

WCPFC CMM Climate Change Vulnerability Assessment

Final Assessment Report

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Table of Contents

Executive Summary.....	3
Introduction and Consultancy Purpose	3
Climate Change and Pacific Fisheries.....	3
WCPFC Response to Climate Change	4
The Need for Vulnerability Assessment.....	4
Consultancy Objectives.....	4
Assessment Scope	5
Targeted CMMs for Assessment	5
Deliverables	5
Literature Review and Conceptual Foundation.....	6
CCVA Framework.....	10
Overview.....	10
Framework design	10
Summary CMM Pilot Assessment Findings.....	12
Key assessment findings.....	12
CMM 2024-07 (Cetaceans).....	12
CMM 2019-05 (Mobulid rays)	12
CMM 2024-05 (Sharks)	13
CMM 2017-04 (Marine pollution).....	14
CMM 2024-06 (NP Striped Marlin)	15
Data Dependencies and Limitations.....	16
Assessment-Specific Data Sources and Gaps	19
Framework Performance as an Informational Tool	21
Recommendations for Framework Application	23
Conclusions	23
Attachments.....	25

Executive Summary

This report presents the final substantive deliverables of the WCPFC CMM Climate Change Vulnerability Assessment consultancy, commissioned following WCPFC21. The consultancy has successfully completed a comprehensive literature review of 500+ global studies on climate vulnerability assessment frameworks, developed a WCPFC-specific Climate Change Vulnerability Assessment (CCVA) Framework based on IPCC AR6 approaches, created comprehensive guidance documentation for framework implementation, and performed five pilot assessments of designated CMMs.

The Excel-based CCVA Framework provides a rapid assessment tool designed to systematically evaluate climate change risks to Conservation and Management Measures through assessment of hazard, exposure, sensitivity, and adaptive capacity. Assessments conducted on the five designated CMMs for 2025³ demonstrate the framework's capability to distinguish climate risk levels (HIGH for cetaceans and mobulids, MEDIUM for sharks and marine pollution, and LOW for North Pacific striped marlin) and identify key management implications, while revealing both the framework's strengths and areas requiring expert input or improved data and information requirements.

The framework offers WCPFC a potential pathway for integrating climate considerations into its decision-making processes, providing an informational tool for identifying climate adaptation priorities and supporting evidence-based discussions about conservation measure effectiveness under changing environmental conditions.

Introduction and Consultancy Purpose

Climate Change and Pacific Fisheries

Climate change poses significant and increasing risks to the effectiveness of the Western and Central Pacific Fisheries Commission's (WCPFC) Conservation and Management Measures (CMMs). The Western and Central Pacific Ocean (WCPO) and its inhabitants are among the most at risk globally from climate change impacts. Climate-driven changes—such as ocean warming, shifting species distributions, and altered productivity—may pose challenges to the effectiveness of current CMMs.

Observed increases in sea temperature, ocean acidification, and frequency of marine heatwaves and violent tropical weather events are causing the degradation of coastal marine ecosystems, including those reliant on coral reef, mangrove and seagrass habitats. These impacts directly affect subsistence fishing productivity, local community fish supply, and long-term food security.

Marine fisheries, particularly tuna resources, are experiencing significant changes from climate change impacts, including redistribution (both eastwards and polewards), stock biomass changes, and changes in catch rates. These changes are directly affecting industrial tuna

³ CMM 2024-07 (Cetaceans), CMM 2019-05 (Mobulids), CMM 2024-05 (Sharks), CMM 2017-04 (Marine pollution), CMM 2024-06 (NP Striped Marlin)

fisheries and also pose a serious threat to Pacific Island Countries and Territories (PICTs) that generate significant revenue from license access fees to fish for tuna within national Exclusive Economic Zones (EEZs).

WCPFC Response to Climate Change

The WCPFC and its subsidiary bodies have been actively discussing and progressing climate change related work since 2008. This work has evolved through several key milestones:

- **Resolution 2019-01:** Recognized serious threats posed by climate change to highly migratory species and wider ecosystems
WCPFC20 (2023): Reaffirmed the resolution and agreed to develop a dedicated workplan
- **WCPFC21 (2024):** Adopted the Climate Change Workplan 2024-2027 and Terms of Reference for the CMM Climate Change Vulnerability Assessment

Following WCPFC21, a consultancy (this project) was commissioned to develop a framework for assessing the vulnerability of CMMs to climate change impacts.

The Need for Vulnerability Assessment

Climate-driven changes may impact the assumptions underpinning certain CMMs as well as alter fishing operations and fleet dynamics, impacting enforcement. Changes in productivity could require adjustments to catch limits and reference points. Altered seasonality may affect the timing and effectiveness of temporal closures and gear restrictions. Disrupted food webs could undermine current bycatch mitigation strategies, and economic and environmental instability may increase pressure on compliance and enforcement systems.

The Commission identified a need for work that aims to ensure that relevant information and data collection are adequate to support improved understanding of climate change impacts and implications for WCPFC fisheries management.

