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Reducing the number of undefined species in the Status of Australian Fish Stocks Reports: Phase one - categorising "undefined" species and addressing the description of this stock status in the nationally agreed classification framework

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Executive Summary

The Status of Australian Fish Stocks (SAFS) reports are relatively new reports which, for the first time in Australian fisheries management, brings together the best available biological, catch and effort information to determine the status of Australia's wild catch fish stocks against a nationally agreed reporting framework. The FRDC National Priority 1 targets of the FRDC Research, Development and Extension plan 2015-20 include two elements relevant to the undefined category in this nationally agreed reporting framework. The first is to increase the number of species covered in SAFS to 200 by 2020. The second is to reduce the percentage of species classified as undefined to less than 10 per cent by 2020. Given that a greater proportion of the additional species to be introduced are likely to be data-limited, since major stocks by value are already included in SAFS, meeting these two targets simultaneously by 2020 poses some challenges.

To address this issue, a project was funded to: (i) Develop and assign categories for the "undefined" classification in SAFS; (ii) Provide improved description of and guidance for the "undefined" classification in SAFS; and (iii) Review how "negligible" catch is addressed in SAFS and provide clear description and Guidance.

The authors reviewed the Undefined and Negligible stocks in the SAFS report. Of the 49 undefined stocks, 19 were potentially assessable, 22 stood as undefined, and 8 could potentially be classified as Negligible catch (Table 2). The number judged potentially assessable may be somewhat inflated, because the authors considered that Murray Cod was assessable, but should be assessed as a single stock (consistent with the text on stock structure in the SAFS report), rather than as 5 separate stocks divided by state and territory. If the authors' judgement about stock structure for Murray Cod was to be accepted, then the total number of undefined stocks would be 45, with 15 potentially assessable, 8 negligible, and 22 undefined. Very few of the reports for the undefined stocks explain whether either fishing mortality (F) or biomass (B) could be assessed. Most reports just point to problems with the data or information and then state that this results in an inability to assess and therefore an undefined classification. The authors used their expert judgement, based on a reading of each report, to judge whether the stock was classified as undefined because F could not be estimated, B could not be estimated, or both. Based on this judgement, they found that 27 were undefined for both F and B, 16 undefined for B, but could possibly be defined for F, and 6 were undefined for F, but could possibly be defined for B. The authors provide added descriptions and guidance for the undefined classification in SAFS, including some discussion on the wording of what constitutes confidence in an assessment. The authors agree with all 19 of the Negligible stock classification, but provide some commentary on why they propose that the "cross-jurisdictional" component of the Negligible catch definition in the proforma should be either deleted or demoted to optional.

This report was compiled for the SAFS Advisory Group to inform the SAFS classification framework and help progress discussion in relation to moving forward to reduce the number of undefined stocks in SAFS as more data-limited species are incorporated over time. These findings will be presented at the May 2017 SASF Advisory Group meeting.

Keywords

Stock status; Status of Australian Fish Stocks, SAFS; Undefined; Negligible; Confidence

Introduction

Background

The stock status classification system for the Status of Australian fish stocks (SAFS) consists of Nationally agreed categories intended to capture the range of potential stock conditions, from sustainable to overfished (Reference 1 and 2). In addition, a classification category "undefined stock" is available for stocks where there is not enough information available, or where conflicts in current information make it difficult to confidently determine stock status. The use of an undefined stock category allows important species to be included in the SAFS reports, despite there being limited or conflicting information on their status. At the same time, consistently and clearly classifying as many SAFS stocks as possible will ensure that the reports are of maximum value to stakeholders and the wider public. SAFS also plays an important role in highlighting stocks that may require additional data collection, research or assessment to be completed so that their current status can be classified. The 2014 SAFS report covered 68 species and 238 stocks, with 68 (29 per cent) of those stocks classified as undefined. The 2016 SAFS report covered 294 stocks over 83 species. Of the 232 stock status classifications that could be assigned from the 294 stocks that were assessed, 49 stocks (17 per cent) were classified as undefined. Although the proportion of stocks classified as undefined is quite high, these stocks account for less than 5 per cent of the total catch of species considered by SAFS.

Need

The FRDC National Priority 1 targets include two elements relevant to the undefined category. The first is to increase the number of species covered in SAFS to 200 by 2020. The second is to reduce the percentage of species classified as undefined to less than 10 per cent by 2020. Given that a greater proportion of the additional species to be introduced are likely to be data-limited, since major stocks by value are already included in SAFS, meeting these two targets simultaneously by 2020 poses some challenges. While the longer-term need is to be able to accurately assess the status of more stocks, the shorter-term need is to gain a better understanding of why the 49 stocks classed as undefined in SAFS 2016 could not be assigned a status category. Preliminary examination of the reports for these 49 stocks suggests that there are several different reasons for their undefined classification. There is a need to better understand these reasons, divide them into categories, and assign the current 49 stocks to these categories. There is also a need to provide clearer guidance to SAFS authors about use of the undefined classification.

Objectives

1. Develop and assign categories for the "undefined" classification in SAFS.
2. Provide improved description of and guidance for the "undefined" classification in SAFS.
3. Review how "negligible" catch is addressed in SAFS and provide clear description and Guidance.

Methods

The project team reviewed the chapter reports that include the 49 stocks classified as undefined in the 2016 SAFS report, and identified the separate classes of reasons for these classifications. Consideration was given to the types of data available for each undefined stock, and the project staff used their expertise to assess whether assessment methods exist that might be able to assign a status classification in the future, for either Biomass (B) or Fishing mortality (F), or for both.

After examining the 49 stocks in the relevant species chapters; the project staff identified several categories corresponding to different reasons for undefined classification, which were organised into an evaluation framework. This framework was used to assign the 49 undefined stocks to these categories

The project team also reviewed the existing descriptions and guidance for both the undefined and negligible classifications, to identify ways to improve the information available to SAFS authors, and to the public, on the undefined stock classification. In doing so, they also consulted with colleagues (see Acknowledgements) on aspects of this information and guidance.

Results

Objective 1. Develop and assign categories for the undefined classification in SAFS

Assigning stocks to categories in the SAFS framework involves assessing status for both fishing mortality F and biomass B (or their proxies). F and B are always estimated with uncertainty, arising from uncertainties in both data and assumptions. We identified several sources of uncertainty that are commonly found in assessing stock status, which, either in combination or if severe enough, can give rise to an undefined status in the SAFS framework. These sources include uncertainty arising in catch data, in effort data, from significant levels of recreational or indigenous fishing, in stock structure, in knowledge of the biology and productivity of the species, and uncertainty arising from significant environmental or anthropogenic (other than from fishing) forcing. Uncertainty in catch and effort data was further classified as arising from:

1. Catch
    a. Problems with species identification
    b. Catch reported at group rather than species level
    c. Lack of data for some gears or sectors
    d. Catch time series incomplete
    e. Confidentiality issues (e.g. 5 boat rule)
    f. Caught outside Australian jurisdiction
2. Effort
    a. Part of multispecies fishery
    b. Variable targeting
    c. Changes in catchability
    d. Changes in spatial distribution of effort

e. Multiple fisheries and gears

This led to the following framework of factors used to assess the reasons for undefined status in SAFS stocks (score numbering provided in brackets):

Reasons for undefined status

1. Commercial catch data incomplete or uncertain
    a. Problems with species identification (1A)
    b. Catch reported at group rather than species level (1B)
    c. Lack of data for some gears or sectors (1C)
    d. Catch time series incomplete (1D)
    e. Confidentiality issues (e.g. 5 boat rule) (1E)
    f. Caught outside Australian jurisdiction including high seas (1F)
2. Commercial effort data uncertain
    a. Part of multispecies fishery (2A)
    b. Variable targeting (2B)
    c. Changes in catchability (2C)
    d. Changes in spatial distribution of effort (2D)
    e. Multiple fisheries and gears (2E)
3. Important or significant recreational or indigenous catch or effort (highlight which) (3)
4. Stock structure uncertain or inappropriate (4)
5. Biology and productivity uncertain or changing; or range changing (5)
6. Significant environmental or anthropogenic forcing (6)

