TWICE FORGOTTEN

The Cultural Loss of Freshwater Fishes



Shoal

ABOUT

SHOAL is a global ecosystem of partners and collaborators who work together to safeguard the health of Earth's freshwater habitats and conserve the most threatened freshwater species. As with a shoal of fish, the strength of the SHOAL lies with the number of partners all working together.

Stay up to date with our work or reach out to collaborate: **shoal.org**

Credits and acknowledgements
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Back cover image: Wild Geese Flying Down the Sumida River (1769), Suzuki Harunobu

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Further reading
1,000 Fishes Blueprint // New Species Reports // Forgotten Fishes // Tiny Fishes



Boys Playing with a Basin of Fish and Turtles, Kitao Shigemasa (Japan, 1739–1820), Courtesy of Met Museum

EXECUTIVE SUMMARY

The cultural associations between communities around the world and freshwater fishes are rich. It's no surprise really, considering communities tend to spring up near sources of freshwater, and the life-giving properties it brings. But with a staggering one in four freshwater fishes assessed on the IUCN Red List as threatened with extinction, these cultural connections, part of the important linkages between biological and cultural diversity, are in danger of dwindling and disappearing as the species themselves decline.

This report celebrates the rich diversity of beliefs and traditions associated with freshwater fishes, and examines this risk of 'double extinction', where species disappear from cultural memory as they disappear from the wild.

Through case studies and examples from around the world, Twice Forgotten highlights just how deeply humans are connected with fishes and the many contributions they make to people, whether as food and livelihood, myths, spirits and symbols, markers of place and of knowledge, or objects of beauty and fascination. It shines a light on what we stand to lose as their populations decline, and draws attention to how, without them, we would be immeasurably poorer.

We are releasing Twice Forgotten at CBD COP17 in Yerevan, as Parties undertake the global review of collective progress in implementing the Kunming–Montreal Global Biodiversity Framework (GBF) and its 2030 targets. SHOAL is involved with producing a session at COP17, *Mainstreaming Social, Cultural and Economic Values of Protecting and Restoring Inland Water Biodiversity*, which will ask how biodiversity's multiple values, including cultural values, can shape conservation, and advocates for integrating traditional and local knowledge and cultural relationships into national biodiversity strategies and action plans (NBSAPs).

The report speaks directly to the GBF's call for the full integration of biodiversity and its multiple values into policies, planning and decision-making (Target 14). Its case studies also show why the effective restoration and conservation of inland water ecosystems, and urgent action to halt human-induced extinction of threatened species, matter to people (Targets 2, 3 and 4), and why the sustainable use of wild species, customary sustainable use, and the full and effective participation of Indigenous Peoples and local communities in decision-making must be part of that work (Targets 9 and 22). At COP17, we want these connections to inform the choices governments and funders make about conserving and restoring inland water biodiversity.

For many of the fishes in this report, there is still time to act. Through the 1,000 Fishes initiative, SHOAL is working with partners to bring urgent management action to 1,000 of the world's most threatened freshwater fishes by 2035. Funders can help local teams protect habitats, recover populations and sustain the traditional knowledge and practices connected to them. The aim is for future generations to know these fishes as living parts of their rivers and lakes, rather than only through stories of what was lost.

Roman mosaics found near Syria Ma'araat, © Cascoly



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Nineteenth century Japanese Katana featuring carp embellishments, courtesy of Met Museum



INTRODUCTION

When a Fish Disappears Twice

Fish and lotus in canal, ceramic, New Kingdom of Egypt, Ramesside ca. 1290–1224 BCE. courtesy of Met Museum

Around the world, freshwater fishes are disappearing at an alarming rate. The inland waters in which they swim are being blocked, drained and polluted, while the fishes are being overexploited. More than one in four freshwater fish species is threatened with extinction[1], in an ecological crisis that is happening mostly out of sight, beneath the water's surface, and often without the attention it needs.

Hidden within this ecological loss is another kind of extinction: a cultural one. For millennia, people have lived alongside and depended on freshwater fishes, developing rich traditions, beliefs, food cultures and stories around them. These cultural connections can endure for many centuries, forming integral parts of communities' identities and sense of place. As these species decline, so too do the stories, rituals and memories associated with them.

When freshwater fish populations are lost, we risk losing the plethora of cultural practices that surround them; without the salmon, there would be no First Salmon Feast[2]. Fishing techniques developed by hunter-gatherer communities from the last ice age are no longer passed from parent to child, breaking a tradition spanning at least 12,000 years[3]. Sacred stories lose their living subjects. Ceremonies, recipes, and seasonal calendars slowly unravel[2,4,5].

Advances in conservation science allow us to measure biological decline with growing precision: we can now estimate populations, distributions and extinction risk with an accuracy that was impossible a few years ago. But these measurements do not tell the full story, and as species disappear, they can suffer a double extinction, with a loss from cultural memory as well as from the natural world.

As governments gather in Yerevan, Armenia, for the Seventeenth Conference of the Parties to the Convention on Biological Diversity (CBD COP17), the international community reaches an important milestone: the first global review of progress towards implementing the Kunming-Montreal Global Biodiversity Framework. The Framework challenges us not only to halt and reverse biodiversity loss, but also to recognise the multiple values of nature, strengthen the role of Indigenous Peoples and local communities, restore ecosystems, and ensure that biodiversity is woven into the decisions societies make every day[6].

Freshwater fishes embody all of these ambitions. They nourish hundreds of millions of people, making up at least 40% of fish consumed every year[7]. They sustain over 60 million people's livelihoods and are worth more than USD 38.5 billion globally[8,9]. They connect mountains to floodplains, forests to estuaries and people to place. Across every inhabited continent, they have inspired myths, shaped religious traditions, defined festivals, informed ecological knowledge and helped create distinctive cultural identities[9,10].

Conserving freshwater fishes and their habitats would contribute to the achievement of numerous targets within the Kunming-Montreal Global Biodiversity Framework[11].

Freshwater ecosystems cover less than 1% of Earth's surface, yet support approximately half of all known fish species and an extraordinary concentration of global biodiversity[12]. Despite their immeasurable importance to people and planet, freshwater remains among the least visible components of global biodiversity.

Freshwater conservation receives only a tiny share of global attention and funding: available regional estimates suggest that freshwater as a whole – not freshwater fishes alone – accounts for only 1–3.2% of conservation finance in some philanthropic and research funding streams, and water represented the smallest allocation (10.9%) in the Global Environment Facility's eighth replenishment cycle[12].

As species are overlooked and allowed to slip into extinction, so too do we risk a crisis of cultural memory.

This report shines a light on these intertwined forms of loss, and shows how ambitious conservation can protect both freshwater fishes and the cultural relationships built around them. Twice Forgotten: The Cultural Loss of Freshwater Fishes brings together 14 case studies of freshwater fishes and species groups, each with a remarkable cultural history.

They were selected using four broad criteria:

1. Most case studies focus on one or more fishes that are globally threatened or already extinct, drawing primarily on the IUCN Red List and SHOAL's Priority Fishes list – a global catalogue of the freshwater fishes most urgently in need of conservation action. A small number fall outside those categories, and have been chosen as their stories offer particularly illuminating examples of cultural relationships with freshwater fishes.
2. Each has well-documented cultural significance extending beyond simple economic importance.
3. Wherever possible, the cultural traditions associated with the fishes in each case study show evidence of decline, fragmentation or increasing risk of being forgotten.
4. Finally, together the case studies represent a broad geographical, cultural and ecological spread, demonstrating that this phenomenon is neither isolated nor confined to one region or one type of fish.



Image: *Shin Yoshiwara Ōnamazu Yurai* (*The Origin of the Great Catfish at New Yoshiwara*), a satirical woodblock print created after the Ansei Great Earthquake in 1855 (Edo period). The print features Namazu, a giant underground catfish depicted in traditional Japanese folklore as causing earthquakes.

Beyond the 14 principal case studies, the report includes shorter examples of other fishes that fulfil some or all of these criteria.

These case studies are not intended to be exhaustive. Rather, they introduce some of the many ways in which freshwater fishes acquire deep cultural meaning, and how that meaning can fade as the fishes themselves disappear.

Together, their stories reveal the extraordinary diversity of ways in which freshwater fishes have shaped human societies around the world: as sources of food and livelihood, sacred beings and symbols, markers of place and identity, repositories of knowledge, objects of beauty and obsession, and warnings of what can be lost.

By telling these stories, we hope to support efforts to document, celebrate and sustain the cultural relationships they represent. Without such efforts, some of these relationships may disappear forever.

The aim of this report is threefold:

- To highlight the cultural significance of freshwater fishes.
- To explore how these cultural ties are being lost.
- To inspire action to protect the species and the cultural relationships that have evolved around them.

The message is simple: conservation is about more than biodiversity. Just as important are the memories, identities and meanings we attribute to it.

The report is organised around six recurring themes that emerge across cultures: food and livelihoods; mythology and symbolism; place and identity; knowledge and tradition; beauty, wonder and obsession; and warning and hope. Although each chapter focuses on one principal theme, many species speak to several at once.

If the Kunming-Montreal Global Biodiversity Framework calls on us to transform humanity's relationship with nature, then understanding these stories matters. They remind us that humanity's relationships with biodiversity live not only in landscapes, but also in languages, memories, rituals and communities.

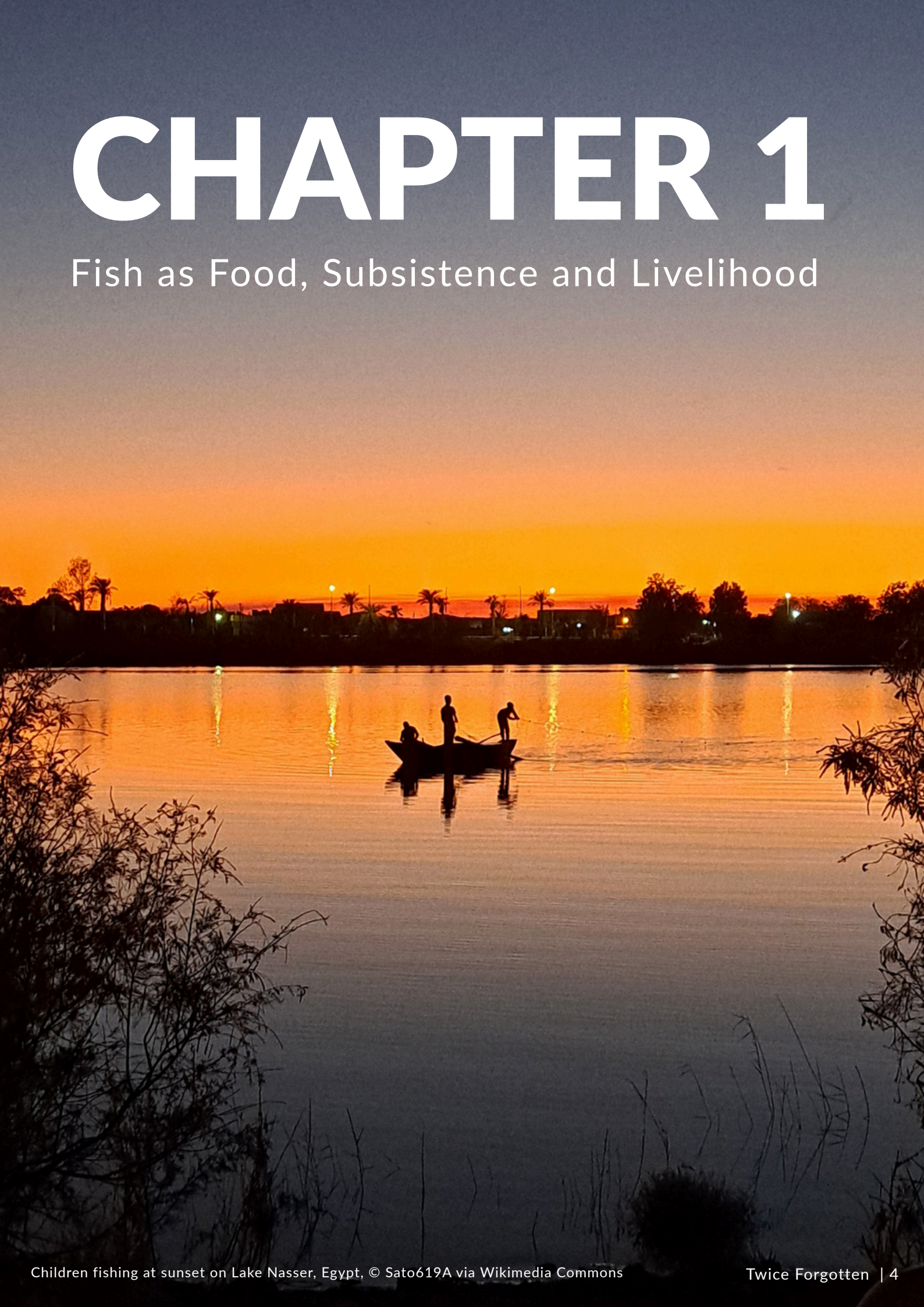
When a fish disappears from both the natural world and cultural memory, part of us disappears with it.

“The message is simple: conservation is about more than biodiversity. Just as important are the memories, identities and meanings we attribute to it.”



CHAPTER 1

Fish as Food, Subsistence and Livelihood



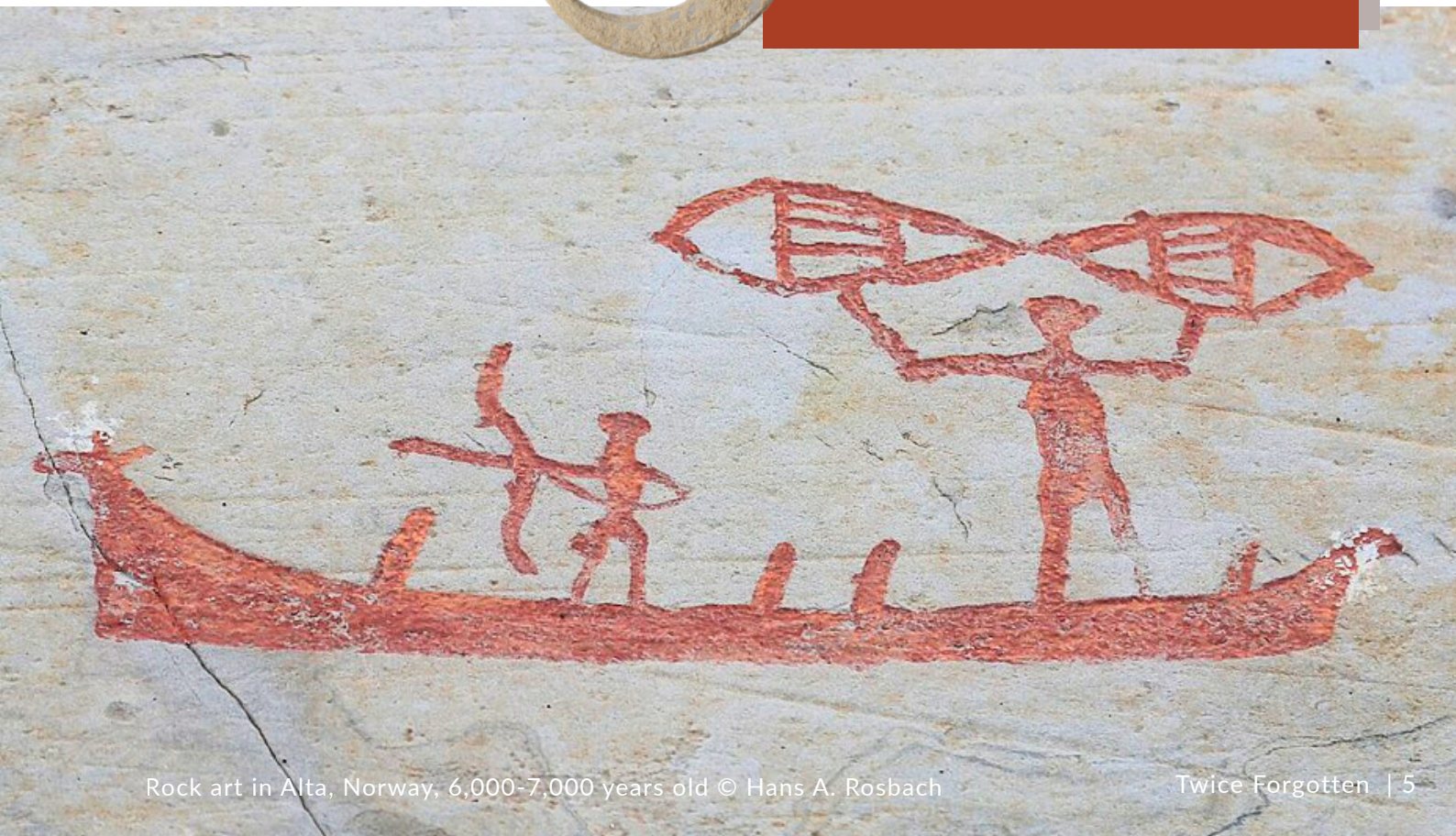
Children fishing at sunset on Lake Nasser, Egypt, © Sato619A via Wikimedia Commons

Freshwater fishes enter human culture most obviously as food. For millennia, they have been caught, cleaned, carried home, sold, smoked, dried, salted, fermented, shared and eaten. They appear in market baskets and cooking pots, in the work of fishers and traders, in the knowledge of when rivers rise, floodplains fill and migratory shoals return.

Human settlements have often developed near reliable sources of freshwater, providing water for drinking, washing and irrigation, as well as fish and other aquatic foods. Small-scale inland fisheries are dispersed, seasonal, and often subsistence-based; as much as a third of what is caught is consumed, exchanged or sold informally without entering official statistics[1]. The work surrounding fish is similarly easy to overlook. Catching may be dominated by men in some places, but women carry out much of the processing, drying, fermenting and market trading that sustains a household and distributes income through the local economy. Globally, women make up 50% of those working in post-harvest roles within small-scale fisheries, and 45% of subsistence fishers[2].

Freshwater abundance also creates calendars. The beginning of a flood, the first rains or the migration of fish into tributaries may determine when traps are repaired, nets set, processing areas prepared, and relatives gathered. Knowledge is carried through repeated actions: where a fish shelters, which moon or water level signals its arrival, how its flesh should be cut, and whether it is best eaten fresh, smoked or preserved for leaner months. When fish decline, these practices can unravel before the species itself disappears.

Fishes were part of the hominin diet long before our own species even existed. Stone tools found alongside the butchered remains of freshwater fishes, turtles, and crocodiles at Koobi Fora, Kenya, show that early hominins were exploiting lake and river resources around 1.95 million years ago[47]. Fishing with tools developed later, with the oldest known fishhooks, carved from sea snail shell, dating back 22,380–22,770 years ago (pictured left). They were found in Sakitari Cave on Okinawa, Japan[48].



Rock art in Alta, Norway, 6,000-7,000 years old © Hans A. Rosbach



Right: Ngege, *Oreochromis esculentus*, © VertNet

Across the Lower Mekong Basin, for example, fishes of the genus *Henicorhynchus* are among the small migratory species collectively known in Cambodia as *trey riel*. Their great seasonal movements have helped sustain one of the world's largest inland fisheries[3]. Much of the catch is eaten fresh, but preservation converts a brief pulse of abundance into food for the rest of the year. Popular belief even links these small fishes to the name of Cambodia's currency, the Cambodian riel, although the origin of the name remains uncertain[49]. Small fishes are salted and fermented to make products including prahok in Cambodia and pa daek in Laos: foods that can be mixed into sauces, soups and relishes and are defining ingredients in everyday cooking. Through the making of prahok, household production preserves both nutrition and culinary knowledge beyond the fishing season[4].

Other species reveal how familiar food fishes can slip quietly from prominence. The Ngege (Singida Tilapia), *Oreochromis esculentus*, was historically one of Lake Victoria's most highly valued food fishes (see p.36).

A fisheries survey conducted in 1927–28 described it as the lake's most important food fish, prized for the quality of its flesh, convenient size, and ability to withstand transportation[5]. It provided income to fishers and food to lakeshore communities well into the twentieth century. However, the uptake of non-selective gill nets began to reduce catch of Ngege by the late 1920s; subsequent pressure from introduced Nile Perch and non-native tilapias, together with habitat and ecological change, drove a severe decline in the main lake. Where populations survive in isolated satellite lakes, Ngege remains a valued food fish, and an active part of local fisheries, preserving the memory of a species that was once commonplace in the Lake Victoria fishery[6].

