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Lost fishes, who is counting? The extent of the threat to freshwater fish biodiversity

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1.1 INTRODUCTION

Freshwater rivers, lakes and wetlands are among the most threatened ecosystems on the planet, facing growing pressures from an expanding human population and increased socioeconomic development (Ormerod *et al.*, 2010; Vörösmarty *et al.*, 2010; Carpenter *et al.*, 2011). This pressure on freshwater ecosystems is accompanied by correspondingly high levels of threat to freshwater biodiversity (Dudgeon *et al.*, 2006; WWF, 2010; Thieme *et al.*, 2011; Collen *et al.*, 2014), as is clearly demonstrated by the high species extinction rates and levels of threat recorded on the IUCN Red List of Threatened Species (www.iucnredlist.org), hereafter referred to as the IUCN Red List. North American freshwater bivalves are, for example, notable for having the greatest proportion of extinct species worldwide. In Europe, freshwater species top the IUCN Red List with the highest proportion of threatened species. Remarkable twenty-first-century extinctions such as the baiji (*Lipotes vexillifer*), the golden toad (*Incilius periglenes*) and the Alaotra grebe (*Tachybaptus rufolavatus*), just to name a few, are all freshwater species. However, no-one has yet comprehensively assessed the level of threat and extinction rates for freshwater fishes at the global scale – and it is likely that many fishes are disappearing without record.

The twenty-first century is a critical time for the future of freshwater fishes. Human actions have a serious impact on freshwater ecosystems around the world and the freshwater fish species face ever increasing risks. Unless actions are taken rapidly to reduce the multiple threats facing freshwater fishes, many species will be lost. A sobering example,

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which serves well to demonstrate the severity of the threat, is the perilous state of the world's sturgeons and paddlefishes (Acipenseriformes). Sturgeon have survived on this Earth for 250 million years, but now face the serious possibility of becoming extinct in this century as a direct result of human activities. Illegal fishing, overfishing, obstructions to migratory routes and pollution has resulted in 23 of the 27 sturgeon species being assessed as threatened on the IUCN Red List. Of these, 17 species are Critically Endangered and four are possibly Extinct, including the Chinese paddlefish (*Psephurus gladius*), the world's longest freshwater fish for which only two adult specimens (both females) have been recorded since 2002. Human exploitation of freshwater ecosystems and the fishes within them must operate within sustainable limits, and critical sites for freshwater species must be identified and protected before it is too late for many species. Much greater attention to conservation action on the ground is required if we are to improve the status of freshwater fishes.

At the time of writing there were 15,750 described species of freshwater fish (Eschmeyer & Fong, unpubl. data), where the definition of 'freshwater' refers to those species that spend a significant part of their life history in freshwater. Diadromous species, which undergo obligatory migrations between marine and freshwater habitats, are included under this definition. This number of species represents 48% of the global diversity of all described fishes (Eschmeyer & Fong, 2013) and approximately 25% of all vertebrate diversity. Freshwater fishes fulfil a wide range of ecological roles essential to the long-term functioning of freshwater ecosystems across the world. They are also of considerable interest to scientists, hobbyists and recreational fishers and, most significantly, provide 33% of the world's small-scale fish catch and employment for an estimated 60 million people (UNEP, 2010). The supply of freshwater fish is critically important for human nutrition, especially in Africa and parts of Asia. Over 200 million of Africa's 1 billion people consume fish and nearly half of this comes from inland fisheries (UNEP, 2010). However, despite the great significance of freshwater fishes, there has been no globally comprehensive assessment of their conservation status and of the major threats to their survival. IUCN (International Union for the Conservation of Nature) and its partners have been actively working to address this information gap since 2002 by collating available information to map species' distributions and assess extinction risk. The work is ongoing and this chapter presents an assessment of the state of knowledge and condition of global freshwater fish diversity in 2013.

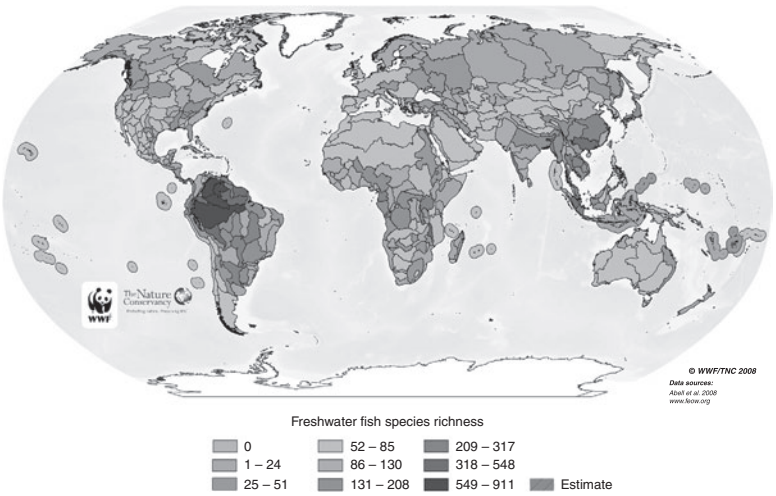

Figure 1.1 Map of freshwater fish species richness showing the numbers of species present in each ecoregion.

