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THE MEKONG'S FORGOTTEN FISHES

...AND THE EMERGENCY RECOVERY PLAN TO SAVE THEM

CONSERVATION INTERNATIONAL

FISHBIO

InFish

IUCN SSC

ASAP ASIAN SPECIES ACTION PARTNERSHIP

FFSG Freshwater Fish Specialist Group

IWMI International Water Management Institute

MCI Mekong Community Institute

Mandai NATURE

re:wild

Shoal

SYNCHRONICITY EARTH

The Nature Conservancy

WorldFish

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Suggested citation:
Hughes, K (2024) The Mekong's Forgotten Fishes and the Emergency Recovery Plan to save them. WWF, Gland, Switzerland

Author: Kathy Hughes

WWF would like to thank USAID Wonders of the Mekong for their support and for funding this report. We would also like to thank all those that have been involved in discussions about this report.

In particular, we would like to thank the following experts for their contributions: Chavalit Vidthayanon, Sinsamout Onboundisane, Zeb Hogan, Harmony Patricio, Khemaksone Phetpasak, Will Duckworth, Viet Hoang, Ian Harrison, Somany Phay, Nerissa Chao, Peng Bun Ngor, Teerapong Pomun, Matthew McCartney, Binh Nguyen Thai, Rupert Collins, Yanyong Srijaroen, Eddie Allison, Camille Coudrat, Michele Thieme, Sui Phang, Catherine Sayer and Marc Goichot.

Finally, we would like to thank Zeb Hogan, Matt Ford, Chavalit Vidthayanon and Paul Loiselle for providing images of the wonderful fishes of the Mekong.

This report was funded through the USAID's 'Wonders of the Mekong' Cooperative Agreement No: AID-OAA-A-16-00057

Supporting organizations:

Association Anoulak

Cambodian Fisheries Administration

Conservation International

FISHBIO

Global Water Center

International Water Management Institute

Inland Fisheries Alliance

InFish

IUCN

IUCN SSC Asian Species Action Partnership (ASAP)

IUCN SSC Freshwater Fish Specialist Group

Living Rivers Siam Association

Mandai Nature

Mekong Community Institute

Re:Wild

Royal University of Agriculture, Cambodia

SHOAL

Synchronicity Earth

The Nature Conservancy

University of Nevada

USAID

Wonders of the Mekong

World Fish Migration Foundation

WorldFish

WWT

Publishing office: WWF International

Cover photography © Elizabeth Everest / Wonders of the Mekong

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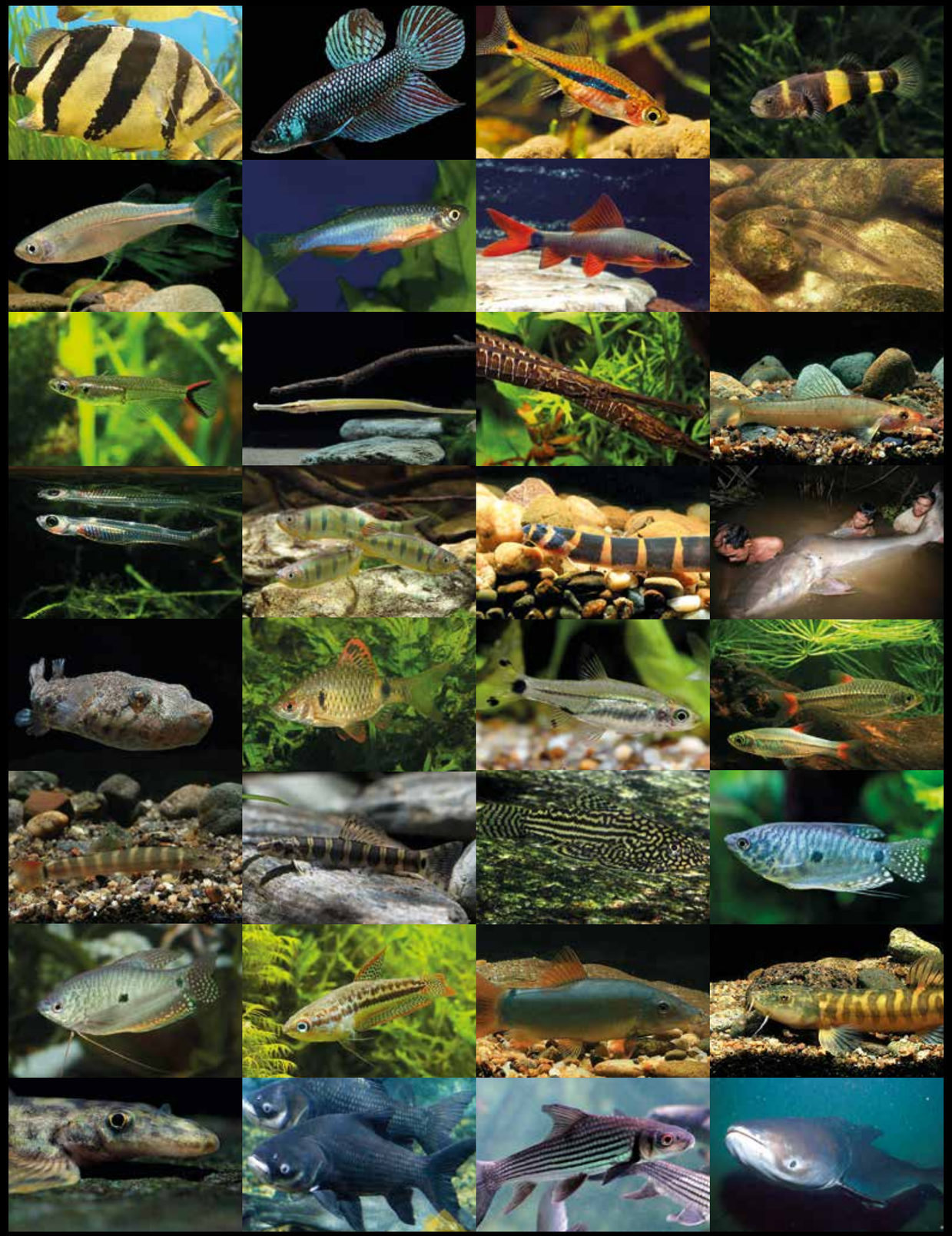
CONTENTS



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FOREWORD

We are at a watershed moment for the Mekong region.

Everywhere we look, we see the worsening impacts of the interlinked climate and nature crises. Our governments are ramping up efforts to fulfill their commitments under the Paris Climate Agreement and the Kunming-Montreal Global Biodiversity Framework and deliver sustainable development. Indeed, there has never been more awareness of – and focus on solving – the pressing environmental challenges we face across the Mekong region.

But there's one glaring exception that seems to have slipped under the decision-making radar: the Mekong's overlooked and undervalued fishes.

Needless to say, the Mekong's fishes have never been forgotten by the millions of people who live along the banks of our mighty river. Their daily lives, food security and livelihoods are deeply entwined with the dazzling diversity of fish in the Mekong – as they have been for millennia. They know the importance of these fishes to their communities and cultures – and to their hopes of a sustainable and prosperous future. These communities are often at the forefront of protecting the Mekong's fishes.

Despite their importance to the wellbeing of our societies and economies, and the overall health of the river, these fishes are often forgotten when decisions about the basin are being made. This is why political and business leaders should read this report. The sheer number of species is reason enough. With 1,148 recognised fish species, the Mekong is the 3rd most species-rich river after the vastly larger Amazon and Congo river basins. This unfathomable diversity includes stingrays the size of cars and minnows that are smaller than your thumb, fish that 'walk' and fish that 'talk', pufferfish and pipefish, and the iconic Mekong giant catfish and giant barb. A quarter of them exist nowhere else on Earth. The Mekong is also home to what is possibly the largest animal migration on the planet, with estimates of around five billion individual fish on the move each year.

Need another reason? This wealth of fishes sustains the largest inland fishery on Earth – a multi-billion dollar industry, which at least 40 million people in the Lower Mekong depend on for food and livelihoods. It is also the foundation of Viet Nam's booming aquaculture industry and potentially lucrative aquarium and ecotourism sectors. And, of course, all these fishes support food webs that sustain Critically Endangered river dolphins and Siamese crocodiles as well as birds and giant turtles.

And the final reason? Thriving fish populations play a foundational role in the health of the Mekong river and its connected ecosystems – ecosystems that provide essential and irreplaceable benefits to people across the region.

Sadly, the Mekong's fishes are in serious trouble. Nearly a fifth are threatened with extinction. Commercial fish catches have declined, while fish populations in Cambodia's Tonle Sap Lake collapsed by 88 per cent in the first two decades of this century. The river's iconic giant fishes are now very rarely seen – if at all. And there's no mystery over why Mekong fish numbers are falling so precipitously: poorly planned hydropower dams, habitat loss, sand mining, pollution, and climate change are among the factors pushing populations to the brink.

Clearly, this can't continue. We cannot afford to lose the Mekong's fishes. We must act, and we must do it urgently because if we leave it much longer, it'll be too late. And the good news is that solutions exist. Countries can join the ambitious Freshwater Challenge – the largest freshwater restoration and protection initiative in history. Governments can implement measures outlined in the science-based Emergency Recovery Plan for freshwater biodiversity. And we can all learn from the knowledge and experience of local communities and collaborate to scale up their solutions – such as Fish Conservation Zones, which have been proven to benefit both fishes and fishers.

So while this report by 26 partner organizations and institutions is definitely intended to be a wake-up call, it is not just a litany of doom and gloom. It is a story of hope because we can still chart a course for a brighter future for the Mekong River – and for all the people and nature that depend on it. Now is the time to factor the fishes of the Mekong into decisions about the basin because they are irreplaceable – for our communities, cities and countries. And for the health of the mighty Mekong, which sustains us all.

I hope you enjoy this celebration of the Mekong's extraordinary fishes. And when you finish, I think you'll agree that we must – and that, together, we can – ensure they survive and thrive.

Lan Mercado

WWF Asia-Pacific Director

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EXECUTIVE SUMMARY

The fishes of the Mekong are not forgotten by the people that live along its banks, whose lives and livelihoods are interwoven with the river and the fish beneath its surface.

But that's not always the case and the Mekong's fishes often remain out of sight and out of mind, especially when it comes to big decisions about the basin. This report sets out why the diverse fishes of the Mekong matter so much, what we'll lose if important regional decisions continue to exclude them, and how adopting a six-point Freshwater Emergency Recovery Plan will lead to a better future for this mighty river and the hundreds of millions of people it supports and nourishes.

Healthy freshwater ecosystems are essential to sustain the Mekong's fishes, while thriving fish populations are an indicator that our freshwater life support systems are healthy enough to underpin our societies and economies – as they provide us with food, water and other essential services. In other words, when fishes do well, so do we – and that's very much the case in the Mekong.

As the Mekong River flows from its source in China to the sea in Viet Nam, it carries water, nutrients and sediments. This connected flow is the lifeblood of the Mekong, and the foundation of the ecosystems and the land that millions of people and an extraordinary number of species rely on. Beneath the surface, the river's connectivity gives rise to one of the largest migrations on Earth.

And it's not just the annual fish migration that is extraordinary – so too is the dazzling diversity of fish species. There are 1,148 fish recognised species in the Mekong River basin, with many more undescribed by science and new ones still frequently being discovered. Along with a remarkable number of carps, catfishes and perches, the Mekong is home to record-breaking giants, including the Mekong giant catfish and giant freshwater stingray – probably the largest freshwater fish on Earth. It also boasts hundreds of endemic fishes and an amazing variety of weird and wonderful species from pipefishes to pufferfishes.

The Mekong River is considered the 'mother of all things'. Culturally, it's of fundamental importance to the entire Mekong region, and its fishes have been an integral part of people's lives for millennia. Some – like the giant catfish and giant barb – are revered as special animals that must be honoured and protected.

In terms of livelihoods and food security, the fishes of the Mekong make an enormous contribution to people living in the region. In total, the Mekong Basin produces 15 per cent of the world's annual inland fish catch – a staggering 2.3 billion tonnes – which makes it the largest inland fishery on the planet, worth more than US$11 billion a year in 2015. But, crucially, a range of threats means the future of this fishery is at risk. Indeed, there is evidence that it's already starting to decline. Losing this irreplaceable resource would have devastating consequences for societies and economies across the basin – with local communities that depend on this fishery suffering the most.

The fishes make other important economic contributions too, for example through the aquarium trade – although in the Mekong region this sector is almost entirely unreported and unregulated. Analysis of publicly available data, prepared for this report, indicates that as many as 14 per cent (120 species) of the fish species from the Mekong may have been part of the aquarium trade at some point. The regional trade's full economic value can only be inferred from anecdotal information, but it's clearly considerable: a single aquarium fish market in Thailand has an annual turnover of more than US$20 million. These fishes could provide significant economic value if sustainable management approaches were more widely implemented, contributing to prosperity for people in the region.

Recreational angling is not yet a widespread activity, but it too holds considerable potential for the region if developed carefully – the Mekong is home to a great diversity of giant and novel freshwater fishes living in beautiful and varied habitats, which could attract anglers from across the globe. When recreational angling is carefully managed and monitored

to avoid potentially negative impacts, it can benefit livelihoods, the economy and well-being, including eco-tourism angling to support fish conservation. There's an array of examples from across the globe to learn from, and a world of opportunity waiting in the Mekong.

Everything, though, depends on the health of the Mekong River Basin, and today it's a hotspot of risks and threats. The evidence we have is piecemeal, but it's still startling: 74 fishes in the Mekong have been assessed as at risk of extinction on the IUCN Red List of Threatened Species, including 18 species that are now Critically Endangered. Officially this means that an estimated 19 percent of known Mekong fish species are threatened. But the data are minimal and the 'known' here is key. An unusually high proportion of Mekong fish species are under-researched and placed in the category of 'Data Deficient' on the Red List so it's safe to say that the true number of globally threatened fish species in the Mekong is much higher than 74.

So, what are the main threats to the Mekong's fishes? They range from fragmentation of the Mekong River and its tributaries by hydropower dams to poorly managed fisheries, unsustainable extraction of sand and gravel for the construction industry, introduction of invasive non-native fish, habitat loss due to infrastructure and wetland conversion for agriculture and urbanization, and changes in water quality as well as climate change, which is exacerbating the other pressures.

However, despite the magnitude of the threats facing the fishes of the Mekong, there's still hope for the future – indeed, there's much to gain from a new approach. The most critical point is that decision makers need to start valuing the importance of the Mekong's freshwater fishes and begin factoring them and their ecosystems into decisions about the basin – this will promote more sustainable development and underpin a more equitable economic pathway, which will benefit people and nature across the region.

The good news is that momentum for action is building. The Mekong countries signed up to the ambitious Kunming-Montreal Global Biodiversity Framework in December 2022, which explicitly includes the commitment to protect 30 per cent of 'inland waters' (rivers, lakes and freshwater wetlands) and restore 30 per cent of degraded inland waters. This agreement paves the way for a new approach to safeguard freshwater biodiversity – a new approach highlighted in the country-led Freshwater Challenge. Cambodia has already joined, and other Mekong countries should become Members too.

But protecting and restoring ecosystems is not enough. What's needed in the Mekong is a transboundary Emergency Recovery Plan for Freshwater Biodiversity – and one already exists. This practical, science-based plan incorporates six pillars, each of which has been implemented elsewhere in the world and could be adopted by Mekong countries, supporting and further facilitating the work of communities, fishers and conservation organisations:

1. Let rivers flow more naturally;
2. Improve water quality in freshwater ecosystems;
3. Protect and restore critical habitats and species;
4. End unsustainable management of resources;
5. Prevent and control invasions by non-native species; and,
6. Protect free-flowing rivers and remove obsolete river barriers.

All interested stakeholders should seize this opportunity to chart a new course to restore and protect the Mekong, and use it sustainably for the benefit of societies and economies. This course must value the Mekong's remarkable diversity of freshwater fishes – and must factor them into development decisions. But it is not just governments: the private sector, civil society organisations and communities also have a role to play in protecting and restoring ecosystems and species. Indeed, there is already a strong foundation of community-led approaches in the Mekong, particularly Fish Conservation Zones, that we need to build upon.

Communities across the Mekong can't afford to lose their forgotten fishes or the freshwater ecosystems they inhabit. And this report shows they don't have to. Mekong countries must take decisions that will drive sustainable development without sacrificing freshwater fishes and ecosystems. This will involve hard choices and difficult trade-offs, but it is possible. And will it pave the way to a brighter future for the Mekong's freshwater fishes and ecosystems – and a brighter future for people and nature across the region.

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THE MIGHTY MEKONG

The flow of water, nutrients and sediments is the lifeblood of the Mekong

At approximately 4,900km in length, the Mekong is the longest river in Southeast Asia, and the 8th longest in the world.

The Upper Mekong River Basin begins in China and comprises the Tibetan Plateau and Three Rivers Area, and the Lancang Basin in both China and Myanmar. Meanwhile, the Lower Mekong River Basin drains a catchment of around 571,000km², covering a large part of north-eastern Thailand, most of Lao PDR and Cambodia, and the southern tip of Viet Nam.

