Listening to Mussels, Listening to Goldberg: A Personal Reflection on "The Mussel Watch" and a Life with *Perna viridis*

Chee Kong Yap*

Department of Biology, Faculty of Science, Universiti Putra Malaysia, 43400 UPM Serdang, Malaysia

***Corresponding author:**

Prof. Dr. Chee Kong Yap,

Full Professor in Biology and Ecotoxicology, Department of Biology, Faculty of Science, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia,
E-mail: yapchee@upm.edu.my

Received : January 27 2026
Published : May 07, 2026

ABSTRACT

Prof. Edward D. Goldberg (1975)'s one-page paper "The Mussel Watch – A first step in global marine monitoring" is widely recognised as the conceptual origin of modern bivalve-based biomonitoring. A recent Scopus search shows that this paper has accumulated 647 citations between 1976 and 2025, confirming its enduring influence on marine pollution science. Yet for me, its impact has never been only about citation counts. Encountering the Mussel Watch idea as a young trainee in 1998 opened a pathway from basic biology to a lifelong dialogue with a single species, the green-lipped mussel *Perna viridis*. In this reflection, I revisit Goldberg (1975)'s vision and trace how it shaped and continues to shape my research trajectory, from early work correlating sediment geochemistry with tissue metal burdens to later explorations of shells, byssus, periostracum and soft tissues as multi-matrix biomonitors in Peninsular Malaysia. I frame this journey around three intertwined dispositions that Mussel Watch helped cultivate in me: curiosity about what mussels are "saying" about their environment, compassion for coastal ecosystems and communities that live with contamination, and the disciplined intellect required to translate those signals into reliable evidence. Revisiting Goldberg (1975)'s paper after many years has renewed a sense of childlike wonder, as if speaking again to the mussels that quietly archived our coastal history. The paper concludes by reflecting on how foundational concepts can nourish a pedagogy of gratitude, where students learn not only methods and statistics but also how to see organisms as partners in understanding planetary health.

Keywords: Mussel Watch, Biomonitoring; Curiosity and compassion; Ecotoxicology; Personal reflection.

INTRODUCTION

Goldberg (1975)'s [1] paper is short, focused and unusually bold in its implications. He proposed that a simple, standardised programme using mussels collected annually at selected coastal sites could provide a practical global monitoring system for heavy metals, halogenated hydrocarbons, petroleum

residues and radionuclides. Instead of relying on sporadic water samples and expensive cruises, he suggested listening to what bivalves had already recorded in their tissues.

When I first read this paper as a training research student in 1998, it felt like a door opening. The idea that a mussel could integrate complex contamination histories into measurable concentrations resonated deeply with my basic training in biology. The organism was no longer just an anatomical specimen. It became a historian of coastal change. That moment set me on the path to *Perna viridis*, to trace metals in sediments and tissues, and to the conviction that careful attention to a single species can illuminate both local and global stories [2,3].

Re-reading Goldberg (1975)'s paper now, with decades of research behind me, I experience the same quiet excitement, but with added gratitude. The 647 citations recorded in Scopus between 1976 and 2025 show how widely his idea has spread across disciplines and regions. For me, however, the most important legacy is more personal. Mussel Watch taught me to be curious, to be compassionate and to use intellect in service of organisms and ecosystems that cannot speak for themselves. These dispositions later became explicit themes in my reflective writing on basic research, passion and student growth [4-6].

THE MUSSEL WATCH VISION AND ITS GLOBAL LEGACY

Goldberg (1975)'s original paper set out three core ideas that later literature would elaborate. First, mussels and related bivalves accumulate contaminants to levels far above those in ambient seawater, making them sensitive indicators of spatial and temporal variation. Second, they are sedentary and relatively easy to collect and identify, which allows comparisons across years and regions. Third, a global network of such biomonitors is both scientifically valuable and economically feasible.

These concepts were developed further in "The Mussel Watch," where Goldberg and colleagues used early United States data to show how metal, DDT, PCB and hydrocarbon loads in mussels could map the contamination geography of American coasts [7]. The later paper "The Mussel Watch concept" distilled this experience into a more general framework for using mussels as sentinel organisms within environmental monitoring and assessment [8].

These early efforts seeded the National Status and Trends Mussel Watch Program of the National Oceanic and Atmospheric Administration in the United States, which has generated decades of time-series data documenting declines in some chlorinated organics and describing persistent or emerging issues for metals and other contaminants [9,10]. The International Mussel Watch initiative, coordinated through the National Research Council, extended the approach to a wider set of regional seas and encouraged adaptation of the method to local species and conditions [11]. Later historical reflections describe Goldberg (1975)'s proposal as a catalytic document that directly inspired these national and international programmes [12].

