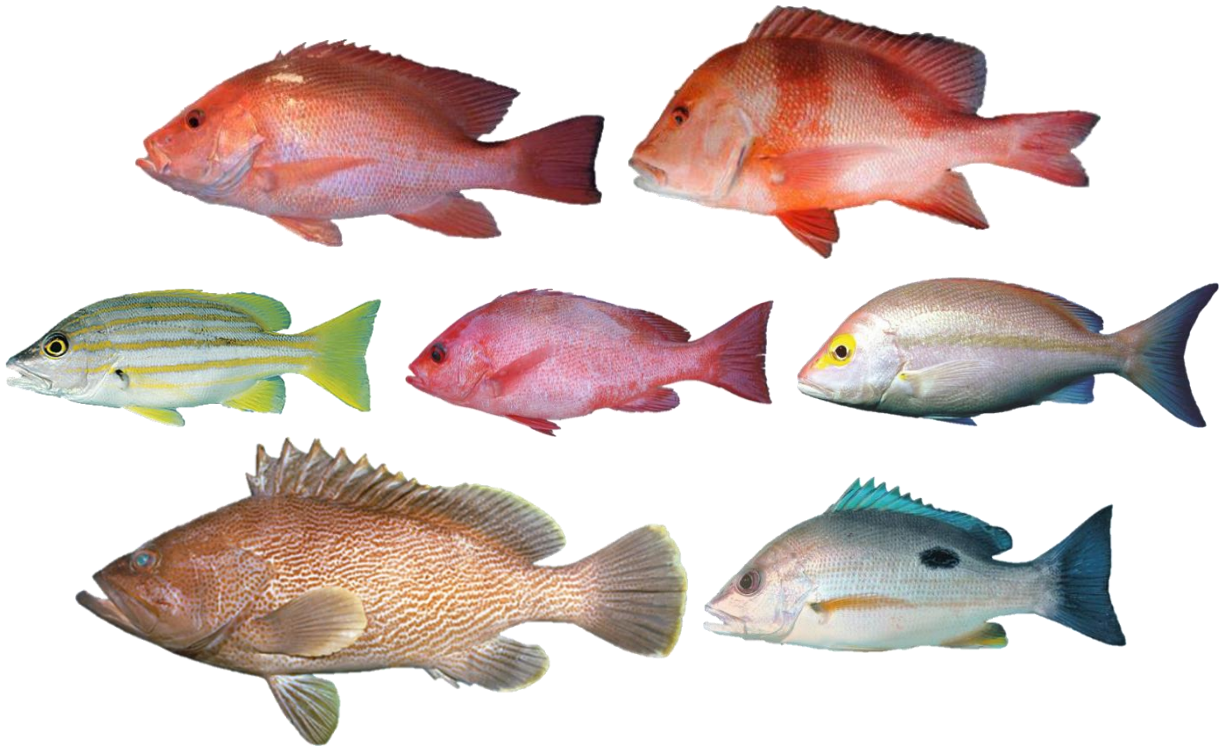
Department of Agriculture and Fisheries

Sustainable Fisheries Strategy 2017–2027

Reef Line Fishery
Level 2 Ecological Risk Assessment

Productivity & Susceptibility Analysis (PSA)



Queensland Government

Level 2 Ecological Risk Assessment
Reef Line Fishery

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NOTE TO READER / DISCLAIMER

In April 2020, management of the Reef Line Fishery (RLF) was transitioned to the *Reef Line Fisheries Harvest Strategy 2020 – 2025*. The *Harvest Strategy* places greater emphasis on the use of output controls and formalised harvest control rules for key species. These rules apply to coral trout, red throat emperor and coral reef fin fish species managed through the *Other Species Quota Management Unit*.

The RLF Level 2 ERA was prepared prior to the introduction of the *Reef Line Fishery Harvest 2020–2025* and risk ratings / recommendations contained in this report are based on the previous management regime. With the release of the harvest strategy, a number of the risks and recommendations have been addressed or enacted. Examples of where the harvest strategy has contributed to the improved management of risk in the RLF include:

- establishing performance indicators and reference points for target species, secondary targets and byproduct species;
- addressing cumulative fishing risks through sector-specific decision rules and catch triggers;
- advancement of a stock assessment program that includes RLF species like the common coral trout, crimson snapper and red emperor; and
- formalising a strategy for reviewing and addressing emerging fishing-related risks.

The above developments mean that sections of this report are now outdated. However, the decision was made to release the RLF Level 2 ERA as it provides a baseline of assessments for key species. These baseline assessments provide insight into areas where risk has been mitigated through the *Queensland Sustainable Fisheries Strategy 2020 – 2027* and areas where additional management may be required.

When and where appropriate, the Level 2 ERA will be updated to assess risk under the new management arrangements. Any updated ERA will take into consideration the content of the harvest strategy and will (likely) result in score reductions for a number of the attributes used to assess the *susceptibility* risk. A copy of the *Reef Line Fisheries Harvest Strategy 2020 – 2025* can be obtained at: https://www.daf.qld.gov.au/business-priorities/fisheries/sustainable/harvest-strategy.

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Executive Summary

The Reef Line Fishery (RLF) is a line-only fishery that targets bottom-dwelling reef species. The RLF primarily operates in the Great Barrier Reef Marine Park with operators retaining high-value coral trout for live export, red throat emperor and a wide range of coral reef fin fish. In July 2019, a whole-of-fishery or Level 1 ERA was released for the RLF (Jacobsen *et al.*, 2019b). The Level 1 ERA provided a broad risk profile for the RLF, identifying key drivers of risk and the ecological components most likely to experience an undesirable event. As part of this process, the Level 1 ERA considered both the current fishing environment and what can occur under the current management regime. In doing so, the outputs of the Level 1 ERA helped differentiate between low and high-risk elements and establish a framework that can be built on in subsequent ERAs.

In the Level 2 ERA, the focus of the assessment shifts to individual species with risk evaluations based on a *Productivity & Susceptibility Analysis* (PSA). The PSA evaluates risk through an assessment of seven biological attributes (*age at maturity*, *maximum age*, *fecundity*, *maximum size*, *size at maturity*, *reproductive strategy*, and *trophic level*) and up to seven fisheries-specific attributes (*availability*, *encounterability*, *selectivity, post-capture mortality, management strategy, sustainability assessments* and *recreational desirability / other fisheries*). As the PSA can over-estimate risk for some species (Zhou *et al.*, 2016), this Level 2 ERA also included a Residual Risk Analysis (RRA). The RRA gives further consideration to risk mitigation measures that were not explicitly included in the PSA and/or any additional information that may influence the risk status of a species (Australian Fisheries Management Authority, 2017). The primary purpose of the RRA is to minimise the number of false positives or instances where the risk level has been overestimated.

The RLF Level 2 ERA was based on the outcomes of a whole-of-fishery (Level 1) assessment (Jacobsen *et al.*, 2019a) and focuses specifically on the Other Species (OS) Quota Management Unit and protected teleosts. The two remaining RLF quota management units, Coral Trout (CT) and Red Throat Emperor (RTE), were not progressed to a Level 2 ERA (Jacobsen *et al.*, 2019b). A review of the RLF catch data produced a preliminary list of 90 OS managed species and seven no-take teleosts. This list was reduced to 39 through a subsequent rationalisation process consisting of 35 OS managed species and four protected teleosts: the humphead Maori wrasse (*Cheilinus undulatus*), Queensland groper (*Epinephelus lanceolatus*), barramundi cod (*Cromileptes altivelis*), and potato rockcod (*Epinephelus tukula*).

When the outputs of the PSA and RRA were considered, all species fell within the medium and high-risk categories. The ratings of 31 species (total) were viewed as precautionary and were considered more representative of the potential risk. **Management of the risk posed to species with *precautionary* risk ratings, beyond what is already being undertaken as part of the *Queensland Sustainable Fisheries Strategy 2017–2027*, is not considered an immediate priority.** With improved information, it is hypothesised that the risk ratings for a number of these species could be reduced and/or they could be excluded from future risk assessments involving the RLF. At the other end of the spectrum, the risk posed to red emperor (*Lutjanus sebae*), saddletail snapper (*L. malabaricus*), crimson snapper (*L. erythropterus*), stripey snapper (*L. carponotatus*), brownstripe snapper (*L. vitta*), hussar (*L. adetii*), spangled emperor (*Lethrinus nebulosus*) and goldband snapper (*Pristipomoides multidens*) require further investigation and potentially management intervention.

Cumulative fishing pressures (commercial, charter plus recreational), stock status uncertainty and a lack of information on biomass indicators (*e.g.* Maximum Sustainable Yield and Maximum Economic

Yield) were identified as the key drivers of risk in this fishery. Some of these risks are being actively addressed through the *Queensland Sustainable Fisheries Strategy 2017–2027* including as part of harvest strategy development process, the *Data Validation* plan, the *Monitoring & Research Plan* and expanded use of *Vessel Tracking* (Department of Agriculture and Fisheries, 2018a; b; c).

The RLF Level 2 ERA takes into consideration the current dynamics of the commercial fishery (*e.g.* catch, effort and participation rates), charter fishery and data from the recreational fishing sector. It provides insight into some of the more immediate risks posed by line fishing activities to key target and non-target species. These results are likely to change if, for example, more information is collected on biology and stock structure, the management regime is reformed and with an improved understanding of the cumulative fishing pressures. Going forward, the following measures would assist with respect to mitigating, managing, and understanding risk in the RLF:

- *Establish a mechanism to manage and minimise the long-term sustainability risk for key target and byproduct species, preferably through the introduction of a fishery-specific harvest strategy with clearly defined harvest control rules and sustainability assessment protocols.*
- *Identify avenues/mechanisms that can be used to monitor the catch of target and byproduct species (preferably in real or near-real time) and minimise the risk of non-compliance.*
- *Review the suitability, applicability and value of data submitted through the logbook program on the dynamics of the fishery, species compositions and release fates including for protected species. As part of this process, it is recommended that the logbook reporting requirements be extended to include information on what fishing symbol is being used.*
- *Improve the level of information on the biology, stock structure, and status of priority OS category target & byproduct species (sustainability assessments).*
- *Review the suitability and applicability of current legal size limits for OS category species and (when and where appropriate) update; taking into account available information on their biology (management strategy).*
- *Utilise fine-scale effort information to better assess true fishing overlap with the distribution of species included in the OS Quota Management Unit and the protected species ecological sub-component.*
- *Quantify the cumulative fishing pressures exerted on key OS category species and, when and where appropriate, identify areas to improve catch monitoring across the recreational and charter fishing sectors (recreational desirability / other fisheries).*
- *Implement strategies that encourage best handling practices for releasing OS category species and protected teleosts proven to help post-release survival rates (post-release mortalities).*
- *Establish a measure to estimate the gear-affected area and, when available and appropriate, reassess the risk posed to key species using a more quantitative ERA method like base Sustainability Assessment for Fishing Effects (bSAFE).*

Summary of the outputs from the Level 2 ERA for the Reef Line Fishery.

Common name	Species name	Productivity	Susceptibility	Risk Rating
Target & Byproduct species (OS category)				
Red emperor	*Lutjanus sebae*	*1.86*	*2.86*	High
Saddletail snapper	*Lutjanus malabaricus*	*1.71*	*2.86*	High
Goldband snapper	*Pristipomoides multidens*	*1.86*	*2.71*	High
Crimson snapper	*Lutjanus erythropterus*	*1.57*	*2.86*	High
Spangled emperor	*Lethrinus nebulosus*	*1.43*	*2.71*	Medium
Stripey snapper	*Lutjanus carponotatus*	*1.43*	*2.71*	Medium
Brownstripe snapper	*Lutjanus vitta*	*1.57*	*2.57*	Medium
Hussar	*Lutjanus adetii*	*1.43*	*2.57*	Medium
Banded rockcod	*Hyporthodus ergastularius*	*2.00*	*2.71*	Precautionary High
Purple rockcod	*Epinephelus cyanopodus*	*2.00*	*2.71*	Precautionary High
Robinson's sea bream	*Gymnocranius grandoculis*	*2.00*	*2.71*	Precautionary High
Collar sea bream	*Gymnocranius audleyi*	*2.00*	*2.71*	Precautionary High
Maori rockcod	*Epinephelus undulatostriatus*	*1.86*	*2.71*	Precautionary High
Birdwire rockcod	*Epinephelus merra*	*1.71*	*2.71*	Precautionary High
Blue spotted rockcod	*Cephalopholis cyanostigma*	*1.71*	*2.71*	Precautionary High
Rosy snapper	*Pristipomoides filamentosus*	*1.71*	*2.71*	Precautionary High
Flame snapper	*Etelis coruscans*	*1.71*	*2.71*	Precautionary High
Green jobfish	*Aprion virescens*	*1.71*	*2.71*	Precautionary High
Greasy rockcod	*Epinephelus tauvina*	*1.57*	*2.71*	Precautionary Medium
Highfin grouper	*Epinephelus maculatus*	*1.57*	*2.71*	Precautionary Medium
Specklefin grouper	*Epinephelus ongus*	*1.57*	*2.71*	Precautionary Medium
Blackspot tuskfish	*Choerodon schoenleinii*	*1.57*	*2.71*	Precautionary Medium
Maori snapper	*Lutjanus rivulatus*	*1.86*	*2.71*	Precautionary Medium
Moses perch	*Lutjanus russellii*	*1.57*	*2.71*	Precautionary Medium
Blacktip rockcod	*Epinephelus fasciatus*	*1.57*	*2.71*	Precautionary Medium
Longnose emperor	*Lethrinus olivaceus*	*1.57*	*2.71*	Precautionary Medium
Yellow spotted rockcod	*Epinephelus areolatus*	*1.43*	*2.71*	Precautionary Medium
Venus tuskfish	*Choerodon venustus*	*1.43*	*2.71*	Precautionary Medium
Purple tuskfish	*Choerodon cephalotes*	*1.43*	*2.71*	Precautionary Medium
Blue tuskfish	*Choerodon cyanodus*	*1.43*	*2.71*	Precautionary Medium
Sharptooth snapper	*Pristipomoides typus*	*1.43*	*2.71*	Precautionary Medium
Longfin rockcod	*Epinephelus quoyanus*	*1.43*	*2.71*	Precautionary Medium
Spotcheek emperor	*Lethrinus rubrioperculatus*	*1.43*	*2.71*	Precautionary Medium
Painted sweetlip	*Diagramma pictum*	*1.43*	*2.71*	Precautionary Medium
Ruby snapper	*Etelis carbunculus*	*1.71*	*2.43*	Precautionary Medium
Protected teleosts (SOCI only)				
Humphead Maori wrasse	*Cheilinus undulatus*	*2.00*	*2.50*	Precautionary High
Queensland groper	*Epinephelus lanceolatus*	*2.00*	*2.50*	Precautionary High
Potato rockcod	*Epinephelus tukula*	*2.00*	*2.50*	Precautionary High
Barramundi cod	*Cromileptes altivelis*	*1.43*	*2.50*	Precautionary Medium

Table of Contents

Table of Tables

Table of Figures

Definitions & Abbreviations

AFMA	–	*Australian Fisheries Management Authority.*
bSAFE	–	*base Sustainability Assessment for Fishing Effects*. The *Sustainability Assessment for Fishing Effects* or SAFE is one of the two ERA methodologies that can be used as part of the Level 2 assessment. This method can be separated into a base SAFE (bSAFE) and enhanced SAFE (eSAFE). The data requirements for eSAFE are higher than for a bSAFE, which aligns more closely to a PSA.
CAAB	–	*Codes for Australian Aquatic Biota.*
CMS	–	*Convention on the Conservation of Migratory Species of Wild Animals.*
CITES	–	*Convention on International Trade in Endangered Species of Wild Fauna and Flora.*
CSIRO	–	*Commonwealth Scientific and Industrial Research Organisation.*
CT	–	Coral Trout. Abbreviation typically used to define the management unit for this species *i.e.* CT Quota Management Unit.
ECIF	–	East Coast Inshore Fishery. Previously referred to as the East Coast Inshore Fin Fish Fishery or ECIFFF.
Ecological Component	–	Broader assessment categories that include *Target & Byproduct* (harvested) species, *Bycatch*, *Species of Conservation Concern*, *Marine Habitats* and *Ecosystem Processes.*
Ecological Subcomponent	–	Species, species groupings, marine habitats and categories included within each Ecological Component.
EPBC Act	–	*Environment Protection and Biodiversity Conservation Act 1999.*
ERA	–	Ecological Risk Assessment.
ERAEF	–	*Ecological Risk Assessment for the Effects of Fishing*. A risk assessment strategy established by (Hobday *et al.*, 2011) and employed by the AFMA.
False positive	–	The situation where a species at low risk is incorrectly assigned a higher risk rating due to the method being used, data limitations *etc.* In the context of an ERA, false positives are preferred over false negatives.
False negative	–	The situation where a species at high risk is assigned a lower risk rating. When compared, false-negative results are considered to be of more concern as the impacts/consequences can be more significant.

FMP	–	Fishery Monitoring Program. Previously referred to as the *Long Term Monitoring Program* or LTMP.
FOP	–	*Fisheries Observer Program*.
ITQ	–	*Individual Transferable Quotas.*
L1, L2 & L3	–	Line (L) fishery symbols most commonly used in the RLF. As a general guide L1 fishery symbols are permitted for use in waters south of 24°30´S. The L2 & L3 fishery symbols are permitted for use north of 24°30´S. Refer to the *Fisheries (Commercial Fisheries) Regulation 2019* for a full description of the prescribed fishing area of the L1, L2 and L3 fishery symbols.
MEY	–	Maximum Economic Yield.
MLS	–	Minimum Legal Size.
MSY	–	Maximum Sustainable Yield.
PSA	–	*Productivity & Susceptibility Analysis.* One of the two ERA methodologies that can be used as part of the Level 2 assessments.
RLF	–	*Reef Line Fishery*. Previously referred to as the Coral Reef Fin Fish Fishery or CRFFF. A line-only fishery which primarily operates within the Great Barrier Reef Marine Park (L2 & L3 fishing symbols) targeting a range of bottom-dwelling coral reef fin fish.
RRA	–	Residual Risk Analysis.
RRF	–	*Rocky Reef Fishery*. Previously referred to as the Rocky Reef Fin Fish Fishery or RRFFF. A line-only fishery which operates within the L1, L2 and L3 fishing symbol areas and targets a small number of demersal and pelagic fin-fish species.
RTE	–	Red Throat Emperor. Abbreviation typically used to define the management unit for this species *i.e.* RTE Quota Management Unit.
SAFE	–	*Sustainability Assessment for Fishing Effects*. One of the two ERA methodologies that can be used as part of the Level 2 assessments. This method can be separated into a base SAFE (bSAFE) and enhanced SAFE (eSAFE). The data requirements for eSAFE is higher than for a bSAFE, which aligns more closely to a PSA.
SAFS	–	The National *Status of Australian Fish Stocks*. Refer to www.fish.gov.au for more information.
SOCC	–	*Species of Conservation Concern*. Term used in the Level 1 and Level 2 ERA to categorise the list of species with ongoing concern.

		The SOCC includes both no-take species and species that are targeted within the ECIF.
SOCI	–	*Species of Conservation Interest.* No-take species that are subject to additional reporting requirements if caught in a commercial fishery operating in Queensland.
TACC	–	Total Allowable Commercial Catch.

1 Introduction

Ecological Risk Assessments (ERA) are important tools for sustainable natural resource management and they are being used increasingly in commercial fisheries to monitor long-term risk trends for target and non-target species. In Queensland, ERAs have previously been developed on an as-needs basis and these assessments have often employed alternate methodologies. This process has now been formalised as part of the *Queensland Sustainable Fisheries Strategy 2017–2027* and risk assessments are being completed for priority fisheries (Department of Agriculture and Fisheries, 2018d). Once completed, ERAs will inform a range of fisheries reforms being undertaken as part of the Strategy including the development of harvest strategies (Department of Agriculture and Fisheries, 2018d; 2020a) and the identification of priority areas for research and monitoring (Department of Agriculture and Fisheries, 2018a).