The Mekong sustains rich ecosystems from source to sea

Main © Zeb Hogan. Inset © WWF-Viet Nam / Cham Team

The Mekong's Forgotten Fishes page 11

Main © Adam Oswell / WWF-Greater Mekong inset © Zeb Hogan

The Lower Mekong Basin incorporates two ecosystems that are also critical for fish, people and nature – the Tonle Sap Lake and the Mekong Delta. The lake is the largest freshwater body in southeast Asia and famous for its dramatic changes in size. During the dry season, the Tonle Sap Lake drains into the Mekong via the Tonle Sap River. However, in the wet season, high flows in the Mekong cause the Tonle Sap River to reverse its direction and flood the lake – increasing its area six-fold from 2,500km^2 to 15,000km^2, and its volume from 1.5km^3 to an astonishing 60-70km^3. At the end of the wet season, the Tonle Sap River resumes flowing downstream, draining excess water off the floodplain around the lake and back into the Mekong. This hydrological cycle supports rich biodiversity, including fishes, other wildlife and plants, on which many local communities rely for their livelihoods.

As for the Mekong Delta, it begins near the Cambodian capital Phnom Penh, when the Bassac River – the Mekong's largest distributary channel – splits from the mainstream, marking the start of one of the largest and most productive deltas in the world.

More than 68 million people live in the Lower Mekong River Basin alone, with around 40 per cent dwelling within 15km of the river. Many of them are dependent on this great river for their water and food security, livelihoods and access to trade (So et al. 2015). But the Mekong flows with far more than water. Every year, it also transports vast amounts of nutrients and sediments. This connected flow is the lifeblood of the Mekong, and the foundation of the ecosystems and the land that so many people and an extraordinary diversity of species rely on.

There are vast natural fluctuations in this flow, which are also essential to the life of the Mekong. Most of its water comes from surface water sources in the Lower Mekong Basin, although upstream flow from snowmelt in China is also important, supplying around a quarter of the Mekong's volume each year. The flood season lasts from June to November and accounts for 70-80 per cent of the total annual flow.

The annual flood season is especially important in the Lower Mekong Basin, when the river brings not only water, but also essential nutrients and sediments. These provided the foundation upon which the rich biodiversity of the Mekong evolved, and their continued flow is central to its survival. Many of the Mekong's ecosystems, and much of its fish biodiversity, have developed and evolved because of this seasonal flow; the Mekong's extensive wetland habitats would not exist without the annual flood and the delta is sustained by the deposition of sediments, while the life cycles of many fishes are governed by its natural rhythms.

In the dry season, the Mekong recedes and fish habitats on the floodplain disappear. Deep pools in the mainstream play a crucial role at this point, providing refuges where many of the Mekong's fish species feed and grow, maintaining the integrity and productivity of the ecosystem. There are at least 170 deep-water pools across the Mekong in Cambodia and Lao PDR alone, with the deepest reaching over 100m.

A mammoth migration

The connectivity running through the Mekong gives rise to one of the largest migrations on Earth, if not the largest in terms of the number of animals (Hogan, 2017). Migrations of land animals are famous, but underwater, without us knowing, fish embark on great migrations every year – and none more so than the fishes of the Mekong. Of 899 freshwater fish species in the Mekong, 321 are migratory, and belong to one of seven separate migratory systems (Kang & Huang, 2022).

One of the most remarkable fish migrations in the Mekong River Basin starts in late September or early October, just after the floodwaters of Tonle Sap reach their peak and the huge lake expels vast quantities of water and fish down the Tonle Sap River towards the Mekong. The first fish to begin the journey are among the world's largest, such as the Mekong giant catfish and the giant barb. Over the next months, they are followed by up to 100 different species of fish, including striped tiger perch, freshwater pufferfish, and mud eels. For reasons unknown to researchers, the numbers peak each month a few days before the full moon. By January, the small, silvery carp known as 'trey riel', or 'money fish', make up the bulk of the migrants. At this time, the river is so full of fish that people easily fill small scoop nets with fish with one dip into the water.

It's impossible to accurately count such a volume of fish as they move underwater, sometimes at depths of more than 30m, so the exact numbers making this migration are unknown. However, catch estimates indicate that more than 5 billion individual fish are involved. This seasonal migration of fish could equal the combined biomass of the herds of wildebeest, zebra and gazelle moving across the East African plains, or amount to 100 times the number of songbirds that migrate between Europe and Africa each year (Hogan, 2017).

JEWELS AND GIANTS

THE FISHES OF THE MEKONG

Mekong freshwater habitats are extremely diverse – and so are the fishes that live in them

© Zeb Hogan

The iconic Mekong giant catfish

A world in a river: the Mekong basin is home to a huge diversity of habitats. Stretching from mountain hill streams to the mangroves of the Mekong Delta, the basin also boasts freshwater cave systems, floodplains, flooded forests, shrub lands and woodlands on karst limestone outcrops as well as mixed wet evergreen, dry evergreen, deciduous and montane forests. The diversity of fish species in some of these habitats can be seen in Fig 1 below. Unsurprisingly given its varied ecosystems and the fact that a large part of it lies within the 'Indo-Burma biodiversity hotspot', the Mekong hosts a staggering diversity of flora and fauna – with 20,000 plant species, 430 mammals, 1,200 birds, 800 reptiles and at least 144 amphibians (MRC, 2019).

And 1,148 fish recognised fish species, including freshwater and brackish water species (MRC, 2019).

However, it's estimated that up to 3,500 species of fish are at least partially dependent on the Mekong, including marine species that rely on the essential nutrients that flow from the river out into the ocean (Rainboth, 2012). Counting freshwater species alone, the Mekong is home to 899 known species, belonging to 368 genera, 87 families, 24 orders, and 2 classes (Kang and Huang, 2022) – making it the third most species-diverse river for freshwater fishes after the Amazon and Congo.

It's estimated that around 25 per cent of fishes in the Mekong are found nowhere else on Earth (Valbo-Jorgensen, 2003). Kang and Huang (2022) identify nine biogeographical regions for fishes in the Mekong, with species richness varying depending on temperature, precipitation, and proximity to the equator. All the different habitats within the river from its high mountain sources to the vast floodplains of Cambodia and Viet Nam have contributed to the dazzling diversity, while the annual monsoon flooding also creates additional habitat complexity, giving fishes even more opportunities to specialize, and so eventually form new species. At times, the Mekong has been connected to other rivers, particularly in the central and northern regions, allowing it to gain species that originally arose outside its catchment. This is the main reason why the Mekong shares many species with the Chao Phraya River in central Thailand.

Many fish species in the Mekong are yet to be described by scientists (Ng & Kottelat, 2023), and new ones are frequently discovered. In 2023, these included the catfish, *Glyptothorax irroratus,* which is found in China and Lao PDR (Ng & Kottelat, 2023), and the stone loach *Nemacheilus pullus,* which is found in central Lao PDR (Kottelat, 2023). Another recently discovered species is the blind fish, *Bangana musaei,* which is distinguished from its relatives by the absence of any eyes and was discovered in caves in Xe Bangfai in central Lao PDR (Kottelat and Steiner, 2011).

The Mekong has it all – from giants to minnows...and everything in between

Cypriniformes (carps and minnows) are the most abundant order of fishes in the Mekong, with 439 known species making up 49 per cent of all the Mekong's freshwater fishes. Perciformes (perches) are the next most dominant order, accounting for 23 per cent, followed by Siluriformes (catfishes), which comprise 19 per cent (Kang and Huang, 2022).

Cypriniformes include carps, minnows, barbs and loaches, and boast many of the Mekong's famous giant fishes, including the revered giant barb, *Catlocarpio siamensis*, Jullien's golden carp, *Probarbus jullieni*, the Mekong giant salmon carp, *Aaptosyax grypus*, and the wolf barb, *Luciocyprinus striolatus*, as well as the Mekong's smallest species, the tiny three-spotted dwarf minnow. This group also includes many important food fishes, such as the Siamese mud carp, *Henicorhynchus siamensis*, notched mud carp, *Henicorhynchus lobatus,* and *Sikukia gudgeri,* while the long pectoral-fin minnow, *Macrochirichthys macrochirus*, which despite its name can reach up to 1m in length, is made into Lao PDR's famous spicy fish dish, ponne pa. Many of the Mekong's cypriniformes are also popular in the aquarium trade (see Chapter 6), including the Siamese algae-eater, *Crossocheilus atrilimes,* the rose danio, *Danio roseus*, and the cherry spot rasbora, *Rasbora rubrodorsalis*. The red-tailed rasbora, *Rasbora borapetensis*, is the most traded of all.

Many cypriniforms are loaches and the stone loach genus, *Schistura,* boasts the largest number of species of all – with at least 66 known species in the Mekong (Kang and Huang, 2022). Other loaches include the stripey eel-loach, *Pangio myersi,* and the hillstream loaches (*Sewellia* species), which are specially adapted for life in fast flows: they're flattened and shaped like mini-stingrays, which, along with pelvic fin adaptations, allows them to cling onto rocks. Another species adapted to fast-flowing life is the stunning blue loach, *Yasuhikotakia modesta*. Many of the Mekong's loaches are found in very restricted areas and exist nowhere else on Earth (see boxed text 20).

The bitterling, *Acheilognathus longibarbatus*, is a cypriniform worthy of special mention, as it, like other bitterlings, is a brood-parasite: the female deposits her eggs inside bivalve molluscs and the young remain inside until they can swim. Other cyprinids include the Mekong's mahseer species – these include the red mahseer, *Tor sinensis,* and *Tor laterivittatus*, a particularly beautiful fish with scales like a broken mirror.

Perciformes[1] include many well-known Mekong species, such as the archerfishes, gouramis and snakeheads. When news of a spitting Asian fish reached Europe around 250 years ago, the scientific community didn't believe it – but three species of archer fish (Toxotidae) have been recorded in the Mekong. They're named for their ability to spit water at high speed to knock prey, such as insects, off leaves and branches and into the water from as far away as 3m.

Jullien's golden carp

© Bristol Zoological Society

1. Aggregated according to the Nelson system of fish classification.

Figure 1.
Of the 899 entirely freshwater fish species recognised in the Mekong, 49% are carps and minnows (Cypriniformes) 23% are perches (Perciformes) and 19% are catfishes (Siluriformes). Source data taken from Kang and Huang (2022).

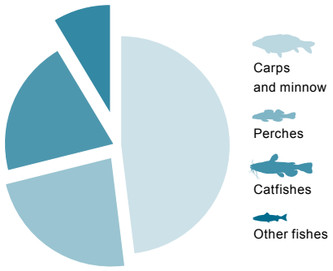
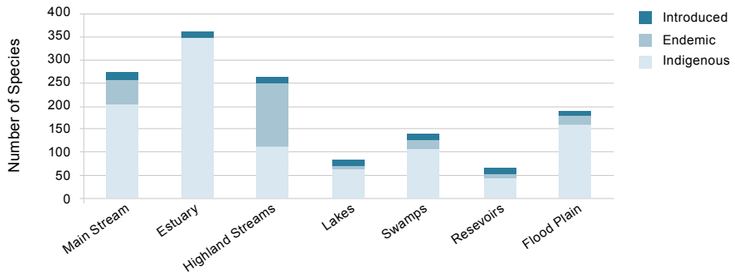


Figure 2.
The number of species found in some of the different aquatic habitat of the Mekong. Taken from Jorgensen, Coates and Hortle (2009).



Despite this remarkable skill, spitting isn't the archerfish's favoured way of hunting. Instead, they often feed on insects that are already floating on the water or leap out of the river to catch insects near the surface (Valbo-Jorgensen, 2003).

The climbing perch, *Anabas testudineus*, is another remarkable species, an obligate air-breather, it's known for its ability to leave the water and 'walk' – and, according to rumours, even climb trees! During the wet season it often enters flooded habitats where it may become trapped as the waters recede so, if necessary, it's able to travel across land for distances of several hundred metres provided it remains moist. Under extreme circumstances, it's even able to enter a state of torpor for several weeks by burying itself in damp ground.

Amazingly, this group includes not only fish that walk, but also fish that talk. The beautiful Mekong croaking gourami, *Trichopsis schalleri*, like other close relatives, can produce audible sounds via specialized pectoral fins, whose tendons and muscles are stretched and plucked by the anterior fin rays as if they were guitar strings. Studies suggest that species of *Trichopsis* can settle conflicts without damaging each other physically by assessing factors such as body weight and length, which are transmitted by both visual and acoustic 'croaking' signals. During courtship, the female produces 'purring' sounds to initiate spawning: they are the only fishes known to do this (Ladich & Schleinzer, 2015).

Mekong perciformes also include the largest goby on Earth – the marbled goby, *Oxyeleotris marmorata,* whose local Cambodian name means 'elephant-fish' (Davidson, 1975). It can reach 50cm and is a prized food fish. Meanwhile, the leaf fish, *Nandus oxyrhynchus,* is named after its leaf-like camouflage, which masks it as it preys on smaller fishes and invertebrates in still and slow-moving waters.

Finally, discussing this group of extraordinary fishes would not be complete without a special mention of the snakeheads: ambush predators whose adapted gills allow them to breathe air. The largest species in the Mekong is the colourful giant snakehead, *Channa micropeltes*, which can grow as long as 90cm and mostly feeds on other fishes and small crustaceans. It is popular to eat and is even cultivated in ponds. Snakeheads build bubble nests among vegetation in slow-moving or swamp-like habitats, in which their eggs are laid and then guarded by the adult fish. Once hatched, fry continue to be guarded until they reach about 5cm in length. One species, the dwarf snakehead, *Channa gachua*, which lives in mountain streams across the Mekong, is a mouth brooder (Kottelat, 2001).

Catfishes (Siluriformes) are the third most dominant order of fishes in the Mekong accounting for 107 known species and making up 19 per cent of all Mekong freshwater fishes (Kang and Huang, 2022). This is perhaps unsurprising given that catfishes are particularly well adapted to turbid environments, such as those in the Mekong mainstream and lowland tributaries, where they can use their sensitive barbels to locate food. Perhaps the best known of the Mekong's catfishes are the nocturnal shark catfishes (*Pangasiidae*), which mostly eat plants and invertebrates off the river bottom. The most famous of all is the legendary Mekong giant catfish, *Pangasianodon gigas* (see box text p20), but there are at least 11 other species, including the iridescent shark catfish, *Pangasianodon hypophthalmus*, and giant pangasius, P*angasius sanitwongse*i, both of which were valued food fishes, but are now highly threatened.

Other catfishes in the Mekong include bagrid catfishes, a diverse group of bottom-dwellers many of which are food fishes; beaded catfishes, which also live on the bottom of the river; torrent catfishes, which inhabit streams with fast currents; walking catfishes, eel lookalikes that can survive out of water; and even a stinging catfish, *Heteropneustes kemratensis*. And last but not least, there is the devil catfish (aka goonch), *Bagarius lica*. This predatory, bottom-dwelling 'sucking catfish' reaches 2m in length and eats other fish as well as amphibians and invertebrates – its Lao and Thai names mean 'crocodile-fish,' giving an idea of its appearance.

The Mekong is also home to a staggering diversity of other fishes

From rays and sawfishes to featherbacks; from herrings and shads to needlefishes and pipefishes; from swamp eels to tonguefishes and pufferfishes – the Mekong really does have it all. And many of these species are particularly weird, wonderful and mysterious.

Asian arowana

Take, for example, the clown featherback, *Chitala ornata*, and the royal featherback, *Chitala blanci*, named for their feather-like dorsal fin. Unusually, their anal fin runs along almost their entire lower body and is connected to their tail: this has evolved to help the fish swim backwards. They can also breathe air, and males take on the role of guarding their eggs and young. The Mekong is also home to the Asian arowana, *Scleropages formosus*. A top predator, this large, attractive and ancient species, only exists in small numbers, and has a slow reproductive rate – but it demonstrates an advanced degree of parental care. Like the famous seahorse, and their featherback neighbours, Asian arowana males are responsible for caring for fertilized eggs and larval fish. However, they don't have a pouch: instead, they protect their young in their mouths.

Pufferfish are mostly known as marine fishes, but the Mekong pufferfish, *Pao suvattii, Pao baileyi, Pao barbatus* and *Pao abei* are entirely freshwater species and are endemic to the Mekong River (Valbo-Jorgenson, Coates and Hortle, 2009; Vidthayanon, 2017). Soles are another typically marine group found in the Mekong, including *Brachirus harmandi* and *B. siamensis;* as is the largetooth sawfish, *Pristis microdon*, which is also called the 'freshwater sawfish', and has been found as far upstream as Khone Falls in Lao PDR – 650km from the sea. Other unexpected fishes in the Mekong are relatives of the seahorse – the pipefish. Two species have been recorded: the beautiful long-snouted pipefish, *Doryichthys boaja*, and the pygmy pipefish, *Doryichthys contiguous*. Sadly, little is known about either species.

The Mekong is also home to two stingrays – the Mekong freshwater stingray, *Hemitrygon laosensis*, and the giant freshwater stingray (aka whipray), *Urogymnus chaophraya* (see box text p20), which is probably the largest freshwater fish in the world!

