



Expert Grief: Epistemic injustice and the paradox of knowledge in social-ecological systems

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ABSTRACT

The systemic marginalization of Indigenous and Local Knowledge (ILK) creates significant blind spots in conservation science, often obscuring the affective and cognitive signals of social-ecological decay. We introduce Expert Grief, a framework describing an epistemic paradox: the cognitive fisheries ecological knowledge that underpins livelihood resilience also amplifies affective distress in response to systemic environmental decline. Using a Philippines-based model system, we analyzed multi-decadal data from 448 artisanal fishers through a retrospective cross-sectional design and Linear Mixed-Effects Models (LMMs) to link shifts in cognitive fisheries baselines with affective livelihood satisfaction. Our results reveal a significant dual erosion, where a multi-decadal simplification of the fishery's trophic structure is mirrored by a concurrent decline in livelihood satisfaction ($\beta = -0.44, p = 0.0012$). Crucially, a significant interaction between fishing experience and time explains the Expert Grief paradox. Although the ILK of veteran fishers sustains their individual catch success ($\beta = 0.006, p = 0.01$), this deeper knowledge correlates with a steeper decline in livelihood satisfaction compared to novice fishers ($\beta = -0.001, p = 0.02$). The Expert Grief framework offers two theoretical advances: mechanistically defining the cognitive drivers of Shifting Baseline Syndrome (SBS) and characterizing an affective, knowledge-mediated form of solastalgia. Exposing this grief reveals that marginalizing local expertise obscures cumulative social-ecological decay and decouples technocratic conservation from the lived realities of those at the forefront of change. Ultimately, we demonstrate that epistemic justice is not just an ethical ideal but a fundamental prerequisite for effective and equitable conservation.

1. Introduction

Systemic marginalization of Indigenous and Local Knowledge (ILK) creates a critical gap between knowledge and action, threatening global mandates like the Kunming-Montreal Global Biodiversity Framework (GBF). This body of knowledge comprises cumulative, adaptive insights built through generations of connection to place, offering the longitudinal perspective required to build resilience in the Anthropocene (Berkes et al., 2000; Brondizio et al., 2021; Maliao et al., 2025). Although global institutions like the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2024) champion ILK as a global imperative, actual integration remains aspirational. Technocratic frameworks often prioritize standardized, short-term metrics over the deep, relational insights held by local communities. This exclusion reinforces knowledge hierarchies that sideline the perspectives necessary for equitable and effective conservation (Blythe

et al., 2018; Barclay et al., 2024; de Angeli Dutra et al., 2025; Maliao and Tóthmérész, 2026a, 2026b).

This shortfall reflects epistemic injustice, wherein the systemic devaluation of ILK perpetuates policy failure and social harm (Nyssa et al., 2024). We argue that this injustice is a primary mechanism actively relegating ILK to the periphery of conservation governance, rather than a byproduct of poor integration. While rooted in neocolonial parachute science (Stefanoudis et al., 2021; Asase et al., 2022; Dawson et al., 2024; de Angeli Dutra et al., 2025; Maliao and Tóthmérész, 2026a, 2026b), these dynamics now manifest as remote-control science (Dáttilo and Rivera-Núñez, 2025). Despite the rhetoric of equitable partnership, this model anchors decision-making power in the Global North and sidelines the autonomy and visibility of Global South scholarship. Academic incentive structures exacerbate this disparity by prioritizing global trends over the place-based ILK necessary for effective conservation (Maliao and Tóthmérész, 2026a, 2026b). The resulting skewed

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narratives inform state-led management, which devalues the ILK and customary governance systems required to solve common-pool resource (CPR) dilemmas (Ostrom, 2009; Silver et al., 2022).

This center-periphery dynamic dictates ecological health metrics, often dismissing local epistemologies as unscientific or anecdotal. While local-led research challenges these hierarchies by demonstrating the empirical dynamism of ILK (Molnár and Babai, 2021; Silvano et al., 2023; Maliao et al., 2025), marginalizing these systems as unobjective continues to undermine place-based conservation (Basurto et al., 2013; Londres et al., 2023; Chapman et al., 2024; de Angeli Dutra et al., 2025; Maliao and Tóthmérész, 2026b). Crucially, this exclusion obscures an insidious affective toll manifesting as the erosion of cultural identity and heritage following the systemic loss of livelihood security. We hypothesize that this harm is most acute for local experts whose longitudinal resource intimacy provides an unshifted baseline of social-ecological health that formalized science rarely records (Brondizio et al., 2021; Hoppenreijns et al., 2024; Molnár et al., 2024). This temporal depth subjects experts to a distinct distress where declining livelihood security and ecological integrity converge, creating an affective reality invisible to technocratic monitoring.

This affective toll spans a spectrum of distinct but overlapping concepts. While eco-anxiety involves apprehension of future degradation, ecological grief describes distress over losses already sustained (Cunsolo and Ellis, 2018). Within this spectrum, solastalgia represents the place-based anguish felt when a home environment is negatively transformed (Albrecht et al., 2007). We propose Expert Grief as a specialized, knowledge-mediated dimension of affective livelihood distress. In this paradox, the longitudinal intimacy that fosters resilience also drives the erosion of livelihood satisfaction. Unlike generalized anxiety, this grief is a systemic response to disrupted place attachments and cultural identities (Brown et al., 2019; Hogg et al., 2021). Because their multi-generational experience provides an unshifted cognitive baselines, local experts witness ecological degradation invisible to those with limited ecological perspectives. By quantifying this distress, we position Expert Grief as a critical, neglected dimension of global environmental change (Tschakert et al., 2019).

Marginalizing local experts creates analytical blind spots that compromise the functional utility of Social-Ecological Systems (SES) frameworks. While SES theory posits that human and natural systems are coupled (Folke, 2006; Ostrom, 2009), it often overlooks the power dynamics and epistemic justice required for equitable outcomes (Leach et al., 2010; Blythe et al., 2018). This exclusion constitutes a functional failure, as management remains blind to the true magnitude of change without the unshifted baselines of its most experienced knowledge holders. A methodological shortfall rooted in the historical amnesia of technocratic monitoring compounds this theoretical gap (Soga and Gaston, 2024). Restricted by narrow temporal windows, standardized monitoring fails to capture the multi-decadal effects of overexploitation (McClenachan et al., 2024), masking the trophic shifts that restructure marine ecosystems. Multi-generational memory inherent in ILK is uniquely suited to reveal this longitudinal degradation (Pauly et al., 1998; Thurstan et al., 2020). In the absence of these insights, technocratic monitoring remains methodologically incomplete, often overlooking the concurrent dual erosion of cognitive and affective signals of social-ecological decay. This reinforces a narrative gap that further marginalizes the very experts situated at the forefront of change.

These gaps are acute in artisanal and subsistence fisheries within megadiverse, data-poor nations. The Philippines serves as a critical model system as the global epicenter of marine biodiversity (Carpenter and Springer, 2005) where coastal communities depend fundamentally on marine resources for livelihood and identity (Maliao et al., 2009a, 2009b; Cabral et al., 2025). In this context, epistemic injustice is a structural reality that dictates social-ecological outcomes. Our research builds an empirical bridge between multi-decadal fisheries decline and livelihood satisfaction, an emergent frontier in the literature (Berkes et al., 2000; Estoque and Wu, 2024). Specifically, we investigate how

sidelining local communities from formal monitoring marginalizes their longitudinal intimacy and triggers Expert Grief. This paradox, where heightened ecological awareness amplifies rather than mitigates livelihood distress, obscures the erosion of security and risks masking the true magnitude of social-ecological change (Steger et al., 2020). By quantifying this grief as a function of knowledge depth and decline, we provide a novel metric for assessing the human dimensions of environmental change in small-scale fisheries globally.