Fish market in Phnom Penh, Cambodia, © SHOAL // Georgie Bull



One of the oldest examples of fish farming worldwide comes from the Common Carp (*Cyprinus carpio*), with archaeological evidence from Jiahu, China, suggesting a history of humans farming fish as far back as 6,200 BCE[7]. China's oldest surviving poetry collection, *The Shijing (Book of Odes)*, may also reference the humble Common Carp in depictions of royal ponds 'leaping with fish'[8]. However, during the Tang dynasty (618-907 CE), the use of Common Carp for food farming came to an unlikely end due to a royal ruling; the surname of the ruling monarchs, Li, had identical pronunciation to the Common Carp, and as such it was forbidden to sell or kill them[9]. A replacement was needed, and a suitor was found in the Mud Carp (*Cirrhinus molitorella*), and the farming of it has since become one of the most enduring aquaculture systems, remaining virtually unchanged until the uptake of wild strain use in the twentieth century[10,11].

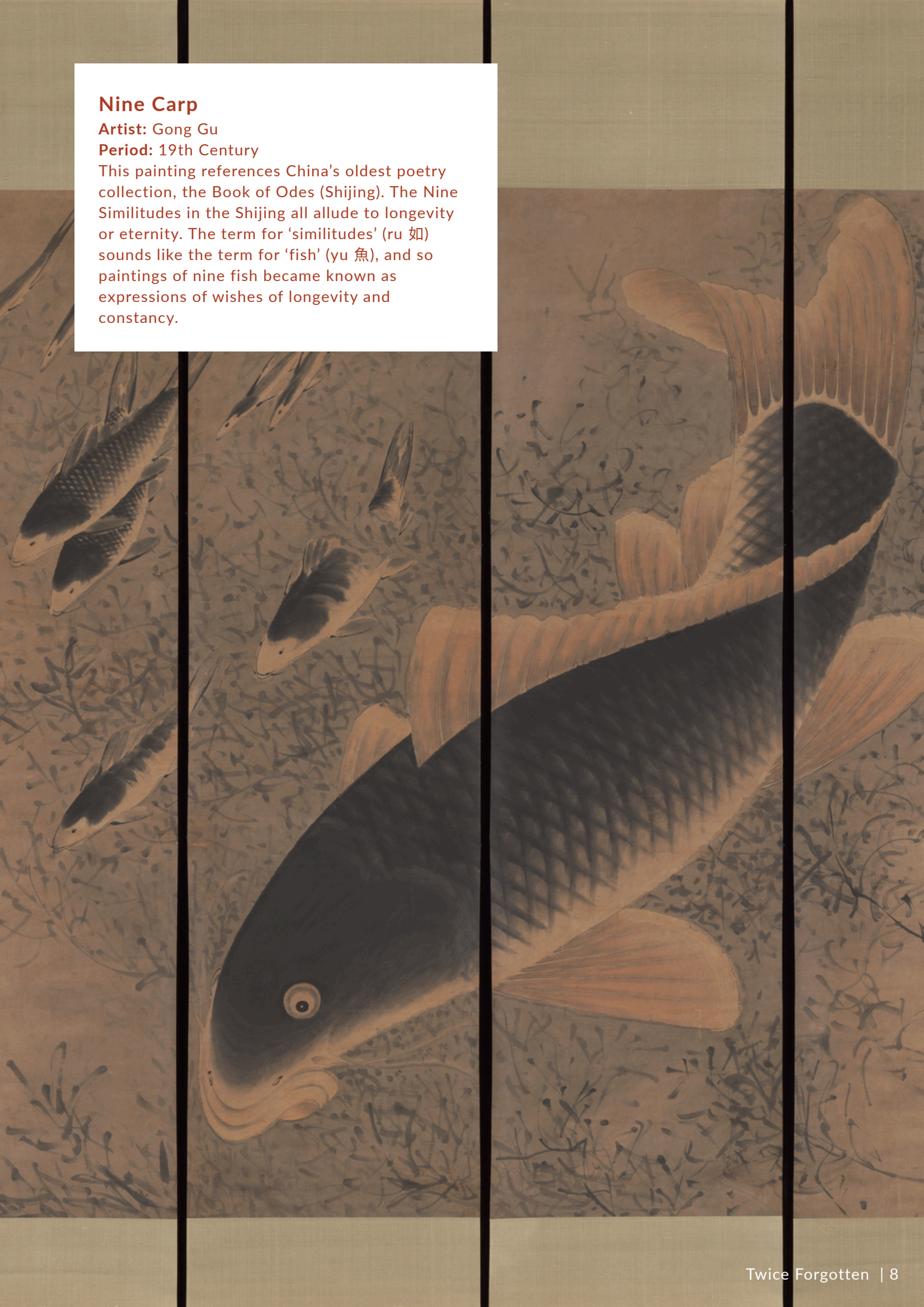
Carps became a dependable food fish within agricultural landscapes, capable of converting organic material and detritus into household nutrition and marketable protein. They are productive and affordable, and widely used to support food systems[10].



The image above is perhaps the best known physical evidence for early carp farming in China. This pottery model depicts the practice of stocking flooded rice fields with carp. It is approximately 2,000 years old, and was discovered in the 1960s from a tomb at Guigang, Panyu, Guangzhou, China. It is now on display at the Hong Kong Museum of History.



Top: © Daderot
Bottom: © USFWS



Nine Carp

Artist: Gong Gu
Period: 19th Century
This painting references China's oldest poetry collection, the Book of Odes (Shijing). The Nine Similitudes in the Shijing all allude to longevity or eternity. The term for 'similitudes' (ru 如) sounds like the term for 'fish' (yu 魚), and so paintings of nine fish became known as expressions of wishes of longevity and constancy.



Whilst the carp has been favoured for its commonality, the Sultan Fish, or Jelawat (*Leptobarbus hoevenii*), has become a highly prized food fish due to its scarcity and flavour profile[12,13]. Native to the Thai-Malay Peninsula, Borneo and Sumatra, it is among the most expensive in Malaysia, fetching around MYR 320/kg (roughly GBP 58 / USD 78)[14], though most fish that make it to market are now farmed instead of wild-caught, with wild-caught specimens fetching an even higher price[12,14]. There are efforts to rebuild wild populations beyond commercial farming, including community-led restocking efforts and fisher-led restrictions[15,16].

Fish can also supply far more than meat. Along the Amur River, Indigenous peoples including Nivkh, Ulch, and the Nanai (known in China as Hezhe) communities developed sophisticated techniques for cleaning, softening and sewing fish skins into clothing, footwear, bags and other objects[17]. The most common species used for this practice was Chum Salmon (*Oncorhynchus keta*). Historical accounts referred to these communities collectively as "Fish Skin Tatars" (魚皮韃子), an outsider's term for a broad group of Indigenous cultures that nevertheless reflects the degree to which river fishes shaped material life[18]. Large fish could provide food and, through their skins, a tough and flexible textile suited to the river environment. Today, museum garments preserve evidence of a body of knowledge disrupted by colonisation, industrial materials, changing livelihoods and reduced transmission between generations[19]. However, the practice survives: in Tongjiang, on the Chinese side of the border, Hezhe elder You Wenfeng continues to teach fish-skin techniques, alongside the traditional Yimakan storytelling of her people's language[20].

These examples illustrate how the loss of a food fish is rarely confined to diet or to household income. Loss also erases the sensory and social markers through which people can recognise home. A substitute fish may provide protein, but cannot replace the knowledge and memory attached to the fish that has gone.

Top: Russian fish leather coat © Welt Museum. Bottom: The Sultan Fish © bob|P-&-S, CC BY-NC-SA 2.0.

Jelawat

Leptobarbus hoevenii



Image: Seki Shūkō, Japan, ca. 1890–92, courtesy of The Met Museum

Foods that mark a place and a season

European Eel (*Anguilla anguilla*): Critically Endangered
Japanese Eel (*Anguilla japonica*): Endangered
New Zealand Longfin Eel (*Anguilla dieffenbachii*): Endangered



Few freshwater fishes are woven into food culture as widely as eels. European, Japanese and New Zealand Longfin Eels inhabit different waters and cultural worlds, but all three have deep cultural significance in the regions in which they live.

In medieval and early-modern Europe, the European Eel was a staple so abundant it served as a form of currency. Its rich flesh, widespread distribution and ability to survive transport without refrigeration made it exceptionally useful. Eels were roasted, stewed, baked into pies, jellied, smoked and preserved. They were particularly valuable during Catholic fasting periods, where meat was prohibited for up to 120 days of the year, but fish could be eaten[21]. In medieval England, rents and dues were commonly paid in eels; in excess of 500,000 eels were owed annually to landlords and religious houses, including numerous eel rents recorded in Domesday Book. Historical research has described an English "eel culture" comparable in its pervasiveness to the country's later association with tea[21,22].

Fragments of that culture survive. Jellied eels remain associated with the working-class food history of London's East End. In the Netherlands, smoked eel is part of a long fishing and trading tradition; live eels were shipped by barge to be sold in London in the Middle Ages, though today the smoking of eels has become a niche pastime rather than an international trade driver[23].

Along the coast of Scania in southern Sweden, Ålakusten ("The Eel Coast"), represents how conserving biodiversity also conserves heritage. This region is the centre of the ålagille, a communal eel feast where catch is fried, smoked, salted, and boiled into soup[24]. The eel fishing here shaped the local identity to such an extent that ålahue ('eel-head') became a regionally used insult[24]. The Ålakustens kulturarvsförening (Eel Coast Heritage Association) now warns that the collapse of the eel endangers not only a species but a formally recognised body of intangible cultural heritage: the specific tools, knowledge, buildings, boats and oral traditions built up around Scania's eel fisheries over generations[25,26].

In southern Italy, *il capitone*, the large female eel, remains strongly associated with Christmas celebrations, particularly *il cenone*, the Christmas Eve feast[27]. This tradition has been documented since at least the nineteenth century, with roots in Christianity (story of the Fall), and older symbolism linked to the ouroboros and the eel's life cycle. The tradition is still practised, but under increased pressure due to declining wild populations.

Left: Victorian image of Eel Pie Island on the Thames, London, named after the abundance of Eel Pies sold at the Inn on the Island.

Right: Fish wife sitting by a basket with eel, Mathias de Sallieth, print maker (1749–1791)







In Japan, unagi occupies an equally recognisable place in national food culture. The best-known preparation is kabayaki: eel split, skewered and repeatedly grilled and glazed with a sweet-savoury sauce, commonly served over rice. Eel restaurants may maintain their sauces and techniques over generations, making flavour itself a form of continuity; Tokyo's Hashimoto, established in 1835, is, at the time of writing, run by the sixth generation of the same family, using a sauce recipe passed down from the founder[28].

The strongest seasonal association is *Doyō no Ushi no Hi*, the midsummer Day of the Ox. Eating eel on this day is popularly believed to restore stamina during hot, humid weather. The custom became widely established during the Edo period, although accounts of its precise origin vary and the often-repeated story that the scholar Hiraga Gennai invented it as a marketing device cannot be treated as certain. What is beyond doubt is that the date now triggers an extraordinary annual concentration of eel consumption (up to 30% higher eel sales cited in one popular supermarket in Japan), linking a migratory wild fish to a fixed point in Japan's cultural calendar[29].

Top left: Kabayaki eel, © Rick888chen, via Wikimedia Creative Commons

Top right: Unashin, an eel restaurant along the Miyagawa River in Japan, was founded in 1957. © gundam2345, via Wikimedia Creative Commons

Bottom right: *Anguilla japonica*, © Opencage, via Wikimedia Creative Commons

THE TALE OF DOYŌ NO USHI NO HI

The widespread folklore around the origins of Doyō no Ushi no Hi tells a tale of an eel merchant struggling with sales during the summer (eel was typically consumed as a winter food during the Edo period). The merchant allegedly asked the inventor and naturalist, Hiraga Gennai, for advice. Gennai supposedly told him to put up a sign reading 'Today is the Day of the Ox' known as Doyō no Ushi no Hi (土用の丑の日) in Japan, playing on a Japanese tradition of eating foods beginning with the letter 'u' on that day – including *unagi* (eel). Supposedly business boomed, and other eel merchants rapidly caught on, and the custom of eating eel on that day has stuck ever since.





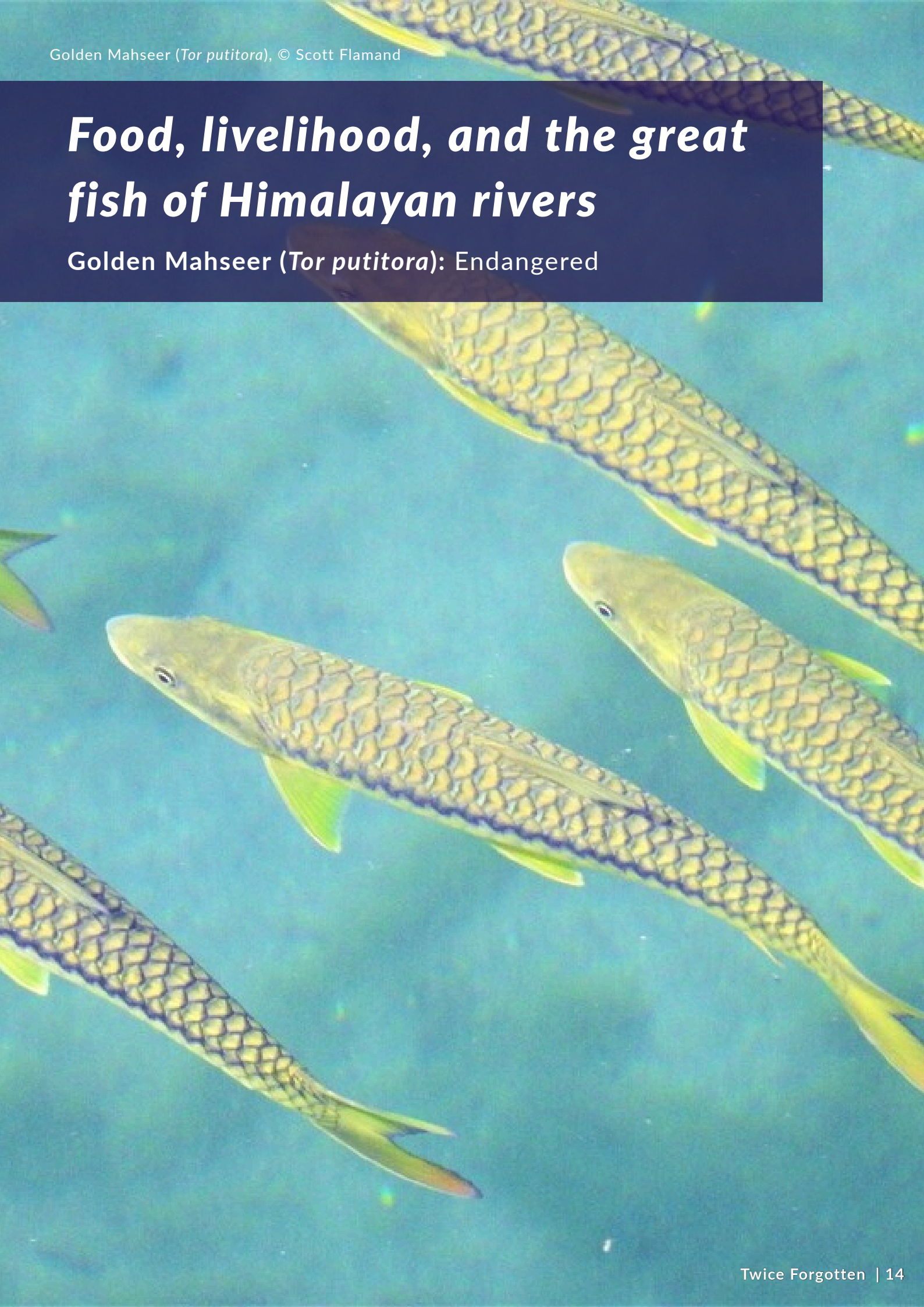
Tuna / New Zealand Longfin Eel, *Anguilla dieffenbachii*, © *Charles J Sharp*

For Māori, freshwater eels collectively known as tuna are *taonga*: cultural treasures bound to food, identity, customary authority, relationships with waterways, and the Māori concept of *whakapapa* (the genealogical relationships connecting people, ancestors and the natural world). The endemic Longfin Eel, or tuna kūwharuwharu, is one of two native freshwater eel species harvested in Aotearoa New Zealand (see also p.48). Māori developed extensive knowledge of eel behaviour and seasonal movement, along with fishing technologies adapted to particular rivers, wetlands and lakes. These included pā tuna or eel weirs, baited traps, nets and spears. Large seasonal catches could be processed and preserved, allowing tuna to support inland communities and gatherings long after the immediate harvest[30,31].

The practices were governed locally rather than uniformly: different iwi and hapū (tribes and subtribes composed of several extended families) possess their own knowledge, names, harvesting places, protocols and preparation methods. An example is rāhui, a temporary fishing ban imposed for ceremonial or conservation reasons, sometimes paired with the release of young eels[32]. Iwi have voluntarily declined to fish their full customary allowance for Longfin Eel in recent years, specifically because of concern about the population[32]. Ensuring the rich tuna culture survives means ensuring healthy eel populations, access to customary waters, and the continued transmission of knowledge within the communities that hold it.

All three species undertake immense oceanic migrations and depend on connected routes between marine and inland habitats. Their declines arise from interacting pressures including fishing, wetland loss, dams and other migration barriers, pollution, hydropower mortality and changes in ocean conditions[32,33,34].

This creates a difficult conversation. Food traditions cannot be protected by consuming depleted wild populations without limit. Yet conservation that treats people merely as a threat can ignore the value of Indigenous-led stewardship, sever human-wildlife relationships, and reduce cultural heritage to museum displays. The goal is to restore eel abundance and migration while supporting community-led stewardship, customary rights and the transmission of harvesting knowledge, which Indigenous cultures have demonstrated for millennia.



Golden Mahseer (*Tor putitora*), © Scott Flamand

Food, livelihood, and the great fish of Himalayan rivers

Golden Mahseer (*Tor putitora*): Endangered

The Golden Mahseer is among the most imposing fishes of the Himalayan region: a powerful, large-bodied carp of clear, fast-flowing rivers, deep pools and connected tributaries. The origin of the name mahseer is disputed, with proposed derivations ranging from words meaning 'great head' or 'large-scaled' to the Persian mahi ('fish') and sher ('lion'). Its burnished scales and strength have made it celebrated among anglers as the 'tiger of the river'. But the language of trophy fishing captures only one part of its importance[35,36].

Across parts of India, Nepal, Bhutan and Pakistan, Golden Mahseer have been highly valued as food and fetched high prices at market. Scientific and fisheries literature has repeatedly described the fish as both an excellent food fish and one of the most highly valued indigenous fishes of the Himalayan belt; its large size and high culinary value have made it an important food and commercial fish in many parts of its range[37].

Its migrations once structured fishing activity along Himalayan rivers. Golden Mahseer move between feeding, refuge, and spawning habitats, ascending tributaries and using gravelly stretches during reproduction before returning to deeper perennial waters. These migrations follow pronounced seasonal changes in rainfall and river conditions, creating predictable periods of greater fishing opportunity[38,39].

At the same time, mahseer have often occupied an ambiguous position between food and sacred life. Fishes of the genus *Tor* possess religious and cultural significance across South and Southeast Asia, and mahseer are protected at several temple pools and river sanctuaries. At the Sringeri Fish Sanctuary on the Tunga River in Karnataka, India, there is a two-hectare no-take zone, where killing or harming fish in this stretch is considered a sin[40]. In Maharashtra, at Walan Kond on the Savitri River, mahseer are regarded as children of the goddess Parvathi[40]. Such sites can

Golden Mahseer (*Tor putitora*), Image credit: Danny Ye



support conspicuous aggregations of large fish. However, beliefs vary substantially between places, and it would be misleading to imply that Golden Mahseer are universally sacred or never eaten. The same species may be revered at one site, protected by a community at another, pursued by anglers elsewhere and harvested for food farther downstream.

