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A lateral line organ for slow co-engaged science for hot messes

Significance:

Surfacing the connections between science engagement, engaged science, and sustainability sciences, we urge a re-evaluation of sustainability science's beneficiaries and goals, by advocating a transdisciplinary approach to address sustainability challenges, based on a relational ontology. Thinking with posthumanist, feminist new materialist and Black feminist theories, we consider the importance of multispecies attention and empathy in scientific research. We propose a concept of evolving new perceptual organs in humans to enhance collective responsiveness, inspired by the lateral line organ in fish and their collaborative intelligence for navigating contemporary social and ecological crises and injustices in 'hot messes'.

Introduction

In this Commentary, we propose a co-engaged 'Slow Science' research in (and beyond) the natural sciences to trouble the perceived gap between science and society. The capitalisation of 'Slow' signifies a focus on depth and quality of engagement rather than simply moving at a slow pace in terms of time, aligning with the principles of the 'Slow movement', Such a research practice is predicated on a relational ontology, which sees the world as entangled and relationships as the way in which entities come into being, rather than assuming that the world consists of discrete, individual entities, with pre-existing characteristics or properties. Such a relational ontology alters the entire orientation of how science is practised, what is entailed in science engagement, and what the nature of an engaged science is. For example, when we consider 'hot messes', or what McGarry[1] calls "hot-stinky messes", to problematise or make messy the concept of sustainability, the notion of *intra-action*, is a crucial one. Intra-action is a neologism developed by the quantum physicist and philosopher, Karen Barad[2], as part of their relational ontological framework called agential realism. Barad distinguishes intra-action from interaction. Interaction assumes that individually constituted entities exist *a priori* and exert an influence, or act on each other, whereas intra-action disrupts this metaphysics of individualism by holding that entities materialise through the intra-action itself. From this viewpoint, individuals only exist in phenomena, where phenomena are "the entanglement — the ontological inseparability — of intra-acting agencies. (Where agency is an enactment, not something someone has, or something instantiated in the form of an individual agent.)"[3]

The warming world comes about through the intra-action of colonialism, capitalism and its most recent incarnation: the neoliberal market-oriented myth machine. Hot messes are necessary to move our thinking beyond the confines of sustainability, to allow for sustainability's shadow side to emerge. The future-obsessed (often historically blind), solution-driven orientation, which erases the reality of wicked problems[4], where solutions can lead to their own problems, feeds into multispecies extinction, GMO fallout, food insecurity, poverty, fossil fuel extractivism and its subsequent historical and contemporary displacement of people, ecosystems and worlds. All of which are fuelling the hottest the earth has been in recorded history. As Stacy Alaimo notes in her scathing critique of how science and objectivity are used to bolster the discourse of sustainability, it "proceeds with the presumption that human agency, technology, and master plans will get things under control"[5], when it is patently obvious that some humans (the privileged minority) have caused irreparable hot-stinky messes for the vast majority.

As such, a techno-scientific solution and future-driven approach to reified concepts like sustainability might not be the best response to such hot messes, particularly in the 'thick present'.[6] In South Africa, in the city of Durban in 2020–2021, we witnessed political insurrection, the COVID-19 pandemic induced lockdown and the worst floods in our history, over the space of 18 months. What allowed for citizens to respond to such a hot mess and sustainability crisis, was not the Sustainable Development Goals (SDGs), sustainability science innovation, nor sustainable government policies, but rather communities of care, which were responsive, had capacity for 'calling and responding' and that practised, convivial community-led meaning-making and citizen responses. As such, we feel it is important for scientists and engaged sustainability scientists to develop organs of perception, codes of practice and forms of rigour that allow for collaborative meaning-making and sense-making, in the thick present, that are also sensitive to the colonial, racist and violent histories that created modern scientific practices. The failures of sustainability science, from our perspective, are failures of perception, of sense-abilities, and of empathetic attentiveness.

The separation of science from social and cultural factors is a hegemonic ideology that blocks a more inclusive understanding of science's entanglement with various histories and worlds. Feminist science scholars, such as Donna Haraway, Karen Barad, Isabelle Stengers and others have challenged this separation and highlighted the porosity of the boundary between science and society. Furthermore, African scholar Bagela Chilisa[7] argues that traditional Western scientific methods may not always be appropriate or effective when conducting research in African contexts. She emphasises the importance of incorporating indigenous knowledge systems, cultural beliefs, and values into the research process to ensure that it is relevant and meaningful to the communities being studied. From an African perspective, science is seen as a holistic and interconnected system that values different ways of knowing, including spiritual and intuitive knowledge, in which knowing and knowledge is ecological and plural and not limited to individual forms of knowing.

