Australian Government

Australian Fisheries Management Authority

Implementing a Multi-Species Harvest Strategy for the Southern and Eastern Scalefish and Shark Fishery (SESSF)

Operationalising the preferred Harvest Strategy

Workshop 1 Report

Daniel Corrie, L. Richard Little, André E. Punt, Beth Fulton, and Sean Pascoe.

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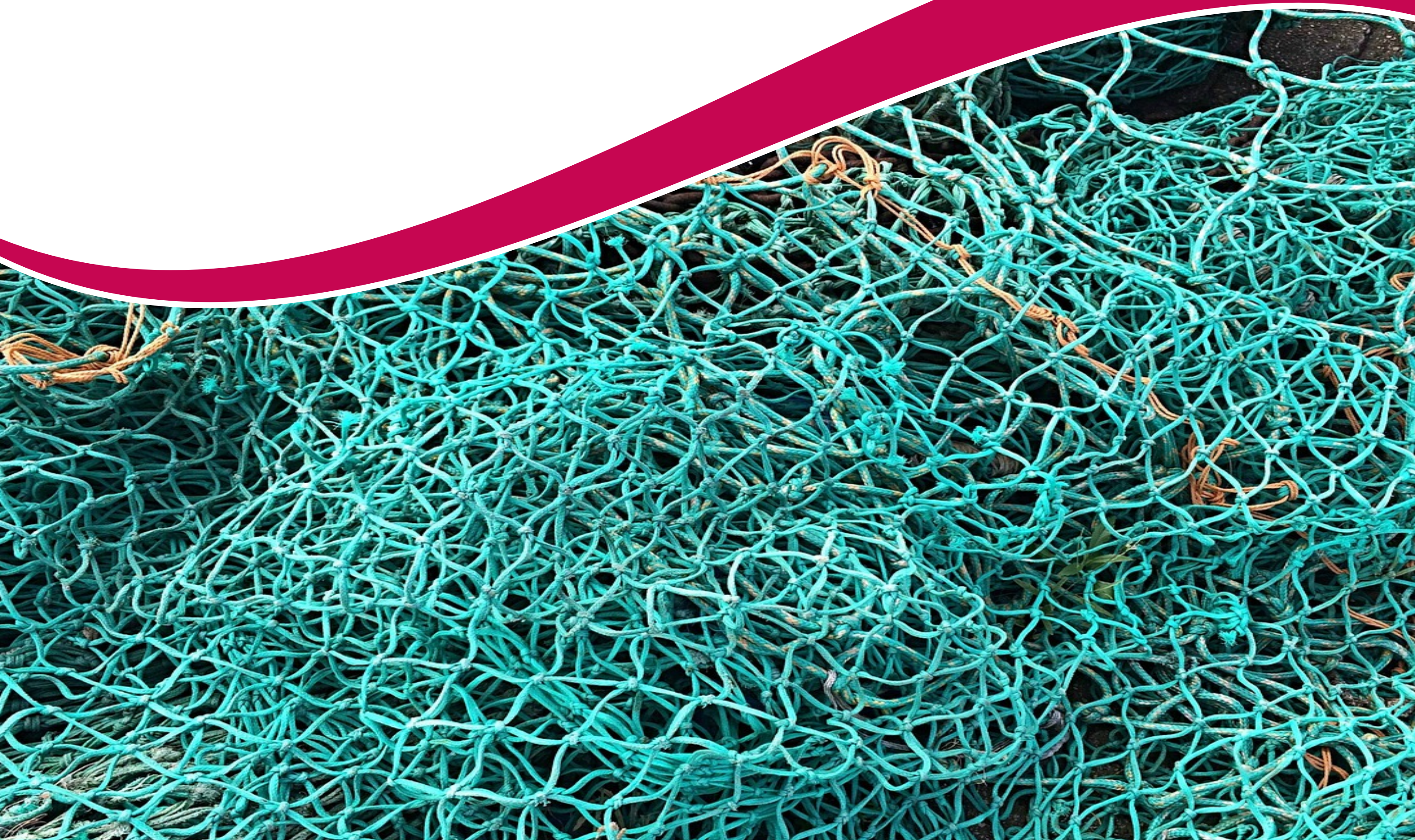

Contents

Version	Date	Updates
1.0	6/10/2023	Discussion paper for MSHS Workshop 1
2.0	8/12/2023	Updated to include Workshop 1 outcomes and future work

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Project overview

Climate-driven shifts in ecosystem function, the failure of some stocks to recover from historical overfishing despite management interventions, competition for marine space and economic pressures pose significant challenges for Commonwealth fisheries. For some sectors, these factors have combined to a point where some operators are no longer viable. Fishing fleets and participation are likely to shrink, leaving smaller fleets that will need to be more efficient.

For the Australian Fisheries Management Authority (AFMA), the cost of doing business, ageing information technology and data management systems, increasing stakeholder expectations, and reporting requirements are making it more complex and more expensive to run a Commonwealth Government regulatory agency, especially one of AFMA's relatively small size.

AFMA must explore avenues for alternative and more efficient ways of doing business by utilising emerging technologies, reviewing policies and harvest strategies, prompting cross-jurisdictional collaboration, and embracing co-management with industry. In isolation, none of these are insurmountable. The challenge, however, is bringing all these solutions together in a cohesive, strategic, and timely manner for each fishery.

This project will focus on the Southern and Eastern Scalefish and Shark Fishery (SESSF), noting many of the proposed solutions are likely applicable in other Commonwealth fisheries. The SESSF is one of the most complex Commonwealth fisheries, with multiple gear types, species and jurisdictional boundaries; there has also been a considerable focus on climate change adaptation (Fulton et al., 2021, 2023) strategic reviews of monitoring and assessment approaches (Knuckey et al., 2017, 2018), application of emerging technologies (Thomson, et al., 2020) and, more recently, structural reform in response to declining stocks and increasing economic pressure.

The current SESSF Harvest Strategy (AFMA, 2009) was implemented in 2009 and is supported by a monitoring, data collection and stock assessment framework (Bergh, et al., 2009) (AFMA, 2021). The harvest strategy has been adapted over time to respond to changes in the fishery, new stock assessment approaches, to reduce the frequency/cost of species-specific stock assessments, and to reflect policy changes (AFMA, 2019, 2022). It is widely recognised that the current harvest strategy, which involves a single-species approach to achieve the objectives of the *Commonwealth Fisheries Harvest Strategy Policy* (HSP) (DAFF, 2018), needs to be updated to reflect the multi-species nature of the fishery, as well as being adaptive to climate-driven changes in the ecosystem.

The Fisheries Research and Development Corporation (FRDC) Project 'Development and evaluation of multi-species harvest strategies in the SESSF' (MSHS) (FRDC 2018-021) commenced in 2019 and aims to develop and evaluate multi-species harvest strategies, including reference points and decision rules, and evaluate monitoring and assessment options identified in the SESSF Monitoring and Assessment Research Project (SMARP) (Knuckey, et al., 2017). This project aims to complement the work being undertaken as part of the MSHS project, with a view to both projects delivering a comprehensive harvest strategy for the SESSF, including revised data, monitoring and assessment plans.

Operationalising and implementing a revised harvest strategy in the SESSF will require a phased approach. Discussion papers will be prepared for each of the topics detailed below with a view to seeking advice from relevant Resource Assessment Groups (RAGs), Management Advisory Committees (MACs) and technical workshops. Each chapter will be updated to include feedback and recommendations as they progress through the various consultative forums.

1. **Fishery overview:** The purpose of this chapter is to understand the size and composition of the fleet, species targeted, the economics of each sector and the capacity to support a revised harvest strategy.
2. **Transitional arrangements:** A transition period will be required to move from the current harvest strategy and operating environment (stock assessments, data collection, monitoring etc.) to a new harvest strategy. Initially, this has involved 'resetting' and rationalising the current stock assessment and data processing schedule to free up and redirect resources towards research or projects that will support longer-term implementation of the revised harvest strategy.
3. **Operationalising the preferred Harvest Strategy:** At the completion of the MSHS project (Est. December 2023) options for a multi-species harvest strategy approach will be identified. This chapter will build on the

recommendations of the MSHS project by identifying which core components can practically be implemented in the short term, and what additional work is required to do so. Future iterations of this chapter will also explore other components considered by the MSHS project team (buffers, metiers, CKMR etc) and by independent projects (e.g., Dynamic B_0, SMARP) for implementation in the longer-term.

4. **Data and monitoring requirements:** Subject to the form and function of the revised harvest strategy, this chapter will focus on the monitoring and data requirements. Consideration will be given to the most efficient mix of monitoring and data collection programs, striking a balance to ensure the needs of the harvest strategy are met whilst maintaining sufficient monitoring and data collection to meet AFMA's broader objectives to minimise impact on non-commercial species and the environment.

Throughout the consultation process, it will be important to understand the risks or shortcomings associated with the transition to a revised harvest strategy. Each chapter will identify and seek to resolve impacts on reporting requirements, resource constraints, policy gaps, or increased risk/uncertainty in management settings.

Discussion papers have been developed for each of the steps identified above to facilitate workshop discussions. This is **Chapter 3 – Operationalising the preferred Harvest Strategy**, and includes outcomes of the first Multi-Species Workshop held on 18 October 2023.

Introduction

The development of a revised harvest strategy better suited to the dynamic and multi-species nature of the Southern and Eastern Scalefish and Shark Fishery (SESSF) is being pursued as part of the project - *Developing and testing a multi-species Harvest Strategy for the SESSF (FRDC 2018-021)* (Little, et al., 2023) (MSHS project).

The MSHS project commenced in June 2019 and is due to be finalised in December 2023. The aim of the MSHS project was to develop and evaluate options for a multi-species harvest strategy. The delivery of a fit-for-purpose (i.e., ready for implementation) harvest strategy was beyond the initial scope of the project. Beyond the life of the project, consideration will need to be given to which of the proposed options can practically be implemented, including whether they meet the requirements of the *Commonwealth Harvest Strategy Policy* (HSP), and what further work is required to specify and operationalise a harvest strategy in the SESSF.

While the final project report is not due until December 2023, the project had progressed to a point where the team could present an overview of the options that have been considered, including the results of simulation testing for some SESSF species. The project team presented their preliminary findings on 18 October 2023, at a workshop attended by stakeholders representing the fishing industry, research organisations, Government agencies responsible for developing policy, fishery regulators (Commonwealth and State), fishery economists and environmental non-Government organisations. The aim of the workshop, intended to be the first in a series of workshops throughout 2023 and 2024, was to seek feedback on the results and recommendations from the MSHS Project, which will provide the basis for deciding which components of the multi-species harvest strategy should be pursued, and what further work is required.

Throughout the process, AFMA will seek to understand the risks or shortcomings associated with the revised harvest strategy approach and explore options to resolve or mitigate them.

Objectives

1. To operationalise a multi-species harvest strategy for the Southern and Eastern Scalefish and Shark Fishery based on recommendations from the project '*Developing and testing a multi-species Harvest Strategy for the SESSF*' (MSHS project).

Actions

In consultation with experts and key stakeholders:

1. identify which components of a multi-species harvest strategy considered by the MSHS project can practically be implemented in SESSF, including which can be implemented in the short term (12-18 months) and which will require additional work, to be incorporated at a later date; and
2. identify impacts on reporting requirements, resource constraints, policy gaps, or increased risk/uncertainty in management settings that may arise and identify options to resolve or mitigate them prior to implementation.

