SERAWG-04-14

4th Meeting of the Stock and Ecological Risks Assessment (SERAWG3)
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Update on the ecological risk assessment of teleost species in SIOFA waters

Relate to agenda item: 9.2

Working paper ☒ Info paper ☐ Restricted ☐

Delegation of Australia

Abstract

This paper updates the SIOFA SERAWG and SC on an ecological risk assessment (ERA) for SIOFA teleosts. This assessment updates previous results of Productivity-Susceptibility Analysis (PSA) and Sustainability Assessment for Fishing Effects (SAFE) tools to assess the vulnerability of teleosts to demersal trawl, midwater trawl, 'shallow trawl' (Saya de Malha bank fishery), demersal line and pelagic line gears in the SIOFA area. The species list was developed using catch and observer records in the SIOFA database and information from annual reports submitted by SIOFA Contracting Parties. Fishing effort data are updated to 2019. Species distribution data was sourced from AquaMaps.org and various probability of occurrence layers were assessed as sensitivities. Life history attribute data was sourced from the CSIRO database that underpins the CSIRO ERA online tool and was available for most species. Results indicated less species were found to be at high or extreme risk compared to the preliminary analysis presented in 2020 and most species found to be at high or extreme risk had missing productivity attributes.

Recommendations

It is recommended that the SERAWG and SC:

Notes: that Australia has updated the teleost ERA following the provision of new catch and effort data for the period 2015-2019.

Notes: revisions have been made to the species list and methodology, but continued taxa identification issues prevent a comprehensive species list being developed.

Notes: the results of the SAFE assessment indicate only a few species at high or extreme risk across all fishing gears and most of these species are data deficient.

Notes: the reduction in risk ratings for some species is due to the use of updated data at a finer spatial scale.

Notes: additional work could be undertaken to further refine the species list and reduce underlying uncertainties. However, this work may be of limited utility unless species reporting issues are rectified in some fisheries and/or the level of fishing effort and its spatial extent increases from that assessed (i.e., 2015-2019).

Recommends: that assessment efforts continue to be focussed on targeted stock that are taken in high volumes.

Recommends: that catches of *Nemadactylus spp* and *Polyprions spp* be closely monitored and consideration of developing catch triggers for further assessment in future.

Recommends: that any future ERA concentrates on other taxa rather than teleosts.

Ecological risk assessment for teleost species caught by demersal fishing gears in the Southern Indian Ocean Fisheries Agreement area

ABARES: T. Emery, T. Timmiss and L. Georgeson[1]

CSIRO Oceans and Atmosphere J. R. Hartog, M Fuller

Introduction

The Southern Indian Ocean Fisheries Agreement (SIOFA) Meeting of the Parties have requested the SIOFA Scientific Committee to provide advice on the status of target, non-target (i.e., by-product) and bycatch (i.e., discarded, including endangered, threatened, and protected) species with which their fisheries interact. Australia has been leading ecological risk assessments (ERAs) to support these objectives.

This paper updates the SIOFA Stock and Ecological Risk Assessment Working Group (SERAWG) and Scientific Committee (SC) on ERAs undertaken for teleost species for which records of interaction with fishing gears (demersal trawl, midwater trawl, shallow demersal trawl, demersal longline and pelagic longline) exist in the SIOFA area. ERA methods and assumptions have been previously outlined (in SC04-27 and SERAWG-02-10) and are not detailed herein. Additional information on the ERA tools can also be found in Zhou et al. (2007, 2011, 2016) and Hobday et al. (2011).

Background

This paper provides an overview of the results of the most recent ERA conducted to assess the relative vulnerability of teleosts to demersal trawl, midwater trawl, shallow demersal trawl, demersal longline and pelagic longline gears in the SIOFA area. The two ERA tools that were applied in this assessment are the same that have been detailed in previous Australian papers to SIOFA (e.g., SERAWG-02-10, SC04-27), that is the Productivity-Susceptibility Analysis (PSA) and Sustainability Assessment for Fishing Effects (SAFE). Updates made to the previous teleost ERA include: (i) a revised species list; (ii) use of more recent fishing effort data (2015-2019); (iii) running sensitivities on the Aquamaps distribution data to explore broader probability of occurrence layers; and (iv) comparison of Aquamaps distribution data with other sources (e.g., FAO Geonetwork).

Methods

PSA and SAFE methods used in this assessment and underlying assumptions are fully described in SC04-27 with minor updates to the PSA susceptibility scoring described in SERAWG-02-10. They are not repeated herein.

Australia received updated catch and effort data for the period 2015 to 2019 from seven Contracting Parties and Participating Fishing Entities (CCPs) via the SIOFA Secretariat. A new species list of 70 species was created using this data. Any species caught in SIOFA by any fishing method was assessed

[1] Formerly ABARES, now Office of the Science Convenor

under all methods. It is important to note that the species list represents only a subset of the species for which interaction records exist in SIOFA due to poor resolution of catch data (e.g., catches reported at a genus or higher taxonomic level). Species reported at a genus level (See Table 1) in the SIOFA dataset were not included in the ERA because there is no 'species-specific' biological and life history information (including distribution) to inform their assessment.

Table 1: Taxa groups not identified to a species level in the SIOFA database and notes on possible species.

