SC-03-07(01)

3rd Meeting of the Southern Indian Ocean Fisheries Agreement (SIOFA) Scientific Committee

20-24 March 2017, Saint Denis, La Reunion

A proposed framework for managing low-information species assessed using ecological risk assessment in the SIOFA Area

Relates to agenda item: 7 Working paper ☒ Info paper ☐

Delegation of Australia

Abstract

The purpose of this paper is to present a possible framework to assist with the management of low information species with which SIOFA fisheries interact.

This is in response to Paragraph 6a of CMM 2016/01, which actions the SIOFA SC to provide advice and recommendations to the Meeting of the Parties on the status of stocks of principal deep-sea fishery resources targeted, and, to the extent possible, taken as bycatch and caught incidentally in these deep-sea fisheries, including straddling fishery resources by 2019.

Recommendations *(working papers only)*

It is recommended that the SIOFA SC:

- **Note** that there are many species caught in SIOFA fisheries and that many of these species are characterised by limited data;
- **Note** that assessment for many of these species may necessitate the use of methods specifically designed for "data limited scenarios";
- **Note** that many of these "data-limited methods" do not estimate biomass depletion and may only provide a proxy estimate for fishing mortality;
- **Note** that ecological risk assessment provides a useful method for prioritising the urgency and order upon which assessment may proceed for these species;
- **Consider** the approach presented in this paper in the context of the tiered stock assessment framework discussed at the SIOFA SAWG workshop 1 (paper SAWG(2018)-01-INF06).
- **Consider** requesting advice from the Meeting of the Parties on the management objectives for non-fish species with which SIOFA fisheries interact, and guidance on suitable levels of mortality caused by SIOFA fisheries.
- **Recommend** to the Meeting of the Parties that the management approach presented in this paper, or a similar approach, be considered for adoption **OR**
- **Recommend** to the Meeting of the Parties that the SC undertake a comprehensive review of possible assessment and management options for low information species as part of its 2019 workplan.

A proposed framework for managing low information species assessed using ecological risk assessment in the SIOFA Area

Georgeson, L[1], Zhou, S[2], Nicol, S[1]

[1] Australian Bureau of Agricultural and Resource Economics and Sciences

[2] The Commonwealth Scientific and Industrial Research Organisation (CSIRO, Australia)

Recommendations

It is recommended that the SIOFA SC:

- **Note** that there are many species caught in SIOFA fisheries and that many of these species are characterised by limited data;
- **Note** that assessment for many of these species may necessitate the use of methods specifically designed for "data limited scenarios";
- **Note** that many of these "data-limited methods" do not estimate biomass depletion and may only provide a proxy estimate for fishing mortality;
- **Note** that ecological risk assessment provides a useful method for prioritising the urgency and order upon which assessment may proceed for these species;
- **Consider** the approach presented in this paper in the context of the tiered stock assessment framework discussed at the SIOFA SAWG workshop 1 (paper SAWG(2018)-01-INF06).
- **Consider requesting** advice from the Meeting of the Parties on the management objectives for non-fish species with which SIOFA fisheries interact, and guidance on suitable levels of mortality caused by SIOFA fisheries.
- **Recommend** to the Meeting of the Parties that the management approach presented in this paper, or a similar approach, be considered for adoption **OR**
- **Recommend** to the Meeting of the Parties that the SC undertake a comprehensive review of possible assessment and management options for low information species as part of its 2019 workplan.

Purpose and rationale

The purpose of this paper is to present a possible framework to assist with the management of low information species with which SIOFA fisheries interact.

This is in response to Paragraph 6a of CMM 2016/01, which actions the SIOFA SC to provide advice and recommendations to the Meeting of the Parties on the status of stocks of principal deep-sea fishery resources targeted, and, to the extent possible, taken as bycatch and caught incidentally in these deep-sea fisheries, including straddling fishery resources by 2019.

Introduction

Assessment of low information species, for example those taken as bycatch or byproduct, continues to be a key challenge in international fisheries. This has led to limited progress on setting harvest strategies and harvest control rules to assist with their management. A number of fish species encountered in SIOFA fisheries, including teleosts and chondrichthyans, fall into these low information categories.