Source: Abell *et al.* (2008); downloaded 21 June 2014 from: www.feow.org/maps/biodiversity/freshwater_fish_species_richness

1.2 GLOBAL DISTRIBUTION OF FRESHWATER FISHES

Our knowledge of the global distribution of freshwater fish species is improving but is still incomplete, with an average of two new freshwater fish species described every three days between 2002 and 2012 (Nicolas Bailey, pers. comm.). Many regions are still poorly surveyed. For example, in the 9 years following publication of the *Checklist of the Freshwater Fishes of South and Central America* (CLOFFSCA) (Reis *et al.*, 2003), an average of one new species was described every 3.5 days, and from Mediterranean freshwaters alone, 99 new species have been described since the year 2000 (representing 22% of the fauna recognised in 2000) (Geiger *et al.*, 2014). The global pattern of distributions is well described at the scales of biogeographic regions (Berra, 2001; Lévêque *et al.*, 2008), freshwater ecoregions (Abell *et al.*, 2008) (Figure 1.1) and river basins (Oberdorff *et al.*, 2011). At the ecoregion scale, more than 6900 of the 13,400 species considered as freshwater-dependent are endemic to a single ecoregion (Abell *et al.*, 2008). Following Abell *et al.* (2008) and previous global assessments such as McAllister *et al.* (1997), Groombridge and Jenkins (1998) and Revenga and Kura (2003), outstanding areas for both fish species richness and endemism include

Box 1.1. The IUCN Red List Categories and Criteria

The IUCN Red List Categories and Criteria are intended to be an easily and widely understood system for classifying species risk of global extinction. Species are assigned to one of nine possible categories: Extinct (EX); Extinct in the Wild (EW); Critically Endangered (CR); Endangered (EN); Vulnerable (VU); Near Threatened (NT); Least Concern (LC); Data Deficient (DD), or; Not Evaluated (NE). Species assessed as Critically Endangered, Endangered, or Vulnerable are considered to be Threatened.

The percentage of the freshwater fishes threatened was calculated as a mid-point estimate (i.e. assuming the DD species are threatened in the same proportion as the species for which there are sufficient data) as follows:

$$\%\ \text{threat} = \frac{(\text{CR} + \text{EN} + \text{VU})}{(\text{total assessed} - \text{EX} - \text{EW} - \text{DD})} \times 100$$

large portions of Africa's Congo basin, the Southern Gulf of Guinea drainages and Lakes Malawi, Tanganyika, and Victoria; Asia's Zhu Jiang (Pearl River) basin and neighbouring systems; and large portions of South America's Amazon and Orinoco basins. Other areas confirmed for globally high species richness include Asia's Brahmaputra, Ganges and Yangtze basins, as well as large portions of the Mekong, Chao Phraya and Sitang and Irrawaddy; Africa's lower Guinea; and South America's Paraná and Orinoco. When species richness is adjusted for ecoregion area, additional systems such as the Tennessee, Cumberland, Mobile Bay, Apalachicola and Ozark highlands in the Southeastern United States; portions of Africa's Niger River Basin; the islands of New Caledonia, Vanuatu and Fiji; China's Hainan Island; and large parts of Sumatra and Borneo, among many other areas, are also noteworthy (Abell *et al.*, 2008).

1.3 STATE OF KNOWLEDGE ON THE EXTENT AND DISTRIBUTION OF THREATS

The IUCN Red List provides the only globally consistent measure of threat to individual species, assessed as the risk of an individual species going extinct. Each species' assessment for the IUCN Red List requires: (i) a map of the species distributions and (ii) an assessment of its risk of global extinction (see Box 1.1). As of 2013, 46% (7301 species) of all described species of freshwater fishes had been mapped to river