Consultancy Objectives

Primary Objectives

The consultancy was commissioned with clear objectives as outlined in the Terms of Reference adopted by the Commission:

- **Review and Identify Vulnerable Provisions:** Review active WCPFC CMMs and identify specific provisions that could benefit from additional discussion among Cooperating Members (CCMs) as being vulnerable to climate change
- **Support Subsidiary Body Functions:**
- **Support Technical and Compliance Committee (TCC) discussions** by identifying monitoring, control, and surveillance (MCS) data and information gaps and potential management challenges
- **Support Scientific Committee (SC) discussions** regarding scientific data and information gaps and research needs

- Improve Commission Understanding: Focus on improving the Commission's understanding of how climate change impacts might affect existing CMM provisions

Assessment Scope

Included in Scope:

- Review of active WCPFC CMMs defined by the Commission
- Assessment based on target or bycatch species, specific geographic areas, different gear types, review periods, and climate considerations
- Analysis using publicly available information including adopted CMMs, published climate advice, peer-reviewed scientific literature, and Indigenous and traditional knowledge
- Focus on climate change vulnerabilities specifically, not other management challenges

Excluded from Scope:

- Advising on specific management actions (limited to informing only)
- Prejudicing members' implementation of existing obligations
- Initiating renegotiation of CMMs
- Assessing compliance capabilities of subsidiary bodies

Targeted CMMs for Assessment

The Commission identified a total of nine specific CMMs for assessment over the 2025-2026 period.

Assessments to be undertaken in 2025 under this contract included⁴:

- CMM 2024-07 (Cetaceans)
- CMM 2019-05 (Mobulid rays)
- CMM 2024-05 (Sharks)
- CMM 2017-04 (Marine pollution)
- CMM 2024-06 (North Pacific striped marlin),

Deliverables

The Terms of Reference established the following deliverables

Deliverable	Evidence of completion
1. Initial compiled list of available information sources (paragraph 12a) in a bibliography and targeted literature review.	Literature Review submitted as NC21-WP-05_suppl
2. A WCPFC-relevant framework for assessing CMM provisions' vulnerability to climate change using	Excel-based framework and word-based framework guidelines Submitted to the Secretariat.

⁴ The Commission also agreed to assess these CMMs in 2026: CMM 2023-01 (Tropical tunas), CMM 2018-04 (Sea turtles), CMM 2018-03 (Seabirds), CMM 2013-04 (Record of Fishing Vessels),

the best available information, per paragraph 12(a), including a definition for "vulnerability" to be used for the Assessment.	The literature review proposes a definition to be used, with a rationale. The definition is incorporated in the framework.
3. A list of the specific CMM provisions identified as being vulnerable to climate change that could benefit from additional discussion among CCMs	Discussed in this report.
4. The identification of MCS and scientific data and information gaps, research needs, and potential management challenges, including in instances where more information would improve the Assessment	Discussed in this report.
5. Suggested metrics of minimum/sufficient information required to be able to categorize CMM provisions as either being "vulnerable" or "not vulnerable" to climate change, as appropriate	The framework sets out that information we advise is required to inform a judgement on climate risk.
6. Results from the Assessment of at minimum the CMMs defined by the Commission provided as information papers to support CCMs during discussions at NC21, SC21, TCC21, and WCPFC22.	Information papers provided: NC21-WP-05 SC: SC21-EB-WP-01 TCC: TCC21-2025-13

Literature Review and Conceptual Foundation

Literature Review Overview

An extensive literature review was conducted between April and June 2025, examining over 536 individual pieces of literature sourced globally across multiple sectors and disciplinary contexts. The review methodology followed PRISMA 2020 guidelines to ensure transparent and replicable reporting.

Scope and Coverage

- **Geographic Coverage:** Global scope with specific attention to Pacific marine environment considerations (73 Pacific region-based references, 58 with clear marine applications)
- **Sectoral Coverage:** Fisheries, agriculture, river systems, natural resource management, urban planning, and disaster risk reduction
- **Framework Analysis:** Over 100 operational vulnerability frameworks were identified and analysed, including both theoretical frameworks and applied case studies

Key Findings

- **Vulnerability Definitions:** No universally accepted definition of vulnerability exists, with over 80 unique definitions identified across literature. While IPCC definitions are widely referenced, they are not consistently applied, with older AR4 definitions (49% of studies) continuing to be more commonly used than the current AR6 framework (only 2% of studies)
- **Framework Diversity:** 132 different operational vulnerability assessment frameworks were identified, ranging from local qualitative assessments to highly quantitative global-scale analyses
- **Methodological Approaches:** Four broad categories emerged: established theoretical frameworks, adaptations of existing frameworks, mixed-methods approaches, and original composite indicator frameworks

Pacific Marine Environment Insights

The review identified specific considerations for Pacific marine vulnerability assessments, including:

- Gender-sensitive approaches for collecting traditional knowledge
- Funding constraints as a significant barrier to effective assessment implementation
- The need for flexible frameworks that can be regularly updated as conditions and knowledge evolve
- Integration challenges between scientific data and traditional/local knowledge systems.