In evaluating the information provided for each of the 49 undefined stocks, we also considered:

SAFS Assessment options

1. SAFS potentially assessable (1)
2. Undefined (2)
3. Should be classified as negligible (3)

SAFS Assessment refinements

1. Undefined B (but can define F) (1)
2. Undefined F (but can define B) (2)
3. Undefined B and F (3)

Additional comments

1. Management measures thought to be ineffective (1)
2. Stock is managed by a well-defined harvest strategy (2)

The first of these classifications (SAFS assessment options) considers the undefined status for each stock. The stock is scored as “SAFS potentially assessable” if, in our expert judgement, we considered

that it might be possible to assign a SAFS status, based on the information currently available, using either alternative assessment methods, or different judgements in a weight of evidence approach. For some stocks, we considered that a negligible classification might be more appropriate.

The second of these classifications (SAFS Assessment refinements) is used to identify what the chapter authors considered was not assessable (i.e. either F, or B, or both). In most instances, this distinction is not stated explicitly in the stock reports, so we based this evaluation on the text provided. Identifying situations where either F or B could be assessed would not change the SAFS undefined classification, but it would provide useful information that could be added to the stock reports.

The third classification (Additional comments) identifies additional features in each stock report, relating to management measures, which seem relevant to overall SAFS classification.

Using this evaluation framework, we compiled a document containing the following information for each of the 49 undefined stocks:

1. Stock structure information copied from the SAFS web site
2. The fishery and assessment text also copied from the SAFS web site
3. The time series of commercial catch data for the stock (provided by FRDC)
4. The average catch over the time series
5. Our general comments and summary of information
6. Our scores against the evaluation framework

The evaluation scores for each of the 49 stocks are shown in Table 1. Summary statistics for each of the four evaluation components (SAFS Assessment options, SAFS Assessment refinements, Reasons for undefined status, and Additional comments) are shown in Tables 2 to 5.

Table 1. Evaluation scores for each of the undefined stocks. See methods for explanation of numbering

Undefined Stock	SAFS Assessment Option	SAFS Assessment refinements	Reasons for undefined status	Additional comments
1. Banded Morwong, Victorian Banded Morwong Fishery (M), Victoria	2	3	1E, 2A, 2C	
2. Black Jewfish, Gulf of Carpentaria (M), Queensland	2	3	1B, 1D, 2A, 3, 4	1
3. Black jewfish, Queensland East Coast (M), Queensland	3	3	2A, 2B, 3, 4	1
4. Blacktip sharks, Gulf of Carpentaria (B), Northern Territory and Queensland	2	3	1B, 2A	
5. Blue Swimmer Crab, West Coast (B), South Australia	2	1	2A, 2B	
6. Commercial Scallop, Bass Strait Central Zone Scallop Fishery (M), Commonwealth	2	3	2D, 6	2
7. Commercial Scallop, Ocean Scallop Fishery (M), Victoria	2	1	2D, 6	
8. Commercial Scallop, Tasmanian Scallop Fishery (M), Tasmania	2	3	2D, 6	2
9. CORAL TROUTS, Gulf of Carpentaria (M), Queensland	3	3	1B, 2A, 2B, 3, 4	
10. Crimson Snapper, East Coast Queensland (B), Queensland	2	3	1B, 3	
11. Dusky Flathead, New South Wales (J), New South Wales	1	1	2E, 3	
12. Dusky Whaler, Eastern Australia (B), Commonwealth and NSW	2	3	1D, 2A, 2B, 2E	
13. Eastern School Prawn, Victoria (J), Victoria	3	3	4, 5, 6	
14. ENDEAVOUR PRAWNS, Northern Prawn Fishery (Red Endeavour Prawn) (M), Commonwealth	1	1	2A, 1B, 2B, 5	
15. Giant Crab, Giant Crab Fishery (Victoria) (M)	1	1	1E, 2A, 2D, 5	
16. Giant Crab, South Australia (J), South Australia	1	1	2B	
17. Goldband Snapper, East coast Queensland (M), Queensland	2	1	1D, 2A, 4	1
18. Golden Snapper, East coast (M), Queensland	2	3	2A, 3, 4	
19. Greenlip Abalone, South Australian Southern Zone Fishery (M), South Australia	1	3	2B	2
20. Gummy Shark, Eastern Australia (B), New South Wales	3	3	2A	
21. MUD CRABS, Estuary General Fishery (M), New South Wales	2	3	2A, 4	
22. Mulloway, Queensland (J), Queensland	2	3	2A, 3	
23. Murray Cod, Australian Capital Territory (J), Australian Capital Territory	1	2	3, 4, 6	
24. Murray Cod, New South Wales (J), New South Wales	1	2	3, 4, 6	
25. Murray Cod, Queensland (J), Queensland	1	2	3, 4, 6	

Undefined Stock	SAFS Assessment Option	SAFS Assessment refinements	Reasons for undefined status	Additional comments
26. Murray Cod, South Australia (J), South Australia	1	2	3, 4, 6	
27. Murray Cod, Victoria (J), Victoria	1	2	3, 4, 6	
28. Orange Roughy, Great Australian Bight (M), Commonwealth	1	1	2B, 2D, 6	
29. Pale Octopus, Victoria (J), Victoria	2	3	1A, 1B, 1C, 2A, 2E, 4	
30. Pipi, New South wales (J), New South Wales	1	3	2B, 2C, 2D, 3	
31. Pipi, Victoria (J), Victoria	2	3	2B, 3	
32. Red Emperor, East Coast Queensland (M), Queensland	2	1	2A, 2E, 3	
33. Red Emperor, Gulf of Carpentaria (M), Queensland	1	3	2A, 2B, 2E	
34. Red Emperor, Northern Territory (J), Northern Territory	1	1	2A	2
35. Saddletail Snapper, East Coast Queensland (B), Queensland	2	1	2A, 2D, 2E, 3	
36. Sandbar Shark, Eastern Australia (B), New South Wales and Queensland	2	3	1A, 1D, 2A	
37. Silver Trevally, Queensland (J), Queensland	2	3	1B, 1E, 2A, 2E, 3, 4	
38. Silver Trevally, Tasmania (J), Tasmania	3	1	2B, 2E	
39. Silver Trevally, Victoria (J), Victoria	1	1	2A, 2B, 2E, 3	
40. Silverlip Pearl Oyster, Northern Territory (J), Northern Territory	1	1	1D, 4	
41. Snapper, East Coast (B), New South Wales, Queensland and Victoria	1	3	2A, 2B, 2D, 3	1
42. Snook, Tasmania (J), Tasmania	2	1	2B, 2E, 4, 5	
43. Snook, Victoria (J), Victoria	2	3	1B, 1E, 2A, 2E	
44. Southern Calamari, Commonwealth (J), Commonwealth	3	3	2A, 2C, 4	
45. Southern Garfish, South Coast WA (B), Western Australia	1	1	2A	
46. Southern Garfish, South-East (B), South Australia	3	3	1E, 2B	
47. Southern Garfish, West coast (South Australia) (B), South Australia	3	3	1E, 2B	
48. Swordfish, South-West Pacific Ocean (M), Commonwealth	1	2	1F, 2A, 2D, 2E, 5	2
49. Yellowtail Kingfish, Eastern Australia (B), Commonwealth	2	3	1F, 2A, 2B, 2E, 3	

SAFS Assessment options

Of the 49 undefined stocks, we found that 19 were potentially assessable, 22 stood as undefined, and 8 could potentially be classified as Negligible catch (Table 2). The number judged potentially assessable may be somewhat inflated, because we considered that Murray Cod was assessable, but should be assessed as a single stock (consistent with the text on stock structure in the SAFS report), rather than as 5 separate stocks divided by state and territory. If our judgement about stock structure for Murray Cod were to be accepted, then the total number of undefined stocks would be 45, with 15 potentially assessable, 8 negligible, and 22 undefined.