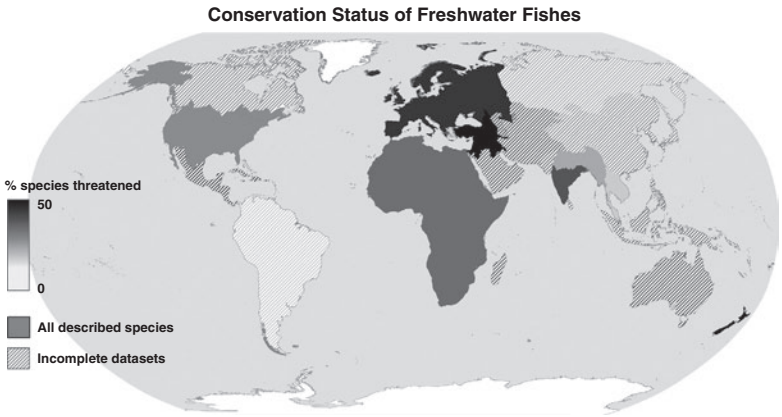

Figure 1.2 Map of global progress in assessment of freshwater fishes for the IUCN Red List of Threatened Species. The level of threat is shown as the percentage of species assessed that are threatened (excluding all species assessed as 'Extinct', 'Extinct in the Wild' or 'Data Deficient'). Those regions depicted with solid shading have been comprehensively assessed, meaning that all described species have been assessed. For those regions with hatched shading, not all species have been assessed such that the overall level of threat may not be representative of all species, representing only a small proportion of species in some regions.

and lake sub-basins, major threats identified and their risk of extinction assessed (IUCN, 2013), according to the IUCN Red List Categories and Criteria (Mace & Lande, 1991) (Figure 1.2). Comprehensive assessments have been completed for all described species in many regions including: Europe, Africa, India, Indo-Burma, United States of America, New Zealand, Oceania and the Middle East. For other regions, only a subset of species have been assessed, leaving significant information gaps in particular for South America, large parts of Northern and Eastern Asia and Indonesia. In these regions, a number of species have been assessed representing the combined results of a random sample (Collen *et al.*, 2014) and ad hoc assessments. As such, the sample of species is potentially biased by a tendency to first assess those species thought most likely to be at risk. For these regions we also draw on additional information from National Red List Assessments and other sources. However, National Assessments often differ in their application of the IUCN Red List Categories and Criteria such that direct regional comparison of numbers of threatened species should be made with caution.

1.3.1 Extent of threat

Of the 7300 freshwater fish species assessed for the IUCN Red List by 2013, 31% are threatened with extinction (classified as Critically Endangered, Endangered, or Vulnerable). This percentage figure excludes the 1571 species for which insufficient information was available to assess the extinction risk (classified as Data Deficient) and the 69 species assessed as either Extinct or Extinct in the Wild. This level of threat is relatively high as compared with other globally comprehensive assessments, which find 13% of birds, 20% of mammals and 34% of amphibians threatened (IUCN, 2013).

Burkhead (2012) applied his own criteria to estimate the background extinction rate for freshwater fishes in the twentieth century as nearly twice that of other vertebrate groups. He used an extrapolation from the North American proportion of extinct species to suggest that around 410 species, 3% of all described freshwater fishes, are extinct globally. Alternatively, Harrison and Stiassny (1999) estimated 245 species (2% of freshwater species) to be potentially extinct or seriously threatened, and Freyhof and Brooks (2011) estimated 2% of European species as being extinct. However, it still remains difficult to definitively assess a species as being extinct. For example, species not recorded for many decades are occasionally rediscovered in poorly known areas. As a result, many fish experts hesitate to declare a species as extinct.

1.3.2 Causes of threat

Why are so many freshwater fishes threatened? The major threats to freshwater ecosystems as summarised by Thieme *et al.* (2011) include: (i) the position of freshwater ecosystems in the landscape as sinks for terrestrial run-off that includes pollutants, pesticides and heavy sediment loads; (ii) intense competition with humans for use of water for various purposes such as hydropower, irrigation, livelihoods and transport; (iii) regionally intense harvest pressures; and (iv) the high degree of connectivity within and between freshwater ecosystems that often facilitates rapid and widespread dispersal of pollutants and invasive alien species. This summary is supported by an analysis of the threat categories assigned to all freshwater fish on the IUCN Red List reflecting the nature and scale of past and present development activities, and highlighting habitat degradation and loss, water abstraction and flow modifications, invasive species, pollution and overexploitation as major threats (Figure 1.3). The inherent features of freshwater fishes

