Australian Government
Australian Fisheries Management Authority

AFMA Climate Risk Framework

Trial Implementation Report

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Contents

1 Introduction

The impact of climate change on Commonwealth-managed fisheries is becoming increasingly evident. The effects of climate change on marine ecosystems are accelerating and Intergovernmental Panel on Climate Change (IPCC) projections indicate that fish production will be further affected within the relatively short term (e.g. 10 years), to the point where management advice that does not consider this change may result in detrimental outcomes for fisheries (Duplisea et al. 2021).

In Australia, climate change is significantly impacting fish stocks, and the marine ecosystems of which they are an integral part, through rising ocean temperatures and sea levels, acidification and changing ocean currents. Further, the critical habitats which help sustain many fish stocks such as coral reefs, mangroves, and seagrasses are being degraded by more frequent marine heatwaves and other extreme weather events. These changes are altering the distribution and abundance of key fish stocks, in turn challenging the effectiveness of existing management regimes, and threatening the livelihoods of fishers and viability of their communities (BoM and CSIRO 2024; Trebilco et al. 2021).

To meet this challenge, AFMA developed the Climate Risk Framework (the Framework) as a formal mechanism to integrate climate change impacts into management decisions for Commonwealth-managed species (also referred to herein where applicable as stocks[1]). The Framework is based on a risk assessment approach to integrate ecosystem and environmental considerations and uncertainty into existing management frameworks, and employs a four-step process:

1. Evaluate the overall risk to the species, integrating climate change impacts with the stock's biological status, using the best available information.

2. Identify current science, management or industry measures that offer sufficiently robust responses to the full spectrum of climate change impacts, both positive and negative.

3. Evaluate the impact of response measures identified at Step 2 and determine the residual risk remaining to the species.

4. Where necessary, recommend to the AFMA Commission any additional measures needed to respond to climate change impacts.

To test and refine the Framework, a trial using a draft iteration of the Framework was completed during 2024 and 2025 across a diverse range of AFMA-managed fisheries encompassing different species, fishing gears, harvest strategy approaches, data availability, geographical locations, and susceptibility to climate change. The objective of the trial was to test the applicability of the draft Framework across the diverse range of fisheries that AFMA manages and to ensure that it could

[1] As defined in the Commonwealth Fisheries Harvest Strategy Policy (DAWR 2018), stock means a unit of management (sub-population) of a particular fish species with common intrinsic population parameters (growth, recruitment, mortality and fishing mortality) and for which extrinsic factors (immigration and emigration) may be ignored. A stock may encompass the whole distribution of a species, in which case the stock and species are in effect the same thing. Or it may be some subset of the distribution of a species, in which case a species would have stock structure and comprise multiple stocks.

effectively trigger adaptation responses where necessary. The trial did not examine the effectiveness of actions triggered by the draft Framework – the performance of the Framework in this regard will be assessed during periodic reviews following implementation.

Generally, the draft Framework was positively received by stakeholders throughout the trial, and stakeholder feedback was critical in ensuring the final Framework offers a robust and systematic, risk-based process for reviewing climate impacts and identifying potential adaptation responses..

The fisheries considered as part of the trial were:

- Southern and Eastern Scalefish and Shark Fishery (SESSF)
- Eastern Tuna and Billfish Fishery (ETBF)
- Macquarie Island Toothfish Fishery (MITF)
- Northern Prawn Fishery (NPF)
- Southern Squid Jig Fishery (SSJF)
- Torres Strait Tropical Rock Lobster Fishery (TSTRLF).

The trial was supported by the Climate Risk Framework Working Group (the Working Group), comprising four world-leading experts in fisheries science, ecology, and management, facilitated by an AFMA Senior Manager. The Working Group's expertise was supplemented for each fishery by relevant experts including AFMA fishery managers, stock assessment scientists, ecologists, climate scientists, and industry representatives.

Importantly, the species assessments referenced in this report were undertaken on a trial basis only and constitute a hypothetical assessment and set of recommendations regarding climate change impacts and responses. They should not be considered a contemporary assessment of species' climate risk. Throughout the trial, opportunities to discuss and seek feedback on the draft Framework from experts was pursued. The feedback has been documented in this trial report and informed the development of the final Framework, endorsed by the AFMA Commission in September 2025.

2 Methodology

The draft Framework was initially developed throughout 2023 following broad and conceptual discussions with fishery stakeholders, and more focussed contributions from the AFMA Commission, fishery managers and other experts in fisheries and climate science. A draft Framework was first presented at a workshop in October 2023 with over 40 participants, including scientists, fishery managers, industry representatives and economists from across multiple jurisdictions.

Following further refinement of the draft Framework and subsequent endorsement by the AFMA Commission in November 2023, fifteen species (or stocks) were selected across six AFMA-managed fisheries to allow a trial application of the draft Framework. These species were selected to comprise a mix of life-history characteristics and fisheries with different fishing gears, harvest strategy approaches, data availability, geographical locations, and susceptibility to climate change. The fisheries and species selected are listed below and shown in Figure 1. An overview of each fishery is available on the AFMA and PZJA websites.

- SESSF – Bight redfish (*Centroberyx gerrardi*), blue-eye trevalla (*Hyperoglyphe antarctica*), elephant fish (*Callorhinchus milii*), gummy shark (*Mustelus antarcticus*), eastern jackass

morwong (*Nemadactylus macropterus*), John dory (*Zeus faber*), orange roughy (*Hoplostethus atlanticus*) and royal red prawn (*Haliporoides sibogae*).

- ETBF – broadbill swordfish (*Xiphias gladius*).
- MITF – Patagonian toothfish (*Dissostichus eleginoides*).
- NPF – brown tiger prawn (*Penaeus esculentus*), grooved tiger prawn (*Penaeus semisulcatus*), blue Endeavour prawn (*Metapenaeus endeavouri*).
- SSJF – Gould's squid (*Nototodarus gouldi*).
- TSTRLF – tropical rock lobster (TRL) (*Panulirus ornatus*).

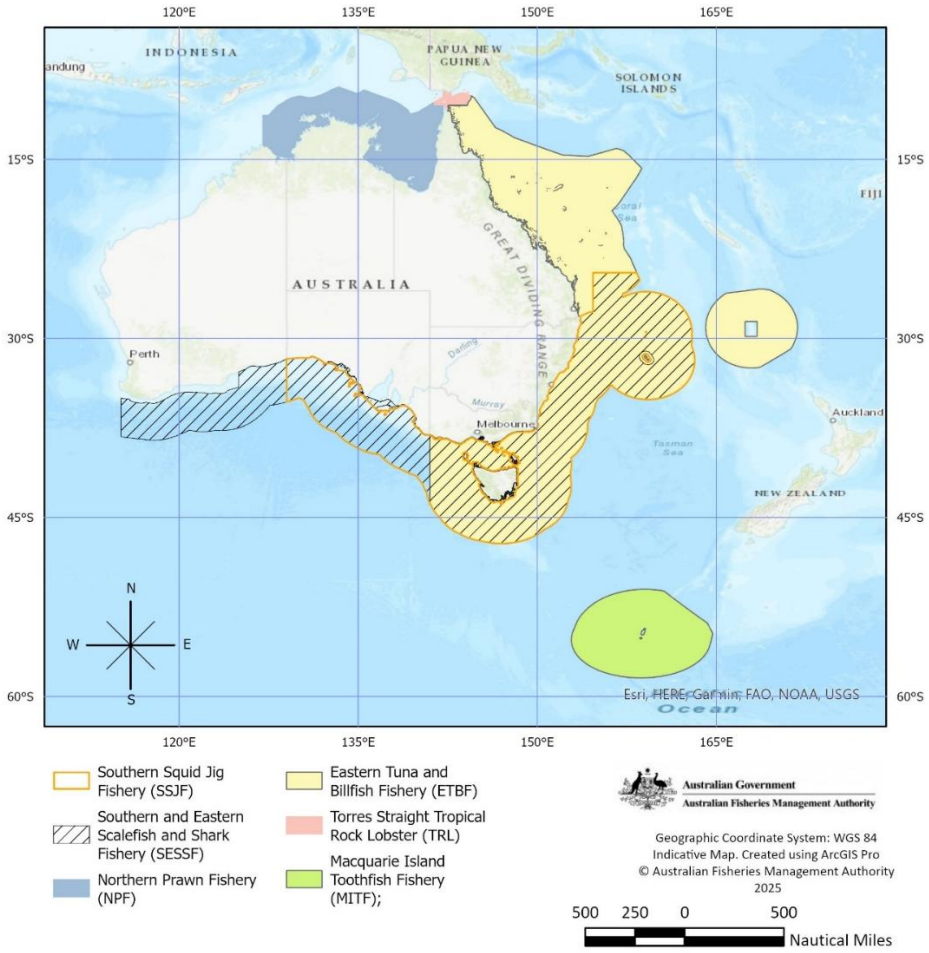

Figure 1 Fisheries selected for a trial application of the draft Climate Risk Framework.