Mkhize and Ntšekhe[8] show how idiomatic reasoning allows for conceptual pathways to be opened in meaning-making. Inspired by idiomatic reasoning, which oftentimes includes other animals, we draw on idiomatic reasoning

with fishes. Contemporary Black feminists like Alexis Pauline Gumbs[9] are developing their form of idiomatic reasoning through embodied scientific inquiries, such as learning from marine mammals. This process of empathetic encounters leads to the development of heightened sensory organs, altering how humans and scientists perceive themselves. Gumbs posits the undoing of traditional Western human definitions intertwined with separation and domination – something that has been keenly and painfully felt in South Africa, and the Global South.

As such, we imagine a new organ of understanding for sustainability science and engaged science, through imagining the growth of a lateral line found in fishes, an organ that might expand our conceptions of scientific education beyond our normative framings of school, classroom, curricula and pedagogies, into a shifting, dynamic, relational ontology, which merges with schools of fishes that change, pivot and respond with micro-empathetic adjustments to each other.

What would sustainable science say if we asked the right questions?

When thinking of how to engage sustainability science, we witness first-hand Vinciane Despret's[10] concept of "rendering each other capable", in which each fish's movements, ability to respond (or response-abilities) and attentiveness to each other, creates an empowerment that fosters interconnectivity, mutual imbrication and a shared relational agency. Despret[11] also asks, "what would animals say if we asked the right questions?", and we ask – how might Slow Science be used to render each other capable as forms of engaging in sustainable practices?

In order to consider how to ask such questions, we refer to a chapter which we co-wrote[12], in which we ask these questions of the physiology of fish. The chapter refers to our collective yearning for a Slow Science, in an attempt to move away from a science that is neutral, objective, or apolitical. We reinforce how scientific findings and research have real-world consequences that are deeply political, and influence justice in ways we often can never fully predict, and we argue that a central proposition for Slow Science is to develop a 'lateral line' organ of perceptivity, which is a science that is inherently a practice in solidarity.

The lateral line

The lateral line (Figure 1), present in most fish[13], is composed of fluid-filled canals running along a fish's body sides just beneath the skin[14]. This system is vital for sensing water movement and pressure, crucial for behaviours like schooling. Specialised sensory cells called neuromasts within these canals detect mechanical and hydrodynamic cues in the water. Neuromasts feature cilia sensitive to water flow, which bend upon contact to generate electrical signals to the fish's brain. Schooling offers fish benefits like predator protection, improved foraging, and better navigation, facilitated by the lateral line system for communication and group cohesion.

The concept of the lateral line could offer insights into understanding through fish physiology, insights into expanding our care and relational capacities in slow sustainability science, engaged science and solidarity science. We suggest that cultivating social perceptual organs (i.e. practices, principles, and ethics) could enable a form of solidarity akin to 'schooling', fostering a lateral awareness that directs our focus towards the well-being and ongoing iterative, attentive, affective relational encounters of those around us. If such a social organ could be cultivated within sustainability science, scholar activism and solidarity research, we could engage in knowledge co-creation that is responsive, caring, and accountable, prioritising attentiveness and responsibility in scientific endeavours.

Learning to move in the dark

Consider the ancient ancestors of modern fish, residing in an enigmatic world of perpetual darkness or turbid waters, that evolved sensory mechanisms that allow them to navigate and thrive in their environment; the lateral line system emerged as one such sensory adaptation, and is considered by some ichthyologists as the most critical sense for fish. We use the lateral line as a figuration, to surface ways of being, knowing and doing that could benefit from a peripheral 'distance touching' in how

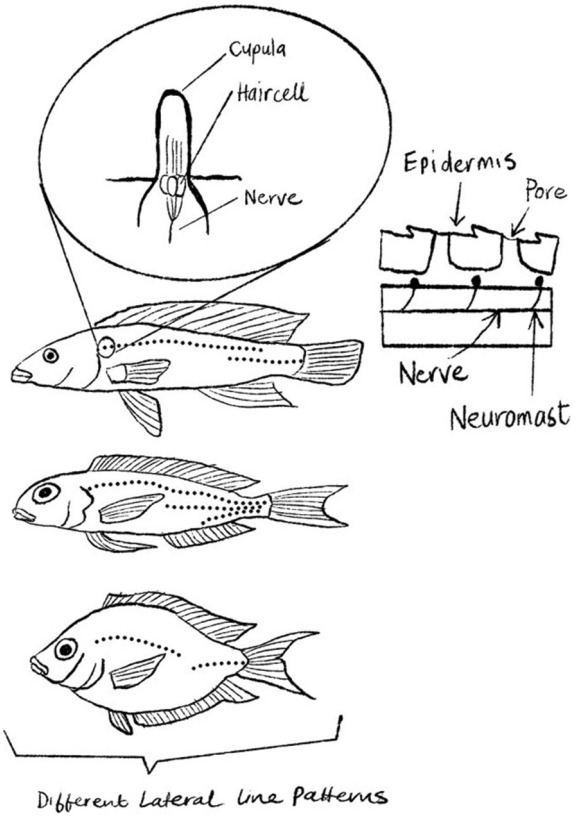

Figure 1: Fish rely on their lateral line system of fluid-filled canals housing neuromasts sensitive to water movement, essential for behaviours like schooling.

we inhabit and conduct scientific research. Inspired by Stengers' work on Slow Science[15], an engaged sustainability science must balance addressing broad societal issues with nuanced, specific analysis, reflecting the lateral line's ability to adapt to diverse environmental demands.