Policy settings

Commonwealth Harvest Strategy Policy

The *Commonwealth Harvest Strategy Policy* (HSP) (DAFF, 2018) establishes the requirements for developing a harvest strategy for Commonwealth-managed fisheries. Objectives for fishery harvest strategies are prescribed by the HSP, along with the need for assessment and evaluation of performance against those objectives. The Guidelines for the Implementation of the Commonwealth Fisheries Harvest Strategy Policy (HSP Guidelines) (DAFF, 2018) provide practical assistance in the development of fishery-specific harvest strategies in Commonwealth-managed fisheries that meet the intent of the HSP.

While the revised SESSF harvest strategy will depart from the current single-species approach and incorporate new ways for managing a multi-species fishery, it must continue to pursue the broader objectives of the HSP – the ecologically sustainable and profitable use of Australia's Commonwealth commercial fisheries resources, where ecological sustainability takes priority. To do this, the harvest strategy must continue to:

- ensure exploitation of fisheries resources and related activities are conducted in a manner consistent with the principles of ecologically sustainable development, including the exercise of the precautionary principle;
- maximise net economic returns to the Australian community from management of Australian fisheries – always in the context of maintaining commercial fish stocks at sustainable levels;
- maintain key commercial fish stocks, on average, at the required target biomass to produce maximum economic yield from the fishery;
- maintain all commercial fish stocks, including byproduct, above a biomass limit where the risk to the stock is regarded as unacceptable (B_{LIM}), at least 90 per cent of the time;
- ensure fishing is conducted in a manner that does not lead to overfishing – where overfishing of a stock is identified, action will be taken immediately to cease overfishing;
- minimise discarding of commercial species as much as possible; and
- be consistent with the *Environment Protection and Biodiversity Conservation Act* 1999 and the Guidelines for the Ecologically Sustainable Management of Fisheries (2nd edition).

The Department of Agriculture, Fisheries and Forestry (DAFF) is currently undertaking a review of the HSP to capture some of the emerging challenges faced by Commonwealth Fisheries, including:

- shocks to both the biological systems (such as marine heatwaves) and to markets (trade disputes, disruptions due to Covid);
- longer term changes to marine ecosystems and species through global warming;
- changing social expectations about resource management;
- increasing competition for resource access and sharing marine spaces;
- increasing demands on fisheries management despite fixed or reducing budgets; and
- decreasing data quality for key inputs to stock assessment and management.

Many of these issues have also been considered as part of the MSHS Project and will be a key focus throughout the workshops. It is critical that AFMA, DAFF and the MSHS project team engage with each other throughout the process to ensure the revised harvest strategy and the HSP are compatible.

Workshop Objectives

Introduction and scene setting

The workshop opened with an introduction to the fishery, including an overview of the transitional harvest strategy arrangements adopted by the SESSF Resource Assessment Group (SESSFRAG) in August 2023 (**Chapter 2 – Transitional Arrangements**). This provided the workshop participants an understanding of the overall state of the fishery, such as the size and dynamics of the fishing fleets, trends in catches and stock status, and the economics of the various sectors. This provided context for future workshops and was intended to serve as a foundation from which to 'build' a fit-for-purpose harvest strategy for the fishery.

Workshop Objectives

The aim of this first workshop was to identify:

1. which approaches considered by the MSHS project can be practically implemented in the SESSF, including timeframes and what additional work is required to do so;
2. any risks or shortcomings of the proposed approaches, including consistency with the requirements of the Commonwealth Harvest Strategy Policy, and identify options to resolve or mitigate them.

Workshop Activities

To achieve this, the workshop included two sessions to discuss the two key challenges associated with managing multi-species fisheries addressed by the project team:

1. Technical interactions

Two approaches have been examined by the MSHS project to address this challenge:

- Pretty Good Multi-Species Yield (PGMSY); and
- Multi-species target reference points (TRPs).

2. Costs

Two approaches have been examined by the MSHS project to address this challenge:

- Indicator Species; and
- Trigger Species.

An overview of each approach was provided by the project team, including results from testing where available. Workshop participants were then given the opportunity to ask questions and provide comments. At the end of each session, workshop participants broke into groups to discuss the issues, including barriers to implementation and how these might be overcome. Speakers were nominated to report back to the workshop on their group's discussion.

The workshop agenda is provided at **Appendix A**. Feedback from each of the sessions is provided under the relevant topics below, followed by key takeaways from the workshop and plans for future work.

Developing and testing a multi-species Harvest Strategy for the SESSF

Overview

The project '*Developing and testing a multi-species Harvest Strategy for the SESSF*' *(FRDC 2018-021)* (MSHS project) was initiated in response to broad recognition that the existing single-species approach employed in the SESSF could not practically achieve fishery-wide maximum economic yield (MEY) due to technical interactions (the catch of a mix of species with specific gear in a specific time and place) and the impacts of climate change. This is expanded on in the project '*Understanding factors influencing undercaught TACs, declining catch rates and failure to recover for many quota species in the SESSF* (Knuckey, et al., 2018) (Declining Indicators project) (FRDC 2016-146).

The objectives of the MSHS project are:

1. to develop and evaluate multi-species harvest strategies, including reference points and decision rules.

2. to evaluate future monitoring and assessment options identified in the SESSF Monitoring and Assessment Research and Declining Indicators projects (Knuckey, et al., 2017) (Knuckey, et al., 2018); and
3. to develop a process and set of design principles for multi-species harvest strategies.

The project has conducted analyses to expand the options for several of the components needed to construct a multi-species harvest strategy, recognizing that the ability of a harvest strategy to satisfy the objectives of fisheries management relates to the data available and how those data are analysed. Some of the new approaches relate to how assessments are conducted, others relate to how the performance of the fishery is defined by the specification of reference points.

This workshop focused on the core component of the multi-species harvest strategy considered by the project team (expanded on below) while subsequent workshops will focus on other components such as the application of buffers, close-kin mark-recapture assessments, dynamic Tier 4 assessments, monitoring and data collection approaches.

The final report includes further detail but is currently in draft. A copy can be provided upon request but has not been attached to this paper.

Pretty good multi-species yield (PGMSY)

Summary

The main challenge of multi-species fisheries management is to ensure that all species are caught sustainably and not just the target species. One of problems is that multispecies technical interactions (i.e., multiple species caught by the same vessels / gear) can lead to “inconsistent” Recommended Biological Catches (RBCs) and/or Total Allowable Catches (TACs), which on one hand can lead to TACs being under caught, but can also lead to severely over caught RBCs to the point that some commercial species, and perhaps even byproduct species, fall below their limit reference points (e.g., B_{20}). PGMSY conducts assessments using the Tier 1 or dynamic Tier 4 methods, but then calculates RBCs by adjusting the fishing mortality of the species according to their technical interactions, but subject to constraints that (a) the key commercial species target is B_{48} or B_{MEY}, and (b) no species is projected to be below B_{20} after a pre-specified number of years. The potential outcome is that fishing mortality and biomass targets for byproduct species can vary given technical interactions and the status of the key commercial species but must remain within the constraints of the harvest strategy policy.

The basic approach involves:

- selecting the metiers[1] (and hence the relative impact of each metier on each species/stock caught by those metiers);
- selecting a set of key (commercial) target species - these are stocks that contribute substantially to the fishery and are the primary target of at least one metier; such species would generally be assessed using an “integrated” catch-at-age stock assessment method such as Stock Synthesis; and
- selecting a set of byproduct species for which RBCs and TACs are needed. The TACs for these species are selected given the fishing pressure by metier from the assessments for the key target species, but RBCs and TACs for these species are constrained such that they are not predicted to be below some pre-specified threshold after (say) 50 years; the species need model-based assessments, but they can be relatively simple (such as the dynamic Tier 4 approach)

The actual calculation process is:

1. conduct assessments of the key target and byproduct species and hence calculate the current fishing mortality in relation to a target biomass;
2. apply the relevant HCRs to the key target species - this will lead to initial prescribed fishing mortalities (F), and thus RBCs;

[1] An explanation of metiers is provided at Appendix B.

3. compute the fishing mortality (F) by metier for each species (key target and byproduct) by multiplying the average recent F (e.g. for the last 5 years) by a multiplier computed from the assessment for the key target species[2]- thus, changes in F for key target species directly impact how F for byproduct species is set; and
4. species are then projected for 50 years using steps 2 and 3 for each year to calculate time-series of species depletions that (after 50 years) basically represent B_{targ} - if the $\underline{B}_{\text{targ}}$ for any species is below the LRP, or a minimum target based on the set of Fs predicted using the assessments for the key target species, fishing mortalities are reduced until there are no species B_{targ} that fall below these limits; this constraint also applies to rebuilding species.

Results and challenges

Results of MSE testing

The proof-of-concept simulations, which are based on four species in the Commonwealth Trawl Sector (CTS), achieved the broad goal that no species is below its limit reference point (Figure 1, top right panel). However, this was achieved at the cost of the stocks being underutilized (Figure 1, bottom left panel). The exact reasons for the underutilization are not known based on the MSE results, but are likely related to a fairly crude implementation of step #4 above, namely that the Fs for all metiers that impact on a species are reduced equally, rather than PGMSY being “strategic” in terms of which metiers are adjusted (e.g., if the Fs for a byproduct species need to be reduced by 50% to achieve the biomass target and one metier reflects 1% of the F for that byproduct species but 80% of the F for a target species, the reduction in F from 1% to 0.5% will reduce the F for the target species by 50%).

[2] For each metier this involves: (a) identifying the key target species for that metier (metier *s*(*m*)), computing the relative change in the F (from that for the last 5? Years) for that metier based on the predicted change in F for its key target species, *rf*(*m*) and computing the change F for each species (key target and byproduct) for that metier by multiplying the average F for the metier by *rf*(*m*).

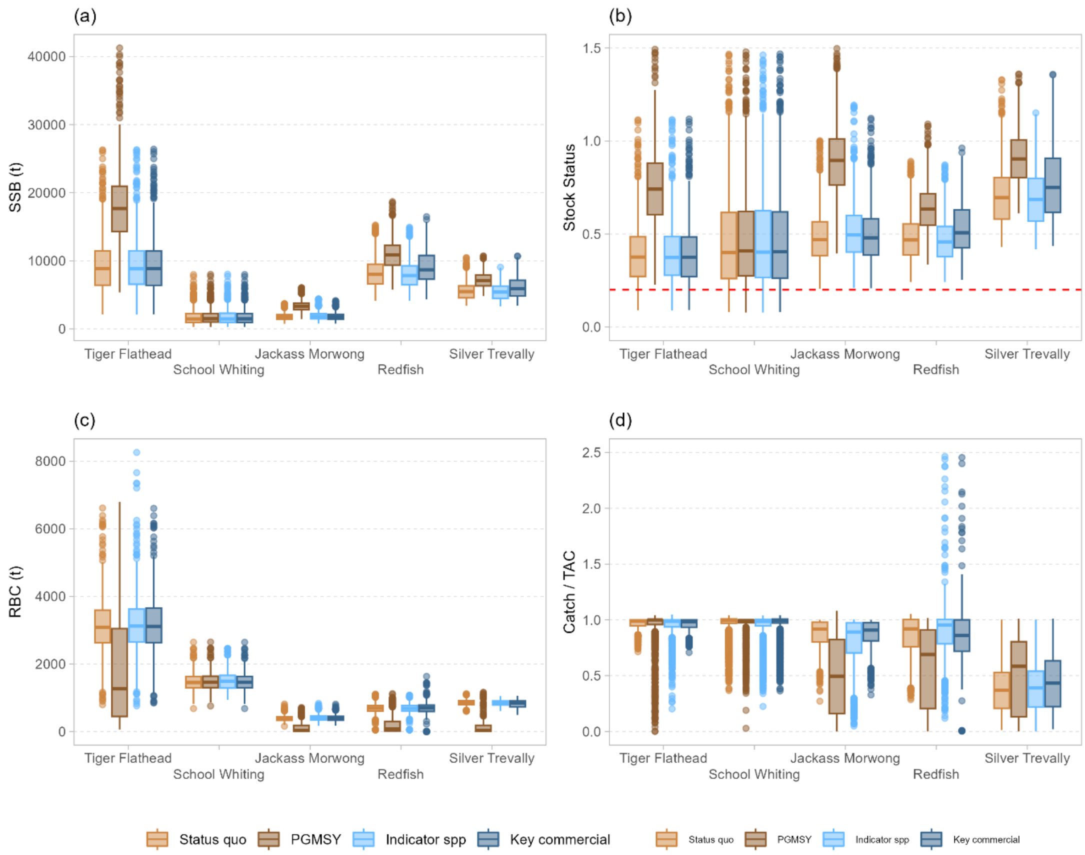

Figure 1 Summary of (a) spawning stock biomass, (b) stock status (spawning stock biomass relative to unfished spawning stock biomass), (c) RBC, and (d) catch relative to TAC for the five species and four harvest strategies for the "medium" data scenario. The box and whisker plots show the medians as the middle lines, the 25th and 75th percentiles as the tops and bottoms of the boxes, the whiskers show the full range of the data and the points are potential outliers in the distribution.