Over the last decade, techniques for the assessment of low information species have improved (see, for example, Zhou et al. 2013) and are increasingly being used as a tool to inform management, noting that most only generate proxy estimates of biomass depletion ($B_{current}$) and fishing mortality ($F_{current}$) (e.g. Dowling et al. 2016). Although many of these methods can be applied at a lower cost per assessment than methods that are more commonly applied to information-rich species, the large number of low information species means that the task of assessing all target and non-target species will not be trivial for SIOFA. Ecological risk assessment (see, for example; Zhou and Griffiths 2008; Hobday et al. 2011, Zhou et al. 2016) provides a useful tool to prioritise those species where the impacts of fishing may be sufficient to warrant quantitative assessment and is relatively cheaper to apply. The most widely used of these in fisheries consider risk to species as a function of their biological productivity and their susceptibility to fishing using various gears. One of these methods—Sustainability Assessment for Fishing Effects (SAFE; Zhou et al. 2007)—derives a proxy for fishing mortality based on the overlap of the fishery and the distribution of the stock and has been applied to both teleosts and chondrichthyans (Zhou and Griffiths 2008; Zhou et al. 2009; Zhou et al. 2011). SAFE-derived estimates of F have recently been compared against those estimated by traditional stock assessment approaches with the results quantifying the robustness of the method for prioritising further analyses (Zhou et al. 2016). An advantage of this method is that in addition to prioritisation of species for quantitative assessment, the proxy estimate of $F_{current}$ can be also used within an interim harvest strategy with defined limit reference points and agreed management rules.

Description of how SAFE works

The SAFE method (Zhou et al. 2007, Zhou and Griffiths 2008, Zhou et al. 2009, Hobday et al. 2011; Zhou et al. 2016) as applied in ecological risk assessment provides an absolute measure of risk by determining the fishing mortality rate u (expressed as the estimated fraction of the population that has died as a result of fishing), as well as quantitative reference points associated with it. The method uses three parameters: spatial overlap, catchability and post capture mortality as described by Zhou et al. (2011) to determine the fishing mortality F_{CURR} as:

$$F_{CURR} = \frac{\sum a_t}{A} q^h q^\lambda (1 - s)(1 - E)$$

where a_t and A represent the area fished and a species' distribution area (i.e. spatial overlap), respectively, q^h and q^λ are the habitat-dependent encounterability and size- and behaviour-dependent catch rate ('catchability'), E is the escapement rate (i.e. the amount of the population that does not get caught by fishing) and s is the post-capture survival rate. Methods for estimating spatial overlap vary depending on the fishery characteristics, including the configuration of gears. Similarly, q^h, q^λ, E and s vary depending on the biology of the species. Zhou et al. (2007 and 2011) describes the different methods used for estimating these parameters for trawl, auto-longline and gillnet fisheries, with these methods underlying the model used for the risk assessment for deepwater chondrichthyans in the SIOFA Area.

The SAFE method relates life history traits that inform natural mortality (M), growth rate and the intrinsic rate of increase (r) to biological reference points using the following six formulae:

$F_{msm} = r/2$, $F_{lim} = 0.75\, r$, and $F_{crash} = r$;

$F_{msm} = M$, $F_{lim} = 1.5\, M$, and $F_{crash} = 2M$;

$F_{msm} = M$, $F_{lim} = 1.5\, M$, and $F_{crash} = 2M$, where

$\ln(M) = -0.0152 - 0.279 \ln(L_\infty) + 0.6543 \ln(k) + 0.4634 \ln(T)$ (Pauly 1980; Quinn and Deriso 1999);

