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Original research article

Assessing the conservation challenges for the European eel through the Delphi technique

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ABSTRACT

The once abundant European eel (*Anguilla anguilla*) is currently classified as a Critically Endangered species by the International Union for Conservation of Nature. Although both the European Union (through the 2007 Eel Regulation) and its member states have implemented various conservation actions, many uncertainties remain regarding the actual and anticipated effectiveness of these measures. This study aimed to identify and prioritise the conservation and recovery measures for the European eel, using the expert-based Delphi technique. We conducted a two-round Delphi survey on eel conservation measures (these measures were derived from an extensive review of the peer-reviewed literature). The findings highlight the need for establishing a pan-European eel recruitment monitoring programme (to obtain reliable eel population estimates), restoring access to suitable inland habitats by removing migration barriers and improving habitat quality. Experts also emphasized the necessity for a more stringent silver eel escapement target and stronger enforcement of this target. While restocking of eel remains a contentious issue, a set of preconditions could render it conditionally acceptable. This study offers important insights into the areas of consensus and divergence among eel experts in the challenging field of eel conservation. We hope these results strengthen eel management decision-making such that this Critically Endangered species does not become a museum specimen for future generations.

1. Introduction

The European eel (*Anguilla anguilla*) has been listed as a Critically Endangered species on the IUCN Red List of Threatened Species since 2008 (Pike et al., 2020). It is a widely distributed species found in most coastal countries of Europe and North Africa during its continental life phase, with its northern distribution limit in the Barents Sea (72ºN) and its southern limit in Morocco (30ºN), spanning the entire Mediterranean basin (van Ginneken, Maes, 2005; see map in Fig. 1 in Righton et al., 2025 for distribution of the species). The species is considered semelparous and panmictic (Als et al., 2011) and undergoes transformation through distinct life stages (egg; leptocephalus larva; glass, yellow and silver eel, respectively).

European eels have a complex life cycle, including spawning migration to the Sargasso Sea and migration to coastal- and freshwater areas for growth (van Ginneken, Maes, 2005). The growth stage is known as yellow eel and it may occur in marine, brackish, transitional, or freshwater zones (ICES, 2024). The yellow eel stage may last anywhere between two to 25 years, but can exceed 50 years, prior to development into the silver eel stage, maturation and spawning migration (ICES, 2024). Some individuals exhibit facultative catadromy, never migrating to freshwater during their growth phase (Tzeng et al., 2000). Although artificial reproduction is possible, the life cycle of European eel has not yet been completed in captivity (Sørensen et al., 2016). Consequently, eel aquaculture production relies entirely on a supply of wild-caught glass eels (Podda et al., 2021).

The European eel has been closely intertwined with human populations in Europe and the Mediterranean basin, as evidenced by archaeological and palaeontological records (Kettle et al., 2008). Eels have been a significant food source since the Mesolithic period (Robson et al., 2013), and were an important fishery resource for the ancient Greeks and Romans (Cataudella et al., 2015; Ganias et al., 2017). Eels were also traded towards northern Europe (Van Neer and Lentacker, 1994) and the Middle East (De Grossi Mazzorin, 2000).

Since the late 1800s, traditional local eel fisheries have expanded with the introduction of new fishing areas, methods, and markets (Dekker, 2019). During the same period, concerns about stock abundance prompted proposals to facilitate migration in inland waters and implementation of restocking schemes (Dekker, 2019). Since the early 1980s, however, the abundance of glass eels arriving in continental waters drastically declined, reaching a historical low in 2011. Unfortunately, the abundance has not recovered since then. Recruitment of glass eels in the North Sea index area was 1.1% of its 1960–1979 levels in 2024 and 0.5% in 2023 (ICES, 2024). Similarly, the yellow eel recruitment index in 2023 was only 11.4% of the 1960–1979 geometric mean (ICES, 2024). Commercial landings, which were around 10,000 tonnes in the 1960s, had dropped to 2028 tonnes by 2022 (ICES, 2023).

Over the last 30 years, a debate has emerged regarding the measures necessary to protect the European eel stock and ensure its recovery, while maintaining its use by commercial and recreational fisheries (ICES, 2023). Due to its wide distribution range and panmixia, the European eel population is a shared resource, exploited at all life stages across Europe and North Africa (Hanel et al., 2019). The species is impacted by a range of anthropogenic and oceanic factors (Feunteun, 2002; Bevacqua et al., 2015; Jacoby et al., 2015). The intensity of fishing on each life stage varies greatly depending on region and catchment (Nielsen and Prouzet, 2008), as well as cultural fishing and consumption patterns (Dekker, 2003). This poses a challenge to the identification of a framework for its protection, and of measures that allow the recovery of this iconic species.

In 2007, the European Union (EU) adopted Regulation (EC) nº 1100/2007 (hereafter referred to as the "Eel Regulation"), which directs EU member states to develop and implement eel management plans aimed at stock recovery (EU, 2007). The Eel Regulation obliges EU member states to reduce anthropogenic mortality such that at least 40% of the silver eel biomass that would have existed in the absence of human impacts, escapes to the sea. Efforts specific to the Mediterranean region have led to the adoption of Recommendation GFCM/42/2018/1 and Recommendation GFCM/46/2023/16, which outline a long-term management plan for European eel in the Mediterranean Sea. In addition, EU member states are required to regularly collect information on stock parameters, landings, restocking, and time-series (ICES, 2024). However, there are differences in the way the data is collected by different countries. Furthermore, some regions suffer from poor data quality and a lack of monitoring (ICES, 2024).

Despite emerging regulations and stock assessment methods, responding to the plight of the European eel requires expert input from across the species extensive geographic range. Though spatial modelling approaches may surmount some stock assessment challenges (Charsley et al., 2023, ICES, 2023), effective conservation still requires detailed knowledge of the specific threats to the species and the identification of effective measures to mitigate or remediate them. Our current understanding of these impacts remains fragmented and there is a lack of cumulative or broader scale assessments on the European eel (but see Righton et al., 2021 for all anguillid eels). Given the vast diversity of eel conservation measures in the literature (including those in the Eel Regulation) with each having a merit of its own, it can be difficult to identify priority measures for eel recovery and conservation without broader expert engagement.