For a young researcher in Malaysia reading this history, the message was clear. A basic, carefully argued idea, grounded in organism biology, could organise an entire field. It also implied that local work on mussels in Southeast Asia could speak into this wider Mussel Watch conversation and into broader debates on coastal pollution and planetary health that I later explored explicitly in reflective essays [2,3].

DISCOVERING *PERNA VIRIDIS*: FROM BASIC BIOLOGY TO BIOMONITOR

Figure 1 illustrates the conceptual pathway through which becomes a powerful coastal biomonitor by integrating multiple biological matrices, ecological functions and analytical approaches. The cycle begins with basic biological curiosity, where mussels are first encountered as simple dissection specimens, and evolves into a sophisticated system of multi-matrix biomonitoring involving soft tissues, byssus, shell and periostracum. Each component contributes unique information: background concentration analysis distinguishes clean from impacted sites; metal speciation studies correlate sediment fractions with tissue burdens; tissue suitability assessments determine the most reliable biomonitoring organs; and byssus and shell analyses archive long-term exposure histories. These scientific dimensions culminate in the recognition of mussels as coastal sentinels that link hydrology, education and environmental interpretation. Together, the diagram captures how foundational curiosity matures into an integrated ecotoxicological methodology capable of informing environmental stewardship and sustainability research.

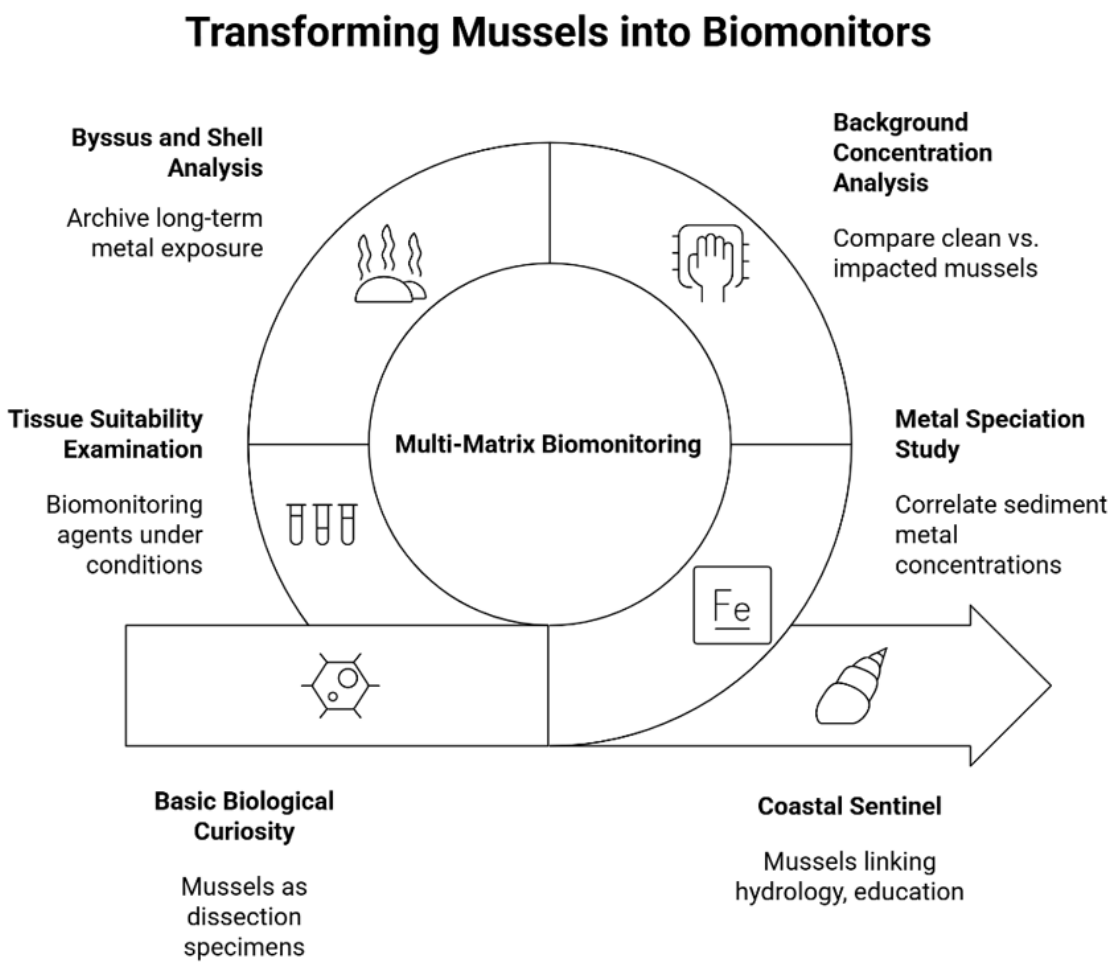

Figure 1: Transforming Mussels into Biomonitoring Tools through a Multi-Matrix Framework.

