Group on Eels (WGEEL). This includes annual updates on recruitment, yellow and silver eel abundance indices, landings and releases and since 2022 all biometric data available (grouped and individual) as well as eel-quality data (optional; e.g. muscle lipid content, *Anguillicola crassus* proportion, etc.). In addition, biomass and mortality indicators are requested every three years. The UK is also an active participant in the Joint EIFAAC/ICES/GFCM Working Group on Eel (WGEEL).

The IUCN Anguillid Eels Species Group periodically reviews the status of European eel and other eel species against the IUCN Red List criteria – the most recent review concluded in 2020 (Pike *et al.* 2020).

The conservation of the species is managed within the EU through national programmes addressing the obligations of the EU's Eel Regulation (EC 1100/2007). Many non-EU countries within the natural range of European eel have developed, or are developing, management regimes akin to those set out in EC 1100/2007.

The EU also sets fishery controls for EU marine waters under the auspices of the Common Fisheries Policy. Member States, and non-EU management countries, implement national measures to control fisheries and other anthropogenic impacts.

The UK continues to be an active collaborator and participant in matters relating to the conservation and sustainable use of European eels both domestically and internationally.

8.2 UK

8.2.1 Wider environment

The UK has chosen to focus its efforts in eel conservation on removing barriers to migration or making them accessible by eel and in avoiding mortality in intakes to power stations, etc.

In England and Wales in the period 2017 to 2019 (Cefas *et al.* 2021), 99 new eel passes were installed restoring access to over 1,100 ha of river habitat (totalling 885 passes since 2009 with access restored to over 9,300 ha) and 24 new screens installed at water intakes during 2017 to 2019 (totalling 52 eel screens since 2009).

Other more recent projects complement this work – for example, approximately £20 million has been invested in the '*Unlocking the Severn*' project (part-funded by LIFE and the National Heritage Lottery Fund) which has restored access by migratory fish (with a focus on twaite shad *Alosa fallax* but also benefitting salmon and eels) to greater than 158 linear miles (253 km) of river habitat in the Severn catchment by removing six major weirs (or making them passable to migratory fish).

In Northern Ireland, for those Eel Management Units (EMUs) whose EMP indicated that they were not compliant in achieving the Eel Regulation conservation target, (because of combined impacts from fisheries and turbine mortalities), the UK has closed commercial fisheries. In their place, the UK (jointly with the Republic of Ireland) established conservation 'trap and transport' fisheries to assist in glass eel migration and silver eel escapement around hydropower stations (the transboundary North Western International River Basin District Eel Management Plan for the Erne catchment shared with the Republic of Ireland).

All commercial fisheries have been closed across Scotland and, more recently, in Wales.

8.2.2 Site protection

The two main glass eel fisheries (on the rivers Severn and Parrett) fall within sites that have statutory protection under several nature conservation designations. These include protection as Sites of Scientific Interest (SSSIs) under the 1981 Wildlife & Countryside Act (as amended) by the following sites: the Severn Estuary SSSI; the Upper Severn Estuary SSSI; and Bridgwater Bay SSSI. European eels are identified as a feature of interest in the citation for the Severn Estuary SSSI. These statutory designations provide protection against actions which might damage the special features for which they were designated.

Protection by these SSSIs also legally underpins additional international designations for the Severn Estuary / Môr Hafren as a wetland of international importance under the Ramsar Convention ('Ramsar sites'), as a Special Area of Conservation (SAC) and as a Special Protection Area (SPA). European eels and the migratory fish assemblage are also listed as a qualifying feature of interest in the Ramsar designation (but not for the SAC).

Lough Neagh is also designated as an Area of Special Scientific Interest (ASSI) under the Environment Order (Northern Ireland) 2002, Part IV, the citation for which refers to European eel as a feature of interest. Together with Lough Beg, it is also designated as a wetland of international importance under the Ramsar Convention and as an SPA.

European sites, such as SACs and SPAs, were originally designated under, respectively, the Habitats and Birds Directives of the European Union and comprised part of their 'Natura 2000' network. With the UK's exit from the EU, these sites now form part of the Bern Convention's 'Emerald Network'; UK site data for SACs and SPAs were transferred to the Bern Convention's database in 2021 (with updates in 2022).

SACs and SPAs, known as 'European sites', are protected under the Conservation of Habitats and Species Regulations 2017 as amended (known as the 'Habitats Regulations'); UK policy also extends this protection to Ramsar sites. An assessment under the Habitats Regulations, known as a Habitats Regulations Assessment (HRA), must be carried out if any proposal for a plan or project could significantly harm the designated features of a European site. Such assessments should take a precautionary approach and a proposal should be refused if one cannot rule out all reasonable scientific doubt of an adverse effect on a site's integrity.

9 Effects of illegal trade on the survival of the species

9.1 Global

Illegal, unreported, and unregulated (IUU) fishing is known to occur across the natural range of the European eel, though it is not quantified at this management scale (ICES 2020). Illegal trade, especially of live glass eels from the EU to east Asia, where they are used in aquaculture, is reported to be significant (UNODC 2020; see also submission of the EU to the 69th meeting of the CITES Standing Committee). Estimates of the extent of illegal trade in live glass eels vary but potentially range from 10 tonnes to 100 tonnes per annum and thus constitute a significant proportion of estimated natural recruitment of 440 tonnes to the region (Bornarel *et al.* 2018).

9.2 UK

The magnitude of illegal trade in yellow and silver eel is considered ‘Medium’ using the guide in Mundy-Taylor *et al.* (2014), because there is good documentation of trade (domestic and international – between UK and continental EU) but the trade chain is difficult to follow.

The magnitude of illegal trade in glass eel is considered ‘Low’ for UK fisheries because there is good documentation and the trade chain is transparent, but ‘High’ for continental Europe because there is mounting evidence of significant quantities of illegal trade between the EU and east Asia being intercepted by control agencies (see above). Illegal trade in European eels is, nevertheless, a priority for the UK CITES Priority Delivery Group and UK’s National Wildlife Crime Unit which, with other UK enforcement agencies (UK Border Force, EA, NRW, relevant Police Forces), actively participates in pan-European enforcement actions such as Operation Lake.

The PGI Registration for Lough Neagh Eel is considered by the EU as providing a high-level traceability system (EU Commission Regulation 668/2014).

10 Products in trade

Live glass eels may be available for export where they are derived from an estimated surplus. Any trade in such specimens will be restricted to live specimens less than 12 cm in length (using CITES specimen code FIG for fingerlings) and to specific purposes (See sections 13.1 and 13.3).

Other products in trade will include, predominantly, live yellow and silver eels from Lough Neagh. These are typically transported within the UK to London (to produce jellied eels) which accounts for 14% of recent trade (see earlier comments on Northern Ireland Protocol, and subsequent Windsor Agreement, section 1.3). The remaining 86% are (and were whilst the UK was within the EU) exported live to the Netherlands for subsequent processing (smoking) and retail within the EU. It is possible that other processed products, such as frozen specimens, may also be traded on occasions. In Northern Ireland, a licence is required to trade eels and it is a legal requirement that details of purchases and of sales must be recorded in a register. These documents are checked regularly by DAERA officials.

11 Socio-economic importance of the trade

Before the COVID-19 pandemic, the glass eel fisheries in England and Wales supported approximately 500 casual dip net fishers in a seasonal fishery, and several permanent employees in the two trading businesses.

Lough Neagh is managed by the LNFCS (Lough Neagh Fishermens Co-operative Society). This cooperative was formed in 1965 of fishermen living around the lough following many decades of competition between local fishermen and the owners of the fishing rights. The Cooperative were ultimately able to purchase the fishing rights to all of Lough Neagh in 1972. They have subsequently been responsible for the management of all the fisheries on the Lough (and outflowing River Bann). As such, the fishery provides an example of community-based natural resource management which is unusual in a European context.

The Lough Neagh eel fishery provides the sole livelihood for 240 people and contributes to the seasonal livelihood of greater than 210 fishermen with licences to fish on the lough. As such, the fishery has great value to the local rural economy (including to businesses that support the fishery such as in boat repairs or fuel sales) and, with eel landings being worth approximately £3 million (€3.36 million) per year, is the most valuable harvest of any finfish (including marine fish) in Northern Ireland. A socio-economic appraisal has been prepared for the LNCFS (Steele 2018).

12 Scientific Basis of the NDF

This overarching NDF assessment is for:

- specified rivers supporting glass eel fisheries in England and Wales
- the yellow and silver eel catches from Lough Neagh, including the Lower River Bann.

12.1 Identifying glass eel fisheries exploiting a surplus of recruitment

Two new analytical approaches were developed to examine the impact of glass eel fisheries on those rivers in which they take place and, particularly, to identify whether any of these fisheries might be exploiting a biological surplus of recruitment. A surplus is defined as the part of the recruitment exceeding that required to achieve carrying capacity within the relevant system. Both methods depend on estimating the recruitment carrying capacity (eels per unit wetted area) for each catchment, comparing this to catches and then implementing measures to ensure the required level of recruitment is able to pass the fishery, after which any additional recruitment can be considered as a surplus.

For both approaches 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 migration through the estuary, the wetted area was estimated from the tidal limit using the Accumulated Area of water upstream calculated with the Network Analyst package. Where feasible, wetted areas were adjusted to take account of barriers to migration limiting the potential production from present-day habitat. Only on the river Parrett was it feasible to fully 'ground-truth' barriers to migration and so provide a better estimate of the true wetted area. For the much larger River Severn, and all other river catchments, the impact of barriers was accounted for by adjusting the biomass production (B_0) estimate based on the General Linear Model (GLM) used in EMP reporting and using the full wetted area for the catchment (so the estimate for the wetted area of 6,380 ha for the Severn was left unchanged). In other words, the estimate for B_0 for the Severn used in the NDF (with the effects of barriers included) was 6.8 kg/ha compared with the B_0 estimated for the EMP (without barriers) which was 11.98 kg/ha.

These two new analytical methods assessing the impact of glass eel fisheries differ in the manner in which the carrying capacity of eel is estimated.

a) *Lough Neagh eel carrying capacity*: from a range of studies (Moriarty 1999; Moriarty & Dekker 1997; Rosell *et al.* 2006), this has been found to be 300 glass eels per hectare (and corroborated in this current study – section 12.2)

b) *According to the pristine silver eel production used in UK EMPs:* 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. This glass eel to silver eel conversion is used in the UK eel management plan assessments (see Annex A of Cefas *et al.* 2021) and by the ICES WGEEL and is based on the following assumptions regarding the life history of eel in UK waters:

   i. a settlement instantaneous mortality of 0.00915 day^{-1}, (95% CI ± 0.00149 day^{-1}) based on an extrapolation from the study of Bisgaard and Pederson (1991) to a glass eel of 80 mm;

ii. a settlement period of 50 days (Briand 2009) assuming a water temperature of 9° C;
iii. an annual instantaneous mortality following settlement of 0.14 yr^{-1} (Dekker 2000);
iv. a 50:50 sex ratio; and
v. males maturing at 11.9 (95% CI ± 0.6) (@ 89.9 g (95% CI ± 3.7g)) and females at 17.8 (95% CI ± 0.8) years (@ 568.9 g (95% CI ± 57.1 g)) (Aprahamian 1988).

These two approaches were applied to the 25 rivers for which commercial glass eel fisheries reported catches to the EA for 2015 to 2017 (Figure 4). The “300 glass eel per hectare” method suggested 13 fisheries with the potential to yield a surplus, by contrast, the “B_0 silver eel escapement” method was more precautionary, suggesting eight fisheries with a surplus. All 13 rivers are shown in Table 2.

The “300 glass eel per hectare” method was discounted in favour of using the more precautionary, and locally relevant, “B_0 silver eel escapement” approach. This analysis, with the adjustments above, indicates the availability of a significant surplus in some key UK glass eel fisheries (Table 2). Two fisheries, the Severn and the Parrett, stand out as having a very large surplus; both these fisheries benefit from the ‘funnelling’ effect of the Severn estuary/Bristol Channel on glass eels arriving to the UK from the south-west.

Control measures to ensure that sufficient glass eels continue to be able to pass the fishery to fill the required carrying capacity for each river have been developed and applied; these continue to be discussed with those engaged with the fishery (see section 13.1).

The scale of the control measures required depends on the assumed exploitation rate. However, our evidence for fishery exploitation rates of glass eels in the UK consists of only one peer-reviewed single season study available for the Severn (Aprahamian & Wood 2021, see below). Similarly, the only published estimates available of the pre-fishery abundance (PFA) of glass eel are limited to outer Severn estuary for February 2012 and 2013 and April 2013 (Walmsley *et al.* 2018). It would be both technically challenging and very expensive to sample eels in coastal waters or estuaries at required spatial and temporal scales to estimate PFA.

For the purposes of the original analyses, exploitation was considered as a highly precautionary 100% catch efficiency, even though this is wholly improbable as it assumes that all glass eels are taken by the fishery when in operation. Therefore, the peer-review literature was consulted to determine estimates of exploitation rates in equivalent fisheries (i.e. those operating similar gear and bank-based). From the studies available (Aprahamian & Wood 2020; Aranburu *et al.* 2016; Lin *et al.* 2017; Lin & Jessop 2020), the mean range of exploitation rates varied from 4–36% (see Appendix 6), In addition, there have been two unpublished estimates on the Severn, where the exploitation rate estimates were lower at 4.7–9.6% and 0.63% in 2022 and 2023, respectively.

One of the studies included in our literature review of exploitation rates was from the River Severn, where mark and re-capture (glass eels dyed in Neutral Red) was used to more accurately estimate exploitation rates. This work (Aprahamian & Wood 2021), although based on only one season disrupted by the Covid-19 pandemic, estimates a full season exploitation rate of approximately 12–16%, within the range of figures referred to in the review, suggesting that 84–88% of glass eels escape the fishery. The paper concludes that fishing pressure is sustainable, and the local population is not over-exploited. The authors also suggest that (density dependent) mortality of glass eels is likely to be very high providing further evidence for the benefits to silver eel escapement of stocking glass eels from such donor regions to other recipient locations where local eel density and thus mortality is lower.

To retain sufficient precaution, and yet recognise that natural recruitment is taking place, a deliberately very precautionary 75% exploitation rate has been applied in this NDF to balance some of the inherent uncertainties in the production modelling. When first selected, this figure was mid-way between the then average highest range of published exploitation rates (55%) and the improbable and over-precautionary 100%. Whether to continue to use this exploitation rate or to use a lower rate has been reviewed; it has been decided to retain the use of this rate of 75% recognising that it is deliberately precautionary (see later discussion in Conclusions - Section 16 - on applying the current ICES advice).

Although it has been shown here that glass eel recruitment to the Severn exceeds its carrying capacity (Table 2), thus creating a surplus that would have died otherwise and can therefore be exploited by the fishery without detriment to silver eel production, the Severn RBD does not comply with the current silver eel escapement ($B_{current}$) target as estimated under the EMP. Aprahamian and Wood (2021) estimated the size of glass eel run in the Severn to be between 22.5 tonnes and 28.8 tonnes in 2019, indicating that the recruitment to the Severn is not a limiting factor, thus the best available silver eel production that would have existed if no anthropogenic influences had impacted the current stock (B_{best}) should be higher than currently estimated from yellow eel surveys under EMP. This also implies that the relative impact of the glass eel fishery in the Severn may be lower than the estimate used in the EMP assessment, with other non-fisheries impacts probably having a greater contribution to the overall mortality.

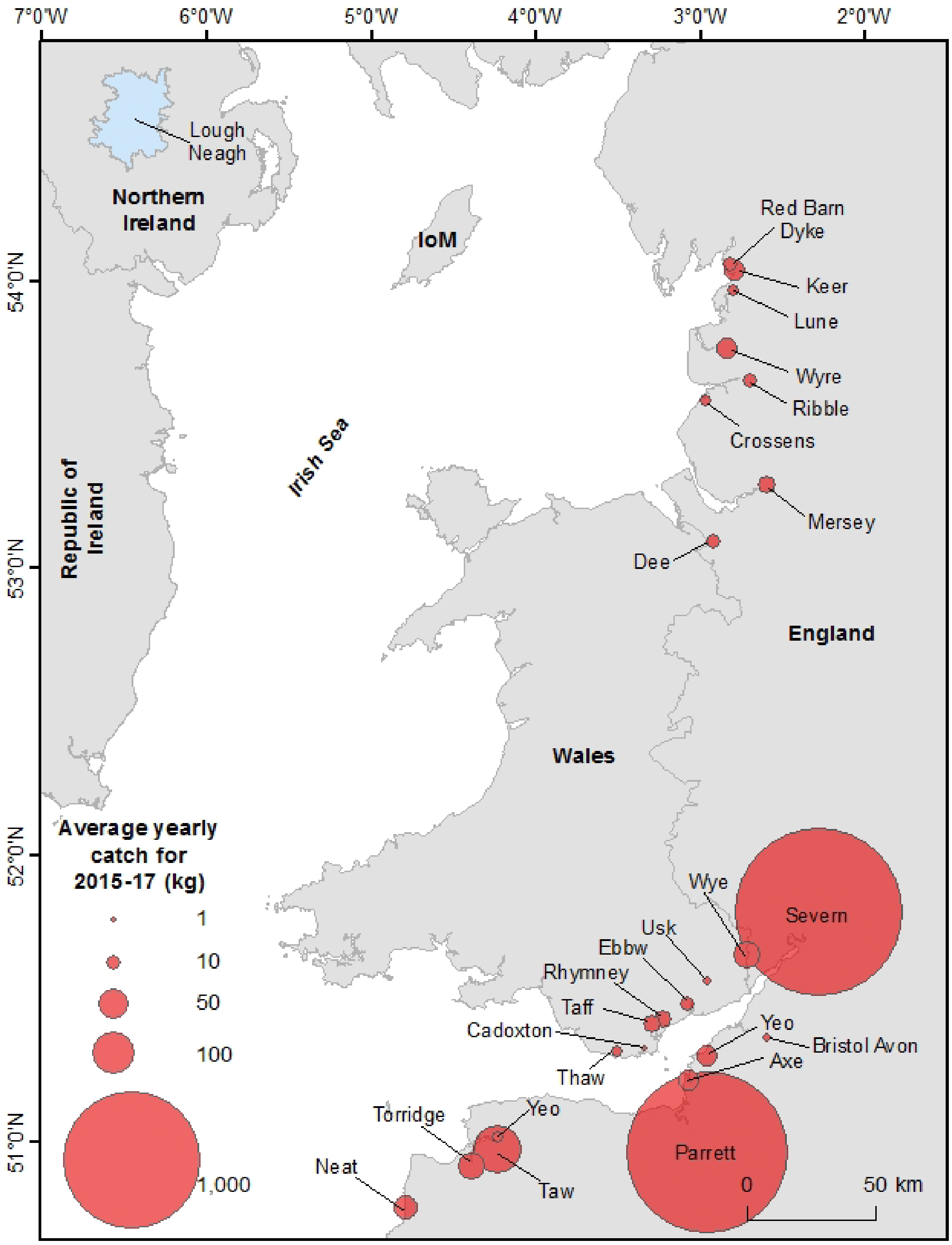

Figure 4. Location and relative size of mean catch (2015 to 2017) of UK glass eel fisheries referred to in Table 1.

Table 2. Data used in estimating recruitment carrying capacity of rivers supporting glass eel fisheries in England and Wales and glass eel surplus estimates based on minimum catch (kg), with possible management options presented. For more information on management measure please see Section 13.1

River	RBD (see Figure 4)	Wetted area (ha)	EMP B0 (kg/ha)	Glass eel required to meet the carrying capacity considering barriers (kg)	Fishery catch (kg) 2015 to 2017		Minimum glass eel surplus – based on average fishery catch	Re-stocking (i) or catch (iii) required to meet management measures based on 75% exploitation rate & minimum catch	
					Average	Range		(i)	(iii)
Severn *	Severn	6,380	6.84	735	1,508.3	1,146 – 1,853	774*	353	2,204
Parrett	South West	438	37.03	273	1,403.4	1,265 –1,597	1,130*	-149	819
Taw	South West	641	28.07	303	119.7	66 – 147	-183	281	909
Neat	South West	55	28.07	26	29.1	18 – 38	3*	20	78
Keer	North West	20	13.98	5	23.7	12 – 31	19*	1	14
Yeo	Severn	49	6.84	6	21.3	0 – 31	16*	6	17
Axe	Severn	109	6.84	13	19.8	3 – 29	7	12	38
Rhymney	Severn	173	6.84	20	18.1	16 – 20	-2	15	60
Red Barn Dyke	North West	7	13.98	2	11.4	19 – 15	10*	-1	5
Yeo	South West	46	28.07	22	9.2	2 – 21	-13	21	65
River Thaw	West Wales	59	13.98	14	6.8	6	-7	12	42
Crossens	North West	20	13.98	5	6.8	3 – 9	2	4	14
Cadoxton River	West Wales	19	13.98	4	2.5	1 – 4	-2	4	13

* Rivers with a positive surplus

Option (i) Glass eel stocking requirements above the fishery: Glass eel escapement past the fishery was subtracted from the glass eel required to meet the carrying capacity. The former was calculated by subtracting the minimum catch from pre-fishery abundance as estimated under the 75% exploitation rate and the latter by multiplying B_0 with the wetted area and dividing it by glass eel to silver eel conversion rate.

Option (iii) Levels of catch required to demonstrate that natural recruitment meets carrying capacity: calculated from glass eels required to meet eel carrying capacity and 75% exploitation rate.

12.2 Lough Neagh eel production

Lough Neagh comprises 39,200 hectares of open water. It has a mean depth of 9.5 m with a maximum of 30 m. It is the largest lake by surface area in Britain and Ireland and, as the water does not stratify and is generally aerated by wind driven circulation throughout the water column, the entire lake-bed area is available to eels. It is classified as hypertrophic due to phosphorus and nitrogen nutrient inputs, now mainly from agricultural land but also from human domestic sources.

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 2018) is estimated at 54.1% of pristine – exceeding the '40%' long term objective (see section 2.2.2.2) (Defra 2018). This success is dependent on the fishery continuing to have access to suitable markets which, in turn, generate the resources for assisted migration and stocking of glass eels, and for the provision of year-round enforcement patrols by the LNFCS. Any loss of markets or closure of the fishery 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 current trading arrangement under the terms of the NIP have thus far provided sufficient market access to avoid these negative scenarios.

