Harvest Strategy Framework for the Marine Scalefish Fishery

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Disclaimer

All Enquiries

Department of Primary Industries and Regions
Sam Stone – Community Fisheries Manager
Level 14, 25 Grenfell Street
GPO Box 1671, Adelaide SA 5001
T 08 8429 2101 M 0439 728 643
E sam.stone@sa.gov.au

Contents

List of abbreviations and acronyms

Act	*Fisheries Management Act 2007*
B_{20}	20% of unfished biomass
B_{40}	40% of unfished biomass
B_{50}	50% of unfished biomass
B_{LIM}	Biomass limit reference point
B_{TARG}	Biomass target reference point
B_{TRIG}	Biomass trigger reference point
CPUE	Catch Per Unit Effort
DEPM	Daily Egg Production Method
HSF	Harvest Strategy Framework
F	Fishing mortality
F_{CUR}	Estimated current fishing mortality
F_{LIM}	Fishing mortality associated with B_{LIM}
F_{TARG}	Fishing mortality associated with B_{TARG}
F_{20}	Fishing mortality associated with B_{20}
F_{40}	Fishing mortality associated with B_{40}
F_{50}	Fishing mortality associated with B_{50}
ITQ	Individual Transferable Quota
M	Natural mortality
MSF	Marine Scalefish Fishery
MSFMAC	Marine Scalefish Fishery Management Advisory Committee
MSE	Management Strategy Evaluation
MSY	Maximum Sustainable Yield
PIRSA	Department of Primary Industries and Regions
RBC	Recommended Biological Catch
TAC	Total Allowable Catch
TACC	Total Allowable Commercial Catch
TMF	Tiered Management Framework

Executive Summary

Overview

This paper describes the Harvest Strategy Framework (HSF) for South Australia's Marine Scalefish Fishery (MSF). The South Australian Fisheries Harvest Strategy Policy provides an overarching framework for the development of consistent harvest strategies for South Australian fisheries. A harvest strategy is defined as "a framework that specifies pre-determined actions in a fishery for defined species (at the stock or management unit level) necessary to achieve the agreed ecological, economic and social management objectives".

South Australia's MSF is a complex, multi-species, multi-gear and multi-sector fishery that has recently undergone significant change through a reform of its commercial fishery which included the implementation of quota based management supported by a new Tiered Management Framework (TMF). Recreational and charter boat fisheries have specified state-wide allocations for several species, which in some instances constitute a large component of the fishery. For all species, the Aboriginal traditional sector has a nominal 1% allocation[1].

The aim of the framework is for robust, transparent, and defensible mechanisms to maintain species within the MSF at sustainable levels and the fishery is managed consistent with the *Fisheries Management Act 2007* and the South Australian Harvest Strategy Policy. The HSF is to sit within the replacement Management Plan for the South Australian Commercial Marine Scalefish Fishery ("the Management Plan") and is to be accompanied by a proposed Implementation Plan which will set out specific target, limit and trigger reference points for specific stocks.

The HSF will be applied by the Department of Primary Industries and Regions (PIRSA), and the Marine Scalefish Fishery Management Advisory Committee (MSFMAC) [2] in developing recommendations for catch limits and other relevant management arrangements. Stakeholder input into the application of the HSF will be funneled through the MSFMAC.

The Marine Scalefish Fishery Harvest Strategy Framework

The objectives of the HSF are to ensure that target species are biologically sustainable; to support economic and social benefits to the community; and to contribute to cost-effective management. The HSF describes the performance indicators for measuring the status of stocks, and the use of these indicators and their associated reference points and decision rules. The reference points are set to achieve preferred stock status (called the target reference point) and to avoid undesirable outcomes (the limit reference point).

The species covered by this framework are the Tier 1, Tier 2 and Tier 3 species of the TMF. Catches from the commercial sectors, as well as the recreational, charter boat and Aboriginal traditional sectors are included as all forms of fishing mortality need to be accounted for, where data are available.

A multi-category approach to deal with different levels of information and uncertainty in assessments of stocks is adopted. The different categories reflect increasing uncertainty with stock status and ways to reduce the risks associated with this uncertainty.

The HSF reference points are:

[1] Where the estimate of the recreational share for a particular species is less than 1%, the Aboriginal traditional allocation has been set at half of the recreational share.
[2] Or any such replacement advisory body for the shared-access marine scalefish fishery

- Biomass limit reference point (B_{LIM}) is 20% of the unfished biomass, or proxy, denoted as B_{20}. The appropriate fishing mortality reference point is F_{LIM}.
- Biomass target reference point (B_{TARG}) is 50% of the unfished biomass, or proxy, denoted as B_{50}. The appropriate fishing mortality reference point is F_{50}.
- Trigger Reference point (B_{TRIG}) is 40% of the unfished biomass, or its proxy (B_{40}).

Tier 1 species (i.e. Snapper, King George Whiting, Southern Garfish and Southern Calamari) are to be maintained, on average, at the biomass target, B_{TARG}. Tier 2 and Tier 3 species are to be maintained as close to the biomass target reference point (or proxy) as practicable. All Tier 1, Tier 2 and Tier 3 species are to be maintained above their biomass limit reference point (B_{LIM}) at least 90 per cent of the time and the biomass of stocks is increasing away from the limit reference point. For many species in the MSF, it is not possible to estimate biomass and/or fishing mortality. For these species, empirical indicators are used together with proxies for the reference points.

Harvest strategy categories and decision rules

The HSF comprises six categories. Category 1 can be described as data-rich, Categories 2-4 data-moderate, and Categories 5 and 6 data-poor. Stocks are allocated to a particular category based on data availability, and the quality and type of assessment that is applicable to the stock. The performance indicators for each stock may need to consider commercial only data if data on recreational catch and effort are not available. However, catches from at least the recreational sector should be included in the harvest strategy where possible and decision rules should consider each sector.

There are broadly two types of decision rules:

- Tier 1 species – A recommended biological catch (RBC) is estimated. The RBC is the total catch that can be taken from the stock, as determined by the harvest strategy, and is allocated to each sector (commercial, recreational, charter boat and Aboriginal traditional) based on the regional distribution of state-wide allocations.
- Tier 2 and Tier 3 species – If the assessment of a fish stock indicates the biomass (or proxy) is declining and/or current fishing mortality is estimated to be greater than the fishing mortality to give F_{50}, the decision rule would be triggered. If the decision rule is triggered, additional analyses and a follow up meeting/workshop are required from which the management action is determined, and monitoring and research needs identified.

A “hockey stick decision rule” applies to Category 1 and Category 2 stocks whereby the fishing mortality is reduced proportionate to the size of the biomass, below the biomass trigger (B_{TRIG}).

Determining the total catch from the RBC

For Tier 1 species, the total catch is determined directly from the RBC. A total allowable commercial catch (TACC) is the adjusted RBC less the regional distribution of state-wide allocations to the recreational, charter boat and Aboriginal traditional fisheries. If the RBC changes in response to application of the harvest strategy, the TACC would be adjusted accordingly. For the other sectors, equivalent adjustment may be required using existing management measures.

Consistent with the Harvest Strategy Policy, which established a more precautionary approach to assessments with less certain information, buffers or discount factors are applied to the RBC to account for this increasing uncertainty at the lower categories. There is no buffer for Category 1 stocks, a 10% buffer is applied to Categories 2-4, and 20% to Categories 5-6.

The monitoring and stock assessment program needs to be commensurate with the scale of the fishery. Consequently, multi-year RBCs may be recommended. In addition, in some circumstances, if there is no risk to the stock, setting a total allowable catch (TAC) and TACC that is different from that given by the decision rule may be appropriate. The HSF provides examples of when this might be considered which include bycatch provisions, a minimum/maximum change rule and step-up/step-down total catch.

Rebuilding depleted stocks

The Harvest Strategy Policy states that for any fish stock or management unit that is classified as depleted, there should be a high probability of stock recovery to levels above the limit reference point, within specified timeframes related to the generation time of the species. Depending on the species and level of depletion, a rebuilding plan or strategy will be required. In addition, an additional buffer could be applied to the RBC to ensure confidence that rebuilding occurs.

Exceptional circumstances

While harvest strategies need to be unambiguous, they also need to be adaptive but not to the point that the harvest strategy is constantly being changed. One way to build in flexibility is to identify the "exceptional circumstances" that may trigger departure from or even suspension of a harvest strategy. The HSF provides examples that may warrant the use of "exceptional circumstances" provisions.

Evaluation, Implementation, and Review

The HSF, including decision rules and buffers, should be formally tested using Management Strategy Evaluation (MSE) and other methods where applicable.

This Harvest Strategy Framework will be integrated into the replacement MSF Management Plan which is to come into effect when adopted by the Minister for Primary Industries and Regional Development, pursuant to section 44 of the *Fisheries Management Act 2007*.

Apart from those stocks for which recovery management measures are already in place, stocks that are assessed to be below B_{LIM} when the HSF is implemented, will be subject to a 2-year period of transitional arrangements. During this transitional period, the take of these stocks will not be reduced immediately to zero; however, management actions shall be directed to rapid rebuilding of these stocks.