Building on the documented schism between social and ecological research in the Philippines (Maliao, 2025; Maliao and Tóthmérész, 2026a), this study investigates the human dimensions of knowledge marginalization. We evaluate the relationship between retrospective cognitive baselines of fisheries health and affective livelihood satisfaction in a tropical small-scale fishery. We test the hypothesis that the Indigenous and Local Knowledge (ILK) inherent in fishing experience drives a steeper decline in affective livelihood satisfaction because it maintains unshifted cognitive baselines of fisheries health. Using the Batan Estuary in the central Philippines as a model system, we employ a retrospective cross-sectional research design, utilizing Linear Mixed-Effects Models (LMMs) to analyze multi-decadal recall data from 448 fishers. This approach quantifies the dual erosion of cognitive fishery baselines and affective livelihood satisfaction while providing a mechanistic foundation for Expert Grief. Our findings contribute to two theoretical advances: a cognitive model for the mechanism of Shifting Baseline Syndrome (SBS) and an affective extension of solastalgia within artisanal fisheries. Our work moves beyond qualitative narrative to delineate the mechanistic process of Expert Grief, highlighting the lived realities of those at the forefront of social-ecological decline.

2. Methods

2.1. Research design and case study justification

Structural inequities in Philippine conservation science inform our research design, necessitating a place-based empirical approach. Systematic modeling of regional scholarship reveals systemic thematic and demographic segregation, providing the methodological rationale for this study (Maliao, 2025; Maliao and Tóthmérész, 2026a). While international scholarship dominates high-visibility conservation discourse, local Philippine research on ethnoecology and governance remains marginalized in global citation indices. Intersectional hierarchies further sideline local female scholars where, despite their expertise in the human dimensions of fisheries, they face high levels of professional erasure (Maliao, 2025; Maliao and Tóthmérész, 2026a).

This epistemic schism obscures the affective toll of ecological change, specifically Expert Grief, because the knowledge systems that articulate it are systemically sidelined. We selected the Batan Estuary in the central Philippines as a model system to address this structural gap. This site allows us to move beyond meta-analytical evidence to develop a high-resolution, mechanistic model of social-ecological decay in small-scale fisheries (Maliao and Tóthmérész, 2026a). By focusing on the structurally undervalued ILK inherent in fishing experience, this framework reconciles the divergence between global conservation targets and localized ecological realities.

2.2. Batan estuary: A tropical model system

We studied the Batan Estuary (11°35' N, 122°29' E) on northern Panay Island in the western Visayas, central Philippines (Fig. 1 and Fig. 2). This semi-enclosed system covers approximately 2640 ha across the municipalities of New Washington, Altavas, and Batan. The Aklan River discharge and Sibuyan Sea influx create a complex hydrology that defines the estuary.

Recent decades of intensive fishing and rapid aquaculture expansion have reconfigured the estuarine landscape. Converting mangrove forests into fish and shrimp ponds caused habitat loss and a paradoxical decline

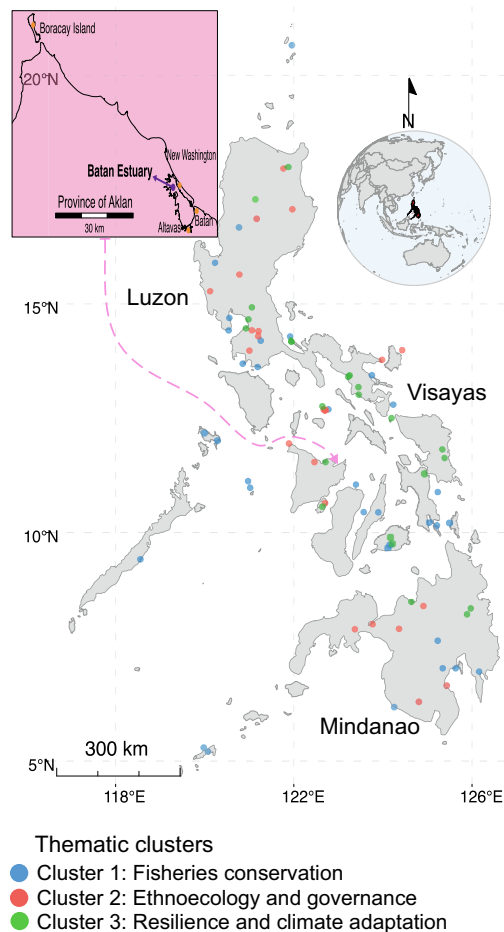


Fig. 1. Spatial distribution of the Philippine aquatic Indigenous and Local Knowledge (ILK) evidence base. The main map illustrates documented study locations ($n = 132$) across the archipelago (data adapted from Maliao and Tóthmérész, 2026a). Colored markers correspond to the three primary research clusters identified in previous scientometric assessments of the country's ILK landscape. The inset provides a high-resolution geographic overview of the Batan Estuary, the focal site for the present investigation into the social-ecological drivers of trophic simplification and the manifestation of the Expert Grief.

in aquaculture productivity (Altamirano and Kurokura, 2010). Human pressures, including sedimentation from upland land-use changes, have shallowed traditional fishing grounds and altered benthic habitats (Santos et al., 2024). Collectively, these stressors drive the trophic simplification that serves as the mechanism for the dual erosion and livelihood distress documented in this research.

Batan serves as a model for tropical artisanal fisheries (Cabral et al., 2025). Under the Philippine Fisheries Code (RA 8550, as amended by RA 10654), these municipal fisheries utilize vessels under three gross tons or shore-based gear within 15 km of the coast. The regional economy depends on these resources. In the municipality New Washington, 58% of the population relies on fishing for their primary livelihood (Añasco and Babaran, 2001). However, this sector faces systemic decline (Altamirano and Kurokura, 2010; Kamiyama et al., 2015; Maliao, 2019) and chronic poverty (Maliao et al., 2023).

2.3. Participant recruitment and the identification of ecological expertise

We defined fishers as harvesters active in the estuary, excluding those in post-harvest or secondary sectors. To capture intimate, generational knowledge, we targeted the primary fisher of each household: an individual at least 18 years old who has fished exclusively within the

Batan Estuary for at least 10 years. We utilized purposive snowball sampling to yield a final sample of $n = 448$. This approach was specifically selected to ensure the inclusion of veteran practitioners whose longitudinal expertise is often absent from top-down administrative records. This non-probability technique was necessary because official registries in the region lack the resolution to identify localized expertise or the historical depth required to observe multi-decadal change. While snowball sampling carries a risk of social network bias, we mitigated this by diversifying initial seeds across each surveyed village (barangay) and distinct gear-user groups. This trade-off was essential to isolate the unshifted baselines of primary fishers and provide the longitudinal authority required to test the Expert Grief framework.

The focus on primary fishers resulted in a 90% male cohort. This skew reflects the gendered structure of Philippine artisanal fisheries, with men typically operate the primary harvesting gear (Maliao and Polohan, 2008). This composition represents a deliberate, theory-driven strategy. We prioritize the ILK derived from direct, subsurface interaction with the aquatic environment, as this serves as the nexus where cognitive fisheries ecological memory and affective livelihood satisfaction intersect. Consequently, focusing on primary fishers was essential to document the specific distress of witnessing multi-decadal trophic decline. By prioritizing these practitioners, we isolate the cognitive and affective toll of observing an ecosystem simplify from beneath the surface, a perspective unique to daily harvesters.

