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Changing Monsoonal Waterworlds

Sensing Delta Volatility through Hilsa Fish

Abstract: This article explores volatility from the perspective of hilsa fish in the Bengal Delta. The hilsa, known as *ilish* in Bengali, takes advantage of monsoonal hydrological dynamics in its life cycle. Today, hilsa are changing in response to anthropogenic activities, which attempt to stabilise delta landscapes in response to perceived volatility, but generate new volatilities that are felt and sensed corporeally by people who are entangled with hilsa lifeways. Interactions with a fisher, a cook, a scientist and an environmental activist during multi-sited ethnographic fieldwork in Bangladesh provide insights into how hilsa are experiencing and responding to spatial, material and temporal environmental transformations. Embodied understandings of hilsa lifeworlds gained through acts of fishing, cooking, dissecting and monitoring reveal the more-than-human reverberations of human-induced volatility.

Keywords: Bengal Delta, hilsa fish, monsoon, multi-species, sensory ethnography

Deltas are dynamic environments. Reorganised and regenerated each year through fluid movements of matter, they are far from fixed or stable (Bremner 2020; Krause 2017). Human interventions, which seek to stabilise delta landscapes, have unanticipated and often volatile consequences for human and non-human life (Strang, this issue). Working with the notion of volatility as 'uncertain and potentially rapid transformations with radical implications for social and ecological life' (Krause and Eriksen, this issue), this article examines experiences of changing delta waterworlds by focusing on one species of fish. Based on fieldwork in Bangladesh, I explore volatility within the Bengal Delta by following hilsa, known scientifically as *Tenualsoa ilisha* or *ilish* in Bengali (Figure 1). In doing so, I take a 'more-than-human' approach (Whatmore 2006) that seeks to convey the constitutive role of non-humans in the production of the world. I also draw on 'new materialism' (Fox and Alldred 2019), which pays attention to the ways in which humans, non-humans, technologies, materials and physical environments are entangled with one another. These theoretical approaches challenge notions of human exceptionalism by adopting an expanded understanding of agency that recognises that things other than humans can be social 'agents' with the 'capacity to affect and be affected' (Deleuze and Guattari 1988: 127–128). From this perspective, events occur as a result of relations between diverse agencies – physical, biological, social and cultural – in complex, contingent and continually emergent ways; as such, the world is not fixed and stable, but materialises through uneven, chaotic and unpredictable dynamics.

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Figure 1. Hilsa fish. Photo: Author.

This article arises from Monsoon Assemblages, a project exploring relations between changing monsoon climates and rapid urban growth in three cities around the Bay of Bengal: Chennai, Dhaka and Yangon. The project challenges the dominant view of the monsoon as a natural meteorological system outside of and distinct from society. Instead it proposes that the monsoon is a co-producer of urban life and space that is enmeshed within lived environments. My research on hilsa fish, as a monsoonal species, took place in the context of this project and was part of the theoretical and methodological approach of 'monsoon as method' (Bremner 2022). While fish may be an unlikely research topic, seemingly removed from urban environments, hilsa are deeply entangled with processes of urbanisation and industrialisation occurring within the Bengal Delta.

In recent decades Bangladesh has become one of the world's fastest growing economies. As industry has replaced agriculture, the urban population of Bangladesh has swollen, and is projected to increase from 10 million in 1990 to 32 million in 2025 (UN-Habitat 2013: 128). Territories have rapidly transformed as the country's cities and economy have accelerated, and construction of dams, barrages, roads, bridges, ports, factories and energy infrastructures has intensified. Such structures facilitate industrialisation and urban growth, but in the process they alter water and sediment flows, intensify nutrient and pollution loads, and disrupt acoustic and olfactory qualities of underwater environments. By modifying ecosystems human interventions reconfigure the delta's material qualities and temporal rhythms, resulting in volatile dynamics for inhabitants including hilsa. Fish, and the monsoon waters they dwell within, are not passive in these processes but respond in unforeseen and unpredictable ways, themselves contributing to volatile dynamics.

Fieldwork observations indicate that delta volatility emerges from complex relations between a myriad of agencies, with fish, sediments, pollutants, monsoons and infrastructures playing an agentive role, often with unanticipated and unpredictable results. This understanding of more-than-human volatility is informed by Barad's (2007) concept of 'intra-action', which emphasises that agency is not an inherent property of an individual or human to be exercised but is a dynamism of forces. When entities intra-act, they do so in constitutive ways, with emergent results. By attending to human–hilsa relations within the Bengal Delta, I demonstrate that volatility involves variously scaled more-than-human agentive processes and beings, ranging from the geomorphological to the ecological.

While human interventions have volatile implications for hilsa, these volatilities are also felt by humans entangled within hilsa ecologies. Although fish are hard to engage with, partly due to the 'alien aquatic spaces' they inhabit (Bear and Eden 2011: 337), people sense hilsa responses to delta volatility through embodied interactions with them. Drawing on Stacy Alaimo's (2010) material feminist concept of 'transcorporeality', I argue that while volatility may be the emergent result of multiple agencies, and perceived differently by humans and non-humans, it is experienced across species in interconnected ways. The concept of transcorporeality draws attention to how porous human and non-human bodies are entwined with one another, and with technologies, materials and physical environments. From this standpoint 'all creatures, as embodied beings, are intermeshed with the dynamic, material world, which crosses through them, transforms them and is transformed by them' (Alaimo 2018: 435). By describing intimate intra-actions with hilsa, this article offers insights into more-than-human volatility and the dynamic relationality of an unpredictable and ever-emergent monsoonal delta.

Hilsa and the Monsoonal Delta

To comprehend the volatile implications of urbanisation and industrialisation, it is first necessary to understand relations between hilsa fish, the delta and the monsoon. Hilsa inhabit the Indian Ocean coastline, their habitat coinciding with the Indian monsoon region (Figure 2). However, they are most abundant in the upper reaches of the Bay of Bengal, where the mighty Ganges, Brahmaputra and Meghna Rivers meet (Miah 2015). At the apex of the bay, the Bengal Delta forms a unique 'ecotone' where monsoon runoff, seasonally reversing ocean currents and semi-diurnal tides 'meet, embrace, clash and transform one another' (Neimanis 2012: 107). These forceful movements create a highly dynamic environment, characterised by erosion, accretion and constantly changing river courses. While the monsoonal materiality of the delta can be destructive, with river bank and *char* collapses, storm surges, floods and cyclones causing 'violent territorial and social disruption' (Bremner 2020: 9), the immense mobilisation of water and sediment is also productive, creating the world's largest delta. The extraordinary fertility enabled by these mobilisations, gathers a tremendous amount of life (Lahiri-Dutt 2014). Hilsa proliferate here, reaching their highest concentrations where monsoonal and tidal systems merge.