An input-output eel production model for Lough Neagh has been developed to investigate the effects of stocking and the fishery on eel production. A full description of the input data, analytical approach and results is provided in Appendix 2 and in Aprahamian *et al.* (2021), but is summarised here, as follows.

12.2.1 Data sources – observed and derived

- Natural glass eel input (kg) was available for 1933 to 1948 and 1960 to 2017, and additional purchased glass eel input (kg) was available for 1984 to 2017. The model used by the WGEEL to forecast glass eel recruitment (ICES 2019b) was used to hind-cast (reconstruct) recruitment for Lough Neagh to 1923.

- Annual time-series catch (kg) data were available for silver eel, separately for each weir from 1905 to 2016, and for yellow eel in the Lough from 1922 to 2017. The yellow eel catch was converted into silver eel equivalents (the number of silver eels that would have been expected to emigrate if the yellow eels had not been caught) using the Scenario-based model for eel populations (SMEP II) (Aprahamian *et al.* 2007; Walker *et al.* 2013).

- A significant relationship ($p < 0.05$) between the silver eel exploitation rate and autumn river flow (discharge from the Lough past the fishery), was derived from mark-release-recaptures from 2003 to 2017, and mean autumn flow for the period back to 1905 that was derived from:

    (i) a correlation between mean river flow for 1 September to 31 December against mean rainfall for the same period for the years 1980 to 2016, and

    (ii) daily rainfall data back to 1837.

- For the period 2003 to 2016 daily catches (C_d) of silver eel, in number of females and males, were available and using the relationship between exploitation rate (E_d) and flow, the total output (N_d) for each day could be calculated as C_d/E_d. The total output (catch plus escapement) for the season was then the sum of the daily (n) estimates.

- The estimates of the total exploitation rate for the fishery and catch as a proportion of the total output has fluctuated over the period 2003 to 2017, with a mean (± 95% C.I.) exploitation by the whole fishery of 24.7 ± 2.1%.
- Age profiles of the yellow and silver eel were available from catch sampling from 2003 to 2017. Sex ratios for silver eel catches were available for 1922 to 1966 (Anon 1966), 1965 to 1974 (Parsons *et al.* 1977), 1975 to 1978 (Kennedy & Vickers 1993), and for the yellow eel catch for 1996 to 2016 (D. Evans, personal communication).
- A density dependent relationship between sex ratio and abundance with an increase in the proportion of males in the silver eel population with increasing stock density (Parsons *et al.* 1977) was further developed yielding a significant relationship between the sex ratio (proportion male) in year *n*+8 and the size of the silver eel population in year *n*.

12.2.2 Results

The dynamics of the eel population in the Lough can be described by a Beverton-Holt Stock recruitment relationship (Figure 5), which shows that silver eel output increases with increasing glass eel input. However, silver eel output reaches a plateau beyond which increasing glass eel input does not correspond to additional silver eel production but rather a consequential rise in natural mortality as indicated by a reducing proportion of glass eel surviving to silver eel phase (Figure 6).

Figure 5 indicates that the carrying capacity of Lough Neagh has changed over the last century with two significant regime shifts (Aprahamian *et al.* 2021). There was a period of low productivity during the early part of the time series affecting the 1923 to 1943 glass eel year-classes (green line in Figure 5), followed by a period of high productivity for the 1944 to 1975 year-classes (blue line in Figure 5). This first shift to increased productivity is attributed to continued eutrophication to a hypertrophic state which started in the 1960s (affecting the year classes from ~1940s onwards). After this period, there is a decline in productivity to pre-1944 levels (green line in Figure 5) which has persisted to the present, despite nutrient levels remaining high. This decline is attributed to competition with roach (*Rutilus rutilus*), not native to the lough, that were unofficially introduced in the early 1970s and which now are the dominant fish both in terms of biomass and number (Aprahamian *et al.* 2021).

The instantaneous rate of natural mortality was density dependent, increasing with the density of glass eel stocked into Lough Neagh. Mortality ranged from a low of approximately 2% per year at low densities of 100–200 glass eel per hectare to a high of 12–14% at densities of 700 glass eel per hectare (Figure 5). The output of silver eel in relation to the density of glass eel stocked shows the converse relationship with, at low densities, approximately 60% of the glass eel stocked being estimated to survive to silver as opposed 10–20% at high densities (Figure 6). An optimum stocking rate of approximately 12 million glass eels (equating to 300 glass eels per hectare) is proposed (Figure 5), supporting previous conclusions of Moriarty (1999), Moriarty and Dekker (1997), and Rosell *et al.* (2006).

Lough Neagh has been stocked in almost every year since 1984. The model shows that this stocking is making a substantial contribution to silver eel production and associated escapement. If stocking had not occurred, the average annual silver eel pre-fishery abundance (PFA) from year to year would have been 69% of that attributable to stocking (237 tonnes versus 344 tonnes), a difference of about 107 tonnes per annum.

Those eels stocked already will continue to supplement production and escapement (i.e. from naturally recruiting glass eels, average over 10 years of 263 kg) for several more years. If stocking ceased, however, escapement would dwindle.

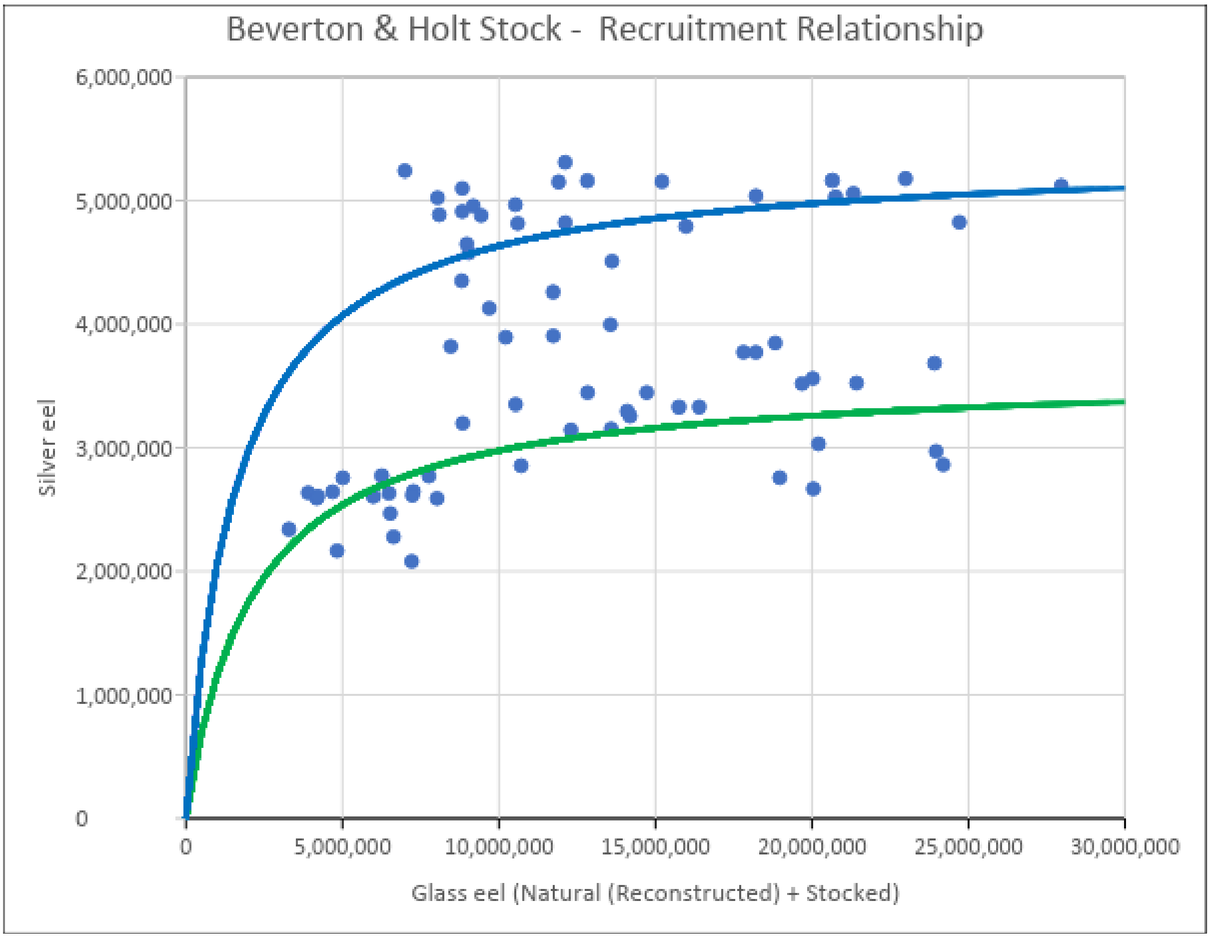

Figure 5. The relationship between glass eel in and silver eel out at Lough Neagh for each glass eel cohort from 1923 to 1988. The blue (upper) line represents the period from 1944 to 1975 and the green (lower) line from 1923 to 1943 and 1976 to 1994 (see text for explanation).

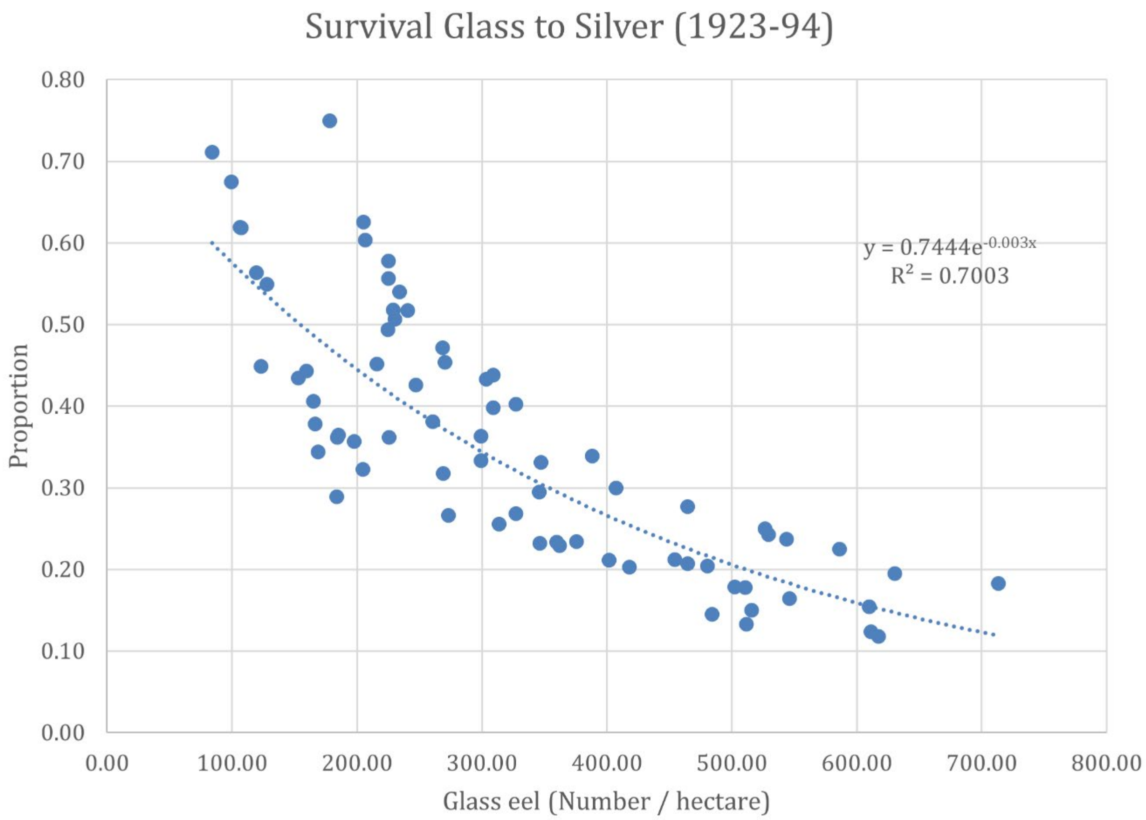

Figure 6. Proportion of glass eel surviving to silver eel at Lough Neagh in relation to stocking density.

In summary, this new input-output model based on over 100 years of data validates the previous studies in concluding a density of 300 recruits per hectare to optimise silver eel escapement against investment in supplementary stocking. Assisted natural recruitment (at 29.1 recruits per hectare) is far below this optimum density at present. Stocking can make use of this potential production ‘gap’, whilst net benefit is maximised where stocked eels are sourced from fisheries exploiting a surplus to recruitment in their ‘donor’ waters (discussed below).

The new model predicts that natural recruitment, via assisted migration, of 371 kg (mean 2010 to 2019) of glass eel into Lough Neagh (equivalent to 29.1 glass eels per hectare) would yield a lifetime silver eel escapement, after the fishery exploitation, of about 81.5 tonnes (Table 3a).

Stocking 2,378 kg of glass eels (equivalent to 186.3 glass eels per hectare) into Lough Neagh would yield a combined additional lifetime silver eel escapement, after the fishery exploitation, of about 172.1 tonnes (Table 3b).

These glass eels, if left *in situ* in the donor catchment in which they were surplus to recruitment (i.e. in excess of carrying capacity), would not have otherwise contributed to silver eel escapement because of elevated density dependent natural mortality.

Table 3a. Silver eel escapement from Lough Neagh based on current recruitment (note 'natural recruitment' refers to glass eels derived from assisted migration up the river Bann; 'surplus' refers to glass eels derived from glass eel fisheries elsewhere in the UK – see section 12.1).

EMU/RDB	Wetted area (ha)	Glass eel input (kg) natural + surplus	Density glass eel ha^{-1}	Survival rate of glass eel to silver eel (Figure 6)	Number of silver eel from donor to sea **	Kg of silver eel from Neagh to sea
Neagh-Bann	38,300	371* + 0	29.06	68.19%	326,243	81,586

Table 3b. Silver eel escapement benefit from stocking donor glass eels into Lough Neagh under current recruitment and current fishing effort (note 'natural recruitment' refers to glass eels derived from assisted migration up the river Bann; 'surplus' refers to glass eels derived from glass eel fisheries elsewhere in the UK – see section 12.1).

EMU/RDB	Wetted area (ha)	Glass eel input (kg) natural + surplus	Density glass eel ha^{-1}	Survival rate of glass eel to silver eel (Figure. A2.4)	Number of silver eel from donor to sea **	Kg of silver eel from donor to sea
Neagh-Bann	38,300	371* + 2,378	215.33	39.0%	688,551	172,138
Neagh-Bann	38,300	371* + 2,230	203.73	40.4%	668,549	167,137
Neagh-Bann	38,300	371* + 1,391	138.02	49.2%	507.900	126,975

* Derived from 2008 to 2017 mean.
** Assumes that a stocked glass eel's contribution to the recipient site is 2/3 as effective as that of a natural recruit.

However, stocking is an expensive investment due to the purchase price of glass eels and transport costs. The presence of the current commercial fishery with its assessed and compliant management structure provides the economic model to fund stocking. The aim is to ensure an input of between 10 and 15 million glass eels per year (equivalent to 261–392 glass eels per hectare) which would meet the economic objectives of the fishery whilst providing a silver eel escapement compliant with the UK conservation target.

The recent average input (2010 to 2019) of glass eel to the Neagh Bann RBD (1,114,200 fish or 29.1 glass eels per hectare) needs to be increased to meet the management objectives of the fishery and its EMP. Stocking is currently funded by the fishery (50%), UK Government and the EU (EMFF) (50%) and thus an economically viable fishery is needed to ensure such an intervention. However, this funding came to an end at the beginning of April 2023.

The task is to ensure:

- an economically viable fishery
- a silver eel escapement which is compliant with the UK conservation target
- a demonstrable net benefit in terms of silver eel escapement over and above that of the stocked glass eel remaining *in situ* in their donor system.

The stocking of glass eels to Lough Neagh has been assessed *post hoc* against the IUCN guidelines for re-introductions and other conservation translocations (IUCN 2013). The translocations to Lough Neagh are both a ‘conservation translocation’ and one that is done to reinforce the population to enable a commercial offtake; indeed, in this case, the two aims are complementary. The approach taken in this NDF, including assessing the risk to donor populations, and the monitoring and adaptive management undertaken, are consistent with the guidelines.

12.3 Lough Neagh Silver Eel Escapement Assessment (40% target compliance)

Silver eel escapement ($B_{current}$) from Lough Neagh has been assessed and monitored by AFBI since 2003 using mark-recapture studies (Appendix 2). These findings have been corroborated following a request from the EU Commission, which lead to the design and use of bespoke hydro-acoustic studies specifically developed for migrating silver eel.

This system is heavily mediated for river flow by a series of sluice gates from the exit of Lough Neagh and along the Bann corridor. There is significant inter-annual variability across the dataset due largely to the effects of environmental parameters such as the changing frequency of:

- storm events;
- warmer/drier summers and autumns; and
- rainfall patterns.

All of these have a consequential effect on flow, sluice gate operating regimes and, ultimately, silver eel migration opportunity.

12.2.3 $B_{current}$ assessment

To assess compliance, annual mark-recapture studies were started in 2003. Between one and six estimates were made each year and the mean value used to estimate escapement for the season. These estimates have been undertaken annually except for 2007. In the development of this project, all these data were combined into an escapement model that incorporated flow as an explanatory variable allowing the exploitation rate to be estimated daily. In addition, access was given to historic catch metrics (daily catch data in the silver eel fishery) not previously available to AFBI scientists. These data, together with River Bann daily flow, have enabled the production of a more finely tuned silver eel escapement ($B_{current}$) estimate using the mark-recapture returns from 2003 to 2016. These data (date of capture, associated catch, and flow at that time) have allowed specific weir estimates of daily escapement to be determined, which are then summed over the entire fishing period.

Though it is not possible to determine the accuracy of the two methods, the revised approach enables hind cast estimates (using flow data) to be determined when no mark-recapture studies have been possible, such as in 2007. These assessments demonstrate the following.

- Using the target range of the Neagh-Bann EMP of 160–240 tonnes, the long-term escapement estimate (2003 to 2019) is 220.4 tonnes from direct assessment. (For the only EMU (Eel Management Unit) in Northern Ireland with a fishery, the GB_Neag RBD (River Basin District), the estimate of pristine escapement (B_0) was determined using historic data including catch and sex ratio, input-output regression analysis and from known productivity of eel growing areas. Using these three methods pointed to a potential natural output in the range of 400 to perhaps 600 tonnes per annum given historical high natural glass eel supplies. This range would estimate the required 40%

level at around 160 tonnes to 240 tonnes (Cefas, Environment Agency, Marine Scotland, Natural Resources Wales, Agri Food & Biosciences Institute 2021).

- In comparison, based on data from 2010 to 2019, direct assessment estimated 227.1 tonne whilst the newly developed escapement model estimated 225.1 tonnes;
- On the triennial EMP Review for 2020 to 2022, the comparative figures are 177.8 tonnes and 189.2 tonnes for direct assessment and the escapement model, respectively. This NDF uses a rolling five-year period, giving a mean of 227 tonnes.

Whilst the output trend is falling closer to the lower levels of the target range, they are still within the range as outlined in the Neagh-Bann EMP. However, as stated in Sections 12.2 and 13.2, this compliance is wholly dependent upon stocking which elevates recruitment input levels closer to those measured during the years associated with the $B_{pristine}$ (B_o) calculation.

12.2.4 Future $B_{current}$ assessment

Given that this EMU has completed its fourth triennial EMP review using data from 2018 to 2021 inclusive, the silver eel escapement calculation for $B_{current}$ has been changed to the more multi-metric escapement model since 2018. This will require the continuing provision of daily silver eel catches throughout a tagging assessment period which should be covered as a requirement under the terms and conditions of this current NDF; the provision of such data will form the basis of ensuring the level of traceability necessary.

13 Control Measures for an NDF

This chapter reviews the controls and conditions that might be necessary to provide the reassurances necessary to ensure that any trade permitted is genuinely non-detrimental. It is likely that destination countries for any exports will want to know that rigorous controls are in place in support of any assessment of non-detriment.

13.1 Measures to ensure a minimum level of glass eel recruitment to donor catchments

Establishing non-detriment for any harvest and trade in glass eels is based on the principle that such fisheries should not prevent optimum recruitment occurring and so the fishery should not affect escapement from the donor river system, recognising that density-dependent mortality is likely to occur (Figure 6). It is assumed, on a precautionary basis, that recorded catches represent **75%** of glass eels entering each river basin (see section 12.1) – only in those cases where catches are sufficiently high that the 25% assumed to escape the fishery significantly exceeds the estimated carrying capacity of the river, will non-detriment be considered feasible. The challenge then is to determine how to ensure that sufficient glass eels make it past any fishery present to ensure carrying capacity is achieved and so contribute to escapement targets.

In the absence of evidence to accurately estimate the exploitation rate of the fishery, a precautionary approach is adopted in assuming the rate is 75%. Options to ensure sufficient recruitment of glass eels to meet carrying capacity in donor catchments include the following.

(i) Restocking (Catch and release):
The amount of glass eels required to meet carrying capacity of any given river is caught, and then restocked above the fishery (in freshwater) on that river. This measure could be undertaken either as "assisted migration" (trap and direct transport over the first barrier on the system), or as a catchment-wide restocking programme; but in either case the glass eels to be restocked would need to be caught before any subsequent commercial exploitation and export is undertaken.

(ii) Fishery Restrictions (Temporal closure):
This measure involves closing a fishery for a sufficient number of days to be confident that carrying capacity is being met through natural recruitment (i.e. by saving glass eels from being caught, using the 75% assumption). The reduction in effort would be calculated on a river-by-river basis, by reviewing previous catch and trade records to predict expected savings.

Other effort restrictions may be possible (e.g. geographic restrictions; limiting the number of nets available to fish; reducing net size, etc.) but have disadvantages in terms of enforcement, equity, and confidence in achieving the required savings.

(iii) Catch tracking / post-fishing deficit restocking:
This option relies on the 75% rate assumption to predict the number of recruits evading the fishery and progressing to freshwater, based on the total catch during a season. If the "catch-recruitment target" is met, then no deficit stocking is required. In-year post-season stocking would be required by default, with the possibility of carrying over any deficit stocking to the subsequent year, subject to agreement and gaining the necessary assurances and stocking permissions.

These options are available to those involved in the fishery and trade, to consider which is likely to be most effective and most practical to implement. They are intended to cover the range of market access/demand scenarios, and facilitate the role of fishers, many of whom have indicated that they would like to donate catch for restocking.