FAO Species Code	Scientific Name	English Name	Notes
AXQ	Acanthurus spp.		Could be several species such as *Acanthurus auranticavus, Acanthurus blochii, Acanthurus dussumieri*
CVY	Coryphaenoides spp.	Grenadiers, whiptails nei	Could be several species such as *Coryphaenoides armatus*
ROK	Helicolenus spp.	Rosefishes nei	Could be several species such as *Helicolenus mouchezi, Helicolenus percoides*, *Helicolenus dactylopterus*
HAX	Hemiramphus spp		Could be *Hemiramphus archipelagicus*, *Hemiramphus far*, *Hemiramphus lutkei* or *Hemiramphus marginatus*
LAP	Lampris spp	Opahs nei	Likely to be *Lampris guttatus*
LEV	Lepidion spp	Lepidion codlings nei	Could be *Lepidion inosimae* or *Lepidion microcephalus*
THB	Nemipterus spp	Threadfin breams nei	Could be *Nemipterus bipunctatus, Nemipterus japanonicus, Nemipterus peronii, Nemipterus randalli or Nemipterus zysron*
RPX	Parupeneus spp		Could be several species such as *Parupeneus barberinus*, *Parupeneus ciliatus*, *Parupeneus heptacanthus*
BAT	Platax spp	Batfishes	Could be *Platax batavianus*, *Platax orbicularis* or *Platax teira*
PBX	Plectorhinchus spp	Sweetlips, rubberlips nei	Could be several different species such as *Plectorhinchus pictus, Plectorhinchus cinctus or Plectorhinchus flavomaculatus*
BIG	Priacanthus spp	Bigeyes nei	Could be *Priacanthus hamrur, Priacanthus prolixus or Priacanthus tayenus*
TZX	Pterocaesio spp		Could be several species such as *Pterocaesio chrysozona, Pterocaesio marri or Pterocaesio pisang*
RAX	Rastrelliger spp	Indian mackerels nei	Could be *Rastrelliger kanagurta (Indian mackerel)*
KGX	Scomberomorus spp	Seerfishes nei	Could be *Scomberomorus commerson*
SPI	Siganus spp	Spinefeet(=Rabbitfishes) nei	Could be several species such as *Siganus luridus, Siganus argenteus, Sigan us canaliculatus*
POX	Trachinotus spp	Pompanos nei	Could be *Trachinotus botla* or *Trachinotus baillonii*
GOX	Upeneus spp	Goatfishes	Could be several different species such as *Upeneus asymmetricus, Upeneus margarethae or Upeneus mascareinsis*
SDX	Decapterus spp	Scads nei	Possible *Decapterus russelli*

SZX	Saurida spp		Possible *Saurida undosquamis*
NGX	Carangoides spp		Possible *Carangoides fulvoguttatus*
GRV	Macrourus spp	Grenadiers nei	Possible *Macruronus novaezelandiae* (Blue Grenadier)
SNA	Lutjanus spp	Snappers nei	Likely covered by species already in list
GPX	Epinephelus spp	Groupers nei	Likely covered by species already in list
BAR	Sphyraena spp	Barracudas nei	Likely covered by species already in list
LZX	Lethrinus spp		Likely covered by species already in list
HAU	Polyprion spp	Hapuka	Likely covered by species already in list
ALF	Beryx spp	Alfonsinos nei	Likely covered by species already in list
AMX	Seriola spp	Amberjacks nei	Likely covered by species already in list

Depth ranges for individual fishing gears were also updated based on the new effort data for 2015 to 2019 (Table 2). The middle 90 percent (i.e., from the 5_{th} to 95_{th} percentiles) of fishing depth records for each gear was defined as the core depth range.

Table 2: Revised depth ranges for each gear (i.e., middle 90% - core depth range) informing vertical overlap (encounterability) for the PSA and SAFE assessments.

Gear	Depth Min (m)	Depth Max (m)
Shallow Trawl (Thai)	50	96
Pelagic Longline	100	150
Demersal Trawl	500	1381
Midwater Trawl	133	888
Demersal Longline	397	2062

Previously, species distribution data was sourced from www.aquamaps.org using the 80-100% probability layer of occurrence. Australia attempted to run sensitivities using different sources of distribution data (from the FAO Geonetwork and IUCN Red List), however there was a lack of distribution maps for teleost species, which meant this work was not pursued further.

A key benefit of using AquaMaps for this assessment was the excellent coverage of species included in the analysis (i.e., very few species were missing distribution data). Consequently, Australia was able to run sensitivities on the AquaMaps distribution data to explore the broader probability of occurrence layers (e.g., 60-100%, 40-100%), in addition to the existing 80-100% probability of occurrence layer that was used in the preliminary teleost ERA.

Results and Discussion

Unless specified, the following results are based on the existing 80-100% probability of occurrence layer from the AquaMaps distribution data.

The PSA assessed 10, 13, 12, 7 and 8 species to be at high relative vulnerability for demersal trawl, midwater trawl, demersal longline, pelagic longline and shallow trawl gears, respectively (Table 2). Of these species, 8 were assessed to be 'data deficient' across all methods, meaning that they were missing information for three or more productivity and/or susceptibility attributes (Table 2).

The SAFE assessed 4, 5, 6, 5 and 4 species to be at high or extreme vulnerability for demersal trawl, midwater trawl, demersal longline, pelagic longline and shallow trawl gears, respectively (Table 2). Of the extreme risk species[2], 3 species were assessed to be 'data deficient' across all gears and 2 species across some of the gear methods, meaning that F-based reference points were unable to be calculated from the available biological data. The only species found to be at extreme risk that was not data deficient was *Nemadactylus macropterus* (grey morwong) in midwater trawl. Catches of this species, however, are low across the period assessed. Two species that were found to be at high risk in demersal longline, which were not data deficient, including, *Polyprion americanus* (Atlantic wreckfish) and *Polyprion oxygeneios* (hapuku wreckfish).

Consistent with the previous results presented in 2020, the PSA resulted in many more species being assessed at medium and high relative vulnerability than the SAFE across all gears. This is an expected result driven by the more precautionary nature of the PSA, in which species can still be assessed to be 'at risk' (based on a combination of their productivity and susceptibility attributes) even if they have no overlap with fishing effort or are only rarely encountered by the gears. In contrast, the SAFE gives a true zero for risk (expressed as an F-estimate of zero) if there is zero overlap between the species range and the fishing effort. In this vein, SAFE is a much more powerful tool for situations where good quality and coverage of effort data are available and there is a high level of confidence around the species distribution data used in the assessment. However, SAFE may fail to accurately represent risk if there are problems with the species distribution and/or effort data. Furthermore, and similarly to the PSA, SAFE can also result in species assessed as being 'at risk' if there is overlap between the fishery and the species distribution, even if those species are rarely or never encountered by the fishing gears.

For the PSA, Figures 1a and 1b show a broad distribution of scores across the productivity axes for each gear. This is to be expected given the varied biology and life history of species included in the ERA, ranging from very high productivity to very low productivity species. Despite this, most species are categorised as moderately productive (i.e., clustered around the 1.5-2 scores on this axis). Distribution in scores across the susceptibility axes for each gear are more variable, with susceptibility for some gears (e.g., shallow demersal trawl) having a narrower distribution than others (e.g., demersal longline). Figures 1a and 1b also show that the remaining 'data deficient' species, defined as those missing three or more productivity and/or susceptibility attributes (and represented by circles as opposed to triangles), are generally assessed to be at higher relative vulnerability. This accords with the precautionary nature of the PSA in which attributes for which there is no information are automatically assigned a high-risk score.