Fisheries-Specific Indicators

The review identified the most commonly used indicators across fisheries studies. These included:

- **Hazard indicators:** Temperature extremes, sea surface temperature changes, ocean acidification, cyclones/storms
- **Sensitivity indicators:** Thermal range, mobility, productivity, spawning requirements, prey specificity
- **Adaptive capacity indicators:** Management effectiveness, gear diversity, livelihood diversification, institutional support.

This comprehensive literature review directly informed the selection of the IPCC AR6 definition for the WCPFC framework and provided the foundation for indicator selection and framework design principles.

Climate Vulnerability Definition

Definition	How we understand it.
Climate Risk <i>Hazard × Exposure × Vulnerability</i>	<p>Risk refers to consequences for human or ecological systems</p> <p>Risks can arise from potential impacts of climate change as well as human responses to climate change</p> <p>Adverse consequences can arise from the potential for a response to climate change failing to achieve its intended outcome; or the intended action creating an adverse outcome elsewhere</p> <p>Example, the term “flood risk” should not be used if it only describes changes in the frequency and intensity of flood events; it would need to be linked explicitly to the consequences of such events for human or ecological systems</p>
Hazard <i>A hazard is the potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources</i>	<p>A hazard is a climate driver of risk</p> <p>A hazard is the climate-related physical event or trend that can cause harm</p> <p>It is specifically about the climate-related physical event or phenomena, not the exposure or vulnerability of systems to them</p> <p>It can include acute events (flood, hurricane) or long-term trends (sea level rise, ocean acidification, temperature increase)</p>
Exposure <i>Exposure is the presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected</i>	<p>Exposure is about what is at risk, not necessarily what will be harmed, but what is located in areas where climate hazards may occur</p> <p>Exposure does not itself equate to harm. Exposure in combination with hazard and vulnerability determines risk</p>
Vulnerability	<p>We understand vulnerability is a function of adaptive capacity and sensitivity</p>

<p><i>Is a function of sensitivity and adaptive capacity</i></p>	
<p>Sensitivity <i>Sensitivity is the degree to which a system is affected, either adversely or beneficially, by climate variability or change</i></p>	<p>Sensitivity is a subset of vulnerability rather than treated as a separate variable. It is linked to both biophysical and socio-economic characteristics of systems</p> <p>Whereas Exposure looks at whether something is in harm's way, sensitivity looks at how much harm it suffers when exposed. We therefore consider what the system, species or group and what makes it sensitive. This depends on biological, physical, economic or social characteristics that help us identify which parts of a system, species or group are most at risk</p>
<p>Adaptive capacity <i>Adaptive capacity is the ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences</i></p>	<p>It is about the potential to adapt, not whether adaptation is currently occurring</p> <p>Adaptive Capacity is dynamic, context specific and inequitably distributed Higher adaptive capacity results in lower vulnerability; lower adaptive capacity results in greater susceptibility to harm</p> <p>Adaptive capacity is about more than ecological adaptation, but the capacity of ecosystems, people and institutions to adapt. It is influenced by resources, resource management, governance and knowledge.</p> <p>It can involve:</p> <ul style="list-style-type: none"> • Reducing vulnerability to climate hazards, • Mitigating potential damage, • Taking advantage of beneficial opportunities (e.g., longer growing seasons in some areas), • Responding effectively to impacts after they occur

See Attachment A for the literature review report.

CCVA Framework

Overview

The original Terms of Reference proposed identifying which specific CMM provisions were vulnerable or not vulnerable on an individual basis. Building on this foundation, we were able to take the assessment approach significantly further during framework development. Recognizing that vulnerability is itself a conceptual function of sensitivity and adaptive capacity - representing just one component of overall climate risk - we expanded beyond binary classifications to capture the complex interactions and nuances inherent in climate vulnerability assessment.

This enhanced approach allowed us to move beyond simple vulnerable/not-vulnerable determinations to conduct holistic examination of a CMM, enabling identification of both what a CMM included and, critically, what it did not include that was relevant to a CCVA. Our comprehensive assessment methodology enables deeper exploration across entire CMMs, clearly identifying where hazards are most relevant and determining the types and extent of vulnerability, which in turn will assist the WCPFC in identifying, relatively quickly, the interventions it wants to make. The framework was designed as a rapid-assessment tool to enable quick identification of areas requiring attention and information gaps, while providing a good sense of climate risk. This expanded approach delivers practical and accessible results for managers to inform planning and management decisions.

Framework design

Excel-Based CCVA Framework

The framework utilizes Microsoft Excel as the development platform, chosen for its global accessibility and familiarity, ease of modification and updating, ability to incorporate automated outputs and long-term reliability without dependency on external software or databases.

Key Design Features:

- Indicator-based assessment: Comprehensive metrics aligned with IPCC AR6 categories
- Automated outputs: Risk-based graphics and summaries generated from indicator inputs
- Clear responsibility allocation: ability to clearly designate roles for Northern Committee (NC), Scientific Committee (SC), and Technical and Compliance Committee (TCC)
- Gap identification: Systematic highlighting of information gaps requiring attention
- Flexible application: Adaptable to different CMM types and assessment scales.