Table 2. Summary of SAFS assessment options scores

SAFS Assessment Options	Score	Total
SAFS potentially assessable	1	19
Undefined	2	22
Should be classified as negligible	3	8

It is important to note that our finding that 15 (or 19) stocks may be assessable is a judgement call, based on our own experience and a reading of the status reports combined with examining the catch trends. We are not experts in the stocks under review, and we are not necessarily saying that the authors of these stock reports have erred in their judgements. It will not be possible to judge the quality of our evaluation until further assessments are undertaken as part of phase 2 of the study to categorise undefined. Nevertheless, it is perhaps encouraging to note that a substantial fraction of the stocks currently classified as undefined might be assessable with further work.

Our assessment of possible negligible categorisation was based in part on the existing guidance about this category (Reference 3) but also on judgements about the significance of absolute catch levels. This is an issue that needs consideration, and is discussed further in the section of the results dealing with objective 2 of this study.

SAFS Assessment refinements

Very few of the reports for the undefined stocks explain whether either F or B could be assessed. Most reports just point to problems with the data or information and then state that this results in an inability to assess and therefore an undefined classification. We have again used our expert judgement, based on a reading of each report, to judge whether the stock was classified as undefined because F could not be estimated, B could not be estimated, or both. Based on this judgement, we found that 27 were undefined for both F and B, 16 undefined for B, but could possibly be defined for F, and 6 were undefined for F, but could possibly be defined for B (Table 3). The ratio of the latter two figures is not surprising given that, for most data-limited stocks, it is generally easier to estimate F than to estimate B. What the analysis does illustrate though, is that for a considerable proportion of the stocks currently classified as undefined, it might be possible to say something about sustainability with regard to either F or B.

Table 3. Summary of SAFS assessment refinements scores

SAFS Assessment Refinements	Score	Total
Undefined B (but can define F)	1	16
Undefined F (but can define B)	2	6
Undefined B and F	3	27

Reasons for undefined status

The categorisation for this component of the evaluation addresses directly the first objective of this study, which is to identify the reasons why stocks are undefined. Table 4 illustrates some interesting patterns.

Table 4. Summary of Reasons for undefined status scores

Reasons for Undefined Status	Score	Total
Problems with species identification	1A	2
Catch reported at group rather than species level	1B	8
Lack of data for some gears or sectors	1C	1
Catch time series incomplete	1D	5
Confidentiality issues (e.g. 5 boat rule)	1E	6
Caught outside Australian jurisdiction including high seas	1F	2
Part of multispecies fishery	2A	28
Variable targeting	2B	18
Changes in catchability	2C	3
Changes in spatial distribution of effort	2D	9
Multiple fisheries and gears	2E	13
Important or significant recreational or indigenous catch or effort	3	20
Stock structure uncertain or inappropriate	4	17
Biology and productivity uncertain or changing; or range changing	5	5
Significant environmental or anthropogenic forcing	6	10

One interesting finding is that stocks are about three times more likely to have uncertainty in effort than in catch (71 reason-stock combinations to 24). For effort, the most common reason was that the species was taken as part of a multispecies fishery. This makes effort hard to assign to a particular species, and generally requires considerable analytical effort and resources to disentangle. It is perhaps not surprising that this effort is not made for many of the undefined stocks, particularly those with relatively low catches and low value. Other issues of note for effort data include variable targeting, and cases where the species is taken in multiple fisheries or by multiple gears. Problems in defining effort lead directly to problems in estimating and using catch per unit effort (CPUE), which is in turn one of the

most common bases for assessing trends in biomass. This is consistent with the finding in the previous component (SAFS assessment refinements) that B is undefined more commonly than F. The least likely reason for problems with effort was 2C (changes in catchability). This may be an artefact of this issue simply not being considered where other problems with effort are more obvious and may increase as species are added that may not have similar stocks that are more data rich from which one can draw information.

Problems with catch data were spread across all reasons, with the most frequent being catch reported at group rather than species level (1B). For 32 of the 49 stocks, no issues with commercial catch data were identified (but note category 3 on recreational catches below), compared with only 8 stocks that had no issues with effort.

Of the other reasons leading to uncertainty in status determination, the most common was a significant component of recreational catch, with uncertainty about stock structure also common (Table 4). The importance of environmental forcing was identified for 10 stocks, but 3 of these were scallops and 5 were Murray Cod. The only other stock where environmental forcing was considered a significant factor contributing to uncertainty was Orange Roughy (GAB). The least commonly encountered of the other reasons was uncertainty about biology, productivity, or range change. The latter may not have been closely examined in the species reports, but may be significant for some species and may impact on stock structure and negligible status determination. Given climate change predictions, this category may become more important over time.

Additional comments

Some of the stock reports identified aspects of stock management that seemed relevant to status determination. We identified two categories here – either comments that existing management measures were thought to be ineffective (e.g. size limits not protecting spawning stock), or, on the positive side, that well-defined harvest strategies were in place. We identified 4 instances of the former and 5 of the latter (Table 5). Not evaluated, but also of possible relevance, are instances where well-defined recovery strategies are in place (e.g. Murray Cod).

Table 5. Summary of additional comments

Additional Comments	Score	Total
Management measures thought to be ineffective	1	4
Stock is managed by a well-defined harvest strategy	2	5

Objective 2. Provide improved description and guidance for the undefined classification in SAFS

Text and guidance on undefined stocks occurs in the species chapter template (Reference 4). This document states (page 5) that:

> *"Stocks should be classified as undefined when there is insufficient information available to confidently assess either biomass size (or likely biomass size) <u>OR</u> the adequacy of control over fishing pressure"*

A key word here is “confidently”. The issue is that interpretation of this word is left to the judgement of chapter authors, and this judgement may well vary across authors and therefore across stocks and species. In our review of the 49 stocks under Objective 1 of this study, we detected apparent differences in approaches to uncertainty or confidence. This variation is likely to arise particularly where data are limited and weight of evidence approaches are required in the absence of the availability of quantitative stock assessments. The SAFS review process may not pick this up either, unless reviewers are examining a large range of species. Some further guidance on what is meant by “confidently” may be required, but we acknowledge that this is an inherently difficult issue to deal with in a clear and objective manner. Nevertheless, we make an attempt to provide such guidance (see Appendix 1). “Confidently” should probably be seen through a weight of evidence, rather than a data rich stock assessment lens.

Reference 4, Attachment B, Table 1 provides recommended language for undefined stocks where either B or F are too uncertain for status determination (page 15). The guidance provides alternatives for both biomass description and fishing pressure description, as follows:

Biomass description

Either:

The assessment of the current level of biomass ([reference]) is considered to be too uncertain to use for status determination.

Or:

There is insufficient information available to confidently classify the status of this stock.

Fishing pressure description

Either:

The assessment of the current level of fishing pressure ([reference]) is considered to be too uncertain to use for status determination.

Or:

There is insufficient information available to confidently classify the status of this stock.