The National Commission for Culture and the Arts (NCCA) of the Philippines funded this research through the e-LAWOD project, awarded to the first author. This project documents and preserves maritime cultural heritage and local ecological knowledge, aligning this inquiry with national mandates to protect intangible maritime assets. The Aklan Research Center for Coastal Studies (ARCCS) at Aklan State University facilitated implementation. We formalized our commitment to ethical reciprocity through approval from Aklan State University. All 448 participants provided informed consent, ensuring data confidentiality and voluntary participation.

2.4. Data collection and retrospective analysis

We employed a retrospective cross-sectional research design, interviewing 448 household primary fishers across the Batan Estuary between 2019 and 2020. We conducted these sessions in Akeanon and Hiligaynon to ensure linguistic precision and cultural safety. After obtaining informed consent and demographic profiles, we used a structured decadal recall framework to collect retrospective data from the 1960s to the 2020s. These retrospective cognitive accounts of fisheries baselines and affective livelihood satisfaction constitute a robust form of Indigenous and Local Knowledge (ILK). As a repository of longitudinal expertise, these data provide a high-resolution foundation for analyzing the dual erosion of the estuarine system.

First, we elicited decadal catch estimates for dominant species that represent the bulk of the estuary's biomass and indicate long-term trophic shifts. To mitigate memory distortion over the 60-year recall period, we used traditional units, recording catch estimates in *gantang*, a dry volume unit standardized at approximately 2.25 kg. For cultural calibration, one *gantang* is locally equivalent to two *tumpok*, or market heaps. By utilizing these lived metrics, we reduced the cognitive load on respondents, allowing for more precise historical reconstruction. This standardization allowed us to convert decadal reports into kilogram estimates. We anchored decadal periods to national political administrations to stabilize temporal benchmarks (Lavides et al., 2016). Finally, we triangulated these reports by cross-referencing with local taxonomic guides and comparing accounts across peer-groups to ensure scientific accuracy before assigning trophic guilds.

Second, respondents provided decadal affective livelihood satisfaction scores using a single-item, 10-point visual ladder scale, where step 1 indicated the worst scenario and step 10 the best (Webb et al., 2004; Maliao and Polohan, 2008). This metric captured the affective



Fig. 2. The multi-dimensional social-ecological landscape of the Batan Estuary. **a.** Wide-angle view of an artisanal fisherman hauling a traditional net, illustrating the intensive manual labor and technical proficiency inherent to the local fishery. **b.** Close-up of the harvesting process featuring the extraction of rabbitfish (*Siganus spp.*), a staple high-value resource in the estuary. **c.** Structural overview of a stationary lift net, representing the traditional gear architecture that characterizes the estuarine zones. **d.** Dried seahorse (*Hippocampus sp.*) displayed against the backdrop of traditional fishing vessels. Locally, dried seahorses are culturally significant for their perceived efficacy in warding off malevolent spirits and their application in traditional medicinal practices. This highlights the deep integration of estuarine biodiversity into the spiritual and medicinal livelihoods of the community, extending beyond simple extractive utility.

dimension of livelihood satisfaction as the estuary changed (Maliao et al., 2023). The use of a single-item measure is a validated approach for capturing life satisfaction, offering comparable reliability to multi-item scales while reducing respondent fatigues in demanding field conditions (Wanous et al., 1997; Cheung and Lucas, 2014). To minimize retrospective bias, we implemented a sequential anchoring protocol where participants reconstructed decadal cognitive fisheries ecological baselines (e.g., catch composition and biomass) prior to providing an affective livelihood satisfaction rating. By requiring respondents to first quantify specific fisheries ecological baselines for a given decade, we created an empirical anchor for their memory. This sequence ensured each livelihood satisfaction score was cognitively tethered to the recalled fisheries baseline, preventing affective blurring where present-state bias might otherwise distort historical ratings. Because the resulting construct is both narrow and unambiguous, our single-item metric of affective livelihood satisfaction is statistically sufficient and valid metric (Sackett and Larson, 1990). By linking affective livelihood satisfaction to decadal cognitive baselines, we isolate Expert Grief as a rational response to social-ecological decay rather than a generalized mood.

Using ILK is a well-established method for reconstructing ecological trends when formal data are fragmented (McClenachan et al., 2024). Our findings of significant social-ecological decline concur with formal scientific assessments at this site (Altamirano and Kurokura, 2010; Kamiyama et al., 2015; Monteclaro et al., 2018; Maliao, 2019; Maliao et al., 2023). Although our retrospective cross-sectional research approach differs from a prospective longitudinal study and lacks external data to triangulate historical livelihood satisfaction, the high thematic consistency across 448 independent experts provides a robust basis for analyzing Expert Grief.

2.5. Analytical framework

Our analytical framework tests theoretical pathways scant in conservation literature, specifically the thematic decoupling of social and ecological dimensions (Maliao and Tóthmérész, 2026a). We used a series of Linear Mixed-Effects Models (LMMs) developed in R (v. 4.3.2) to

evaluate these dynamics.

To track functional ecological shifts, we assigned each taxonomic family to one of five ecological guilds (Table 1) based on feeding strategies from FishBase (Froese and Pauly, 2025) and SeaLifeBase (Palomares and Pauly, 2025). We then tested for three phenomena: (1) dual erosion in affective livelihood satisfaction and cognitive fisheries baselines; (2) the ecological signature of Shifting Baseline Syndrome (SBS) using an interaction between decade and fishing experience; and (3) the presence of Expert Grief by applying that same interaction to our affective livelihood satisfaction model. All LMMs included a random intercept for each fisher to account for nested decadal measures and a random slope for the effect of time on each individual.

We treated time as a continuous linear variable (relative decade) after Akaike Information Criterion (AIC) comparisons confirmed this approach was most parsimonious. To track ecological shifts, we used the first axis of a non-Metric Multidimensional Scaling (nMDS) ordination (nMDS1 score) performed on $\log(x + 1)$ transformed catch data. This integrated measure captures functional restructuring, including the emergence of novel target species, which simplistic metrics like predator proportions would overlook. This nMDS axis serves as a proxy for community change, and post-hoc analysis confirmed a strong correlation with fishing down the food web (Pearson's $r = -0.78$, $p < 0.001$). Finally, we probed the link between ecological decline and livelihood distress using Pearson correlations of reconstructed individual slopes and a Redundancy Analysis (RDA).

2.6. Positionality statement

The lead author is a Filipino academic and faculty member at the College of Fisheries and Marine Science, Aklan State University, an institution situated directly within the Batan Estuary. This study is a central component of the lead author's doctoral research at the University of Debrecen, Hungary, where the second author serves as mentor and primary advisor. Our collaboration operationalizes a model of pluralistic knowledge braiding by synthesizing the lead author's embedded local perspective with the second author's training in

Table 1

Ecological guild assignments enable analysis of functional shifts in coastal fisheries. Classification of each taxonomic family into one of five ecological guilds based on predominant feeding strategies in a Philippine coastal and estuarine context. These assignments facilitate the analysis of functional shifts in the fishery over time.

