



THE WORLD'S FORGOTTEN FISHES





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WWF wish to thank collaborators Ian Harrison, Will Darwall, Richard Lee, Dean Muruven, Carmen Revenga, Julie Claussen, Abby Lynch, Adrian Pinder, Robin Abell, Paula Martinelli, Mike Baltzer, Michele Thieme, Sonja Jähnig, Jeff Opperman, Herman Wanningen, Jeremy Monroe and Harmony Patricio for their support in writing this report. Furthermore, we wish to thank experts Richard van der Laan, Tim Lyons, Paul Van Damme, Mark Owen, Hannah Rudd, Joao Campos-Silva, Leandro Castello, Vidyadhar Atkore, Thadoe Wai, Simon Funge-Smith, John Jorgensen, Naren Sreenivisan, Mark Lloyd, Arlin Rickard and Matt Gollock for their support with individual case studies.

About this report and its collaborators

Promoting thriving populations of freshwater fishes and the ecosystems within which they thrive is a priority for WWF and the 15 organisations and alliances that produced this report.

Publishing office: WWF International

Cover photography © Karine Aigner / WWF-US

Design by Lou Clements

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FOREWORD

World ignores freshwater fish at their peril – and ours



We're entering a critical time for the future of the planet, and the nations of the world finally seem to be getting the message. Governments are working to ramp up their climate change commitments under the Paris

Agreement and will be meeting in 2021 to agree new targets to protect and restore nature under the Convention on Biological Diversity. There's consensus on the urgent need to stop deforestation, wetland degradation, ocean pollution and the decline in species populations, and a growing wave of support for conserving 30 per cent of our planet by 2030. Meanwhile, environmental issues like the impact of our food systems, unsustainable production and consumption, and microplastics are becoming mainstream concerns.

In short, there's never been more awareness of – or efforts made to solve – the pressing environmental challenges we face. But there's one glaring exception that seems to have slipped under the decision-making radar: our overlooked and undervalued freshwater fishes. Not many people realize how important these species are and even fewer realize quite how seriously they're threatened.

Let's take their importance first. Did you know there are more fish species living in fresh water than in all our seas and oceans? Or that hundreds of millions of people around the world rely on them for their food and livelihoods, particularly in vulnerable communities and among indigenous peoples? Freshwater fishes are also critical for the health of all kinds of ecosystems, and support food webs that extend from birds to bears, and from mountains to mangroves. Beyond that they drive multibillion-dollar industries for anglers and aquarium-lovers alike, while historically they've been entwined in cultures on every continent.

Nevertheless, our freshwater fishes are in terrible trouble. Migratory populations have fallen by three-quarters in the last 50 years.

During the same period, populations of larger species – the so-called 'megafish' – have crashed by a staggering 94 per cent. Nearly a third of all freshwater fish species are threatened by extinction – and for 80 extinct species it's already too late.

There's no mystery about why freshwater fish numbers are falling so precipitously: habitat degradation, poorly planned hydropower, pollution, over-abstraction of water, unsustainable sand mining, the introduction of invasive non-native species, wildlife crime and, of course, climate change are among the factors pushing fish populations to the brink.

Clearly this can't continue: we must act, and we must do it urgently because if we leave it much longer it'll be too late. That's why WWF and the 15 NGOs and alliances signed up to this report are championing an Emergency Recovery Plan for freshwater biodiversity and taking action to reverse decades of decline.

The six-pillared plan is based on sound science and real experience: we know the measures it contains can work. By protecting and restoring natural flows, water quality and critical habitats while working to undo the harm caused by overfishing, sand mining and invasive species, we can make a decisive difference.

We can and we must act now. Freshwater fishes, in all their dazzling diversity, have been forgotten for too long. I hope that when you read this report you'll agree, and that together we can pull them back from the brink.

Dr Jon Hutton,
WWF Executive Director
Global Conservation Impact



INTRODUCTION

This report is a celebration of freshwater fishes – and it’s a call to action too.

Rivers, lakes and wetlands are among the most biodiverse places on earth. They cover less than 1 per cent of the planet’s total surface, yet they’re home to almost a quarter of all vertebrate species – including over half of all the world’s fish species. It’s an extraordinary fact: of 35,768 known species of fish, 18,075 – or 51 per cent – live in freshwater¹. And more are being discovered all the time.

But few people have any idea of the unimaginable diversity that swims below the surface of the world’s freshwater ecosystems or how critical these undervalued and overlooked freshwater fishes are to the health of people and nature around the world.

INTRODUCTION

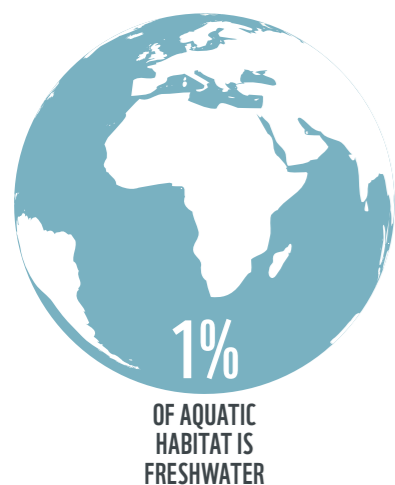
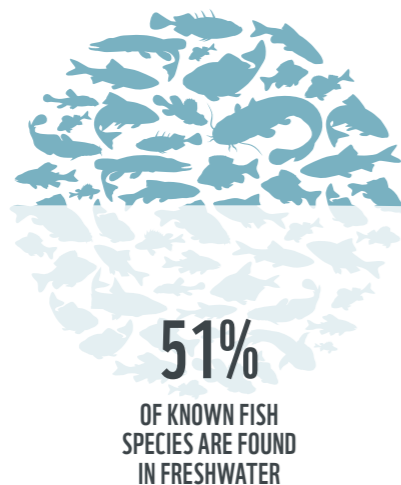


Figure 1: Approximately 1% of the earth's surface area is freshwater and 71% is marine, yet over half of known fish species are found in freshwater.

Freshwater fishes are amazing for so many reasons. From the spectacular ornamental species like the angelfish* that are amongst the world's most popular pets to the beluga sturgeon that historically grew as large as a great white shark², and the gilded catfish that migrate over 10,000km³, freshwater fishes have adapted to life in a dizzying variety of ways. They have evolved to fill every available niche in almost every freshwater ecosystem from clear alpine streams to sediment rich tropical rivers, from shallow ponds to the world's great lakes, from flooded forests to waters flowing through underground caves. And many migrate between ecosystems – and even thousands of kilometres out to sea.

They have swum through our societies since the beginning of human history. They have fed us for millennia and are critical for the food and nutrition security, livelihoods and cultures of hundreds of millions of people across the globe. Meanwhile, the challenge of catching iconic or even common species – from salmon to mahseer, tigerfish to carp – inspires millions of anglers to spend billions of dollars each year on the vast recreational fishing industry. And when it comes to both angling and keeping aquariums, just being around fishes is good for our health by reducing stress and lowering our blood pressure.

Freshwater fishes play important roles within our ecosystems and serve as indicators of the health of those ecosystems. They are an aquatic version



of the canary in the coalmine for the world's rivers, lakes and wetlands. If our freshwater ecosystems deteriorate to the point where they can't support a healthy population of fish, we can be sure they won't be fit for humans either.

Yet, in many senses, these are the world's forgotten fishes. Today, nearly a third of freshwater fish species are threatened with extinction due to a devastating combination of threats from damming rivers to draining wetlands, abstracting too much water for irrigation to releasing too much untreated waste, from unsustainable and damaging fishing practises to introductions of invasive non-native species – and, of course, the escalating impacts of climate change. Since the 1970s, migratory freshwater fish populations have declined by an estimated 76 per cent on average⁴, while populations of freshwater mega-fishes (fish heavier than 30kg) have declined by an even more catastrophic 94 per cent⁵. But very few people have any inkling of the speed at which freshwater fishes are being lost – or what the consequences will be if we don't reverse this disastrous trend.

Despite their importance and the magnitude of the threats they face, freshwater fishes, and freshwater biodiversity in general, remain an afterthought for policymakers and the public at large. Rivers continue to be valued primarily as water pipes for cities, industry, agriculture and power, ignoring their many 'hidden' benefits, such as the freshwater fisheries they sustain. Very rarely, for example, are the full values of freshwater fisheries factored into decisions about hydropower dams or dredging for navigation or sand mining.



This can't continue. Humanity can't afford to lose any more of the world's forgotten fishes or the freshwater ecosystems they inhabit. Rivers, lakes and wetlands are our life support systems and the extraordinary diversity of fishes within them are essential to their health and ours. To secure our own future, we must act now.

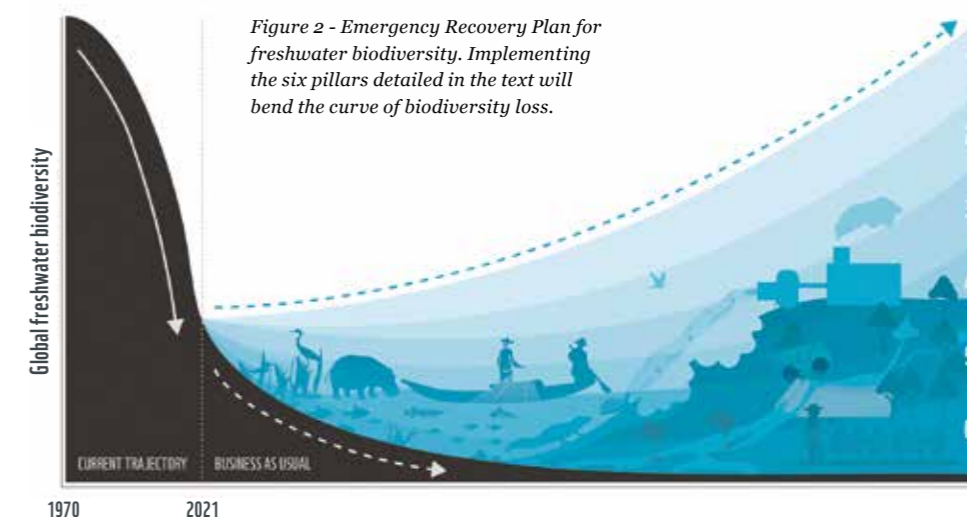
The good news is that we know what needs to be done: the world must implement an Emergency Recovery Plan for freshwater biodiversity⁶. Developed by scientists and freshwater experts from across the world, this practical, science-based plan incorporates six pillars – each of which has been implemented in different parts of the world:

1. Let rivers flow more naturally;
2. Improve water quality in freshwater ecosystems;
3. Protect and restore critical habitats;
4. End overfishing and unsustainable sand mining in rivers and lakes;

5. Prevent and control invasions by non-native species; and
6. Protect free-flowing rivers and remove obsolete dams.

Only by implementing this plan, which is echoed in the Convention on Biological Diversity 5th Global Biodiversity Outlook, can we hope to restore the world's freshwater ecosystems and reverse decades of decline in freshwater fish populations. By committing to this plan, countries can enhance the health of their rivers, lakes and wetlands – and secure the future of their fish and fisheries.

There are indications that some are finally starting to take the fate of freshwater fishes into account. Cambodia's widely praised decision to impose a 10-year moratorium on hydropower dams on the mainstem of the Mekong river seems to have been partly based on the devastating impact that the proposed Sambor and Stung Treng dams would have had on the



river's hugely productive fisheries – fisheries that feed millions of people in Cambodia and Vietnam. But factoring freshwater fishes into development decisions is still very much the exception: it needs to be the rule.

We'll look at the Emergency Recovery Plan in more detail in the concluding section on solutions, but first let's find out more about the amazing diversity of the world's forgotten fishes...

DAZZLING DIVERSITY

*Freshwater habitats are extremely diverse
– and so are the fishes that live in them*





Wonders of the wild:
Snorkelling near Cape
Town, South Africa

SHARKS PATROL THESE (FRESH)WATERS!

“We have very little idea of the geographic distribution of these sharks, much less their general biology. They show up like ghosts, few and far between, in a handful of scattered localities. Finding one is cause for celebration.”