The HSF should be reviewed within 5 years following implementation to ensure it is fit for purpose as the recent changes in the fishery are bedded down.

1. Overview

1.1. South Australian Fisheries Harvest Strategy Policy

A harvest strategy is defined as “a framework that specifies pre-determined actions in a fishery for defined species (at the stock or management unit level) necessary to achieve the agreed ecological, economic and social management objectives”. The South Australian Fisheries Harvest Strategy Policy provides an overarching framework for the development of consistent harvest strategies for South Australian fisheries, to further the objectives of the *Fisheries Management Act 2007* (PIRSA 2015a). It is broadly consistent with the National Guidelines to Develop Fisheries Harvest Strategies (Sloan et al. 2014).

The policy, and guidelines for implementing the policy, identify core principles and steps in the implementation of harvest strategies. The policy implements a risk management approach, whereby exploitation levels are reduced as uncertainty around biological stock status increases, or stock levels decline to unacceptable levels. This is to ensure fisheries are managed at an acceptable level of risk, irrespective of level of knowledge. Consequently, ecological objectives such as protecting aquatic resources from over-exploitation and ensuring they are not endangered have primacy over economic and social objectives.

The policy and guidelines, while covering the key aspects of harvest strategies and their implementation, are not prescriptive regarding the settings for the more technical elements of a harvest strategy such as performance indicators, reference points and decision rules, except for managing risk. Specifically, regardless of the level of uncertainty in assessments, harvest strategies must ensure that there is a high likelihood that stocks will not fall below a limit reference point (the point below which recruitment overfishing may occur). This likelihood is set such that there is a 90% probability a stock will be above the limit reference point over time (e.g. 9 years in 10). For species below the limit reference point, rebuilding timeframes are specified.

1.2. The Marine Scalefish Fishery Harvest Strategy Framework

The Marine Scalefish Fishery (MSF) Harvest Strategy Framework (HSF) describes the performance indicators for measuring the status of stocks, and the use of these indicators and their associated reference points in management decisions through the application of decision rules, consistent with the policy objectives. The aim of the framework is for robust, transparent, and defensible mechanisms to maintain species within the MSF at sustainable levels and the fishery is managed consistent with the *Fisheries Management Act 2007* and the South Australian Harvest Strategy Policy.

The HSF is to sit within the replacement Management Plan for the South Australian Commercial Marine Scalefish Fishery (“the Management Plan”) and is to be accompanied by a proposed Implementation Plan which will set out specific target, limit and trigger reference points for specific stocks.

The HSF needs to consider catches from the commercial sectors (MSF, Rock Lobster, Prawn, and Lakes and Coorong fisheries), as well as the recreational, charter boat and Aboriginal traditional sectors (when that information is available). That is, all forms of fishing mortality need to be accounted for where data are available.

A multi-category approach to deal with different levels of information and uncertainty in assessments of stocks is adopted, similar to that used in many harvest strategy frameworks including the Commonwealth Southern and Eastern Scalefish and Shark Fishery (SESSF) (Smith and Smart 2022, Department of Agriculture and Water Resources 2018). Each of the six categories corresponds to a

given availability of data and a method to assess biological status for individual stocks or management units. The different categories reflect increasing uncertainty with stock status and ways to reduce the risks associated with this uncertainty.

Category 1 represents stocks with the most information and integrated model-based stock assessments (i.e. Snapper, King George Whiting and Southern Garfish). Category 6 represents stocks with the least information, where only catch data and/or raw catch rates are available. Decision rules were selected for each category to inform the appropriate management response.

Reference Points

The overarching reference points are:

- **Limit reference point** – biomass limit reference point is B_{LIM} with 20% of the unfished biomass, or its proxy, as the default value denoted as B_{20}. The appropriate/corresponding fishing mortality[3] reference point is F_{LIM}.
- **Target reference point** – biomass target reference point is B_{TARG} with 50% of the unfished biomass, or its proxy, denoted as B_{50}. The appropriate/corresponding fishing mortality[4] reference point is F_{50}.
- **Trigger Reference point (B_{TRIG})** – 40% of the unfished biomass, or its proxy (B_{40}).

The above default for B_{LIM} is commonly used and the default for B_{TARG} is within the range of typically used target reference points and have a sound basis (see for example Smith and Smart (2022), Department of Agriculture and Water Resources (2018)).

For many species in the MSF, where data are limited, it is not possible to estimate biomass and/or fishing mortality. For these species, empirical indicators are used together with proxies for the reference points.

The species covered by this framework are the Tier 1, Tier 2 and Tier 3 species (Smart et al. 2022a). However, in multi-species fisheries, it is challenging to maintain all species at a target reference point due to technological and ecological interactions. Consequently, whilst Tier 1 species are to be maintained, on average, at the biomass target, B_{TARG}, Tier 2 and Tier 3 species are to be maintained as close to the biomass target reference point (or proxy) as practicable. All Tier 1, Tier 2 and Tier 3 species are to be maintained above their biomass limit reference point (B_{LIM}) at least 90 per cent of the time and the biomass of stocks is increasing away from the limit reference point.

1.3. Objectives of the MSF HSF

The objectives of the MSF HSF are:

1. To ensure that target species are biologically sustainable by:

1.1. maintaining Tier 1 stocks, on average, at the biomass target reference point (or proxy), and maintaining Tier 2 and Tier 3 stocks as close to the biomass target reference point (or proxy) as practicable.

[3] Reference points relating to exploitation rate are provided in terms of the instantaneous fishing mortality rate (F), as opposed to estimates of harvest fraction. This does not preclude harvest fractions from being calculated and communicated for specific species/stocks.
[4] See 1

1.2. maintaining all stocks above the biomass limit reference point (or proxy) at least 90% of the time, and demonstrating the biomass of stocks is increasing from the limit reference point.

1.3. recovering depleted stocks to above the limit reference point within specified timeframes.

2. To support economic, and social benefits to the community by:

2.1. setting the target biomass reference point (or proxy) for Tier 1 stocks at a level that supports improved economic returns for commercial fisheries.

2.2. recovering and maintaining stocks at levels that support healthy recreational, charter, and Aboriginal traditional fishing sectors.

3. To contribute to cost-effective management by:

3.1. adopting a tiered approach to harvest strategy categories based on stock assessment type.

3.2. applying pragmatic assessment approaches and decision rules commensurate with the value of the fishery.

In achieving these objectives the HSF will implement Goal 1 of the replacement Management Plan – Ensure the MSF resources are harvested within ecologically sustainable limits [TO UPDATE CONSISTENT WITH FINAL REPLACEMENT MANAGEMENT PLAN]. The objectives are consistent with ecologically sustainable development (ESD)[5] and adopt a precautionary approach to managing risk. Objective 1 explicitly seeks to ensure stocks are biologically sustainable which is recognised as an important component of achieving wider ecological sustainability of the fisheries accessing marine scalefish species. The broader impacts of fishing on the ecosystem (such as habitat impacts, bycatch and interactions with threatened, endangered or protected species (TEPS)) will be considered in the replacement Management Plan and wider Department of Primary Industries and Regions (PIRSA) policy.

1.4. Governance

The MSF is managed by PIRSA according to the *Fisheries Management Act 2017* and subordinate regulations. Management details are available in the Management Plan.

The Marine Scalefish Fishery Management Advisory Committee (MSFMAC) was established in 2021 by the Minister for Primary Industries and Regional Development under Section 20 of the Act. This committee provides advice directly to the Minister on management arrangements and research needs for the commercial marine scalefish, charter boat, recreational and Aboriginal traditional fisheries (the shared access fisheries), consistent with the objectives of the Act. This includes advice on the development, review and implementation of the Management Plan, related harvest strategies, other shared fisheries management plans where necessary, and any other matter referred to it by the Minister

[5] As provided in the *Fisheries Management Act 2007,* ***ecologically sustainable development*** comprises the use, conservation, development and enhancement of the aquatic resources of the State in a way, and at a rate, that will enable people and communities to provide for their economic, social and physical well-being while—
(a) sustaining the potential of aquatic resources of the State to meet the reasonably foreseeable needs of future generations; and
(b) safeguarding the life-supporting capacity of the aquatic resources of the State; and
(c) avoiding, remedying or mitigating adverse effects of activities on the aquatic resources of the State,
(taking into account the principle that if there are threats of serious or irreversible damage to the aquatic resources of the State, lack of full scientific certainty should not be used as a reason for postponing measures to prevent such damage).

that supports the sustainable management of shared access marine scalefish fisheries in South Australia.

The MSFMAC is supported by a Science Sub-committee (SSC). The SSC advises the MSFMAC on matters the MSFMAC determines need technical scientific analysis and evaluation, including proposed catch limits such as recommended biological catches (RBCs) and total allowable catches (TACs).

