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**CONSERVATION MANAGEMENT
SPECIES CASE STUDY:**

European eel (*Anguilla anguilla*)

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INTRODUCTION

The European eel (*Anguilla anguilla*) is an enigmatic and critically endangered species (Pike *et al* 2020) that has fascinated people for hundreds of years, although these days its attention is mainly sought by researchers and conservationists. It is known for its extraordinary life cycle, which includes a remarkable long-distance migration between its spawning grounds in the Sargasso Sea and freshwater or coastal environments across Europe and North Africa (Wright *et al.* 2022.) Despite its biological importance and historical abundance, the species has been classified as 'Critically Endangered' by the International Union for Conservation of Nature (IUCN) due to a dramatic population decline over the last few decades. The eel faces a complex array of threats, from habitat loss to illegal smuggling and climate change. Understanding these issues and the conservation efforts underway is crucial for its recovery.

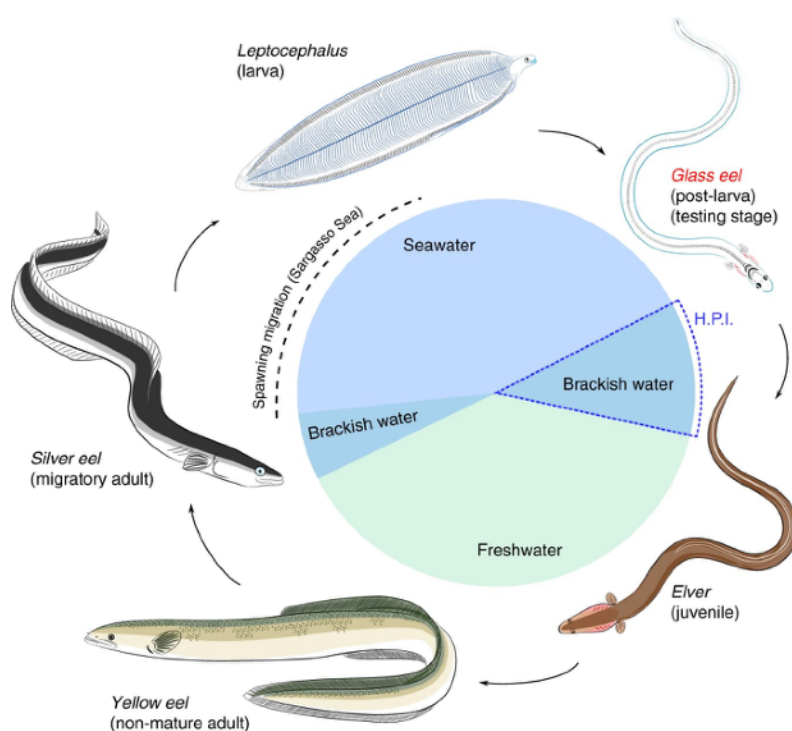


Species lifecycle

The life cycle of the European eel is remarkable: it is a catadromous fish and is one of 16 species of the genus *Anguilla*.

Fertilised pelagic eggs begin life in the Sargasso Sea and drift on oceanic currents towards the European continent for between 7 months and 3 years, first hatching into tiny leptocephalus larvae which subsequently metamorphose into transparent 'glass' eels (Cresci *et al.*, 2019). As they reach coastal areas, they use tides to carry themselves upstream into estuaries where they acclimatise to a freshwater habitat. The freshwater initiates pigmentation and the glass eels become recognisable as small versions of the adults, called 'elvers'. At around 8cm these young eels migrate further upstream looking for a suitable habitat to grow and thrive in. The freshwater stage of the eel, known as the 'yellow eel', is the longest period of an eel's life and ranges from 6-20 years dependent on sex, resources and temperature. Upon reaching a larger size, and with adequate fat stores, the yellow eel transforms once again for the final stage.