Leonard Compagno, IUCN shark expert

Of all the freshwater fishes that we know next to nothing about, the five river sharks of the *Glyphis* genus are among the most mysterious. IUCN estimates that only 2,500 spartooth sharks remain in the mangrove-lined rivers of Australia and New Guinea. Even less is known about the other species. Our knowledge of the Irrawaddy river shark goes back to a single 19th century specimen from Myanmar, and we don't have much more to go on when it comes to the Borneo river shark. The New Guinea river shark and India's Ganges river shark make up the vanishingly rare quintet; all those assessed by IUCN are categorised as Endangered or Critically Endangered.



New species of river shark, *Glyphis garricki*, discovered in 2008 in Port Romilly, Gulf District, Papua New Guinea

Buffalo fish migrating in Tennessee, USA



There are millions of rivers, lakes and wetlands across the world, and they boast their own distinct and dynamic conditions. Many are also completely isolated from each other. Isolation and the complex web of ecological niches in freshwater ecosystems has led to the evolution of a disproportionate number of fish species relative to the total area they inhabit⁷.

This all adds up to perhaps the most staggering – but little known – fact about freshwater fishes: there are more freshwater species than saltwater ones. As surprising as it may seem, freshwater fishes account for more than half of all known fish species – around 51 per cent. The current total is 18,075, which also amounts to around a quarter of all the world's vertebrate species. And they are extraordinary.

Did you know that freshwater fishes include some of the smallest vertebrates on earth, such as a minnow that lives in peat swamps in Indonesia and is just 8mm long and weighs in at 0.004g? Or that the mammoth fish of the Mekong – the giant catfish, giant freshwater stingray, giant barb, and the wonderfully named dog-eating catfish – can all grow over 3m and tip the scales at more than 300kg?

And while many are simply silver, others have made breathtaking use of the world's colour palette. Like the bright red and blue of the cardinal tetra or the vivid red stripe along the side of the denison barb or the red spot of Australia's crimson spotted rainbowfish.

Speaking of the crimson spotted rainbowfish: science has shown that they can actually remember things

for around a year – one third of their lives⁸. While archerfish treat water as a hunting tool, spitting it like a projectile to knock unsuspecting prey into the water. Africa's elephantfishes use weak electrical pulses to communicate with others about sex, size, predators and prey. South American leaffishes – as their name suggests – mimic dead and decaying leaves to catch their prey unawares. And Siamese fighting fish build a nest of bubbles for their eggs.

While we're on the subject of parental care: the female spraying characin in the Amazon lays her eggs on overhanging leaves and the male is then tasked with keeping them moist until they hatch by constantly squirting them with water. Equally fascinating are the mouthbrooding cichlids found in Africa and South

America, which protect their eggs and fry in their mouths. Meanwhile, some daffodil cichlids forgo the opportunity to breed and choose instead to help parent the offspring of relatives⁹. Less admirable behaviour is seen in another Lake Tanganyika species – the cuckoo catfish. Like its famous avian namesake this fish tricks another species into caring for its offspring. It does this by creating chaos at spawning time, and confusing unsuspecting female cichlids into scooping up the spawn of the cuckoo catfish, which they subsequently brood in their mouths.

And we haven't even delved into the 11,000 species that migrate at some point in their lives (see boxes on gilded catfish, European eels and sturgeon).

© Tim Watts



THE EUROPEAN EEL: MYSTERIOUS MIGRATORY MARVELS

There's a lot that we still don't know about European eels, *Anguilla anguilla* (and its 15 anguillid sister-species around the world, for that matter). Nobody really understands how or why after 10 years or more of quiet freshwater living, European eels suddenly swim as far as 8,000km to spawn in the north Atlantic's remote Sargasso Sea - and their early life history is equally mysterious. But we do know that eel larvae drift towards Europe in enormous numbers and the tiny 'glass eels', which eventually arrive to make their homes in our coasts, estuaries, rivers and lakes, have historically thrived across the continent. In the 19th century, eels made up about a third of the total European freshwater catch by value.

Today, though, they're listed as Critically Endangered by IUCN. In 1980, their numbers began to fall by about 15 per cent each year, until by 2010 glass eels were arriving in Europe in just 1 per cent of their historical numbers. While overfishing played a part in the decline of European eels, they face a range of threats today, including river barriers that block their migration, hydropower dams whose turbines slice and dice them, poaching for the illegal wildlife trade (eels constitutes the largest illegal wildlife trade out of Europe), pollution, diseases and parasites, and climate change, which may already be impacting their journey to and from their spawning grounds.

Freshwaters are also home to living lineages of truly ancient animals, such as lampreys, which along with hagfishes, are the only surviving species of jawless fishes – the very first type of fish to appear on Earth around 530 million years ago. Around 400 million years ago, fish gave rise to tetrapods, a group of related four-limbed animals that includes today's amphibians, reptiles, birds and mammals. Today the birchir is the only living relative of this ancient type of fish. Lungfishes are another ancient group that evolved around 380 million years ago. Contemporary to the dinosaurs are the gar, sturgeon, paddlefish and bowfin, which all evolved around 120-130 million years ago. Meanwhile, in 2020, a 'new' species of freshwater fish belonging to a new family – the dragon snakeheads – was discovered¹⁰ in India with Gonwanan lineage dating back 120 million years.

This extraordinary diversity churns out a myriad of weird and wonderful names. So along with the leaffishes and lungfishes, there are ricefishes, rainbowfishes, sunfishes, mosquitofishes, toadfishes, half-beaks, galaxiids, noodlefishes and mooneyes. And many more.

The greatest diversity of freshwater fishes is found in the tropics, with the Amazon leading the way with over 2400 known species¹¹. But there is a long way to go until we

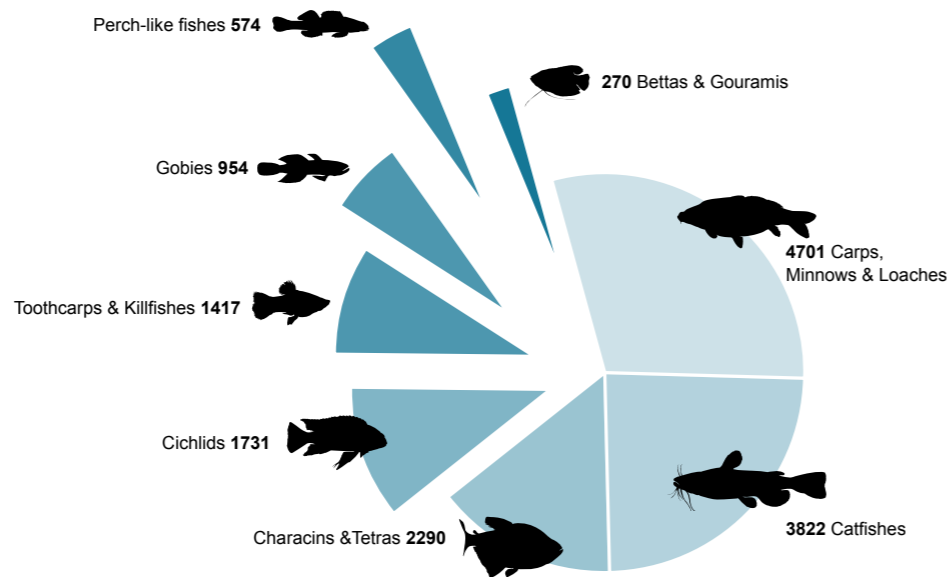


Figure 3: Almost 90% of freshwater fish species are found in eight orders: carps, minnows and loaches (*Cypriniformes*), catfishes (*Siluriformes*), characins and tetras (*Characiformes*), cichlids (*Cichliformes*), toothcarps and killfishes (*Cyprinodontiformes*), gobies (*Gobiiformes*), perch-like fishes (*Perciformes*), and bettas and gouramis (*Anabantiformes*).



© Camilo Diaz / WWF Colombia

know exactly how many there are: astonishingly, there are still hundreds, possibly thousands, of freshwater fishes to discover. In South America alone, more than 104 new species of freshwater fish have been identified every year for the past decade – an average of two new species a week¹². Even where species are described, data deficiency remains a huge barrier: at the time of writing 2,164 freshwater fishes assessed by IUCN are classed as Data Deficient. Since many freshwater fishes are endemic with small geographical ranges, such knowledge gaps can prove particularly problematic for conservation.

There's so much we still don't know about these incredibly diverse freshwater creatures. Two things we definitely do know, though, are that healthy freshwater fish populations are critically important for people and nature, and that freshwater fishes are facing an unprecedented crisis.



© Ad Konings / Cichlid Press

THE AMAZING RADIATIONS OF CICHLIDS

Cichlids (*Cichlidae*) are one of the most diverse families of freshwater fish on earth, with almost 2000 known species. Most are found within South America and Africa. There are at least 1600 species of cichlids in Africa's Great Lakes, including Victoria, Tanganyika and Malawi, with hundreds of species yet to be described¹³. Within these lakes, cichlids have adapted to occupy almost every niche and position in the food chain, including carnivore, herbivore and detritivore. Some are generalists, others specialists, and they have developed an array of morphological and behavioural adaptations to their particular niche. The diversity of Africa's Great Lake cichlids is one of the most spectacular examples of speciation in the world and provides scientists with a unique opportunity to better understand the drivers of species evolution.



Main © A. Cambone, R. Itoiti / Homo ambiens, insets p47

HEALTHY FRESHWATER FISHERIES = HEALTHY RIVERS, LAKES & WETLANDS

*Critical indicators of
the resilience of our life
support systems*



Healthy freshwater ecosystems are essential to sustain thriving populations of freshwater fishes. But widespread ignorance of the wealth of freshwater fishes has blinded us to just how critical they are to the health of the world's rivers, lakes and wetlands.

Fishes are the dominant organisms in most freshwater ecosystems in terms of biomass and feeding ecology¹⁴. With their vital role as scavengers, predators and prey, they play a regulatory and foundational function within an ecosystem and are central to the natural balance. Take for example, the importance of Alaska's salmon runs in fattening up bears ahead of hibernation and transporting essential nutrients from the sea to nourish riparian woodlands. Or the major role fishes play in dispersing the seeds of tropical floodplain trees in the Amazon¹⁵. Or migratory fishes of the Mekong whose seasonal journeys provide an impetus for movements of the river's top predator – the Irrawaddy river dolphin.

When we tip the scales by drastically reducing freshwater fish populations and speeding a third of species towards extinction, we undermine the functioning of many of the world's freshwater ecosystems – our very life support systems. Two billion people currently source their drinking water directly from rivers, which also irrigate 190 million hectares, accounting for about a quarter of total global food production¹⁶. Healthy freshwater ecosystems are also critical to the fight against climate change. Peatlands, for example, store twice as much carbon as the world's forests, while functioning floodplains reduce the impact of extreme floods.

But the diverse benefits of healthy freshwater ecosystems continue to be undervalued and overlooked – until they are gone. Unfortunately, they're disappearing at a shocking rate. We've lost 35 per cent of the world's remaining wetlands in the past 50 years¹⁷. Only a third of rivers over 1000km still flow freely from source to sea¹⁸. Just 40 per cent of Europe's waters are classified as in good ecological health¹⁹.

The decline in freshwater fish populations is the clearest indicator of the damage we have done – and are still doing – to our rivers, lakes and wetlands. And that collapse only exacerbates the crisis. Freshwater fishes need healthy freshwater ecosystems. And so do people. But we're losing them both far too fast.

WILD FRESHWATER FISHERIES ARE PRICELESS

*Under-reported, undervalued
and under pressure*

Main © James Suter / Black Bean Productions / WWF-US, insets p47



AT LEAST 85% OF TANZANIA'S FISH PRODUCTION COMES FROM FRESHWATER FISHERIES²³; 65% IN BANGLADESH AND 44% IN MYANMAR²⁴

AT LEAST 43% OF WILD FRESHWATER FISH HARVEST COMES FROM 50 LOW-INCOME FOOD DEFICIENT COUNTRIES²⁵

Read almost anything about the global fish catch and you'll be left with the distinct impression that people only catch fish in the ocean – that the only fish species that matter for societies and economies are the ones that inhabit our coastal waters or deep seas. Yet, wild-caught freshwater fisheries provide food security and livelihoods for hundreds of millions of people across the world.