Recreational angling for mahseer has a rich history across South Asia that spans millennia. The twelfth-century Sanskrit treatise *Manasollasa*, written by King Someshvara III, devotes an entire chapter to Matsyavinoda 'the amusement of angling' and details the joy of catching mahseer and other fish on rod and line[41,42]. A range of traditionally developed angling techniques is still used today to catch mahseer, including the combination of rolling maize and cow dung into a ball which is wedged between two stones in knee-deep water to lure juvenile mahseer[43]. While not tied to mahseer, fish hooks are also some of the earliest prehistoric artefacts in India, dating back some 4,500 years ago[44].

But the reputation of mahseer has crossed boundaries; accounts from British colonisers and later travellers frequently celebrated their size, endurance, and ability to fight in heavy currents[36]. Specialist angling camps and river tourism, targeted at international enthusiasts, were popularised from their far-reaching reputation, creating economic incentives in some places to maintain living Golden Mahseer populations[45]. Local, non-commercial recreational fishing of mahseer continues in northeastern India, and community-organised mahseer angling festivals take place on the Manas River, which generate income for local fishing communities[46].

Catch-and-release fisheries have in recent times been promoted as a conservation tool capable of generating local employment through guiding, accommodation, transport and river protection. These models can create conservation incentives where economic benefits reach nearby communities. They can also produce tensions if benefits are distributed unevenly or conservation priorities conflict with those of nearby communities[45]. Golden Mahseer conservation cannot rest on sporting prestige alone; it must recognise the fish's multiple meanings of food, income, sacred being, river indicator and source of community identity.

The species is threatened by dams and river fragmentation, destructive and excessive fishing, aggregate extraction, pollution and the degradation of spawning and nursery habitat. Because Golden Mahseer migrate between different sections of a river system, protecting an isolated pool or stocking hatchery-reared fish cannot compensate for the loss of connected, free-flowing habitat[35,36,38,39].

As Golden Mahseer become scarce, the cultural change may be subtle. A famous fish can persist in stories, fishing-lodge photographs, temple pools, and conservation logos, while disappearing from the ordinary lives of people along the river. Younger fishers may know its reputation but no longer encounter it in their nets. Families may remember its flavour but cook another species instead. The danger is that the great fish vanishes, surviving primarily as an icon, and detached from the seasons, meals and river knowledge through which its meaning was created.



Right: Golden Mahseer (*Tor putitora)* © Charles J Sharp

CHAPTER 2

Fish as Myth, Spirit and Symbol

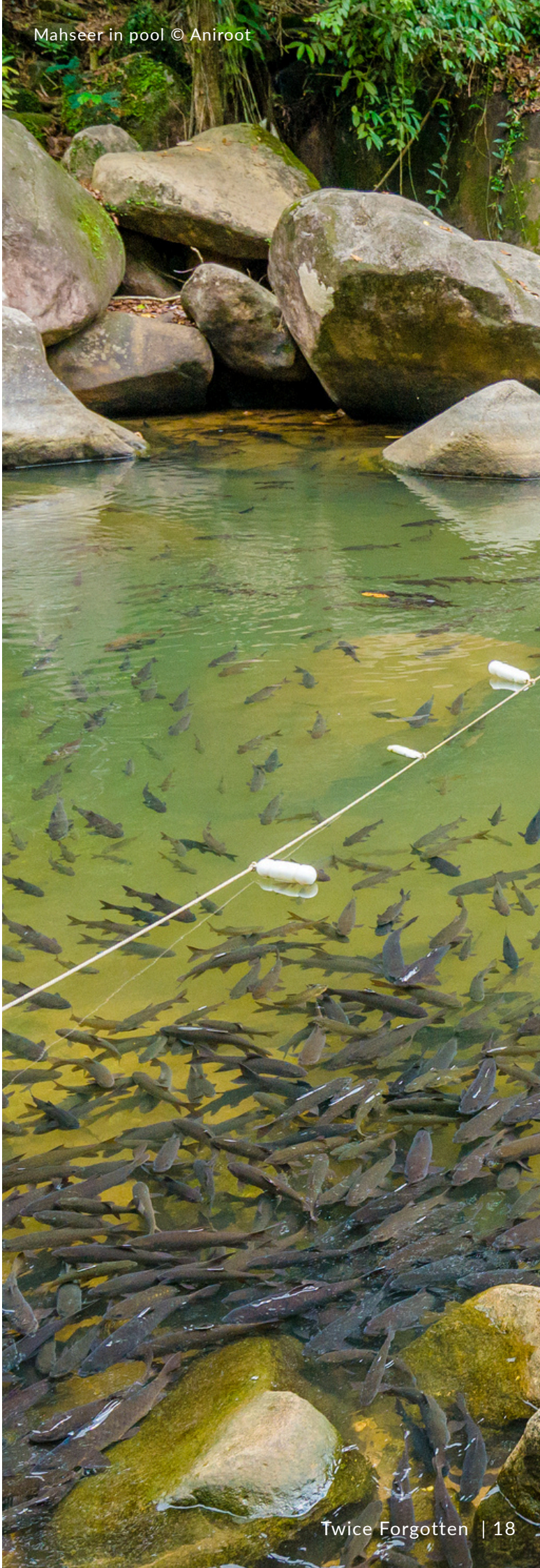


Ceramic Boy Holding up a carp, 1860, Japan, decorated in coloured enamels and gold (Satsuma ware), courtesy of The Met Museum

Long before fishes were classified by science, they were understood through stories. Their sudden appearances and disappearances, transformations between life stages, immense migrations and ability to inhabit a world hidden beneath the surface made them natural carriers of meaning. In many cultures, freshwater fishes became ancestors, messengers, protectors, omens and embodiments of divine power. They helped people explain where life came from, why rivers flooded, how humans should behave and what might happen when relationships between people, animals and water were disturbed. These beliefs can govern communities' interactions with the fishes and their habitats, such as defining whether a fish may be caught, where fishing is permitted, and what offerings must be made to specific deities before entering a body of water.

A species protected by taboo may survive in a temple pool or sacred spring after disappearing from surrounding waters. Reverence can therefore function as conservation, although it does not always do so neatly. Sacred pools may become polluted or overcrowded, while religious releases intended to save animals can introduce disease or non-native species. Nevertheless, spiritual relationships often create obligations towards fishes that extend beyond their value as food or commodities. Studies exploring the intersection of traditional ecological knowledge and fish conservation within the context of sacred waters have found that taboos, rituals and prohibitions on fishing can protect both fishes and their habitats, sometimes creating community-managed refuges that pre-date formal protected areas[1].

In South Asia, mahseers offer one of the clearest examples. Large *Tor* species are protected at numerous temples, shrines and bathing places, where visitors feed congregations of fishes that have become accustomed to people. Some Hindu communities associate mahseers with Matsya, the fish incarnation of Vishnu who warns Manu (humanity) of an approaching


Mahseer in pool © Aniroot

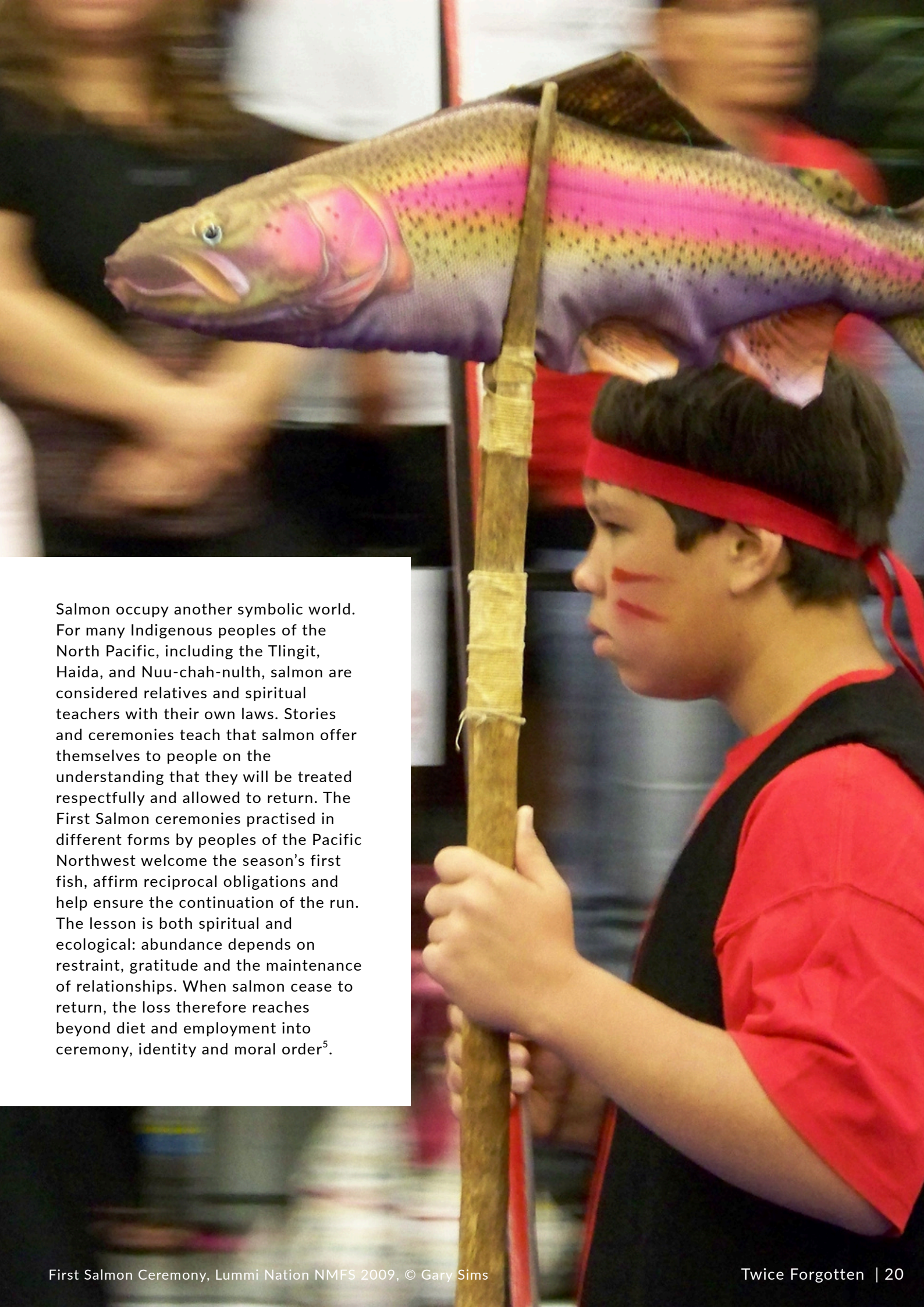
flood and preserves life through the catastrophe. The precise species inhabiting individual sacred pools varies, and it would be misleading to treat every mahseer population as an object of worship. Yet religious protection has created important local sanctuaries for threatened fishes, including Golden Mahseer (see p.14). These sanctuaries also reveal the vulnerability of culturally protected populations: when a sacred pool is poisoned or polluted, ecological loss is experienced as desecration as well as decline[2].

Across the Mekong Basin, enormous fishes occupy a similarly charged imaginative space. Folklore and local narratives present the Mekong Giant Catfish as a sacred or extraordinary being whose movements belong to the deeper life of the river. In some Thai communities, exceptional catches have been interpreted as profound spiritual events, where the fisher had come close to the manifestation of a water spirit, or *Naga*. Disrespectful treatment of the fish, failing to perform the proper rituals, or killing the sacred fish is believed to invite severe bad luck or anger from water spirits[3].

Large fishes are kept and protected at some Buddhist temples in the region, where feeding fish is considered a way to make merit (*tham bun*) and gain good karma. Such beliefs are not uniform across the basin, but they demonstrate how a fish can become an expression of the Mekong itself: immense, mysterious, and increasingly imperilled[4].



Giant Mekong Catfish with Wonders of the Mekong Team © Wonders of the Mekong



Salmon occupy another symbolic world. For many Indigenous peoples of the North Pacific, including the Tlingit, Haida, and Nuu-chah-nulth, salmon are considered relatives and spiritual teachers with their own laws. Stories and ceremonies teach that salmon offer themselves to people on the understanding that they will be treated respectfully and allowed to return. The First Salmon ceremonies practised in different forms by peoples of the Pacific Northwest welcome the season's first fish, affirm reciprocal obligations and help ensure the continuation of the run. The lesson is both spiritual and ecological: abundance depends on restraint, gratitude and the maintenance of relationships. When salmon cease to return, the loss therefore reaches beyond diet and employment into ceremony, identity and moral order[5].

First Salmon Ceremony, Lummi Nation NMFS 2009, © Gary Sims

Chinese traditions provide further examples of fishes linking earthly and cosmic fortune. Because the word for fish, *yú*, sounds similar to the word for abundance, fish frequently symbolise prosperity[6]. Carp are associated with perseverance and transformation through the story of a carp that swims against the current and leaps the Dragon Gate, becoming a dragon. The image has long been used to represent success through effort, particularly achievement in education or public life[7]. In contemporary Chinese aquarium culture, these older associations between fish, water, dragons and fortune have contributed to the extraordinary symbolic value of the Asian Arowana (see p.23).

Ritual release adds another dimension. The practice known in Chinese as *fangsheng* – releasing captive animals to preserve life and generate merit – developed particularly within Chinese Buddhism, and is also practised in some Daoist contexts[8,9]. Fish and turtles are among the animals most commonly released. At its heart is a recognition that non-human lives possess moral value. Yet when animals are purchased specifically for release and placed in habitats where they are non-native, the ritual is likely to cause ecological damage[10]. When spiritual intention causes biological harm in this way, the challenge is not to dismiss the tradition, but to work with religious communities so that compassion is expressed in ecologically informed ways[10,11].

Right: Carp Ascending a Waterfall, Shibata Zeshin, nineteenth century, courtesy of The Met Museum





Not every mythic fish corresponds to a threatened species – or even to a real one. In Japanese folklore, Namazu is a gigantic catfish said to live beneath the islands. When the deity Kashima loosens his restraint over it, Namazu thrashes and causes earthquakes. The creature belongs to cosmology rather than zoology, but its catfish form illustrates how an unseen inhabitant of dark inland waters became a way of imagining forces hidden beneath the ground. After major nineteenth century earthquakes, popular namazu prints depicted the catfish as destroyer, punisher, agent of redistribution or even healer. The imaginary fish helped society interpret a natural disaster and debate who benefited from the upheaval[12].

Whether worshipped in a temple pool, released to gain merit, greeted through ceremony or invoked to explain an earthquake, fishes have enabled people to think with water. They give visible form to otherwise invisible ideas: fortune, reciprocity, transformation, danger, continuity and the presence of powers beyond human control. When such fishes decline, the loss is therefore not only of an organism – it may also erode a community's language for explaining the world.

Image: Jeffrey Surianto

The fish that carries fortune

Asian Arowana (*Scleropages formosus*): Endangered



The Asian Arowana has undergone one of the most extraordinary cultural transformations of any freshwater fish. Native to slow-moving rivers, forest swamps and wetlands in Southeast Asia, it was historically caught locally for food. During the late twentieth century, however, it became an international luxury animal: the “dragon fish”, displayed in homes, offices, restaurants and businesses as an embodiment of prosperity, prestige and protection[13].

Its symbolism rests first on appearance. An arowana’s long body, large metallic scales, upward-pointing mouth and two barbels are understood to resemble the Chinese dragon. As it swims close to the surface, its broad fins and sinuous movement can evoke a dragon passing through the air. Red and gold colour forms carry particularly auspicious associations: gold with wealth and abundance, red with vitality, success and protection. Cambridge University Press’s overview of freshwater overexploitation describes the species as a symbol of luck and prosperity in Chinese culture, and its coveted status has made it one of the most valuable fishes in the aquarium trade[14].

The beliefs surrounding individual fishes are diverse and should not be presented as a single codified religious tradition. Much of what is described as arowana “feng shui” belongs to modern, commercial and popular aquarium culture rather than to an ancient doctrine. Nevertheless, several ideas recur among keepers. Water is associated with the movement and accumulation of wealth, the dragon signifies authority and auspicious power, and the living fish activates these qualities within the building where it is housed. A healthy arowana swimming steadily through a prominent aquarium can therefore be interpreted as guarding the fortunes of a household or business[15].

One of the most striking beliefs is that an arowana can absorb misfortune intended for its owner. When a fish dies unexpectedly (or, in some accounts, leaps from its aquarium), it may be understood to have intercepted danger, ill health or financial disaster. Rather than indicating that the charm has failed, the fish’s death can be interpreted as an act of protection: the misfortune has been carried away or exhausted in the animal. This is widely repeated within aquarium communities, but it is difficult to trace to a definitive historical source, and it is therefore better understood as contemporary belief or aquarium folklore, not as an established principle shared by all Chinese or Southeast Asian cultures[16].

Bottom: Arowana mural in Singapore Botanic Gardens, © Choo Yut Shing Taman





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© Chote99

Symbolism has helped turn the arowana into a conspicuous marker of wealth. Exceptional individuals, especially intensely coloured red or gold fishes, have commanded extremely high prices. The Asian Arowana has been described as the world's most expensive aquarium fish, with individual specimens reportedly commanding as much as USD 300,000[13,17]. Scarcity increases prestige, while pedigree, colour, body shape and even swimming behaviour are scrutinised by collectors. The fish can consequently operate both as a supposed generator of prosperity and as visible evidence that prosperity has already been achieved.

This value has had contradictory conservation effects. Intense harvesting for the aquarium trade contributed to severe declines and local disappearances, alongside the loss of forest and wetland habitat. The species is assessed as Endangered[18] and has been listed in Appendix I of CITES since 1975[19], placing international commercial trade under the Convention's strictest controls. Legal international trade is permitted from registered captive-breeding operations; exported fishes are individually marked, commonly with implanted microchips, and accompanied by documentation[20].

Captive breeding now supplies much of the legal international trade and has created a commercial constituency invested in keeping the fish alive. Yet the animal celebrated as a bringer of abundance has become scarce in much of its home range. Few fishes are more closely associated with wealth, but that association has also made the Asian Arowana exceptionally vulnerable to possession, trade and exploitation.



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Sacred Fishes of the Nile

The Mormyrid Fishes

Image: Oxyrhynchus fish, Late Period - Ptolemaic Period (664–30 BCE), Egypt, courtesy of The Met Museum



Mormyrids are an ancient African family of freshwater fishes distinguished by their unusual shapes and remarkable sensory abilities. Many possess elongated snouts or chins, giving rise to names such as Elephant Fish and Elephantnose Fish. Beneath their sometimes strange appearance lies an extraordinary capacity: mormyrids produce weak electrical fields and detect distortions in those fields, allowing them to navigate, communicate and locate objects in dark or turbid water[21]. To modern science, they are important models for understanding brains, behaviour and electrosensory perception[22]. To the inhabitants of ancient Egypt, at least some mormyrids belonged to the world of gods and sacred stories.

The best documented example is the medjed or Oxyrhynchus fish, associated with the ancient Egyptian city of Per-Medjed, known later to the Greeks as Oxyrhynchus, which is on the site of present-day el-Bahnasa. The Oxyrhynchus fish, meaning "sharp-nosed", was frequently depicted in bronze statuettes, and has commonly been identified as *Mormyrus* species, particularly the Nile fishes now known as *Mormyrus kannume* and *Mormyrus caschive*[23]. Exact identification is difficult because ancient artists did not produce scientific illustrations and because the skeletal differences between these species are subtle. Archaeologists therefore use "Oxyrhynchus" as a cultural and zoological category while acknowledging some uncertainty over the species involved[23].

The fish was embedded in the myth of Osiris. According to a tradition recorded by the Greek writer Plutarch, after Seth (ancient Egyptian god of chaos, deserts, and storms) murdered and dismembered Osiris (god of fertility, agriculture, and the afterlife), Isis recovered the scattered parts of his body but could not find his penis because it had been eaten by fishes – variously identified in the text as the *Oxyrhynchus*, *Lepidotes* and *Pagrus*[24]. This episode may partly explain why certain fishes, including mormyrids, were considered taboo, ritually significant, or even prohibited from being consumed in particular places and periods in ancient Egypt[23].