At the inception of the trial, AFMA established a Working Group to support and provide strategic advice to the AFMA Commission and AFMA Management on the development and trial implementation of the draft Framework. The Working Group membership included Dr Beth Fulton, Dr Alistair Hobday, Dr David Smith and Dr Keith Sainsbury.

Applying the methodology detailed in the draft Framework, species assessment reports were first drafted by the AFMA Climate Adaptation team with input from AFMA fishery managers. The assessments were then distributed to industry and scientific members on the relevant resource assessment groups (RAGs) to ensure that technical aspects of the assessments were accurate (e.g. characterisation of stock assessment or research outcomes). A Working Group meeting was then held with representatives from AFMA Management, industry, and scientific stakeholders. Assessments for each species were reviewed and, where necessary, updated to ensure the risk scores (Step 1), adaptation measures (Step 2), residual risk scores (Step 3) and advice to the AFMA Commission (Step 4) were grounded in the most robust and contemporary information

available. Of note, the draft Framework provides for Steps 2 and 3 to be bypassed when a species is assessed as 'low' or 'very low' risk (positive or negative) at Step 1. However, for the purposes of the trial, all steps were undertaken for each species.

Following the Working Group meetings, species assessment reports were reviewed and provided for consideration and advice to fishery-specific RAG and management advisory committee (MAC) meetings. The results of the assessments, including advice on adaptation measures from the relevant advisory committees, would typically be presented to the AFMA Commission as part of annual total allowable catch (TAC) or effort (TAE) setting processes. However, given the trial nature of application, species assessment reports were only provided to the AFMA Commission to support their consideration of the final Framework.

In the early stages of the trial, feedback received through initial meetings of the Working Group identified substantive changes to the draft Framework. Key changes included to:

- restructure the draft Framework's steps to follow a more traditional risk assessment process
- refine to how stock risk was characterised and assessed
- broaden the scope of response measures that may be considered at Step 2, including further guidance on adaptation options across science, management and industry.

The trial was paused (i.e. the species assessment reports that had been considered by the Working Group were not progressed to the RAGs and MACs) while these changes were considered. These changes were incorporated into a new iteration of the draft Framework and subsequently endorsed by the AFMA Commission in July 2024. Those species assessment reports that had already been drafted were updated in line with the new iteration of the draft Framework and consideration through the Working Group, RAGs and MACs recommenced. The species assessment reports referred to in this trial report are based on the July 2024 iteration of the draft Framework. For ease of reference, the tables used to assess risk at Step 1 are provided at **Appendix A**.

3 Results

The results are presented here in two sections: first, species-specific assessment results including details of RAG and MAC discussions; second, broader feedback on the draft Framework including its general application, implementation and how it was amended throughout the trial.

3.1 Species Assessments

The results of the species assessments referred to in the following section are based on the July 2024 iteration of the draft Framework. The assessment approach has changed significantly between that iteration and the final Framework. As such, these results should not be considered an accurate nor contemporary indication of climate risk for those species assessed and they should be viewed for the purposes of the trial only, not for use in management or for other purposes.

Southern and Eastern Scalefish and Shark Fishery (SESSF)

The SESSF is a complex multi-sector, multi-species, multi-gear fishery that covers almost half of the Australian Fishing Zone (AFZ). The area of the fishery extends south from Fraser Island in southern Queensland, around Tasmania, to Cape Leeuwin in southern Western Australia

(Figure 1). The fishery operates in both Commonwealth and State waters under Offshore Constitutional Settlement (OCS) arrangements between the Commonwealth and each State government.

The fishery comprises four major sectors, each of which has a defined area of operation:

- Commonwealth Trawl Sector (CTS)
- East Coast Deepwater Trawl Sector (ECDWTS)
- Gillnet, Hook and Trap Sector (GHATS)
- Great Australian Bight Trawl Sector (GABTS).

The draft Framework was applied to eight species in the SESSF. One species from the GABTS – Bight redfish; four species from the CTS – eastern jackass morwong, John dory, royal red prawn and orange roughy; and three species from the GHATS – blue-eye trevalla, elephant fish and gummy shark.

Step 1 risk scores, reflecting both climate impacts and stock status, ranged from 'very low' to 'extreme' (Table 1). For most species initially assessed as 'low' or 'very low' risk, the residual risk scores remained unchanged because no additional adaptation measures were considered necessary in Steps 3 and 4, indicating that current management practices were adequate. This highlighted the Framework's utility in documenting and validating low-risk assessments, even for climate-resilient species, and in establishing monitoring schedules to detect any future changes in risk profiles.

Table 1 Draft Climate Risk Framework results for species in the Southern and Eastern Scalefish and Shark Fishery. As these results are based on a draft (and since superseded) version of the Framework, they should not be considered an accurate nor contemporary indication of climate risk for those species assessed and they should be viewed for the purposes of the trial only, not for use in management or for other purposes.

Species	Risk Score (Step 1)	Adaptation Responses (Step 2)	Residual Risk (Step 3)
Bight redfish ***Centroberyx gerrardi***	Low	Not required	Low
Jackass morwong (East) ***Nemadactylus macropterus***	Extreme	Sufficient to reduce risk	Medium
John dory ***Zeus faber***	High	Insufficient to reduce risk	High
Royal red prawn ***Haliporoides sibogae***	Very Low	Increase due to uncertainty	Low
Orange roughy (East) ***Hoplostethus atlanticus***	Very Low	Not required	Very Low

Blue-eye trevalla (slope) ***Hyperoglyphe antarctica***	Low	Not required	Low
Elephant fish ***Callorhinchus milii***	Low	Not required	Low
Gummy shark ***Mustelus antarcticus***	Very Low	Not required	Very Low

The residual risk score for royal red prawn, was *increased* from ‘very low’ to 'low' due to uncertainty in the climate impact and stock assessment outputs. While this was considered an appropriate final risk score, the process prompted further discussion within the Working Group about how to address uncertainty. They decided, contrary to the approach taken with royal red prawn, that uncertainty should be addressed by adjusting the risk score at Step 1, accompanied by an explanation about why. Residual risk scores should only be amended to reflect the impact of adaptation measures identified at Step 2, not to reflect uncertainty in climate impacts or stock status. This is discussed further below under Determining residual risk scores.

The blue-eye trevalla assessment followed a unique process. Initially, a 'medium' risk score was assigned in Step 1, reflecting a ‘medium’ (negative) climate change impact and a 'below target' stock status based on a 2023 Tier 4 stock assessment. However, during the November 2024 South East RAG (SERAG) meeting, a revised Dynamic Tier 4 stock assessment was considered (Sporcic and Bessell-Browne 2024). Consequently, the species assessment report was updated, and the Step 1 risk score was reduced to 'low', as the new assessment estimated a stock status of 36%B_0, or 'near target'. This example illustrates the importance of timing of assessments when applying the Framework. Where possible, the stock assessment and climate impacts assessments should be resolved prior to application of the Framework to ensure consistent sharing of information. If assessments are updated during the application of the Framework, all stakeholders involved in the initial assessment should be informed. This is discussed further below under Timing of assessments.

One common critique of the draft Framework, and observed in assessments across a range of species, was its insufficient direction on establishing residual risk scores. Throughout the trial, residual risk scores tended to be based on whether the guidance associated with that score at Step 3 seemed appropriate as opposed to an objective assessment of whether the adaptation measures identified at Step 2 would be expected to result in changes to the stock status or climate vulnerability of the species. The draft Framework only included the guidance shown in Figure 3. In the final version, this was revised to reflect the updated guidance in Figure 4, following a review of the Step 3 residual risk process by the Working Group. This resulted in a more considered and objective approach. Two examples are described below and are discussed further under Determining residual risk scores.