The aim of this study is to initiate a wider discussion on the areas of consensus (or dissensus) among eel experts regarding the conservation and management of the European eel, focusing on the impacts, ongoing efforts, and their effectiveness. Thus, the objectives of this study are to:

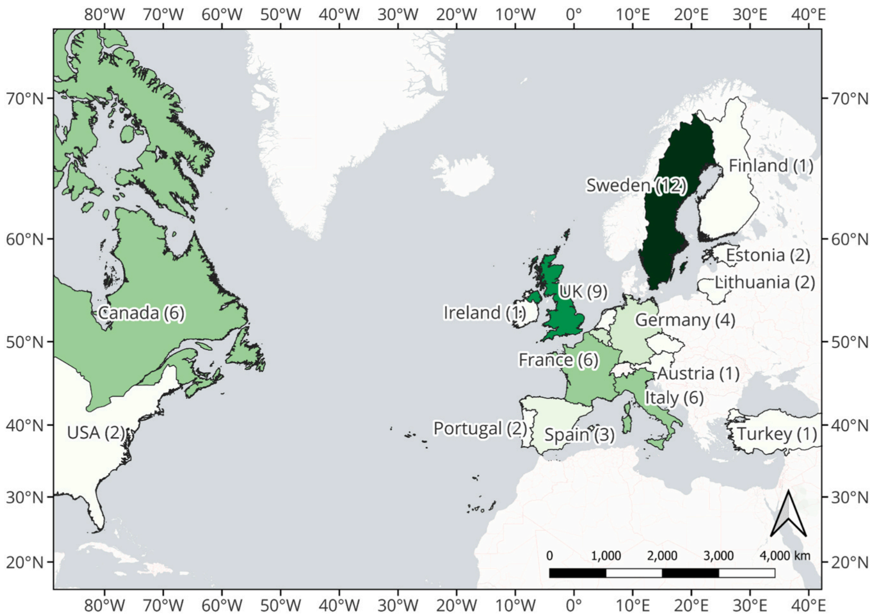

Fig. 1. Distribution of nationalities of the participants from Round 1 of the Delphi technique.

- identify priority conservation topics for the European eel based on a thorough review of the literature;
- identify key monitoring and assessment challenges, knowledge gaps, and points of consensus based on expert knowledge on the European eel*;*
- prioritise European eel conservation measures suggested in the literature based on expert knowledge and deliberation.

2. Methods

We used a two-pronged approach for this study comprising (i) a literature review and (ii) an expert-based Delphi technique (Mukherjee et al., 2015). The literature review was used to develop the evidence base for this project and the Delphi survey. Specifically, it aimed to identify the main management measures presented in the literature to conserve the European eel and to identify key authors (hereafter referred to as 'experts') engaged in research on the European eel. In Delphi technique-based studies, it is common to include an outgroup of experts to mitigate biases. Accordingly, experts working on the American eel (*Anguilla rostrata*) were included. The American eel shares the same spawning area and faces conservation threats and stock assessment challenges similar to the European eel (Cairns et al., 2022). Thus, studies on *A. rostrata* were included in the literature review.

The literature review was followed by a Delphi survey (Mukherjee et al., 2015) designed to identify priority topics in European eel conservation, including challenges in monitoring and assessment. The Delphi technique is an anonymous consensus-building qualitative method for expert elicitation (Mukherjee et al., 2015). It consists of iterative rounds of structured questions that need to be answered by expert respondents individually. After each round, an anonymized synthesis of all responses is sent to the respondents, allowing participants to reflect on the perspectives of their peers. The Delphi technique is useful for decision making as it is relatively free from a range of psychological biases which routinely plague other expert-based techniques (such as "Ego effect" or "Groupthink"). It allows experts from different geographic locations to participate in a safe (and anonymous) setting without the undue influence of power (e.g., dominance effect) (Mukherjee et al., 2015). It is especially useful when potentially conflicting interests need to be addressed simultaneously. Unlike traditional surveys, the Delphi technique does not require a representative sample as it is based on expert knowledge. Reported sample sizes in published studies range from 2 to 58 participants (Mukherjee et al., 2018).

2.1. Literature review

In order to develop a holistic understanding of European eel conservation and recovery, we conducted a comprehensive review of the peer reviewed literature. We trialled different combinations of keywords (see Supplementary Information [SI], Annex 1). Given the vast volume of literature, the search for peer-reviewed articles and reviews was limited to the last 10 years (2012–2022), following common practice in Delphi-based studies (e.g. Donfrancesco et al., 2019). The searches were conducted in the Web of Science and Scopus databases on 14 October 2022. The resulting list of publications was collated using EndNote, and duplicates of articles were removed using the "de-duplication method" described by Bramer et al., (2016).

The list of publications was screened for relevance to European eel recovery, conservation and management. Four researchers independently screened the titles and abstracts using the online platform Rayyan.ai (Ouzzani et al., 2016). Any differences in interpretation regarding the relevance of publications were resolved through discussion until consensus was achieved (see SI, Annex 2 for exclusion criteria).

The resulting relevant articles were used to identify firstly the experts for the Delphi survey and secondly the measures relevant to European eel recovery. A thematic analysis yielded 33 recovery measures, which were subsequently formulated into 33 statements following several rounds of deliberation (see Annexes 4 and 5).

2.2. Expert-based approach: the Delphi technique

The Delphi technique consisted of two rounds. The first round was a mix of open-ended and closed-ended questions while the second round consisted entirely of closed-ended questions. In each round, respondents were asked to score each statement on a scale of 1 (totally disagree) to 7 (totally agree).

(i) **Selection of experts**

Experts were identified through the screening of the literature following established practice in Delphi studies (Mukherjee et al., 2015). The preliminary expert list was cross-checked by the advisory group (which included a member of the Joint EIFAAC/ICES/GFCM Working Group on Eels (WGEEL) responsible for the annual stock assessment for the European eel) to ensure that no key experts were omitted. A total of 295 experts were invited to participate in the Delphi technique for Round 1. Participation in the Delphi process was voluntary, with experts effectively self-selecting by responding to the first-round invitation.

(ii) **Round 1**

In the first round (henceforth R1), we asked experts to identify their country of affiliation, academic disciplines, the geographic region of their research and the number of years of experience in eel research (see Annex 3 for the full questionnaire in SI). Experts were also asked to identify the main challenges to eel monitoring and assessment as well as the most robust method for eel stock assessment. This was followed by the evaluation of 33 eel conservation and recovery statements. The survey was kept open from 1st to 20th March, 2023 with a reminder being sent on 14 March, 2023.

(iii) **Round 2**

In the second round (henceforth R2), the experts who had completed R1 were invited to re-rank the 33 statements in light of the anonymized feedback from R1. In addition, as opinions diverged on restocking, several additional statements on this topic were included (Annex 4 in SI):

In R2, respondents were also asked to indicate their confidence in each response alongside their scores for each statement. The R2 survey was open from 6 July to 25 August 2023. Spearman correlation was calculated to assess consistency between rounds. Data analysis was conducted in R version 4.3 (Team, R. Core, 2024).

3. Results

3.1. Literature search

The literature search resulted in 944 unique peer reviewed articles (after removing 507 duplicates). The screening resulted in 206 relevant abstracts which were used to identify eel experts and the thirty-three eel conservation and recovery statements for the Delphi

Table 1

Ranking of statements by experts in R1 and R2 of the Delphi technique based on average scores for each statement. The ranking is ordered according to the average scores (from high to low, with score 1 indicating: totally disagree, to score 7 indicating: totally agree) from Round 2 of the Delphi survey.