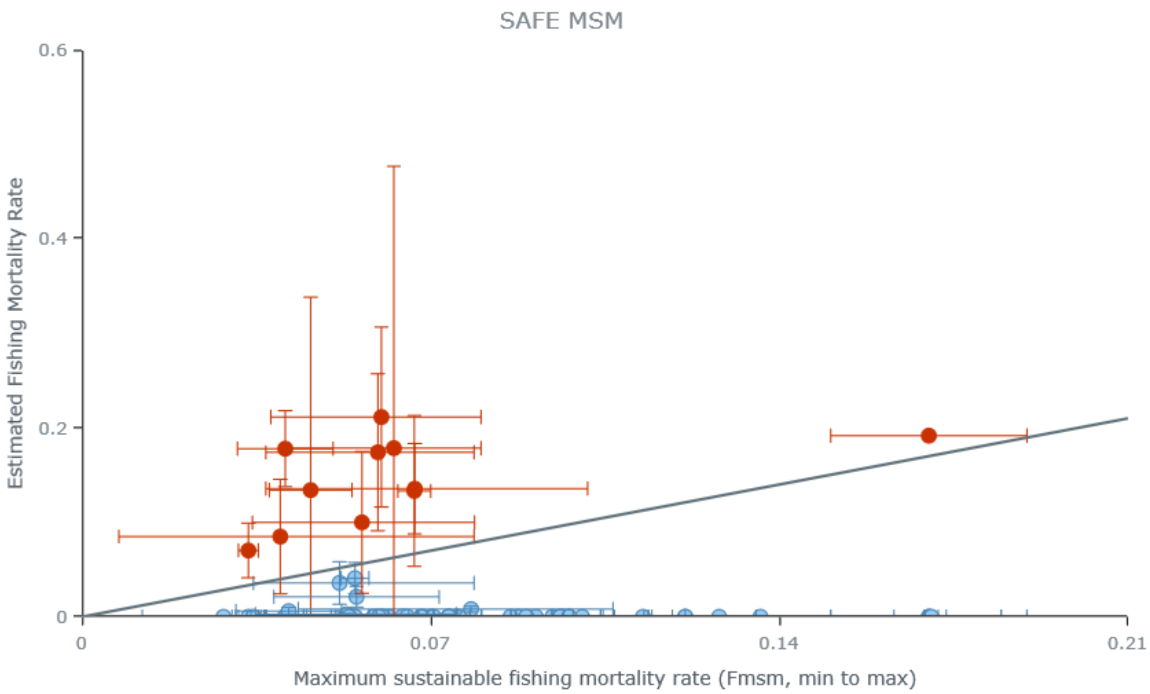
$F_{msm} = M$, $F_{lim} = 1.5\, M$, and $F_{crash} = 2M$, where $\ln(M) = 1.44 - 0.982 \ln(t_m)$ (Hoenig 1983).

$F_{msm} = M$, $F_{lim} = 1.5\, M$, and $F_{crash} = 2M$, where $M = 10^{0.566-0.718\ln(L_\infty)} + 0.02T$ (www.Fishbase.org);

$F_{msm} = M$, $F_{lim} = 1.5\, M$, and $F_{crash} = 2M$, where $M = 1.65/t_{mat}$ (Jensen 1996);

The model uses the average of the six methods for defining the midpoint on the X-axis. Where information is not available for one or more methods, the model uses the average of the remaining methods. Variance on the Y-axis is calculated based on the annual variability of fishing effort, such that 'fisheries' for species with relatively stable effort will exhibit less variability on this axis and vice versa (see Figure 1).

Figure 1 An example of a SAFE assessment output showing all assessed species (red and blue dots) in relation to their estimated fishing mortality rate and their maximum sustainable fishing mortality rate. The black line represents the maximum sustainable mortality rate reference point. This line changes depending on the reference point being examined.



The reference points used in a SAFE assessment are expressed in more detail below:

1. F_{msm} – Fishing mortality rate corresponding to maximum sustainable fishing mortality (*MSM*) at *Bmsm* (biomass that supports *MSM*, equivalent to *MSY*)
2. F_{lim} – Fishing mortality rate corresponding to limit biomass B_{lim}, where B_{lim} is defined as 50% biomass that supports the *MSM*

3. F_{crash} – minimum unsustainable fishing mortality rate that theoretically may lead to population extinction in the long term

The result is that *F* can be considered against *msm, lim* and *crash*, giving an absolute measure of risk. Risk categories are assigned as per the framework in Table 1.

The reference points used in the SAFE method are based on 'classical' fisheries assessment and management theory. In this context, the SAFE method of deriving a proxy for *F* and considering this in relation to defined biological reference points is only relevant to fish stocks (including teleosts and chondrichthyans). The method has not been adapted for non-fish species (e.g. seabirds or marine mammals). The parameters for calculating *F* have been scaled to allow comparison between SAFE estimates of risk for teleosts and chondrichthyans.