Stakeholder input

The HSF will be applied by PIRSA and the MSFMAC[6] in developing recommendations for RBCs, catch limits and other relevant management arrangements. As the MSFMAC is the lead advisory body for the shared-access MSF, stakeholder input into the application of the HSF will be funneled through the MSFMAC. The MSFMAC includes positions from all key sectors that have an interest in the fishery, and relevant peak bodies will also be invited to input into MSFMAC business and meetings that will apply the HSF.

2. Background to the MSF

South Australia's MSF is a complex, multi-species, multi-gear and multi-sector fishery. Commercial fishers in the MSF are permitted to catch over 60 species, of which around 20 species are assessed to determine stock status, of which Snapper, King George Whiting, Southern Garfish and Southern Calamari are the most important (Tier 1 species). Species are managed as state-wide stocks or regional stocks. There are 30 types of fishing gear endorsed for use in the fishery and these differ across the fishery depending on location and the species targeted. In addition, licence holders from the Rock Lobster, Prawn and Lakes and Coorong fisheries have varying levels of access to MSF species.

Recreational and charter boat fisheries have specified state-wide allocations for several species, which in some instances constitute a large component of the fishery. For example, the recreational allocation (recreational and charter combined) of King George Whiting is 48.5%. For all species, the Aboriginal traditional sector has a nominal 1% allocation.

In July 2021, the commercial MSF underwent a significant reform that included the regionalisation of the fishery through four new zones of management (Spencer Gulf, Gulf St Vincent/Kangaroo Island, the West Coast and the South East), and fleet rationalisation that reduced the number of MSF licences from 307 to 205. Fish stocks are managed according to their management tier assigned via a Tiered Management Framework (TMF) (Smart et al. 2022b). All Tier 1 stocks are managed according to the four new zones using total allowable commercial catches (TACCs), with some stocks further managed via individual transferable quotas (ITQs). An over-catch and under-catch policy also applies. Other stocks may be managed at the regional or state-wide level, depending on the level of the assessment and data available.

Further details can be found in Smart et al. (2022b).

3. Monitoring

Data used to assess the status of fish stocks in the MSF include:

[6] Or any such replacement advisory body for the shared-access marine scalefish fishery

Commercial fisheries statistics – fishers in South Australia are required to complete detailed logbooks recording catch and effort by gear and area, as well as Catch Disposal Records (CDRs) for the ITQ managed Tier 1 species.

Biological sampling – a sub-set of species are sampled at Adelaide and regional markets. Fish are measured, weighed, sexed and the stage of reproduction recorded. Otoliths are removed for ageing using standard and validated methods. Sample numbers are sometimes augmented from research cruises or industry surveys.

Fishery independent data – for Snapper, the daily egg production method (DEPM) is used to provide a fishery independent estimate of spawning biomass for the Gulf St Vincent and Spencer Gulf stocks.

Recreational fishing surveys – to obtain catch and effort statistics for the recreational fishing sector, state-wide recreational fishing surveys (telephone/diary surveys) have been undertaken at approximately 5-year intervals since 2000/01. The latest survey was undertaken in 2021/22 (Beckman et al. 2022).

In addition, specific research projects are undertaken to address biological and ecological uncertainties.

Data used to monitor social and economic objectives include:

Annual economic and social indicator reports – each year reports are published for South Australian commercial fisheries, including the MSF, outlining performance against economic and social indicators.

4. Harvest strategy categories and decision rules

4.1. Overview

The HSF comprises six categories which are defined below. Category 1 can be described as data-rich, Categories 2-4 data-moderate, and Categories 5 and 6 data-poor.

Stocks are allocated to a particular category based on data availability and quality and the type of assessment that is applicable to the stock. Not all categories are currently being used but have been included to accommodate species moving between management tiers and for a greater range of assessment methods to be used, if additional data become available.

The performance indicators for each stock may need to consider commercial only data, if data on recreational catch and effort are not available (or at an appropriate spatial scale). However, catches from at least the recreational sector should be included in the harvest strategy where possible and decision rules should consider each sector.

There are broadly two types of decision rules:

- **Tier 1 species** – An RBC is estimated. The RBC is the total catch that can be taken from the stock, as determined by the harvest strategy, and is allocated to each sector (commercial, recreational, charter boat and Aboriginal traditional) based on the regional distribution of state-wide allocations. For those species with ITQ management arrangements implemented for a fishing region, a TACC will be set for the commercial sector annually and a corresponding quota unit value determined. For species in zones for which ITQs are not in place (e.g. West Coast King George Whiting) a commercial catch cap will be implemented.

- **Tier 2 and Tier 3 species** – If the assessment of a fish stock indicates the biomass (or proxy) is declining (as defined in a decision rule) and/or current fishing mortality is estimated to be greater than the fishing mortality to give $F_{50,}$ the decision rule would be triggered.

If the decision rule is triggered, additional analyses and a species/sector specific workshop are required from which management options are considered and monitoring and research needs identified and reported to the MSFMAC.

The assessment type for each category is summarised in Appendix 1 - Table summarising HSF categories and assessment type.

4.2. Description of categories and associated decision rules

Decision Rule

A “hockey stick decision rule” (Figure 1) applies to Category 1 and Category 2 stocks whereby the fishing mortality is reduced proportionate to the size of the biomass below the biomass trigger (B_{TRIG}). The fishing mortality is:

- stable when the biomass (B) is above the target reference point (B_{TARG}),
- reduced when B falls below the trigger reference point (B_{TRIG}), and
- zero when B falls below the limit reference point (B_{LIM})[7]

For other stocks (Categories 3-6), alternative empirical approaches are applied that are consistent with the above approach to reduce fishing mortality proportionate to the size of the biomass.

Category 1 – Robust integrated stock assessment

Applies to stocks with a robust quantitative integrated stock assessment that provides estimates of mature biomass, B, and fishing mortality, F. These assessments use a wide range of data inputs including fishery-dependent (e.g. catch per unit effort – CPUE) and -independent (e.g. DEPM) abundance indices or estimates, size and age composition, biological parameters, and commercial and recreational catch data.

The decision rule has the recommended fishing mortality declining below a trigger reference point (B_{TRIG}), termed a “hockey stick decision rule” (Figure 1).

The target reference point is B_{TARG} with B_{50} as the default.

The limit reference point is B_{LIM} with B_{20} as the default.

The target fishing mortality is F_{TARG} with F_{50} as the default. F declines below the trigger reference (B_{TRIG}) point at a default of B_{40}.

RBC calculation: the RBC is determined by applying the fishing mortality as determined by the decision rule to the estimated current biomass.

[7] Pending applicable bycatch provisions, exceptional circumstances or transitional arrangements.

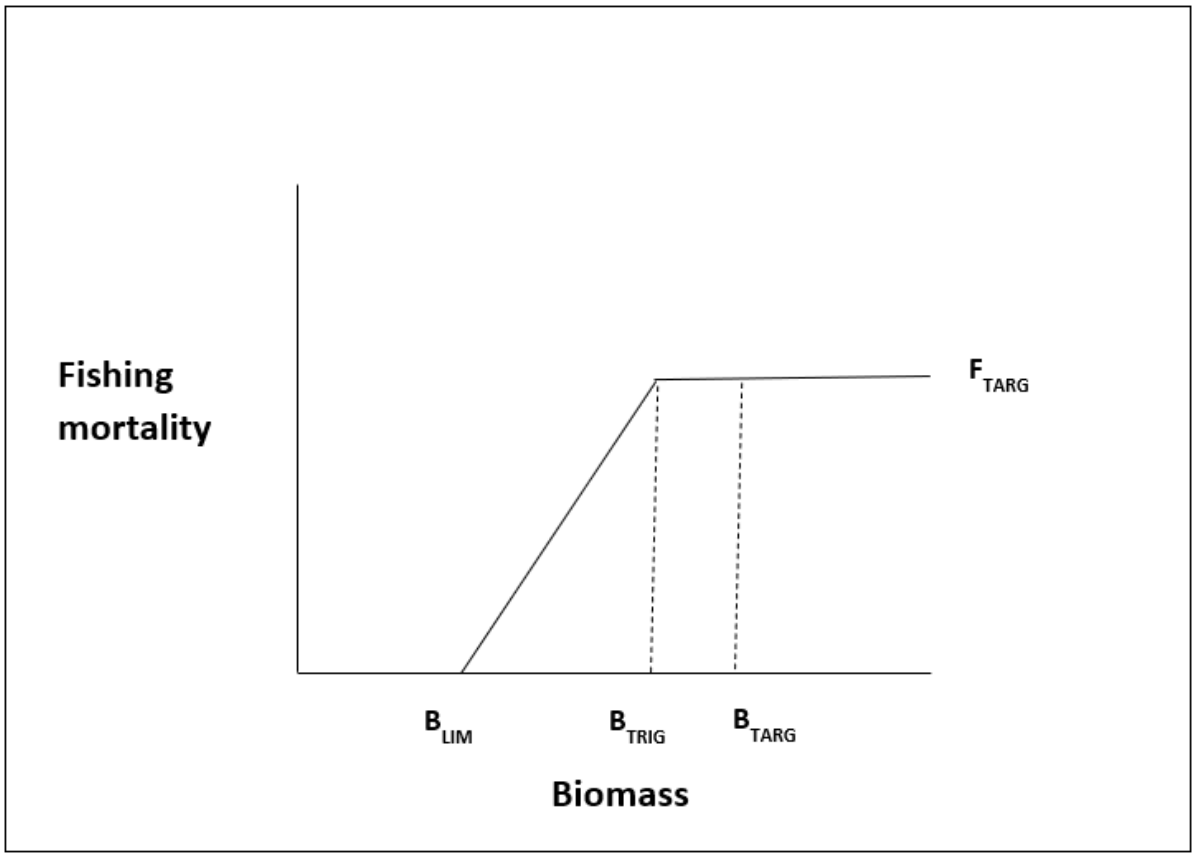

Figure 1. The “hockey stick” decision rule with associated reference points.

