J. Northw. Atl. Fish. Sci., Vol. 57, Special Issue: 69–77
Conference article
Publication (Upload) date: 11 Sep. 2026

From Principle to Practice: A Pragmatic Pathway for Ecosystem-Based Fisheries Management in a Data-limited RFMO

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Milardi, M. 2026. From Principle to Practice: a pragmatic pathway for Ecosystem-Based Fisheries Management in a data-limited RFMO. *J. Northw. Atl. Fish. Sci.*, **57(1)**: 69–77. https://doi.org/10.2960/J.v57.m756

Abstract

The Southern Indian Ocean Fisheries Agreement (SIOFA) is legally mandated through its founding agreement to implement an Ecosystem Approach to Fisheries Management (EAFM). However, like many Regional Fisheries Management Organizations (RFMOs), translating this principle into effective practice poses significant challenges, particularly in data-limited environments. This viewpoint paper traces SIOFA's pragmatic journey in operationalizing EAFM. We detail the organization's early adaptive strategies, which included precautionary alignment with other RFMOs for managing seabirds and Vulnerable Marine Ecosystems (VMEs), and evidence-based conservation measures for deepwater sharks driven by targeted ecological risk assessments. While effective, these approaches highlighted a fundamental barrier: the Scientific Committee's limited access to integrated fisheries data. In response, SIOFA developed an internal synthesis tool—the SIOFA Ecosystem Summary, to synthesize and streamline data access, thereby directly supporting science-based advice. This perspective paper argues that SIOFA's experience demonstrates a pragmatic, phased pathway for EAFM implementation that reflects broader trends among RFMOs. While similar ecosystem synthesis tools exist in other bodies (*e.g.*, NAFO, ICES, IOTC), SIOFA's process is distinctive in its iterative co-development between the Secretariat and Scientific Committee within a resource-constrained setting. This paper contends that such adaptive, context-sensitive approaches offer practical insights for data-limited RFMOs seeking to operationalize EAFM.

Keywords: Adaptive Management; Fisheries Governance; Precautionary Approach; Science-Policy Interface; SIOFA

Introduction

The Ecosystem Approach to Fisheries Management (EAFM, FAO, 2003) has emerged as a cornerstone of modern international fisheries governance, advocating for a holistic strategy that moves beyond a single-species focus to consider the entire ecosystem—including target and non-target species, habitats, and human communities—and thereby seeks to balance ecological, economic, and social objectives for long-term sustainability. While the principle is widely endorsed, its practical implementation by Regional Fisheries Management Organizations (RFMOs) remains a significant and complex challenge (Ramirez-Monsalve *et al.,* 2016), especially in data-limited contexts and for newer RFMOs (*i.e.*, established after the early 2000s) that need to build their management frameworks from the ground up (Fletcher, 2020).

The journey from the high-level principle of EAFM to its tangible, effective practice requires pragmatic solutions, institutional learning, and adaptive strategies (see *e.g.*, Fletcher *et al.,* 2010). This transition is fraught with operational hurdles, including reconciling short-term economic interests with long-term sustainability, managing uncertainties, and building the institutional capacity for complex systems thinking (*e.g.*, Fletcher, 2008). These challenges resonate strongly with concepts in the literature on adaptive management, which emphasizes iterative learning and flexible decision-making in the face of uncertainty (*e.g.*, Walters, 1986; Holling, 1978; Plagányi *et al.,* 2014; Fletcher and Bianchi*,* 2014). It is within this global context that the experience of the Southern Indian Ocean Fisheries Agreement (SIOFA) offers a valuable case study in applied adaptive management.

Established in 2012, but active starting from 2016, SIOFA is a relatively young RFMO that embodies this challenge, governing a vast and ecologically-significant area (Fig. 1). Comprising 10 Contracting Parties, one Participating Fishing Entity, and two Cooperating Non-Contracting Parties, SIOFA's core objectives are to ensure the long-term conservation and sustainable use of non-highly-migratory fishery resources in the high-seas of the agreement area, and to promote their sustainable