Invariably overlooked, wild capture freshwater fish officially make up around 13 per cent of the world's annual catch, totalling 12 million tonnes each year²⁰. This is, without a doubt, a massive underestimate because global statistics only show country level documented catches, but freshwater fish are hauled in by artisanal and subsistence fishers in Asia, Africa and Latin America and are rarely documented. In fact, recent research in local markets suggests the actual freshwater catch is likely to be around 65 per cent higher than reported²¹.

Including these unaccounted for 'hidden harvests', freshwater fisheries are estimated to be worth over US\$38 billion per year. However, they are worth far more than this to the local communities and indigenous people who rely on

them. Freshwater fisheries provide the primary source of animal protein as well as essential nutrients, like lysine and calcium²², for at least 200 million people globally, particularly in vulnerable communities in Asia and Africa. In developing countries, small-scale fisheries produce more than half the fish catch, and around 90 per cent of this is consumed locally in rural settings where poverty rates are high and good-quality nutrition is sorely needed.

Wild freshwater fisheries capture is more concentrated than marine capture and in 2018 just 16 countries produced 80 per cent of the world's reported wild freshwater catch. Asia accounted for 2/3rd of the global catch with China, India, Bangladesh, Myanmar, Cambodia and Indonesia reporting the largest hauls. Africa accounted for 25 per cent with Uganda, Nigeria, Tanzania, Egypt, DR Congo and Malawi leading the way. Meanwhile, a team from Hull International Fisheries Institute and FAO found that 50 per cent of global freshwater fish catch can be attributed to just 7 river basins – the Mekong, Nile, Irrawaddy, Yangtze, Brahmaputra, Amazon and Ganges²⁶.

While overall catch size is lower, it's worth noting that at 2.56kg, Africa's annual catch per capita is significantly higher than Asia's 1.99kg. This underlines the particular importance of wild freshwater fisheries in Africa, especially in land-locked and low-income countries. The African Great Lakes fisheries (which understandably have more reporting than the thousands of smaller freshwater fisheries in rivers, streams, ponds and rice-paddies) alone produce more than a million tonnes of fish each year, roughly double the size of the next largest fishery on the continent's west coast.

Freshwater fisheries also provide jobs for around 60 million people across the world – more than half of whom are women. In total, jobs in freshwater fisheries account for between 2.5-6 per cent of the global agricultural workforce. What's more: rivers, lakes and floodplains support even more fishers, processors and traders than marine sectors.

But these statistics do not tell the whole story because freshwater fisheries are extremely difficult to replace. Or rather, being forced to replace wild fisheries that have been destroyed or depleted by short-sighted decisions will result in considerable long-term costs – such as increased deforestation to free up more land for crops or livestock, which are needed to replace lost sources of protein and micronutrients. Losing freshwater fisheries will also wreak havoc on communities whose cultures have always been deeply intertwined with them.

Just take Cambodia as an example. Cambodians currently get around 16 per cent of their animal protein and 28 per cent of their lysine from freshwater fish, particularly from the astonishingly abundant, but increasingly threatened, fishery of the Mekong river basin – one of the world's most productive freshwater fisheries. If Cambodia's freshwater fishery failed (and dams and droughts have led to historically low levels on the Mekong in recent years), one study found the nation would need to increase its pasture lands by as much as 155 per cent and its crop lands by 59 per cent to continue to meet its nutritional needs²⁸. Change on such a monumental scale – if it were possible at all – would have massive social, economic and environmental impacts.

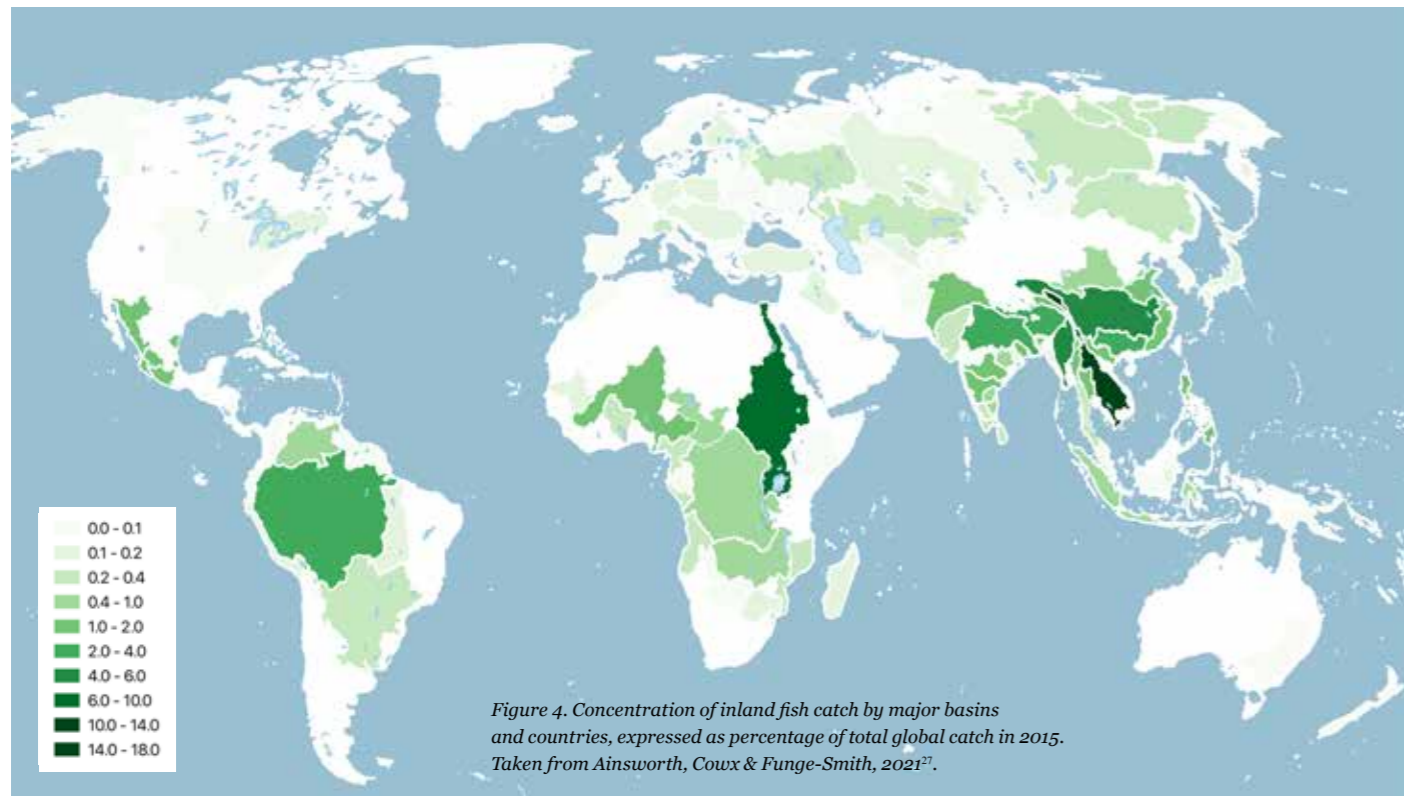


Figure 4. Concentration of inland fish catch by major basins and countries, expressed as percentage of total global catch in 2015. Taken from Ainsworth, Cowx & Funge-Smith, 2021²⁷.



Baka villager with the day's catch from their local stream. Freshwater fishes are critical for many indigenous people.

© Daniel Neilson

90% OF GLOBAL FRESHWATER FISH CATCH COMES FROM RIVER BASINS WITH ABOVE-AVERAGE STRESS LEVELS³¹

But the reality is that like the freshwater ecosystems on which they depend, the world's wild freshwater fisheries are under increasing pressure from two main threats.

Environmental factors – The primary drivers of freshwater fisheries health are environmental: sustainable fisheries need resilient and healthy

ecosystems. Pollution, excessive water abstraction, dams and other infrastructure, sand mining, and land use change (e.g., loss of floodplains) are undermining the ecological viability of critical fishery habitats. Take India's Ganges river basin where over half the human population is below the poverty line and where many people rely on freshwater fish as their primary source of protein. Multiple environmental threats have contributed to a huge decline in the Ganges fishery over the last 70 years. Perhaps the biggest decline has been observed in the hilsa fishery, which made up the majority of catch in the Lower Ganges. For example, the hilsa fishery upstream of Farakka crashed from 19 tonnes per year to just 1 tonne per year after the construction of the Farakka barrage in the 1970s, strongly indicating that the barrage had prevented the fish from reaching their spawning grounds²⁹.

Unsustainable fishing pressures – High intensity fishing, destructive fishing practices (e.g., mosquito nets and dynamite fishing), targeting threatened species, and the stocking of invasive non-native species threaten the future of many freshwater fisheries. And overfishing can have devastatingly swift consequences. After a bumper harvest of 64,000 tonnes of salmon in Russia's Amur river in 2016, excessively high quotas led to a catastrophic drop in the country's largest salmon run. In the autumn of 2018, WWF researchers counted an average of 1 chum salmon per 10,000 square feet of river at their spawning grounds, compared to the norm of around 500 fish. In the summer of 2019, the average was 0. This collapse will have far reaching impacts on local communities and the ecosystem as a whole.

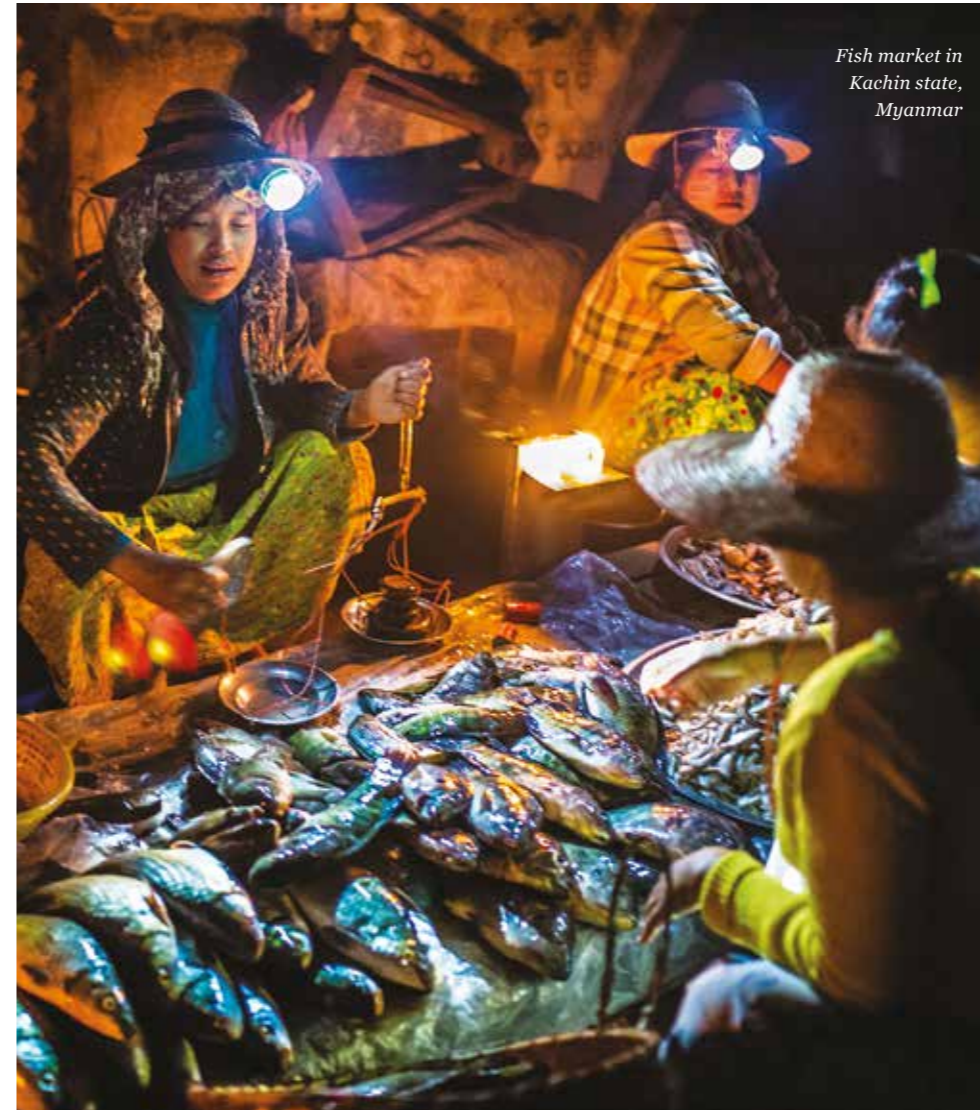
For many of the world, though, freshwater fisheries' relative invisibility means they have been easy to ignore. It's hard to believe, but they aren't mentioned specifically in any of the 169 indicators of the UN Sustainable Development Goals (SDGs) despite the essential role they play in alleviating hunger and poverty for some of the world's poorest people³². Theoretically, freshwater fisheries are included in marine fisheries under SDG 14 (Life under Water) but when it comes to reporting and assessing them, they fall off the map. There is a growing realisation of the essential contribution freshwater fisheries make towards both nutritional and economic security for hundreds of millions of people, but it is far too limited and far too slow. Recognising these gaps, six global organisations formed the Inland Fisheries Alliance in 2021 to raise the profile of freshwater fisheries and catalyse efforts to improve their health and management.