These measures have some administrative, financial and enforcement costs to implement, the most effective approach will be put in place to achieve carrying capacity and so ensure non-detriment. In recent years, temporal closure has been applied on the Parrett and catch tracking and stocking any deficit on the Severn. In 2023, temporal closure only has been applied to the fisheries on both rivers. The UK will continue to work on refining these measures in consultation with those involved in the fishery, to achieve both the conservation objectives and to have measures which work in practice for the fisheries.

Subsequently, there is a need to be able to trace glass eels harvested to ensure they are not mixed with glass eels from other river basins (in which non-detriment might not have been found to be achieved). The UK already has a full traceability scheme for glass eel fisheries and trade and this scheme will continue.

13.2 Measures to ensure an NDF for the Lough Neagh Fishery

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). Controls needed for the stocking of, and fishery in, Lough Neagh will include:

a) ensuring that glass eels for stocking only come from fisheries for which non-detriment is achieved.

- This depends upon having traceability controls above, and the fishery being willing to restrict the sources from which they purchase glass eels. In this respect, there is good traceability of glass eel movements within the UK and statutory authorities are given advance notice of movement of glass eels to Lough Neagh. Any eels sourced by the LNFCS from other fisheries will need to be accompanied by an NDF.

b) managing harvest of yellow and silver eels to ensure that the Neagh Bann EMP remains compliant with the escapement targets of the EU Eel Regulation (section 2.2.2), note the revised $B_{current}$ calculation in section 12.3.

- Based on the Beverton-Holt model produced for Lough Neagh (with current outputs derived from periods of historically low recruitment and sub-optimal levels of stocking), the predicted levels of yellow and silver eel harvest and associated escapement for the years 2017 to 2023 are outlined in Table 4. In the light of improved natural recruitment and/or access to the suggested stocking densities outlined in section 12.1, these outputs would rise accordingly.

c) to ensure that the products of the fishery in international trade are not mixed with products from other fisheries.

- Lough Neagh eels have a Protected Geographical Indication (PGI) status in the EU. The EU protected food name scheme highlights regional and traditional foods whose authenticity and origin can be guaranteed. The risk of eels from beyond Lough Neagh being introduced into their supply chain is thus extremely low and doing so would jeopardise the reputation for quality built up by the fishery (see section 9.2).

d) 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.

Table 4. Predicted catch from Lough Neagh (yellow) and River Bann (silver) under current fishery operations and subsequent escapement for the years 2017 to 2023.

Year	Total weight (kg)	Yellow catch (kg)	Silver catch (kg)	Silver escapement (kg)
2017	476,215	250,927	56,702	168,586
2018	444,149	234,031	52,884	157,234
2019	407,013	214,463	48,462	144,088
2020*	378,303	199,335	45,044	133,924
2021*	361,234	190,341	43,011	127,881
2022	350,800	184,843	41,769	124,188
2023	343,649	181,075	40,918	121,656

Note that the commercial fishery on Lough Neagh was heavily impacted by COVID19 restrictions on fishing activity from 2020–2022 which will have an as-yet-unrealised forward impact on the projections from the output model given that the yellow eel harvest was significantly reduced, which will result in the production of additional silver eel escapees in the ensuing years. The impact of COVID19 and related changing fishing patterns means the model will need a 5-year period of settled fishing conditions to be re-run.

13.3 Trade controls

A separate document, providing details of the UK government approach to export of specimens of European eel over and above non-detriment will be made available.

However, it is not planned to use export quotas to regulate any international trade in **glass eels** because these do not provide any added value for the achievement of non-detriment (for other trade controls see section 13.3).

14 Meeting the requirements of Article IV.3 of CITES

Article IV.3 of the Convention requires Scientific Authorities to monitor trade to determine that a species is being maintained '*throughout its range at a level consistent with its role in the ecosystems in which it occurs and well above the level at which that species might become eligible for inclusion in Appendix I*' and, if that is not the case, to advise the Management Authority of suitable measures to be taken to limit the grant of export permits for specimens of that species..

14.1 Role of the species in the ecosystem

Understanding the role of a species in an ecosystem is not straightforward and determining whether trade is detrimental to a species' role is more difficult still. It is not clear what attributes or parameters ought to be measured to determine this and the role of a species in the ecosystem may change over time or by life stage.

We note, however, that the UK fisheries for glass, yellow and silver eels are not new and have been happening, in some cases, for many hundreds of years. Any ecosystem impacts are likely to be long-standing and probably are not now easily detectable (even if we knew what to measure). Nor are we aware of any observed or reported differences between similar ecosystems in the UK that are, or are not, fished for eels. Indeed, eels are more likely to have been detrimentally affected by changes to, and losses of, ecosystems (caused by factors other than fishing), than the ecosystems are likely to be affected by any reduction in eel numbers due to harvests.

The populations in the UK of some species which prey on eels, such as otters (*Lutra lutra*), bitterns (*Botaurus stellaris*) and cormorants (*Phalacrocorax carbo*), are recovering or healthy, including in the catchments affected by eel fisheries. There is no evidence of any of these predators declining in response to declines in glass eel recruitment indices, indeed the recovery in abundance and range of otters (Sainsbury *et al.* 2019) and bitterns, and the increase in distribution by cormorants, has taken place whilst eel recruitment indices have declined. This suggests that sufficient eels remain to provide prey or that these predators have been able to shift to alternative fish species.

In the absence of any known parameters that we can measure to indicate changes in ecosystems due to harvests, we believe the precautionary measures described in this document are likely to provide sufficient safeguards to maintain the role of the species in the ecosystems in which harvests are taking place. Nevertheless, we continue to take measures to work towards the long-term recovery of European eels and the ecosystems they occupy, and to increase their access to suitable habitats from which they are currently excluded.

14.2 Inclusion in Appendix I

We have not made an assessment at the full population level as to whether European eel might qualify for Appendix I, nor has a proposal for an Appendix I listing been made to the Conference of the Parties to CITES. Nevertheless, it seems very likely that, given the status of the species, it would meet some of the biological criteria for inclusion in Appendix I contained in Annex 1 of Res. Conf. 9.24.

Article IV.3 suggests that, in such cases, the Scientific Authority should advise on measures to restrict international trade. However, for reasons summarised in section 15 and detailed elsewhere in this NDF, restricting trade from the UK is unlikely to contribute to the recovery of European eel, indeed quite the opposite for the two fisheries considered here. Nor, for a population shared by many countries, can measures taken by one country alone ensure the species is maintained at, or restored to, a level well above that which it might become eligible for Appendix I. To achieve this requires coordinated and coherent measures at national and international level, such as proposed through the CMS (section 8.1). Nor can any measures be limited solely to limiting or restricting international trade (as suggested by Article IV.3) as the status of the species is affected by many other additional factors (see section 4).

This NDF, made at a smaller spatial scale than that of the full stock, seeks to ensure that the UK contributes to such international recovery measures by ensuring that any harvests for international trade are not only without detriment but also achieve a net benefit to the conservation of the species. However, these NDF measures are only a small component of those which the UK is already taking, through its Eel Management Plans, to contribute to the recovery of the population of the species overall (see section 8.2).

In summary, the species is likely to meet some of the criteria for inclusion in Appendix I and so is not 'well above' such a level; however, the measures described in this NDF are aimed at contributing to the recovery of the species; and simply restricting trade is likely to be counter-productive and unlikely to contribute to stock recovery.

15 Risk assessment

When undertaking this assessment for a non-detriment finding, we have sought to identify and mitigate risks and uncertainties.

These risks, for example, include those relating to the conservation status and biological vulnerability of the species, to the high demand and prices paid for glass eels in east Asia and the associated challenge arising from high levels of illegal trade of eels sourced from continental Europe. The UK's exit from the European Union has affected access to former markets for GB glass eels which, in turn, has affected fishing effort, harvests and the ease by which specimens can be traded to Lough Neagh for stocking.

There are compliance risks also for the UK in ensuring that our actions are sufficiently robust and evidence-based to respond to any challenges through, for example, the CITES Review of Significant Trade (Res. Conf. 12.8 (Rev CoP18) – which can impose recommendations to curtail or suspend harvests – and also to ensure we comply with other domestic legislation, such as for the protection of internationally designated sites through assessments under the Habitats Regulations (failure to meet requirements might also force the closure of fisheries).

Although the species is data-rich when compared with other CITES-listed species, there are also significant gaps in knowledge and uncertainties relating, for example, to the role of the species in the ecosystem and exploitation rates for glass eel fisheries. Addressing all of these has informed the degree of precaution we have applied to this NDF.

16 Conclusions: NDF for the export of European eel from the UK

This assessment sought to determine whether non-detriment could be achieved at finer spatial scales than those addressed by ICES (2015); the evidence collated suggests that **for some UK glass eel fisheries and for Lough Neagh yellow and silver eel fisheries, a positive NDF can be made subject to certain safeguards outlined earlier**. However, if considered at the level of the entire stock, this review has already concluded that a positive NDF is not feasible for trade in European eel from the UK (see Appendix 1).

The estimate of surplus glass eel from some glass eel fisheries in England and Wales takes, deliberately, a **highly precautionary approach** of assuming that the fishery exploits 75% of the recruitment to the relevant river. Only limited data are so far available to quantify the actual exploitation rate in UK rivers but given the characteristics of the fishing gear – bank based, one-man operated, small hand-held nets – and of evidence from published literature (see section 12.1; Appendix 6; Aprahamian & Wood 2020), this rate is likely to be much less than 75%. Consequently, recruitment upstream of the fishery and the available surplus are likely to be much greater than applied in this assessment. It is likely, however, that the exploitation rate will vary between fisheries and between years and reflect local circumstances. Even so, we believe that this high degree of precaution (that is, using a 75% exploitation rate) is warranted to reflect the limited number of peer reviewed studies currently available on glass eel exploitation rates in the UK, to ensure the fishery does not detrimentally affect the Severn Estuary/Môr Hafren European site (and so enables a positive Habitats Regulation Assessment), and to reflect the precaution applied in the current ICES (2022) advice.

Accordingly, this assessment finds that some international trade in live glass eels could be permitted from GB without detriment to the species provided these came from river basins with a demonstrable surplus over and above that required to meet carrying capacity in the donor catchment and with complementary control measures. In addition, UK glass eels are of very high quality for stocking because the dip net method used causes little damage to the fish and UK waters are not known to contain eel diseases which are endemic in the rivers of continental Europe. The UK could thus act as a source of high-quality glass eels for stocking to enhance escapement elsewhere, as has previously been the case.

This assessment also provides strong evidence that the current levels of catch for European eel from Lough Neagh and associated River Bann are not likely to be detrimental to the species. Indeed, the maintenance of a commercial fishery with associated stocking of glass eel from GB fisheries exploiting a recruitment surplus provides a **net benefit** in terms of silver eel escapement and hence a contribution to future spawning stock.

This conclusion is based on:

a) eel fisheries in Lough Neagh and River Bann being under the sole management of the Lough Neagh Fishermen's Cooperative Society which enables harvest levels to be controlled and the fishery to be policed;

b) a scientific assessment of silver eel production and escapement from Lough Neagh demonstrating a net benefit of stocking with glass eels that are surplus to recruitment in their donor rivers (Aprahamian *et al.* 2021; Appendix 3);

c) a scientific assessment of UK glass eel fisheries demonstrating an exploitable surplus in select, identifiable river basins; and

d) a series of trade conditions and control measures that will be enforced to ensure the NDF conditions are maintained.

Notably, we have good long-term data from Lough Neagh which enables us to quantify, with high confidence, the levels of recruitment of glass eels and escapement of silver eels, to assess the standing crop of yellow eels in the lough, and to model the stock-recruitment relationship (Aprahamian *et al.* 2021). We can thus predict the impact of changing levels of recruitment and/or levels of harvest on future escapement.

This NDF will take an adaptive approach such that, as further or new information on species abundance, distribution and harvest becomes available, harvest (and trade) levels and related control measures can and will be re-assessed and adjusted as required to achieve both non-detriment and recovery goals. Harvest levels will be managed by relevant fisheries agencies and improvements over time in management arrangements will be incorporated as part of ongoing adaptive management and the export approval process. Should the NDF situation deteriorate, for example, were silver eel escapement from Lough Neagh to decline below the EMP long term objective (40% of pristine based on a five-year rolling mean) for a period of three or more consecutive years, or stocking of Lough Neagh at sufficient levels cannot be provided from fisheries exploiting a demonstrable surplus of recruitment, international trade will be suspended until such time as conditions exceed the criteria again.

Recent advice from ICES (2021, 2022) for zero catches of eels in all habitats, including for restocking, is noted. However, if we were to follow this advice and close the GB glass eel fisheries, it is our view, based on the evidence provided, that this would not result in increased escapement of silver eels from donor rivers (because these glass eels are surplus to carrying capacity and so are subject to density dependent mortality). It would, nevertheless, result in the loss of jobs and income to fishers; there would thus be a negative economic impact but no positive conservation benefit to European eel conservation and recovery to justify this. We note further that ICES considers restocking as a conservation measure in the UK and EU Eel Regulations; EIFAAC (2022) notes that this is dependent on a glass eel catch and the ICES advice thus contradicts restocking activity. Moreover, ICES also notes that its advice does not apply to catches to enable migration across barriers within the same waterbody, such as trap and transport up the River Bann (EIFAAC 2022).

Similarly, closing the Lough Neagh fishery based on the same advice would have an even greater social and economic impact on this community-owned cooperative. In the short-term, such a closure would result in an increase in escapement as previous cohorts of eels stocked in the lough matured to the silver eel stage. However, in the long term, the absence of sufficient stocking (because GB glass eel fisheries were closed and because glass eel recruitment from catch and transport up the Bann is insufficient) would result in escapement diminishing below target and ultimately ceasing altogether; there would be no long-term conservation benefit from such an outcome. The Lough Neagh fishery needs to stock from a sustainable source in order not to undermine the basis of this NDF (achieving a net benefit of silver eel escapement from surplus glass eels) and needs to be economically viable to fund this; we are not aware of other sources of glass eels (beyond those described in this document) that are of demonstrable non-detrimental origin. Paradoxically, the outcome of the UK applying the current ICES advice to both fisheries would, therefore, be perverse for, and detrimental to, the conservation and recovery of the species.

A scientific examination of the other yellow and silver eel fisheries of England and Wales did not provide, at this stage, supporting evidence of an NDF for these fisheries (Appendix 3), therefore, international trade cannot be authorised.

In addition to annually reviewing harvest levels, control measures, and any trade measures applied, the UK CITES Scientific Authority (Fauna), in collaboration with other UK partners, will formally review these positive and negative NDFs at three-yearly intervals.

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18 Glossary

Assisted migration	This is the practice of trapping and transporting juvenile eels within the same river catchment to assist their upstream migration beyond difficult or impassable barriers, without significantly altering the production potential (B_{best}) of the catchment.
Eel Management Plan (EMP)	The terms and conditions under which an EMU (see below) is managed in accordance with the Eel Regulation (EC 1100/2007, retained for use in GB). Council Regulation (EC) No 1100/2007 of 18 September 2007 establishing measures for the recovery of the stock of European eel.
Eel Management Unit (EMU)	A term derived from the Eel Regulation (EC 1100/2007, retained for use in GB), namely: "The Secretary of State shall identify and define the individual river basins lying within the United Kingdom that constitute natural habitats for the European eel (eel river basins) which may include maritime waters. If appropriate justification is provided, the Secretary of State may designate the whole of the United Kingdom or an existing regional administrative unit as one eel river basin. In defining eel river basins, the Secretary of State 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]."
Elver	Young eels, in their 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 eels are included in the glass eel term.
EMFF	European Maritime Fisheries Fund.
Escapement (silver eel)	The amount of silver eel that leaves (escapes) a water body, after taking account of all natural and anthropogenic losses.
Glass eel	Young, unpigmented eel, recruiting from the sea into continental waters. ICES consider the glass eel term to include all recruits of the 0+ cohort age. In some cases, however, this also includes the early pigmented stages. In line with the recommendations of the CITES Animals Committee, the term here refers to eels up to 12 cm in length and corresponds to the specimen code for fingerlings (FIG) used in CITES.
Non-detriment finding (NDF)	A fundamental requirement under Article IV.2 of CITES without which an export permit shall not be granted, namely that a Scientific Authority of the State of export has advised that such export will not be detrimental to the survival of that species.

	This requirement is transposed into Article 5.2.a of the Wildlife Trade Regulation (EC 338/97), as retained and modified for use by the UK (GB), whereby: '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 stocked.
Panmictic	A population is panmictic if individuals in a population are able to interbreed without restrictions, such that random mating of individuals within a population occurs.
Semelparous	A species is considered semelparous if it is characterized by a single reproductive episode before death.
Silver eel production	The amount of silver eels produced from a water body. Sometimes referred to as escapement + anthropogenic losses, or production-anthropogenic losses = escapement.
River Basin District	An 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 EU's Water Framework Directive as the main unit for management of river basins.
Silver eel	Migratory phase following the yellow eel phase. Eels in this phase are characterized by darkened back, silvery belly with a clearly contrasting black lateral line, enlarged eyes. Silver eels undertake downstream migration towards the sea and, subsequently, onwards to the Sargasso Sea. This phase mainly occurs in the second half of calendar years, although some are observed throughout winter and following spring.
Stocking (restocking)	Stocking (formerly called restocking) is the practice of adding fish [eels] to a waterbody from another source, to supplement existing populations or to create a population where none exists. The purpose of stocking might vary from seeking to boost silver eel escapement or to support a commercial fishery or both.
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 (osmo-regulatory, 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’). Sometimes also referred to as brown eels, especially in Northern Ireland.

Appendix 1. Applying the ICES guidance for non-detriment findings for European eel to the whole stock

The ICES criteria

The criteria and thresholds suggested by ICES are summarised as follows (ICES 2015b).

i) *Criteria (such as stock indicators) and if possible, thresholds that could be used to make a Non-Detriment Finding*.

ICES advised that the following criteria and thresholds could be used in the development of an assessment for a non-detriment finding (NDF) for European eel:

A. Relevant population indices should be above levels at which the species might qualify for listing in Appendix I of CITES. For European eel, ICES advised that when the guidelines provided in CITES Resolution Conf. 9.24 are applied, the glass eel recruitment indices, as the longest and most reliable time-series, constitute an index of abundance and that the threshold should be set at 15% of the baseline for the ICES stock assessment, which is the average recruitment in the period 1960 to 1979. Criterion A) is the prerequisite (i.e. essential first step) but is not sufficient in itself. If A) is met, the following should be considered:

B. A precautionary framework considering both stock biomass and anthropogenic mortalities. ICES advised that if escapement of silver eel is above 40% of the pristine biomass and the total anthropogenic mortality from glass eel to silver eel escapement is at or below the instantaneous mortality rate of 0.92, this should be considered as a positive sign for an NDF assessment.

C. Stock recovery. Indications of stock recovery are considered a positive sign for an NDF assessment. ICES advised that a significant positive glass eel recruitment trend over a minimum of one eel generation (about 10–15 years) is an indication of a **recovering** stock, and that glass eel recruitment indices fluctuating within confidence limits of the 1960 to 1979 reference baseline are an indicator of a **recovered** stock.

There is no scientific hierarchy or ranking to criteria B and C. The criteria are not independent of each other but were proposed to provide CITES Scientific Authorities options for developing a case depending on the data available to them.

ii) *Assessment of the scale that could be used to make a Non-Detriment Finding*

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 would require that information on the contribution of the eel from the sub-area/life stage to the spawning stock were available and sufficient to assess the eel subpopulation in question applying the advised criteria. Until such information is available ICES advised that the scale to be used to make an NDF assessment should cover the entire stock of the European eel.

iii) *Assessment of possible conditions that could be used in association with a Non-Detriment Finding.*

ICES advised that a condition for an NDF assessment should be that the relevant geographical area or the life stages concerned are subject to management plans.

NDF assessment against the ICES criteria

The following assesses the available information against each criterion provided by ICES in point (i) of their advice. As European eels are considered to be a single panmictic population, the criteria are first assessed at a **whole population level** as advised in point (ii) of the ICES advice. Population-wide data are derived from the annual ICES WGEEL reports.

Entire Stock of European Eel

(i) Criteria (such as stock indicators) and thresholds that could be used to make a Non-Detriment Finding

A. Relevant population indices should be above the level at which the species might qualify for Appendix I.

ICES (2015) suggested the relevant population indices should exceed 15% of baseline – the level below which the species would meet the decline criterion for inclusion in CITES Appendix I. ICES suggested the glass eel recruitment indices were the most reliable time-series index of abundance, with baseline being set as the average recruitment in the period 1960 to 1979.

The latest stock assessment (ICES 2022) reported the 'North Sea' glass eel recruitment index was 0.5% in 2022 (provisional) and 0.6% in 2021 (final) and for the 'Elsewhere Europe' index was 9.7% in 2022 (provisional) and 5.5% in 2021 (final). These indices have not exceeded 15% of the 1960 to 1979 baseline since 1986 for the North Sea index and 2002 for the 'Elsewhere Europe' index. The index for young yellow eel recruits to European waters was 24%, but this index is made up of multiple age classes of eel and is, therefore, less relevant to compare with time trends (Figure A1.1).