John dory was assessed ‘high’ risk at Step 1, reflecting a climate impact assessment of ‘medium’ and a stock status of ‘depleted’. While a range of management responses were identified at Step 2, including the introduction of a bycatch TAC, area closures and a reduction in the number of active boats, only the bycatch TAC was specifically targeted at John dory. The other measures were primarily aimed at constraining catches of eastern jackass morwong, a species caught alongside John dory when targeting tiger flathead in the CTS. On this basis, the residual risk score

was maintained as ‘high’. However, this prompted discussions about whether the draft Framework guidance associated with a residual risk of ‘high’ was appropriate.

For species with a residual risk of ‘high’, the draft Framework required – *Measures must be implemented that allow for rapid response before the next fishing season* (Figure 3). John dory was first assessed as depleted in 2021. AFMA’s immediate response was to implement a bycatch TAC – a requirement of the SESSF Harvest Strategy. Over the following 18 months, primarily driven by the need to constrain catches of eastern jackass morwong, a series of closures and gear modifications were introduced. Now, in 2025, AFMA is considering alternative stock assessment methods and is in the process of developing a rebuilding strategy for John dory. This staged and measured approach is more aligned with updated guidance for Step 3 provided in the final version of the Framework for ‘high’ risk species (refer to Figure 4) and is discussed further under Timing of assessments and Determining residual risk scores.

Eastern jackass morwong was the only species in the SESSF assessed as ‘extreme’ risk at Step 1, reflecting a climate impact assessment of ‘high’ and a stock status of ‘depleted’. The residual risk score was reduced to ‘medium’ on the basis that significant adaptation measures were identified at Step 2. The guidance provided in the draft Framework for a ‘medium’ risk species was – *Immediate action not required, but measures must be identified that allow for rapid response to future changes in risk profile* (Figure 3). This guidance aligned with what SERAG and the South East MAC (SEMAC) considered AFMA had achieved through their response to climate-driven declines in the stock.

However, considering the risk matrix (Figure 2), if climate impacts are considered a constant, a residual risk score of ‘medium’ would require the eastern jackass morwong stock to recover to a point where it is considered ‘near target’. Projections from the 2021 stock assessment (Day et al. 2021) estimated that even in the absence of fishing the stock would only recover to 40%B_0. With constant catch of around 50 tonnes the stock eventually recovers to 32%B_0 and catches of 100 tonnes would have the stock recover to just above the limit reference point (LRP) – 21%B_0. In this context, eastern jackass morwong would more appropriately be considered ‘high’ risk on the basis that recent catches (which are uncertain but likely less than 100 tonnes) would only see the stock recover to above the LRP, not towards the target reference point (TRP).

Figure 2 A reduction in the risk score for eastern jackass morwong from 'extreme' to 'medium' would require that the adaptation measures identified at Step 2 would allow for recovery to 'near target'.

See Determining residual risk scores for a discussion on how this informed update to the final Framework.

Eastern Tuna and Billfish Fishery (ETBF)

The ETBF is a multi-species fishery operating in the waters off the east coast of Australia, extending from far north Queensland to the Victorian-South Australian border (Figure 1). It uses longline and minor line (including handline, troll, rod and reel) to target tuna and billfish species. As these species have ranges extending outside the AFZ into the high seas and the Exclusive Economic Zones (EEZs) of other countries, Australia cooperates with regards to their management through the Western and Central Pacific Fisheries Commission (WCPFC). While Australia's catch of tuna is a very small part of the total regional catch, catch of billfish is more significant. As a result, billfish (broadbill swordfish and striped marlin) are managed under the ETBF Harvest Strategy.

Broadbill swordfish was selected as a trial species in the ETBF as it offered an opportunity to examine the application of the draft Framework to a straddling stock which is managed under both domestic and regional management frameworks.

The initial draft of the species assessment report concluded that the Step 1 risk score was 'medium' for broadbill swordfish. This was on the basis that preliminary projections (Fulton et al. 2021) indicated a 5-60% decrease in abundance predicted by 2040 (with medium confidence), equating to a 'high' climate impact. The stock status was assessed as being 'near target' based on a 2021 stock assessment which estimated the latest spawning stock biomass to be 46%B_0 though there was significant uncertainty around this estimate (Ducharme-Barth et al. 2021). A range of adaptation measures were identified at Step 2. However, given the preliminary projections' large range, additional information was requested by the Tropical Tuna RAG (TTRAG) before Step 1 and the remaining steps could be finalised (further details below).

A key issue that arose during the assessment, which is also relevant to assessments in other fisheries, was which reference points to use to assess the stock status. The draft Framework did not provide guidance on the matter. At the regional level, although regular stock assessments are undertaken by the WCPFC, unlike for tuna, the WCPFC have yet to adopt a LRP or TRP for this stock. Domestically however, under the ETBF Harvest Strategy the species is managed using a catch-per-unit-effort (CPUE) based harvest control rule with Maximum Economic Yield (MEY)-based LRP and TRP. It was decided the results of the most recent regional stock assessment and proxy LRP and TRP as per the Commonwealth Fisheries Harvest Strategy Policy (CHSP) (DAWR 2018) be applied. As the stock status changes depending on which reference points (and associated stock status information) is used, this highlighted the need for additional guidance on the selection of reference points when applying Step 1 of the Framework. This is discussed further below under Assessing stock status.

Consultation on the species assessment was undertaken through the Working Group as well as out-of-session with AFMA management and key stakeholders. However, when considered by the TTRAG in July 2025, further information was requested regarding the preliminary projections used to derive the climate impacts score before finalising their advice. Given the timing of subsequent RAG meetings, this was unable to be resolved prior to the end of the trial. The scheduling of the Tropical Tuna MAC also prevented their consideration of the species assessment prior to the end of the trial. As such, the Step 1 assessment was unable to be finalised prior to the end of the trial. This example reinforces the importance of ensuring the right experts are in the room when considering species assessments, particularly where stakeholders may not be familiar with key research being used to formulate risk scores. It also demonstrates that some species assessments may take multiple rounds of consultation to before they can be finalised, and this should be factored into implementation schedules.

TTRAG also noted that there was significant uncertainty in the 2021 stock assessment results. Although guidance on how to account for uncertainty was provided in the draft Framework, the effect of this on the stock status risk score for broadbill swordfish was not discussed. This example reinforces the need to explicitly consider stock assessment uncertainty when formulating risk scores and should be a focus when implementing Step 1 of the final Framework.

Macquarie Island Toothfish Fishery (MITF)

The MITF targets Patagonian toothfish in the sub-Antarctic waters surrounding Macquarie Island, an island about 1,500 km south of Tasmania (Figure 1). While the MITF sits outside the area covered by the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR), management approaches consistent with those of CCAMLR have been adopted for the fishery.

Patagonian toothfish was selected as a trial species in the MITF as it offered an opportunity to leverage the expertise of the Working Group and understand how climate impacts can be incorporated in the management strategy evaluation (MSE) testing of the MITF Harvest Strategy.

The initial draft of the species assessment report for Patagonian toothfish concluded that the Step 1 risk score was 'low' on the basis that preliminary projections (Fulton et al. 2021) indicated a high sensitivity to climate change, with a 20% through to 60% decline in abundance predicted by 2040 (with medium confidence), equating to a 'high' climate impact. The stock status was assessed as being 'above target' based on the 2023 stock assessment which estimated the 2024 spawning stock biomass to be 73%B_0 (Bessell-Browne and Hillary 2023).

A Working Group meeting attended by fishery managers, industry and stock assessment scientists, resolved that the stock is not as high risk to climate impacts as the projections suggest; while the drivers are unclear, body condition has been improving, and recent recruitment is above average (Downie et al. 2023; Bessell-Browne and Hillary 2023). This empirical and more contemporary information was considered sufficient to decrease the climate impact risk score from 'high' to 'medium' resulting in an overall Step 1 risk score of 'very low' (Table 2).