Class	Order	Family	Trophic Guild
Bivalvia	Cardiida	Cardiidae	Benthic invertebrate
Bivalvia	Venerida	Cyrenidae	Benthic invertebrate
Bivalvia	Cardiida	Psammobiidae	Benthic invertebrate
Bivalvia	Venerida	Veneridae	Benthic invertebrate
Cephalopoda	Myopsida	Loliginidae	Benthic carnivore
Cephalopoda	Octopoda	Octopodidae	Benthic carnivore
Chondrichthyes	Myliobatiformes	Dasyatidae	Benthic carnivore
Malacostraca	Decapoda	Palaemonidae	Benthic invertebrate
Malacostraca	Decapoda	Penaeidae	Benthic invertebrate
Malacostraca	Decapoda	Portunidae	Benthic invertebrate
Malacostraca	Decapoda	Sergestidae	Benthic invertebrate
Teleostei	Anguilliformes	Moringuidae	Generalist piscivore
Teleostei	Carangiformes	Carangidae	Generalist piscivore
Teleostei	Cichliformes	Cichlidae	Herbivore/Detritivore
Teleostei	Clupeiformes	Clupeidae	Planktivore
Teleostei	Clupeiformes	Engraulidae	Planktivore
Teleostei	Elopiformes	Megalopidae	Generalist piscivore
Teleostei	Gobiiformes	Butidae	Generalist piscivore
Teleostei	Gobiiformes	Gobiidae	Benthic carnivore
Teleostei	Gonorynchiformes	Chanidae	Herbivore/Detritivore
Teleostei	Kurtiformes	Apogonidae	Generalist piscivore
Teleostei	Leiognathiformes	Leiognathidae	Planktivore
Teleostei	Lutjaniformes	Lutjanidae	Benthic piscivore
Teleostei	Mugiliformes	Ambassidae	Planktivore
Teleostei	Mugiliformes	Mugilidae	Herbivore/Detritivore
Teleostei	Mulliformes	Mullidae	Benthic carnivore
Teleostei	Perciformes	Caesionidae	Planktivore
Teleostei	Perciformes	Chaetodontidae	Herbivore/Detritivore
Teleostei	Perciformes	Gerreidae	Benthic carnivore
Teleostei	Perciformes	Haemulidae	Generalist piscivore
Teleostei	Perciformes	Nemipteridae	Benthic carnivore
Teleostei	Perciformes	Polynemidae	Benthic carnivore
Teleostei	Perciformes	Scatophagidae	Herbivore/Detritivore
Teleostei	Perciformes	Serranidae	Generalist piscivore
Teleostei	Perciformes	Terapontidae	Generalist piscivore
Teleostei	Pleuronectiformes	Cynoglossidae	Benthic carnivore
Teleostei	Pleuronectiformes	Paralichthyidae	Benthic carnivore
Teleostei	Pleuronectiformes	Soleidae	Benthic carnivore
Teleostei	Scombriformes	Scombridae	Generalist piscivore
Teleostei	Scombriformes	Sphyraenidae	Generalist piscivore
Teleostei	Siganiformes	Siganidae	Herbivore/Detritivore
Teleostei	Spariformes	Lethrinidae	Benthic carnivore
Teleostei	Syngnathiformes	Callionymidae	Benthic carnivore
Teleostei	Tetraodontiformes	Tetraodontidae	Benthic carnivore

Note: Each taxonomic family reported in the Indigenous and Local Knowledge (ILK) data was assigned to one of five ecological guilds based on their predominant feeding strategy, informed by data from FishBase (Froese and Pauly, 2025) and SeaLifeBase (Palomares and Pauly, 2025). We chose this functional guild approach over a mean trophic level calculation to better capture functional diversity within the Philippine coastal and estuarine context. The guilds included (1) Generalist Piscivores, carnivores preying on fish and large mobile invertebrates; (2) Benthic Carnivores, predators foraging on or within the benthos, including demersal fish and cephalopods; (3) Planktivores, species that feed on plankton; (4) Herbivore/Detritivores, species primarily consuming plant matter or detritus; and (5) a functional fisheries category of Benthic Invertebrates for other targeted invertebrates like crustaceans and mollusks.

theoretical ecology and conservation. All field assistants were recruited from the local community. This institutional and geographical embeddedness, built through decades of presence, provided the trust necessary to access the cognitive fisheries ecological baselines and affective livelihood satisfaction of the local community documented in this study. We navigated academic power dynamics by treating all knowledge holders as expert colleagues and sharing findings with community leaders to ensure they accurately reflect their lived experience.

3. Results

3.1. Evidence of multi-decadal ecological and livelihood erosion

The study included 448 primary fishers, reflecting the gendered structure of local artisanal fishing (89.8% male; $n = 401$). On average, respondents were 48.7 years old (± 11.25 SD) with 22.2 years (± 11.52) of direct fishing experience and 39.38 years (± 16.26) of residency in the estuary. These households face high dependency ratios and low formal education (8.49 ± 3.05 years), with an average family size of 3.68 members and a reported maximum of 14.

These fishers rely overwhelmingly on the estuary. Capture fisheries provide their primary income, supplemented by small-scale aquaculture like oyster culture and crab fattening. Seasonal manual labor, such as construction or carpentry, remains the predominant alternative to fishing. The reliance on traditional boats reflects this vulnerability where 41% of respondents operate non-motorized bancas (outrigger canoes), restricting their range to degraded nearshore waters. This dependency exists within profound socio-economic precarity. Since the pre-pandemic period, the proportion of households living below the national poverty threshold (PHP 12,030; ~USD 200 monthly) escalated from 78% to 91% (Maliao et al., 2023). Currently, 60% of the community reports monthly incomes below PHP 5000 (~USD 83). This systemic poverty creates the high-stakes environment where ecological decline and Expert Grief converge.

The thematic consistency across 448 independent experts provides a robust basis for analysis, confirming that these trends represent a systemic phenomenon. The sampled small-scale fisheries (SSF) use diverse methods, including stationary gears (barrier nets, filter nets, fish corrals) and active gears (gill nets, pots, hook and line, and gleaning). Over the 60-year recall window, average daily catch fell from a historical peak of 3.7 kg to 2.8 kg in the 2020s. A significant functional restructuring accompanied this biomass loss. While catches from the 1960s to the 1980s featured high-trophic bony fishes and large crustaceans, the modern fishery has shifted toward cephalopod mollusks and batoid elasmobranchs. This trophic simplification drives distress among veteran fishers who maintain unshifted baselines of the estuary's former biodiversity.

This catch degradation, encompassing lost biomass and eroded diversity, mirrors a decline in livelihood satisfaction. Satisfaction scores, anchored to shifting ecological baselines, showed a significant downward trend. By requiring respondents to reconstruct the estuary's state before rating their satisfaction, our protocol ensured that this affective index remained cognitively grounded in the reality of the fishery. These results represent the systematic coupling of ecological restructuring and distress rather than a clinical diagnosis. We interpret this trajectory as Expert Grief, capturing the affective toll on fishers whose identities are tethered to a degrading resource base (Maliao et al., 2023). This parallel decline provides the evidence for dual erosion in the Batan Estuary, whereby the fishery's degradation mirrors the diminishing satisfaction of its most experienced experts.

3.2. Dual erosion of ecology and livelihood satisfaction

Our analysis demonstrates a concurrent, multi-decadal decay in cognitive fisheries baselines and affective livelihood satisfaction (Table 2). Livelihood satisfaction fell significantly over time ($\beta = -0.44$, $p = 0.001$; Fig. 3a), with mean scores ($\pm$ SD) dropping from 8.3 ± 1.32 to 5.6 ± 1.03 . This trajectory quantifies the distress felt by the most experienced fishers in the estuary. In parallel, the proportion of high-trophic predators in the catch decreased significantly ($\beta = -0.06$, $p = 0.003$; Fig. 3b), while low-trophic guilds increased ($\beta = 0.15$, $p = 0.001$; Fig. 3c). These results provide empirical evidence of ecosystem-level trophic decline, with the average proportion of high-trophic predators plummeted from 31.5% at the historical baseline to 19.8% in recent decades. This statistical coupling confirms a dual erosion where the

Table 2

Linear Mixed-Effects Models (LMMs) evaluating multi-decadal trends in estuarine trophic structure, catch composition, and fisher livelihood satisfaction (N = 448). Summary of parameter estimates (β), standard errors (SE), and random effects variance components evaluating (1) dual erosion across multi-decadal trends (1960s–2020s) in affective livelihood satisfaction, mean trophic level, high-trophic predator catch, and low-trophic catch; (2) the ecological signature of Shifting Baseline Syndrome (SBS; Decade $\times$ Experience interaction on catch trajectories); and (3) Expert Grief (Decade $\times$ Experience interaction on affective livelihood satisfaction).