At Oxyrhynchus, the sharp-snouted fish became the focus of a local cult and gave the settlement its enduring name. Bronze images show it wearing a horned solar disc similar to the crown associated with the goddess Hathor; some figurines include suspension loops and may have been worn or carried as amulets[25]. These objects presented the animal as a divine or sacred presence, crossing the boundary between the Nile's biological life and Egypt's religious cosmos[23].

For many years, evidence for the cult consisted largely of classical texts and representations. Excavations at Oxyrhynchus have since uncovered an extensive Late Period ritual deposit containing large quantities of fish remains. Researchers identified bones from at least three mormyrid groups, including *Mormyrus*

Peters's Elephantnose Fish, *Gnathonemus petersii*, © Slowmotiongli



species corresponding to the traditional Oxyrhynchus. The discovery provided physical evidence that mormyrids were deposited in ritual contexts. It also showed that the sacred category was broader and more archaeologically complicated than a single perfectly identifiable species[23].

The mormyrids' unusual snouts probably helped make them visually distinctive, but we cannot know precisely what ancient Egyptians understood of their nocturnal lives or electrical senses. It would be tempting to suggest that their ability to navigate invisibly through dark water generated their sacred reputation, though there is no firm historical evidence for that connection. Their cultural importance must instead be reconstructed from names, texts, images, offerings and archaeological remains.

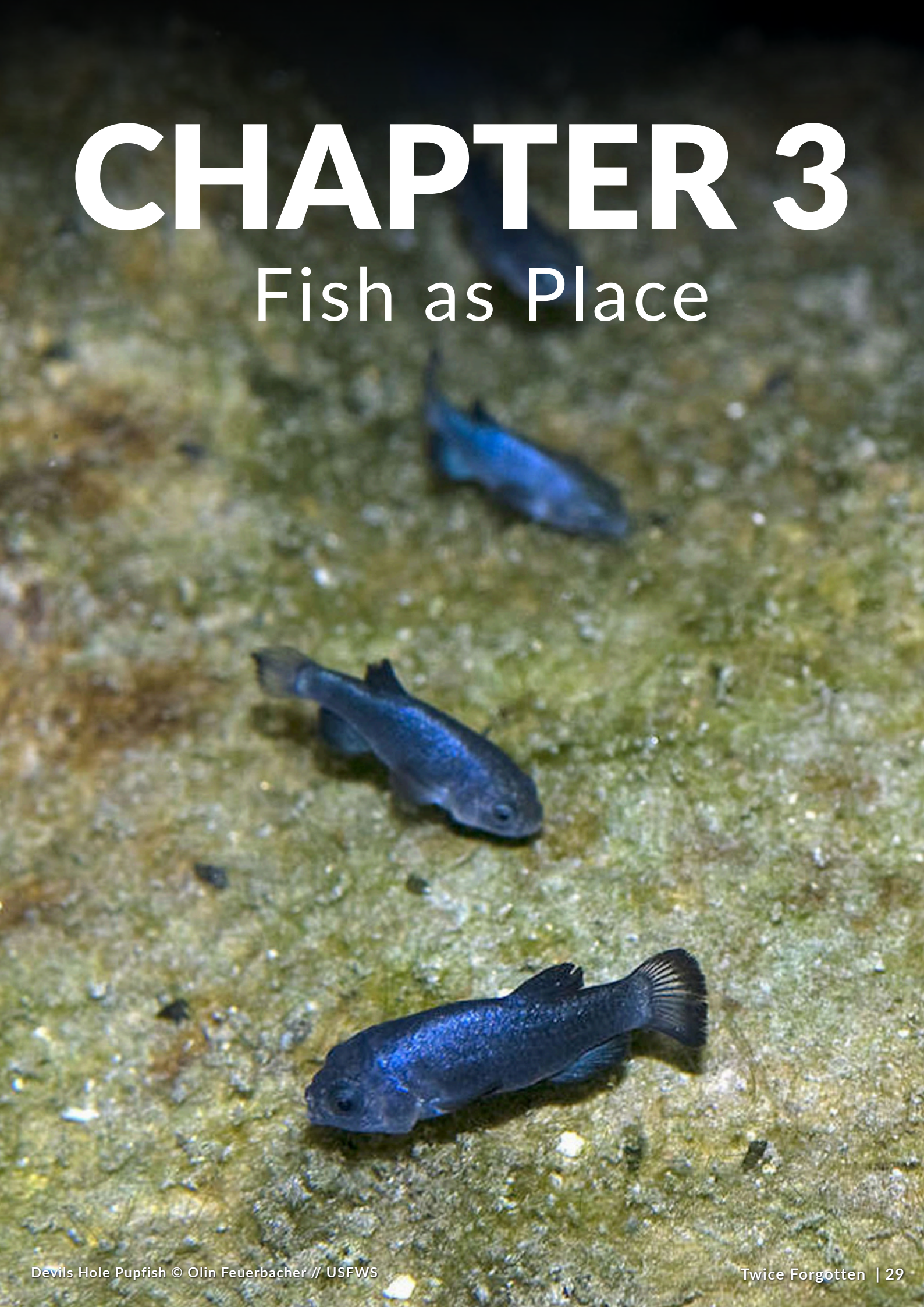
Today, the Oxyrhynchus cult's legacy survives in museum collections, archaeological sites and the name of a city that became famous for the thousands of ancient papyri preserved in its sands. The story demonstrates how thoroughly a freshwater fish can enter human cosmology. A mormyrid became an actor in the death and restoration of a god, an emblem worn as an amulet and the sacred identity of an entire place. Without these species' cultural legacy, there would be no recognition that they were once participants in a world shared by animals, humans and gods.

Oxyrhynchus fish, Late Ptolemaic, © Walters Art Museum via Wikimedia Commons



CHAPTER 3

Fish as Place



Devils Hole Pupfish © Olin Feuerbacher // USFWS

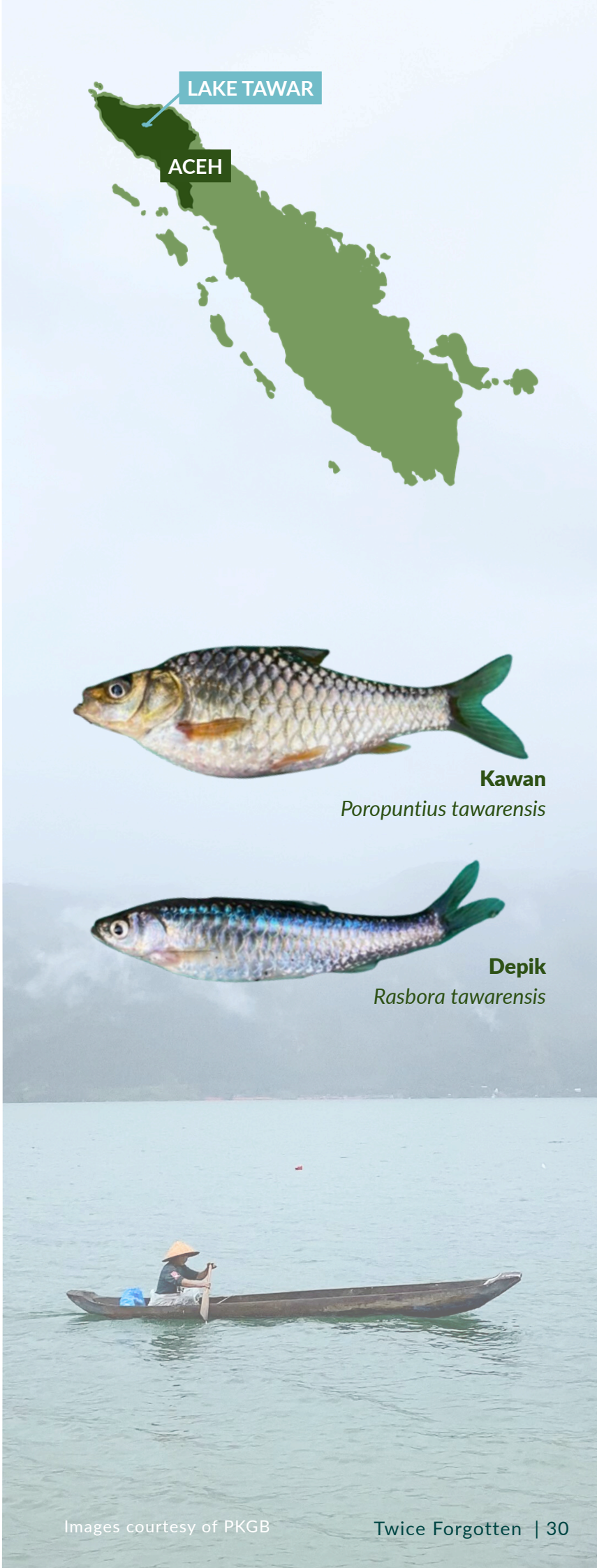
Inland waters are far more than freshwater habitats. Through the lives that gather around them, they develop layers of meaning: the foods people eat, the animals they recognise, the stories they tell, the seasons they anticipate, the names they give to the landscape – culture!

Freshwater fishes can become deeply woven into those relationships. Sometimes the connection is so close that a species becomes almost impossible to separate from its home.

This deep connection to place can be particularly pronounced with freshwater fishes, as so many have such highly restricted distributions. A mountain ridge can divide two river systems, and the fishes living in them, completely. A waterfall may isolate a population for thousands of years. In deserts, a single spring can function as a highly diverse ecological island in a region defined by its aridity. Across generations, fishes adapt to those places – as do the stories and cultural connections.

At the most extreme end is the Devils Hole Pupfish, *Cyprinodon diabolis*. Its entire natural range is a single geothermal, water-filled limestone cavern in the Mojave Desert in Nevada[1]. Here, the relationship between species and place is absolute: there is no wild Devils Hole Pupfish without Devils Hole, and Devils Hole wouldn't be the same place without the pupfish.

In the highlands of Aceh in northern Sumatra, Lake Laut Tawar has its own endemic fishes, including the Depik, *Rasbora tawarensis*. Research into the ethnobiology of Depik records its importance among Indigenous Gayo people not simply as food, but as a fish associated with prosperity, happiness, togetherness and affection[2].



Images courtesy of PKGB

Sometimes a fish gives a place its identity in an even more literal way. Idaho's Redfish Lake takes its name from Sockeye Salmon, *Oncorhynchus nerka*. The salmon that return to the Sawtooth Valley undertake an extraordinary migration from the Pacific Ocean, travelling roughly 1,400 kilometres inland and climbing to around 2,000 metres above sea level. As sockeye approach spawning they change from oceanic silver to intense red, giving the fish its name – 'sockeye' is an adaptation of 'suk-kegh', a Coast Salish Halkomelem word meaning 'red fish'[3].

The Snake River sockeye population collapsed during the twentieth century and was listed under the U.S. Endangered Species Act in 1991, when only four adults returned to the basin; a single male that reached Redfish Lake the following year became famous as "Lonesome Larry"[4,5]. The name Redfish Lake preserves the memory of an abundance that nearly disappeared from the place itself.

The Sockeye show how the relationship between fish and place need not require strict endemism. Ilish, *Tenualosa ilisha*, again highlights this: it migrates between marine and freshwater environments across South Asia, yet has become one of the strongest animal symbols of Bengali identity. It is the national fish of Bangladesh and an economically and culturally important fish throughout the Bengal region. Ilish is associated with celebration, hospitality and prosperity, and fish feature prominently in Bengali culinary and social traditions[6]. Its cultural geography extends across borders, connecting people to the great delta and river systems of Bengal rather than to a single pool or lake. Here, place is carried through taste, memory and migration.



Sockeye Salmon © Mlharing

At the opposite extreme are fishes whose connection with place may disappear before the species has been properly recorded. Perhaps one of the strangest examples is the Fat Catfish, *Rhizosomichthys totae*, a species known only from Lake Tota, high in the Colombian Andes. The only member of its genus, it was named for the remarkable rings and deposits of fatty tissue surrounding its body – an unusual anatomy that may have helped it survive in the lake's cold, high-altitude waters, although the function remains uncertain[7]. It is only known from a few specimens used in the original description and one specimen collected in 1958 – the last time the species was reliably recorded, despite subsequent searches. It is currently considered Critically Endangered (Possibly Extinct)[8].

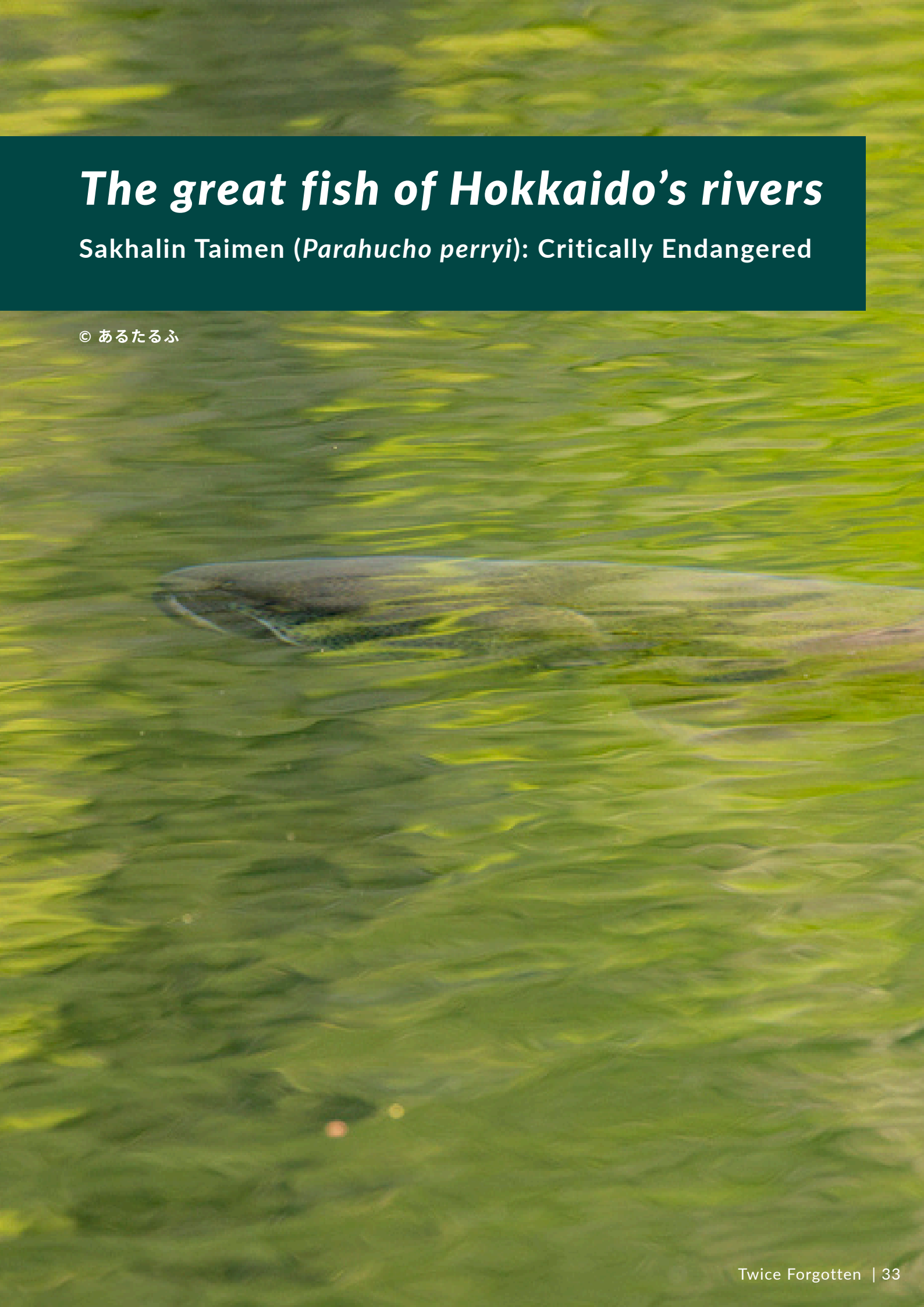
SHOAL has worked with local partners and researchers to search historical records, archaeological evidence and local traditions for earlier traces of the fish, and learned how it was once so plentiful in Lake Tota, that local people exploited its fattiness by impaling it on sticks and setting it alight to help illuminate their homes. But the species is fading into obscurity, with no individuals having been recorded since 1958, and an ageing generation of people who could still remember it. With every unsuccessful search, the Fat Catfish seems ever more likely to be extinct. And, as the species disappears from view, so too do the remarkable stories surrounding it[9].

One of the only known specimens of the Fat Catfish, © Ictiología y Cultura



The great fish of Hokkaido's rivers

Sakhalin Taimen (*Parahucho perryi*): Critically Endangered



© あるたるふ

Few freshwater fishes embody the rivers of northern Japan and the Russian Far East as dramatically as the Sakhalin Taimen. One of the world's largest salmonids, the species occurs around the Sea of Okhotsk, including Hokkaido, Sakhalin and parts of the Russian mainland. It is a long-lived, slow-growing predator, and populations can include both freshwater-resident and migratory individuals that move between rivers and coastal waters[10,11].

In Hokkaido and Sakhalin, however, the species also has a rich history within Indigenous Ainu culture, particularly before and into the nineteenth century. Its principal Ainu name, recorded across both regions, is chirai, although historical records preserve other local names and distinctions. In Bihoro in eastern Hokkaido, for example, Ainu knowledge distinguished three forms called tosiri, ciray and operaype, with further terminology distinguishing males and females[12].

As food, Sakhalin Taimen were sufficiently important for the relationship to be expressed through the seasons themselves. A Hokkaido guide to Ainu culture records the saying "spring is taimen, autumn is salmon", describing chirai as an important traditional food that was smoked or dried for preservation[13].

In Tokachi, this seasonal association extended into Ainu botanical knowledge. The early-flowering *Amur adonis* was called chirai-mun – "taimen grass". When its yellow flowers appeared in early spring, taimen were beginning their spawning migration upstream, and the flowering of the plant provided a signal that the time for taimen fishing had arrived[14]. Another recorded name, chirai-apappo – "taimen flower" – preserves a similar association elsewhere in eastern Hokkaido[15]. The fish was embedded within a wider reading of the landscape: flower, season, river and fish migration were understood together.



Bottom: Chirai-apappo, *Amur adonis* flower, © Dae jeung kim
Right: Sakhalin Taimen, © Vince Golder

Almost every part of a large chirai had value. Its exceptionally tough skin was fashioned into clothing and footwear[12,13]. Ethnographic records preserved by the National Ainu Museum describe the lower jaw of Sakhalin Taimen being used for divination in Shari and Bihoro, both in Hokkaido. In one recorded practice, the jawbone was placed on the fish's head and allowed to fall; the way it landed could indicate whether fishing would be successful[12].

Its presence is also written into language and landscape. Ainu place names incorporating chirai survive in Hokkaido: within Yakumo Town, for example, is the place name Chirai-hattar, literally 'Sakhalin Taimen pool'[16]. Such names preserve ecological knowledge about where particular animals occurred or were encountered.

Then there are the stories. Sakhalin Taimen appears in Ainu tradition as an animal of extraordinary, sometimes monstrous power. Government cultural interpretation in Hokkaido records legends of chirai capable of attacking bears and deer and becoming so enormous that a fish could obstruct the flow of a river[17]. Other retellings describe a gigantic taimen swallowing a deer and, after its death, blocking a river so completely that a lake formed behind its body[18]. The real fish's unusual size and predatory behaviour had been enlarged through storytelling until chirai became almost part of the geography itself.

This all makes its modern decline especially resonant. A large Sakhalin Taimen is the product of a functioning, connected river landscape. Individuals can live for more than 20 years, moving between spawning tributaries, larger rivers and estuaries; some also use nearby coastal waters[19,20]. Habitat degradation and overexploitation have driven sharp population declines, and a 2020 survey detected it in only seven of 120 Hokkaido rivers surveyed[10].

The result is a particularly clear example of double extinction. The biological species has not yet disappeared. Nor has the Ainu word chirai. But many of the relationships that once surrounded that word have already become difficult to practise.