The PSA vs. SAFE results (Figures 2a and 2b), in which PSA scores (low, medium and high) are compared against the SAFE estimates (low, medium, high and extreme, expressed as the ratio of the F-estimate to the F_{LIM} threshold) generally show a high level of potential false positives in the PSA, which are

2 See Zhou et al. (2011) https://www.sciencedirect.com/science/article/pii/S0165783610002481 for a full description of the reference points and ecological consequence.

species assessed to be at high relative vulnerability in the PSA that are probably not vulnerable to fishing activities during the period assessed.

Australia also investigated running different sensitivities using various probability of occurrence layers from Aquamaps. Results presented in this paper are for 80-100% probability of occurrence layer from Aquamaps. Results were also analysed for the 60-100%, 40-100% and >0-100% probability of occurrence. Generally, the lower probabilities result in the range of species within the SIOFA area increasing in size. This resulted in a reduction in the overall risk score (Table 3) of some species as they are assumed to be distributed over a larger area and this usually reduces the overlap between the fishery and the species distribution.

Table 3: List of species that changed SAFE estimates across various probability of occurrence layers from Aquamaps, which informs horizontal overlap (availability) for the PSA and SAFE assessments.

Species	**Gear type**	**Overlap**			
		>0-100	**40-100**	**60-100**	**80-100**
Hoplostethus atlanticus	Demersal longline	Low	Low	Low	Medium
Pseudocyttus maculatus	Demersal longline	Low	Low	Extreme	Low
Polyprion americanus	Demersal longline	Low	Low	High	High
Polyprion oxygeneios	Demersal longline	Low	Low	Medium	High
Polyprion americanus	Demersal trawl	Low	Low	Low	Medium
Polyprion oxygeneios	Demersal trawl	Low	Low	Low	Medium
Nemadactylus macropterus	Midwater trawl	Low	Low	Medium	Extreme
Polyprion americanus	Midwater trawl	Low	Low	Medium	Medium
Polyprion oxygeneios	Midwater trawl	Low	Low	Low	Medium

However, for one species, *Pseudocyttus maculatus* (smooth oreo-dory) this increased the risk at the 60-100% probability of occurrence layer, as the assumed increase in species range led it to overlapping with a fishery where no such overlap occurred in the 80-100% layer. Australia did not pursue this analysis further as there was a limited number of species that changed SAFE estimates. This analysis does highlight that the SAFE method appears robust to assumptions about species distribution and how they subsequentially overlap with fishing effort for teleosts in SIOFA.

Species identification issues reduce confidence that all species of interest are included in the ERA. An example of a significant limitation of this assessment is that it does not include any *Nemipterus* spp. (i.e., threadfin breams), of which several thousand tonnes were recorded as caught in SIOFA fisheries between 2015 and 2019. This genus is listed under the group code 'THB' in the SIOFA databases but are not included in our assessment because there is no 'species-specific' biological and life history information (including distribution) to inform their assessment. To properly resolve these problems, catches should ideally be recorded and reported at the species level, but we recognise that there may be several practical constraints to this and that these sorts of changes take time to implement.

In conclusion, the results indicate that there are fewer species considered to be at extreme or high risk compared to the previous assessment presented in 2020. One of the main factors driving this change is the provision of more comprehensive and updated fishing effort data from 2015 to 2019, by CCPs, which reduced the spatial overlap with some species. The results of the SAFE analysis indicate that a lack of productivity data for five species is responsible for most of the extreme risk ratings. The SAFE methodology is designed to be precautionary and the lack of data results in assuming the species have the lowest possible productivity score for the missing attributes. It is possible that some of these species could be genuinely high risk, but experience elsewhere has shown that most of these species will be found to be at lower risk once the productivity attributes of these species are known. Further work on the productivity attributes of these species could reduce the uncertainty in the assessment. The three species with all productivity attributes known, which were found to be at extreme or high risk with the SAFE methodology were *Nemadactylus macropterus* in the midwater trawl fishery and *Polyprion americanus* and *Polyprion oxygeneios* in the demersal longline fishery. While the reported catch of these species is not high, the level of discards is not known, and it is recommended that the CCPs who operate in this fishery consider further analysis or management action to ensure the catch of this species is sustainable within the SIOFA area.

Figure 1a. PSA results for 70 teleost species thought to occur and have the potential to interact with demersal trawl, midwater trawl and shallow trawl gears in the Southern Indian Ocean. Size of symbol represents number (n) of species with the same vulnerability score, while the shape equates to whether the species is 'data deficient' (circle) or 'data robust' (triangle). Data deficient species are defined as those missing three or more productivity and/or susceptibility attributes. Based on the existing 80-100% probability of occurrence layer from the AquaMaps distribution data.