Table 2 Draft Climate Risk Framework results for Patagonian toothfish in the Macquarie Island Toothfish Fishery. As these results are based on a draft (and since superseded) version of the Framework, they should not be considered an accurate nor contemporary indication of climate risk for those species assessed and they should be viewed for the purposes of the trial only, not for use in management or for other purposes.

Species	Risk Score (Step 1)	Adaptation Responses (Step 2)	Residual Risk (Step 3)
Patagonian toothfish ***Dissostichus eleginoides***	Very low**Error! Bookmark not defined.**	Not required	Very low**Error! Bookmark not defined.**

This process illustrates an appropriate application of the draft Framework where, unlike in the case of royal red prawn, the Step 1 risk score was adjusted based on an improved understanding of the climate impacts, not during the residual risk step (Step 3). Adjustments during the residual risk process should only result from effective adaptation measures. This is discussed further below under Determining residual risk scores.

When considered by the Sub-Antarctic RAG (SARAG) in August 2025, it was noted that while the risk scores reflected the information available at that time, a revised stock assessment was under consideration and the species assessment would need to be updated in time to reflect this new information. However, given the end of the trial was imminent and timing of subsequent meetings, it was agreed that there was little utility in updating the information for the purpose of the trial. The scheduling of the South MAC also prevented their consideration of the species assessment prior to the end of the trial. As such, the assessment was unable to be endorsed by South MAC prior to the end of the trial.

Northern Prawn Fishery (NPF)

The NPF is a multi-species fishery extending from Joseph Bonaparte Gulf (JBG) across the Top End of the Northern Territory to the Gulf of Carpentaria (Figure 1). Banana and tiger prawns are the main species targeted in the fishery, accounting for around 90% of the fishery's total prawn catch. Byproduct species include other prawn species (Endeavour, king and black tiger), squid, bugs, scallops, cuttlefish and scampi.

The draft Framework was applied to three species in the NPF – brown tiger prawn, grooved tiger prawn and blue Endeavour prawn.

The initial drafts of the species assessment reports concluded that the Step 1 risk scores, were 'low' for both tiger prawn species and 'medium' for blue Endeavour prawn. However, additional information was identified for incorporation at Step 1 before this and the remaining steps could be finalised (further details below). While a range of adaptation measures were identified at Step 2, none were considered sufficient to reduce the risk at Step 3, though this advice was only preliminary given finalisation of Step 1 was pending.

Consultation on the species assessments were undertaken through the Working Group as well as out-of-session with AFMA Management and key stakeholders. However, when considered by the Northern Prawn Fishery RAG (NPRAG) and Northern Prawn Fishery MAC (NORMAC) in May and August 2025, respectively, it was noted that the climate risk information included in the species assessment reports was not reflective of the current understanding of species-specific climate change impacts. The initial drafts of the reports used preliminary projections (Fulton et al. 2021) as an indicator of climate impacts. For blue Endeavour prawn the projections indicated a >20% decline in abundance predicted by 2040 (with high confidence). For both tiger prawn species, the projections indicated a variable 10-20% decline in abundance predicted by 2040 (with high confidence).

At the NPRAG meeting in May 2025, the preliminary results of a project using 'models of intermediate complexity for ecosystem assessments' (MICE) to provide a better understanding of the key environmental drivers for tiger prawn stocks in the NPF (the Tiger MICE project) were considered. The results provided a more nuanced understanding of the impacts of climate change on different prawn species, compared to the preliminary projections. However, the results were preliminary and were yet to be published. NPRAG recommended that the outcomes of the Tiger MICE project should be incorporated before the assessments were finalised. NORMAC agreed with this advice. Given this, the assessments were unable to be finalised prior to the end of the trial. This highlights the importance of considering the timing of assessments and is discussed in more detail under Timing of assessments. It also demonstrates that some species assessments may take multiple rounds of consultation to before they can be finalised, and this should be factored into implementation schedules.

An assessment of stock status relative to a TRP depends on whether the TRP is based on MEY or Maximum Sustainable Yield (MSY). MEY typically requires a higher standing biomass than MSY, meaning that the same stock biomass may be considered above or below the TRP depending on which reference point is applied.

As was the case in the ETBF, careful consideration was given to the choice of reference points for assessing stock status. Under the NPF Harvest Strategy, key target species are managed using MEY-based TRPs. When assessing stock status, species that are above their MEY-based TRP are generally at lower ecological risk from climate change than those closer to or below MSY-based reference points, due to the higher biomass required to achieve MEY.

To ensure consistency in evaluating ecological sustainability, it was decided to assess stock status against MSY-based reference points. However, for tiger prawn species in particular, the outcome of the assessment can vary significantly depending on whether MSY or MEY-based TRPs are used. This is because, under current economic conditions, such as high fishing costs, achieving MEY requires higher catch rates and thus a higher standing biomass than what is needed to meet MSY.

Assessing stock status solely against MSY-based TRPs may therefore overlook the economic vulnerability of the fishery to climate change. Since maximising net economic returns is a key objective in the management of Commonwealth fisheries, alongside ecological sustainability, the selection of reference points should reflect this dual focus, especially where MEY-based assessments are available.

This issue is explored further in the section Assessing Stock Status.

Southern Squid Jig Fishery (SSJF)

The SSJF is a single-species fishery targeting Gould's squid over a large area extending south from southern Queensland around to the South Australian-Western Australian border (Figure 1). Gould's squid is a short-lived, fast-growing species that that is sensitive to environmental conditions resulting in highly variable recruitment and biomass, meaning traditional management approaches are not effective. The data and information available to manage the fishery is relatively poor and it is primarily managed through effort restrictions and monitoring triggers.

Gould's squid was assessed as 'very low' risk at Step 1, reflecting a climate impact assessment of 'neutral' and a stock status of 'near target' (Table 3). While a range of adaptation measures were noted at Step 2, residual risk scores remained unchanged and current management practices were considered adequate.

Table 3 Draft Climate Risk Framework results for Gould's Squid in the Southern Squid Jig Fishery. As these results are based on a draft (and since superseded) version of the Framework, they are not an accurate indication of climate risk for those species assessed and they should be viewed for the purposes of the trial only, not for use in management or for other purposes.

Species	Risk Score (Step 1)	Adaptation Responses (Step 2)	Residual Risk (Step 3)
Gould's Squid ***Nototodarus gouldi***	Very Low	Not required	Very Low

The draft Framework provided for Steps 2 and 3 to be bypassed when a species is assessed as 'low' or 'very low' risk at Step 1. However, for the purposes of the trial, all 4 steps were undertaken for each species, including Gould's squid. When considering Steps 2 and 3 for Gould's squid, the additional information and consideration provided under these steps did not add value to the assessment, particularly in light of the resourcing required to undertake these additional steps. This example provides support for the bypass of these steps for 'low' and 'very low' risk species and it remains a feature of the final Framework.

Torres Strait Tropical Rock Lobster Fishery (TSTRLF)

The TSTRLF is a single-species fishery that targets TRL in Australian waters of the Torres Strait Protected Zone (TSPZ) and Australia's declared 'outside but near area'. The Torres Strait lies between Cape York Peninsula (north Queensland) and Papua New Guinea and connects the Arafura and Coral Seas (Figure 1). TRL is a shared stock between Australia and Papua New Guinea and is managed cooperatively under the 1985 Torres Strait Treaty. With regards to management within Australia's jurisdiction, AFMA delivers day-to-day management of the TSTRLF on behalf of the Torres Strait Protected Zone Joint Authority (PZJA). The PZJA comprises the ministers from the Australian and Queensland governments responsible for fisheries, and the Chair of the Torres Strait Regional Authority (TSRA), and are the decision-makers concerning the management of the TSTRLF and other Torres Strait fisheries.

While the TSTRLF was selected to evaluate the application of the draft Framework to a jointly-managed fishery, the process was unable to be completed by the end of the trial period due to resourcing constraints. AFMA will continue to work with other PZJA agencies, and the PZJA itself, regarding the application of the final Framework to Torres Strait fisheries.

Overall results

Stakeholders generally responded positively to the Framework throughout the trial, and their feedback played a crucial role in shaping a final version that offers a robust and practical approach to formally integrating climate risk into decision-making processes.