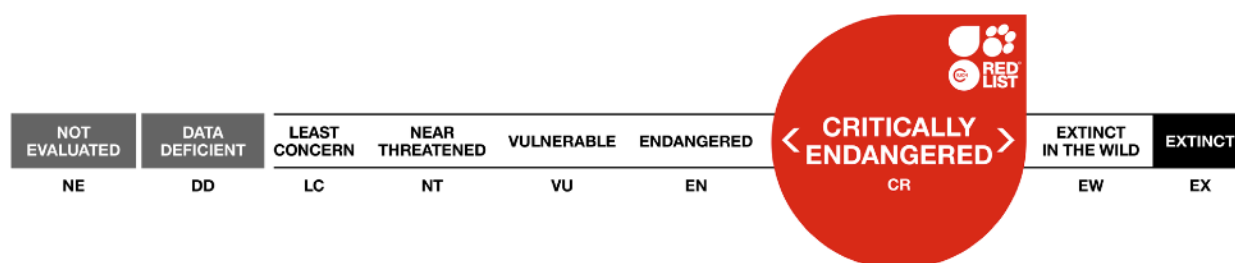
This final stage is known as the 'silver eel'. This impressive metamorphosis sees it change colour again, its pectoral fins widen, digestive tract shuts down, its eyes grow up to 10 times their original size and muscle mass increases as it sexually matures. All these changes aid the eel on its journey back to the Sargasso Sea to start the cycle again.



Artwork credit A. Cresci.

Conservation status

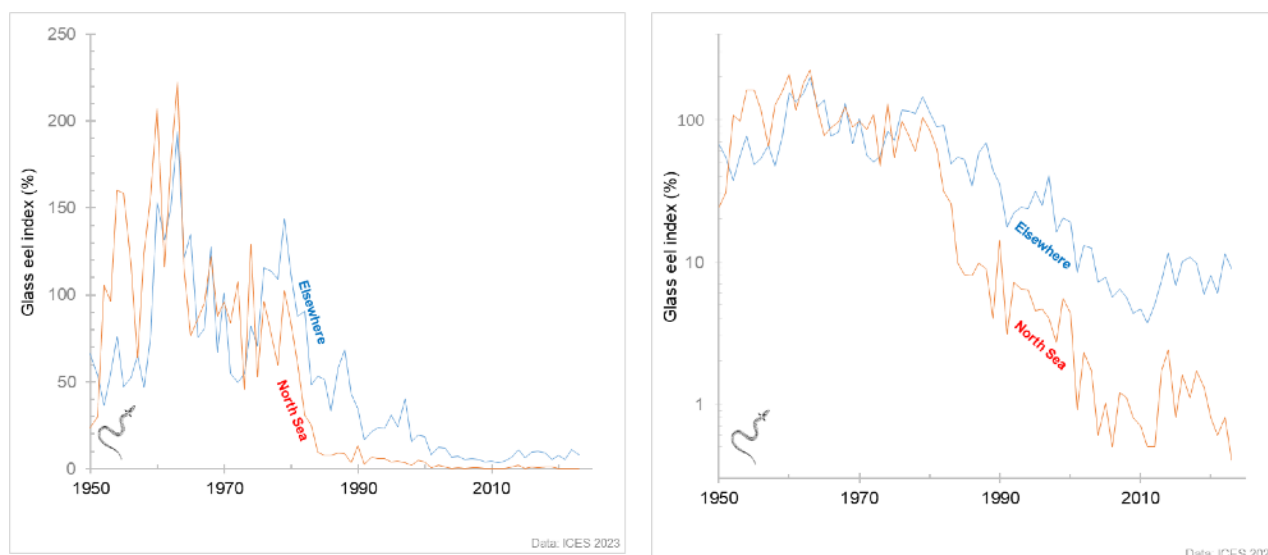
The European eel's decline has been so severe that its population is estimated to have decreased by more than 90% since the 1970s (Verhelst *et al.*, 2018). Once a common sight across Europe's rivers, estuaries, and coastal waters, the species is severely depleted. The European eel is listed under Appendix II of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) (Fleming *et al.*, 2023), indicating that international trade must be controlled to avoid further endangerment. concerted conservation actions.



Its presence in the IUCN Red List as 'Critically Endangered' reflects the urgent need for intervention.

The decline of the European eel

Eel numbers are at a historical low, after a decline of many decades (if not centuries). Stock abundance and fishing yield have declined gradually since at least the mid-1900s, and the recruitment of young eels from the ocean declined rapidly from 1980 until 2010. If nothing changes then extinction could occur. In 2007 however, the EU adopted the 'Eel Regulation', setting a framework for protection across Europe, to recover the stock to its historic level of abundance (Dekker, 2018).