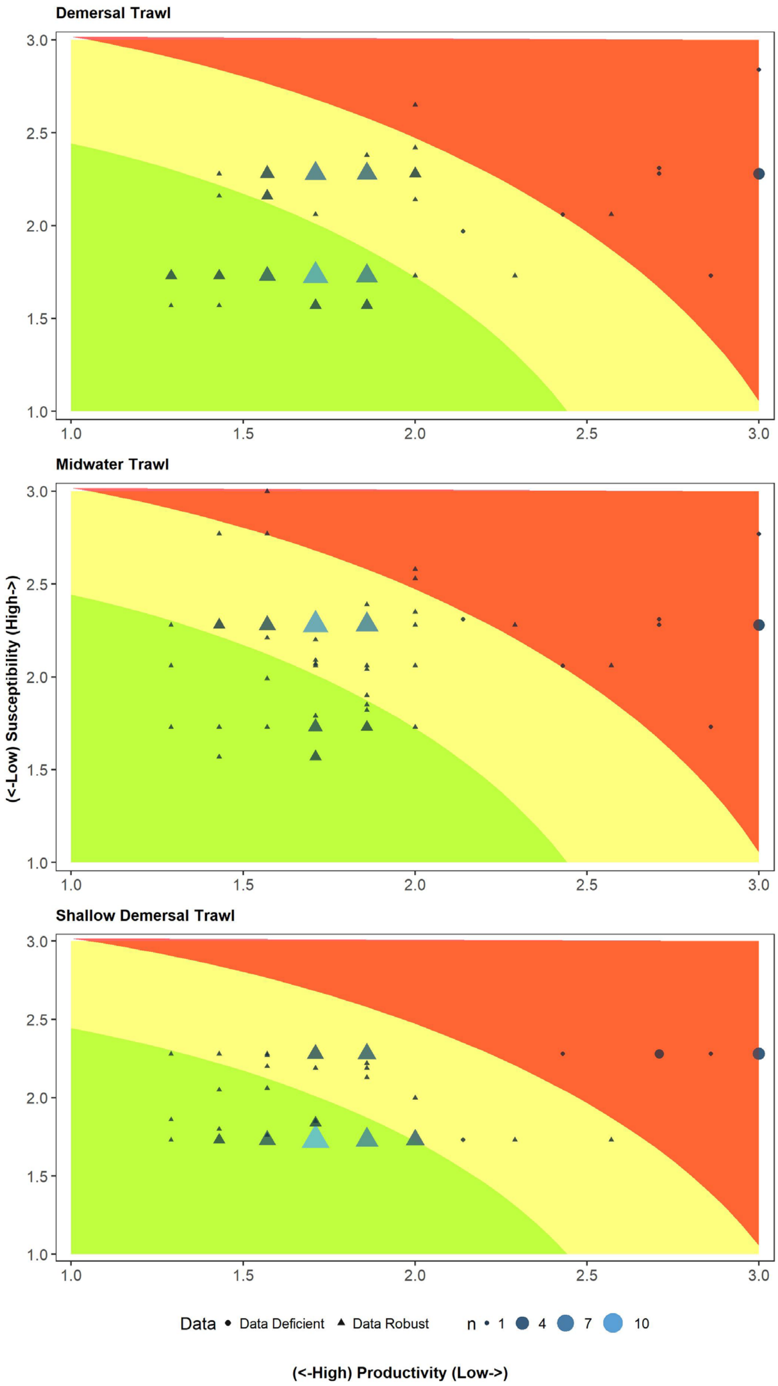

Figure 1b. PSA results for 70 teleost species thought to occur and have the potential to interact with demersal longline and pelagic longline gears in the Southern Indian Ocean. Size of symbol represents number (n) of species with the same vulnerability score, while the shape equates to whether the species is 'data deficient' (circle) or 'data robust' (triangle). Data deficient species are defined as those missing three or more productivity and/or susceptibility attributes. Based on the existing 80-100% probability of occurrence layer from the AquaMaps distribution data.

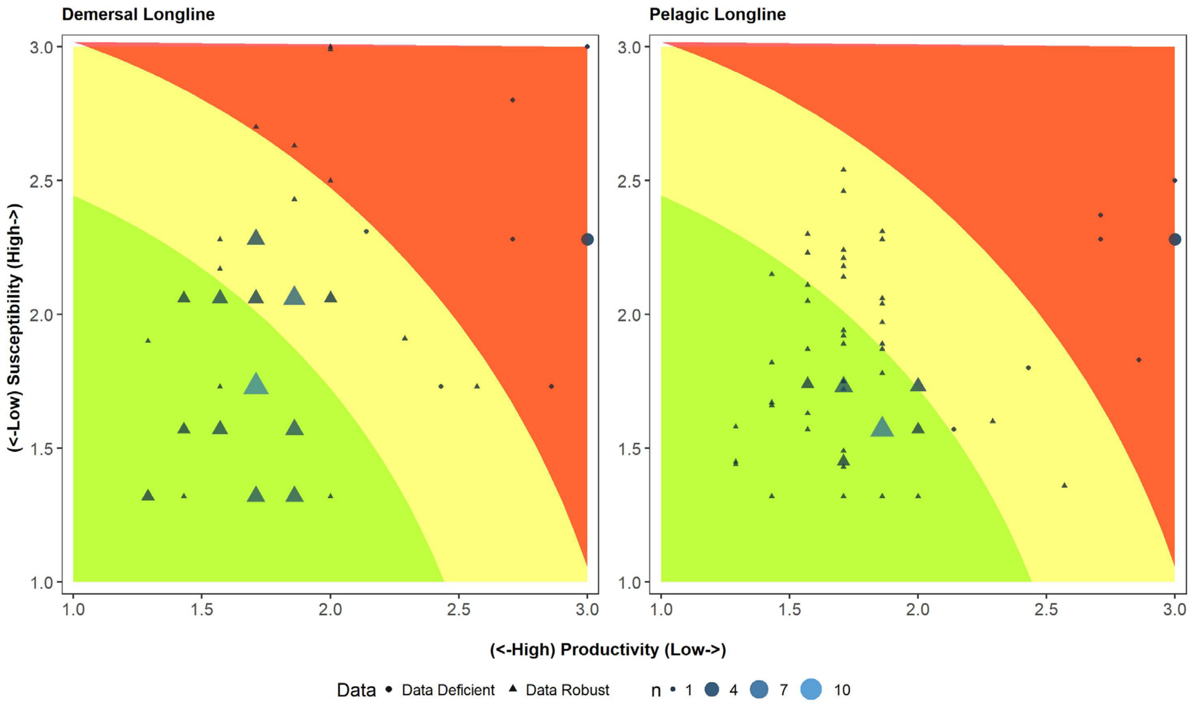

Figure 2a: Relationship between SAFE and PSA results for 70 teleost species thought to occur and have the potential to interact with demersal trawl, midwater trawl and shallow demersal trawl in the Southern Indian Ocean. Points are coloured yellow and green to signify species classified as medium and low vulnerability, respectively, in the SAFE. Dashed red and orange lines represent PSA risk high and medium score boundaries. Six species are not shown on the panels as *F*-based reference points were unable to be calculated. Based on the existing 80-100% probability of occurrence layer from the AquaMaps distribution data.