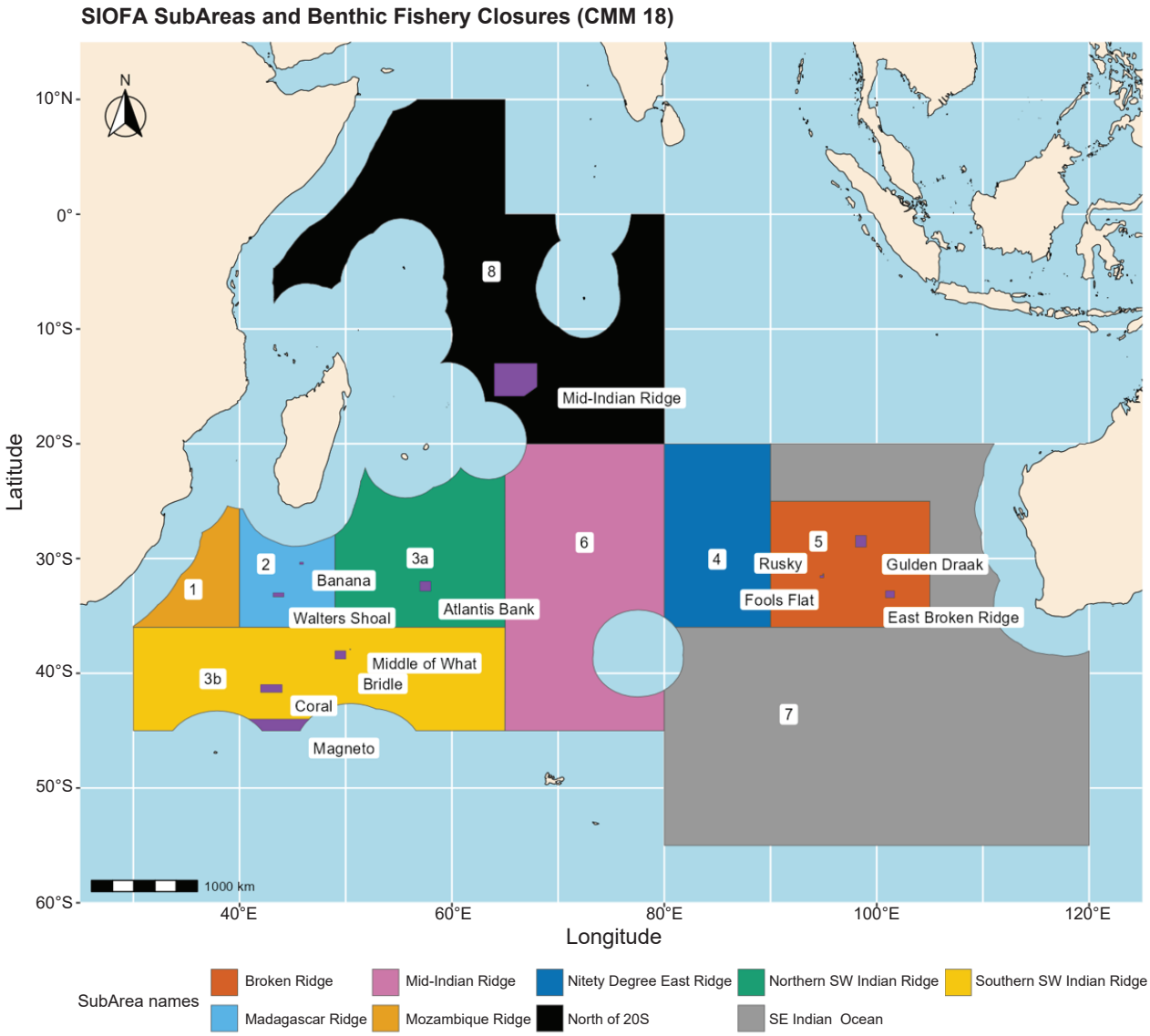

Fig. 1. The SIOFA Area and Subareas (source: SIOFA Spatial database). The map highlights SIOFA Benthic Fishery Closures (in purple) as defined in CMM 18(2025) (Table 1 and 2). All the benthic fishery closures have been labelled by name for easier recognition. Reproduced from the SIOFA Ecosystem Summary 2026 (SIOFA Secretariat 2006).

development. Its founding agreement legally embeds an ecosystem approach as part of its mandate, creating a compelling imperative to translate this principle into action (SIOFA 2006, Article 4a) and placing EAFM at the heart of SIOFA's legal identity and operational mission. However, as with many RFMOs (*e.g.*, Juan-Jordá *et al.,* 2018; Haas *et al.,* 2020; Shen and Song, 2023), translating this principled commitment into consistent and effective practice has been a significant challenge.