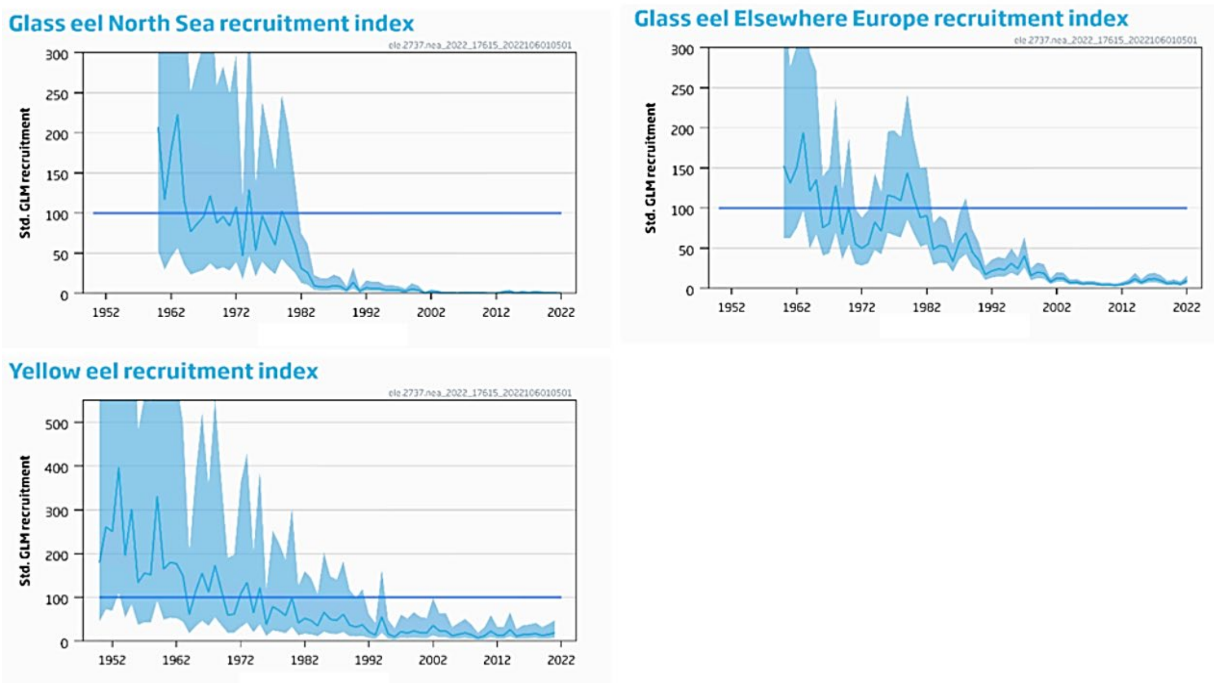

Figure A1.1. European eel. Indices, geometric mean of estimated glass eel recruitment for the continental "North Sea" (top-left panel) and "Elsewhere Europe" (top-right panel) series. A statistical model was fitted to 57 time-series comprising either pure glass eel or a mixture of glass and yellow eels (26 "North Sea" and 31 "Elsewhere Europe"). The results were scaled in percentage to the 1960 to 1979 geometric mean. The "North Sea" series are from Norway, Sweden, Germany, Denmark, the Netherlands, UK, and Belgium; the "Elsewhere" series are from UK, Ireland, France, Spain, Portugal, and Italy. In the Baltic area, recruitment occurs at the yellow eel stage only, and series are thus not included in the glass eel recruitment index. Bottom panel: estimated yellow eel recruitment trends for Europe. A statistical model was fitted to 22 yellow eel time-series and scaled in percentage to the 1960 to 1979 geometric mean. The series are from Denmark, Germany, Ireland, Sweden, France, and UK. The horizontal line on each panel represents the likely R_{lim} (calculated from the 1960 to 1979 geometric mean) (ICES 2022).

***Concluding assessment – criterion A*: this criterion – which is seen by ICES as an essential prerequisite, is not met. The species seems to meet the decline criterion in Res. Conf. 9.24 and so precludes making a positive NDF at the entire stock level.**

B. ***A precautionary framework considering both stock biomass and anthropogenic mortalities*.**

ICES suggested that silver eel escapement should be above 40% of the pristine biomass and the total anthropogenic mortality at or below 0.92.

ICES (2018a) advised that the values of reported biomass of silver eel escapement are uncertain and incomplete and not suitable to provide stock-wide estimates. However, for the reporting EMUs, escapement biomass ranged from 0% to 140% (140% in heavily restocked areas) of the reported pristine biomass estimates, averaging 25%. Anthropogenic mortality rates were not reported but from visual examination of figure 4.7 in the WGEEL 2015 report (ICES 2015c), for reporting EMUs the pooled rate was about 2.10 in 2014.

The WGEEL 2015 (ICES 2015c) collated the silver eel escapement biomass and mortality rate estimates reported by EU Member States in 2015, concluding that "the stock in most reporting countries/areas was not within the biomass limits of the Eel Regulation and in most management units, anthropogenic mortality is not at a level that can be expected to lead to recovery". ICES (2022) state that time-series from 1980 to 2022 show that glass eel recruitment remains at a very low level.

***Concluding assessment – criterion B*: this criterion is also not met at the whole stock level – neither escapement nor mortality thresholds are reached, on average, for those EMUs for which data were reported.**

C. ***Stock recovery.***

ICES suggested that a significant positive glass eel recruitment trend over a minimum of one eel generation indicates a recovering stock, and recruitment indices fluctuating within confidence limits of the 1960–1979 reference baseline indicate a recovered stock.

It is several years since WGEEL conducted a trend analysis of recruitment indices. However, visual examination of the glass and yellow eel recruitment indices presented by ICES (ICES 2022: Figure A1.1 copied above) do not demonstrate a significant positive glass eel recruitment trend over a minimum of one eel generation (indicator for recovering), let-alone indices fluctuating within confidence limits of the 1960–1979 reference baseline (indicating a recovered stock). ICES considered it is likely that the stock size is well below potential biological limit reference points (ICES 2022).

***Concluding assessment – criterion C*: this criterion is also not met at the full stock level. Recruitment indices are fluctuating, but around the post-2000 nadir with no consistent positive upward trend.**

(ii) Assessment of scale that could be used to make a Non-Detriment Finding

ICES advised that an NDF assessment should cover the entire stock of European eel – that has been the approach in this first step of the NDF assessment.

***Concluding assessment – (ii)*: this recommendation is met**.

(iii) Assessment of possible conditions that could be used in a Non-Detriment Finding

ICES advised that a condition for an NDF assessment should be that the relevant geographical areas are subject to management plans. Although there are EMPs for the UK and most (or all) EU Member States in the natural range of European eel, there are not EMPs or equivalents for all the non-EU States.

***Concluding assessment – (iii)*: this condition is met for the UK and EU but not for most other range States outside the EU.**

Overall NDF assessment against ICES criteria and recommendations: an assessment of the whole stock against the criteria suggested by ICES suggests 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.

Appendix 2. Lough Neagh eel production model

Details of Lough Neagh and its catchment can be found in Wood and Smith (1993). It has a total wetted area of 385 km^2 draining a catchment of 4,453 km^2 of which the majority of the land use is grassland (67%) followed by rough grazing (10%) (Foy *et al.* 2003). The Lough is relatively shallow, average depth nine metres and is currently considered to be hypertrophic. The chronology of enrichment has been described by Foy *et al.* (2003).

Description of the fishery

A detailed description of the fishery can be found in Frost (1950) and Rosell *et al.* (2005). Emigrating silver eels are caught in fixed Coghill nets lowered into the flow at two weirs (formerly three) at Toome on the River Bann at its outlet from Lough Neagh and at Kilrea further downstream, usually from August to the end of December. There have been significant changes in the structures of the weirs, most notably at Toome (Frost 1950), with the current arrangement operating since 1947.

Yellow eels are fished in the Lough between May and September, the traditional means being a long-line of 1,200 hooks fished overnight. Hook baits include earthworms (*Lumbricus* spp.), fish fry captured in bait nets, pieces of fish flesh, and more recently mealworms (various coleopteran larvae available through the pet food trade). There is also draft net fishing, using an 80–100 m seine net with a cod-end deployed from a boat in open water. The recent addition of hydraulic net haulers to the draft net boats has increased the ease of use of this formerly hand-hauled gear and permits many more hauls per day. Increases in effort through improved efficiency measures, such as haulers, are to some extent compensated for by decreases in the number of active boats. Because of market forces and the ageing fisher population, boat numbers have decreased to around 90 in 2018, from about 200 in 1985 (Lough Neagh Fishermen's Co-operative Society Ltd (LNFCS), personal communication). Yellow eel fishery conservation measures in place include daily quotas (a cap on the weight of eel which the LNFCS will buy from any one fisher), and method restrictions – only draft nets and long-lines are currently permitted. The use of otter trawls for the taking of eels began on a trial basis in 1960 but by 1963 had become established on a large scale with probably about 50 out of 150 boats reporting using this method (Anon., 1965). The trawlers operated between May and October. Trawling ceased in 1977 and is currently not permitted because of the risk of overexploitation, damage to the bed of the Lough and its incompatibility with long-line fishing on the same fishing grounds. There is a 2-day weekend cessation on the yellow eel fishery. The LNFCS applies a minimum marketable grading length for yellow eel of 40 cm, which was subsequently matched by an increase in the minimum landing size from 30 cm to 40 cm prescribed in State legislation. Undersized eels are returned to the water.

Glass eels ascending the river are trapped at the top of the estuary at a weir (the Cutts), 9.7 km from the sea, and transported by road and released into Lough Neagh. From 1984 to the present 103 million River Bann glass eel have been transported in this way. Since 1984 stocking of glass eel has played a major role in the management of eel in the lough with 110 million individuals stocked at a cost of €5 million, of which the EU funded €1.6 million.

Modelling Analyses

An input – output eel production model has been developed to investigate the effects of natural recruitment, stocking, and the management of the commercial fishery on the Lough Neagh eel population.

Stock recruitment relationship (See section 12.2 for data series and metrics)

The dynamics of the eel population in the Lough are best described by a Beverton-Holt Stock recruitment relationship (Figure A2.1), which shows that silver eel output increases with increasing amounts of glass eel entering the Lough, reaching a plateau beyond which no further silver eels are produced and glass eel mortality rises. Figure A2.1 suggests that the carrying capacity of Lough Neagh has changed over the last century. There was a period of low productivity during the early part of the time series affecting the 1923 to 1943 glass eel year classes, followed by a period of high productivity impacting on the 1944 to 1975 glass eel year classes. After this there is a decline in productivity which has persisted until today. It is thought that the increase may relate to eutrophication to a hypertrophic state which started in the 1960s (affecting the year classes from ~1940s onwards) and the current decline relating to competition with roach (*Rutilus rutilus*) that entered the lake in the early 1970s.

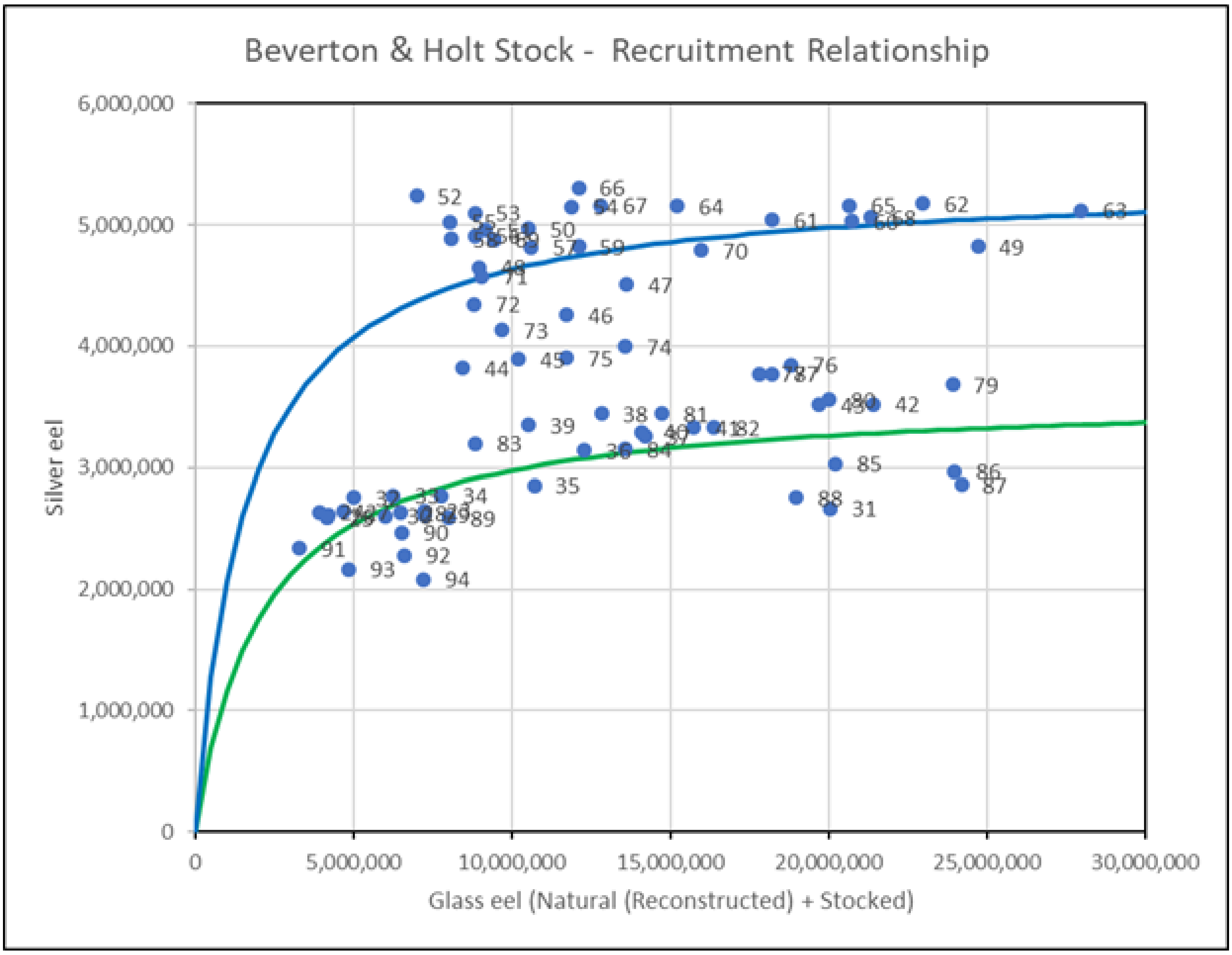

Figure A2.1. The relationship between glass eel in and silver eel out for each glass eel input cohort from 1923 to 1988. The blue line represents the period from 1944 to 1975 and the green line from 1923 to 1943 and 1976 to 1988. The numbers refer to glass eel year class.

The model used to forecast output and estimate the effect of stocking was based on the 19761994 data (green line in Figure A2.1). A comparison of the model prediction with the observed indicated a systematic bias which increased over time (Figure A2.2).

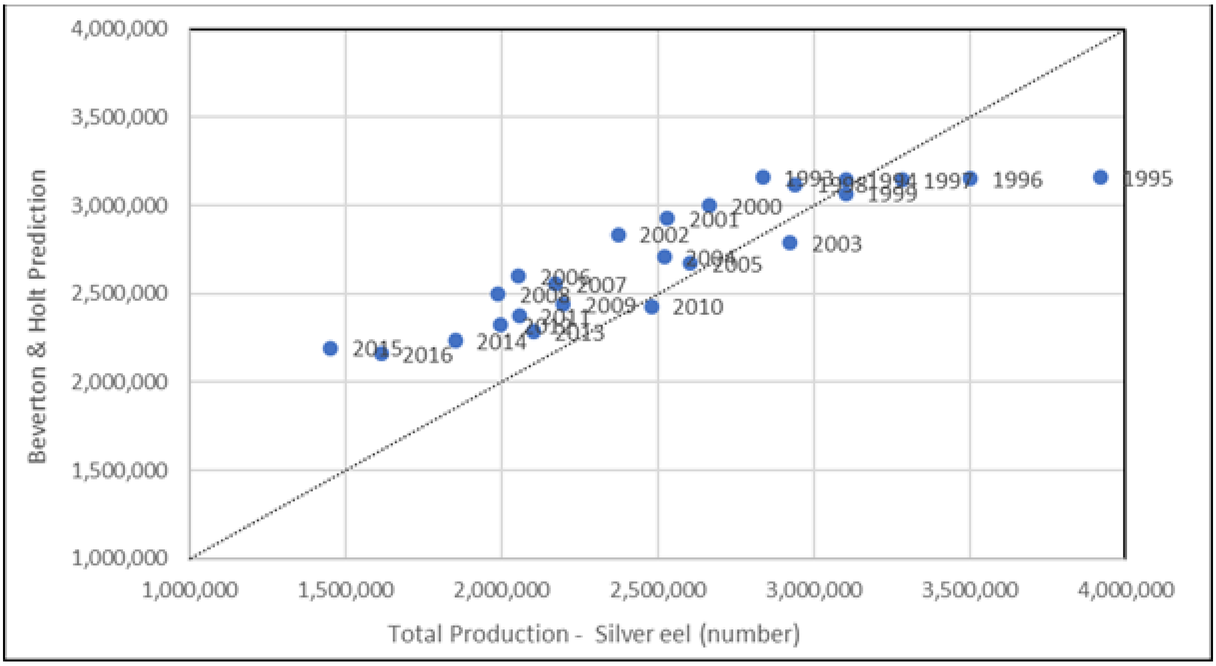

Figure A2.2. A comparison between estimated output from the model and observed. The dashed black line represents 1:1.

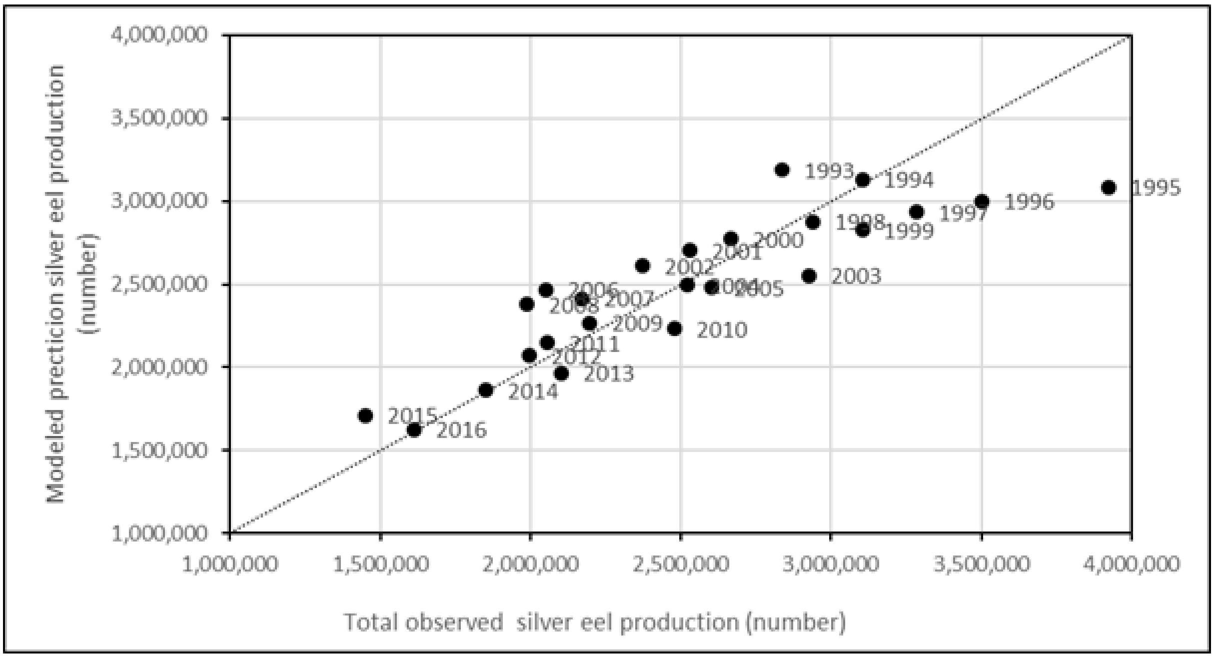

Figure A2.3. A comparison between estimated output from the model, which considers temperature and the proportion of glass eel stocked from outside the catchment and observed silver eel production.

The predictive capability of the model improved with the inclusion of summer water temperature during the eel's first year in freshwater and with the proportion of stocked glass eel (Figure A2.3).

Density-dependent mortality in glass eel

From such a long-term data series, our analysis has been able to demonstrate that as glass eel numbers increase the proportion surviving from glass eel to silver eel will decrease. Figure A2.4 shows how the proportion of glass eels surviving through to the silver eel stage drops as the number of glass eels entering the Neagh system increases. This has provided an indication of what optimal glass eel density for Lough Neagh is in terms of silver eel output (carrying capacity for eel). However, this also appears to have fluctuated over time and may be linked to the introduction of roach in the 1970s thereby altering the Lough's carrying capacity for eel.

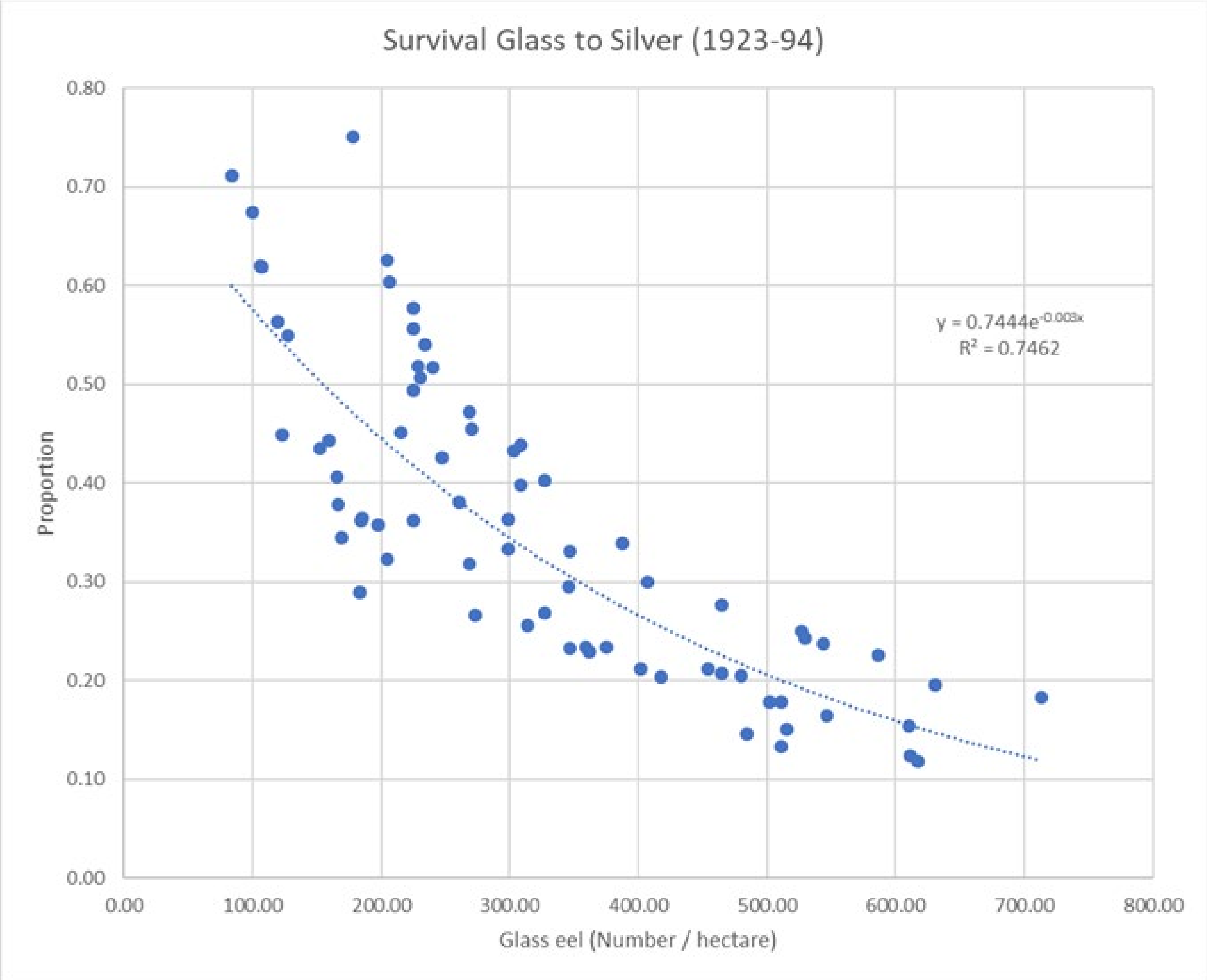

Figure A2.4. Proportion of glass eel surviving to silver eel in relation to stocking density at Lough Neagh.