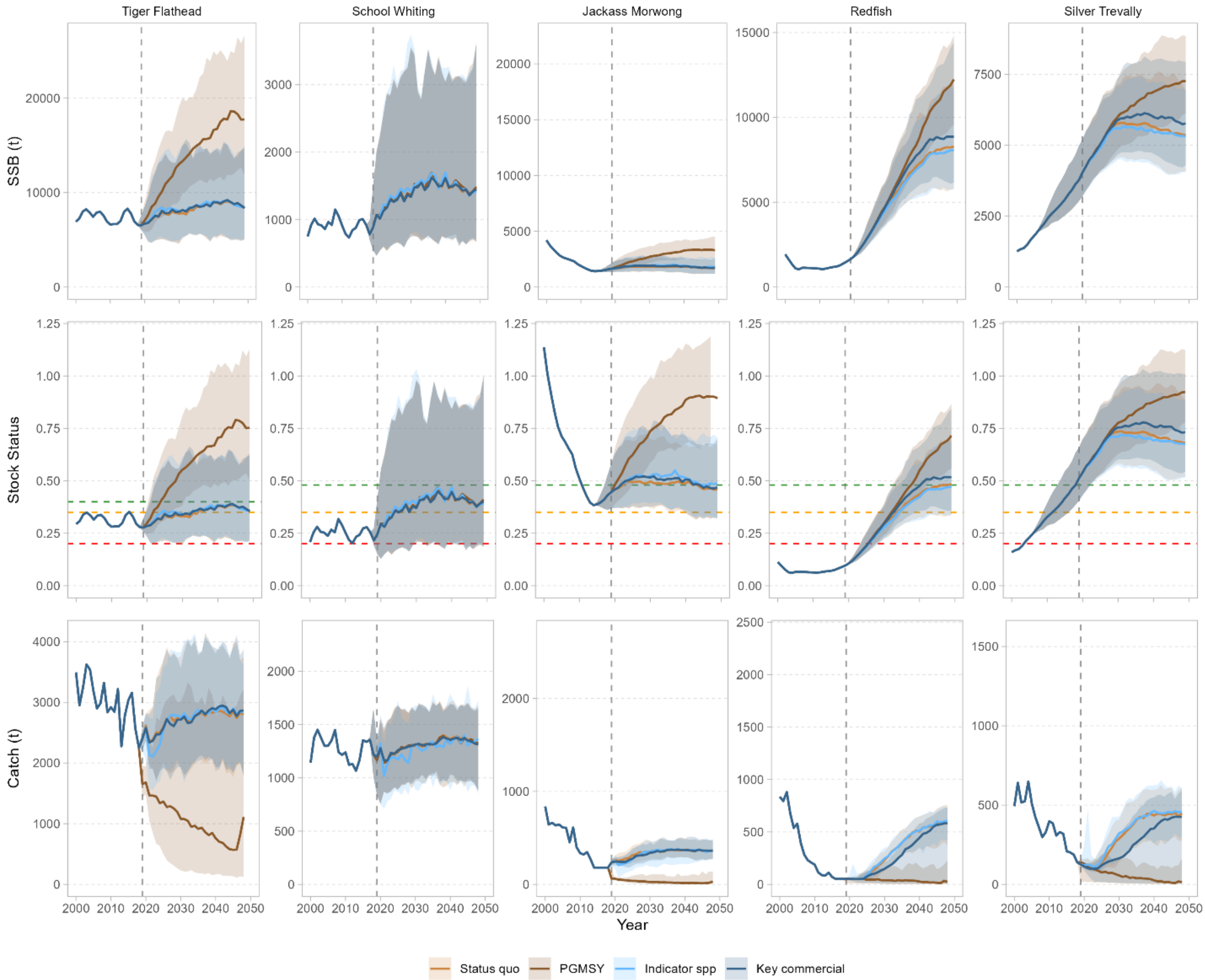

Figure 2 Time series of simulated historical and projections from 2020 under four harvest strategies of (a) spawning stock biomass, (b) stock status (spawning stock biomass relative to unfished spawning stock biomass), (c) catches of the five species for the "medium" data scenario.

Recommendations and insights

Insights

PGMSY was the only option considered that explicitly accounted for technical interactions among species and simultaneously aimed to keep all species above their limit reference points.

What is needed to apply PGMSY?

There are several steps that would be needed before a PGMSY approach be applied in actuality:

- the key target species (and their associated target reference points) would need to be selected;
- the byproduct species included in the PGMSY framework would need to be identified;
- qn approach (e.g., trigger points / indicator species) would need to be selected for the other actively managed species;
- a decision will need to be made regarding the biomass below which stocks are not projected to drop.
- the algorithm to adjust F by metier (step 4 above) will need to be refined to better reflect priorities related to avoiding stock depletion and achieving target biomass levels; and
- the PGMSY approach would need to be integrated with the buffers selected to reflect assessment-related uncertainty (Tier buffers) and the time since the last assessment (time buffers).

Challenges with PGMSY

PGMSY requires that model-based assessments (e.g., Stock Synthesis or dynamic Tier 4) are conducted for the selected key target and byproduct species. This means that data collection (at least for the key target species) needs to remain (minimally) at the current level.

There are several aspects associated with PGMSY that could not be tested using the MSE analyses:

- the simulations assumed that assessments for key target and byproduct species are conducted annually. PGMSY can be run with assessments on different schedules but the code for the method needs to be modified to ensure this is the case. Moreover, the consequences of different assessment frequencies need to be evaluated; and
- the byproduct species were assessed using one version of the dynamic Tier 4 approach, but multiple versions are now available.

Other issues:

- in principle, the assessments of the byproduct species could be “driven” using the results of CKMR-based methods, but this has yet to be done; and
- methods (e.g., the indicator species approach) will need to be selected to handle the provision of management advice for species for which RBCs are not computed using PGMSY (i.e., species for which no reliable assessment is available).

Workshop Feedback

<u>Clarifying points</u>

- While the approach adjusts F in each of the metiers, a single TAC is set across the fishery i.e., management by metiers is not required.
- From a research perspective, once the fundamental ‘tuning’ is done, the added workload in the assessment process is quite minimal, and hence the cost. Most of the work is in the data collection and assessments.

<u>Observations</u>

- Notwithstanding the impacts of climate change, the approach is likely to lead to less overfishing so there will be less management costs associated with having to rebuild depleted stocks.
- Stock assessments will still be required for non-target species to allow estimates of F, so there may be costs associated with additional data collection and stock assessments.
- Most sub-fisheries in the SESSF are not complex – they utilise one gear type and target a small number of species. The approach is really only applicable to the shelf component of the CTS, which is the part of the fishery that can least afford the cost of the required stock assessments.
- The project used catch and effort in the CTS prior to the structural adjustment, which will have implications for the results and application of the PGMSY. It could take five years before the fishery settles and the outputs of the metier analyses can be considered reliable.
- As it is currently drafted, F gets adjusted for all metiers regardless of species, and F for depleted species is derived from the harvest control rule, so reduces catch to zero. As a result, target species F is also significantly reduced. The approach would need to be fine-tuned to allow depleted species catch to be set based on longer rebuilding timeframes or calibrated to account for other measures like closures or voluntary catch arrangements.

<u>Things to consider</u>

- Consider the application of discount factors (including in any future MSE testing) to account for uncertainty in target species stock assessments.
- Run it in parallel (or retrospectively) with the existing harvest strategy to understand the implications on TACs.

Multi-species Maximum Economic Yield

Summary

Maximum Economic Yield (MEY) is a primarily a single-species concept. However, within a single fishery the same fishing gear may catch several species simultaneously. Moreover, vessels may catch different combinations of the same sets of species depending on where they fish spatially, or which gear types are being used. These area/gear/targeting specific activities are termed “métiers” and are associated with different catch compositions for a given level of fishing effort. When such technical interactions occur, deriving estimates of MEY requires taking into account all species in the fishery, and profits are maximised for the fishery as a whole. A result, each species’ biomass at the fishery-level MEY will be different to its individual B_{MEY} level if each was caught independently.

This is illustrated for a hypothetical four-species fishery in Figure 3. The upper panel shows a fishery's revenue earned from four individual species and its total costs for different effort levels. The lower panel depicts total revenue (summed across the four species), total costs and total profit. For each effort level, each species will be associated with a given biomass level (with effort and biomass being inversely related). The level of fishing effort that maximises total sustainable fishery profits is around six units (shown by the dark green vertical line). At this level of effort, each species is associated with a given biomass that achieves fishery-wide MEY (denoted B_{FMEY}). For example, species 1 is fished beyond its MSY such that its $B_{FMEY} < B_{MSY}$ on a ‘single species’ basis, species 2 is close to its B_{MSY} (such that $B_{FMEY\ approx.} = B_{MSY}$), and B_{FMEY} for species 3 and 4 are below B_{MSY} and close to what may be considered their single species B_{MEY}. In this example, profits are also maximised at a level close to maximum sustainable revenue, although this is not always the case.

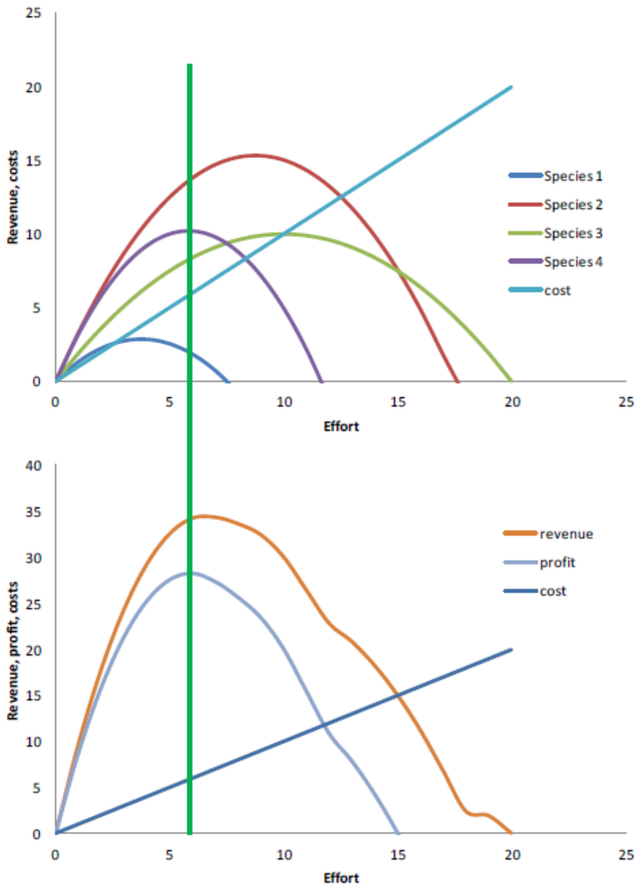

Figure 3 Conceptual multi-species equilibrium bioeconomic model

The model developed for the key Commonwealth trawl species (Pascoe, et al., 2018) differs from the simple surplus production models illustrated above, but the general principles still remain. The model includes five species (plus an aggregated “other”), which are caught across ten fishery métiers differentiated by gear type (four Danish seine and six otter trawl), fishing region and key target species (i.e., whiting, morwong or flathead). The model is age-structured with a stock recruitment function included for each species. The model optimises the level of fishing effort applied across the 10 métiers to determine the long-run equilibrium catch that maximises total fishery profits. From this, the biomass of each species associated with this catch can be determined (Table 1).