And from mammoth to minute: the Mekong is also home to one of the smallest freshwater fishes, the three-spotted dwarf minnow, *Boraras micros*, which grows to just 13mm (Welcomme & Vidthayanon, 2003).

And from miniature to mysterious: the giant mottled eel, *Anguilla marmorata*. Reaching up to 2m in length, this eel can be found in freshwater ecosystems between the east coast of Africa and French Polynesia, including the Mekong. They spend their adult lives feeding and growing in freshwater ecosystems, but once they are ready to spawn, which they do only once in their lifetime, they leave their freshwater ecosystems and never return. To spawn they head out to the open ocean. But here's the mystery: no one knows where giant mottled eels go next. Only one eel spawning site is known in the Indian Ocean, and three far away in the Pacific Ocean (Kuroki, 2020) – but where eels from the Mekong actually spawn remains to be discovered. Wherever it is, though, it's likely to mean an extremely long journey for these mysterious fish. The next generation will return to the Mekong as tiny 'glass eels' and the life cycle will start again. There are two other known anguillid eel species in the Mekong: the short-fin eel, *Anguilla bicolour* and the Japanese eel, *Anguilla japonica*.

THE MEKONG: THE MOTHER OF RECORD-BREAKING GIANTS

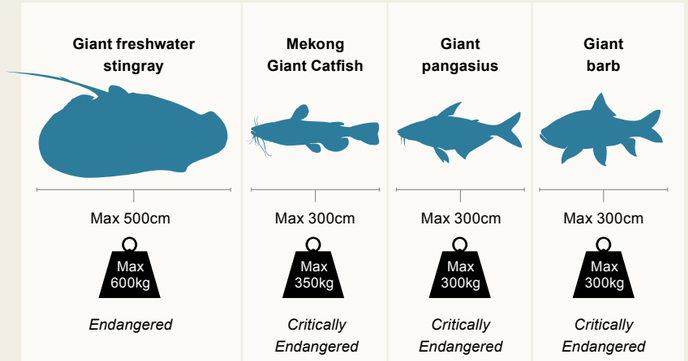
Giant Freshwater Stingray

Mekong Giant Catfish

Giant Pangasius

Giant Barb

Images © Dao Van Hoang



The Mekong is home to a great diversity of giant fish species, with over a dozen species that grow over 50kg or 1.5m in length. Some far exceed that size, the most amazing being the giant freshwater stingray. In June 2022, a specimen from Cambodia became the largest freshwater fish ever caught and officially recorded (Millward, 2022). More information on this endangered giant is urgently needed so that conservation activities can be prioritized (Campbell & Hogan, 2023).

Until 2022 another Mekong giant – the Mekong giant catfish – held the record for the world's largest freshwater species caught: a behemoth that was 2.7m in length and weighed 293kg. But like other giant fishes, this long-lived species (it can live up to 60 years) is now Critically Endangered and on the brink of extinction. Conservation efforts are underway: nowadays it's illegal to harvest these fish in Thailand, Lao PDR and Cambodia, and captive-bred fish are being reintroduced. However, the threats are numerous, and sadly only a few hundred are estimated to be left in the Mekong (WWF, 2009).

Garra fasciacauda

© Nonn Panitvong

Hillstream loach

© Charles König

Stone loach

© Nonn Panitvong

Endemic fishes of the Mekong

Along with fish giants and fish migrants, the Mekong is also home to a huge diversity of narrow-range endemic fishes. These fishes have morphological and behavioural adaptations to the specific requirements of their environment, and consequently they often have a small range. Many locations, particularly smaller and upstream tributaries of the Mekong in Lao PDR, Thailand and Cambodia, have species that are only found in that individual river. These species are particularly vulnerable to threats and even extinction because they find it difficult to adapt to different situations.

These fishes include many small species such as stone loaches, hill stream loaches, and suckermouth barbs. They tend to live in smaller, fast-flowing rivers and hill streams and have evolved adaptations such as sucker mouths, flattened bodies and adapted fins, which help them cling onto rocks in the current. One such fish is the stone loach, *Schistura quasimodo*, which is only known from a single stream from the Nam Ngum basin in Lao PDR – and, like its namesake, has a hump. Due to their attractiveness, small size and interesting stories, this stone loach and several other narrow-range endemic fishes from the Mekong are popular in the global aquarium trade (see p36).

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Wide range of habitats in the Mekong have driven the evolution of a dazzling diversity of fishes

Critically Endangered Irrawaddy dolphins rely on healthy fish populations

HEALTHY FRESHWATER FISHES= HEALTHY MEKONG

Fishes are critical indicators of the resilience of humanity's life support systems

Healthy freshwater ecosystems are essential to sustain thriving populations of freshwater fishes. But we sometimes forget how the reverse is also true: freshwater fishes are essential to the health of freshwater ecosystems. And healthy rivers, lakes and wetlands are critical for humanity as they provide us with food, water and other services that underpin our societies and economies.

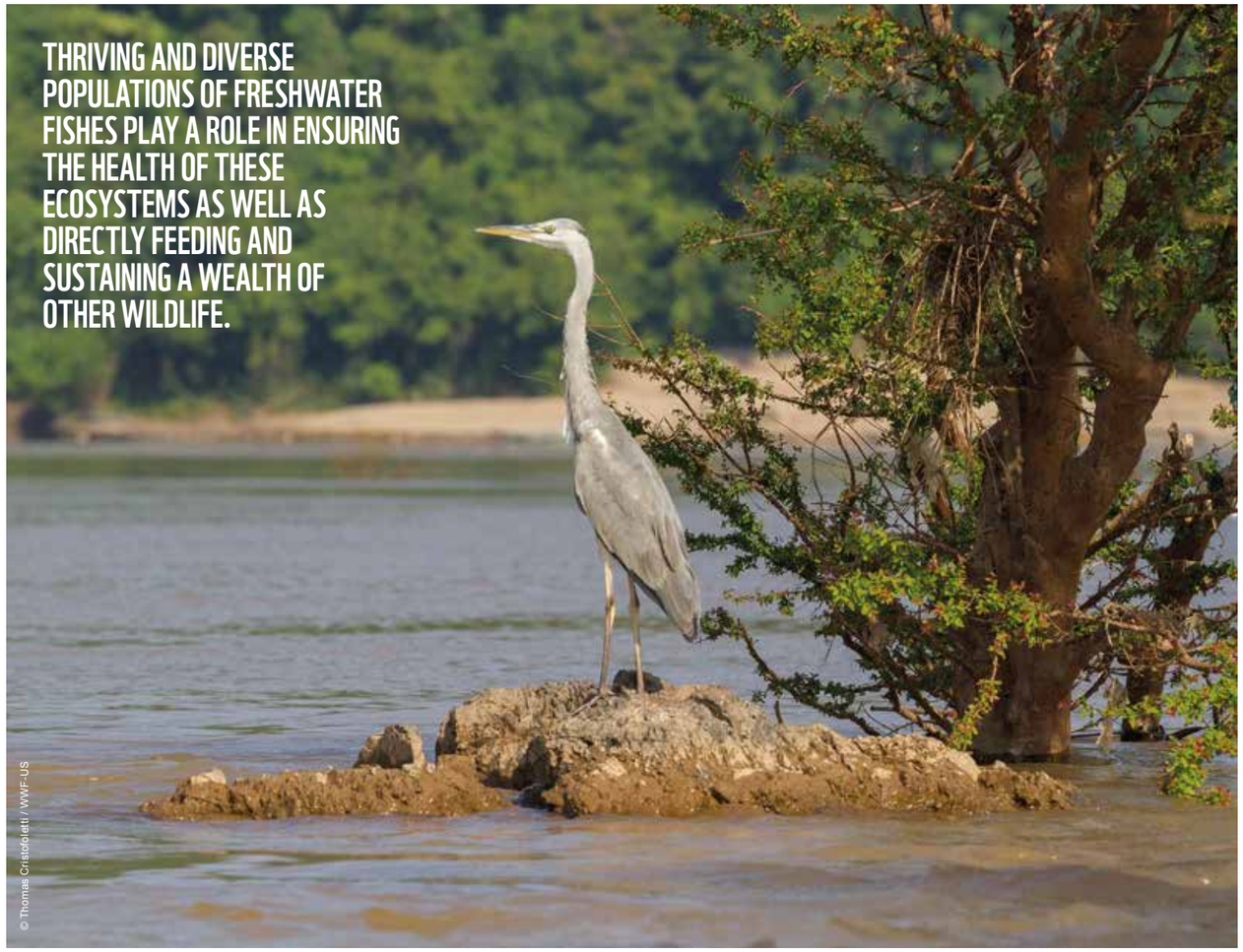
The incredibly diverse fishes of the Mekong play a regulatory and foundational role within the ecosystem and are central to its natural balance. They perform many different functions within the river – including piscivores, insectivores and other predators, as well as herbivores and detritivores – with fishes eating and thereby controlling populations of plants and other animals, and in turn being eaten. But when we drastically reduce freshwater fish populations in the Mekong, we upset the delicate equilibrium and threaten the healthy functioning of the system that so many people and species rely on.

The Greater Mekong area is known as Asia's 'fish bowl' and 'rice bowl'. The Mekong Delta alone contributes 50 per cent of Viet Nam's rice production, 65 per cent of its aquaculture output and 70 per cent of its fruit production – comprising 31 per cent of the country's total agricultural GDP. It's also responsible for up to 95 per cent of Viet Nam's rice exports and 60 per cent of its fish exports.

On average, an astounding 15,000m^3 of water flows into the Mekong mainstream from the surrounding basin every second – enough to meet the daily needs of 100,000 people. The water nourishes large tracts of forest and numerous and varied wetlands, which support diverse social, economic and cultural systems, and serve as habitats for thousands of species. Wetlands play a vital role in supporting the livelihoods of local people, providing a productive environment for agriculture, aquaculture, capture fisheries, non-fish aquatic goods and tourism. They also supply markets with a vast array of plant and animal products, including foods, medicines and dyes (MRC, 2023).

Healthy natural wetlands also provide a host of important benefits:

- Some inland wetlands and floodplains absorb potentially disastrous floodwaters during the wet season;
- Mangroves prevent erosion, buffer communities from storm surges, and trap nutrients that contribute to agricultural and fisheries productivity; and
- Urban and peri-urban wetlands filter excessive nutrients and toxins from agricultural, industrial and municipal wastewater before it enters the Mekong mainstream.



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Thriving and diverse populations of freshwater fishes play a role in ensuring the health of these ecosystems as well as directly feeding and sustaining a wealth of other wildlife. Take, for example, one of the Mekong's top predators – the Critically Endangered Irrawaddy river dolphin, whose diet mostly consists of Mekong fishes. Irrawaddy river dolphins appear to be adaptable in their feeding preferences, with some indication that they're opportunistic and generalist. This could be why the dolphins follow the great seasonal migration of fishes in the Mekong – it's a meal too irresistible to ignore. Many other species rely on fishes as their primary source of food, including the Critically Endangered Siamese crocodile and Jagor's water snake.

Many piscivorous birds live along the Mekong and rely on its fish for most of their food. This includes no fewer than ten species of kingfisher, numerous storks, specialist fish-owls, fish-eagles, and many cormorant, heron and egret species, as well as birds such as the darter and the river-channel inhabiting, Mekong wagtail. There was formerly a rich community of breeding terns of several species, all primarily piscivorous, in the Mekong and its major tributaries, but these are now largely extinct.

While most parts of the world have just one otter species, the Mekong has four, including the Asian small-clawed otter, smooth-coated otter, hairy-nosed otter, and the Eurasian otter – three of which are specialist fish-eaters. It is also home to other remarkable freshwater species, including the Asian giant softshell turtle, which can reach up to 1m in length.

But it is not just these fish-eaters that are at risk from the increasing threats to freshwater fishes. The entire Mekong ecosystem depends on healthy freshwater fish populations, including a vast array of non-piscivorous – and indeed non-freshwater – species. And, of course, tens of millions of people.

FISHES AND RICE: FROM PADDY FIELD TO PLATE

Inscribed on a stone tablet from the Sukhothai period – a Thai kingdom that existed between the early 1200s and early 1400s – is the sentence "there is rice in the fields, fish in the water" (Halwart & Gupta, 2004). Today, this is a Thai proverb that means people who live in a land where both fish and rice are abundant will never go hungry. Rice-fish systems have multiple benefits, including a reduced need for chemicals to control pests or as fertilizer, more efficient use of scarce water resources and land, increased resilience to the impacts of extreme weather, and increased contribution to local food and livelihoods security (Freed et al., 2020).

When carefully managed, rice fields can be home to a rich diversity of invertebrates, including snails and crabs, as well as fishes, birds, small mammals, reptiles, amphibians, and plants – many of which can be eaten. However, this rich biodiversity, in particular fishes, also plays an important role in rice production through nutrient recycling. Firstly, fishes contribute nutrients directly through their faeces, and when they die and decompose. Secondly, their foraging aids the release of nutrients from the soil. Thirdly, their disturbance of the soil makes it more porous and less compacted, which helps rice to take up nutrients. And finally, fishes assist in the recycling of nutrients when they graze on plants, algae, and other organisms. A rice field with fish has a higher capacity to produce and capture nitrogen than one without fish, while fish can also improve water quality by increasing water movement. Fish in rice fields can also help the phosphorus cycle and act as natural pest controllers, for example by eating mosquito larvae and golden apple snails, pests of humans and rice, respectively.

Rice-fish farming is practised in many countries in the world, particularly in Asia. Each country has evolved its own unique approach, although there are some widely applied techniques such as increasing the depth of water for fish and preventing them from escaping. The trick for the farmer is to find the right balance – between the ecosystem and its biodiversity, the cultivation of the farm, and the cultivation of fish of the right species and in the right quantities (Halwart & Gupta, 2004). In the Mekong Delta, WWF is working with farmers to grow an ancient variety of floating rice and farm fish in their fields during the natural flood season to restore natural sediment deposition, improve soil fertility and health, and counter land subsidence, while creating new markets and improving the resilience and income of famers – a true win-win for people and nature.

Floating rice and fish farming in the delta


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MEKONG WILD FRESHWATER FISHERIES ARE PRICELESS

Under-reported, undervalued and under pressure

THE MEKONG PRODUCES 15 PER CENT OF THE WORLD'S ANNUAL INLAND FISH CATCH MAKING IT THE LARGEST INLAND FISHERY ON THE PLANET.

Main © Zeb Hogan, inset © Elizabeth Kemf / WWF

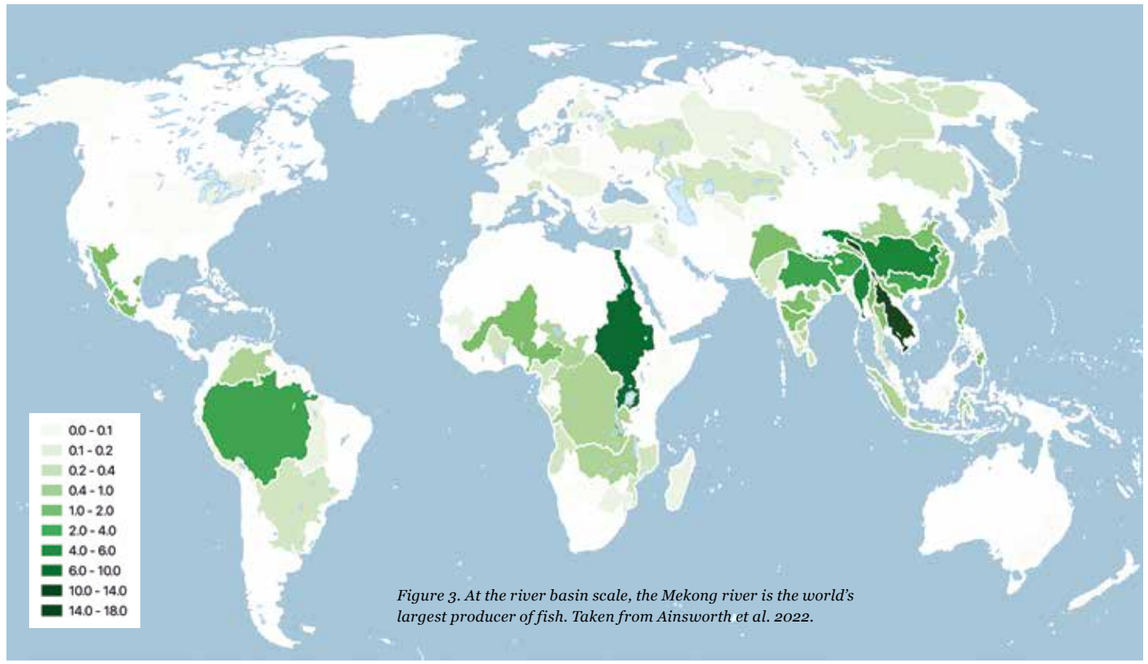

Figure 3. At the river basin scale, the Mekong river is the world's largest producer of fish. Taken from Ainsworth et al. 2022.

On paper, wild-capture freshwater fisheries account for 13 per cent of the world's annual catch, totalling 12 million tonnes each year (FAO, 2020). However, this is without a doubt a considerable underestimate: global statistics only show documented country-level catches, and freshwater fish caught by artisanal, small-scale and subsistence fishers are rarely documented. In fact, recent research suggests the actual freshwater catch is likely to be around 65 per cent higher than reported (Fluet-Chouinard et al. 2018).