A key objective of the trial was to test the applicability of the Framework across the diverse range of fisheries that AFMA manages and to ensure that the Framework triggered action where necessary. Overall, the draft Framework was able to be applied to all species included in the trial, with the exception of TRL in the TSTRLF (due to resourcing constraints). In summary, for the 14 species assessed:

- At Step 1, five species were assessed to be 'very low' risk, three 'low' risk, one 'high' risk and one 'extreme' risk. Step 1 was unable to be completed for four species.
- At Step 2, scientific, management and industry adaptation measures were able to be identified for all species. However, the majority of measures were existing measures with some utility in adapting to climate change but not designed or implemented for that express purpose (e.g. implemented for other fisheries management purposes). This is appropriate for those species assessed to be 'low' or 'very low' risk. However, for those species assessed as 'medium' risk or higher, consideration was given under Step 3 to both a review of existing adaptation measures as well as the development and implementation of additional measures where existing measures are not sufficiently responsive.
- The application of Step 3 resulted in changes to the risk scores for two species – royal red prawn increased from 'very low' to 'low' risk and eastern jackass morwong decreased from 'extreme' to 'medium' risk.

- Advice for ten species was formulated at Step 4. One of these ten assessments was unable to be finalised due to the MAC not meeting before the trial ended. For the four remaining species, these required resolution of issues raised by the RAG and/or MAC at Step 1 before this and the remaining steps (including Step 4) could be considered. As a result, these four assessments were not finalised.

It is expected that for some species (or fisheries), it may take multiple rounds of consultation to resolve issues and finalise species assessments. Given the limited timeframe in which to complete the trial, this was not possible for some fisheries. However, what the trial did demonstrate in those cases where all steps were completed was that the draft Framework was effective in assessing climate risks, supporting the identification and documentation of adaptation measures, some of which were already in place, underway or planned, as well as incorporating this information into the formulation of advice to be provided to decision-makers. For some stakeholders, the trial was the first time they had been provided with information concerning species-specific climate risks and was an important educational opportunity. In some instances, the species assessments also triggered discussion as to how the information on climate risks could inform other work being undertaken (e.g. MSE testing of harvest strategies, development of research priorities).

3.2 Consultation feedback

Consultation, beginning with the October 2023 workshop, consistently highlighted the need for a process that practically integrates climate risk advice into fisheries management decision-making, prioritising clear and objective consideration within RAGs and MACs. To this end, throughout the course of the trial, a diverse range of feedback was received that has been used to improve the function and effectiveness of the Framework, including how it is considered and applied by RAGs and MACs. Details of key feedback are provided below.

Assessing climate impacts

Consideration of impacts other than changes to productivity

The draft Framework focused on assessing impacts on a species' abundance as a result of climate-driven changes to physical ocean properties and variables. However, a species' response to these changes can also be in the form of changes to their distribution, phenology (e.g. where the timing of life history events such as migration, or reproduction shift as the environmental cues have shifted) and physiology (e.g. where increased temperatures speed up the metabolism influencing the growth and condition of an individual). While many impacts will be direct, there can also be indirect impacts on ecosystems which can impact a species in different ways (e.g. prey and habitat availability, disease outbreaks, harmful algal blooms) (Fulton et al. 2020).

Although impacts on a species' distribution, phenology or physiology may not always directly affect a species' ecological sustainability, they can have significant implications for fisheries management, particularly when species cross jurisdictional boundaries. Given this, these additional impacts, although not explicitly assessed under the draft Framework, should be cited and considered when developing advice and adaptation measures to ensure responsive and resilient fisheries under changing environmental conditions. Should a deeper understanding of these impacts be needed, there are numerous approaches, tools and methodologies available. One such tool is the Adaptation of Fisheries Management to Climate Change Handbook (Fulton et al. 2020).

Further guidance on how to ensure these additional impacts are considered has been included in the final Framework.

Climate and ecosystem indicators

Under the draft Framework, attribution studies, modelling of projected impacts and climate sensitivity assessments could all be used to assess climate impacts on the future state of a species or stock. A fourth tier of information was included in the draft Framework concerning the use of climate and ecosystem indicators. While a number of data-poor species were assessed under the draft Framework (e.g. elephant fish, Gould's squid), all species had a higher tier of information available with which to assess climate impacts, and as such climate and ecosystem indicators were not used as the basis of any species assessment.

Climate and ecosystem indicators are measurable variables or metrics that are used to track changes in the environment over time. They provide essential insights into how ecosystems are responding to human activities and natural processes – including climate change. Climate and ecosystem indicators, as they were framed in the draft Framework and used by AFMA, refer to short to medium term trends of various oceanographic and ecosystem variables presented at regional scales. While they may provide an early warning of significant changes as they emerge, in their current form, they are not informative of expected long-term changes to individual species or ecosystems. In addition, how the existing climate and ecosystem indicators relate to particular ecosystem components has yet to be refined to the point where expected changes at the species level can be derived.

The final Framework provides guidance that climate and ecosystem indicators should be considered contextually to support or strengthen the assessment of climate impacts, not form its basis.

Uncertainty in context

Uncertainty in species assessments can arise in various forms, including conflicting evidence from multiple sources despite a large volume of data, high natural variability in species' traits or responses to environmental change, or limited or no data, resulting in a lack of understanding of climate impacts.

In the context of Commonwealth-managed fisheries, assessments of climate impact categorised as 'uncertain' are generally considered to represent a medium level of climate risk (Table 1 of the draft Framework refers). This reflects the assumption that some baseline information, such as species distribution and environmental associations, is typically available for Commonwealth-managed species, even if comprehensive data is lacking. However, in jurisdictions with poorer information bases, the same level of uncertainty may warrant a higher risk classification. Therefore, the interpretation of 'uncertain' should be context-specific and informed by the quality and extent of available data.

Further guidance has been included in the final Framework, to aid in interpretation of this consideration.

Assessing stock status

Under Step 1 of the draft Framework, stock status was generally determined by assessing the current biomass or fishing mortality of a species against a LRP and TRP. A reference point is a specified level of an indicator used as a basis for managing a stock or fishery. Reference points will generally be based on indicators of either the total or spawning stock size (biomass) or the amount of harvest (fishing mortality). Indicators can be an observation of the state of a species (e.g. CPUE trends) or the output from a more formal assessment (e.g. estimates of biomass or fishing

mortality). For data-poor fisheries, however, an expert opinion-based approach may apply (DAWR 2018).

During the course of the trial, different approaches were taken with regards to the selection of reference points when determining stock status, highlighting the need for further guidance on this matter. In particular, while the draft Framework provided guidance on how to assess stock status depending on the assessment method and levels of uncertainty, it did not provide guidance in terms of selecting the thresholds (i.e. reference points) against which to undertake the assessment or where there might be multiple reference points available. The following are examples of some of the disparate approaches observed during the trial:

- SESSF – Bight redfish is assessed under a MEY-based TRP of 41%B_0. This TRP is based on bioeconomic modelling undertaken in 2012. While dated, this TRP was used to determine stock status.
- ETBF – at the regional level, although regular stock assessments are undertaken by the WCPFC, unlike for tuna, the WCPFC have yet to adopt a LRP or TRP for this stock. Domestically however, under the ETBF Harvest Strategy the species is managed using a MEY-based LRP and TRP. The most recent regional stock assessment and proxy LRP and TRP as per the CHSP were used, as the regional assessment was more quantitative than that undertaken domestically.
- NPF – under the NPF Harvest Strategy, the key target species are managed under MEY-based TRPs. In order to gauge the ecological sustainability of species, it was decided that stock status be assessed against MSY-based reference points.

For Commonwealth-managed fisheries, harvest strategies are not only designed to control the ecological state of a fishery, but also the economic (and in some cases social) conditions. To ensure consistent application with regards to the selection of reference points, guidance has been included in the final Framework, drawing on policy guidance under the CHSP. Where reference points have been determined for a species (e.g. through a formally adopted harvest strategy), these should be used in determining stock status as they best reflect the specific objectives of the fishery and in most cases will have been formally tested (e.g. through MSE testing).

For jointly managed international species, domestic harvest strategies (including reference points) are required where Australia is a major harvester of the stock, and no harvest strategy has been determined internationally. In these cases, the domestic harvest strategy (and associated assessments) should be used to assess stock status. Where Australia is not a major harvester and does not have complementary management for foreign fleets, a domestic harvest strategy would not be effective, and the harvest strategy (and associated assessments) adopted by the relevant regional fisheries body should be used. In cases where reference points have not been adopted internationally, Australia's negotiating position on reference points specific to the species in question should be used.