Density-dependent mortality and assessment of "surplus" at glass eel fisheries

The density-dependent mortality relationship in Figure A2.4 has application for eel populations elsewhere but in this current analysis, may be particularly relevant to the main UK glass eel fisheries (Section 12.1).

By way of a complementary analysis to that from section 12.1 and Annex A of Cefas *et al.* 2021, this density-dependent mortality relationship was used to assess the availability of "surplus" glass eel from donor sites. The net benefit, in terms of silver eel escapement, of stocking any identified surplus into Lough Neagh was estimated assuming the current fishery practice and survival of stocked eel as derived from the relationship in Figure A2.3.

The relationship developed from the model infers a two-fold benefit from stocking in that:

- any additional input of glass eels above a system carrying capacity will NOT increase silver eel output, but conversely accelerates mortality; and
- "thinning out" any carrying capacity surplus from a donor site and stocking them into a recipient site below carrying capacity, will lead to an increase in silver eel output from the two combined systems (i.e. it provides a 'net benefit').

To explore this further, three different scenarios were explored.

Each used recent UK glass eel catch data from 2016 to derive their density dependent mortality, the relevant wetted area (Section 12.1 Table 1) and its subsequent influence on silver eel production. As in Section 12.1 & Annex A of Cefas *et al.* 2021, exploitation of glass eel was assumed to be 100%. Estimated outputs are shown in Table A2.1.

Scenario 1: Natural Conditions

This was taken as glass eel recruitment to local system from the two main donor catchments (Severn, Parrett).

Scenario 2: Thinning out two donor rivers – and estimate of surplus available

"Thinning out" the two main donor catchments to an optimal density, which was taken as 300 glass eel.ha^{-1}, derived from Moriarty (1999), Moriarty and Dekker (1997) and Rosell *et al.* (2005) and Figure A2.1, suggests that output reaches the asymptote at approximately 11.5 million glass eel.

If the stocking density in the donor rivers was reduced to 300 glass eel.ha^{-1} this would generate a surplus of 2.23 tonnes of glass eel that could be stocked elsewhere.

Scenario 3: Stocking estimated surplus glass eel in to Lough Neagh

This was calculated based on stocking donor surplus glass eels into Neagh under current fishery practice.

1) mean recruitment of last 10 years (371 kg.yr^{-1}),
2) the presence of current yellow and silver eel fisheries, and
3) the long-term silver eel escapement estimate (43%, from 2003–2017, section 12.2).

From Scenario 2, it is estimated that there is a surplus of 2.2 tonne of glass eel. If these glass eel were stocked into Lough Neagh in conjunction with those from natural recruitment (about 371 kg.yr^{-1}) the estimated total output from Lough Neagh would be 0.78 million silver eel, of which a direct component from stocking is estimated to be 0.67 million (Table A2.1).

Table A2.1. Calculation of glass eel survival rate (based on density-dependent mortality model) and subsequent silver eel production from surviving proportion if left in situ, a surplus removed or any surplus stocked into Lough Neagh. ** Based on thesis that that stocked glass eel contribution to the recipient site is two-thirds (2/3) as effective as that of a natural recruit (ICES 2009; and current study findings).

Scenario 2						
Based on Neagh Bann EMP & Rosell *et al* (2006) recommended density of 300 glass eel ha-1 and no exploitation						
Severn	6380	1508.3				
Parrett	438	1403.4				
				TOTALS	618,709	2,230
				surplus glass eel for stocking		2,230
Scenario 3						
Stocking donor GE into L. Neagh under current recruitment and current fishing effort, which includes escapement estimates. (*from 08-17 mean)						
Neagh Bann	38300	263* + 2,230				
				TOTALS	808,256	202,064
				Silver eel from wild Glass eel	122,538	
				Silver eel from stocked Glass eel	685,718	
**Based on stocked glass eel contribution to the recipient site is 2/3 as effective as that of a natural recruit (ICES, 2009; and current study findings).						

Predicted versus Observed catch outputs

To test the model, the observed fishery output from the years 1993-2017 were compared with that predicted using the green line stock-recruitment co-efficient from Fig. A2.1 as that relationship best described the current knowledge of the fishery dynamics. Figures A2.5a & b illustrate a close agreement between that predicted and the observed catch of silver and yellow eels in the fishery.

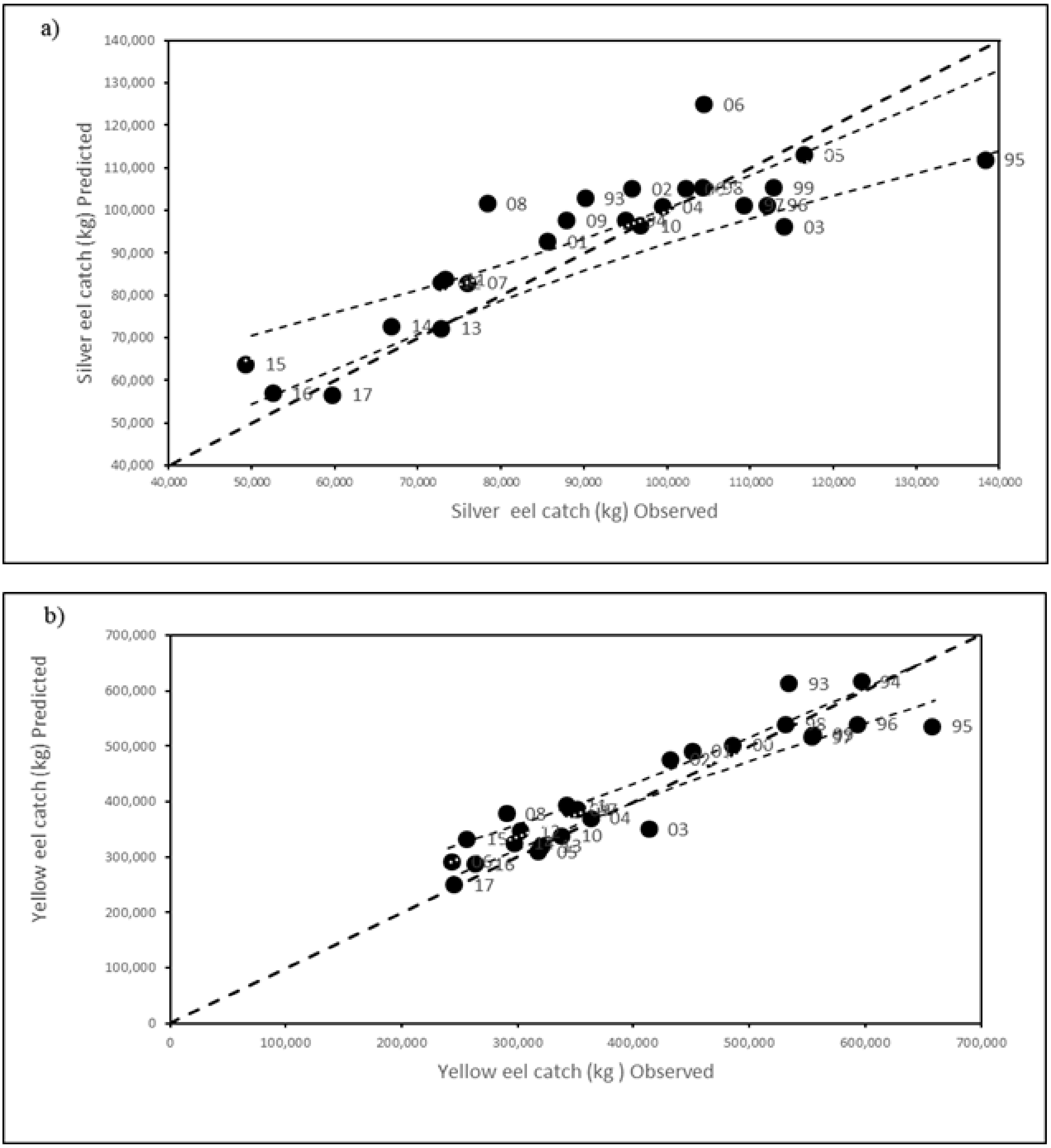

Figure A2.5 (a & b). Predicted silver (a) and yellow eel catch (b) (kg) estimated using the Beverton-Holt model in relation to the observed catch (kg) for the year 1993 to 2016. The dashed black line represents 1:1 and the dotted lines represent upper and lower 95% C.I. around the least square regression line (not shown).

a) Predicted fishery outputs

Applying the terms of the current Neagh Bann EMP, the model was used to predict the fishery catch and silver eel escapement from Lough Neagh from 2017–2023, based on known recruitment inputs to date (Table A2.2).

Table A2.2. Predicted catch under current fishery operations and subsequent escapement for the years 2017 to 2023.

Year	Total weight (kg)	Yellow catch (kg)	Silver catch (kg)	Silver escapement (kg)
2017	476,215	250,927	56,702	168,586
2018	444,149	234,031	52,884	157,234
2019	315, 532	166, 242	37,246	112, 044
2020	378,303	199,335	45,044	133,924
2021	361,234	190,341	43,011	127,881
2022	350,800	184,843	41,769	124,188
2023	343,649	181,075	40,918	121,656

b) Contemporary comparison of 2017, 2018 and 2019 harvest (observed and predicted) and calculated total production

Table A2.3. Contemporary comparison of 2017, 2018 and 2019 harvest (observed and predicted) & calculated total production.

Year	Life stage	Observed (kg)	Predicted (kg)	Difference (%)
2017	Yellow	244,984	250,027	2.4
	Silver (catch)	59,683	56,702	-5.3
	Total Production.	538,839	476,214	-13.2
2018	Yellow	235,012	234,031	0.03
	Silver (catch)	94,010	52,884	-72.5
	Total Production.	716,021	444,149	-61.2
2019	Yellow	221,190	214,463	-3.1
	Silver (catch)	45,601	48,462	5.9
	Total Production.	492,106	407,013	-20.9

A comparison with the model predictions for the 2017 to 2019 harvest years shows that the Beverton-Holt model accurately predicted the silver and yellow eel catch, though it under-estimated total production (Table A2.3). The unexpected yet highly significant catch and escapement of silver eels in 2018 were so different from that predicted that they are not an error in the model but a significant event in their own right (as illustrated by the model's accuracy for 2017 and yellow eel catch in 2018). The warm summer of 2018 (https://www.metoffice.gov.uk/news/releases/2018/end-of-summer-stats) may also explain the severe underestimation of the silver eel catch and escapement by the model.

Impact of stocking

Since 1984, stocking has played a major role in the management of eel in the Lough (Figure. A2.6). The model was used to determine any impact that stocking had on the eel population and Lough Neagh outputs, and possible consequences if glass eel had not been stocked. In all fishing metrics, the inclusion of stocking within Lough Neagh has produced more eels than would have been present based on natural recruitment inputs alone. It is estimated that stocked glass eel could have contributed between 1.35% – 21.42% over the period 1993–2016 to the total output (fisheries and escapement) (Figure A2.7). Stocking is forecasted to contribute about 35% of the output by 2021.

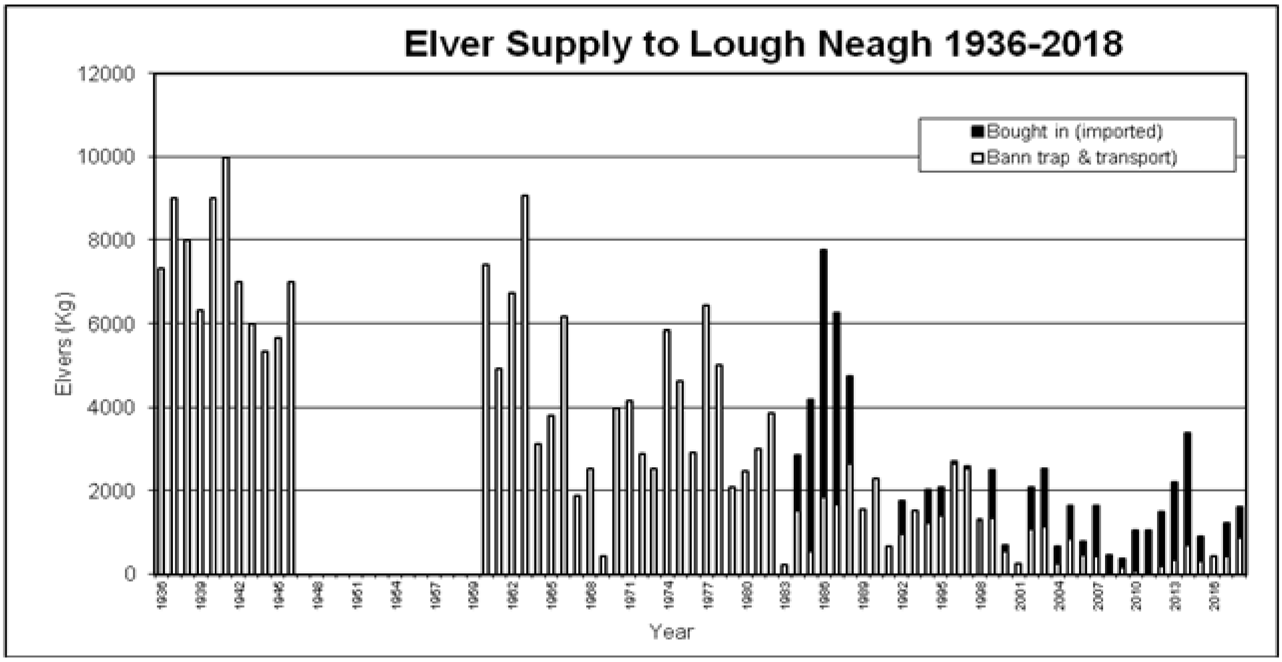

Figure A2.6. Recruitment and stocking history into Lough Neagh 1936 to 2018.

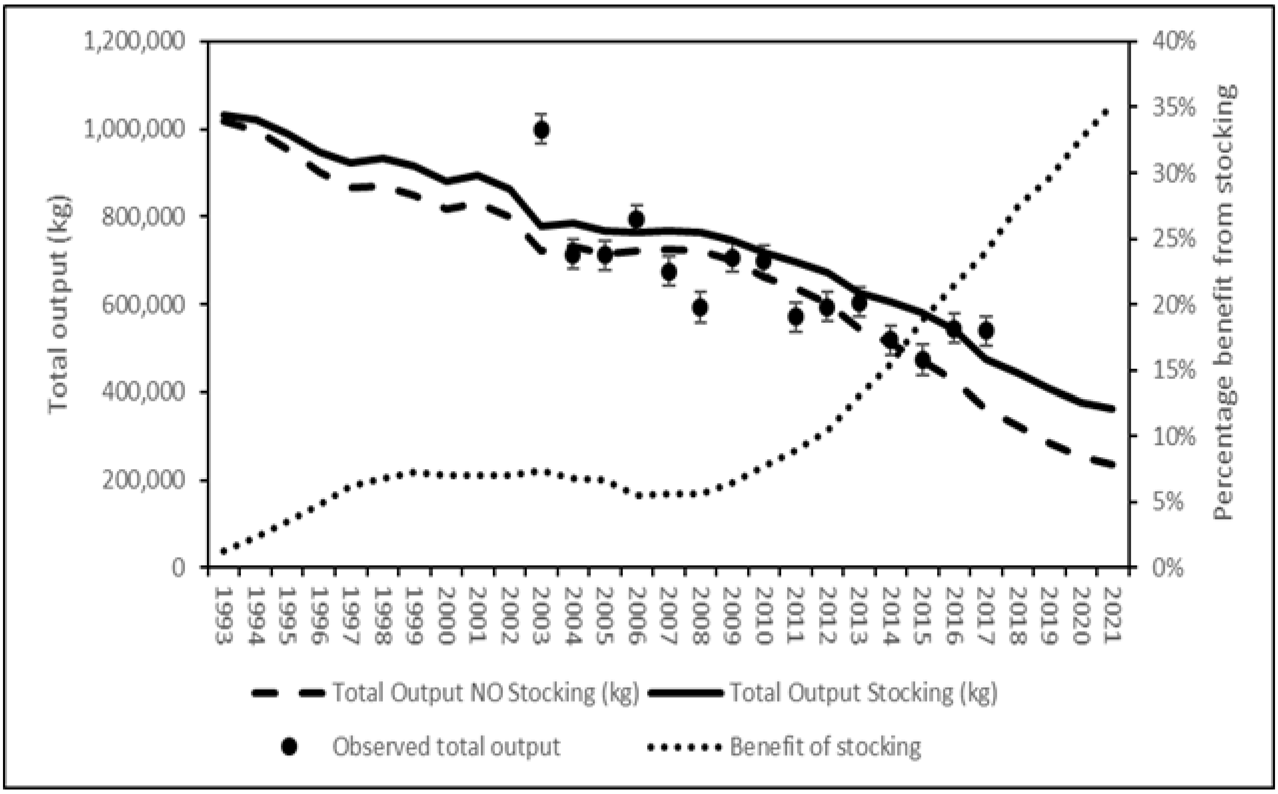

Figure A2.7. Total output (kg) in the presence and absence of stocking as estimated from the model between 1993 to 2021 and the observed output between 2001 to 2017. The dotted line represents the percentage benefit from stocking.

CITES Compliance Reference Points

ICES has advised the EU CITES Scientific Review Group on reference points for the eel stock that could be used in developing, and reviewing, an application for an NDF, under circumstances of any future improvement of the stock (ICES 2015a; see Annex 1). The five reference points addressed in the following section were developed specifically using CITES guiding principles for an NDF and are based, in part, on the reference points suggested in ICES (2015a):

- Criterion A: Recruitment Threshold (15% baseline).
- Criterion B: Silver Eel Escapement Assessment (40% EU target compliance).
- Criterion C: Assessment of Scale (Neagh/Bann EMU).
- Criterion D: Demonstration of overall Net Benefit.
- Criterion E: Anthropogenic mortality (∑A) below ICES recommended limit of 0.92.

Criterion A: Recruitment Threshold (15% baseline)

The Neagh/Bann EMU has a trap-and-transport (assisted migration) operation for natural recruits, starting in 1933. Figure A2.8 presents the time-series as an index of the average 1960 to 1979 period.

Natural recruitment has exceeded the ICES (2015a) proposed threshold of 15% baseline on four occasions since the year 2000 (and on 19 occasions since the recruitment crash in 1983). However, natural recruitment to Lough Neagh reflects conditions of the wider European stock rather than this specific EMU.

Since 1984, eel production in Lough Neagh has been supplemented by stocking from other donor waterbodies with 88% of input being derived from UK glass eel fisheries. Lough Neagh has been stocked with approximately 110 million elvers at a total cost of €5 million, of which €1.6 million was grant aided under the European Maritime Fisheries Fund (EMFF) via DCAL/DAERA, since 2009.

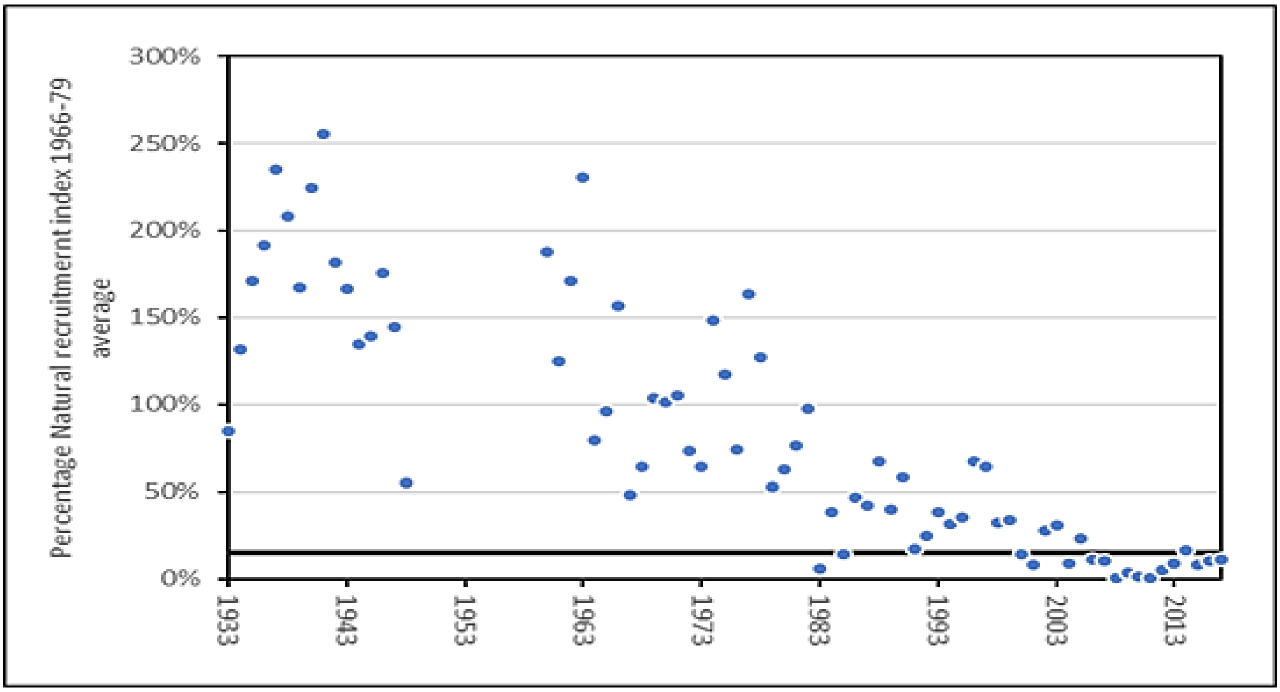

Figure A2.8. Neagh/Bann natural recruitment of glass eel, expressed as a % of the 1960–1979 baseline average (blue circles). The black line illustrates the 15% threshold proposed by ICES (2015a).