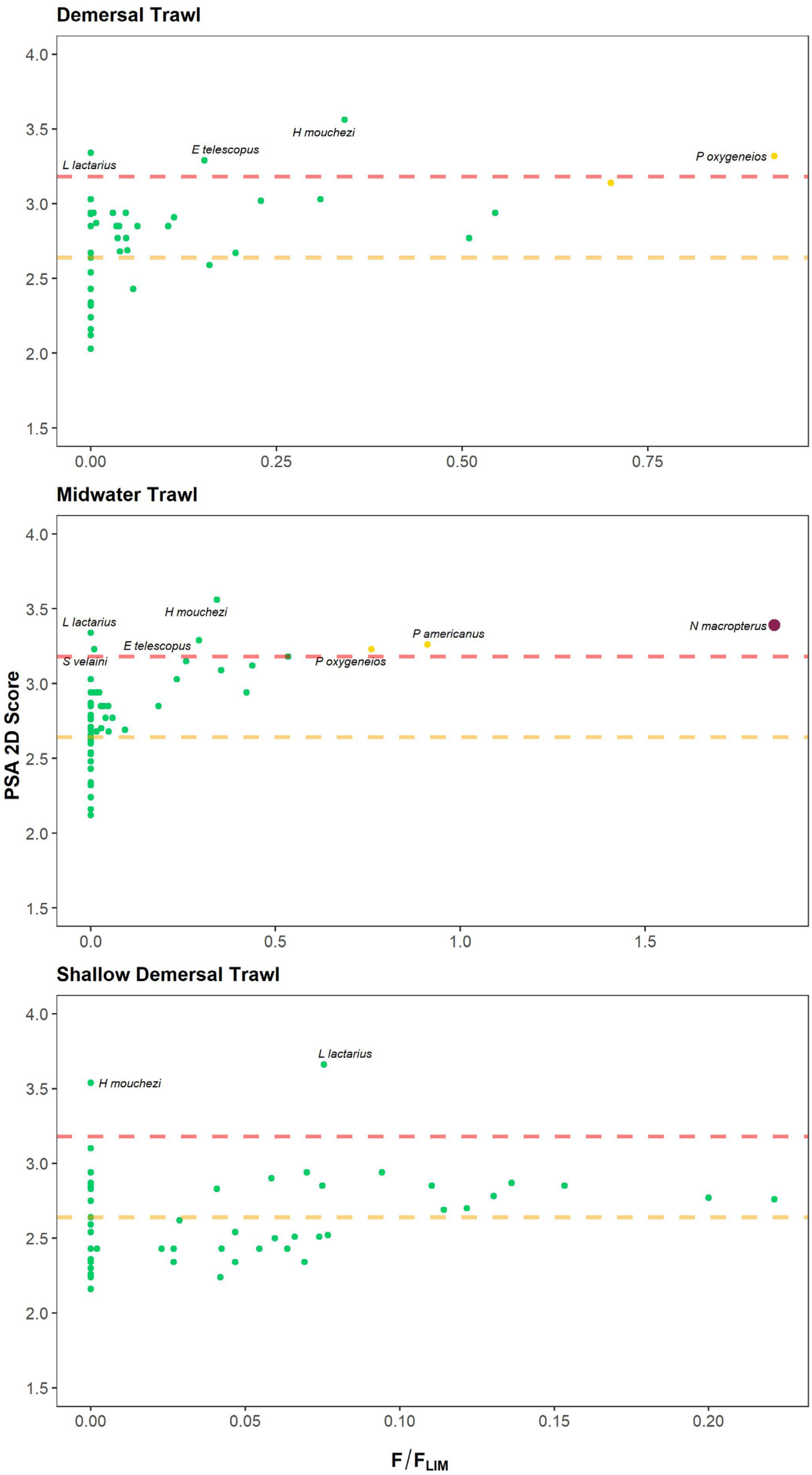

Figure 2b: Relationship between SAFE and PSA results for 70 teleost species thought to occur and have the potential to interact with demersal longline and pelagic longline gears in the Southern Indian Ocean. Points are coloured dark red, light red, yellow and green to signify species classified as extreme, high, medium and low vulnerability, respectively, in the SAFE. Dashed red and orange lines represent PSA risk high and medium score boundaries. Six species are not shown on the panels as *F*-based reference points were unable to be calculated. Based on the existing 80-100% probability of occurrence layer from the AquaMaps distribution data.