Category 2 – Integrated stock assessment model – less robust or preliminary assessment only

Similar inputs as in Category 1 but greater uncertainty in some data and/or conflicting signals and lack of stability in model fits, and hence greater uncertainty. This may include integrated models where sensitivity analyses demonstrate influential model assumptions or data sources may influence conclusions. This category also applies to preliminary assessments, until such a time that an assessment is considered sufficient and further model development is not required.

RBC calculation: the decision rule (hockey stick) and calculation of the RBC is as per Category 1 but discount/buffers are applied (see Section 5).

Category 3 – Aggregate production models

Surplus production or biomass dynamic models require catch and an index of abundance, usually CPUE. They provide estimates of F and B. Extensions include age-structured production models and delay-difference models. These require some biological information such as estimates of natural mortality, and maturity- and length-at-age. Aggregate production models are generally more uncertain than integrated models and hence are assigned to a lower category.

RBC calculation: RBCs are calculated from the ratios of current F and B to F_{50} and B_{50}, respectively.

Category 4 – Empirical estimates of F and M and pre recruit analyses

This category requires data available on the age structure of catches (often snapshots) and some biological information including an estimate of natural mortality (M), and length, weight and fecundity at

age. Fishing mortality (F) is estimated from the observed age structure. Yield per recruit analyses are used to estimate F values providing the biomass at the limit and target reference points, i.e., F_{20} and F_{50}.

RBC calculation: a similar decision rule is applied as for Category 1 and Category 2, where F is reduced below F_{50} and the RBC is estimated from the ratio of F_{RBC} and F_{CUR}, applied to the current catch.

F_{RBC} is the F selected from the decision rule, F_{50} is the target fishing mortality and F_{CUR} is the estimated current fishing mortality.

Category 5 – Standardised CPUE

Standardised CPUE provides an index of abundance estimated from catch and effort data by accounting for aspects of the fishery dynamics (such as area, gear, fisher, etc.) that influence CPUE. Reference periods are selected from the standardised CPUE time series to represent periods when the stock was thought to be close to the target biomass, as well as the average catch during this period to provide proxy target and limit reference points. Similarly, a reference period for standardised CPUE can be selected when the stock was thought to be close to the limit. Alternatively, the limit standardised CPUE can be designated as a proportion of the target standardised CPUE.

RBC calculation: the RBC is calculated from the ratio of the difference in current average standardised CPUE and the limit standardised CPUE, and the difference between the target standardised CPUE and limit standardised CPUE applied to the target catch.

Category 6 – Weight of evidence methods

This category encompasses data-poor stocks for which the above assessment approaches cannot be undertaken and/or raw CPUE is not considered a reliable index of abundance. Methods used could include catch only approaches (e.g. CatchMSY), noting that depletion estimates from such approaches are highly uncertain, risk assessments, and simple triggers related to catches and catch composition.

RBC calculation: the RBC recommendation will take into account a number of these methods and the reasoning used must be well documented.

The values of the various target, limit and trigger reference for specific stocks that correspond with the above categories and decision rules will be set out in the proposed Implementation Plan.

5. Determining the total catch from the RBC

For Tier 1 species, the total catch is determined directly from the RBC, less the buffer (see Section 5.1). A TACC is the adjusted RBC less the regional distribution of state-wide allocations to the recreational, charter boat and Aboriginal traditional fisheries. If the RBC changes in response to application of the harvest strategy, the TACC would be adjusted accordingly. For the other sectors, equivalent adjustment may be required using existing management measures.

5.1. Buffers

Consistent with the Harvest Strategy Policy, which established a more precautionary approach to assessments with less certain information, buffers or discount factors are applied to the RBC to account for this increasing uncertainty at the lower categories. This is an application of the catch cost risk framework described in the Guidelines for implementing the South Australian Harvest Strategy Policy (PIRSA 2015b).

The following buffers are considered appropriate to apply:

- Category 1 – No buffer
- Data moderate categories (Categories 2-4) a 10% buffer is applied
- Data poor categories (Categories 5-6) a 20% buffer is applied.

5.2. Multi-year RBCs for Tier 1 Stocks

The stock assessment program needs to be commensurate with the scale of the fishery. Consequently, it may not be possible or feasible to undertake stock assessments for Tier 1 stocks each year. In such circumstances the assessment could be used to recommend a multi-year RBC (i.e. the RBC each year for a maximum of three years) providing:

- the current biomass is greater than B_{LIM} or proxy.
- to account for uncertainty, a multi-year RBC may be stable or decreasing but not increasing.
- the projections demonstrate the multi-year RBC does not increase any risk to the stock.
- in some circumstances, depending on the stock and its status, an additional buffer may be required if an assessment is not undertaken for several years.

During the years when a formal stock assessment is not undertaken, basic fishery indicators such as CPUE and where possible size/age composition must be examined. If there are very significant differences in the performance of the fishery indicators compared with the previous stock assessment, the arrangement must be re-evaluated. For example, if an assessment is based on increasing CPUE, but CPUE declines between assessments this would act as a trigger for examination of the arrangement. The guidance on what is considered a significant departure will be species/stock specific and described in the proposed Implementation Plan.

5.3. Departures from the decision rule

If there is no risk to the stock, in some cases, it may be appropriate to set a total catch and resulting TACC that is different from that given by the decision rule. The following meta-rules would apply:

- Bycatch provisions when the RBC is zero (i.e. stock is in a depleted state) – this would account for incidental catches of a stock due to the multi-species nature of the MSF. This could be considered when the level of targeting can be reduced and the ability of fishers to avoid the stock is clear. Any incidental catch must not stop the stock rebuilding.
- A minimum/maximum change rule may be applied to avoid very small or very large changes to the TACC from year to year, as long as there are no trends in the RBCs that could lead to an increased risk to the stock.
- In some cases, it may be recommended that the TACC be at a lower level than that derived from the RBC, due to, for example, market constraints.
- Step up/step down total catch – this may be applied such that a total catch is increased or reduced over several years rather than in one year as determined by the RBC. The aim would be to minimise, for example, impacts on the fishery due to large episodic recruitment and provide the best means of managing this recruitment. However, the intent of the harvest strategy policy

still needs to be met and risks to stock sustainability by adopting such an approach can be assessed.

6. Rebuilding depleted stocks

The Harvest Strategy Policy states that for any fish stock or management unit that is classified as over-fished (i.e. depleted), there should be a high probability of stock recovery to levels above the limit reference point, within specified timeframes related to the generation time of the species.

The specified time frames are typically between T_{MIN} and $2xT_{MIN}$, where T_{MIN} is defined as the time for recovery to the limit reference point in the absence of fishing. Where it is not possible to estimate this, the mean generation time plus 10 years or 3x the mean generation time can be used.

Depending on the species and level of depletion, a rebuilding plan or strategy will be required. In addition, an additional buffer could be applied to the RBC to ensure confidence that rebuilding occurs.

7. Exceptional circumstances

While harvest strategies need to be unambiguous, they also need to be adaptive. One way to build in flexibility is to identify the 'exceptional circumstances' that may trigger departure from or even suspension of a harvest strategy. However, having flexibility to vary from the harvest strategy under certain clearly specified circumstances should not be seen as broad flexibility in interpreting the results of assessments and applying the harvest decision rules, which would undermine the harvest strategy. Section 5.3 provides some flexibility given considerations of risks to the stock. Other examples that may warrant the use of exceptional circumstances provisions are:

- A Category 1 assessment is rejected through technical and/or peer review, or an assessment has not been completed because of unforeseen reasons.
- Where there has been a major change to the fishery that, for example, demonstrable evidence indicates mean catch and effort statistics no longer provide a reliable index of relative abundance.
- Where there has been a demonstrable change in the ecological environment of the fishery unrelated to impacts of fishing (e.g., a climate induced regime shift).

8. Evaluation

The Harvest Strategy Policy states that all harvest strategies should be tested for robustness prior to implementation to demonstrate they meet the intent of the policy. While the HSF and categories haven't been tested explicitly for the MSF, all categories and assessment types have been shown to be robust in other fisheries and jurisdictions. However, the HSF, including buffers, should be formally tested using Management Strategy Evaluation (MSE) and other methods where applicable.