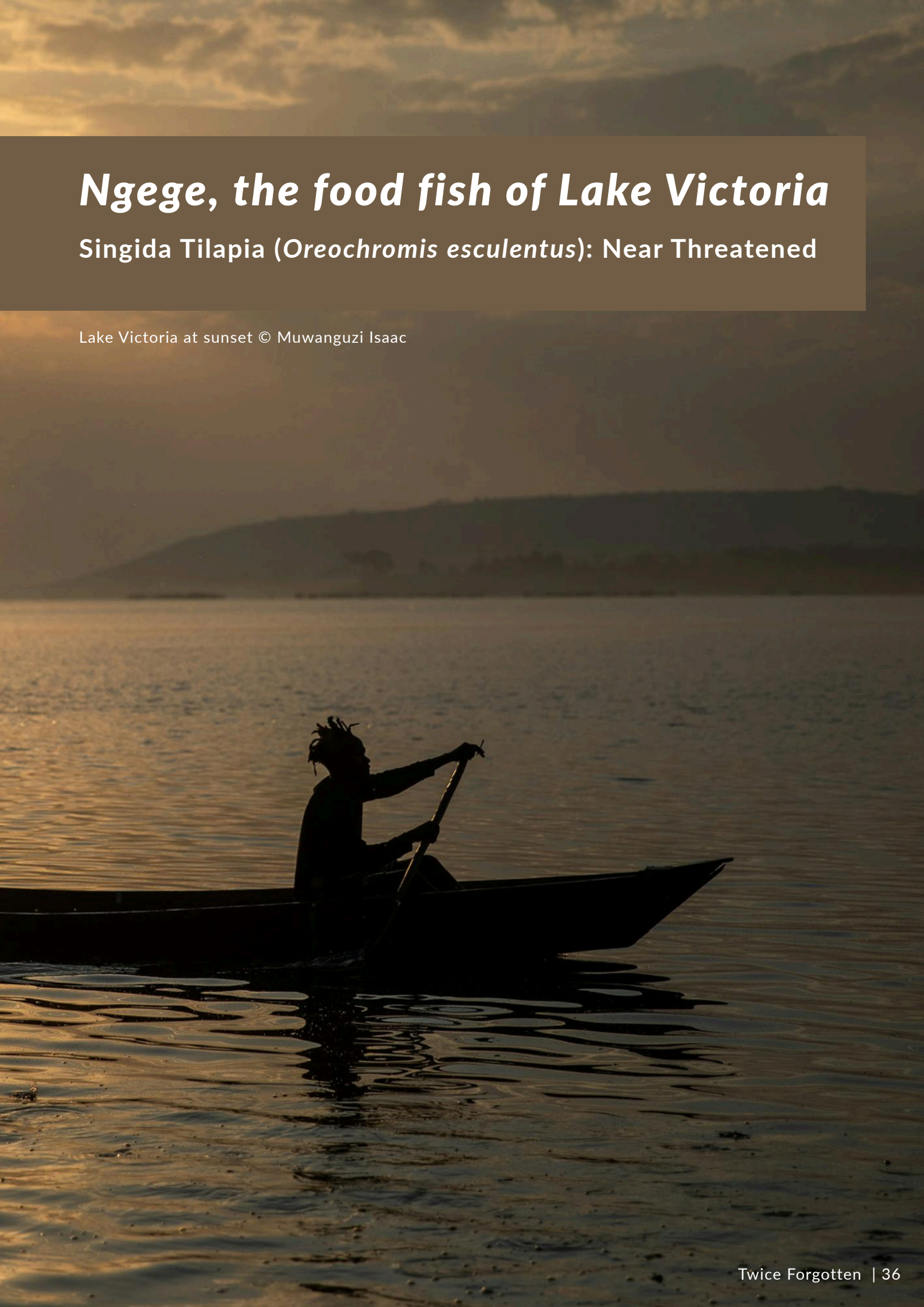
A great chirai is the living referent for a body of Indigenous language, ecological knowledge, material practice and story. If Sakhalin Taimen disappears from Hokkaido's rivers, those cultural traces may remain in museums, dictionaries and place names. But the relationship that created them, between people, fish and river, will have been severed.

Bottom: A world-famous angling target
© Шипилов Виталий



Ngege, the food fish of Lake Victoria

Singida Tilapia (*Oreochromis esculentus*): Near Threatened



Lake Victoria at sunset © Muwanguzi Isaac



The Singida Tilapia is native to the Lake Victoria basin, including Lake Victoria, Lake Kyoga and associated satellite waters. As its name suggests, it has also been introduced into Tanzania's Lake Singida. Across its range, it is widely known as *Ngege*.

When British fisheries biologist Michael Graham surveyed Lake Victoria in 1927 and 1928, Ngege was already one of the lake's defining food fishes. Graham described *Tilapia esculenta*, as the species was then known, as the most important food fish of the lake. He noted the quality of its flesh, its useful size for trade, and its abundance compared with other commercially valuable fishes[21].

That description reveals a form of cultural importance that is more visceral than mythological or ceremonious: that of being eaten.

For communities around a great lake, a familiar fish can become part of the identity of the water through repetition. The Singida Tilapia appears in nets, boats and markets, in meals and livelihoods, in the knowledge of where and when it can be caught. Its local name becomes part of everyday vocabulary.

Ngege became so valued as a food fish that people attempted to recreate its success elsewhere. The Singida Tilapia was introduced beyond its native range into a number of East African lakes and reservoirs for fisheries purposes[22]. Meanwhile, its position within its ancestral waters deteriorated.

Lake Victoria underwent one of the most profound ecological transformations documented in a major tropical lake during the twentieth century. Fishing pressure, eutrophication, habitat degradation and the introduction and subsequent expansion of non-native fishes – most famously Nile Perch (*Lates niloticus*) and Nile Tilapia (*Oreochromis niloticus*) – radically altered the fish community. Singida Tilapia declined severely within its natural range[22], exposing the danger of treating freshwater food fishes as interchangeable. "Tilapia" describes a large group of fishes, not a single ecological or cultural entity, and the continued availability of other tilapias cannot recreate the particular biological history of *O. esculentus* or the relationship represented by the name *Ngege*.

Ngege represents what happens when a fish that was once characteristic of a great lake becomes increasingly detached from it. The fish and Lake Victoria survive. But the relationship between Lake Victoria and one of its historically most important food fishes has been profoundly altered.

Top: Ngege, *Oreochromis esculentus*, © VertNet
Right: © Ana Kenk

Cambodia's National Fish

Giant Barb (*Catlocarpio siamensis*): Critically Endangered



Catlocarpio siamensis © David Tan - Mandai Wildlife Group via Adobe Stock

The Giant Barb is one of the world's largest cyprinid fishes, native to the great river systems of mainland Southeast Asia. In Cambodia it is known as Trey Kahor, among other Khmer names, and historically occurred within the enormous interconnected system of the Mekong, Tonle Sap, tributaries and floodplains. It is a fish scaled to the river system that produced it.

Its relationship with Cambodia stretches back at least to the twelfth and thirteenth centuries, when images of it were carved into the temples of Angkor[23]. There are stories of the huge scales – growing nearly as large as a human palm – being used to make a type of shuttlecock for a Khmer game in which players stand in a circle and keep it in the air with their feet[23]. Its flesh is highly valued for eating and preservation, making the species both culturally significant and commercially valuable across parts of the Mekong.

In 2005, Cambodia formally designated it as the national fish of the Kingdom of Cambodia[23].

Cambodia is one of the most freshwater-dependent countries on Earth. The Mekong and Tonle Sap are fertile foundations of food production, livelihoods and culture. Each year the Tonle Sap undergoes an extraordinary seasonal expansion as the Mekong flood pulse reverses the direction of the Tonle Sap River and pushes water into the lake and surrounding floodplain. Fish exploit this vast temporary habitat before moving back towards permanent waters as floods recede.

Cambodia's inland fisheries have long provided fish on an exceptional scale: around the turn of the century, annual freshwater catches were estimated at 290,000 to 430,000 tonnes. Fish processing traditions, such as making prahok, a fermented fish paste, and fish sauce, allow seasonal abundance to be preserved and consumed throughout the year[24].

Bottom: 78 kg Giant Barb, Dai 2C, Tonle Sap River, Nov 2025, © Wonders of The Mekong





78 kg Giant Barb, Dai 2C, Tonle Sap River, Nov 2025, © Wonders of The Mekong

The Giant Barb is a spectacular expression of the Mekong's productivity, with extraordinary sizes historically being recorded. Cambodia's Royal Decree records individuals of 150 to 300 kilograms and two to three metres in length[23]. Among some fishing communities around Tonle Sap, encounters with exceptionally large Giant Barb retain a spiritual dimension. In 2017, fisherman Phan Sopoeun accidentally caught two Giant Barb weighing approximately 110 and 130 kilograms. Their potential market value was enormous: Sopoeun estimated that selling the pair would have earned him more than USD 20,000. Instead though, he reported the catch to fisheries authorities and released both fish. Before doing so, he held a small ceremony, lighting incense, spraying perfume, and praying for peace[25].

Sopoeun said the Giant Barb and Mekong Giant Catfish, another Mekong Giant, were not only endangered species that are intrinsically linked to Cambodia's national identity, but were associated with the spirits that protect particular places. Selling them, he said, would be equivalent to "selling the Cambodian national identity"[25]. Another Tonle Sap fisherman interviewed after catching two Giant Barb of more than 110 kilograms each described being frightened, as the fish was "like a god or spirit"; he prayed to the fish before releasing them, and asked for good fortune in return[26].



These accounts show that, for some people living directly from the Tonle Sap, the Giant Barb can sit somewhere between a valuable catch, a national symbol, and a powerful water spirit.

Such giants are now rare, and populations have declined sharply as large-bodied migratory fishes across the Mekong face intense fishing pressure, habitat alteration and disruption of river connectivity. Cambodian fishery records indicate that around 200 tonnes of Giant Barb were harvested in 1964. By 1980, the recorded catch had fallen to approximately 50 individual fish; by 2000, to just ten[27]. At the Khone Falls in southern Laos, large Giant Barb were remembered as formerly common and important in local catches. Yet during intensive monitoring of fisheries between 1993 and 1999, researchers recorded only a single specimen[28].

Large individuals have become scarce, with relatively few fish now surviving until maturity – a pattern that is playing out among other giant fishes of the Mekong. Having been listed as Critically Endangered since 2011, its national status carries an uncomfortable tension: it was chosen to symbolise a country whose history, food and culture are intimately connected to freshwater, yet the ecological conditions capable of producing these giants are themselves under pressure.

If future generations encounter Giant Barb only in carvings and stories, a living expression of the Mekong's abundance, and the relationships that Cambodians developed with that, will disappear with it.

Carvings at Angkor Wat, Cambodia © Georgie Bull // SHOAL

The desert's most famous fish

Devils Hole Pupfish (*Cyprinodon diabolis*): Critically Endangered

Devils Hole Pupfish at Ash Meadows Fish Conservation Facility, © Olin Feuerbacher // USFWS



There may be no clearer example of a fish becoming inseparable from a place than the Devils Hole Pupfish.

The species' entire natural distribution is in Devils Hole, a geothermal, water-filled limestone cavern with an opening of just 22 metres by 3.5 metres, located in Death Valley National Park in the Nevada desert, USA. The fish depend heavily on a shallow submerged rock shelf where sunlight drives biological productivity and where much of the feeding and spawning takes place[1].

The location and the species couldn't be more linked: when somebody thinks of the pupfish, they think of Devils Hole; when somebody thinks of the location, they think of the Devils Hole Pupfish.

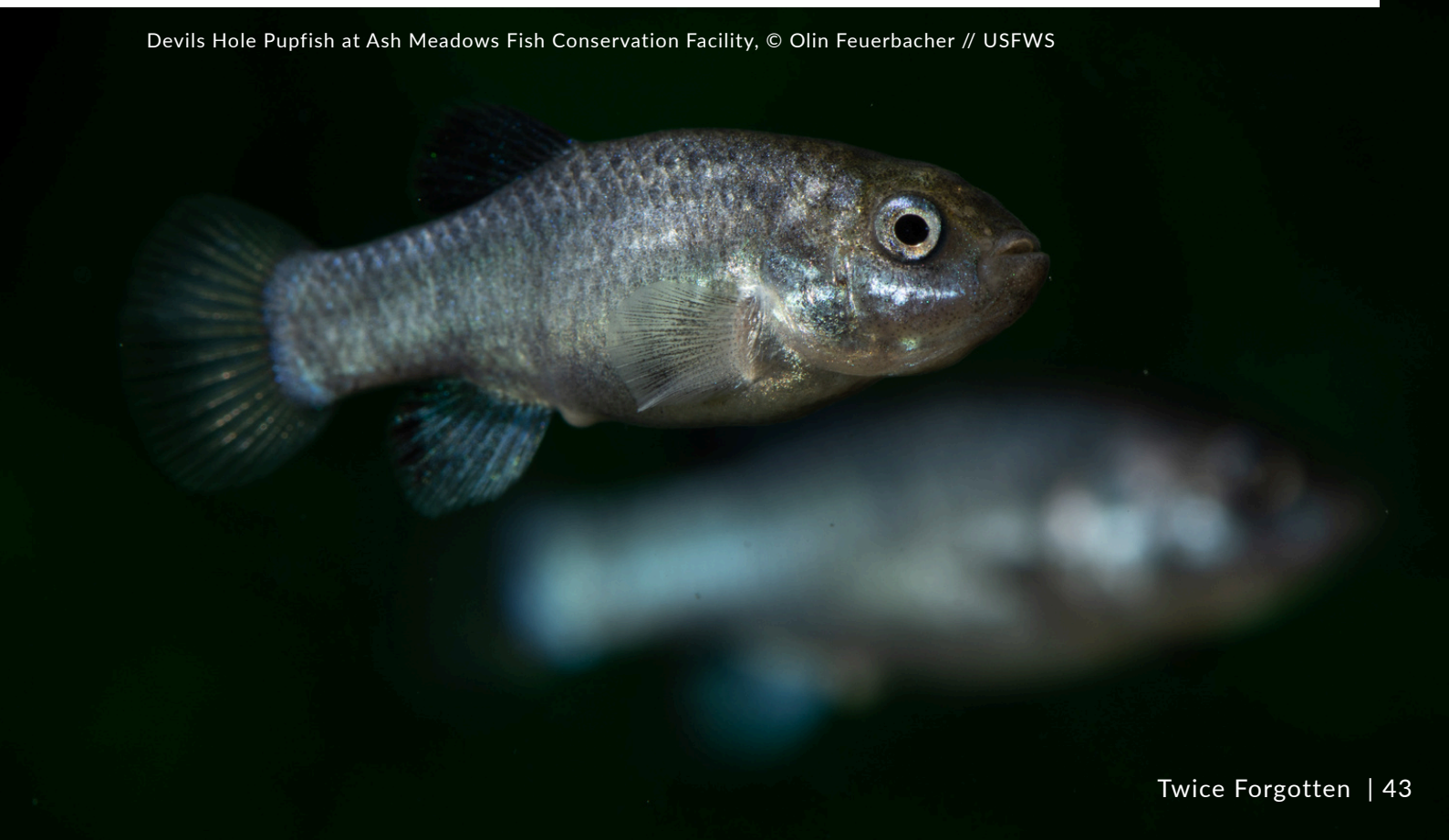
Both the species and the location have been made famous by one of the most extraordinary species conservation programmes in the world.

During the 1960s and early 1970s, groundwater pumping for agricultural development in the surrounding area lowered the water table by approximately 0.7 metres, threatening the shallow shelf on which the pupfish depended, and temporarily reducing pupfish habitat by around 85% in 1972[29].

The U.S. National Park Service and the Department of Justice sued Cappaert Enterprises, the ranchers responsible for pumping the water from Devils Hole, with the dispute escalating all the way to the United States Supreme Court.

In the landmark 1976 case Cappaert v. United States, the Court upheld a federal reserved water right sufficient to maintain the water level required to preserve the pupfish and its habitat[30]. A tiny desert fish had become central to a nationally important legal battle over groundwater and the extent to which water outside a protected area could be regulated when its extraction threatened the environment within it.

Devils Hole Pupfish at Ash Meadows Fish Conservation Facility, © Olin Feuerbacher // USFWS



Even with the legal protection afforded from the 1976 case, the pupfish population entered a prolonged and still incompletely understood decline from the late 1990s. Biologists from the U.S. Fish and Wildlife Service, National Park Service and Nevada Department of Wildlife had been conducting twice-yearly counts since the 1970s, and in spring 2013, only 35 observable pupfish were recorded[31].

Conservationists responded by trying to reproduce the ecological conditions of Devils Hole ex situ.

Completed in 2013, the Ash Meadows Fish Conservation Facility contains a roughly 100,000-gallon refuge tank designed to replicate important features of Devils Hole, including its shallow shelf and environmental conditions. Staff collect pupfish eggs along with algae and aquatic invertebrates from Devils Hole, rear fish at the facility, and maintain a captive assurance population[32].

The work has become increasingly important as the wild population has continued to fluctuate dramatically.

In spring 2024, 191 pupfish were counted – the highest spring count in 25 years. But earthquakes in December 2024 and February 2025 disturbed Devils Hole, washing material from the shallow shelf and contributing to another severe population crash. For the first time, managers transferred captive-bred Devils Hole Pupfish from the Ash Meadows facility back into the wild population. By spring 2026, 77 fish were counted in Devils Hole, while several hundred remained in captivity[31,33].

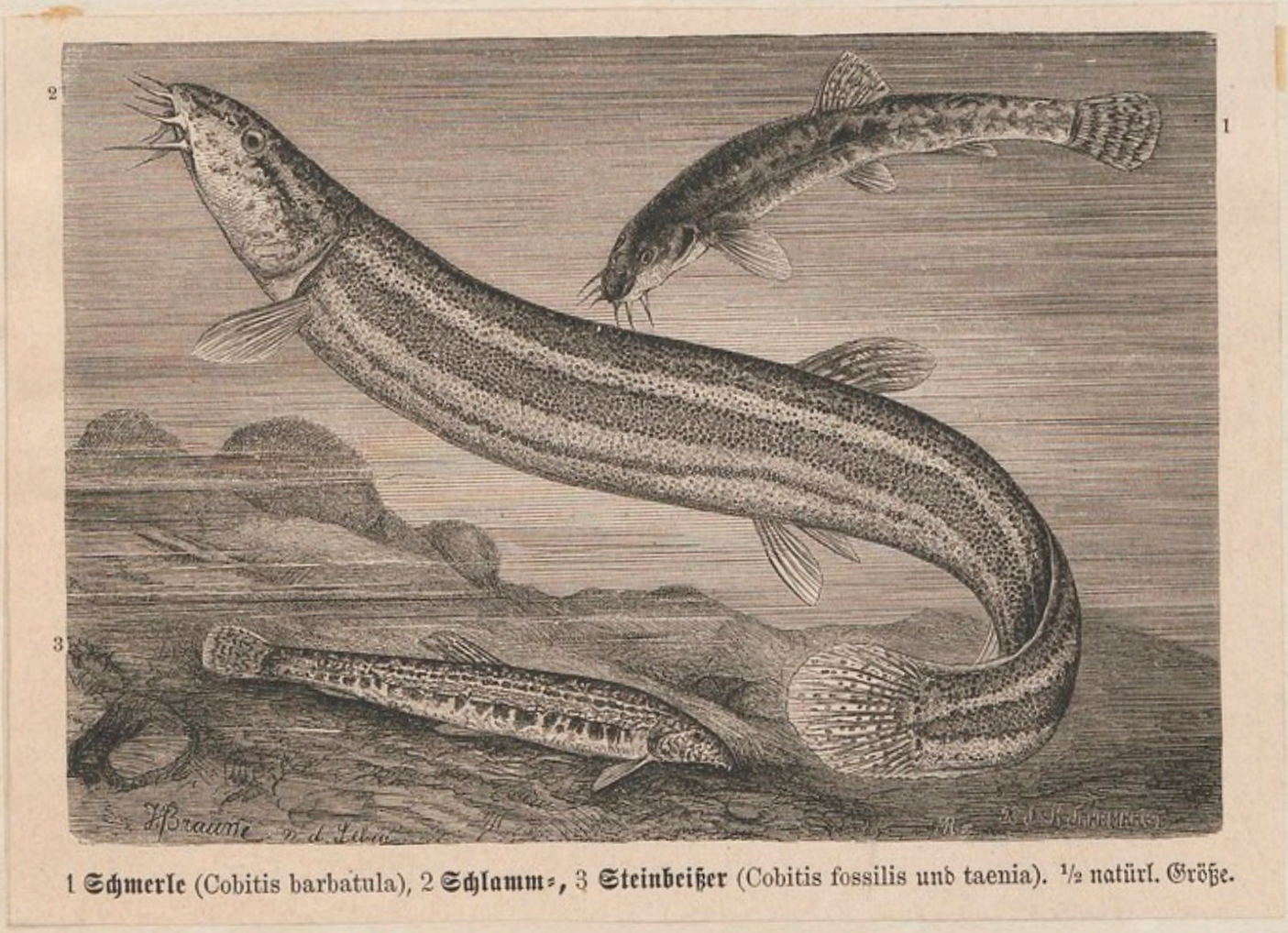
Without the pupfish, Devils Hole might be known principally as a geological curiosity: a deep, hot, water-filled fissure in the desert. Because of the fish, it has become a protected site, a scientific observatory, the subject of a Supreme Court case and one of the most famous examples of species conservation in the United States.