The Reef Line Fishery (RLF) is a line-only fishery that targets bottom-dwelling reef species. The RLF primarily operates in the Great Barrier Reef Marine Park with operators retaining high-value coral trout for live export, red throat emperor and a wide range of coral reef fin fish. In July 2019, a whole-of-fishery or Level 1 ERA was released for the RLF (Jacobsen *et al.*, 2019b). [1] The Level 1 ERA provided a broad risk profile for the RLF, identifying key drivers of risk and the ecological components most likely to experience an undesirable event. As part of this process, the Level 1 ERA considered both the current fishing environment and what can occur under the current management regime (Jacobsen *et al.*, 2019b). In doing so, the Level 1 ERAs helped differentiate between low and high-risk elements and established a framework that can be built on in subsequent ERAs.

For the Level 2 ERA, the focus of the analysis shifts to a species-specific level and the scope of the assessment is refined to the current fishing environment. Applying more detailed assessment tools, Level 2 ERAs establish risk profiles for individual species using one of two methods: the semi-quantitative *Productivity & Susceptibility Analysis* (PSA) or the quantitative *Sustainability Assessment for Fishing Effects* (SAFE) (Department of Agriculture and Fisheries, 2018d; Hobday *et al.*, 2007; Zhou & Griffiths, 2008). While both methods have been developed for use in data limited fisheries, the use of the PSA or SAFE will be dependent on the species being assessed, the level of information on gear effectiveness, and the distribution of the species in relation to fishing effort (Hobday *et al.*, 2011).

The completion of a Level 2 assessment for the RLF provides further depth to this fishery's ERA profile. With the focus shifting to individual species, the Level 2 ERA provides management with further avenues to explore the existence of both real and potential risks (Department of Agriculture and Fisheries, 2018d). Outputs from the RLF Level 2 ERA will inform working group discussions and help identify fishery-specific risk management priorities. The Level 2 ERA builds on results contained in the whole-of-fishery (Level 1) assessment and strengthens linkages between the ERA process and the remaining areas of reform (Department of Agriculture and Fisheries, 2017).

[1] *Fishery formally identified as the Coral Reef Fin Fish Fishery (CRFFF). Additional information on the management and configuration of the RLF is provided in the scoping study (Department of Agriculture and Fisheries, 2019c).*

2 Methods

2.1 The Fishery

As the PSA and SAFE are primarily used to assess risk in commercial fisheries, a large proportion of the Level 2 ERA will concentrate on commercial fishing activities conducted under the L1, L2 and L3 fishery symbols. With that said, the majority of catch and effort reported in the RLF comes from the Great Barrier Reef Marine Park (GBRMP) and involves commercial operations fishing under the L2 and L3 fishery symbols (Department of Agriculture and Fisheries, 2019c).

The commercial RLF is principally managed through a quota management system that is applied unevenly across three units: *Coral Trout* (CT), *Red Throat Emperor* (RTE) and *Other Species* (OS; Department of Agriculture and Fisheries, 2019c). The quota system is supported by a range of input controls that include the use of annual closures and minimum legal size limits (Department of Agriculture and Fisheries, 2019c). These measures will continue to be built upon as part of the *Queensland Sustainable Fishery Strategy 2017–2027* with the eventual objective being to establish and implement a broader harvest strategy for RLF. As this harvest strategy is still in development, the Level 2 ERA only considered management arrangements in effect at the time of the assessment.

In addition to commercial fishing, the charter fishing sector will be a risk factor for a number of the reef line species (Department of Agriculture and Fisheries, 2020b). Similar to the commercial sector, charter operators must adhere to licencing and reporting requirements, but catch/effort is not restricted by quota. As with all fishing sectors, the charter sector must abide by spatial and seasonal closures, minimum and maximum size limits and gear restrictions. In addition to the commercial fishery, the RLF Level 2 ERA will take the charter sector into consideration when assessing fishing impacts to assessed reef line species.

While noting the importance of the commercial fishery, coral reef fin fish attract a significant level of attention from the recreational fishing sector. As both commercial and recreational fishers use similar apparatus, this sector will interact with a similar range of target and non-target species. Surveys from this sector estimate that recreational fishers harvested around 344,000 cods, groupers, emperors, tropical snappers and sea perch (Department of Agriculture and Fisheries, 2020b; Webley *et al.*, 2015). For a number of these species, the recreational fishing sector makes a notable contribution to the annual rate of fishing mortality and (overall) levels of risk. Given these factors, the Level 2 ERA considered the impact of this sector on target and non-target species. As the recreational fishery does not have a designated area (excluding spatial closures), the Level 2 ERA incorporated recreational data from across the State (Department of Agriculture and Fisheries, 2020b; Webley *et al.*, 2015).

Additional information on the boundaries of the RLF, the broader management regime and catch, effort, and licence trends can be found in the Scoping Study and Level 1 (available at: https://www.daf.qld.gov.au/business-priorities/fisheries/monitoring-research/data/ecological-risk-assessments).

2.2 Information Sources / Baseline References

Where possible, baseline information on the life history constraints and habitat preferences for each species were obtained from peer-reviewed articles. In the absence of peer-reviewed data, additional information was sourced from grey literature and publicly accessible databases such as *FishBase* (www.fishbase.org), *SeaLifeBase* (www.sealifebase.ca), *Fishes of Australia*

(www.fishesofaustralia.net.au), *Seamap Australia* (www.seamapaustralia.org) and the *IUCN Red List of Threatened Species* (www.iucnredlist.org). Additional information including on the distribution of key seabirds, fish and endangered species was obtained through the *Atlas of Living Australia* (www.ala.org.au), *Species Profile and Threats Database* (Department of Environment and Energy, www.environment.gov.au/cgi-bin/sprat/public/sprat.pl) and resources associated with the management and regulation of marine national parks *e.g.* the *Moreton Bay Marine Park* and *Great Sandy Marine Park.* Where possible regional distribution maps were sourced for direct comparison with effort distribution data (Whiteway, 2009).

Fisheries data used in the Level 2 ERA were obtained through the fisheries logbook program (including *Species of Conservation Interest* or SOCI logbook), a previous *Fisheries Observer Program* (FOP), the *Fishery Monitoring Program* (FMP)[2], and the *Statewide Recreational Fishing Survey* (Department of Agriculture and Fisheries, 2020b; 2021; Webley *et al.*, 2015).

2.3 Species Rationalisation Processes

The RLF fishery is primarily managed under output controls which is unevenly split between three quota management units: Coral Trout (CT), Red Throat Emperor (RTE) and Other Species (OS) (Department of Agriculture and Fisheries, 2019c). While all three were assessed as part of the whole-of-fishery (Level 1) ERA, only the OS Quota Management Unit was progressed to a Level 2 ERA (Table 1). At the time of writing, risk ratings for the CT and RTE Quota Management Units did not warrant further consideration or assessment (Jacobsen *et al.*, 2019a). Of the remaining ecological components assessed, protected teleosts was the only other subgroup progressed to a finer scale assessment (Table 1; Department of Agriculture and Fisheries, 2018a; Jacobsen *et al.*, 2019b).

Table 1. *Summary of the outputs from the Level 1 (whole-of-fishery) ERA for the RLF. * Does not include Species of Conservation Concern or target & byproduct species that were returned for to the water due to (e.g.) regulations, product quality etc.*

Ecological Component	Level 1 Risk Rating	Progression
Target & Byproduct	CT – Low	Not progressed further.
	RTE – Low	Not progressed further.
	OS – Intermediate/High	Level 2 ERA (this report).
Bycatch*	Low	Not progressed further.
Marine turtles	Low/Intermediate	Not progressed further.
Sea snakes	Negligible	Not progressed further.
Crocodiles	Negligible	Not progressed further.
Dugongs	Negligible	Not progressed further.
Cetaceans	Low	Not progressed further.
Protected teleosts (SOCI only)	Intermediate/High	Level 2 ERA (this report).
Batoids	Low	Not progressed further.
Sharks	Low	Not progressed further.

[2] *The Fishery Monitoring Program was previously known as the Long-Term Monitoring Program (LTMP).*

Ecological Component	Level 1 Risk Rating	Progression
Syngnathids	Negligible	Not progressed further.
Seabirds	Low	Not progressed further.
Terrestrial mammal	Negligible	Not progressed further.
Marine Habitats	Intermediate	*Progressed through the Monitoring & Research Plan.*
Ecosystem Processes	Low/Intermediate	Not progressed further.

A preliminary list of target & byproduct species was compiled using catch data submitted through commercial logbooks from 2016–2018 (inclusive). Catch reported against each species or species complex was summed across years and ranked from highest to lowest. Cumulative catch comparisons were then used to identify the species and species complexes that made up 95% of the total catch. *Codes for Australian Aquatic Biota* (CAAB; http://www.cmar.csiro.au/caab/) were used to expand multi-species catch categories. A secondary review was then undertaken to remove duplicates, species with low or negligible catches, species that have limited potential to interact with the fishery, and species where risk is being effectively managed through harvest strategies or output controls (*e.g.* TACC limits linked to detailed stock assessments and biomass reference points).

The list of *Species of Conservation Interest* formed the basis of Level 2 assessments involving protected teleosts. *Species of Conservation Interest* or SOCI refers specifically to a limited number of non-target species that are subject to mandatory commercial reporting requirements (Queensland Government, 2018d). This list was expanded though a review of Commonwealth and State legislation (*e.g.* the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), *Fisheries Declaration 2019*, the *Nature Conservation Act 1992*) and international conventions with the potential to influence fishing activities in Queensland *e.g.* the *Convention on the Conservation of Migratory Species of Wild Animals* (CMS) an the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES). For the purpose of this ERA, this above collective of species were referred to as the *Species of Conservation Concern* or SOCC. This classification aligns with the Level 1 ERA (Jacobsen *et al.*, 2019b).

Where possible, the species rationalisation process was done in consultation with key stakeholders including (where applicable) *Fisheries Working Groups*[3] established under the *Queensland Sustainable Fishery Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017). A full account of the species rationalisation process for has been provided in Appendix A and B.

2.4 Ecological Risk Assessment Methodology

Methodology used to construct the Level 2 ERA aligns closely with the *Ecological Risk Assessment for the Effects of Fishing* (ERAEF) and includes two assessment options: the *Productivity & Susceptibility Analysis* (PSA) and the *Sustainability Assessment for Fishing Effects* (SAFE) (Australian Fisheries Management Authority, 2017; Hobday *et al.*, 2011; Zhou & Griffiths, 2008). Data inputs for the two methods are similar and both were designed to assess fishing-related risks for data-poor species (Zhou *et al.*, 2016). Similarly, both methods include precautionary elements that limit the potential for false negatives, or high-risk species being incorrectly assigned a lower risk rating. However, the PSA tends to be more conservative and, research has shown that it has a higher potential to produce false

[3] *Scope of the Level 2 ERA discussed with the Reef Line Working Group at the 30–31 July 2019 meeting.*

positives. That is, low-risk species being assigned a higher risk rating due to the conservative nature of the method, data deficiencies *etc.* (Hobday *et al.*, 2011; Hobday *et al.*, 2007; Zhou *et al.*, 2016).

In the PSA, the level of risk (low, medium or high) is defined through a finer scale assessment of the life-history constraints of the species (*Productivity*), the potential for the species to interact with the fishery and the associated consequences (*Susceptibility*). In comparison, the SAFE method quantifies risk by comparing the rate of fishing mortality against key reference points including the level of fishing mortality associated with *Maximum Sustainable Fishing Mortality* (F_{msm}), the point where biomass is assumed to be half that required to support a maximum sustainable fishing mortality (F_{lim}) and fishing mortality rates that, in theory, will lead to population extinction in the long term (F_{crash}) (Zhou & Griffiths, 2008; Zhou *et al.*, 2016; Zhou *et al.*, 2011). As SAFE is a quantitative assessment, the method provides an absolute measure of risk or a continuum of values that can be compared directly to the above reference points (Hobday *et al.*, 2011). This contrasts with the PSA which provides an indicative measure (low, medium, high) of the potential risk (Hobday *et al.*, 2007).

While research has shown that SAFE produces fewer false positives, it requires a sound understanding of the fishing intensity and the degree of overlap between a species' distribution and fishing effort (Hobday *et al.*, 2011; Zhou *et al.*, 2009). These requirements mean that SAFE may not be suitable for species with insufficient data; typically protected species (*e.g.* especially mammals, reptiles and seabirds) and marine invertebrates (Australian Fisheries Management Authority, 2017). The method also requires a sound understanding of the gear-affected area (Zhou & Griffiths, 2008) or the proportion of the fished area that a species resides in that is impacted on by the apparatus (Zhou *et al.*, 2019; Zhou *et al.*, 2014).

In a line fishery, determining the gear-affected area can be difficult as it will depend on a range of factors including the number of lines/hooks, the way in which the hooks are used (*i.e.* number of hooks per line), the fishing method employed (trolling versus demersal), the distance between lines, the frequency with which the lines are retrieved, variations in fishing power and the use (if applicable) of ancillary equipment *e.g.* viewing buckets.[4] In the RLF, commercial fishers are required to submit information on the number of tenders, crew numbers, line numbers and fishing method (handline/reel or trolling). While operators are also supply a fishing location, this information only reflects the position of the greatest daily catch. As a consequence, locational data collected on line-fishing activities may not reflect the spatial extent of the fishery or the total area fished by the primary boat and any associated tenders.

From an ERA perspective, the above deficiencies are important as they introduce a degree of uncertainty surrounding the fine-scale distribution of fishing effort and the level of fishing intensity. This by extension has a bearing on the accuracy of any estimates involving the gear-affected area. Other factors including the distance over which a species may be attracted to the bait may also impact the estimate (Zhou *et al.*, 2019). This again will be difficult to determine without data on of hook-soak times and line retrieval frequencies (*pers. comm*. Z. Zhou).

In addition to the gear-affected area, coral reef fin fish are targeted by recreational fishers and this sector will contribute to the overall level of risk. The SAFE method was principally developed for use in commercial fisheries and the method has yet to evolve to a point where it can accurately account for recreational fishing pressures. In Queensland, the majority of information from this sector is obtained

[4] In the RLF, the use of viewing buckets are more commonly associated with fishers operating in the live coral trout market.

through the voluntary localised collection of data (the boat ramp survey program, keen angler program and other initiatives undertaken through the *Fishery Monitoring Program*) and a more expansive voluntary recreational fisher survey (Department of Agriculture and Fisheries, 2020b; Webley *et al.*, 2015). However, the level of data required to inform the SAFE method goes beyond what is collected by these programs. This makes it difficult to accommodate recreational fishing data within the SAFE. Without this data, the ERA would not account for a notable source of fishing mortality.

Given the importance of the gear-affected area and the above uncertainties, the PSA was adopted for the RLF Level 2 ERA. While the use of a PSA increases the potential for false positives, previous ERAs have successfully modified this method to account for recreational fishing (Furlong-Estrada *et al.*, 2017; Patrick *et al.*, 2010). To this extent, it was considered to be the best method to assess the collective risk posed by line fishing. As a high number of the initiatives instigated under the *Queensland Sustainable Fisheries Strategy 2017–2027* are designed to improve information levels (Department of Agriculture and Fisheries, 2017), there may be more avenues to apply SAFE in subsequent ERAs.

2.4.1 Productivity & Susceptibility Analysis (PSA)

The PSA was largely aligned with the ERAEF approach employed for Commonwealth fisheries (Australian Fisheries Management Authority, 2017; Hobday *et al.*, 2011). As a detailed overview of the methodology and the key assumptions are provided in Hobday *et al*. (2007), only an abridged version will be provided here.

The *Productivity* component of the PSA examines the life-history constraints of a species and the potential for an attribute to contribute to the overall level of risk. These attributes are based on the biology of the species and include the *size and age at sexual maturity*, *maximum size and age*, *fecundity*, *reproductive strategy* and *trophic level* (Table 2). *Productivity* attributes used in the Level 2 assessment were consistent with the ERAEF (Hobday *et al.*, 2011) and were applied across all ecological components subject to a PSA. Criteria used to assign each attribute a score of low (1), medium (2) or high (3) risk are outlined in Table 2.

Table 2. *Scoring criteria and cut-off scores for the productivity component of the PSA undertaken as part of the Level 2 ERA. Attributes and the corresponding scores/criteria align with national (ERAEF) approach (Hobday et al., 2011).*

Attribute	High productivity (low risk, score = 1)	Medium productivity (medium risk, score = 2)	Low productivity (high risk, score = 3)
Age at maturity	<5 years	5–15 years	>15 years
Maximum age	<10 years	10–25 years	>25 years
Fecundity**	>20,000 eggs per year	100–20,000 eggs per year	<100 eggs per year
Maximum size	<100cm	100–300cm	>300cm
Size at maturity	<40cm	40–200cm	>200cm
Reproductive strategy	Broadcast spawner	Demersal egg layer	Live bearer (& birds)
Trophic level	<2.75	2.75–3.25	>3.25

***Fecundity for broadcast spawners was assumed to be >20,000 eggs per year (Miller & Kendall, 2009).*

For the *Susceptibility* component of the PSA, ERAEF attributes were used as the baseline of the assessment and included *availability*, *encounterability*, *selectivity* and *post-capture mortality* (Hobday *et al.,* 2007; Hobday *et al.,* 2011). The following provides an overview of the *susceptibility* attributes used in the PSA with Table 3 detailing the criteria used to assign scores for this part of the analysis.

- **Availability**—Where possible, *availability* scores were based on the overlap between fishing effort and the portion of the species range that occurs within the broader geographical spread of the fishery. To account for inter-annual variability, percentage overlaps were calculated for three years (2016, 2017 and 2018) and the highest value used as the basis of the *availability* assessment. Regional distribution maps were sourced from the *Atlas of Living Australia*, the *Species Profile and Threats Database* (Department of Environment and Energy, *www.environment.gov.au/cgi-bin/sprat/public/sprat.pl*), the *Commonwealth Scientific and Industrial Research Organisation* (CSIRO) and, where possible, refined using bathymetry and topographical data (Whiteway, 2009).

  In instances where a species did not have a distribution map, *availability* scores were based on a broader geographic distribution assessment (global, southern hemisphere, Australian endemic) described in Hobday *et al.* (2007) (Table 3). A full summary of the overlap percentages used to assess availability has been provided in Appendix C.

- **Encounterability**—*Encounterability* considers the likelihood that a species will encounter the fishing gear when it is deployed within the known geographical range (Hobday *et al.*, 2007). The *encounterability* assessment is based on the behaviour of the species as an adult and takes into consideration information on the preferred habitats and bathymetric ranges. For the PSA, both parameters (adult habitat overlap and bathymetric range overlap) are assigned an individual risk score with the highest value used as the basis of the *encounterability* assessment.

- **Selectivity**—*Selectivity* is effectively a measure of the likelihood that a species will get caught by the apparatus. Factors that will influence *selectivity* include the fishing method, the apparatus used and the body size/morphology of the species in relation to the gear size (*e.g.* mesh size, trap opening). For the purpose of the RLF, *selectivity* scores were based on the likelihood that the animal will actively interact with the apparatus (*e.g.* attraction to the bait) and/or become hooked.

- **Post-capture mortality**—*Post-capture mortality* is one of the more difficult attributes to assess; particularly for non-target species and catch discards. For the majority of target & byproduct species that fall within the prescribed regulations, survival rates are considered to be zero as they will (most likely) be retained for sale. Survival rates for the remainder of the species / ecological components will vary, may be subject to data limitations, and may require further qualitative input or expert opinion.

In addition to the four baseline attributes, the Level 2 ERA included three additional *susceptibility* attributes for target & byproduct species: *management strategy*, *sustainability assessments* and *recreational desirability / other fisheries*. These attributes were included in the assessment to address risks associated with other fishing sectors (*e.g.* recreational and charter fisheries) and management limitations for key species (*e.g.* an absence of effective controls on catch or effort). While the additional attributes are not included in the ERAEF, variations of all three have been used in risk assessments involving species experiencing similar fishing pressures (Furlong-Estrada *et al.*, 2017; Patrick *et al.*, 2010). As part of this ERA, the three additional attributes considered the following.

Table 3. Scoring criteria and cut-off scores for the susceptibility component of the PSA. Attributes and the corresponding scores/criteria are largely aligned with national (ERAEF) approach (Hobday et al., 2011).