The question now is will decision makers finally start factoring freshwater fisheries – and the hundreds of millions of human mouths they feed – into their equations? And if so, will they do it fast enough to stave off disaster?



FRESHWATER AQUACULTURE RELIES ON HEALTHY WILD POPULATIONS OF FRESHWATER FISHES

Aquaculture constitutes 46 per cent of world fish production – 63 per cent (51 million tonnes)³³ of which is freshwater aquaculture³⁴. With the global population expected to reach 9.8 billion by 2050, humanity's reliance on aquaculture for food security is expected to grow. But aquaculture is not a substitute for wild fisheries. Sustainable fish production from aquaculture relies on healthy and genetically varied brood stock, which is collected from the wild³⁵. Furthermore, millions of people rely on wild populations for subsistence fishing, while for poor families, aquaculture fish are less affordable than wild caught.



Fish market in Kachin state, Myanmar

© Hkun Lat / WWF-Myanmar

DOES RESTOCKING WITH HATCHERY FISH HELP OR HARM DECLINING WILD FISHERIES

When wild freshwater fisheries decline, fisheries managers often aim to enhance populations through the stocking of hatchery-reared fish. Stocking is a widely used fisheries management tool within freshwater ecosystems, especially in Asia and Africa. While no global evaluations have been conducted on whether stocking has increased or maintained any fisheries, there is scientific evidence that releasing live fishes into the wild can have significant negative impacts on wild fish populations by reducing the genetic health of wild fishes that breed with hatchery-produced fish. Stocking also risks ecological health as it may introduce competition, predation and disease to native fishes, as well as result in the establishment of invasive non-native fishes. To overcome the impacts on wild fish populations, countries should develop responsible stocking and hatchery guidelines and policies as well as review their current programmes to safeguard against unintentional harm to freshwater biodiversity.



Figure 5. Threat scores for river basins that support (indicative) freshwater fisheries. Out of the 87 basins assessed, 15 are considered at 'high' threat, and 33 at 'moderate' threat due to pressures from pollution, water use (abstraction), climate variability, land use, loss of riverine connectivity and population density. Taken from FAO, 2020³⁶.

COMMUNITY MANAGEMENT BENEFITS FISH AND PEOPLE: CASE STUDIES FROM ASIA, AFRICA AND THE AMAZON

Evidence of the positive impact from community conservation exists across the world. In Laos, Community Fisheries Conservation Zones boosted the diversity of fishes caught in 32 villages³⁶. One of the keys to their success was that the approach was decided through consensus building with local communities and fishers. This approach was echoed in the Salween River basin in Thailand, where a network of fish sanctuaries across 23 communities resulted in increased fish diversity, density and biomass³⁷. Community conservation has also resulted in positive impacts in Tanzania, where the dagaa fishery in Lake Tanganyika is critically important to the Tongwe/Bende people. Working with The Nature Conservancy, the local community set up nine community Beach Management Units to protect fish breeding and nursery zones, and prevent the use of destructive beach seine nets and other nets with under-sized meshes. “In my heart, I feel hopeful because I have already seen changes,” said Richard Nkayamba, Buhingu Beach Management Unit leader. “In this zone, beach seines are almost completely gone and the high dagaa catch we have seen this season is probably due to the reduced use of beach seines.”

Meanwhile, community management along Brazil’s Juruá River has transformed the arapaima fishery. As an obligate air-breather, the Amazon’s giant arapaima must return to the surface every 20 minutes or so – making them easy to catch. Known as the ‘cod of the Amazon’ overfishing contributed to a severe decline in their numbers, posing a risk to the species and the people who rely upon them. To address this, Juruá River communities embarked on a resource management plan, which resulted in an increase in both the arapaima population and the annual catch – boosting household incomes by US\$1,000 per year and village incomes by a whopping US\$10,000, and proving how critical it is to involve local communities in sustainable fisheries management³⁸. Seeing the impact, the number of communities pursuing this approach has increased from 4 in 1999 to over 2000 now across Brazil, Peru and Guyana.

Fishers in a community conservancy in Laos



Fishing on Lake Edward, Democratic Republic of Congo



SMALL FISH PLAY A GIANT ROLE IN THE HEALTH OF COMMUNITIES IN SUB-SAHARAN AFRICA

Small pelagic (open water) freshwater fishes play a major role in food security and nutrition across sub-Saharan Africa. Yet, these small silver fishes – such as dagaa, kapenta, salanga and usipa – receive much less attention than larger and more economically valuable species. Sometimes called ‘poor man’s fish’ or ‘vitamin fish’, these species are hugely important to many communities. Due to the high reproductive turnover rate of small pelagic fishes, they may be able to reproduce their own biomass five times or more a year³⁹. As species lower on the food chain, daaga might present an example of a ‘balanced harvest’. This is where each level within the food chain is fished proportional to its abundance rather than focusing on large fishes. Alternatively, an unbalanced harvest leads to fishing down the food chain and results in fish catches that gradually consist of smaller and smaller species. Support for what is known as a ‘balanced harvest’ is growing and may be a more sustainable option for humanity.

FISHING FOR FUN... IS BIG BUSINESS

*Angling is one of the world's
favourite pastimes*

Whether the motivation is adventure, challenge or simply rest and relaxation, recreational fishing is often the closest connection many people around the world have with their environment and wild freshwater fishes. Indeed, hundreds of millions of people (including around 90 million anglers in China, 39 million in USA and almost 26 million in Europe) do it every year, casting bait and flies into rivers and lakes in an attempt to lure unsuspecting fish onto their hooks. And they spend vast amounts of money in the process.

Globally, recreational fishing generates over US\$100 billion each year⁴⁰ pumping much-needed cash into local and national economies, and boosting employment. In Europe, recreational fishing supports hundreds of thousands of jobs⁴¹, including 37,000 in England and Wales, providing over US\$1.3 billion to the economy⁴², and 4300 jobs in Scotland, where salmon anglers spend around US\$6,400 per person on average every year⁴³. In the USA, 13 per cent of the population identify as inland recreational anglers⁴⁴, and together they generate around US\$83 billion in economic activity each year and support over 500,000 jobs⁴⁵.

Some of the world's freshwater fishes hold almost mythical status among anglers – such as the African tigerfish or legendary hump-backed mahseer. Some anglers are prepared to travel far and wide to catch these prize fishes contributing to local economies as they do so. For example, the African tigerfish – its mouth bristling with razor-sharp teeth – is the number one target for anglers on the Zambezi River system. In northeast Namibia, it is estimated that up to 70 per cent of tourist lodge revenue comes from anglers hoping to hook a 'tiger' – revenue that is a major source of income for local communities⁴⁶. Maintaining healthy freshwater ecosystems and healthy tigerfish populations directly benefits communities, who rely on this fearsome fish not only for funds but also for food security.

Meanwhile, the hump-backed mahseer – the largest of the iconic mahseer species – has been luring anglers to India's River Cauvery since the 1970s. The income generated from international anglers has supported the transformation of former poachers into angling guides and



“EARLIER OUR GOAL WAS TO KILL THE FISH. BUT AFTER WORKING IN THE ANGLING CAMPS, WE REALISE IT IS BETTER FOR THE COMMUNITY TO KEEP THEM ALIVE. WE SAW THE BENEFIT.”



CHEMBA, ANGLING GUIDE ON INDIA'S CAUVERY RIVER



Bull trout in Roaring River, USA

river guardians, incentivised to protect the mahseer and their lucrative new income stream. But the role of anglers in conserving the hump-backed mahseer goes beyond economics. In 2015, a team of international scientists analysed the detailed catch-log books kept by angling camps, which revealed that the endemic mahseer population was in perilous decline – evidence that supported the formal recognition of the hump-backed mahseer as a separate species and its subsequent classification as Critically Endangered on the IUCN Red List. If it had not been for anglers, this freshwater mega-fish may have gone extinct without ever being recognised as a valid species. Thankfully, there is now an international multi-stakeholder effort to bring the species back from the brink of extinction⁴⁷.

Or take Japan's highly prized miyabe charr, a subspecies endemic to Lake Shikaribetsu. Back in the 1970s, too many anglers and too little management led to a collapse in numbers. Fortunately, this spurred concerted action and numbers of miyabe charr are now healthy again, with anglers flooding in from all over Japan to fish the lake, boosting the local economy and providing a long-term lifeline for the species⁴⁸.

Meanwhile, some communities, like the Rewa community in the Amazon in Guyana, have been capitalising on the presence of the arapaima, the world's largest scaled freshwater fish, to attract tourist dollars by investing in recreational fishing operations. While the jungle giant can grow up to 3m, overfishing and habitat destruction mean that it's now

“From the point of view of a biologist and angler, seeing large predatory fish is a sign that this lake, this river, is healthy. If they're not there, the water is in trouble, and if the water's in trouble, well, I tell you that we are also in big trouble. I've been fishing for over 50 years now... and what has shocked me really is that even in remote places it's very hard to find those fish. The decline of big fish is happening right in front of us, and this is often because of uncontrolled removal of fish, which has a very rapid effect on a healthy river.”

Jeremy Wade, Angler, biologist and TV presenter

rare to find one longer than 2m – but that's still huge enough to make it an irresistible draw for freshwater anglers. And their fees help to sustain communities, protect their heritage, and strengthen the governance, management and conservation of their traditional territories. It is certainly a more sustainable alternative than mercury-laced gold mining or commercial logging⁴⁹.

The angling industry relies on healthy freshwater ecosystems to support thriving populations of fish, from South Africa's yellowfish to Australia's Murray cod and Europe's barbel. Healthy freshwater environments also offer a greater and more diverse fishing challenge – and a relaxing place to fish.

Indeed, a less appreciated benefit of angling is the impact it has on human wellbeing. Just being out in nature, listening to the soothing sounds of water and watching your fishing line bob up and down has been found to alleviate stress. In the USA, angling is used as a rehabilitation therapy by psychologists, counsellors, and physical therapists. The US Veterans Health Administration has adopted fly fishing as a recreational therapy for injured military veterans because it is a calming, repetitive and low-impact way to help them regain strength. In England, angling has been used as an 'added value' social, environmental and therapeutic activity to help to overcome social problems and aid development of disadvantaged young people.