Millions of dollars, decades of research and an incredible amount of human ingenuity have been devoted to ensuring that a tiny blue fish continues swimming in one particular patch of water.

It is difficult to imagine a more literal expression of Fish as Place.

Devils Hole Pupfish at Ash Meadows Fish Conservation Facility, © Ryan Hagerty // USFWS





1 **Schmerle** (Cobitis barbatula), 2 **Schlamm-**, 3 **Steinbeißer** (Cobitis fossilis und taenia). ½ natürl. Größe.

CHAPTER 4

Fish as Knowledge

Misgurnus fossilis in *Iconographia Zoologica*, Karl Gustav Jahrmargt (1842–1906)

Spend long enough observing a river, and you'll learn its rhythms and subtleties: its changing colours, water level and speed can follow the turning of the seasons. The moon can help determine when fish will move, and the sudden arrival of certain fishes can reveal that distant floodplains have filled. A certain splash can be the giveaway that a fish is present, and even what kind of fish it is and how large it might be. For people who have spent generations living alongside freshwater systems, these observations can accumulate into detailed bodies of knowledge about species, migrations, breeding seasons, habitats and weather, of when to fish and when to leave fish alone, of where species once occurred and where they no longer do.

There are various terms for this rich understanding. 'Local ecological knowledge' is usually understood as knowledge developed through sustained interaction with an environment. 'Traditional ecological knowledge' carries an additional sense of transmission between generations. 'Indigenous knowledge systems' have their own intellectual and cultural foundations and, while there is not one single way of being Indigenous, there are some characteristic ways of seeing and being that suggest Indigenous communities the world over tend to view and interact with the world in specific ways[1]. Some Indigenous knowledge systems emphasise relationships between spiritual and material realms and understand humans as part of a living, interconnected environment. This belief locates humanity as part of Mother Earth's ecosystems alongside our relations in the natural world[2].

What local ecological knowledge, traditional ecological knowledge, and Indigenous knowledge systems share is a recognition that understanding the natural world is not only produced through formal scientific institutions, but can also arise through repeated observation, practice, memory, language, and experience accumulated across lifetimes and generations[3].

The Mekong provides an example. Scientists trying to understand the migrations of hundreds of fish species faced an obvious problem. The river is enormous, many species travel hundreds of kilometres, and conventional tagging and sampling programmes could cover only a fraction of it. Fishers, however, had been watching these movements for generations.

From 1997, the Mekong River Commission began systematically collecting that knowledge. Researchers interviewed fishers and fish sellers along the river in Cambodia, Lao PDR, Thailand and Viet Nam, asking where particular fishes occurred, when they moved, where they were believed to spawn and how these movements related to changing river conditions[4]. The resulting picture showed migrations closely tied to the annual flood pulse. It also provided information on species whose rarity made them extremely difficult for scientists to study directly.

When researchers later searched for the Critically Endangered Mekong Giant Catfish using environmental DNA, sampling locations included deep pools identified through local ecological knowledge, alongside sites selected from historical records of the fish's occurrence[5]. In northern Cambodia, interviews with 96 fishers have also been used to reconstruct changes in the abundance and size of eight species of freshwater megafauna, among them the Giant Barb and Mekong Giant Catfish[6]. Memories of catches made 20 years earlier can reveal a decline that a recent scientific survey has no baseline against which to measure.



Traditional Fisher and fishing boat, Myanmar



Weather Loach, © Manoel Jr via Wikimedia Commons

Fish can also become signs by which environmental change is read. The Weather Loach species, *Misgurnus anguillicaudatus* and *Misgurnus fossilis*, are famous for this. Across East Asia and Europe the fishes acquired a reputation for becoming unusually restless before changes in the weather, an association generally linked to their sensitivity to atmospheric pressure. The belief travelled with the fish into the aquarium trade, where “Weatherfish” and “Weather Loach” remain standard English names[7]. Whether a loach can forecast a storm with useful accuracy is beside the point – people watched its behaviour, connected that behaviour with changes in the atmosphere and gave the fish a name that preserved the association.

In Australia, knowledge of the Murray Cod is key to a creation story: for the Ngarrindjeri people, the giant Murray Cod Pondi features in the Ngarrindjeri creation story of Ngurunderi and the formation of the Murray River and its landscape[8]. The story belongs to a living knowledge system concerned with country, ancestry and responsibility for water, and is relevant to contemporary river management: Australia's National Cultural Flows Research Project has worked to bring First Nations knowledge and cultural values into decisions about water, recognising that stories of waterways carry understandings and obligations accumulated over generations[9]. Pondi is therefore more than an old story attached to a famous fish – the cod remains part of how relationships with the Murray are remembered and articulated.

The Danube Salmon, or Huchen (*Hucho hucho*), shows how ecological knowledge can survive in a different form. Centuries of fishing produced a written record of the species across Central and Eastern Europe. Polish sources from the sixteenth to the early twentieth centuries describe its distribution, value, and methods of catching it, along with attempts to breed and propagate it. Those records now have scientific value. They show, for instance, that Huchen survived in the Dniester basin until around the beginning of the eighteenth century, a former part of its range omitted from many modern accounts[10]. Old fishing knowledge has become evidence for reconstructing what was lost.

This highlights how knowledge can outlive a fish population. But it can also fade quickly. The disappearance of a species removes the repeated encounters through which detailed knowledge is maintained. Fishing techniques fall out of use, local names become unfamiliar, and memories of when a run used to arrive or how large the fish once grew become harder to pass on.

Freshwater fish conservation often begins by asking how many fish remain. In many places there is another useful question: what do people know about them? The answer may reveal where a fish breeds, where it used to live, how its abundance has changed, or what its movements once told people about the river. Lose the fish, and that accumulated knowledge may eventually go with it.

Knowing tuna

New Zealand Longfin Eel (*Anguilla dieffenbachii*): Endangered

© Cameleonseye via Getty Images





New Zealand Longfin Eel,
© Goddard_Photography
via Getty Images

For Māori, *tuna* (freshwater eels) are a revered *taonga* (treasure) and a vital *mahinga kai* (traditional food resource). They hold deep spiritual significance through creation legends, and represent a cornerstone of Indigenous ecology, sustainable harvesting, and tribal identity (see also Fish as Food, Subsistence and Livelihood, p.13). Long before scientists began tagging New Zealand's freshwater eels, Māori had built up a formidable body of knowledge about them.

The general Māori word 'tuna' covers freshwater eels, including the endemic longfin *Anguilla dieffenbachii* and shortfin *A. australis*. Within that broad category is a much richer vocabulary. Historical records contain a multitude of Māori names for different forms of tuna. Some refer to colour or appearance, others to behaviour, size, locality or season[11]. *Tuna heke*, for example, describes migrating eels. Other names distinguish pale, dark, large-headed or otherwise recognisable forms.

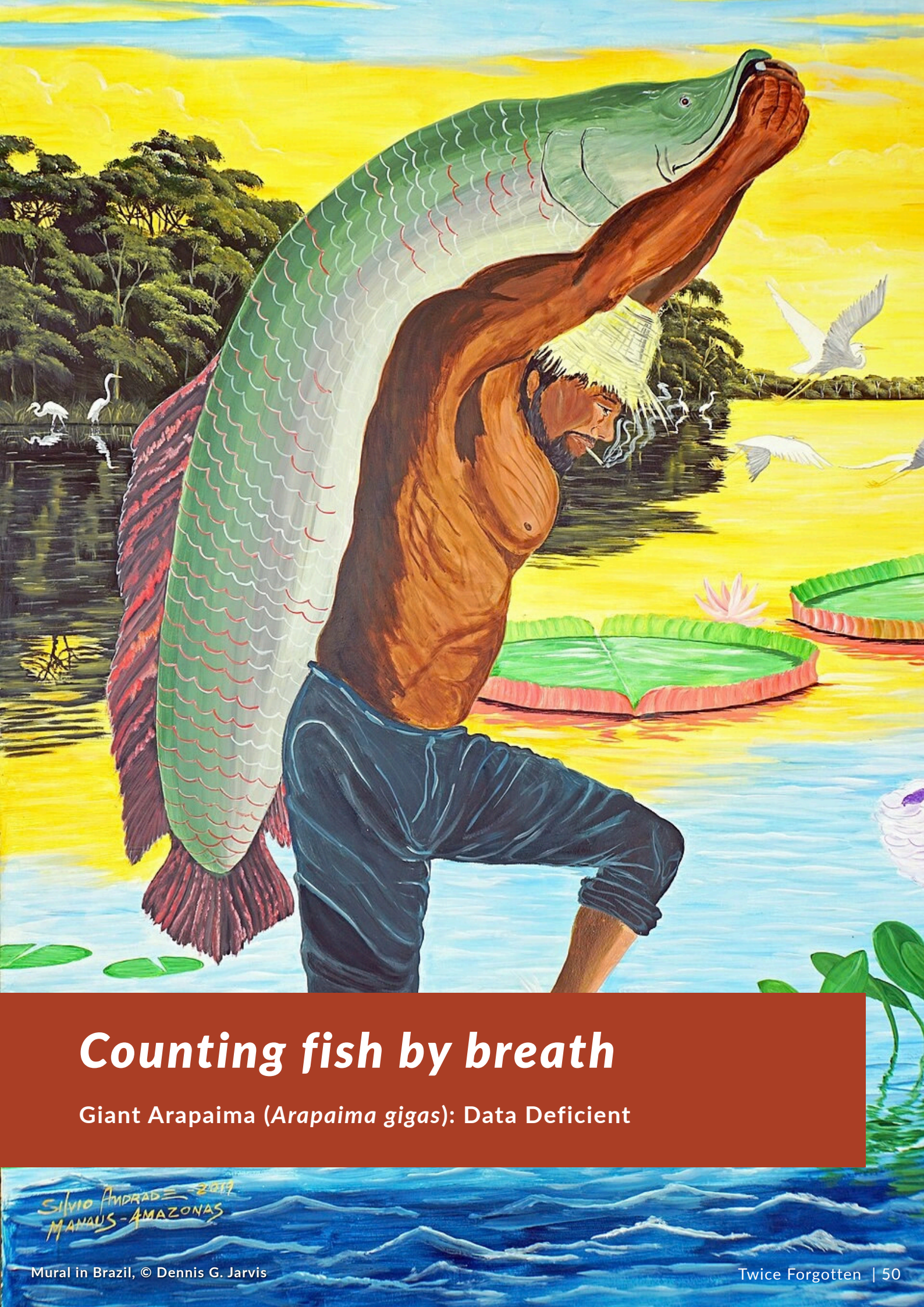
These categories do not correspond neatly with the species boundaries used by modern ichthyologists, but preserve a different kind of attention to the animal. It can be easy to imagine how, for somebody harvesting eels, knowledge of whether it was migrating, where it lived, how large it was and how it behaved, were useful distinctions quite apart from the anatomical features used to separate *Anguilla dieffenbachii* from *A. australis*.

Catching them required another body of knowledge. Māori developed specialised eel traps, *hīnaki*, alongside spears and large *pā tuna* or eel weirs. Weirs were built across waterways to exploit the downstream migration of adult eels heading towards the sea[12]. Their successful use depended on anticipating when tuna would move and understanding how they travelled through a particular waterway.

Timing could also be read through the *maramataka*, Māori lunar calendars that vary between *iwi* (tribe) and region. Historical maramataka identify certain nights as favourable for catching tuna, and sometimes go so far as specifying appropriate fishing methods. Research commissioned by Fisheries New Zealand describes these calendars as part of a wider system through which harvesting could be timed and restrained[13].

The Indigenous knowledge system of *mātauranga* remains part of eel conservation. An inventory of iwi eel research found communities using local knowledge to assess tuna abundance and availability, monitor waterways and inform decisions about sustainable harvest[13]. Māori guardians known as *Kaitiaki* have also been involved in practical measures such as moving eels past barriers that interrupt migration[14].

The New Zealand Longfin Eel is listed as Endangered globally[15]. It faces fishing pressure, habitat degradation, wetland loss and barriers to migration. As the fish declines, so too does the rich body of knowledge handed down through generations of Māori. As populations continue to trend downward, each generation inherits a poorer river than the previous one.



Counting fish by breath

Giant Arapaima (*Arapaima gigas*): Data Deficient

Mural in Brazil, © Dennis G. Jarvis



Top Left: Pirarucu à Casaca, meaning "Pirarucu in a Jacket", a traditional, festive dish from the Amazonas region of Brazil made using Arapaima © Agência de Notícias do Acre via Wikimedia Commons
Top: Catch and release flyfishers with an Arapaima, © Jijiladouceur via Wikimedia Commons

Fishers of the freshwater giant Arapaima, also known as Pirarucu, in the Brazilian Amazon know how to count them without catching them.

The skill comes from the fish's biology. Arapaima are obligate air breathers and must surface regularly. Fishers who have spent years hunting them learn to watch and listen for subtle visual and acoustic cues when the fish surface. Experienced counters can distinguish individual fish and avoid counting the same animal repeatedly.

Biologist Leandro Castello conducted a study in the Mamirauá Sustainable Development Reserve, where counts made by experienced fishers were compared with independent estimates obtained using scientific mark-and-recapture methods. The findings showed an exceptionally strong correlation of 0.98 between the fishers' counts and the independent mark-and-recapture estimates[16].

Castello's paper describes conventional mark–recapture surveys of Arapaima as "slow and expensive" and, with the fishers already possessing a workable census method, the technique was built into community Arapaima management. For example, on the Juruá River, teams of experienced fishers have carried out these surveys using both sight and sound, with population estimates then used to set controlled harvests[17].

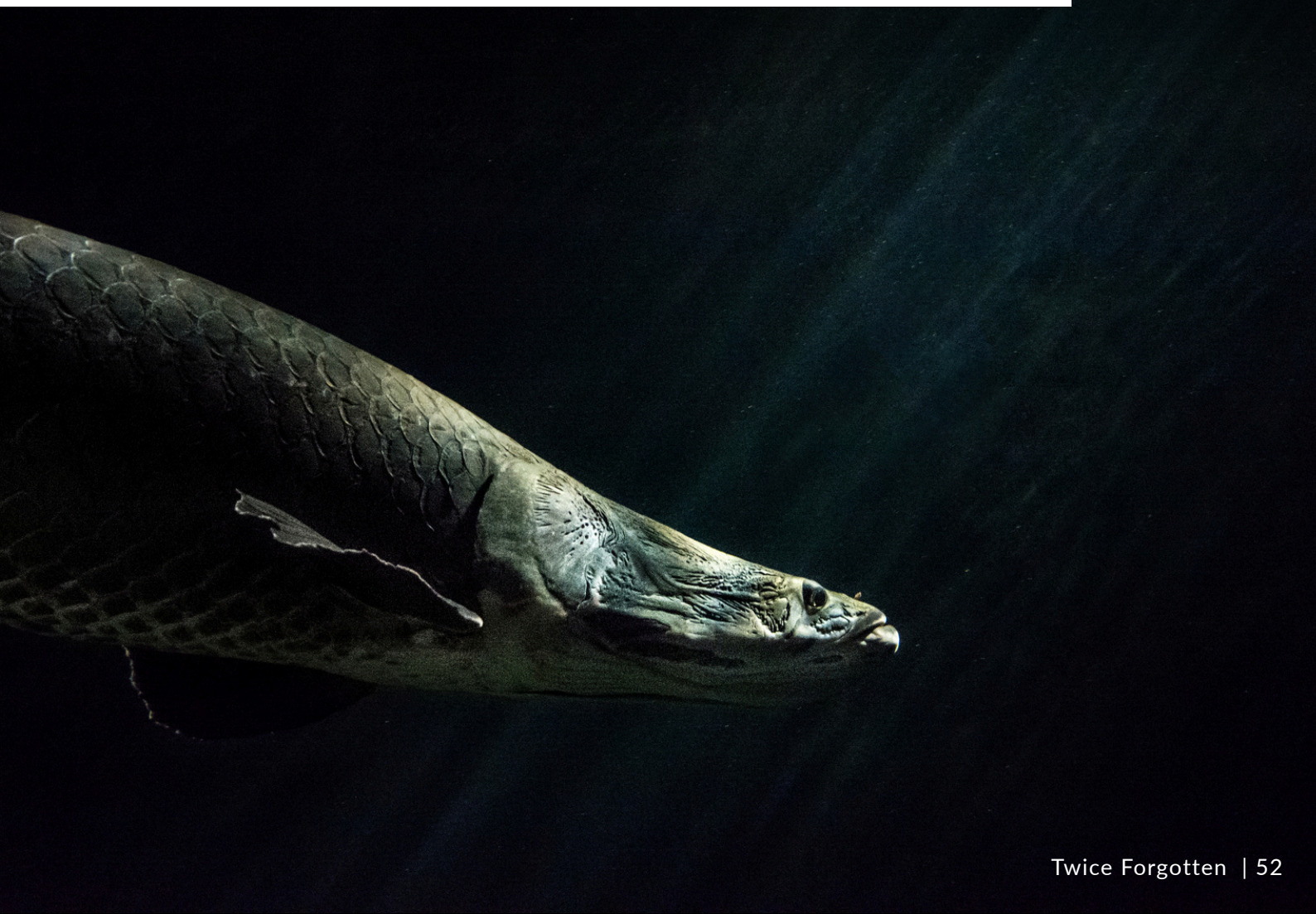
The result of this management is that community-managed lakes in the Juruá have recorded strong recoveries of Arapaima, while comparable unprotected waters have supported far fewer fish. The approach expanded rapidly. The model was first tested in four communities in 1999; by 2006, 108 communities were participating, and by 2023, 407 fishing communities in Amazonas were authorised to harvest Arapaima under the counting-based co-management system[18,19].

There is a deeper history behind the method. Pirarucu have supported Amazonian fisheries for centuries and were once so heavily exploited that salted Arapaima became known as the “cod of the Amazon”. By the late twentieth century the species had been badly depleted in many accessible floodplain systems. Fishing restrictions alone were difficult to enforce across such a large landscape. Community management worked partly because it put people who knew the fish at the centre of counting and protecting it[20].

The case has become one of the clearest demonstrations of local ecological knowledge producing data that can stand alongside conventional fisheries science. The fishers’ knowledge was not replaced by a scientific technique – their technique became key to the management system.

It also shows how biological decline can threaten knowledge before anybody notices that the knowledge is disappearing. Learning to count Arapaima takes practice. A fisher has to see and hear enough fish to learn what different surfacing events mean. In a lake emptied of Arapaima, that apprenticeship becomes impossible.

The recovery of Arapaima in community-managed lakes has therefore kept a distinctive piece of Amazonian ecological knowledge in use. Each census depends on knowledge accumulated over years beside the water: knowing how an air-breathing giant behaves when it surfaces.