My own relationship with *Perna viridis* began with basic biological curiosity. As a student, I saw the green-lipped mussel first as an organism to be dissected, measured and classified. Its soft tissues, shell layers and byssus were biological structures to be described in the familiar language of anatomy and physiology. Guided by Goldberg (1975)'s idea, I slowly learned to see these structures as archives of environmental history.

Early in my career, with colleagues, I studied the correlation between metal speciation in sediments and metal concentrations in mussel soft tissues along the west coast of Peninsular Malaysia [13]. By relating the geochemical fractions of cadmium, copper, lead and zinc in sediments to tissue burdens in *P. viridis*, we tested directly the Mussel Watch assumption that bivalves integrate local contamination in meaningful, interpretable ways. That early paper later became a touchstone in my own reflective account of mussels as "recorders of the coast" and of coastal pollution as a planetary health concern [2].

From that starting point, further questions followed almost naturally. What are the "background" concentrations in relatively clean mussels, and how do they compare to those from more impacted sites [14]. Could the byssus and shell itself archive long-term exposure to metals, alongside soft tissues [14-17]? Subsequent studies showed that cadmium, lead and zinc were readily accumulated in whole shells and that shell concentrations could reflect site-specific contamination in Peninsular Malaysia [17].

We then turned to the byssus, finding that it could act as a more sensitive biomonitoring organ for certain metals, especially zinc, under both field and experimental conditions [15]. Other work examined different soft tissues and their suitability as biomonitoring agents under varying environmental conditions [16,18]. This multi-matrix perspective was later synthesised in a conceptual way when I reflected on *P. viridis* as a coastal sentinel linking hydrology, education and environmental interpretation [3].

DOI: https://doi.org/10.35702/nutri.10025

In retrospect, this whole programme of multi-matrix biomonitoring can be seen as a regional conversation with Mussel Watch. The sentinel is the same kind of organism that Goldberg had in mind, but now rooted in Malaysian waters, local pollution sources and local ecological realities [1,13,19].

CURIOSITY: ASKING WHAT THE MUSSELS ARE TRYING TO SAY

Figure 2 presents the sequential process through which mussel-based research transforms fragmented knowledge of ocean health into a more comprehensive ecological understanding. The pathway begins with limited ocean insight, reflecting the inherent challenge of monitoring dynamic marine systems. Field campaigns expand this understanding by sampling mussels across diverse coastal settings, capturing spatial variation in contamination. Laboratory experiments then allow controlled exposure studies that clarify mechanistic responses to pollutants. The integration of biological and metal data links field and laboratory findings, enabling researchers to detect patterns, validate hypotheses and contextualise tissue burdens within broader environmental processes. Ultimately, the synthesis of these steps produces a deeper, system-level interpretation of ocean dynamics. The figure highlights how mussels serve not only as bioaccumulators but also as methodological bridges that connect observational, experimental and analytical approaches into a coherent framework for marine environmental interpretation.