Asia accounts for two-thirds of global inland wild fisheries production. The Mekong produces 15 per cent of the world's annual inland fish catch making it the largest inland fishery on the planet. Tonle Sap alone produces almost 2 per cent of the world's inland fish catch (Ainsworth, 2022; Figure 3). Approximately 120 species are commercially traded, but 10-20 species account for most of the region's wild catch (Coates et al., 2005).

The Lower Mekong Basin is particularly productive, and in 2012, more than 2.3 million tonnes of fish were captured (MRC, 2019). The catch was estimated to be worth a staggering US$11 billion a year in 2015 – US$2.8 billion in Cambodia, US$1.3 billion in Lao PDR, US$6.4 billion in Thailand, and US$0.8 billion in Viet Nam (Nam et al., 2015). This is critical to national economies with these values representing 18 per cent of total GDP for Cambodia and 13 per cent for Lao PDR – and almost 3 per cent for the whole Lower Mekong Basin (Nam et al. 2015).

Incredibly, nearly two-thirds of households in the Lower Mekong Basin – more than 40 million people – are either dependent on or engaged in fisheries (World Bank, 2012). However, many of them are part-time or seasonal, considering themselves as farmers rather than fishers. Figure 4 shows that the country with the most fishers is Thailand, closely followed by Cambodia (Nam et al., 2015). Fishing is done by both men and women. Whilst men often fish from boats, women often set fish traps and use lift nets. In addition, women are involved in fish processing, marketing and gear-making (Hortle, 2009).

Economics aside, the Mekong fishery is priceless as a food source for people in the basin, particularly those closest to the poverty line. Inland fishes and other aquatic animals account for more than half the animal protein consumed by people in the Lower Mekong Basin, ranging from almost 50 per cent in Lao PDR and Thailand to almost 60 per cent in Viet Nam, and 80 per cent in Cambodia (Hortle, 2007).

Fish consumption from wild capture fisheries averages 33.4 kg/capita/year across the region ranging from 53.6kg in Cambodia to 37 in Thailand, 36.2 in Lao PDR and 16.1 in Viet Nam (Nam et al., 2015) – vastly above the average across Asia of just 1.99 kg/capita/year (FAO, 2018). And this fish is nutritious food. It is packed with essential protein and micronutrients, including lysine, which is essential for growth. It is estimated that Cambodians currently get around 56 per cent of both their animal protein and animal lysine from fish (Pittock et al., 2017), while women in Cambodia and Viet Nam get 42 per cent of their protein, 41 per cent of calcium, 25 per cent of vitamin A, 22 per cent of fats and 10 per cent of iron from fish and fish products (Bunthang et al., 2018).

	Cambodia	Lao PDR	Thailand	Viet Nam	LMB
Fishers	1,009,190	526,300	1,065,900	689,910	**3,291,300**
Fish farmers	80,976	782,800	315,948	279,552	**1,459,276**
Processors	220,464	NA	NA	133,705	**354,169**
Traders	NA	NA	NA	72,786	**72,786**
Total	1,310,630	1,309,100	1,381,848	1,175,953	**5,177,531**

Figure 4. The number of people engaged in Lower Mekong Basin fisheries. Taken from Nam et al. 2015

A fishery at risk

But the reality is that like the freshwater ecosystem on which it depends, the world's largest wild freshwater fishery is under increasing pressure. Long-term datasets (1995-2016) show a general decline in commercial fish catches (Vu, 2021), while research in Tonle Sap Lake shows that fish populations fell by 88 per cent between 2003 and 2019 (Chevalier, 2023). Recent estimates indicate the economic value of the Mekong fishery dropped more than a third between 2015 and 2020 (Cowx, Lai and So, 2024).

The risks facing the Mekong fishery are two-fold:

Environmental factors: The primary drivers of the declining health of freshwater fisheries are environmental: sustainable fisheries need resilient and healthy ecosystems. Dams and other river infrastructure, pollution, the extraction of sand and gravel, habitat loss, and agricultural expansion and conversion are just a few of the threats impacting the Mekong's priceless fishery (MRC, 2019). Despite its importance to societies and economies across the basin, the Mekong fishery is at risk from a combination of loss of hydrological connectivity, land use change and habitat loss – giving it as risk score of High to Intermediate according to the FAO/USGS indicator for assessing threats to inland fisheries (FAO, 2020; Figure 5). To confirm this, the recent fall in the economic value of the Mekong fishery was linked to low river flows and reduced flooding, conversion of floodplains to farmland causing a loss of fish nursery areas, and the impact of dam construction

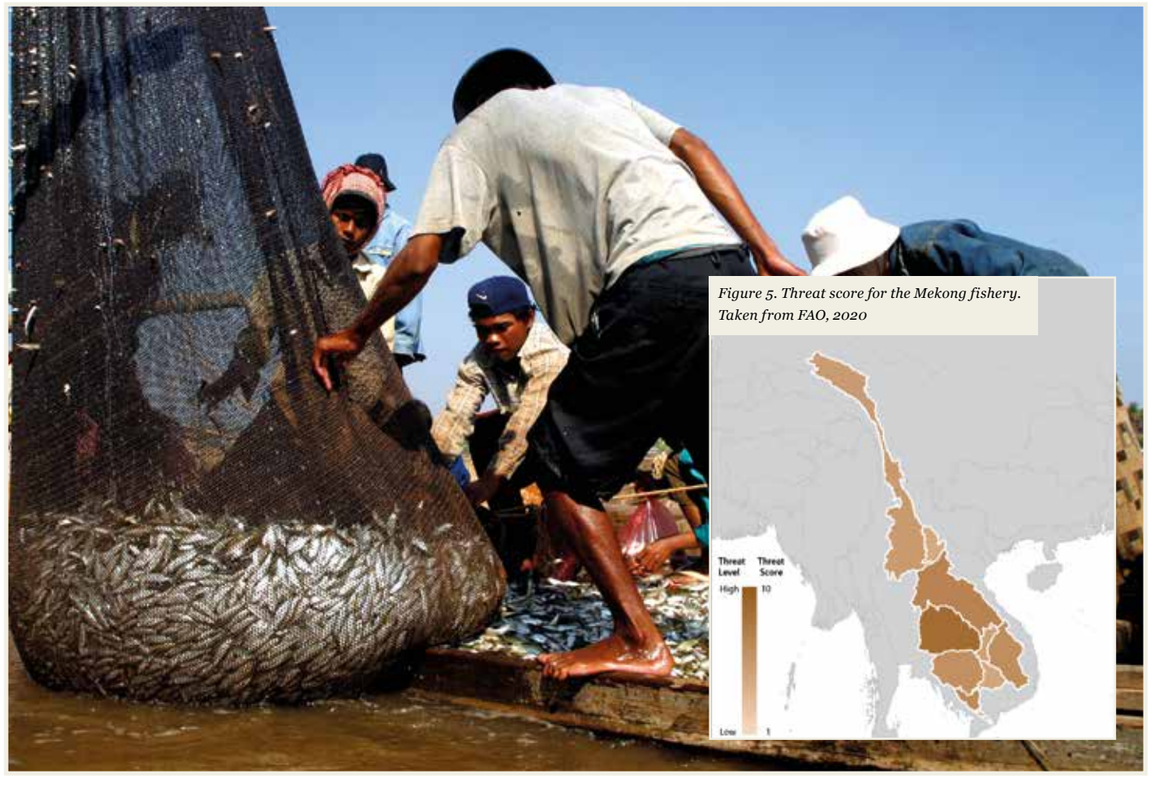

Figure 5. Threat score for the Mekong fishery. Taken from FAO, 2020

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Figure 5. Threat score for the Mekong fishery. Taken from FAO, 2020

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and aggregate mining on nutrient and sediment flow and its resultant impact on productivity (Cowx, Lai and So, 2024).

Unsustainable fishing pressures: High intensity fishing, destructive fishing practices and the stocking of invasive non-native species threaten the future of many freshwater fisheries. Both the Mekong and the Tonle Sap fisheries have been subject to destructive fishing methods (explosives, poisons and electrocution), and illegal fishing in spawning season and at spawning grounds (Coates et al., 2003; Nuon & Gallado, 2011; Ngor et al., 2018; Chan et al., 2020). However, fishers themselves recognize the risks and consequences of overfishing (Vu, 2021), are the custodians of Traditional Ecological Knowledge, and can offer and engage in sustainable management solutions (see box text below on FCZs).

Given the importance of the Mekong's fishery to food security, the evidence of risk and decline is stark – as is the urgent need to address the threats, all of which are discussed in more detail on pages 44-53.

REAPING THE REWARDS OF COMMUNITY-BASED FISH CONSERVATION ZONES

Fish Conservation Zones (FCZs) and Community Fisheries (Cfis in Cambodia) are widely used management models in the Mekong River Basin. FCZs are areas that are closed off to fishing or implement fisheries management measures and other activities to protect habitats, provide refuges for fish, and restore fish populations. Reserves have been established by hundreds of communities throughout the region, particularly in deep pools and floodplain waterbodies (Baird. et al., 2005; Loury et al., 2018). They can be critically important as refuges during the dry season when located around deep pools, which is frequently the case. Local people and fishers are aware of the importance of deep pools for both resident and large bodied migratory species that rely on them as refuges until the rains come and the river volume increases.

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There is evidence that such approaches are effective. WWF has been supporting FCZs in Lao PDR and Thailand for more than 15 years and monitoring data from these sites has demonstrated an increase in fish diversity (Butorac, 2020). And nearby in the Salween Basin in Thailand, a study of 23 community-based fish conservation zones found that they led to greater richness, density and biomass of fishes (Koning et al., 2020). This growing body of evidence demonstrates how fishers themselves are part of the solution and it is essential that their knowledge is harnessed and used for decision making in the Mekong.

THE MEKONG WILD-CAPTURE FISHERY IS IRREPLACEABLE

What would losing the Mekong fishery look like for regional food availability? One study found that a 50 per cent reduction in the Mekong wild capture fishery would require staggeringly large food replacements (Ainsworth et al. 2022). Aquaculture production alone would need to expand dramatically with an estimated increase of 75 per cent for pangasius, 148 per cent for tilapia and a whopping 607 per cent for carp, while beef production would need to increase by 130 per cent. Such scenarios would mean a significant increase in water demand; beef alone would increase regional water demand by 8 per cent.

And it's not just more water: food replacement with beef would require a 231 per cent increase in land-use conversion to agriculture (an additional 83,388 km²) and pork would require a 143 per cent increase (an additional 51,540 km²). Replacement of the wild fishery would also result in significant increases in carbon emissions, particularly from chicken, pangasius and beef production (the latter adding an additional 45 million tonnes of greenhouse gases). Moreover, this research does not account for the rich and varied micronutrients and protein provided by a diverse wild capture fishery.

If Cambodia's freshwater fishery failed, 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 needs (Pittock et al. 2019). And in Lao PDR, local fishers are already reporting declines in catches and communities are resorting to less sustainable ways of generating incomes, like growing cassava for export to Thailand and Viet Nam – driving rapid land conversion.

The loss of the Mekong's wild capture fishery would have massive social, economic and environmental impacts across the basin, particularly for the poorest and most marginalized in society. In the long term, poverty will only be reduced and health improved if the environment continues to provide services and resources that people need and if resources are managed sustainably so that they can support long-term development. It's essential that more steps are taken to safeguard the wild fishery, the people that rely on it and the freshwater ecosystems we all call home.

AQUACULTURE

Globally, aquaculture production has doubled since 2000 and continues to grow, constituting 46 per cent of world fish production. Asia is responsible for 93 per cent of inland aquaculture, which contributed 2.1 million tonnes to the Mekong fishery in 2012 and was worth an estimated US$5.8 billion in 2015 – up from less than US$1 billion in 2003. Of the 2015 figure, US$4.9 billion came from Viet Nam, with Cambodia, Lao PDR and Thailand's aquaculture industries making up the rest (Nam et al., 2015). As this shows, Viet Nam is by far the largest regional aquaculture producer – indeed, it's the fourth largest in the world – with over half of its production coming from inland waters in the Mekong Delta (FAO, 2020). This accounts for 90 per cent of aquaculture production in the Mekong, mainly with the iridescent shark catfish, tilapia species and black tiger shrimp (Nam et al., 2015). And Viet Nam has continued to expand its aquaculture sector thanks to strong trading links with fast-growing Chinese markets (FAO, 2020).

When wild capture fisheries decline, aquaculture is sometimes seen as a solution, but for inland wild capture fisheries the story is more complex. In the Mekong, millions of people rely on wild populations for subsistence fishing, while for poor families, aquaculture fish can be less affordable or readily available than wild caught fish. Furthermore, there is evidence that replacing the nutritionally diverse catch of a wild inland fishery with the production of a few species of farmed fish is likely to reduce the micronutrient content and increase the risk of malnutrition (Heilpern et al., 2021).

Unless very carefully managed, aquaculture production can also threaten the health of freshwater ecosystems due to habitat destruction, pollution and the introduction or escape of non-native species, adding to the threats facing fishes and wild capture fisheries. Sustainable fish production from aquaculture also relies on healthy and genetically varied brood stock, which requires healthy ecosystems containing healthy populations of wild species (FAO, 2019).

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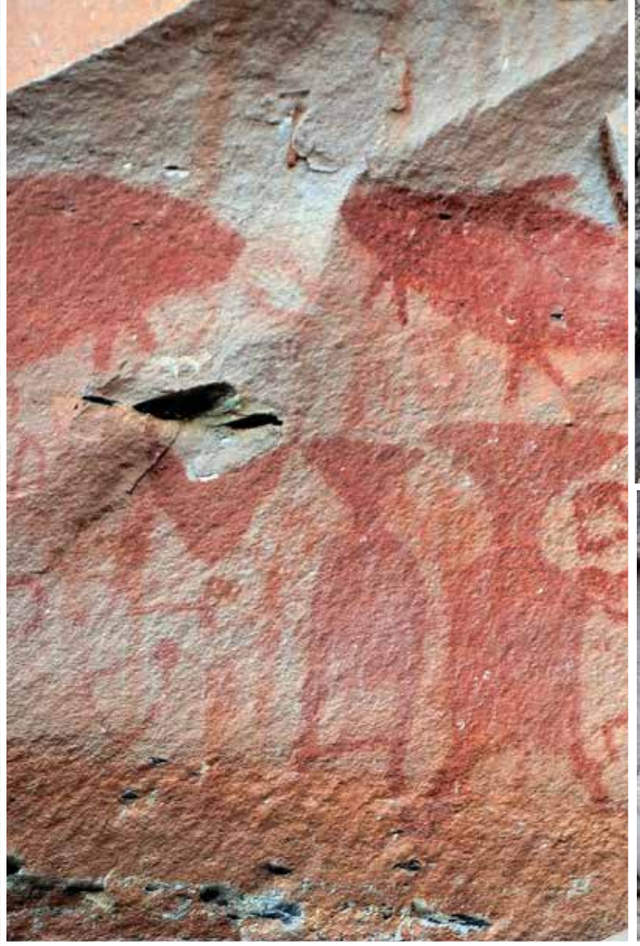
THE MEKONG'S FRESHWATER HERITAGE

Freshwater fishes have swum through the region's cultures for millennia

The Mekong River translates as the "mother of all things": it's of fundamental cultural importance to the entire Mekong region (Kang & Huang, 2022). Traditional communities value their overarching relationship to the river, celebrating festivals and daily rituals that are key parts of their cultural heritage (Groenfeldt, 2019). The fishes of the Mekong are just as important, and many have been an integral part of the lives, culinary histories and cultures of people within the river basin for millennia. There is, of course, no way to do justice to the full cultural importance of freshwater fish in the Mekong in this report, so here we showcase just a handful of the countless stories that could be told.

Giant barb is the national fish of Cambodia



Main © Dao Van Hoang, inset © Zeb Hogan

Many fishers in the Mekong regard the Mekong giant catfish and other megafishes, like the giant barb, as special animals that must be honoured and protected, and that can bring curses down upon their family if they are killed (Campbell et al., 2020). In Cambodia, there are large statues of the giant barb, which is the country's national fish (Baran, Jantunen & Chong, 2007), while the country's 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.

There's a long history between the Mekong giant catfish and the people of the Mekong – indeed, cave paintings of the species found near Ubon Ratchathani in Thailand are around 3,000 years old (Tan, 2014). In Thai folklore, special rituals and offerings are made before fishing for the species, while in Cambodia the Mekong giant catfish is called 'trey reach' or 'royal fish', signifying its special status in Khmer heritage. Many Lao people believe that it should be eaten once a year to ensure a long life and active old age (Davidson, 1975). As a sacred fish its white skin represents cleanliness and purity, while its eyes look downwards like the eyes of the Buddha. According to ancient tradition in Thailand and Lao PDR, these mammoth catfish swim upstream to pay respects to Buddha, the creator of the river (Hongsuwan, 2011).