Statements	mean R1	mean R2	Rank R1	Rank R2
A Europe-wide eel recruitment monitoring scheme is required.	6.14	6.53	33	33
Wetland destruction and loss of habitat quality plays a major role in European eel decline.	5.45	6.44	30	32
The loss of upstream habitat availability due to obstacles in watercourses plays a major role in European eel decline.	5.49	6.23	31	31
Climate change creates additional threats to eels. This means eel managers should follow a precautionary approach, to minimise additional (cumulative) negative effects on eel conservation.	5.55	6.19	32	30
Common stock assessment methods should be designed and applied across the whole range of the European eel.	5.40	6.14	29	29
Acoustic telemetry (hydrophones) is a good method to assess migration behaviour of silver eels.	5.02	6.11	27	28
River rehabilitation (e.g. re-meandering) is an effective measure for eel conservation.	4.55	6.05	24	27
Satisfactory implementation of European environmental directives (such as the Water Framework Directive) would contribute to solving pollution and connectivity issues affecting eels.	5.14	6.03	28	26
In case restocking of eels is used, it is advised to restock with wild-caught glass eels.	4.69	5.85	26	25
Shutting down hydro power plant turbines at night is an effective measure to help reduce eel mortality.	4.49	5.54	22	24
Restocking eels to some upstream freshwater environments is a futile measure. Better escapement is achieved in restocking eels to coastal waters or undammed freshwater systems with a direct connection to the sea.	4.25	5.43	20	23
The integrated management of water level control structures and abstraction rates is an effective way to minimise eel entrainment and delay.	4.03	5.42	19	22
Limited opening of tidal barriers during tidal rise is an effective measure to improve upstream glass eel migration, without significant intrusion of saltwater.	3.85	5.40	17	21
Allowing –regulated- eel fisheries to continue is an effective way to ensure societal support for eel stock recovery, as it maintains the cultural linkages between humans and eels.	4.42	5.33	21	20
Even if stocking could increase the number of eels escaping to the sea, there is no indication these eels contribute to the spawning biomass.	4.62	4.95	25	19
Using selective and appropriate fishing gear (e.g. large J hooks) to reduce deep hooking and the catch of undersized eel is an effective way to avoid unwanted eel mortality.	3.60	4.79	14	18
"Maximum anthropogenic mortality" would be a better management objective than the 40% escapement management objective.	3.74	4.77	16	17
A total closure of eel fisheries should be implemented across Europe.	4.54	4.67	23	16
Fish return systems at nuclear power plants are effective in reducing eel mortality.	3.28	4.40	7	15
Stocking of yellow eels that have matured from glass eels in captivity leads to anthropogenic spreading of viruses (such as Anguillid Herpesvirus 1 AngHV1), and should hence be avoided.	3.98	4.33	18	14
Illegal fishing is likely to cause larger fishing mortality on eels compared to legal fishing in Europe.	3.62	4.29	15	13
Motion-activated eel ladder camera (ELC) works just as well as a monitoring tool as physical methods.	3.37	4.25	9.5	12
Installing fish passages is not effective. Only removing all obstacles to eel migration will significantly increase habitat connectivity for eels. (Please qualify your response based on downstream…	3.51	4.03	11	11
Aquaculture is a threat to eel population recovery as it creates more incentives for fishing.	3.57	3.91	13	10
Guiding eels through passages by way of facilitating technology (e.g. light (LED) adjustment; electrified horizontal bar rack bypass systems; infrasound deterrents) is an effective way to reduce eel mortality.	3.37	3.84	9.5	9
Trap & transport (T&T) of landlocked eels beyond obstacles is a cost-effective eel conservation measure.	3.54	3.69	12	8
Restocking of glass eels is an effective measure for eel conservation.	3.32	3.61	8	7
As eels are bottom dwellers, only deep bypass structures with entrances near the bottom increase eel passage effectiveness.	3.11	3.48	5	6
Defining minimum landing size (MLS) is an effective measure for eel conservation.	2.57	3.45	1	5
Currently available fisheries data are reliable to inform eel management and conservation.	3.17	3.29	6	4
Liming of freshwater habitats increases eel abundance.	2.69	3.27	2	3
Fishing has a limited impact on silver eel escapement from the Baltic Sea.	2.80	3.11	3	2
Limiting the number of eel predators, like seals and cormorants, is an effective measure for eel conservation.	3.08	2.98	4	1

technique.

3.2. Delphi technique

Of the 295 researchers invited, 65 participated in R1 (22% response rate). Of the 65 participants in R1, 45 participated in R2 (69%). Collectively, respondents had worked on a wide range of topics relating to the European eel across the species' global distribution (Annex 5). Fig. 1 provides an overview of the nationalities of R1 respondents (Fig. 1). The nationality of the respondents included Sweden, United Kingdom, Spain, France, Canada, Germany, Finland, Estonia, Italy, the Czech Republic, The Netherlands, Belgium, USA, Lithuania, Portugal, Ireland, New Zealand and Austria (Fig. 1). The majority of respondents stated that they had a disciplinary background in environmental sciences and ecology. The respondents had a median of 15.35 years (range 2–53 years) of research experience on eels.

3.2.1. Prioritisation of eel conservation and management measures

The Delphi survey identified priority measures for European eel conservation based on expert evaluations across two rounds. The highest average score was assigned to implementing a Europe-wide eel recruitment monitoring scheme, followed by addressing the loss of habitat quality and availability (Table 1). Reducing migration obstacles in inland waters and mitigating the impacts of climate change also received high average scores. Most experts acknowledged the existence of a regulated eel fishery, but opinions diverged. Some supported maintaining small-scale fisheries for socio-economic, cultural, and stewardship reasons, while others questioned whether such arguments justify continued fishing given the species' critical status. By contrast, liming of freshwater habitats and limiting the number of eel predators (seals, cormorants) had some of the lowest scores and were therefore rated as lower priorities by most experts. Overall, there was a significant correlation in the responses between the rounds (Spearman's correlation, rho=0.94, $p < 0.001$). The consensus increased from R1 to R2. The mean score and rank of each statement in both rounds can be found in Table 1.

3.2.2. Main challenges in eel monitoring and assessment

There was strong consensus among experts that the most pressing challenge for eel conservation and management is the need to improve monitoring and assessment methods and to have a consistent Europe wide recruitment monitoring scheme. Ideally, stock assessment estimates should be differentiated by river basins as well as by age categories and life history stages. The general difficulty of observing and detecting eels was identified as a major challenge to assess eel population according to life history stages. The lack of international coordination and strategic planning for monitoring and stock assessment, as well as the lack of standardisation and harmonisation of eel data collection and analysis methods were also identified as challenges (e.g. sampling station selection and sampling equipment needs to be better defined and standardised). Related to this, respondents mentioned the need for improved reporting to the EU and the International Council for the Exploration of the Sea (ICES). Non-fishery impacts such as habitat loss, hydropower, migration obstacles were considered difficult to quantify for stock assessment purposes. Several experts further highlighted the lack of funding and political commitment as persistent barriers to effective monitoring and assessment.