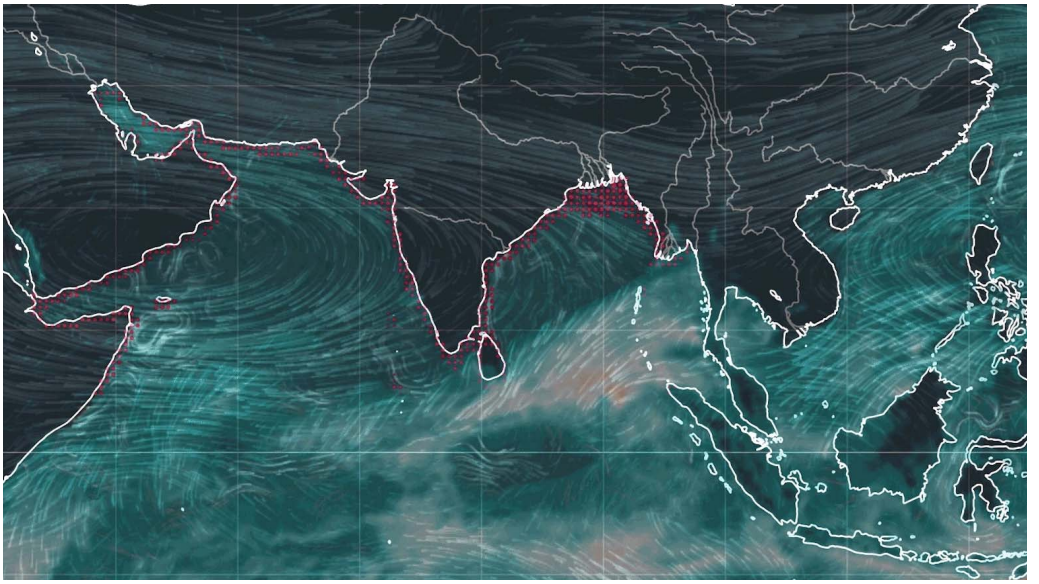

Figure 2. Monsoonal distribution of hilsa. Drawing: John Cook.

Although powerful fluctuations of fresh and salt waters, tides and currents, sediments and silts may be perceived as dangerous from certain human perspectives, hilsa depend on the fecundity they create, attuning their migrations to these material mobilisations. The monsoonal materiality of the delta is critical for hilsa reproduction. They are an anadromous fish, meaning they spend most of their adult lives at sea but migrate to fresh water to breed (Wahab et al 2019). When the southwest monsoon commences, rainwater lowers the bay's salinity, sweetening the waters of connected river estuaries. Hilsa trace these freshwater pathways, moving upstream against thick, silted flows to spawn. After hatching, young, known as *jatka*, are nursed in river channels before descending back to the sea to mature. Juveniles spend at least a year in the fertile waters of the bay before returning to rivers as breeding adults to complete the cycle (Figure 3).

The monsoonal migration of hilsa was once a defining component of Bengal. According to historical accounts, hilsa used to migrate vast distances, breeding in the upper reaches of the region's major rivers (Figure 4). Colonial-era observers describe the fish travelling as far as Agra and Kanpur, thousands of kilometres inland, reaching the 'utmost abundance and perfection' around Calcutta and Dhaka (Hamilton 1822: 244). Recently, the migratory range of hilsa has shrunk markedly, with fish constrained to coastal areas, adjacent estuaries and lower reaches of rivers. Related to these changing mobilities, hilsa numbers began to decline dramatically in the 1970s, reaching an all-time low in the early 2000s. The diminishing range and dwindling numbers of the fish are powerful indicators of shifting human–non-human relations.

Changing hilsa lifeways are a particular concern in Bangladesh, where the fish is a 'cultural keystone species' (Garibaldi and Turner 2004: 1), a term given to species that form the 'contextual underpinnings of a culture' due to their roles in diet, as materials, or medicine, in language, ceremonies and narratives. Known as the country's