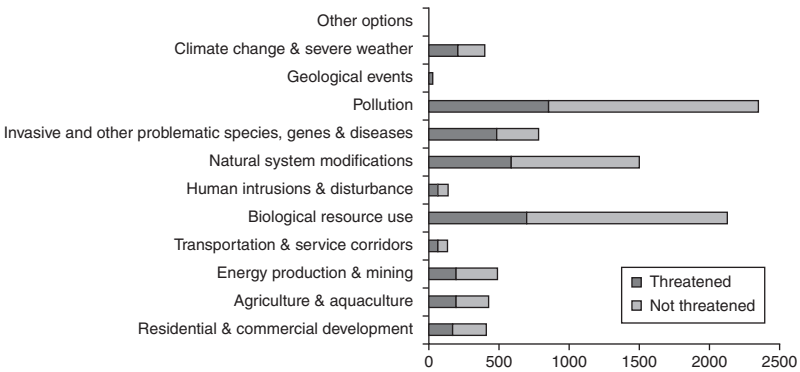

Figure 1.3 The numbers of species classified to each of the main categories of threat as coded in the IUCN Red List.

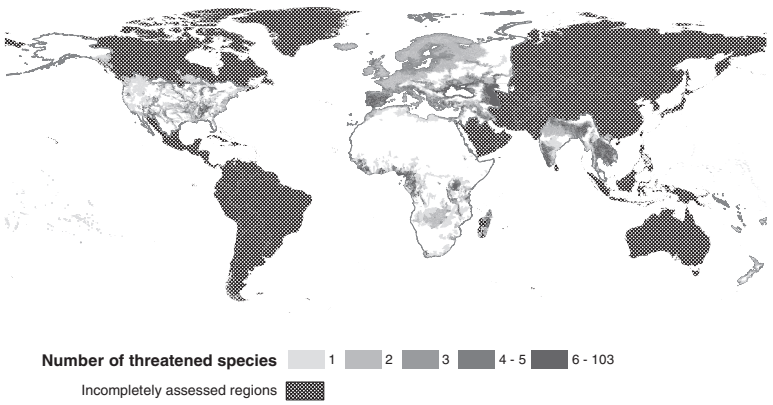

Figure 1.4 Map showing the distribution of all freshwater fish species assessed as threatened showing the number of threatened species within individual river and lake subcatchments. Data are presented for those regions of the world where all described species have been assessed.

that make them so susceptible to these types of threat are addressed in Chapter 2.

1.3.3 Regional comparisons

Patterns of richness for threatened species are displayed for all comprehensively assessed regions (Figure 1.4). The extent and distribution of threats varies significantly at the regional scale, thus warranting an

overview of each region covering patterns of species distributions and the levels and types of threat faced.

1.3.3.1 *Europe*

The most recent assessment of European freshwater fishes identifies 531 valid species native to the region (Freyhof & Brooks, 2011). Almost 42% (200 species) are threatened with global extinction and 15 species are globally Extinct or Extinct in the Wild (Kottelat & Freyhof, 2007). The geographic distribution of threatened species is shown in Figure 1.4.

The 12 species known to be Extinct in Europe include 6 species of *Coregonus* and 2 *Salvelinus*. All were strongly impacted by modifications to their lake environments. The Lake Constance whitefish *Coregonus gutturosus* and the charr *Salvelinus profundus* were endemic to Lake Constance where they formed the basis of a commercial fishery until the 1960s, but disappeared as the lake became highly eutrophic. Eutrophication of Central European lakes is believed to have wiped out a significant proportion of the endemic fish fauna (Vonlanthen *et al.*, 2012).

Of particular concern are the fishes of Mediterranean rivers that are subject to water abstraction, dam construction and alien species invasion. This region is inhabited by many endemic species, most of which are highly vulnerable to a range of threats. Despite the Mediterranean being highlighted as a global biodiversity hotspot (Myers, 1988; Mittermeier *et al.*, 1999), its freshwater ecosystems receive limited conservation support. Another highly threatened group are the diadromous migrants, especially salmonids and sturgeons. Six of the seven sturgeons have been assessed as Critically Endangered, an optimistic view given that many populations only persist through artificial stocking.

The single most important threat to European freshwater fishes is the over-abstraction of ground and surface water from rivers and lakes. In the Mediterranean region this is a major concern for many species, especially as the extraction is often illegal and poorly policed. This situation is becoming increasingly serious as drought events increase and the rates of water consumption rise. Many of those countries already suffering from limited water supplies also support high numbers of endemic and threatened species.

Invasive species are recorded as a threat to about 55% of species in Europe. Kottelat and Freyhof (2007) recorded 28 established alien species introduced from outside of Europe and an additional 77 species native to Europe but expanding beyond their natural range. Once established, their spread is often rapid, as demonstrated for the topmouth

gudgeon (*Pseudorasbora parva*), a Chinese cyprinid that spread across much of Europe in 40 years.