Our experience in reviewing the 49 undefined stocks is that the second alternative (Or) was used in every case, and there was no attempt made to separately identify whether either B or F could be confidently assessed. This seems to be a pity in two respects. First, it does not require the authors to state clearly just where the problems lie and which particular factors lead to a lack of confidence and whether this could be addressed in the future. Our observation is that in most reports, the authors outline what is known about the stocks, identifying problems where they exist, but then move directly to the “Or” statement without clearly drawing the links and reasoning. The second issue has already been alluded to in the results for Objective 1 of this study. It would seem useful to identify stocks where there is sufficient information to assess either F or B (but not both), even if this still leads to an undefined status.

A solution to both these issues would be to remove the “Or” option in the status summary, and also to require a much clearer statement about uncertainty in assessing both B and F for undefined stocks. We suggest specific text in Appendix 2.

Objective 3. Review how "negligible" catch is addressed in SAFS and provide clear description and guidance

Reference 3 provides a template and rationale for assigning stocks to negligible catch status. Reference 3 states:

> *“On a case by case basis, a stock status assessment may not be justifiable for some stocks identified for a species. These stocks must have a historically low to negligible catch, must be generally not targeted and must not be part of a cross jurisdictional stock. The reports should note the estimated level of catch for such stocks (if known), but would not undertake a status assessment”*

The 13 negligible stocks are summarized in Table 6. All the negligible stock conforms to the low catch and no targeting rule. In three of the 13 negligible stocks, the jurisdiction authors were less sure about the cross-jurisdictional nature of the stock. We agree with the classification of all the 13 negligible stocks. There does seem to be less difficulty in classifying this group, compared to classifying undefined, as the bar is high to conform to the negligible stock classification. This means that there is a tendency to place a stock in the undefined or one of the assessed classifications, unless it very clearly conforms to the rules for the negligible classification. Given our comments on the undefined classification, and that of the stocks we reviewed there, we would have classified several as negligible, there does seem to be some question with regard to the rules for negligible classification. The main one is the cross-jurisdictional rules as discussed further below.

Table 6. Summary of information provided by jurisdictions as motivation for negligible stocks. Last column are comments added by the authors. The score out of 3 is whether they conformed to each of the 3 rules for negligible (low or negligible catch (C), not targeted and not cross-jurisdictional -CJ)

Name of species and stock	Jurisdiction	Historical catch description	Confirmation not targeted	Cross-jurisdictional	Assessment
1. Balmain Bug (*Ibacus alticrenatus, I. brucei, I. chacei, I. peronii*) – negligible in the 2014 SAFS report	WA	max 0.3 min 0	Balmain Bug – this stock is generally not targeted by commercial fishers and not recorded by charter operators or in recreational surveys	Balmain Bug – this species is not managed as a cross jurisdictional stock	Negligible C; not targeted; not CJ (3/3)
2. Balmain Bug (*Ibacus alticrenatus, I. brucei, I. chacei, I. peronii*) – negligible in the 2014 SAFS report	Vic	Since 2000/01 the average annual catch has been 15 tonnes for Victoria (mostly taken off the east coast) with a maximum of 40 tonnes in 2001/02 and a minimum of 4 tonnes in 07/08. Over the last 5 years the total annual catch has ranged between 10 and 16 tonnes.	This species is taken as part of a multi-species fishery which does not specifically target bugs. This fishery also lands prawns, crabs and a variety of finfish species.	Balmain Bug – this species is not managed as a cross jurisdictional stock.	Low C; not targeted; not CJ (3/3)

Name of species and stock	Jurisdiction	Historical catch description	Confirmation not targeted	Cross-jurisdictional	Assessment
3. Balmain bug (*Ibacus peronii*). The stock structure of this species along the southern coast of Australia is unknown. Management units are the individual Spencer Gulf and Gulf St Vincent prawn fisheries.	SA	Annual total catch of *I. peronii* from SA has averaged 5.2 tonnes in the last 10 years (2006¬–2015) and has not reached 10 tonnes in any of these years.	This species is landed by the three prawn trawl fisheries as by-product and is not taken by any other fishing method. Over the last 10 years, the ratio of Balmain bugs harvested to the targeted Western King Prawns is ~0.2% by weight; such a low percentage is evidence that this species is not targeted.	The stock structure of *I. peronii* along the southern coast of Australia is unknown. Nevertheless, this species is not considered part of a cross-jurisdictional stock and, because landings are so small, *I. peronii* is not assessed.	Low C; not targeted; not CJ (3/3)
4. Barramundi (*Lates calcarifer*) – South East Queensland (south of 26 Degrees), limited suitable habitat; no genetic information; maybe a marginal/sink population; inclusion with the Central Queensland genetic stock tends to skew the catch per unit effort due to the incidental nature of the catch.	South-east coast	Historical catch (1988-2015) between 0 and 5.5 t – highest catch in 2003. It has had an average harvest of 123 kg over the last 10 years. It was accepted as negligible for SAFS in 2013. Reported catch since was 40kg 2014 and 0kg in 2015.	Stock is not targeted by commercial/recreational or charter fishers – occasional catches of small numbers by net or line when targeting other species	Occurrence in New South Wales is considered to be extralimital only and is not assessed therefore does not cross jurisdictional boundary.	Low C, not target, not cross-jurisdictional; stock at catchment level (3/3)

Name of species and stock	Jurisdiction	Historical catch description	Confirmation not targeted	Cross-jurisdictional	Assessment
5. Blacklip abalone (*Haliotis rubra*) – not included in the 2014 SAFS report	WA	max 0.4 min 0	Blacklip abalone – this stock is generally not targeted by commercial fishers and not recorded by charter operators. Very small catches by recreational fishers recorded in recreational surveys.	Blacklip abalone – this species is not managed as a cross jurisdictional stock	Negligible C; not targeted; not CJ (3/3)
6. Tiger prawn (*Penaeus esculentus*)	NSW	Historical commercial catch is small (2009/10 to 2014/15) between 3.5 and 8.7 t p.a. Not a major component of recreational landings.	Stock is not targeted by commercial/recreational or charter fishers	Biological stock structure is unknown	Low C; not target, stock unknown (3/3)
7. Pale Octopus (*Octopus pallidus*). There is no information regarding the stock structure of O. pallidus in South Australian waters.	SA	South Australian commercial fishers who target octopus do not discriminate between species. Historic Statewide catches, which have rarely exceeded 10 t, are comprised of multiple octopus species including Maori Octopus (*O. maorum*), Pale Octopus (*O. pallidus*) and Southern Octopus (*O. australis*).	There have only been two years in the last decade where >5 fishers have specifically targeted octopus. Of those a single fisher has typically accounted for the majority (>80%) of the targeted catch.	It is suggested that the Pale Octopus is a highly structured biological stock with discrete subpopulations in Bass Strait (<100 km apart) due to their limited dispersal potential. However, further work is required to confirm the overall population structure along southern Australia. For the purposes of the SAFS assessment the stocks have been assessed at a jurisdictional level.	Low C; multiple spp, rarely targeted; may be/not CJ (2 or 3/3)