This is not to say that the practice of recreational fishing is all smooth sailing: there are potential risks as well



AS ANGLERS KNOW, FISHING IS BOTH EXHILARATING AND RELAXING, AND IS GREAT FOR THE MIND AND SOUL. ANGLING ALSO BRINGS RESPONSIBILITY AS ANGLERS ARE THE EYES AND EARS OF THE RIVER, AND THE VOICES OF FISHES THEMSELVES. ANGLERS CAN PLAY A FUNDAMENTAL ROLE IN THE CONSERVATION OF FISHES BY IMPLEMENTING BEST PRACTICE: NOT LEAVING GHOST GEAR OR NETS; ENSURING FISH WELFARE IS PRIMARY; USING NON-DESTRUCTIVE BAITS; PRACTISING CATCH AND RELEASE IN THE BEST POSSIBLE WAY; NOT ANGLING FOR CERTAIN SPECIES DURING CLOSED SEASONS; AND NOT CAUSING HARM TO OTHER WILDLIFE. AND BY SUPPORTING FISH CONSERVATION PROJECTS ACROSS THE WORLD.

MARINA GIBSON - ANGLING AMBASSADOR

as benefits. In some places, such as the UK, catch is usually released, whereas elsewhere, like Eastern Europe, Central Asia or China, recreational catch is usually taken to consume. Problems arise when a recreational fishery is poorly managed and can include the introduction of invasive non-native fishes and hatchery fish, poor fish handling and damaging hooks, and litter, in particular discarded fishing nets,

hooks and lines that are a threat to all wildlife. By following best practices, the angling community can reduce these risks and contribute to freshwater conservation. Indeed, anglers are often the first to notice problems in their local rivers and lakes – and are among the most proactive when it comes to doing something about it. Many anglers, such as musician Fergal Sharkey, and angling groups, such as

Trout Unlimited, are powerful voices for conservation. However, anglers as a whole still punch way below their collective weight when it comes to advocating for the future of freshwater fish. Imagine if all the world's anglers – tens of millions of them – cast their voices in support of efforts to reverse the collapse in freshwater fish. They would certainly hook the attention of some key decision makers.



THE WORLD'S MOST POPULAR PETS

Not dogs or cats but freshwater fishes

It's the same picture from the United States to the United Kingdom and beyond: freshwater fish consistently top the polls when it comes to pet numbers. Keeping a home aquarium is a truly global hobby – and one that is also good for our health. Having a fish tank (or visiting an aquarium) has been found to reduce stress, anxiety and blood pressure, and even help us to sleep⁵⁰. Another study found that reduced heart rate and increased feelings of wellbeing correlated with greater fish diversity in aquaria⁵¹. It's certainly not a coincidence that many doctors' and dentists' waiting rooms have an aquarium!

6. THE WORLD'S MOST POPULAR PETS

Needless to say, a major industry has grown up on the back of our passion for pet fish. Today, some 5,300 species of ornamental fish – 90 per cent of which are tropical freshwater species – are traded every year in 125 countries, at a retail value of US\$15-30 billion⁵². Around 30 species dominate the market, the most common are the guppy, neon tetra and molly. Around 90 per cent of traded fish now originate from ones bred in captivity but certain species continue to be harvested from the wild, while captive stocks must be bolstered by wild stocks from time to time to maintain genetic health. Like inland fisheries and angling, this is an industry that needs thriving populations of freshwater fishes in healthy freshwater ecosystems.

However, there are concerns about the impacts of the industry, which can be a pathway for the introduction of invasive non-native species (through poorly managed breeding facilities and pet keepers releasing fish that grow too large for their tanks). The guppy, for example, a diminutive fish originally native to the Lesser Antilles, is now established in at least 69 countries on every continent except Antarctica⁵³. Problems also arise from over-harvesting and destructive harvest techniques in the wild, and high levels of mortality can occur from poor handling and long quarantines⁵⁴. Take Brazil's strikingly attractive, black-and-white striped zebra catfish. Endemic to a small portion of the Xingu river, it was caught and sold at such an unsustainable rate that it was added to Brazil's list of threatened species in 2004 and the government banned its export to give it a chance



© Meredith Kohu / WWF-US

of surviving in the wild. The species is now bred in large quantities in high tech facilities in Asia, but the remaining wild populations are still threatened by poaching and plans to build hydropower dams in the Amazon⁵⁵. Without urgent action, the only living specimens of this catfish will be the ones born and raised in aquaria.

On the other hand, while data are hard to come by, sustainably managed wild fisheries supplying the aquarium trade can provide much-needed incomes in poor communities and an incentive to conserve specific species and their freshwater habitats. Take cardinal tetras. The vivid reds and blues of these gloriously beautiful fish flash through many a home aquarium. Native to the upper Orinoco and Rio Negro in South America, these tiny fish account for an impressive 70 per cent of Brazil's ornamental fish exports – supporting 10,000 jobs and 80 per cent of the economy around the city of Barcelos. Through the Project Piaba initiative⁵⁶,

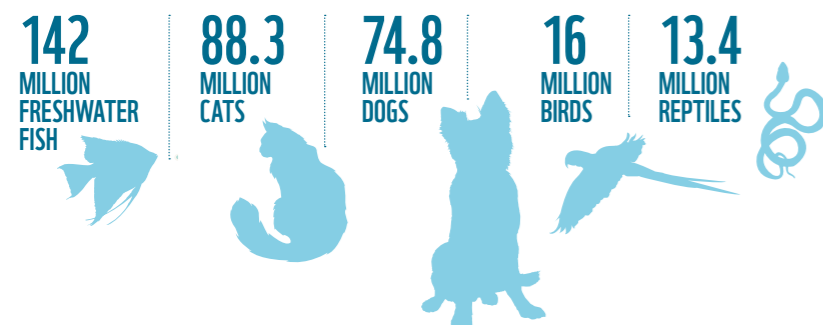
the cardinal tetra trade on the Rio Negro has become a model of sustainability with the local communities catching the fish from the shaded rainforest pools where they gather during the dry season, and spending the rest of the year acting as forest stewards, conserving the ecosystem that sustains the tetras – and their communities and culture.

Another aquarium favourite lives on the other side of the world – the liquorice gouramis. These tiny jewels of South East Asia's peat swamp forests are only beginning to be discovered and understood by science. But their habitat has already shrunk dramatically, primarily due to forest clearance for oil palm expansion, and all of them are now threatened. Thankfully, a collection of aquarists has banded together to launch the *Parosphromenus* Project, which aims to conserve the genus by maintaining a strong ex-situ population of each species. Similar aquarist initiatives are run by the American Killifish Association and the CARES Preservation Program. Sadly, some freshwater fishes now can only be found in captivity. The Mexican Fish Ark in the Hause des Meeres in Vienna, for example, houses the only living examples of Mexico's Extinct in the Wild fishes.

In 2019, a new global initiative, Shoal, was launched to address the freshwater species crisis and halt the extinction of freshwater fishes. As part of its efforts, Shoal provides a platform for millions of freshwater fish enthusiasts to direct their passion towards helping to conserve the wild freshwater origins of their pets. The sooner they all join in, the better.

THE UNITED STATES OF AQUARIA

The US National Pet Owners Survey puts freshwater fish far out in front:



© Alan64 / iStock

HUMANITY'S FRESHWATER HERITAGE

The history of humanity is tied to waterways – and freshwater fish. In what is now France, Paleolithic people carved a spectacular relief sculpture of a salmon on a cave wall – 25,000 years ago! Long after that, our civilisations developed beside rivers and lakes; our cities, towns and villages relying on them for water, food, power, navigation and sanitation. People's lives have long been shaped by the life cycles of fishes and the pulsing flows of the rivers they live in, from traditional fishers on Lake Oguemoué in Gabon to those on the Tonlé Sap in Cambodia, whose lives, livelihoods and cultures are adapted to the seasonality of freshwater fish abundance.

An indelible part of our collective inheritance, freshwaters and the fishes that live in them still remain culturally important to this day. Like mohinga, the fish and noodle soup that is eaten widely across Myanmar. Or carp which are eaten for Christmas in eastern Europe. Or the long list of beers that are named after freshwater fishes, such as Steelhead Extra Pale Ale, Mahseer IPA and Sturgeon beer! Or place names, such as Hilsa (India), Ely (England), Pikesville and Bullhead (United States) and the Nga Phe Monastery (Myanmar).

In some parts of the world entire festivals are held in honour of freshwater fishes. Take England's Ely Eel Festival, which commemorates the town's historic relationship with the European eel from days when eel fishing was the town's main industry. On the other side of the world anguillid eels are also celebrated. In New Zealand, they were long a source of food and income – and also reverence – for Maori communities. They're represented in gatherings, funerals, proverbs, songs, artwork and mythology: by tribal

tradition, they are the most important freshwater fish of all. Still a customary food source for Maori people⁵⁷, the eels also make up a commercially significant freshwater fishery in New Zealand, with annual landings of around 700 tonnes⁵⁸. Meanwhile, a large mythical eel called Abaia is said to protect the other creatures in freshwater lakes across Polynesia. In Cambodia, the national Water Festival marks the annual reversal of the flow of the Tonle Sap river and the flooding of Tonle Sap lake, which transports essential nutrients to the lake and fuels the productivity of its fishery. Dating back to the 12th century, the festival is intimately bound up with the year's fish and rice harvests.

But freshwater fishes permeate our societies far deeper than festivals, foods or place names. In some cultures, they are sacred. As long ago as the 3rd century, the Indian Emperor Ashoka decreed that fishes, including freshwater sharks and eels, should be protected. The first temple sanctuary for fish in India was established nearly 1,200 years ago. Today, the Endangered Himalayan golden mahseer is still revered by local communities in India and Bhutan and protected around temples along several stretches of the Ganges, where devotees come to feed the fish with puffed rice. Fishing is not allowed in these locations, and pilgrims, temple authorities and local communities protect these fishes. In 2008, the Mahseer Trust was established to raise awareness of the mahseers as flagships for river conservation throughout South and Southeast Asia. Despite these efforts all mahseer species are highly threatened by human impacts.

Some freshwater fish even brought salvation – the other common name for the candlefish. This little migratory fish returned to rivers to spawn at the end



of the North Pacific winter, providing vital sustenance to keep indigenous peoples in that part of Canada and USA from starvation. It also had an additional use: the fish was so oily that it could literally be used as a candle. Its oil was also traded – creating the 'grease trails' of British Columbia and southeast Alaska⁵⁹. Nowadays, the salvation fish is threatened by habitat degradation, over-exploitation and pollution – and are in need of salvation themselves.

In addition to food and candles, some communities use freshwater fishes as medicine. This includes freshwater rays and various cichlids in the Amazon basin, where the fat of the trahira is used to treat earaches⁶⁰.

There is no way to do justice to the full cultural importance of freshwater fish in this report. We've showcased just a handful of the countless stories that could be told. Sadly, we are continuing to degrade our rivers, lakes and wetlands and allow both iconic and humble freshwater fishes to slip silently away. Their loss is a loss for all humanity, which will have far reaching consequences for communities and cultures.

Freshwater fishes have swum through our cultures for centuries

FRESHWATER FISH IN FREEFALL

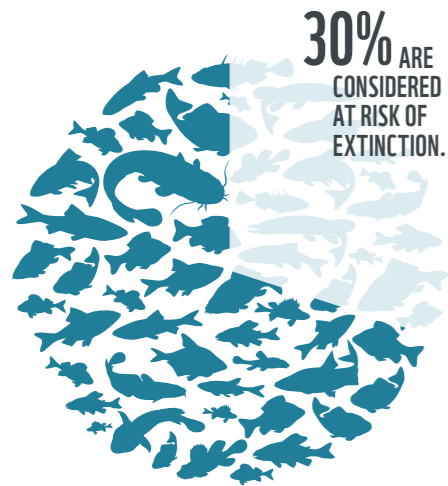
The sharp end of the biodiversity crisis

NOWHERE IS THE WORLD'S BIODIVERSITY CRISIS MORE ACUTE THAN IN FRESHWATER ECOSYSTEMS. AROUND A THIRD OF FRESHWATER FISH SPECIES ARE THREATENED WITH EXTINCTION.