Touching the space between us

The lateral line in fish facilitates communication through detecting movements and vibrations, allowing for swift coordination within the school as fish sense changes in water pressure and temperature between them. This unique ability to 'distance touch' challenges the conventional idea of touch requiring direct physical contact, underscoring the importance of perception and sensory connections. How can we touch each other in this way, towards a collective response-ability?

The reef-dwelling cleaner wrasse (*Labroides dimidiatus)* is a vibrant small fish that is highly regarded for its careful and thorough cleaning habits (Figure 2). The fish set up designated cleaning spots on coral reefs where they cater to various 'customers', such as larger fish, by eliminating parasites and old skin cells. Cleaner wrasse play a crucial role in preserving the well-being of reef ecosystems. Their cleaning not only benefits the creatures they service but also contributes to controlling the transmission of parasites and diseases within the coral reef community. This symbiotic relationship illustrates the complex interactions among species in marine settings.

Predatory fish frequent these cleaning stations to rid themselves of parasites and shed skin. These predators temporarily cease their perpetual forward movement, their hunting activities and slow down, open themselves up to inspection while being cleaned, enabling smaller cleaner fish to fulfil their essential function in sustaining the ecosystem's health. Through these affective relationships, cleaner wrasse and 'client' become significant subjects and objects for each other where a deeper, more intimate touching and cleaning take place. In this way, bodies are rendered capable through their significance for each other, where each partner is changed in their encounter.

In the realm of science, equipped with a lateral line, 'distance-touch' and 'temporarily allowing ourselves for cleaning' speak to our ethical responsibility in how we engage with our surroundings. McKittrick refers to a form of science that acknowledges its past involvement in scientific racism and actively seeks accountability as it progresses forward. She explains that our understanding of Black life is created by interconnected but asymmetric (oftentimes sovereign) knowledge systems. Science is only a part of this exploration, tied to the other ways of knowing, being and doing in the world, but is also restless, uneasy, and multifaceted, rather than an absolute and oppressive force.

Sustainability science needs to slow down and allow itself to be cleaned of its past involvements in harm and racism, and develop an accountability that requires this stillness and vulnerability demonstrated by predatory fish and cleaner wrasse.

Schooling or shoaling?

The lateral line is vital in maintaining group cohesion among fish (Figure 3). When swimming closely together, fish's lateral lines are near each other, allowing them to sense the movements of nearby individuals, without bumping into each other. This continuous feedback loop (or what Kulundu et al.[16] referred to as "call and response transgressive learning" emergent in South Africa and the Global South) enables fish to adjust their swimming speed and direction to stay together, preventing straying or separation from the group. We emphasise the importance of research inquiries conducted collectively, iteratively, transparently, and ecologically, with a readiness to challenge conventional identities and disciplines, and move as an intuitive and relational collective.

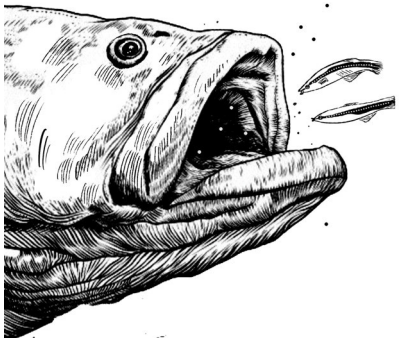

Figure 2: Cleaner wrasse cleaning the mouth of a predatory grouper. We explore this practice as a figurative practice of accountability in sustainability science.

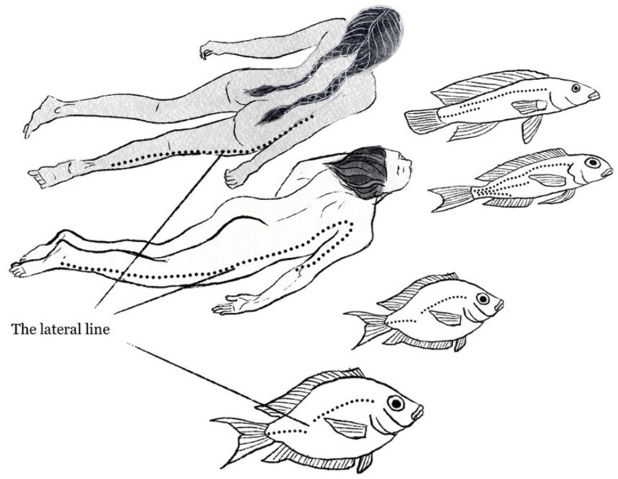

Figure 3: The lateral line in fish aids in maintaining group cohesion by enabling them to sense nearby movements without colliding. This feedback loop, known as call and response transgressive learning, helps fish adjust speed and direction to stay together. We imagine this organ to aid our think and theorising into the value of collaborative, iterative, and transparent research.