The need for long-term, consistent eel monitoring was strongly emphasised, as such data enabled time series analyses. Next to the current indicator of silver (adult) eel escapement to the sea, additional metrics are suggested such as the age of migrating adults (i.e. generation time or length), the prevalence of *Anguillicola crassus* (a parasitic nematode worm) among eels, the eel population sex ratio, contaminant loads, and the impacts of climate change. *A. crassus* is a swim bladder parasite, that naturally occurs in the Japanese eel and was probably introduced into Europe in the early 1980s, through imports of live eels from Taiwan (Koops and Hartmann, 1989). The extent to which this parasite has contributed to the decline of the European eel remains uncertain.

3.2.3. Best method for eel sampling and stock assessment

Experts provided a range of recommendations regarding suitable methods for eel sampling and stock assessment. Suggested sampling methods included: mark recapture studies, electrofishing, eDNA collection, fyke-net surveys in rearing habitat (ideally combined with otolith sampling for age analysis), chemical analysis of otoliths to identify individual life history traits, and telemetry (which consists of applying electronic tags to eels to study their behaviour and/or migration). Suggested assessment methods included: spatial modelling, scenario-based modelling, analysis of time series of glass eel recruitment, mortality estimates, habitat-based catchment models, and trend-based assessments of eel recruitment. A differentiation of sampling methods by life stage was also proposed.

3.2.4. Pollution

Experts were asked to identify the three pollutants they considered to have the greatest negative effect on eel spawner quality, based on a predefined list of seven pollutants compiled from the literature: - Heavy metals, Fipronil, Cocaine, PCBs, Toxic textile dyes, Flame retardants (PBDEs), PAHs and Tributyl phosphate. Heavy metals, PCBs and flame retardants (PBDEs) were the most frequently selected pollutants. One expert highlighted the risks posed by lipophilic contaminants:

> *Q1: "The highly lipophilic contaminants such as PCBs and PBDEs may accumulate in fat stores of yellow eels prior to silvering and will not be eliminated during migration. In fact, they may be mobilized and affect reproduction and the offspring. A strong correlation has also been found between heavy metals and a reduced condition of eels."*

In addition to PCBs, the impact of cocaine was also noted by some of the respondents:

Q2: *"The high concentration of cocaine present in some rivers causes the loss of orientation of the species. Also, it turns out to be more vulnerable to predators. PCBs cause endocrine problems that interfere with reproduction."*

Most experts emphasised that further research is urgently needed in this area:

Q3: *"This is highly under discussion. Needs further studies on eel quality and survival to spawning areas."*

Q4: *"In order to truly investigate this question, we would need to know the effects on fitness (reproduction and offspring survival), which currently cannot be done."*

The experts also noted the following pollutants which were not mentioned in the list: a) Substituted diphenylamines: these have been found in very high concentrations in eels and have a high fish toxicity; b) DDT, c) HCB, d) Bisphenol A, e) Dioxins/furans, f) Anxiolytic and psychiatric drugs frequently detected in wastewater treatment plant effluents.

3.2.5. *Escapement target*

Experts were asked whether the 40% escapement target set by the Eel regulation in 2007 was sufficient for eel stock recovery, or whether a different escapement percentage should be adopted. There were a range of opinions on this topic. Most respondents suggested a higher target (ranging from 50% to 100%) noting that many silver eels do not survive migration. One expert commented:

Q5 *"In general, while the eel stock status is as poor as it is the target should be as indicated by WGEEL: all anthropogenic mortality 0. If the signs of recovery via improved recruitment appears the targets should be re-evaluated, and set accordingly to support recovery."*

Other experts commented on the challenges in implementing the existing target:

Q6 *"We haven't seen countries reduce mortality and increase escapement enough to see an effect. The lack of a time scale is also a hindrance. We need a timescale and hard actions to demonstrate compliance with the EU regulation."*

3.2.6. *Restocking conditions*

An additional question on restocking was included in R2 to understand which conditions should be met in order to make restocking better aligned with eel population recovery. Among respondents, there was agreement on most of the hypothetical conditions for restocking with "*restocking should be performed in eel habitats where there is a high probability of escapement*" (88%) and restocking being done from "*donor areas with a demonstrable surplus of arriving glass eels*" (81%) being ranked the highest (Fig. 2). Respondents showed a

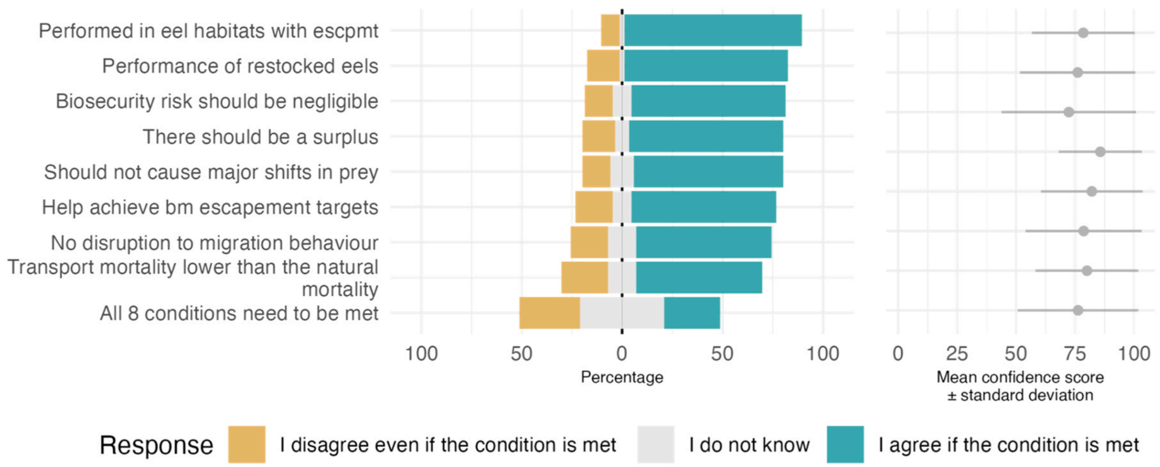

Fig. 2. Left: Responses to the conditions for successful eel restocking in R2 of the Delphi technique. Right: Mean confidence score for each of the conditions. [Full list of labels: S1: For restocking to be acceptable, restocking should be performed in eel habitats where there is a high probability of escapement (i.e. no significant barriers that impede migration, no fishery or hydropower, or polluted areas). S2: For restocking to be acceptable, the performance of restocked eels in terms of survival, growth, navigation and reproductive fitness should be similar to those of naturally recruited eels. S3: For restocking to be acceptable, the biosecurity risk (e.g. spreading of disease and/or parasites) of harvesting and restocking glass eels should be negligible. S4: For restocking to be acceptable, there should be a demonstrable surplus (recruitment above the carrying capacity of the system) of arriving glass eels in the donor areas. (A "surplus" is defined as the proportion of the glass eel population in the donor areas which can be safely harvested without endangering the escapement targets). S5: For restocking to be acceptable, restocking should not cause major shifts in prey abundance and other aquatic biota at both donor and release site. S6: For restocking to be acceptable, restocking should help achieve biomass escapement targets (like the 40 % target of the European eel regulation) in receiving countries without jeopardising escapement in donor countries such as France and Spain. S7: For restocking to be acceptable, the movement of eels from the eel donor basin to the recipient basin should not disrupt their migration behaviour. S8: For restocking to be acceptable, mortality during harvest, transport, quarantine and releasing of glass eels should be lower than the natural mortality which glass eels would have experienced if they were allowed to stay, during the same period, in the waters they were naturally recruited. S9: For restocking to be acceptable, all 8 above mentioned conditions need to be met.].