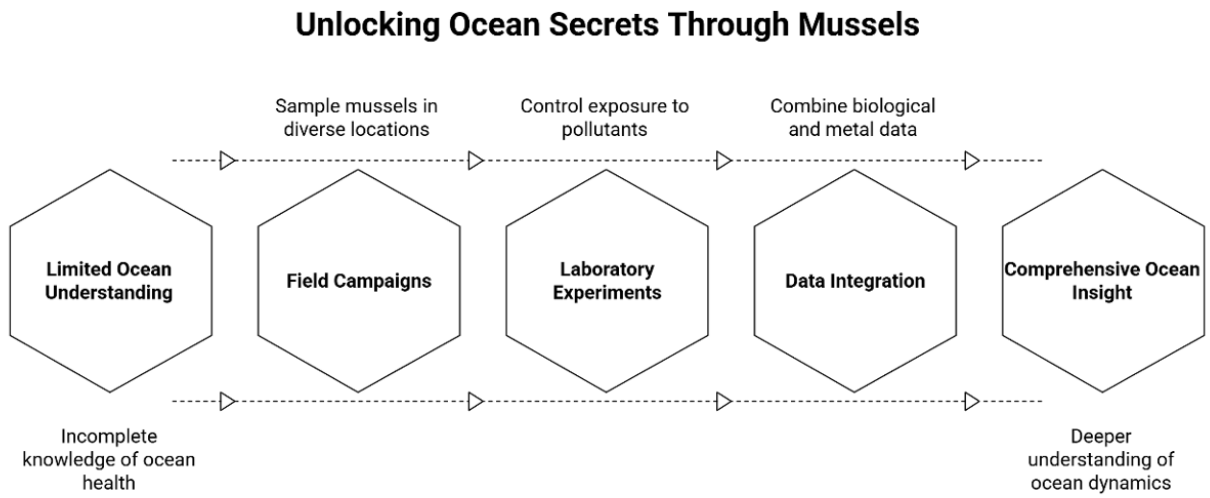

Figure 2: Unlocking Ocean Secrets Through Mussel-Based Ecotoxicological Pathways.

Curiosity is the first gift I received from Mussel Watch. Goldberg's paper is, at its core, a question framed as a proposal: what would the global ocean look like if we listened systematically to mussels [1]? As a trainee in 1998, I internalised this as an invitation to ask, repeatedly and patiently, what *Perna viridis* was trying to communicate. The same triad of curiosity, compassion and intellect that I later explored through the lens of Charles Darwin and the FIKR (facet, insight, knowledge and resilience) framework provided a broader philosophical language for this attitude to scientific observation [20].

This curiosity expressed itself in many forms. It drove the design of field campaigns along the west coast of Peninsular Malaysia, where we sampled mussels from aquaculture sites, estuaries and less disturbed locations to see how metal profiles shifted with geography and human activity [13,14,18]. It motivated laboratory experiments on accumulation and depuration, where mussels were exposed to controlled cadmium and zinc levels to understand kinetic patterns and tissue distributions [15,16]. It also encouraged the integration of biological variables, such as size, tissue type and condition, into our interpretations of metal burdens [19].

Curiosity in this context is not just a desire for more data. It is the willingness to keep asking "why" and "what else" even when the first set of results seems adequate for publication. If metals in soft tissue correlate with sediment fractions, what about the shell, the byssus or the periostracum [17]. If background sites appear "clean", what is their true baseline and how stable is it over time [14]? In my later reflection on Darwin through FIKR, I argued that such sustained questioning is a hallmark of scientific curiosity that refuses to be satisfied with surface answers and keeps returning to organisms as teachers [20].

DOI: https://doi.org/10.35702/nutri.10025

For me, this curiosity often felt like "talking to the mussels". I imagined them as patient teachers, sitting on ropes and rocks, recording fluctuations that my instruments could only capture intermittently. Each new dataset was a partial translation of their long, silent conversation with the sea. That sense of dialogue later became a central metaphor in my reflective note on mussels, memory and coastal history [2] and in my broader reflections on passion and basic ecological research [4,5] which themselves echo the FIKR-based argument that curiosity is one of the enduring foundations of scientific discovery [20].

COMPASSION: CARING FOR COASTS, COMMUNITIES AND ORGANISMS

Figure 3 illustrates how mussel-based ecotoxicology evolves from a purely technical monitoring approach into a broader, ethically grounded planetary health narrative. The progression begins with conventional analytical schemes focused on detecting and quantifying contaminants. It then moves into an ethical dimension where the purpose of monitoring expands to include recognising, addressing and preventing environmental harm. Scientific empathy emerges as researchers begin to treat organisms not merely as data sources but as living participants that reveal the pressures placed on coastal ecosystems. This empathetic stance naturally leads to research designs that foreground policy implications, ensuring that biomonitoring outcomes support risk reduction, environmental justice and sustainable coastal management. The pathway culminates in a planetary health narrative that integrates ecological, social and ethical responsibilities. Through this framework, mussels become more than indicators; they become partners in reshaping how science understands and protects interconnected human–environment systems.