Attribute	Low susceptibility (low risk, score = 1)	Medium susceptibility (medium risk, score = 2)	High susceptibility (high risk, score = 3)
Availability			
Option 1. Overlap of species range with fishery.	<10% overlap.	10–30% overlap.	>30% overlap.
Option 2. Global distribution & stock proxy considerations.	Globally distributed.	Restricted to same hemisphere / ocean basin as fishery.	Restricted to same country as fishery.
Encounterability			
Option 1. Habitat type	Low overlap with fishery area.	Medium overlap with fishery area.	High overlap with fishery area.
Option 2. Depth check	Low overlap with fishery area.	Medium overlap with fishery area.	High overlap with fishery area.
Selectivity	Low susceptibility to gear selectivity.	Moderate susceptibility to gear selectivity.	High susceptibility to gear selectivity.
Post-capture mortality	Evidence of post-capture release and survival.	Released alive with uncertain survivability.	Retained species, majority dead when released, interaction likely to result in death or life-threatening injuries.
Management strategy	Species-specific management of catch or effort (*e.g.* TACC limits) based on biomass estimates/reference points. Management regime able to actively address emerging issues within the current framework.	Catch or effort restricted in some capacity (*e.g.* species-specific TACC limits or analogous arrangements), restrictions based on arbitrary or outdated biomass estimates / reference points. Limited capacity to address emerging catch and effort trends without legislative amendments or reforms.	Harvested stocks do not have catch limits or robust input & output controls. Management regime based at the whole-of-fishery level.
Sustainability assessments	Sustainability confirmed through stock assessments / biomass estimates.	Sustainability confirmed through indicative sustainability assessments & weight of evidence approach *e.g.* national SAFS.	Not assessed, biomass depleted, declining or not conducive to meeting Strategy targets.
Recreational desirability / other fisheries	<33% retention.	33–66% retention.	>66% retention.

- **Management strategy**— Considers the suitability of the current management arrangements including the ability to manage risk through time *e.g.* the presence of an effective control on total catch or effort (if appropriate), regional management, biomass estimates that are directly linked to species-specific TACC limits *etc*. This attribute was considered of particular relevance to multi-species fisheries where the management regime often lacks species-specific control measures. Alternatively, this attribute provides the assessment with greater scope to assess risk mitigation measures including the use of quotas based on biomass reference points like *Maximum Sustainable Yield* (MSY) and *Maximum Economic Yield* (MEY).

- **Sustainability assessments**—The *sustainability assessment* attribute is directly linked to the level of information that is available on the stock structure and status of harvested species. Species where sustainability status has been confirmed through stock assessments or the national *Status of Australian Fish Stocks* (SAFS) will be assigned a lower risk scores. Conversely, species that are being fished above key biomass reference points (*e.g.* MSY), have been assessed as depleting, overfished, or recovering in the most recent SAFS assessment and/or have no assessment will be assigned more precautionary risk scores.

- **Recreational desirability / other fisheries**—Specifically included in the PSA to account for the risk posed by other sectors of the fishery (*e.g.* recreational and charter fisheries) or other commercial fisheries that can retain the species for sale. In the PSA, preliminary risk ratings are based on retention rate estimates obtained through recreational fishing surveys (Webley *et al.*, 2015). Under the criteria used (Table 3), species with higher retention rates will be assigned more conservative risk scores.

  For the purpose of this ERA, recreational retention rates were used as an indicative assessment of a species popularity across sectors (*i.e.* recreational and charter fisheries). It is however acknowledged that the charter fishery is monitored and managed as a separate entity. When and where appropriate the impacts of this sector will be given further consideration as part of the *Residual Risk Assessment* (RRA).

The three additional *susceptibility* attributes were only applied to retainable product and therefore were not included in assessments involving protected teleosts.

2.4.2 PSA Scoring

Each attribute was assigned a score of 1 (low risk), 2 (medium risk) or 3 (high risk) based on the criteria outlined in Table 2 and Table 3 (Brown *et al.*, 2013; Hobday *et al.*, 2011; Patrick *et al.*, 2010). In instances where an attribute has no available data and in the absence of credible information to the contrary, a default rating of high risk (3) was used (Hobday *et al.*, 2011). This approach introduces a precautionary element into the PSA and helps minimise the potential occurrence of false-negative assessments. The inherent trade off with this approach is that the outputs of the Level 2 ERA can be conservative and may include a number of false positives (Zhou *et al.*, 2016). Issues associated with false positives and the overestimation of risk will be examined further as part of the Residual Risk Analysis (RRA).

Risk ratings (*R*) were based on a two-dimensional graphical representation of the *productivity* (*x*-axis) and *susceptibility* (*y*-axis) scores (Fig. 1). Cross-referencing of the *productivity* and *susceptibility* scores provides each species with a graphical location that can be used to calculate the Euclidean distance or the distance between the species reference point and the origin (*i.e.* 0, 0 on Fig. 1). This

distance is calculated using the formula $R = ((P - X_0)^2 + (S - Y_0)^2)^{1/2}$ where *P* represents the *productivity* score, *S* represents the *susceptibility* score and X_0 and Y_0 are the respective *x* and *y* origin coordinates (Brown *et al.*, 2013). The further a species is away from the origin the more at risk it is considered to be. For the purpose of this ERA, cut offs for each risk category were aligned with previous assessments with scores below 2.64 classified as low risk, scores between 2.64 and 3.18 as medium risk and scores >3.18 classified as high risk (Brown *et al.*, 2013; Hobday *et al.*, 2007; Zhou *et al.*, 2016).

As the PSA includes an *uncertainty* assessment and RRA (refer to section *2.4.3 Uncertainty* and *2.4.4 Residual Risk Analysis*), the initial risk ratings may be subject to change. To this extent, scores assigned as part of the PSA analysis can be viewed as a measure of the potential risk for each species (Hobday *et al.*, 2007) with the final risk scores determined on completion of the RRA.

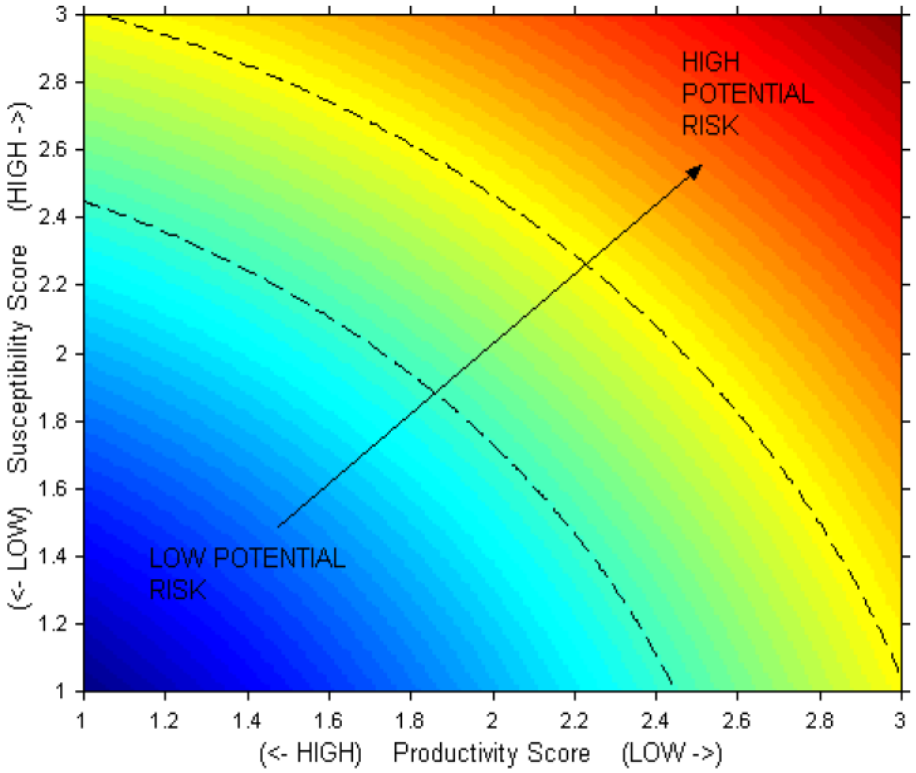

***Figure 1**. PSA plot demonstrating the two-dimensional space which species units are plotted. PSA scores for species units represent the Euclidean distance or the distance between the origin and the productivity (x axis), susceptibility (y axis) intercept (excerpt from Hobday. et al., 2007).*

2.4.3 Uncertainty

A number of factors including imprecise or missing data and the use of averages or proxies can contribute to the level of uncertainty surrounding the PSA. Examples of which include the use of a default high score for attributes missing data and the use of values based at a higher taxon *i.e.* genera or family level (Hobday *et al.*, 2011). In the Level 2 ERA uncertainty is examined through a baseline assessment of each risk profile to determine the proportion of attributes assigned a precautionary high-risk rating due to data deficiencies. As species with greater data deficiencies are more likely to attract the default high-risk rating, their profiles are more likely to fall on the conservative side of the spectrum. In these instances, it may be more appropriate to address these risks and data deficiencies

through measures like the *Queensland Sustainable Fisheries Strategy—Monitoring and Research Plan* (Department of Agriculture and Fisheries, 2018a).

2.4.4 Residual Risk Analysis (RRA)

Precautionary elements in the PSA combined with an undervaluation of some management arrangements can result in more conservative risk assessments and a higher number of false positives. Similarly, the effectiveness of some attributes may be exaggerated and subsequent risks could be underestimated (false negatives). To address these issues, PSA results were subject to a RRA. The RRA gives further consideration to risk mitigation measures that were not explicitly included in the attributes and any additional information that may influence the risk status of a species (Australian Fisheries Management Authority, 2017). In doing so, the RRA provides management with greater capacity to differentiate between potential and actual risks (Department of Agriculture and Fisheries, 2018d) and helps refine risk management strategies.

The RRA framework was based on guidelines established by CSIRO and the *Australian Fisheries Management Authority* (AFMA) (Australian Fisheries Management Authority, 2018). These guidelines identify six avenues where additional information may be given further consideration as part of a Level 2 assessment. Given regional nuances and data variability, a degree of flexibility was required with respect to how the RRA guidelines were applied to commercial fisheries in Queensland and the justifications used. The RRA was also expanded to include a seventh guideline titled *Additional Scientific Assessment & Consultation*. While a version of this guideline has been used in previous risk assessments involving Commonwealth Fisheries, it has since been removed as part of a broader RRA procedural review (Australian Fisheries Management Authority, 2018). In Queensland, this guideline was retained as the broader ERA framework includes a series of consultation steps that aid in the development and finalisation of both the whole-of-fishery (Level 1) and species-specific (Level 2) ERAs (Department of Agriculture and Fisheries, 2018d).

In instances where the RRA resulted in an amendment to the preliminary score, full justifications were provided (Appendix D) including the guidelines in which the amendments were considered. A brief summary of each guideline and the RRA considerations is provided in Table 4.

Table 4. *Guidelines used to assess residual risk including a brief overview of factors taken into consideration. Summary represents a modified excerpt from the revised AFMA Ecological Risk Assessment, Residual Risk Assessment Guidelines (Australian Fisheries Management Authority, 2018).*

Guidelines	Summary
Guideline 1*: Risk rating due to missing, incorrect or out of date information.*	Considers if *susceptibility* and/or *productivity* attribute data for a species is missing or incorrect for the fishery assessment and is corrected using data from a trusted source or another fishery.
Guideline 2*: Additional scientific assessment & consultation.*	Considers any additional scientific assessments on the biology or distribution of the species and the impact of the fishery. This may include verifiable accounts and data raised through key consultative processes including but not limited to targeted consultation with key experts and oversite committees established as part of the *Sustainable Fisheries Strategy 2017–*

Guidelines	Summary
	2027 e.g. Fisheries Working Groups and the *Sustainable Fisheries Expert Panel*.
***Guideline 3**: At risk with spatial assumptions.*	Provides further consideration to the spatial distribution data, habitat data and any assumptions underpinning the assessment.
***Guideline 4**: At risk in regards to level of interaction/capture with a zero or negligible level of susceptibility.*	Considers observer or expert information to better calculate *susceptibility* for those species known to have a low likelihood or no record of interaction nor capture with the fishery.
***Guideline 5**: Effort and catch management arrangements for target & byproduct species.*	Considers current management arrangements based on effort and catch limits set using a scientific assessment for key species.
***Guideline 6**: Management arrangements to mitigate against the level of bycatch.*	Considers management arrangement in place that mitigate against bycatch by the use of gear modifications, mitigation devices and catch limits.
***Guideline 7**: Management arrangements relating to seasonal, spatial and depth closures.*	Considers management arrangements based on seasonal, spatial and/or depth closures.

2.5 Consultation & Review

The ERA framework has a number of feedback loops that refine the scope of the assessment and the accuracy of the preliminary risk ratings. This feedback may include direct consultation with *Fisheries Working Groups*, targeted consultation with key stakeholders, obtaining additional information from members of the scientific community, and through the *Sustainable Fisheries Expert Panel.* This consultation was done in accordance with the *Queensland Ecological Risk Assessment Guidelines* (Department of Agriculture and Fisheries, 2018d).

3 Results

3.1 Target & Byproduct Species

A review of catch data submitted through the logbook system produced a preliminary list of 90 target & byproduct species (Appendix B). This list represented 95% of the catch reported against the OS Quota Management Unit over the 2016–2018 period (inclusive). This list was divided into primary and secondary species based on feedback provided from the *Reef Line Working Group*.[5] Primary species (*n* = 35) were prioritised for assessment (this report) and included commonly caught species such as goldband snapper (*Pristipomoides multidens*), red emperor (*Lutjanus sebae*) and saddletail snapper (*Lutjanus malabaricus*). Secondary species (*n* = 55) were not included in the Level 2 assessment and will be considered as a part of future ERAs involving the RLF (Appendix B).

The PSA produced preliminary *productivity* scores between 1.43 and 2.29 (*average* = 1.73). Given the predatory niches occupied by coral reef fin fish, all species were assigned a high (3) risk score for the *trophic level* attribute. *Maximum age* was the only other *productivity* attribute to have an average score

[5] *Preliminary species list discussed at the 30–31 July 2019 meeting of the Reef Line Working Group.*

Table 5. Preliminary risk ratings compiled as part of the Productivity & Susceptibility Analysis (PSA) including scores assigned to each attribute used in the assessment. Final PSA values are calculated using the scores assigned to each attribute and in accordance with the methods outlined in Hobday et al. (2007). Pink boxes with '*' represent attributes that were assigned precautionary score due to an absence of species-specific data.

Common name	Species name	Age at maturity	Maximum age	Fecundity	Maximum size	Size at sexual maturity	Reproductive strategy	Trophic level	Productivity	Availability	Encounterability	Selectivity	Post-capture mortality	Management strategy	Sustainability assessments	Recreational desirability / other fisheries	Susceptibility	*PSA score*
Target & Byproduct Species																		
Saddletail snapper	*Lutjanus malabaricus*	2	2	1	2	1	1	3	1.71	3	3	3	3	3	3	2	2.86	**3.33**
Goldband snapper	*Pristipomoides multidens*	2	3	1	1	2	1	3	1.86	3	3	3	3	3	3	3*	3.00	**3.53**
Spangled emperor	*Lethrinus nebulosus*	1	2	1	1	1	1	3	1.43	3	3	3	3	3	2	2	2.71	**3.07**
Red emperor	*Lutjanus sebae*	2	2	1	2	2	1	3	1.86	3	3	3	3	3	3	1	2.71	**3.29**
Stripey snapper	*Lutjanus carponotatus*	1	2	1	1	1	1	3	1.43	3	3	3	3	3	3*	1	2.71	**3.07**
Greasy rockcod	*Epinephelus tauvina*	3*	1	1	1	2	1	3	1.71	3	3	3	3	3	3*	1	2.71	**3.21**
Banded rockcod	*Hyporthodus ergastularius*	2	3	1	2	2	1	3*	2.00	3	3	3	3	3	3*	1	2.71	**3.37**
Yellow spotted rockcod	*Epinephelus areolatus*	1	2	1	1	1	1	3	1.43	3	3	3	3	3	3*	1	2.71	**3.07**
Highfin grouper	*Epinephelus maculatus*	1	2	1	1	3*	1	3	1.71	3	3	3	3	3	3*	1	2.71	**3.21**
Birdwire rockcod	*Epinephelus merra*	2	3*	1	1	1	1	3	1.71	3	3	3	3	3	3*	1	2.71	**3.21**
Specklefin grouper	*Epinephelus ongus*	1	3	1	1	1	1	3	1.57	3	3	3	3	3	3*	1	2.71	**3.14**
Maori rockcod	*Epinephelus undulatostriatus*	3*	3*	1	1	3*	1	3*	2.14	3	3	3	3	3	3*	3*	3.00	**3.69**

Common name	Species name	Age at maturity	Maximum age	Fecundity	Maximum size	Size at sexual maturity	Reproductive strategy	Trophic level	Productivity	Availability	Encounterability	Selectivity	Post-capture mortality	Management strategy	Sustainability assessments	Recreational desirability / other fisheries	Susceptibility	*PSA score*
Blue spotted rockcod	*Cephalopholis cyanostigma*	2	3	1	1	1	1	3	1.71	3	3	3	3	3	3*	1	2.71	**3.21**
Purple rockcod	*Epinephelus cyanopodus*	3*	3*	1	2	3*	1	3	2.29	3	3	3	3	3	3*	1	2.71	**3.55**
Hussar	*Lutjanus adetii*	1	2	1	1	1	1	3	1.43	3	3	3	3	3	2	2	2.71	**3.07**
Brownstripe snapper	*Lutjanus vitta*	2	2	1	1	1	1	3	1.57	3	3	3	3	3	2	2	2.71	**3.14**
Crimson snapper	*Lutjanus erythropterus*	3*	3	1	1	1	1	3	1.86	3	3	3	3	3	3	2	2.86	**3.41**
Rosy snapper	*Pristipomoides filamentosus*	1	3	1	2	1	1	3	1.71	3	3	3	3	3	3*	3*	3.00	**3.46**
Venus tuskfish	*Choerodon venustus*	1	2	1	1	1	1	3*	1.43	3	3	3	3	3	3*	2	2.86	**3.19**
Purple tuskfish	*Choerodon cephalotes*	3*	3*	1	1	3*	1	3	2.14	3	3	3	3	3	3*	2	2.86	**3.57**
Blue tuskfish	*Choerodon cyanodus*	1	2	1	1	1	1	3	1.43	3	3	3	3	3	3*	2	2.86	**3.19**
Blackspot tuskfish	*Choerodon schoenleinii*	1	2	1	2	1	1	3	1.57	3	3	3	3	3	3*	2	2.86	**3.26**
Sharptooth snapper	*Pristipomoides typus*	1	2	1	1	3*	1	3	1.71	3	3	3	3	3	3*	3*	3.00	**3.46**
Ruby snapper	*Etelis carbunculus*	3*	3	1	2	1	1	3	2.00	1	1	1	3	1	3*	3*	2.71	**3.37**
Maori snapper	*Lutjanus rivulatus*	1	2	1	1	2	1	3	1.57	3	3	3	3	3	3*	3*	3.00	**3.39**
Flame snapper	*Etelis coruscans*	1	2	1	2	2	1	3	1.71	3	3	3	3	3	3*	3*	3.00	**3.46**
Green jobfish	*Aprion virescens*	1	2	1	2	2	1	3	1.71	3	3	3	3	3	3*	3*	3.00	**3.46**

Common name	Species name	Age at maturity	Maximum age	Fecundity	Maximum size	Size at sexual maturity	Reproductive strategy	Trophic level	Productivity	Availability	Encounterability	Selectivity	Post-capture mortality	Management strategy	Sustainability assessments	Recreational desirability / other fisheries	Susceptibility	*PSA score*
Moses perch	*Lutjanus russellii*	1	2	1	1	3*	1	3	1.71	3	3	3	3	3	3*	1	2.71	**3.21**
Blacktip rockcod	*Epinephelus fasciatus*	3*	2	1	1	1	1	3	1.71	3	3	3	3	3	3*	1	2.71	**3.21**
Longfin rockcod	*Epinephelus quoyanus*	1	2	1	1	1	1	3	1.43	3	3	3	3	3	3*	1	2.71	**3.07**
Painted sweetlip	*Diagramma pictum*	1	2	1	1	1	1	3	1.43	3	3	3	3	3	3*	3*	3.00	**3.32**
Robinson's sea bream	*Gymnocranius grandoculis*	3*	3*	1	1	3*	1	3	2.14	3	3	3	3	3	3*	3*	3.00	**3.69**
Spotcheek emperor	*Lethrinus rubrioperculatus*	1	2	1	1	1	1	3	1.43	3	3	3	3	3	3*	3*	3.00	**3.32**
Collar sea bream	*Gymnocranius audleyi*	3*	2	1	1	3*	1	3	2.00	3	3	3	3	3	3*	3*	3.00	**3.61**
Longnose emperor	*Lethrinus olivaceus*	3*	2	1	2	3*	1	3	2.14	3	3	3	3	3	3*	3*	3.00	**3.69**
Protected teleosts																		
Humphead Maori wrasse	*Cheilinus undulatus*	2	3	1	2	2	1	3	2.00	3	3	3	1	n/a	n/a	n/a	2.50	**3.20**
Queensland groper	*Epinephelus lanceolatus*	2	3	1	2	2	1	3	2.00	3	3	3	1	n/a	n/a	n/a	2.50	**3.20**
Barramundi cod	*Cromileptes altivelis*	1	2	1	1	1	1	3	1.43	3	3	3	1	n/a	n/a	n/a	2.50	**2.88**
Potato rockcod	*Epinephelus tukula*	2	3	1	2	2	1	3	2.00	3	3	3	1	n/a	n/a	n/a	2.50	**3.20**

>2.00 (Table 5). Conversely, all species were assigned the lowest possible value for *fecundity* and *reproductive strategy*. These scores reflect the fact that all 35 species are broadcast spawners.