Predictor / Model Term	Livelihood Satisfaction β (SE)	Mean Trophic Level β (SE)	High-Trophic Catch β (SE)	Low-Trophic Catch β (SE)
Fixed Effects				
Intercept	6.564*** (0.123)	3.421*** (0.015)	4.852*** (0.119)	3.125*** (0.089)
Dual Erosion:				
Decadal Shift	−0.445*** (0.046)	−0.060*** (0.003)	−0.319*** (0.025)	+0.151*** (0.019)
Fishing Experience	−0.021*** (0.004)	+0.001† (0.001)	+0.025*** (0.004)	−0.019*** (0.003)
Expert Grief: Decade $\times$ Experience Interaction	−0.001† (0.001)	–	+0.006* (0.002)	−0.014*** (0.002)
Random Effects Variance Component				
Respondent Intercept	0.592	0.009	0.551	0.312
Respondent Slope	0.039	–	–	–
Residual Variance	0.226	0.013	0.782	0.442

Note. Unstandardized regression coefficients (β) are presented with Standard Errors (SE) in parentheses. All models were estimated using Restricted Maximum Likelihood (REML) with random intercepts specified for individual respondents ($n = 448$ primary artisanal fishers). Livelihood satisfaction additionally specifies random slopes across decadal time points. Significance thresholds: † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

simplification of the fish community mirrors the diminishing satisfaction of the fishers.

3.3. Expert Grief paradox: Catch resilience and livelihood distress

Fishing experience moderates the perception of trophic decline in the estuary. An LMM interaction shows that veteran fishers reported a slower decline in high-trophic catch compared to novices ($\beta = 0.0057$, $p = 0.012$; Fig. 4a). This divergence is even more pronounced for low-trophic guilds, evidenced by a strong negative interaction ($\beta = -0.014$, $p = 0.001$; Fig. 4b) indicating that primarily novices reported an increase in low-trophic species. We attribute these findings to a practical ecological proficiency derived from decades of accumulated ILK and sustained environmental interaction. This deep knowledge allows veterans to target high-value, high-trophic species effectively even as the broader fishery undergoes structural simplification, a process marked by the shifting of functional diversity.

Consequently, veteran catch composition acts as a lagging indicator of fisheries community restructuring. Novice catches provide an unfiltered signature of trophic shift, as they lack the specialized ILK required to bypass the lower-trophic taxa associated with ecosystem simplification. This disparity reveals the study's central paradox: although ILK supports a resilient fishing livelihood, this same group experienced the steepest decline in livelihood satisfaction. A significant negative interaction between decade and fishing experience in our livelihood satisfaction model confirms this dynamic ($\beta = -0.0012$, $p = 0.015$; Fig. 4c), providing an empirical signature of Expert Grief. While ILK facilitates catch resilience, it also drives livelihood distress. Those with the deepest memory of historical abundance are the most acutely aware of the

current degraded state.

3.4. Systemic livelihood distress: A collective response to degradation

Our analysis reveals that this distress is a community-level phenomenon rather than a response to individual fishing success. Pearson correlations between individual satisfaction trajectories (slopes) and ecological trend slopes showed no significant relationship ($r(438) = 0.03$, $p = 0.49$; Fig. 5a). This decoupling suggests that personal catch performance does not dictate an individual's livelihood satisfaction. Redundancy Analysis (RDA) and non-Metric Multidimensional Scaling (nMDS) confirmed that fishing gear drives catch composition. Despite ecological noise, gear type explains 6.8% of the community variance ($p = 0.001$; Fig. 5b). This confirms that catch shifts are systematic rather than stochastic. This finding justifies our focus on primary fishers, whose gear interactions shape the ILK regarding species decline and trophic simplification.

A minimal nMDS stress (0.002) confirms the ordination's robustness, showing how gear types act as filters for the ecological reality fishers observe. Decoupling individual success from satisfaction demonstrates that distress is a systemic response to the shared ecosystem's degradation. Expert Grief represents a shared recognition of a declining fishery, where the collective sense of loss transcends any single fishing effort.

4. Discussion

This study defines Expert Grief as a paradox where the ecological knowledge facilitating livelihood resilience also intensifies the distress of witnessing trophic simplification. High thematic consistency across 448 independent experts confirms that the erosion of livelihood satisfaction and catch structure is a systemic social-ecological phenomenon rather than a collection of anecdotal accounts. This represents the human dimension of dual erosion, wherein the concurrent degradation of a fishery's trophic structure and the affective state of its community become inextricably linked. Our Expert Grief framework offers two theoretical advances: a mechanistic model for the cognitive drivers of Shifting Baseline Syndrome (SBS) and the affective, knowledge-mediated extension of solastalgia within a tropical fishery. This knowledge paradox exposes the epistemic barriers limiting technocratic conservation, as these frameworks often overlook the nuanced, place-based ecological knowledge held by local experts. Far from being a collection of ancillary data points, such expertise constitutes the foundational knowledge-base required for a resilient and equitable conservation science.

4.1. The signature of grief: Shifting baselines and collective distress

Expert Grief stems from the documented degradation of the Batan Estuary. Our data reveal a signature of fishing down the food web (Pauly et al., 1998), a pattern of ecosystem simplification where high-trophic predators decline as the community undergoes functional restructuring (Howarth et al., 2014). This decline aligns with multiscale stressors identified in the estuary, such as overexploitation, landscape conversion, and mangrove deforestation (Altamirano and Kurokura, 2010; Kamiyama et al., 2015; Monteclaro et al., 2018; Maliao, 2019). These pressures accelerate sedimentation, shallowing the estuary and altering its ecological character (Santos et al., 2024). Such degradation heightens social vulnerability in a community already facing severe economic constraints (Maliao et al., 2023). Declining livelihood satisfaction is a salient human dimension of fisheries degradation, consistent with both Philippine (Maliao et al., 2009a, 2009b; Muallil et al., 2014; Anticamara and Go, 2016; Cabral et al., 2025) and global trends (Pauly et al., 1998; Howarth et al., 2014; Gutgesell et al., 2024).