9. Implementation

This HSF will be integrated into the replacement MSF Management Plan which is to come into effect when adopted by the Minister for Primary Industries and Regional Development, pursuant to section 44 of the *Fisheries Management Act 2007*.

The HSF will be applied by PIRSA and the MSFMAC[8] in developing recommendations for RBCs, catch limits and other relevant management arrangements. Stakeholder input into the application of the HSF will be funnelled through the MSFMAC.

Apart from those stocks for which recovery management measures are already in place, stocks that are assessed to be below B_{LIM} when the HSF is implemented, will be subject to a 2-year period of transitional arrangements. These will be identified in the proposed Implementation Plan. During this transitional period, the take of these stocks will not be reduced immediately to zero; however, management actions shall be directed to rapid rebuilding of these stocks. These transitional arrangements will apply for no more than two years. The HSF will apply to all stocks in full following this transitional period, which means that fishing of species below B_{LIM} will then cease.

10. Review

The Harvest Strategy Policy states all harvest strategies should be periodically reviewed to ensure they are up to date and take into account the best available information and understanding of the fishery.

The MSF has been through very significant change. Consequently, this HSF should be reviewed within 5 years following implementation to ensure it is fit for purpose as the changes in the fishery are bedded down.

[8] Or any such replacement advisory body for the shared-access marine scalefish fishery

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Appendix 1 - Table summarising HSF categories and assessment type.

Category	Assessment type
1	Robust integrated stock assessment model with fishery independent/dependent biomass indices
2	Integrated stock assessment model with fishery independent/dependent biomass indices – less certain or preliminary assessment
3	Biomass dynamic, surplus production models Stock reduction analysis
4	Empirical estimation of fishing mortality (size/age data) Spawner biomass per recruit
5	Trends in standardised CPUE
6	Weight of evidence e.g., catch only methods, raw catch rates, species composition, risk assessments

Appendix 2 – Glossary

Biomass (*B*) Based Indicators	Quantitative values that refer to a given stock size. For example, $\mathbf{B_{40}}$ refers to the Biomass at 40% of the unfished stock size. Biomass based indicators can also align with specific reference points such as limit ($\mathbf{B_{LIM}}$) and target ($\mathbf{B_{TARG}}$) reference points.
Buffer/Discount	An additional reduction, usually applied as a percentage, to a Recommended Biological Catch (RBC) that accounts for uncertainty in an assessment. Stocks in a higher harvest strategy category would have smaller buffers applied (or possibly no buffer at all) in comparison to stocks in lower harvest strategy categories.
Catch-Cost Risk Trade-Off	The trade-off between the increased profits from larger catches against the increased costs of management and scientific assessments required to support the risk posed by higher exploitation.
Data-Limited Assessments	Stock assessment methods applied to stocks with limited fishery or biological data. These assessment methods provide greater levels of uncertainty than integrated stock assessments due to the reduced level of information or data available.
Decision Rules	Also referred to as Harvest Control Rules (HCRs). Decision rules are pre-determined management actions linked directly to the performance of the fishery, relative to reference points.
Fishing Mortality (*F*)	The instantaneous rate of fish deaths due to fishing a component of the fish stock. F reference points may be applied to entire stocks or segments of the stocks. Instantaneous fishing mortality rates of 0.1, 0.5, 1.0, and 2.0 are equivalent to annual exploitation rates of 9.5 per cent, 39.3 per cent, 63.2 per cent and 86.5 per cent respectively.
Fishing Mortality (*F*) Based Indicators	Quantitative values that refer to the fishing mortality that correspond to a given stock size or reference point. For example, F_{50} refers to the *F* that maintains Biomass at 50% of the unfished stock size. Fishing mortality based indicators can also align with specific reference points such as limit (F_{LIM}) and target (F_{TARG}) reference points.
Generation time	The average age of mature animal in an unexploited population.
Harvest Strategy Category	Each category corresponds to a given availability of data and a method to assess status. This inevitably means that categories based on less certain information will need to be more precautionary in nature. Harvest strategy categories are also referred to as 'Tiers'.
Hockey Stick Decision Rule	A decision rule where the fishing mortality ramps down linearly, at a breakpoint, following the breach of a trigger or target reference point.

	While the performance indicator remains above the trigger reference point the decision rule remains constant, thus giving a “hockey stick” shape.
Management Strategy Evaluation (MSE)	The testing of different management options using model-based assessments to examine the most desirable outcome(s).
Management Tier	Tiers are assigned to each stock in the MSF based on the Tiered Management Framework. These Tiers determine the level of management (TACC, RBC, or basic monitoring) required for each stock.
Maximum Sustainable Yield (MSY)	The maximum sustainable yield (MSY) is the maximum long term catch that can be taken when a stock is at a healthy size, i.e., at or above B_{MSY}.
Meta Rule	A rule that enables a total catch to be set that is a departure from the decision rule.
Operational Objectives	The overarching goal of a harvest strategy, such as having a high likelihood of maintaining stocks at or near the targets and meeting the probability or risk requirements in relation to avoiding depletion to, or below, the limits.
Performance Indicators	A quantity that can be measured and used to track changes with respect to achieving an operational objective. There are two types of performance indicators: model-based and empirical. Model-based indicators refer to estimates of fishing mortality (*F*) and/or biomass (*B*) determined through stock assessment models. Empirical indicators are not model-based and do not directly refer to estimates of *B* or *F.* Instead, they use proxies to infer these quantities such as catch, effort, CPUE, recruitment indices, and mean size or age.
Rebuilding Plan	A strategy is to cease overfishing and rebuild the overfished stock to above the limit reference point or to the target reference point with a reasonable level of certainty, within a specified time frame.
Recommended Biological Catch (RBC)	The maximum annual biomass that can be sustainably harvested from a stock, as determined via the decision rules. An RBC accounts for stock size when determining what level of catch is sustainable. If a management goal was to increase stock size, then the appropriate measure would be to make sure that catches remain below the estimated RBC so that population growth can occur.
Reference Points	The value of a performance indicator that can be used as a benchmark of performance against an operational objective. Harvest strategies generally have three types of reference points. Limit reference points

	define the values of a performance indicator that identifies an undesirable outcome to be avoided with high probability, for example recruitment overfishing. Trigger reference points define the values of a performance indicator at which a change in the management is considered or adopted. Target Reference Points define the values of a performance indicator that are desirable or ideal and at which management should aim.
Tiered Management Framework (TMF)	Grouping of stocks under different management tiers based on scoring across several criteria. For further information, see FRDC report 2017-014 – Informing the structural reform of South Australia's Marine Scalefish Fishery, available at https://www.frdc.com.au/sites/default/files/products/2017-014-DLD.pdf

Appendix 3 – Example applications of the harvest strategy framework for the Marine Scalefish Fishery

To help explain the application of the HSF, some examples are provided in this Appendix. It must be emphasised that there is no status associated with these examples; rather their purpose is to demonstrate approaches for the assessment of selected stocks under the HSF, and these largely depend on the information available. The final decision regarding catch quotas and other management outcomes will continue to rest with the Minister for Primary Industries and Regional Development, but the HSF has been developed to guide the MSFMAC in making recommendations to the Minister.

Scope

Here, the HSF is applied to two Tier 1 stocks, King George Whiting (KGW) and Southern Calamari (both from Spencer Gulf, SG), and a Tier 2 stock, Yellowfin Whiting (YFW) from Gulf St Vincent/Kangaroo Island (GSV/KI) (Table 1). Perhaps more relevantly, these stocks represent different categories of data, ranging from Category 1 for data-rich stocks through to Category 6 for data-poor stocks, and therefore, approaches that are currently available for assessment. Specifically, the KGW SG stock is assessed using a robust fully-integrated model (Category 1), the YFW GSV/KI stock is assessed by weight-of-evidence and supplemented with standardised catch rates (Category 2), and the Southern Calamari SG stock is also assessed by weight-of-evidence, but uses raw catch rates and is supplemented with catch-only methods (e.g. catch-MSY model) (Category 6) (Table 1).

Table 1: Application example of the harvest strategy framework.

Example	Species	Stock	Tier	Category	Key indicator(s)	Decision rule	Outcome(s)
1	KGW	SG	1	1	*B*, *F*	Hockey stick	RBC, TACC
2	YFW	GSV/KI	2	5	CPUE (std)	CPUE ratio	RBCC
3	Southern Calamari	SG	1	6	CPUE, catch	Hockey stick	RBCC, TACC

Abbreviations:
B, biomass
F, fishing mortality
CPUE, catch per unit effort
std, standardized
RBC, recommended biological catch
TACC, total allowable commercial catch
RBCC, recommended biological commercial catch

Currently, there is only one stock—KGW from the West Coast (WC)—that falls under data Category 2, which, like Category 1, includes species/stocks that are assessed using a fully-integrated model, but there is considerable uncertainty associated with the assessment. The KGW WC stock is not included here since it follows the same approach and decision rule as Category 1 species/stocks, except that it also has a precautionary buffer applied to offset this uncertainty. There are currently no species/stocks that fall within data Category 3 or Category 4.