Name of species and stock	Jurisdiction	Historical catch description	Confirmation not targeted	Cross-jurisdictional	Assessment
8. Snook (*Sphyraena novaehollandiae*)	NSW	Historical commercial catch very small (2009/10 to 2014/15) between 20 and 72 kgs p.a. Not a major component of recreational landings.	Stock is not targeted by commercial/recreational or charter fishers	Unknown – suspect it is part of the Victorian stock	Low C, not target, may be CJ (2 maybe 3/3)
9. Southern sand flathead (*Platycephalus bassensis*) – negligible in the 2014 SAFS report	WA	"remove" NULL	Southern sand flathead – this species has never been recorded in commercial logbooks, charter logbooks or recreational surveys (it possibly could be one of the species not identified under the general flathead category)	Southern sand flathead – unknown stock in WA	Negligible C; not targeted; not CJ (3/3)
10. Southern Sand Flathead (*Platycephalus bassensis*) – South Australia	SA	The species is rare in South Australia. It is not individually differentiated in the catch returns of commercial fishers. Nevertheless, between 2005 and 2015 the annual State-wide catches for all flathead species combined (including Southern sand flathead if any were caught) only ranged from 0.7 to 5.7 t.	Commercial catch returns indicate that the low catches across all species of flathead are taken when other species such as King George whiting and snapper are being targeted. As such, it appears that flathead of all species are rarely targeted.	The previous SAFS report indicated that the biological stock structure for this species has not been addressed using genetic or other techniques. In the absence of information about stock structure and because each of the jurisdictions have different management arrangements, status was reported at the jurisdictional level.	Neg to Low C; not targeted; may be CJ but at juris level (2 or 3/3)
11. Spotted Mackerel (*Scomberomorus munroi*) – new for the 2016 SAFS report	WA	Max 2.2 min 0	Spotted Mackerel – this stock is generally not targeted by commercial fishers. Very small catches taken by charter operators (1149 individuals	Spotted Mackerel – this species is not managed as a cross jurisdictional stock	Negligible C; not targeted; not CJ (3/3)

Name of species and stock	Jurisdiction	Historical catch description	Confirmation not targeted	Cross-jurisdictional	Assessment
			retained since 2000) and recorded in recreational surveys.		
12. Ornate rock lobster (*Panulirus ornatus*) – negligible in the 2014 SAFS report	WA	Max 0 min NULL	Tropical Rocklobster – this stock is generally not targeted by commercial fishers. Very small catches taken by charter operators (504 individuals retained since 2000) and recorded in recreational surveys.	Tropical Rocklobster – this species is not managed as a cross jurisdictional stock	Negligible C; not targeted; not CJ (3/3)
13. Vongoles (Mud Cockle) (*Katelysia* spp) – new for the 2016 SAFS report	WA	Max 1.5 min 0	Vongole (Mud Cockle) – this species occurs in inlets on the south coast when conditions are favourable but disappears in years of high freshwater flushing of these systems. There is a general commercial ban on the take of this species in WA. During the 1990s exemptions to take this species was given to a couple of operators however since the exemptions expired no requests have been made to renew. Catch reporting during the exemption period is uncertain. Anecdotal information of very small catches by recreational fishers but not recorded in recreational surveys.	Vongole (Mud Cockle) – this species is not managed as a cross jurisdictional stock	Negligible C; not targeted; not CJ (3/3)

As part of this study, we sought opinions from colleagues on both the template, and on the issue of whether threshold catch levels should also be identified corresponding to negligible catch status, and if so at what levels of catch. The question of thresholds elicited several responses:

- Tonnage values would need to be different for finfish, molluscs and crustacea, due to large differences in value per tonne among groups (and sometimes among species within groups).
- A "guide" tonnage may be useful, but not a set tonnage, and decisions about assigning negligible status should still be referred to the SAFS Advisory Committee.
- It was noted that there are around 600 fish stocks in New Zealand of which almost half (292) are removed from status reporting as they are considered nominal stocks (TACC or catch less than about 10 t per year, or other indications of no proven development potential).
- Noting that the intended increase in number of species considered to about 200 will likely increase the focus on the negligible category, this needs to be defined with greater transparency.
- One suggestion is to set a proportional based threshold, e.g. negligible catch is less than x% of the total Australian commercial catch, rather than a fixed tonnage as an average over the past 10 years.

Regarding thresholds, the options seem to be:

1. A fixed tonnage threshold, which would vary for different taxa
    a. e.g. 10 t for finfish, 2 t for molluscs, 4 t for crustacea
2. A proportional threshold, as a percent of total Australian commercial landings
    a. e.g. The average catch from the stock or jurisdiction is 5% of total Australian commercial landings
3. A fixed value threshold
    a. e.g. Landed value of less than $20K per year
4. A combination of the above, e.g., 1 and 2 or 1 and 3

This issue is being discussed, albeit in a slightly different context, by the Commonwealth which is trying to find objective approaches to define what constitutes a byproduct species. In the South-east Scalefish and Shark Fishery (SESSF), plots of cumulative percentage of GVP and catch by individual species were created, where these were then used to categorise species as Primary target (>1.7% GVP), a secondary target (0.5% < 1.7%), Byproduct (0.1% <0.5%) and Bycatch (<0.1%). Expert opinion was then used to refine this list (Reference 5). A similar approach was used for the Eastern Tuna and Billfish Fishery (ETBF), although the cut off numbers were different as the shape of the cumulative plot differed. A similar approach could be attempted here, although the above points regarding the relative differences in value and catch tonnage of finfish, molluscs and crustaceans would also need to be considered.

An alternative to defining thresholds might be the application of a risk-based method such as PSA to identify stocks which are clearly at low risk and therefore likely to be classified as "sustainable".

Combining such a risk-based approach with threshold levels may be the most appropriate way of determining negligible status.

Another issue in determining negligible status is how or whether to consider recreational and indigenous take for stocks where this is substantial relative to commercial landings.

An aspect of the definition of negligible that seemed unclear was the description of "must not be part of a cross jurisdictional stock". One interpretation of a cross-jurisdictional stock is that it is a common genetic stock but was separated on jurisdictional grounds e.g. Murray cod. Here one would rather expect the stocks to be assessed together and not be split by jurisdiction. However, the more common usage seems to occur when a stock is a small (probably) separate stock where one or more neighbouring jurisdictions have very healthy fisheries on the same species i.e. it appears on the list because of another jurisdiction's fishery which is not negligible, but it is deemed a separate stock. It does seem that there is some inconsistency in these cases in terms of its SAFS classification. Some have assessed these independently of the other jurisdiction and assessed the stock as negligible if the catch is low and no targeting of the species occurs. However, it appears that, more commonly, the species is classified as Undefined *because* it is a cross-jurisdictional species (here defined as a species that occurs in multiple jurisdictions but assessed separately). It is unclear why this would be the case and perhaps this requires more thought. If a stock is deemed separate, it should be assessed independently of other stocks of the same species and allowed to be classified as negligible, and if it is deemed as connected then these should be combined. It is also unclear whether the grey area of uncertain stock separation should default to separation and classification of a cross-jurisdictional stock, and therefore not negligible by definition.

Figure 1 (below) illustrates a case where the application of the cross-jurisdictional rule for Negligible can cause confusion and result in false negative status assignments. In this example, false negatives arise when a stock that should legitimately be assigned as Negligible is not assigned to this category, and would default to Undefined.

Three stock structure scenarios are illustrated in Figure 1. In all cases, it is assumed that the species is valuable in a fourth jurisdiction (not shown), which is why it is on the list of species to be assessed. However, the species' distribution also covers three additional States (e.g. Qld, NSW, Vic) where the catches in all of them are negligible and not targeted i.e. they conform to two of the three conditions for assigning Negligible status.

In the first scenario (left hand case in Figure 1), the actual stock comprises a single stock across all 3 jurisdictions. With perfect information about stock structure, it would be defined as 1 stock (correct), 1 Low Catch (correct), but cross-jurisdictional. The conclusion therefore would be to assess this stock as not conforming to the Negligible category, a false negative. With imperfect knowledge about the stock structure, the stock would likely be divided by jurisdiction resulting in 3 management areas, 3 low catches and 3 not cross-jurisdictional stocks, i.e. 3 stocks classified as Negligible when there should only have been 1 Negligible (but seems appropriate given the lack of knowledge, and not a false negative).