The model included two stock-recruitment relationships and two assumptions about how price changes with changing quantity landed. These both impacted the target biomass reference points, with including price changes in the model resulting in a higher target biomass level and lower equilibrium catches.

Table 1 Estimated catch (tonnes), economic profits ($m) and relative spawning stock biomass at fishery level MEY

Stock-recruitment relationship	Price assumption	Flathead	Whiting	Morwong	Redfish	Trevally	Fishery economic profit ($m)
Catches (tonnes)							
Beverton-Holt	Constant	2,548	2,017	861	500	545	12.2
	Variable	2,103	868	285	34	41	7.7
Ricker	Constant	3,266	2,499	1,202	726	759	16.7
	Variable	2,528	2,436	942	40	53	9.1
Relative spawning stock biomass							
Beverton-Holt	Constant	0.469	0.545	0.674	0.738	0.558	
	Variable	0.590	0.819	0.897	0.983	0.972	
Ricker	Constant	0.537	0.649	0.703	0.766	0.582	
	Variable	0.724	0.692	0.814	0.994	0.988	

The results (Table 1) suggest that a “standard” B_{MEY} definition of 0.48 B_0 is likely to be an underestimate for most species, particularly those that contribute only a small proportion of income to the fleet (e.g., Redfish and Trevally). Previous studies (Pascoe, et al., 2020) suggest that optimal outcomes can be achieved in multispecies fisheries through focusing on key target species only. Including price variability (i.e., market response to landings) results in a low sustainable catch and a higher biomass, as the lower catch is offset by higher prices while lower fishing effort results in lower costs. This, however, ignores the additional cost to consumers through paying a higher price for their fish. Maximising the sum of both producer surplus (e.g., fleet profits) and consumer surplus (i.e., benefits to consumers) generally results in a catch and biomass closer to that if we assume no price changes (Pascoe, et al., 2018).

Recommendations and insights

The results of the analysis highlight the importance of considering technical interactions when setting target reference points. Given these interactions, achieving single-species based catch targets in the short term is impractical, potentially resulting in underutilised quota for less valuable species. While not observed in the SESSF modelling, the potential exists for target biomass of some species to be lower than B_{MSY} (i.e., less than the B_{MSY} proxy of 0.4B_0). Conversely, attempting to achieve B_{MSY} or a single-species related B_{MEY} may result in these species acting as a choke on production in the broader fishery, or (more likely) discarding of the species as fishers continue to harvest the other species.

The analysis is limited to only a sub-set of the species in the fishery, with other species being aggregated into a generic “other” category. Expanding the number of species considered in the analysis would be beneficial, requiring appropriate stock dynamic models (and associated parameters). Similarly, expanding the model to include the western part of the fishery would also be beneficial.

The analysis also does not include ecological interactions between the species, which adds a potential further complication. Predator-prey relationships (if they exist) may result in different optimal biomass targets.

Workshop Feedback

Observations

- While there are many fixed costs in the fishery (e.g. levies, insurance, crew wages) the variable costs (e.g. fuel, fish price) are so volatile it is difficult to effectively build economics into the decision making process – the TAC-setting process is likely to become even more uncertain than it is now.
- In almost all cases, estimates of species MEY in a multi-species context are higher than the proxies currently used. Practically, some of these are probably too high, but they should at least be considered when choosing target reference points under a revised multi-species harvest strategy.

Things to consider

- Consider adjusting the current proxies to be more consistent with the estimated target reference points under MSMEY and then use those targets to inform PGMSY.

Indicator species approach

Summary

One of the key challenges in the SESSF is the time, cost and allocation of resources (including data collection) to support stock assessments for so many species. The indicator species approach identifies species that are representative of the productivity, value and vulnerability in a group of species and uses them to track the status of the broader resource, including the ecosystem, and to trigger management actions.

Knuckey, et al., (2017) classified species in the SESSF as either key commercial, secondary commercial, byproduct or bycatch species according to their contribution to total catch and fishery value. The proposed indicator species approach identifies indicator species based on criteria developed by Newman et al (2018), and the Lenfest working group on Benchmarks for Ecosystem Assessment:

- Ecological Vulnerability (biological attributes);
- current depletion (based on assessments or expert advice);
- management and cultural importance (Target, Byproduct, Bycatch, Lightly Fished, Protected); and
- ecological significance (ETP and/or species with key ecological role).

All species that interact with the fishery were classified into one of 4 categories;

- Vulnerable – likely to be heavily impacted by fishing (due to life history characteristics; biomass is typically low, but fishing mortality can be high or low)
- Target – main target species (biomass and fishing mortality is expected to be near target)
- Lightly fished – these are very robust species with high productivity or species the fishery does not interact much with so fishing pressure is relatively light (biomass is high and fishing mortality is low)
- Ecologically significant – these species are particularly important to the structure or functioning of the ecosystem (the intent is for these to be kept above target levels, so fishing pressure is expected to be low)

From each of these categories, one or more indicator species are selected. To keep the number of indicator species manageable a limited number are selected based on a small number of criteria (see Table 2). Specifically, for the SESSF these criteria are:

- inherent vulnerability (biological attributes such as productivity, and for Australian fisheries this information can be taken from ERAs);
- risk to sustainability (i.e. current stock status or ERA risk status); and
- management importance (i.e. species important to commercial, social or cultural value)

Table 2 Indicative scoring table for elements in selecting indicator species. The scores from each table can multiplied to give and overall species score. From (Newman, et al., 2018)

	Score				
Scoring element	1	2	3	4	5
Current impact status	minor or negligible impact	lightly exploited; underfished; likely above Bmsy	fully exploited; not recruitment overfished; broadly about Bmsy	heavily exploited; perhaps recruitment overfished; broadly about ½ Bmsy	very heavily exploited; recruitment overfished; collapsed/ now rare, below ½ Bmsy
Inherent vulnerability	Wide distribution & one stock; short lived (<5y) & early maturity (<1y); consistent productivity/ recruitment; limited availability to fishery	Wide distribution & large stocks; short-moderate lived (5-15y) & maturity (2-4y); relatively consistent production/ recruitment	Endemic to region & single stock in fishery; medium lived (15-25y) & maturity (4-8y); moderately variable production/ recruitment; widespread spawning	Endemic to region & multiple stocks in fishery; medium-long lived (25-40y) & maturity (8-12y); variable production/ recruitment; spawning aggregations	Endemic to fishery; long lived (>40y) & slow maturity (>12y); very low fecundity; spawning aggregations
Management importance					
Commercial value	negligible	some -moderate	medium	high	critically dependent
Subsistence & customary value	negligible	some	moderate	major	primary importance
Non-extractive value (existence, tourism etc)	negligible	small	moderate	high	critically dependent
Conservation status	no concerns	some concerns	at risk, near threatened	Vulnerable, endangered	critically endangered

The potential indicator species are identified by selecting the species per category in each of the SESSF sub-fisheries that is the strongest combination of most vulnerable, greatest risk to sustainability and of greatest management importance (Table 3). By placing the focus on the monitoring the status on these species, the assumption is that the more robust species are doing as well if not better than these species. Reference points are defined for each category of species. All categories have a B_{lim} (default of 20%B_0), but for the target species category B_{targ} is also used, this could be B_{MEY} or B_{PGMEY}. The aim for lightly exploited and ecologically significant species should be to keep $B > B_{\text{targ}}$ (B_{MEY} or B_{PGMEY}).

Table 3 From (Little, et al., 2023). Indicator Species list for the SESSF.

Gear	Spatial Zone	Protected / Vulnerable	Target	Lightly Fished	Ecologically significant	Other fishery targets. AFMA fisheries	Other fishery targets. Non-AFMA fisheries
Trawl	Shelf	Albatross Fur Seals Gemfish	Tiger Flathead Blue Warehou Redfish Jackass Morwong	Ocean Jacket	Long-lived habitats (e.g. cold water corals)	Sardine, redbait, Jack Mackerel, Blue Mackerel (AFMA SPF, NSW, SA, VIC, TAS)	
	Slope	Albatross	Blue Grenadier Pink Ling Silver Warehou	Frostfish	Mesopelagics*, long-lived habitats		
	Deepwater	Gulper Sharks Harrison's Dogfish	Orange Roughy		Mesopelagics		
	GAB	Gulper Sharks Harrison's Dogfish†	Deepwater Flathead Bight Redfish				
Danish seine	Shelf		Tiger Flathead School Whiting		Long-lived habitats and nursery habitats		Tiger Flathead, School Whiting (NSW)
Line	Shelf	Albatross	Gummy Shark				
	Slope	Albatross	Pink Ling Blue-eye Trevalla		Mesopelagics		Blue-eye Trevalla (NSW, Vic)
	Seamounts		Blue-eye Trevalla				
Gillnet	Shelf	Little Penguins Dolphins† White Shark	Gummy Shark† School Shark†				Gulper Shark† School Shark† (NSW, VIC, SA, TAS)
	GAB	Australia Sealion	Gummy Shark† School Shark†				
Invert.	Shelf		Royal Red Prawn	Sth Calamari.†		Sth Calamari.† Scallops	Scallops (VIC, TAS)
	Slope			Arrow Squid.†		Arrow Squid †	Arrow Squid † (NSW, VIC, TAS)
Reference Points		$B \sim B_{unfished}$ $B > B_{lim}$	$B \sim B_{\mathrm{target}} = 0.48B_0$ $B > B_{\mathrm{lim}}$	$B \sim> B_{\mathrm{target}} = 0.48B_0$ $B > B_{\mathrm{lim}}$	$B \sim B_{\mathrm{target}} = 2B_{\mathrm{MSY}}$ $B > B_{\mathrm{lim}}$	$B \sim B_{\mathrm{target}} = 0.48B_0$ $B > B_{\mathrm{lim}}$	$B \sim B_{\mathrm{target}} = 0.3B_0$ $B > B_{\mathrm{lim}}$

† Also 'Ecologically significant'

* These will need to be tracked using data other than catch data – for example bioacoustics, which may be available form boats of opportunity

Setting RBCs with the Indictor species approach

In setting RBCs and TACs, indicator species are directly assessed, and RBCs set as they currently are with the intent of checking whether they meet expected biomass and F levels under the Commonwealth Harvest Strategy Policy and Bycatch Policy. Additional assessments (using banked data from previous data collection) may be triggered if there is evidence for departure from policy requirements (particularly if conditions are poorer than expected). For the non-Indicator species, species status and RBC are dictated by pairing it with an indicator species. The simplest form of this sees non-Indicator species RBCs set based on changes to the RBCs of the representative Indicator species, i.e:

$$RBC_{non-Ind}(y) = RBC_{non-Ind}(y-1) \times \bar{\Delta}_{Ind}(y)$$

where $\bar{\Delta}_{Ind}(y)$ is the average change in RBC over relevant Indicator species during year *y* (or over a specific review period).