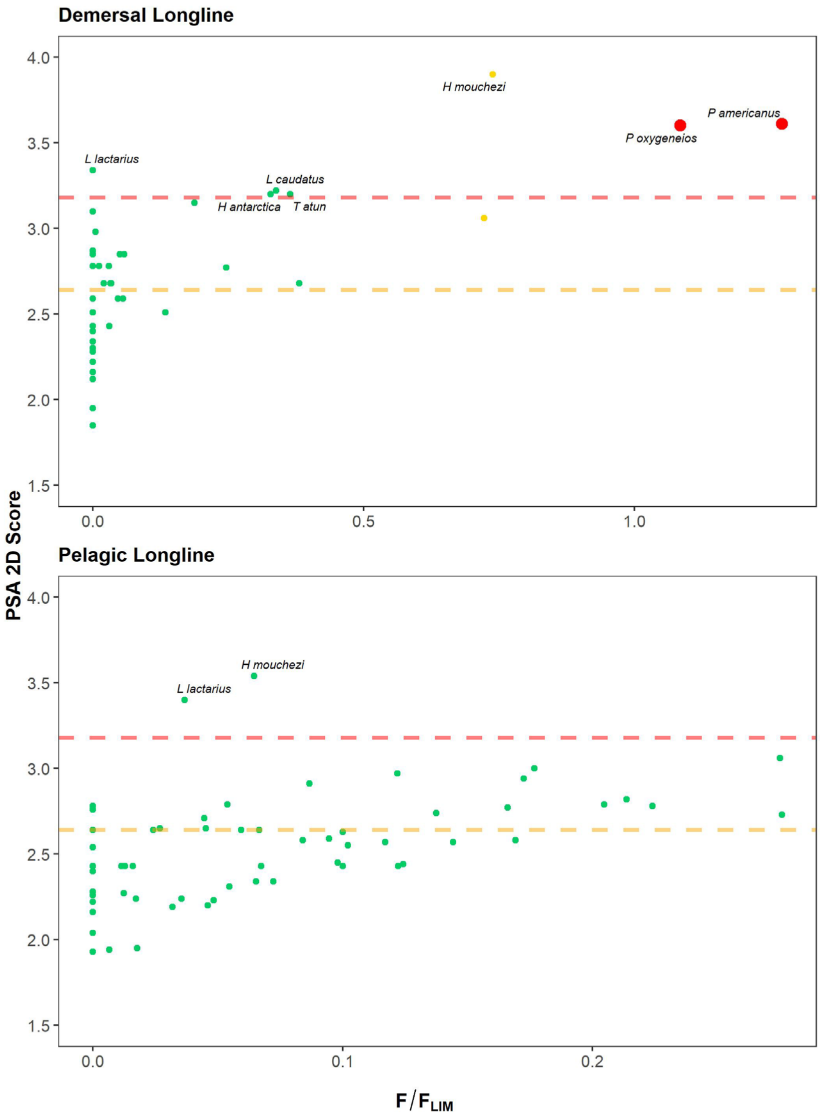

Table 3. Overview of PSA and SAFE vulnerability categories for each species and each gear type included in the assessment. Note that PSA DD ('Data Deficient') denotes species included in the PSA that were missing three or more productivity and/or susceptibility attributes. SAFE DD denotes species included in the SAFE for which F-based reference points (F_{msm}, F_{lim} and F_{crash}) were unable to be estimated. Based on the existing 80-100% probability of occurrence layer from the AquaMaps distribution data.

Species	Demersal Trawl		Midwater Trawl		Demersal Longline		Pelagic Longline		Shallow Demersal Trawl		PSA DD	SAFE DD
	PSA	SAFE	PSA	SAFE	PSA	SAFE	PSA	SAFE	PSA	SAFE		
Allocyttus niger	Medium	Low	Medium	Low	Medium	Low	Low	Low	Low	Low		
Allocyttus verrucosus	Medium	Low	Medium	Low	Medium	Low	Low	Low	Low	Low		
Aluterus monoceros	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low		
Antimora rostrata	Medium	Low	Medium	Low	Medium	Low	Low	Low	Low	Low		
Aprion virescens	Low	Low	Medium	Low	Low	Low	Medium	Low	Medium	Low		
Barbourisia rufa	High	Extreme	High	Extreme	High	Extreme	High	Extreme	High	Extreme	DD	DD
Beryx decadactylus	Medium	Low	Medium	Low	Low	Low	Low	Low	Low	Low		
Beryx splendens	Medium	Low	Medium	Low	Low	Low	Low	Low	Low	Low		
Borostomias antarcticus	High	Extreme	High	Extreme	Medium	Extreme	Medium	Extreme	High	Extreme	DD	DD
Caesio cuning	Medium	Low	Medium	Low	Low	Low	Low	Low	Medium	Low		
Carangoides fulvoguttatus	Low	Low	Low	Low	Low	Low	Low	Low	Medium	Low		
Cephalopholis sonnerati	Low	Low	Low	Low	Low	Low	Medium	Low	Medium	Low		
Cyttus traversi	Medium	Low	Medium	Low	Low	Low	Low	Low	Low	Low		
Decapterus russelli	Low	Low	Medium	Low	Low	Low	Low	Low	Low	Low		
Dissostichus eleginoides	Medium	Low	Medium	Low	Medium	Low	Low	Low	Medium	Low		
Elagatis bipinnulata	Low	Low	Low	Low	Low	Low	Medium	Low	Medium	Low		
Epigonus telescopus	High	Low	High	Low	Medium	Low	Medium	Low	Medium	Low		
Epinephelus fasciatus	Low	Low	Low	Low	Low	Low	Medium	Low	Medium	Low		
Epinephelus marginatus	High	Extreme	High	Extreme	High	Extreme	High	Extreme	High	Low	DD	DD
Epinephelus morrhua	Low	Low	Medium	Low	Low	Low	Low	Low	Low	Low		
Epinephelus multinotatus	Low	Low	Low	Low	Low	Low	Low	Low	Medium	Low		
Etelis carbunculus	Low	Low	Medium	Low	Low	Low	Medium	Low	Low	Low		
Etelis coruscans	Low	Low	Medium	Low	Low	Low	Medium	Low	Low	Low		
Gnathanodon speciosus	Low	Low	Low	Low	Low	Low	Low	Low	Medium	Low		

Helicolenus dactylopterus	High	Extreme	High	Extreme	High	Extreme	High	Extreme	High	Extreme	DD	DD
Helicolenus mouchezi	High	Low	High	Low	High	Medium	High	Low	High	Low	DD	
Helicolenus percoides	Medium	Low	Medium	Low	Medium	Low	Low	Low	Low	Low		
Hoplostethus atlanticus	Medium	Low	Medium	Low	Medium	Medium	Low	Low	Low	Low		
Hoplostethus intermedius	Medium	Low	Medium	Low	Low	Low	Low	Low	Low	Low		
Hyperoglyphe antarctica	Medium	Low	Medium	Low	High	Low	Medium	Low	Medium	Low		
Lactarius lactarius	High	Low	High	Low	High	Low	High	Low	High	Low	DD	
Latridopsis forsteri	Low	Low	Medium	Low	Low	Low	Medium	Low	Medium	Low		
Lepidocybium flavobrunneum	Medium	Low	Medium	Low	Medium	Low	Low	Low	Low	Low		
Lepidopus caudatus	Medium	Low	Medium	Low	High	Low	Low	Low	Low	Low		
Lethrinus mahsena	High	Low	High	Low	High	Low	High	Extreme	High	Extreme	DD	DD
Lethrinus nebulosus	Low	Low	Low	Low	Low	Low	Low	Low	Medium	Low		
Lutjanus bohar	Low	Low	Medium	Low	Low	Low	Medium	Low	Medium	Low		
Lutjanus lutjanus	Low	Low	Low	Low	Low	Low	Low	Low	Medium	Low		
Macruronus novaezelandiae	Medium	Low	Medium	Low	Medium	Low	Low	Low	Low	Low		
Microcanthus strigatus	Low	Low	Low	Low	Low	Low	Medium	Low	Medium	Low		
Mora moro	Medium	Low	Medium	Low	Medium	Low	Low	Low	Low	Low		
Nemadactylus macropterus	Medium	Low	High	Extreme	Medium	Low	Low	Low	Low	Low		
Neocyttus rhomboidalis	Medium	Low	Medium	Low	Medium	Low	Low	Low	Low	Low		
Pagellus affinis	High	Low	High	Low	High	Low	High	Low	High	Low	DD	DD
Pentaprion longimanus	Low	Low	Medium	Low	Low	Low	Medium	Low	Medium	Low		
Plagiogeneion rubiginosum	Low	Low	Medium	Low	Medium	Low	Low	Low	Low	Low		
Platycephalus australis	Low	Low	Medium	Low	Low	Low	Medium	Low	Medium	Low		
Plectropomus laevis	Low	Low	Low	Low	Low	Low	Low	Low	Medium	Low		
Polyprion americanus	Medium	Medium	High	Medium	High	High	Medium	Low	Medium	Low		
Polyprion oxygeneios	High	Medium	High	Medium	High	High	Medium	Low	Medium	Low		
Pristipomoides filamentosus	Low	Low	Medium	Low	Low	Low	Medium	Low	Low	Low		
Promethichthys prometheus	Medium	Low	Medium	Low	Medium	Low	Low	Low	Low	Low		
Pseudocaranx georgianus	Medium	Low	Medium	Low	Medium	Low	Low	Low	Low	Low		
Pseudocyttus maculatus	Medium	Low	Medium	Low	Medium	Low	Low	Low	Medium	Low		