In the *susceptibility* analysis, the majority of attributes assessed received higher risk ratings (Table 5). All 35 species were assigned a high risk (3) score for at least four of the attributes assessed (*encounterability*, *selectivity, post-capture mortality* and *management strategy*). Two additional attributes, *availability* and *sustainability assessments*, had an average score >2.90 (Table 5). When all of the attributes were taken into consideration, all 35 target & byproduct species registered *susceptibility* scores between 2.71 and 3.00 (Table 5).

When the *productivity* and *susceptibility* scores were considered, target & byproduct species were assigned preliminary risk scores ranging between 3.07 and 3.69 (*average* = 3.33). Based on the prescribed assessment criteria, all of the preliminary risk scores assigned to species within the OS Quota Management Unit fell within medium (*n* = 7) and high (*n* = 28) risk categories (Table 5; Fig. 1).

3.2 SOCC—Protected Teleosts

While seven teleost species are classified as no-take in Queensland waters, only the humphead Maori wrasse (*Cheilinus undulatus*), Queensland groper (*Epinephelus lanceolatus*), potato rockcod (*E. tukula*) and barramundi cod (*Cromileptes altivelis*) are classified as no-take for conservation reasons (Jacobsen *et al.*, 2019b). Given their habitat preferences, all four have the potential to interact with the RLF and were included in the Level 2 ERA (Appendix B). The remaining three species are classified no-take as they are not fit for human consumption / are poisonous: chinaman fish (*Symphorus nematophorus*), paddletail (*Lutjanus gibbus*) and red bass (*L. bohar*). As there are no pressing conservation concerns for these species in Australian waters, they were omitted from the analysis.

Risk profiles for the protected teleosts were similar to that reported for the target & byproduct species ecological component (Table 5). While *productivity* scores were marginally higher (*average*: 1.86; *range* = 1.43–2.00), the subgroup registered the lowest *susceptibility* scores (*average* & *range* = 2.50) of the assessment.

When the *productivity* and *susceptibility* scores were taken into consideration, protected teleosts recorded preliminary PSA scores between 2.88 and 3.20 (Table 5). Based on the scoring criteria, preliminary assessments for three of the four species fell within the medium (*n* = 1) and high risk (*n* = 3) categories (Table 5; Fig. 1).

3.3 Uncertainty

Where possible, PSA scores were supported by data on the biology of the species and their potential to interact with the fishery. However, sixteen species were missing biological information for at least one of the *productivity* attributes including *size* and *age at maturity*, *maximum age*, and *trophic level* (Table 6). In line with the PSA methodology, all attributes with missing data were assigned precautionary high (3) risk scores as part of the preliminary assessment.

In the *susceptibility* assessment, data deficiencies were confined to just two attributes: *sustainability assessments* and *recreational desirability / other fisheries* (Table 6). As these two attributes were only applied to retainable product, therefore only impacted risk assessments involving the target & byproduct species ecological component (Table 5 & 6).

Table 6. *Summary of the number of attributes that were assigned a precautionary high (3) score due to data deficiencies. *Represents attributes that were only applied to retainable product.*

	Productivity							Susceptibility						
	Age at Maturity	Maximum age	Fecundity	Maximum size	Size at maturity	Reproductive strategy	Trophic level	Availability	Encounterability	Selectivity	Post-capture mortality	Management strategy*	Sustainability assessments*	Rec. desirability / other fisheries*
Species with data	29	34	39	39	30	39	36	39	39	39	39	35	7	22
Species missing data	10	5	0	0	9	0	3	0	0	0	0	0	28	13
% Unknown	26%	13%	0%	0%	23%	0%	8%	0%	0%	0%	0%	0%	80%	37%

3.4 Residual Risk Analysis (RRA)

The following provides a brief overview of the key changes that were adopted as part of the RRA (Table 7). A full overview of the RRA including the key considerations for each species has been provided in Appendix D.

3.4.1 Target & Byproduct: Other Species Quota Management Unit

A number of changes were made to scores assigned to target & byproduct species as part of the initial *productivity* assessment. In the PSA, 16 species had insufficient data and were allocated a precautionary high-risk score (3) for at least one of the attributes (Table 5). A number of these precautionary scores were refined in the RRA with the use of proxies from closely related species (Appendix D). These substitutes/proxies provided a more accurate account of these species' biology; particularly the *size* and *age at maturity* (Appendix D). For two species, Robinson's sea bream (*Gymnocranius grandoculis*) and collar sea bream (*G. audleyi*), precautionary high scores for *size* and *age at maturity* were retained due to a lack of suitable proxies. As a result of RRA adjustments, average *productivity* scores for 12 OS category species decreased (Table 7; Appendix D).

Susceptibility attributes for several target & byproduct species were adjusted as a part of the RRA (Table 7). In the PSA, twelve species were assigned a precautionary high-risk score (3) for the *recreational desirability / other fisheries* attribute (Table 5). These preliminary assessments were considered too precautionary and further consultation facilitated a score reduction for this attribute (Appendix D). Seven other species also had their preliminary *recreational desirability / other fisheries* score reduced as part of the RRA. Conversely, red emperor was the only species to have a score increased as part of the RRA. In this instance, the preliminary score assigned to *recreational desirability / other fisheries* was increased from low (1) to medium (2) (Table 5 & 7; Appendix D).

Changes made as part of the RRA altered the final risk scores for 26 target & byproduct species (Table 5 & 7; Appendix D). These changes resulted in the lowering of the risk scores for 25 species with 14 species receiving a risk rating reclassification from high to medium for 14 (Table 5 & 7).

3.4.2 Protected teleosts

No score adjustments were made to scores assigned to the four protected teleosts (Table 5 & 7).

Table 7. Residual Risk Analysis (RRA) of the scores assigned to each attribute as part of the Productivity & Susceptibility Analysis (PSA). Pink shaded squares represent the attribute scores that were amended as part of the RRA. Refer to Appendix D for a full account of the RRA including key justifications. '*'Denotes species attributes that received a precautionary high (3) score in the final assessment.

Common name	Species name	Age at maturity	Maximum age	Fecundity	Maximum size	Size at sexual maturity	Reproductive strategy	Trophic level	Productivity	Availability	Encounterability	Selectivity	Post-capture mortality	Management strategy	Sustainability assessments	Recreational desirability / other fisheries	Susceptibility	*PSA score*
Target & Byproduct Species																		
Saddletail snapper	*Lutjanus malabaricus*	2	2	1	2	1	1	3	1.71	3	3	3	3	3	3	2	2.86	**3.33**
Goldband snapper	*Pristipomoides multidens*	2	3	1	1	2	1	3	1.86	3	3	3	3	3	3	1	2.71	**3.29**
Spangled emperor	*Lethrinus nebulosus*	1	2	1	1	1	1	3	1.43	3	3	3	3	3	2	2	2.71	**3.07**
Red emperor	*Lutjanus sebae*	2	2	1	2	2	1	3	1.86	3	3	3	3	3	3	2	2.86	**3.41**
Stripey snapper	*Lutjanus carponotatus*	1	2	1	1	1	1	3	1.43	3	3	3	3	3	3	1	2.71	**3.07**
Greasy rockcod	*Epinephelus tauvina*	2	1	1	1	2	1	3	1.57	3	3	3	3	3	3	1	2.71	**3.14**
Banded rockcod	*Hyporthodus ergastularius*	2	3	1	2	2	1	3	2.00	3	3	3	3	3	3	1	2.71	**3.37**
Yellow spotted rockcod	*Epinephelus areolatus*	1	2	1	1	1	1	3	1.43	3	3	3	3	3	3	1	2.71	**3.07**
Highfin grouper	*Epinephelus maculatus*	1	2	1	1	2	1	3	1.57	3	3	3	3	3	3	1	2.71	**3.14**
Birdwire rockcod	*Epinephelus merra*	2	3	1	1	1	1	3	1.71	3	3	3	3	3	3	1	2.71	**3.21**
Specklefin grouper	*Epinephelus ongus*	1	3	1	1	1	1	3	1.57	3	3	3	3	3	3	1	2.71	**3.14**
Maori rockcod	*Epinephelus undulatostriatus*	2	3	1	1	2	1	3	1.86	3	3	3	3	3	3	1	2.71	**3.29**

Common name	Species name	Age at maturity	Maximum age	Fecundity	Maximum size	Size at sexual maturity	Reproductive strategy	Trophic level	Productivity	Availability	Encounterability	Selectivity	Post-capture mortality	Management strategy	Sustainability assessments	Recreational desirability / other fisheries	Susceptibility	*PSA score*
Blue spotted rockcod	*Cephalopholis cyanostigma*	2	3	1	1	1	1	3	1.71	3	3	3	3	3	3	1	2.71	**3.21**
Purple rockcod	*Epinephelus cyanopodus*	2	3	1	2	2	1	3	2.00	3	3	3	3	3	3	1	2.71	**3.37**
Hussar	*Lutjanus adetii*	1	2	1	1	1	1	3	1.43	3	3	3	3	3	2	1	2.57	**2.94**
Brownstripe snapper	*Lutjanus vitta*	2	2	1	1	1	1	3	1.57	3	3	3	3	3	2	1	2.57	**3.01**
Crimson snapper	*Lutjanus erythropterus*	2	3	1	1	1	1	3	1.71	3	3	3	3	3	3	2	2.86	**3.33**
Rosy snapper	*Pristipomoides filamentosus*	1	3	1	2	1	1	3	1.71	3	3	3	3	3	3	1	2.71	**3.21**
Venus tuskfish	*Choerodon venustus*	1	2	1	1	1	1	3	1.43	3	3	3	3	3	3	1	2.71	**3.07**
Purple tuskfish	*Choerodon cephalotes*	1	2	1	1	1	1	3	1.43	3	3	3	3	3	3	1	2.71	**3.07**
Blue tuskfish	*Choerodon cyanodus*	1	2	1	1	1	1	3	1.43	3	3	3	3	3	3	1	2.71	**3.07**
Blackspot tuskfish	*Choerodon schoenleinii*	1	2	1	2	1	1	3	1.57	3	3	3	3	3	3	1	2.71	**3.14**
Sharptooth snapper	*Pristipomoides typus*	1	2	1	1	2	1	3	1.57	3	3	3	3	3	3	1	2.71	**3.14**
Ruby snapper	*Etelis carbunculus*	1	3	1	2	1	1	3	1.71	1	3	3	3	3	3	1	2.43	**2.97**
Maori snapper	*Lutjanus rivulatus*	1	2	1	1	2	1	3	1.57	3	3	3	3	3	3	1	2.71	**3.14**
Flame snapper	*Etelis coruscans*	1	2	1	2	2	1	3	1.71	3	3	3	3	3	3	1	2.71	**3.21**
Green jobfish	*Aprion virescens*	1	2	1	2	2	1	3	1.71	3	3	3	3	3	3	1	2.71	**3.21**

Common name	Species name	Age at maturity	Maximum age	Fecundity	Maximum size	Size at sexual maturity	Reproductive strategy	Trophic level	Productivity	Availability	Encounterability	Selectivity	Post-capture mortality	Management strategy	Sustainability assessments	Recreational desirability / other fisheries	Susceptibility	*PSA score*
Moses perch	*Lutjanus russellii*	1	2	1	1	2	1	3	1.57	3	3	3	3	3	3	1	2.71	**3.14**
Blacktip rockcod	*Epinephelus fasciatus*	2	2	1	1	1	1	3	1.57	3	3	3	3	3	3	1	2.71	**3.14**
Longfin rockcod	*Epinephelus quoyanus*	1	2	1	1	1	1	3	1.43	3	3	3	3	3	3	1	2.71	**3.07**
Painted sweetlip	*Diagramma pictum*	1	2	1	1	1	1	3	1.43	3	3	3	3	3	3	1	2.71	**3.07**
Robinson's sea bream	*Gymnocranius grandoculis*	3*	2	1	1	3*	1	3	2.00	3	3	3	3	3	3	1	2.71	**3.37**
Spotcheek emperor	*Lethrinus rubrioperculatus*	1	2	1	1	1	1	3	1.43	3	3	3	3	3	3	1	2.71	**3.07**
Collar sea bream	*Gymnocranius audleyi*	3*	2	1	1	3*	1	3	2.00	3	3	3	3	3	3	1	2.71	**3.37**
Longnose emperor	*Lethrinus olivaceus*	1	2	1	2	1	1	3	1.57	3	3	3	3	3	3	1	2.71	**3.14**
Protected teleosts																		
Humphead Maori wrasse	*Cheilinus undulatus*	2	3	1	2	2	1	3	2.00	3	3	3	1	n/a	n/a	n/a	2.50	**3.20**
Queensland groper	*Epinephelus lanceolatus*	2	3	1	2	2	1	3	2.00	3	3	3	1	n/a	n/a	n/a	2.50	**3.20**
Barramundi cod	*Cromileptes altivelis*	1	2	1	1	1	1	3	1.43	3	3	3	1	n/a	n/a	n/a	2.50	**2.88**
Potato rockcod	*Epinephelus tukula*	2	3	1	2	2	1	3	2.00	3	3	3	1	n/a	n/a	n/a	2.50	**3.20**

4 Risk Evaluation

There are three main demersal line fisheries operating on the Queensland east coast: the RLF, the *Rocky Reef Fishery* (RRF) and the *East Coast Inshore Fishery* (ECIF)[6] (Department of Agriculture and Fisheries, 2019c; f; g; h). Of these three, the RLF is the only one where fishers are required to hold quota to operate in the fishery.[7] This quota is unevenly split between the three management units: *Coral Trout* (CT), *Red Throat Emperor* (RTE) and *Other Species* (OS). In addition to a quota holding, licence holders are required to have a L1, L2 or L3 fishing symbol endorsement (Department of Agriculture and Fisheries, 2019h; Jacobsen *et al.*, 2019a). These line fishing symbols allow a licence holder to retain a range of species including those not managed as part of the RLF

Outside of quota, the three demersal-line fisheries are primarily differentiated by the species being retained; as opposed to fisheries-specific endorsements or separate areas of operation. If for example an operator (with quota) retained a coral trout (*P. leopardus*) and a goldband snapper (*P. multidens*) during a single fishing event, then all of the catch and effort would be reported against the RLF. However, if an operator retained a coral trout and a non-quota species (*e.g.* trevally) in a single fishing event, they would technically be fishing in both the RLF and ECIF. This is because the coral trout catch would be reported against the RLF with the trevally catch reported against the ECIF. In this instance, the catch would be allocated to each of the respective fisheries with effort (days fished) reported in both the RLF and ECIF.

In this Level 2 ERA, the scope of the assessment was limited to target & byproduct species managed under the RLF umbrella (Appendix B). Species from other commercial fisheries (when and where appropriate) will be assessed in ERAs examining the risk posed by fishing activities in the RRF or ECIF (Jacobsen *et al.*, 2021a; b; Pidd *et al.*, 2021; Walton & Jacobsen, 2021).

4.1 Target & Byproduct Species (OS category)

When the outputs of the PSA and RRA were taken into considerations, all of the targeted reef line species were classified as medium (n = 21) or high risk (n = 14). For the majority of these species (n = 27), final risk ratings were viewed as more representative of the potential risk *verse* the actual risk. While not universal, these assessments were influenced by data deficiencies and/or involved species with comparatively low but consistent catch rates (Department of Agriculture and Fisheries, 2019h). This includes many of the cods, groupers, emperors, tropical snappers, sea perch, and tuskfish (Table 8). Given these factors and the potential for risk levels to be overestimated, these 27 species were assigned *precautionary* risk ratings (Table 8). This decision was supported by an ad-hoc *Likelihood & Consequence Analysis* (LCA) which provides further insight into the probability of the risk coming to fruition over the short to medium term (Appendix E).[8]

[6] *The ECIF is primarily a mesh net fishery however operators are permitted to line fish for key species under an L1, L2 or L3 fishery symbol (Department of Agriculture and Fisheries, 2019f; Jacobsen et al., 2019c).*

[7] *A quota-managed Spanish mackerel fishery operates on the Queensland east coast. This fishery targets pelagic species using troll fishing vs. demersal species.*

[8] *In the Level 2 ERA, the Likelihood & Consequence Analysis (LCA) was used to provide further insight into the probability of the risk coming to fruition over the short to medium term (Appendix E). The LCA is a fully qualitative assessment and was used to provide an indicative assessment of how conservative an assessment might be. As the LCA is qualitative and lacks the detail of the PSA, the outputs should not be viewed as an alternate or competing risk assessment and the results of the PSA/RRA will take precedence over the LC*A.

Management of the risk posed to species with *precautionary* risk ratings, beyond what is already being undertaken as part of the *Queensland Sustainable Fisheries Strategy 2017–2027*, is viewed as a lower priority. With improved information, it is plausible that a number of the species with *precautionary* ratings could be excluded from future iterations of the RLF Level 2 ERA. Similarly, these species would benefit from additional assessment using the SAFE approach. Comparisons have shown that SAFE produces fewer false positives and may provide greater differentiation in terms of the risk posed to each species (Zhou *et al.*, 2016). As SAFE compares fishing mortality to reference points based on natural mortality and growth rates (Zhou & Griffiths, 2008), it may provide a more informative account of how these (secondary) species respond to fishing pressures. Given the available data, the base SAFE (bSAFE) is viewed as the most viable option for this fishery. Information thresholds for the bSAFE are lower than the enhanced version (eSAFE) and are comparable to the PSA. The ability to assess these species using bSAFE though will still be predicated on management's ability to quantify the gear-affected area.

For the eight remaining species, final risk ratings are more representative of a real or actual risk (Table 8). Of these eight, red emperor (*L. sebae*), saddletail snapper (*L. malabaricus*), goldband snapper (*P. multidens*), and crimson snapper (*L. erythropterus*) were all classified as high risk (Table 7 & 8). These species have annual commercial harvests ranging from 10 to 87t (2016–18) and they are considered primary targets in both the commercial and non-commercial fishing sectors (Department of Agriculture and Fisheries, 2019c; 2020b; 2021). For these species, there is a more pressing need to collect additional information, review the suitability of current management arrangements and/or the need for management intervention.