Performance indicators and reference points

Depletion is a key indicator in the HSF for the assessment of many stocks; however, it is currently not estimated by models developed at SARDI (e.g., 'WhitEst' for KGW). Therefore, a reference year or period needs to be selected as a benchmark for when the fishery was considered to be performing well, and for which other years can be scaled against. The current stock assessment models began in 1983/84 when commercial logbooks were introduced. However, exploitation of most species pre-dates this by several decades. As a result, we cannot assume that the unfished biomass (B_0) corresponds with the biomass in 1983/84. Instead, it would be safe to assume that stocks were already depleted at this time and, therefore, the best years in the fishery correspond to a biomass at or greater than a depletion of 50% (B_{50}). The HSF defines the target (B_{targ}), trigger (B_{trig}) and limit (B_{lim}) reference points at a biomass that has been depleted to 50%, 40% and 20% of its unfished level, respectively (i.e., $B_{targ} = B_{50}$, $B_{trig} = B_{40}$, $B_{lim} = B_{20}$).

Example 1: King George Whiting SG stock (Tier 1, Category 1)

Hockey stick rule

Where biomass and depletion (biomass relative to unfished biomass, B/B_0) proxies are estimated for any assessment, the 'hockey stick rule' can be applied. Provided the estimated biomass exceeds B_{TRIG}, the fishery is considered to be at sustainable levels, and the fishing mortality (F) or proxy is set at a level that aims to maintain the biomass above B_{TRIG} and moving towards B_{TARG}. While the estimation of F is a key aim under the HSF, some of the approaches used (including those presented here) express fishing mortality in terms of the harvest fraction (H) (i.e., catch relative to biomass) as a proxy if H is considered more appropriate. It is also a description of fishing mortality that has been ubiquitous in South Australian fishery assessments.

For some of the Tier 1 species/stocks, a target harvest fraction (H_{TARG}), as defined in the current Management Plan (PIRSA 2013; which may be subject to review), is multiplied by the biomass estimate to calculate the recommended biological catch (RBC). If, however, the biomass falls below B_{TRIG} (but is above B_{LIM}), then fishing mortality needs to be reduced (along the ramp on the hockey stick). Here, the H that corresponds to where the estimated biomass falls between B_{TRIG} and B_{LIM} is multiplied by the biomass estimate to calculate the RBC. And if the biomass falls below B_{LIM}, then fishing mortality is set to zero (subject to any transitional arrangement that may be applicable).

Settings

The H_{TARG} for KGW is set at 0.28 as per the 2013 Management Plan. This may need to be reassessed as appropriate and updated in the HSF Implementation Plan.

For this analysis, depletion is estimated using the consistent definition of biomass outlined in the 2021/22 stock assessment, which includes all fish ≥ 280 mm total length (TL). The fishable biomass, whose definition changes with each change in legal minimum length, is used when applying the H determined from the decision rule, given that this is the component of the stock available to fishing at the time the HSF is applied.

Based on the available time-series, a depletion of 50% is assumed to correspond to the highest estimate of biomass ≥ 280 mm TL, which occurred in 1998/99 (Fig. 1).

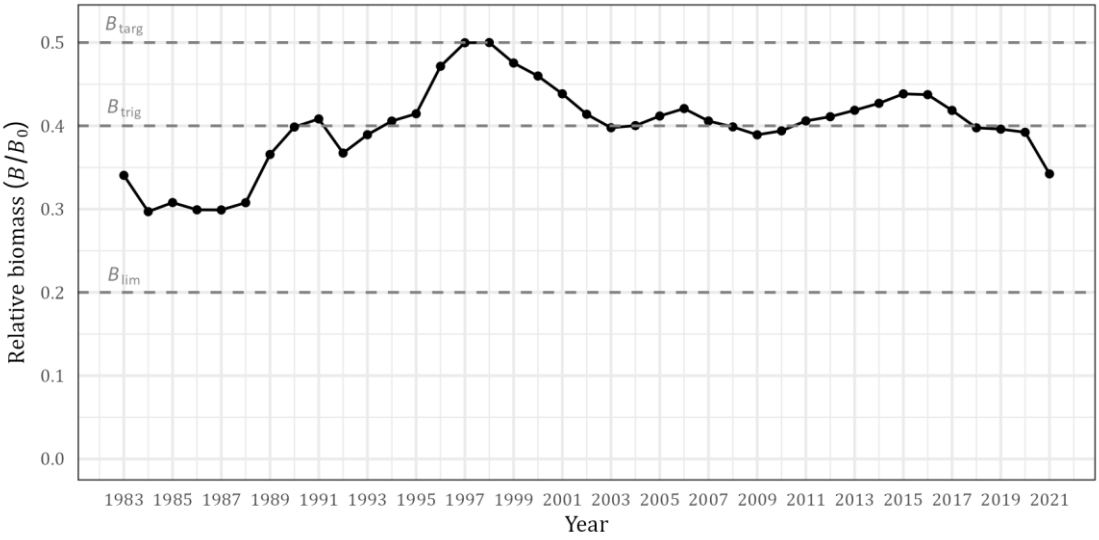

Figure 1: Estimated biomass relative to unfished biomass (≥ 280 mm TL) for King George Whiting Spencer Gulf stock from 1983/84–2021/22.

Application

The biomass fell below B_{TRIG} in 2018/19, and has remained below this reference point since. Therefore, the H_{TARG} of 0.28 was not applied. Instead, a reduction in fishing mortality (in the form of a linear decrease in H) prescribed by the HSF was applied. Based on the assumed 50% depletion in 1998/99, the estimated biomass in 2021/22 of 1,115 t equates to a depletion estimate (i.e., relative biomass) of 0.34, which corresponds to a H of 0.20 using the hockey stick rule (Fig. 2). This results in an RBC of 222 t and a TACC of 98 t based on the commercial catch share of 44% for this stock in the 2013 Management Plan (Table 2).

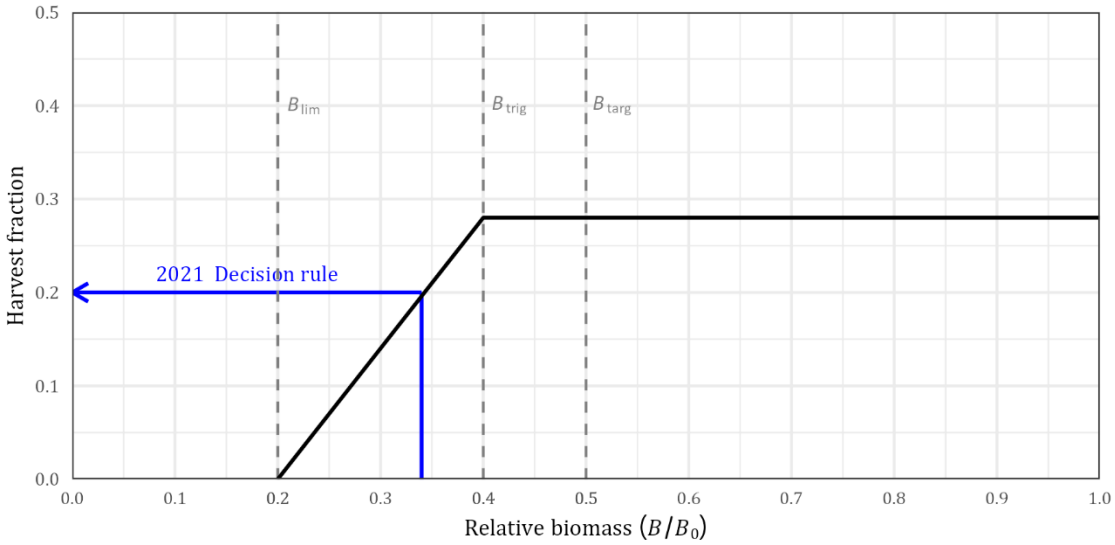

Figure 2: Application of the hockey stick rule to the 2021/22 relative biomass of the King George Whiting Spencer Gulf stock.

Table 2: Harvest strategy outputs from the 2021/22 assessment of the King George Whiting Spencer Gulf stock.

Year	Fishable biomass	Relative biomass	Decision rule harvest fraction	RBC	TACC
2021	1115	0.34	0.2	222	98

Abbreviations:
B, biomass
F, fishing mortality
CPUE, catch per unit effort
std, standardized
RBC, recommended biological catch
TACC, total allowable commercial catch
RBCC, recommended biological commercial catch

Example 2: Yellowfin Whiting GSV/KI stock (Tier 2, Category 5)

Standardised CPUE

Standardisation of CPUE provides an index of abundance from catch and effort data by accounting for (i.e., removing) the impact of factors that can otherwise influence catch rates but are not related to abundance (Maunder and Punt 2004). Generalised linear modelling is the most common method used for standardising CPUE (Nelder and Wedderburn 1972). The 2021/22 assessment of the YFW GSV/KI stock was supplemented with standardisation of CPUE using a generalised linear model (GLM), with fishing year as the main effect, and month, targeting behaviour, and gear type nested within licence holder as the explanatory terms (Smart et al. 2023). Using the standardised CPUE and annual catch time-series, reference periods are selected to represent consecutive years when the stock was considered to be close to the target biomass, thus providing a baseline for assigning a proxy target (and limit) reference point.

