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Synergistic patterns of threat and the challenges facing global anguillid eel conservation

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HIGHLIGHTS

- The first global review of anguillid population data and conservation status.
- Eel population data currently fall short of required length and geographic range.
- Multiple, synergistic, yet variable threats face eels across all life-history stages.
- Key recommendations made for input into international eel conservation strategies.

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ABSTRACT

With broad distributions, diadromous fishes can be exposed to multiple threats at different stages of development. For the primarily catadromous eels of the family Anguillidae, there is growing international concern for the population abundance and escapement trends of some of these species and yet incomplete knowledge of their remarkable life-histories hampers management and conservation. Anguillids experience a suite of pressures that include habitat loss/modification, migration barriers, pollution, parasitism, exploitation, and

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fluctuating oceanic conditions that likely have synergistic and regionally variable impacts, even within species. In beginning to redress this rather fragmented picture, we evaluated the extinction risk of these species using the IUCN Red List of Threatened Species Categories and Criteria to infer population-wide trends from catch and monitoring data. Here we consolidate and build upon these species assessments by presenting an overview of the current state of global eel data and conservation, categorising the knowledge gaps and geographic regions where resources are needed and discussing future recommendations to improve our understanding of anguillids. We find stark disparity between the quality and length of data available to assess population trends and conservation priorities in temperate and tropical anguillids. Of the 13 species assessed, four were listed as 'Threatened' (Vulnerable, Endangered or Critically Endangered); four were Near Threatened, three were Data Deficient and two were deemed Least Concern. Comparing with other diadromous species, we examine the multiple threats that impact eels during their different life-history stages, highlighting the challenges of applying the Red List Categories and Criteria to geographically-expansive, catadromous and panmictic groups of species.

1. Introduction

The reduction in both quality and quantity of freshwater, estuarine and coastal habitat and the resulting loss of biodiversity have become a cause for global concern (Dudgeon et al., 2006; Lotze et al., 2006 and Davidson, 2014). The need to increase monitoring efforts and co-ordinate international conservation strategies for freshwater fish populations has never been greater, particularly for the relatively small number of diadromous fishes that migrate between saline and freshwater environments (McDowall, 1999; Jelks et al., 2008; Limburg and Waldman, 2009). However, achieving these goals for species that have complex life-histories and broad geographic ranges can often be difficult, especially as a disproportionate percentage of the diadromous fishes are also heavily exploited (McDowall, 1992).

As a taxonomic group, freshwater eels of the family Anguillidae are globally distributed, inhabiting the fresh waters, brackish estuaries and coastal waters of more than 150 different countries (IUCN, 2014). Despite its frequent use, the term 'freshwater' eel can be misleading. Anguillid eels are generally facultatively catadromous, as it is known that a proportion of any population may reside in estuaries, lagoons and coastal waters, rarely, if ever, entering fresh water (e.g. Arai et al., 2004 and Lamson et al., 2006). Their life-history is further complicated by multiple life stages, semelpary, and panmixia—their pelagic spawning areas are far from their growth habitats[1] (Aida et al., 2003; van Ginneken and Maes, 2005).

Like many other fish species, anguillid eel populations, most notably in temperate Northern Hemisphere regions, have seen dramatic declines in recent decades because of a number of factors, including overexploitation (Haro et al., 2000; Dekker, 2003; Casselman, 2003; Tsukamoto et al., 2003; Miller and Casselman, 2014). Indeed other diadromous species have suffered a similar fate with all major sturgeon fisheries having now past their peak productivity levels (Pikitch et al., 2005) and many salmonids showing declines in abundance and distribution throughout historically productive habitats (Thurow et al., 1997). However, it would be misleading to claim that declines in anguillid eels are solely due to exploitation as it is increasingly apparent that these are driven by multiple factors. Barriers in the form of dams and weirs, which prevent the upstream and downstream migration of eels and reduce available freshwater habitat or, worse still, cause the direct mortality of migrating eels, are a major concern (Jansen et al., 2007). For example, two large hydropower facilities in the St. Lawrence River, Canada were estimated to cause cumulative annual downstream silver eel mortality of ∼40% (Verreault and Dumont, 2003) and across the waterways of Europe over 24,000 hydropower plants are now installed (van der Meer, 2012). The role of changing oceanic conditions as a result of climate change is increasingly being discussed in relation to eel larval migration and the subsequent recruitment of glass eels to continental waters (Castonguay et al., 1994; Dekker, 2004; Bonhommeau et al., 2008; Miller et al., 2009; Baltazar-Soares et al., 2014; Pacariz et al., 2014) although decoupling the impact of climate change from historic, natural variability in recruitment is difficult (Kim et al., 2004). Other factors that are implicated in affecting anguillid abundance include disease and parasites, predation, and pollutants (Robinet and Feunteun, 2002; Fazio et al., 2012; Wahlberg et al., 2014). As such, the conservation of anguillid eels faces a myriad of scientific, political, socioeconomic and logistical challenges that require broad and co-ordinated input from a variety of national and international stakeholders. These challenges mean that, currently, a lack of integrated governance of eel remains a significant obstacle in many parts of the world.

While the conservation and management of anguillid eels is, to a large degree, hampered by the fact that there are still huge knowledge gaps relating to these species, it is important that this dearth of knowledge does not impede action (Darwall et al., 2009; IUCN, 2012a,b). Amid growing concern among stakeholders relating to the decline of a number of anguillid

[1] The giant mottled eel, *Anguilla marmorata* is believed to have more than one spawning location and therefore may not be truly panmictic (Minegishi et al., 2008).