Possible framework using this method

Zhou et al. (2007) provide a useful mechanism to set management rules for non-target species that are assessed using the SAFE analyses. It includes clearly defined ecological consequences and associated management rules against the explicit reference points. We have added to this framework the prioritisation rule that the SC may also wish to apply with regard to progressing to more quantitative assessment (or alternatively, as a trigger for other advice). Similarly we have added information triggers that the SC may wish to utilise as new information becomes available.

Table 1 A possible management framework for low-information fish species in SIOFA

	$F < F_{msm}$	$F_{lim}>F>F_{msm}$	$F_{crash}>F>F_{lim}$	$F>F_{crash}$
Ecological Risk Assessment Category	Low (L)	Medium (M)	High (H)	Extreme (E)
Stock status interpretation	Overfishing not occurring. May keep population above 50% of virgin level	Overfishing is occurring but population can be sustainable	May drive population to very low levels in the longer term	Population is unsustainable in long term – possibility of extinction
Management rule	Reduction of *F* not needed	Reduction in *F* may be required if this level of *F* occurs over seven consecutive years*	Reduce fishing mortality below F_{msm} if this *F* occurs in five consecutive years*	Reduce fishing mortality below F_{msm} if this *F* occurs in three consecutive years*
Prioritisation rule	No requirement for quantitative assessment of stock status	Low priority for quantitative assessment of stock status	Medium priority for quantitative assessment of stock status	High priority for quantitative assessment of stock status and enhanced data collection
Scientific Committee triggers		If a species in these categories triggered the management rule they would be immediately prioritised for quantitative stock assessment, in addition to the reduction in *F*		
	Reassessment using SAFE would be immediately undertaken if new productivity or susceptibility information becomes available including information on stock structures			

F_{msm} = fishing mortality rates corresponding to the maximum sustainable fishing mortality (MSM) at B_{msm} (biomass that supports MSM); F_{lim} = fishing mortality rate corresponding to limit biomass B_{lim}, where B_{lim}

is defined as half of the biomass that supports a maximum sustainable fishing mortality (0.5*Bmsm*); and F_{crash} = minimum unsustainable fishing mortality rate that, in theory, will lead to population extinction in the longer term. Note: SAFE method assumes that F_{msm} = 0.87 *M* (teleosts) and $F_{msm} = 0.41\ M$ (elasmobranchs) Source: Adapted from Zhou et al. 2007, *provided as an example only of the type of rule that could be formulated and agreed to.

Other considerations

A consideration with using these techniques is the level of uncertainty in the input parameters for estimating fishing mortality and reference points. If the uncertainty is high then there is also a high level of uncertainty around the estimated risk. To link uncertain outputs with particular management outcomes or objectives requires a precautionary, but pragmatic approach. Higher priority for quantitative assessment may be given to species with higher confidence that the estimated risk category is correct. The response for species with high uncertainty in estimated risk may include actions that incentivise the collection of information on these species. Improved collection of information may also be a necessary requirement species with high certainty on risk classification if the information available is insufficient for quantitative assessment of stock status.

Under such a framework, the SIOFA ERAWG/SC may wish to consider the level of uncertainty around ERA risk categorisations that may influence the possible management rules. Guidance on what constitutes sufficient certainty for confidence in results could be determined by sensitivity analyses or management strategy evaluation.

Seabirds, marine reptiles and marine mammals

As well as teleosts and chondrichthyans, there has been progress internationally on setting fishing mortality thresholds and associated management rules for other species, including seabirds, marine reptiles and marine mammals. The SIOFA SC may wish to consider the extent to which a framework such as that presented herein could be modified to deal with such species. Consideration of such a framework may require a mutual understanding and agreement of the management objectives for such species. For example, a framework may provide for maximum potential biological removal (PBR) thresholds for certain species based on methods that allow abundance and associated sustainability thresholds to be estimated. Such frameworks and associated methods exist and are in use, for example under the *US Marine Mammal Protection Act* and in New Zealand's domestic fisheries (see, for example, Richard and Abraham 2013).

The SC may wish to request direction from the Meeting of the Parties on the management objectives for these other species, including guidance on acceptable levels of mortality caused by SIOFA fisheries.