The biology of target & byproduct species in the RLF display typical *r*-selected life-history traits *e.g.* faster rates of growth, higher levels of fecundity and an earlier onset of sexual maturity (Adams, 1980). These characteristics contributed to the subgroup receiving lower scores for the majority of the *productivity* attributes (Table 7). The exception being the *trophic level* attribute which was assigned higher scores due to the predatory niches occupied by these species. It is noted though that almost half of the target & byproduct species (n = 16) were assigned at least one precautionary high (3) score due to data deficiencies (Table 5). In a number of instances, these precautionary scores were refined in the RRA with the use of proxies (Table 7; Appendix D). While the use of proxies helped refine risk profiles, future ERAs would benefit from additional data on the biology of these species; particularly from stocks and populations within the Great Barrier Reef Marine Park.

The s*usceptibility* component of the PSA had a stronger influence on the final risk ratings. This was to be expected given that a) this aspect of the Level 2 ERA focused specifically on key target & byproduct species and b) these species are targeted across their preferred habitats including in areas where they are more likely to be encountered. This was reflected in scores assigned to *selectivity*, *availability* and *encounterability* attributes (Table 7). Evidently, these three attributes played a significant role in all species receiving higher risk ratings. However, *management strategy* and *sustainability assessments* were also identified as attributes that contributed to the production of more conservative risk profiles (Table 7).

When compared to coral trout (*Plectropomus* spp.) and red throat emperor (*Lethrinus miniatus*), species within the OS Quota Management Unit have smaller harvests and attract lower levels of commercial effort (Department of Agriculture and Fisheries, 2019c; 2020b). Coral trout and red throat emperor are also targeted with more regularity by fishers in the charter and recreational fishing sectors

(Department of Agriculture and Fisheries, 2020b; Webley *et al.*, 2015). In this context, OS species may be viewed as lower priorities in terms of research, monitoring and management. This inference is partly reflected in the amount of information that is available on the stock structure of OS species and in the (limited) specificity of their broader management regime.

Both coral trout and red throat emperor have positive stock status evaluations and quota limits informed by stock assessments (Albury & Fairclogh, 2018; Bessell-Browne *et al.*, 2018; Campbell *et al.*, 2019; Leigh *et al.*, 2006). These factors were given significant consideration as part of the Level 1 ERA and underpinned the decision not to progress the CT and RTE Quota Management Units to a fine-scale (Level 2) ERA (Jacobsen *et al.*, 2019b). In comparison, none of the OS species have been the subject of a detailed stock assessment and only the spangled emperor and hussar (*Lutjanus adetii*) have positive stock status evaluations *i.e.* SAFS assessment (Department of Agriculture and Fisheries, 2018e; Newman *et al.*, 2018b). The stock status of the remaining species are classified as *undefined* or not assessed (Department of Agriculture and Fisheries, 2018e; 2019c; Fisheries Research and Development Corporation, 2018).

***Table 8**. Overview of risk ratings for target & byproduct species (OS Quota Management Unit) assessed as part of the Level 2 ERA, including those identified as priority assessments and those that are considered to be more precautionary.*

Common name	*Species name*	Final risk rating
Priority assessments		
Red emperor	*Lutjanus sebae*	**High**
Saddletail snapper	*Lutjanus malabaricus*	**High**
Goldband snapper	*Pristipomoides multidens*	**High**
Crimson snapper	*Lutjanus erythropterus*	**High**
Spangled emperor	*Lethrinus nebulosus*	**Medium**
Stripey snapper	*Lutjanus carponotatus*	**Medium**
Brownstripe snapper	*Lutjanus vitta*	**Medium**
Hussar	*Lutjanus adetii*	**Medium**
Precautionary assessments		
Banded rockcod	*Hyporthodus ergastularius*	**Precautionary High**
Purple rockcod	*Epinephelus cyanopodus*	**Precautionary High**
Robinson's sea bream	*Gymnocranius grandoculis*	**Precautionary High**
Collar sea bream	*Gymnocranius audleyi*	**Precautionary High**
Maori rockcod	*Epinephelus undulatostriatus*	**Precautionary High**
Birdwire rockcod	*Epinephelus merra*	**Precautionary High**
Blue spotted rockcod	*Cephalopholis cyanostigma*	**Precautionary High**
Rosy snapper	*Pristipomoides filamentosus*	**Precautionary High**
Flame snapper	*Etelis coruscans*	**Precautionary High**
Green jobfish	*Aprion virescens*	**Precautionary High**
Greasy rockcod	*Epinephelus tauvina*	**Precautionary Medium**
Highfin grouper	*Epinephelus maculatus*	**Precautionary Medium**
Specklefin grouper	*Epinephelus ongus*	**Precautionary Medium**
Blackspot tuskfish	*Choerodon schoenleinii*	**Precautionary Medium**

Common name	*Species name*	Final risk rating
Maori snapper	*Lutjanus rivulatus*	**Precautionary Medium**
Moses perch	*Lutjanus russellii*	**Precautionary Medium**
Blacktip rockcod	*Epinephelus fasciatus*	**Precautionary Medium**
Longnose emperor	*Lethrinus olivaceus*	**Precautionary Medium**
Yellow spotted rockcod	*Epinephelus areolatus*	**Precautionary Medium**
Venus tuskfish	*Choerodon venustus*	**Precautionary Medium**
Purple tuskfish	*Choerodon cephalotes*	**Precautionary Medium**
Blue tuskfish	*Choerodon cyanodus*	**Precautionary Medium**
Sharptooth snapper	*Pristipomoides typus*	**Precautionary Medium**
Longfin rockcod	*Epinephelus quoyanus*	**Precautionary Medium**
Spotcheek emperor	*Lethrinus rubrioperculatus*	**Precautionary Medium**
Painted sweetlip	*Diagramma pictum*	**Precautionary Medium**
Ruby snapper	*Etelis carbunculus*	**Precautionary Medium**

For a number of the OS species, low harvest rates reduce the need to invest significant resources evaluating the status of their stocks on the Queensland east coast. This was recognised as part of the Level 2 ERA with the assignment of precautionary risk ratings (Table 8). These assessments though are based on the current fishing environment and there is considerable scope for catch and effort to increase for one or more of these species (Department of Agriculture and Fisheries, 2019c). This is because the OS Quota Management Unit is a multi-species category and there is limited capacity within the system to address shifting fishing behaviours *e.g.* in response to increased market demand. This scenario is best exemplified by a non-RLF species, black jewfish (*Protonibea diacanthus*), where market demand for swim bladders encouraged exponential growth in catch rates and forced management intervention (Department of Agriculture and Fisheries, 2019f; i; 2020b; Jacobsen *et al.*, 2019c). While this species is not managed as part of the RLF,[9] it provides a good example of how market demand can alter fisher behaviour.

At a whole-of-fishery level, the risk of over-exploitation is expected to be low for a high proportion of the species assessed. In the Level 2 ERA, the strength of this hypothesis could not be fully tested as data deficiencies limited the extent of comparisons between harvest rates and biomass reference points. As a consequence, a high proportion of the species were assigned the highest score for *management strategy* and *sustainability assessments* (Table 7). Subsequent ERAs involving the RLF would benefit from more information on the stock structure and status of these species. This information would not only help to refine individual risk profiles but also minimise the number of false positives or risk overestimations. If for example, data improved to a point where all species could be assigned a medium (2) risk rating for the *sustainability assessment*, all but seven would fall into the medium-risk category (Fig. 1).

For most of these species, indicative sustainability evaluations and a weight-of-evidence approach is viewed as the most appropriate course of action *verse* a detailed stock assessment. It is however recommended that species with more definitive risk assessments be prioritised in this process *e.g.* red emperor, saddletail snapper, goldband snapper, crimson snapper, spangled emperor, stripey snapper,

[9] *Black jewfish (Protonibea diacanthus) is managed as part of the East Coast Inshore Fishery (ECIF).*

hussar and brownstripe snapper (Table 8). The suitability and applicability of undertaking assessments for the remaining species will be dependent on their risk rating (Table 7), the key drivers of risk (*e.g.* data deficiencies, biology or fishing pressures), commercial harvest levels and their popularity within the charter and recreational fishing sectors.

The resolution of the catch data was also identified as a notable risk factor for the OS category. This risk applies to both the commercial and charter fishing sectors where large proportions of the catch are still reported in broader categories such as *Cod–unspecified* (Department of Agriculture and Fisheries, 2019c). It is recognised that reporting catch to species level can be difficult in an active fishing environment, especially given the diversity of teleosts retained in RLF (Department of Agriculture and Fisheries, 2019c; Queensland Government, 2018d). There is however a need to improve the level of information on catch compositions and catch variability within the OS category. Going forward, this data will be of significant importance when attempting to understand how rates of fishing mortality compare to key biomass reference points.

In the recreational fishing sector, the majority of the reef line catch data is obtained through voluntary localised monitoring programs and more expansive voluntary recreational fisher surveys (Department of Agriculture and Fisheries, 2020b; Webley *et al.*, 2015). Recreational harvest estimates derived from surveys are useful for common target species, but estimates for rarer or infrequently caught species are often unusable (*i.e.* low confidence) due to limited sampling power (Department of Agriculture and Fisheries, 2020b; Webley *et al.*, 2015). This limits the scope of any assessment of the cumulative fishing risks and species-specific estimates of the total rate of fishing mortality (*e.g.* harvest rates across the commercial, charter and recreational fishing sectors).

In addition to the retained product, undocumented discard mortalities will contribute to the level of risk posed to target & byproduct species. Within all fishing sectors, minimum legal size limits and seasonal closures mean that some fish are returned to the water. In the recreational and charter fishing sectors, discards will include fish that were returned to the water due to species-specific and general in possession limits (Appendix F; Department of Agriculture and Fisheries, 2019c). While most line-caught fish are discarded in a live state, expectations are that a proportion of the released fish will die as a result of their encounter with the fishery/sector. Examples of where this could occur include due to depredation, prolonged exposure or stress, hook-induced injuries, poor handling techniques and barotrauma (Broadhurst *et al.*, 2005; Mitchell *et al.*, 2018; Sumpton *et al.*, 2010).

While post-release survival rates for OS species are poorly understood, research has shown that some species and groups are more susceptible to post-interaction mortalities. For example, Tuskfish are highly susceptible to barotrauma at even shallow depths (>10m), and, given the minimum legal size limits for this group, it is highly likely that a large proportion of tuskfish species will be discarded in a moribund state (Fairclough, 2005; Northern Territory Government, 2020). Gaining a better understanding of total fishing mortality (*i.e.* retained and discard mortalities) will assist in applying more accurate risk ratings in future assessments.

At a whole-of-fishery level, the commercial fishery will be a key driver of risk for a number of the OS species. With that said, the risk posed by recreational and charter fishing activities will be equal to or greater than the commercial fishery for some species. Saddletail and crimson snapper are good examples of this, where the estimated recreational catch (120t & 50t respectively)[10] exceeds that of

[10] *Estimates based on the Statewide Recreational Fishing Survey 2013–14 (Webley et al., 2015).*

the commercial fishery (85t & 11t respectively)[11] (Department of Agriculture and Fisheries, 2020b; McPhee *et al.*, 2002; Saunders *et al.*, 2018a; Saunders *et al.*, 2018b). These factors contributed to some species receiving higher scores for the *recreational desirability* attribute and these cumulative risks will need to be taken into consideration as part of a broader RLF harvest strategy.

While the RLF is the only commercial fishery permitted to harvest OS species, other fisheries such as trawl and net will interact with coral reef fin fish. Any fish that cannot be retained for sale in these fisheries will be discarded as bycatch. As commercial trawl and net fisheries operate within the Great Barrier Reef Marine Park, they will be a contributing risk factor for the OS species (Department of Agriculture and Fisheries, 2019f; Pears *et al.*, 2012). These fishing-induced mortalities go beyond what is recorded in logbooks or surveys and, until cumulative impacts are better quantified, the true level of risk to OS category species will remain unknown.

Target & Byproduct (OS category)—Recommendations

1. ***Identify avenues/mechanisms to validate catch data, improve species resolution and monitor the take of OS category species across sectors.***

   The use of broad-scale catch categories in the commercial data makes it difficult to quantify individual rates of fishing mortality. The same is true for the charter and recreational fishing sectors where similar categories are used; particularly for lesser caught species. In the Level 2 ERA, this uncertainty limited the scope of the assessment and contributed to the production of more conservative risk profiles. Collecting more information on catch compositions and species-specific catch rates will improve the accuracy of future ERAs and may facilitate a risk score reduction for one or more of the species assessed. More broadly, improving the resolution of the catch data would assist when attempting to understand the impact of the fishery on regional stocks/populations and with the development of more detailed assessments, namely stock assessments or indicative sustainability evaluations.

   Of significance, this risk is being actively addressed as part of the *Queensland Sustainable Fisheries Strategy 2017–2027*. This includes through the development of a RLF-specific harvest strategy, exploring the use of new or improved monitoring tools (*e.g.* e-logs) and enhanced catch monitoring / data validation (retained and discards) across Queensland fisheries. A number of these measures are included and/or are being discussed as part of broader *Data Validation Plan* (Department of Agriculture and Fisheries, 2017; 2018a; b).

2. ***Identify mechanisms to improve the management and monitoring of catch and effort directed at key species and/or species complexes (management strategy).***

   While a TACC limit is applied to the OS category, the management unit includes more than 150 species. Multi-species TACCs afford individual species with limited protection if, for example, the fishing environment were to change significantly over the short to medium term. Refining management arrangements to account for species-specific fishing pressures more adequately would help to minimise this risk and the long-term risk of overexploitation.

   Consideration should be given to expanding the use of TACC limits for key OS species or subgroups. It is recognised that output controls will be less suited to some species; particularly

[11] *2018 catch data.*

those with low harvest rates and fewer cumulative fishing pressures. There is however considerable scope within the harvest strategy development process to explore the suitability and applicability of applying TACC limits to additional species (Department of Agriculture and Fisheries, 2020a). The outputs of the Level 2 ERA provide insight into the species that should be prioritised for inclusion (if applicable) in a broader RLF harvest strategy and/or species complexes that would benefit from more refined management.

If it is determined that the current management structure should be retained, measures should be introduced that allow for improved monitoring of individual rates of harvest, catch trends and discard rates. These measures will increase the responsiveness of the current management system and help mitigate risks relating to the over-exploitation of species included in the broader OS management unit.

3. ***Improve the level of information on the biology, stock structure, and status of priority species (sustainability assessments).***

   With data deficiencies limiting the extent of biological and sustainability assessments, improving the level of information on the biology, stock structure and status of OS category species is viewed as a priority. The *Monitoring & Research Plan* already identifies saddletail snapper, crimson snapper, stripey snapper, red emperor and spangled emperor as priority species. Biological data collected for these species will be used to refine assessments involving the *sustainability assessments* attribute and inform future stock assessments and stock status evaluations. When appropriate, consideration should be given to extending this program to include goldband snapper, brownstripe snapper, and hussar. It is recognised though that the ability to expand this program will be highly dependent on the available resources.

4. ***Review the suitability, applicability and value of data submitted through the logbook program on the dynamics of the fishery. As part of this process, it is recommended that the logbook reporting requirements be extended to include information on what fishing symbol is being used.***

   Operators are not currently required to nominate a fishing symbol that they are operating under. As platforms can have multiple symbols attached, it can be difficult to assess how many symbols are operating in each of the respective fisheries. While this is considered more of an issue in the net fishery, there are inherent benefits of collecting additional information on symbol usage *e.g.* providing further insight into the number of active symbols within each category (L1, L2 or L3) and/or the on how management changes may impact individual symbols.

5. ***Utilise fine-scale effort information to better assess true fishing overlap with species' distributions.***

   Overlap percentages used to assign *availability* scores were based on effort distribution data submitted as part of the logbook reporting program. Under the *Queensland Sustainable Fisheries Strategy 2017–2027*, the use of *Vessel Tracking* has been expanded to all fisheries including all primary vessels and tenders used in the RLF. As *Vessel Tracking* is now mandatory, the quality of the effort distribution data will improve through time. This data will directly inform assessments involving the *availability* attribute and provide further insight into a species' *availability* and *encounterability* potential. A more precise understanding of the spatial relationship between the

fishery and OS category will help inform future ERAs by reducing the number of precautionary high risks *i.e.* assessments that were influenced by imprecise or missing data.

6. ***Quantify the cumulative fishing pressures exerted on key species and, when and where appropriate, identify areas to improve catch monitoring across the recreational and charter fishing sectors (recreational desirability / other fisheries).***

   This recommendation is intimately linked with recommendation 5. For some reef species, fishing pressure from non-commercial sectors will be greater than the commercial fishery. For many OS category species (*e.g.* cods and groupers), cumulative fishing pressures remain poorly understood. Gaining a better understanding of total interaction (retained plus discards) and mortality (harvested plus post-capture) rates will help refine assessments involving the *post-capture mortality* and *recreational desirability / other fisheries* attribute.

7. ***Review the suitability and applicability of current legal size limits for OS category species and (when and where appropriate) update; taking into account available information on their biology (management strategy).***

   Complex-specific size limits (*e.g.* those applied to cods and groupers) may not provide adequate protection from some species *e.g.* birdwire (*E. merra*) and blue spotted rockcod (*C. cyanostigma*). In these two examples, species-specific maximum size estimates (35cm and 30cm respectively) sits below the 38cm minimum legal size limit applied to cods and groupers (Appendix F) (Choat, 2018; Pothin *et al.*, 2004; Queensland Government, 2018a; b; c). A review of minimum legal size limits based on updated biological data may better protect reproduction while reducing unnecessary discarding.

8. ***Establish a measure to estimate the gear-affected area and, when available, reassess the risk posed to teleosts using a more quantitative ERA method e.g. bSAFE.***

   The RLF Level 2 ERA had a comparatively high number of precautionary risk ratings (Table 8). A proportion of these will be false-positive results where the risk posed to a species has been overestimated. Research suggests that the SAFE method produces fewer false positives and a move to this method may provide further insight into the risk posed by this fishery. This however will require an effective measure of the gear-affected area which can be difficult to assess in a demersal line fishery.

9. ***Implement strategies that encourage best handling practices for releasing OS category species including those with a proven track-record of improving post-release survival rates (post-release mortalities).***

   Reef fish can experience stress and injuries from angling and can suffer from impacts of barotrauma even at shallow depths. The effects of barotrauma will vary between species, be influenced by the depth of the water being fished and in some instances be unavoidable. However, education programs directed towards fishers across all sectors encouraging best handling practices may help reduce some of these injuries, thereby improving post-release survival rates.

4.2 Protected Teleosts (SOCI only)

Risk profiles for protected SOCI shared a number of similarities with the target & byproduct species ecological component (Table 7). Queensland groper (*Epinephelus lanceolatus*), humphead Maori wrasse (*Cheilinus undulatus*) and potato rockcod (*E.* tukula) were all found to be at high risk with the barramundi rockcod (*Cromileptes altivelis*) assessed as medium risk (Table 8). While all four occupied higher risk ratings, this was partly attributed to data deficiencies; particularly in the catch data. For this reason, risk ratings for protected teleosts are viewed as more representative of the potential risk *verse* an actual risk (see the *Ecological Risk Assessment Guidelines*). As with the target & byproduct species, addressing these risks through species-specific measures is viewed as a lower priority.

***Table 9**. Overview of protected teleost species and their final risk ratings.*

Common name	***Species name***	**Final Risk Rating**
Humphead Maori wrasse	*Cheilinus undulatus*	**Precautionary High**
Queensland groper	*Epinephelus lanceolatus*	**Precautionary High**
Potato rockcod	*Epinephelus tukula*	**Precautionary High**
Barramundi cod	*Cromileptes altivelis*	**Precautionary Medium**

While the life histories of the protected teleosts shared similarities with the target & byproduct species, the humphead Maori wrasse, Queensland groper, potato rockcod and barramundi cod tend to be larger, live longer, and reach sexual maturity at a later age (Fennessy *et al.*, 2018; Pollard *et al.*, 2018; Russell, 2004). This was reflected in the *productivity* assessment where three of the four species recorded assessment high scores of 2.00 (Table 7). From an ERA perspective, these conservative life-history traits make the Queensland groper, humphead Maori wrasse and potato rockcod more susceptible to the detrimental effects of fishing (commercial, recreational and charter).