For data-poor species, species-specific reference points (or associated stock status information) may not be available. In these cases, an expert opinion-based approach weighing up all available lines of evidence regarding a species' status should apply. At a minimum, for most data-poor species, the results of the most recent Ecological Risk Assessment (ERA) should be available. Higher-tier ERAs provide a measure of instantaneous fishing mortality (F) against the species-specific F_{MSY}. While this is not a measure of stock status, it provides a useful assessment of whether the stock is at risk from the impacts of fishing.

The reference points used to assess stock status at Step 1 should be clearly documented in species assessment reports.

Determining residual risk scores

One common critique of the draft Framework, observed in assessments across a range of species, was its insufficient direction on establishing residual risk scores (Step 3). This prompted a review of the residual risk process and resulted in what is now a more considered and objective approach.

Adaptation versus input refinement

In applying the draft Framework, different approaches were taken when adjusting risk scores:

- Royal red prawn – residual risk score was increased from ‘very low’ to 'low' due to uncertainty in the climate impact and stock assessment outputs.
- Patagonian toothfish – additional supplementary information relevant to the species’ climate impact risk was incorporated by adjusting the risk score at Step 1.

Guidance included in the final Framework now provides that adjustments to residual risk scores should only result from adaptation measures identified at Step 2, as seen with eastern jackass morwong. Adjustments due to uncertainty in initial assessments (e.g. royal red prawn) or additional supplementary information (e.g. Patagonian toothfish), should be addressed in Step 1.

Guidance on adjusting risk scores

The draft Framework provided some guidance (and examples) on how adaptation measures identified at Step 2 could be assessed to determine a residual risk score at Step 3, including the scale of adjustments. However, during the development of species assessments, it became clear that additional guidance was needed for this step of the process.

Residual risk refers to the level of climate-related risk that remains after adaptation measures have been applied. These responses, identified in Step 2, are considered the treatment and may include scientific research, management interventions, or industry-led responses. Residual risk should be evaluated based on the expected change in stock status or climate vulnerability resulting from the implementation of these measures. Throughout the trial, residual risk scores tended to be adjusted based on whether the guidance associated with individual risk scores (Figure 3) seemed appropriate as opposed to an objective assessment of whether the adaptation measures identified at Step 2 would be expected to result in changes to the stock status or climate vulnerability of the species.

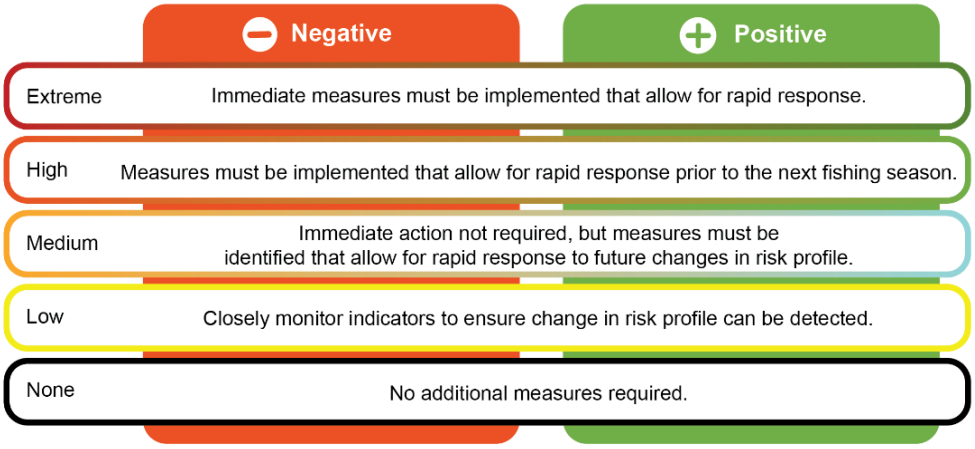

Figure 3 Guidance provided in the draft Framework for determining Step 3 residual risk scores. This has been updated to include more considered and objective guidance based on the expected effects of measures identified at Step 2.

For example, eastern jackass morwong was assessed as 'extreme' risk at Step 1. The residual risk score was reduced to 'medium' on the basis that significant adaptation measures were identified at Step 2. The guidance provided in the draft Framework for a 'medium' risk species was – *Immediate action not required, but measures must be identified that allow for rapid response to future changes in risk profile* (Figure 3). This guidance aligned with what the RAG and MAC considered AFMA had achieved through their response to climate-driven declines in the stock.

However, considering the risk matrix (Figure 2), if climate impacts remain unchanged, a residual risk score of 'medium' would require the stock status for eastern jackass morwong to recover to a point where it is considered 'near target'. Stock assessment projections did not support this expectation, instead indicating the stock will only recover to around 32%B_0, equating to a stock status risk of 'below target' and overall risk of 'high'.

Additional guidance has been provided in the final Framework (including Figure 4) to ensure adjustments to residual risk scores are based on the expected change to the stock status or climate vulnerability for a species resulting from the implementation of adaptation measures.

Residual Risk	Negative	Positive
Extreme	**The species is highly vulnerable to climate change and expected to remain or continue to fall further below the limit reference point.**	**The species will likely benefit from climate change and remain, or increase to, well above the target reference point.**
	For depleted species, management actions outlined in the harvest strategy will be implemented before the next fishing season. Over the following 12 months, additional adaptation measures will be developed to support long-term, climate-responsive, and data informed strategies - including for species with positive impacts.	
High	**The stock remains vulnerable to climate change and will either remain below, or rebuild above, the limit reference point.**	**The stock is expected to benefit from climate change and either remain at, or increase to, above the target reference point.**
	For depleted species, management actions outlined in the harvest strategy will be implemented before the next fishing season. Over the following 24 months, additional adaptation measures will be developed to support long-term, climate-responsive, and data informed strategies - including for species with positive impacts.	
Medium	**The species may still be vulnerable to climate change. Current management measures are expected to maintain the stock at, or promote recovery towards, the target reference point.**	**The species may still benefit from climate change. Current management measures are expected to maintain the stock at, or return it towards, the target reference point.**
	Monitoring and data collection programs should be reviewed to ensure they are capable of detecting changes in risk profiles, including climate-driven changes in stock status or distribution.	
Low	**Climate change is not expected to have an immediate impact on this species.** No response is needed beyond periodically reviewing existing monitoring and data collection programs.	
Very low	**Climate change is not expected to have long-term impact on this species.** No response is required.	

Figure 4 Updated guidance provided in the final Climate Risk Framework for determining Step 3 residual risk scores.

Timely management responses for at-risk stocks

The draft Framework provided guidance (Figure 3) on the expected scale of response needed and timeframes for implementing adaptation measures depending on a species' climate risk score. Concerns were raised in the SESSF regarding the timeframes for species assessed as 'high' and 'extreme' risk. For 'high' risk species, the draft Framework required – *Measures must be*

implemented that allow for rapid response before the next fishing season. For 'extreme' risk species, the draft Framework required – *Immediate measures must be implemented that allow for rapid response*.

Concerns were that the timeframes may not be feasible in some cases, implementing significant measures all at one time may not be practical or necessary (staged approaches need to be accommodated) and may not reflect the rate of climate-induced change (and therefore timeframes in which measures need to be implemented).

In the case of John dory, while a range of adaptation measures were identified at Step 2, none were considered sufficient to adjust the 'high' risk score at Step 3. This prompted discussions about whether the guidance associated with a residual risk of 'high' was appropriate. John dory was first assessed as depleted in 2021. AFMA's immediate response was to implement a bycatch TAC – a requirement of the SESSF Harvest Strategy. Over the following 18 months, primarily driven by the need to constrain catches of another depleted species, eastern jackass morwong, a series of closures and gear modifications were introduced. AFMA is now considering alternative stock assessment methods and is in the process of developing a rebuilding strategy for John dory.

This case demonstrates that while some 'immediate' and 'rapid' responses are important for species at 'high' or 'extreme' risk, not all measures can (or need to) be developed and implemented quickly. A staged approach is appropriate in most cases, with immediate responses focusing on stock assessment adjustments and other short-term measures (e.g. TAC adjustments) followed by longer-term actions (e.g. closures, gear modifications) within a reasonable timeframe. Eastern jackass morwong is an example of such a staged approach.