In the second scenario (middle case in Figure 1), there are 2 actual stocks with stock 1 in Qld and NSW; stock 2 in NSW and Vic. With perfect information, it would be defined as 2 stocks, 2 low catches and 2 cross-jurisdictional cases – the latter making it not Negligible, another false negative. With imperfect information, it would be defined as 3 management areas, 3 low catches and 3 not cross-jurisdictional stocks, leading to 3 Negligible stocks when it should have been 2 (but not a false negative).

Finally, scenario 3 (right hand case in Figure 1), has 3 separate stocks; 1 in Qld, 1 in NSW and 1 in Vic. With perfect information, there are 3 stocks, 3 low catches, 3 not cross-jurisdictional stocks, leading to defining 3 Negligible stocks (correct). With imperfect information, these would be 3 management areas, 3 low catches and 3 not cross-jurisdictional stocks, leading to 3 Negligible stocks (again correct).

In these scenarios, interestingly, the more that is known about the structure for a stock that crosses jurisdictional boundaries, the less likely is it to be able to place the stock correctly in the Negligible category. Only when stocks are truly separated by management areas, do both the perfect and imperfect information scenarios result in the same correct answer. Of course, these are simple examples and the reality is usually more complex. However, they highlight that the cross-jurisdiction rule can create false negative results, even (especially) where there is good information. In the scenario provided, if the cross jurisdictional rule is deleted, then Scenario 1: perfect information = 1 Negligible (correct), imperfect information = 3 Negligible (instead of 1); Scenario 2: perfect information = 2 Negligible (correct), imperfect information = 3 Negligible (when it should be 2); Scenario 3: perfect information = 3 Negligible (correct), imperfect information = 3 Negligible (correct)

As a result, it is recommended that the cross-jurisdictional rule be excluded or added only as an optional case.

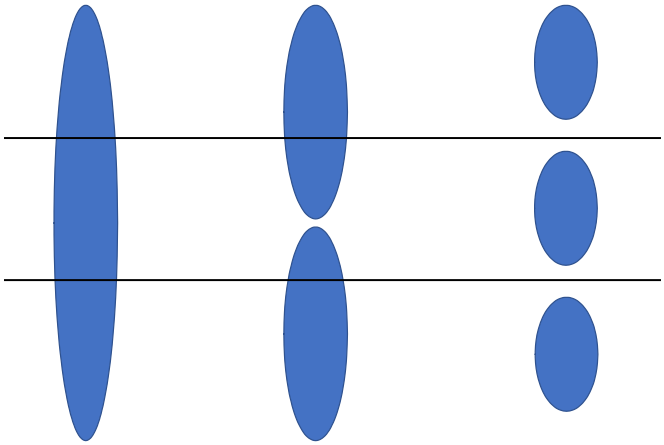

Figure 1. Three stock scenarios for a species whose distribution covers three jurisdictions – blue is the actual stock structure and each line is a jurisdictional boundary. See text for further explanation.

Discussion

As noted earlier in this report, uncertainty is a feature of all methods and attempts to define stock status, even where good data exist and quantitative stock assessments are possible. The SAFS reporting framework adopts a weight of evidence approach to stock status classification, requiring assessment of both biomass and fishing pressure, and requiring that these can be "confidently" assessed (Reference 4). Stocks are classified as undefined where the authors consider that they cannot confidently assess both biomass and fishing pressure, sufficient to provide a classification. Confidence (or its inverse, uncertainty) can rarely be estimated quantitatively, especially in weight of evidence approaches, so its evaluation is left to the judgement of the authors of the species reports, and this judgement is likely to be made differently by different authors. The review process and the SAFS Advisory Group may help improve consistency, but on reading the reports for undefined stocks there clearly is still progress to be made in this regard. Some guidance on the use of proxies for B and F was made available to authors in preparing the 2016 SAFS reports (Reference 1), with the advice that "if the available data and a particular analysis fails to provide any reliable or convincing basis for stock status classification, that status will remain undefined". With regard to the use of proxies, this guidance also states that "each data set should be critically evaluated to determine whether it can be considered to be representative, reliable and consistent over time". On the face of it, this sets quite a high bar for demonstrating "confidence" in any status determination. Other factors that can undermine confidence include the ability to identify limit reference points for proxy indicators, and situations where status from different lines of evidence is conflicting.

The framework we used to evaluate the 49 undefined stocks attempts to interrogate several (but arguably not all) aspects of data reliability and consistency. The primary focus was on catch and effort data. Time series of reliable catch data are needed for most assessment methods, and several new "catch only" assessment methods are potentially applicable to several of the currently undefined stocks (see review in Reference 6). Stocks with a large recreational catch are generally less certain about catch levels than those predominantly or entirely caught by commercial fisheries.

As pointed out in Reference 1, CPUE is widely used in assessments as a proxy for changes in biomass, so the focus on reliability and consistency of effort data is also important. Many of the undefined species reports pointed to the unreliability of effort data, often due to the stocks being part of multispecies and/or multi-gear fisheries, and this was a major feature limiting better assessment for these stocks. Our findings show that uncertainty about effort is in most cases a greater problem than uncertainty about catch.

Most of the stocks examined were undefined due to limitations in data (type, quantity and reliability), but in a couple of cases much more data were available although the authors still assigned them as undefined. We examined these in a more detail and in several cases concluded that status assignment could be possible (based on the descriptions of information in the status reports and our own expert judgement – while acknowledging that we are not experts in those particular species). We discuss two of these species in a bit more detail here.

The reports for undefined stocks 6, 7 and 8 – commercial scallops – emphasize that a lot of research effort and management focus have been brought to bear on this species. Nevertheless, these stocks are classified as undefined, and we agree with this classification. This is because it is extremely difficult to assess biomass for this highly spatially patchy and intermittently recruiting species, and likely always will be, even with a very large monitoring and research effort. However, two of these

stocks (6 and 8) have highly developed and well-thought-through harvest strategies in place, while the fishery for the other is effectively closed. This means that fishing pressure is very closely monitored and controlled and clearly sustainable. It is problematic that these stocks are likely to remain undefined, with no information on status available to the public and stakeholders, even though catches can be considered to come from well-managed fisheries. This is a particular problem given that they are (at times) high volume, clearly high value, and of considerable consumer interest. This case emphasizes the problems (in some instances) of requiring confidence in status on both F and B, and the potential benefits of finding a way to report on cases where there is confidence in one or the other. There would also be further benefit in reporting that a fishery is managed using harvest strategies.

The second case concerns Murray Cod (stocks 23 to 27). We are not experts on this species, but reading the extensive reports, several issues emerge. First, despite noting that there is effectively a single biological stock in the entire Murray-Darling basin, the decision is made to report at jurisdictional level. This really makes no sense, particularly for immediately adjacent jurisdictions sharing the same stretches of important rivers such as the Murray (e.g. Victoria and NSW). Second, the species is currently listed as vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), a process that previously assessed status in some detail, and currently requires stringent management actions aimed at stock recovery, which have been in place for some time, and show some evidence of success, at least locally. Despite the undoubted uncertainties arising from uncertainty in catches and variations in management measures by jurisdiction, clear evidence of past depletion (to 10 per cent of unfished levels) combined with recovery management and some evidence of recovery would seem to allow for a categorisation of transitional recovering under a weight of evidence approach, particularly when the stock is viewed as a whole and not by jurisdiction.

As we identified in reviewing the 49 stocks, there were some that were undefined due to inability to determine both F and B (as noted above for scallops), but where we were of the view that it did seem possible to define one or the other of these. This issue is likely to arise, even with future attempts to reduce the number of undefined stocks by application of alternative “data limited” assessment methods (Reference 6). For example, some of the risk assessment methods, such as PSA and SAFE, which could be applied to many currently undefined stocks, can estimate F (or proxies) but not B. Although outside the direct focus of this project, consideration could be given by the SAFS Advisory Group to providing information to stakeholders and consumers where either F or B can be reliably determined, but not the other. Arguably, this would be better than providing no information at all, though a separate reporting framework might be needed to distinguish the approaches.