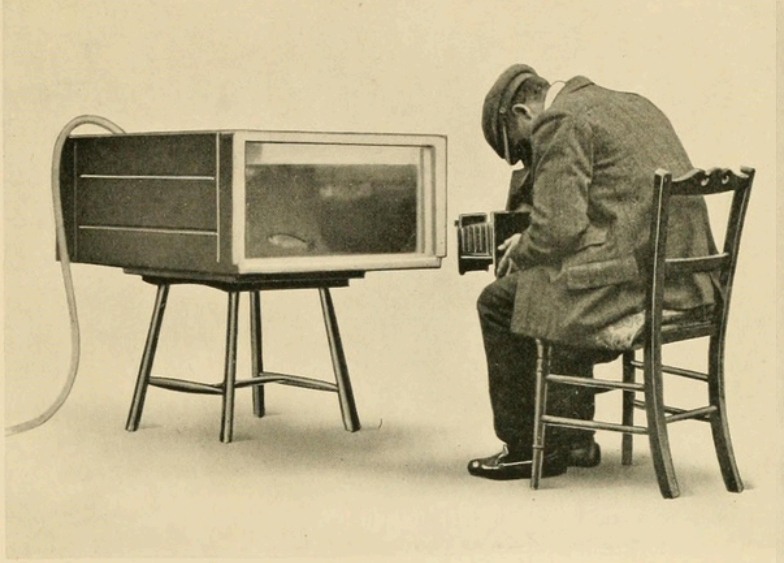




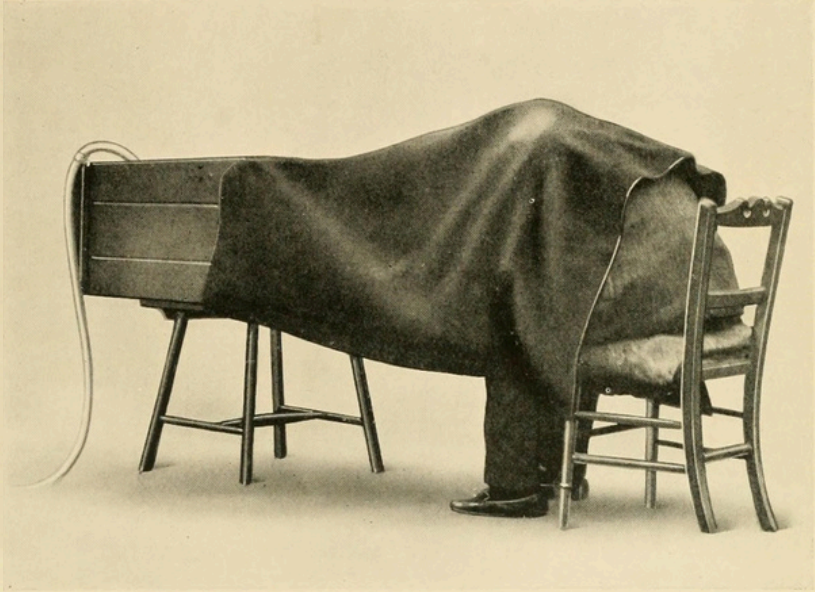
CHAPTER 5

Fish as Beauty, Wonder and Obsession

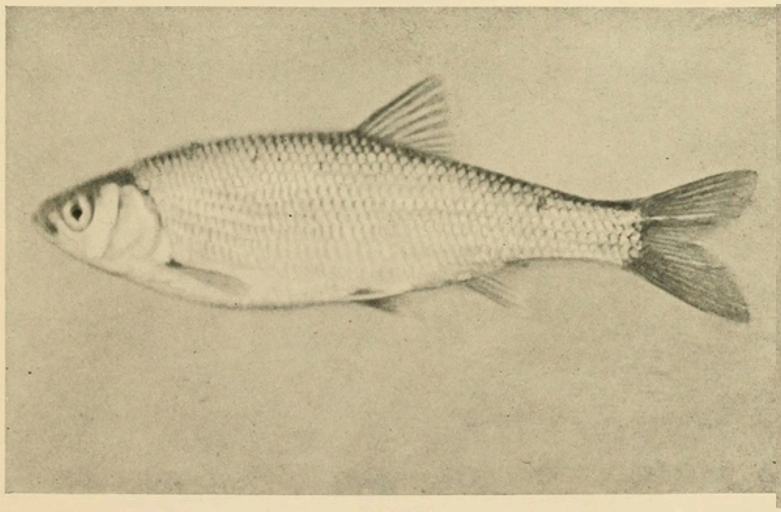
Book plate from *River gardens*, S. Low, 1857, courtesy of the Biodiversity Heritage Library



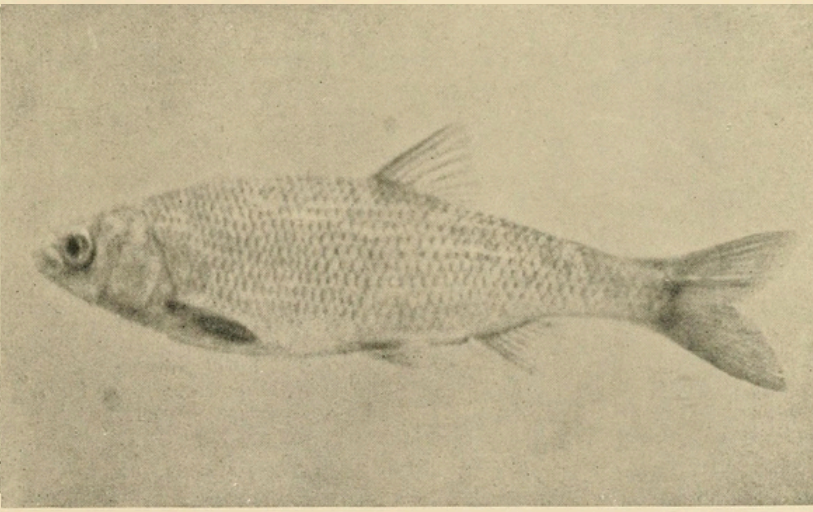
PHOTOGRAPHING A DACE, LIGHTED BOTH FROM ABOVE AND FROM IN FRONT.
This is how we usually see fish in tanks and aquaria.



PHOTOGRAPHING A DACE, LIGHTED ENTIRELY FROM ABOVE.



DACE.
Result of photograph taken as in the above illustration.



DACE REFLECTING ITS DARK SURROUNDINGS.
Result of photograph taken as shown in the above illustration.

Book plates from *Marvels of fish life as revealed by the camera*, Cassell, 1912.

There is a particular kind of person who can spend hours looking into a glass box.

To anyone untouched by the aquarium habit, this may be difficult to understand. Yet fishkeepers learn to see things that pass almost unnoticed by others. Experienced hobbyists speak of personalities amongst the individuals in their shoal, and recognise that the fish they keep are sentient animals with cognitive abilities far richer than their reputation might suggest[1]. They understand the nuances of courtship and spawning. They swap fishes, photographs and information, travel to specialist shops and shows, and devote entire rooms of their homes to their tanks.

Freshwater fishes have inspired this obsession for centuries, with China providing the clearest early record. During the Tang dynasty, between 618 and 907 CE, people were deliberately selecting unusually coloured fish and placing them in ornamental ponds and water gardens. Under the Song dynasty (960 to 1279 CE), goldfish breeding became increasingly sophisticated. Yellow-gold fish were associated with the imperial family, while repeated artificial selection gradually turned a wild-looking crucian carp into something quite different[2,3].

After more than 1,000 years of selection, goldfish now include animals with paired tails, shortened bodies, missing dorsal fins and fleshy head growths. Charles Darwin was fascinated by how selective breeding in China had transformed wild Asian carp into ornate goldfish with extraordinary physical changes[2]. Some of the major forms familiar in goldfish today can be traced to Chinese breeding traditions of the fifteenth and sixteenth centuries[4].

A second great ornamental tradition emerged in Japan in the early nineteenth century. In the mountainous communities of Niigata, villagers raised dark magoi carp as food. Young fish grew among the rice in terraced paddies, while others were kept in ponds; before winter, carp were moved to household ponds as a source of food through the snowbound months. When unusually coloured fish appeared, farmers kept and selectively bred them. Over generations, this practice gave rise to nishikigoi – 'brocaded carp' – known outside Japan as koi[5].

Today, koi are judged with an attention to detail that to outsiders can feel bewildering. Pattern, symmetry, skin quality, colour, lustre and body shape all matter. Breeders have refined prized lineages through successive generations of selection. The best fish are objects of connoisseurship, and are promoted as 'swimming jewels'[6]. A fish once kept through winter as a reliable source of protein has morphed into living artwork.





Top & Bottom: Plates from *Histoire Naturelle Des Dorades De La Chine*, 1780, demonstrating highly selected traits already present in goldfish.

Europe's aquarium culture was formed through a different route. During the nineteenth century, developments in glass manufacture, and a growing understanding of the relationship between aquatic plants, oxygen and animals, made it possible to maintain functioning aquatic communities that could be viewed from the side, rather than from above. The British naturalist Philip Henry Gosse became the great populariser of the idea. He helped stock the Fish House which opened at London Zoo in 1853 and helped make the word 'aquarium' become a household name. His lavishly illustrated 1854 book *The Aquarium: An Unveiling of the Wonders of the Deep Sea* helped trigger what became known as Victorian "aquarium mania"[7].

Aquaria proliferated in middle-class homes as objects of fascination and decoration. What to many people had previously been hidden beneath the surface became viewable at eye level. The home aquaria trend enabled people, mostly for the first time, to easily witness the fascinating behaviours and sumptuous colours that fish fanatics fall in love with.

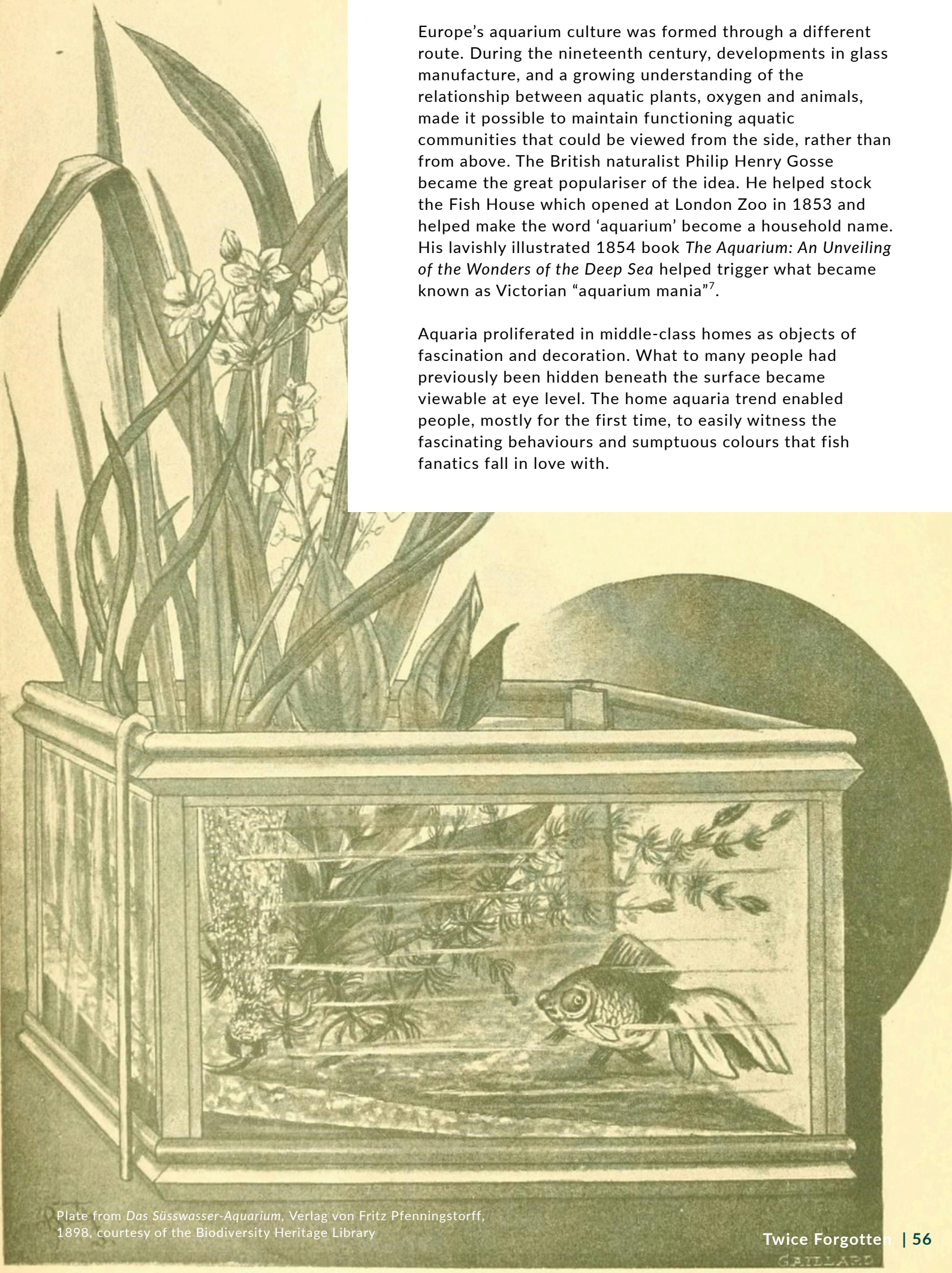


Plate from *Das Süsswasser-Aquarium*, Verlag von Fritz Pfenningstorff, 1898, courtesy of the Biodiversity Heritage Library



That desire to recreate underwater worlds has since developed into an art form of its own. Japanese photographer and aquarist Takashi Amano pioneered his “Nature Aquarium” approach from the 1980s, arranging aquatic plants, stones, wood and small fishes into carefully composed landscapes. His aquaria might evoke a forest clearing, a riverbank or a mountain valley rather than a conventional fish tank. Amano's books carried the approach worldwide, and modern aquascaping competitions now attract entries from scores of countries[8]. Here, fishes are part of a living composition: their size, movement and colour chosen in much the same way that a painter considers figures within a landscape.

A modern aquascape, © ComR78 from Getty Images



For others, wonder comes from the fish itself. Some freshwater species challenge expectations about what a vertebrate can be. *Paedocypris progenetica*, described from peat-swamp forests in Sumatra, reaches sexual maturity at an extraordinary size: the smallest mature female in the original description measured just 7.9 millimetres. Its tiny, partly transparent body made international news when the species was described in 2006[9]. Many aquarists are drawn to such novelty – miniature fishes, cave fishes without eyes, air-breathing fishes, electric fishes, mouthbrooders, shell-dwellers – and the fascination often deepens as they learn how those oddities evolved.

The modern ornamental trade has made that diversity available on an unprecedented scale. More than 5,300 freshwater fish species have been recorded in the trade, although around 1,000 are widely available and a much smaller group accounts for most sales[10]. For specialist hobbyists, obscurity can become alluring. There are aquarists who maintain a single genus, exchange locality-specific populations, record pedigrees, and travel internationally to find fishes that would mean almost nothing to the average visitor to a pet shop.

That passion has complicated consequences for conservation.

Demand for rare fish can place dangerous pressure on small wild populations, particularly where collection is poorly regulated. Aquarium fishes released or escaped outside their natural range can become invasive. Captive populations can also lose their conservation value when distinct geographical forms or species are casually hybridised[11].

Yet aquarium hobbyists also possess something conservation organisations often struggle to manufacture: sustained attention to obscure species. Serious aquarists can spend decades learning how to keep and breed fishes that few professional conservation programmes have the capacity to maintain. Specialist societies have funded research, exchanged ecological observations with scientists and participated directly in conservation projects[11]. The CARES Preservation Program has gone further, encouraging aquarists to maintain threatened freshwater fishes specifically as conservation populations. An analysis of the programme found nearly 600 priority taxa, and 24 species classified as Extinct in the Wild[12].

Captive populations cannot replace the migrations, ecological relationships and evolutionary pressures experienced by fishes in the wild, or their cultural connections to a place. But fascination can create constituencies for animals that would otherwise remain almost invisible.



Bottom Right: *Paedocypris progenetica*, © Maurice Kottelat
Top Left: *Paedocypris progenetica*, © Tan Heok Hui

From fighter to living ornament

Siamese Fighting Fish (*Betta splendens*): Vulnerable

Few fishes reveal the creative power of human fascination as clearly as the Siamese Fighting Fish.

There are clear differences between wild and domestic Bettas, with the wild fishes being relatively subdued, short-finned animals, while the modern strains can carry tails spreading through 180 degrees, rays extending like the points of a crown, rich, metallic scales, marble patterning and colours ranging from deep crimson to iridescent blue, white, yellow and near-black. Some barely resemble the animal from which the breeding tradition began.

Beauty, however, was not the original objective.

In Thailand, the Siamese Fighting Fish belongs to a long tradition of keeping *pla kat* – biting fish – for staged fights. Wild males are territorial, confronting rivals with flared fins and gill covers before attacking. People collected them and increasingly bred animals for aggression, stamina and fighting performance. Contests attracted gambling, and fighting strains became cultural objects in their own right. The tradition goes back centuries[13].

Over time, breeders began paying increasing attention to appearance. Selection moved in a new direction. The same plasticity that had allowed people to exaggerate fighting behaviour proved capable of generating an extraordinary diversity of colours and forms.

Modern genomics is now revealing just how profound this domestication has been. Researchers comparing wild and domestic Bettas have identified genetic regions associated with traits including colour, fin morphology and sex determination. They have also uncovered evidence of hybridisation between domesticated ornamental Bettas and several closely related wild *Betta* species[14]. Today's show fish is therefore not simply a wild species with brighter colours. It carries a complicated genetic history written by generations of human preference.

Thailand formally designated the Siamese Fighting Fish its national aquatic animal in 2019, recognising its cultural heritage as well as its international economic importance[13]. The decision captures how far the animal has travelled culturally, from rice fields and fighting contests to a national symbol sold and bred around the world. Domestic Bettas are now widespread. Wild *B. splendens*, by contrast, has been assessed as Vulnerable, while 11 other *betta* species are assessed as Critically Endangered[15]. The aquarium can therefore create an illusion of security: millions of brightly coloured domestic animals bearing the name *Betta* tell us little about the prospects of the fishes from which that culture ultimately arose.

Bottom images: SHOAL-ASAP Partner, Airlangga University is working with local communities to protect the remaining 5 hectares of habitat for *Betta burdigala*. © Veryl Hasan.



A fish worth more with the forest standing

Cardinal Tetra (*Paracheirodon axelrodi*): Least Concern

© Peter Maguire



Cardinal Tetras are ubiquitous in the aquarium trade, and so important to Barcelos, on Brazil's Rio Negro, that they are one of the two emblematic fishes at the town's annual Ornamental Fish Festival.

The appeal is immediate. A brilliant blue stripe catches the light above a band of intense red running much of the length of the body. In an aquarium, a shoal can look almost electrically illuminated. It has captured so many people's attention that its beauty created an entire industry.

After the species entered the international aquarium trade in the twentieth century, the middle Rio Negro became one of the world's great centres for collecting ornamental freshwater fishes[16]. Around Barcelos, specialist fishers known as *piabeiros* developed detailed knowledge of the floodplain: where particular fishes occurred, how water levels changed their distribution, and which techniques and equipment could be used in catching them[17].

By the 1990s, Cardinal Tetras dominated the trade. Data collected through Project Piaba recorded approximately 18.9 million ornamental fishes leaving Barcelos during seven months in 1995–96; more than 17.3 million were Cardinal Tetras[18].


© mirceax via Getty Images

The relationship produced an unusual conservation argument: Project Piaba, established around research begun in the late 1980s, examined whether the Rio Negro ornamental fishery could provide livelihoods while giving communities an economic reason to maintain healthy forest and freshwater habitats. The resulting slogan – 'Buy a Fish, Save a Tree' – was deliberately provocative. The premise was that a sustainably harvested wild fish could link the purchasing decisions of an aquarist in another country to the continued value of an intact Amazonian ecosystem.

The instinctive conservation response – that taking wild animals must necessarily be worse than breeding them in captivity – does not capture the whole picture. Many of the fishes involved are naturally abundant and productive, while the livelihoods generated by their collection depend upon functioning aquatic habitat. Research on the aquarium trade has consequently used the Rio Negro as a prominent example of wild harvest potentially contributing to conservation, provided collection and supply chains remain properly managed[10].

Cardinal Tetras have also become part of Barcelos's cultural identity. The town's Festival do Peixe Ornamental, or Ornamental Fish Festival, celebrates the trade on which many local families have depended. Research by Project Piaba recorded thousands of visitors attending the event and more than 1,000 children taking part in preparations for rival dance performances[18]. The aquarium fish had travelled full circle: distant people found it beautiful, and it subsequently became the subject of celebration in the place it was caught.