8. FRESHWATER FISH IN FREEFALL

Figure 6: Of the 10,336 (56%) freshwater fishes whose conservation status has been assessed by IUCN, 30% are considered at risk of extinction.



Nowhere is the world's biodiversity crisis more acute than in freshwater ecosystems. Around a third of freshwater fish species are threatened with extinction⁶¹, and 80 species have already been declared Extinct. Populations of migratory fishes – the travellers of the freshwater world, including sturgeon, salmon, hilsa and gilded catfish – have fallen by 76 per cent since 1970⁶². And populations of large iconic fish, the titans of the freshwater world, like the beluga sturgeon and the Mekong giant catfish, have been hit particularly hard,

declining by a catastrophic 94 per cent since 1970⁶³.

The reasons for such precipitous falls are not hard to identify when we look at what's happening to the world's rivers, lakes and wetlands:

- Treating freshwater ecosystems as wasted space:** Undervaluing the diverse benefits of healthy freshwater ecosystems and their riparian habitats paves the way for them to be dammed, drained, dredged, damaged and converted into farmland or paved over – wrecking the habitat of freshwater fishes in the process. For example, floodplains, continue to be disconnected from their rivers and built upon, not only destroying essential fish spawning habitat but also increasing the risk of flooding. Around 35 per cent of wetlands have been lost in the past 50 years⁶⁴ and the rate shows no signs of abating.
- Unnatural river flows:** Decisions about water flows related to hydropower, dams and abstraction are still driven by human needs rather than environmental ones, impacting fishes that have evolved their lifecycles in relation to the seasonal changes in the timing and quantity of flows, including natural flood pulses.
- Chopped up rivers:** Millions of existing barriers from mega-dams to small dams, weirs and culverts fragment rivers across the world, blocking fish migration and disrupting the flow of water, sediments and nutrients. In Europe alone, there are an estimated 1 million river barriers – at least 100,000 of which are obsolete⁶⁵. And more are yet to come. Thousands of new hydropower dams are on the drawing board across the world from the Amazon to the Zambezi, including hundreds in protected areas. Only 1/3rd of long rivers are still free flowing⁶⁶ and many of these are threatened by proposed hydropower projects, as are many of the shorter wild rivers in regions like the Balkans and the Himalayas.

- Flood of pollutants:** From untreated sewage to agricultural run-off, industrial wastewater and mercury from gold mining, pollutants are pouring into rivers, lakes and wetlands, poisoning fishes and fuelling toxic algae blooms. 300-400 million tonnes of pollution are dumped into freshwater ecosystems every year⁶⁷, and over 80 per cent of all wastewater is flushed untreated back into nature⁶⁸.
- Sucking rivers dry:** Poor management has resulted in far too much water being abstracted from river systems, primarily for irrigation. Agriculture uses around 70 per cent of all water abstracted globally⁶⁹ – and this is likely to increase since the world's demand for food is projected to grow by 50 per cent by 2050⁷⁰.
- Dredging up too many fish and too much sand:** Critical natural resources in freshwater ecosystems are being unsustainably plundered in many areas. Overfishing is threatening many species populations, especially when combined with destructive fishing methods, which also threaten the health of the environment. Meanwhile, unregulated and illegal sand mining alters the structure of rivers and deltas, destroying critical habitat, including fish spawning habitat, putting the survival of freshwater – and coastal – fishes at risk.

- Wildlife crime:** While most people believe wildlife crime is all about elephant ivory, tiger bones and rhino horns, poaching and the illegal wildlife trade are grave threats to many freshwater fishes, including sturgeons for illegal wild caviar, European eels, the giants of the Mekong, stingrays and some endangered ornamental species.
- Species invasions:** The intentional and accidental spread of invasive non-native species and diseases are becoming more common, unbalancing freshwater ecosystems and directly threatening native species.
- Our warming world:** Climate change is already making its presence felt, melting glaciers that feed rivers and altering peak river flow events in high mountain regions, changing weather patterns and increasing water temperatures. Freshwater fishes are particularly vulnerable to climate change⁷¹. Many are like polar bears: they have nowhere to go when their part of the world changes.

To compound these issues, freshwater fishes are contending with other threats to biodiversity that we're only just beginning to understand, such as noise, light and microplastics pollution to name a few⁷². There is no silver bullet for these myriad threats, but there are tried and tested solutions. It's time to scale them up.

IUCN RED LIST STATUS	Number of species
Extinct	80
Extinct in the Wild	10
Critically Endangered (presumed extinct)	583 (115)
Endangered	870
Vulnerable	966
Near Threatened	511
Least Concern	5332
Data Deficient	264
Total assessed	10516

Fig 7. Summary of IUCN status of freshwater fishes⁷³



STURGEON: WORLD'S MOST THREATENED FAMILY OF FRESHWATER FISHES

These gentle giants have been around since the age of the dinosaurs, but 23 of the 27 species are now threatened with extinction due to hydropower dams blocking their migration routes along the Yangtze, Danube, Rhine and other rivers, overfishing, poaching for the illegal wild caviar trade, pollution and habitat loss. Indeed, the Chinese paddlefish was declared extinct in 2020. Ongoing developments, including navigation projects, dredging activities and hydropower dams, are increasing the pressure on sturgeon populations in Europe, many of which already depend on reintroduction programmes as a last glimmer of hope.

For hundreds of years, sturgeon have played a major role in local economies, providing food and livelihoods for many – chronicles from the 11th century mention that beluga sturgeon were used to feed hungry troops marching along the Upper Danube. A beluga sturgeon measuring 7.2m was once caught in the Volga river, but few giants are spotted these days. Indeed, few sturgeon of any size are seen in the wild these days. WWF has set up a new global initiative to safeguard these ancient creatures. Hopefully, it will ensure that no sturgeon species follow the Chinese paddlefish to extinction. Because if we can save sturgeons, we will save so much more – helping to revive the rivers they live in for the benefit of people and nature.



GILDED CATFISH: RECORD-BREAKER AT RISK

These silver-gold South American catfish can grow to 2m, but not until they've survived the longest freshwater migration of all fishes, which starts when they spawn high in the foothills of the Andes at the headwaters of the Amazon. The young fish drift and swim 5,800km down to the mouth of the river, where they live for two or three years before tackling the mammoth return leg. Rising waters after the rainy season are the signal for them to head back upstream: one year later they're back in the mountains, ready to breed. But the gilded catfish's astonishing migration can only take place when there are healthy, free-flowing rivers to support it. Hydropower dams are increasingly blocking their way, while deforestation and mining are threatening crucial spawning areas from Colombia to Bolivia. As well as being an important source of food for indigenous people and local communities along the river, this so-called 'goliath catfish' is an indicator of freshwater ecosystem health – and its future survival is in doubt. It's an alarming sign for the whole river system.

800 SPECIES EXTINCT

2020 was a bleak year for freshwater fish. It began with confirmation of the extinction of the iconic Chinese paddlefish, an endemic giant of the Yangtze river and ended with the IUCN Red List for Threatened Species™ announcing the loss of 15 more species in the Philippines. Overall, 80 freshwater fishes have been declared Extinct by IUCN, while 10 more have been declared Extinct in the Wild and 115 are classified as 'Critically Endangered Possibly Extinct'.

LAMPREYS

- Ukrainian migratory lamprey, *Eudontomyzon sp. nov. 'migratory'*. Ukraine, Russia.

STURGEONS AND PADDLEFISHES

- Chinese paddlefish, *Psephurus gladius*. China

ASIAN KNIFEFISHES

- Giant featherback, *Chitala lopis*. Indonesia

CARPS AND MINNOWS

- Beyşehir bleak, *Alburnus akili*. Turkey
- Iznik shemaya, *Alburnus nicaeensis*. Turkey
- Anabarrilius macrolepis*. China
- Pait, *Barbodes amarus*. Philippines
- Barbodes baoulan*. Philippines
- Barbodes clemensi*. Philippines
- Barbodes disa*. Philippines
- Barbodes flavifuscus*. Philippines
- Barbodes herrei*. Philippines
- Barbodes katolo*. Philippines
- Barbodes lanaoensis*. Philippines
- Barbodes manalak*. Philippines
- Bitungu, *Barbodes pachycheilus*. Philippines
- Bitungu, *Barbodes palaemophagus*. Philippines
- Barbodes palata*. Philippines
- Bagangan sa Erungan, *Barbodes resimus*. Philippines
- Barbodes tras*. Philippines

- Bitungu, *Barbodes truncatulus*. Philippines.

- Barbus microbarbis*. Rwanda
- Snake river sucker, *Chasmistes muriei*. USA

- Skadar nase, *Chondrostoma scodrense*. Montenegro

- Yilong carp, *Cyprinus yilongensis*. China

- Mexican dace, *Evarra tlahuacensis*. Mexico

- Mexican dace, *Evarra eigenmanni*. Mexico

- Mexican dace, *Evarra bustamantei*. Mexico

- Thicktail chub, *Gila crassicauda*. USA

- Labeo worthingtoni*. Malawi, Mozambique, Zambia

- Pahrnagat spinedace, *Lepidomeda altivelis*. USA

- Hula bream, *Mirogrex hulensis*. Israel

- Harelip sucker, *Moxostoma lacerum*. USA

- Durango shiner, *Notropis aulidion*. Mexico

- Phantom shiner, *Notropis orca*. Mexico, USA

- Salado shiner, *Notropis saladonis*. Mexico

- Clear Lake splittail, *Pogonichthys ciscoideus*. USA.

- Eğirdir Minnow, *Pseudophoxinus handlirschi*. Turkey

- Las Vegas dace, *Rhinichthys deaconi*. USA

- Danube Delta gudgeon, *Romanogobio antipain*. Romania, Ukraine

- Schizothorax saltans*. Kazakstán

- Stump-tooth minnow, *Stypodon signifier*. Mexico

- Ukliva dace, *Telestes ukliva*. Croatia

CATFISHES

- Scioto madtom, *Noturus trautmani*. USA

- Siamese flat-barbelled catfish, *Platyptropius siamensis*. Thailand

SALMON, TROUT AND CHARR

- Longjaw ciscoe, *Coregonus alpenae*. Canada, USA

- Coregonus bezoulet*. France

- Féra, *Coregonus fera*. Switzerland

- Kilch, *Coregonus gutturosus*. Austria, Germany, Switzerland

- Gravenchi, *Coregonus hiemalis*. Switzerland

- Deepwater ciscoe, *Coregonus johanna*. Canada, USA

- Blackfin ciscoe, *Coregonus nigripinnis*. Canada, USA

- Houting, *Coregonus oxyrinchus*. Belgium, France, Germany, Netherlands, UK

- Férit, *Coregonus restrictus*. Switzerland

- New Zealand grayling, *Prototroctes oxyrinchus*. New Zealand

- Lake Sidi Ali trout, *Salmo pallaryi*. Morocco

- Silver trout, *Salvelinus agassizii*. USA

- Jaunet, *Salvelinus neocomensis*. Switzerland

- Tiefseesäibling, *Salvelinus profundus*. Austria, Germany, Switzerland

CICHLIDS

- Ptychochromis onilahi*. Madagascar

- Tristramella intermedia*. Israel

- Tristramella magdelainae*. Syria

- Long jaw tristramella, *Tristramella sacra*. Israel

SILVERSIDES

- Cunning silverside, *Atherinella callida*. Mexico

TOOTH-CARPS

- Gölcük killifish, *Aphanius splendens*. Turkey

- Aplocheilichthys sp. nov. 'Naivasha'*. Kenya

- Parras characodon, *Characodon garmani*. Mexico

- Santa Cruz pupfish, *Cyprinodon arcuatus*. USA

- Villa Lopez pupfish, *Cyprinodon ceciliae*. Mexico

- Charco azul pupfish, *Cyprinodon inmemoriam*. Mexico

- Ash Meadows poolfish, *Empetrichthys merriami*. USA

- Whiteline topminnow, *Fundulus albolineatus*. USA

- Amistad gambusia, *Gambusia amistadensis*. USA

- San Marcos gambusia, *Gambusia georgei*. USA

- Catarina pupfish, *Megupsilon aporus*. Mexico

- Pantanodon madagascariensis*. Madagascar

PERCH-LIKE FISHES

- Maryland darter, *Etheostoma sellare*. USA

STICKLEBACKS

- Techirghiol stickleback, *Gasterosteus crenobiontus*. Romania

- GOBIES

- Utah Lake sculpin, *Cottus echinatus*. USA

EXTINCT IN THE WILD

CARPS AND MINNOWS

- Ameca shiner, *Notropis amecae*. Mexico

SALMON, TROUT AND CHARR

- Kunimasu, *Oncorhynchus kawamurae*. Japan
- Inconnu, *Stenodus leucichthys*. Caspian Sea