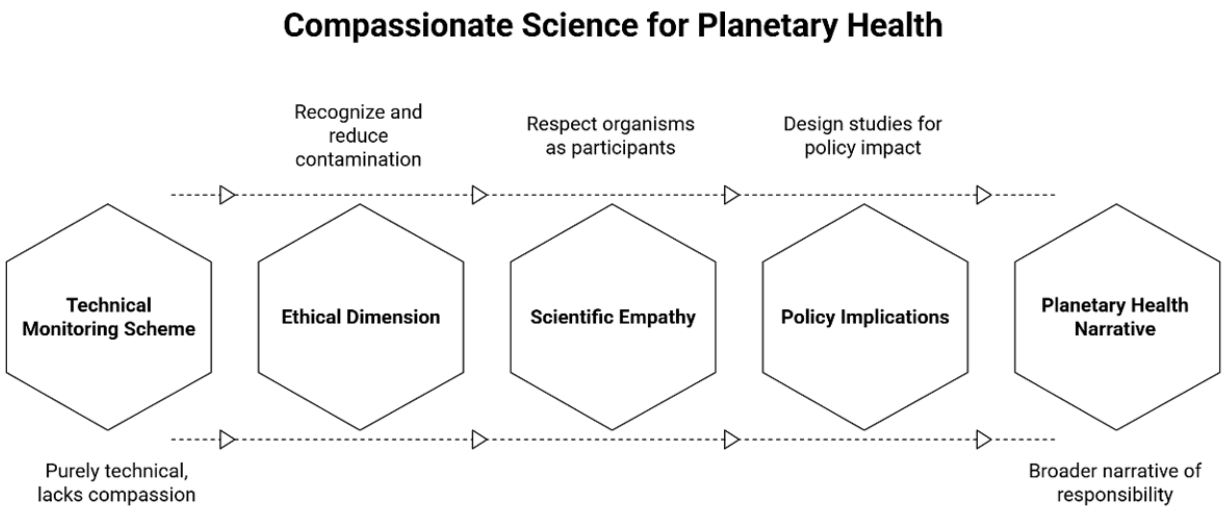

Figure 3: Compassionate Science as a Pathway from Technical Monitoring to Planetary Health

Goldberg's vision carries a clear ethical dimension. Mussel Watch was not only about scientific curiosity. It aimed to provide societies with a simple tool to recognise and eventually reduce harmful contamination of coasts and seas [7,8]. This ethical undercurrent shaped how I learned to relate to *Perna viridis* and to the coastal communities that depend on it. In later work revisiting Darwin through the FIKR framework, I developed this idea more explicitly by framing compassion as a core disposition that keeps scientific practice connected to the vulnerabilities of organisms, ecosystems and people [20].

Working with mussels in Malaysian waters brings one very close to fishers, mussel farmers and consumers whose livelihoods and health are intertwined with these organisms. Biomonitoring results cannot remain abstract numbers. They relate to seafood safety, the sustainability of aquaculture and the integrity of estuarine and coastal ecosystems [18]. Compassion, in this context, means allowing these realities to matter when we interpret our data and when we decide which questions deserve attention. This linkage between technical data, human livelihoods and planetary health later formed the core of my reflective writing on heavy metals, coastal pollution

DOI: https://doi.org/10.35702/nutri.10025

and planetary well-being [2] and is consistent with the FIKR emphasis on compassion as a necessary counterweight to purely instrumental intellect [20].

Compassion also implies a kind of scientific empathy for the organism itself. Mussels in contaminated sites are forced to handle elevated loads of metals and other pollutants they did not choose. Their tissues, shells and byssus record both our industrial history and their physiological effort to maintain homeostasis [14,15]. Seeing *Perna viridis* as a biomonitor does not reduce it to an instrument. It invites us to respect it as a living participant in our understanding of coastal change.

This sense of compassion influences how I frame research projects for students and collaborators. We design studies that not only refine biomonitoring methods but also ask what findings mean for policy, for environmental justice and for the long-term resilience of coastal ecosystems [2,3]. In that way, Mussel Watch becomes part of a broader narrative about planetary health and responsibility, rather than a purely technical monitoring scheme. This approach mirrors the argument I made in the Darwin–FIKR reflection that compassion is not an optional "soft" value, but an organising principle that shapes what kinds of scientific questions we are willing to pursue [20].

INTELLECT: FROM FOUNDATIONAL BIOLOGY TO MULTI-MATRIX ECOTOXICOLOGY

Figure 4 highlights the intellectual architecture that supports modern mussel-based ecotoxicology, illustrating how foundational biological knowledge, methodological skills, multi-matrix approaches and sustainability frameworks converge into a coherent scientific practice. At the biological level, understanding bivalve physiology and contaminant chemistry forms the basis for interpreting how *Perna viridis* accumulates and records environmental pollutants. Methodological skills such as sediment geochemistry and statistical analysis provide the analytical depth needed to link tissue burdens with environmental conditions. Multi-matrix ecotoxicology extends this foundation by incorporating shells, soft tissues and other biological compartments to capture different temporal and chemical dimensions of exposure. Finally, sustainability frameworks connect these technical insights to larger concerns, including climate change and ESG-related responsibilities, situating biomonitoring within contemporary debates about environmental governance and planetary health. Together, these components demonstrate how intellect transforms basic biological inquiry into meaningful evidence for sustainable coastal management.