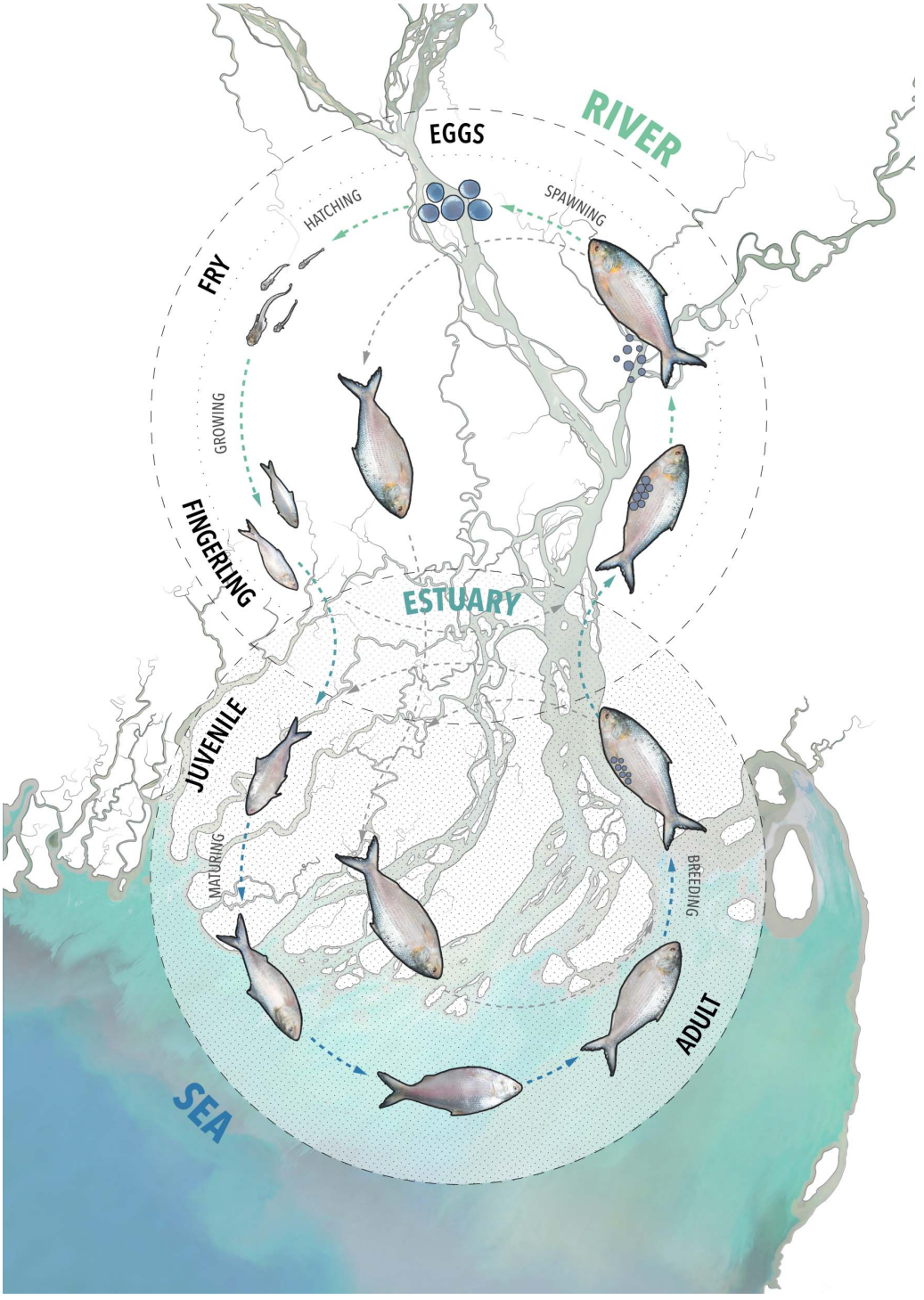

Figure 3. Lifecycle of hilsa. Drawing: John Cook.

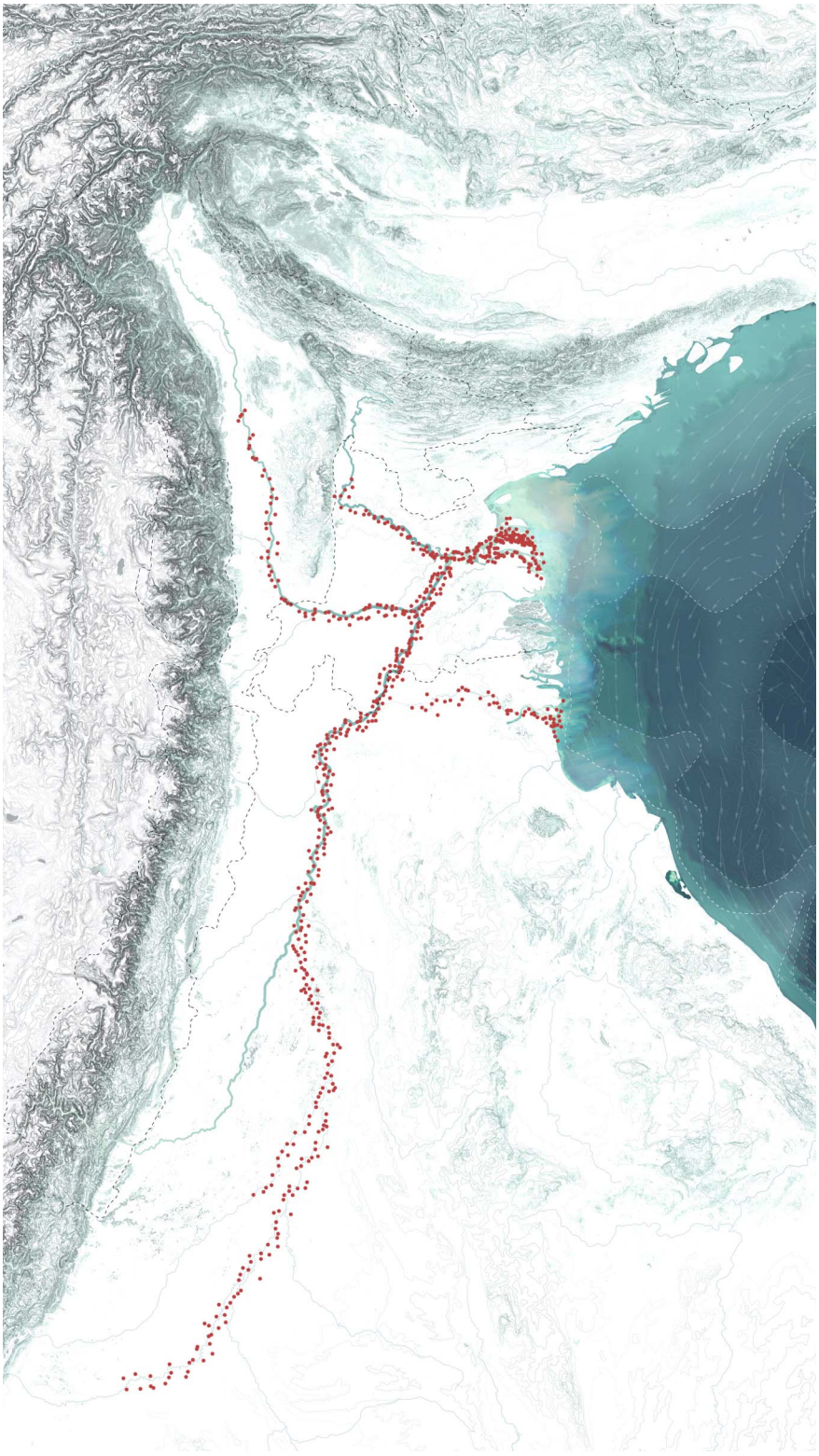

Figure 4. Eighteenth-century hilsa migration routes in the Bengal Delta. Drawing: John Cook.

national fish, hilsa is cherished by Bangladeshis for its distinctive aroma, rich flavour and texture of its flesh. The glittering silver-scaled fish is incorporated into wedding festivals, religious rituals and culinary traditions, 'the queen of fishes in a fish-eating society' (Shornomoyee 2013: 394). Although hilsa is beloved, its lifeways are increasingly threatened, with pressures intensifying as Bangladesh has endeavoured to reach 'middle-income country' status – desire for economic progress vying with desire for fish. Inspired by the assertion that 'human involvement in multi-species worlds is a place to begin' (Tsing 2013: 34), the next sections explore changing delta waterworlds and more-than-human volatility through sensory encounters with hilsa.

