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

20-24 March 2017, Saint Denis, La Reunion

Ecological Risk Assessment for Deepwater Chondrichthyans in the Southern Indian Ocean

Relates to agenda item: 7.2.1 Working paper ☒ Info paper ☐

Delegation of Australia

Abstract

This paper updates the SIOFA Scientific Committee on the ecological risk assessment (ERA) for the effects of fishing on deepwater chondrichthyans in the Southern Indian Ocean Fisheries Agreement (SIOFA) Area using Productivity-Susceptibility Analysis (PSA) and Sustainability Assessment for Fishing Effects (SAFE) methods. The assessment identified a number of species categorised at high or extreme risk from fishing using demersal trawl, midwater trawl, demersal longline and gillnet gears.

Recommendations *(working papers only)*

It is recommended that the SC:

- **Note** that 28 deepwater chondrichthyan species were categorised as being at high or extreme risk to the effects of fishing from at least one of the four gear types.
    - 23 species were categorised at high or extreme risk using the SAFE method.
    - 19 species were categorised at high risk using the PSA method.
    - 14 species were categorised at high or extreme risk by both SAFE and PSA methods.
    - 9 species were only categorised at high or extreme risk using the SAFE method.
    - 5 species were only categorised at high risk using the PSA method.
    - Data was missing for three or more productivity and/or susceptibility attributes for 11 species categorised at high or extreme risk.
- **Note** that it is likely that these results include a number of yet to be identified false positives and false negatives. The SC will need to consider if the advice it generates for the Meeting of the Parties is robust to these potential errors or whether additional analyses are required to identify and correct any potential erroneous categorisations.
- **Note** the ERA has prioritised species for which better information is needed and those for which explicit management actions may be required.
- **Consider** the formulation of advice to the Meeting of the Parties on an ecological risk management framework for developing responses that are commensurate with the risk exposure due to fishing.
- **Consider** the formulation of advice to the Meeting of the Parties on improved data collection for deepwater chondrichthyans and access to this information by the SC.
- **Consider** the formulation of advice to the Meeting of the Parties around possible future harvest strategies and other potential management requirements for high or extreme risk species.

Southern Indian Ocean Fisheries Agreement Scientific Committee

3rd meeting, March 2018

Ecological risk assessment for the effects of demersal and midwater trawl, demersal line and demersal gillnet gears on deepwater chondrichthyans in the Southern Indian Ocean Fisheries Agreement Area

Australia

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Purpose of this paper

This paper updates the SIOFA Scientific Committee on the ecological risk assessment (ERA) for the effects of fishing on deepwater chondrichthyans in the Southern Indian Ocean Fisheries Agreement (SIOFA) Area using Productivity-Susceptibility Analysis (PSA) and Sustainability Assessment for Fishing Effects (SAFE) methods. Detail on the background and specific methods can be found in SC-02-09 [01], Zhou et al. 2007; 2011; 2016, Hobday et al. 2011 and the summary record of the 1st meeting of the SIOFA ERA Working Group (ERAWG; Annex 1).

A presentation was developed for the ERAWG Hobart workshop and is available here (http://www.siofa.org/node/66). It is recommended that this paper is read after viewing the presentation and reading the ERAWG Hobart workshop summary (Annex 1).

This paper details:

- results arising from the PSA and SAFE assessments
- modifications made to the input data
- data and methodological limitations in the assessment
- recommendations for the SC's consideration.

Recommendations

It is recommended that the SC:

- **Note** that 28 deepwater chondrichthyan species were categorised as being at high or extreme risk to the effects of fishing from at least one of the four gear types.
    - 23 species were categorised at high or extreme risk using the SAFE method.
    - 19 species were categorised at high risk using the PSA method.
    - 14 species were categorised at high or extreme risk by both SAFE and PSA methods.
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    - 5 species were only categorised at high risk using the PSA method.
    - Data was missing for three or more productivity and/or susceptibility attributes for 11 species categorised at high or extreme risk.
- **Note** that it is likely that these results include a number of yet to be identified false positives and false negatives. The SC will need to consider if the advice it generates for the Meeting of the Parties is robust to these potential errors or whether additional analyses are required to identify and correct any potential erroneous categorisations.
- **Note** the ERA has prioritised species for which better information is needed and those for which explicit management actions may be required.
- **Consider** the formulation of advice to the Meeting of the Parties on an ecological risk management framework for developing responses that are commensurate with the risk exposure due to fishing.
- **Consider** the formulation of advice to the Meeting of the Parties on improved data collection for deepwater chondrichthyans and access to this information by the SC.
- **Consider** the formulation of advice to the Meeting of the Parties around possible future harvest strategies and other potential management requirements for high or extreme risk species.