(i) Linear scale

(ii) Logarithmic scale

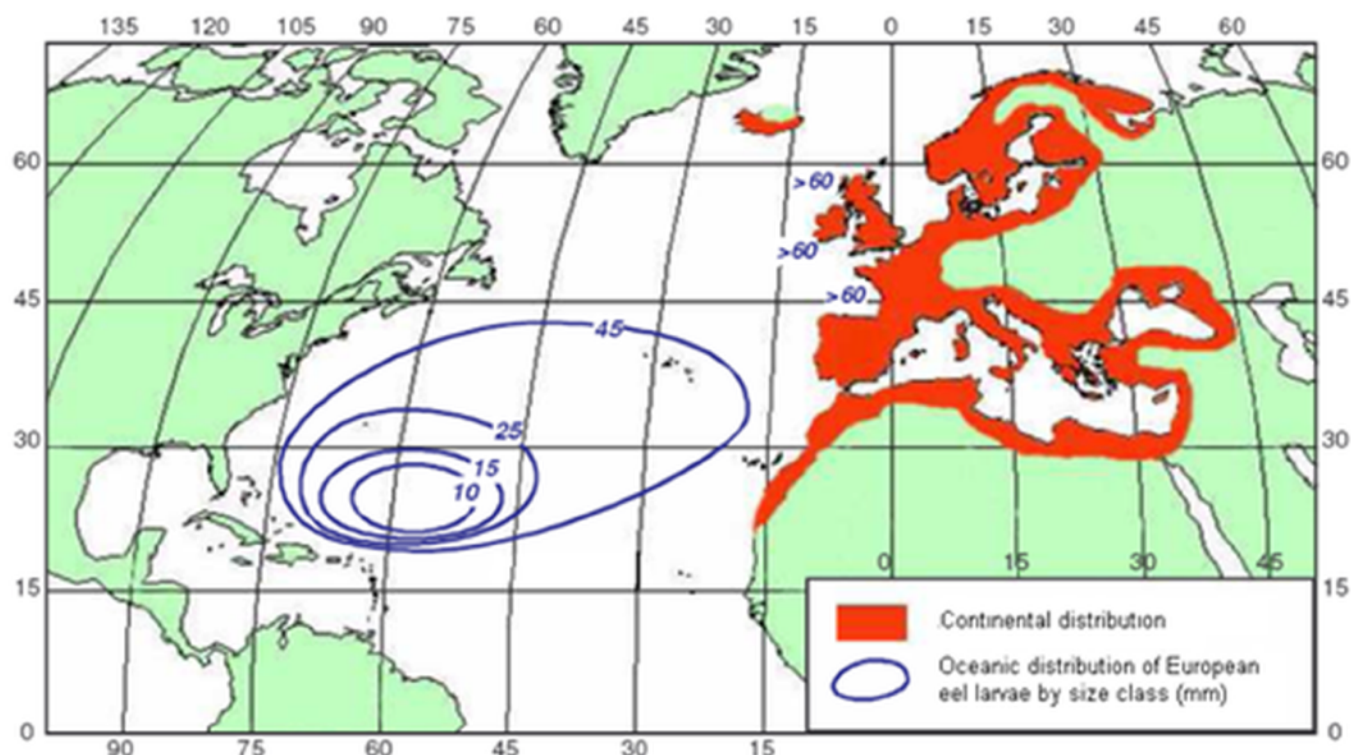
a) Recruitment as Glass Eel Index (ICES data, 2023)

Global distribution & habitat

The European eel surely has one of the greatest ranges of any fish. A critical part of its life cycle is to undertake a lengthy migration, an active swim of 5,000–10,000 km across the Atlantic to spawn in the Sargasso (Wright *et al.*, 2022b), and then a return journey swept as plankton by the Gulf stream. Not only do they have the ability to live in both sea and freshwater (catadromous), they also have the remarkable ability to breathe through their skin, allowing them to overcome barriers and small obstacles such as waterfalls by moving out of the water and slithering over land throughout their lives in search of diverse watery habitats. As they spend the majority of their life in freshwater or brackish water systems this adaptation increases their reach throughout the European river system from estuaries and large rivers, into small streams, lakes, ponds and ditches spanning an impressive continental area.

Consequently, their natural distribution ranges from northern Europe, including Iceland and Scandinavia and coastal areas surrounding the Baltic Sea, to much of mainland Europe, the entire Mediterranean and Black Sea coastal regions, and even North African coastlines as far down as Morocco the Western Sahara. (OSPAR, 2022)

Distribution area for *A. anguilla*, adapted from Adam (1997)



Identification

The European eel is characterised by its long, snake-like body, which can grow up to 1.5 meters. It has a serpent-like head, with a rounded snout and wide protruding eyes, its body is very long and narrow and its dorsal, caudal and anal fins form a continuous ribbon around the tail. Their colour varies dramatically. Generally adult European eels are brown or olive green, while the belly is typically pale - although migratory mature adults become silver. The European eel has no scales and has a protective covering of mucus.