Sensory Ways of Knowing Fish

Food was an important part of my time in Bangladesh. Sharing meals provided a way of bonding, learning and exchanging. Conversations around food frequently began with a number of questions: 'do you like Bengali food?', 'can you eat spicy food?', 'can you eat fish with bones' and invariably, 'have you tried hilsa?' In this way, I was introduced to *ilish*. Over shared meals, people revealed unique insights about the fish gained through intimate exchanges, including fishing, eating, dissecting, and monitoring its waters. I was struck by the sensory dimensions of these encounters as people relayed tastes, smells, sounds and textures. This presented an avenue for ethnographic engagement, and I began to focus on people's memories and narratives of hilsa encounters, supplemented by participant observation and focused interviews.

My approach to understanding human–hilsa relations was informed by sensory ethnography (Pink 2015), which attends to the role that senses play in relations between bodies and environments in order to access tacit, mundane, almost unconscious everyday experiences and meanings that are difficult to articulate or taken for granted. As I reflected on conversations, I realised that people's narratives were not restricted to their own sensory experiences but also considered the sensory experiences of fish. Although many aspects of the hilsa's world remain inaccessible to humans, and there are undoubtedly sensory incompatibilities between species, understandings that emerge from embodied encounters convey the sensory life of the fish, the materiality of monsoonal waterscapes and how these are changing.

Fieldwork was carried out with assistance from a local NGO during three visits to Bangladesh between February 2018 and September 2019, focusing on Dhaka city and the Padma–Meghna river system. Influenced by multispecies ethnography (Kirksey and Helmreich 2010), multi-sited ethnography (Marcus 1995) and follow-the-thing methods (Appadurai 1986; Cook 2004), I visited fishing villages, fish markets, kitchens and research stations. Travelling along urban waterscapes and the Meghna River, I followed hilsa through the delta and social worlds paying close attention to characters that emerged along the way, and the politics and infrastructures that hilsa become entangled with. Despite spending time in Bangladesh, as a white British woman and cultural outsider, I could not experience hilsa in the same way as my interlocutors. I do not have the same sensory and emotional connections with the fish, and without long-term lived attachments to place cannot not feel the physical and psychological effects

of changing monsoon waterworlds. Instead, I listened, recorded and empathised with the sensory witnessing of others.

The following sections are structured around four people I met during my fieldwork: a fisher, a scientist, a cook and an activist. Each of these figures are uniquely situated actors who know and care for hilsa fish, but do so differently. Due to their positionality, each one divulged various facets of hilsa ecologies and human–hilsa relations, and divergent experiences and perceptions of volatility gained from situated and embodied experiences. Their knowledge, influenced by their social standing and correspondence with hilsa, provides insights into the effects of human activities on hilsa environments and how changing hilsa lifeways affect humans in turn, as well as the multiple more-than-human agencies that contribute to volatile dynamics. The stories of these characters, which overlap and interconnect, reveal a complex meshwork of relations within a delta world in flux.

The Fisher

Hilsa form the largest single-species fishery in Bangladesh. The fish directly support half a million fishers, and an estimated 2.5 million people indirectly depend on them (van Brakel et al 2018), including traders, transporters, daily labourers, processors, brokers, ice producers, and those involved in net making and mending, boat making and repairing. The hilsa fishery is mainly artisanal: fish are harvested from wooden boats, which can be mechanised or not, using a range of cast and weighted gillnets. Until recently fishing has been largely unregulated, and smaller fishers and hilsa have been negatively affected by larger-scale fishing operations run by powerful businessmen, and commercial fishing in the Bay of Bengal. Although the incomes of artisanal fishers fluctuate dramatically, with lean periods lasting up to six months, there are limited alternative livelihood options. Described as 'among the most vulnerable communities in society' (Ahmed et al 2021: 2), these fishers face food insecurity through the year, particularly following extreme weather events.

In the fishing villages situated precariously along the banks of the Meghna River, people's lives are oriented around the seasonal lifecycle of hilsa. Traditionally, the main hilsa fishing season lasts from July to November, coinciding with their monsoonal migration, peaking in September and October. In July 2018, I visited a community of Muslim fishers near Chandpur, a small town hosting the largest hilsa market in the country. At this time of year, the Meghna River is usually teeming with boats, but rains were late and catches low. Fishers who depend on the monsoon catch were frustrated and anxious. Abdul, an experienced older fisher, exclaimed: 'Hilsa is supposed to be available from July. At this time, our boats should be full and the market should be flooded.' To catch hilsa, fishers gauge their environment; fishing tactics and gear are adjusted to water current, depth, tidal phase, weather conditions and movements of the fish. Through embodied practices, fishers learn to sense the river and the fish; as Abdul told me, 'I have been fishing this river since my childhood, I can sense its pulse.'

Because artisanal fishers interact with 'the total phenomenon of fish-in-its-environment' (Krause 2014: 355), they are highly sensitive to environmental changes.

Fishers I spoke with ascribe the unpredictability of hilsa movements to the increasingly inhospitable Padma–Meghna river system. 'The river has changed; the difference is like day and night. When we were children the flow was much higher.' Many believe reduced riverine flow is caused by the Farakka Barrage near the India–Bangladesh border. Commissioned in 1975, the barrage, one of the longest in the world (2.6 km long), was conceived during colonial times but implemented by Indian authorities in the post-independence period. The constant oscillation, shoaling and accretion of the Bengal Delta confounded colonial administrators, and made the region hard to fix, measure, allocate, tax and build on. This led to hydraulic strategies to transform, stabilise and control what was perceived as a threatening and volatile terrain (Bhattacharyya 2021). Farakka was one such measure, designed to divert water to flush out 'problematic' sediment deposits from the Kolkata Port and improve the navigability of the Bhāgirathi–Hooghly river system, to increase revenue (Mukherjee et al, this issue). While this immense infrastructural insertion sought to separate water and its sediments, based on colonial conceptual frameworks, it had many unforeseen consequences (Micheaux et al 2018). The silts, sediments and waters of the delta did not conform to modernist hydraulic techniques, behaving in unpredictable and unexpected ways. The structure not only increased sediment deposits in the Kolkata Port and adjacent shipping channels, it also disrupted downstream water flow and sediment movements with volatile ramifications for hilsa and the fishers who depend on them.