Criterion B: Silver Eel Escapement Assessment (40% EU target compliance)

Silver eel escapement (B *current*) from Lough Neagh has been assessed and monitored by AFBI since 2003 using mark-recapture studies. These findings have been corroborated following a request from the EU Commission, which lead to the design and use of bespoke hydro-acoustic studies specifically developed for migrating silver eel.

This system is heavily mediated for river flow by a series of sluice gates from the exit of Lough Neagh and along the Bann corridor. There is significant inter-annual variability across the dataset due largely to the effects of environmental parameters such as an increasing frequency of storm events, atypical rainfall patterns and consequential sluice gate operating regimes.

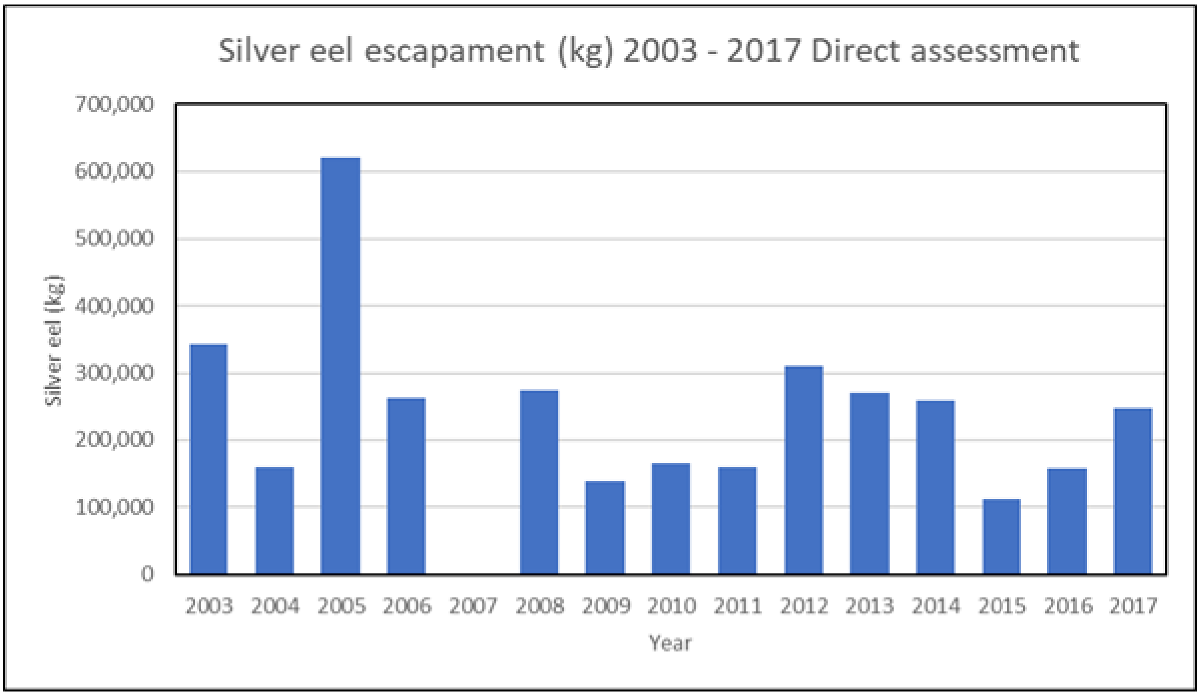

Figure A2.9. Lough Neagh silver eel mark-recapture study results for EU conservation target compliance assessment.

$B_{current}$ assessment

For the purpose of assessing compliance, mark-recapture studies were started in 2003. Between 1 and 6 estimates were made each year and the mean value used to estimate escapement for the season. These estimates have been undertaken annually, with the exception of 2007 (Figure A2.9). In the development of this project, all these data were combined into a model that incorporated flow as an explanatory variable, allowing the exploitation rate to be estimated daily. In addition, access was given to historic catch metrics (daily catch data in the silver eel fishery) not previously available to AFBI scientists. These data, together with River Bann daily flow, have enabled the production of a more finely tuned silver eel escapement ($B_{current}$) estimate using the mark-recapture returns from 2003–2016. These data (date of capture, associated catch and flow at that time) have allowed specific weir estimates of daily escapement to be determined, which are then summed over the entire fishing period (Figure A2.10).

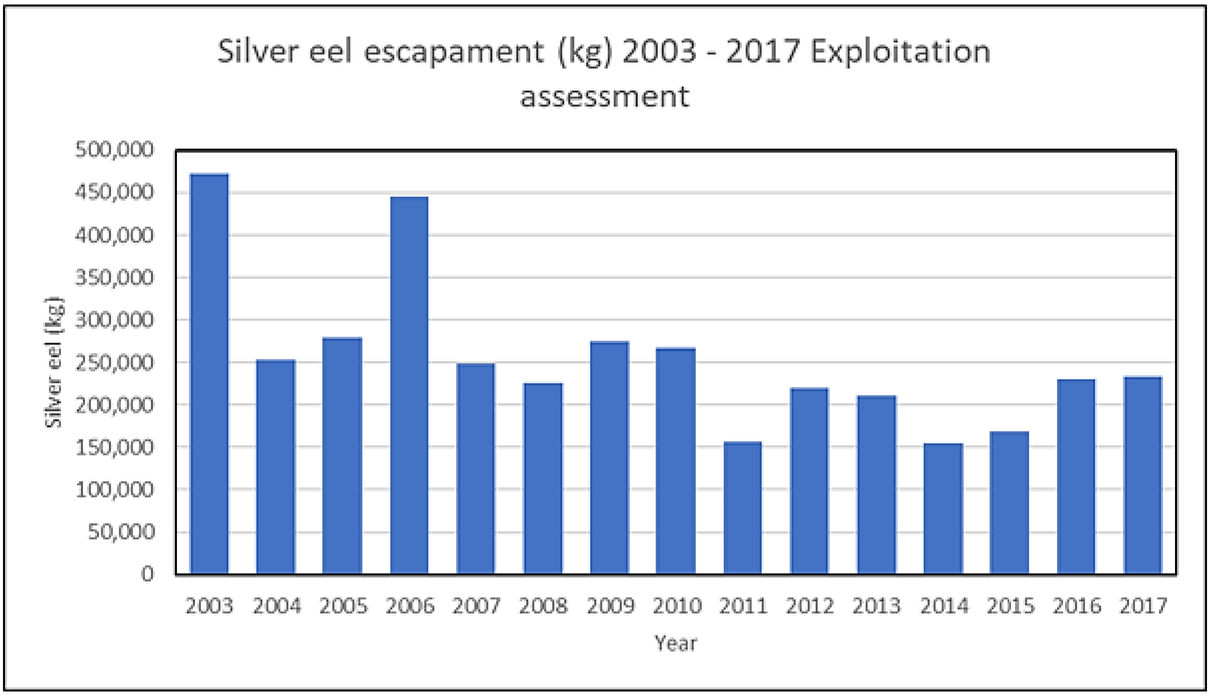

Figure A2.10. Lough Neagh silver eel estimates based on exploitation ~ flow model.

Though it is not possible to determine the accuracy of the two methods, the model approach enables hind-cast estimates to be determined when no mark-recapture studies were possible, as in 2007.

Using the target range of the Neagh-Bann EMP of 160–240 tonnes, the long-term escapement estimate (2003 to 2017), is 218.7 tonnes from direct assessment (Figure. A2.9), in comparison with the newly developed exploitation method estimate of 256 tonnes (Figure A2.10; updated in section 12.3 to 2019 inclusive).

On a triennial basis (2015 to 2017), the comparative figures are 172 tonnes and 211 tonnes, respectively. These are within the Eel Regulation target range as outlined in the Neagh-Bann EMU (updated in section 12.3 to 2019 inclusive).

Future $B_{current}$ assessment

Given that this EMU has completed its third triennial EMP review, using data from 2015-2017 inclusive, it is proposed that the silver eel escapement calculation for $B_{current}$ is now changed to this more robust multi-metric method from 2018 onwards. This will require the provision of daily silver eel catches throughout a tagging assessment period which could be covered as a requirement under the terms and conditions of this current NDF document in that the provision of such data will form the basis of ensuring the level of traceability necessary.

Criterion C: Assessment of Scale (Neagh/Bann EMU)

ICES (2015b) advised that *"an NDF assessment should cover the entire stock of the European eel."*, but also acknowledged "*the possibility of a positive NDF 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*". Prior to the development of the current model, it was deemed that "*sufficient data to assess the relative contribution of the eels in the Neagh/Bann EMU towards the global stock was not available and as such was impossible to test this subpopulation scenario".* However, extensive investigations over the last two years have produced a wealth of information covering a wide range of metrics associated with both fishery and environmental parameters. It is from this platform that sufficient data now exists enabling the extrapolation of five management scenarios at the Neagh Bann EMU "finer scale" level (Table A2.4). This range of management scenarios also includes Scenario E, the removal of the historic assisted migration intervention for elvers, which "traps & transports" them around a series of sluice gate barriers placing them directly into Lough Neagh. The absence of a commercial fishery means the resources needed for this operation would cease and elvers would theoretically remain in the much-reduced area of the tidal limit of the Bann estuary.

Neagh Bann EMU management options

Scenario A) No commercial harvest of eel: System stocked.

> If no commercial harvest was taken, then the average predicted escapement (from 2017 to 2021) is estimated at 313 tonnes: this however is driven by the current management regime which entailed supportive stocking during the years 1989 to 2016 in order to produce this.

- *This scenario raises the question of who/how future stocking would be funded?*

Scenario B) No commercial harvest of eel: System unstocked.

> If no stocking had been undertaken and the eel population was driven entirely from current assisted migration practice, then the estimated escapement in the absence of any commercial harvest is predicted to be reduced from Scenario A by 89 tonnes to an average 224 tonnes.

- *This scenario raises the question of who/how would undertake the assisted migration catch and releases if the fishery was not available to fund it?*

Scenario C) Commercial harvest: System stocked.

> Under the current management regime of a commercial fishery exploiting both silver and yellow eel in conjunction with supportive stocking, the estimated mean escapement over the period 2017 to 2021 is predicted to be 146 tonnes.

- *This is current practice.*

Scenario D) Commercial harvest: System unstocked.

> If no supported stocking had been undertaken but in the presence of a fishery, the escapement would have fallen by 43 tonnes to 103 tonnes.

- *This scenario places the Neagh Bann EMP well below the EU Regulation conservation target.*

Scenario E) Assisted migration intervention ends.

In the absence of any commercial harvest and the resources to fund assisted migration into Lough Neagh, the natural recruits would theoretically remain in the much-reduced area of the tidal limit of the Bann estuary (347 ha). It is estimated that silver eel escapement from the Lough would be 0.16 tonne.

- *This scenario produces the most natural, yet lowest, of all outputs for the Neagh Bann EMU*

Table A2.4. Estimates of escapement (kg) in the presence or absence of a fishery, stocking, or assisted migration of recruits; scenarios A to D include ongoing assisted migration of glass eels.

Scenario	**A**	**B**	**C**	**D**	**E**
Condition	No Fishery	No Fishery	Fishery	Fishery	No Fishery
Year	Stocking	No Stocking	Stocking	No Stocking	No assisted Migration or Stocking
2017	225,288	171,368	168,586	128,237	160
2018	259,166	192,874	157,234	114,070	147
2019	349,441	253,154	144,088	101,402	182
2020	369,059	259,658	133,924	90,188	172
2021	364,387	247,610	127,881	82,892	161
Mean	313,468	224,933	146,343	103,358	164

Criterion D: Demonstration of overall Net Benefit

From Table A2.1 (Section 2.ii above), the net benefit is derived from:

1) Scenario 2: identifies a surplus of 2,230 kg of glass eel.

2) Scenario 3: whereby the total net benefit of

   - thinning out the glass eel stock in the donor rivers (thereby reducing density dependent mortality) and

   - stocking the surplus into Lough Neagh producing 0.685 million silver eels from that surplus of glass eel (in Scenario 2).

Similarly, running the model on the calculated surpluses derived from the alternative assessment in Section 12.1 (Table 2), still yields additional net benefit of silver eel outputs ranging from 126 to 172 tonnes if stocked into Lough Neagh (Table A2.5), with the fishery operating as currently.

Whilst the two calculation methods produced different levels of surplus available, the ***principle*** behind the use of that identified surplus reached the same conclusion.

Table A2.5. Silver eel escapement benefit from stocking donor GE into Lough Neagh under current recruitment and current fishing effort. (* from 2010–19 mean).

EMU/RDB	Wetted area (ha)	Glass eel input (kg) natural + surplus	Density glass eel ha^{-1}	Survival rate of glass eel to silver Eel (Figure A2.3)	Number of silver eel from donor to sea **	Kg of silver eel from donor to sea
Neagh Bann	38,300	371* + 2,378	215.33	39.0%	688,551	172,138
Neagh Bann	38,300	371* + 2,230	203.73	40.4%	668,549	167,137
Neagh Bann	38,300	371* + 1,391	138.02	49.2%	507,900	126,975

** Based on stocked glass eel contribution to the recipient site is two-thirds (2/3) as effective as that of a natural recruit (ICES 2009; and current study findings).

In other words, stocking glass eels into Lough Neagh, derived from donor catchments in England and Wales (and trap and transport up the River Bann), leads to more silver eel production and associated escapement, even after fishery exploitation, than leaving the surplus glass eels in donor waters. This echoes the general findings of the ICES review on stocking (WKSTOCKEEL – ICES 2016).

It is of critical importance to highlight that these benefits are wholly dependent upon economically viable fisheries. Revenue derived from commercial fishing is crucial to purchase glass eel. Lough Neagh provides the opportunity to produce net benefit from a recruitment surplus in some glass eel fisheries.

Criterion E: Anthropogenic mortality (∑A) below ICES recommended 0.92

Total anthropogenic mortality for Neagh Bann EMU:

- for the period 2003–2017 is 0.85
- for the period 2015–2017 is 0.88

WGEEL suggested benchmark for ∑A is 0.92 (ICES 2016).

Appendix 3. Review of other UK eel fisheries

Authorisations to fish for yellow and silver eel require the same level of reporting as glass eel (detailed above). Reported catches for 2016 were extracted from the information supplied to the International Council for the Exploration of the Sea (ICES) for the annual international stock assessment. These catches were only available disaggregated to Eel Management Area. Catches per waterbody would be available from the EA and NRW, but this level of detail was not required for this report.

Table A3.1 presents the area catch weights (kg) of yellow and silver eel, and the combined catches for England and Wales. The yellow eel catch, at almost 28 tonnes, is far greater than the silver eel catches of just over 5 tonnes. The majority of the catch is reported from the Anglian (48%) and South West (34%) areas.

Table A3.1. Yellow and silver eel catches for 2016 per management area, as reported to the EA or NRW (extracted from UK reports to ICES). Note that zero catches were reported from Northumberland, Severn, and Solway-Tweed areas so these are not included in the Table.

Eel Management Area	Reported catches (kg)		
	Yellow	**Silver**	**Total**
Humber	155	49	204
Anglian	12,273	3,664	15,937
Thames	2,473	152	2,625
South East	825	252	1,077
South West	10,261	947	11,208
West Wales	1,345	150	1,495
Dee	73	24	97
North West	187	33	220
Total	**27,593**	**5,271**	**32,864**

Unlike the glass eel catches which may be used for restocking and therefore support eel conservation measures, the yellow and silver eel catches are all used for consumption.

It is thought that a significant proportion of the yellow and silver eel catch was formerly sold to the rest of the EU prior to the UK's exit. However, it is very difficult to quantify the extent of this former trade from import/export statistics, because (i) it is not possible to differentiate between eel originating in the UK vs that being imported then (re)exported (i.e. traded with other Member States within the EU) through the UK, and (ii) eel might be shipped as live, chilled, frozen or processed. A traceability scheme has been implemented for glass eel, but not for yellow and silver eel. It is likely that the best way to develop this information is directly from those catching and trading in eels.

There is no principle of a biological surplus for silver eels because there is unlikely to be any density-dependent mortality at this stage when the eels are on their way to the ocean. The same is probably true for yellow eels, at least by the time they have grown to reach the minimum landing size for fisheries in England of 30 cm.

There might be a case to be made for an NDF based on management purposes if the silver eel escapement from the area fished was above the target set in the Eel Management Plan (sometimes referred to as the 40% of pristine biomass). However, escapement is presently estimated to be above this target only in the South East Eel Management Area, and even there it is very close to 40%. Therefore, no positive NDF based on management measures is proposed.

As such, it does not seem possible currently to build a case for a positive NDF for yellow or silver eel catches in England and Wales.

Appendix 4. UK responses to ICES peer review of draft non-detriment finding

The UK sent its draft NDF document (SRG84/6/1) to ICES for peer review. A response from ICES was received on 18 January 2019 (ICES. 2019).

We are reassured by the positive and supportive conclusions from the ICES Advisory Committee (ACOM, hereafter referenced as ICES) and the individual reviewers, which recognised that:

- “the scientific work is of a high standard, given the availability of data and knowledge gaps for this species”;
- “the reviewed papers appear to have followed ICES standards for data acceptance and approaches to analyses”;
- “The availability and demand of eel for stocking purposes has been carefully examined, and adaptive management outlined, which is essential for a positive NDF”;
- “it is clear that the data available to input to them, the limitations of which are acknowledged by the authors, is comprehensive compared to most, if not all, other datasets relating to the species. This gives confidence in the conclusions drawn”;
- “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.”; and
- “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”.

ICES have made some recommendations for improvements/modifications to the approach described in Papers 1 and 2 (submitted to them)(note that ‘paper 1’ submitted to ICES is SRG84/6/1, an earlier version of this document; ‘paper 2’ is the Lough Neagh Eel Production Model – it now forms Appendix 2 of this document), set out in the Main section and in the reports from the individual reviewers. We have considered, and welcome, all of these and have addressed the majority. Some will take longer to address but we suggest, as confirmed by ICES, that our approach is based on the best available scientific information and is consistent with the CITES Strategic Vision: 2008–2020 and Res. Conf. 16.7 (Rev. CoP17). Our approach is also consistent with the draft Decisions on eels set out in document CoP18 Doc. 63 for consideration at CITES CoP18 in May 2019

Several of the comments from ICES and the Reviewers refer to knowledge gaps and uncertainties in the data, approaches and understanding of eel life cycle and production dynamics. We fully agree with these comments, having acknowledged them in our NDF documents and in UK Eel Management Plans and associated Progress Reports. Our desire is to fill these gaps (annexed), albeit in a manner prioritised according to their practicality and effectiveness in ensuring an improved scientific basis to our NDF approach and the conclusions drawn.

These gaps and uncertainties are not easy or quick to fill and these apply across the entire range/stock of European eel and are not shortfalls specific to this NDF. We are addressing many through local, national, and international research programmes, in many cases working in partnership with eel experts in various EU countries and throughout the EIFAAC/ICES/GFCM scientific community. It is anticipated that as these knowledge gaps are addressed, the results can be utilized in the adaptive management strategy outlined in the NDF.

Revised UK non-detriment finding for European eel: UK responses to ICES peer review

Paper 1 = UK NDF (SRG84/6/1); Paper 2 = Lough Neagh Eel production model (now Appendix 2 of this document).

Table A: Main Advice section

Number	Task
1 (p. 3)	*Paper 1: 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.* Response: We acknowledge that these key knowledge gaps should be filled, and our proposed 'adaptive management process' will take account of new information when it becomes available over the coming months and years. We have listed in our cover note (SRG86/6/1) several of the knowledge gaps that we intend to address in the coming years. Whilst not listed in their entirety some of the suggested actions, such as marking glass eel restocked into Lough Neagh, are already being undertaken.
2 (p. 3)	*Paper 1: 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.* Response: This appears to be a misunderstanding because it is noted in Paper 1 that there are no estimates of the glass eel production in the rivers that host fisheries that might be used for stocking. At time of submitting the papers for review, the only information available on glass eels was the fishery catch. The calculation was intended to identify the maximum amount of glass eel recruits that could be utilised in the catchments (allowing for assumptions of mortality), for the dual purpose of demonstrating a surplus of recruitment but also so that restocking or fishery control measures could be introduced to safeguard the recruitment. The approach is clearly precautionary as it is based on pristine production estimates. Production estimates have been extrapolated from yellow eel sampling within the catchments or wider River Basin Districts, and therefore carry further caveats.

Number	Task
3 (p. 3)	*Paper 2: 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.* Response: While we agree with the reviewer about the issue of uncertainty, we are reassured of the robustness of the approach by the closeness of the model predictions of catch and escapement in 2017 with those observed (see Table 7 in Paper 2). That said, further development of this approach will form an integral part of the work leading to the next 3-year review as new catch metrics, etc., become available.
4 (p. 3)	*Paper 2: 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.* Response: This is noted, but we are in agreement with ICES in favour of the other approach (Paper 1, Method 2), and we would like to clarify that the example use of the Lough Neagh carrying capacity in comparison with English and Welsh river fisheries was only to illustrate the principle behind the use of any identified surplus, and therefore will not pursue this recommendation of applying a precautionary buffer when extrapolating from the Lough Neagh carrying capacity.
5 (p. 4)	*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.* Response: We support ICES' recommendation to use the pristine silver eel production-based target (Method 2). The recommendation to apply a precautionary buffer to Method 2 is a little confusing because earlier in the document ICES recommended applying the precautionary buffer to Method 1. And in the reviewer reports it is noted that assuming the fishery catches all of the glass eel is highly precautionary. We note that modelling the impact of barriers (i.e. identifying accessible habitat) is fairly straightforward whereas modelling the impact of partial obstacles ins more difficult. Estimates of current production carry more caution due to the nature of the assumptions applied and the sampling data they are derived from.