This perspective paper documents SIOFA's journey in meeting that challenge, arguing that its pragmatic, tiered approach provides a context-specific example of how data-limited RFMOs can operationalize EAFM through adaptive learning—building on, rather than replicating, experiences from other bodies.

Early Practices: Pragmatic Management in a Data-Limited Context

Faced with the imperative to implement EAFM amidst the data-scarce reality common to many recently established RFMOs (*i.e.*, after the early 2000s), SIOFA's initial path was necessarily pragmatic. Before the development of a comprehensive, internal evidence base, the organization employed adaptive strategies to fulfil its conservation mandate. These early initiatives can be broadly categorized into two complementary approaches:

precautionary alignment with other *management* bodies and proactive, evidence-based conservation driven by targeted research, each demonstrating a flexible response to varying levels of information availability.

Precautionary and Harmonized Management: Interim Measures for Seabirds and VMEs

In areas where SIOFA-specific data were initially lacking, such as for seabird bycatch and the location of Vulnerable Marine Ecosystems (VMEs), the organization adopted a precautionary strategy in line with the Agreement. Recognizing the high potential for serious and irreversible harm, SIOFA looked to measures already established by other, more data-rich RFMOs operating in other regions. By harmonizing its Conservation and Management Measures (CMMs; SIOFA 2025)—for example, adopting standardized bycatch mitigation protocols for seabirds and established thresholds for identifying and protecting VMEs—SIOFA achieved several critical objectives. First, it enacted a precautionary safeguard without delay, erring on the side of conservation while local data were being accumulated. This is best exemplified with the adoption of the Northwest Atlantic Fisheries Organization (NAFO, 2026) threshold for Vulnerable Marine Ecosystems (VME) encounters with bottom trawl gear (Article 22.1 of the NAFO Conservation and Enforcement Measures) while SIOFA was building up its own knowledge of VME indicator taxa bycatch in its own area; a practical solution, even if perhaps not scientifically sound as it assumed the SIOFA Area would have similar densities and distributions of benthic taxa as the northwest Atlantic. Second, this approach promoted management consistency for fishing vessels operating across RFMO boundaries, thereby simplifying compliance and enhancing overall governance effectiveness (Cullis-Suzuki and Pauly, 2010; Pentz *et al.,* 2018). A good example of this is the adoption of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR, 2013) threshold for VME encounters with demersal longline gear (CM 22-07), which allows vessels targeting Patagonian toothfish (*Dissostichus eleginoides*) in the southern areas of SIOFA to implement a single measure across boundaries. This strategy demonstrated a practical understanding that in a data-limited context, leveraging existing knowledge is a responsible and efficient interim step in EAFM (Fletcher *et al.,* 2014; FAO, 2025).

The decision to harmonize measures for seabirds and VMEs with other RFMOs was not merely administrative; it represented a strategic choice grounded in the precautionary approach. This approach acknowledged the high ecological stakes and the improbability of obtaining perfect, SIOFA-specific data in the short term. However, this strategy also carried inherent limitations. Dependence on external benchmarks raised questions about the universal applicability of measures developed for different ecological and socio-economic contexts. Despite this potential drawback, the approach was justified as a necessary, risk-averse strategy to prevent irreversible damage while building local knowledge, in line with the SIOFA Agreement (SIOFA 2006, Article 4c).

Proactive Management: Evidence-Based Conservation for Deepwater Sharks

Conversely, where specific risks were identified and the capacity for targeted assessment existed, SIOFA demonstrated its ability to conduct proactive, science-driven management. A clear example is SIOFA's approach to deepwater sharks; commissioning a dedicated ecological risk assessment (Hobday *et al.,* 2011) provided the necessary evidence to identify some species as a high priority for conservation. This targeted research used the Sustainability Assessment for Fishing Effects (SAFE) methodology to evaluate 94 chondrichthyan species across three gear types (demersal trawl, midwater trawl, demersal longline), using three distribution mapping sources (AquaMaps, FAO GeoNetwork, IUCN Red List). The analysis identified 14 deepwater shark species at high or extreme vulnerability to demersal longline fishing, directly informing the development of CMM 12 (SIOFA, 2025), which established a ban on targeting these species and other measures to mitigate risks to shark populations from bycatch. This case illustrates SIOFA's commitment to moving beyond general precaution to targeted, evidence-based action when specific information becomes available, showcasing a capacity for nuanced management tailored to distinct ecological challenges.

