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Amazonian fish migration as a social–cultural–ecological process

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Abstract

1. In this study, we highlight the rich perspectives and explanations of fish migration held by Indigenous groups across the Amazon.
2. We present the aspects of Indigenous cosmological stories, drawing from our exploratory review of cultural ethnographies and grey literature, as well as the authors' own experiences. We ask, how do Amazonian peoples characterize fish migrations in story and cosmovision? We apply a movement ecology framework to present perspectives on fish migration across the Amazon.
3. Indigenous descriptions of fishes and their movements are specific, relating to particular species, waterscape features, directions of movement and seasons; furthermore, fish migrations are important within Amazonian cosmologies, relating to broader processes of transformation and movement across space, time and worlds.
4. *Synthesis and applications*. We posit that researchers and conservation practitioners can learn from Indigenous stories about fish and freshwater, and we encourage collaborations that protect biocultural riverscapes of the Amazon.

KEYWORDS
biocultural diversity, ethnoichthyology, freshwater, Indigenous and traditional knowledge, movement ecology, relational values, South America

1 | INTRODUCTION

Indigenous and place-based peoples often define and come to understand their own belonging through stewardship of specific ecosystems and species (Whyte, 2018). Recognition of the interdependencies between biological and cultural diversity, or 'biocultural diversity', has emerged as a translational concept to highlight the myriad ways of relating to nature (Bridgewater & Rotherham, 2019; Maffi, 2018). Indigenous practices and experiences with nature are often rhythmic, varying with the seasonal abundance and phenology of species (Jackson et al., 2025). The observation of animal migrations, which often occur seasonally, features in biocultural knowledge systems across various landscapes. For example, migrations of terrestrial and marine mammals are celebrated by Iñupiaq and other Arctic peoples, who rely on seasonal movements of animals in their hunting calendars (Kassam & Bernardo, 2022; Nuttall, 2007). Monarch butterfly migrations hold spiritual significance for Jñato and Hñähñu communities in central Mexico, who witness the arrival of the orange butterflies as the souls of deceased ancestors returning to visit (González-Duarte & Méndez-Arreola, 2024). Nonetheless,

the concept of biocultural diversity, to our knowledge, has not been explicitly applied to understand the social–cultural significance of migrations for both animals and people. Here, we draw on the concept of biocultural diversity to consider the social–cultural–ecological nature of fish migration and movement in the Amazon Basin.

As the largest fluvial system in the world, the Amazon Basin is a site of immense freshwater biocultural diversity. The Basin is home to at least 410 distinct Indigenous groups (Athayde et al., 2021) and is the global centre of freshwater fish species richness and endemism (Oberdorff et al., 2019). The importance of fishes to local and Indigenous peoples cannot be overstated, as they provide food security, are features of material culture and are central to numerous Indigenous origin stories (Athayde et al., 2025; Borea & Yahuarcani, 2020; Duponchelle et al., 2021; Navarro, 2021). As we argue in this paper, the movements of fishes across the waterscape also co-construct Amazonian understandings of place, time and sociality.

The life histories of many of the most economically and culturally important fish species involve a migratory component that is often linked to the rhythms of the Amazon River (Herrera-R et al., 2024). Through their movements, migratory fish transport carbon and nutrients, disperse plant seeds and connect distant food webs (Flecker et al., 2010; Winemiller & Jepsen, 1998). With 223 scientifically confirmed migratory fish species in the Basin, migrations occur across vast distances and along diverse pathways and can involve massive, multispecies schools (Herrera-R et al., 2024). For example, Goliath catfishes conduct longitudinal migrations along the river channel, travelling more than 11,000 km from the Andean headwaters to the eastern estuaries and back (e.g. *Brachyplatystoma rousseauxii*, *Brachyplatystoma platynemum* and *Brachyplatystoma vaillantii*) (Barthem et al., 2017). Many other species, including bocachico (*Prochilodus nigricans*), undertake longitudinal migrations at various life stages, linking disparate headwater and lowland habitats (Goulding et al. 2019). Lateral migrations occur between the river channel and floodplain and are linked to seasonal variations in the river level (Correa & Winemiller, 2014; Duponchelle et al., 2021). This phenomenon is particularly impressive in the lowland Amazon, where portions of the forest and floodplain are seasonally inundated, up to 18 m in the tri-frontier region (Henao et al., 2020). Dozens of Characid species take advantage of this temporary habitat, moving across newly connected forests and lakes, dispersing seeds as they move (Correa et al., 2015). The high-water season is often seen as a time of abundance within many lowland riparian communities, and interactions between people and fishes are mediated by the rhythms of the Amazon River (Harris, 1998; Jackson et al., 2022). These social–cultural interactions, however, are often overlooked in the scientific literature on Amazon fish migration, which traditionally has emphasized the ecological, biological and economic importance of this process (Goulding et al., 2019; Prestes et al., 2022).

In this paper, we ask: How do Amazonian peoples characterize fish migrations in story and cosmovision? We present fish migration as an important social–cultural–ecological process for Amazonian Indigenous groups, who have responsibilities, ancestries, memories and futures linked to fish migrations. After an overview of aquatic cosmology, the paper is structured following the movement ecology framework for Amazon fish migrations as presented by Herrera-R et al. (2024). This framework follows four questions to study fish movement: (1) Who moves? (2) Where to move? (3) When to move? and (4) Why move? We apply these questions to selected Indigenous literature and cultural ethnographies from different parts of the Amazon, namely, Magüta/Tikuna,[1] Kukama-kukamiria and Shipibo-Konibo of the Western Amazon, Desana, Yepamahsã/Tukano, Utãpinopona/Tuyuka and Medzeniakonai/Baniwa from the Negro Basin[2] and the Enawenê-Nawê people of the Juruena Basin (Figure 1). We rely on the movement framework as a starting point for thinking with Indigenous ideas about fish migration. The flexibility of the questions within the framework allows us to bridge the fields of freshwater ecology, Indigenous studies and anthropology.

2 | METHODS & POSITIONALITY

The idea for this paper was inspired from a reading of *Homens, peixes e espíritos: a pesca ritual dos Enawenê-Nawê* (dos Mendes Santos & dos Mendes Santos, 2008), an ethnography detailing the Enawenê-Nawê yãkwa fishing ceremony and associated fish movements. This led to the idea for a review paper about fish migration as described by varied Amazonian communities. In December 2021 and April 2022, the first author (LVL) conducted exploratory literature searches in the Florida International University library database, Web of Science and Google Scholar, using search terms 'cosmovision' and 'Amazon' and 'Indigenous' and 'fish' or 'migratory fish' and 'water' in English, Spanish and Portuguese. These initial searches helped to identify potential Indigenous groups with connections to water, but the resulting publications often did not detail specific stories involving fish. Therefore, we conducted a more directed literature search for Indigenous groups known to have important relations with freshwater, specifically groups who identify as Water People[3] and other riparian communities, including the Enawenê-Nawê and Tukanoan people. We used the Ehraf World Heritage database to locate ethnographies and oral literature on these selected communities and applied a snowball approach to find additional literature. The resulting literature spanned large areas of the Amazon and included the following river basins: the Loretoyacu and Yahuarcaca rivers in the Colombian Amazon (Magüta and Kukama-kukamiria lands), the Ucayali and Marañon Basins of Peru (Shipibo-Konibo and Kukama-kukamiria lands), the Negro Basin of Brazil (Desana, Tuyuka, Tukano and Baniwa lands) and the Juruena Basin of Brazil (Enawenê-Nawê lands) (Figure 1).

[1]Magüta people are also known as the Tikuna, which is an outsider-given name. There is some local debate on the origins of the name Tikuna, but it is likely either a Tupi war name for the Magüta or a name given by white settlers. Many community members now prefer the name Magüta.

[2]Within this paper, we refer to Tukano, Tuyuka and Baniwa with their English translation names, but Levis et al. (2024) apply longer names: Yepamahsã/Tukano, Utãpinopona/Tuyuka and Walimanai or Medzeniakonai/Baniwa.

[3]Based on the first author's ethnographic fieldwork, there are four ethnic groups that self-identify as water people: Magüta, Kukama-kukamiria, Omagua and Yagua. The latter two cosmologies were not detailed here, as published ethnographic accounts were limited.