The barrage triggered calamitous changes in Bangladesh. Downstream, rivers became shallower with some drying completely, profoundly altering hilsa movements (Gain and Giupponi 2014). Depth is important for non-human species that move *through* rivers. Being a light-sensitive fish, hilsa prefer to stay below the euphotic zone, requiring a depth of 18–20 metres for stress-free migration (Hossain et al 2019). Following its construction, mature hilsa can no longer be found upstream of the barrage, hindering their breeding migration (Das et al 2017). Fishers also believe Farakka causes siltation that further obstructs hilsa movements. As Abdul explained, 'The water flow in the Meghna is failing, the bottom is silted up. Now due to siltation there are islands in the river. If hilsa face such obstacles, they turn and go back to sea.' By modifying the flow, depth and underwater topography of rivers, the barrage produces 'nonhuman mobilities and immobilities that radically alter the dynamics of life' (Barua 2021: 1).

Effects of the barrage are compounded by changing weather patterns, which further affect river depth and flow. Although the monsoon is broadly predictable, it is becoming less so with climate change. Trends suggest Bangladesh's summer monsoon season is becoming shorter and rains more erratic. Hilsa time their migrations with the monsoon because rains swell the rivers, enabling upstream movement. As rains help hilsa to travel, fishers eagerly await their arrival. However, Chandpur fishers told me: 'before there was a rhythm of raining. Nowadays the rhythm is not there, it is absent, the pattern is changing.' Without sufficient rainfall, rivers are too shallow for this deep-water-loving fish. As Abdul explained: 'there is not enough rain, the river is still very shallow. They need enough water at the mouth of the Bay, but it is not the right height, they want more.'

Due to hindered upstream migration, fishers are catching more fish in coastal areas. As Abdul told me, 'Once we caught hilsa from the river, but now the situa-

tion has reversed. We are collecting more hilsa from the sea and the river harvest has reduced.' Fishing in the turbulent bay requires motorised boats, mechanised vessels, larger nets and sonar devices, which few artisanal fishers can afford. Many are forced to take loans from moneylenders, which ensnares them in vicious cycles of debt, or they work seasonally as labourers on the boats of wealthy owners, and some even search for work on deep-sea commercial trawlers. Venturing out into the Bay of Bengal is highly risky due to tropical depressions and cyclones, which regularly cause financial losses and casualties (Islam et al 2020: 1). Because the hilsa fishing season coincides with the monsoon, it aligns with months of heightened cyclonic activity. The bay is experiencing greater turbulence due to climate change, with cyclonic intensity increasing. As fishers are forced into the bay following the fish, their vulnerability to extreme weather intensifies, demonstrating how non-humans can transform human lives through their shifting movements.

The Scientist

In recent decades, Bangladesh has seen dramatic changes in hilsa populations. Hilsa catches from inland waters declined by 41 percent compared to the 1960s (Rahman et al 2019: 53). Catches of mature hilsa reduced while under-sized young hilsa increased, indicating an unstable population and intensifying anthropogenic pressures. During the twentieth century, Bangladesh experienced remarkably high urban growth following independence in 1971. After intense socio-political and environmental upheaval, kick-started by the Bhola cyclone and the liberation war, Dhaka became one of the fastest growing cities in the world. Between 1990 and 2005, the capital doubled in size, from 6 to 12 million (Benton-Short and Short 2013: 191), gaining megacity status. Increased purchasing power of urban middle classes led to greater fish consumption (Apu 2014). As demand for hilsa spiralled, unsustainable fishing proliferated. Hilsa catches fell to record lows in the early 2000s, prompting concerns of a fisheries collapse.

Bangladeshi scientists stepped in to stabilise volatile hilsa populations, partly due to their contribution to the national economy. The hilsa fishery is estimated to generate US$1.3 billion annually, approximately 4.3 percent of the country's GDP (Porras et al 2016). A network of national government research stations is tasked with carrying out hilsa research, alongside international organisations, to conserve the species. Having previously worked within these agricultural research networks, I used my contacts to connect with scientists. Spending time at a riverine research station, I observed how this technoscientific industry has created yet more livelihoods revolving around the fish, adding to the plethora of ways in which hilsa influence emergent humans and their socialities.

Mohammad, a junior scientific officer stationed at a government research station, focuses on understanding hilsa breeding and migration patterns to inform fishing policies. Partly educated abroad but having returned to Bangladesh to work on hilsa, his research involves spending weeks on boats, netting, examining, weighing and observing fish. Hilsa are caught from specific locations at different periods to understand the

spatiotemporal dynamics of their lifecycle. Interactions with fish are proximate and intimate. Males and females are stripped of milt and eggs to assess sexual maturity. Body condition is examined, with lean, thin forms indicating diseased or spent fish. Observations are verified through dissection. Through sensorial contact, scientists gain in-depth understandings of hilsa lifeways. The resulting knowledge is produced not through human efforts alone but through distributive agency (Straughan 2015: 365), with hilsa playing a vital role, even in death.

Scientific research has revealed that peak hilsa spawning occurs five days before and after the full moon during the Bengali month *Ashwin* (September to October), towards the end of the summer monsoon season. The reasons are not well understood, but scientists believe it may be due to huge tidal fluctuations that occur at full moon when rivers are in peak flow. As Mohammed explained, 'Now at the beginning of the monsoon season, the tide will be around ten to twelve feet high, but during full moon in the month of October, it will be around fifteen to twenty feet higher than the normal range.' He speculates that gravid females and oozing males time their spawning migration to coincide with the tidal fluctuations and seasonal eddies, because eggs and milt 'get a chance to mix properly in the water'. Strong winds and current velocity also facilitate movement and high turbidity provides food and camouflage.