Although the evaluation of the 49 stocks was useful in identifying several common underlying reasons for undefined status, most of these are inherent in the nature of the species and fisheries involved, so it is not clear that much can be done to remedy the problems. Some can certainly be addressed – better catch reporting, further analysis of targeting, uncertainty in biology – but these will take time to remedy and the issue remains, what can be done given the existing data and information deficiencies? Clearly, the best hope lies in further analysis, and the application of assessment methods and tools that are suited to data limited situations, but factors that cause data biases will remain problematic.

The evaluation revealed (not surprisingly) that having a large recreational catch component was a frequent factor associated with undefined status. Information deficits for recreational fisheries have long been identified and are perhaps slowly being rectified (e.g. through periodic catch censuses).

The “problem” of recreational fisheries for SAFS reporting is likely to be ongoing for some time, and its solution is beyond the scope of this report.

In the case of negligible stocks, the role of the cross jurisdictional clause is unclear. In fact, it seems that if one has little stock information and the stock is split by jurisdiction (even if incorrectly so), one is more likely to be able to define a low catch and a non-targeted stock as negligible than the case where more is known and the species crosses boundaries. The role of this clause needs a rethink and at present we would not recommend its inclusion (at least not at the same level in the decision tree as the other two rules of low catch and not targeted). One of the most common reasons that we assessed an undefined species as negligible involved our down-weighting the importance of this clause.

Conclusions

This project was developed to start to address the challenges posed by the decision to increase the number of species reported in SAFS, while simultaneously decreasing the proportion of stocks assessed as undefined. It has identified the main reasons why stocks are currently classified as undefined, by developing an evaluation framework and using it to examine the reports for the 49 undefined stocks in the 2016 SAFS report. It has also identified possible improvements to the guidance for the undefined and negligible categories.

Key findings include:

1. A framework was developed to identify likely reasons why stocks are classified as undefined. Wording has been suggested in this report for inclusion in the National framework for stock status reporting to be considered by the SAFS Advisory Group.

2. For commercial fisheries, there is greater uncertainty about effort than about catch. This hinders use of assessments that rely on CPUE, removing one of the key indicators used to assess biomass status.

3. Uncertainty about recreational catch (and management) was a significant factor for 20 of the 49 stocks evaluated. Assessing and classifying stocks with a large recreational component remains a challenge.

4. Uncertainty about stock structure, including the inability to match information at jurisdictional and biological stock scales, is a contributing factor to undefined status in a significant number of cases (17 of 49).

5. Although not clearly stated in the undefined stock reports, it may be possible to assign status for either biomass or fishing pressure in a significant proportion of cases (22 of 49).

6. The analysis identified the potential to assign SAFS status categories for a significant number of currently undefined stocks (19 of 49). This number is based on expert judgement, applied without detailed knowledge of the species and stocks in question, and will remain uncertain until properly tested in the second phase project.

7. The guidance for classifying undefined stocks, and the consistency in doing so, could be improved by more clearly stating what is meant by “confidence” in status determination.

Appendix 1 provides some suggested wording for guidance on this issue, to be considered by the SAFS Advisory Group.

8. Justification for undefined status determination in the reports could be improved by requiring that authors state explicitly and separately whether there is confidence in assessing both biomass and fishing pressure. This would also increase the information content of the reports. Consideration should be given to how to communicate this information in the status reporting. Wording has been suggested in this report (Appendix 2) for inclusion in the National framework for stock status reporting to be considered by the SAFS Advisory Group.

9. There is support for further guidance on assigning negligible status for stocks. While assignment of negligible status should remain a decision for the SAFS Advisory Group on a case by case basis, the possibility of identifying catch or value thresholds, either absolute or relative, perhaps combined with some form of simple risk assessment, should be considered (see Results for Objective 3).

10. There is also a need to discuss the value and use of the term cross-jurisdictional stock in the negligible classification definition. Wording has been suggested in this report for inclusion in the National framework for stock status reporting to be considered by the SAFS Advisory Group.

Implications

Implications of the findings of this study are discussed here in relation to the challenge of increasing the number of species assessed in SAFS while decreasing the proportion of stocks assessed as undefined.

The good news is that the analysis of currently undefined stocks has identified a significant proportion for which it might be possible to assign a SAFS status category other than undefined. It is important to note, however, that this is based on the judgement of the project staff, who in most cases do not have a detailed knowledge of the stocks evaluated, and relied on the available information in the stock reports, together with information on catch trends. The project staff relied also on their knowledge of data-limited assessment methods, which is a currently active research field nationally and internationally, including the development of tools such as FishPath (Reference 7). Plans are in development for a second phase study that would attempt to assess the larger number of species that will be required for the 2020 SAFS report, using some of the newer methods for assessing data limited stocks (Reference 6), as well as risk-based methods. Until that study is well underway, it will be difficult to determine what proportion of currently undefined and so-far unassessed (additional) stocks will be assessable.

The bad news is that most of the reasons identified for undefined status are inherent in the nature of these (mostly) data limited fisheries, and those reasons are not going to vanish. In fact, they are likely to get worse, as most of the stocks and species currently assessed in SAFS are those of higher value with a reasonable information base and existing assessments, while most of the species and stocks to be added will be of lower catch and value, with less information and fewer existing assessments.

This study has brought into sharper relief, for the study authors, the nature and magnitude of the challenge facing the SAFS process as many more species and stocks are added. Elements of this challenge include:

1. Most of the added stocks will be data limited, so inherently more are likely to be undefined (or negligible).

2. The requirement to assess against both biomass and fishing pressure will become even more difficult to meet.

3. Although data-limited assessment methods can be brought to bear on the problem, all of them come with higher levels of uncertainty. How will this be reconciled with the requirement for "confidence" in the assessments and category assignments? How will the same level of confidence be applied across species and stocks?

4. Some of the data-limited assessment methods, such as PSA, are designed to be risk averse (low probability of false negative results – i.e. identifying low risk when it is actually high). This feature in turn leads to more false positive results (identifying high risk when it is actually low) which would result in a higher proportion of additional stocks failing to meet the "sustainable" classification. An extension of this approach that allows for the PSA classification to highlight whether a stock is high risk due to lack of data would be helpful here. However, the false positives would have consequences for public perceptions about the status of Australian fish stocks, even if qualifying statements are included that (for example) the great majority of Australian commercial fish catch comes from sustainable stocks. This same concern applies to a lesser extent even for assessment methods, such as SAFE and some of the catch-only methods, that do not have inbuilt biases towards avoiding false negatives. For example, SAFE has been shown to produce roughly equal proportions of false positives and false negatives, but it also has high variance in assessed versus "true" status, so will likely also identify a significant number of stocks as "not sustainable", even where they may be.

5. Many of the additional species and stocks may be assigned negligible status (in which case what was the benefit of adding them?). This could help reduce the proportion of undefined stocks, but also emphasizes the importance of the precise way in which negligible stocks are assigned.

How these interacting and conflicting issues are dealt with is an important consideration for the SAFS Advisory Group.

Recommendations

The main initial audience for this report is the SAFS Advisory Group. This section on recommendations is framed as the outline of key points for consideration in a potential covering "agenda paper" for a meeting of the SAFS Advisory Group where this report is considered.