Settings

The RBC is calculated from the ratio of the difference between the current average and limit CPUE (Fig. 3) and the difference between the target and limit CPUE applied to the target catch (C_{targ}; Fig. 4).

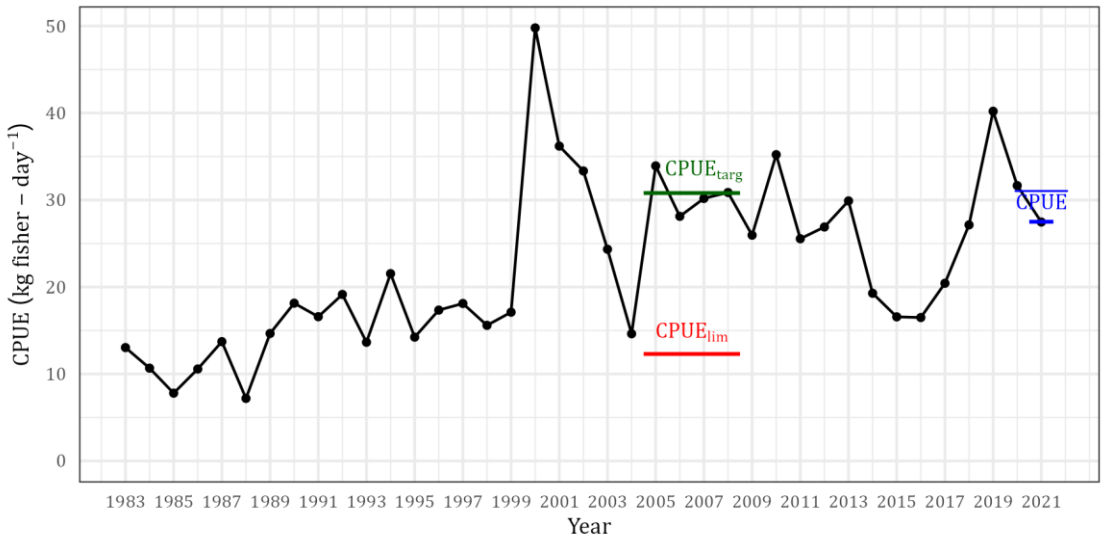

Figure 3: Standardised mean CPUE of Yellowfin Whiting Gulf St Vincent/Kangaroo Island stock from 1983/84–2021/22.

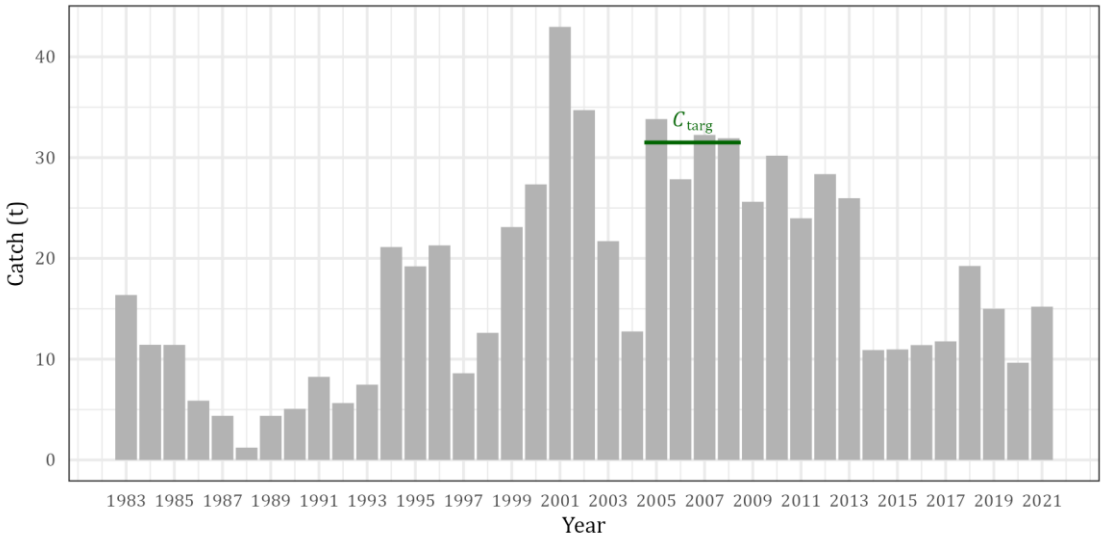

Figure 4: Annual catch of Yellowfin Whiting Gulf St Vincent/Kangaroo Island stock from 1983/84–2021/22.

The application of the CPUE ratio approach using standardised CPUE time-series is described by Eq. 1 (after Little et al. 2011):

$$\mathrm{RBC} = C_{\mathrm{targ}} \times \max\left(\frac{\overline{\mathrm{CPUE}} - \mathrm{CPUE}_{\mathrm{lim}}}{\mathrm{CPUE}_{\mathrm{targ}} - \mathrm{CPUE}_{\mathrm{lim}}}, 0\right) \quad (1)$$

Where:
C_{targ} and $\mathrm{CPUE}_{\mathrm{targ}}$ are catch and CPUE targets, respectively, and are set to the average catch and CPUE during a period of relative stability;
$\overline{\mathrm{CPUE}}$ is the average CPUE over the past *m* years (*m* will be assessment and stock-specific); and $\mathrm{CPUE}_{\mathrm{lim}}$ is the limit CPUE (= 0.4 * $\mathrm{CPUE}_{\mathrm{targ}}$).

Based on the available time-series for CPUE (standardised) and catch, fishing years 2005/06–2008/09 appear to represent a period of stability for the YFW GSV/KI stock, and so the respective targets were set at 30.8 kg fisher-day^{-1} and 31.5 t. Given the assessment is undertaken annually, the CPUE was obtained only from the most recent year, 2021/22.

Application

Since the standardisation of CPUE for the YFW GSV/KI stock uses commercial data only, the calculated RBC is actually a recommended biological commercial catch (RBCC):

$$\text{RBCC} = 31.5 \times \left(\frac{27.5-12.3}{30.8-12.3}, 0\right)$$

$$= 25.9$$

Further to this calculation, and consistent with the South Australian fisheries harvest strategy policy (PIRSA 2015), which establishes a precautionary approach to assessments with less certain information, a buffer is applied to the RBCC of 25.9 t to account for increasing uncertainty at lower data categories. Given the YFW GSV/KI stock falls within category 5, this is subject to a 20% buffer. Therefore, the adjusted RBCC is 20.7 t.

Example 3: Southern Calamari SG stock (Tier 1, Category 6)

Catch-MSY

The catch-MSY method (Martell and Froese 2013) is regarded as a model-assisted data-poor method. While it only requires a time-series of catches from a fishery and some prior notion of the relative resilience or expected productivity of the species being fished, the validity of the outputs relies on key assumptions being met (Haddon et al. 2019). This method assumes that the catch time-series is responsive to and reflects changes in depletion; however, this may not be the case, as other factors unrelated to abundance can influence this (e.g. management changes, gear restrictions, fisher behaviour, etc.). It also assumes that the fishery dynamics are adequately represented by the underlying model equations. Given the potential violation of these assumptions, the outputs of the catch-MSY method may be highly uncertain and should be interpreted with caution. Rather, where possible, they should be considered among other basic (e.g., catch and effort, risk assessment) indicators as part of a weight-of-evidence approach.

Note that, while this method produces estimates of reference points that relate to maximum sustainable yield (MSY), these are replaced here with ‘target’ reference points to be consistent with the terminology of the HSF.

Settings

While high-resolution commercial catch and effort data are only available from 1983/84, annual State-wide catches of Southern Calamari since 1973/74 were obtained from *SAFISH* magazines, with historic ratios applied to estimate the SG component (Fig. 5). The catch-MSY method needs the catch time-series to exhibit contrast through time (i.e., it should increase but also decrease) (Haddon et al. 2019), therefore this additional ten years of data is particularly useful as it captures most of the years when exploitation of Southern Calamari was increasing from a low level.