The relationship (pairing) between the indicator and non-indicator species are based on correlations in historical CPUE (or catch) time series. Where relationships are volatile through time, periodic updates in the relationship could (should) be undertaken.

Results

A retrospective example for pairing Indicator and non-Indicator species compares the CPUE time series of eastern school whiting (WHS), a non-Indicator species, and eastern morwong (MWO) and tiger flathead (FLT), both Indicator species. The correlation of the eastern trawl CPUE (Figure 4) gives a correlation r^2 of -0.23 for flathead-whiting but a more reasonable 0.42 for morwong-whiting.

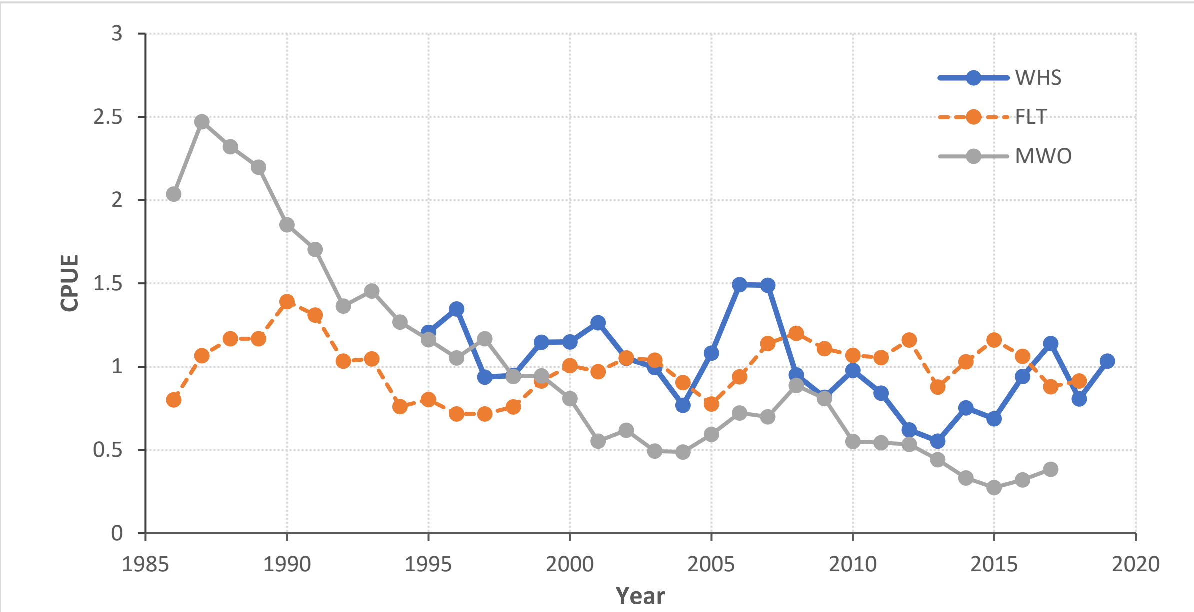

Figure 4 A comparison of the CPUE time series for eastern school whiting (WHS), a non-Indicator species, and eastern morwong (MWO) and tiger flathead (FLT) in eastern shelf trawl sub-fishery.

If MWO is paired with WHS, as a result, changes in the RBC for eastern morwong should be reflected in eastern school whiting. A retrospective comparison of what the eastern school whiting TAC would have been based on the morwong TAC changes, versus the actual TAC used historically for whiting are shown in Figure 5.

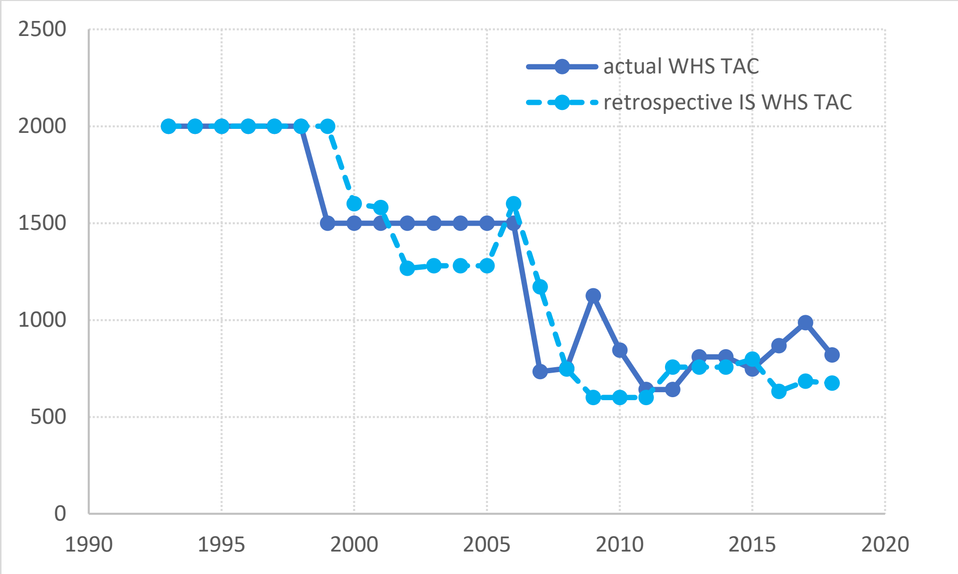

Figure 5 Retrospective comparison of the actual TAC for eastern school whiting and what the TAC would have been if using an indicator species based approach with eastern morwong as the indicator species.

This is at the "upper end" of how well the retrospectives match, more conservative TACs (i.e. retrospectives where TAC is lower than produced by direct assessment) are likely by the nature of using the most vulnerable species as the indicator species.

Results from the Ratpack model and preliminary results from Atlantis indicate the RBCs for the Indicator species approach do not differ substantially from status quo for indicator species, such as tiger flathead, which is not surprising as they are treated in the same manner as in the status quo (assessed regularly). TACs can be quite similar to those from status quo, even though the RBC was updated less frequently where the non-Indicator species have a strong correlation with the indicator species (e.g. school whiting and silver trevally). The RBCs and catches can be quite different to status quo where correlations are not as strong. More complete Atlantis examples of this were provided in the meeting.

Recommendations and insights

Review Period

Periodic checks are required to ensure indicator species conservatively represent the most vulnerable species in their category. The period for review is initially suggested to be 5 years, but could be tied to both trigger events and risk levels. For example, a putative sudden change in productivity could represent such an event. Alternatively, a periodic check could be linked to ERA outcomes (with the frequency of those able to be relaxed as the bycatch species covered by the ERA would themselves be represented through the different categories of the indicator species approach).

Species pairing

A discussion is needed about what "historical" period is a suitable basis for this mapping (i.e. when do we have confidence that a historical period was sustainable and reflective of current productivity). If history is not reflective of current conditions, then checking correlations between species will be required more frequently.

If an indicator species is assessed as having dropped in biomass and comes under a recovery plan then any paired non-indicator species will need to be assessed, and if needed re-paired with another indicator species.

Assessment and monitoring requirements

A small number of species have been listed per category per sub-fishery. This is because no one species covers all criteria and species-pairing correlations. We appreciate that the resulting list of species to assess is not that much smaller than the list already assessed in the fishery. While this reflects the immense complexity of the fishery (and is much smaller than the many hundreds of species considered in the categorisation and the 10s per category originally shortlisted) it will still be challenging to follow if resources are limited. A single species per category could be selected but we would caution that any indicator-non-indicator pairing and TAC changes would need to be very conservative in that case given the additional associated uncertainty.

Data for use with this method may be fishery-dependent or independent. At a minimum, data should be collected on the indicator species as well as non-indicator species so that information is available should a more in-depth analysis be required in the future. A fisheries-independent survey could be undertaken periodically to collect the data for indicator species that are not targeted (noting that analysis of the fisheries independent survey data previously available for the fishery indicate that catch and CPUE from the survey are not well correlated with fishery-dependent catches or catch rates for many species).

While the approach is largely agnostic to the types of assessments used (e.g. quantitative or qualitative) the project team identified a preferred approach to assessments, including a proposal for how RBCs for non-indicator species would be set in the absence of a regular stock assessment. Target species would be assessed using Tier 1 stock assessments using default TRPs (unless species-specific TRP is known), and byproduct species assessed using Tier 4 assessments. Lightly fished, bycatch and Protected species would be assessed using eSAFE, and their risk ratings determined according to relevant default reference points – LRP for bycatch, TRP for lightly fished and Protected. The ecologically significant species would be best managed using some form of a direct biomass estimate (e.g. survey index or quantitative assessment). However, resource constraints on assessment eSAFE may need to be used instead.

Where a species is currently assessed as overfished, such as blue warehou or jackass morwong, they need not be included as an indicator species, however, noting the principles of the PGMSY approach, TACs for the indicator species (e.g. tiger flathead), would need to be constrained to ensure catch of depleted species allow for recovery.

Workshop Feedback

Clarifying points

- Species do not shift between categories. For example, Jackass Morwong and Redfish are still included in the 'target' species category despite being depleted.
- While an ecosystem model has been used to test the application in 'Atlantis', the approach could be implemented using single-species stock assessments.

Observations

- This approach has been implemented with some success on the Australian west coast and in the tropics. However, there have been issues in areas with strong climate-driven shifts in range extending species. It is not clear whether abundance has declined or there has been range shift.
- Under the tested approach, about half of the existing stock assessments are not completed on a regular basis. AFMA is required to demonstrate adherence to the policy objectives, including that stocks are not overfished or subject to overfishing. Less frequent assessments for some species is going to increase uncertainty – there will likely be implications for ABARES Status Reports.
- The number of stock assessments run under this approach is a management choice based on risk/cost/catch. An indicator (and trigger) approach could be tailored to the SESSF to achieve an appropriate balance between the three.
- There would need to be strong correlations between species pairings (what value?), retrospective analyses conducted, and further MSE testing before there was sufficient comfort to implement this approach - a 'light' indicator approach could be tested with only a select few species.

Things to consider

- The current reference points are based on proxies. AFMA should consider adjusting these to be closer to those estimated under MSMEY, and then use those as the basis of a PGMSY approach.

Trigger species approach

Summary

The trigger species approach is similar to the Indicator species approach, in that only a small number of species, in this case representative of economic or management importance to the fishery, are directly assessed and other species follow simpler rules. One of the main differences from the Indicator species approach, where species pairing occur and the RBC of non-Indicator species fluctuate with the Indicator species, there is no pairing in the Trigger species approach. RBCs of trigger species remain constant (with a potential time discount) unless an assessment is triggered. This would likely see key commercial species assessed regularly, with by-product species catches and CPUE monitored but assessments only occurring if breakout conditions are met. Breakout conditions being proposed by the project team for trigger species relate to market conditions, percentage of TAC caught, stock status and CPUE trends. If no breakout rules are met, the TAC is rolled over, subject to a time buffer so that the annual reduction in TAC over time will eventually trigger an assessment and reset.

At its August 2023 Chair's meeting, the Southern and Eastern Scalefish and Shark Fishery Resource Assessment Group (SESSFRAG) adopted an interim approach to managing trigger species, subject to further development under the MSHS project (See Chapter 2 – Transitional Arrangements).