Number	Task
6 (p. 4)	*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.* Response: The assessment of surplus does not take account of fine scale habitat quality because that level of information is not available at present – it is one knowledge gap we will work to address in the future. Production is estimated as a rate (kg per hectare) applied across the whole catchment area. However, the method to estimate the impacts of partial barriers does take into account the influence of latitude, longitude, distance from the sea and river gradient and these can be considered as gross indicators of eel habitat.
7 (p. 4)	*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.* Response: The habitat area has been estimated upstream from the head of tide (i.e. the freshwater part of the basin only). This is because the head of tide provides a well-documented point on the map which is understandable to all. There may be some settlement of eel between the top of the fishery in the estuary and the head of tide, but this will be a relatively small area compared to the total area of freshwater habitat. The fishing method (dip nets) catches eels that are progressing upstream towards the non-tidal part of the river basin, supporting our assumption.
8 (p. 4)	*In Annex 1 of Paper 1, the (ICES 2015b) indicators were applied to the stock level (the title of the section erroneously mentions "UK" level; this should be corrected).* Response: The review is correct, and the title of Annex 1 in Paper 1 has been amended.

Number	Task
9 (p. 4)	*The latest ICES advice for eel (ICES 2019b) 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.* Response: The latest ICES advice also notes that stocking of eels is considered a management action in the EU regulation and many eel management plans, and that this stocking is reliant on a glass eel fishery catch, and that when stocking to increase silver eel escapement and thus aid stock recovery, an estimation of the prospective net benefit should be made prior to any stocking activity. The extensive analysis reported in Paper 2 demonstrates that production and escapement of silver eel from eel stocked into Lough Neagh is as high as can be expected while recruitment (natural and stocked) is below that meeting carrying capacity in Lough Neagh. It should also be noted that the trade of yellow and silver eels is from a combined harvest of naturally recruited and stocked glass eels since 1984, as approved under the terms of the Neagh Bann EMP and in compliance with the EU Eel Regulation (EC 1100/2007).
10 (p. 4)	*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.* Response: This comment only applies to the Lough Neagh analyses (presented in both papers), because there has been very little restocking in rivers with glass eel fisheries in England and Wales. For the Lough Neagh analyses, the biomass calculation (in Paper 2, Figure 32) contains restocked glass eel, as do the projections for future catches and escapement (Paper 2, Table 6). However, the calculation of mortality rates (Paper 2, Table 5) is not based on restocking and therefore is compliant with the ICES recommendation.
11 (p. 4)	*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.* Response: Paper 2 demonstrates that eel stocked into Lough Neagh develop into silver eels that emigrate from the river basin. However, we acknowledge that the spawning success of stocked versus naturally recruiting eels remains unknown. The few studies that have attempted to address this by tracking silver eel migrations using satellite tags have shown how difficult it will be to fill this gap. For the meantime, as ICES (2015b) stated, it is assumed that all basins contribute to the spawning stock, and we apply this assumption until information to suggest otherwise is available.

Number	Task
12 (p. 4)	*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.* Response: This is discussed in Paper 2, Annex 3 section 1. Since 1984 to the present, 103 million River Bann glass eels have been transported via assisted migration upstream into Lough Neagh. From 1984, stocking of glass eel has played a major role in the management of eel in the lough with 110 million individuals stocked at a cost of € 5 million, of which the EU and local Government Department funded € 1.6 million since 2012 recognising it as a conservation measure as prescribed by the EU Eel Regulation. The comprehensive analysis of Lough Neagh eel production dynamics in Paper 2 demonstrates the successfulness of the restocking programme in terms of contributing to silver eel production and its associated escapement (directly assessed since 2003) while at the same time supporting an economically important fishery necessary to fund the purchase of glass eel. And as one reviewer states in relation to the Lough Neagh fishery management framework, “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.”

Number	Task
13 (p. 4)	*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 (B0) 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.* Response: We acknowledge that where removal of potential recruitment affects subsequent eel density there may be some effects on population structure, but in the absence of understanding what should be the ideal population structure this is another argument for our approach of applying the B_0 target method (Method 2) because it aims to achieve a structure similar to that before the overall recruitment decline for the international stock. Any effects on the broader ecosystem are even more difficult to quantify and while they are undesired, cannot be addressed at this time because they are a knowledge gap. Although one reviewer stated, "it is unclear how there could be a surplus production", the ICES Advice stated that "The availability and demand of eel for stocking purposes has been carefully examined, and adaptive management outlined, which is essential for a positive NDF". In response to the suggested comparison between B_0 and B_{best}, we would like to clarify that such a comparison is not mathematically appropriate in this case because the B_{best} reported in Paper 1 is not estimated for the specific area of the proposed NDF but for a larger geographic scale including neighbouring rivers and estuary. The impact of barriers to eel in the 1980s was taken into account in setting B_0 and it was assumed that all habitat was potentially available to eel production. Present day production can only be from the habitat presently available, and targets have been set accordingly. Installation of eel passes is one of the main recovery measures being implemented throughout England and Wales in order to recover lost habitat. As habitat is recovered this will be factored into future analyses.
14 (p. 4)	*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).* Response: The UK will adopt the Eel Regulation into national legislation at the time of EU Exit and will continue to be an active and willing collaborator in the international management of this shared stock.

Table B: Reviewer 1

Number	Task
15 (p. 8)	*Paper 1: Chapter 7 - 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.* Response: There are no fishery-independent sources of data with which to quantify glass eel recruitment to these rivers. The reviewer has misunderstood the content of Table 1 in Paper 1 – this table presents the results of applying methods 1 or 2 based solely on the glass eel fishery catch data. The title of the 'catch' column has been amended to make clear that these are fishery data.
16 (p. 9)	*Paper 1: Chapter 12 - Both (glass eel surplus) methods are associated with considerable uncertainty and an uncertainty buffer may be appropriate for the application to EMPs as a precautionary measure.* Response: As agreed by the reviewers, the assumption that the fishery is 100% efficient (exploitation rate = 100%) is extremely precautious because if it were true there would be no yellow eel production upstream. Therefore, we consider that our assumptions are precautious already and do not require a further buffer for uncertainty.
17 (p. 10)	*Paper 1, though discussing the LN production model: 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.* Response: As in response to point 3, above, we have acknowledged the unknown levels of uncertainty within the modelling approach, but we are reassured of the robustness of the approach by the closeness of the model predictions of catch and escapement in 2017 with those observed (see Table 7 in Paper 2). That said, further development of this approach will form an integral part of the work leading to the next 3-year review as new catch metrics, etc, become available (see Table 7 in Paper 2).

Number	Task
18 (p. 10)	*Paper 1, though discussing the LN production model: 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. 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.* Response: As noted in both papers, the Neagh Bann EMP is compliant, in the long term, with the EC Eel Regulation. As regards describing the catch relative to production, in addition to Chapter 12.2 providing a description of the production and fishery, the LN fishery catch is briefly described in chapter 3.1.2 that summarises the commercial fisheries in the UK, the *DAERA* fisheries statistics (referenced in section 5.2) contains all relevant catch metrics, including those for silver eel as requested, and Annex 3 section 1 references Rosell *et al.* (2005) for a description of the fishery.

Table B: Reviewer 2

Number	Task
19 (p. 13)	*Paper 2: 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* Response: See point 1 above.
20 (p. 14)	*Paper 1: Page 16 - 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.* Response: To clarify, the 40% target is not being used as a metric to justify the NDF for the specific river fisheries for glass eel in England and Wales. This is because the 40% target is set and managed at the large geographic scale of the Eel Management Unit (akin to River Basin District) whereas the NDF is proposed for specific rivers. There is not the same comprehensive level of data for the EMUs across England and Wales as there is for the Neagh Bann. However, the management measures for these EMUs (Severn, South West, West Wales, and North West) are described in their eel management plans, available at (https://www.gov.uk/government/publications/2010-to-2015-government-policy-freshwater-fisheries/2010-to-2015-government-policy-freshwater-fisheries)
21 (p. 14)	*Paper 1: Page 25 - 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.* Response: See responses to point 6 above.
22 (p. 15)	*Paper 1: Page 31 - As carrying capacity has only been assessed using available habitat and not quality, this feels like a rather definitive statement.* Response: As explained above (Point 6) this is our best approach under the present state of knowledge.

Number	Task
23 (p. 15)	*Paper 1: Page 35 - 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.* Response: Such catastrophic events are a risk, albeit a low risk for a whole river based on their frequency in the UK. As noted in the Paper and by the reviewers, the approach to determine surplus is precautionary already and this would help to mitigate against this risk. It should also be recognised that the yellow eel population in these donor rivers consists of multiple year cohorts, and this provides a natural buffer against catastrophic one-off events impacting a year's recruitment.
24 (p. 15)	*Paper 1: Simply stocking glass eels into unfished rivers is not conservation; there needs to be a follow-up monitoring on the benefits and impacts of this activity.* Response: Although we disagree with the reviewer's comment since a restocked eel does not need to be monitored in order to contribute to the spawning stock (the ultimate metric of conservation) and restocking into unfished rivers would be following the ICES advice from 2018 that restocking should be where survival to silver eel escapement is high, we agree that monitoring should be conducted to check the benefits of this activity and this already features as part of the DAERA/AFBI eel research commitments.
25 (p. 15)	*Paper 1: Page 38 - '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.* Response: This is correct. Developing improved estimates of these relationships will form an integral part of the work ahead of the next 3-year review, as new catch metrics, etc, become available.
26 (p. 15)	*Paper 1: Page 38 - should the title of Annex 1 not be 'for the stock across its range' and not 'the UK'?* Response: The reviewer is correct, and the title has been revised.
27 (p. 16)	*Paper 2: 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:* Response: The sentence on page 33 has been changed to start "Under the assumption that there is no difference". This no longer contradicts the later sentences because the assumption was an initial step forming part of the exploratory analysis.
28 (p. 16)	*Several recommendations on marking stocked fish, satellite tracking eel during oceanic migrations, using fisheries-based data, and that others should use the UK papers as an example of best practice in developing an NDF.* Response: We appreciate and support these recommendations and we will follow them up as and when we can, but no further information is requested or, in our opinion required, in the present papers.

Table C: Reviewer 3

Number	Task
29 (p. 18)	*Comment 1: 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.* *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.* Response: First, it appears that the reviewer may have mis-understood the spatial scale of the proposed NDFs, as evidenced by their reference to EMUs. To clarify, while EMUs are set at regions, typically River Basin Districts, the NDF is being applied at the smaller scale of individual river basins. On the other hand, we fully agree with the reviewer that the fishery-dependent (catch) data would not represent complete counts, efforts are ongoing to generate better data, recognising that the catches are not complete counts. There are no fishery-independent glass eel data for the specific river basins, as we noted in the papers. The response to Point 7 above also answers the comment here about extrapolating data from tidal fisheries to freshwater recruitment. The papers do not address facultative catadromy because we assume that all eel upstream of the tidal fisheries will remain in freshwater until they silver and return to the ocean. This assumption may not be entirely correct for some eels but there is no local information on which to adopt a different approach at this time. This is one of the knowledge gaps that we will seek to address in future.

Number	Task
30 (p. 18)	*Comment 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 has 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.* Response: The term 'glass eel' is used in the papers to represent eel at age 0 so they may include eels with no pigment and a range of pigment stages as a season progresses. The 3000 glass eels/kg is a well-established mean value for European eel numbers to weight conversion used by the EIFAAC/ICES/GFCM Working Group on Eel and CITES, etc., and it takes into consideration changes in per unit weights over a fishing season and across years. The reviewer raises an interesting point about the potential effect of variability in glass eel size and weight and this is an issue that could be explored in the future. For the present paper and management framework, however, the method incorporates a large buffer for uncertainty, and it is more practical to manage a fishery for a particular year based on a single analysis, so that all interested parties know what is expected, than to adapt management within a fishing season as implied by the reviewer. We note also that the East River-Chester mean elvers per kg data presented by the reviewer are for American eel, *Anguilla rostrata*, and therefore while they demonstrate the interannual variation they should not be taken as values necessarily representative of European eel (*Anguilla anguilla*).
31 (p. 19)	*Comment 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-, (95% CI ± 0.00149 day-) 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.* Response: We agree that there are a number of uncertainties within the proposed approach, and in the future, we will aim to investigate the sensitivity of the results to these uncertainties. We would correct the reviewer in that the back-casting is to 80 mm, not 80 cm, but we assume that this was a typo. The analysis is based on an 8 cm eel because this was considered as the maximal length for a glass eel at settlement phase.

Number	Task
32 (p. 19)	*Comment 4: adopt the WGEEL definition of a glass eel, i.e. all recruits of the 0+ cohort age (included pigmented stages).* Response: That is the definition applied in the papers.
33 (p. 19)	*Comment 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; Figures13 and 14, Paper 2) the relationship between eel recruitment and silver eel production in kilograms.* Response: The glass eel data presented in Figure 5 of Paper 1 are the number of glass eel stocked into Lough Neagh, but the reviewer is correct in that this is a weight converted to a number. The results were presented in this manner because only weight metrics are known for glass eel inputs/purchase and standard input-output relationships are always derived from a numerical basis.
34 (p. 19)	*Comment 6: Reporting of the goodness of fit statistics for both the Beverton–Holt and Ricker models (Paper 2) would be helpful.* Response: We will try to do this in the future.
35 (p. 19)	*Comment 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.* Response: This is an interesting hypothesis and one that might be considered in the future if such data become available.
36 (p. 20)	*Comment 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 Bo, '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.* Response: As noted above, the reviewer appears to have misunderstood that the NDF is being proposed at the individual river basin scale, not at the large EMU scale which contains many rivers. As noted above, we would like to clarify that the proposed comparison is not mathematically appropriate in this case because the B_{best} reported in Paper 1 is not estimated for the specific area of the proposed NDF but for a larger geographic scale including neighbouring rivers and estuary.

Number	Task
37 (p. 20)	*Comment 9: Tables A2.1 and A2.12* Response: This comment appears to be presenting extracts of tables in support of the Reviewer's comment 8, and so we refer to the response to comment 8 (response point 36).
38 (p. 20)	*Comment 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.* Response: As noted above, the reviewer appears to have misunderstood that the NDF is being proposed at the individual river basin scale, not at the large EMU scale which contains many rivers. Therefore, the reference to SMEP II modelling, and the other components of the approach to estimate B_0, B_{best} and $B_{current}$ is not directly transferrable as a measure of 'usefulness' to the individual river basins with fisheries. That said, the reviewer raises a good point about exploring yellow eel survey data for trends over time and we will investigate this as a potential additional source of information for future years.
39 (p. 20)	*Comment 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 & Dekker 1997; 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.* Response: The empirical approach of the current study found in its input-output analysis that Lough Neagh carrying capacity for eel is 300 glass eels per hectare. This finding corroborates carrying capacity figures for Neagh quoted in the studies referenced.

References:

ICES. 2019. 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 In Report of the ICES Advisory Committee, 2019, sr.2019.01. https://doi.org/10.17895/ices.advice.4688

Appendix 5. UK responses to peer review comments by the CITES Animals Committee

The UK submitted on 16 September 2021 its draft NDF to the CITES Animals Committee (AC), under the then CITES Decision 18.197.a, for their opinion and advice with any supporting rationale, on the UK's non-detriment finding (NDF), specifically with respect to one key question:

a) *will trade in European eel, using the approach and conditions described in the UK non-detriment finding, be detrimental to the survival of European eel?*

'Non-detriment' is taken here to mean as described in Article 4.2.a of the Convention and as elaborated in the recommendations to Scientific Authorities in Res. Conf. 16.7 and in Article 4.2.a of EU Regulation 338/97 (as incorporated in UK law), that permitting trade: 'would 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, taking account of the current or anticipated level of trade.'

Subsidiary questions

Considering the outcome of the ICES workshop on NDFs for European eel, the Animals Committee are also asked to provide any advice and observations on the following questions.

i. *Noting the criteria in the previous ICES advice, has the UK provided sufficient justification to make an NDF at a smaller spatial scale than that of the full stock?*
ii. *Is the UK approach to estimating a 'surplus' of glass eels in SW Britain justified by the available evidence[1]?*
iii. *Do the analyses presented in this NDF provide evidence of a conservation net benefit from stocking Lough Neagh[2]?*
iv. *Are there are any inadequacies in the science that are necessary* ***for the UK*** *to specifically address to make a robust NDF at the smaller spatial scale (recognising that there are many unanswered wider questions about European eels that remain to be addressed by science collectively)?*

A response was received from the Chair of the Animals Committee (Mathias Loertscher) on 16 December 2021 with the summary opinion provided below.

- *In relation to this request, the Animals Committee discussed the documents and received in particular two comments which are attached to this communication. They do contain specific questions and comments which may help improve and clarify the submitted documents and analysis.*

- *The current system as described by the UK in the NDF document gives the Committee sufficient assurance that the export of the surplus of glass eels is not detrimental to the survival of the species in the UK. The document provides the explanation that the take*

[1] Noting that in the absence of data on carrying capacity for donor river basins, the UK NDF applies a proxy of surplus, which is recruitment in excess of the amount needed to produce pristine silver eel biomass (B_0) according to the EMP.
[2] Noting that Article 7.8 of EC Regulation 1100/2007 states that "*Restocking shall be deemed to be a conservation measure …… provided that: … it contributes to the achievement of the 40% target level of escapement*".

of glass eels from the Severn catchment is unlikely to affect silver eel production in this catchment, while the transfer of these glass eels to Lough Neagh results in adequate production and escapement of silver eels from this system. This surplus will be able to contribute to the reproduction of the species in the Sargasso Sea and therefore benefit the population as a whole.

- *On the other hand, the Animals Committee is of the view that the comments and questions raised by the Peter Paul van Dijk and the North American region are relevant as well and the Committee is also concerned about the medium- and long-term stability of the population and the suitability of the natural water systems for eels in the UK. The system described in the NDF document is basically an artificial system that has worked for several years and contributed to the survival of the species. The aim, however, should be that the river systems where the glass eels arrive on their journey from the Sargasso Sea should find sufficient habitat and possibilities to migrate in order to fulfil the whole natural cycle in the natural water systems. Today this does not seem the case and the system presented can only be regarded as an intermediary system before the river catchments can again fulfill their natural role.*

- *And finally, the Animals Committee is also of the view that the NDF submitted might benefit from a review by the IUCN Eel Specialist Group.*

This was accompanied by two more detailed sets of comments from the Nomenclature Specialist (Peter Paul van Dijk; NS in table below) and from Mexico (MX in Table below) as the CITES North America representative on the AC; UK responses to these are provided below.

Reviewer	Comment & UK response
MX1	We consider that adaptive management (as presented in the UK's NDF) is the right way to go. The UK seems to have reached a good reference level with the best information to date on *A. anguilla* in their river systems, and it can be improved/updated periodically, as well as the management strategy for the species.
	UK response. We note this and agree.
MX2	In the best-case scenario, management of the European eel should prove to be non-detrimental to the species in each river/water body of the UK (considering these as management units at small spatial scale). If that were the case, the species management would prove to be sustainable and the harvesting non-detrimental at a regional level (i.e. all rivers and water bodies in the UK). Finally, this management could be integrated at a higher level (i.e. in other countries and in the EU) to evaluate shared stocks of the species.
	UK response. We agree that any harvest of eels in any water body should be non-detrimental and not prevent escapement targets being attained. All our Eel Management Plans (EMPs) have this as a goal and actions are in place to achieve this.
MX3	We consider that at least the most relevant rivers/water bodies (i.e. those that account for the highest proportion of regional density of the species in the UK) should be evaluated to conclude that current harvesting rates are non-detrimental regionally (at UK level). A clear panorama (adding a numbered map and corresponding table) of the situation of all rivers where eels are harvested within UK -and the level of information available for each one- would help to better understand the NDF, specially by those not familiar with UK's geography
	UK response. The NDF focuses only on those rivers where harvests for trade can be shown to be non-detrimental. Assessments of fisheries in other water bodies are reported on separately in our submissions to ICES and in periodic reports against the EMPs. We have mapped the location of glass eel fisheries and of Lough Neagh. We have not provided a map of other fisheries as they are not being considered here. Many have, in any case, now been closed.
MX4	The best source of information to have a clear picture of the status of eel populations at a river/water body level (at least the most relevant ones), is fishery independent data taken before the first point of harvest (e.g. at the river mouths) and compared to the densities further in the rivers, ideally after the last point of harvest (i.e. ongoing catch-release studies in the UK). This source of information is also the best to prove the impact of restocking of the species in any water body.
	UK response. Collation of fishery-independent data on the size of glass eel stocks in estuaries or at river mouths is technically challenging and expensive but has been undertaken on occasions.
MX5	All catches ideally should operate under a Total Allowable Catch (TAC) system, to avoid overharvesting that could be detrimental to the species at small spatial scale (each water body).
	UK response. We have not found the use of TACs to be the best way forward to manage glass eel fisheries because the volume of glass eels entering rivers cannot be predicted between years. Our approach has been to ensure that fisheries can demonstrate they are genuinely only harvesting a surplus to recruitment. Levels of catch of yellow and silver eels, based on the fisheries model, can be adjusted as required in Lough Neagh to ensure escapement targets are achieved.

Reviewer	Comment & UK response
MX6	In models (surplus model included) extrapolations that are used to estimate harvest, should consider: • Precautionary reduction of TAC including only habitats with high probability of the species occurrence (e.g. more than 70% of probability). One alternative is to consider habitat use patterns of *A. anguilla*. In a study in 2019, it was detected that probability of eel occurrence decreased with distance from the river mouth, and was dependent on water temperature, coarser substrate, and the size of the river (Degerman, E., Tamario, C., Watz, J., Nilsson, P. A., & Calles, O. 2019. Occurrence and habitat use of European eel (*Anguilla anguilla*) in running waters: lessons for improved monitoring, habitat restoration and stocking. Aquatic ecology, 53(4), 639-650) • Precautionary reduction of TAC to consider IUU (even if the self-assessed level of IUU is low).
	UK response. As before we are not using TACs for glass eel fisheries and the Lough Neagh system is managed using the model described in Annex 2.
MX7	For equations 1 and 2 (in Annex 2 of the NDF. NB Annex 2 of the NDF has now been replaced by a reference to Annex A of Cefas *et al.* 2021.), a better explanation of the units and signs used would be useful, particularly to those not familiar with the eel management system. Instinctively “Barriers impact” and “Glass eel catch” should have a negative value in equation 1 (both are negative impacts to the population) and the integration of the resulting units could be detailed. In equation 2, Fishing mortality appears to also consider Glass Eel catch, so it appears that GE in equation 1 is considered twice.
	UK response. The equations are explained in the text just above them and below them in the relevant sections (see now Annex A of Cefas *et al.* 2021). The units are in kg. Barrier impacts and glass eel catch should not be negative in first equation as B_{best} is current production with no impacts and given the model uses yellow eel surveys to calculate silver eel biomass, it already includes impacts of barriers in the system and glass eel fisheries. So, we add these impacts back to get the higher value that would exist if no barriers and glass eel fisheries were there (B_{best}). The second equation is, perhaps, more confusing as we then again take out the glass eel catch, as they are an impact, but this was the way to account for relevant gain for B_{best} and losses for $B_{current}$. So, if for example we only have glass eel impacts in a river and no other mortalities, after getting our model output based on yellow eel data, we would add glass eels as the equivalent silver eels that would be produced if there were no fisheries. This would provide B_{best} (current escapement expected if there were no impacts), but to estimate $B_{current}$, we go back to taking the glass eel out (so model output in this case but in other we would take silver eel fisheries and anything happening after yellow eel phase).