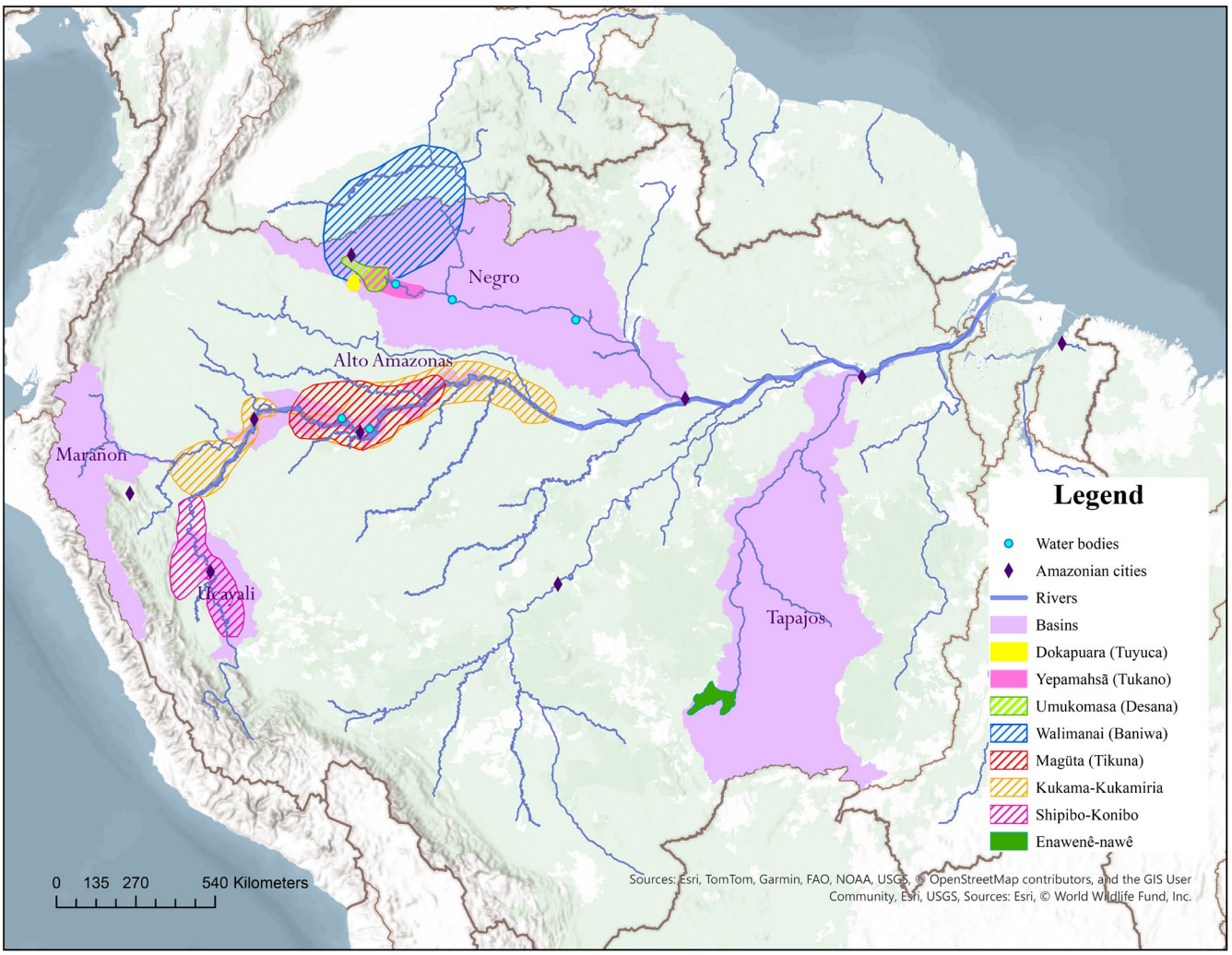

FIGURE 1 River basins, water bodies and territories of Indigenous peoples whose cosmologies are presented in this article.

The stories described in this paper are illustrative, as we did not aim to capture all references to migratory fishes from published ethnographies. Many more cosmologies of migratory fishes likely exist, and explanations may vary by storyteller. Indigenous oral history is detailed and complex, involving many species, places and ideas beyond fish migrations. Furthermore, Amazonians may have different definitions or classifications of fish and other aquatic biota (Tobes et al., 2022). We apply a Western lens in this respect, defining fishes as gill-bearing vertebrates with fins, excluding aquatic mammals such as dolphins and manatees.

Our authorship covers various disciplinary and ethnic backgrounds, including social and environmental researchers from North and South America and one Magüta author (JD). The paper was deeply influenced by several co-authors' experiences as observers or participants in biocultural practices of Amazonian Indigenous peoples. This paper is also informed by the first author's (LVL) ethnographic fieldwork with Magüta and Kukama-kukamiria communities in Colombia, which was conducted between 2022 and 2025. This fieldwork was approved by the FIU Institutional Review Board (IRB # 22-0324) and Indigenous authorities in Colombia, with verbal consent confirmed by all participants.

3 | AQUATIC COSMOLOGY IN THE AMAZON: AN OVERVIEW

Here, we provide an overview of the aquatic social–cultural universe in Amazonia to contextualize the waterscapes within which migratory fishes move. Whereas Western ontologies often see a binary between nature and culture, a relational ontology posits a world where the supernatural and biophysical worlds are interconnected and continuous (Fabiano et al., 2021; Escobar, 2015). Indigenous Amazonian cosmovisions often take on an animist ontology, wherein humans and nonhumans have interiority, or sentience, yet vary in their physical forms (Descola, 2006). This interiority endows all beings with sociality, or human-like characteristics; humans, plants and animals live in their own villages, conduct ceremonies and follow ethical norms (de Castro, 1998). Many Amazonian cosmologies describe the universe as having various world layers, with varying degrees of connection between them; some beings, including fishes, spirits and shamans, move between dimensions (Table 1). Different beings can alter and be altered by events in other worlds. Thus, the waterscape itself is actively co-created and negotiated by

different beings through their interaction (Campanero Reig, 2018). Interactions between beings are not inert exchanges, but social bonds. As Descola (2006) describes, beings can share a diversity of hierarchical and non-hierarchical social relations, including care, protection, seduction, hostility and predation.

Freshwater is central to many Amazonian cosmovisions. According to the Magüta and Kukama-kukamiria, freshwater flows across and connects various world layers. The origin narratives of many Indigenous Amazonians describe a cosmic flood in the creation of the universe, such as those of the Urarina (Dean, 1994), Tukano (Nimuendaju, 1952) and Cashinahua/Huni Kuin (Lagrou, 1998) people. Fishes are central creatures in the origin of Tukanoan peoples; humanity was transformed from the original fish people or Wai Masa, but some Wai Masa remained in the water as fishes (Cabalzar, 2005). The Baniwa and Magüta people were also created through the transformations of fishes, as described in later sections (dos Monteiro Santos, 2012; Santos Angarita, 2013).

Amazonian Indigenous people recognize a variety of aquatic spirits, who occupy specific spaces and temporalities (Figure 2; Santos-Granero & Fabiano, 2023). Different elements of freshwater, such as specific water bodies or species, often have a dueño (guardian) or madre (mother) whose function is to protect and ensure its well-being. The category of dueños has been the subject of anthropological study for decades, as they are central and complex beings across many Amazonian cosmovisions (e.g. Descola, 2006). In the cosmologies of the Magüta, Kukama, Cashinahua and other peoples, a serpentiform entity (anaconda, black boa or giant eel) is the guardian of fishes and other aquatic beings; shamans negotiate with these beings in aquatic affairs, such as a human disappearance or a degraded fishery (Århem, 1996; Lagrou, 1998; Moreira & Colombier, 2019; Navarro, 2021; Ruiz, 2022; Santos Angarita, 2013). As elders often discussed in the first author's fieldwork, dueños and other spirits can be dangerous if humans mistreat aquatic ecosystems, and this is manifested via impacts to fish catch or direct harms to fishermen for disrespecting fishing norms (Fabiano et al., 2021; Moreira & Colombier, 2019). Other spirits, such as the pink dolphin (*Inia geoffrensis*) and sirena (mermaid), have become incorporated in lowland Amazonian folklore and likely originate from Indigenous oral literature (Galeano, 2009; Slater, 1994). Many fishermen have stories about an interaction with a water spirit and describe cities within the river where these spirits dwell; these sites include eddies, small spirals of water (muyunas in Kukama-kukamiria, checkü in Magüta) or bocanas, the confluence of two rivers (Ruiz, 2022).

Although each being deserves greater depth than our paper allows, this context is essential to understanding the spatial–temporal dimensions within which Amazonian fishes move. These more-than-human beings facilitate the management of aquatic ecosystems within Amazonia; both due to fear of harm by these spirits through disrespect and out of a sense of responsibility that the aquatic world is conscious (Fabiano et al., 2021; Campanero Reig, 2018). We focus on the roles of migratory fishes within this universe and how Indigenous Amazonians describe the movements of these beings within the waterscape.

4 | WHO MOVES, AND WHERE? ORIGIN STORIES OF MIGRATORY FISHES AND PEOPLE

We take an expansive concept of movement as it relates to Amazonian fishes, asking: who moves and where? From a movement ecology perspective, these questions seek to identify which species are migratory, the directions of movement and the habitats utilized by fishes (Herrera-R et al., 2024). The following narratives address these questions, referring to particular species, directions and habitats. However, we take the question of who moves further, considering: how can movement be defined in a landscape that is equally cosmological and physical? Here, we present a portion of the origin story of the Magüta people of the triple-frontier region in the Western Amazon and describe the origin of different fish genera according to the Desana and Baniwa peoples of the Negro Basin, Brazil. We also reflect on fish movement across freshwater habitats from Shipibo-Konibo and Kukama-kukamiria perspectives. These narratives illustrate that the movement of fishes occurs across space, time and life forms. Furthermore, fish migration relates to larger processes of transformation and movement within Indigenous cosmologies.

4.1 | Transformation of caterpillars to fishes

The Magüta are gente del agua, Water People. In the Magüta origin story, three gods (Yoí, Ípi and Techi) went fishing in sacred Quebrada Eware[4] during the high-water season, when fish migrate upstream in the mijanos (see Figure 3; Santos Angarita, 2013). As they pulled up each fish, it transformed into a different being, depending on the type of bait used; first, using palm fruit as bait, the captured fishes transformed into animals such as jaguar and peccary. When the gods used sweet manioc as bait, they caught a sábalo[5] (*Brycon* spp.), which transformed into the original Magüta people, the pogütagü. Fishing features in several Indigenous Amazonian cosmologies; through a series of events, including fishing, the Tukano people were also transformed from fishes in their origin story (Cabalzar, 2005; Nimuendaju, 1952). For the Enawenê-Nawê, fishes were once human but were transformed into fishes due to misbehaviour (dos Mendes Santos, 2006).