Pseudopentaceros richardsoni	Medium	Low	Medium	Low	Medium	Low	Medium	Low	Medium	Low	DD	
Rexea solandri	Medium	Low	Medium	Low	Medium	Low	Low	Low	Low	Low		
Ruvettus pretiosus	Medium	Low	Medium	Low	Medium	Low	Low	Low	Low	Low		
Sargocentron rubrum	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low		
Saurida undosquamis	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low		
Schedophilus velaini	Medium	Low	High	Low	Medium	Low	Medium	Low	Medium	Low		
Selar crumenophthalmus	Low	Low	Medium	Low	Low	Low	Medium	Low	Medium	Low		
Selaroides leptolepis	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low		
Seriola dumerilli	Low	Low	Medium	Low	Low	Low	Medium	Low	Low	Low		
Seriola lalandi	Medium	Low	Medium	Low	Medium	Low	Low	Low	Low	Low		
Seriolella punctata	Medium	Low	Medium	Low	Low	Low	Low	Low	Low	Low		
Seriolina nigrofasciata	Low	Low	Low	Low	Low	Low	Medium	Low	Medium	Low		
Sphyraena obtusata	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low		
Thyrsites atun	Low	Low	Medium	Low	High	Low	Low	Low	Low	Low		
Trachurus novaezelandiae	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low		
Zeus faber	Low	Low	Medium	Low	Low	Low	Low	Low	Low	Low		

Table 4. Overview of SAFE vulnerability categories, susceptibility (F-estimate) scores and F-based reference points (F_{msm}, F_{lim} and F_{crash}). Based on the existing 80-100% probability of occurrence layer from the AquaMaps distribution data.

Species	Pelagic longline		Demersal longline		Demersal trawl		Midwater trawl		Shallow demersal trawl		F_{msm}	F_{lim}	F_{crash}
	Vulnerability	F estimate	Vulnerability	F estimate	Vulnerability	F estimate	Vulnerability	F estimate	Vulnerability	F estimate			
Allocyttus niger	Low	0	Low	0	Low	0	Low	0	Low	0	0.12	0.19	0.25
Allocyttus verrucosus	Low	0.017	Low	0.002	Low	0.008	Low	0.003	Low	0	0.11	0.17	0.23
Aluterus monoceros	Low	0.011	Low	0	Low	0	Low	0	Low	0.026	0.42	0.62	0.83
Antimora rostrata	Low	0.033	Low	0.01	Low	0.031	Low	0.008	Low	0.001	0.33	0.49	0.65
Aprion virescens	Low	0.154	Low	0	Low	0	Low	0	Low	0.073	0.37	0.56	0.75
Barbourisia rufa	Extreme	0.117	Extreme	0.097	Extreme	0.055	Extreme	0.043	Extreme	0.017			
Beryx decadactylus	Low	0.034	Low	0.022	Low	0.017	Low	0.019	Low	0.022	0.31	0.47	0.63
Beryx splendens	Low	0.034	Low	0.029	Low	0.025	Low	0.031	Low	0.014	0.34	0.52	0.69
Borostomias antarcticus	Extreme	0.039	Extreme	0.014	Extreme	0.035	Extreme	0.022	Extreme	0.003			
Caesio cuning	Low	0	Low	0	Low	0	Low	0	Low	0	0.81	1.22	1.63
Carangoides fulvoguttatus	Low	0.016	Low	0	Low	0	Low	0	Low	0.069	0.62	0.92	1.23
Cephalopholis sonnerati	Low	0.055	Low	0	Low	0	Low	0	Low	0.086	0.82	1.23	1.64
Cyttus traversi	Low	0.041	Low	0	Low	0.037	Low	0.07	Low	0	0.5	0.75	1
Decapterus russelli	Low	0.079	Low	0	Low	0	Low	0	Low	0.056	0.62	0.94	1.25
Dissostichus eleginoides	Low	0	Low	0	Low	0	Low	0	Low	0	0.12	0.18	0.24
Elagatis bipinnulata	Low	0.136	Low	0	Low	0	Low	0	Low	0.085	0.51	0.77	1.02
Epigonus telescopus	Low	0.013	Low	0	Low	0.023	Low	0.044	Low	0	0.1	0.15	0.2
Epinephelus fasciatus	Low	0.091	Low	0	Low	0	Low	0	Low	0.073	0.22	0.33	0.44
Epinephelus marginatus	Extreme	0.056	Extreme	0.303	Extreme	0.241	Extreme	0.219	Low	0			
Epinephelus morrhua	Low	0.066	Low	0	Low	0	Low	0	Low	0.027	0.26	0.39	0.52
Epinephelus multinotatus	Low	0.046	Low	0	Low	0	Low	0	Low	0.074	0.25	0.37	0.49
Etelis carbunculus	Low	0.094	Low	0	Low	0	Low	0	Low	0.028	0.29	0.44	0.59
Etelis coruscans	Low	0.088	Low	0	Low	0	Low	0	Low	0.033	0.29	0.43	0.57
Gnathanodon speciosus	Low	0	Low	0	Low	0	Low	0	Low	0	0.51	0.77	1.03
Helicolenus dactylopterus	Extreme	0.099	Extreme	0.067	Extreme	0.027	Extreme	0.028	Extreme	0.042			