Reviewer	Comment & UK response
NS1	Within nomenclature, there are no issues with the European Eel, *Anguilla anguilla*. Note, however, that a cursory search for scientific articles on European eel genetics turned up several papers that purported to document genetic differences between the populations inhabiting different water drainage basins, which erodes the confidence in the assumption that the European Eel is a panmictic species (i.e. any male can mate with any female, regardless of their location of growing into a yellow and silver eel, i.e. a male from Sweden could mate with a female eel from Egypt). On the other hand, a recent analysis of range-wide Eel genomes indicated no significant geographic partitioning (https://www.sciencedaily.com/releases/2021/01/210121132037.htm)
	UK response. We agree and no action is needed
NS2	Table 3 (page 39 of NDF) enabled me to calculate an average weight for glass eels (0.289 grams per glass eel) and silver eel (250 grams per average silver eel – very roughly a 1000-fold increase in biomass). The actual numbers for male and female silver eels are on page 29. Implementing the values on page 29, a helpful conversion ratio is that it will require 11.67–14.55 glass eels to produce one average silver eel, BUT this is an order of magnitude different from the survival ratio indicated on page 36 (roughly half of all glass eels surviving for a decade to become silver eels seems optimistic; if these are ANNUAL survival rates, that should be explicitly stated). It would have been convenient if the NDF provided these metrics, and a discussion of variance (including explaining the apparent order-of-magnitude differences), early on (e.g. in the life history discussion).
	UK response. We do not fully understand this comment and we feel the text is self-explanatory. However, it is important to recall that different approaches and methods were used for Lough Neagh (data-rich modelling approach) and for GB glass eel fisheries (less data rich, more assumptions) and the two should not be mixed. In relation to silver eels, very few eels' silver at 10 years of age.
NS3	For the purposes of this NDF, the species is assumed to be panmictic, thus there is presumed to be no segmentation of the population, and assumes that distribution of larvae and glass eels across river systems is a function of passive oceanic dispersal, independent of which rivers their parents grew up in (i.e., complete mixing of parental animals on the breeding grounds, and no indication of 'homing' of larvae/glass eels into their parent's home rivers).
	UK response. Agree – no action needed
NS4	Based on these assumptions, it is evident that the Severn Estuary represents a topographical 'funnel' that will capture a particularly substantial component of the larvae/glass eels from the Gulf Stream. In turn, this would support speculation that glass eel input into the Severn estuary does not positively or negatively affect glass eel supply to other estuarine catchments; instead, it may be assumed (though not shown in the NDF) that fluctuations in glass eel intake in the Severn estuary would mirror glass eel intake at other European estuaries, because all intakes depend on the same underlying trends in silver eel escapement in the preceding year(s), migration mortality, spawning success, and leptocephalus larval survival in the Gulf Stream.
	UK response. We broadly agree with these assumptions.

Reviewer	Comment & UK response
NS5	Under these assumptions, an NDF is challenging, as the offtake does not concern a 'closed' population, but a part of a 'commonage' population, where recruitment is largely independent from production and escapement from that river basin, but the river basin has a small but significant contribution and 'responsibility' for the annual production of the maturing adults to maintain the global population. In other words, all other populations being left unchanged, one could leave the entire Severn population untouched/unexploited, or one could extract it into local extinction, and it would be difficult to detect any changes in the local population, and little in the global population.
	UK response. if exploited to local extinction, then there would be a noticeable and measurable change locally. However, we have measures in place to prevent that happening and we will continue to aim to achieve escapement and recovery targets. We are also working on the assumption that, as we do not know the contribution that any regional 'sub-stocks' make to the spawning stock, all escapement is potentially significant. As stated in ICES (2015): '***In the absence of decisive evidence** on what part of the continental stock successfully contributes to the reproduction however, the precautionary approach is to assume that any or all parts of the continental stock might contribute to the spawning process, even if some parts might not*'. However, we agree that we cannot detect any contribution that silver eels from the Severn or Lough Neagh, or the UK, make to overall spawning stock and global population trends.
NS6	Consequently, with reference to supplementary questions i. and iv., my personal assessment is that an NDF or assessment at a smaller spatial scale than the full stock is only defensible if that smaller assessment meets or exceeds the conditions for a positive NDF finding across the entire stock. In other words, the UK's approach to partial stock assessments is acceptable as long as it is understood that it depends on the integrity and confidence of other (non-UK) stock assessments and management measures also meeting the ICES and NDF parameters. My reading of the available information is that the UK's recent past and planned future management activities are consistent with the wider management objectives.
	UK response. We agree that our current and future management actions are consistent with agreed management objectives captured in UK and EU eel regulations. We also agree that the full recovery of European eels will be dependent on actions taken across the species' range, not just in the UK. However, we feel that the evidence presented means that the UK NDF can stand independently and is not reliant on any actions that might, or might not, have been taken elsewhere. Nevertheless, we are all working towards the same or similar targets and using the same indices.
NS7	I will observe that the NDF concerns two entirely different, though interrelated, fisheries, one being a wild capture of glass eels that warrants close scrutiny for non-detriment, and the other effectively a stocked commercial fishery producing yellow and silver eels; while linked by the transfer of glass eels, these are effectively two separate fisheries, and their NDFs should be treated in parallel, rather than interwoven in the way they are in the current submission.

Reviewer	Comment & UK response
	UK response. It is correct that there are two separate fisheries and these need to be treated separately to establish non-detriment. However, establishing non-detriment for Lough Neagh depends on stocking from non-detrimental sources. In that respect, the Lough Neagh fishery cannot be entirely separated from the glass eel fisheries that supply it. The GB glass eel fisheries and Lough Neagh are thus strongly inter-woven, and our demonstration of net benefit depends on the link between the two. Using glass eel supplies from other sources without demonstrable NDF would undermine the ability to make a positive NDF for Lough Neagh.
NS8	Reading through the information on the Severn glass eel fishery, it appears obvious that the main restraints on the basin producing the required escapement of silver eels are related to barriers to immigration (weirs) and habitat quality available after settlement for the elvers. In that regard, the glass eel fishery's removal of 8% to 16% (non-covid year) of total glass eel influx would appear not to be detrimental. But the silver eel productivity of the Severn region overall is shockingly low at 2.3% of B [zero](table 1, page 18), and escapement increase measures should consider a portfolio of actions in the Severn, including transfer of glass eels over the weirs (esp. the Tewkesbury weir, but also into minor tributaries blocked by flood defences), modification of the weirs to enable glass eel passage unassisted, and possibly/likely habitat management (pollution minimization, habitat structuring/rewilding) measures in the upstream, non-tidal part of the river basin district. Seems plausible for the Severn.

Reviewer	Comment & UK response
	UK response. The EMP for the Severn and, indeed, other river basin districts, do address a portfolio of actions, foremost amongst which is removing barriers where possible or enabling passage around them if not (note the related expenditure on the *Unlocking the Severn* project referred to in the text). There are also measures to avoid entrainment in intakes and other losses. The NDF focuses on the fisheries because they are the source of the specimens in trade and because the NDF it is not meant to simply duplicate the relevant Eel Management Plans; it is meant to answer the question: can international trade occur without detriment to the survival of the species in the wild? It is our view that the glass eel fishery, with the management measures we describe, and considering recent research, strongly suggests that the fishery is not the cause of any failure of the Severn River Basin District to meet the escapement target. Note the Severn River Basin District Eel Management Plan (peer reviewed by ICES and accepted by the European Commission) noted that: *Closing the glass eel fishery without increasing the amount of habitat or improving access is likely to result in an increase in density-dependent mortality in the estuary and lower reaches of rivers, and no long-term increase in silver eel output.* The general focus of the UK's eel conservation efforts continues to be improving access to habitat and making barriers to migration passable by eels and in avoiding mortality in intakes to power stations, etc. The UK has invested significant effort and resources in removing barriers to migration or making them accessible. In England and Wales in the period 2017–2019 (Cefas *et al.* 2021), 99 new eel passes were installed restoring access to over 1100 ha of river habitat (totalling 885 passes since 2009 with access restored to over 9300 ha) and 24 new screens installed at water intakes during 2017–2019 (totalling 52 eel screens since 2009). Other projects also complement this work – for example, the c£20m 'Unlocking the Severn' project (part LIFE funded and part Heritage Lottery Funded amongst others) aims to restore access by migratory fish (with a focus on twaite shad *Alosa fallax* but also benefitting salmon and eels) to greater than 158 linear miles of river habitat in the Severn catchment by removing six major weirs (or making them passable to migratory fish). See section 8.2 in the NDF (this text added in response to the reviewer's comments)
NS9	But the Severn glass eel fishery paper left me without answering a key question: very roughly, the glass eel immigration in the Severn estuary (not the Parrett) amounts to about 50 million glass eels in spring 2020. Elsewhere the NDF notes that the Severn does not meet its aim of 40% escapement – but what is the number of silver eels meant to escape during 2020? For example, what is the approximate stock size and emigration quantity for the basin? Surely not 50 million silver eels, probably not five million. Somewhere in the 12 to 20 years between glass eel immigration and silver eel emigration is a huge population loss (presumably not the glass eel fishery) which should preferably be addressed if it is not habitat carrying capacity.
	UK response. Losses of this sort are wholly indicative of the huge natural mortality that exists within eel as a species (e.g. only 16% of GE arriving at Neagh reach silver stage), and Lough Neagh has an unusually high survival rate. See comments also in the final paragraph of revised section 12.1

Reviewer	Comment & UK response
NS10	Regarding the Lough Neagh yellow/silver eel fishery, the fundamental challenge is that the lake is subject to waterways infrastructure that greatly inhibit eel migrations. Having blocked the natural immigration of glass eels into Lough Neagh, this basin is now largely (entirely?) dependent on human input of glass eels to maintain an eel population, and eel fishery. The cynical view would be to consider Lough Neagh a huge aquaculture production facility when it comes to eels, with an artificially-maintained population for more than three eel generations, and no natural population since before CITES, making the whole Lough Neagh fishery a topic for Res Conf 17.7 and the only Significant Trade aspect being the question of non-detriment of fingerling acquisition (which brings us back to the Severn estuary).
	UK response. The lough is now entirely dependent on human intervention and stocking as described. However, it does not correspond to a huge aquaculture or captive-production (ranching) operation in CITES terms (though we note and understand the parallels suggested) because it does not meet the definition of a controlled environment in Res. Conf. 10.16 (Rev.CoP19) – therefore Res. Conf. 17.7 (Rev. Cop19) does not apply, and all the specimens are of wild origin. The Lough Neagh population contributes to the annual wild mature migrating cohort. The issue of whether source code R for ranching could be applied to captive production of eels remains under discussion but is separate to this NDF (and would not apply to Lough Neagh for the reasons cited above).
NS11	I am completely mystified by the unexplained difference between the green and blue lines in figure 5. What was different during 1944–1975 that Lough Neagh had a productivity of nearly five million silver eels, whereas before and after its productivity just exceeds 3 million silver eels? Either way, the glass eel: silver eel ratio shown in this graph does not match the glass eel to silver eel conversion rates (10–60%) on page 36 (particularly on the left extreme, where the silver eel production is higher than the glass eel input, and I can't imagine glass eels cloning themselves).
	UK response. This explanation has now been provided in section 12.2 but was originally contained in Annex 3 of the NDF and is expanded upon in Abrahamian & Evans *et al*. 2021. Put simply, there were two regime shifts in productivity of the lough, one (positive) caused by eutrophication and one (negative) by the introduction of a fish not native to the lough.
NS12	On page 42, the sentence "only in those cases where catches significantly exceed the estimated carrying capacity of the river will non-detriment be considered feasible" is rather confusing: If catch exceeds carrying capacity, a population will decline to extinction…
	UK response. Section 13.1 has been revised to clarify our meaning
NS13	Table 4 (page 45) shows a worrisome, predicted decline in future eel production and escapement. One can only presume that this is a time-dependent effect of past (lower) glass eel stocking volumes, which will in a decade's time be increased by increasing glass eel stocking volumes at present; but it hints at the Lough Neagh system not meeting its 40% escapement target in the not-too-distant future.
	UK response. The model does predict a decline which indeed reflects the levels of earlier stocking (and the impact of competition from roach). If the model predicts escapement to decline below 40%, measures will be put in place (such as restricting yellow or silver eel fishing) to ensure the target is achieved.

<table>
<tr><th>Reviewer</th><th>Comment & UK response</th></tr>
<tr><td rowspan="2">NS15</td><td>Quantifying the pre-anthropogenic-modification productivity of Lough Neagh as 500 tonnes/year pre-anthropogenic impact is an interesting exercise; it could be argued to be a matter to satisfy the EU and UK regulations concerning eels, though not necessarily CITES. But regardless of whether a UK, EU or CITES mandate, it appears logical to consider measures to reinstate / re-enable the immigration of glass eels through the river Bann by modifying the waterways' infrastructure. Indeed, this would cost many times more than the annual value of the local eel fishery but can also be considered as overdue rectification of an environmental injustice done by the 19th century canal works (as well as an economic stimulus locally).</td></tr>
<tr><td>UK response. The barriers on the river Bann and on Lough Neagh itself are required for flood control There is no foreseeable prospect of them being removed, regardless of how desirable this might be. In any case, the numbers of glass eels now caught at the mouth of the Bann are too low to be able to meet future escapement targets. Reliance of natural immigration alone, even without barriers, would lead to failure to meet the aims of the EMP.</td></tr>
<tr><td rowspan="2">NS16</td><td>I am not enamoured of the argument that trade is necessary to ensure assisted migration of glass eels into Lough Neagh and safeguard continued production of silver eels (page 35); I would instead argue that it is long overdue to mitigate the glass eel barriers created by canalization of the Bann in the 19th century. Yes, that would cost several times over the annual value of the eel fishery, but it will pay for itself in the long run and is essentially an overdue restoration due from those who decided to canalize the Bann in the first place.</td></tr>
<tr><td>UK response. On the first point, it is important to stress that the fishery on Lough Neagh, through its long-term funding of both re-stocking and assisted migration, has created significant additional silver eel production and associated escapement where nothing comparable would have existed before; this can be demonstrated because of the long time series of data made available by the fishery and related research. The series of sluice gates are for flood alleviation needs and will not be removed under current climate action plans.

See previous comments on barriers on the Bann. The presence of barriers to migration on rivers is not unique to the UK or to Lough Neagh. However, on the Neagh-Bann system there are elver traps on the barriers allowing their collection by the fishery and upstream assisted migration; the river-spanning flood mitigation barriers do not prevent downstream movement (if they did so, the fishing weirs on the river Bann would not be able to catch silver eels), ordinarily their sluice gates are open at times of flood, coinciding with silver eel migration timings. The fishing weirs have a 10% river span free gap to enable a proportion of fish to pass any nets when they are set; the fishery has also funded mitigation measures (assisted migration of glass eels) for decades which we have already described. The Bann itself is not 'canalised'.

It is not clear that removing the barriers would 'pay for itself' over time. Any cost-benefit analysis would need to look not only at the fishery but at the costs of flooding which the barriers currently prevent. In addition, current natural recruitment is probably insufficient to achieve escapement targets in the long-term, which will depend on both catch and transport of glass eels up the river Bann and stocking from GB or any other non-detrimental source (we know of no others at present).</td></tr>
</table>

Reviewer	Comment & UK response
NS17	What is not clarified in the NDF is why the silver eel production in the Severn RBD is deplorably low (2.3%) compared to the huge glass eel presence in the lower parts of at least the Severn River, and similarly why/how the Parrett's abundant glass eel input relates to the even worse 0.6% silver eel escapement compliance. Even if the vast majority of these RBDs' rivers are blocked to glass eel migrations by waterway infrastructure, major fisheries restocking efforts could compensate for blocked immigration. If so, there would be other, more local markets for the Severn and Parrett glass eel fisheries than the Neagh-Bann RBD, potentially providing continued economic viability to these glass eel fisheries (versus the doom scenario sketched on page 48).
	UK response. See the comments in the revised section 12.1. The failure of both RDBs to meet their escapement targets is not linked to a lack of recruitment but to other factors. As such, stocking might not lead to any enhancement of escapement and, regardless, there is currently no external funding to drive such a local market for glass eels for stocking.

Appendix 6. Literature review of glass eel exploitation rates

Table A6.1. Exploitation rates of glass stages of genus *Anguilla* across different catchments (data compiled 2020). Shaded rows indicate studies which were identified as having medium or high relevance to GB glass eel fisheries.

Species	Area	Time period	Fisheries	Data used	Mean Exploitation rate	Authors	Relevance
American eel	East River, Canada	1996–1998	Dip net fishery (April to June).	Fishery catches and trapping.	Average total annual exploitation: **38.23 ± 6.79 (range: 30.8-51.8 %).** Daily exploitation: 43.63 ± 3.39 % on average (41.07–62.9 %).	Jessop 2000	High; superseded by the study Lin and Jessop (2020), thus not included in the calculation of mean estimates.
Japanese eel	Shuang-chi River, Taiwan	1982–1983	Mixed: Hand nets and boat beam trawling nets (November to February).	Fishery data.	Average exploitation: **62.89** ± **4.52 % (range: 44.1–74.5%**). Average exploitation from a mark-recapture study: 60.10 ± 9.01 % (43.8–74.9 %).	Tzeng 1984	Low (not possible to separate between land and boat-based fishery)
Japanese eel	Shuang River, Taiwan	1981–1994	Hand nets and small hand-towed trawl nets (October to March). The vessel-based fisheries on glass eels were nearly non-existent or of no importance (informed by the author).	Fishery data.	Overall exploitation rate varied from **0.83%–53.70%** with considerable variability among seasons. Average exploitation rate was estimated as **25.96 ± 4.79**.	Lin *et al.* 2017 (additional raw data provide by the author)	Medium
Giant mottled eel	Shuang River, Taiwan	1981–1994	Hand nets and small hand-towed trawl nets (October to March). The vessel-based fisheries on glass eels were nearly non-existent or of no importance (informed by the author).	Fishery data.	Overall exploitation rate in a season varied from **1.14% to 58.54%** with considerable variability among seasons. Average exploitation rate was estimated as **27.38 ± 4.81**.	Lin *et al.* 2017 (additional raw data provide by the author)	Medium

Species	Area	Time period	Fisheries	Data used	Mean Exploitation rate	Authors	Relevance
Japanese eel	East Asia	1954–2010	Hand and bag nets reported.	Reports and annual fishery statistics.	Average exploitation range over years: **~ 20–55 %** (taken from the figure, no raw data available).	Tanaka 2014	Low (not confirmed by the author to be only hand based plus no raw data available, so estimates taken from the plot).
European eel	Vilaine and Garonne estuary	1950–2004	Boats with pushed and hand scoop-nets.	A proxy for exploitation used: 1- %S/R; proportion of settled glass eels relative to a non-impacted situation.	Vilaine: 1- %S/R = **94.5 % (90–98 %)** Garonne: 1- %S/R = **22 %**	Beaulaton & Briand 2007	Low
European eel	Adour estuary, France	1998–2001	Boats with pushed and hand scoop-nets (November-March)	Fishery and scientific monitoring data used.	Mean exploitation range: **13–30 %**	Prouzet, 2002	Low
European eel	Adour estuary, France	1998–2005	Boats with pushed and hand scoop-nets (November-March).	Fishery and scientific monitoring data used.	Overall exploitation rate estimated as **15.7 % (range: 8.3–25.0 %).**	Bru *et al.* 2009	Low
European eel	Vilaine estuary, France	1996–2000	Boat fisheries (November-April).	Fishery and trapping data.	Mean overall exploitation rate estimated as **98.32 % (range 95.6%–99.4%).**	Briand *et al.* 2003	Low
European eel	Loire estuary, France	2003–2006	Boats with push-nets.	Fishery and scientific monitoring data.	Mean global exploitation rate when corrected **16.03 % (range: 13.5–18.9 %).** Before correction this varied between 13.4 and 26.3 %.	Prouzet *et al.* 2008	Low
European eel	Isle River, tributary of Dordogne	1996–2007	Boats with push-nets.	Fishery and scientific monitoring data used.	Mean global seasonal exploitation rate estimated as **11.98 (range: 0.7–33.2 %).**	Prouzet *et al.* 2008	Low
European eel	Oria, Bay of Biscay	2003–2014	Land based (October-March, and from 2019 November-January).	Fishery and scientific data.	Mean exploitation rate: **11% (range: 3–18%) when using average recruitment estimates.**	Aranburu *et al.* 2016 (raw data for land-based fisheries provided by the author).	Medium
American eel	East River, Canada	1996–2018	Dip net fishery (April-June).	Fishery catches and effort data.	Mean exploitation rate: **12.50% (range: 2.89–32.54%).**	Lin & Jessop 2020	High

Species	Area	Time period	Fisheries	Data used	Mean Exploitation rate	Authors	Relevance
European eel	Severn estuary, UK	2020	Land-based hand nets	Fishery data (mark-recapture)	Mean exploitation rate estimated as **7.8%** (6.7–8.6). However, this was estimated to be **12–16%** without Covid disruption, thus these were the values used in the review.	Aprahamian & Wood 2020	Very high

Table A6.2. Mean range of exploitation rates of glass stages of genus *Anguilla* for land-based fisheries as informed by the literature. Only studies with medium and high relevance were used in these calculations.

Land based fishery	
Mean exploitation range (%) ± SE	**3.97 ± 2.05 – 35.76 ± 8.82**

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