The increasing numbers of dams across Europe are also of concern as water flows are disrupted, habitats transformed and fish migration routes disrupted. Few rivers in Europe remain free of hydropower or irrigation dams. In many cases migratory species have lost all former spawning areas. For example, the beloribitsa (*Stenodus leucichthys*), a migratory species of the Caspian Sea, is now considered to be Extinct in the Wild as it is unable to complete its 3000-km upriver migration into the Volga to spawn following construction of the Volgograd dam in 1959 (Freyhof & Kottelat, 2008).

1.3.3.2 Western Asia

Western Asia, or the Middle East, is biogeographically similar to Europe with many fish genera shared between the two regions and the conservation concerns are similar to those for the Mediterranean region. Western Asia covers the countries south of the Caucasus such as Georgia and some adjacent parts of Russia, Azerbaijan, Armenia, Turkey (only the Asian part), Cyprus, Syria, Jordan, Lebanon, Israel, Iraq, Kuwait, the countries of the Gulf and Iran. The freshwater fish diversity of Western Asia has never been reviewed comprehensively and only rough estimates of species numbers are known. Approximately 450 described species occur, and of these, around 30 established species are alien to the region. Some of these alien species are from within the region but have been translocated outside of their natural ranges. Western Asia is still poorly explored when it comes to freshwater biodiversity including fishes; at least 100 species, maybe considerably more, are awaiting description. Of an estimated 520 native species (including both described and undescribed species), 320 (approximately 60%) are endemic. The centres of endemism are Western and Central Anatolia and Central Iran, where many species with highly restricted ranges occur, particularly within the genera *Aphanius*, *Pseudophoxinus* and *Cobitis*. The largest river system, the Euphrates and Tigris drainage, is inhabited by an almost entirely endemic fish fauna of around 100 species including 5 species of cave fish and one of the largest cypriniform fishes in the world, the pike barbel, (*Luciobarbus esocinus*) growing to more than 2 m in length. Preliminary results of an assessment for the IUCN Red List clearly demonstrate that the fish fauna is subject to high threat levels across this mostly arid region that supports a dense human population. At least 13 species are already thought to be extinct. The habitats of the long-spine bream

(*Acanthobrama centisquama*) (Lake Amiq, Turkey) and *Mirogrex hulensis* (Lake Hula, Israel) were both drained. Introduced alien species caused the extinction of a number of other lacustrine endemics in Anatolia.

The main threat to freshwater fishes, as in other arid or semi-arid areas across the world, stems from the intense competition between people and biodiversity for a limited water resource. Across the region, dams for irrigation and hydropower production have been constructed, and many more are planned or are under construction. In many, possibly the majority, of cases, no water flows out of the reservoirs during dry periods. In large rivers such as the Euphrates, large reservoirs lead to significant loss of water through evaporation which, when combined with water withdrawals for irrigation, leave a considerably reduced supply downstream. The impacts of dams are not only restricted to the dry parts of Western Asia. For example, almost all rivers flowing to the Southern Caspian Sea are blocked shortly before they enter the sea such that all populations of migratory fishes are now almost entirely conservation-dependent. For example, sturgeons (*Huso huso*, *Acipenser* spp.) are no longer able to spawn naturally. Even highly valued migratory fishes such as the Black Sea roach (*Rutilus frisii*) rely almost entirely on artificial breeding. Below the dams, poaching levels are so high that the rivers from which broodstock are taken for artificial reproduction are now protected by armed guards.

Surface and ground water are abstracted in huge quantities throughout the dry parts of Western Asia and abstraction is rarely sustainable. Recently, Voss *et al.* (2013) found that large parts of Western Asia are losing groundwater reserves at an alarming rate. The overall rate of freshwater loss from the region during the seven-year study period is one of the highest in the world, second only to water loss in India. Climate change scenarios that predict reduced rainfall in this region (Chenoweth *et al.*, 2011) suggest a bleak future for freshwater fishes in large parts of Western Asia. Many areas have already dried out and many fish species, once widespread, are now restricted to small refuges. For example, the once extensive spring areas at Ras al Ain in Northern Syria have almost completely dried out, as has the famous spring of the Barada River near Damascus, along with almost the entire Damascus hydrological basin.

1.3.3.3 Continental Africa

Africa has a diverse fish fauna of almost 3000 described species of which 27% are threatened (Snoeks *et al.*, 2011). The distribution of threatened freshwater fish species (Figure 1.4) is largely focused in a