See Attachment B for the CMM CCVA Framework master template.

Comprehensive Guidance Document

The "WCPFC CCVA Framework - Guidance and procedural information document" provides a comprehensive overview of the WCPFC CCVA Framework, its design and methodology for

establishing, operationalizing and maintaining the framework as a standard WCPFC tool to support sustainable fisheries management in the WCPO.

The guidance document outlines:

- Conceptual Framework based on IPCC AR6 definitions
- Key design features and indicator design
- Scoring methodology and calculations
- Step-by-step assessment process
- Data requirements and quality standards
- Standardized reporting template.

See Attachment C for the Guidance and information document.

Identification of Data Requirements and Gaps

The framework systematically identifies critical data gaps and uncertainties to guide future research, monitoring, and data collection efforts. Key data elements include climate data, ecological data, fisheries data, management performance data, and socio-economic data.

All deliverables were designed to be as practical, implementable (within existing WCPFC meeting cycles and resource constraints), and responsive (to the specific information needs of WCPFC decision-makers) as possible.

Testing and refinement

The Commission identified specific CMMs for the 2025 pilot assessments, which provided an excellent breadth of the types of conservation and management measures under WCPFC's responsibility. The selection included:

- Two bycatch CMMs: CMM 2024-07 (Cetaceans) and CMM 2019-05 (Mobulids)
 - Cetaceans deals with a species which falls under the primary mandate of another international organization
 - Mobulids involves species listed on the IUCN and in other Conventions as vulnerable or endangered
- A mixed target / bycatch CMM: CMM2024-05 (Sharks)
- An operational CMM: CMM 2017-04 (Marine pollution), and
- A target species CMM: CMM 2024-06 (NP striped marlin).

This diversity enabled comprehensive testing of the framework's applicability across the full spectrum of WCPFC management measures.

One of the key design principles for framework success was ensuring that anyone could use it, not just large institutions with extensive technical capacity. Throughout the development process, we asked ourselves: "Can the average person do this?" - and we considered ourselves to be that average person. This user-centric approach drove our design decisions toward simplicity, accessibility, and practical implementation, ensuring the framework would be viable for all WCPFC members regardless of their technical resources or capacity constraints.

The pilot assessments provided valuable insights into framework performance across different CMM types and revealed both the strengths and limitations of the assessment methodology when applied to diverse management contexts.

Summary CMM Pilot Assessment Findings

Key assessment findings

See Attachments D (1-5) for individual CMM CCVA assessment reports and Attachments E (1-5) for individual CMM CCVA Framework assessments.

CMM 2024-07 (Cetaceans)

Climate Risk Result: HIGH

Key Risk Drivers

- **High Hazard Rating:** Driven by significant climate stressors including ocean warming, acidification, deoxygenation, and altered current patterns that directly affect cetacean habitat and prey availability
- **High Exposure Rating:** Cetacean populations frequently encounter identified climate hazards across their broad distributional ranges in areas experiencing significant oceanographic changes, including warming waters and shifting current patterns
- **High Sensitivity Rating:** Reflects cascading effects of climate change through marine food webs, affecting cetacean distribution patterns, migration timing and ranges, and reproductive ability
- **Medium Adaptive Capacity:** Limited by biological constraints, though supported by international conservation frameworks.

Management Implications

The HIGH climate risk rating identified for cetaceans may warrant examination of the cumulative impact that fishing pressure is having on these species. When species have limited capacity to adapt to climate change, reducing other anthropogenic stressors becomes a critical conservation strategy.

This assessment aligns with global scientific literature showing that 72% of marine mammal stocks are highly vulnerable to climate change, validating the framework's effectiveness in identifying climate risks.

CMM 2019-05 (Mobulid rays)

Climate Risk Result: HIGH

Key risk drivers

- **Medium Hazard Rating:** Driven by a medium level of identified climate stressors on mobulids, taking into consideration their biological traits such as high mobility and high distribution across the WCPF Convention Area, and their reliance on prey species (zooplankton) that are likely to be impacted by climate change, particularly in tropical zones
- **High Exposure Rating:** High exposure of habitats, food-webs and mobulid populations were identified which drove the high exposure rating. A total of six indicators (35%) were scored as ‘unknown’ as a result of identified information gaps and limitations
- **High Sensitivity Rating:** Reflects the key biological and ecological sensitivities of mobulids including to increased sea-surface temperatures, a dependence on single prey species, low levels of reproductive fecundity. Additionally, a lack of knowledge on stock statuses and the current IUCN classifications of WCPFC mobulids as vulnerable or endangered highlighted increased sensitivity in enabling effective management and decision-making
- **Low Adaptive Capacity:** Driven by both the biological and ecological traits of mobulids (based on best available information) and the lack of available scientific information and monitoring information to clearly understand how mobulids may respond and adapt to climate changes. A total of 10 (45%) of adaptive capacity indicators were scored as “unknown” highlighting significant information gaps.