Lao PDR used to see traditional gatherings for the ceremonial catch of the Mekong giant catfish. One notable example was 25km upstream of Vientiane at Ang Tong Nong Chao, the 'golden basin', in Ban Ang. Also known as the 'house of the catfish', the 'abyss' and the 'Lord's Lake', this enormous deep pool, along with other deep pools nearby, was the legendary home of the Mekong giant catfish. It was believed that the fish only came out once a year – during the three days and nights before the full moon of the third Buddhist month. Fishing for the Mekong giant catfish, and the giant catfish, *Pangasius sanitwongsei*, took place during the three days leading up to the full moon, following four days of ceremony (Hartman, 2008). Interference with the Mekong giant catfish at any other time of the year was said to bring terrible misfortune. There were many spirit chiefs, whose duty was to guard the river, who would be offered food and drink. These included the spirits Chao Dan, Siri Mangala, Golden Basin and Golden Swan. Offerings for Golden Basin, for example, would require a procession of boats carrying swords, nuts and leaves, and silver. Beeswax, coconuts, candles, a gong and flutes would all be offered to the spirit. There was another, unusual custom – fishers had to hurl abuse at each other throughout the fishing period, such as shouting, "I will lay with your mother, you bald-headed fool!" At its peak, around ten fish would be caught each year, but by the 1970s this had dwindled to just one or two fish (Davidson, 1975). Now there are none.

History binds people to the Mekong giant catfish

But the Mekong is not just about the Mekong giant catfish. For example, snakeheads were sacrificed in the river to call for rain in Thailand (Baran, Jantunen, & Chong, 2007), and there was also a belief that eating giant snakehead helped to heal the body, for example, after surgery or severe cuts. There are also superstitions around the wallago catfish, *Wallago attu*. While it is eaten across the Mekong, superstition says it's unsuitable for women after childbirth. And while some happily eat the devil catfish or goonch, others are adamant that you should avoid it because it could make you feverish (Davidson, 1975).

THE MAD FISH

Sultan fish

The English name for *Leptobarbrus rubipinna* is sultan fish, a name which gives the imagination very little to conjure with. However, the Thai name for this fish – Pla ba - translates as 'mad fish', which reflects the fish's sometimes strange behaviour. These fish sometimes gorge on the seeds of the 'mad apple', *Datura stramonium*, known as Pong or Lampong in Thai and Lao; a species that can cause delirium if eaten. Fish that eat the seeds reportedly become intoxicated and accumulate the toxic substance. Understandably, many people in Lao PDR avoid eating this fish, but those that do are advised to cut off its head, which is usually the tastiest part. However, where the fish does not come across 'mad apple' seeds, it is still eaten. Sultan fish are migratory, travelling upstream in January and February and downstream in June and July. Historically, some Lao people have referred to this as an annual pilgrimage, as the fish are known to travel to an area in Thailand near Thakhek where there is a relic Buddha. And villagers know when the sultan fish are on the way, because another fish, the Pa sieu (a type of minnow), makes a noise like crickets – perhaps its alarm call – which signals the sultan fish's arrival (Davidson, 1975).

Above © Zeb Hogan. Inset © wrangel / iStock

MEKONG'S FISHES ARE THE WORLD'S PETS

The Mekong in your home – wherever that may be

Line 1: *Epalzeorhynchos frenatum* © Choy Heng Wah, *Pethia stoliczkana* © Nonn Panitvong, *Danio roseus* © Paul Loiselle. Line 2: *Annamia normani* © Enrico Richter, *Yasuhikotakia modesta* © Nonn Panitvong, *Homaloptera confuzona* © Enrico Richter

Keeping a fish tank or visiting an aquarium have been found to reduce stress, anxiety and blood pressure and even help us to sleep (Clements et al., 2019), so it's perhaps unsurprising that freshwater fishes are one of the world's most popular pets. Globally, some 5,300 species of aquarium 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 billion (Evers, Pinnegar & Taylor, 2019).

The value of the trade in aquarium fishes from the Mekong can only be inferred from anecdotal information. For example, one aquarium fish market – Thailand's Banpong Fish Village – has an annual turnover of more than US$20 million. Fish in this market, many of which are Mekong species, are both farmed in captivity and harvested from the wild. About 80 per cent are sold to domestic consumers, with the rest exported to Singapore, Canada, USA and Japan, as well as the Middle East and Europe (Samphawamana, 2015).

Analysis of publicly available data, prepared for this report, indicates that as many as 14 per cent of freshwater fish species from the Mekong may have been available in the aquarium trade at some point (R. Collins, pers. comms 2023[2]) – this equates to more than 120 species, some of which are among the world's favourite fish.

Take for example the gourami: the Mekong is home to several popular gourami species including the three-spot gourami, *Trichopodus trichopterus,* snakeskin gourami, *Trichopodus pectoralis*, moonlight gourami, *Trichopodus microlepis*, and sparking gourami, *Trichopsis pumila*. Other Mekong aquarium favourites include the Siamese algae-eater, *Crossocheilus atrilimes*, Chinese algae eater, *Gyrinocheilus aymonieri*, the Thai stone sucker, *Garra cambodgiensis,* rose danio, *Danio roseus,* scissortail rasbora, *Rasbora trilineata,* the cherry spot rasbora, *Rasbora rubrodorsalis,* and the red-tailed rasbora, *Rasbora borapetensis*, which is the most traded of all. Meanwhile, the rainbow shark, *Epalzeorhynchos frenatum,* is a fish many aquarists aspire to keep. Other popular species include the hillstream loaches and the stone loaches, although some of them are not yet identified at the species level and it's difficult to keep track of them in the trade. Larger loaches are also prized, including the blue loach, *Yasuhikotakia modesta* and skunk loach, *Yasuhikotakia morleti*.

Some Mekong species in the aquarium trade can be impractical to keep as pets. Such fish might be bought at a very young age when they're small, but as adults they can easily outgrow the average tank. Take the stunning blackshark minnow, *Labeo chrysophekadion*, which can grow to 90cm. Or the giant gourami, *Osphronemus goramy,* which can reach 70cm. Or the clown featherback, *Chitala ornata*, which can end up as long as 1m. Another unusual species sometimes found in the aquarium trade is the Mekong pufferfish, *Pao suvattii*, but they're very specialist pets due to their predatory behaviour. The crystal-eyed catfish, *Hemibagrus wyckii,* is a food fish in the Mekong and has the reputation of being the most aggressive aquarium fish in the world. Reaching up to 70cm in length, it's adapted to fast flowing currents, and in captivity – where it probably gets bored – it has the strength to knock the lid off its tank, and chew tank furniture. However, a few aficionados covet the species as it's reported to be a particularly intelligent fish and very interesting to keep.

The Mekong fighting fish (aka emerald fighting fish), *Betta smaragdina,* is one of the most famous of the Mekong's aquarium fishes, and arguably one of the most beautiful fishes in the world. Native to the Lower Mekong Basin, it's found in the domestic and specialist international pet trade and is also used for game fighting. For many years, its close relative the Siamese fighting fish, *Betta splendens,* has generated millions of dollars for Thailand with an export value estimated at around US$5.6 million in 2018 (Sermwatanakul, 2019). However, the value of the Mekong fighting fish is not known and, like many fish in the Mekong, it has been assessed as 'Data Deficient' by the IUCN, which also states that it's at risk from collection for the pet trade and from hybridization with captive-bred individuals released into the wild (IUCN, 2023). This highlights a key issue with the aquarium trade: for communities and economies to continue to reap the value of aquarium fishes, it's essential that we better understand these species through monitoring and ensure that the harvest is managed sustainably.

Otherwise, more species will end up like the famous Siamese tiger perch, *Datnioides pulcher,* whose popularity in the aquarium trade has resulted in its dramatic decline. Once widespread across the Lower and Middle Mekong River, it's now considered Critically Endangered. It has been extirpated from Thailand and is extremely rare in the rest of its range in Lao PDR, Cambodia and Viet Nam, where its population is estimated to have declined by more than 90 per cent over the last 20 years (IUCN, 2023).

The Mekong's freshwater fishes have huge value in the aquarium trade in terms of the number and variety of species, as well as economically. But the species in the Mekong are poorly known, and their trade is almost entirely unreported and unregulated. Some species are not yet described to science, and the health and status of almost all the species in the trade remain unmonitored. Of the species that we know best, many are threatened. It's not known what proportion of aquarium fish from the Mekong are harvested from the wild, compared with farmed in captivity – although globally, it's estimated that approximately 10 per cent of all freshwater specimens are harvested directly from wild populations (Olivier, 2001).

There's an urgent need to better understand the status and trends of ornamental species, to monitor and manage harvesting to make it sustainable, and to regulate the international aquarium trade. There's also an urgent need to capture data on this trade and to assess the impact that it's having: advances in DNA methods may be able to support this (Collins et al., 2012).

Aquarium fishes of the Mekong can provide significant economic value: if sustainable approaches are implemented, they could contribute to future prosperity for many people across the region.

THE PRICELESS AROWANA

Also called the dragonfish, the stunning Asian arowana, *Scleropages formosus*, is believed to bring good luck and fortune. Demand for this species in the aquarium trade is high, and depending on their colour and size, individuals can sell for huge sums – but it is estimated to have declined by between 50-90 per cent across its range, with unsustainable harvest for the pet trade being a primary cause. As a CITES Appendix 1 species, international trade in the Asian arowana is illegal, and domestic legislation also prevents its capture and trade. However, enforcement is very poor, and given the prices it can command, the incentives to continue to trade this species illegally are very high.

Male arowana are targeted by harvesters when they're mouthbrooding their babies. Harvesters kill the males or scare them into releasing their babies from their mouths. Although harvesters are aware of the need to protect male arowana for future generations, they are killed around 80 per cent of the time (Rowley, 2008). The fish are sold to traders who export them internationally and who may even provide cash advances to harvesters.

The continued illegal trade in Asian arowana is unsustainable, and if continued will result in the loss of this species and the livelihoods it provides. In recognition of this fact, different approaches have been used in two locations in Cambodia to protect the species and benefit local communities. Since 2002, harvesters in Tatai Kraom commune have only been permitted to harvest juveniles for four weeks a year (14 April – 14 May) and to take half the fish from the mouth of each brooding male. Traders must register and pay approximately US$250 to the commune for the rights to purchase fish from them during the harvest period. Harvesters are only allowed to use handheld dip nets to catch brooding males. Any violation of these regulations results in arrest and large fines.

Meanwhile, the harvest and trade of Asian arowana from Thmar Daun Pouv commune was successfully halted after 2006 as the result of an incentive agreement with Conservation International (CI), which ran until 2011. While harvesters agreed to a ban on collecting this species and to using nets and fishing gear at its breeding sites, villagers from local communities were employed as 'community rangers' to patrol the pools and ensure compliance. In return, CI provided support to the communities in the form of agricultural and educational support and daily stipends to patrol the pools. Surveys suggested that there was higher juvenile recruitment after the incentive was initiated (Rowley, 2008).

However, as in many other countries, the freshwater habitat of the Asian arowana is under increasing pressure from agricultural expansion, deforestation and hydropower developments, so fishery regulation alone will not be sufficient to ensure the long-term sustainability of this magnificent species.

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2. Taken from an analysis of IUCN and FishBase 'Use in Trade' list produced by Dalia Conde and FishBase 'Mekong' list produced by Rupert Collins. Analysis by Rupert Collins.

Giant snakeheads could lure more anglers to the Mekong

RECREATIONAL ANGLING IN THE MEKONG

An eco-tourism opportunity?

Hundreds of millions of people around the world enjoy recreational angling, generating over US$100 billion each year and providing hundreds of millions of jobs (FAO, 2020). In the Mekong, recreational angling is not yet a widespread activity (Hortle, 2009) – but the Mekong is home to a huge diversity of giant and novel freshwater fishes living in beautiful and varied habitats, and has the potential to attract anglers from across the globe.

Mekong giant fish are an attraction in stocked lakes, which can contain species such as the Siamese giant barb, *Catlocarpio siamensis*, the giant snakehead, *Channa micropeltes*, the giant gourami, *Osphronemus goramy*, and the wallago, *Wallago attu*, a giant nocturnal catfish that can reach up to 2.4m. Smaller Mekong fishes are also targeted, including the smallscale archerfish, *Toxotes microlepis*, which reaches just 15cm. While many of the fish stocked in lakes are native to the Mekong, non-native species are also stocked. These include the arapaima, *Arapaima gigas,* and peacock bass, *Cichla* spp., from South America, and alligator gar, *Atractosteus spatula*, from North America. However, the accidental escape of these non-native species poses a significant threat to native freshwater fishes of the Mekong.

Recreational angling on the river itself is also possible. Although of limited scale, there are several operators offering river fishing in Viet Nam, Cambodia and Lao PDR. Angling trips on the river in Cambodia are advertised for almost US$200 for one day's fishing[3], with the main attraction being Mekong giant catfish and giant freshwater stingray. The wolf barb is an Endangered giant fish that can reach up to 2m in length. Now only found in Lao PDR, it is sought by many fly fishers and in Nakai-Nam Theun National Park, there has been an increase in recreational angling for this species. However, conservationists are concerned that this could pose an added threat due to the lack of governance and monitoring of the fishery.

Recreational angling in the Mekong Delta is bigger business and is more varied than elsewhere on the river: tourists are invited to experience the Mekong Delta by catching a fish with their bare hands for US$124 for a day[4]. Recreational angling also occurs in national parks, with 22 per cent of domestic tourists coming to Viet Nam's Tram Chim National Park for the purpose (Nguyen, 2022), while 30 per cent of U Minh Thuong National Park's funding is generated from anglers, who pay around US$250 a day to fish (Montague, 2013).

There are clear benefits to recreational angling in terms of livelihoods, the economy and well-being; and, when carefully managed, eco-tourism angling can also support fish conservation. Around the world there are many examples of where angling eco-tourism has funded livelihoods, supported the economy, and conserved freshwater fishes and their ecosystems, such as the hump-backed mahseer eco-tourist angling in India's Cauvery River (WWF, 2021). Meanwhile, on the Salween River in Thailand, communities have set up no-fishing zones, where they charge Thai fly-fishers around US$15 per day to fish in their reserves. These anglers also need to hire a local guide for approximately US$10 for the day, who leads them to the appropriate fishing areas and makes sure they abide by catch-and-release.

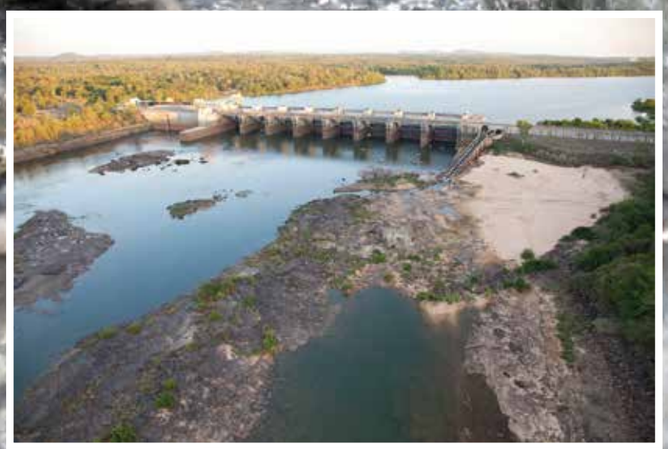
However, issues can arise when a recreational fishery is not managed or is managed poorly. In the Mekong, this would need to be managed at a species level to be sustainable. Other issues include the introduction of invasive non-native fishes and hatchery fish; poor fish handling and damaging hooks that injure fish; and litter, particularly discarded fishing nets, hooks and lines, which are a threat to all wildlife.

But with prior research to understand and manage any potential negative impacts, close collaboration with communities, and governance to ensure sustainability, experts believe that promoting the development of recreational angling in the Mekong Basin within the framework of eco-tourism principles could aid the conservation of species and benefit local communities (Hogan, 2011).

3. https://atcambodia.com/our-tours/mekong-river-fishing-tour/
4. https://www.bestpricetravel.com/mekong-delta-tours/experience-mekong-delta-with-fish-catching-by-bare-hands.html

MEKONG FISHES IN FREEFALL

The sharp end of the biodiversity crisis



The Mekong River Basin is a biodiversity hotspot for fishes and other species, but it's also a hotspot of threats and risks. The situation is worse than can be seen on the surface as relatively few conservation assessments have been carried out. Those that were conducted have not provided enough detail for a solid baseline, while some are very old – meaning wildlife declines have occurred without referencing or without anyone even noticing.

The evidence we do have is piecemeal but it's startling. We know that 74 fishes in the Mekong are threatened with extinction; we know that fishes make up the majority of the Critically Endangered vertebrates in Southeast Asia; we know that some fishes have not been seen in decades; we know there's evidence of an 88 per cent collapse in the population size of fishes in Tonle Sap Lake (Chevalier et al., 2023); and we know that the economic value of the Mekong fishery has dropped more than a third in recent years associated with environmental threats (Cowx, Lai and So, 2024). Finally, we know that the Mekong faces many and cumulative pressures, which present a significant and worsening threat to biodiversity (Soukhaphon et al., 2021).

So, let's explore the impact of this in more detail....

74 freshwater fishes in the Mekong are threatened with Extinction – including 18 Critically Endangered fishes, 21 Endangered fishes and 35 Vulnerable fishes[5] (Figure 6).