Introduction

This ERA groups the potential risk to deepwater chondrichthyans in the SIOFA Area into extreme, high, medium and low risk categories for demersal trawl, midwater trawl, demersal longline and gillnet gears. The list of deepwater chondrichthyans species that interact with each fishery is likely to be incomplete due to the relatively low level of historical fishing in SIOFA, past data collection

requirements and existing reporting arrangements. This incompleteness is compounded by the rareness of interactions with deepwater chondrichthyans for some trawl and longline operations due to their fishing strategies that specifically target other species. The analysis undertaken has included deepwater chondrichthyan species whose distributions are known to overlap with SIOFA fisheries but zero or very few records of interaction have been reported. As a consequence the results can be considered precautionary as they may include false-positives (i.e. species could be included in high risk categories but in reality may not interact with the fishery).

Species grouped into higher risk categories have undergone additional sensitivity analyses. The results of this sensivity analyses are provided in a complementary information paper (note this Information paper will be submitted after the 30 day SIOFA SC paper deadline but before the SC meeting). The sensivity analyses provide information on the robustness of the results to uncertainties in the input data and the quantity of change in attributes that would be required to alter the risk grouping.

The results from the ERA should provide the SC with the information it requires to generate advice to the Meeting of the Parties for each species. This is likely to vary from:

1. implementing management action(s) such as avoidance measures or catch/effort limits; to
2. improved data collection (including species identification) or stock assessment to more accurately estimate risk; or
3. a combination of both.

The analyses undertaken have highlighted information gaps on the biology of many species, particularly in terms of their productivity, distribution, stock structuring and other life history attributes. In this context, the ERA results should aid the SC in prioritising where more information may be required to inform actions to manage deepwater chondrichthyans in the SIOFA Area.

PSA results

The following species were assessed to be at high relative potential risk in the PSA:

Species	Common name	DT	MWT	DLL	DGN
*Bythaelurus bachi**	-				
*Bythaelurus lutarius**	-				
Centrophorus granulosus	Gulper Shark				
Centroselachus crepidater	Golden Dogfish				
*Chimaera buccanigella**	-				
*Chimaera didierae**	-				
*Chimaera willwatchi**	-				
Dalatias licha	Black Shark				
Deania calceus	Brier Shark				
Deania profundorum	-				
Etmopterus viator	-				
Lamna nasus	Porbeagle				
*Mitsukurina owstoni**	-				
Odontaspis ferox	Smalltooth Sandtiger Shark				
Plesiobatis daviesi	Giant Stingaree				
Pseudotriakis microdon	False Catshark				
Scymnodon plunketi	Plunket's Dogfish				
Somniosus antarcticus	Southern Sleeper Shark				
Zameus squamulosus	Velvet Dogfish				

* = Missing three or more productivity and/or susceptibility attributes; DT = Demersal Trawl; MWT = Midwater Trawl; DLL = Demersal Longline; DGN = Demersal Gillnet.

SAFE results

The following species were assessed to be at high (H) or extreme (E) risk in the SAFE:

Species	Common name	DT	MWT	DLL	DGN
*Anacanthobatis marmorata**	-	E	E	E	E
*Bythaelurus bachi**	-	E	E	E	E
*Bythaelurus tenuicephalus**	-	E	E	E	E
Centrophorus granulosus	Gulper Shark	E	E	E	E
Centroselachus crepidater	Golden Dogfish	E	E	E	E
*Chimaera buccanigella**	-	E	E	E	E
*Chimaera didierae**	-	E	E	E	E
*Chimaera willwatchi**	-	E	E	E	E
*Chlamydoselachus anguineus**	Frill Shark	E	E		E
Dalatias licha	Black Shark	E	E	H	H
Deania calceus	Brier Shark	E	E	E	E
Deania profundorum	-	E	E	E	E
Etmopterus alphus	-	H	H		
Etmopterus granulosus	-				E
Etmopterus pusillus	Slender Lanternshark	E	E		E
Etmopterus viator	-	E			
*Euprotomicrus bispinatus**	Pygmy Shark	E	E		
*Heteroscymnoides marleyi**	-	E	E		E
*Mitsukurina owstoni**	-				E
Scymnodalatias albicauda	-	E	E	E	E
Scymnodon plunketi	Plunket's Dogfish	E	E	E	H
Somniosus antarcticus	Southern Sleeper Shark	E	E		E
Zameus squamulosus	Velvet Dogfish	E	E	E	E

* = Missing three or more productivity and/or susceptibility attributes; DT = Demersal Trawl; MWT = Midwater Trawl; DLL = Demersal Longline; DGN = Demersal Gillnet; H = High Risk; E = Extreme High Risk.