While scientists struggle to comprehend the swirling, unruly and unpredictable hydrological complexity of the delta, fish flourish within these material mobilisations. Although monsoonal waters may appear chaotic, hilsa are able to perceive rhythms within the turbulence. Through dissecting and investigating the anatomical features of hilsa, fisheries researchers have discovered that lunar-tidal rhythms are so profound they are inscribed in the body of the fish. Small calcifications, called otoliths, accrete through the life of a fish, serving as temporal markers that reveal fish life histories (Swanson 2017). Hilsa otoliths have rings that appear rhythmically, corresponding to the lunar-tidal cycle; thinner rings form during neap tide periods, and thicker rings during spring tides when hilsa are most active (Rahman and Cowx 2006: 343). This suggests that hilsa depend on a 'dynamic pattern of repetition and reformation that provides stability and texture in an environment of underlying instability' (Steinberg and Peters 2015: 248), and highlights the extent to which hilsa are materially constituted by their environment.

Drawing on scientific information painstakingly collected from hilsa flesh, in 2011 the Bangladesh government introduced targeted temporal and spatial bans, informed by lunar-tidal and monsoonal cycles. Although bans are not physical interventions, they form a policy infrastructure that strives to order and regulate human–hilsa relations. A 22-day fishing ban is imposed in October at the end of the summer monsoon season to save 'mother hilsa'. Another is put in place from March to April in the pre-monsoon season to allow juveniles to return to the ocean to mature. As one fisheries researcher explained: 'The strict ban period is March to April. We say, now it's your turn to go back to the ocean. Go peacefully, without interruption.' This knowledge is not new: traditionally, Bengalis would not consume hilsa between October and February, the major hilsa breeding season (Das Gupta 2010a). Such practices deteriorated as urbanites with disposable income began eating hilsa year-round, no longer adhering to seasonal rhythms.

Fishing bans have had a positive impact on fish populations, with hilsa numbers increasing markedly in recent years. However, attempts by scientists to reassert seasonal consumption have unsettled the livelihoods of artisanal fishers who now rely on fishing throughout the year. Bans result in loss of income, making the lives of already vulnerable fishers more precarious. Although the government provides incentives, including supplies of rice and support for alternative income generation, these exacerbate socio-economic tensions. Rice sales fall during ban periods, affecting retailers and farmers; fishers seek alternative work as labourers, reducing local wages resulting in conflict; demand for credit increases, leading to rising interest rates plunging fishers further into debt (Mohammed et al 2014). While bans introduce some protection for the fish, because hilsa support millions of people the volatile effects of bans ripple through social worlds, with many flouting the restrictions, threatening their effectiveness. Fisheries researchers have tried to find other solutions, such as artificially rearing hilsa, but despite intensive research they refuse to breed in captivity, perhaps because they need the turbulent waters and complex rhythms of the delta, which cannot be easily replicated in human-made environments.

The Cook

Hilsa is cooked in a myriad of ways: *pantaa ilish* (with fermented rice), *ilish bhaja* (fried), *bhapa ilish* (steamed), *ilish tel jhol* (hilsa broth) and *shorshe ilish* (cooked in mustard sauce). Shibu, a university lecturer and keen amateur cook, told me that purchasing is an essential part of the cooking process. River hilsa are tastier than marine hilsa. The smell, taste and flavours of fish change as they migrate (Alam et al 2019). Fat and protein ratios adjust as they move upstream, their flesh taking on the taste of the river as ocean salinity is washed away (Ghosh 2017). The longer they spend in *mishti johl*, or sweet water, the tastier they become. The most delectable hilsa are those that travel farthest upriver (Das Gupta 2010b), their taste peaking with the monsoon. According to Shibu, 'These are things you learn through osmosis if you are born here.'

Taste varies from river to river, and purchasing often revolves around determining whether fish were caught in the Padma or Meghna River. As Shibu explains, 'When you go to the market, the first thing you learn is how to spot a Padma from a Meghna hilsa.' *Poddar ilish*, or hilsa from the river Padma, are considered the tastiest of them all. Their taste is attributed to the particular characteristics of the river and its waters. Meghna, another keen cook, told me: 'The Padma meanders all over . . . before coming to Bangladesh. As it travels, it collects sediments. The river produces the best, most tasty hilsa because of the sediment it gathers on its journey.' The qualities of the Padma contribute a unique taste and mouth-watering smell that Bengalis find irresistible.

To get from rivers to markets, and between markets, hilsa are packed in ice and boxes or baskets and carried over long distances via water, road and rail. As a valuable yet perishable commodity, fast transportation is required to prevent spoilage, but this is often hindered by inadequate infrastructure (Shareef et al 2020). Construction of 'all-weather roads' is a priority for Bangladesh to allow movement in all seasons and improve connectivity. The Padma multipurpose road–rail bridge, one of the lon-

gest river crossings in the world (6.15 km), aims to stabilise transportation and stimulate economic growth by replacing a 'hazardous ferry' and 'saturated road network', providing a reliable link between the capital Dhaka and the 'poverty-stricken' southwest (Sham 2015). Commissioned and financed by the Bangladesh government, the bridge is one of the largest infrastructure projects the country has ever undertaken. Despite national and international criticism, the Prime Minister has declared the project 'a symbol of Bangladesh's pride, honor and ability' (Mahmud 2022: np). While this immense structure may help to stabilise routes to market and regulate commodity chains, making it a site of hope and promise, it is also thought to be contributing to the decline of the country's most delectable hilsa (Roy and Tusher 2015). The bridge demonstrates how infrastructures become '*agents* that interact unpredictably with other bio-chemical, ecological and socio-economic agents' in complex ways (Jensen and Morita 2020: 4).

During monsoon months, the Padma River is fast flowing and morphologically dynamic. To stabilise the bridge, 42 columns have been installed across the river, demanding extensive piling and dredging (Hasan 2019). 'River training' is also being undertaken, including a ten-kilometre embankment (Neill et al 2010). Such attempts to 'harness', 'tame' and 'control' rivers (Lahiri-Dutt 2000: 2399) have been part of infrastructural developments since colonial times, with violent impacts on river ecologies. As well as constraining river flow and morphology, construction causes significant underwater noise and vibration, to which hilsa are highly sensitive (Roy and Tusher 2017). Hilsa navigate using a system of tactile sense organs that detect movement, vibration, pressure and obstacles. The intramuscular pin bones that make hilsa challenging to eat may be part of this sensory system, helping them detect tiny changes in the water (Sahu et al 2014). Pile-driving generates loud noise and vibrations, churns up the river bed and increases turbidity, driving fish away. Such disturbances will continue after the bridge's completion as noise from road and rail traffic will be transmitted through the water, resulting in a loss of fish feeding, breeding and nursing sites (Bangladesh Bridge Authority 2010: 63).