For non-harvested species, the *susceptibility* component of the PSA is reduced to four attributes; *availability, encounterability, selectivity* and *post-capture mortality* (Table 7). The primary reason for this is that targeting and harvesting of these species are not permitted in Queensland waters. These protections, in effect, negate the need to undertake fisheries-based stock assessments or quantify sustainability reference points. As the species cannot be retained for sale, they also registered lower scores for the *post-capture mortality* attribute. This contributed to the subgroup registering a lower average score for *susceptibility* assessment; *average* = 2.50 *verse* 2.84 for the target & byproduct species (Table 7).[12] With further information on interaction rates, discard fates, and fine-scale effort movements, *susceptibility* scores for these species could be reduced further.

As with target & byproduct species, the use of a hook and line apparatus means that gear selectivity will be high for protected teleosts. As the four SOCI share similar diet preferences to harvested species, the chance of them being attracted to bait and/or becoming hooked is also high. This

[12] *Target & byproduct species average based on all seven attributes. When only the four shared attributes are taken into consideration (e.g. availability, encounterability, selectivity and post-capture mortality) this differential increases to 2.50 to 3.00.*

hypothesis is supported by the SOCI data which includes >3000 interactions between protected teleosts and demersal line fishing operations (2015–2019 inclusive; Department of Agriculture and Fisheries, 2019c; e). This data indicates that the majority of these interactions were with barramundi cod (48.5%) and humphead Maori wrasse (51.4%). Almost all (99%) of the SOCI reports indicate that the affected fish was released alive (Department of Agriculture and Fisheries, 2019c).

While noting release fates documented through the SOCI logbooks (commercial and charter fisheries), there is limited capacity within the current management regime to validate this data. This issue is compounded by a current inability to monitor and track SOCI interactions in the recreational fishing sector. As catch data for this sector focuses on retainable product, recreational SOCI interactions are largely undocumented. However, it is anticipated that a proportion or the recreationally caught fish will be discarded in a moribund state and/or die as a direct or indirect result of their interaction with the fishery *e.g.* due to depredation, increased stress, hook-induced injuries and barotrauma.

The Department aims to combat the above deficiencies through the *Monitoring and Research Plan* and the *Data Validation Plan* (Department of Agriculture and Fisheries, 2018a; b). Both of these plans were implemented as a part of the *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2018b) and are designed to improve the quality of the data collected across sectors. These plans though may not address all of the data deficiencies including those relating to the recreational fishing sector. Further, initiatives instigated under both plans will take time to develop and implement on the Queensland east coast. The establishment of both plans will contribute to the production of more accurate risk assessments over the longer term.

Overall, outputs from the Level 2 ERA are viewed as more representative of the potential risk. However, interactions with protected teleosts are likely in the RLF and further information is required on the extent of these interactions and their release fates including post-capture mortalities (*e.g.* the effects of barotrauma, depredation). This information will need to be supplemented by data from the recreational fishing sector; particularly in areas where cumulative fishing pressures are greatest.

Protected teleost species—Recommendations

1. ***Obtain better information on catch rates and release fates across sectors (commercial, charter and recreational fishing).***

   Commercial and charter fishers are required to report interactions with SOCI but challenges remain with validating this data and (if applicable) the extent of any under-reporting. While information on catch rates is collected from the recreational fishing sector, this data is primarily based on retainable species. Gathering more information from these sectors will help refine subsequent ERAs and provide further insight into the cumulative fishing pressures these species are exposed to.

2. ***Education on best handling procedures when releasing protected teleost species back into the water.***

   As the Queensland groper, humphead Maori wrasse, barramundi cod and potato rockcod are no-take species, they would derive benefit from any measure that helps reduce post-interaction mortalities. This includes initiatives designed to improve handling and release practices across fisheries and sectors.

3. ***Utilise fine-scale effort information to better assess true fishing overlap with species' distributions.***

   Vessel Tracking data, once well established, will significantly assist with refining fishing effort overlap with protected species distributions. A more precise understanding of the spatial relationship between the fishery and protected teleosts will help inform future ERAs by reducing the number of precautionary high risks driven by unknowns.

5 Summary

The Level 2 ERA provides managers with a snapshot of the risks posed to key targets in the RLF and a number of protected teleosts. The results of the Level 2 ERA suggest that all of the assessed species are at an elevated risk from fishing activities in the RLF. This was to be expected given that many of the species are actively targeted in their preferred habitats by commercial operators and recreational/charter fishers. It is recognised that the dynamics of a fishery will change through time with catch and effort fluctuating at a whole-of-fishery, regional and species level. The results of the Level 2 ERA though provide a sound baseline of assessments that can be reviewed and amended (where appropriate) to accommodate additional data or management reforms.

While the outputs of the Level 2 ERA indicate that the RLF poses a higher risk to the species assessed, this risk is not expected to be uniform. For a number of species, the final risk ratings are viewed as precautionary and have a high probability of being reduced with additional information. If for example data sets improved to a point where the scores assigned to one attribute could be reduced by one category (*e.g.* from high to medium), the risk rating of at least ten species would reduce from high to medium. If this was replicated in a second attribute, all 35 target & byproduct species would be at medium risk. In this context, the following measures would assist with respect to mitigating, managing and understanding risk in the RLF.

- *Establish a mechanism to manage and minimise the long-term sustainability risk for key target and byproduct species, preferably through the introduction of a fishery-specific harvest strategy with clearly defined harvest control rules and sustainability assessment protocols.*
- *Identify avenues/mechanisms that can be used to monitor the catch of target and byproduct species (preferably in real or near-real time) and minimise the risk of non-compliance.*
- *Review the suitability, applicability and value of data submitted through the logbook program on the dynamics of the fishery, species compositions and release fates including for protected species. As part of this process, it is recommended that the logbook reporting requirements be extended to include information on what fishing symbol is being used.*
- *Improve the level of information on the biology, stock structure, and status of priority OS category target & byproduct species (sustainability assessments).*
- *Review the suitability and applicability of current legal size limits for OS category species and (when and where appropriate) update; taking into account available information on their biology (management strategy).*
- *Utilise fine-scale effort information to better assess true fishing overlap with the distribution of species included in the OS Quota Management Unit and the protected species ecological sub-component.*

- *Quantify the cumulative fishing pressures exerted on key OS category species and, when and where appropriate, identify areas to improve catch monitoring across the recreational and charter fishing sectors (recreational desirability / other fisheries).*
- *Implement strategies that encourage best handling practices for releasing OS category species and protected teleosts proven to help post-release survival rates (post-release mortalities).*
- *Establish a measure to estimate the gear-affected area and, when available and appropriate, reassess the risk posed to key species using a more quantitative ERA method bSAFE.*

Of significance, a number of these risks are already being actively addressed as part of the broader *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017; 2019d). These include mandating the use of *Vessel Tracking*, the development of a dedicated RLF harvest strategy (Department of Agriculture and Fisheries, 2020a) and improved catch monitoring and validation techniques (Department of Agriculture and Fisheries, 2018b). These initiatives have the potential to reduce the risk posed to reef line species and mitigate some of the longer-term risks identified (Jacobsen *et al.*, 2019a). These measures though will take time to develop, implement and evaluate for effectiveness.

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7 Appendix

Appendix A – Species rationalisation process.

Appendix B – Species rationalisation process: justifications and considerations.

Appendix C – *Availability* overlap percentages.

Appendix D – *Residual Risk Analysis* justifications.

Appendix E – *Likelihood & Consequence Analysis*.

Appendix F – Summary of management arrangements for reef line species.

Appendix A—Species rationalisation process.

Catch data submitted through the commercial logbook system was used to construct a preliminary list of target & byproduct species that were considered for inclusion in the Level 2 ERA. Logbook data were considered over a three year period (2016–2018 inclusive) with the final species list refined using the following steps.

1. Data for each catch category (*i.e.* species or species groupings) was summed across the relevant period (2016–2018 inclusive) and ranked in order from highest to lowest.

2. Cumulative catch analysis was used to identify all of the categories that made up 95% of the total catch reported from the fishery over this period.

3. Species that fell below the 95% catch threshold were reviewed and, if no anomalies were detected, omitted from the initial list of target & byproduct species. Retention rates for most of these species are low and they are generally viewed as secondary byproduct species. When and where appropriate, these secondary species will be considered for inclusion in subsequent ERAs.

4. Species above the 95% catch threshold (*i.e.* those that were not omitted from the analysis) were than reviewed and the following steps undertaken:

    a. Where possible, multi-species catch categories were expanded using the relevant CAAB codes (*e.g.* blacktip shark CAAB code 37 018903 includes *Carcharhinus limbatus* and *C. tilstoni*). All additions took into consideration the operating area of the fishery and the potential for the species to interact with the fishery. In some instances, this required the re-inclusion of species that fell below the initial 95% cut-off.

    b. Duplications resulting from expansion of multi-species catch categories were then removed.

    c. Catch categories that could not be refined to species level such as *Fish—unspecified* were excluded from the analysis.

    d. Species managed under Total Allowable Commercial Catch (TACC) limits that are directly linked to biomass estimates or managed under harvest strategies (*e.g.* coral trout) were also removed. The premise being that the risk posed to this species is currently addressed through management controls. As a precautionary measure, any species whose TACC was not based on a stock assessment or had a stock assessment >5 years old was retained in the assessment.

5. A summary of the species rationalisation process was then completed and justifications provided for why each a target or byproduct species was included or omitted from the analysis.

Appendix B—Species rationalisation process: justifications and considerations.

*CAAB = *Codes for Australian Aquatic Biota* available at https://www.cmar.csiro.au/caab/.

Ecological component	Common name	Species name	CAAB*	Level 2 ERA	Justifications & Comments
Target & Byproduct species ***(OS category)***	Saddletail snapper	*Lutjanus malabaricus*	37346007	Assessed	• Synonym—large mouth nannygai • Included based on catch records / FWG recommendations
	Goldband snapper	*Pristipomoides multidens*	37346002	Assessed	• Synonym—Goldbanded jobfish • Included based on catch records / FWG recommendations
	Spangled emperor	*Lethrinus nebulosus*	37351008	Assessed	• Included based on catch records / FWG recommendations
	Red emperor	*Lutjanus sebae*	37346004	Assessed	• Included based on catch records / FWG recommendations
	Stripey snapper	*Lutjanus carponotatus*	37346011	Assessed	• Included based on catch records / FWG recommendations
	Greasy rockcod	*Epinephelus tauvina*	37311057	Assessed	• Included based on catch records / FWG recommendations
	Banded rockcod	*Epinephelus ergastularius*	37311147	Assessed	• Included based on catch records / FWG recommendations
	Yellow spotted rockcod	*Epinephelus areolatus*	37311009	Assessed	• Included based on catch records / FWG recommendations
	Highfin grouper	*Epinephelus maculatus*	37311011	Assessed	• Included based on catch records / FWG recommendations

Ecological component	Common name	Species name	CAAB*	Level 2 ERA	Justifications & Comments
	Birdwire rockcod	*Epinephelus merra*	37311063	Assessed	• Synonym—honeycomb rockcod/grouper, dwarf spotted rockcod • Included based on catch records / FWG recommendations
	Specklefin grouper	*Epinephelus ongus*	37311069	Assessed	• Included based on catch records / FWG recommendations
	Maori rockcod	*Epinephelus undulatostriatus*	37311086	Assessed	• Included based on catch records / FWG recommendations
	Blue spotted rockcod	*Cephalopholis cyanostigma*	37311136	Assessed	• Synonym—blue spotted hind • Added based on FWG recommendations
	Purple rockcod	*Epinephelus cyanopodus*	37311145	Assessed	• Synonym—blue Maori rockcod, speckled blue grouper • Included based on catch records / FWG recommendations
	Hussar	*Lutjanus adetii*	37346033	Assessed	• Synonym—yellow banded snapper / sea perch • Included based on catch records / FWG recommendations
	Brownstripe snapper	*Lutjanus vitta*	37346003	Assessed	• Synonym—brownstripe sea perch • Included based on catch records / FWG recommendations
	Crimson snapper	*Lutjanus erythropterus*	37346005	Assessed	• Synonym—small mouth nannygai • Included based on catch records / FWG recommendations

Ecological component	Common name	Species name	CAAB*	Level 2 ERA	Justifications & Comments
	Rosy snapper	*Pristipomoides filamentosus*	37346032	Assessed	• Synonym—rosy/crimson jobfish • FWG indicated that this species is caught with less frequency but naming discrepancies[13] within the industry meant it was assessed as a precaution.
	Venus tuskfish	*Choerodon venustus*	37384042	Assessed	• Included based on catch records / FWG recommendations
	Purple tuskfish	*Choerodon cephalotes*	37384004	Assessed	• Synonym—grass tuskfish • Included based on catch records / FWG recommendations
	Blue tuskfish	*Choerodon cyanodus*	37384072	Assessed	• Included based on catch records / FWG recommendations
	Blackspot tuskfish	*Choerodon schoenleinii*	37384010	Assessed	• Included based on catch records / FWG recommendations
	Sharptooth snapper	*Pristipomoides typus*	37346019	Assessed	• Synonym—Sharptooth jobfish, goldband snapper • FWG recommended this species is included in the assessment despite lower recorded catch (see footnote).
	Ruby snapper	*Etelis carbunculus*	37346014	Assessed	• Included based on catch records / FWG recommendations
	Maori snapper	*Lutjanus rivulatus*	37346016	Assessed	• Synonym—Maori sea perch, blubberlip snapper

[13] *The FWG indicated that sharptooth and rosy snapper are frequently confused with each other in the fishing industry; more product is recorded against rosy snapper but it is likely that this is actually sharptooth snapper. Both species are difficult to identify from one another in addition to this. As a precaution, both species were included in the assessment.*

Ecological component	Common name	Species name	CAAB*	Level 2 ERA	Justifications & Comments
					• Included based on catch records / FWG recommendations
	Flame snapper	*Etelis coruscans*	37346038	Assessed	• Synonym—deepwater longtail red snapper, flametail snapper/jobfish • Included based on catch records / FWG recommendations
	Green jobfish	*Aprion virescens*	37346027	Assessed	• Included based on catch records / FWG recommendations
	Moses perch	*Lutjanus russellii*	37346065	Assessed	• Synonym—Moses snapper • Included based on catch records / FWG recommendations
	Blacktip rockcod	*Epinephelus fasciatus*	37311014	Assessed	• Added based on FWG recommendations
	Longfin rockcod	*Epinephelus quoyanus*	37311040	Assessed	• Added based on FWG recommendations
	Painted sweetlip	*Diagramma pictum*	37350003	Assessed	• Synonym—slatey bream • Included based on catch records / FWG recommendations
	Robinson's sea bream	*Gymnocranius grandoculis*	37351005	Assessed	• Synonym—big-eye bream, blue-lined large-eye bream, Maori sea bream • Included based on catch records / FWG recommendations
	Spotcheek emperor	*Lethrinus rubrioperculatus*	37351012	Assessed	• Synonym—red-eared emperor
	Collar sea bream	*Gymnocranius audleyi*	37351018	Assessed	• Synonym—iodine bream
	Longnose emperor	*Lethrinus olivaceus*	37351004	Assessed	• Synonym—longface bream

Ecological component	Common name	Species name	CAAB*	Level 2 ERA	Justifications & Comments
	Camouflage grouper	*Epinephelus polyphekadion*	37311047	Not assessed	• Was not identified as a priority species by FWG
	Flowery rockcod	*Epinephelus fuscoguttatus*	37311021	Not assessed	• Was not identified as a priority species by FWG
	Convict grouper	*Epinephelus septemfasciatus*	37311060	Not assessed	• Was not identified as a priority species by FWG
	Peacock rockcod	*Cephalopholis argus*	37311082	Not assessed	• Was not identified as a priority species by FWG
	Coral rockcod	*Cephalopholis miniata*	37311083	Not assessed	• Was not identified as a priority species by FWG
	Tomato rockcod	*Cephalopholis sonnerati*	37311045	Not assessed	• Was not identified as a priority species by FWG
	Comet grouper	*Epinephelus morrhua*	37311151	Not assessed	• Was not identified as a priority species by FWG
	Smalltooth jobfish	*Aphareus furca*	37346036	Not assessed	• Was not identified as a priority species by FWG
	Lavender snapper	*Pristipomoides sieboldii*	37346064	Not assessed	• Was not identified as a priority species by FWG
	Sixbar grouper	*Epinephelus sexfasciatus*	37311017	Not assessed	• Was not identified as a priority species by FWG
	Radiant rockcod	*Epinephelus radiatus*	37311042	Not assessed	• Was not identified as a priority species by FWG
	Whitelined rockcod	*Anyperodon leucogrammicus*	37311085	Not assessed	• Was not identified as a priority species by FWG

Ecological component	Common name	Species name	CAAB*	Level 2 ERA	Justifications & Comments
	Chinaman rockcod	*Epinephelus rivulatus*	37311022	Not assessed	• Was not identified as a priority species by FWG
	Whitespotted grouper	*Epinephelus coeruleopunctatus*	37311070	Not assessed	• Was not identified as a priority species by FWG
	Coral grouper	*Epinephelus corallicola*	37311066	Not assessed	• Was not identified as a priority species by FWG
	Wirenet rockcod	*Epinephelus hexagonatus*	37311064	Not assessed	• Was not identified as a priority species by FWG
	Black rockcod	*Epinephelus daemelii*	37311077	Not assessed	• Was not identified as a priority species by FWG
	Puzzling grouper	*Hyporthodus perplexus*	37311153	Not assessed	• Was not identified as a priority species by FWG
	Eightbar grouper	*Hyporthodus octofasciatus*	37311152	Not assessed	• Was not identified as a priority species by FWG
	Blackspotted rockcod	*Epinephelus malabaricus*	37311150	Not assessed	• Was not identified as a priority species by FWG
	Snubnose grouper	*Epinephelus macrospilos*	37311149	Not assessed	• Was not identified as a priority species by FWG
	Blacksaddle rockcod	*Epinephelus howlandi*	37311148	Not assessed	• Was not identified as a priority species by FWG
	Speckled grouper	*Epinephelus magniscuttis*	37311173	Not assessed	• Was not identified as a priority species by FWG
	Foursaddle grouper	*Epinephelus spilotoceps*	37311173	Not assessed	• Was not identified as a priority species by FWG

Ecological component	Common name	Species name	CAAB*	Level 2 ERA	Justifications & Comments
	Whitedotted grouper	*Epinephelus polystigma*	37311154	Not assessed	• Was not identified as a priority species by FWG
	Brownbarred rockcod	*Cephalopholis boenak*	37311008	Not assessed	• Synonym–banded rockcod • Was not identified as a priority species by FWG
	Dot-head rockcod	*Cephalopholis microprion*	37311139	Not assessed	• Was not identified as a priority species by FWG
	Strawberry rockcod	*Cephalopholis spiloparaea*	37311141	Not assessed	• Was not identified as a priority species by FWG
	Flagtail rockcod	*Cephalopholis urodeta*	37311142	Not assessed	• Was not identified as a priority species by FWG
	Sixband rockcod	*Cephalopholis sexmaculata*	37311140	Not assessed	• Was not identified as a priority species by FWG
	Leopard rockcod	*Cephalopholis leopardus*	37311138	Not assessed	• Was not identified as a priority species by FWG
	Eastern pigfish	*Bodianus unimaculatus*	37384061	Not assessed	• Was not identified as a priority species by FWG
	Goldspot pigfish	*Bodianus perditio*	37384007	Not assessed	• Was not identified as a priority species by FWG
	Bumphead parrotfish	*Bolbometopon muricatum*	37386004	Not assessed	• Was not identified as a priority species by FWG
	Bicolour parrotfish	*Cetoscarus ocellatus*	37386007	Not assessed	• Was not identified as a priority species by FWG