The guidance in the final Framework (including Figure 4) has been updated as a result to address these considerations.

Timing of assessments

The draft Framework required the most recent and robust information available when assessing a species. There were cases during the trial where the timing of the assessments was important in order to ensure a species assessment was based on the best available information. In the case of blue-eye trevalla, SERAG identified that a new stock assessment had been undertaken and the species assessment was updated as a result. In the case of the NPF, NPRAG identified an important research project which would provide a better understanding of the key environmental drivers for tiger prawn species. However, project finalisation was pending, so the RAG recommended the species assessments not be finalised until the outcomes of the project could be incorporated. There were also cases identified by the Working Group where key information was missing from assessments even following review by RAGs and MACs.

In response to these issues, when planning to apply the final Framework to species, it is important to consider what new information may be updated during the process (e.g. stock assessments) or pending, and its likely importance to the assessment. However, it is often the case that work is underway to improve the information used in such assessments. In considering whether to delay an assessment, the principles of ecologically sustainable development, including the exercise of the precautionary principle should be applied. Particularly relevant in this context, is the principle that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. If it is known that a species assessment relies on data that is outdated, uncertain, or less robust than pending research, this can be clearly noted in the assessment. That context can

inform advice to the AFMA Commission, which may include a recommendation to defer management action until the pending research is available. The review process under the final Framework also ensures new information will be picked up in a timely manner and reflected in updated species assessments. Further details below.

Review process

The draft Framework referred to an annual review of species assessments. During the trial it became apparent that individual species assessments, even for low risk and data-poor species, can be time-consuming. Some species assessments also took multiple rounds of consultation over more than a year before they could be finalised, making it infeasible to review the assessments annually. The final Framework details a review approach based on triggers to ensure climate risks are considered in a timely manner.

Species assessments will be updated if there is any new information regarding climate impacts or stock status, including extreme events that would undermine previous assessments, or there have been changes to science, management or industry arrangements that would change the risk score. The Working Group and RAGs will be asked to provide advice on the need to update species assessments annually.

The final Framework itself will undergo periodic review of its performance every five years, focussing on a high-level review of the key components of the Framework, how it has been applied over time, and the extent to which adaptation measures have been effectively implemented.

Recognising climate-driven changes in productivity

Changes in a species' abundance can be due to environmental factors (e.g. biotic such as predator and prey interactions and abiotic (e.g. temperature and salinity, ocean currents, dissolved oxygen, and habitat structure) parameters), or non-environmental factors (e.g. fishing pressure, fishing technology, and market demand) (Fulton et al. 2024). A good understanding of what is driving changes in a species' abundance, is fundamental to adaptive and effective management.

However, distinguishing between fishery-driven and environmentally-driven declines in a species is a key challenge. Under the draft Framework, the 'extreme' risk category presented a particular issue, as it applied to both recoverable species (where reduced fishing pressure or other fisheries management interventions would be expected to result in recovery) and unrecoverable species (those impacted by long-term environmental changes and therefore unlikely to recover through fisheries management interventions alone). Climate change is causing such long-term environmental changes and is already influencing fished species in south-east Australia. Warming in this region has seen at least 100 species shift their spatial distributions, leading to the formation of novel ecosystems, community restructuring, habitat loss, and shifts in the productivity of individual species (Fulton et al. 2024).

Some stocks in Commonwealth-managed fisheries have been overfished (e.g. depleted) and managed under rebuilding strategies for many years without evidence of recovery. The reasons for this failure to recover are unclear, but in some instances the impact of climate change is likely to be a factor (e.g. blue warehou and eastern gemfish). However, regardless of why it became or remains depleted, the CHSP currently requires that if a stock is identified as depleted, immediate action is required to cease overfishing and recover the stock to levels that ensure long-term sustainability and productivity of the ecosystem (DAWR 2018). These requirements may be unrealistic if a stock's decline has primarily been driven by long-term environmental shifts (e.g.

climate change). In order to meet these CHSP requirements, the aim of fisheries management, particularly in multi-species fisheries, is to balance catch restrictions for the recovering species with maintaining a viable fishery overall. However, non-recovering species can act as 'choke species' and can force a fishery closure. This policy constraint is a significant concern for fishery managers, particularly for stocks where failure to recover is due to factors other than fishing and management interventions have limited efficacy.

The policy settings regarding overfished species have been considered as part of the review of the CHSP that is currently underway. The review considers further work is required to understand why some species are not recovering and to determine next steps when failure to recover is found to be due to factors other than fishing. A technical review undertaken as part of the broader policy review suggested that where there is sufficient evidence to determine failure to recover has been primarily influenced by environmental factors, it may be useful to categorise these stocks as 'environmentally determined' rather than overfished (DAFF 2024). While the draft Framework can be used to highlight these issues, ultimately the response for such species will be driven by the policy settings at the time. This issue will be revisited once the CHSP review is finalised.

Selecting species for assessment

The CHSP generally refers and is applied to 'key commercial' and 'byproduct' species. These species are typically managed under fishery harvest strategies and subject to targeted monitoring and assessment regimes, including quantitative stock assessments. On the other hand, general bycatch and species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) fall under the Commonwealth Fisheries Bycatch Policy and are managed under bycatch strategies. Monitoring is primarily focused on reporting requirements (e.g. ETP species) and Ecological Risk Assessment (ERA) Framework assessments.

Given these policy settings, further guidance is provided in the final Framework regarding which species the Framework should be applied to. Application of the final Framework will include:

- all quota species
- all non-quota key commercial species
- selected non-quota byproduct species.

Given the different size and scale of fisheries, there is no single approach to the categorisation of species (e.g. key commercial, byproduct, bycatch). This should be determined on a fishery-by-fishery basis. Guidance is provided in the CHSP and will be used to inform the application of the Framework. With regards to non-quota byproduct species, these will be selected on the basis that they are managed under a harvest strategy and/or a TAC/E or other form of catch limit and their relative importance to the overall economic performance of a fishery.

Application in multi-species fisheries

During the trial, species assessment reports were developed individually. However, it became clear that in multi-species fisheries, particularly where technical interactions occur between species, the adaptation measures applied to one species (such as spatial closures or gear restrictions) can have unintended consequences or benefits for others.

While the final Framework retains a single-species approach for initial risk assessments, it now includes specific guidance for multi-species contexts. This guidance supports the consideration of existing adaptation measures and the development and implementation of additional measures at broader scales, such as sub-group, sectoral, or whole-of-fishery levels, where appropriate. It also

encourages the use of reference species from functional groups or species baskets in data-limited situations, enabling more holistic and practical responses. This approach helps ensure that adaptation strategies are ecologically coherent and operationally feasible across species that interact or are jointly managed.

Stakeholder engagement

The draft Framework was explicitly designed to integrate with existing stakeholder engagement and decision-making processes for Commonwealth-managed fisheries, to ensure the right experts critical to informing species assessments were engaged and information on climate risks ended up with the decision makers responsible for taking action.

Stakeholder engagement took the form of the Working Group (formed for the purpose of the trial, and will continue to support the implementation of the final Framework) and already established RAGs and MACs for individual fisheries. These groups comprised a broad spectrum of experts in science, fisheries management, industry, economics and conservation. The involvement of these groups was critical to ensuring species assessment reports were properly considered and included all relevant sources of information. In considering the broader application of the Framework in other jurisdictions, consideration should be given to incorporating the process with existing stakeholder engagement and decision-making processes.

Cross-jurisdictional considerations

During the trial, it was observed that rarely is it the case that Commonwealth commercial fishers are the only users of a stock, they are often shared (e.g. State commercial, recreational, charter, customary). However, it was noted that the draft Framework focussed on adaptation measures for Commonwealth-managed fisheries. When a stock is shared, broader consideration was needed.

Guidance on this issue is provided in the final Framework. When a stock is shared across jurisdictions, it is important to consider the relative contributions and responsibilities of each party in managing climate-related risks. If another jurisdiction has a greater share of the catch or fewer adaptation measures in place, the Commonwealth should not be expected to carry a disproportionate burden in responding to risks.