TOOTH-CARPS

- Banded allotoca, *Allotoca goslinei*. Mexico

- Perrito de Potosí, *Cyprinodon alvarezi*. Mexico

- La Palma pupfish, *Cyprinodon longidorsalis*. Mexico

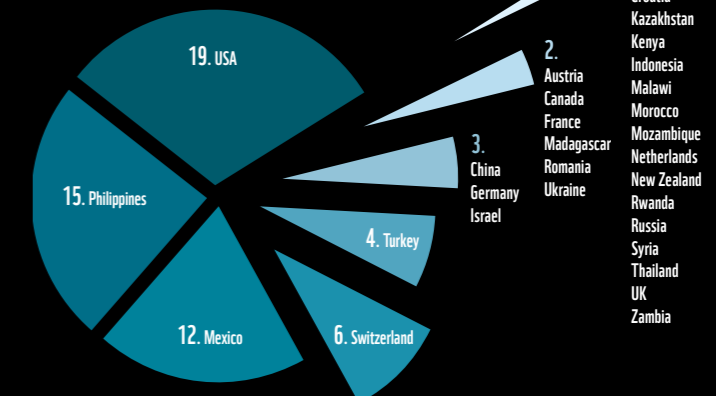
- Charco palma pupfish, *Cyprinodon veronicae*. Mexico

- Golden skiffa, *Skiffia francesae*. Mexico

- Monterrey platyfish, *Xiphophorus couchianus*. Mexico

- Marbled swordtail, *Xiphophorus meyeri*. Mexico

STATES OF EXTINCTION



A BRIGHTER FUTURE FOR FRESHWATER FISHES

Emergency Recovery Plan for freshwater biodiversity

In 2021, governments may have their last chance to chart a new course that could reverse the loss of nature and put the world back onto a sustainable path. Countries have to seize the opportunity and agree on an ambitious and implementable new framework to tackle the loss of habitats and species at the conference of the Convention of Biological Diversity – a framework that must, for the first time, pay just as much attention to protecting and restoring our freshwater life support systems as the world's forests and oceans.



If we do, we will bring life back to our dying rivers, lakes and wetlands. And we will bring freshwater fishes back from the brink too – securing food and jobs for hundreds of millions of people, safeguarding cultural icons and our favourite pets, ensuring prey for threatened predators from river dolphins to fishing cats, and further enhancing the health of the freshwater ecosystems that underpin our societies and economies.

And we don't need to conjure up a magical silver bullet or some innovative new solution. We know what works and what needs to be done. A blueprint has already been developed: it's in the 5th Global Biodiversity Outlook (GBO5), which was the result of a collective effort from the conservation community, including parties to the Convention on Biological Diversity, other governments, observers and a host of global experts. Echoing the Emergency Recovery Plan for freshwater biodiversity, GBO5 outlines the pathway for a sustainable freshwater transition.

This freshwater transition is a realistic and pragmatic one, based on measures that have already been tried and tested in at least some rivers, lakes and wetlands. It is a comprehensive plan that moves us away from today's ad hoc conservation successes towards a

strategic approach that can deliver solutions at the scale necessary to reverse the collapse in biodiversity – and set us on course to a future where our freshwater ecosystems are once again fully healthy and teeming with freshwater fishes and other wildlife.

The transition calls for rapid measures to be implemented globally to let rivers flow more naturally, protect and restore critical habitats and species, and reduce pollution levels. It outlines the need to control the spread of invasive non-native aquatic species and end overfishing, destructive fishing and unsustainable sand mining.

And these measures really do work. Take the example of dam removals: since the dams on America's Penobscot river were pulled down allowing fish to migrate up from the sea once again, river herring numbers have skyrocketed from a few thousand to over 2.8 million! Or the Cambodian governments decision not to build mega hydropower dams on the Mekong, which will help protect vital freshwater fisheries. Or securing international protection for Colombia's entire Bitá River under the Ramsar Convention. So, what specifically needs to be done?

COMMIT

Governments must agree to ambitious targets for 2030, which will safeguard freshwater ecosystems and the future of freshwater fishes and other species, in the new global framework on nature that will be agreed at the 2021 CBD conference – building on the freshwater transition outlined in the 5th Global Biodiversity Outlook. But agreeing an ambitious agenda for the next decade is not enough: countries must commit to implementing the solutions that will achieve the targets they have set. We have learnt our lessons with the Paris Agreement, the Sustainable Development Goals (SDGs) and the failure to achieve the previous Aichi targets under the CBD: this time we need more action and less talk, more effort and less excuses. And remember, it is possible to have global commitments that are actually implemented; we only need to look at the Montreal Protocol and how effective it has been in protecting the ozone layer.

Implementing the new biodiversity agenda also needs to move beyond the realm of conservation. Governments must incorporate specific new targets into the Sustainable Development Goals for freshwater fishes, which are almost entirely absent from the current 169 SDG indicators despite their obvious links to poverty (SDG1), hunger (SDG2), responsible consumption and production (SDG 12), and life under water (SDG14) and on land (SDG 15). This will be crucial if governments truly are committed to delivering the ambitious agenda.

PRIORITIZE

However much we would like to, there is no way to protect and restore all the world's rivers, lakes and wetlands: there will need to be trade-offs. This will involve hard decisions, particularly in the short to medium term as countries begin to implement their economic recovery strategies from the Covid-19 pandemic. We will need a delicate balancing act to ensure that these strategies do not put us on a path towards further loss. Countries will need to prioritize – basing their decisions on the values of their most important freshwater ecosystems, including healthy freshwater fisheries, and their potential contribution to fulfilling their commitments under the SDGs, CBD and the Paris Agreement on climate change.

But conservation organizations also need to prioritize. To save freshwater fishes, we need to rally behind the GBO's Sustainable Freshwater Transition and the Emergency Recovery Plan for freshwater biodiversity. We need to speak with one voice so that governments, businesses, cities and communities are clear about what needs to be done. And then we need to prioritize programmes and activities that help governments to achieve the new targets that they will set.

PARTNER AND INNOVATE

While the solutions exist, real progress towards halting the loss of freshwater fishes and ensuring healthier freshwater ecosystems will only be achieved through collective action involving governments, businesses, investors, NGOs and communities. Corporate water stewardship provides an opportunity to explore partnerships and creates a space for the private sector to come on board as a key partner to improve the health of freshwater ecosystems, while financial institutions can invest in innovative financial solutions, like bankable projects, that can strengthen resilience and generate returns.

VALUE FRESHWATER FISHES

Last but not least, it's time to pay attention to the fact that there are 18,075 species of freshwater fishes – and how important they are to people and nature. They have been forgotten for far too long, despite swimming through our cultures and feeding people for millennia. They might be out-of-sight below the surface of our rivers, lakes and wetlands but it's time to look at the critical role they play in societies, economies and ecosystems. And it's time to factor them into all development decisions about rivers, lakes and wetlands.

Reversing decades of decline will be difficult, but we know what needs to be done. All the organizations involved in this report are fully committed to ensuring a brighter future for the world's freshwater fishes because that will mean a brighter, sustainable future for people and nature. We hope you will join us.

ENSURING A BRIGHTER FUTURE FOR THE WORLD'S FRESHWATER FISHES...WILL MEAN A BRIGHTER FUTURE FOR PEOPLE AND NATURE.



FOOTNOTES

1 Fricke R, Eschmeyer WN & Van der Laan R (eds). Eschmeyer’s Catalog of Fishes: Genera, Species, References. <http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp>. Electronic version accessed 3rd February 2021.

2 The largest beluga sturgeon recorded was from the Volga estuary in 1827 and was 7.2 m in length and weighed 1571 kg. From: Wood GL (1983) The Guinness Book of Animal Facts and Feats. Sterling Pub Co Inc. ISBN 978-0-85112-235-9.

3 Barthem R, Goulding M, Leite R *et al.* (2017) Goliath catfish spawning in the far western Amazon confirmed by the distribution of mature adults, drifting larvae and migrating juveniles. Scientific Reports, Volume 7, Article number: 41784. <https://doi.org/10.1038/srep41784>

4 Deinet S, Scott-Gatty K, Rotton H, Twardek WM, Marconi V, McClrae L, Baumgartner, LJ, Brink K, Claussen JE, Cooke SJ, Darwall W, Eriksson BK, Garcia de Leaniz C, Hogan Z, Royte J, Silva LGM, Thieme ML, Tickner D, Waldman J, Wanningen H, Weyl OLF and Berkhuysen A (2020) The Living Planet Index (LPI) for migratory freshwater fish - Technical Report. World Fish Migration Foundation, The Netherlands.

5 He F, Zarfl C, Bremerich V, David JNW, Hogan Z, Kalinkat G, Tockner K, Jähnig SC (2019) The global decline of freshwater megafauna. Global Change Biology, Volume 25, Issue 11, pp 3883-3892.

6 Tickner D, Opperman J, Abell R, Acreman M, Arthington A, Bunn S, Cooke S, Dalton, J, Darwall W, Harrison I, Edwards, Hughes K, Jones T, Leclère D, Lynch AJ, Leonard P, McClain M, Murruven D, Olden J, Ormerod S, Robinson J, Tharme RE, Thieme M, Tockner K, Wright M and Young L (2020) Bending the curve of global freshwater biodiversity loss – an emergency recovery plan. Bio-Science, Volume 70, Issue 4, pp 330–342.

7 Ormerod SJ (2003) Current issues with fish and fisheries: editor’s overview and introduction. *Journal of Applied Ecology*. Volume 40, Issue 2, pp 204-213. <https://doi.org/10.1046/j.1365-2664.2003.00824.x>.

8 Brown C (2001) Familiarity with the test environment improves escape responses in the crimson spotted rainbowfish, *Melanotaenia duboulayi*. Animal Cognition, Volume 4, pp 109–113.

9 Wong MLY and Balshine S (2020) The evolution of cooperative breeding in the African cichlid fish, *Neolamprologus pulcher*. Biological Reviews, Volume 86, Issue 2, pp 511-30.

10 Britz R, Dahanukar N, Anoop VK, Philip S, Clark B, Raghavan R and Rüber L (2020) Aenigmachannidae, a new family of snakehead fishes (Teleostei: Channoidei) from subterranean waters of

South India. Scientific Reports, Volume 10, Article number: 16081.

11 Jézéquel C, Tedesco PA, Bigorne R *et al.* (2020) A database of freshwater fish species of the Amazon Basin. Scientific Data, Volume 7, Issue 96. <https://doi.org/10.1038/s41597-020-0436-4>.

12 Reis RE, Albert JS, Di Dario F, Mincarone MM, Petry P and Rocha LA (2016) Fish biodiversity and conservation in South America. *Journal of Fish Biology*, Volume 89, pp 12–47.

13 Nelson, JS (2006) Fishes of the World. John Wiley & Sons, Inc. <ISBN 978-0-471-25031-9>.

14 See reference 7

15 Anderson JT, Saldaña Rojas JS and Flecker AS (2009) High-quality seed dispersal by fruit-eating fishes in Amazonian floodplain habitats. *Oecologia* Volume 161, Issue 2, pp 279-290.

16 Opperman J, Orr S, Baleta, H, Dailey M, Garrick D, Goichot M, McCoy A, Morgan A, Turley L and Vermeulen A (2018) Valuing Rivers: How the diverse benefits of healthy rivers underpin economies. WWF, Switzerland.