References

Dowling, N.A., Wilson, JR., Rudd,MB., Babcock, EA., Caillaux, M., Cope, J., Dougherty, D., Fujita, R., Gedamke, T., Gleason, M., Gutierrez, N., Hordyk, A,. Maina, GW., Mous, PJ., Ovando, D., Parma, AM., Prince, J., Revenga, C., Rude, J., Szuwalski, C., Valencia, S., Victor, S. (2016). FishPath: A decision support system for assessing and managing data- and capacity- limited fisheries. In: T.J. Quinn II, J.L. Armstrong, M.R. Baker, J. Heifetz, D. Witherell (Eds.), Assess. Manag. Data-Limited Fish Stock., Alaska Sea Grants, University of Alaska Fairbanks, 2016: pp. 59–96. doi:http://doi.org/10.4027/amdlfs.2016.03

Hobday, A, Smith, A, Stobutzki, I, Bulman, C, Daley, R, Dambacher, J, Deng, R, Dowdney, J, Fuller, M, Furlani, D, Griffiths, S, Johnson, D, Kenyon, R, Knuckey, I, Ling, S, Pitcher, R, Sainsbury, K, Sporcic, M, Smith, T, Turnbull, C, Walker, T, Wayte, S, Webb, H, Williams, A, Wise, B & Zhou, S

(2011). Ecological risk assessment for the effects of fishing, *Fisheries Research*, vol. 108, pp. 372–384.

Richard, Y & Abraham, E (2013). Application of Potential Biological Removal methods to seabird populations, New Zealand Aquatic Environment and Biodiversity Report No. 108, New Zealand Ministry of Primary Industries, Wellington.

Zhou, S, Smith, T & Fuller, M (2007). *Rapid quantitative risk assessment for fish species in selected Commonwealth fisheries*, prepared by CSIRO for the Australian Fisheries Management Authority

Zhou, S., Griffiths, S. (2008) Sustainability Assessment for Fishing Effects (SAFE): A new quantitative ecological risk assessment method and its application to elasmobranch bycatch in an Australian trawl fishery. Fisheries Research 91:56-68 DOI: 10.1016/j.fishres.2007.11.007

Zhou, S., Griffiths, S. Miller, M. (2009). Sustainability assessments for fishing effects (SAFE) on highly diverse and data-limited fish bycatch in a tropical Australian trawl fishery. Marine and Freshwater Research. DOI: 10.1071/MF08207

Zhou, S., Smith ADM., Fuller M (2011). Quantitative ecological risk assessment for fishing effects on diverse data-poor non-target species in a multi-sector and multi-gear fishery. Fisheries Research 112:168-178. DOI: 10.1016/j.fishres.2010.09.028

Zhou, S., Pascoe, S., Dowling, N., Haddon, M., Klaer, N., Larcombe, J., Smith, A.D.M., Thebaud, O., Vieira, S., and Wayte, S. (2013). Quantitatively defining biological and economic reference points in data poor fisheries. Final Report on FRDC Project 2010/044. Canberra, Australia.

Zhou, S., Hobday, AJ, Dichmont CM., Smith ADM. (2016). Ecological risk assessments for the effects of fishing: A comparison and validation of PSA and SAFE. Fisheries Research. DOI: 10.1016/j.fishres.2016.07.015

Appendix 1 List of fish species reportedly caught in SIOFA fisheries

Species Code	**Species Name**	**Common Name**	**Catch rank (volume)**
SCK	*Dalatias licha*	Kitefin shark	1
RIB	*Mora moro*	Common mora	2
ANT	*Antimora rostrata*	Blue antimora	3
PFM	*Pristipomoides filamentosus*	Crimson jobfish	4
TOP	*Dissostichus eleginoides*	Patagonian toothfish	5
RPG	*Pagrus pagrus*	Red porgy	6
GRV	*Macrourus spp*	Grenadiers nei	7
KCS	*Paralithodes spp*	King crabs	8
AVR	*Aprion virescens*	Green jobfish	9
SNA	*Lutjanus spp*	Snappers nei	10
BHY	*Bathyraja spp*	Bathyraja rays nei	11
EMP	*Lethrinidae*	Emperors(=Scavengers) nei	12
EPI	*Epigonus telescopus*	Black cardinal fish	13
MON	*Lophius piscatorius*	Angler(=Monk)	14
SBX	*Sparidae*	Porgies, seabreams nei	15
GPX	*Epinephelus spp*	Groupers nei	16