From this we can estimate that 19 per cent of assessed Mekong fish species are threatened[5], which is lower than the global average of 25 per cent of assessed species. But the data are minimal. Of the assessed species, 38 per cent are Data Deficient. This means they are so poorly known that their threat status can't be assessed.

This figure is considerably higher than the 14 per cent global average for species considered Data Deficient (Cazalis et al., 2023). It is also cause for serious concern since global research suggests that 50 per cent of all Data Deficient species are threatened (Borgelt et al., 2022). So, it's safe to say that the true number of globally threatened fish species in the Mekong is likely much higher than 74.

To name just a small proportion, they include the long-snouted pipefish, *Doryichthys boaja*, which is the world's

THREATENED MEKONG FISHES

CRITICALLY ENDANGERED – ASAP SPECIES	*Aaptosyax grypus*	Mekong giant salmon carp
	Altigena zhui	
	Catlocarpio siamensis	Giant barb
	Cyprinus daliensis	
	Cyprinus megalophthalmus	
	Datnioides pulcher	Siamese tiger perch
	Glaucostegus typus	Giant guitarfish
	Oreoglanis lepturus	Stone sucker catfish
	Pangasianodon gigas	Mekong giant catfish
	Pangasius sanitwongsei	Giant pangasius
	Poropuntius cogginii	
	Poropuntius exiguus	
	Probarbus jullieni	Jullien's golden carp
	Pristis pristis	Common sawfish
	Scaphognathops theunensis	Nam Theun thin-lipped barb
	Schistura leukensis	
ENDANGERED	*Schistura tenura*	
	Sewellia breviventralis	
	Cosmochilus cardinalis	
	Hemimyzon tchangi	
	Laubuka caeruleostigmata	Leaping barb
	Luciocyprinus striolatus	Wolf barb
	Pangasianodon hypophthalmus	Iridescent shark catfish
	Poropuntius bolovenensis	
	Poropuntius consternans	
	Poropuntius deauratus	
	Poropuntius lobocheiloides	
	Poropuntius solitus	
	Probarbus labeamajor	Thicklip barb
	Pterocryptis inusitata	
	Rhinogobius lineatus	
	Schistura bairdi	
	Schistura bolavenensis	
	Schistura nudidorsum	Naked back stream loach
	Schistura quasimodo	Humpback stream loach
	Scleropages formosus	Asian arowana
	Schizothorax taliensis	
	Sewellia patella	Butterfly loach
	Terateleotris aspro	
VULNERABLE	*Akysis brachybarbatus*	
	Ambastaia nigrolineata	Black-lined loach
	Bangana musaei	Cave bangana
	Cirrhinus microlepis	Small-scaled mud carp
	Creteuchiloglanis gongshanensis	
	Datnioides undecimradiatus	Mekong tiger perch
	Devario apopyris	
	Epalzeorhynchos munense	River Mun red-fin shark
	Glyptothorax deqinensis	
	Hemimyzon confluens	
	Hemimyzon elongatus	
	Hypsibarbus lagleri	
	Incisilabeo behri	Mekong dolphin carp
	Labeo pierrei	
	Mystacoleucus lepturus	
	Mystus bocourti	Flag fin bagrid catfish
	Nemacheilus banar	
	Osphronemus exodon	Elephant ear gourami
	Oxygaster pointoni	
	Pangasius krempfi	Bonglao catfish
	Poropuntius speleops	Thai cave barb
	Pseudohemiculter dispar	
	Rhinogobius albimaculatus	
	Rhinogobius chiengmaiensis	Chiangmai stream goby
	Rhodeus laoensis	Lao bitterling
	Scaphognathops bandanensis	
	Schistura atra	
	Schistura kaysonei	Kaysone's cave loach
	Schistura kontumensis	
	Schistura tubulinaris	
	Serpenticobitis cingulata	Serpent loach
	Tenualosa thibaudeaui	Mekong herring
	Tor sinensis	Red mahseer
	Troglocyclocheilus khammouanensis	Khammoun cave barb
	Wallago attu	Wallago

Figure 6. The 74 fish species of the Mekong River Basin assessed as threatened (Critically Endangered, Endangered or Vulnerable) by the IUCN Red List of Threatened Species (2023)

© Charlotte Bleijenberg

largest freshwater pipefish species, as well as the pygmy pipefish, *Doryichthys contiguous*; the Mekong flying barb, *Esomus longimanus,* which has enlarged pectoral fins to help them to 'fly'; and the unusual freshwater blenny, *Phenablennius heyligeri,* from the Mekong Delta. Many Data Deficient species are also fishery species including: the almost transparent long-fin glass catfish, *Ompok pinnatus*; the giant sharkminnow, *Osteochilus schlegelii*, which is used to make the salted fish paste prahok (Thai) and padek (Lao); the sultan fish, *Leptobarbus rubripinna,* which eats insects and fruits, including poisonous ones; and the rat-faced pangasiid, *Helicophagus leptorhynchus,* and elongate catfish, *Pangasius elongatus*, which are both relatives of the Mekong giant catfish.

In addition to the Data Deficient species, many have not yet had their conservation status assessed, and some have not been described by science. In addition, many new species are found each year. Furthermore, a lot of the assessed species were analysed over ten years ago, and there's a pressing need to reassess them: one immediate conservation action in the Mekong should be to increase the monitoring of its fish species.

Other evidence also points to concerning conclusions. Take for example Tonle Sap Lake. An analysis of catch data for 110 fish species recorded there between 2003 and 2019 found that fish populations have declined by 88 per cent, with a statistically significant decline for >74 per cent of species (Chevalier et al., 2023). Declines were more pronounced for larger and previously abundant species, including the rat-faced pangasiid and the giant snakehead. Ten previously recorded species had disappeared altogether by the time of the 2018–2019 catch, including the forest snakehead, *Channa Lucius*, the walking catfish, *Clarias batrachus*, the moonlight gourami, *Trichopodus microlepis*, the catfish *Hemibagrus filamentus,* and the Mekong giant catfish (Chevalier, 2023). Many of the species highlighted by this research had been assessed globally in the IUCN Red list as Near-Threatened or Data Deficient, with just one being Critically Endangered. This underlines the urgent need to evaluate all the data available and for more investigations to understand the real levels of risk faced by fishes in the Mekong.

5. Best estimates based upon Mekong Basin HydroSHEDS Level 3 and IUCN Red List Spatial Dataset 'Species from the class Actinopterygii found within freshwater systems'. Updated: 11th December 2023. Accessed 2nd February 2024: The IUCN Red List of Threatened Species. Version 2023-1. https://www.iucnredlist.org. The final list was generated following ground-truthing of results was undertaken by the SSC IUCN Freshwater Fish Specialist Group.

THREATENED SPECIES CASE STUDIES

Mekong giant catfish

Endemic to the Mekong River, the Mekong giant catfish, *Pangasianodon gigas,* is one of the world's largest freshwater fishes. But despite its size and sacred status, its story is one of dramatic decline. Evidence indicates that species numbers have fallen by at least 80 per cent since the 1980s, and despite once being an important fishery species it's now very rare to see one at all. When the species was last assessed in 2011 it was listed as Critically Endangered, with unregulated and poorly managed fishing being its largest threat. While traditional fishing rituals exist in Thailand and Lao PDR, which protected the species from excessive exploitation, demand has increased recently and driven prolonged, intense and indiscriminate fishing – and this in turn has led to declines in the abundance and size of Mekong giant catfish and other large-bodied fishes.

In addition, dams and reservoirs present a significant threat to long distance migrating species such as the Mekong giant catfish, by altering habitat and preventing the species from reaching upstream habitats and completing its lifecycle. If new proposed dams are built, it's likely we'll lose this species for good, as has been demonstrated by the case of the now Extinct Chinese paddlefish in the Yangtze River.

The story of the Mekong giant catfish is shared by other enigmatic and Critically Endangered Mekong giants, including the giant barb, *Catlocarpio siamensis*, Jullien's golden carp, *Probarbus jullieni*, the giant pangasius, *Pangasius sanitwongsei*, the Mekong giant salmon carp, *Aaptosyax grypus*, and the Endangered giant freshwater stingray, *Urogymnus polylepis*. Fishers speak of a dramatic decline in the presence and body size of these megafishes: for example, fishers surveyed in Cambodia reported that over a 20-year period most megafishes changed from common to uncommon, rare, or locally extirpated, with a dramatic decline in body size of all species. Of the giants, the Mekong giant catfish was the rarest, with fishers reporting that the last time they saw one was eight years earlier.

Siamese tiger perch

The Siamese tiger perch, *Datnioides pulcher*, (photo above) was once widespread in Indochina, from the Maekhlong and Chao Phraya basins in Thailand, to the Middle and Lower Mekong. However, since the 1990s the Siamese tiger perch has been extinct in the Maekhlong and Chao Phraya basins, and it's now considered extremely rare in the Mekong – evidence indicates that its population has fallen by 90 per cent in the last 20 years. While it was once also a food fish, overexploitation for the international aquarium trade is the major reason for this decline, and although it's now very rare, when it is found, the incentive to fish for it is difficult to resist as it fetches high prices on the international market. Attempts to save the species have occurred, and it's now illegal to catch or possess it in Thailand, although enforcement of the legislation could be improved. Around 14 per cent of Mekong fishes are in the unmonitored and unreported aquarium trade. Until scrutiny and regulation are considerably improved, other aquarium fishes in the Mekong risk sharing the same fate as the Siamese tiger perch.

Restricted range endemics

The tributaries of the Mekong are home to many small, specialized species with limited ranges, known as restricted range endemic species (see Box 20). Species of small range are particularly vulnerable to threats. Living in just one restricted range means that their whole population may be at risk from one disaster or environmental threat, such as a new dam or pollution; and having specific adaptations to one restricted range may mean that the species is unable to survive, or at least disperse to, anywhere else. In the Mekong, these species include the hillstream loaches and stone loaches, which have adapted to live in fast-flowing hill streams. One example is *Schistura tenura*, a small stone loach known from the Nam Leuk River north-east of Vientiane in Lao PDR. The known geographic range of this species occurs almost entirely downstream of the Nam Leuk dam – where, since the dam was installed in 1999, very little water remains. There's no suitable habitat upstream either, as this little fish is adapted to live in fast-flowing streams, and upstream now is only a deep reservoir. There have been no sightings of this species since 1998, and it's believed it could now be extinct (Kottelat, 2000). There are countless other restricted-range endemic fishes in the Mekong, many of which haven't been identified, and most of which aren't monitored. Yet they're all facing multiple threats, and it's very possible we're losing some of them before we even know they exist.

Above left © Suthep Kritsanavarin, above right © Daiju Azuma

THREATS TO FISHES IN THE MEKONG

Today, the future of the Mekong's fishes is under considerable pressure from rapid economic growth and the threats posed by hydropower dams, agricultural and industrial expansion, and sand and gravel mining (MRC, 2019). Consequently, several previously important fishery species in the basin have declined significantly and are now considered Critically Endangered, including Jullien's golden carp, the giant barb, and the giant pangasius (Poulsen et al., 2004).

The Mekong is no longer a free-flowing river

The flow of water, sediment and nutrients is the lifeblood of the Mekong. This flow is vital to all fishes of the Mekong, particularly its 321 migratory fishes (Kang and Huang, 2022), which participate in one of the largest migrations of animals on Earth.

However, the Mekong and its tributaries are no longer free-flowing due primarily to hydropower dams. The construction of large dams began on the Mekong in 1965 but the vast majority were built after 2010 (Soukhaphon, Baird and Hogan, 2021). According to the Mekong Infrastructure Tracker, as of December 2023, there are 126 large, operational dams in the Mekong Basin, with an additional 35 currently under construction, and a further 287 planned[6]. This drastic alteration of the basin's natural flows is the primary threat to fishes in the Mekong (Kang & Huang, 2022; Vu 2021; Kang et al., 2009; Baran, Jantunen and Chong, 2007) as it impacts them in many ways, while also exacerbating other threats.

Firstly, dams create a barrier across the river preventing passage of fishes upstream and downstream. This can restrict access to essential spawning or feeding grounds needed for a fish to complete its lifecycle. 'Fish passes' or 'ladders' have been fitted on some dams, but generally these aren't effective in the Mekong: they were designed mostly for salmonid fishes in northern latitudes, which are far better adapted to navigate such installations (ICEM, 2010). Meanwhile, the turbines on hydropower dams can seriously injure or kill fish moving downstream. Secondly, dams transform the river from a flowing to a still-water system when reservoirs are created behind the dam wall (Pelicice, Pompeu and Agostinbo, 2015). For fishes that evolved to survive in a flowing environment this is a considerable change, and many simply can't adapt. And for 90 per cent of the Mekong species that migrate, their known migration trigger is a rise in water flows: with changes in the flow regime, this signal can be lost and could mean fish migrations don't even begin (Baran, 2006). Larvae and juveniles of many Mekong fish disperse downstream during periods of high flow, a key adaptation that enables young fish to reach productive floodplain feeding grounds. Researchers described the megadiverse assemblage of

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6. Stimson Center, 2023. https://www.stimson.org/2020/mekong-infrastructure-tracker-tool/ Accessed 22nd December 2023

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larval and juveniles utilizing this life history strategy, recording 168 species drifting down the Mekong River near Phnom Penh over a 10-year period (Chhuoy et al. 2023). Dams also hold back sediment and nutrients, preventing them from travelling downstream. For example, the Chinese reservoir cascade in the Upper Mekong has resulted in reductions of 60-70 per cent in sediment concentrations directly downstream (MRC, 2019). Trapping so many nutrients and sediments alters the Mekong's natural dynamics and other biogeochemical processes, and leads to an overall reduction in productivity (Sarkkula et al., 2010), which impacts the Mekong's fishes, fisheries and other ecosystem services.

An assessment of the impacts of hydropower dam development between 2007 to 2014 in the Sekong, Sesan, and Srepok Basins (three major tributaries to the Mekong River) found reduced fish biodiversity. In the Sesan, the number of fish species fell from 60 to 42, and in the Srepok from 29 to 25 (Sor et al., 2023). At the Mekong scale, modelled predictions indicate that basin-wide, the development of 77 dams in the Mekong would result in the loss of between 550,000 tonnes and 880,000 tonnes of wild capture fisheries, which is equivalent to between 23-39 per cent of the total yield. And if all eleven mainstream dams in the Lower Mekong are completed, catch losses are estimated at almost 240,000 tonnes (44%) for Cambodia and almost 360,000 tonnes (42%) for Viet Nam (Ainsworth et al., 2022). Attempts to compensate for the loss of free-flowing rivers with reservoir fisheries are well meaning, but not sufficient; reservoir installations are estimated to replace just 10 per cent of a wild fishery lost through dam installation (ICEM, 2010). Replacing lost Mekong fisheries with other foods also faces huge costs and challenges as discussed on p30.

Unsustainable sand mining is a concrete, but understudied threat to Mekong fishes

Sand is critical to societies and economies as it is the primary raw material in concrete and asphalt. Globally, it is the second most exploited natural resource after water. But unsustainable sand mining to meet the soaring demands of the construction industry is having negative social and environmental impacts across the globe, including in the Mekong. The combination of hydropower dams trapping large amounts of sediment and large-scale sand mining in the Mekong has drastically reduced the amount of sand and gravel in the river, extracting far more than can naturally be replenished. At current rates of sand mining, a WWF report estimated that the Mekong Delta would run out of sand by 2035 with far-reaching consequences for the delta and the people and species that rely on it. Already the delta is sinking and shrinking, losing on average 1.5 football fields every day (Anthony et al., 2015). But it is not just the delta that is being impacted. Unsustainable sand mining creates deeper rivers (some Mekong channels are now 3m deeper than 25 years ago (Brunier et al., 2014)), undermines riverbanks, and exacerbates the erosion of shorelines, including the loss of mangrove forests – all of which poses risks to people and nature, including fishes.

The impacts from sand and gravel extraction can be direct or indirect (Koehnken et al., 2020). Direct impacts come from the destruction of habitats, such as the riverbed or floodplain, and noise or pollution in the mining area. Indirect impacts are those observed at the system scale and can be a large distance from the mining operation itself, for example in the Mekong Delta. A review of global evidence found that fishes are negatively impacted by both, including the direct destruction of fish spawning, feeding or refuge sites, and from the indirect alteration to hydrology, habitats and water quality at scale (Koehnken et al., 2020) and it has been linked to negative impacts on fisheries in Cambodia (Asif and Arragon, 2023). With demand for sand increasing there is an urgent need to ensure that sand mining is sustainable and that other alternatives are promoted. And there is evidence that this is possible and that sand can be extracted more sustainably, including in the Mekong (Cooke et al., 2023).

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Mekong habitats are being lost

Significant habitat loss and alteration have also occurred in the Mekong and its tributaries due to the hydrological changes caused by dams as well as sand and gravel mining, the construction of dikes and levees, conversion to agriculture and aquaculture ponds, and other associated infrastructure (i.e. irrigation canals), flood management structures and navigation improvements.