relatively high degree of consensus on each of the individual conditions for restocking. Disagreement arose, however, on the question of whether or not all eight conditions needed to be met. Only 28% percent of respondents considered meeting all eight conditions essential.

4. Discussion

Our study identified 33 eel conservation and management-related measures through a literature review and identified priority topics for eel conservation based on collective expert knowledge. While numerical data on the European eel stock is regularly collated by the ICES Working Group on Eel (WGEEL) and individual country reports submitted to ICES, this is the first Delphi study to engage with eel experts across the global distribution of the species to prioritise conservation and management measures of this panmictic species. The systematic, stepwise collection of expert knowledge by way of a Delphi approach sheds light on the convergence and divergence of international expert opinions on specific eel conservation and management measures. The results highlight the breadth of views across measures and allow readers to explore these differences in detail (as shown in Table 1).

The experts highlighted the need for a Europe-wide eel recruitment monitoring scheme to improve understanding of the impact of conservation interventions. Existing methods include methods to track the silver eel escapement limits (e.g. the 40% target of silver eel biomass according to the Eel Regulation), management targets for individual rivers, river basins, River Basin Districts, eel management units and nations, and for assessing compliance of current escapement with these limits/targets. Current WGEEL reports note that these methods require various permutations of data on e.g. landings, recruitment length/age structure, abundance (as biomass and/or density) or restocking for estimating silver eel biomass, fishing and other anthropogenic mortality rates. However, there is a lack of standardised, consistent and cost-effective methodological approaches to quantify all life stages of the eel across its range according to the experts in this study. Experts also note that time series data, though present, is fragmented across different countries. Assessment and (recruitment) monitoring of eel populations are therefore considered central to eel management, consistent with the conclusions of Righton et al. (2021).

The other highly ranked topics were addressing the loss of habitat quality and availability. The relative contribution of habitat (quality) loss is harder to pinpoint and to quantify, due to the complexity in measuring mortality for a migrating species and the multiplicity of synergistic effects. Despite documented phenotypic plasticity in habitat use (Arai et al., 2006), the overall loss of eel habitat and degradation of habitat quality is expected to heavily reduce their natural range (Feunteun, 2002; Jacoby et al., 2015). The WGEEL has recommended shifting focus to “eel management units” (EMUs), but confusion persists regarding definitions, which vary from river basin districts (as per the Water Framework Directive) to national or regional management units (e.g., Sweden and Tunisia respectively).

The experts identified that habitat availability issues can be reduced by removing or remediating barriers to fish movement, such as dams, weirs, and road-culverts. This suggestion to reduce barriers to fish movement has also been highlighted in several country reports (UK, Belgium, Sweden, Denmark, The Netherlands, and Lithuania) (WGEEL, 2024). Eels can also be trapped and die in turbines and pumps associated with larger dams. River rehabilitation to restore free flow and habitat connectivity, wetland protection, and reduced contamination loads were considered to be important by the experts in this study. Effective implementation of EU environmental directives could support these efforts. Research indicates that prioritising high-impact habitat restoration sites is critical for conservation and recovery of eels (Degerman et al., 2019). This re-emphasizes the need for long-term, site-specific monitoring of eel abundance and behaviour to identify high-priority river stretches and wetlands. The contribution of hydropower plant mortality to European eel decline was highlighted by the experts in this study and has also been mentioned in the literature (e.g., by Baker et al., 2020; Halvorsen et al., 2020).

The cross-cutting effects of climate change motivated the respondents to broadly agree on a precautionary approach to eel conservation that accounts for synergistic and poorly understood impacts on eel survival. This is in line with the review of Drouineau et al., (2018), who concluded that climate change effects exceed the adaptive capacity of eels. Climate change has also been highlighted in the country reports and ICES reports for the last decade (WGEEL, 2024). A recent study in Turkey by Mestav et al., (2024) identified the potential predictors of future climate change effects on eel distribution patterns (based on catch data from 1967 to 2020). Future eel conservation measures should consider local habitat characteristics and climate variability throughout the entire range of the species (WGEEL, 2024).

Restocking is currently listed as a possible management option beside others in the European eel regulation (EU, 2007). However, restocking of eel is subject to controversy (ICES, 2021). The restocking issue was illustrated by quotes from respondents in this study criticising current restocking practices (e.g., regarding site selection, as restocking sites are not necessarily the sites with the most suitable eel habitat; see also Westin, 2003). Furthermore, translocation of glass eels through restocking programs may negatively impact the abundance of eels in southern Europe where glass eels are caught and could pose biosecurity risks (ICES; 2021; Kullmann et al., 2022; Verhelst et al., 2025). This practice does not necessarily support long-term recovery of the eel stock as a whole (Westin, 2003; ICES, 2021). However, experts in this study seem to have pragmatic opinions about restocking, provided certain conditions are met. The challenge, however, is that the meeting of these conditions can often not be demonstrated, and this uncertainty of the conditions seems to have influenced responses from some of the respondents. One such example is the condition that restocking is acceptable if donor areas have a demonstrable surplus of glass eels. As many as 81% of the respondents have answered that restocking is acceptable if this condition is met. However, at the same time, multiple respondents have responded that the condition is unlikely to be met anywhere where glass eels are caught for restocking purpose, or that it is currently not possible to demonstrate the existence of a surplus.

Another example is the statement that the performance of restocked eels in terms of survival, growth, navigation and reproductive fitness should be similar to those of naturally recruited eels. There was a strong consensus among the respondents that restocking is acceptable if this condition is met, but at the same time multiple respondents pointed out that it is not likely. On the contrary, low survival rates of restocked eels have been documented (Essl et al., 2016; Nzau Matondo et al., 2020; Lyach, 2022). Here, experts were concerned about the conditions in which eels were transported, density of eel prey, juvenile eel recruitment, sex ratios, eel density, and the size and age of eels, issues that have been highlighted by several authors (van Ginneken, Maes, 2005; Bevacqua et al., 2015; Bernotas et al., 2020; Teichert et al., 2020). Overall, the responses indicate that restocking is considered acceptable if, and only if, certain conditions are met. Whether or not these conditions are met in practice, or if they can be demonstrated to be met, was beyond the scope of the current Delphi survey.