During fieldwork along the Loretoyacu and Yahuarcaca creeks in Colombia (September 2023 to May 2024), Magüta collaborators explained the phenomenon of mijanos: multispecies, mass migrations of fishes from the mainstem Amazon towards tributaries and floodplains. One guide explained that mijanos typically occur during the rising or high-water season, around the month of April, and involve populations of palometa (*Myloplus* spp.; *Mylossoma* spp.), sábalo (*Brycon* spp.), bocachico (*P. nigricans*) and other species. In some descriptions of the mijanos, fish move upstream in search of the great garza, a white egret (*Ardea alba*)

[4]In Magüta, é or huito in Spanish (*Genipa americana*) is a culturally important fruit tree. The fruits are used to create a dark dye for body paint. Many characid fishes eat and disperse é fruits. Waré means black, referring to the colour of the Eware creek and the dye made from é.
[5]Not all accounts specify the capture of a sábalo fish.

TABLE 1 Description of Indigenous communities whose oral histories are referenced within this study.

Ethnic group	Main river basin (modern country)	Linguistic family	Modern population	General details of cosmovision	References
Magüta/Tikuna	Mainstem of Alto-Amazonas (Colombia, Peru, Brazil)	Tikuna	57,571 (Instituto Socio-Ambiental 2018)	Water People; the Magüta world has three layers (above, present, below), each with a guardian spirit; great serpent spirits (*yewae*) guard aquatic ecosystems; fish migrations are social events/parties for fishes, who travel on the backs of their mother-boa; the Magüta were transformed from fishes into human-people; some fish movements are transformations of caterpillars to fishes; annual *pelazon* ceremonies align with fish migrations in many communities	Instituto Socio-Ambiental (2018); Santos Angarita (2013); LVL field notes
Kukama-kukamiria	Mainstem of Alto-Amazonas, Ucayali, Maranon (Colombia, Peru, Brazil)	Tupi-Guarani	19,052 (Instituto Socio-Ambiental 2018)	Water People; the Kukama describe at least two world layers; the muiwatsu are great serpents that guard and give life to aquatic ecosystems; *karuara* are diverse aquatic spirits who live in underwater cities	Instituto Socio-Ambiental (2018); Ruiz (2022); Imaina (2016)
Shipibo-Konibo	Ucayali Basin (Peru)	Panoan	23,000 (Espinosa, 2012)	Shipibo-konibo world is made of four layers (water, forest, disease, celestial), which shamans travel during ayahuasca journeys; spirit beings are referred to as *yoshinbo*; the anaconda is protector of rivers, fishes and other beings; anaconda is the source of all creativity and her body is covered in Shipibo *kené* designs	Espinosa (2012); Borea and Yahuarcani (2020); Roe (1982)
Enawenê-nawê	Juruena (Brazil)	Arawak	~1000 (Carvalho, 2024; Silva, 2016)	Enawenê-nawê world has four layers (celestial, terrestrial, subterranean, open-space); fish-people (*kõhase wayate*) transformed from human-people in ancestral times; fish are children of the malevolent *iakayreti* water-spirits; the Enawene calendar is designed around ceremonies to please the *iakayreti*	Carvalho (2024); Silva (2016); dos Mendes Santos (2006); dos Mendes Santos and dos Mendes Santos (2008)

(Continues)

TABLE 1 (Continued)

Ethnic group	Main river basin (modern country)	Linguistic family	Modern population	General details of cosmovision	References
Yepamahsâ/Tukano	Tiquié, Papuri and Uaupés, Upper Negro (Brazil, Colombia)	Eastern Tukanoan (Tukano is main language spoken; Tukanoan peoples intermarry, share aspects of cosmology and language)	~30,000 (Cabalzar, 2005; all Tukanoan)	Tukano and Tuyuka worlds have seven layers (water, forest, air, rain, cloud, winds, open-space); oral histories describe a series of transformations, driven by the Snake-Canoe of Transformation, from fruits, body parts or snakes into fish people (*Wai masa*), then into human people (*Yepamahsâ*); some *Wai masa* remain as fishes in the water layer; depending on their origin, classes of fish require different use/treatment; some fish migrations understood as transformations of animals and birds into fish	Instituto Socio-Ambiental (2018); Cabalzar (2005)
Dokapuara/Tuyuka	Tiquié, Papuri and Uaupés, Upper Negro (Brazil, Colombia)				
Umukomasã/Desana	Tiquié, Papuri and Uaupés, Upper Negro (Brazil, Colombia)			The Desana world is made of five layers (land, air, fruits, water, earth); each layer is held by a basket of arumã (*Ischnosiphon* spp.; grows in semi-flooded areas); Desana oral history denotes transformations of various fishes from the body of a large snake	Cabalzar (2005)
Walimanai/Baniwa	Içana, Upper Negro (Colombia, Venezuela, Brazil)	Arawak	5800 (Içana River; dos Monteiro Santos, 2012)	Baniwa describe at least four world layers (place of bones, human-world, other-world, sky-world) with various people-spirits; in some narratives, Baniwa ancestors originated from the holes of rapids along the Aiari River; extensive oral history about fish-people describe proper uses and treatment of species and habitats to ensure spiritual–ecological sustainability; describe fish migrations as parties of the fishes	Instituto Socio-Ambiental (2018); dos Monteiro Santos (2012)

FIGURE 2 Mural at Radio Ukamara station, Nauta, Peru, showing the many aquatic beings of Amazonia. Created by artists from the Comunidad Tawantinsumu, 2015 (Photo credit LVL, 2022).

FIGURE 3 The fishing of the Magüta in Eware, original drawing by Jesús Dámaso 2024 (Magüta, community of La Playa, Leticia).

FIGURE 4 Hunting the heron: The mijano of fishes with their guardian spirit, original drawing by Jesús Dámaso 2024 (Magüta, community of La Playa, Leticia).

(Figure 4). Multiple Magüta collaborators described how the origin point of all fish movement, including the mijanos, comes from Lake Eware;

> The Magüta are from Lake Eware[6] in Brazil. In Eware there are giant trees, including the Ceiba,[7] which is the birthplace of all fish. On this tree, you can see thousands of caterpillars[8] in huge quantities. When it starts to rain a lot, to storm, to form thunder and lightning—all the caterpillars start to drop from the trees and fall into the water. That is when the fish move: at the beginning of the rising-waters. The caterpillars fall from the tree, transform into fish, and move upstream from Brazil into all the streams and lakes of Colombia and Peru. Each time that the fish move, the water rises. The fishes always move on top of the Mother Boa. She moves beneath the fish, guiding them as their mother into the lakes and rivers upstream.—
>
> Magüta guide, Puerto Nariño, Colombia, 2 October 2023

For the Magüta, the mijanos are explained through a transformation of life forms: a movement from rain, to tree, to caterpillars, to fish. In turn, people are created through a transformation of life forms: from fish, to animal, to family clans. Movement of fishes across Magüta territory, then, is understood also as a form of transformation:

[6]Most accounts referred to Eware as a creek, but some people referred to it as a lake.

[7]The Ceiba (*Ceiba* spp.) is central to the Magüta origin story. The Ceiba Woné and its child tree Wochiné are the origin of all fishes and waters of this world; from these trees came the Chonine, *árboles de los peces*—modern fruit tree species where caterpillars transform into fishes (see Figure 5).

[8]The term typically referred to within this story is '*gusanos*', which translates as worms; after clarification with local collaborators, however, caterpillar felt like a more precise translation of this story.

FIGURE 5 Transformation of caterpillars to fishes, original drawing from Jesús Dámaso 2024 (Magüta, community of La Playa, Leticia).

the fish are both transforming across time as rain–tree–caterpillars–fish, and across space as the undulating boa with fish on her back.

The fish migration–transformation also coincides with environmental transformation. As the above narrative explains, there is synchrony between the movements of water and fishes because 'each time the fish move, the water rises'. Importantly, the logic of movement–transformation is not linear or sequential, but relational or spiralic; it is less important that the rains cause the caterpillars to transform, or the fish cause the waters to rise—these relations occur at once, across various dimensions or worlds. This transformation continues to occur each year, both because of and in response to the movements of water.

Magüta knowledge-holders also describe the Woné of Quebrada Eware, where all primordial fishes originated. Today, various species of fruit trees are described as Chónine, or árboles de los peces (trees of the fishes; Figure 5). Some guides, on forest walks during LVL's fieldwork (2022–25), would point to a tree with a large termite nest and explain that the tree was pregnant; during the low-water season, caterpillars crawl inside empty termite and mochilero (*Psarocolius decumanus*) nests and wait until the rains of the rising water season. Chónine are only found in special locations, such as remote lakes or headwaters. Connections between Chónine and fishes are specific, implying a cosmological and trophic significance; multiple Magüta collaborators explained how each fruit tree has its caterpillar, and each caterpillar transforms into a particular species of fish. For example, the yarumo fruit tree (*Cecropia* spp.) is often host to a large, striped caterpillar called manllín, which transforms into the migratory fish lisa (*Schizodon fasciatus*).

4.2 | Origins of fishes in the Negro Basin

One narrative from the Negro Basin, Brazil, links a particular action, or movement, to the creation of specific fishes. In a collaboration with Museu da Amazonia, Desana and Tukano artist Feliciano Lana illustrate[9] how the pirarucu (*Arapaima gigas*) and traíra fishes (*Hoplias* spp.) were created during a chase between two spirits, one who took the form of a human and one who took the form of the giant anaconda (Lana et al., 2016). The human chases the anaconda across the landscape, scraping the modern meandering path of the Amazon River. The human then shoots the anaconda with a blowgun, killing the snake. He drags the dead snake across the earth, and its biggest scales scrape off, falling into various oxbow lakes. These scales transform into the pirarucu we know today. The human picks off the remaining smaller scales from the tip of the tail and the head and throws them to the headwaters of the Tiquié, Papuri and Uaupés rivers, tributaries of the Negro, where they transform into traíra fish (*Hoplias* spp.).