A number of species, including possible target species with low productivity, were classified as low or medium risk. These included *Centrophorus squamosus*, *Centroscymnus coelolepis*, *Centroscymnus owstonii*, *Deania quadrispinosa*, *Pseudocarcharias kamoharai* and some of the Rajiidae species. These results, which may or may not be false negatives, appear to relate more to the susceptibility attributes in terms of species' horizontal (distributon) and vertical (depth) overlap with fishing effort (for example, some species had a very low distribution overlap with fishing effort, despite some of these occurring frequently in bycatch records). Species with limited horizontal and vertical distributions may be assessed to be higher risk if they have a larger proportion of overlap with fishing effort because a larger proportion of their populations will be susceptible to encountering the gears (and vice versa). This sensitivity to the susceptibility axis is to be expected given the generally low productivity (and resulting high risk scores on this axis) of most of the species included in this assessment.

Bycatch data can be analysed to assess the likelihood that certain gears interact with particular species, such that potential false positives and false negatives can be identified. As for some fishing effort data, the availability of bycatch data is limited and additional bycatch data would assist in identifying the plausibility of various results.

PSA and SAFE results for midwater trawl gears are likely to be less robust than those for other gears. This is due to the limitation of the modelling approach that assumes that midwater trawl fishing overlaps with the bottom habitat of deepwater chondrichthyans. In reality, midwater trawl gears only sometimes touch the seafloor. This limitation is likely to contribute to a higher number of false positives (i.e. species assessed to be high risk that are actually low risk). These and other limitations are discussed in additional detail below.

A number of species were identified as high risk due to missing productivity attribute data. These were generally rare or newly described species. The ERAWG Hobart workshop discussed that these may be candidates for a greater focus on data collection, including identification and biological sampling.

Sensitivity analyses

To be provided in a complementary Information paper.

Modifications to productivity and susceptibility attributes

Several modifications to the productivity and susceptibility attributes used in the risk assessment were made to those presented at SC2. These modifications are highlighted in red in the tables below.

Productivity attributes and risk categorisations

Attribute	Low productivity (high risk, score 3)	Medium productivity (medium risk, score 2)	High productivity (low risk, score 1)
P1. Average age at maturity	>15 years	5–15 years	<5 years
P2. Average maximum age	>25 years	10–25 years	<10 years
P3. Fecundity	<10 pups/egg cases per year	10-20 pups/egg cases per year	>20 pups/egg cases per year
P4. Average maximum size **(rescaled for deepwater chondrichthyans)**	>200 cm	70–200 cm	<70 cm
P5. Average size at maturity **(rescaled for deepwater chondrichthyans)**	>150 cm	40–150 cm	<40 cm
P6. Reproductive strategy	Live bearer	Egg case layer	Broadcast spawner (teleosts)
P7. Trophic level	>3.25	2.75–3.25	<2.75

Productivity attributes used for the PSA and SAFE were reviewed intersessionally and at the ERAWG Hobart workshop. Changes were recommended for attributes *P4: Average maximum size* and *P5: Average size at maturity*. The previous attribute values for P4 and P5 described a strong negative relationship between size and productivity, which was based on frequency of sizes across >2000

Australian species, including teleosts and chondrichthyans. However, small and large deepwater chondrichthyans can exhibit similar productivity. An analyses of the size-productivity relationship using data from the global database for deepwater chondrichthyans held by James Cook University estimated the relationship to be weaker than that previously used and the attribute values for P4 and P5 were rescaled accordingly.

Susceptibility attributes and risk categorisations

Attribute	Low susceptibility (low risk, score = 1)	Medium susceptibility (medium risk, score = 2)	High susceptibility (high risk, score = 3)
S1. Availability	<10% horizontal overlap	10-30% horizontal overlap	>30% horizontal overlap
S2. Encounterability **(rescaled based on fishing effort data)**	Low vertical overlap with fishing gear (<10%) based on middle 90% of the gear depth range*	Medium vertical overlap with fishing gear (10-30%) based on middle 90% of the gear depth range*	High vertical overlap with fishing gear (>30%) based on middle 90% of the gear depth range*
S3. Selectivity (scores vary by gear type)	Demersal and midwater trawl: 0-15 cm; > 500 cm in length Line: 0-40 cm; >500 cm in length Gillnet: 0-70 cm; >140 cm in length	Demersal and midwater trawl: 15-30 cm; 400-500 cm in length Line: 40-80 cm; 200-500 cm in length Gillnet: 70-80 cm; 130-140 cm in length	Demersal and midwater trawl: 30-400 cm in length Line: 80-200 cm in length Gillnet: 80-130 cm in length
S4. Post-capture mortality (scores may vary by fishery and gear type)	Evidence of post capture release and survival	Bycatch species	Retained species, or majority dead when released