The region has experienced a rapid growth in agriculture resulting in conversion of habitats to support the production and trade of commodities such as rice, cassava, wood, sugar cane, oil palm, and farmed fish. Take the Mekong Delta, which has been transformed over the last three decades, with wetlands, marshes, and mangroves replaced by aquaculture, permanent crops and arable land. Between 1990 and 2019, researchers observed that the area covered by wetlands had decreased from 28 per cent to 5 per cent, while the area with permanent crops had almost doubled, and the area used for aquaculture had soared from just 2 per cent to 19 per cent. This has resulted in aquaculture covering almost the entire coastal delta zone, with mangroves being converted mostly to shrimp farming (Nguyen et al., 2022). This is corroborated by the Mekong River Commission, which estimate that just 2 per cent of the delta is still in its natural state (MRC, 2018).

The destruction of mangrove forests has led to the loss of their important ecosystem services, such as protection against storms, but also to the loss of spawning and nursery areas for fresh, brackish and saltwater fishes. There are signs that the dramatic decline in mangrove forests is now stabilising due to national and regional reforestation programmes (Nguyen et al., 2022). Nonetheless, the original baseline must be remembered: in the 1950s mangrove forest coverage was estimated at 200,000 hectares (Phan & Hoang Thi San, 1993) – a figure that had dropped to only 82,000 hectares by 1999 (Do et al., 2005).

The threat of habitat loss, deforestation and conversion to agriculture is not restricted to the Mekong Delta. Between 2000 and 2017, land use for crops, rice, and plantation increased across 30 sites in the Lower Mekong Basin, while upland forest and flooded forest areas have decreased (Tromboni et al., 2021). Take for example, the Tonle Sap Lake and floodplain, where considerable habitat loss has occurred as rice paddies have expanded (Mahood et al., 2020). Or the seasonally flooded forests of the Lower Mekong Basin – a particularly valuable habitat for fish – which have experienced significant habitat conversion and deforestation. In Cambodia and the Srepok, Sesan and Sekong Rivers (Cambodia, Lao PDR and Viet Nam), 19 per cent of primary forest was lost between 1992 and 2017, with more floodplain forest (31%) lost than upland forest (18%) (Lohani et al., 2020).

Pollution is an issue to consider more carefully

Although not recognized as one of the largest threats to fishes in the Lower Mekong, evidence from MRC fish population monitoring found that fish population density was linked to locations with good water quality (MRC, 2021). Indeed, pollution and poor water quality are known to be a serious threat at the local level, particularly near heavily populated areas (MRC, 2019; Tromboni et al., 2021). In addition, deforestation and agricultural conversion have been linked with increases in nutrient pollution in the Lower Mekong (Tromboni et al., 2021), although the issue is a complex one since the main water quality issue recognized by MRC is the reduction in nutrient carrying sediments (MRC, 2019). Poor water quality can impact fish directly as well as affecting reproduction, as some fishes require clean oxygenated water for their eggs to survive. Polluted water can also have sub-lethal effects, increasing the likelihood of fish suffering from disease or parasites, while some pollutants, such as flame retardants and heavy metals, can accumulate in their bodies. But much is still unknown. What is clear is that efforts need to be made to better understand how changes in water quality in the Mekong at both the local and system scale impact fish species and populations.

The Mekong is at risk from unsustainable fishing practises

Freshwater fishes have been critical to societies in the Mekong since early in the history of the region, but demand and exploitation really began to soar during the colonial period. Fishing pressure intensified in Viet Nam and Cambodia in the 1950s and later in Lao PDR, facilitated by improved access due to road and other infrastructural development and the availability of modern fishing gear (e.g. nylon gill nets) at affordable prices.

Fisheries resources have also been threatened in both the Mekong River and Tonle Sap Lake by the use of destructive fishing methods (explosives, poisons and electrocution), and illegal fishing in spawning season and at spawning grounds (Coates et al., 2003; Nuon & Gallado, 2011; Ngor et al., 2018; Chan et al., 2020). Furthermore, Tonle Sap Lake's flooded forest is facing degradation from the expansion of fishing, harvesting of the forest for fuel wood, and conversion to agricultural land (MRC, 2021). Currently, the Mekong River Commission ranks pressure on wild capture fisheries as 'Red', which means it's a major concern and urgent action is needed (MRC, 2019).

However, many fishers recognize the risks and consequences of overfishing (Vu, 2021), and many are keen to engage in better practices where possible. Fishers in the Mekong have the knowledge needed to improve fishery management for the better, and many do by imposing restrictions on fishing gear, areas and seasons; establishing more protected areas and community conservation zones. Fishers are also a source of invaluable Traditional Ecological Knowledge, which should be the foundation of decision making in the Mekong. However, these management measures need to be adopted faster and on a much wider scale, and fishers' knowledge needs to be harnessed and utilised by decision makers, if we are to safeguard fishes and fisheries in the Mekong.

Invasive non-native species are a potential threat the Mekong's native fishes

Introductions of non-native fishes (also referred to as 'aliens' or 'exotics') in the Mekong date back to the late 17th century. Species have been introduced primarily for aquaculture and reservoir stocking for food but also for pest control, sport fishing, and the aquarium trade (Welcomme & Vidthayonom, 2003). And once they're established, it's extremely difficult, if not impossible, to remove non-native fishes.

The first introduction was the goldfish, *Carassius auratus*, which was brought from China sometime between 1692 and 1697. Many others followed, including the African sharptooth catfish, *Clarias gariepinus*, which was originally introduced from the Central African Republic to Viet Nam for aquaculture in 1974. It then spread to Cambodia, Lao PDR and Thailand. Male African sharptooth catfish have since formed hybrids with females from the related native species, the bighead walking catfish, *Clarias macrocephalus*. The Nile tilapia, *Oreochromis niloticus*, arrived in the region in 1965 when it was introduced to Thailand not from its native Africa but from Japan. It is now widely disseminated as fry from hatcheries. Its relative, the Mozambique tilapia, *Oreochromis mossambicus*, arrived even earlier, when it was introduced from Malaysia to Thailand in 1949 (Ingthamjitr, 2009).

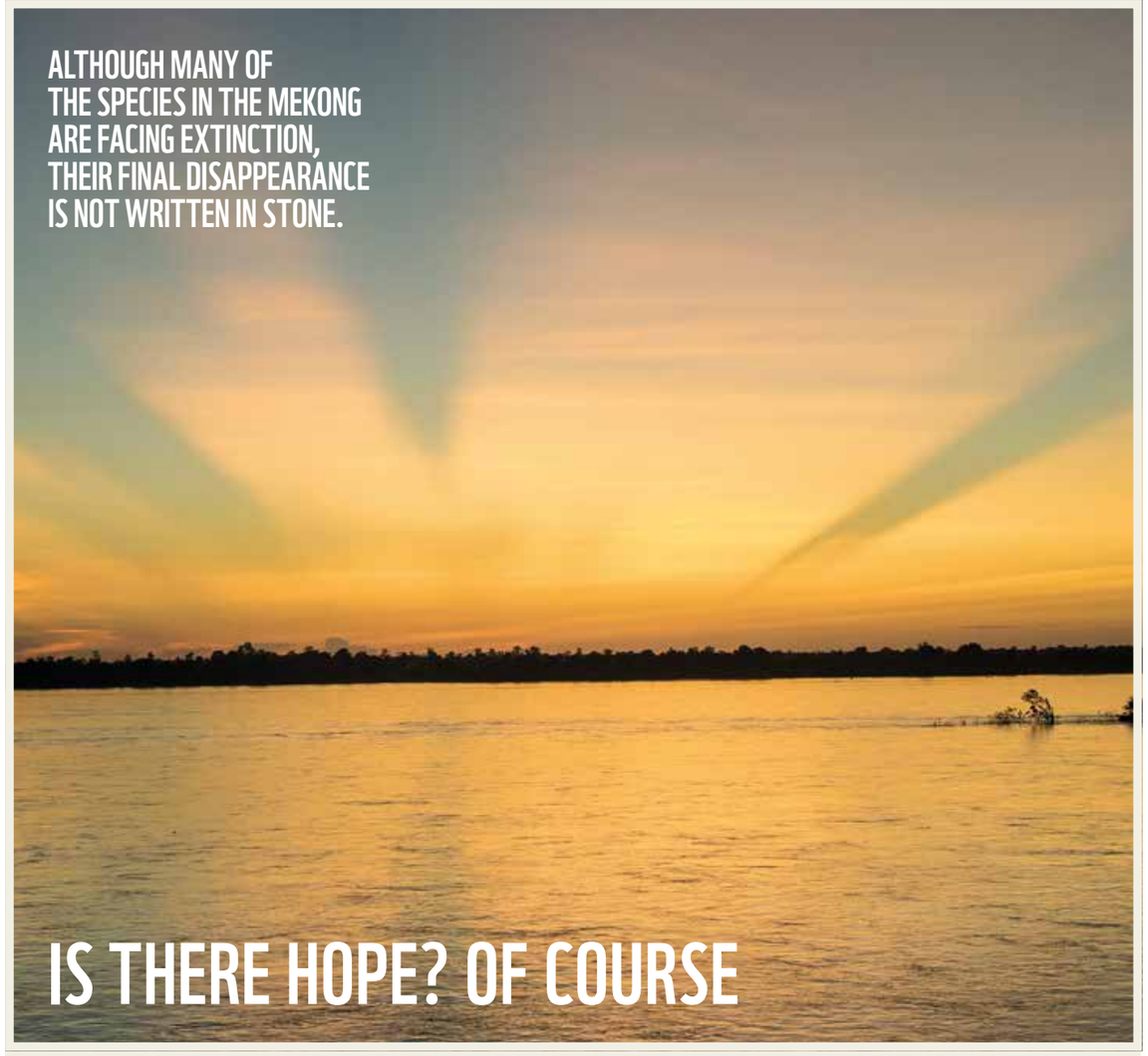
In 2003, Welcomme & Vidthayonom recognized the presence of 17 non-native fishes in the Mekong that had established populations or that the likelihood of establishing one was a very high. In addition to those above, this included the Mrigil carp, *Cirrhinus cirrhosis*, mosquitofish, *Gambusia affinis,* sailfin molly, *Poecilia velifera* and sailfin catfish, *Pterygoplichthys plecostomus*. Today, the Global Invasive Species Database lists 22 invasive non-native fish species, four of which have the dubious honour of being on the 100 World's Worst invasive Alien Species list – common carp, *Cyprinus carpio*; mosquitofish; Nile perch, *Lates niloticus*; and the Mozambique tilapia – due to their serious impact on biodiversity[7]. However, there could be many more, with the Mekong River Commission recently listing the presence of 41 non-native fish species (MRC, 2021).

Non-native species can pose a significant threat to native fishes due to increased competition for resources, direct predation, genetic interference and the introduction of disease. And although most non-native species have been introduced to support food security, it appears that many people still prefer to eat native fish – and consequently native Mekong fishes tend to fetch better prices (Ingthamjitr, 2009). One Cambodian fish farmer near Phnom Penh noted that even though he and two of his brothers farm one of the cheapest indigenous species, the iridescent shark catfish, its price compared favourably with non-native tilapia. He also noted that native catfish was a better ingredient for many Cambodian and Vietnamese dishes than tilapia. In fact, a survey of prices for 14 indigenous fishes and 5 non-native fishes in 2005 at Savannakhet market in Lao PDR found that the average price of indigenous species was roughly double the price of non-native species. Twelve of the indigenous fishes (catfishes, carps and featherbacks as well as an eel and a snakehead) fetched higher prices than the three most expensive non-native species (common carp, tilapia and African catfish) (Ingthamjitr, 2009).

Other invasive non-native species in the Mekong include waterplants. These can severely impact habitat quality and water quality and are found in several wetlands of the Mekong. The most dominant species in the Mekong include the floating species of giant salvinia and water hyacinth.

Climate change

The impact of climate change exacerbates all other threats. In the Lower Mekong Basin, average temperatures are projected to increase by 3–5°C by the end of the century, while rises of 2–3°C along the Srepok, Sesan and Sekong Rivers and in the delta could be reached before 2050 (ICEM, 2013). Precipitation throughout the basin is predicted to increase by between 3-14 per cent – amounting to 35-365mm of additional rain each year. Projections also indicate that climate change will alter the Mekong's hydrobiological seasons, with the wet season starting one to two weeks earlier and the dry season beginning one to three weeks earlier. Higher flows during the wet season could benefit fisheries and fishes, but changes to flows in response to temporal changes in precipitation could disrupt the movement of migrating species (MRC, 2010). And while some fish species may benefit from changing conditions, others may not: overall, a decline in biodiversity is expected (ICEM, 2013). But there is hope: protecting and restoring healthy and hydrologically functioning rivers and their associated habitats can provide a buffer against many climate change impacts on people and fishes.



This report highlights the extrinsic and intrinsic values of the freshwater fishes of the Mekong. It also tells a story of decline and bears a warning for the future. But critically, there is hope. Around the world, species have recovered when given the chance. Small changes can have big consequences for fishes, especially when conservation efforts are led and supported by local communities. And although many of the species in the Mekong are facing extinction, their final disappearance is not written in stone.

Take the Mekong giant salmon carp, *Aaptosyax grypus* – a fish so rare it has been nicknamed the 'ghost fish'. Assessed as Critically Endangered on the IUCN Red List, it hadn't been spotted in the Mekong since 2004 and was feared lost – until, in 2022, an individual turned up at a fish market in northern Cambodia. This has raised hopes that the species is still clinging on in the Mekong, and that it could yet make a recovery.

Another cause for hope is the recent capture of the largest freshwater fish ever recorded – a giant freshwater stingray, *Urogymnus chaophraya*. On 14 June 2022, a 300kg female was captured in the Mekong River in northern Cambodia. Working with the Wonders of the Mekong project, FISHBIO scientists surgically implanted her with an acoustic tag – the first time such a tag had ever been used to study this species. Since then, scientists have been able to monitor the record-breaking stingray's habitat preferences and have found one area that is particularly important for her – and potentially for other stingrays. This information will help conservationists in their fight to halt the decline of this river giant.

7 IUCN SSC Invasive Species Specialist Group, 2023. Global Invasive Species Database: https://www.iucngisd.org/gisd/. Accessed 23rd December 2023.

Giant Barb

A BRIGHTER FUTURE FOR MEKONG FISHES

Rising to the Freshwater Challenge in the region

Despite their rich biodiversity and their critical role in food security, the economy, and the overall health of the river, the freshwater fishes of the Mekong have invariably been an afterthought for national and regional decision makers. This cannot continue, especially given the magnitude of the threats they face – and the far-reaching consequence for people and nature across the region if the drastic decline in the Mekong's freshwater fishes continues.

A healthy Mekong and thriving freshwater fish populations are critical to sustainable development. Millions of people depend on the river's fisheries for food security and livelihoods – fisheries that are irreplaceable and are being lost at an alarming rate. Economic and development decisions must factor in their impact on the river system as well as the fishes, other biodiversity and ecosystems it sustains because long term, equitable economic growth, which reduces poverty and improves human well-being, depends on protecting and restoring the overall health of the environment. The simple fact is that the people of the Mekong cannot afford to lose their fishes or the freshwater ecosystems they inhabit.

The good news is that policymakers are finally starting to take notice of freshwater ecosystems, and major global milestones towards their conservation have recently been achieved. In 2022, countries signed up to the new Kunming-Montreal Global Biodiversity Framework, which explicitly includes the commitment to protect 30 per cent of 'inland waters' (rivers, lakes and freshwater wetlands) and restore 30 per cent of degraded inland waters. This ambitious agreement paves the way for a new approach to transform freshwater biodiversity. The critical issue now is implementation, with countries ensuring restoration and protection targets are incorporated into their National Biodiversity Strategies and Action Plans.

One opportunity that countries across the globe – and across the Mekong – should seize is to join the Freshwater Challenge. Launched in March 2023 at the UN Water Conference in New York, this country-led initiative aims to restore 300,000km of degraded rivers and 350 million hectares of degraded wetlands globally by 2030, and protect key freshwater ecosystems. Already over 40 countries have joined the Challenge, including Cambodia. Other Mekong countries should become Members as well and then set ambitious targets to restore and protect rivers and wetlands within the Mekong river basin. Funders and private sector investors should then follow through with concrete commitments of resources and actions – benefiting societies, economies and ecosystems across the region as well as the fishes of the Mekong.

But protecting and restoring freshwater ecosystems alone is not enough. What's needed in the Mekong is a transboundary Emergency Recovery Plan for Freshwater Biodiversity (Tickner et al., 2021) and – more good news – one already exists. 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 and could be adopted by Mekong countries, supporting and further facilitating the work already carried out by communities, fishers and conservation organisations:

Let Rivers Flow More Naturally

Water volume and flow conditions in the Mekong mainstream are considered 'Amber' by MRC, meaning there are significant issues to address. The MRC Secretariat has recorded a decrease in wet season flow and an increase in dry season low flows, as well as an increase in daily flow fluctuations in some stretches of the mainstream. Some fishing communities have also noted reductions in flows leading to a decline in the health of their fisheries. This is mostly related to the operation of dams, reservoirs, dykes and other impoundments, as well as climate variability.