The Baniwa, Tukano and Tuyuka people of the Negro Basin describe various transformations related to fish, people and spirits (Andrello, 2012; Cabalzar, 2005; dos Monteiro Santos, 2012). Cabalzar (2005) describes the transformation–creation of many migratory species, including kurubisa (needlefish, *Potamorrhaphis guianensis*), ñosowi (*Acestrorhynchus falcatus*) and jeju (*Erythrinus* spp.). For the Baniwa, based on Monteiro dos Santos' study (dos Monteiro Santos, 2012, 102), the origin of a fish determines rules for its consumption, as outlined in Baniwa narratives. Fishes that were transformed from trees are safe to eat, but restrictions exist for fishes such as tucunaré-açu (*Cichla temensis*), pacu (*Myleus* spp.; *Tometes* spp.), piranha (Serrasalmidae), araripará (*Chalceus macrolepidotus*) and jacundá (*Crenicichla macrolepidotus*),[10] which were transformed from an enemy to the sun god, Ñapirikoli. For similar reasons, the Tukano people also avoid consumption of pacu and piranha, among other species (Cabalzar, 2005, 57). Across cosmologies, fish species relate to particular spatial and cosmological elements of the ecosystem, and these relations influence how fish species are used or seen.

4.3 | Fish migrations across worlds

In their movements, fish also traverse dimensions, according to the Shipibo-Konibo of the Ucayali Basin, Peru. The Shipibo-Konibo describe four interconnected worlds: celestial, terrestrial, disease and water worlds (Roe 1982; Borea & Yahuarcani, 2020). As described in Roe's ethnography (1982), the World Tree stands in the centre of all world layers, rooted in the water world, with its crown in the celestial world. Various rivers traverse these dimensions and flow through the World Tree. Fishes move freely across different worlds through their migrations in these multidimensional rivers. The Shipibo-Konibo describe how, when people die, they are carried on the backs of fishes to the celestial world. The World Tree is

[9]See illustrations of these narratives published with Museu da Amazonia: https://museudaamazonia.org.br/diadoe-origem-do-matapi-e-dos-pirarucus-e-trairas/.

[10]dos Monteiro Santos (2012) did not list the genera or species, only common Portuguese names; these taxa were identified via Cabalzar (2005).

sometimes described as giving birth to all fishes or described with the body of caiman or boa (snake), which are also the guardians of the fishes.

Many freshwater habitats also function as important eco-cosmological places for Amazonians. The Kukama-kukamiria describe a rich aquatic cosmology, where fishes, dolphins and other aquatic people, or karuara, live in vast underwater cities in the Amazon mainstem (Imaina, 2016; Moreira & Colombier, 2019). Specific waterscape features serve as entries to these cities, such as muyunas (eddies) (Ruiz, 2022). In turn, rules dictate how to care for certain habitats; quirumas (sunken logs) are left untouched, as they are considered casas de los peces, houses of the fishes (Moreira & Colombier, 2019).

In these narratives, fish movements occur across cosmological and physical space, across time and across life forms; importantly, their movements also reflect broader cosmo-ecological changes in the landscape. For Water People, a serpentine spirit guides and protects migrating fishes. As Magüta collaborators described, the role of this spirit, Yewae, is to '*hacer mover el territorio*', to create movements or change within the territory (LVL field notes, August 2024). Movements of Yewae create the serpentine shape of the Amazon River and drive the seasonal flood pulse dynamic. The presence of more minor serpent spirits, boa madres, facilitates the wetting and drying of oxbow lakes, ensuring stable fish populations. The Kukama-kukamiria describe how the movements of a serpent-spirit, muiwatsu, drive the creation of beaches, mudslides and oxbow lakes across the Basin (Ruiz, 2022). Tukanoan people also discuss a 'great snake of transformation' within their cosmovision (Cabalzar, 2005), and many non-Indigenous folktales describe a great aquatic serpent-spirit (Galeano, 2009).

As presented in Table 2, the fishes featured in this paper represent a relatively small selection of species. Herrera-R et al. (2024) estimated 223 migratory species in the Amazon Basin and we discussed 11 fishes. These species' cultural significance may relate to their broad geographic distribution in the Basin (e.g. *Brycon* spp., *P. nigricans*, *S. fasciatus*, *Leporinus fasciatus*) and ecological importance; many species are frugivorous and disperse seeds of flooded forests (genera: *Brycon*, *Leporinus*, *Myloplus*, *Mylossoma*, *Myleus*, *Utiaritichthys*; Correa et al., 2015). Some narratives detailed fruit species such as urucu (*Bixa orellana*), huito (*Genipa americana*), yarumo (*Cecropia* spp.) and ceiba (*Ceiba* spp.), suggesting cosmological and perhaps trophic links with migratory fishes. Some Tukanoan stories detailed by Cabalzar (2005) feature transformations of non-migratory taxa, such as wiwasõ (*Copella compta*), moa piku (*Characidium* spp.), doe (*Hoplias* spp.), mere bue (*Synbranchus* spp.) and watirisero (*Apistogramma* spp.). These taxa may have different dietary restrictions and cosmological roles than migratory species. By highlighting the significance of different fishes, oral history may help identify candidate species for co-monitoring of migration with Indigenous peoples across the Amazon (or other regions), or as a starting point for exploring trophic connections between different species or habitats.

5 | WHEN AND WHY MOVE? SEASONALITY AND SOCIALITY OF FISH MOVEMENT

This section explores why and when fishes move. From an ecological perspective, fish migrations in the Amazon are often motivated by feeding, reproduction or dispersal needs and co-occur with hydrological changes in the Amazon River (Herrera-R et al., 2024; Duponchelle et al., 2021). Feeding migrations of herbivorous species typically occur during high waters, when floodplain productivity peaks (Correa & Winemiller, 2014; Flecker et al., 2010). Predatory species may follow schooling migrations during the low water season as they leave shrinking lakes (Goulding, 1980). Many Characiform fishes spawn during the rising water season in whitewater channels, relying on the flood pulse to disperse larvae throughout the floodplain (Herrera-R et al., 2024).

The flood pulse also shapes human social life in the Amazon, as it is intrinsically rhythmic and responsive to the movements of water (Harris, 1998; Jackson et al., 2022). Changes in river level and flow often structure local livelihood practices and cultural activities, including ceremonies and recreation (Anderson et al., 2019; Cabalzar, 2016; Tallman et al., 2024). Jackson et al. (2022) emphasized that seasonality is more than an external set of environmental changes to which human beings respond. Instead, seasonality can be understood as movement through time that is co-constituted by the rhythms of rivers, people and non-human life.

In this section, we describe how the rhythms of Amazonian fish migration create a dual sociality: for the Enawenê-Nawê and Baniwa people of the Juruena and Negro Basins of Brazil, respectively, migration is proof of fish sociality. Furthermore, the predictable, seasonal nature of fish migration builds a shared sociality between fishes and human communities. We overview the Enawenê-Nawê yãkwa ceremony, followed by Baniwa reflections on multispecies migrations of fishes, or fish parties. Enawenê-Nawê and Baniwa perspectives reflect an animist ontology towards fishes, and narratives suggest a specific order and timing of fish migration.

5.1 | Fish have parties, too

The Enawenê-Nawê world is made up of celestial, terrestrial and subterranean spheres. The Enawenê-Nawê ensure harmony across these worlds through seasonal ceremonies for gods and spirits. One of the most important annual ceremonies, the yãkwa, occurs in synchrony with the falling waters (February–April), when many fishes leave the flooded forest areas for streams and larger river channels (dos Mendes Santos & dos Mendes Santos, 2008; Nahum-Claudel, 2019). In the weeks leading up to the fish migration, the Enawenê-Nawê construct wooden traps along forest streams through which the fish pass as they move downstream (dos Mendes Santos & dos Mendes Santos, 2008;

TABLE 2 Fish species mentioned within Amazonian oral literature and selected ethnographies.