Management responses should reflect the scale of impact and level of intervention across jurisdictions. Collaborative approaches are encouraged, but fairness and proportionality must guide decisions to ensure that all jurisdictions contribute appropriately to responses to climate-related risks.

4 Discussion

Overall, the trial of the draft Framework demonstrated that it was an effective tool to compile relevant information and support consideration and discussion of species- and fishery-level climate risks, options for responding and formulation of advice for decision-makers. The draft Framework has utility for both high and low risk species. For most species, the outputs of the draft Framework were expert-informed species-level assessments of climate-related risks and evidence-based advice to inform decision-makers. For low risk species or those with effective monitoring and adaptive measures in place to address climate change impacts, the application of the draft Framework served as an audit of the best available information and provided a transparent rationale for the current status. In the limited cases where the draft Framework was applied to

higher risk species, the Framework supported discussions on targeted responses to climate-related risks. However, given the limited timeframe in which to complete the trial, discussion for some species remained unresolved.

From the trial, there were a number of key learnings that have been incorporated into the final Framework:

- Assessing climate impacts – given they are still in the early stages of development, climate and ecosystem indicators should be used as contextual information to better understand climate change risks, not as the basis for assessments.
- Assessing stock status – when assessing stock status, reference points that best reflect a species' and/or fishery's objectives should be selected.
- Determining residual risk scores – additional guidance was needed on how to determine residual risk scores, the expected scale of response needed and timeframes for developing and implementing adaptation measures.
- Timing of assessments – species assessments should be scheduled to make use of the best available information, but not delayed unnecessarily.
- Review process – the review process should be efficient and ensure species assessments are updated when new information becomes available.
- Application in multi-species fisheries – there can be significant cross-over in adaptation measures in multi-species fisheries which should be more explicitly considered.
- Stakeholder engagement – the involvement of stakeholders was a critical component of both the development and trial application of the draft Framework. It is expected that for some species (or fisheries), it may take multiple rounds of consultation to resolve issues and finalise species assessments. When implementing the final Framework, a focus on engagement is needed.
- Cross-jurisdictional considerations – when a stock is shared, broader consideration is needed of the role and responsibilities of other jurisdictions in responding to climate change risks.

While the final Framework aims to incorporate the key learnings from the trial (above), there remain some gaps as well as opportunities for future extension:

- The draft Framework focused on assessing impacts on a species' abundance as a result of climate-driven changes to physical ocean properties and variables. However, a species' response to these changes can also be in the form of changes to their distribution, phenology and physiology. While the final Framework provides the opportunity for these other impacts to be cited and considered when developing advice to decision-makers, a structured approach is missing. A future work program could include the evaluation and selection of the most suitable approach for assessing these additional impacts within the context of Commonwealth fisheries.
- When considering adaptation measures, the draft Framework largely considered those that had already been implemented (Step 2) and whether they were effective in reducing risk (Step 3). However, for species that remain high risk, further guidance is needed with regards to how to evaluate and implement adaptation measures when existing measures are insufficient to respond to the risk. A future work program could include, for those higher risk species and/or fisheries, a targeted and structured discussion of adaptation options (e.g. RAG or MAC sub-group, fishery workshop). The format of the discussion will be determined by the scale of the identified risks. For example, if the risk is limited to a single species, a targeted discussion within the RAG or MAC may be most appropriate. However, if the risk pertains to multiple species within a single sector or fishery, a more comprehensive workshop may be warranted.

- As our understanding of climate change risks continues to evolve, collaboration with other affected jurisdictions will become increasingly critical to ensure the effectiveness of adaptation measures. Opportunities and appropriate pathways in which to pursue this collaboration should be identified as part of a future work program.
- Commonwealth fisheries policy settings should recognise where there have been climate-driven declines in the abundance of some stocks, and where existing or future management intervention is unlikely to be effective in arresting the decline or recovering stocks to pre-determined levels.

The final Framework has been developed specifically to align with legislative and policy requirements and integrate with existing decision-making processes for Commonwealth fisheries. If the final Framework is to be applied in other jurisdictions, the following adaptations should be considered to ensure its relevance and effectiveness:

- Define the scope of species to be assessed, aligning with any relevant legislative or policy requirements and guidance.
- Where it makes sense to do so, structure the assessment process so that it integrates with existing consultation and decision-making processes. In doing so, identify the relevant stakeholders that should be engaged as part of the process (e.g. stakeholder engagement plan), including but not limited to fishery managers, stock assessment scientists, ecologists, climate scientists, and industry representatives.
- Determine what is the context for uncertainty (discussed above under Uncertainty in context).
- Tailor Step 1 to reflect available climate impact and stock status information.
- Tailor Step 3 to reflect any relevant legislative or policy requirements and guidance.

5 Implementation

When planning the implementation of the final Framework, consideration should be given to the scale of species and fisheries involved, their expected risk (a rapid assessment under Step 1 may assist to prioritise species and/or fisheries for assessment), the available resourcing and communication strategy.

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Appendix A

Table A-1 AFMA Climate Risk Framework – climate risk ranking criteria.

CLIMATE RISK	1. Attribution studies or counterfactual simulations	2. Preliminary projections of change in abundance	3. Climate sensitivity assessment	4. Climate and ecosystem indicators
High	Climate change is the primary driver of stock abundance.	>20% change by 2040 with moderate to high confidence, OR >40% change with low confidence.	If projections are not available, where climate sensitivity has been rated high.	Relevant climatic or ecosystem indicators show adverse/positive signals in the near history and in short-medium term predictions
Uncertain	Where no information is available, significant uncertainty exists in available modelling and/or assessments, or both increases and decreases are considered equally possible.			
Medium	Climate change is contributing to changes in stock abundance.	10-20% change by 2040 with medium or high confidence, OR 10-40% change with low confidence.	If projections are not available, where climate sensitivity has been rated medium.	General climatic or ecosystem indicators indicate some changes to system productivity (e.g., recent marine heatwave in the fishery region)
Low	Climate Change is only a minor contributor to changes in stock abundance.	Up to 5% change by 2040 with medium or high confidence, OR 5-10% change with low confidence.	If projections are not available, where climate sensitivity has been rated low.	General climatic or ecosystem indicators indicate negligible changes to system productivity.
Neutral	Climate change does not have an influence on the stock.	Projections predict relative stability in abundance.		General climatic or ecosystem indicators indicate no change in system productivity

Table A-2 AFMA Climate Risk Framework - stock status risk ranking criteria.

STOCK STATUS RISK	1. Robust assessments of F and B	2. Empirical or index-based assessments	3. Data-poor methods or weight of evidence approaches
Depleted	Biomass is estimated to be below the limit reference point (LRP).	Recent index of abundance is estimated to be below the LRP. e.g., $CPUE_{REC}$ <$CPUE_{LIM}$	Available information suggests that the stock is depleted. Assessed as extreme high risk in the most recent ERA.
Below Target	Biomass is estimated to be above the LRP, but less than 75%B_{TARG}. e.g., <36%B_0 relative to a B_{48} target.	Recent index of abundance is estimated to be above the LRP but less than 75% of the TRP. e.g., $CPUE_{REC}$ < .75*$CPUE_{TARG}$.	Available information suggests the stock is not depleted or biomass is uncertain. Assessed as high risk in the recent ERA.
Near Target	Biomass is estimated to be within 25% of B_{TARG}. e.g., Between 36%B_0 and 60%B_0 relative to a B_{48} target.	Recent index of abundance is estimated to be within 25% of the TRP. e.g., $CPUE_{REC}$ is 0.75-1.25*$CPUE_{TARG}$.	Available information suggests the stock is sustainable and not subject to overfishing. Assessed as low risk in the most recent ERA
Above Target	Biomass is estimated to be more than 25% above the TRP. e.g. >60%B_0 relative to a B_{48} target.	Recent index of abundance is estimated to be more than 25% above the TRP. e.g., $CPUE_{REC}$ is >1.25*$CPUE_{TARG}$.	Available information suggests the stock has only been lightly exploited. Assessed as low risk in the most recent ERA
Well above target	Biomass is estimated to be within 25% of virgin biomass. i.e., >75%B_0.	Recent index of abundance is estimated to be more than 50% above the TRP. i.e., $CPUE_{REC}$ is >1.5*$CPUE_{TARG}$	

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