Helicolenus mouchezi	Low	0.02	Medium	0.229	Low	0.106	Low	0.106	Low	0	0.21	0.31	0.41
Helicolenus percoides	Low	0	Low	0	Low	0	Low	0	Low	0	0.23	0.35	0.46
Hoplostethus atlanticus	Low	0.022	Medium	0.13	Low	0.098	Low	0.076	Low	0	0.12	0.18	0.24
Hoplostethus intermedius	Low	0.016	Low	0.01	Low	0.013	Low	0.016	Low	0.018	0.22	0.33	0.44
Hyperoglyphe antarctica	Low	0.019	Low	0.105	Low	0.099	Low	0.113	Low	0	0.21	0.32	0.42
Lactarius lactarius	Low	0.042	Low	0	Low	0	Low	0	Low	0.086	0.76	1.14	1.52
Latridopsis forsteri	Low	0	Low	0	Low	0	Low	0	Low	0	0.21	0.31	0.41
Lepidocybium flavobrunneum	Low	0.075	Low	0.026	Low	0.019	Low	0.025	Low	0.014	0.35	0.52	0.7
Lepidopus caudatus	Low	0.006	Low	0.176	Low	0.119	Low	0.121	Low	0	0.35	0.52	0.7
Lethrinus mahsena	Extreme	0.144	Low	0	Low	0	Low	0	Extreme	0.065			
Lethrinus nebulosus	Low	0.016	Low	0	Low	0	Low	0	Low	0.069	0.3	0.45	0.6
Lutjanus bohar	Low	0.103	Low	0	Low	0	Low	0	Low	0.056	0.31	0.46	0.62
Lutjanus lutjanus	Low	0.029	Low	0	Low	0	Low	0	Low	0.072	0.42	0.63	0.84
Macruronus novaezelandiae	Low	0	Low	0	Low	0	Low	0	Low	0	0.24	0.36	0.48
Microcanthus strigatus	Low	0	Low	0	Low	0	Low	0	Low	0	0.28	0.42	0.55
Mora moro	Low	0.047	Low	0.015	Low	0.048	Low	0.013	Low	0	0.31	0.46	0.61
Nemadactylus macropterus	Low	0	Low	0.122	Low	0.163	Extreme	0.592	Low	0	0.22	0.32	0.43
Neocyttus rhomboidalis	Low	0.004	Low	0	Low	0.001	Low	0.002	Low	0	0.16	0.25	0.33
Pagellus affinis	Low	0	Low	0	Low	0	Low	0	Low	0			
Pentaprion longimanus	Low	0.045	Low	0	Low	0	Low	0	Low	0.076	1.24	1.86	2.48
Plagiogeneion rubiginosum	Low	0	Low	0	Low	0	Low	0	Low	0	0.36	0.54	0.72
Platycephalus australis	Low	0.1	Low	0	Low	0	Low	0	Low	0.079	0.39	0.58	0.78
Plectropomus laevis	Low	0	Low	0	Low	0	Low	0	Low	0	0.31	0.47	0.62
Polyprion americanus	Low	0.012	High	0.229	Medium	0.126	Medium	0.164	Low	0	0.12	0.18	0.24
Polyprion oxygeneios	Low	0	High	0.217	Medium	0.184	Medium	0.152	Low	0	0.13	0.2	0.26
Pristipomoides filamentosus	Low	0.083	Low	0	Low	0	Low	0	Low	0.037	0.33	0.5	0.66
Promethichthys prometheus	Low	0.055	Low	0.014	Low	0.014	Low	0.011	Low	0.022	0.31	0.47	0.63
Pseudocaranx georgianus	Low	0.041	Low	0.101	Low	0.08	Low	0.219	Low	0	0.27	0.41	0.54
Pseudocyttus maculatus	Low	0	Low	0	Low	0	Low	0	Low	0	0.16	0.23	0.31
Pseudopentaceros richardsoni	Low	0.011	Low	0.077	Low	0.046	Low	0.106	Low	0	0.27	0.41	0.54

Rexea solandri	Low	0	Low	0	Low	0	Low	0	Low	0	0.28	0.41	0.55
Ruvettus pretiosus	Low	0.051	Low	0.018	Low	0.018	Low	0.019	Low	0.022	0.35	0.52	0.7
Sargocentron rubrum	Low	0.016	Low	0	Low	0	Low	0	Low	0.069	1.6	2.4	3.2
Saurida undosquamis	Low	0	Low	0	Low	0	Low	0	Low	0	0.56	0.85	1.13
Schedophilus velaini	Low	0.021	Low	0.002	Low	0.003	Low	0.004	Low	0	0.26	0.39	0.52
Selar crumenophthalmus	Low	0.048	Low	0	Low	0	Low	0	Low	0.062	0.71	1.06	1.41
Selaroides leptolepis	Low	0.018	Low	0	Low	0	Low	0	Low	0.033	0.96	1.44	1.92
Seriola dumerilli	Low	0.077	Low	0	Low	0	Low	0	Low	0.037	0.38	0.56	0.75
Seriola lalandi	Low	0.052	Low	0.032	Low	0.021	Low	0.015	Low	0.03	0.37	0.55	0.73
Seriolella punctata	Low	0	Low	0	Low	0	Low	0	Low	0	0.33	0.5	0.66
Seriolina nigrofasciata	Low	0.106	Low	0	Low	0	Low	0	Low	0.082	0.58	0.87	1.17
Sphyraena obtusata	Low	0	Low	0	Low	0	Low	0	Low	0	0.42	0.63	0.84
Thyrsites atun	Low	0.007	Low	0.197	Low	0.031	Low	0.099	Low	0	0.36	0.54	0.71
Trachurus novaezelandiae	Low	0	Low	0	Low	0	Low	0	Low	0	0.46	0.69	0.93
Zeus faber	Low	0.016	Low	0.067	Low	0.08	Low	0.219	Low	0	0.33	0.5	0.66