Indigenous people	Name of fish (in original language)	Species name	Place or habitat (see also map in Figure 1)	Direction or type of movement	Season	References/ source
Magüta	Ngechí	*Brycon* spp.	Quebrada Eware, Brazil Lake, river channel, creek	Upstream; from river channel to lakes and creeks	Rising-waters; periods of rain	LVL field notes
Magüta	Pakú	*Myloplus* spp., *Mylossoma* spp., *Myleus* spp.	Quebrada Eware, Brazil Lake, river channel, creek	Upstream; from river channel to lakes and creeks	Rising-waters; periods of rain	LVL field notes
Magüta	Cawecha or kaweya, depending on dialect	*Prochilodus nigricans*	Quebrada Eware, Brazil Lake, river channel, creek	Upstream; from river channel to lakes and creeks	Rising-waters; periods of rain	LVL field notes
Magüta	Waraku or ota, depending on dialect	*Schizodon fasciatus*, *Leporinus fasciatus*	Tree of abundance: Yarumo tree (*Cecropia* spp.)	Transformation: fruit-caterpillar-fish	Rising-waters; periods of rain	LVL field notes
Desana and Tukano	Pirarucu (*Portuguese, native names were not mentioned in original text*)	*Arapaima gigas*	Oxbow lakes of the Negro River, Brazil	Transformation: anaconda scales-fish	Not specified	Lana et al. (2016)
Desana and Tukano	A poaro or doe (Tukano, *according to* Cabalzar 2005)	*Hoplias* spp.	Headwaters of Tiquié, Papuri and Uaupés rivers, Brazil	Transformation: anaconda scales-fish	Not specified	Lana et al. (2016)
Tukano	Kurubisa	*Potamorrhaphis guianensis*	Papuri River	Transformation from the body of a slain god	Not specified	Cabalzar (2005)
Tuyuka	Ñosowi	*Acestrorhynchus falcatus*	Papuri River	Transformation from the body of a slain god	Not specified	Cabalzar (2005)
Tukano	Jeju, tubo	*Erythrinus* spp.	Papuri River	Transformation from the body of a slain god	Not specified	Cabalzar (2005)
Enawenê-Nawê	Pacu (*Portuguese, as used in original text*) Or Kayare (*according to* Carvalho, 2024)	*Utiaritichthys* spp., *Myleus* spp.	River channel, floodplain	Upriver, downriver; specific order of movement	Falling-waters	dos Mendes Santos and dos Mendes Santos (2008); Costa (1995)
Enawenê-Nawê	Hoxikya or Muxikia (*according to* Carvalho, 2024)	*Brycon* spp.	River channel, floodplain	Upriver, downriver; specific order of movement	Falling-waters	dos Mendes Santos and dos Mendes Santos (2008)
Enawenê-Nawê	Dokose	Species unknown; described as giant catfish	River channel, igarape floodplain	Upriver, downriver	Falling-waters	dos Mendes Santos and dos Mendes Santos (2008)

Nahum-Claudel, 2019). Traps are placed in the same locations in the river basin across generations, and many of these fishing sites are in places where fish spawn (Carvalho, 2024; Costa, 1995). The yãkwa is an important ceremony in the Enawenê-Nawê cultural calendar, relating to specific expressions of reciprocity with the gods and spirits (dos Mendes Santos & dos Mendes Santos, 2008; Nahum-Claudel, 2019).

The seasonal yãkwa fishing ritual also relates to events from Enawenê-Nawê cosmological narratives. Fishes were once human beings who shared villages with the Enawenê-Nawê. They practiced healing arts, spoke complex languages and played musical instruments. After a series of conflicts with celestial gods and other beings, the fish-people were cast to the anarchy of rivers (dos Mendes Santos, 2006). The yãkwa trap-fishing narrative explains the origins of fish migration as well as various fishing methods, such as the use of ichthyotoxic plants, woven nets and trap-fishing. The story involves several fishes,[11] including pacu (*Myleus* spp.; *Utiaritichthys* spp.), the needlefish (Ctenoluciidae or *Acestrorhynchus* spp.), hoxikya (matrinxã, *Brycon* spp.) and dokose, a giant catfish that is considered the father of all fishes (species unknown). Floodplain plants described in this narrative include urucu (*B. orellana*) and huito (*G. americana*) (dos Mendes Santos & dos Mendes Santos, 2008).

According to various accounts of the yãkwa, a school of fish-people is involved in a long chase with an Enawenê-Nawê god who takes the form of the dokose catfish. The fish-people kill dokose, devouring him whole. To get revenge on the fish-people, the father of the fallen Enawenê-Nawê god transforms into a hoxikya and plants countless fruit-bearing trees and caterpillars in the river floodplain. The hoxikya then invites other fishes to follow him upriver to feast on the new fruits and flowers. While they feast, he builds the yãkwa trap system, which captures the fish-people as they move back downstream (dos Mendes Santos, 2006; Nahum-Claudel, 2019).

The yãkwa narrative suggests both a direction of fish movement (downstream during the falling waters) and an order of fish movement (matrinxã leads shoals of pacu and other fishes upstream). Importantly, yãkwa trap-fishing provides food for the community at a time when fish are concentrated in streams, optimizing community effort (Nahum-Claudel, 2019). Some fish are offered back to the fish guardian spirit, dokose. In return, dokose directs the fish to return again the following year. In this way, the yãkwa fishing narrative is both adaptive and reciprocal; the Enawenê-Nawê can monitor the fish populations they rely on and ensure the guardian spirits allow the fishes to return (Nahum-Claudel, 2019). Finally, the yãkwa ceremony reveals the fishes' humanness. Like the Enawenê-Nawê, the fishes themselves are bound to the ritual practices of the yãkwa; during their migrations, the fishes, too, must recite specific songs and drink masato (dos Mendes Santos & dos Mendes Santos, 2008). Thus, the yãkwa ties fishes and humans in a common origin and ritualized sociality (Nahum-Claudel, 2019).

Additional Amazonian communities describe the culture of fishes very directly and see migratory activity as evidence of fishes' humanness. The Cashinahua/Huni Kuin of the Purus River describes fish migrations as ceremonies of the fishes, who travel upstream in search of ritual ornaments (dos Mendes Santos & dos Mendes Santos, 2008). Similarly, according to the Baniwa people of the Negro Basin, each species of fish has its own maloka or ceremonial house. The fish leave their maloka annually, migrating to meet other members of their species and reproduce (dos Monteiro Santos, 2012). The synchronous, multispecies movements from river channel to floodplain are a party for the fishes; as they move upstream, the fishes pass by their relatives' homes, who join the party, bringing their instruments with them (dos Mendes Santos & dos Mendes Santos, 2008). The fishes sing songs as they swim, and when they reach the upstream forests, they celebrate the harvest of their forest gardens (dos Mendes Santos, 2006). The Makuna of the northwestern Amazon also describe fish as cultured people who grow fruit crops in their forest gardens (Århem, 1996). In the tri-frontier region, some elders described fish migrations as a fish cultural custom. One elder explained that the fishes throw parties during el Friaje, a cold period that marks the start of the low-water season;

> In our culture, as my grandfather explained, during the Friaje, the fishes are going to their parties. They go to their ceremonies, they go conquer. Just like us human beings, just like we have the pelazón ritual, the fish also have rituals.—
>
> resident of San Sebastian, Colombia, 11 May 2024

6 | DISCUSSION

In this paper, we illustrated the social–cultural–ecological importance of fish migrations in the Amazon Basin. We applied a movement ecology framework to outline how Indigenous oral history contributes to knowledge on Amazonian fish migrations, which occur in specific directions, seasons and habitats, and across worlds and life forms. Furthermore, we emphasized the role of fish migration within Amazonian cosmovisions, showing how migratory fishes help to tell stories about transformation, change and creation across the Amazon. Indigenous narratives featured specific migratory fish taxa; for example, palometa/pacu (*Myloplus* spp., *Mylossoma* spp., *Myleus* spp., *Utiaritichthys* spp.), sábalo/matrinxã (*Brycon* spp.), bocachico (*P. nigricans*) and a giant catfish (Pimelodidae) are described as moving from one habitat to another for various purposes during key seasons. Magüta stories relayed a multispecies migration from Brazilian lakes to upstream floodplain habitats during rising waters. An Enawenê-Nawê narrative

[11]In the original text, fish were only listed with their common name (in Portuguese or the Indigenous language). For species identification based on these names, we relied on a recent report on Enawenê-Nawê fisheries for the Alto Juruena (Carvalho, 2024).

specifies the order of fish migration during the falling-water season, describing how one fish species (matrinxã) leads shoals of other Characiform species from forest streams to the main river channel. Various narratives from Tukanoan peoples describe migration–transformations, detailing the origin of fish species and their relations with other taxa or habitats. Other stories detailed why fishes migrate: fish migrations relate to social, trophic and reproductive processes and are motivated by the social lives of fishes. These details about where, when and why fishes move are important to ecological understanding, given the limited information on Amazon fish migration in the published scientific literature (Herrera-R et al., 2024).

Indigenous storytelling is essential to the transmission of biocultural knowledge (Fernández-Llamazares & Cabeza 2018). Oral histories reflect relational values and lessons that are developed through long-term relationships with ecosystems, which are intended to guide Indigenous environmental practice (Whyte, 2018). Relational values refer to the virtues developed through being in relationship, such as respect, care and responsibility (Chan et al., 2018). For example, an animist view of fishes may promote feelings of care towards freshwater, motivating actions to protect aquatic spaces where spirits and fish-people live. Within Amazonian stories, emphasis on transformation may remind listeners to be adaptive and responsive—not fearful—in the face of environmental change. Oral histories discussed in this paper also revealed environmental monitoring practices specific to each social–cultural–ecological context. For Magüta and Kukama communities in the tri-frontier region, the aggressiveness of a lake's boa madre determines its sacredness. An aggressive boa madre often indicates a fish spawning area, so aggressive lakes are considered no-fishing zones (see also Fabiano et al., 2021 on Urarina wetland spirits). The Enawenê-Nawê monitor fish populations by placing fishing trap systems in the same sites over generations and returning to those places at the same time each year. Baniwa and Tukanoan stories detail dietary rules and health concerns for fishes, which have the potential to influence fish populations if they align with spawning periods (dos Monteiro Santos, 2012; Cabalzar 2005).

Indigenous oral histories hold important details about the ecology of culturally important species, cosmological and spiritual meanings tied to place and cultural monitoring practices for particular ecosystems. Therefore, external researchers and practitioners should value oral histories as central to Indigenous self-governance of territory and orient their own role within environmental management accordingly. In some cases, researchers and practitioners could provide resources to support existing monitoring practices, such as traditional methods of tracking migration (Herrera-R et al., 2024). In other cases, communities may invite researchers to co-develop research products that reflect biocultural knowledge, such as seasonal calendars (Jackson et al., 2025), or participate in inter-generational storytelling and dialogue (Fernández-Llamazares & Cabeza 2018). Practitioners' engagement with Indigenous worldviews in this way, and on their terms, offers possibilities for the co-development of strategies towards sustainable management of freshwater.