Similar species

One of the species it may be confused with is the related American eel (*Anguilla rostrata*), which has a very similar appearance but is found primarily in North America. DNA analysis is the best tool to distinguish between the European Eel and other species. *Anguilla rostrata* (originally thought to be the same species due to similarities in appearance and behaviour) differ in chromosome count and various molecular

markers. The common way to distinguish species is the number of vertebrae: *A. anguilla* having between 111 - 119 (usually 114 - 116) vs *A. rostrata* counting 102 - 112 (usually 106 - 108) (Pike *et al.*, 2018.)

ECOLOGY

Feeding

The European eel is carnivorous, feeding on a diet that varies with age and habitat. Juveniles primarily consume invertebrates such as insects and small crustaceans, while adult eels target larger prey including fish, molluscs, and amphibians. Adult eels are both predators and scavengers, feeding on dead animals, fish eggs, invertebrates and other fish. Eels are known to be opportunistic feeders, making them versatile in different ecological niches, and great recyclers!

Glass eels enter freshwater as sexually undifferentiated individuals. Development and differentiation of the sexual organs are thought to be closely correlated with body size and associated with the yellowing phase of the life history. Sex determination is principally driven by environmental factors with density- dependence producing more males at high densities (Davey and Jellyman, 2005.)

Behaviour & ecological interaction

European eels exhibit a range of fascinating behaviours. Their nocturnal habits help them avoid predators, and their ability to breathe through their skin allows them to survive out of water for extended periods (Moigne *et al.*, 1986), and move between water bodies over land. During their migration, eels display an extraordinary navigation ability, possibly using ocean currents, magnetic fields, and chemical cues to find their way.

They are integral to aquatic ecosystems, serving as both predator and prey. They play a role in controlling populations of smaller fish and invertebrates, while themselves providing food for larger predators such as otters, herons, and large fish. Their decline has led to disruptions in these ecological relationships.

Threats

The European eel faces numerous threats that have contributed to its sharp population decline:

1. **Barriers to migration:** Hydroelectric dams, weirs, and other obstructions have fragmented eel habitats, preventing them from completing their migratory cycle. Without access to the Sargasso, eel populations cannot sustain themselves. (Belletti *et al.*, 2020)
2. **Overfishing:** Eels are harvested at various life stages, particularly as glass eels, which have been exported to Asia for growing into adult eels to be farmed and eaten. Historic unsustainable fishing pressure has had an impact, , especially in countries like Portugal, Spain, France, and the UK (ICES, 2023). There has been a thriving black market trade in glass eels (now reducing) and smuggling them internationally is worth millions of pounds annually.
3. **Pollution:** Eels accumulate pollutants like heavy metals and PCBs (polychlorinated biphenyls) in their tissues, which can affect their growth, reproduction, and immune systems. These pollutants also accumulate in their fat reserves, which they rely on during migration. (Martínez-Gómez *et al.*, 2023)
4. **Parasites:** The invasive parasite *Anguillicoloides crassus*, introduced from Asia, infects the swim bladders of eels, impairing their ability to migrate and reducing their chances of survival during the transatlantic journey (Dzido *et al.*, 2020.)
5. **Climate Change:** Rising sea temperatures and changing ocean currents may affect the migration patterns of eels and reduce the success rate of larvae reaching European coasts from the Sargasso Sea. It may also affect the food webs on which the planktonic eels feed and grow whilst transported by the Gulf Stream.

6. **Habitat Loss:** Loss of, and damage to, freshwater habitats greatly reduces Eel's ability to mature and successfully reproduce.

CONSERVATION EFFORTS

Given the complexity of the threats, multi-faceted conservation efforts are necessary to save the European eel from extinction. Several projects and collaborations are underway across Europe, with the aim of reversing the eel's decline.