Bruno Latour[17] calls for matters of concern, rather than matters of fact, which was further expanded as "co-defining matters of concerns" by Lotz-Sisitka et al.[18], where concerns are surfaced iteratively throughout the research design, and this creates research that is more accountable, inclusive, responsive and based on principles of solidarity. Decolonial scholars reject the 'universalist' assumptions inherited from the Enlightenment era and advocate for a pluriversal approach to research, where research questions are collaboratively defined. Rather than seeking to capture and universalise knowledge, these scholar-activists employ various sources and narratives to question the act of capturing itself and the underlying motivations behind it. This is one way sustainability science can learn to shoal/school in dynamic processes of relationality.

Mkhize and Ntšekhe[8] discuss how pre-colonial forms of reasoning were inherently idiomatic, utilising idioms, proverbs, and myths as interpretive tools for understanding and responding to immediate struggles. This underscores the importance of storytelling and active listening as a lateral perception tool that could support the advancement of Slow Science. The lateral line could employ storytelling and active story-listening (engaging in both learning and unlearning) as a method of 'call-and-response' research, as one way of developing a lateral line organ. Kulundu et al. illustrate this concept by likening it to the practice of call-and-response singing in southern Africa. This iterative and continuous process of creating meaning serves as a form of 'endemic method-making', adapting to localised and contextual changes in our immediate environments. Just as a school of fish adjusts to an oncoming threat or obstacle in its dynamic aquatic realm, this involves embracing and grappling with unfamiliar or challenging ways of knowing that may lie outside our own belief systems or worldviews, fostering an inclusive approach to diverse forms of knowledge created beyond disciplinary constraints.

Slowing down fast science

How might this reciprocity enter into how we practise engaged science? What if we embraced the vulnerability of our science, seeking assistance in removing parasites and outdated concepts or philosophies through a thorough cleaning process? What does it require to become vulnerable and response-able in the very conducting of our research? How might we include others, not just in the collection of data but in the collaborative analysis and meaning-making? What might it look like to co-create claims from said data and analysis?

Perhaps we can answer these questions by first separating science from its alignment with neoliberalism and its associated logics. The commercialisation of science further impedes its effectiveness towards 'so-called' sustainability, and its servitude to society and ecosystem entanglements. The increasing corporatisation of higher education is likely to further impact scientific sustainability practices by fostering competition, promoting hostility towards perceived rivals, emphasising metrics such as Newtonian conceptions of 'impact' and publication outputs, exerting control over research outcomes, complying with managerial requests for reports, pursuing grant funding, and promoting the privatisation and commodification of knowledge for utilitarian purposes. The concept of sustainability science should not solely revolve around speed, efficacy and meeting future-orientated 'sustainability goals' but rather should prioritise in-depth, co-engaged, and present-time research that addresses pressing contemporary issues, incorporating past and future considerations.

Sustainability science in our current era should not be confined to serving industry or academia alone but should extend to addressing a wide array of social, political, cultural, economic, and ecological issues. Knowledge generated through scientific endeavours must not remain exclusive but should be disseminated in diverse forms to facilitate broad access and participation in knowledge creation.

We argue that this necessitates fostering an ecology of practices where diverse forms of knowledge are cultivated across various settings by different participants, allowing for cross-pollination of ideas and perspectives. Slow co-engaged science must transcend academic privilege and engage with the public to enable broader participation and

inclusivity, emphasising that academics are not isolated entities but part of a larger community that should actively involve diverse stakeholders in the scientific process. Moreover, science needs to embrace new modes of engagement, drawing inspiration from collaborative intelligence observed in fish communities as they collectively respond to threats for survival.

This shift towards collaborative science endeavours can be transformative, reorienting scientific and transdisciplinary studies through a diffractive approach that thinks with multiple disciplines and theoretical perspectives. As Stengers[19] highlights, an ecology of practices encourages experimental thinking, emphasising the importance of learning from encounters with others and questioning assumptions. This approach underscores the need for divergent modes of thinking, feeling, and acting, promoting a space where unexpected outcomes and novel insights can emerge, challenging preconceived notions and fostering openness to diverse perspectives.

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Declarations

We have no competing interests to declare. We have no AI or LLM use to declare. All authors read and approved the final version.

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