Management implications

The HIGH climate risk rating of mobulids, warrants immediate attention to fill identified information gaps. It is encouraging to see that projects to understand fisheries characteristics, biological traits and to establish stock assessments for key WCPFC mobulid species are included in the 2021-2030 Shark Research plan.

The current prohibition of fishing approach for mobulids is considered effective to ensure that fishing pressure is minimized until further information on stock status and life-biology is known. However, more cumulative impact research is also required noting mobulids face multiple hazards, including exposure to marine pollution, vessel strike, loss of spawning habitats etc., that need to be understood in order to effectively improve understanding of overall climate risk and species-specific vulnerability.

CMM 2024-05 (Sharks)

Climate Risk Result: MEDIUM

Key risk drivers

- **High Hazard Rating:** reflects the significant levels of climate hazards faced by WCPO shark species, including temperature extremes, increased sea surface temperatures, ocean acidification, deoxygenation and current changes. These collective hazards are all identified stressors that could affect shark distribution, growth, development, feeding behaviours and reproductive success
- **High Exposure Rating:** high levels of exposure to identified climate hazards include sharks habitats, Pacific shark populations and relevant fishing fleets. However, a total of

nine (47%) of indicators were unable to be scored as a result of identified information gaps / limitations

- **Medium Sensitivity Rating:** driven by a range of “low” to “High” indicator scores. While sharks are sensitive to environmental changes, in particular their reliance on seasonal cues and low age-at-maturity, the high mobility, broad distribution and opportunistic feeding behaviours provides resilience against identified climate hazards
- **High Adaptive Capacity rating:** this rating suggests Pacific shark species managed by the WCPFC are in a relatively good position to effectively respond and adapt to climate change stressors. This rating is mainly driven by natural traits such as high mobility, broad distribution and opportunistic feeding behaviour, coupled with a WCPFCs relatively flexible management framework, research plans (2021-2030 Shark Research Plan), and capacity and support for responsive decision-making and implementation

Management implications

Although a Medium climate risk assessment score is promising, a key limitation in the assessment is the share breadth of shark species managed by the WCPFC and the CMM (72 species). This is also reflected in the management approach to sharks by the WCPFC, with clearly identified key shark species and non-key shark species. Despite this, there is a good and improving amount of information associated with key shark species, including stock status, biological function, effects from fishing, and vulnerability to climate change, enabling greater ability to identify how climate stressors may affect Pacific sharks.

Key considerations for WCPFC include:

- Strengthening information of both key and non-key shark species, including stock status
- CCVA of individual shark species (both key and non-key species noting the diverse nature of species covered by the CMM)
- addressing identified CCM CCVA information gaps
- incorporating environmental indicators as standard practice into shark stock assessments
- developing climate-informed reference points for key shark species
- greater investment in research and monitoring activities (noting the 2021-2030 Shark Research Plan represents a significant investment).

CMM 2017-04 (Marine pollution)

Climate Risk Result: Medium

Key Risk Drivers

- **Operational vs. Biological Hazards:** The assessment revealed a fundamental distinction between biological/ecological hazards (rated LOW) and operational hazards (rated MEDIUM to HIGH) . Climate change increases pollution risk primarily through extreme weather events rather than direct environmental changes
- **High Exposure Rating:** Based on the frequent occurrence of operational hazards in the WCPO, including 25-30 tropical cyclones annually in the Western Pacific and regular storm events affecting major fishing ports

- **Framework Limitations:** No sensitivity indicators within the framework were found relevant to this operational CMM, highlighting that the framework was primarily designed for species-focused assessments

Management Implications

The assessment demonstrates that climate change acts as a risk multiplier for marine pollution rather than a direct driver. Climate impacts create conditions that make proper waste management more difficult or impossible to maintain. Key considerations include:

- Development of climate-specific waste management protocols for extreme weather conditions
- Strengthening port waste reception facility resilience to climate impacts
- Enhanced vessel waste storage systems to withstand operational hazards
- Improved crew training on waste management during emergency conditions
- This assessment highlighted climate as a risk multiplier rather than a direct driver. It leads to the need to consider operationally practical solutions that can minimise risks of waste management and storage and potentially related issues affecting crew well-being.

CMM 2024-06 (NP Striped Marlin)

Climate Risk Result: LOW

Key Risk Drivers

- **Medium Hazard Rating:** Moderate levels of climate-related threats including temperature extremes, ocean acidification, and current changes, balanced by the species' pelagic nature reducing infrastructure-related impacts
- **High Exposure Rating:** Broad distributional range across areas experiencing significant oceanographic changes, though with substantial data gaps (36% unknown scores)
- **Medium Sensitivity Rating:** Moderate susceptibility balanced by biological characteristics including broad thermal tolerance, high mobility, and opportunistic feeding behaviour
- **High Adaptive Capacity:** Strong biological resilience (mobility, distribution, feeding flexibility) combined with WCPFC's flexible management framework and scientific monitoring programs

Management Implications

The LOW climate risk rating suggests current management approaches are likely to remain effective under projected climate scenarios, though continued vigilance is required. Key considerations include:

- Enhanced monitoring of stock distribution and abundance patterns to track climate-related changes

- Strengthened data collection on environmental-biological relationships to reduce uncertainty
- Improved integration of climate considerations into stock assessments
- Maintenance of flexible management measures that can adapt to changing conditions
- Continued rebuilding efforts to maximize resilience to climate impacts
- This positive assessment reflects both the inherent resilience of this highly mobile pelagic species and the adaptive management framework in place.