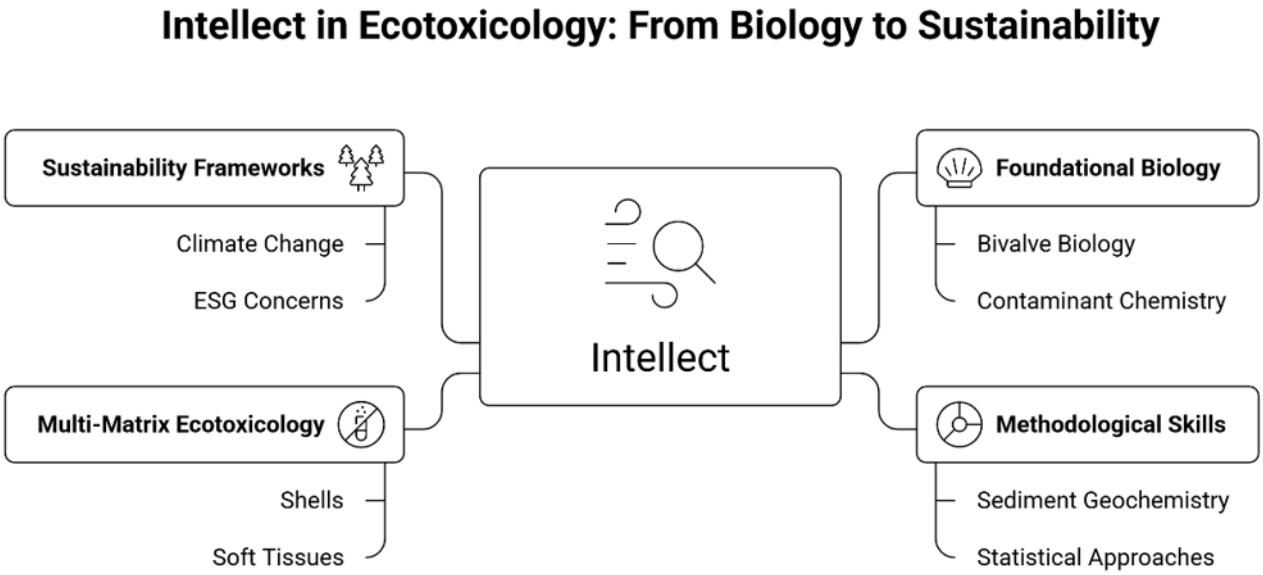

Figure 4: Intellect in Ecotoxicology: Integrating Biology, Methods and Sustainability.

Curiosity and compassion require an intellectual framework to become rigorous science. Mussel Watch itself rests on a clear understanding of bivalve biology, contaminant chemistry and environmental monitoring design [1,8]. To follow in that tradition, I had to deepen my own methodological and analytical skills. In my later reflection on Darwin through FIKR, I described intellect as the disciplined capacity to connect detailed observations to larger conceptual structures, a description that fits closely with how Mussel Watch shaped my own ecotoxicological thinking [20].

This meant learning sediment geochemistry well enough to interpret fractionation schemes and link them meaningfully to tissue burdens [13]. It required designing field sampling strategies that balanced replication, spatial coverage and logistical constraints. It pushed me to adopt statistical approaches that could handle multiple covariates, including body size, tissue type, site characteristics and temporal variation [16,19].

Intellect also played a role in expanding Mussel Watch ideas beyond a single matrix. Our work on shells, byssus, periostracum and different soft tissues sought to test and refine the assumption that different parts of the mussel may record different temporal windows or aspects of contamination [14-16,18]. More recently, this intellectual expansion has included reframing molluscs as integrators of marine pollution, climate change and Environmental, Social and Governance concerns at the conceptual level [21], and connecting Mussel Watch explicitly with the seafood–water–energy nexus in coastal systems [22]. These developments required careful evaluation of analytical detection limits, normalisation strategies and potential confounding factors, but also a willingness to situate biomonitoring within broader sustainability frameworks. The FIKR-based reflection on Darwin provided a parallel narrative about how intellect turns scattered observations into coherent stories of nature and responsibility [20].

In my later essays on academic life and basic biology, I argued that this kind of patient, integrative intellect is the unseen foundation of both good research and meaningful teaching [4-6]. The discipline of thinking through matrices, covariates and uncertainties in *P. viridis* biomonitoring became, over time, a model for thinking through the complexities of student learning, personality and research mentorship.