5. Limitations of the study

The study has some caveats. Firstly, there might be gaps in our study due to our focus on the English language and peer-reviewed publications (Haddaway and Bayliss, 2015). We might have inadvertently missed out on valuable information published in the grey literature (non-peer reviewed literature such as reports and the authors therein) or in languages other than English. Secondly, information on gender was not collected in either round of the Delphi technique. Thirdly, we did not explicitly have representatives from outside academia. The lack of representation from other groups (e.g. the fishing industry or eel consumers) is a limitation of this study. However, this was beyond the scope of the study and widening the expert pool might have introduced potential conflicts of interest. We did not differentiate between experts who had worked on coastal sites versus those who have worked on mountain and upland sites. Perhaps this can be explored in a subsequent study.

6. Conclusion

The findings of this study includes a broad consensus among experts regarding the priorities for European eel conservation. Most respondents emphasized similar management actions, such as the removal of migratory barriers, river and wetland habitat restoration, climate change mitigation efforts and standardized monitoring and assessment efforts. Given the critically endangered status of the eel, further attention needs to be paid to fishery closures for certain durations where possible, stricter restrictions on pollutants causing eel decline and improved implementation of escapement targets, including consideration of higher thresholds for silver eels where relevant. These priorities closely align with previous research and expert assessments (e.g., Dekker and Beaulaton, 2016; Froehlicher et al., 2023), reinforcing their relevance and urgency. The convergence of expert opinion across different regions suggests a clear direction for future conservation strategies. We hope that the insights provided by this study will serve as a valuable resource for policymakers and managers involved in developing and implementing eel management plans across EU member states. There is an urgent need for enhanced international cooperation. Joint efforts—including the establishment of a standardized monitoring framework, coordinated habitat restoration initiatives, removal of physical and ecological barriers to migration, and the integration of climate adaptation strategies—are essential to ensure the survival and recovery of this ecologically and culturally important species.

Contribution statement

NM and JH designed the research and conducted the Delphi technique and literature review. AC, HS, MS, AM, JWG helped with the literature screening, designing the questions and analysis. NM and JH wrote the draft manuscript. SW, SJH and PV provided extensive comments on the draft. All authors contributed to the Delphi survey and reviewing and editing of the manuscript.

CRediT authorship contribution statement

NM and JH designed the research and conducted the Delphi technique and literature review. AC, HS, MS, AM, JWG helped with the literature screening, designing the questions and analysis. NM and JH wrote the draft manuscript. SW, SJH and PV provided extensive comments on the draft. All authors contributed to the Delphi survey and reviewing and editing of the manuscript.

Ethics statement

Ethics clearance from Brunel University London (40109-MHR-Oct/2022–41843-1).

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Declaration of Competing Interest

The authors declare no conflict of interest. We have nothing to declare.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.gecco.2026.e04257.

Data availability

Data will be made available on request.

References

Als, T.D., Hansen, M.M., Maes, G.E., Castonguay, M., Riemann, L., Aarestrup, K., Munk, P., Sparholt, H., Hanel, R., Bernatchez, L., 2011. "All Roads Lead to Home: Panmixia of European Eel in the Sargasso Sea. Mol. Ecol. 20 (7), 1333–1346. https://doi.org/10.1111/j.1365-294X.2011.05011.x.

Arai, T., Kotake, A., McCarthy, T.K., 2006. "Habitat Use by the European Eel *Anguilla anguilla* in Irish Waters. Estuar. Coast. Shelf Sci. 67 (4), 569–578. https://doi.org/10.1016/j.ecss.2006.01.001.

Baker, N.J., Boubee, J., Lokman, P.M., Bolland, J.D., 2020. "Evaluating the Impact of Hydropower on Downstream Migrating Anguillid Eels: Catchment-Wide and Fine-Scale Approaches to Identify Cost-Effective Solutions. Sci. Total Environ. 748, 141111. https://doi.org/10.1016/j.scitotenv.2020.141111.

Bernotas, Priit, Öğlü, Burak, Nõges, Peeter, 2020. "How Do Environmental Factors Affect the Yield of European Eel (*Anguilla anguilla*) in a Restocked Population?". Fish. Res. 230. https://doi.org/10.1016/j.fishres.2020.105649.

Bevacqua, D., Melia, P., Gatto, M., De Leo, G.A., 2015. "A Global Viability Assessment of the European Eel. Glob. Change Biol. 21 (9), 3323–3335. https://doi.org/10.1111/gcb.12972.

Bramer, W.M., Giustini, D., de Jonge, G.B., Holland, L., Bekhuis, T., 2016. "De-Duplication of Database Search Results for Systematic Reviews in Endnote. J. Med. Libr. Assoc. 104 (3), 240–243. https://doi.org/10.5195/jmla.2016.24.

Cairns, D.K., Benchetrit, J., Bernatchez, L., Bornarel, V., Casselman, J.M., Castonguay, M., Charsley, A.R., Dorow, M., Drouineau, H., Frankowski, J., Haro, A., Hoyle, S.D., Knickle, D.C., Koops, M.A., Poirier, L.A., Thorson, J.T., Young, J., Zhu, X., 2022. "Thirteen Novel Ideas and under-Utilized Resources to Support Progress toward a Range-Wide American Eel Stock Assessment. Fish. Manag. Ecol. 29, 516–541. ⟨https://pubs.usgs.gov/publication/70232200⟩.

2015. S.CataudellaD.CrosettiF.Massa"Mediterranean coastal lagoons: sustainable management and interactions among aquaculture, capture fisheries and the environment Studies and Reviews"S.CataudellaD.CrosettiF.MassaGeneral Fisheries Commission for the Mediterranean95FAORome278No.

Charsley, Anthony R., Grüss, Arnaud, Thorson, James T., Rudd, Merrill B., Crow, Shannan K., David, Bruno, Williams, Erica K., Hoyle, Simon D., 2023. "Catchment-Scale Stream Network Spatio-Temporal Models, Applied to the Freshwater Stages of a Diadromous Fish Species, Longfin Eel (*Anguilla dieffenbachii*). Fish. Res. 259. https://doi.org/10.1016/j.fishres.2022.106583.

De Grossi Mazzorin, J., 2000. "État De Nos Connaissances Concernant Le Traitement Et La Consommation Du Poisson Dans L'antiquité à La Lumière De L'archéologie.". MéLanges De. l'École Française De. Rome Antiq. é (MEFRA) 112, 155–167. ⟨https://www.persee.fr/doc/mefr_0223-5102_2000_num_112_1_2120⟩.