The paradox of Expert Grief emerges from this dual erosion. The central mechanism is a perceptual divide driven by generational experience. This divergence produces two distinct outcomes: a cognitive

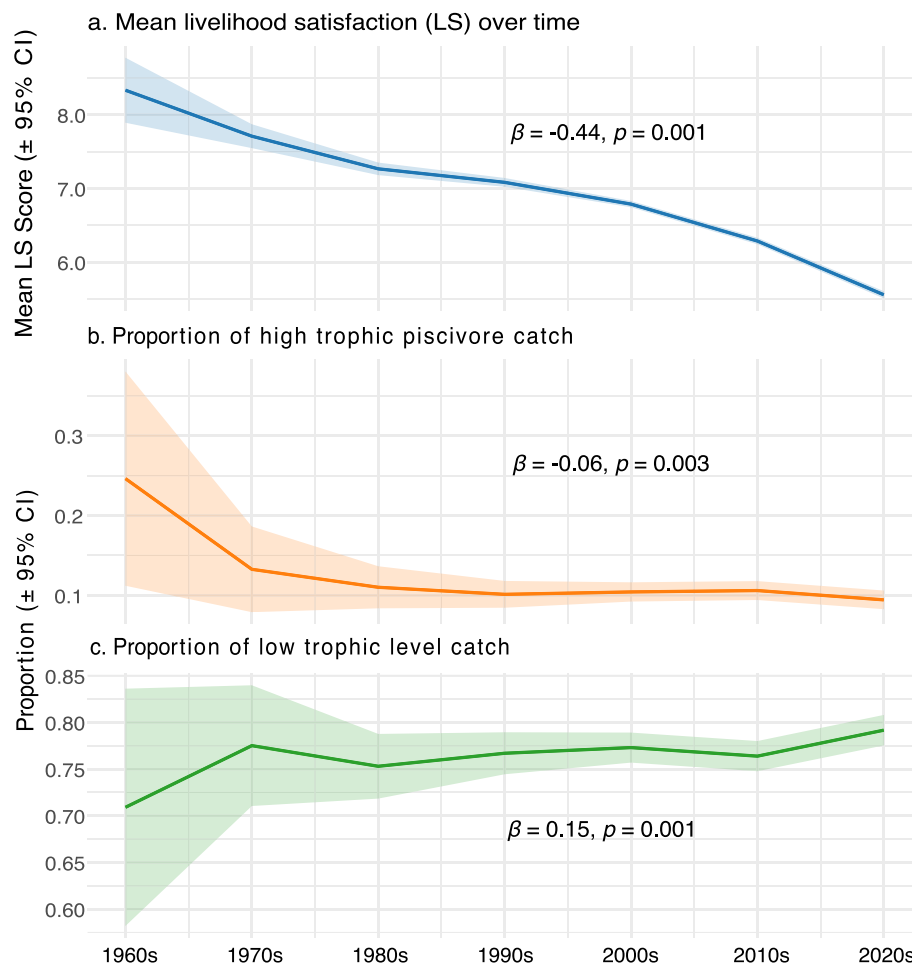


Fig. 3. Dual erosion reveals declining fisher livelihood satisfaction and cascading trophic shifts. Decadal trends in socio-ecological indicators from the Batan estuary case study ($N = 448$ fishers). Solid lines represent the mean value per decade; shaded ribbons are the 95% confidence interval. All trends were tested with Linear Mixed-Effects Models (LMMs). **a.** Perceived fisher livelihood satisfaction declined significantly ($\beta = -0.44, p = 0.001$). **b.** The proportion of high-trophic predators decreased significantly in the catch ($\beta = -0.06, p = 0.003$). **c.** The proportion of low-trophic guilds increased significantly in the catch ($\beta = 0.15, p = 0.001$).

outcome, modeled as the social mechanism of Shifting Baseline Syndrome (SBS) (Pauly, 1995; Soga and Gaston, 2024), and an affective outcome, modeled as solastalgia (Albrecht et al., 2007; Cunsolo and Ellis, 2018). By delineating these interdependencies, we show the decay of cognitive fisheries baselines is mirrored by the erosion of the affective state for those whose identities are entwined with the water.

Originally, SBS described the decay of ecological perceptions as successive generations adopt impoverished biological baselines (Pauly, 1995). Our Expert Grief framework operationalizes this theory by providing an empirical account of the cognitive mechanism underpinning this decay. Experience and ecological knowledge modulate the perception of decline, acting as the primary cognitive drivers of SBS. While novices normalize a degraded fishery as a functional reference, veteran fishers utilize unshifted baselines to recognize the magnitude of multi-decadal trophic shifts. This cognitive divergence between the memory of a complex past and the normalization of a simplified present illustrates that biodiversity loss remains invisible only to those lacking a historical point of reference (Jones et al., 2020). Crucially, this reveals the Expert Grief paradox, wherein the cognitive depth of ecological knowledge required for livelihood resilience precludes the affective normalization of decay. An individual's ecological intimacy dictates the magnitude of their Expert Grief.

This perceptual divide creates a significant governance challenge, as achieving consensus is difficult when community members do not uniformly detect ecological change (Blythe et al., 2018; Quinn et al., 2019).

By reducing ecological expectations, SBS may hinder management and diminish the perceived urgency for intervention (Soga and Gaston, 2024). We elevate SBS from a perceptual bias to a connective concept (Alleway et al., 2023), linking the reality of trophic decline to social dynamics regarding intergenerational equity and cultural heritage.

While community-wide livelihood satisfaction is declining, Expert Grief is most acute among veteran fishers. A striking duality emerges wherein the same intimate knowledge that facilitates resilience also mediates profound affective distress (Silvano et al., 2023; Maliao et al., 2025). This ecological intimacy forces veterans to witness the erosion of a fishery that defines their cultural identity and place attachment (Devine-Wright, 2013; Quinn et al., 2019). Consequently, the cognitive memory supporting a fisher's success also drives their affective toll. This mechanism models solastalgia within a fisheries context, where the depth of ecological knowledge dictates the response to social-ecological decay. This identifies the cognitive mediators of affective distress, bridging the gap between resource status and the human dimensions of conservation.

The decoupling of affective states from individual catch performance confirms that Expert Grief is systemic. The lack of correlation between personal catch and satisfaction suggests that distress is a collective response to degradation rather than an aggregation of individual economic frustrations. This reveals a split in drivers. While technical gear choices dictate catch composition, the affective toll reflects a shared, localized recognition of resource erosion. This departs from the