Data Dependencies and Limitations

The framework's effectiveness relies heavily on access to relevant climate data and information, which presented limitations across all assessments.

Regional Climate Projection Uncertainties

All five assessments faced challenges with limited spatial and temporal resolution of climate projections specific to the WCPO region. Global climate models often lack the regional specificity needed to accurately assess localized climate risks.

Extreme Event Frequency and Intensity Data

Critical gaps existed in projections for extreme weather events, which proved particularly important for operational assessments:

- Limited long-term projections for cyclone frequency and intensity changes
- Uncertainty about storm track modifications affecting different fishing areas
- Insufficient data on compound extreme events (e.g., simultaneous storms and marine heatwaves)

Ocean Chemistry Trend Information

Assessments revealed substantial gaps in regional ocean chemistry projections:

- Limited high-resolution ocean acidification information for specific WCPO areas and/or species
- Uncertainty about deoxygenation patterns and timing
- Gaps in understanding of chemical change interactions with biological systems.

These climate data limitations fundamentally constrain the framework's precision, regardless of the quality of biological or operational information available.

This information will be more critical if the WCPFC wants to undertake these assessments on a longer time horizon. The consultants used available data and scientific literature, where available, to draw inferences; however this is a limitation if the study does not relate to the direct circumstances of the assessment.

Additional Critical Data Gaps

Fleet Operational Response During Extreme Weather

The marine pollution assessment particularly highlighted the absence of data on:

- How fishing operations adapt waste management procedures during extreme weather
- Vessel operational decision-making under climate stress conditions
- Fleet behavioural responses to increasingly frequent extreme events
- Economic and safety trade-offs affecting environmental compliance during emergencies.

Infrastructure and Asset Resilience

Across all assessments, limited information was available on:

- Port waste reception facility climate resilience and adaptation capacity
- Fishing infrastructure vulnerability to sea-level rise and storm damage
- Communication and monitoring system reliability during extreme events
- Supply chain resilience affecting fishing operations and compliance systems.

Common Data Gaps Across Assessments

Spatial Resolution and Distribution Data

- **Cetaceans:** WCPFC does not typically hold comprehensive biological and ecological data on cetacean populations, requiring reliance on published literature for most assessment components. However, global and regional scientific studies provided substantial evidence on cetacean climate vulnerability that proved highly informative for the assessment. Expert review by marine mammal specialists would be valuable to verify the appropriateness of applying global findings to WCPO populations and to address regional climate projection uncertainties
- **Mobulids:** WCPFC specific information on mobulid distribution was limited, however available information did provide good insights into specific species distributions based on observer reporting. In order to provide more certainty on spatial distribution of individual species and migratory movements, key monitoring gaps need to be addressed particularly for longline fleet coverage. Input and review from mobulid ray specialists would be valuable to identify additional information sources and research approaches to help strengthen this information for future assessments
- **Sharks:** there was relatively good spatial and distributional data available for key shark species, although there are clear information gaps associated with non-key shark species. However, general shark distributional information was able to be used to improve confidence in information used in the assessment. Input from global and Pacific shark experts could refine understanding of shark distributions throughout the WCPF Convention Area, to help better understand how these may change in response to different climate projections

- **Marine Pollution:** No WCPFC-specific data available about vessel operations and waste management performance during extreme weather events, though maritime safety literature and regional climate vulnerability studies provided logical frameworks for assessment. Input from maritime safety experts and vessel operators would strengthen future assessments, particularly regarding fleet operational responses and infrastructure resilience
- **North Pacific Striped Marlin:** While WCPFC holds regular stock assessments and fisheries data, uncertainty remained about how climate impacts vary spatially across the species' range, though scientific literature on billfish climate responses filled many knowledge gaps. Expert input from billfish researchers could refine understanding of regional variations, particularly given climate projection uncertainties

Member-Specific Institutional Capacity

All five assessments noted that while WCPFC maintains information on management frameworks and compliance, detailed member-specific institutional capacity and governance arrangements were not accessible to external assessors. Many adaptive capacity indicators required country-level information including:

- Economic diversification capabilities
- Livelihood diversification potential
- Institutional support structures
- Resource availability for implementation
- Infrastructure and asset resilience capacity at national levels

Expert verification by Members themselves would likely significantly improve adaptive capacity ratings by incorporating detailed institutional knowledge not available to external assessors.

Climate-Biological Relationships

- WCPFC's focus on fisheries management means limited direct climate monitoring data, though peer-reviewed literature provided extensive evidence on climate impacts for target species
- Regional oceanographic data and climate projections from scientific sources supplemented WCPFC's fisheries-focused datasets, though significant uncertainties remain in regional climate projections
- International scientific reports proved valuable for understanding species responses to environmental variability, but gaps persist in extreme event frequency and ocean chemistry trend information

Expert review by regional oceanographers and climate scientists could validate the application of broader climate projections to specific WCPO contexts and help address assessment uncertainties.