Ecological component	Common name	Species name	CAAB*	Level 2 ERA	Justifications & Comments
	Redstripe tuskfish	*Choerodon vitta*	37384006	Not assessed	• Was not identified as a priority species by FWG
	Bluetooth tuskfish	*Choerodon typus*	37384014	Not assessed	• Was not identified as a priority species by FWG
	Wedgetail tuskfish	*Choerodon sugillatum*	37384009	Not assessed	• Was not identified as a priority species by FWG
	Darkspot tuskfish	*Choerodon monostigma*	37384008	Not assessed	• Was not identified as a priority species by FWG
	Dagger tuskfish	*Choerodon jordani*	37384077	Not assessed	• Was not identified as a priority species by FWG
	Graphic tuskfish	*Choerodon graphicus*	37384075	Not assessed	• Was not identified as a priority species by FWG
	Gomon's tuskfish	*Choerodon gomoni*	37384203	Not assessed	• Was not identified as a priority species by FWG
	Bridled tuskfish	*Choerodon frenatus*	37384074	Not assessed	• Was not identified as a priority species by FWG
	Harlequin tuskfish	*Choerodon fasciatus*	37384073	Not assessed	• Was not identified as a priority species by FWG
	Anchor tuskfish	*Choerodon anchorago*	37384071	Not assessed	• Was not identified as a priority species by FWG
	Threadfin emperor	*Lethrinus genivittatus*	37351002	Not assessed	• Synonym—lancer • Was not identified as a priority species by FWG
	Redspot emperor	*Lethrinus lentjan*	37351007	Not assessed	• Synonym—pink-eared emperor

Ecological component	Common name	Species name	CAAB*	Level 2 ERA	Justifications & Comments
					• Was not identified as a priority species by FWG
	Yellow tail emperor	*Lethrinus atkinsoni*	37351013	Not assessed	• Was not identified as a priority species by FWG
	Variegated emperor	*Lethrinus variegatus*	37351014	Not assessed	• Was not identified as a priority species by FWG
	Paddletail seabream	*Gymnocranius euanus*	37351022	Not assessed	• Synonym–Japanese seabream • Was not identified as a priority species by FWG
	Orangespotted emperor	*Lethrinus erythracanthus*	37351025	Not assessed	• Synonym–yellowspotted emperor • Was not identified as a priority species by FWG
	Mozambique seabream	*Wattsia mossambica*	37351027	Not assessed	• Was not identified as a priority species by FWG
	Ironjaw jobfish	*Aphareus rutilans*	37346001	Not assessed	• Synonym—rusty jobfish • Was not identified as a priority species by FWG
	Bass groper	*Polyprion americanus*	37311170	Not assessed	• Was not identified as a priority species by FWG
	Hapuku	*Polyprion oxygeneios*	37311006	Not assessed	• Was not identified as a priority species by FWG
Protected teleosts (SOCI only)	Humphead Maori wrasse	*Cheilinus undulatus*	37384038	Assessed	
	Queensland groper	*Epinephelus lanceolatus*	37311061	Assessed	
	Barramundi cod	*Cromileptes altivelis*	37311044	Assessed	

Ecological component	Common name	Species name	CAAB*	Level 2 ERA	Justifications & Comments
	Potato rockcod	*Epinephelus tukula*	37311068	Assessed	
No-take teleosts	Chinaman fish	*Symphorus nematophorus*	37346017	Not assessed	• Species classified as no-take due to health reasons. • No pressing sustainability concerns for this species in Australian waters *verse* sustainability concerns (Russell *et al.*, 2016a)
	Red bass	*Lutjanus bohar*	37 346029	Not assessed	• Species classified as no-take due to health reasons. • No pressing sustainability concerns for this species in Australian waters *verse* sustainability concerns (Russell *et al.*, 2016c).
	Paddletail	*Lutjanus gibbus*	37 346028	Not assessed	• Species classified as no-take due to health reasons. • No pressing sustainability concerns for this species in Australian waters *verse* sustainability concerns (Russell *et al.*, 2016b).

Appendix C—*Availability* overlap percentages.

Common name	Species	% Overlap			Highest overlap %	Availability score
		2016	2017	2018		
Saddletail snapper	*Lutjanus malabaricus*	48.7	47.9	45.1	48.7	3
Goldband snapper	*Pristipomoides multidens*	50.9	52.1	51.0	52.1	3
Spangled emperor	*Lethrinus nebulosus*	46.8	44.8	42.1	46.8	3
Red emperor	*Lutjanus sebae*	47.5	45.8	43.2	47.5	3
Stripey snapper	*Lutjanus carponotatus*	47.0	44.9	42.1	47.0	3
Greasy rockcod	*Epinephelus tauvina*	39.5	36.9	35.7	39.5	3
Banded rockcod	*Hyporthodus ergastularius*	42.6	40.3	38.8	42.6	3
Yellow spotted rockcod	*Epinephelus areolatus*	37.5	33.7	31.9	37.5	3
Highfin grouper	*Epinephelus maculatus*	39.5	36.9	35.6	39.5	3
Birdwire rockcod	*Epinephelus merra*	39.5	36.9	35.6	39.5	3
Specklefin grouper	*Epinephelus ongus*	38.5	36.9	35.5	38.5	3
Maori rockcod	*Epinephelus undulatostriatus*	41.7	40.5	39.2	41.7	3
Blue spotted rockcod	*Cephalopholis cyanostigma*	38.6	37.4	35.5	38.6	3
Purple rockcod	*Epinephelus cyanopodus*	39.2	36.6	35.3	39.2	3
Hussar	*Lutjanus adetii*	39.3	32.2	29.9	39.3	3
Brownstripe snapper	*Lutjanus vitta*	46.6	47.5	44.2	47.5	3
Crimson snapper	*Lutjanus erythropterus*	47.1	46.6	43.6	47.1	3
Rosy snapper	*Pristipomoides filamentosus*	38.5	38.1	37.8	38.5	3
Venus tuskfish	*Choerodon venustus*	48.3	46.4	43.5	48.3	3
Purple tuskfish	*Choerodon cephalotes*	45.7	43.0	38.8	45.7	3
Blue tuskfish	*Choerodon cyanodus*	42.1	36.7	33.0	42.1	3

Common name	Species	% Overlap			Highest overlap %	Availability score
		2016	2017	2018		
Blackspot tuskfish	*Choerodon schoenleinii*	47.3	45.1	42.5	47.3	3
Sharptooth snapper	*Pristipomoides typus*	42.1	44.2	48.0	48.0	3
Ruby snapper	*Etelis carbunculus*	9.2	7.6	9.1	9.2	1
Maori snapper	*Lutjanus rivulatus*	47.2	45.5	42.9	47.2	3
Flame snapper	*Etelis coruscans*	16.2	15.2	16.0	16.2	3
Green jobfish	*Aprion virescens*	47.3	45.7	43.0	47.3	3
Moses perch	*Lutjanus russellii*	47.5	45.5	42.4	47.5	3
Blacktip rockcod	*Epinephelus fasciatus*	39.5	36.9	35.6	39.5	3
Longfin rockcod	*Epinephelus quoyanus*	39.5	36.9	35.7	39.5	3
Painted sweetlip	*Diagramma pictum*	47.1	45.3	42.3	47.1	3
Robinson's sea bream	*Gymnocranius grandoculis*	44.3	40.7	38.6	44.3	3
Spotcheek emperor	*Lethrinus rubrioperculatus*	48.4	47.1	44.7	48.4	3
Collar sea bream	*Gymnocranius audleyi*	46.2	45.0	38.5	46.2	3
Longnose emperor	*Lethrinus olivaceus*	45.5	45.9	41.0	45.9	3
Humphead Maori wrasse	*Cheilinus undulatus*	47.4	45.5	42.7	47.4	3
Queensland groper	*Epinephelus lanceolatus*	39.5	36.9	35.6	39.5	3
Barramundi cod	*Cromileptes altivelis*	38.7	37.6	35.6	38.7	3
Potato rock cod	*Epinephelus tukula*	38.7	34.9	32.9	38.7	3

Appendix D—*Residual Risk Analysis* justifications.

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
Target & Byproduct Greasy rockcod (*E. tauvina*) Blacktip rockcod (*E. fasciatus*) Crimson snapper (*L. erythropterus*)	*Age at maturity (Productivity)*	3	2	Based on the PSA methodology, unknown *productivity* or *susceptibility* attributes are automatically assigned a precautionary high-risk score (3). Information gaps in the life histories of the greasy rockcod, blacktip rockcod and crimson snapper meant that all three were assigned a high-risk rating for the *age at maturity* attribute. In the RRA, proxy species from within the same genus were used to assign more accurate *productivity* scores. As part of this process, consideration was given to scores assigned to the *age at maturity* attribute for other *Epinephelus* and *Lutjanus* species. In the PSA, all of these species were assigned risk scores of low (1) or medium (2) for this attribute. Given the precautionary nature of the assessment, greasy rockcod, blacktip rockcod and crimson snapper were assigned the higher of the two scores (medium risk, 2). As *age at maturity* for these species is unlikely to exceed the criteria for a high-risk rating (>15 years of age), these changes are not expected to lead to a false-negative result. ***Key changes to the PSA scores*** Default high-risk scores assigned to the *age at maturity* attribute were reduced to match other species within the *Epinephelus* and *Lutjanus* genera. These changes were done in accordance with *Guideline 1: Risk rating due to missing, incorrect or out of date information* and *Guideline 2: Additional scientific assessment & consultation.*
Target & Byproduct Ruby snapper (*E. carbunculus*)	*Age at maturity (Productivity)*	3	1	Information gaps in the life history of ruby snapper resulted in the species receiving a precautionary high-risk rating (3) for the *age at maturity* attribute. In the RRA, proxy species from within the same genus were used to assign more accurate *productivity* scores for ruby snapper. The *age at maturity* attribute for other *Etelis* spp. was assessed as low (1) with species reaching sexual maturity at around 4.5 years of age (*e.g.* flame snapper, *Etelis coruscans*). Based on the available information, it is unlikely that the *age at*

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
				maturity for ruby snapper would differ markedly from what is known about other species in the genus. ***Key changes to the PSA scores*** Default high-risk scores assigned to the *age at maturity* attribute were reduced to match other species within the *Etelis* genus. These changes were done in accordance with *Guideline 1: Risk rating due to missing, incorrect or out of date information* and *Guideline 2: Additional scientific assessment & consultation.*
Target & Byproduct *Highfin grouper (E. maculatus)*	*Size at maturity (Productivity)*	3	2	Information gaps in the life history of the highfin grouper resulted in the species receiving a precautionary high-risk rating (3) for the *size at maturity* attribute. In the RRA, proxy species from within the same genus were used to assign more accurate *productivity* scores. Scores assigned to the *size at maturity* attribute for other assessed *Epinephelus* species ranged from low (1) to medium (2). Given the precautionary nature of the assessment, highfin grouper was assigned the higher of the two scores (medium, 2). Based on the available information, this species will not exceed the criteria for a medium-risk rating (40–200cm). ***Key changes to the PSA scores*** Default high-risk scores assigned to the *size at maturity* attribute were reduced to match other species within the *Epinephelus* genus. These changes were done in accordance with *Guideline 1: Risk rating due to missing, incorrect or out of date information* and *Guideline 2: Additional scientific assessment & consultation.*

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
Target & Byproduct Longnose emperor (*L. olivaceus*)	*Age at maturity (Productivity)*	3	1	Information gaps in the life history of longnose emperor resulted in the species receiving a precautionary high-risk rating (3) for both *age at maturity* and *size at maturity*. In the RRA, proxy species from within the same genus were used to assign more accurate *productivity* scores. The *age at maturity* and *size at maturity* attributes for other assessed *Lethrinus* species was scored low (1). Based on the available information, it is unlikely that the longnose emperor would reach sexual maturity at an age or size remarkably different other species within the same genus. ***Key changes to the PSA scores*** Default high-risk scores assigned to the *age at maturity* and *size at maturity* attribute were reduced to match other species within the *Lethrinus* genus. These changes were done in accordance with *Guideline 1: Risk rating due to missing, incorrect or out of date information* and *Guideline 2: Additional scientific assessment & consultation.*
	Size at maturity (Productivity)	3	1	
Target & Byproduct Birdwire rockcod (*E. merra*) Maori rockcod (*E. undulatostriatus*) Purple rockcod (*E. cyanopodus*)	*Maximum age (Productivity)*	3	3	Information gaps in the life histories of the birdwire, Maori and purple rockcod resulted in all three species receiving precautionary PSA scores for the *maximum age* attribute. In a number of other species, the RRA used poxy values from the same genus to assign more accurate *productivity* scores. However, scores assigned to the *maximum age* attribute for other *Epinephelus* spp. varied from low (1) to high (3). Given the precautionary nature of the assessment, all three rockcods retained their high-risk score as there was not sufficient evidence to justify lowering the score. Cods and groupers are a taxon that have more conservative life history traits compared to other teleosts, including greater longevity (Sumpton & Ryan, 2004). Of the assessed cods and groupers, *maximum age* varies from the blue spotted rockcod (*Cephalopholis cyanostigma)* reaching 46 years of age to the greasy rockcod (*Epinephelus tauvina*) at a much shorter 10.7 years (Choat, 2018; Hamsa & Kasim, 1992).

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
				While the maximum age for birdwire, Maori and purple rockcod remain unknown, it is possible that these three rockcod species have lifespans that exceed the intermediate risk criteria for maximum age (>25 years). ***Key changes to the PSA scores*** No changes were made to scores assigned as part of the RRA. These considerations though were highlighted as part of the RRA as it is an avenue where the risk profile of all three species can be improved and refined.
Target & Byproduct Maori rockcod (*E. undulatostriatus*) Purple rockcod (*E. cyanopodus*)	*Age at maturity (Productivity)*	3	2	Information gaps in the life histories of Maori and purple rockcod have meant that both the *age at maturity* and *size at maturity* attributes for this species was scored high (3) in the preliminary assessment. In the RRA, proxy species from within the same genus were used to assign more accurate *productivity* scores. In the PSA, *age at maturity* and *size at maturity* scores for *Epinephelus* spp. ranged from low (1) to medium (2). Given the precautionary nature of the assessment, both species were assigned the higher of the two scores (2). It is unlikely that Maori and purple rockcod would reach sexual maturity at an age or size remarkably different other species within the same genus. ***Key changes to the PSA scores*** Default high-risk scores assigned to the *age at maturity* and *size at maturity* attribute were reduced to match other species within the *Epinephelus* genus. These changes were done in accordance with *Guideline 1: Risk rating due to missing, incorrect or out of date information* and *Guideline 2: Additional scientific assessment & consultation.*
	Size at maturity (Productivity)	3	2	

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
Target & Byproduct Purple tuskfish (*C. cephalotes*)	*Age at maturity (Productivity)*	3	1	Information gaps in the life history of purple tuskfish resulted in a number of the *productivity* attributes being assigned precautionary high-risk ratings (3) as part of the PSA including *age at maturity, maximum age*, and *size at maturity*. In the RRA, proxy species from within the same genus were used to assign more accurate *productivity* scores. In the PSA, *Choerodon* species were assigned low (1) risk ratings for the *age at maturity* and *size at maturity* attributes. Scores assigned to the *maximum age* were marginally higher at 2 or medium risk. Based on the life history traits of the other tuskfish, the purple tuskfish was assigned the same scores as a part of the RRA. ***Key changes to the PSA scores*** Default high-risk scores assigned to the *age at maturity, maximum age* and *size at maturity* attributes were reduced to match other species within the *Choerodon* genus. These changes were done in accordance with *Guideline 1: Risk rating due to missing, incorrect or out of date information* and *Guideline 2: Additional scientific assessment & consultation.*
	Maximum age (Productivity)	3	2	
	Size at maturity (Productivity)	3	1	
Target & Byproduct Sharptooth snapper (*P. typus*)	*Size at maturity (Productivity)*	3	2	Information gaps in the life history of sharptooth snapper resulted in the species receiving a precautionary high (3) risk rating for the *size at maturity* attribute. In the RRA, proxy species from within the same genus were used to assign more accurate *productivity* scores. The *size at maturity* attribute for the other species within the *Pristipomoides* genus were assigned risk scores of low (1) or medium (2) for this attribute. Given the precautionary nature of the assessment, the sharptooth snapper was assigned the higher of the two scores (medium risk, 2). It is unlikely that sharptooth snapper would reach sexual maturity at a size remarkably different other species within the same genus. ***Key changes to the PSA scores***

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
				Default high-risk scores assigned to the *size at maturity* attribute for were reduced to match other species within the *Pristipomoides* genus. These changes were done in accordance with *Guideline 1: Risk rating due to missing, incorrect or out of date information* and *Guideline 2: Additional scientific assessment & consultation.*
Target & Byproduct Moses perch (*L. russellii*)	*Size at maturity (Productivity)*	3	2	Information gaps in the life history of Moses perch resulted in the species being assigned a precautionary high (3) score for the *size at maturity* attribute as part of the PSA. In the RRA, proxy species within the same genus were used to assign more accurate *productivity* scores. Scores assigned to the *size at maturity* attribute for other *Lutjanus* species ranged from low (1) to medium (2). Given the precautionary nature of the assessment, Moses perch was assigned the higher of the two scores (2). Based on the available information, it is unlikely that *size at maturity* differs markedly from other species in the same genus. ***Key changes to the PSA scores*** Default high-risk scores assigned to the *size at maturity* attribute were reduced to match other species within the *Lutjanus* genus. These changes were done in accordance with *Guideline 1: Risk rating due to missing, incorrect or out of date information* and *Guideline 2: Additional scientific assessment & consultation.*
Target & Byproduct Robinson's sea bream (*G. grandoculis*)	*Age at maturity (Productivity)*	3	3	Information gaps in the life history of the two sea bream species resulted in them receiving a precautionary high (3) risk rating for the *age at maturity* and *size at maturity* attributes as part of the PSA. In a number of other species, the RRA used poxy values from the same genus to assign more accurate *productivity* scores. However, all of the *Gymnocranius* spp. assessed had

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
Collar sea bream (*G. audleyi*)	*Size at maturity (Productivity)*	3	3	missing information for both the *age at maturity* and *size at maturity* attributes. While other species were also considered, the genus as a whole contains relatively few species (*n* = 6; *Fishes of Australia*), and life-histories of these are also poorly understood. This meant that no proxy values were available and preliminary scores were retained for the Robinson's sea bream and the collar sea bream. ***Key changes to the PSA scores*** No changes were made to scores assigned as part of the RRA. These considerations though were highlighted as part of the RRA as it is an avenue where the risk profile of both species can be improved and refined.
Target & Byproduct Robinson's sea bream (*G. grandoculis*)	*Maximum age (Productivity)*	3	2	Information gaps in the life history of Robinson's sea bream resulted in the species being assigned a precautionary high (3) score for the *maximum age* attribute as part of the PSA. In the RRA, proxy species within the same genus were used to assign more accurate *productivity* scores. The *maximum age* attribute for the other assessed *Gymnocranius* species was scored medium (2) and it is unlikely that the biology of the Robinson's sea bream would differ markedly from this assessment. ***Key changes to the PSA scores*** Default high-risk scores assigned to the *maximum age* attribute were reduced to match other species within the *Gymnocranius* genus. These changes were done in accordance with *Guideline 1: Risk rating due to missing, incorrect or out of date information* and *Guideline 2: Additional scientific assessment & consultation.*

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
Target & Byproduct Red emperor (*L. sebae*)	*Recreational desirability / other fisheries (Susceptibility)*	1	2	Red emperor was scored low (1) for the *recreational desirability / other fisheries* attribute in the preliminary assessment as the retention rate for this species was estimated at 23% (high confidence) (Webley *et al.*, 2015). While noting this assessment, red emperor is likely to be at more elevated risk from non-commercial fishing activities. While recreational retention rates for this species were below 33% (PSA criteria), red emperor's 2018 SAFS assessment estimated recreational catch of this species on the Queensland east coast to be around 83t (Newman *et al.*, 2018a). Further, charter data for the 2016–2018 calendar years reveal that 12–21t of red emperor are harvested per year by this sector (Department of Agriculture and Fisheries, 2020b). Due to these reasons and uncertainty surrounding total catch numbers (*e.g.* retained plus discards), the RRA concluded that red emperor should be assigned a more precautionary score for this attribute. ***Key changes to the PSA scores*** The low (1) risk score assigned to the *recreational desirability / other fisheries* attribute as part of the PSA was increased to medium (2). The decision to increase the score assigned to this attribute was precautionary and done in accordance with *Guideline 1: Risk rating due to missing, incorrect or out of date information* and *Guideline 2: Additional scientific assessment & consultation.* It is recognised that decision to increase this score is precautionary and it may lead to a risk overestimate. This decision though is consistent with the precautionary nature of the Level 2 assessment.
Target & Byproduct Goldband snapper (*P. multidens*)	*Recreational desirability / other fisheries (Susceptibility)*	3	1	Of the attributes assessed, *recreational desirability / other fisheries* attribute was the most affected by data deficiencies. A high number of the RLF species had a) no information of recreational retention rates or b) were included in broader groupings with low species

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
Maori rockcod (*E. undulatostriatus*) Rosy snapper (*P. filamentosus*) Sharptooth snapper (*P. typus*) Ruby snapper (*E. carbunculus*) Maori snapper (*L. rivulatus*) Flame snapper (*E. coruscans*) Green jobfish (*A. virescens*) Painted sweetlip (*D. pictum*) Robinson's sea bream (*G. grandoculis*) Spotcheek emperor (*L. olivaceus*) Collar sea bream (*G. audleyi*)				resolution *e.g. Jobfish unspecified* (Webley *et al.*, 2015). In these instances, species were assigned a precautionary high (3) risk score for this attribute. Further examination of recreational surveys and charter fishery data indicated that the listed species were less likely to be targeted in the charter and recreational fisheries and would, therefore, attract lower cumulative fishing pressures. The adjusted scores were based on a combination of the following factors: • The recreational survey data indicates that the species or species complex are caught and retained in fewer numbers; • Charter data for the most recent three calendar years (2016–18) indicated that the species or species complex are retained in lesser amounts. ***Key changes to the PSA scores*** Default high-risk scores assigned to the *recreational desirability / other fisheries* attribute for these cods, emperors and tropical snappers were reduced to low (1). These changes were done in accordance with *Guideline 2: Additional scientific assessment & consultation* and are unlikely to contribute to a false-negative approach.