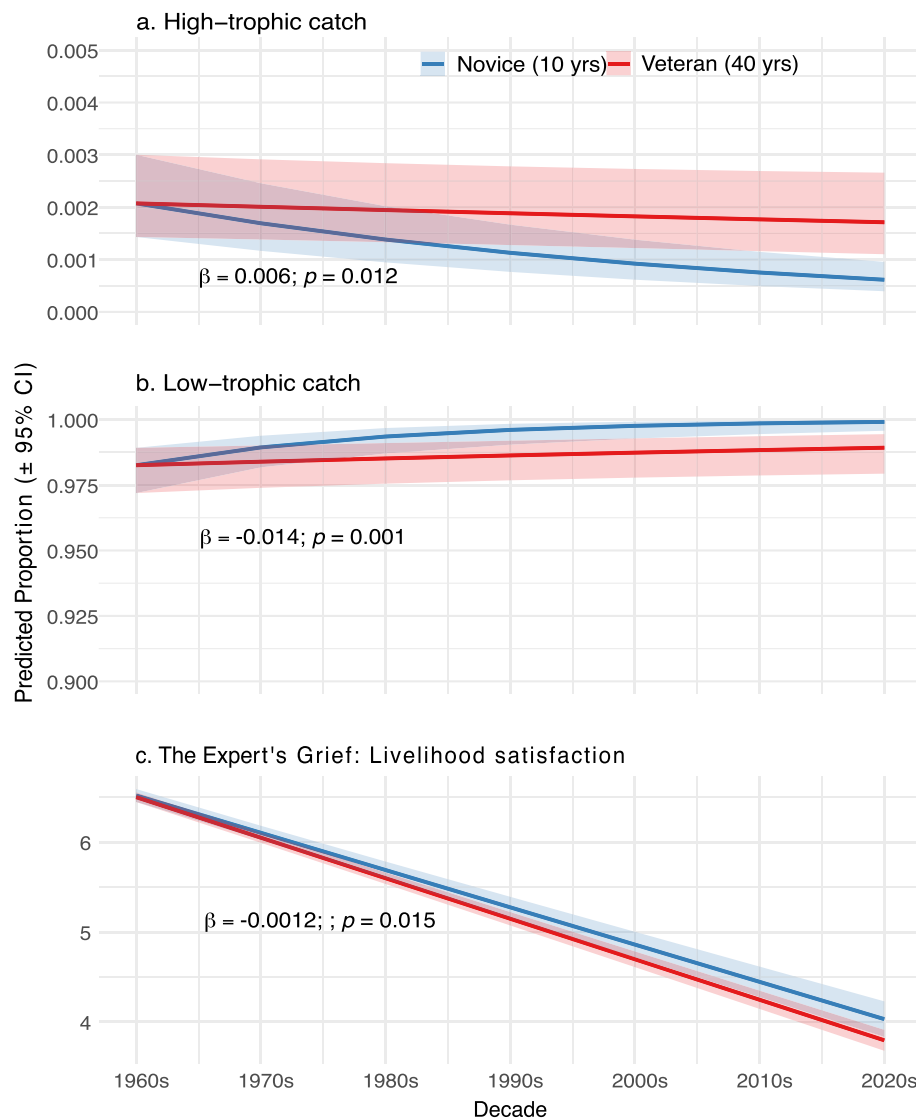


Fig. 4. The Expert's Grief paradox: veteran fishers report steeper declines in livelihood satisfaction despite perceiving a more resilient catch. a–c, The panels show that veteran fishers perceive a slower decline in high-trophic catch (a) and do not perceive the increase in low-trophic catch seen by novices (b), yet they experience a significantly sharper fall in livelihood satisfaction over time (c). All panels show predicted trends from Linear Mixed-Effects Models (LMMs) for a representative novice fishers (10 years of experience) and veteran fishers (40 years of experience). Solid lines are predicted means; shaded ribbons represent 95% confidence intervals. The key decade $\times$ experience interaction term was significant in all three models (high-trophic catch, $p = 0.012$; low-trophic catch, $p = 0.001$; livelihood satisfaction, $p = 0.015$).

methodological individualism prevalent in technocratic management (Ostrom, 2009). Instead, it frames community distress as a systemic phenomenon where the shared observation of a declining estuary transcends the extractive success of any single fisher.

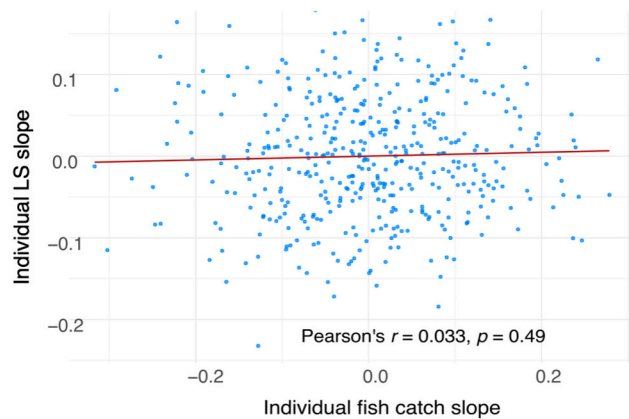
This distinction confirms that Expert Grief is a primary response to ecological erosion rather than a secondary symptom of poverty. Neglecting this affective dimension constitutes a form of epistemic injustice, leading to the misdiagnosis of social-ecological challenges (Nyssa et al., 2024). When conservation interventions ignore the emotional toll of environmental loss, they risk overlooking the fundamental drivers of fisher well-being. Our Expert Grief framework highlights the necessity for an inclusive science that operationalizes the intangible human dimensions of decline. By rendering these states visible and quantifiable, we ensure that the human costs of biodiversity loss are no longer sidelined in global frameworks (Tschakert et al., 2019).

4.2. The roots of invisibility: Structural schisms and epistemic siloing

The invisibility of Expert Grief is a systemic outcome of structural inequities and epistemic siloing in conservation science (Maliao, 2025; Maliao and Tóthmérész, 2026a, 2026b). Recent modeling of the Philippine research landscape reveals a profound demographic and thematic schism: high-visibility research by internationally affiliated scholars focuses on standardized metrics, while local scholarship documenting nuanced, affective dimensions remains siloed in lower-visibility ethnology sectors. This segregation, compounded by intersectional hierarchies of affiliation and funding, relegates the knowledge systems capable of detecting cognitive and affective signals to the margins. Consequently, this epistemic siloing masks the human dimensions of environmental change, rendering the true magnitude of social-ecological decay invisible to global policy.

This epistemic schism enforces conditional visibility, whereby local insights are integrated only when they align with international modeling priorities (Maliao, 2025; Maliao and Tóthmérész, 2026a). Such

a. Coupling of fish catch and livelihood satisfaction (LS) trajectories



b. Faceted nMDS ordination of fish community by fishing gear

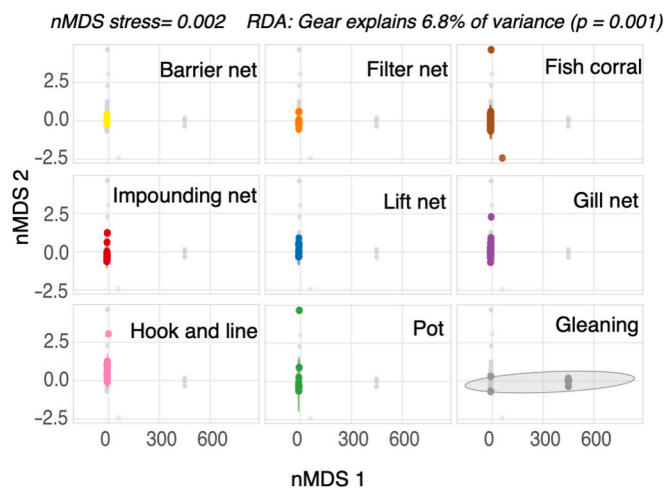


Fig. 5. Grief is a systemic phenomenon, not a response to individual catch success. a, Correlation between an individual fisher's livelihood satisfaction trajectory and their perceived ecological trajectory (catch trend slope) ($n = 448$). The relationship is not statistically significant (Pearson correlation, $r = 0.03$, $p = 0.49$). b, Non-metric Multidimensional Scaling (nMDS) ordination of fish community structure, faceted by primary fishing gear. Each panel highlights samples from a specific gear type (colored points) against all other samples (grey points). Ellipses represent the 95% confidence interval for each gear type.

prioritization privileges biological metrics over human dimensions, reinforcing the observation that we often know more about the fish than the fishers (Johannes, 1998). Decoupled from ecological analysis, Expert Grief remains invisible to top-down monitoring. This fragmentation drives policy failure. When science silos social and ecological components, it cannot account for the relational attachments inherent in common-pool resources such as fisheries (Basurto et al., 2013; Blythe et al., 2018). In political ecology, this struggle over legitimized reality creates a mismatch between top-down policy and on-the-ground complexity (Robbins, 2019; Currie et al., 2023; Chapman et al., 2024). This explains the persistent failure of *paper* Marine Protected Areas (MPAs). Such command-and-control approaches often provoke social resistance when they ignore local socio-political contexts or place attachments (Folke, 2006; Maliao et al., 2009a, 2009b; Devine-Wright, 2013; Bennett et al., 2017; Relano and Pauly, 2023).