* Ranges are included below

The ERAWG Hobart workshop, noted that there were a number of different methods for defining the encounterability attribute and associated risk categorisations. Given that some depth data for fishing operations and data for species depth ranges was available, the ERAWG selected a method for calculating encounterability based on the vertical overlap between fishing effort and species depth ranges. The ERAWG agreed to use the middle 90 percent (i.e. from the 5th to 95th percentiles) of fishing depth records for each gear as the 'core depth range'. Outliers, zeros and data deemed to be implausible were consequently discarded. The agreement to use the middle 90 percent of depth records from the available data translated into the following depth ranges for the encounterability attribute. The relevant risk categorisations based on the percentage of vertical overlap are included in the table above.

Gear	Depth Min (m)	Depth Max (m)
Demersal Trawl	700	1235
Midwater Trawl	430	970

Demersal Longline*	597	1716
Demersal Gillnet	810	1390

* Updated with France Territories depth data

Frequency histograms (including sample sizes) of fishing depth data that were provided can be found in the presentation formulated for the ERAWG workshop, which is available here on the SIOFA website. Additional fishing depth data from all fishing nations would be useful for refining these depth ranges.

Data and modelling limitations

Species list and productivity attribute data

The summary record of the ERAWG Hobart workshop details the process used for developing the species list and productivity attribute data, and associated limitations relating mostly to a general lack of biological data for many species. Consequently, these details are not included in this paper. At that workshop, it was demonstrated that the compilation of productivity attribute data was built on a large literature base and with a high level of expert input. It was noted that this level of analysis is not generally typical for other ERAs.

Species distribution data

Species distribution data were derived from a variety of sources, including the FAO Geonetwork database, the IUCN Red List and various other sources in the published literature. Differences in the mapping methodology and assumptions used for these different sources are likely to have influenced the PSA and SAFE results. This is discussed in more detail below.

Fishing effort and depth data

Fishing effort and bycatch data were requested from all bottom fishing nations for the relevant bottom fishing gears for 2012 to 2016. Fishing effort data were received from Australia, Cook Islands (2 out of 3 vessels), the European Union, France (Territories) and Japan. Depth records were patchy (noting that these were not explicitly requested). Bycatch or catch data were provided by Australia, Cook Islands and Japan. Fishing effort and bycatch data were not provided by Korea.

Based on the fishing effort in SIOFA as shown in the table below, up to 25% of trawl effort data was unavailable for some years (e.g. 2012 and 2013). For longline gears, 81% and 55% of effort data were missing for 2012 and 2013, respectively. For longline gears in particular, this limitation is likely to have resulted in the overestimation of risk to some species because the proportion of the overlap of species distributions with the available spatial distribution of fishing effort will be greater. Because of the lack of the availability of longline data for some years, it is possible that there will be a larger number of false positives for longline gears for the PSA and SAFE results. The precautionary principle would suggest that this lack of data should not be used as a reason to preclude the formulation of management actions to safeguard species caught by longline fishing that may be at high or extreme risk.

Table 3 Fishing effort in SIOFA fisheries, 2011–15

Flag	Gear	2011	2012	2013	2014	2015
Australia	Trawl days	132	104	32	63	12
	Trawl hrs	294	252	62	106	14
	Longline hooks	0	0	0	0	1,800
Cook Islands	Trawl days	599	490	524	523	501
European Union	Longline hooks	na	na	na	na	2,221,000
	Gillnet km	0	0	5,442	4,945	1,121
France Overseas Territories	Longline hooks	509,414	503,478	731,883	634,682	443,492
Japan	Trawl days	58	90	118	126	356
	Trawl Hrs	550	528	1,001	707	2,260
	Longline hooks	0	0	96,480	0	0
Korea	Trawl days	50	238	217	0	0
	Trawl hrs	286	623	233	0	0
	Longline hooks	355,192	2,193,460	1,023,252	0	0
Total Trawl days		**839**	**922**	**891**	**712**	**869**
Total Trawl hrs*		**1130**	**1403**	**1,296**	**813**	**2,274**
Total hooks		**864,606**	**2,696,938**	**1,851,615**	**634,682**	**2,664,492**
Total Gillnet km		**0**	**0**	**5,442**	**4,945**	**1,121**

Another potential limitation relating to the depth data used in the assessment is that the encounterability (S2) attribute method (based on 90 percent of the gear depth range) would be influenced by the inclusion of records from additional fishing effort data for those gears and years where data has not been provided.