The ecological risk assessment for deepwater sharks exemplified a more targeted, data-generating approach. The methodology itself—assessing a species' susceptibility to the fishery and its potential for recovery—provided a structured framework for prioritizing conservation actions. This moved SIOFA from a position of general precaution to one of specific, evidence-based priority-setting. The subsequent evolution of CMM 12, which recently also included some spatially explicit measures (a catch limit for one species in SIOFA Subarea 2, a 5-nautical-mile move-on rule in SIOFA Subarea 4 when shark catch exceeds 50% of haul, and a ban on bottom longline fishing in Subarea 5 until a stock assessment is completed and endorsed), demonstrated an ability to translate complex scientific assessments into actionable management. This case highlights a critical success factor: the availability of scientific expertise and resources to conduct such targeted assessments, which may not be feasible for all ecosystem components simultaneously.

Synthesis: Establishing a Baseline of Adaptive Management

Together, these two approaches established a baseline of adaptive management for SIOFA, proving the organization's ability to act decisively across a spectrum

of information availability. However, these strategies also revealed their inherent limitations. The precautionary approach, while vital, remained inherently reactive and dependent on external benchmarks (*e.g.*, VME thresholds set for other geographic areas and taxa). Similarly, the targeted assessments, though effective, were resource-intensive and focused on single issues (*e.g.*, risk from deepwater shark bycatch). Consequently, a more integrated, sustainable, and self-sufficient solution was needed to fully empower the Scientific Committee and systematically implement EAFM across all facets of SIOFA's remit. This recognition set the stage for the development of a more comprehensive tool.

The Implementation Challenge: The Need for an Integrated Evidence Base

The limitations of the early practices culminated in the recognition of a systemic bottleneck. While valuable, both the precautionary and targeted-risk approaches were inherently fragmented. They addressed symptoms of data scarcity rather than the underlying cause: the absence of a centralized, accessible, and ongoing evidence synthesis process. The core of this challenge was a practical one: the SIOFA Scientific Committee, the subsidiary body tasked with providing ecosystem advice to the Meeting of the Parties, faced significant difficulties in efficiently accessing and synthesizing the fisheries data collected by the Secretariat. These data, while existent, were not readily available in a format tailored for scientific analysis aimed at answering ecosystem-scale questions and were not accessible to all the members of the Scientific Committee. The need was not just for more data, but for a dedicated mechanism to transform disparate data into coherent ecosystem intelligence (Levin *et al.,* 2009) that could be accessed by the SIOFA Scientific Committee.

This gap meant that the Scientific Committee's ability to provide integrated ecosystem advice was constrained. For instance, understanding the cumulative impact of fisheries on different trophic levels or identifying synergistic effects between various pressures remained a significant challenge. This potentially limited the Committee's ability to move beyond reactive advice on specific issues towards proactive, strategic guidance on fisheries management accounting for ecosystem considerations. Moreover, this accessibility barrier risked constraining EAFM to a series of discrete projects rather than an embedded, guiding principle. Without a mechanism to easily synthesize data on species distributions, bycatch events, and environmental interactions, identifying emerging trends in fisheries impacts on the ecosystem remained a formidable task. It became clear that to truly transition from principle to practice, SIOFA needed to bridge this gap between data collection and scientific analysis, thereby fostering a more direct and efficient science-policy interface.

A Solution: The Development of the SIOFA Ecosystem Summary

In direct response to the need for an integrated evidence base, SIOFA initiated the development of an internal synthesis tool: the SIOFA Ecosystem Summary (SIOFA Secretariat, 2026), developed in 2022 and published for the first time in 2023. Similar in function to tools already developed in other RFMOs, *e.g.* the NAFO Ecosystem Summary Sheets or the International Council for the Exploration of the Sea (ICES) ecosystem overviews (Roux and Pedreschi, 2024), and comparable ecosystem synthesis products being developed or used by ICCAT, IOTC, and IATTC — the SIOFA Ecosystem Summary was conceived as a practical bridge between data management and scientific analysis, the Summary is a living document curated by the SIOFA Secretariat in close consultation with the Scientific Committee and updated annually ahead of the Scientific Committee's main meeting. Its specific aim is to synthesize available fisheries and ecological data into an accessible format for the Scientific Committee (Fig. 2), thus streamlining the Committee's access to information, thereby empowering efficient and holistic ecosystem assessments.