Species	Attribute	PSA Score	RRA Score	Justifications and Considerations
Longnose emperor (*L. olivaceus*)				
Target & Byproduct Hussar (*L. adetii*) Brownstripe snapper (*L. vitta*) Venus tuskfish (*C. venustus*) Purple tuskfish (*C. cephalotes*) Blue tuskfish (*C. cyanodus*) Blackspot tuskfish (*C. schoenleinii*)	*Recreational desirability / other fisheries (Susceptibility)*	2	1	The listed species were scored intermediate (2) for the *recreational desirability / other fisheries* attribute in the preliminary assessment as retention rates for these species or species complexes fell within the 33–66% bounds (Webley *et al.*, 2015). Further examination of recreational surveys and charter fishery data indicated that the preliminary scores overestimated the cumulative risks for these species. The adjusted scores were based on a combination of the following factors: • The most recent recreational survey data indicates that the species or species complex are caught and harvested in fewer numbers; • Charter data for the most recent three calendar years (2016–18) indicated that the species or species complex are retained in lesser amounts. ***Key changes to the PSA scores*** Intermediate (2) risk scores assigned to the *Recreational desirability / other fisheries* attribute for these tuskfish and tropical snappers were reduced to low (1). These changes were done in accordance with *Guideline 2: Additional scientific assessment & consultation.*

Appendix E—*Likelihood & Consequence Analysis*.

1. Overview & Background

The *Productivity & Susceptibility Analysis* (PSA) includes a number of elements to minimise the risk of a false-negative result *i.e.* high-risk species being incorrectly assigned a lower risk rating. However, the PSA tends to be more conservative and research has shown that it has a higher potential to produce false positives. That is, low-risk species being assigned a higher risk score due to the conservative nature of the method, data deficiencies *etc*. (Hobday *et al.*, 2011; Hobday *et al.*, 2007; Zhou *et al.*, 2016). In the Level 2 Ecological Risk Assessment (ERA), false positives are addressed through the *Residual Risk Analysis* (RRA) and the assignment of *precautionary* risk ratings.

To inform the assignment of *precautionary* risk ratings, each species was subjected to a *Likelihood & Consequence Analysis* (LCA). The LCA, in essence, provides a closer examination of the magnitude of the potential consequence and the probability (*i.e.* likelihood) that those consequences will occur given the current management controls (Fletcher, 2014; Fletcher *et al.*, 2002; Fletcher *et al.*, 2005). A flexible assessment method, the LCA can be used as a screening tool or to undertake more detailed risk assessments (Fletcher, 2014).

In the Level 2 ERA, a simplified version of the LCA was used to provide the risk profiles with further context and evaluate the applicability of the assessment to the current fishing environment. More specifically, the LCA was used to assist in the allocation of *precautionary* risk ratings which are assigned to species with more conservative risk profiles. The benefit of completing a fully qualitative assessment following a more data-intensive semi-quantitative assessment is the reduction of noise in the form of false positives. This was considered to be of particular importance when identifying priority risks for this fishery.

As the LCA is qualitative and lacks the detail of the PSA, the outputs should not be viewed as an alternate or competing risk assessment. To avoid confusion, the results of the PSA/RRA will take precedence over the LCA. The LCA was only used to evaluate the potential of the risk coming to fruition over the short to medium term.

2. Methods

The LCA was constructed using a simplified version of the *National ESD Reporting Framework for Australian Fisheries* (Fletcher, 2014; Fletcher *et al.*, 2002; Fletcher *et al.*, 2005) and focused specifically on the *Risk Analysis* component. It is recognised that the *National ESD Reporting Framework* incorporates additional steps including ones that establish the context of the assessment and identifies key risks. As these steps were fulfilled with the completion of a *Scoping Study* (Department of Agriculture and Fisheries, 2019a) and whole-of-fishery (Level 1) assessment (Jacobsen *et al.*, 2019d), they were not replicated for the Level 2 ERA. For a more comprehensive overview of the *National ESD Reporting Framework for Australian Fisheries* consult Fletcher *et al.* (2002) and Fletcher (2014).

Risk Analysis considers a) the potential consequences of an issue, activity or event (Table E1) and b) the likelihood of a particularly adverse consequence occurring due to these activities or events (Table E2). Central to this is the establishment of a Likelihood *x* Consequence matrix that estimates the risk based on scores assigned to each component (Table E3).

***Table E1**. Criteria used to assign indicative scores of the likelihood that fishing activities in the Reef Line Fishery (RLF) will result in or make a significant contribution to a Severe or Major consequence.*

Level	Score	Definition
Likely	5	Expected to occur under the current fishing environment / management regime.
Occasional	4	Will probably occur or has a higher potential to occur under the current fishing environment / management regime.
Possible	3	Evidence to suggest it may occur under the current fishing environment / management regime.
Rare	2	May occur in exceptional circumstances.
Remote	1	Has never occurred but is not impossible.

***Table E2**. Criteria used to assign scores to the Consequence component of the analysis.*

Level	Score	Definition
Negligible	0	Almost zero harvest / mortalities with impact unlikely to be detectable at the scale of the stock or regional population.
Minor	1	Assessed as low risk through the PSA and/or fishing activities will have minimal impact on regional stocks or populations.
Moderate	2	Assessed as a medium risk through the PSA / harvest levels or mortalities at, near or approaching maximum yields (or equivalent).
Severe	3	Species assessed as high risk through the PSA / harvest or mortalities at levels that are impacting stocks and/or has high vulnerability and low resilience to harvest.
Major	4	Species assessed as high risk through the PSA / harvest levels or mortalities has the potential to cause serious impacts with a long recovery period required to return the stock or population to an acceptable level.

***Table E3**. Likelihood & Consequence Analysis risk matrix used to assign indicative risk ratings to each species: blue = negligible risk, green = low risk, orange = medium risk and red = high risk.*

		Consequence				
Likelihood		**Negligible**	**Minor**	**Moderate**	**Severe**	**Major**
		0	1	2	3	4
Remote	1	0	1	2	3	4
Rare	2	0	2	4	6	8
Possible	3	0	3	6	9	12
Occasional	4	0	4	8	12	16
Likely	5	0	5	10	15	20

For the consequence analysis (Table E2), criteria used to assign scores (0–4) were based on the outputs of the semi-quantitative assessment (*e.g.* PSA/RRA results outlined in section 4, Table 7). In the likelihood assessment (Table E1), scores reflect the likelihood of the fishery causing or making a significant contribution to the occurrence of the most hazardous consequence (Fletcher *et al.* 2002). Once scores are assigned to each aspect of the LCA, they are used to calculate an overall risk value (*Risk = Likelihood x Consequence*) for each species (Table E3).

As the Level 2 ERA uses the LCA as a supplementary assessment, risk scores and ratings were not linked to any operational objective; as per the *National ESD Reporting Framework* (Fletcher, 2014; Fletcher et al., 2005). Instead, these issues are addressed directly as part of the Level 2 ERA through fisheries-specific recommendations. Criteria used to assign scores for likelihood and consequence are outlined in Table E1 and E2 respectively. The Likelihood *x* Consequence matrix used to assign risk ratings is provided as Table E3.

3. Results

The LCA for RLF target & byproduct species and protected teleosts produced risk ratings from low to moderate. Saddletail snapper (*Lutjanus malabaricus*), goldband snapper (*Pristipomoides multidens*), red emperor (*L. sebae*) and crimson snapper (*L. erythropterus*) received the highest risk ratings. All remaining target & byproduct species and the four protected teleost species were assigned low-risk ratings (Table E4).

***Table E4**. Results of the Likelihood & Consequence Analysis for species assessed as part of the RLF Level 2 ERA.*

Species name	Common name	Likelihood	Consequence	Matrix score	Risk category
Target & Byproduct					
Lutjanus malabaricus	Saddletail snapper	2	3	6	Moderate
Pristipomoides multidens	Goldband snapper	2	3	6	Moderate
Lethrinus nebulosus	Spangled emperor	2	2	4	Low
Lutjanus sebae	Red emperor	2	3	6	Moderate
Lutjanus carponotatus	Stripey snapper	2	2	4	Low
Epinephelus tauvina	Greasy rockcod	1	2	2	Low
Hyporthodus ergastularius	Banded rockcod	1	3	3	Low
Epinephelus areolatus	Yellow spotted rockcod	1	2	2	Low
Epinephelus maculatus	Highfin grouper	1	2	2	Low
Epinephelus merra	Birdwire rockcod	1	3	3	Low

Species name	Common name	Likelihood	Consequence	Matrix score	Risk category
Epinephelus ongus	Specklefin grouper	1	2	2	Low
Epinephelus undulatostriatus	Maori rockcod	1	3	3	Low
Cephalopholis cyanostigma	Blue spotted rockcod	1	3	3	Low
Epinephelus cyanopodus	Purple rockcod	1	3	3	Low
Lutjanus adetii	Hussar	2	2	4	Low
Lutjanus vitta	Brownstripe snapper	2	2	4	Low
Lutjanus erythropterus	Crimson snapper	2	3	6	Moderate
Pristipomoides filamentosus	Rosy snapper	1	3	3	Low
Choerodon venustus	Venus tuskfish	1	2	2	Low
Choerodon cephalotes	Purple tuskfish	1	2	2	Low
Choerodon cyanodus	Blue tuskfish	1	2	2	Low
Choerodon schoenleinii	Blackspot tuskfish	1	2	2	Low
Pristipomoides typus	Sharptooth snapper	1	2	2	Low
Etelis carbunculus	Ruby snapper	1	2	2	Low
Lutjanus rivulatus	Maori snapper	1	2	2	Low
Etelis coruscans	Flame snapper	1	3	3	Low
Aprion virescens	Green jobfish	1	3	3	Low
Lutjanus russellii	Moses perch	1	2	2	Low
Epinephelus fasciatus	Blacktip rockcod	1	2	2	Low
Epinephelus quoyanus	Longfin rockcod	1	2	2	Low
Diagramma pictum	Painted sweetlip	1	2	2	Low
Gymnocranius grandoculis	Robinson's sea bream	1	3	3	Low
Lethrinus rubrioperculatus	Spotcheek emperor	1	2	2	Low

Species name	Common name	Likelihood	Consequence	Matrix score	Risk category
Gymnocranius audleyi	Collar sea bream	1	3	3	Low
Lethrinus olivaceus	Longnose emperor	1	2	2	Low
Protected teleosts					
Cheilinus undulatus	Humphead Maori wrasse	1	3	3	Low
Epinephelus lanceolatus	Queensland groper	1	3	3	Low
Cromileptes altivelis	Barramundi cod	1	2	2	Low
Epinephelus tukula	Potato rock cod	1	3	3	Low

4. Considerations

Outputs of the LCA were lower than the PSA for all species assessed. Even so, the LCA maintains the support of higher risk ratings assigned to at least four species: saddletail snapper, goldband snapper, red emperor and crimson snapper. These species are influenced by cumulative fishing pressures and there is a great deal of uncertainty surrounding their stock status. In the context of the broader Level 2 ERA, these results provide further weight to the notion that the outputs of the PSA (refer Table 5 & 7) are more representative of a real or actual risk *verse* the potential risk.

The remaining target & byproduct species (n = 31) were assigned low-risk scores in the LCA, indicating that the likelihood of the risk coming to fruition over the short to medium term is lower than what was presented by the PSA (refer to Table 7). The LCA results support the assignment of *precautionary* risk ratings for the majority of target & byproduct species given their lower potential to be at risk from fishing pressures in the RLF (Table 7).

Spangled emperor, stripey snapper, hussar and brownstripe snapper were the only species to register a low-risk rating that were not assigned precautionary risk rating (Table 7). Scores for these four species were marginally higher (4 *verse* 2 or 3; Table E4) and they are more susceptible to cumulative fishing pressures. In these four instances, the decision was made to retain the original risk score (*i.e.* the assessments were not viewed as *precautionary*). This decision aligns with the broader objectives of the Level 2 ERA where uncertainty surrounding harvest levels supports the adoption of more conservative assessments.

As with target & byproduct species, the LCA for protected teleosts produced risk ratings that were lower than the PSA. In the PSA, the final risk ratings for protected teleosts were heavily influenced by information gaps surrounding the extent of the fishery's interaction with these species. The decision to score the sub-group with *precautionary* risk ratings in the PSA was therefore supported by the results of the LCA.

Appendix F—Summary of management arrangements for reef line species.

All OS category species fall under a 956t TACC limit (as of 1 September 2019; *Fisheries Quota Declaration 2019*), and there are two closures per year aligned with spawning events in October and November for the whole Reef Line Fishery (Department of Agriculture and Fisheries, 2019b). This list is not exhaustive and further information on the restrictions applied to each species and across the *Reef Line Fishery* is available through the Department of Agriculture and Fisheries website (https://www.daf.qld.gov.au/) and within the fisheries legislation (https://www.daf.qld.gov.au/business-priorities/fisheries/sustainable/legislation).

Common Name	Species Name	Size Limit	Rec. Possession Limit
Red emperor	*Lutjanus sebae*	55cm (min)	Limit of 5, with a combined limit of 20 for all Coral Reef Fin Fish
Saddletail snapper	*Lutjanus malabaricus*	40cm (min)	Combined limit of 9 for all crimson and saddletail snapper, with a combined limit of 20 for all Coral Reef Fin Fish
Goldband snapper	*Pristipomoides multidens*	38cm (min)	Limit of 5, with a combined limit of 20 for all Coral Reef Fin Fish
Crimson snapper	*Lutjanus erythropterus*	40cm (min)	Combined limit of 9 for all crimson and saddletail snapper, with a combined limit of 20 for all Coral Reef Fin Fish
Spangled emperor	*Lethrinus nebulosus*	45cm (min)	Limit of 5, with a combined limit of 20 for all Coral Reef Fin Fish
Stripey snapper	*Lutjanus carponotatus*	25cm (min)	Limit of 5, with a combined limit of 20 for all Coral Reef Fin Fish
Brownstripe snapper	*Lutjanus vitta*	25cm (min)	Limit of 5, with a combined limit of 20 for all Coral Reef Fin Fish
Hussar	*Lutjanus adetii*	25cm (min)	Limit of 10, with a combined limit of 20 for all Coral Reef Fin Fish
Banded rockcod	*Hyporthodus ergastularius*	38cm (min)	Limit of 5, with a combined limit of 20 for all Coral Reef Fin Fish
Purple rockcod	*Epinephelus cyanopodus*	38cm (min)	Limit of 5, with a combined limit of 20 for all Coral Reef Fin Fish
Robinson's sea bream	*Gymnocranius grandoculis*	25cm (min)	Limit of 5, with a combined limit of 20 for all Coral Reef Fin Fish
Collar sea bream	*Gymnocranius audleyi*	25cm (min)	Limit of 5, with a combined limit of 20 for all Coral Reef Fin Fish

Common Name	Species Name	Size Limit	Rec. Possession Limit
Maori rockcod	*Epinephelus undulatostriatus*	45cm (min)	Limit of 5, with a combined limit of 20 for all Coral Reef Fin Fish
Birdwire rockcod	*Epinephelus merra*	38cm (min)	Limit of 5, with a combined limit of 20 for all Coral Reef Fin Fish
Blue spotted rockcod	*Cephalopholis cyanostigma*	38cm (min)	Limit of 5, with a combined limit of 20 for all Coral Reef Fin Fish
Rosy snapper	*Pristipomoides filamentosus*	38cm (min)	Combined limit of 8 for all rosy and lavender snapper, with a combined limit of 20 for all Coral Reef Fin Fish
Flame snapper	*Etelis coruscans*	38cm (min)	Limit of 5, with a combined limit of 20 for all Coral Reef Fin Fish
Green jobfish	*Aprion virescens*	38cm (min)	Limit of 5, with a combined limit of 20 for all Coral Reef Fin Fish
Greasy rockcod	*Epinephelus tauvina*	38cm (min); 100cm (max)	Limit of 5, with a combined limit of 20 for all Coral Reef Fin Fish
Highfin grouper	*Epinephelus maculatus*	38cm (min)	Limit of 5, with a combined limit of 20 for all Coral Reef Fin Fish
Specklefin grouper	*Epinephelus ongus*	38cm (min)	Limit of 5, with a combined limit of 20 for all Coral Reef Fin Fish
Blackspot tuskfish	*Choerodon schoenleinii*	30cm (min)	Combined limit of 6 for all tuskfish Combined limit of 20 for all Coral Reef Fin Fish
Maori snapper	*Lutjanus rivulatus*	25cm (min)	Limit of 5, with a combined limit of 20 for all Coral Reef Fin Fish
Moses perch	*Lutjanus russellii*	25cm (min)	Limit of 5, with a combined limit of 20 for all Coral Reef Fin Fish
Blacktip rockcod	*Epinephelus fasciatus*	38cm (min)	Limit of 5, with a combined limit of 20 for all Coral Reef Fin Fish
Longnose emperor	*Lethrinus olivaceus*	38cm (min)	Limit of 5, with a combined limit of 20 for all Coral Reef Fin Fish
Yellow spotted rockcod	*Epinephelus areolatus*	38cm (min)	Limit of 5, with a combined limit of 20 for all Coral Reef Fin Fish
Venus tuskfish	*Choerodon venustus*	30cm (min)	Combined limit of 6 for all tuskfish Combined limit of 20 for all Coral Reef Fin Fish

Common Name	Species Name	Size Limit	Rec. Possession Limit
Purple tuskfish	*Choerodon cephalotes*	30cm (min)	Combined limit of 6 for all tuskfish Combined limit of 20 for all Coral Reef Fin Fish
Blue tuskfish	*Choerodon cyanodus*	30cm (min)	Combined limit of 6 for all tuskfish Combined limit of 20 for all Coral Reef Fin Fish
Sharptooth snapper	*Pristipomoides typus*	38cm (min)	Limit of 5, with a combined limit of 20 for all Coral Reef Fin Fish
Longfin rockcod	*Epinephelus quoyanus*	38cm (min)	Limit of 5, with a combined limit of 20 for all Coral Reef Fin Fish
Spotcheek emperor	*Lethrinus rubrioperculatus*	25cm (min)	Limit of 5, with a combined limit of 20 for all Coral Reef Fin Fish
Painted sweetlip	*Diagramma pictum*	25cm (min)	Limit of 5, with a combined limit of 20 for all Coral Reef Fin Fish
Ruby snapper	*Etelis carbunculus*	38cm (min)	Limit of 5, with a combined limit of 20 for all Coral Reef Fin Fish