EEP	*Epinephelus morrhua*	Comet grouper	17
KCD	*Paralithodes camtschaticus*	Red king crab	18
FIN	*Osteichthyes*	Finfishes nei	19
BYS	*Beryx splendens*	Splendid alfonsino	20
ETC	*Etelis coruscans*	Deepwater longtail red snapper	21
ALF	*Beryx spp*	Alfonsinos nei	22
BYX	*Bathyraja smirnovi*		23
MZZ	*Osteichthyes*	Marine fishes nei	24
ETA	*Etelis carbunculus*	Deep-water red snapper	25
AMX	*Seriola spp*	Amberjacks nei	26
LTQ	*Lethrinus mahsena*	Sky emperor	27
RFA	*Raja taaf*	Whiteleg skate	28
CGX	*Carangidae*	Carangids nei	29
TOT	*Dissostichus spp*	Antarctic toothfishes nei	30
NGU	*Carangoides fulvoguttatus*	Yellowspotted trevally	31
ORH	*Chiloscyllium plagiosum*	Whitespotted bambooshark	32
ARG	*Argentina spp*	Argentines	33
OIL	*Ruvettus pretiosus*	Oilfish	34
WHA	*Polyprion oxygeneios*	Hapuku wreckfish	35
ORY	*Hoplostethus atlanticus*	Orange roughy	36
CDL	*Epigonus spp*	Cardinal fishes nei	37
BOR	*Caproidae*	Boarfishes nei	38
AMB	*Seriola dumerili*	Greater amberjack	39
WRF	*Polyprion americanus*	Wreckfish	40
REG	*Sebastes marinus*	Golden redfish	41
DGX	*Squalidae*	Dogfish sharks nei	42
YTC	*Seriola lalandi*	Yellowtail amberjack	43
EFT	*Cephalopholis sonnerati*	Tomato hind	44
SRX	*Rajiformes*	Rays, stingrays, mantas nei	45
RAJ	*Rajidae*	Rays and skates nei	46
ZEX	*Zeidae*	Dories nei	47
EML	*Plectropomus laevis*	Blacksaddled coralgrouper	48
SEY	*Schedophilus velaini*	Violet warehou	49
SLS	*Palinurus gilchristi*	Southern spiny lobster	50
SKX	*Elasmobranchii*	Sharks, rays, skates, etc. nei	51
BBF	*Barbourisia rufa*	Velvet whalefish	52
SNK	*Thyrsites atun*	Snoek	53
EEA	*Epinephelus fasciatus*	Blacktip grouper	54
SKH	*Selachimorpha (Pleurotremata)*	Various sharks nei	55
EDR	*Pseudopentaceros richardsoni*	Pelagic armourhead	56
HFR	*Helicolenus percoides*	Red gurnard perch	57
SOR	*Somniosus rostratus*	Little sleeper shark	58

BNS	*Benthosema suborbitale*	Smallfin lanternfish	59
TUZ	*Trachurus novaezelandiae*	Yellowtail horse mackerel	60
GUX	*Triglidae*	Gurnards, searobins nei	61
SHL	*Etmopterus spp*	Lanternsharks nei	62
BOE	*Allocyttus niger*	Black oreo	63
SSO	*Pseudocyttus maculatus*	Smooth oreo dory	64
BWA	*Hyperoglyphe antarctica*	Bluenose warehou	65
PRP	*Promethichthys prometheus*	Roudi escolar	66
ALS	*Carcharhinus albimarginatus*	Silvertip shark	67
TAK	*Nemadactylus macropterus*	Tarakihi	68
EWU	*Epinephelus multinotatus*	White-blotched grouper	69
SLO	*Palinurus elephas*	Common spiny lobster	70
OEO	*Oreochromis karongae*		71
OCT	*Octopodidae*	Octopuses, etc. nei	72
GAR	*Belone belone*	Garfish	73
COX	*Congridae*	Conger eels, etc. nei	74
RRU	*Elagatis bipinnulata*	Rainbow runner	75
MWG	*Melanostigma gelatinosum*	Limp eelpout	76
PUX	*Tetraodontidae*	Puffers nei	77
CVX	*Carcharhiniformes*	Ground sharks	78
BRT	*Borostomias antarcticus*	Snaggletooth	79
HDS	*Hadropenaeus lucasii*	Trident shrimp	80
RSS	*Rhabdosargus sarba*	Goldlined seabream	81