Degerman, Erik, Tamario, Carl, Watz, Johan, Nilsson, P.Anders, Calles, Olle, 2019. "Occurrence and Habitat Use of European Eel (*Anguilla anguilla*) in Running Waters: Lessons for Improved Monitoring, Habitat Restoration and Stocking. Aquat. Ecol. 53 (4), 639–650. https://doi.org/10.1007/s10452-019-09714-3.

Dekker, Willem, 2003. "On the Distribution of the European Eel (*Anguilla anguilla*) and Its Fisheries. Can. J. Fish. Aquat. Sci. 60 (7), 787–799. https://doi.org/10.1139/f03-066.

Dekker, Willem, 2019. "The history of commercial fisheries for European eel commenced only a century ago. Fish. Manag. Ecol. 26 (1), 6–19. https://doi.org/10.1111/fme.12302.

Dekker, Willem, Beaulaton, Laurent, 2016. "Climbing Back up What Slippery Slope? Dynamics of the European Eel Stock and Its Management in Historical Perspective. ICES J. Mar. Sci. 73 (1), 5–13. https://doi.org/10.1093/icesjms/fsv132.

Donfrancesco, Valerio, Ciucci, Paolo, Salvatori, Valeria, Benson, David, Andersen, Liselotte Wesley, Bassi, Elena, Blanco, Juan Carlos, Boitani, Luigi, Caniglia, Romolo, Canu, Antonio, Capitani, Claudia, Chapron, Guillaume, Czarnomska, Sylwia D., Fabbri, Elena, Galaverni, Marco, Galov, Ana, Gimenez, Olivier, Godinho, Raquel, Greco, Claudia, Hindrikson, Maris, Huber, Djuro, Hulva, Pavel, Jedrzejewski, W.łodzimierz, Kusak, Josip, Linnell, John D.C., Llaneza, Luis, López-Bao, José Vicente, Männil, Peep, Marucco, Francesca, Mattioli, Luca, Milanesi, Pietro, Milleret, Cyril, Mysłajek, Robert W., Ordiz, Andres, Palacios, Vicente, Pedersen, Hans Christian, Pertoldi, Cino, Pilot, Malgorzata, Randi, Ettore, Rodríguez, Alejandro, Saarma, Urmas, Sand, Håkan, Scandura, Massimo, Stronen, Astrid Vik, Tsingarska, Elena, Mukherjee, Nibedita, 2019. "Unravelling the Scientific Debate on How to Address Wolf-Dog Hybridization in Europe. Front. Ecol. Evol. 7. https://doi.org/10.3389/fevo.2019.00175.

Drouineau, Hilaire, Durif, Caroline, Castonguay, Martin, Mateo, Maria, Rochard, Eric, Verreault, Guy, Yokouchi, Kazuki, Lambert, Patrick, 2018. "Freshwater Eels: A Symbol of the Effects of Global Change. Fish Fish 19 (5), 903–930. https://doi.org/10.1111/faf.12300.

Essl, Katharina, Gassner, Hubert, Schabetsberger, Robert, Jagsch, Albert, Kaiser, Roland, 2016. "The development of stocked eels (*Anguilla anguilla*) in previously eel-free Austrian Alpine lakes. Ecol. Freshw. Fish. 25 (1), 17–26. https://doi.org/10.1111/eff.12179.

EU, 2007. "Council of the European Union. "Council Regulation (EC) No 1100/2007 of 18 September 2007 establishing measures for the recovery of the stock of European eel.". Off. J. Eur. Union 248, 17–23.

Feunteun, Eric, 2002. "Management and Restoration of European Eel Population (*Anguilla anguilla*): An Impossible Bargain. Ecol. Eng. 18 (5), 575–591. https://doi.org/10.1016/s0925-8574(02)00021-6.

Froehlicher, H., Kaifu, K., Rambonilaza, T., Daverat, F., 2023. "Eel Translocation from a Conservation Perspective: A Coupled Systematic and Narrative Review. Glob. Ecol. Conserv. 46, e02635. https://doi.org/10.1016/j.gecco.2023.e02635.

Ganias, Kostas, Mezarli, Charikleia, Voultsiadou, Eleni, 2017. "Aristotle as an Ichthyologist: Exploring Aegean Fish Diversity 2,400 years Ago. Fish Fish 18 (6), 1038–1055. https://doi.org/10.1111/faf.12223.

van Ginneken, Vincent J.T., Maes, Gregory E., 2005. "The European Eel (*Anguilla anguilla*, Linnaeus), Its Lifecycle, Evolution and Reproduction: A Literature Review. Rev. Fish. Biol. Fish. 15 (4), 367–398. https://doi.org/10.1007/s11160-006-0005-8.

Haddaway, N.R., Bayliss, H.R., 2015. "Shades of Grey: Two Forms of Grey Literature Important for Reviews in Conservation. Biol. Conserv. 191, 827–829. ⟨https://www.sciencedirect.com/science/article/abs/pii/S0006320715300689⟩.

Halvorsen, Silje, Korslund, Lars, Gustavsen, Per Ø., Slettan, Audun, 2020. "Environmental DNA Analysis Indicates That Migration Barriers Are Decreasing the Occurrence of European Eel (*Anguilla anguilla*) in Distance from the Sea. Glob. Ecol. Conserv. 24. https://doi.org/10.1016/j.gecco.2020.e01245.

Hanel, R., Briand, C., Diaz, E., Döring, R., Sapounidis, A., Warmerdam, W., Andrés, M., Freese, M., Marcelis, A., Marohn, L., Pohlmann, J.D., van Scharrenburg, M., Waidmann, N., Walstra, J., Werkman, M., de Wilde, J., Wysujack, K., 2019. Research for Pech Committee – Environmental, Social and Economic Sustainability of European Eel Management. Policy Department for Structural and Cohesion Policies. European Parliament, Brussels.

ICES. Joint Eifaac/Ices/Gfcm Working Group on Eels (Wgeel), and Country Reports 2020–2021. ICES Scientific Reports, 2021.

ICES, 2023. Work. Group Eur. Eel (Wgeel Outputs 2022 Meet.).

ICES, 2024. Work. Group Eur. Eel (Wgeel Outputs 2022 Meet.).

Jacoby, David M.P., Casselman, John M., Crook, Vicki, DeLucia, Mari-Beth, Ahn, Hyojin, Kaifu, Kenzo, Kurwie, Tagried, Sasal, Pierre, Silfvergrip, Anders M.C., Smith, Kevin G., Uchida, Kazuo, Walker, Alan M., Gollock, Matthew J., 2015. "Synergistic Patterns of Threat and the Challenges Facing Global Anguillid Eel Conservation. Glob. Ecol. Conserv. 4, 321–333. https://doi.org/10.1016/j.gecco.2015.07.009.

Kettle, A.J., Heinrich, D., Barrett, J.H., Benecke, N., Locker, A., 2008. "Past Distributions of the European Freshwater Eel from Archaeological and Palaeontological Evidence. Quat. Sci. Rev. 27 (13-14), 1309–1334. https://doi.org/10.1016/j.quascirev.2008.03.005.