Bycatch data

Bycatch data are useful for assessing the plausibility of risk scores. If a species assessed to be at high or extreme risk is rarely or never recorded in bycatch records, this may indicate a false positive. Bycatch data were received for most gears, although data quality was variable. The Cook Islands and relevant vessel masters are thanked for their cooperation in providing relatively comprehensive bycatch records from the FV Will Watch and FV Nikko Maru. Both datasets can be drawn on to identify possible false positives.

Modelling limitations

The selection of 20 minute resolution blocks for fishing effort assumes that fishing takes place across the entire area. Additionally, both PSA and SAFE methods assume that species are homogenously distributed across their ranges. In reality, this is not the case, but this is a precautionary approach based on trade-offs between data availability and intended outcomes of the risk assessment. For species assessed to be at high or extreme risk, finer resolution effort data could be used for particular gears, but the cost of doing so for all species (and processing all effort data at this resolution) could be prohibitively high and this cost may not be commensurate with the intended outcomes of the risk assessment.

The overlap of species distribution with fishing effort (which informs the availability (S1) attribute) is calculated on the percentage of the species distribution within the SIOFA area and not the percentage of overlap of effort with the entire species distribution. This is primarily because the lack of data on fishing effort adjacent to the assessment area would act to skew the risk categorisation. The risk needs to be assessed in terms of the risk to the population of the species within the SIOFA area. This ERA does not attempt to assess the risk of the SIOFA fishery to the global distribution of the species as SIOFA may not have the flexibility to implement or guide management responses outside the fishery.

The use of the availability (S1) and encounterability (S2) attributes considers the horizontal and vertical distribution of species in relation to fishing effort. Consequently, it was deemed to be unnecessary to specify which distribution datasets are depth based (i.e. within a total distribution extent) or representative of the entire distribution with no depth filter. Nonetheless, the variation in results from this assessment appeared to be more closely correlated to susceptibility attributes than

to productivity attributes and exploration of these sensitivities could form the basis for future research. The model, at this resolution, is fairly robust to this potential variation in spatial data used and does not necessarily require different interpretation of results based on different spatial data sources.

The ERAWG Hobart workshop, identified an important difference in the PSA and SAFE methodology for the availability (S1) attribute in circumstances where there is no overlap between species distribution and fishing effort. In these situations, a 1 is given for the risk score in the PSA. The SAFE method instead gives a zero, meaning that the risk from fishing mortality is a true zero.

In relation to the availability (S1) and encounterability (S2) attributes, an important limitation of the applicability of the method to midwater trawl gears was identified during the ERAWG Hobart workshop, which relates to the modelling assumption that midwater trawl gears interact with the seafloor, and that the model considers species' depth ranges independently of the fact that most midwater trawl operations rarely contact the seafloor. Given that many species' habitats are at the bottom of the water column (noting that some species have diurnal or nocturnal vertical or lateral (i.e. up and down slope) migrations), the method when applied to midwater trawl will tend to overestimate risk and result in more false positives. These residual risks can be addressed through the systematic review of risk scores.

A potential limitation of the risk assessment is that the assumptions around gear configurations influencing selectivity (S3) are incorrect. The ERAWG discussed that selectivity curves will vary for sharks, rays and chimaeras. Selectivity assumptions used in the risk assessment were based on sharks, which comprised most (76%) of the species assessed. Sensitivities around the use of different selectivity assumptions could be explored if deemed necessary, but data to inform the choice of different selectivity assumptions for sharks, rays and chimaeras is generally limited. It was recommended that the SIOFA SC consider the selectivity assumptions used for this assessment and propose any potential amendments.

The post capture mortality (PCM) risk categorisations were discussed at the ERAWG Hobart workshop. The default in the model is to assign high risk to target or byproduct species and medium risk to bycatch species. The attribution of low risk is generally taxa dependent (for example, may include air breathing or protected species), but this category was not used for this assessment. The ERAWG expressed concern over this assumption for deepwater chondrichthyans, noting that in the absence of information to suggest otherwise (and in line with the precautionary principle) that the preference was for all species in this ERA to be assigned a high risk for PCM. Consensus was unable to be reached by the ERAWG, and the ERAWG requested SIOFA SC to provide advice on PCM risk categorisations for the species included in the assessment. To explore possible outcomes of PCM assumptions, a sensitivity assuming 100% PCM was undertaken.

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