A social–cultural–ecological perspective on migration also highlights broader threats which block the ability of animals and peoples to move freely across landscapes. Environmental degradation and resource extractivism erase Indigenous peoples and their social–ecological relations while generating benefits to other sectors of society, and this dynamic demonstrates a continuation of settler-colonialism (Boelens et al., 2023; Whyte, 2020). For Amazonian freshwaters, patterns of hydropower development provide an example: the entire Enawene-Nawe population lives in a single village along the Juruena River, yet 31 hydroelectric dams are currently in operation within the Upper Juruena (Mato Grosso state, Brazil), 11 of which are situated upstream of the Enawenê-Nawê territory (Carvalho, 2024). An additional 148 hydroelectric projects are planned or operating in the basins surrounding their territory (Carvalho, 2024). Hydroelectric dams often block fish migratory routes and alter the timing and extent of the seasonal flood pulse, which fishes rely on to access spawning and feeding habitats (Couto et al., 2021). Several reports highlight the profound impacts of these dams on fishing ceremonies and food sources for the Enawenê-Nawê people (Almeida, 2014; Carvalho, 2024). Declines in fish populations as a consequence of dam development have forced the Enawenê-Nawê to purchase farmed fish for ceremonies and food, which signifies a grave spiritual loss for the Enawenê-Nawê and magnifies the violence of dam development in the Neotropics for riverine communities (Almeida, 2014). In other parts of the Amazon, Indigenous people continue to resist the existential threats of mining, oil, highway and agribusiness development in their lands, which have demonstrably dire consequences for freshwater diversity and Indigenous health (Orta-Martínez & Finer, 2010).

Climate change makes 'enduring colonial injustices and structures visible' (Reibold 2023), exacerbating harms of environmental degradation to Indigenous peoples and migratory species. Climate change can alter environmental cues that animals rely on for navigation and timing of migration, resulting in phenological mismatch for various taxa including Arctic geese (Lameris et al., 2018) and Pacific salmon (Wilson et al., 2023). These phenological changes to migrations can profoundly impact Indigenous rhythms of life and access to culturally important species (Kuletz et al., 2024). For freshwater, climate change can impede the connectivity of disparate habitats via alterations to seasonal flood pulse dynamics (Herrera-R et al., 2020). During the extreme drought of 2023, fish were unable to move between the Amazon River and floodplain habitats, worsening already challenging conditions for subsistence fisheries for numerous Indigenous communities (Marengo et al., 2024). In the tri-frontier region, several communities faced food insecurity amid the drought and raised concerns over the future of fish migrations. Critically, the impacts of climate change are both material and cosmological, threatening Indigenous people' dependence on fishes for nutrition and income, as well as their beliefs, values, memories and embedded spiritualities with local ecologies.

We hope this paper is the first of many to deepen understanding of the social–cultural–ecological significance of fish or other animal migration. Scientific articles may acknowledge the economic importance of migration for Indigenous and local communities or present a general discussion on the 'human dimensions' of various natural phenomena, but can fail to appreciate the ontological and social–cultural meanings tied to migration. As others have argued, mobilizing the values, co-dependencies and shared cultures of humans and local ecologies is necessary for stewardship of nature in the Anthropocene (Tengö et al., 2017). Our study contributes to these efforts by demonstrating how Indigenous relationships with fish offer stories and lessons that could inform biocultural approaches to environmental monitoring and management. We invite researchers to engage with social–cultural–ecological dynamics of migration across landscapes and reflect on how Indigenous and place-based peoples define, relate, observe and track animal migration. Important questions at this intersection of literatures may include: how do animal movements figure into spirituality and ontology? Do cultural practices and oral history reveal traditional methods for monitoring migration across space and time? How do colonial legacies influence the free movement of both animals and people? These questions could help expand the nature of movement research and have important implications for the transboundary management of lands and waters, requiring collaboration between researchers, Indigenous and local people and governments.

AUTHOR CONTRIBUTIONS

Our study includes authors from different countries of origin, including the Amazonian countries of Peru, Brazil and Colombia. This work was also deeply informed by conversations and collaborations with Magüta and Kukama-Kukamiria elders and scholars in the tri-frontier region; one such collaborator (Jesús Dámaso) was interested in co-authorship. Roles in the development of this paper included the following: LuLu Victoria-Lacy conducted literature searches, leading analysis and writing with support from Thiago B. A. Couto, Natalia C. Piland, Stephannie Fernandes, Simone Athayde and Elizabeth P. Anderson. LuLu Victoria-Lacy and Jesús Dámaso conducted ethnographic fieldwork, and Jesús Dámaso created Figures 3–4, contextualizing Magüta perspectives on fish migration.

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CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to report.

DATA AVAILABILITY STATEMENT

Data utilized to create the map in Figure 1 are listed below as Data Sources. Key references are cited in text and within tables.

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REFERENCES

Almeida, J. (2014). Between distinct voracities: The hydro-energetic machine and the Iyakaliti's response. *Tipiti: Journal for the Society for the Anthropology of Lowland South America*, *12*(2), 93–98. https://doi.org/10.70845/2572-3626.1182

Anderson, E. P., Jackson, S., Tharme, R. E., Douglas, M., Flotemersch, J. E., Zwarteveen, M., Lokgariwar, C., Montoya, M., Wali, A., Tipa, G. T., Jardine, T. D., Olden, J. D., Cheng, L., Conallin, J., Cosens, B., Dickens, C., Garrick, D., Groenfeldt, D., Kabogo, J., … Arthington, A. H. (2019). Understanding rivers and their social relations: A critical step to advance environmental water management. *WIREs Water*, *6*(6), e1381. https://doi.org/10.1002/wat2.1381

Andrello, G. (2012). *Rotas de criação e transformação: Narrativas de origem dos povos indígenas do Rio Negro* (pp. 1–263). Instituto Socioambiental & Federação das Organizações Indígenas do Rio Negro.

Århem, K. (1996). The cosmic food web: Human-nature relatedness in the Northwest Amazon. In P. Descola & G. Palsson (Eds.), *Nature and society: Anthropological perspectives* (pp. 165–185). Rutledge.

Athayde, S., Shepard, G., Cardoso, T., van der Voort, H., Zent, S., Rosero-Peña, M., Zambrano, A. A., Cuvi, N., Surui, G., & Larrea, D. (2021). Critical interconnections between the cultural and ecological diversity of Amazonian peoples and ecosystems. In C. A. Nobre (Ed.), *Amazon assessment report*. United Nations Sustainable Development Solutions Network. https://www.theamazonwewant.org/spa-reports/

Athayde, S., Utsunomiya, R., Victoria-Lacy, L., Beveridge, C., Jenkins, C. N., Laufer, J., Heilpern, S., Olivas, P., & Anderson, E. (2025). Interdependencies between Indigenous peoples, local communities and freshwater systems in a changing Amazon. *Conservation Biology*, *39*(3), e70034. https://doi.org/10.1111/cobi.70034

Barthem, R. B., Goulding, M., Leite, R. G., Cañas, C., Forsberg, B., Venticinque, E., Petry, P., Ribeiro, M. L. d. B., Chuctaya, J., & Mercado, A. (2017). Goliath catfish spawning in the far western Amazon confirmed by the distribution of mature adults, drifting larvae and migrating juveniles. *Scientific Reports*, *7*(1), 41784. https://doi.org/10.1038/srep41784

Boelens, R., Escobar, A., Bakker, K., Hommes, L., Swyngedouw, E., Hogenboom, B., Huijbens, E. H., Jackson, S., Vos, J., Harris, L. M., Joy, K. J., de Castro, F., Duarte-Abadía, B., de Tubino Souza, D., Lotz-Sisitka, H., Hernández-Mora, N., Martínez-Alier, J., Roca-Servat, D., Perreault, T., … Wantzen, K. M. (2023). Riverhood: Political ecologies of socionature commoning and translocal struggles for water justice. *The Journal of Peasant Studies*, *50*(3), 1125–1156. https://doi.org/10.1080/03066150.2022.2120810

Borea, G., & Yahuarcani, R. (2020). Amazonian waterway, Amazonian water-worlds. In *Liquid ecologies in Latin American and Caribbean art* (pp. 106–124). Routledge. https://doi.org/10.4324/9780367199005-9

Bridgewater, P., & Rotherham, I. D. (2019). A critical perspective on the concept of biocultural diversity and its emerging role in nature and

heritage conservation. *People and Nature*, *1*(3), 291–304. https://doi.org/10.1002/pan3.10040

Cabalzar, A. (2005). In A. Cabalzar (Ed.), *Peixe e Gente no Alto Rio Tiquié: Conhecimentos tukano e tuyuka, ictiologia, etnologia*. Instituto Socio-Ambiental/Foirn - Federação das Organizações Indígenas do Rio Negro.

Cabalzar, A. (2016). *Ciclos anuais no rio Tiquié: Pesquisas colaborativas e manejo ambiental no noroeste amazônico*. Instituto Socioambiental & Federação das Organizações Indígenas do Rio Negro.

Campanero Reig, M. (2018). Humanidad territorializada. Madres, dueños y personas que cuidan. *Revista de Antropología Iberoamericana*, *13*(2), 189–212. https://doi.org/10.11156/aibr.130204

Carvalho, R. C. (2024). *Monitoramento da Atividade Pesqueira na Terra Indígena Enawenê-Nawê, sub-bacia do Alto Juruena*. Relatório Técnico, Operação Amazônia Nativa.