The development of the SIOFA Ecosystem Summary can be understood as an exercise in creating an institutional knowledge system. The process involved not just technical data compilation but also important sociological elements, such as building trust and a common language between the data-holding Secretariat and the science-providing Committee, as well as across SIOFA parties. The iterative, collaborative nature of its development was crucial for ensuring the tool's practical utility. For example, initial versions focused on basic fishery metrics, but through feedback, evolved to include indicators of ecosystem health, such as bycatch ratios of non-target species or spatial overlaps with known VME indicators and fisheries area closures. This evolution underscores the tool's role as what theory refers to as a 'boundary object' (Star and Griesemer, 1989; Cooke *et al*., 2023), an artifact that is both adaptable to different viewpoints and robust enough to maintain a common identity across social worlds (*e.g.*, scientists, managers), thereby facilitating communication across different institutional roles. This framing offers a key conceptual takeaway for other RFMOs: that investing in shared information artifacts can serve as a pragmatic mechanism for building trust, aligning expectations, and fostering collaboration between data holders, scientists, and decision-makers. In contexts where formal top-down EAFM frameworks may be impractical, such boundary objects can provide a tangible entry point for operationalizing ecosystem-informed management, even with limited resources.

The Secretariat, rather than a dedicated Work Group like in other RFMOs (*e.g.*, NAFO), took the lead in

SIOFA Ecosystem Summary 2026

Contents

Fig. 2. The SIOFA Ecosystem Summary 2026 heading and table of contents (source: source: SIOFA Secretariat 2026).

collating data from fishing activities, observer reports, and scientific surveys, focusing on synthesizing information relevant to EAFM, such as species catch distributions (including non-target species), bycatch events, and interactions with vulnerable ecosystem indicators. This synthesis transformed raw data into a structured overview, highlighting trends, patterns, and knowledge gaps. For instance, a key finding is the elaboration of previously unclear ecological trends and the reporting of key outcomes of SIOFA research projects (*e.g.* on benthic species distribution maps within the SIOFA Area), providing a significantly clearer picture of the ecosystem context in which fisheries operate, as well as a record of the evolution of ecosystem knowledge within SIOFA.

The Ecosystem Summary is not a static report but an evolving tool. Its structure and content are continuously refined based on feedback from the Scientific Committee, ensuring it remains tailored to their advisory needs. By providing a consolidated baseline of information, the Summary directly facilitates the Committee's work, allowing them to focus on interpretation and risk analysis rather than data gathering. This tool, therefore, represents a significant step towards institutionalizing EAFM within SIOFA, creating a sustainable mechanism to support science-based advice and moving the organization from ad-hoc solutions towards a systematic, data-informed approach to fisheries management.

So far, the SIOFA Ecosystem Summary, contributed to help the Scientific Committee and the other SIOFA bodies to comprehensively visualize, for the first time, the current status of knowledge on ecosystem effects. This has improved the capacity of the Scientific Committee to direct the Secretariat on data practices (*e.g.*, linkages between the catch effort and scientific observation data), assess the observer coverage in fisheries, the bottom fishing footprint and the extent of bycatch, particularly for species of sharks covered under SIOFA CMM 12 (SIOFA, 2025). While the Summary does not itself enact management measures, it provides the evidence base that enables the Scientific Committee to formulate advice and prioritize issues—such as the refinement of spatially explicit measures in CMM 12 — thereby facilitating the translation of ecosystem intelligence into actionable conservation outcomes.

Looking Ahead: Consolidating the Practice and Future Directions

SIOFA's journey in implementing EAFM demonstrates a pragmatic evolution—from necessary interim measures to the development of a dedicated tool for integrated governance (Fig. 3 – A schematic representation of the SIOFA EAFM pathway through its history, and the role of the Ecosystem Summary within it.).

The initial strategies of precautionary alignment and targeted risk assessments proved the organization's capacity for adaptive management. The subsequent development of the SIOFA Ecosystem Summary represents a strategic advancement, addressing the core challenge of data accessibility and creating a sustainable foundation for ecosystem-based advice to manage fisheries. This progression underscores that effective EAFM implementation is not a binary state but a continuous process of adaptation and institutional learning.