This glorious little fish demonstrates how human desire can alter the value attached to an ecosystem. In this case, millions of people wanting a tiny red-and-blue fish in their aquarium helped create livelihoods based on fishes that require the Rio Negro's waters and surrounding forest to remain healthy.

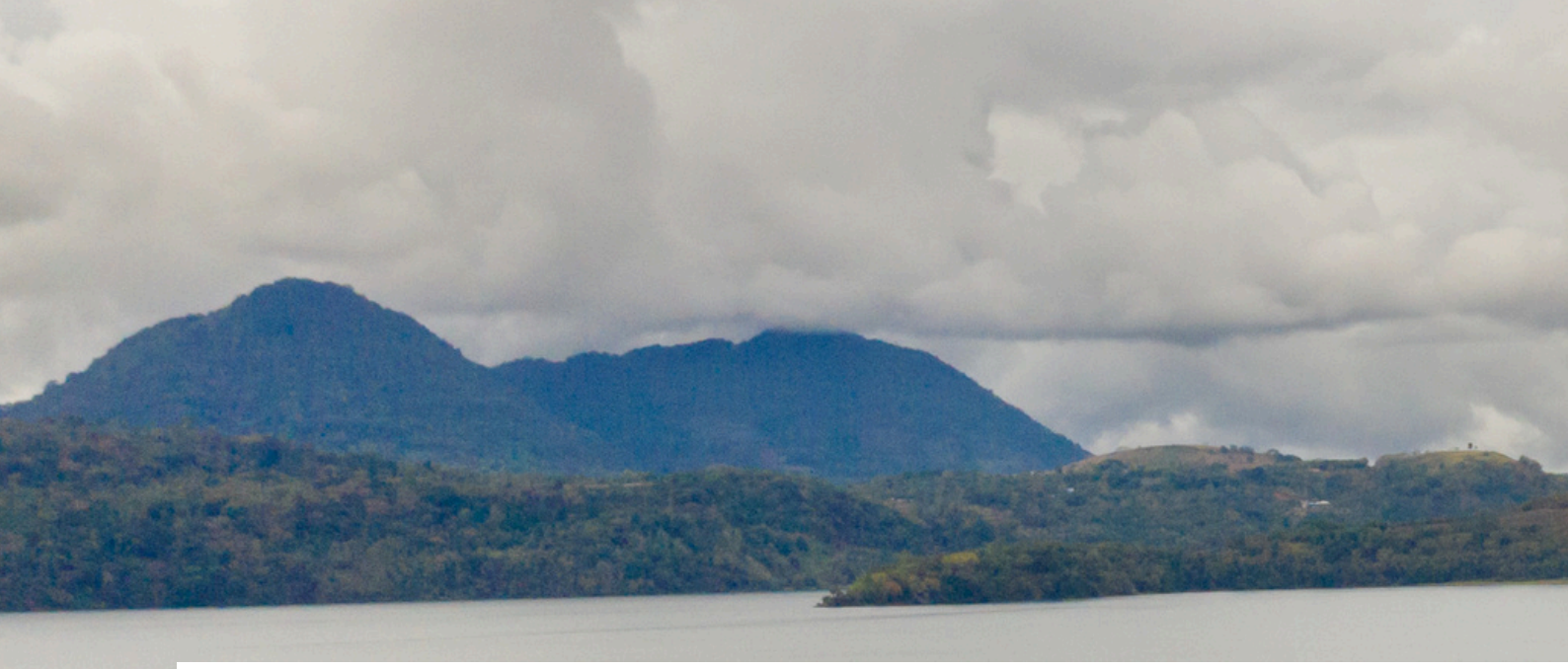
Beauty became an economic value. Under the right conditions, that value can become an argument for keeping a place intact.

CHAPTER 6

Fish as Warning and as Hope



Día de Muertos celebrations in Teuchitlán, Mexico, the home of the Tequila Splitfin © SHOAL // Michael Edmondstone



Biological extinction is an endpoint that can be quantified, i.e. the moment when the last individual of a species dies. Cultural extinction is much less tangible or precise. It can begin much earlier than the biological extinction, as a species disappears from nets and markets, or from seasonal rituals. Or it can happen afterwards, as memories, knowledge and practices gradually fade, even where photographs, museum specimens or written accounts remain.

Freshwater fishes offer warnings of both kinds. Inland waters are particularly vulnerable to the cumulative pressures of water abstraction, pollution, invasive species, overfishing, habitat fragmentation, and a changing climate. For fishes confined to fragmented rivers, lakes and springs, escape is often impossible as the conditions they need deteriorate. And the cultures that developed alongside freshwaters are changed too as the fish they celebrate disappear.

Take Lake Lanao in the southern Philippines. The ancient lake was famous among ichthyologists for having an extraordinary radiation of endemic cyprinids. It is the ancestral homeland of the Maranao people (the name itself translates as "people of the lake") and the lake lies at the heart of Maranao social, economic and cultural life[1,2]. Its endemic fish species were known individually, with local names including baolan, lindog, manalak, palata, sirang and tumba, and several supported important fisheries. In the early twentieth century, lindog was described as the lake's second most prized endemic cyprinid after baolan. Even in 2008, when it had become desperately rare, lindog and tumba were the most expensive fishes recorded in market surveys, with regular customers willing to buy them immediately[1].

Then the fish community changed. Introduced species proliferated, while habitat change, exploitation and other pressures compounded the decline of the native fishes. By 2008 researchers could find only two of the lake's endemic cyprinids, together comprising a tiny fraction of the catch. Fishers interviewed during that survey commonly believed that all of the endemic cyprinids had already disappeared[1]. In 2020, the IUCN assessed 15 Lake Lanao *Barbodes* species as Extinct[3]. The remarkable species flock that had evolved alongside one of Southeast Asia's great lake cultures had, within decades, been largely erased.

Lake Lanao © Alex Punker via Getty Images

But with the challenges of species extinction recognised in time, and the right level of ambition to turn back the clock, there is hope. In South Africa's Cederberg mountains, the Clanwilliam Sandfish (*Labeo seeberi*) once made conspicuous seasonal migrations through the Olifants-Doring river system. Its movement was part of the rhythm of the region: historical accounts describe large numbers moving upstream to spawn, and recent reporting from the Biedouw Valley records how the annual migration marked the coming of spring and once supported local subsistence[4,5]. Pictographs interpreted as Clanwilliam Sandfish survive on sandstone cave walls in the Cederberg, painted by Indigenous San communities thousands of years ago[5]. Today, however, the Sandfish is South Africa's most threatened migratory freshwater fish. Invasive black bass introduced during the twentieth century devour juveniles, dams interrupt connectivity, and water abstraction places further pressure on rivers already exposed to severe drought[4].

But the fish's story doesn't end there. Conservationists now rescue young Sandfish from tributaries where they would otherwise be eaten or stranded as pools dry, rear them in predator-free 'sanctuary' dams, and return them to the river when they are large enough to have a better chance of survival. Some of those sanctuaries are farm dams offered by local landowners. An agricultural landscape that contributes to pressure on scarce water is therefore also becoming part of the solution: farmers, scientists and conservationists are collectively keeping alive a migration that once helped announce spring in the valley[5,6]. Cultural connection here can be renewed through conservation itself.

Right: Clanwilliam Sandfish, © Jeremy Shelton





Snail Darter, *Percina tanasi*, © Jerry A. Payne, USDA Agricultural Research Service

An even stranger example comes from the United States. The Snail Darter (*Percina tanasi*) became an unlikely focus of national debate in the United States in the 1970s when construction of the Tellico Dam threatened the only population then known. Its scientific name memorialised Tanasi, the historic Cherokee town beside the Little Tennessee River from which Tennessee ultimately took its name[7]. When the dam was completed, the reservoir submerged the archaeological site of Tanasi itself, along with other important Cherokee sites[8]. A fish carrying the name of a drowned Cherokee town had therefore become entangled in the fight over the dam that drowned it.

The Snail Darter became a cultural symbol far larger than the fish itself. Critics portrayed it as proof that environmental law had become absurd: a tiny, obscure fish standing in the way of a major federal project. In 1978 the U.S. Supreme Court nevertheless ruled that the newly enacted Endangered Species Act required protection of the species, even though the Tellico Dam was already almost complete. Congress subsequently exempted the project and the dam was finished[9]. Yet the fish did not disappear. Individuals were moved to other rivers, additional populations were discovered, habitat conditions improved and, in 2022, the U.S. Fish and Wildlife Service removed the Snail Darter from the endangered species list on the grounds that it had recovered[7].

There is now an unexpected final twist. In 2025, genomic and morphological research concluded that the Snail Darter is not, in fact, a distinct species, but an eastern population of the more widespread Stargazing Darter (*Percina uranidea*)[10]. The fish still helped define how Americans argued about extinction, public works and the value of obscure species. Its story demonstrates something important about cultural significance itself: fishes do not have to be ancient food animals or sacred symbols to enter human culture. Sometimes the struggle over whether they should survive becomes the story.

These histories sit on opposite sides of a narrow line. Lake Lanao shows what it means to cross it. The Clanwilliam Sandfish shows a population approaching it. The Snail Darter shows that decline can be reversed. And the Tequila Splitfin (see p.69) shows something more remarkable still: that even a fish already lost from the wild can, in exceptional circumstances, be returned.

Thousands of threatened freshwater fishes are currently somewhere along that continuum. Many are poorly known; some occupy a single spring, stream or lake; others are disappearing before conservation programmes can be established. Their futures will depend not only on science, but on whether governments, communities, aquariums, conservation organisations and funders act while there are still fishes to save.



A warning

Chinese Paddlefish (*Psephurus gladius*): Extinct

Depiction of the Chinese Paddlefish in *Searching the Mountains for Demons*, a 17th-century scroll

There are photographs of the last known Chinese Paddlefish. That, in itself, makes its extinction feel disconcertingly close.

For generations of fishers on the Yangtze, this was a well-recognised species. With historical accounts of it growing to more than six metres in length, it was among the largest freshwater fishes on Earth: an enormous, migratory predator with an elongated, sword-like rostrum. The fish was known in modern Chinese as *báixún* or 'white sturgeon'.

Its sheer size lodged it firmly in the culture of the upper Yangtze. Sichuan fishers commonly called it *xiangyu* or 'elephant fish', after its long, trunk-like snout, and paired it with two other great Yangtze fishes in the saying: 'a thousand-jin lazi, a ten-thousand-jin elephant; huangpai so big it defies belief' – referring respectively to the Chinese Sturgeon, Chinese Paddlefish and Chinese Sucker (jin is a Chinese unit of measurement close to 500 grams)[11]. The numbers were deliberate exaggeration, but the saying conveyed the almost mythical scale these fishes could attain.

Around Yibin, close to important former spawning grounds, older fishers could still recall encounters with enormous paddlefish late in the twentieth century. One fisher remembered catching a fish weighing more than 100 kilograms in 1993 that required two ox-drawn carts to carry; the catch prompted the local government to erect a sign proclaiming the area a 'home of the Chinese Paddlefish'[12]. A sculpture of the species also stood in a public square in Yibin County[13]. These traces – nicknames, sayings, individual memories and local landmarks – show that the paddlefish was part of how people understood and described the river itself.

Until recently, Chinese Paddlefish were harvested commercially, with annual catches reportedly reaching around 25 tonnes during the 1970s[14]. Then the population collapsed.

Fishing pressure had already taken a toll, but the decisive disruption came from changes to the Yangtze itself. The Gezhouba Dam, completed in the early 1980s, blocked the species' migration between downstream habitats and spawning areas in the upper river. Unlike some threatened fishes, there was no secure captive population waiting in reserve[14,15].

By the time scientists understood how close the species was to extinction, opportunities were disappearing with the fish. Thirty-two individuals were recorded in 1985; juveniles were still observed in the mid-1990s, but encounters became rare. In January 2003, a 150-kilogram female was accidentally caught near Yibin. Researchers fitted her with a tracking tag and released her into the Yangtze[14]. The signal was lost within hours.

No Chinese Paddlefish was ever confirmed alive again.

Extensive searches failed to relocate the species. Researchers later reconstructed its decline and concluded that it was likely functionally extinct by 1993 – meaning that too few remained to sustain a viable population – and biologically extinct sometime between 2005 and 2010[15]. The IUCN formally assessed it as Extinct in 2022.

The Chinese Paddlefish survived profound geological and climatic changes. Its lineage stretched back tens of millions of years. Yet its disappearance happened fast enough for people who once saw the fish in markets and fishing boats to live into a world in which no child can ever see one alive.

Today there are preserved Chinese Paddlefish in museums. There are photographs, measurements, drawings and fragments of memory. There are old fisher's names and sayings about giants in the Yangtze. But there are no fish.



Chinese Paddlefish, © Muséum d'histoire Naturelle via Wikimedia Commons



Hope

Tequila Splitfin (*Zoogoneticus tequila*): Endangered

Día de Muertos celebrations in Teuchitlán, Mexico, the home of the Tequila Splitfin and Golden Skiffia © SHOAL // Michael Edmondstone



The Tequila Splitfin is small enough to fit in the palm of a hand. Its recovery nevertheless required decades of work across countries, universities, zoos, aquariums and one Mexican community.

The species is endemic to the headwaters of the Ameca River basin in Jalisco, western Mexico. Its name comes from the Volcán de Tequila, which rises above the landscape near the springs of Teuchitlán where the fish evolved[16]. It belongs to the Goodeidae, a family of live-bearing fishes whose centre of diversity lies in the Mexican highlands. Many occupy tiny ranges and many are now severely threatened by pollution, habitat modification, water extraction and invasive species.

The Tequila Splitfin was formally described only in 1998, from specimens originally collected in 1955[16]. By then, surveys had failed to find it for two decades. In 2000, however, a remnant population of fewer than 100 individuals was rediscovered. The last confirmed wild collection followed in 2008[17]; two years later, severe drought dried the habitat of this final population, and subsequent surveys failed to find the species. It was classified as Extinct in the Wild[18].

But aquarists and conservation breeding programmes had kept the fish alive. Captive populations in Mexico, Europe and the United States became an insurance policy against extinction – exactly the kind of safety net that had not existed for the Chinese Paddlefish. At the Universidad Michoacana de San Nicolás de Hidalgo, the Mexican Fish Ark programme began preparing captive Tequila Splitfins for a return to their native waters[19].

The process was deliberately slow. Fish bred in captivity were first placed in outdoor ponds, allowing generations to adapt to more natural conditions. Researchers studied their survival, diet and behaviour, while also removing invasive species from their natural habitat in the Teuchitlán system[18]. At first hundreds, and ultimately more than 1,500 fish, were released, and monitoring demonstrated that the new wild population was surviving and reproducing[18,19]. A peer-reviewed evaluation published in 2026 describes the reintroduction as successful[19]. The species is now listed as Endangered on the IUCN Red List, with its population increasing.

The Fish Ark team worked with local government, NGOs and residents of Teuchitlán, and developed an environmental education programme around the river and its native fishes. Children and community members learned about species living virtually on their doorstep that many had never encountered or known were unique to their home[18].



The project deliberately connected the fish's return with one of Mexico's most important cultural traditions. The team chose Día de Muertos, 2 November 2016, to begin the reintroduction: a day on which departed loved ones are traditionally welcomed back, used here to mark the return of a species that had disappeared from the wild[18]. In a festival centred on remembrance and the continuing relationship between the living and the dead, a fish that had disappeared from the wild was being brought back to its river.

The Tequila Splitfin does not carry a centuries-old body of folklore comparable with some fishes elsewhere in this report. Its cultural story is being created through its conservation. A species that could easily have vanished unnoticed has instead become something communities can recognise as belonging to their landscape.

Its recovery has also become a model for other Mexican goodeids. The knowledge, facilities and partnerships developed through Fish Ark and the Tequila Splitfin reintroduction are now informing broader efforts to conserve a whole group of highly threatened fishes. This is what hope looks like in freshwater conservation: people deciding that disappearance is unacceptable – keeping a species alive when its habitat cannot, repairing the conditions that caused its loss, and finally returning the fish to the place from which it came.

Día de Muertos celebrations in Teuchitlán, Mexico, the home of the Tequila Splitfin and Golden Skiffia © SHOAL // Michael Edmondstone



CONCLUSION

Keeping Fish in Rivers and Memory

Rubbing of the Churning of the Sea of Milk, Cambodia, twentieth century, Courtesy of The Met Museum

The fishes in this report matter for different reasons. They feed families and sustain livelihoods, inhabit stories, beliefs and sacred landscapes. They carry knowledge accumulated over generations, and have become national symbols, objects of beauty and obsession, and markers of home. They are so deeply embedded in human cultures that their disappearance would leave a huge gap in cultural consciousness. Freshwater fish conservation is, ultimately, about people as well as fishes.

The populations of many of them are declining, some catastrophically so. This report shines a light on the impacts of this population loss, and explores the idea of 'double extinction', whereby the cultural and historical connections to species degrade and disappear as the species themselves decline. Extinction can, in other words, become a loss of knowledge, identity, memory, livelihood and cultural richness.

The value of cultural connections in biodiversity is embedded in the Kunming-Montreal Global Biodiversity Framework (KMGBF). The Framework recognises Indigenous Peoples and local communities as custodians of biodiversity, and partners in its conservation, and explicitly recognises traditional knowledge, values and practices as key allies in turning the tide on biodiversity loss. The KMGBF 2030 Targets call for the restoration of degraded inland waters, conservation of areas important for biodiversity, sustainable management of wild species that provides social, economic and environmental benefits, and respect for customary sustainable use and traditional knowledge[1].

CBD COP17 in Yerevan comes at a critical point. The world is approaching the halfway point between the adoption of the KMGBF in 2022 and its 2030 targets, and COP17 will consider the first global review of collective progress in implementing the Framework[2]. The question is not what governments and conservation organisations have promised, but whether sufficient action and finance are reaching the species, ecosystems and communities where those commitments have to become real.

Yet despite the scale of the decline and their importance to people, freshwater fishes remain chronically overlooked in conservation. There is no single solution to the freshwater biodiversity crisis. But there are many places where modest, well-directed investment can make a profound difference.

Through the landmark 1,000 Fishes initiative, SHOAL is working with partners globally towards conservation action for 1,000 of the world's most threatened freshwater fishes by 2035. That means identifying priorities, bringing together the right partners, building capacity, supporting locally led conservation, and directing resources towards species that might otherwise remain invisible.

The stories in this report show that conservation can do more than prevent extinction. It can recover depleted populations, return fishes to the wild, sustain ecological knowledge, and keep relationships between people and species alive.

Funding turns knowledge into action. For freshwater fishes, relatively small investments can be enough to move conservation from identifying the problem, to sustained action on the ground. And action is most sustainable when the

Indigenous Peoples and local communities that live alongside the species being conserved are central to the conservation process. They often hold invaluable knowledge about the species and habitats that may be absent from scientific datasets and formal conservation assessments. Simply put, Indigenous, traditional and local knowledge can provide vital insights into how freshwater ecosystems function, and how they have changed over time. And conservation succeeds most powerfully when protecting a fish also strengthens the human relationships that give people reasons to protect it.

Acting now means drawing on local ecological knowledge before it degrades with the disappearance of the fishes. It also means intervening while conservationists still have options, before populations become tiny and fragmented, habitats severely damaged, and recovery considerably harder.

Wherever possible, the goal must be to keep fishes functioning within living ecosystems, and vibrant in living cultures. Funders can make a decisive difference here.

At CBD COP17, governments, conservation organisations, Indigenous Peoples and local communities, scientists, businesses and funders will gather to assess whether the world is delivering on its promises for nature. Freshwater biodiversity must be part of that conversation – and freshwater fishes cannot remain an afterthought. The opportunity for funders is clear: invest before rarity becomes extinction, support conservation that protects species while sustaining the knowledge and relationships built around them, and help locally led projects move from good ideas to sustained action.

Success means that future generations can still find these fishes in inland waters, and still understand why they matter.



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CHAPTER 1: Fish as Food, Subsistence, and Livelihood

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CHAPTER 6: Fish as Warning and as Hope

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