Addressing flow in the Mekong is essential to protect freshwater fishes and fisheries – and now is the time for action. The MRC Secretariat monitors changes in seasonal and daily flows, which provides the evidence base to advise water sectors on how to better balance water use with development activities: water users must now put this advice into action. Another way to enhance the overall approach is to implement responses based on the River Connectivity Index Assessment Tools (Grill, 2021). This is designed to monitor volumes of water, sediment and nutrients and guide the creation of regulatory baselines and objectives.

Improve Water Quality in Freshwater Ecosystems

While water pollution linked to agriculture and industry is an issue in the Upper Mekong and localized parts of the Lower Mekong, many of the water quality changes in the river are associated with the loss of suspended sediments and nutrients, due to impoundment by dams, dykes and other infrastructure. This has changed the ecosystem of the Mekong from a turbid, nutrient-rich system to one with reduced sediments and nutrients, and more clear water. Fish diversity is linked to river productivity, which is dependent on its overall health, including the concentration of sediments and nutrients – this is one of the reasons the Mekong boasts such a rich diversity.

There's an urgent need to identify and implement measures to mitigate the effects of reduced sediment concentrations in the Mekong, and to minimize further reductions. Central to this is addressing the decline in suspended sediments, notably in relation to the trapping effect of hydropower reservoirs. In addition, tackling water pollution requires improvements in agricultural practices to enhance soil quality and reduce the use of chemical pesticides and fertilizers, as well as measures to reduce pollution from industry, urbanization and development.

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7 https://www.confluvio.com/project/connectivity-in-the-mekong-region

Protect and Restore Critical Habitats and Species

The MRC considers the threat posed by the loss of wetlands and riverine habitats to be 'Red' (MRC, 2019). It calls for urgent action to protect habitats, including addressing the lack of sufficient data. Furthermore, it recommends agreement on clear regional objectives, joint strategies and action plans for protecting and sustainably managing the remaining important wetlands and riverine habitats.

The Mekong region is particularly well placed to contribute towards Global Biodiversity Framework targets to protect and restore ecosystems, and prevent species loss. Freshwater Key Biodiversity Areas have been identified and validated through stakeholder consultations in the Lower Mekong, while there's already a network of protected areas and Other Area-based Conservation Measures (OECMs), such as Fish Conservation Zones.

Countries across the region should build upon and expand existing protected area networks to specifically include important areas for fish spawning, such as floodplain habitats, protect restricted range species, and prioritize the most threatened species as set out in the Strategic Framework to accelerate urgent conservation action for ASAP Freshwater Fishes in Southeast Asia (Patricio, 2023). Critically, area-based conservation targets should be strategically planned, equitably delivered and rigorously monitored to ensure that they have the biggest impact for people, fishes, biodiversity and ecosystem services.

In addition, it may be necessary to maintain ex-situ populations of some fishes most at risk of extinction for captive breeding and eventual reintroductions. Furthermore, it's vital to improve the monitoring of all fish species within the Mekong, particularly those that are at risk due to their narrow range or have been assessed as Data Deficient or Threatened by IUCN Red List.

End Unsustainable Management of Resources

The unsustainable exploitation of sand and gravel in the Mekong has the potential to significantly impact fish populations in the immediate vicinity and at a wider basin scale. Research is required to create evidence-based policies to minimize this impact. In addition, Mekong countries need to: 1) have the tools to monitor essential river-related resources; 2) register sand as a strategic resource that is key to climate resilience and economic growth; 3) add sand exploitation management to existing regional and country policies and procedures; and 4) shift away from the unsustainable exploitation of river sand to alternative sources and materials, since natural flows of sand and gravel are critical to building resilience to climate change, particularly in the delta. Best practice approaches exist and need to be implemented and scaled up across the Mekong.

The Mekong's wild fishery is priceless. Yet, it is at increasing risk from environmental threats – and unsustainable fishing practises. Almost all fisheries in the Lower Mekong are classified as disturbed by the MRC Secretariat, and there's an urgent need to implement the approved Mekong Basin-wide Fisheries Management and Development Strategy to conserve them (MRC, 2021). But decision-makers in all countries must first develop comprehensive fisheries policies, including policies on fish stocking and professionalizing fisheries management, to support the regional strategy at a more granular level. All fisheries should have management plans, management targets, monitoring and reporting systems, and the necessary governance to implement them. Critically, fisheries policies must consider fisheries within the scope of the whole ecosystem, and at the Basin scale, and, for example, tackle environmental threats to fisheries such as poor water quality, or barriers to fish migration. Fishers are part of the solution, and many are already engaging in improved practises; the Mekong already boasts an important network of community-led Fish Conservation Zones (FCZ), which have proven to increase fish diversity and abundance and benefit fishers. Expanding these FCZs and other co-management approaches would improve the basin's fisheries and should be supported by decision makers in all countries. In addition, decision makers should harness the Traditional Ecological Knowledge held by fishers to support decisions within the basin.

The Mekong is home to many species found in the aquarium pet trade. The extent and scope of the trade is not well documented and so is almost completely unregulated, and while laws protecting some species exist, they're seldom adequately enforced. Harvested populations should be monitored, along with traded and exported species. Governments should also enforce best practice management and harvest methods, including setting harvest targets.

Prevent and Control Invasions by Non-Native Species

There has been a significant expansion in the number of non-native species in the Mekong in the last 20 years, and some are particularly invasive and a threat to native fishes. The GBF Target 6 recommends that the rate of introduction and establishment of invasive non-native species should be reduced by 50 per cent, and control and eradication measures implemented. It's essential to increase monitoring of these invasive species in the Mekong to assess their status, trends, distribution and impacts, particularly on native fishes with restricted ranges that may be more at risk. Regional and country-scale management plans are also needed to prevent the introduction of new invasive species, and to manage and control existing invasive and non-native species. These should include stricter stocking management plans to prevent further stocking of invasive species, while encouraging the use of native species in aquaculture.

Protect Free-Flowing Rivers

The Mekong's flow of water, nutrients and sediments has been compromised by the installation of dams and other infrastructure. The endorsement by MRC countries of the Preliminary Design Guidance for Proposed Mainstream Dams in the Lower Mekong Basin and guidelines for Transboundary Environmental Impact Assessments in the Lower Mekong Basin are significant steps forwards, although the preliminary design guidance should be extended to tributary dams. MRC's Joint Environmental Monitoring Guidelines should be consulted when selecting monitoring stations close to dam sites (MRC, 2021). Other important steps include ensuring that integrated river management plans consider the removal of potentially obsolete dams and other river barriers, such as dykes, as well as fragmentation caused by the loss of connectivity with side channels and floodplains. When such river infrastructure is necessary, it's essential that decision-makers factor in the impacts on fish and fisheries and agree on the least ecologically harmful design and location.

All stakeholders and decision makers have the opportunity to chart a new course to restore and protect the Mekong, and use it sustainably for the benefit of societies and economies today and in the future – a future in which the river's extraordinary freshwater fishes survive and thrive. But we need to act now.

Commit to action: Governments should set ambitious national biodiversity targets for 2030 that will safeguard the Mekong's freshwater ecosystems and the future of freshwater fishes and other species as set out in the Global Biodiversity Framework. And then they should develop and implement practical plans to achieve those targets. The MRC should ensure that these targets are coordinated at the basin level to maximise the overall impact and benefits for people and nature.

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 creates a space for the private sector to invest in collectively improving the health of freshwater ecosystems and mitigating risks, while financial institutions should invest in innovative financial solutions that can strengthen resilience and generate returns.

Value freshwater fishes: Last but not least, it's time for decision makers to value the dazzling diversity of fishes in the Mekong: an astonishing 1,148 species that are essential to the health and resilience of the Mekong – and the people and nature that rely on it. Freshwater fishes have swum through the region's cultures, tales and legends for millennia and are still vitally important to the daily lives of millions of people, yet they are invisible to many decision makers. It is time they recognised the critical role freshwater fishes play in societies, economies and ecosystems – and began to factor them into decisions impacting the basin.

The people of the Mekong cannot afford to lose their freshwater fishes or the freshwater ecosystems they inhabit. Rivers, lakes and wetlands are their life support systems and the extraordinary diversity of fishes within them are essential to their health. Reversing decades of decline will be difficult, but it is possible – if we act collectively and urgently.

All the organizations involved in this report are fully committed to ensuring a brighter future for the Mekong's freshwater fishes, because that will mean a brighter, sustainable future for people and nature across the region. We hope you'll join us.

THE PEOPLE OF THE MEKONG CANNOT AFFORD TO LOSE THEIR 'FORGOTTEN' FISHES OR THE FRESHWATER ECOSYSTEMS THEY INHABIT

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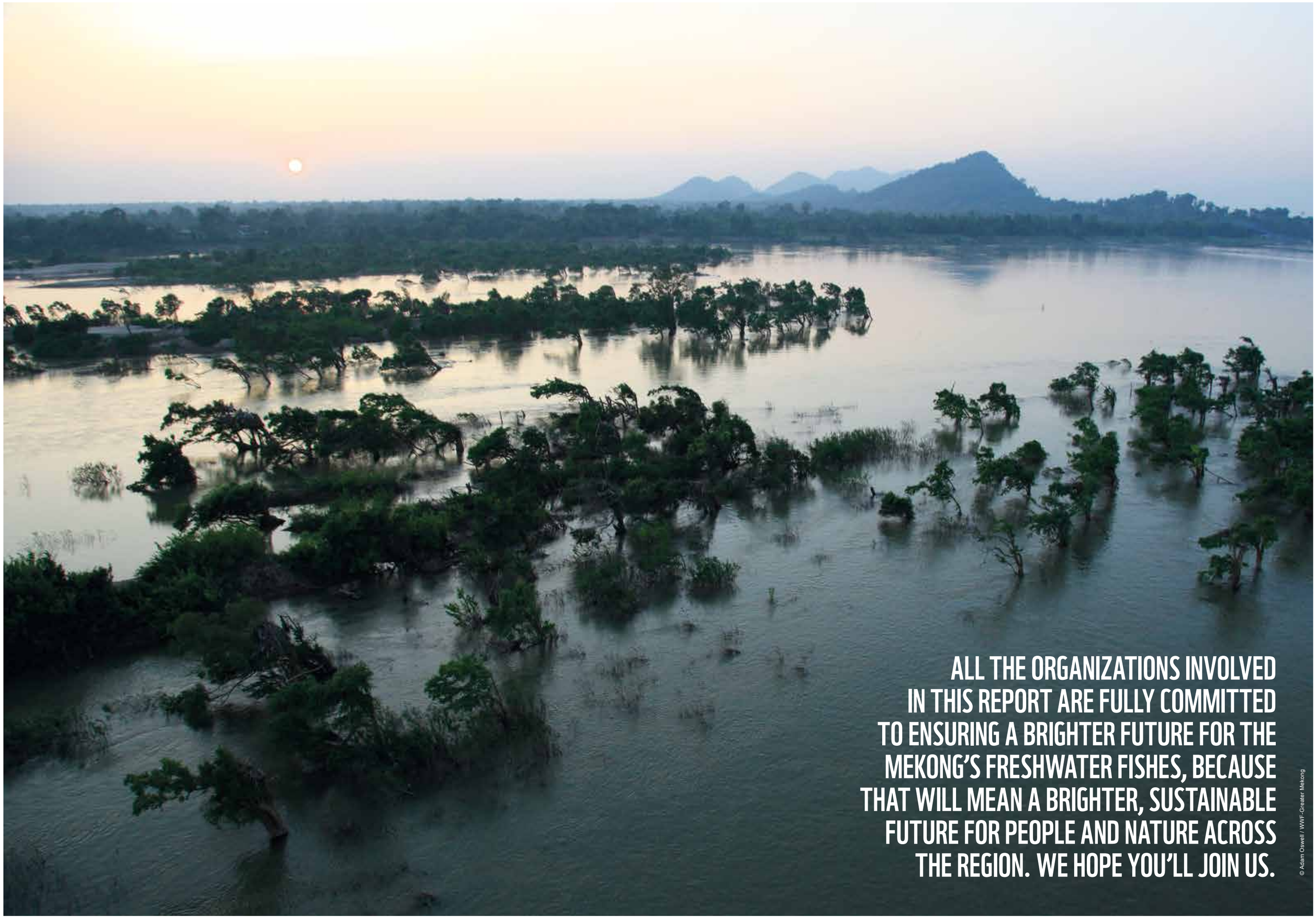
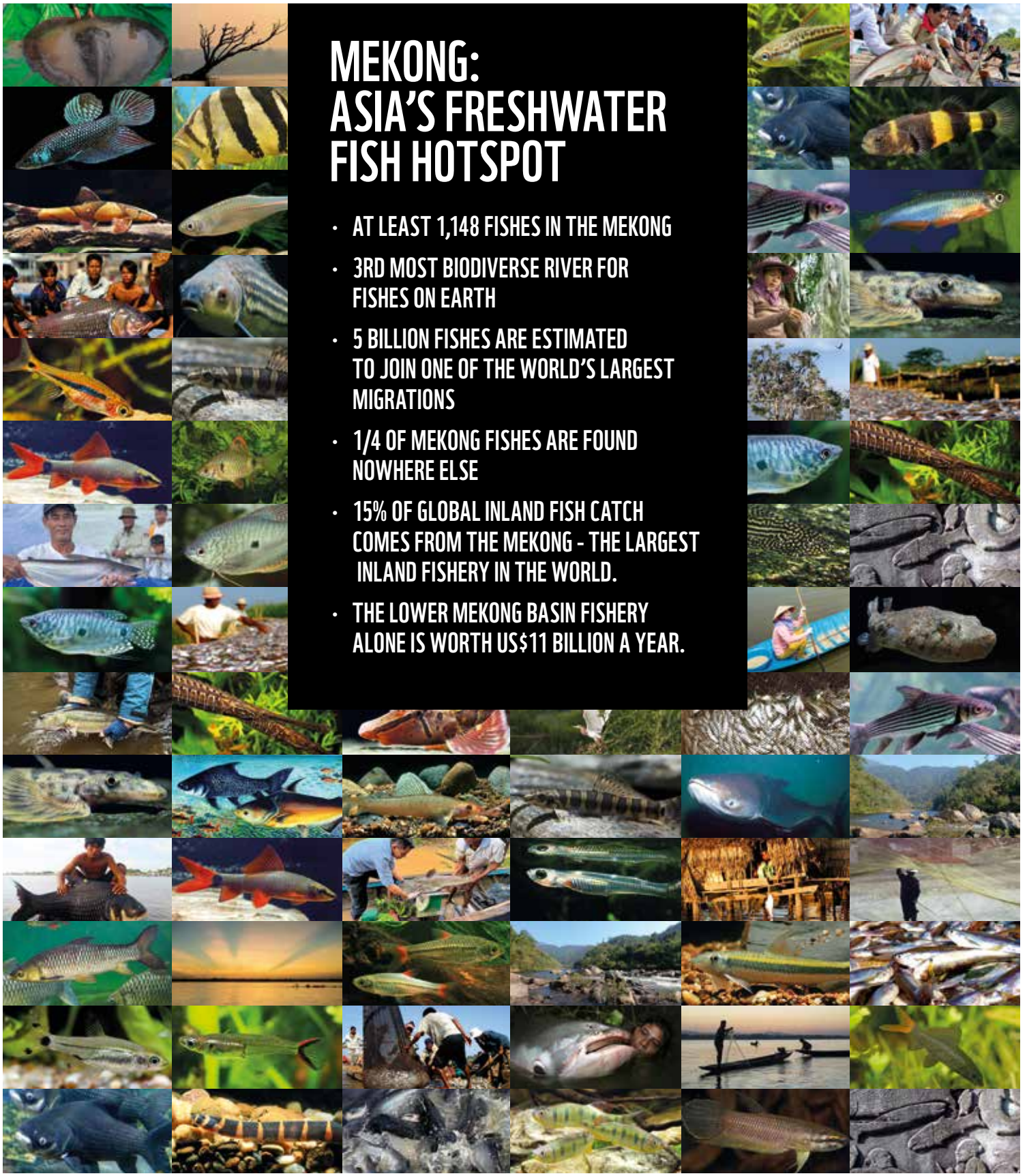


ALL THE ORGANIZATIONS INVOLVED IN THIS REPORT ARE FULLY COMMITTED TO ENSURING A BRIGHTER FUTURE FOR THE MEKONG'S FRESHWATER FISHES, BECAUSE THAT WILL MEAN A BRIGHTER, SUSTAINABLE FUTURE FOR PEOPLE AND NATURE ACROSS THE REGION. WE HOPE YOU'LL JOIN US.



MEKONG: ASIA'S FRESHWATER FISH HOTSPOT

- AT LEAST 1,148 FISHES IN THE MEKONG
- 3RD MOST BIODIVERSE RIVER FOR FISHES ON EARTH
- 5 BILLION FISHES ARE ESTIMATED TO JOIN ONE OF THE WORLD'S LARGEST MIGRATIONS
- 1/4 OF MEKONG FISHES ARE FOUND NOWHERE ELSE
- 15% OF GLOBAL INLAND FISH CATCH COMES FROM THE MEKONG - THE LARGEST INLAND FISHERY IN THE WORLD.
- THE LOWER MEKONG BASIN FISHERY ALONE IS WORTH US$11 BILLION A YEAR.

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