The primary lesson that SIOFA learnt from its experience is the strategic value of a flexible, phased, and adaptive approach. Rather than being paralyzed by the ideal of a comprehensive EAFM system from the outset, SIOFA adopted a learning-by-doing philosophy. While other frameworks are also valuable, SIOFA's experience demonstrates the efficacy of a bottom-up, internally driven process that builds institutional capacity and ownership from the start. This tiered strategy—starting with harmonization, advancing to targeted assessments, and culminating in a dedicated knowledge tool—is a good example of EAFM implementation in newer or data-limited bodies. It demonstrates that EAFM is an iterative cycle of action, evaluation, and adaptation, effectively balancing urgent conservation needs with the long-term goal of evidence-based, ecosystem-level management of fisheries.

However, SIOFA can learn many lessons from EAFM implementation experience in other organizations which have progressed further along the way. For example, NAFO has developed a comprehensive roadmap to EAFM with a tiered approach (Koen-Alonso *et al.,* 2019) and is possibly one of the RFMOs which have progressed the most (Fletcher, 2020). Similarly to NAFO, the International Council for the Exploration of the Sea (ICES) has developed comprehensive system of ecosystem overviews, fishery summaries and risk assessments, which are weaved into a Framework for Ecosystem-Informed Science and Advice (Roux and Pedreschi, 2024), and have become the main tools for their EAFM advice. Other RFMOs, including ICCAT, IOTC, and IATTC, are also developing ecosystem synthesis products—such as pilot EcoCards and Ecosystem Fisheries Overviews—that serve a broadly similar function in synthesizing information to support scientific advice, even if the specific formats vary. A common feature of the more established approaches, exemplified by NAFO and ICES, is the use of dedicated Working Groups as a mechanism to advance cumulative impact analysis—a mechanism that SIOFA could consider replicating as capacity allows..

While several RFMOs and institutions—including NAFO, ICES, and the Western and Central Pacific Fisheries Commission (WCPFC)—are advancing ecosystem monitoring through quantitative indicators and spatial modelling (Fletcher, 2020), SIOFA's path forward must reflect its data-limited context and institutional capacity. Looking ahead, SIOFA's work could focus on enhancing