17 Ramsar Convention on Wetlands (2018) Global Wetland Outlook: State of the World’s Wetlands and their Services to People. Gland, Switzerland: Ramsar Convention Secretariat.

18 Grill G, Lehner B, Thieme M *et al.* (2019) Mapping the world’s free-flowing rivers. *Nature*, Volume 569, pp 215–221. <https://doi.org/10.1038/s41586-019-1111-9>.

19 European Environment Agency (2018) European waters - assessment of status and pressures. Report No 7/2018. ISBN 978-92-9213-947-6.

20 FAO (2020) The State of World Fisheries and Aquaculture. Sustainability in Action. Rome. <https://doi.org/10.4060/ca9229en>.

21 See reference 20.

22 Funge-Smith S and Bennett A (2019) A fresh look at inland fisheries and their role in food security and livelihoods. *Fish and Fisheries*, Volume 20, Issue 6, pp 1176-1195.

23 Breuil, C and Grima D (2014) Baseline Report Tanzania. SmartFish Programme of the Indian Ocean Commission, Fisheries Management FAO component, Ebene, Mauritius.

24 See reference 20.

25 Funge-Smith (2018) Review of the State of World Fishery Resources: Inland Fisheries. FAO Fisheries and Aquaculture Circular No. C942 Rev.3, Rome. ISBN 978-92-5-130793-9.

26 Ainsworth R, Cowx IG and Funge-Smith SJ (2021) A review of major river basins and large lakes relevant to inland fisheries. FAO Fisheries and Aquaculture Circular No. 1170. Rome, FAO. Rome, FAO. <https://doi.org/10.4060/cb2827en>.

27 See reference 26.

28 Pittock J, Dumesque D and Orr S (2017) The Mekong River: trading off hydropower, fish, and food. *Regional Environmental Change*, Volume 17, pp 2443–2453.

29 Chandra R (1994). Some endangered, vulnerable and rare miscellaneous fishes of the Ganga River System: *Hilsa ilisha* and *Setipinna phasa*. Barrackpore, India, Central Inland Capture Fisheries Resource Institute. pp 7-11.

30 See reference 20.

31 McIntyre PB, Reidy Liemann CA and Revenga C (2016) Linking freshwater fishery management to global food security and biodiversity conservation. *PNAS*, Volume 113, Issue 45, pp 12880-12885.

32 Lynch AJ, Elliott V, Phang SC *et al* (2020) Inland fish and fisheries integral to achieving the Sustainable Development Goals. *Nature Sustainability*, Volume 3, pp 579–587. <https://doi.org/10.1038/s41893-020-0517-6>.

33 47 million tonnes of which is finfish (as opposed to crustaceans and molluscs).

34 See reference 20.

35 FAO (2019) The State of the World’s Aquatic Genetic Resources for Food and Agriculture. FAO Commission on Genetic Resources for Food and Agriculture assessments. Rome.

36 Botorac D, Santos P, Phouvin P and Guegan F (2020) Freshwater fisheries conservation can increase biodiversity. *Plos One* <https://doi.org/10.1371/journal.pone.0233775>.

37 Koning AA, Martin Perales K, Fluet-Chouinard E & McIntyre PB (2020) A network of grassroots reserves protects tropical river fish diversity. *Nature*, Volume 588, pp 631–635. <https://doi.org/10.1038/s41586-020-2944-y>.

38 Campos-Silva J & Peres, C. Community-based management induces rapid recovery of a high-value tropical freshwater fishery. *Science Reports* 6, 34745. <https://doi.org/10.1038/srep34745>

39 Kolding J, van Zwieten P, Marttin F, Funge-Smith S & Poulain F (2019) Freshwater small pelagic fish and their fisheries in the major African lakes and reservoirs in relation to food security and nutrition. FAO Fisheries and Aquaculture Technical Paper No. 642. Rome, FAO.

40 Direct value estimated at around \$44 billion per year and indirect value at over \$100 billion per year. See reference 22.

41 <https://www.eaa-europe.org/about-eaa/ea-brochure.html>

42 Mawle GW & Peirson G (2009) Economic evaluation of inland Fisheries. Environment Agency. ISBN: 978-1-84432-975-5

43 An Analysis of the Value of Wild Fisheries in Scotland, Marine Scotland (2017): H:\1407\10ScotGov\Rep\Final\FINAL PACEC report on value of wild fisheries 3rd final.docx

44 RBFF (Recreational Boating & Fishing Foundation). 2019. 2019 Special report on fishing. Alexandria, VA

45 ASA (American Sportfishing Association). 2018. Sportfishing in America: an economic force for conservation. Alexandria, VA.

46 Tweddle D, Cowx IG, Peel RA & Weyl OLF (2015) Challenges in fisheries management in the Zambezi, one of the great rivers of Africa. *Fisheries Ecology and Management*, Volume 22, Issue 1, pp99-111.

47 Pinder AC, Raghavan R & Britton JR (2020) From scientific obscurity to conservation priority: Research on angler catch rates is the catalyst for saving the hump-backed mahseer, *Tor remadevii*, from extinction. *Aquatic Conservation: Marine and Freshwater Ecosystems*, Volume 30, Issue 9, pp1809-1815.

48 Yoshiyama T, Tsuboi Ji & Matsuishi T (2017) Recreational fishery as a conservation tool for endemic Dolly Varden, *Salvelinus malma miyabei*, in Lake Shikaribetsu, Japan. *Fisheries Science* 83, pp171–180. <https://doi.org/10.1007/s12562-016-1051-3>.

49 Lynch A, Beard D & Cox A *et al* (2016) Drivers and Synergies in the Management of Inland Fisheries: Searching for Sustainable Solutions. In: *Freshwater, Fish and the Future: Proceedings of the Global Cross-Sectoral Conference*. Eds: Taylor WW, Bartley DM & Goddard CI *et al*. ISBN-13: 978-92-5-109263-7.

50 Clements H, Valentin S, Jenkins N, Rankin J, Baker JS, Gee N, *et al.* (2019) The effects of interacting with fish in aquariums on human health and well-being: A systematic review. *PLoS ONE* 14(7): e0220524. <https://doi.org/10.1371/journal.pone.0220524>.

51 Cracknell D, White MP, Pahl S, Nichols WJ & Depledge MH (2016) Marine Biota and Psychological Well-Being: A Preliminary Examination of Dose–Response Effects in an Aquarium Setting. *Environment and Behaviour* Volume 48, Issue 10, pp 1242–1269.

52 Evers H, Pinnegar JK & Taylor M (2019) Where are they all from? – sources and sustainability in the ornamental freshwater fish trade. *Fish Biology*, Volume 94, Issue 6, pp 909-916.

53 Deacon AE, Ramnarine IW & Magurran AE (2011) How Reproductive Ecology Contributes to the Spread of a Globally Invasive Fish. *Plos One*, Volume 6, Issue 9. <https://doi.org/10.1371/journal.pone.0024416>.

54 Dey VK (2016) The global trade in ornamental fish. *Infofish International*, Volume 4, pp 52– 55.

55 See reference 52.

56 <https://projectpiaba.org>

57 Noble M, Duncan P, Perry D, Prosper K, Rose D, Schnierer S, Tipa G, Williams E, Woods R & Pittock J (2016) Culturally

significant fisheries: keystones for management of freshwater social-ecological systems. *Ecology and Society*, Volume 21, Issue 2. <http://dx.doi.org/10.5751/ES-08353-210222>.

58 Shortland T & Tipene-Thomas J (2019) Inventory of Iwi And Hapu Eel Research. Fisheries New Zealand. ISBN 978-1-98-859449-1.

59 Pochardt M, Allen JM, Hart T *et al* (2019) Environmental DNA facilitates accurate, inexpensive, and multiyear population estimates of millions of anadromous fish. *Molecular Ecology Resources*, Volume 20, Issue 2, pp 457-467.

60 Begossi A, Hanazaki N and Ramos RM (2004) Food chain and the reason for fish taboos among Amazonian and Atlantic Forest fishers (Brazil). *Ecological Applications*, Volume 14, Issue 5, pp 1334-1343.

61 The IUCN Red List of Threatened Species™. Version 2020-3. <https://www.iucnredlist.org>. Accessed 22nd January 2021.

™ The IUCN Red List of Threatened Species is a trademark of IUCN, International Union for Conservation of Nature and Natural Resources.

62 Deinet, S, Scott-Gatty K, Rotton H *et al* (2020) The Living Planet Index for migratory freshwater fish - Technical Report. World Fish Migration Foundation, The Netherlands.

63 He F, Zarfl C, Bremerich V *et al.* (2019) The global decline of freshwater megafauna. *Global Change Biology*, Volume 25, Issue 11, pp 3883-3892. <https://doi.org/10.1111/gcb.14753>.

64 See reference 17

65 <https://amber.international/>.

66 See reference 18

67 IPBES (2019) Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. ES Brondizio, J Settele, S Díaz & HT Ngo (eds). IPBES secretariat, Bonn, Germany.

68 WWAP United Nations World Water Assessment Programme (2017). The United Nations World Water Development Report Wastewater, The Untapped Resource. Paris, UNESCO.

69 FAO (2020) The State of Food and Agriculture 2020. Overcoming water challenges in agriculture. Rome.

70 FAO (2017) The future of food and agriculture – Trends and challenges. Rome.

71 Poff L, Olden J & Strayer D (2012) Climate Change and Freshwater Fauna Extinction Risk. In: Hannah L. (eds) *Saving a Million Species*. Island Press/Center for Resource Economics. https://doi.org/10.5822/978-1-61091-182-5_17.

72 Reid J, Carlson AK, Creed IF, Eliason EJ, Gell PA, Johnson PTJ, Kidd KA, MacCormack TJ, Olden JD, Ormerod SJ, Smol JP, Taylor WW, Tockner K, Vermaire JC, Dudgeon D, Cooke SJ (2018) Emerging threats and persistent conservation challenges for freshwater biodiversity. *Biological Reviews*. Volume 94, issue 3 pp 849-873.

73 See reference 61

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Scientific names of freshwater fishes in the report

Page 8
 Angelfish
 Beluga sturgeon
 Gilded catfish

genus
Pterophyllum
Huso huso
Brachyplatystoma rousseauxii

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 Archerfish
 Cardinal tetra
 Crimson spotted rainbowfish
 Cuckoo catfish
 Daffodil cichlid
 Denison barb
 Dog-eating catfish
 Elephantfishes
 Giant catfish
 Giant freshwater stingray
 Giant barb
 Leaffishes
 Minnow
 Siamese fighting fish
 Spraying characin

Toxotes
Paracheirodon axelrodi
Melanotaenia duboulayi
Synodontis multipunctatus
Neolamprologus pulcher
Sahyadria denisonii
Pangasius sanitwongsei
 Mormyridae
Pangasianodon gigas
Himanturachaophraya
Catlocarpio siamensis
 Polycentridae
Paedocypris progenetica
Betta
Copella arnoldi

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 Irrawaddy river shark
 Borneo river shark
 New Guinea river shark
 Ganges river shark

Glyphis glyphis
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Glyphis fowlerae
Glyphis garricki
Glyphis gangeticus

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 Birchir
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Amia calva
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Dipnoi
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Hilsa ilisha

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 Community fisheries box
 Arapaima

Arapaima gigas

Page 27
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 Hump-backed mahseer

Hydrocynus vittatus
Tor remadevii

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 Murray cod
 Yellowfish

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 Molly
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Poecilia reticulata
Parosphromenus
Poecilia gillii
Paracheirodon innesi
Hypancistrus zebra

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 Candlefish
 Golden mahseer
 Trahira

Thaleichthys pacificu
Tor putitora
Hoplias malabaricus

Page 39
 Gilded catfish box
 Gilded catfish

Brachyplatystoma rousseauxii

Page 40
 Chinese paddlefish

Psephurus gladius



%

FRESHWATER
FISHES
ACCOUNT
FOR 51% OF
ALL FISH
SPECIES



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