By linking cognitive trophic baselines to affective livelihood states, this study redresses the epistemic schism identified in our previous modeling (Maliao and Tóthmérész, 2026a). Our Expert Grief operationalizes the intangible costs of change into a quantifiable framework for Social-Ecological Systems (SES) theory. This necessitates integrating

local expertise and Indigenous and Local Knowledge (ILK) to better inform policy (Hill et al., 2015; Steger et al., 2020; Barclay et al., 2024). Effective conservation must expand its diagnostic scope to include the affective toll of biodiversity loss. These costs are primarily borne by marginalized local experts whose insights remain critical yet undervalued in global sustainability discourse (Berkes et al., 2000; Estoque and Wu, 2024). Ignoring these interdependencies erodes the resilience needed for future perturbations, compromising the long-term sustainability of both the fishery and the community. Entrenched neglect of these social-ecological interdependencies produces an epistemic mismatch, where technocratic metrics perceive a facade of stability while the community experiences deep-seated affective distress (Folke, 2006; Bodin and Tengö, 2012; Hill et al., 2015; Reyers et al., 2022).

4.3. Pathways to justice: Implications for policy and management

Epistemic justice requires a structural shift that centers local expertise and Indigenous and Local Knowledge (ILK) as foundational to conservation. We propose using Expert Grief as a sentinel indicator of declining social-ecological resilience, representing a form of precautionary foresight technocratic metrics overlook. While bioindicators detect physical shifts, Expert Grief captures the cognitive and affective signals of insecurity and destabilized bonds that mark the erosion of social-ecological memory and place attachment. Since these elements determine adaptive capacity, recognizing this distress necessitates a re-conceptualization of expertise. This involves integrating ILK holders into co-management as legitimate partners rather than subsidiary data sources (Johannes, 1998; Silvano et al., 2023).

Our Expert Grief framework thus necessitates knowledge co-production, anchoring adaptive governance in the social-ecological memory essential to navigate environmental change (Folke, 2006; Bodin and Tengö, 2012; Hill et al., 2015; Brown et al., 2019; Steger et al., 2020). This approach positions fisheries monitoring as a holistic process where cognitive and affective signals are braided with biological metrics, effectively bridging the silos that fragment the scientific record. By addressing these inequities, we respond to the emotional roots of community distress while recognizing the true scale of change. This builds a resilient future that operationalizes the deep expertise of local fishers.

Ignoring Expert Grief carries significant costs. Without this lens, conservation science risks entrenching social-ecological traps (Cinner, 2011) through epistemic siloing. This exclusion creates a functional blindness to the cognitive and affective dimensions of change, eroding the capacity for long-term adaptation. Addressing this epistemic injustice requires a reorientation of our metrics. Resilience must be viewed not only as an ecosystem's ability to withstand disturbance, but as a community's capacity to navigate change without losing its identity (Folke, 2006; Eurich et al., 2024). By integrating the fish and the fisher into a unified framework, we move toward a conservation model that is as scientifically robust as it is humanly just.

4.4. Deliberate design and future directions

We prioritize analytical generalization over statistical breadth, using the Batan Estuary as a strategic case to isolate the mechanisms of Expert Grief (Yin, 2009). The estuary serves as a social-ecological microcosm where rapid trophic decline converges with multi-generational social memory. By employing a retrospective cross-sectional design, we acknowledge that where formal longitudinal data are fragmented, social memory is the primary diagnostic resource for deciphering long-term social-ecological dynamics (Folke, 2006; Johannes, 1998; Steger et al., 2020). While retrospective data requires managing cognitive bias, our use of sequential anchoring positions ILK as a robust and reliable repository for the multi-decadal histories needed to operationalize Shifting Baseline Syndrome (SBS) (Johannes, 1998; McClenachan et al., 2024; Maliao et al., 2025). This place-based approach leverages the longitudinal intimacy of local experts as a primary analytical strength,

enabling the detection of cognitive and affective signals that technocratic surveys overlook. This intimacy was systematically captured through purposive snowball sampling, which allowed us to bypass the limitations of incomplete official registries and intentionally engage the veteran practitioners who serve as the true custodians of the estuary's shifting baselines.

A single-item metric for livelihood satisfaction reflects strategic parsimony. It effectively isolates the affective core of decline while respecting the operational constraints of the Batan Estuary. While debates on multi-dimensional well-being persist (Diener et al., 2018; Helliwell et al., 2021), this single indicator was necessary because fisher availability is strictly governed by tides and food security. In artisanal fisheries, this calibrated proxy provides a reliable, culturally resonant measure of resource-linked security without the participant fatigue often caused by multi-metric indices (OECD, 2013). Crucially, because our sequential anchoring protocol tethers affective satisfaction to specific cognitive baselines, the resulting construct is both narrow and unambiguous. As argued by Sackett and Larson (1990) and Wanous et al. (1997), single item measures are statistically sufficient and valid instruments for such well-defined assessments. This methodological adaptation to data-limited, high-pressure environments provides a robust baseline for investigating Expert Grief across social-ecological landscapes. Centering these cognitive and affective signals transforms site-specific observations into a scalable framework for global governance, directly addressing the epistemic injustice that characterizes remote-control conservation science.

Furthermore, gendered dimensions represent a critical frontier for future inquiry. While our sample aligns with the predominantly male demographic of regional harvesting, environmental change is experienced unevenly across gender and social roles (Maliao and Polohan, 2008; Hill et al., 2015; Cavole et al., 2025). Expert Grief likely manifests differently across gendered seascapes. While the male cohort witnesses subsurface trophic decline, women in gleaning or processing roles likely experience a distinct form of grief tied to the loss of estuarine biodiversity. Ultimately, acknowledging these nuances is prerequisite for a truly just science. Framing these intersecting identities as a future research priority is vital to keeping the Expert Grief construct remains gender-responsive and epistemically inclusive. By elucidating the Expert Grief paradox, we provide the empirical basis for a more equitable conservation model that operationalize the expertise of those at the forefront of social-ecological change.

5. Conclusion: Advancing epistemic justice in conservation

The Batan Estuary exemplifies a feedback loop of social-ecological decay, where fisheries simplification drives the erosion of affective livelihood security. We demonstrate that Expert Grief is a robust diagnostic signal of fundamental social-ecological decay, exposing its roots in an entrenched epistemic schism where cognitive and affective signals are overlooked in technocratic records. Our framework extends Shifting Baseline Syndrome (SBS) from a passive cognitive decay to a social-ecological trap. Veteran fishers do not adopt impoverished baselines, which precludes the normalization of loss. Consequently, we frame solastalgia as a knowledge-mediated distress where the memory of a complex past intensifies the perceived impoverishment of the simplified present. This transforms the ILK holder from a subsidiary data source into a witness bearing the systemic burden of social-ecological decay. Our Expert Grief framework suggests that technocratic monitoring may overlook this expertise, revealing a schism that restricts the capacity to detect change occurring in plain sight. Recognizing local experts as legitimate partners is therefore a methodological requirement for effective governance rather than a mere courtesy. Addressing the invisibility of Expert Grief is fundamental to Target 22 of the Kunming-Montreal Global Biodiversity Framework (GBF). By engaging those who know the waters best, we find that the stability of subsistence communities is bound to ecological complexity. Ultimately, braiding ILK with

technocratic conservation transforms epistemic justice from a theoretical, tokenistic ideal into an active, operational vehicle for inclusive and equitable global environmental governance.

CRediT authorship contribution statement

Ronald J. Maliao: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Béla Tóthmérész:** Writing – review & editing, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Ethics approval and consent to participate

Aklan State University (Philippines) granted ethical approval for Batan estuary case study.

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Data availability

Data will be made available on request.

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