In teaching, I try to convey to students that intellect in ecotoxicology is not only about mastering instruments or software. It is about constructing coherent questions, choosing appropriate organisms and matrices, and situating local data within a global framework that reaches back to foundational contributions like Goldberg (1975)'s [1] paper, the 1978 synthesis and the 1986 conceptual elaboration [1,3,7,8,13,21,22]. The FIKR lens reinforces this by showing students that curiosity, compassion and intellect form an integrated triad at the heart of scientific discovery, whether one is reading Darwin or listening to mussels [20].

REREADING GOLDBERG AFTER MANY YEARS: GRATITUDE AND RENEWAL

Returning to Goldberg (1975)'s paper after many years feels like sitting again with an old mentor. The paper is still only one page long. The language remains concise and understated. Now, however, each sentence carries decades of accumulated meaning for me. I cannot read his phrase "a first step in global marine monitoring" without thinking of long Mussel Watch time series in the United States, international workshops and my own datasets from Peninsular Malaysia [1,7,9-11,13].

There is also a personal emotion that is hard to separate from the science. I feel happy that my early curiosity found such a strong anchor. I feel excited that a simple idea from 1975 remains relevant for current questions about climate change, coastal urbanisation and emerging contaminants. Above all, I feel grateful that a short paper could sustain a lifetime of research, mentorship and collaboration. Farrington and colleagues described Goldberg's proposal as a pivotal contribution whose significance became clearer over forty years [12]. My own experience echoes that observation at the personal scale. The importance of Mussel Watch has grown with each new generation of students and each new coastal site where we deploy *Perna viridis* as a biomonitor [2,3].

When I reread Goldberg now, I recognise the same feeling I had as a young trainee: the feeling of a child who still sees the world with wonder. To "talk to the mussels" is to acknowledge that their quiet, continuous presence along our coasts has allowed us to reconstruct histories of contamination, to test hypotheses about metal cycling and to argue for better environmental stewardship. That sense of enduring wonder and commitment to the basics of ecological observation is at the heart of my later reflections on passion, mentorship and basic research [4,5].

TEACHING WITH MUSSEL WATCH: PASSING ON CURIOSITY, COMPASSION AND INTELLECT

One of the most satisfying aspects of this journey has been integrating Mussel Watch into teaching and supervision. When students handle *Perna viridis* in the laboratory or the field, I try to situate their measurements within the lineage that runs from Goldberg (1975)'s proposal through national and international Mussel Watch programmes to our local studies [1,7,9-11,13-16,18].

Curiosity is encouraged when students compare sites, seasons and tissues, and when they speculate about why a particular location shows higher cadmium levels or why byssus responds differently to zinc than soft tissue. Compassion is cultivated when we discuss how these patterns relate to nearby communities, seafood safety and broader sustainability concerns [2,3]. Intellect is developed through a critical engagement with sampling design, quality control and the interpretation of uncertainties in metal data, linking the laboratory bench with broader questions of basic research, personality and student growth [4,6]

In this way, Mussel Watch becomes more than a citation in an introduction. It becomes a pedagogical tool. Students learn that foundational papers can be both historically important and personally transformative. They see that basic research on a single mussel species can connect to larger discussions about environmental policy, planetary health and their own future roles as scientists and citizens [2,5].

CONCLUSION

Goldberg (1975)'s Mussel Watch paper has shaped the architecture of global marine pollution monitoring and, at the same time, the inner architecture of my own scientific life. Through *Perna viridis*, I learned to exercise curiosity about environmental signals, compassion for ecosystems and communities affected by contamination and the disciplined intellect needed to make biomonitoring evidence robust and useful.

Re-encountering this paper after many years is a reminder that foundational ideas in biology do not grow old; they become richer as new data, new methods and new generations of researchers grow around them. The Mussel Watch concept remains a living framework in which new matrices, new contaminants and new regions can be explored. It also remains a quiet invitation to listen more carefully to the organisms that share our coasts. For that invitation, and for the journey it enabled, I remain profoundly grateful and still a little bit like the student of 1998 who was happy simply to sit with mussels and learn how to hear what they were saying.