Note key findings from the study

- Points 1 to 6 in the Conclusions

- Greater uncertainty in effort than catch
- Problem of recreational fisheries and catch
- Stock structure uncertainty
- Possibility of reporting on F and B separately
- Possibility of assigning SAFS status for some of the currently undefined stocks

Consider for action

- Points 7 to 10 in the Conclusions
  - Incorporation of suggested text on “confidence” in guidance to authors (Appendix 1)
  - Desirability of reporting separately on F and B, in addition to overall SAFS status and specific wording to justify undefined status for each element (Appendix 2)
  - Threshold levels for catch and/or value for negligible classification
  - Interpretation and possible removal of the cross-jurisdictional stock criterion in the template for negligible

Discuss

- Possible resolution of the trade-offs implicit in the Implications

Further development

This project provides input into the second phase of this work, which is being developed, and which will involve attempts to provide status assignment for many of the species that will be added to the SAFS reporting framework by 2020. In particular, the second phase project should consider the key findings of this study in relation to reasons for current undefined status, the issues discussed around “confidence”, and any agreements by the SAFS Advisory Group on changes to wording and guidance, arising from the present study.

Extension and Adoption

The findings, conclusions, implications and recommendations of this study will be presented to and discussed at the next meeting of the SAFS Advisory Group, May 2017.

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Project materials developed

A working document summarising information about and evaluation of the 49 stocks, according to the framework developed in this study.

Appendix 1

Possible text to clarify what is meant by “confidently”.

The SAFS template for authors requires that

> “Stocks should be classified as undefined when there is insufficient information available to **confidently** assess either biomass size (or likely biomass size) OR the adequacy of control over fishing pressure.”

Confidence is the inverse of uncertainty, which is widely acknowledged as a pervasive feature of fishery stock assessments. Where quantitative (usually model-based) assessments are undertaken, considerable effort is usually put into quantifying and representing uncertainty in estimates of biomass and fishing mortality. Recently, a considerable number of so-called data-limited assessment methods have been developed (Carruthers et al 2014). The uncertainty in estimates of stock status derived from such methods is usually quite large, and not always estimated or reported. It is even more difficult to estimate and express uncertainty in more qualitative approaches, such as weight of evidence. Clearly, status assignment in SAFS occurs for a wide range of species and stocks with varying levels of information and knowledge available, and therefore across a broad spectrum of levels of uncertainty. At what point in this spectrum does assessment become so uncertain that category assignment can no longer be undertaken “confidently”?

There is no easy answer to the question just posed, but some considerations from attempts to define uncertainty in quantitative model-based assessments may help. These considerations include:

- Undertaking sensitivity tests to assess robustness of results to parameter uncertainty (such as estimates of natural mortality M or stock recruitment steepness h) affecting stock productivity
- Undertaking retrospective analyses that test predictions of stock status against later outcomes
- Checking that status is consistent across multiple lines of evidence (for example by excluding or reweighting particular data time series) or across multiple model types
- Including an evaluation of data quality, variance and bias as part of the overall evaluation of assessment uncertainty

For data-limited methods, where applying these approaches is not entirely straightforward, consideration can and should be given to information in the scientific literature about the “robustness” of such methods, and the circumstances in which they may fail. This information on robustness of methods can come either from simulation testing, or from empirical evaluations that test the application of the data-limited method across a range of data-rich cases where the “true” status can be determined from more quantitative modelling approaches. The clear lesson here is that authors applying such data-limited methods (including some risk-based methods) or making use of such assessments, should be aware of the uncertainties and pitfalls inherent in the methods, and should reflect this information in the expression of confidence in the assessments.

Notwithstanding these attempts to more rigorously define and express uncertainty, there remains the difficult issue of determining a standard or limit to the level of uncertainty deemed acceptable. Words or phrases such as “confident”, “high degree of confidence”, and “on the balance of probabilities” express different ways in which confidence can be described. Where uncertainty can be estimated quantitatively, such expressions can then be equated to probabilities that a stock’s biomass is above a limit reference point (see, for example, usage and definitions adopted by the Marine Stewardship Council).

The choice of such a standard for judging and expressing confidence has important implications for the number of stocks that are likely to be judged as undefined in the SAFS framework. Requiring a “high degree of confidence” will mean that assessments based on most data-limited methods will be excluded, while requiring that confidence only be “on the balance of probabilities” (equal chance of being above or below a limit, for example) may diminish public confidence and credibility in the overall framework and approach.

Appendix 2

Possible extra text for “undefined”

Explanation is required of why status assessment is not possible for stocks determined to be undefined. This should include discussion of attempts to estimate both biomass and fishing pressure, and why these have failed.

The RUSS project (Reference 8) used the following as key areas of uncertainty with respect to biomass or fishing mortality:

- “there is insufficient data, information or indicators to make a scientifically robust determination of status
- the available lines of evidence show inconsistent trends, or are substantially influenced by external drivers, and there is no basis to weight particular lines of evidence more highly than others
- the available quantitative assessments are very sensitive to parameter assumptions, lack key data inputs (for example, observer data, aging data, length frequency data), or have large confidence intervals in terms of the outputs
- the available quantitative assessments, may be uncertain if the approach is unlikely to be appropriate for the species involved, the assessment is dated and there are no valid indicators of recent trends”

Specifically, for biomass and fishing mortality:

Biomass

Reasons for being unable to assess current level of biomass could include one or several of the following:

- The current biomass of this stock has been assessed using method X (reference) but the uncertainties in that assessment are judged to be too high for the following reasons:
    - Data quality or bias, such as missing or incomplete data for some gears or sectors
    - Problems with species identification or catch reported at group rather than at species level
    - Method too uncertain for this stock (discuss reasons)
    - Conflicting evidence that can't be resolved, such as inconsistent indicators
    - Other
- It is very difficult to assess biomass for stocks of this type due to the following factors:
    - High stochasticity due to strong environmental forcing precludes the assumption of an "equilibrium" biomass (e.g. scallops)
    - It is caught outside Australian jurisdiction including the high seas and a multi-national assessment has not been undertaken
    - Other
- Proxies for biomass are available, but are judged to be too uncertain
    - E.g. CPUE is thought to be an unreliable measure of relative abundance for this stock due to …
    - Other
- Estimates of or proxies for biomass are available, but it is not possible to assign a credible reference point for such indicators due to …
- Estimates of or proxies for biomass are not available, but consideration has been given to how they might be determined (describe); it has been concluded that, given the type, quantity and quality of information available, no credible estimates of biomass are possible.

Having discussed and justified the reasons why biomass cannot be reliably assessed, the report should end with the following statement:

The assessment of current level of biomass is therefore considered to be too uncertain to use confidently for SAFS status determination.

Fishing pressure

Reasons for being unable to assess the current level of fishing pressure could include one or several of the following:

- The current fishing pressure on this stock has been assessed using method X (reference) but the uncertainties in that assessment are judged to too high for the following reasons:
    - Data quality or bias
    - Conflicting evidence such as inconsistent indicators
    - Part of a multi-species fishery and/or targeting is variable
    - Changes in catchability over time cannot be determined but is likely to have changed significantly
    - Method too uncertain for this stock (discuss reasons)
    - Conflicting evidence that can't be resolved
    - Other

- Proxies for fishing pressure are available, but are judged to be too uncertain due to
    - Uncertainties about catch levels for some significant sectors (e.g. recreational)
    - Absence of information on spatial distribution of effort precludes risk based methods of estimating F such as SAFE
    - The effectiveness of current management measures to limit fishing pressure is considered to be inadequate or too uncertain
    - Other
- Estimates of or proxies for fishing pressure are available, but it is not possible to assign a credible reference point for such indicators due to …
- Estimates of or proxies for fishing pressure are not available, but consideration has been given to how they might be determined (describe); it has been concluded that, given the type, quantity and quality of information available, no credible estimates of fishing pressure are possible.

Having discussed and justified the reasons why fishing pressure cannot be reliably assessed, the report should end with the following statement:

The assessment of current level of fishing pressure is therefore considered to be too uncertain to use confidently for SAFS status determination.