Results

In the Rat-pack model the main target species that are assessed frequently (flathead and school whiting) show similar results to the status quo harvest strategy as these species are assessed at the same frequency. Those under trigger rules also showed little difference to status quo under this harvest strategy in Ratpack. A more complete Atlantis example of this was provided in the meeting, but preliminary results suggest this approach is sensitive to the productivity of the system.

Recommendations and insights

Strong changes in system productivity that have a marked effect on individual species productivity, trophic or technical interactions strongly undermine any harvest strategy where there are delays in assessment and monitoring. The preliminary results from Atlantis (which concurs with previous work by Brown, et al., (2012) and Fulton, et al., (2014) indicates that delays in management actions when there is declining productivity or through a period of low productivity (e.g. due to environmental change) results in a greater probability of stock degradation and breaching of the B_{LIM} reference point. While few stocks completely collapse in the simulations considered in the present study the average stock status is lower under slower assessment cycles (i.e. the roll over between trigger events). This is generally true of all approaches, not just the trigger species approach.

Workshop Feedback

Clarifying points

- 'Trigger' refers to the lower risk species that are grouped together and monitored, but not assessed until a certain threshold of catch, CPUE or time (i.e. trigger) is reached. It does not include key commercial species.
- There is still a requirement to monitor trends in catch, CPUE etc, for trigger species. It is not set and forget, so the species stand on the strength of their own data and monitoring – there is no inferred relationship with other species.

Observations

- There were mixed views on whether this approach increases risk. While there are less assessments scheduled (at least on paper) it also puts checks and balances in place to formalise a process that is effectively already being pursued for some species.
- This approach is expected to save time and resources. However, the longer-term costs depend on the level of monitoring required in the period between assessments, how often the triggers are breached, and what type of assessment is eventually completed.
- Sufficient monitoring and MSE testing would need to be implemented before this approach could satisfy the policy requirements, that all stocks are demonstrably sustainable and not subject to overfishing.

Workshop summary

Overview

The workshop was well attended, and participants engaged in valuable discussions regarding design options for a new multi-species fisheries harvest strategy (MSHS) for the Southern and Eastern Scalefish and Shark Fishery (SESSF). The transition to a MSHS was often referred to as a 'bold step'. However, there was little doubt amongst participants that the current approach is not effectively delivering against AFMA's objectives, and a new approach is required. What that looks like remains the subject of ongoing consideration.

In isolation, none of the approaches were considered to effectively resolve the key issues in the SESSF. However, a combination of the PGMSY, Indicator and Trigger species approaches tailored specifically for the SESSF was considered the most likely option, even if a staged implementation is required to allow further testing. Of the sectors in the SESSF, the shelf area of the CTS was considered the most in need of a multi-species approach due to the complex mix of species caught and increasing challenges associated with climate change.

Understanding how the Multi-Species MEY (MSMEY) approach translates to modified target reference points (TRPs) and catches was considered useful contextual information. However, the volatile nature of some economic drivers in the fishery would require regular reviews of TRPs and lead to increased variability in annual TACs. This is true even for single-species fisheries. Participants generally agreed that strict application of MSMEY is unlikely to translate to improvements over use of the existing MEY proxies. It was noted, however, that all modelled MSMEY targets were higher than the proxies currently applied.

Concerns continue to be raised about whether the proposed multi-species solutions could be coupled with a monitoring and assessment framework that satisfy the policy requirements, including that there is sufficient information to show that all stocks are sustainable and not subject to overfishing. This issue exists even under the current harvest strategy approach and will require ongoing discussions between AFMA and the relevant Government departments. There may be an opportunity to address some of these concerns as part of the policy reviews currently underway.

None of the approaches considered as part of the FRDC project were intended to act as 'silver bullets' or resolve some of the underlying issues in the SESSF, such as assessment uncertainty, lack of data (fishery dependent and independent), competition for marine space, and non-recovering species. However, a revised multi-species harvest strategy will have a direct bearing on many of these issues, so the implications of implementing any of the approaches need to be considered, including assessment frequency, data and monitoring plans, and dealing with risk and uncertainty.

The prevalence of species with declining indicators, and those that have not recovered despite substantial reductions in fishing effort, will continue to be a constraining factor. Regardless of the approach taken under a revised harvest strategy, monitoring stocks that have suffered the impacts of historical overfishing and climate change will arguably be the most difficult hurdle to pass. AFMA must continue taking measures to constrain catches and ensure overfishing is not occurring. The unavoidable consequence is a degradation of fishery-dependent data and reliable stock assessments. For some time now, collection of fishery-independent data has been identified as the only viable alternative. The issue, however, is the cost of collecting such data. While acoustic surveys and close-kin mark-recapture (CKMR) approaches are in place for a handful of species, fishery-independent data collection, including vessel-based surveys, is prohibitively expensive to implement in a cost-recovered environment. AFMA has taken steps to free up some of the fishery budget to allow pursuit of more strategic research, but additional funding must be secured if these measures are to be pursued.

Workshop participants were acutely aware of the financial constraints across the fishery. Of all the sectors, the Commonwealth Trawl Sector (CTS) is the most in need of an improved approach but is also the sector most susceptible to increased costs. Levies in the CTS as a proportion of GVP are currently the lowest they have been for several years, due largely to the increased catch of Blue Grenadier by factory freezer boats in the 'Slope' area of the fishery. The levy allocation model in the SESSF, developed in consultation with industry, weights the allocation of levies to the licence holders that, a) catch the most fish, and b) attract management and research costs. If the factory freezer boat catch of Blue Grenadier were to cease, the balance of the levies would fall back to the licence holders operating in the 'Shelf' area – considered by industry as the part of the fishery that can least afford it. Perhaps now, while GVP is relatively high, is the time to invest in research and programs that will set the fishery up for the long term. AFMA must be cognisant, however, of establishing a framework that increases levies beyond what the fishery is able to sustain in the long term or under more adverse economic or ecological circumstances.

While acknowledging the fishery-specific challenges that exist in the policy and regulation space, the encroaching issue of spatial squeeze, or competition for shared marine space, threatens to remove productive fishing grounds and further undermines representative data collection. Currently, there are two primary uses of the marine space that are likely to exclude commercial fishing; Conservation (Marine Protected Areas governed by Parks Australia) and energy production (fossil fuel extraction and offshore wind development). It is rare, and unlikely in the future, that commercial fishing can coexist in the same space. **Figure 6** illustrates the extent to which access to commercial fishing grounds has been excluded in the SESSF. The imperative for AFMA, then, is to review the existing network of fishery-specific closures, which in themselves contribute to spatial squeeze, and whether they remain fit for purpose and/or necessary to achieve the management objectives they were intended to.

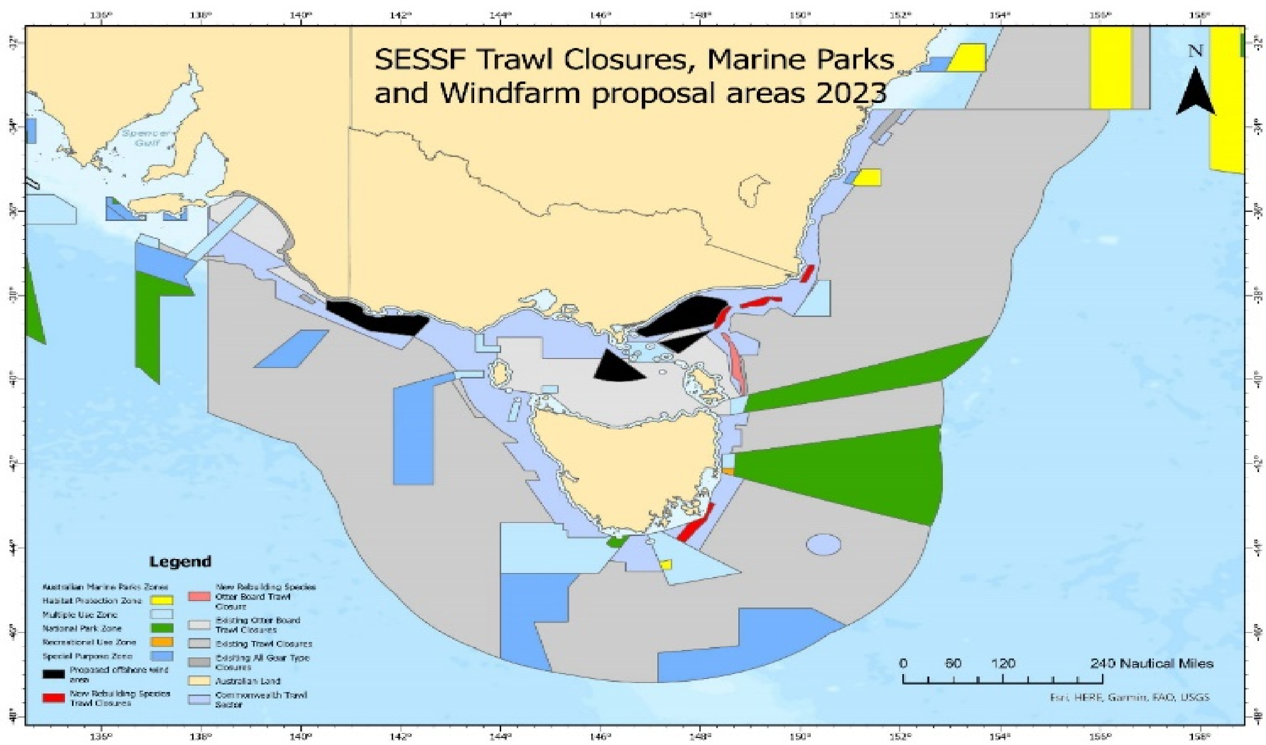

Figure 6 Areas excluding commercial fishing, including proposed zoning for offshore wind farms. Note: the declaration of an area for offshore windfarm development does not equate to an immediate (or even eventual) ban on fishing in that area.

Next Steps

The conclusions and actions in the following section were not explicitly discussed or agreed at the workshop. Rather, they are the view of the primary author based on feedback received from workshop participants and subsequent discussions with the workshop facilitator, Dr Anthony Smith, and the MSHS Project lead, Dr Richard Little.

Long-term

Notwithstanding some of the issues raised, workshop participants were supportive of progressing a harvest strategy that incorporates a combination of the PGMSY, Indicator and Trigger Species approaches developed by the Project team. Until now, these have mostly been discussed in a theoretical sense, with testing only applied to a few species in the SESSF. Further specification and testing is required to understand how these approaches could be applied, and to what extent they would be effective in the SESSF. To support this, once a general approach is agreed, AFMA must resolve which species are to be explicitly managed under the harvest strategy including what the objectives are for each of them (i.e. manage to MEY, MSY or something else?) and identify the monitoring and assessment options to support the harvest strategy.

This could be achieved by undertaking an extension project to further develop the approaches considered by the Project team – effectively 'Phase 2' of the MSHS Project (FRDC 2018-021). The project would involve designing, specifying and testing a number of harvest strategies specifically tailored to the SESSF, using different combinations of the PGMSY, Trigger and Indicator Species approaches, coupled with various data, monitoring and assessment regimes, e.g., data light($), medium($$) and heavy ($$$). These would be MSE tested to identify the most likely candidates, and then run alongside the existing harvest strategy to understand the risk/catch/cost implications and be fine-tuned accordingly.

Action

AFMA, in consultation with the MSHS Project team, will draft a project proposal to be considered by the Commonwealth Research Advisory Committee for 'MSHS Phase 2'.

Short/Medium-term

The transition to a revised harvest strategy is likely to take several years. The additional specification and testing required is a major undertaking and will require additional funding and dedicated resources. The immediate challenge will be to maintain the existing harvest strategy and take account of the multi-species nature of the fishery, whilst ensuring it continues to meet the policy requirements.