Chan, K. M. A., Gould, R. K., & Pascual, U. (2018). Editorial overview: Relational values: What are they, and what's the fuss about? *Current Opinion in Environmental Sustainability*, *35*, A1–A7. https://doi.org/10.1016/j.cosust.2018.11.003

Correa, S. B., Araujo, J. K., Penha, J. M. F., da Cunha, C. N., Stevenson, P. R., & Anderson, J. T. (2015). Overfishing disrupts an ancient mutualism between frugivorous fishes and plants in neotropical wetlands. *Biological Conservation*, *191*, 159–167. https://doi.org/10.1016/j.biocon.2015.06.019

Correa, S. B., & Winemiller, K. O. (2014). Niche partitioning among frugivorous fishes in response to fluctuating resources in the Amazonian floodplain forest. *Ecology*, *95*(1), 210–224. https://doi.org/10.1890/13-0393.1

Costa, J. P. (1995). *A Pesca na sociedade Enawenê: Estudo das potencialidades e manejo dos recursos naturais na área indígena Enawenê-Nawê*. Relatório Técnico, Operação Amazônia Nativa.

Couto, T. B., Messager, M. L., & Olden, J. D. (2021). Safeguarding migratory fish via strategic planning of future small hydropower in Brazil. *Nature Sustainability*, *4*(5), 409–416. https://doi.org/10.1038/s41893-020-00665-4

de Castro, E. V. (1998). Cosmological deixis and Amerindian perspectivism. *The Journal of the Royal Anthropological Institute*, *4*(3), 469. https://doi.org/10.2307/3034157

Dean, B. (1994). The poetics of creation: Urarina cosmogony and historical consciousness. *Latin American Indian Literatures Journal*, *10*(1), 22–45.

Descola, P. (2006). Beyond nature and culture. *Proceedings of the British Academy*, *139*, 137–155.

dos Mendes Santos, G. (2006). *Da cultura à natureza: Um estudo do cosmos e da ecologia dos Enawene Nawe* [Doctoral dissertation]. Universidade de São Paulo, Biblioteca Digitais de Teses e Dissertações da USP. http://www.teses.usp.br/teses/disponiveis/8/8134/tde-21052006-224829/

dos Mendes Santos, G., & dos Mendes Santos, G. (2008). Homens, peixes e espíritos: A pesca ritual dos Enawene-Nawe. *Tellus*, *14*, 39–59.

dos Monteiro Santos, S. R. (2012). *Narrativas quase esquecidas: Leitura dos mitos Baniwa* [Doctoral dissertation]. Universidade Federal do Amazonas, Sistema de bibliotecas da Universidade Federal do Amazonas. http://tede.ufam.edu.br/handle/tede/2367

Duponchelle, F., Isaac, V. J., Doria, C. R. D. C., Damme, P. A. V., Herrera-R, G. A., Anderson, E. P., Cruz, R. E. A., Hauser, M., Hermann, T. W., Agudelo, E., Bonilla-Castillo, C., Barthem, R., Freitas, C. E. C., García-Dávila, C., García-Vasquez, A., Renno, J.-F., & Castello, L. (2021). Conservation of migratory fishes in the Amazon basin. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *31*(5), 1087–1105. https://doi.org/10.1002/aqc.3550

Escobar, A. (2015). Territorios de diferencia: La ontología política de los "derechos al territorio". *Cuadernos de Antropología Social*, *41*, 25–38.

Espinosa, O. (2012). To be Shipibo nowadays: The Shipibo-Konibo youth organizations as a strategy for dealing with cultural change in the Peruvian Amazon region. *The Journal of Latin American and Caribbean Anthropology*, *17*(3), 451–471.

Fabiano, E., Schulz, C., & Brañas, M. M. (2021). Wetland spirits and Indigenous knowledge: Implications for the conservation of wetlands in the Peruvian Amazon. *Current Research in Environmental Sustainability*, *3*, 100107. https://doi.org/10.1016/j.crsust.2021.100107

Fernández-Llamazares, Á., & Cabeza, M. (2018). Rediscovering the potential of Indigenous storytelling for conservation practice. *Conservation Letters*, *11*(3), e12398. https://doi.org/10.1111/conl.12398

Flecker, A. S., McIntyre, P. B., Moore, J. W., Anderson, J. T., Taylor, B. W., & Hall, R. O. (2010). Migratory fishes as material and process subsidies in riverine ecosystems. *American Fisheries Society Symposium*, *73*, 559–592.

Galeano, J. C. (2009). *Folktales of the Amazon*. Libraries Unlimited.

González-Duarte, C., & Méndez-Arreola, R. (2024). "Living in the time of the butterfly": Engaging more-than-human temporalities to rethink biodiversity conservation. *Journal of Political Ecology*, *31*(1), 217–233.

Goulding, M. (1980). *The fishes and the forest: Explorations in Amazonian natural history*. University of California Press.

Goulding, M., Venticinque, E., Ribeiro, M. L. D. B., Barthem, R. B., Leite, R. G., Forsberg, B., Petry, P., Lopes da Silva-Júnior, U., Ferraz, P. S., & Cañas, C. (2019). Ecosystem-based management of Amazon fisheries and wetlands. *Fish and Fisheries*, *20*(1), 138–158. https://doi.org/10.1111/faf.12328

Harris, M. (1998). The rhythm of life on the Amazon floodplain: Seasonality and sociality in a Riverine Village. *The Journal of the Royal Anthropological Institute*, *4*(1), 65. https://doi.org/10.2307/3034428

Henao, E., Cantera, J. R., & Rzymski, P. (2020). Conserving the Amazon river basin: The case study of the Yahuarcaca lakes system in Colombia. *Science of the Total Environment*, *724*, 138186. https://doi.org/10.1016/j.scitotenv.2020.138186

Herrera-R, G. A., Heilpern, S. A., Couto, T. B. A., Victoria-Lacy, L., Duponchelle, F., Correa, S. B., Farah-Pérez, A., López-Casas, S., Cañas-Alva, C. M., Doria, C. R. C., & Anderson, E. P. (2024). A synthesis of the diversity of freshwater fish migrations in the Amazon basin. *Fish and Fisheries*, *25*(1), 114–133. https://doi.org/10.1111/faf.12795

Herrera-R, G. A., Oberdorff, T., Anderson, E. P., Brosse, S., Carvajal-Vallejos, F. M., Frederico, R. G., Hidalgo, M., Jézéquel, C., Maldonado, M., Maldonado-Ocampo, J. A., Ortega, H., Radinger, J., Torrente-Vilara, G., Zuanon, J., & Tedesco, P. A. (2020). The combined effects of climate change and river fragmentation on the distribution of Andean Amazon fishes. *Global Change Biology*, *26*(10), 5509–5523. https://doi.org/10.1111/gcb.15285

Imaina, L. T. (2016). Prólogo. In L. T. Imaina & S. Boyd (Eds.), *Karuara: La gente del río* (p. 8). Associacion Quisca and Radio Ucamara.

Instituto Socio-Ambiental. (2018). *Povos Indigenas no Brasil*. Retrieved July 22, 2025, from https://pib.socioambiental.org/en/Main_Page

Jackson, S., Anderson, E. P., Piland, N. C., Carriere, S., Java, L., & Jardine, T. D. (2022). River rhythmicity: A conceptual means of understanding and leveraging the relational values of rivers. *People and Nature*, *4*(4), 949–962. https://doi.org/10.1002/pan3.10335

Jackson, S., Piland, N., Woodward, E., McTaggart, P., Wali, A., Lemos, A. A., Alvira Reyes, D., Lins, J., Cabalzar, A., Victoria-Lacy, L., Douglas, M., Tharme, R. E., & Anderson, E. P. (2025). Understanding temporality in the lives of rivers and riverine human communities through seasonal calendars. *Freshwater Science*, *44*(2), 239–250. https://doi.org/10.1086/735837

Kassam, K. A. S., & Bernardo, J. (2022). Role of biodiversity in ecological calendars and its implications for food sovereignty: Empirical assessment of the resilience of indicator species to anthropogenic

climate change. *GeoHealth*, *6*(10), e2022GH000614. https://doi.org/10.1029/2022GH000614

Kuletz, K. J., Ferguson, S. H., Frederiksen, M., Gallagher, C. P., Hauser, D. D., Hop, H., & Seitz, A. C. (2024). A review of climate change impacts on migration patterns of marine vertebrates in Arctic and subarctic ecosystems. *Frontiers in Environmental Science*, *12*, 1434549. https://doi.org/10.3389/fenvs.2024.1434549

Lagrou, E. M. (1998). *Cashinahua Cosmovision: A Perspectival Approach to Identity and Alterity* (pp. 1–375) [Doctoral thesis]. University of St. Andrews. https://research-repository.st-andrews.ac.uk/handle/10023/1676

Lameris, T. K., van der Jeugd, H. P., Eichhorn, G., Dokter, A. M., Bouten, W., Boom, M. P., Litvin, K. E., Ens, B. J., & Nolet, B. A. (2018). Arctic geese tune migration to a warming climate but still suffer from a phenological mismatch. *Current Biology*, *28*(15), 2467–2473. https://doi.org/10.1016/j.cub.2018.05.077

Lana, F., Azevedo, F., & Azevedo, M. (2016). Diadoe: Origem do matapi e dos pirarucus e trairas. *MUSA Museo da Amazonia*. https://museudaamazonia.org.br/diadoe-origem-do-matapi-e-dos-pirarucus-e-trairas/

Levis, C., Rezende, J. S., Barreto, J. P. L., Barreto, S. S., Baniwa, F., Sateré-Mawé, C., Zuker, F., Alencar, A., Mugge, M., Simon de Moraes, R., & Fuentes, A. (2024). Indigenizing conservation science for a sustainable Amazon. *Science*, *386*(6727), 1229–1232. https://doi.org/10.1126/science.adn5616

Maffi, L. (2018). Biocultural diversity. In *The international encyclopedia of anthropology* (pp. 1–14). Wiley. https://doi.org/10.1002/9781118924396.wbiea1797

Marengo, J. A., Cunha, A. P., Espinoza, J. C., Fu, R., Schöngart, J., Jimenez, J. C., Costa, M. C., Ribeiro, J. M., Wongchuig, S., & Zhao, S. (2024). The drought of Amazonia in 2023-2024. *American Journal of Climate Change*, *13*(3), 567–597.