By altering river ecologies, infrastructural interventions make underwater environments more volatile, affecting the taste, smell and texture of fish, which is sensed by those who consume them. In Bangladesh, eating is tactile, 'Bengalis eat everything with their fingers . . . What after all, could be better than one's own sensitive fingers to pick out the treacherous bones of fish like hilsa . . . the fingers provide an awareness of texture which becomes as important as that felt by the tongue' (Banerji 1991: 18). These sensory interactions are 'knowing' activities that make people intensely aware of the food they consume (Heldke 1992: 212), fingers and tongues forming sites of engagement where much bodily knowledge resides.

According to many, the taste of hilsa is changing. As Shibu explained, 'Hilsa come with a smell, a strong aroma, but nowadays, the quality is not good . . . I don't know why their aroma and taste has changed but I think it reflects environmental disturbance everywhere.' Stress from altered riverine flows and sediment regimes may be changing hilsa palatability. Research has found that high concentrations of hyperoxides, compounds that accrue in the body during stress, cause foul smells and bitter taste in fish (Bane 2015). The sudden deterioration in the quality of hilsa is a cause of deep concern

and anxiety, discussed over meal tables, at market places and in newspapers. Although hilsa are still present in the delta, they are withdrawing from the Padma River, affecting human lifeways in the process. Unexpected ecological transformations, such as those affecting *Poddar ilish*, impact people's sense of place, their identity, physical and mental health and general wellbeing, even leading to 'solastalgia', distress caused by changes occurring in people's home environment (Albrecht et al 2007). Such volatilities, and the emotional responses they elicit, indicate that as a cultural keystone species, the decline and potential future loss of hilsa will fundamentally alter regional ecologies and the cultures they support.

The Activist

Sharif, an environmental activist, is not hopeful about the future of the fish: 'Hilsa will disappear from Bangladesh within the next ten years because the survival of our rivers is in question.' He grew up in Old Dhaka on the banks of the Buriganga River, and witnessed it transform into one of the most polluted rivers in the world. Its once clear waters are now a glossy blue-black, covered with islands of rampant water hyacinth which feed on pollutants, blocking light and reducing oxygen levels. The river carries an indescribable, all-pervasive stench, resulting from effluents spewed from garment factories, tanneries, cement plants and fertiliser manufacturers along its banks. The river that once hosted hilsa in abundance was declared 'biologically dead' in 2010 (Khan 2010).

Sharif works to protect the river, observing and reporting factories along the river that discharge untreated wastewater. The industries along the Buriganga reflect national efforts to reach middle-income country status by moving away from an agricultural economy affected by erratic rainfall, floods, temperature extremes, river erosion and cyclones. The garment industry, which produces cheap clothes for western consumers, has grown exponentially under neoliberal policy arrangements. Since the 1970s, the sector has become a central pillar of the country's economy, fuelling Dhaka's rapid expansion (Cullen 2022). Garment production depends on water in virtually all steps of manufacturing. Profits rely on 'cheap labour' and 'cheap nature' (Moore 2015), with factories utilising 'free' hydrological resources. Disposal of untreated waste is widespread, operating on a perception that rivers and oceans can endlessly absorb inputs (Rahman et al 2019). The same monsoonal mobilisations that hilsa depend on for their upstream migration are utilised by factories to dispose of wastewater and effluent, seasonal inundations helping to wash unwanted by-products downstream.

Although many welcome the economic growth that such industries bring, the benefits are unequally distributed, and while export-led industrialisation strives to stabilise the country's economy, the material outputs have destabilising and unwanted effects for some. As the monsoon carries pollutants downstream, fishers report yellowish 'jaundiced' water in the mouth of the Meghna estuary, which they attribute to flows from the Buriganga (Deb 2015: 543). As contaminants become pervasive, they form 'chemical infrastructures' (Murphy 2017), pathways and processes that materi-

ally shape human and non-human life. As these are largely imperceptible, fish play a key role in alerting people to their presence through their altered behaviour.

Fishery experts in Bangladesh believe pollutants are partly responsible for changing hilsa migration routes. As one researcher explained: 'When the river water carries that water from Dhaka city they don't migrate. Hilsa can smell hydrogen sulphide, that rotten egg smell.' During their freshwater migratory phase, many anadromous fish locate spawning grounds via olfactory cues (Plec et al 2017). It is not known whether hilsa rely on such cues to navigate, but research shows they have a highly developed olfactory organ, making them sensitive to smell and taste (Malick et al 2018). While such scientific understandings are not common knowledge, people have an intuitive understanding that pollutants act as olfactory disruptors. As Sharif explained: 'Hilsa are a very special fish. They are extremely sensitive, as soon as they sense pollution in the water they will stop coming to avoid it.' Through his activism, Sharif communicates with communities around Bangladesh who report that pollution is already affecting hilsa migration routes.

While changing migration may be due to the repellent effect of pollutants, more pernicious dynamics could also be at work. Fish concentrate pollutants in their bodily tissue, directly from water and through food. Persistent organic pollutants are hydrophobic (water hating) and lipophilic (fat-loving). In marine systems, they bind strongly to solids, entering organisms where they are stockpiled in fatty tissue (Ashraf 2017). As a carnivorous species, hilsa concentrate contaminants to a higher degree than other species (Das and Das 2004). Pollution absorption has complex neurotoxic effects on fish behaviour, personality and cognition, making them unpredictable. Chronic pollution affects fish dispersal and migration, their impeded mobility further increasing their exposure (Jacquin et al 2020). Studies also demonstrate reproductive impairment in fish exposed to high levels of pollutants, implying that aquatic contamination may impede recovery of populations even in the absence of fishing (Dewhurst-Richman et al 2016: 47). Such intra-actions indicate that pollutants may be playing an agentive role in changing delta dynamics. As they make their way into the waters of the delta, these recombinant substances create 'volatile ecologies' (Barua 2014), with profound implications for fish and human–fish relations.

Although scientific research has generated inconclusive results on the impact of pollutants on hilsa populations, Sharif speaks regularly with people who rely on rivers for their livelihoods, usually the most economically marginalised. River dwellers report increasing occurrences of diseased hilsa, which they attribute to rising pollution levels. Those who share the river with the fish, and utilise the same waters for drinking, washing, cooking and bathing, have an embodied understanding of the impact of pollutants. As the river becomes more contaminated, skin diseases and lesions are common complaints. Pustules that fishers observe on the scales of fish are something they are intimately familiar with, as their own bodies increasingly blister and itch from the river water.