AFMA has already taken the steps to incorporate a 'trigger species' approach (See Discussion Paper 2 – Transitional Arrangements), but to what extent can (or should) aspects of the PGMSY or Indicator Species approaches be considered while the longer-term work is underway?

PGMSY

The aim of the PGMSY approach is to set RBCs of key target species according to the SESSF HCR, whilst ensuring that catches of associated species (byproduct and bycatch) are sustainable. The current harvest strategy policy and bycatch policy require the same thing; however, it is how we implement this that currently differs from the PGMSY approach.

The basic PGMSY approach involves:

1. Selecting the metiers (and hence the relative impact of each metier on each species/stock caught by those metiers).
2. Selecting a set of key (commercial) target species. These are stocks that contribute substantially to the fishery and are the primary target of at least one metier. Such species would generally be assessed using an "integrated" catch-at-age stock assessment method such as Stock Synthesis.
3. Selecting a set of byproduct species for which RBCs and TACs are needed. The TACs for these species are selected given the fishing pressure by metier from the assessments for the key target species, but RBCs and TACs for these species are constrained such that they are not predicted to be below some pre-specified threshold after (say) 50 years. The species need model-based assessments, but they can be relatively simple (such as the dynamic Tier 4 approach).

Key target species, which are typically the primary target of at least one metier, and their associated byproduct species can be identified. For example:

- **Flathead** is the key target species for most otter trawl metiers on the Continental shelf, and is associated with catch of Squid, Ocean Jacket, Jackass Morwong, Redfish etc.
- **Gummy Shark** is the key target species of all shark hook and shark gillnet metiers on the Continental shelf and is associated with catches of Elephant Fish, Sawshark and School Shark.
- **Pink Ling** and **Blue-eye Trevalla** are the key target species of all hook metiers on the Continental slope, and are associated with catches of Ribaldo, Ocean Perch, Gemfish, Hapuku and Blue Grenadier.
- **Deepwater flathead** is the key target species for Danish seine and otter trawl metiers on the GABT Continental shelf, and is associated with catches of Bight Redfish, Leatherjackets, Latchet, Squid, Boarfish and Angelsharks.

Under the existing harvest strategy, RBCs for byproduct species are not derived from estimates of fishing pressure (F) in key species metiers, rather, they are based on species-specific (mostly data-poor or empirical) assessments, not model-based assessments. In other words, the byproduct species RBCs are completely independent of RBCs for key target species.

There are some instances, though, where the TACs for key commercial species have been adjusted to constrain catches of associated byproduct or bycatch species due to sustainability concerns, and in this regard can take account of the multi-species nature of the fishery. For example, the 2022 stock assessment for Tiger Flathead resulted in a three-year average RBC of 2,831 t which would have translated to a 2023 TAC of 2,495 t – a 162 t increase to the 2022 TAC of 2,333 t. Jackass Morwong was assessed as overfished in 2021 and total mortality (including discards) needed to be reduced from 110 t (average recent catch) to 50 t to allow rebuilding to the limit reference point within the timeframe required by the HSP. A companion species analysis estimated the Flathead TAC would need to be reduced by 500 t to achieve this, so rather than increase the flathead TAC in 2023, the TAC was constrained to 2022 levels and a series of closures were introduced to further reduce catches of eastern Jackass Morwong. While closures are not the preferred option, they may be an alternative to large reductions in TACs for key commercial species and offer a balanced approach to minimise the overall impact on the fishery.

As an alternative, qualitative, and less formal approach to PGMSY, periodic companion species (metier) analyses could be carried out for key commercial species when technical interactions are suspected to create ‘choke’ species. Doing so would provide an understanding of what the ‘unavoidable’ catch of associated byproduct and bycatch species is under different TACs. Then, these could be compared to the RBCs from the most recent stock assessments for byproduct and bycatch species to ensure total mortality, at least in the short to medium term, does not exceed F_{LIM} or some other agreed value of F that represent low risk. If total mortality for a particular companion species is too high, based on an agreed level of catch that represents low risk to the stock, then AFMA would consider measures to reduce fishing mortality, such as reduced target species TACs, gear modification or spatial management. Conversely, if catch of companion species was sufficiently low, AFMA may consider ‘relaxing’ some of the existing measures, such as unconstrained target species TACs, closure reviews or application of buffers.

See Appendix C for a worked example using theoretical target, byproduct and bycatch species.

Action

AFMA will consult with relevant advisory groups regarding a short-term and qualitative alternative to PGMSY to formally account for technical interactions in the existing harvest strategy. This may include using PGMSY analyses in an informal advisory role to inform RBC setting, rather than a formal component of the harvest strategy.

Indicator Species

The Indicator Species approach requires a relationship (pairing) between the indicator and non-indicator species with strong correlations in historical CPUE (or catch) time series. The comparison of the CPUE time series for eastern trawl provided at the meeting showed a correlation r^2 of -0.23 for flathead-whiting and 0.42 for morwong-whiting. A relationship between two variables is generally considered strong when their r value is larger than 0.7 (i.e. approximately half the variables explain), and workshop participants expressed concerns over using this approach generally without comprehensive MSE testing and, to the extent possible, demonstrating a relationship between two species strong enough to rely on the outputs of one assessment to control the RBC of another.

This approach is unlikely to be adopted in the short term, so what might constitute an alternative? First let’s consider the objectives – to reduce the frequency (i.e. cost) of assessments required for some species by relying on the outputs of others. Further testing will be required before the dependency of one stock on another can be established, however, adjusting the frequency of stock assessments can still be achieved. It does, however, come with an increased level of risk that must be accounted for.

Chapter 2 – Transitional arrangements, outlines an approach recently adopted by AFMA to reduce the costs of undertaking stock assessments for so many species in the SESSF. Using the SMARP preferred scenario (Knuckey, et al., 2017) as a starting point, AFMA has 'recast' the stock assessment and data processing schedule in the SESSF. The revised schedule (See Appendix D) includes transitioning species to either a two- or four-year MYTAC and only undertaking data processing every second year. While this approach reduces the overall costs by approximately $280,000 per year it also introduces uncertainty by extending MYTAC periods and excluding data analyses every other year that would typically be used to monitor non-assessed species.

Action

To account for this increased risk and uncertainty resulting from amendments to the assessment and data analysis schedule, AFMA will explore:

- Automated and produce data reports to supplement (in off years) the various data reports provided by CSIRO; and
- application of 'buffers' (discount factors) to account for uncertainty in Tier 1 stock assessments (data and

While the approaches adopted here go some way to reducing the number of stock assessments required in the SESSF, they should not be considered an 'alternative' to the Indicator Species approach because they do not offer the same level of monitoring or oversight for non-assessed species. This will need to be progressed as a separate piece of work under the 'MSHS Phase 2' project.

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Appendix A

Workshop 1 - Agenda

Date: 18 October 2023

Time: 0900 to 1730

Location: Melbourne. Four Points Sheraton, Docklands.

Facilitator: Dr Tony Smith

<table>
<tr><th>Time</th><th>Item</th><th>Purpose</th><th>Presenter</th></tr>
<tr><td>09:00 - 09:30</td><td>Preliminaries
a. Acknowledgement of Country
b. Introductions
c. Workshop objectives</td><td>For Noting</td><td>Tony Smith
(30 mins)</td></tr>
<tr><td colspan="4">Notes
The aim of this workshop is to develop a better understanding of what the road to implementation for a multi-species harvest strategy in the SESSF looks like. To do this, workshop participants will be asked to provide feedback on:
- which approaches considered by the MSHS project can practically be implemented in the SESSF, including timeframes and what additional work is required to do so; and
- any risks or shortcomings of the proposed approaches, including consistency with the requirements of the Commonwealth Harvest Strategy Policy, and identify options to resolve or mitigate them.
In the months following the workshop, AFMA will update the discussion paper – operationalising the preferred harvest strategy – to include a clearer and more strategic roadmap towards implementing a multi-species harvest strategy in the SESSF based on feedback from workshop participants.</td></tr>
<tr><td>09:30 - 10:15</td><td>Scene Setting
a. <u>SESSF Overview</u>
Fleet dynamics, sustainability, economics
b. <u>Transitional harvest strategy arrangements</u>
Interim assessment scheduling, species classification, monitoring and reporting</td><td>For Information</td><td>Dan Corrie
(45 mins)</td></tr>
<tr><td colspan="4">Notes
The purpose of this agenda item is to provide workshop participants with an overview of the fishery, including recent trends in catch and effort in each of the sectors. This should provide participants the context with which to consider the overall objective of this workshop and the question being asked – what does a multi-species harvest strategy look like for the SESSF?</td></tr>
<tr><td>10:15 - 10:45</td><td>MSHS Project Overview</td><td>For information</td><td>Rich Little
(30 mins)</td></tr>
<tr><td colspan="4">Notes
The purpose of this agenda item is to provide an overview of the MSHS project, including what has been considered beyond the ‘core’ approaches being discussed today. This should provide participants with an understanding of what is ‘in’ and ‘out’ of scope for the discussions today, and what will be discussed at future workshops.</td></tr>
</table>

10:45 - 11:00	*Morning Tea (15 mins)*		
11:00 - 13:30	**<u>Session 1</u> - Multi-species MEY & Pretty Good Multi-Species Yield** a. Overview, results & discussion (45 mins) b. Individual group discussions (45 mins) c. Group report back to workshop (1 hr)	For Discussion	Andre Punt & Sean Pascoe (2.5 hrs)
13:30 - 14:00	*Lunch (30 mins)*		
14:00 - 16:30	**<u>Session 2</u> - Indicator & Trigger Species** a. Overview, results & discussion (45 mins) b. Individual group discussions (45 mins) c. Group report back to workshop (1 hr)	For Discussion	Beth Fulton (2.5 hrs)
During Session 1 and 2, participants will consider the options being explored by the MSHS project team to address the multi-species dynamics of the SESSF. These sessions are your opportunity, in your groups, to discuss each of these approaches and whether they can (individually or together) practically be implemented in the fishery. We have provided some questions at Attachment B1 and B2 to prompt your thinking, but please don't feel constrained by these questions and feel free to expand on your ideas. **Please pick a scribe and nominate someone to report back to the workshop on key discussion points from your group.**			
16:30 - 16:45	Afternoon Tea (15 mins)		
16:45 - 17:30	**Conclusions and next steps.**	For Discussion	Tony Smith (45 mins)
At the end of the workshop, the facilitator will provide some final thoughts and observations about what was discussed throughout the workshop, including what the likely next steps are for AFMA. In the months following the workshop, a workshop report will be drafted and provided to workshop participants along with an updated discussion paper – operationalising the preferred harvest strategy.			
17:30	**Workshop Close**		

Table 4 Participants (as of 13/10/23) and proposed list of groups for breakaway sessions.