Moreira, D. F., & Colombier, M. R. (2019). Mi casa pequeña, mi corazón grande. Política territorial y cosmológica del pueblo Kukama. *Mundo Amazónico*, *10*(1), e73980. https://doi.org/10.15446/ma.v10n1.73980

Nahum-Claudel, C. (2019). From mastery to subjection: An embodied ethics of entrapment in Amazonia. *Journal of Material Culture*, *24*(4), 473–490. https://doi.org/10.1177/1359183519828767

Navarro, A. (2021). The world of Anaconda: The myth of the snake-canoe and its relationship with the stilt villages from eastern Amazon. *Brasiliana: Journal for Brazilian Studies*, *9*(2), 30–51. https://doi.org/10.25160/bjbs.v9i2.121588

Nimuendaju, C. (1952). In R. Lowie (Ed.), *The Tukuna* (Vol. *45*). University of California Press.

Nuttall, M. (2007). An environment at risk: Arctic Indigenous peoples, local livelihoods and climate change. In J. B. Ørbæk, R. Kallenborn, I. Tombre, E. Hegseth, S. Falk-Petersen, & A. Hoel (Eds.), *Arctic alpine ecosystems and people in a changing environment* (pp. 19–35). Springer Berlin Heidelberg.

Oberdorff, T., Dias, M. S., Jézéquel, C., Albert, J. S., Arantes, C. C., Bigorne, R., Carvajal-Valleros, F. M., Wever, A. D., Frederico, R. G., Hidalgo, M., Hugueny, B., Leprieur, F., Maldonado, M., Maldonado-Ocampo, J., Martens, K., Ortega, H., Sarmiento, J., Tedesco, P. A., Torrente-Vilara, G., … Zuanon, J. (2019). Unexpected fish diversity gradients in the Amazon basin. *Science Advances*, *5*(9), eaav8681. https://doi.org/10.1126/sciadv.aav8681

Orta-Martínez, M., & Finer, M. (2010). Oil frontiers and Indigenous resistance in the Peruvian Amazon. *Ecological Economics*, *70*(2), 207–218. https://doi.org/10.1016/j.ecolecon.2010.04.022

Prestes, L., Barthem, R., Mello-Filho, A., Anderson, E., Correa, S. B., Couto, T. B. D. A., Couto, T. B. D., Venticinque, E., Forsberg, B., Cañas, C., Bentes, B., & Goulding, M. (2022). Proactively averting the collapse of Amazon fisheries based on three migratory flagship species. *PLoS One*, *17*(3), e0264490. https://doi.org/10.1371/journal.pone.0264490

Reibold, K. (2023). Settler colonialism, decolonization, and climate change. *Journal of Applied Philosophy*, *40*(4), 624–641. https://doi.org/10.1111/japp.12573

Roe, P. (1982). *The cosmic zygote: Cosmology in the Amazon Basin*. Rutgers University Press.

Ruiz, R. R. (2022). Reconociendo al río: Gran serpiente acuática como ser vivo en la cosmología animista kukama-kukamiria de la Amazonía peruana. *Amazonía Peruana*, *35*, 89–114. https://doi.org/10.52980/revistaamazonaperuana.vi35.301

Santos Angarita, A. A. (2013). *Percepción tikuna de Naane y Naüne: Territorio y cuerpo* [Masters thesis]. Universidad Nacional de Colombia, UNAL Repositorio Institucional. https://repositorio.unal.edu.co/handle/unal/51667

Santos-Granero, F., & Fabiano, E. (2023). *Urban imaginaries in native Amazonia: Tales of alterity, power, and Defiance*. University of Arizona Press.

Silva, M. (2016). Demografia e antropologia em contraponto: Os Enawene-Nawe e suas derivas matrimoniais. *Revista Brasileira de Estudos de População*, *33*(2), 349–373. https://doi.org/10.20947/S0102-30982016a0030

Slater, C. (1994). *Dance of the dolphin: Transformation and disenchantment in the Amazonian imagination*. University of Chicago Press.

Tallman, P. S., Piland, N. C., Villarmarzo, M., Victoria-Lacy, L., & Valdés-Velásquez, A. (2024). Waterscapes meet socio-ecological models: A relational framework to examine water insecurity and human health and well-being. *People and Nature*, *6*(3), 1036–1047. https://doi.org/10.1002/pan3.10635

Tengö, M., Hill, R., Malmer, P., Raymond, C. M., Spierenburg, M., Danielsen, F., Elmqvist, T., & Folke, C. (2017). Weaving knowledge systems in IPBES, CBD and beyond—lessons learned for sustainability. *Current opinion in environmental sustainability*, *26*, 17–25. https://doi.org/10.1016/j.cosust.2016.12.005

Tobes, I., Carrillo-Moreno, C., Guarderas-Flores, L., Jácome-Negrete, I., & Velázquez-Cárdenas, Y. (2022). Ethnoichthyology and ethnotaxonomy of the Kichwa Indigenous people of Arawanu (Arajuno), in the Ecuadorian Amazon. *Frontiers in Ecology and Evolution*, *10*, 826781. https://doi.org/10.3389/fevo.2022.826781

Whyte, K. (2018). What do Indigenous knowledges do for Indigenous peoples. In M. Nelson & D. Shilling (Eds.), *Traditional ecological knowledge: Learning from Indigenous practices for environmental sustainability* (pp. 57–82). Cambridge University Press.

Whyte, K. (2020). Too late for Indigenous climate justice: Ecological and relational tipping points. *Wiley Interdisciplinary Reviews: Climate Change*, *11*(1), e603. https://doi.org/10.1002/wcc.603

Wilson, S. M., Moore, J. W., Ward, E. J., Kinsel, C. W., Anderson, J. H., Buehrens, T. W., Carr-Harris, C. N., Cochran, P. C., Davies, T. D., Downen, M. R., Godbout, L., Lisi, P. J., Litz, M. N. C., Patterson, D. A., Selbie, D. T., Sloat, M. R., Suring, E. J., Tattam, I. A., & Wyatt, G. J. (2023). Phenological shifts and mismatch with marine productivity vary among Pacific salmon species and populations. *Nature Ecology & Evolution*, *7*(6), 852–861. https://doi.org/10.1038/s41559-023-02057-1

Winemiller, K. O., & Jepsen, D. B. (1998). Effects of seasonality and fish movement on tropical river food webs. *Journal of Fish Biology*, *53*, 267–296. https://doi.org/10.1111/j.1095-8649.1998.tb01032.x

DATA SOURCES

ESRI ArcGIS Hub. (2013). *World cities feature layer*. https://hub.arcgis.com/datasets/esri::world-cities/about

Google Earth V 7.3. (2021a). *Yahuarcaca Lakes, Colombia*. 4°11′07″ S, 69°57′36″ W, Google, Landsat/Copernicus Satellite Imagery. Retrieved January 2025 from earth.google.com

Google Earth V 7.3. (2021b). *Tarapoto Lakes, Colombia*. 3° 46′37″ S, 70°22′56″ W, Google, Landsat/Copernicus Satellite Imagery. Retrieved January 2025 from earth.google.com

Google Earth V 7.3. (2021c). *Loretoyacu River, Colombia*. 3° 45′18″ S, 70°25′51″ W, Google, Landsat/Copernicus Satellite Imagery. Retrieved January 2025 from earth.google.com

Google Earth V 7.3. (2021d). *Tunetu and Eware Creeks, Brazil*. 4° 04′12″ S, 69°33′27″ W, Google, Landsat/Copernicus Satellite Imagery. Retrieved January 2025 from earth.google.com

Google Earth V 7.3. (2021e). *Negro River, Brazil*. 0° 35′16″ S, 63°15′32″ W, Google, Landsat/Copernicus Satellite Imagery. Retrieved January 2025 from earth.google.com

Google Earth V 7.3. (2021f). *Tiquie River, Brazil*. 0° 07′02″ S, 67°37′28″ W, Google, Landsat/Copernicus Satellite Imagery. Retrieved January 2025 from earth.google.com

Google Earth V 7.3. (2021g). *Papuri and Vaupes River, Brazil*. 0° 27′14″ S, 69°08′37″ W, Google, Landsat/Copernicus Satellite Imagery. Retrieved January 2025 from earth.google.com

Lehner, B., & Grill, G. (2013). Global river hydrography and network routing: Baseline data and new approaches to study the world's large river systems. *Hydrological Processes*, *27*(15), 2171–2186. https://doi.org/10.1002/hyp.9740

New York Dept. of State: Geographic Information Gateway. (2023). *Indigenous territories: Native land digital*. https://opdgig.dos.ny.gov/datasets/NYSDOS::indigenous-territories-native-land-digital/about

World Wildlife Fund Brazil: Programa de Ciencias. (2019). *Amazon sub basins feature layer*. ESRI ArcGIS Online. https://www.arcgis.com/home/item.html?id=27a5eb41cbdc4ab3adbfc06418233134

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Data S1. Data used to create map in ArcGIS Pro 3.5.

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