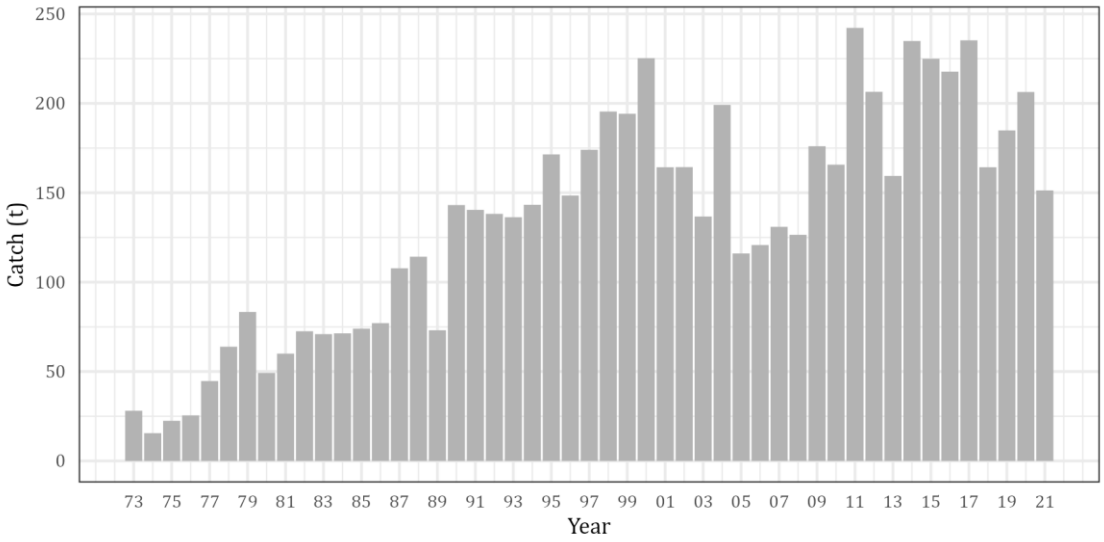

Figure 5: Annual catch of Southern Calamari Spencer Gulf stock from 1973/74–2021/22.

In addition to the catch time-series for the Southern Calamari SG stock, this species/stock was assumed to have medium to high productivity or resilience, with an associated *r* range of 0.3–1.2.

Model outputs

After running the catch-MSY model, final estimates for *r* and *K* (the carrying capacity or B_0) of 0.67 and 1196 t, respectively, were obtained. From these, C_{targ} ($\frac{rK}{4}$), B_{targ} ($\frac{K}{2}$) and H_{targ} ($\frac{C_{\text{targ}}}{B_{\text{targ}}}$) were derived (Table 3).

Table 3: Catch-MSY model outputs for the Southern Calamari Spencer Gulf stock.

r	K	C_{targ}	B_{targ}	H_{targ}
0.65	1214	199	607	0.33

Application

The lack of reliable catch estimates of Southern Calamari from SG by the recreational sector means that this analysis includes only commercial catches and therefore, a RBCC is calculated.

Application of the catch-MSY model shows that the stock has remained above B_{trig} throughout the catch time-series. The fishable biomass at the end of the 2021/22 fishing season was estimated to be 640 t at a depletion of 0.50 (Fig. 6), which means that, according to the hockey stick rule (Fig. 7), the H_{targ} of 0.33 is applicable. This results in an RBCC of 212 t. Given the Southern Calamari SG stock is at Category 6, this is subject to a 20% buffer. Therefore, application of the catch-MSY method within the HSF would suggest a TACC of 170 t (Table 4); however, other information may be considered in a weight-of-evidence approach.

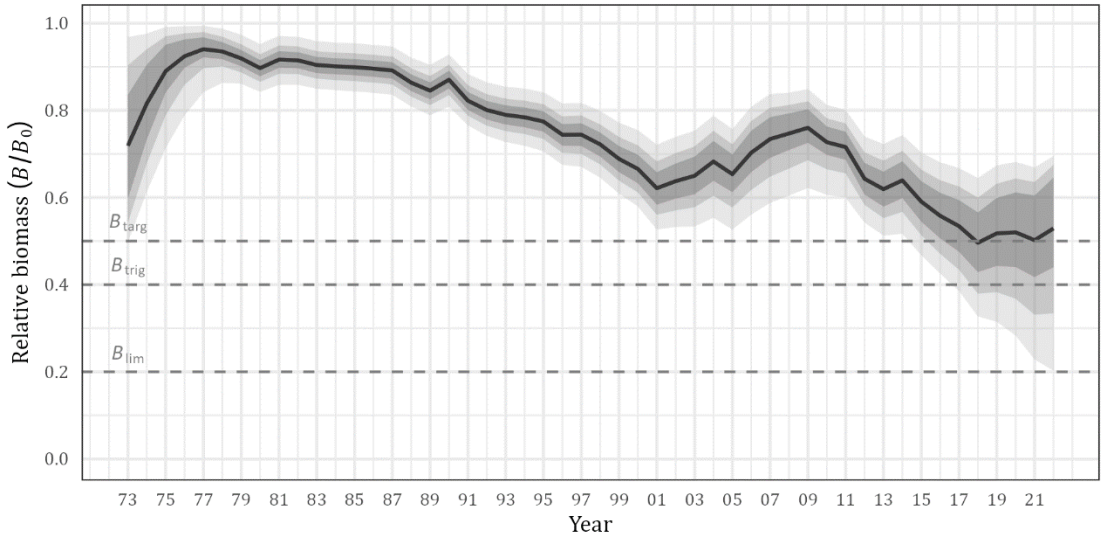

Figure 6: Estimated biomass relative to unfished biomass for Southern Calamari Spencer Gulf stock from 1973/74–2021/22.

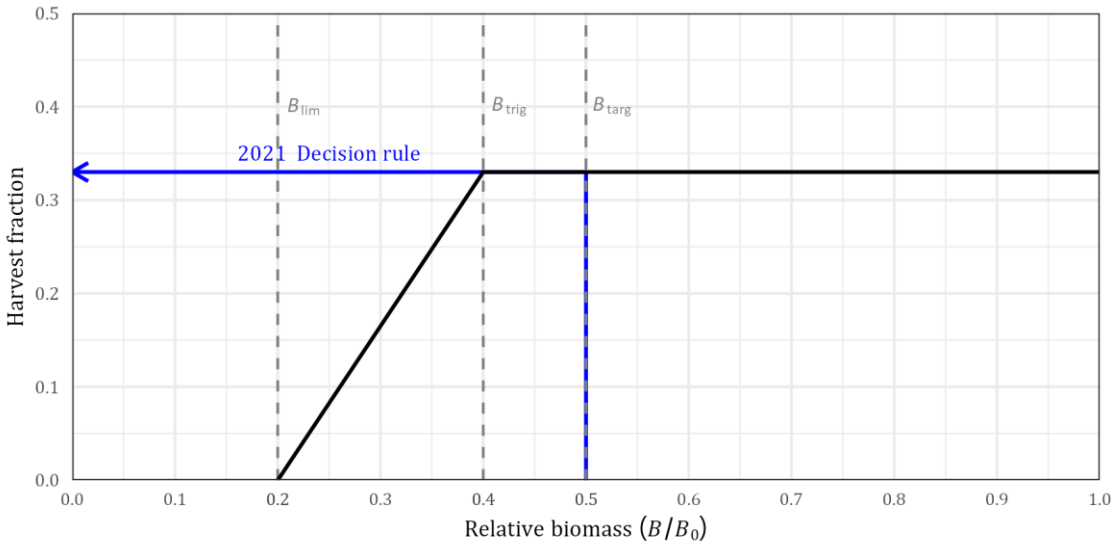

Figure 7: Application of the hockey stick rule to the 2021/22 relative biomass of the Southern Calamari Spencer Gulf stock.

Table 4: Harvest strategy outputs from the 2021/22 assessment of the Southern Calamari Spencer Gulf stock.

Year	Fishable biomass	Relative biomass	Decision rule harvest fraction	RBCC	TACC
2021	640	0.5	0.33	212	170

Summary of examples

Although the applications of the HSF presented here are examples only and have no bearing on the management of these stocks, it is useful to illustrate how the TACCs determined from these examples compare to the actual TACCs that were determined for the 2023/24 fishing year (Table 5).

Table 5: Comparison of TACCs determined from application of the HSF to actual TACCs determined for the 2023/24 fishing year.

Species	Stock	Tier	TACC		Difference
			Actual determination	HSF application	
KGW	SG	1	122.72 t	98 t	-20.1%
YFW	GSV/KI	2	*Not applicable (Tier 2 stock)*		
Southern Calamari	SG	1	211.45 t	171 t	-19.1%

Note that when recommending the 2023/24 TACCs, the MSFMAC agreed that, because there were no changes to stock status and that the HSF was in development, there was no basis to change the catch limits that were in place for the 2022/23 season for all stocks except for Snapper in the South-East.

Although the 2023/24 TACC for the KGW SG stock remained the same as the previous year, the MSFMAC noted a decline in recruitment and subsequent small decline in estimated biomass in recent years. For the Southern Calamari SG stock, the 2023/24 TACC was determined without accounting for any of the uncertainty that exists with these data, whereas this is explicitly recognised under the HSF

through application of a buffer (of 20%). Therefore, for different reasons, the lower TACCs (by ~20%) determined in the example applications are consistent with considerations of the MSFMAC.

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