Koops, H., Hartmann, F., 1989. "Anguillicola-Infestations in Germany and in German Eel Imports. J. Appl. Ichthyol. 5 (1), 41–45. https://doi.org/10.1111/j.1439-0426.1989.tb00568.x.

Kullmann, L., Adamek, M., Steinhagen, D., Thiel, R., 2022. "Glass Eels and Viruses - a Lesson Learnt from Stocking the Eastern German Baltic Sea Coast. Transbound. Emerg. Dis. https://doi.org/10.1111/tbed.14765.

Lyach, Roman, 2022. "The Effect of Fishery Management on the Yield of the Critically Endangered European Eel *Anguilla anguilla* in Mesotrophic Rivers and Streams in Central Europe. Fishes 7 (1). https://doi.org/10.3390/fishes7010042.

Mestav, Burcu, Özdilek, Şükran Yalçın, Acar, Zahide, Gökkaya, Kemal, Partal, Nurbanu, 2024. "Climate change effects on abundance and distribution of the European eel in Türkiye. Fish. Manag. Ecol. 31 (6), e12732.

Mukherjee, Nibedita, Hugé, Jean, Sutherland, William J., McNeill, Jeffrey, Van Opstal, Maarten, Dahdouh-Guebas, Farid, Koedam, Nico, 2015. "The Delphi Technique in Ecology and Biological Conservation: Applications and Guidelines. Methods Ecol. Evol. 6 (9), 1097–1109. https://doi.org/10.1111/2041-210x.12387.

Mukherjee, Nibedita, Zabala, Aiora, Huge, Jean, Nyumba, Tobias Ochieng, Adem Esmail, Blal, Sutherland, William J., 2018. "Comparison of Techniques for Eliciting Views and Judgements in Decision-Making. Methods Ecol. Evol. 9 (1), 54–63. https://doi.org/10.1111/2041-210x.12940.

Nielsen, T., Prouzet, P., 2008. "Capture-Based Aquaculture of the Wild European Eel (*Anguilla anguilla*)." (Edited by). In: Lovatelli, A., Holthus., P.F. (Eds.), Capture-Based Aquaculture. Global Overview. FAO, Rome.

Nzau Matondo, Billy, Benitez, Jean-Philippe, Dierckx, Arnaud, Rollin, Xavier, Ovidio, Michaël, 2020. "An Evaluation of Restocking Practice and Demographic Stock Assessment Methods for Cryptic Juvenile European Eel in Upland Rivers. Sustainability 12 (3). https://doi.org/10.3390/su12031124.

Ouzzani, M., Hammady, H., Fedorowicz, Z., Elmagarmid, A., 2016. "Rayyan- a Web and Mobile App for Systematic Reviews. Syst. Rev. 5 (1), 210. https://doi.org/10.1186/s13643-016-0384-4.

Pike, C., Crook, V., Gollock, M., Beaulaton, L., Belpaire, C., Dekker, W., Díaz, E., Durif, C.M., Hanel, R., 2020. Anguilla anguilla. IUCN Red. List Threat. Species 2020.

Podda, Cinzia, Sabatini, Andrea, Palmas, Francesco, Pusceddu, Antonio, 2021. "Hard Times for Catadromous Fish: The Case of the European Eel (*Anguilla anguilla*, L. 1758). Adv. Oceanogr. Limnol. 12 (2). https://doi.org/10.4081/aiol.2021.9997.

Righton, D., Verhelst, P., Westerberg, H., 2025. "The Blueprint of the European Eel Life Cycle: Does Life-History Strategy Undermine or Provide Hope for Population Recovery?". Fish. & Fish. 0, 1–15.

Righton, David, Piper, Adam, Aarestrup, Kim, Amilhat, Elsa, Belpaire, Claude, Casselman, John, Castonguay, Martin, Díaz, Estibaliz, Dörner, Hendrik, Faliex, Elisabeth, Feunteun, Eric, Fukuda, Nobuto, Hanel, Reinhold, Hanzen, Celine, Jellyman, Don, Kaifu, Kenzo, McCarthy, Kieran, Miller, Michael J., Pratt, Thomas, Sasal, Pierre, Schabetsberger, Robert, Shiraishi, Hiromi, Simon, Gaël, Sjöberg, Niklas, Steele, Kristen, Tsukamoto, Katsumi, Walker, Alan, Westerberg, Håkan, Yokouchi, Kazuki, Gollock, Matthew, 2021. "Important Questions to Progress Science and Sustainable Management of Anguillid Eels. Fish Fish 22 (4), 762–788. https://doi.org/10.1111/faf.12549.

Robson, Harry, Soren, H.Andersen, Craig, Oliver, Ritchie, Kenneth, 2013. "Eel Fishing in the Late Mesolithic and the Early Neolithic: A Preliminary Report from the Stratified Kitchen Midden at Havnø, Denmark.". Archaeofauna 22 22, 167–178. https://doi.org/10.15366/archaeofauna2013.22.013.

Sørensen, Sune Riis, Tomkiewicz, Jonna, Munk, Peter, Butts, Ian A.E., Nielsen, Anders, Lauesen, Peter, Graver, Christian, 2016. "Ontogeny and Growth of Early Life Stages of Captive-Bred European Eel. Aquaculture 456, 50–61. https://doi.org/10.1016/j.aquaculture.2016.01.015.

Team, R. Core, 2024. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria.

Teichert, N., Tetard, S., Trancart, T., de Oliveira, E., Acou, A., Carpentier, A., Bourillon, B., Feunteun, E., 2020. "Towards Transferability in Fish Migration Models: A Generic Operational Tool for Predicting Silver Eel Migration in Rivers. Sci. Total Environ. 739, 140069. https://doi.org/10.1016/j.scitotenv.2020.140069.

Tzeng, W.N., Wang, C.H., Wickström, H., Reizenstein, M., 2000. "Occurrence of the Semi-Catadromous European Eel *Anguilla anguilla* in the Baltic Sea. Mar. Biol. 137 (1), 93–98. https://doi.org/10.1007/s002270000330.

Van Neer, Wim, Lentacker, An, 1994. "New Archaeozoological Evidence for the Consumption of Locally-Produced Fish Sauce in the Northern Provinces of the Roman Empire." (no.). Archaeofauna 3 3, 53–62. https://doi.org/10.15366/archaeofauna1994.3.004.

Verhelst, Pieterjan, Hellmann, John, Stein, Florian M., 2025. "How to Deal with Confiscated European Eels (*Anguilla anguilla* L.) Destined for Reintroduction?". Fish. Res. 284. https://doi.org/10.1016/j.fishres.2025.107309.

Westin, L., 2003. "Migration Failure in Stocked Eels *Anguilla anguilla*. Mar. Ecol. Prog. Ser. 254, 307–311. https://doi.org/10.3354/meps254307.