Assessment-Specific Data Sources and Gaps

Cetaceans (HIGH Risk)

WCPFC Data Limitations

- Limited comprehensive biological data on cetacean populations within WCPFC holdings
- Inadequate longline observer coverage affecting interaction data quality
- Limited spatial data on cetacean-fishery interactions

Scientific Literature Contributions and Climate Data Constraints

The assessment was significantly strengthened by extensive scientific literature, including global vulnerability assessments showing 72% of marine mammal stocks are highly vulnerable to climate change. Key literature provided evidence on:

- Climate impacts on cetacean distribution, migration timing, and reproductive success
- Physiological responses to ocean warming and acidification
- Ecosystem-level impacts on prey species and food webs

However, the assessment was constrained by regional climate projection uncertainties and limited ocean chemistry trend information specific to cetacean habitat areas. Expert review by cetacean specialists familiar with WCPO populations would be valuable to verify whether global patterns apply regionally and to address climate data limitations.

Mobulids (HIGH risk)

WCPFC Data Limitations

There were clear data and information gaps on WCPFC mobulids with little understanding on stock status, biology and ecology of individual species.

Specific indicator information gaps were found across all four climate risk categories:

- **Hazard:** 10% of indicators classified as “Unknown”
- **Exposure:** 40% of indicators classified as “Unknown”
- **Sensitivity:** 18% of indicators classified as “Unknown”
- **Adaptive capacity:** 45% of indicators classified as “Unknown”.

Identified information limitations not only applied to biological and ecological themed indicators but also across themes related to management, socio-economics, and the effects of fishing operations on mobulid populations.

Scientific Literature Contributions and Climate Data Constraints

Although there is some good recent scientific reporting on general mobulid traits, populations, and vulnerabilities to overfishing and other hazards, there is limited robust information on the effects of climate change on these species, with general observations of Chondrichthyes used to draw insights into how mobulids may be affected. Nevertheless, this information provided useful insights and information to draw on to effectively perform the CCVA.

Sharks (MEDIUM risk)

WCPFC Data Limitations

WCPFC holds a lot of information and reporting on Pacific sharks, mostly focussed on research planning, stock assessment information and sustainability risk assessments from fishing. However, there is limited to no information held by the WCPFC on the effects of climate change and associated shark vulnerabilities (for both key and non-key shark species).

Specific indicator information gaps were found across three climate risk categories:

- **Exposure:** 53% of indicators classified as “Unknown”
- **Sensitivity:** 21% of indicators classified as “Unknown”
- **Adaptive capacity:** 30% of indicators classified as “Unknown”.

Identified information limitations not only applied to biological and ecological themed indicators but also across themes related to management, socio-economics, and the effects of fishing operations on sharks.

Scientific Literature Contributions and Climate Data Constraints

A wealth of scientific literature on sharks is available, including species specific climate vulnerability assessments that were drawn on to inform the assessments. However, regional climate scenario uncertainties, and ecological consequences (e.g., increased competition as species distribution changes) was limited. However, despite key shark species of commercial importance there is limited information available on other non-key sharks and rays in the Pacific. Expert review and input from Pacific shark scientists and researchers could help fill these identified gaps, to strengthen the overall assessment.

Marine Pollution (MEDIUM risk)

WCPFC Data Limitations

- No operational data on vessel waste management performance during extreme weather
- Limited information on equipment failure modes during climate hazards
- Absence of behavioural data on crew responses under operational stress
- No data on fleet operational responses during extreme weather events
- Limited information on infrastructure and asset resilience of port facilities

Literature and Logical Inference with Climate Data Constraints: Given the operational nature of marine pollution prevention, the assessment relied heavily on:

- Maritime safety literature on extreme weather impacts on vessel operations
- Regional climate vulnerability studies for Pacific Island ports and infrastructure
- Logical inferences about climate hazard impacts on waste storage and handling systems

However, the assessment was significantly constrained by limited extreme event frequency and intensity projections, making it difficult to assess future operational risks. This assessment would particularly benefit from expert input from vessel operators, maritime safety specialists, and port authorities who could validate assumptions about operational impacts and provide insights into infrastructure resilience.

North Pacific Striped Marlin (LOW Risk)

WCPFC Data Strengths and Gaps

WCPFC's relatively robust knowledge base for this species included regular stock assessments, biological research, and fisheries monitoring data. However, gaps remained in:

- **Exposure:** 36% of indicators scored as "Unknown"
- **Adaptive Capacity:** 43% of indicators scored as "Unknown"
- **Limited regional climate projection specificity for the species' habitat range**

Scientific Literature Supplementation with Climate Data Limitations

Extensive peer-reviewed literature on billfish biology and climate responses provided crucial evidence:

- Studies on striped marlin environmental preferences and habitat use
- Research on billfish responses to climate variability and environmental change
- International scientific reports on species distribution modelling and climate projections

However, regional climate projection uncertainties and limited ocean chemistry trend information specific to billfish habitat contributed to the high proportion of "Unknown" scores. Expert review by billfish researchers and regional stock assessment scientists could help resolve uncertainties, though climate data limitations remain a fundamental constraint.