These human–fish correspondences draw attention to the fact that our planetary hydrocommons 'is not just a network of interconnected geophysical and meteorological waters; it is also made up from all the bodies that materialise and transform these

waters in their own fur and flesh, and in their celled and cyborg forms' (Neimanis 2012: 111). These bodies intra-act with 'perpetual flows of water, nutrients, toxicants and other substances' (Alaimo 2010: 157–158). As industrial chemicals permeate human and non-human life, their effects cascade across bodies; however, the harm they cause is often unequally distributed (Murphy 2017). Whereas those who attempt to control and stabilise are often furthest removed from delta ecologies and buffered from the volatile effects, those who are most viscerally entwined are more vulnerable, with limited power to effect change. Despite the efforts of activists, the knowledge of the marginalised – be they human or fish – is not enough to combat the powers that profit from these aquatic contaminations.

Conclusion

Following hilsa through social worlds reveals that the Bengal Delta is not a passive background to social life, but a dynamic monsoonal space, formed through intra-active processes of mutual becoming in which bodies and places are intimately entangled. Far from being an inert, empty space or a 'resource' for human use, the delta is 'a world of fleshy beings' (Alaimo 2018: 2) who hold valuable knowledge about the waterworlds in which they reside. Engaging with the fleshy being of the hilsa fish provides insights into the relational configuration of delta ecologies, which are shaped by a multitude of human and more-than-human forces, processes of colonial and capitalist expansion, and the volatile consequences of attempts to stabilise, leverage and control them. Although such volatility may be set in motion by human interventions, it manifests through complex intra-actions between diverse agents at multiple scales from monsoon weather and delta river systems, to sedimentary particles and the fatty molecules of fish.

Changing movements, behaviours and propensities of hilsa offer insights into how aquatic life is responding to such interventions and highlight the value of non-human perspectives, which are often marginalised, ignored or undervalued. Understanding how animal bodies respond, and the implications, broadens the range of sentient subjects through which deltas are sensed and known (Barua 2021), disturbing the idea that human beings are the sole benefactors of and contributors to such environments. Hilsa also show that relationships between humans and other species are co-constitutive – and that such 'companion species' (Haraway 2003) are lively participants that play agentive roles in delta lifeworlds. With this in mind, understanding deltas should not be a single-species project but one that recognises and incorporates knowledge that emerges within 'biosocial loops' (Rose 2013) and human–non-human entanglements.

The fisher, the scientist, the cook and the activist reveal the plethora of ways in which people know, relate to, engage with and depend on hilsa. Entangled with multiple human agents, the fish shows how one species can have manifold relations with different people, places and things. Their stories and experiences, which overlap and interconnect, point to the nuances and complexities of human–fish relations that shape and are shaped by political, economic and cultural forces. Embodied and sensory understandings resulting from these relations reveal an array of perspectives on

volatility and the unequal experiences and uneven consequences of rapid delta transformations for fish and people. These perspectives show that not all beings experience volatility in the same way: what may be volatile for humans may not be volatile for non-human species, and vice versa, with a diversity of experience within and between species.

Although humans and non-humans may inhabit, perceive and know environments differently, ultimately these modes of habitation intersect, albeit in complex ways – their entanglements contributing to the formation of shared landscapes within a shared world. As a transboundary monsoonal organism, hilsa–human relations are not restricted to Bangladesh; the fish is loved across geographies, nationalities, religions, environments and culinary traditions. My fieldwork in Bangladesh formed part of research in three cities around the Bay of Bengal, with hilsa emerging as a significant species in each. Over five years it became apparent that, despite cross-border affections for the fish, anthropogenic activities are impacting hilsa lifeways around the bay. In Tamil Nadu, hilsa no longer ascend the Cauvery River because of the Mettur dam, in West Bengal hilsa are shifting from the Hooghly River due to siltation, and in Myanmar water pollution is affecting hilsa populations in the Ayeyarwady Delta. Although the political, economic and cultural assemblages in each of these places are distinct, hilsa provide a common connection. Through their entanglement in diverse social worlds, hilsa reveal that volatility manifests across bodies and borders, requiring transcorporeal and transboundary collaborations.

Storying how volatility is perceived and experienced across human–non-human bodies serves to displace separations between humans, the environment and non-human species and highlights the importance of anthropological holism for understanding more-than-human assemblages. It also demonstrates the necessity of exploring connections and tensions between human and non-human agencies when they meet in unequal, dynamic and unpredictable ways. Volatility as a framing device (Krause and Eriksen, this issue) has enabled a nuanced exploration of rapidly changing delta landscapes at different and interconnected scales, from a range of sensory perspectives. In this time of climate change, pollution and mass extinction, sensing and empathising with non-humans is imperative. Acknowledging transcorporeal multispecies relations, and working with understandings that emerge through embodied and sensory encounters, may offer ways of navigating current and future planetary volatility.

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Les eaux changeantes du delta sous l'influence de la mousson: Percevoir la volatilité d'un espace aquatique particulier à travers le poisson hilsa

Résumé: Cet article analyse la volatilité du point de vue du poisson hilsa dans le delta du Bengale. Le hilsa, également connu sous le nom de *ilish* en bengali, exploite la dynamique hydraulogique de la mousson au cours de son cycle de vie. Aujourd'hui, on constate que le poisson hilsa a changé en réponse aux activités anthropique qui tentent de stabiliser l'espace du delta contre sa volatilité perçue. Cette action créé une nouvelle volatilité qui est perçu par les personnes vivant étroitement avec le poisson hilsa. L'étude est basée sur une ethnographie multisite et des interactions avec un pêcheur, un cuisinier, un scientifique et un activiste écologique au Bangladesh, dont l'objectif était de comprendre comment les expériences avec et l'étude du hisla permettent de saisir les transformations de l'environnement à l'œuvre. Le savoir incorporé des rythmes de vie du hilsa à travers l'activité de pêche, de cuisine, de dissection ou de surveillance donne à voir les réverbérations sur le non-humain de la volatilité induite par l'homme.

Mots-clés : bassin fluvial du Bengale, ethnographie sensorielle et multi-espèces, mousson, poisson hilsa