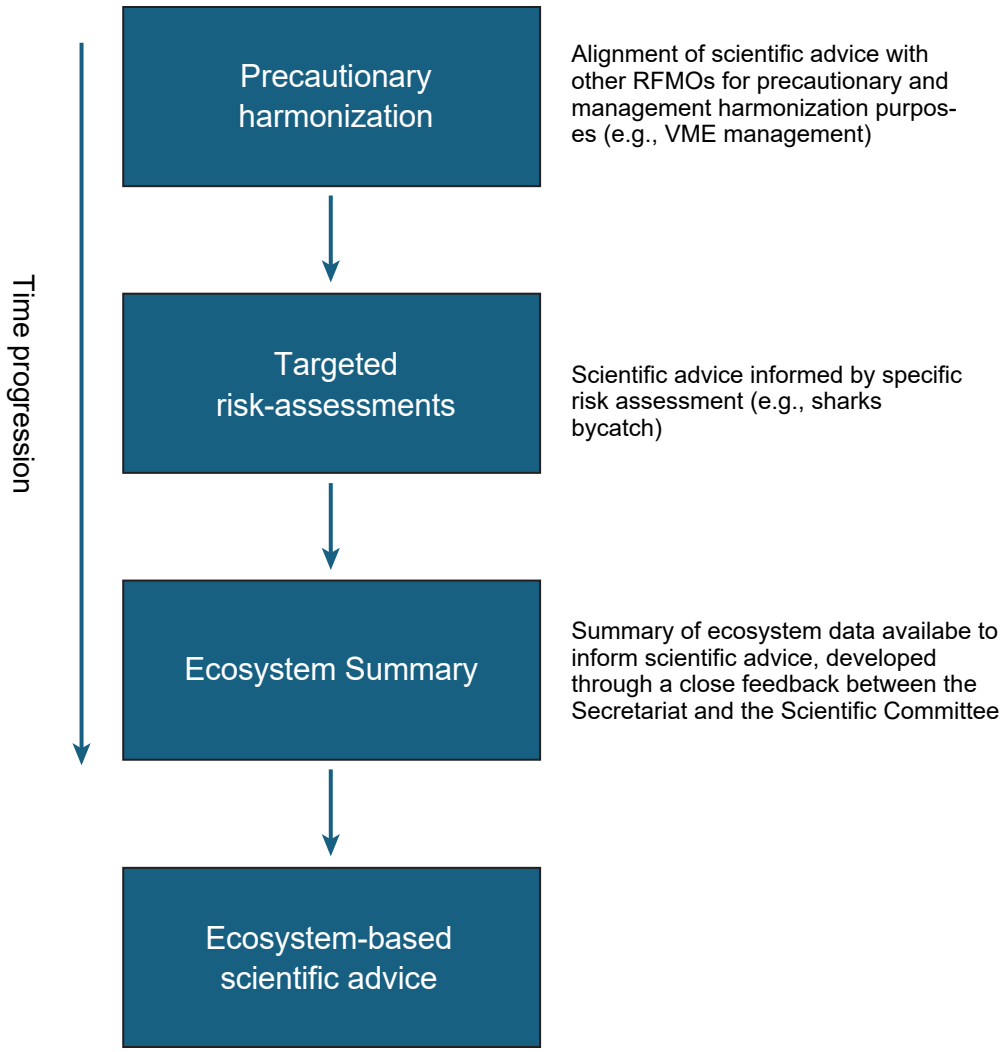

Fig. 3. A schematic representation of the SIOFA EAFM pathway through its history, and the role of the Ecosystem Summary within it.

the analytical sophistication of the Ecosystem Summary and its utility for evaluating cumulative impacts. This could involve developing quantitative ecosystem indicators to track trends over time or employing spatial modelling to predict interactions under different management scenarios. However, the Summary should not replace—but rather guide—dedicated scientific research, such as planned research cruises or specific projects, to fill persistent knowledge gaps, particularly concerning benthic ecosystems and the impacts of climate change. Indeed, integrating climate change effects (Pinsky and Mantua, 2014)— which alter ecological baselines and create novel species interactions—will be a significant scientific challenge, testing the adaptability of any management framework.

Furthermore, a critical frontier for SIOFA will be to more fully integrate the human dimension of EAFM. While this paper has focused on ecological and governance challenges, achieving true sustainability requires addressing socio-economic considerations and equity (FAO, 1995; Jentoft and Chuenpagdee, 2009). Socio-economic dimensions remain underdeveloped across the RFMO landscape (Fletcher, 2020), presenting a shared frontier for future integration. Future efforts could explore how the Ecosystem Summary, or a complementary tool, might incorporate data on social and economic outcomes, and how stakeholder engagement processes—particularly with fishing communities and industry—can be strengthened to ensure management measures are not only ecologically sound but also socially equitable and economically viable.

The intermediate goal could be to use the Summary not only to inform fisheries management advice but also to identify knowledge gaps and priority areas, thereby

stimulating targeted strategies to strengthen the evidence base. However, the ultimate goal for SIOFA could be to create a virtuous cycle that fosters a culture of adaptive management, in which the Ecosystem Summary is not just a reporting tool but a central component of a dynamic feedback loop—continuously informing and refining research priorities and management decisions in response to a changing ecosystem.

Yet this vision must be pursued with clear-eyed realism. Despite promising progress, SIOFA's path toward fully realized EAFM faces three interrelated challenges. First, there is an inherent risk that the Ecosystem Summary could evolve into a procedural formality rather than a catalyst for actionable advice; its long-term value depends on remaining dynamic and directly relevant to pressing management questions. Second, even the most robust scientific tools cannot automatically overcome political hurdles: the translation of the Scientific Committee's advice—however well-informed by the Summary—into effective Conservation and Management Measures remains a consensus-driven political process (Mooney-Seus and Rosenberg, 2007) among Contracting Parties with potentially competing economic interests and possibly limited resources to consider the Scientific Committee advice and translate it into policy. Third, the sustainability of this approach hinges on securing ongoing institutional commitment and resources to maintain and update the Summary, ensuring it does not become a static snapshot but continues to serve as a living core of SIOFA's adaptive management cycle.

Acknowledging these considerations is not a critique of the progress made, but a recognition that the journey from principle to practice is an ongoing negotiation between scientific innovation, institutional will, and political reality. In conclusion, SIOFA's experience offers a replicable model for moving from the principle of EAFM to its tangible practice. By embracing adaptive management, bridging data gaps with pragmatic tools, and maintaining a clear focus on long-term sustainability, SIOFA is charting a viable course for achieving its mandate. This journey—echoing Gandhi's observation that "Earth provides enough to satisfy every man's needs, but not every man's greed"—reflects a commitment to a balanced, equitable, and ecosystem-conscious future for fisheries governance in the Southern Indian Ocean.

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