Framework Performance as an Informational Tool

The pilot assessments demonstrated that the WCPFC CCVA Framework enables **rapid completion** of vulnerability assessments, with each assessment completed within weeks rather than months or years. However, these rapid assessments revealed the critical

importance of **group review and expert verification** to ensure technical accuracy and to capture important research nuances that might be missed by individual assessors.

The framework functions effectively as a **broad-brush informational tool** for problem identification and triage, helping to quickly identify which CMMs may face higher climate risks and where critical data gaps exist. However, given its rapid assessment nature, it should be used as an **informational rather than instructional tool** - providing valuable insights to guide further investigation and expert consultation rather than definitive management directives.

The pilot assessments demonstrate that the framework excels as a **rapid triage tool** for:

1. Problem Identification

- Quickly distinguishing between high-risk (cetaceans) and low-risk (striped marlin) CMMs
- Identifying possible drivers of climate risk
- Identifying where climate risk may be a significant concern requiring further attention
- Highlighting CMMs where current approaches may need adaptation
- Revealing where climate data limitations most critically constrain assessment quality

2. Data Gap Identification

- Systematically revealing where critical information is missing
- Identifying areas where targeted research or expert consultation is needed
- Highlighting indicators where "Unknown" scores suggest assessment uncertainty
- Pinpointing specific climate data needs (regional projections, extreme events, ocean chemistry)

3. Climate Data Dependency Mapping

- Demonstrating which assessments are most constrained by regional climate data uncertainties
- Identifying where extreme event frequency and intensity data gaps most affect risk evaluation
- Highlighting the critical need for improved ocean chemistry trend information

4. Prioritization for Detailed Analysis

- Providing evidence-based justification for allocating resources to high-risk CMMs
- Identifying which assessments would benefit most from expert input
- Guiding where more detailed, species-specific vulnerability studies may be warranted
- Highlighting where investment in regional climate data would most improve assessment quality

Recommendations for Framework Application

1. Rapid Assessment + Expert Review Process Future applications could follow a two-stage process, which could also be achieved through full review by subsidiary bodies and Members mobilising experts:

- Initial rapid assessment using the framework to identify key risks and data gaps
- Follow-up expert review sessions to validate findings and capture technical nuances
- Explicit acknowledgment of climate data limitations and their impact on assessment confidence

2. Climate Data Investment Priorities The assessments highlight critical needs for:

- Enhanced regional climate projections with higher spatial and temporal resolution
- Improved extreme event frequency and intensity projections for the WCPO
- Better ocean chemistry trend monitoring and projection capabilities
- Regional infrastructure and asset resilience assessments

3. Collaborative Validation with Climate Expertise Group review processes should include relevant experts (species specialists, operational experts, regional scientists) and regional climate scientists to address projection uncertainties and validate climate assumptions.

4. Transparent Uncertainty Communication The framework should clearly communicate where climate data limitations constrain assessment confidence, helping users understand which risk ratings are well-supported versus those affected by fundamental data gaps.

The pilot assessments confirm that the WCPFC CCVA Framework successfully serves its intended purpose as a rapid, informational vulnerability screening tool, while highlighting both the critical importance of regional climate data and the value of expert verification to address technical uncertainties within existing climate data constraints.

Conclusions

The WCPFC CCVA Framework offers a potential pathway for integrating climate change considerations into fisheries management decision-making within the Commission. By providing a systematic approach to evaluating climate vulnerability across diverse Conservation and Management Measures, the framework could enable WCPFC to identify and consider climate adaptation needs within its existing governance structures and resource constraints.

The pilot assessments suggest the framework's potential value in helping to distinguish between measures that may face higher climate risks (such as cetacean protection) and those where current approaches appear more robust from a climate perspective (such as North Pacific striped marlin management), while systematically identifying data gaps and research priorities. This capability could support more informed discussions about resource allocation and management priorities in the context of climate change.

The framework may also provide a foundation for adaptive management approaches by offering a standardized methodology that could evolve with improving climate science and expanding institutional capacity. As regional climate projections improve and expert input becomes available, such a framework could become a useful tool for informing discussions about whether WCPFC's conservation and management measures remain appropriate under changing environmental conditions.

Should the Commission choose to adopt and refine this approach, the CCVA Framework could contribute to WCPFC's ongoing efforts to ensure effective fisheries management while maintaining the collaborative, evidence-based approach that characterizes the Commission's work in managing the world's largest and most productive tuna fishery.

Attachments

Attachment A: Literature Review report

Attachment B: CMM CCVA Framework (Master template)

Attachment C: CMM CCVA Framework – Guidance and information

Attachment D: CMM Pilot Assessment Reports (D1-5)

Attachment E: CMM CCVA Framework results (E1-E5)