European Eel Recovery Plan

In response to the drastic population decline, the European Union introduced the European Eel Recovery Plan (EERP) in 2007 (THE COUNCIL OF THE EUROPEAN UNION, 2007). The plan requires all EU member states to develop and implement national eel management plans. These plans include measures to reduce eel fishing, improve habitat quality, and facilitate eel migration by constructing fish passes around barriers like dams and weirs. Furthermore, the EERP mandates the release of a portion of caught eels back into the wild to support population recovery. Annex B of the Wildlife Trade Regulations which implement CITES in the UK, means 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.

Sustainable Eel Group (SEG)

The Sustainable Eel Group (SEG) is a key player in European eel conservation, working to promote sustainable practices across industries that interact with eels. SEG has developed the 'SEG Standard', a certification scheme for responsible eel fishing and

trade (Sustainable Eel Group, 2023). The group also works with fishery managers, eel farmers, and retailers to ensure that eel harvesting and sales are traceable and legal. SEG has also been involved in campaigns to raise awareness of the eel's plight among consumers and the wider public.

Collaboration with NGOs & research institutions

Conservation efforts for the European eel have involved collaborations between governments, NGOs, research institutions, and local communities (BIOMAR 'Initiatives for the preservation of European eel', 2024.) Citizen science projects, university researchers, charities and volunteers have come together combining efforts tagging and tracking eels using satellite and radio telemetry, scientists are gathering critical data on their movements and behaviours, which inform conservation strategies.

Education

Small regional projects like "Eels in the Classroom" run by various groups engage school children and communities in conservation activities, such as monitoring eel populations and releasing juvenile eels into rivers. These education programs have fostered a sense of stewardship and awareness among younger generations. For example: <https://www.cnn.com/world/video/eels-somerset-uk-school-children-c2e-spc>

Habitat restoration

Restoring appropriate habitats is a cornerstone of many conservation projects. In several European countries, efforts are underway to remove or modify barriers to migration. Fish passes and eel ladders are being installed at dams, weirs, and other

obstructions to allow eels to migrate more easily between freshwater and marine environments. In Denmark, for example, eel passes have been installed in many rivers, which has led to significant increases in eel numbers upstream. Many freshwater habitats are being 're-wilded' or improved, to increase biodiversity, including for eels.

Population monitoring, assistance & stocking

Across Europe, programmes for "trap and transport" (downriver transport of silver eels), and "assisted migration" (upriver transport of elvers), are in place to provide eels with access to habitat that has been lost through the construction of migratory barriers. Many European countries have implemented stocking programmes, releasing glass eels into rivers and lakes where eel populations have declined. This method has proven successful in increasing eel numbers in the short term, though long-term results depend on continued improvements in habitat and migration routes. In the Netherlands, for example, stocking programs have contributed to stabilising eel populations in some areas.

FUTURE PROSPECTS

Ongoing challenges

Despite the significant conservation efforts underway, the European eel's future remains uncertain. Attitudes seem hopeful given the efforts by many bodies and the protective legislation in place, but effective implementation is still needed. Pressure on illegal traffickers must be maintained, as must continued work to improve eel passage at the 1 million+ barriers to migration across Europe and more of the commercial sector should be encouraged to embrace fishing and trading responsibly in line with recommended guidelines.

Climate change remains an unpredictable and growing threat, with warming oceans and changing currents potentially disrupting the eel's migration routes and breeding success.

What still needs to be done

1. **Stronger Enforcement of Regulations:** Ensuring that international agreements such as CITES are fully enforced is crucial to combating illegal eel trade. Strengthening monitoring and reporting mechanisms in the eel fishing industry is also essential.
2. **Research on Climate Change Impacts:** More research is needed to understand how climate change is affecting eel migration and breeding success. Adaptive management strategies will be critical in addressing these challenges as new data emerges.
3. **Restoration of Wetlands and River Systems:** Wetland and river restoration projects should be expanded to enhance the availability of suitable habitats for eels. Removing or modifying barriers to migration, such as dams, remains a priority.
4. **Public Awareness and Education:** Increasing public awareness about the European eel's plight is essential to ensuring long-term conservation success. Engaging communities, schools, and stakeholders in eel conservation will help foster a culture of stewardship and accountability.

Conclusion

The European eel is a species of great ecological, cultural, and economic importance. However, its dramatic decline has raised alarm bells among conservationists. The combination of barriers to migration, overfishing, pollution, parasites, and climate change has created a perfect storm of threats to this species. While significant progress has been made through conservation efforts like the European Eel Recovery Plan, Sustainable Eel Group initiatives, and habitat restoration projects, the long-term survival of the European eel still hangs in the balance.

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