Group 1 (in-person)	Group 3 (online)
Alice McDonald (AFMA)	Dan Corrie (AFMA)
Wez Norris (AFMA)	Ryan Murphy (AFMA)
Mark Grubert (AFMA)	Sally Weekes (AFMA)
Cathy Dichmont (SESSFRAG Chair)	Michelle Henricksen (AFMA)
Robin Thomson (CSIRO)	James Woodhams (ABARES)
Beth Fulton (CSIRO)	George Day (DAFF)
Adam Briggs (DCCEEW)	Ian Knuckey (Fishwell)
Sarah Jennings (Economist)	Sean Pascoe (CSIRO)
Toby Piddocke (FRDC)	Sandy Morison (SharkRAG Chair)
Simon Boag (SETFIA)	Keith Sainsbury (Project team)
Dave Galeano (ABARES)	Nathan Bicknell (FRDC)
Group 2 (in person)	Andre Punt (CSIRO)
Tony Smith (Workshop Facilitator)	Neil Garbutt (DCCEEW)
Anna Willock (AFMA)	Bill Tweit (DFW)
Lara Ainley (AFMA)	
Rich Little (CSIRO)	
Geoff Tuck (CSIRO)	
Pia Bessel-Browne (CSIRO)	
David Smith (Commissioner)	
Neil MacDonald (GABIA)	
Anissa Lawrence (ENGO)	
Brett McCallum (Commissioner)	

Appendix B – Metiers

Multi-species or mixed-species fisheries catch a range of species. In most cases it is not possible to separately target individual species in multi-species or mixed-species fisheries, resulting in bycatch. Species that are caught together in this manner are said to be affected by “technical interactions”.

A key component in the development of a multi-species harvest strategy is the identification of metiers. A metier is a group of fishing operations targeting a specific assemblage of species, using a specific gear, during a precise period of the year and/or within the specific area (after EU, 2008). Metiers capture the range of technical interactions in a fishery.

Multivariate classification methods are typically used to identify fishing activity with similar landings compositions and hence potential metiers (e.g., Marchal, 2008; Deporte, et al., 2012; Ziegler, 2012; Ono, et al., 2017). A similar approach is undertaken here, but using the species composition of the landed value rather than the landed weight since targeting is most likely to be driven by the value of landings than their weight. A fleet was then defined as a group of vessels showing similar fishing practices, in other words showing similar effort allocations among metiers, with statistical clustering methods used to identify groups of vessels showing similar fishing practices.

Defining metiers involved two main steps:

1. Clustering of fishing hauls based on landings profiles (in value) using multivariate statistical methods,
2. A post-hoc refinement of the clusters identified by the clustering algorithm to
   a) group clusters that do not show substantial differences in terms of value profile, and
   b) make sure that clusters reflect an intended targeting based on expertise from members of the fishing industry.

The statistical clustering analysis (step 1) follows the first three steps of the workflow developed by Deporte et al. (2012) and integrated in the R package vmstools. Separate clustering analyses were run for each of the groups specified in Table 1, which reduced the size of the data set to cluster and resulted in more relevant clusters. The East-West boundary was the 147-degree meridian (also used in the management of certain stocks).

The refinement phase (step 2) consisted of: (a) grouping clusters that had similar value profiles, and then (b) assigning clusters whose landed value was dominated by species that were not identified as targeted species by members of the fishing industry to a “mixed” metier (as they are likely to be the result of chance than intended targeting).

Table 5 Gear classification and groups used for clustering.

Sector	Gear	Logbook abbreviation	Group for clustering	Number of events 2012-2017
CTS	Otter trawl	TDO, TW	Trawl-east	59,383
			Trawl-west	21,044
	Danish Seine	DS	Danish seine	54,984
GHTS	Automatic longline	AL	Hooks	17,042
	Bottom trawl	BL		
	Dropline	DL		

Application in the SESSF

The species composition of landed catch was derived from fishery logbook data for calendar years 2012 to 2017, with this period selected to have a recent description of the fishery. Annual fish prices were retrieved from the Australian Fisheries and Aquaculture Statistics Report (Mobsby, 2018).

Tables 2, 3 and 4 describe the species composition of the clusters identified by clustering of fishing hauls based on landings profiles (in value) and provides the number of hauls in each cluster. They also specify how each cluster has then been attributed to a metier based on the refinement approach. The initial clustering led to 15, 6 and 6 clusters for trawl-east, trawl-west, and Danish seine respectively. After refinement, those clusters were merged into respectively 10, 6 and 3 metiers. Hauls were attributed to the mixed shelf metier when vessels were operating at depths shallower than 250m and to the mixed slope metier when they were operating at depths greater than 250m when mixed clusters were found across a wide range of depths (e.g., cluster 3 for trawl-west).

Table 6 Metier description for eastern zones (10,20,30) in the CTS of the SESSF. "Cluster step 1" is the cluster number following the initial clustering step, "Cluster step 2.1" is the cluster name following the step of combining clusters with similar value profiles, and "Cluster 2.2" is the final cluster (the metier) after the expert judgement step.

Cluster step 1	Main spp	Secondary spp	Depth zone	Zone	Season	% hauls	Cluster step 2.1	Cluster step 2.2
13	Flathead (87%)		Shelf	10;20;30	All year	23	Flathead	Flathead
1	Flathead (61%)	John dory, squid, latchet, jackets, others	Shelf	10;20;30	All year	24	Flathead	Flathead
2	RRP (87%)	Mirror dory, others	Shelf	Ulladulla	All year	3	RRP	RRP
3		Flathead John dory, squid, others	Shelf	10;20;30	All year	12	Mixed shelf	Mixed shelf
4	Ocean jackets (43%)	Flathead, John dory	Shelf	10;20	Except winter	5	Ocean jackets	Ocean jackets
5	Morwong (53%)	Flathead, jackets, squid, others	Shelf	20	Summer	2	Morwong	Morwong
7	Silver trevally (62%)	Flathead, jackets, others	Shelf	10	Dec-Jan; April-June	3	Silver trevally - flathead	Mixed shelf
11	School whiting (57%)	Flathead, others	Shelf	10	April-May	2	School whiting	Mixed shelf
12		Others (65%), flathead, squid	Shelf-slope	10;20;30	All year	3	Mixed (shelf-slope)	Mixed (shelf-slope)
9	Squids (60%)	Flathead	Shelf-slope	10;20;30	Summer-Autumn	5	Squid	Squid
10	Ling (69%)	Ocean perch – offshore, blue grenadier, mirror dory	Slope	20	Not in summer	7	Ling	Ling
6	Ocean perch - offshore (59%)	Ling, mirror dory, gemfish, others	Slope	10	July-Oct	3	Ocean perch -ling	Mixed slope
8		Blue grenadier, mirror dory, gemfish, others	Slope	10;20;30	All year	6	Mixed slope	Mixed slope
14	Frostfish (60%)	Mirror dory, ling	Slope	10;20;30	Winter	2	Frostfish	Frostfish
15	Orange roughy (90%)	Oreos	Deep	St Helens	Not in summer	1	Orange roughy	Orange roughy

Table 7 Metier description for western zones (40, 50) in the CTS of the SESSF. "Cluster step 1" is the cluster number following the initial clustering step, "Cluster step 2.1" is the cluster name following the step of combining clusters with similar value profiles, and "Cluster 2.2" is the final cluster (the metier) after the expert judgement step.

Cluster step 1	Main spp	Secondary spp	Depth zone	Zone	Season	% hauls	Cluster step 2.1	Cluster step 2.2
4		deepwater flathead, squids, silver warehou, latchet, other species	Shelf-slope	50	Winter - Spring	25	Mixed (shelf-slope)	Mixed (shelf-slope)
3	Squids (58%)	silver warehou, mirror dory, pink ling, blue grenadier	Shelf-slope	50	Summer-Autumn	13	Squids	Squids
2	Pink ling (75%)	blue grenadier, king dory, silver warehou	Slope	40	Spring	13	Pink ling	Pink ling
5	Blue grenadier (79%)	Pink ling	Slope	40-50	Winter	14	Blue grenadier	Blue grenadier
1		blue grenadier, pink ling	Slope	40-50	Summer-Autumn	25	Mixed slope	Mixed slope
6		deepwater sharks, oreos, ribaldo, orange roughy	Deep	40-50	Summer-Autumn	10	Deepwater basket	Deepwater basket

Table 8 Metier description for the Danish seine CTS of the SESSF. "Cluster step 1" is the cluster number following the initial clustering step, "Cluster step 2.1" is the cluster name following the step of combining clusters with similar value profiles, and "Cluster 2.2" is the final cluster (the metier) after the expert judgement step.

Cluster step 1	Main spp	Secondary spp	Depth zone	Zone	Season	% hauls	Cluster step 2.1	Cluster step 2.2
1	Flathead (48%)	gummy shark, other species	Shelf	20	Drop in summer	13	Flathead	Flathead
2	Flathead (85%)		Shelf	20	Drop in summer	22	Flathead	Flathead
3	Flathead (98%)		Shelf	20	Spring-Summer	42	Flathead	Flathead
4	School whiting (91%)		Shelf	20	Drop in summer	12	School whiting	School whiting
5	School whiting (58%)	Flathead, other species	Shelf	20	Drop in summer	9	School whiting	School whiting
6		Other species (72%), school whiting, flathead	Shelf	20	Winter-Spring	2	Mixed	Mixed

Appendix C – Example of adjustments to key commercial species TACs to account for technical interactions.

Species	2023 RBC (t) (from most recent assessment)	Recent total mortality (3-yr average)	Recent landed catch (3-yr average)	RBC @ F_{TARG}	Total mortality above or below F_{TAR}	RBC @ F_{25}	Total mortality above or below F_{LIM}	Catch reduction required?
Target Sp.	2,674	2,132	1,980	2,665	Below	3,268	Below	No
Byproduct Sp. 1	421	197	186	208	Below	536	Below	No
Byproduct Sp. 2	1,100	1,356	1,165	1,157	Above	1,900	Below	No
Byproduct Sp. 3	138	105	83	109	Below	230	Below	No
Bycatch Sp. 1	50	157	121	130	Above	70	Above	Yes
Bycatch Sp. 2	60	68	66	64	Above	90	Below	No

Appendix D – Revised assessment plan for the SESSF

RAG	Area	Species	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
GABRAG		Bight redfish				1				1				1			
		Deepwater flathead	1					1				1				1	
		Orange roughy - Albany & Esperance			3				3				3				
SERAG	Shelf	Flathead				1				1				1			
		School whiting		1		1		Update		1		Update		1		Update	
		Mirror dory	4	4		4		4		4		4		4		4	
		Ocean perch	Trigger														
		Jackass morwong	Annual bycatch TAC - Metier Analyses as required - Assessment as required (if possible)														
		Blue warehou															
		John dory															
		Redfish															
		Silver trevally	4														
	Slope	Blue grenadier			1			1				1				1	
		Pink ling		1				1				1				1	
		Silver warehou		1		Update		1				1				1	
		Blue eye trevalla (Slope)	4	4		4		4		4		4		4		4	
		Royal red prawn	4					4				4				4	
		Blue-eye trwevalla (seamount)	Trigger														
		Alfonsino															
		Ribaldo															
		Gemfish - west															
		Gemfish - east	Annual bycatch TAC - Metier Analyses as required - Assessment as required (if possible)														
	Deep	Orange roughy - east			1		Update				1				1		
		Orange roughy - Cascade Plateau	WOE		3						3				3		
		Oreo basket		4				4				4				4	
		Deepwater shark east	4	TBC													
		Deepwater shark west	4														
		Oreo smooth - cascade			3	Trigger											
		Oreo smooth - other															
		Orange roughy - South	Annual bycatch TAC - Metier Analyses as required - Assessment as required (if possible)														
		Orange roughy - west															
SharkRAG		Gummy shark	1			1				1				1			
		School shark		1			1				1				1		
		Saw shark	Trigger														
		Elephant fish															
RAG	Area	Species	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Data Analyses		Data Processing	1	1		1		1		1		1		1		1	
		CPUE Standardisations	1	1		1		1		1		1		1		1	
		Discard Estimation	1	1				1				1				1	
		Data Summary	1	1		1		1		1		1		1		1	
		Catch Summary	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		Ageing	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Monitoring		ISMP	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		Crew-data	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		VMS	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		EM	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		Logbooks/CDR	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		Ad-hoc research	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1