REFERENCES

1. Goldberg ED. (1975). The Mussel Watch: A first step in global marine monitoring. Marine Pollution Bulletin. 6(7):111–114.
2. Yap CK. (2025a). Mussels, memory, and the recorders of the coast: A reflective note on heavy metals, coastal pollution, and planetary health. Journal of Life Science Systems and Technology. 1(1):1-6.
3. Yap CK. (2025b). *Perna viridis* as a coastal sentinel for hydrology and education: A reflective and conceptual synthesis. International Journal of Hydrology. 9(2):80–83.
4. Yap CK. (2025c). Where the flame endures: Passion, mentorship, and writing rooted in basic ecological research. MOJ Biology and Medicine. 10(2):76–78.
5. Yap CK. (2025d). The basic is still basic: A biology professor's philosophy and personal reflection. i TECH MAG. 7:79–82.
6. Yap CK. (2025e). The unseen foundations: Reflections on basic research, student growth, and the role of personality in learning. Education, Sustainability & Society, 8(1):45-46.
7. Goldberg ED. (1978). The Mussel Watch. Environmental Conservation, 5(2):101–125.
8. Goldberg ED. (1986). The Mussel Watch concept. Environmental Monitoring and Assessment, 7(1):91–103.
9. O'Connor, TP. (1998). Mussel Watch results from 1986 to 1996. Marine Pollution Bulletin, 37(1–2):14–19.
10. O'Connor TP. (2002). National distribution of chemical concentrations in mussels and oysters in the USA. Marine Environmental Research. 53(2):117–143.
11. National Research Council. (1980). The International Mussel Watch: Report of a workshop. Washington, DC: National Academy Press.

DOI: https://doi.org/10.35702/nutri.10025

12. Farrington JW., Tripp BW., Tanabe S, Subramanian A. (2016). Edward D. Goldberg's proposal of "The Mussel Watch": Reflections after 40 years. Marine Pollution Bulletin. 110(1):1–2.

13. Yap,CK., Ismail A, Tan SG., Omar H. (2002). Correlations between speciation of Cd, Cu, Pb and Zn in sediment and their concentrations in total soft tissue of green-lipped mussel *Perna viridis* from the west coast of Peninsular Malaysia. Environment International, 28(1–2):117–126.

14. Yap, C. K., Ismail, A., Tan, SG. (2003a). Background concentrations of Cd, Cu, Pb and Zn in the green-lipped mussel *Perna viridis* (Linnaeus) from Peninsular Malaysia. Marine Pollution Bulletin. 46(8):1044–1048.

15. Yap CK, Ismail A, Tan SG. (2003b). Can the byssus of green-lipped mussel *Perna viridis* (Linnaeus) from the west coast of Peninsular Malaysia be a biomonitoring organ for Cd, Pb and Zn? Field and laboratory studies. Environment International. 29(4):521–528.

16. Yap CK, Ismail A, Tan SG. (2003c). Different soft tissues of the green-lipped mussel *Perna viridis* (Linnaeus) as biomonitoring agents of copper: Field and laboratory studies. Malaysian Applied Biology, 32(1):9-18.

17. Yap CK, Ismail A, Tan SG, Omar H. (2003d). Can the shell of the green-lipped mussel *Perna viridis* from the west coast of Peninsular Malaysia be a potential biomonitoring material for Cd, Pb and Zn? Estuarine, Coastal and Shelf Science. 57(4):623–630.

18. Yap CK., Ismail A, Tan SG. (2004a). Heavy metal (Cd, Cu, Pb and Zn) concentrations in the green-lipped mussel *Perna viridis* (Linnaeus) collected from some wild and aquacultural sites in the west coast of Peninsular Malaysia. Food Chemistry. 84(4):569–575.

19. Yap CK, Ismail A, Tan SG, Rahim Ismail A. (2004b). Assessment of different soft tissues of the green-lipped mussel *Perna viridis* (Linnaeus) as biomonitoring agents of heavy metals in the west coastal waters of Peninsular Malaysia. Pertanika Journal of Science and Technology. 12:85-99.

20. Yap CK, Leow CS, Vincent Leong WS. (2025). Charles Darwin revisited through the lens of FIKR (Facet, Insight, Knowledge, and Resilience): Reflections on curiosity, compassion, and the intellect as foundations of scientific discovery. Global Open Access Journal of Science, 1(1):22–33.

21. Yap CK, Aguol KA, Ong MC, Wan Mohd Syazwan, Nulit R, Okamura H, et al. (2024). The role of molluscs in monitoring marine pollution and its connection to climate change and ESG. Current World Environment. 19(3):1–13.

22. Yap CK, Okamura H, Horie Y, Ong MC, Setyawan AD, Zakaly HMH, et al (2023). The connections between Mussel Watch for potentially toxic metals and Nexus seafood-water-energy. Journal of Biomedical Research & Environmental Sciences.