Sustainable Fisheries Strategy

2017–2027

Marine Aquarium Fish Fishery

Level 1 ERA – Whole-of-Fishery Assessment

Level 1 Ecological Risk Assessment
Marine Aquarium Fish Fishery

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Executive Summary

The Queensland *Ecological Risk Assessment Guidelines* (the Guideline) was released in March 2018 as part of the *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017a; 2018). This Guideline provides an overview of the strategy being employed to develop Ecological Risk Assessments (ERAs) for Queensland's fisheries. The Guideline describes a four-stage framework consisting of a Scoping Study; a Level 1, whole-of-fishery qualitative assessment; a Level 2, species-specific semi-quantitative or low-data quantitative assessment and; a Level 3 quantitative assessment (if applicable).

The aim of the Level 1 ERA is to produce a broad risk profile for each fishery based on the qualitative ERA method described by Astles *et al.* (2006). The method considers a range of factors including the current fishing environment (*e.g.* current catch, effort and licensing trends), limitations of the current management arrangements (*e.g.* the potential for harvest to be transferred onto alternate species or, changing target species) and life-history constraints of the species complexes being assessed. In the *Marine Aquarium Fish Fishery* (MAFF), the Level 1 ERA examined fishing related risks in 15 broader ecological components including *target species*, *bycatch*, *marine turtles*, *sea snakes*, *crocodiles*, *dugongs*, *cetaceans*, *protected teleosts*, *batoids, sharks, syngnathids, seabirds, terrestrial mammals, marine habitats* and *ecosystem processes.*

To construct the risk profiles, seven fishing activities (*harvesting*, *discarding*, *contact without capture*, *loss of fishing gear*, *travel to/from fishing grounds, disturbance due to presence in the area, boat maintenance and emissions*) were assigned an indicative score (low, intermediate, high) representing the risk posed to each ecological component. Each ecological component was then assigned a preliminary risk rating based on the highest risk score within their profile. The preliminary risk ratings are precautionary and provided an initial evaluation of the low-risk elements within each fishery. Preliminary risk ratings were then subject to a secondary assessment examining the likelihood to the risk coming to fruition in the MAFF over the short to medium term.

In the MAFF, the whole-of-fishery assessment indicated that 11 of the ecological components were at negligible to low risk of experiencing an undesirable event. Target species (intermediate), sharks (low/intermediate), batoids (low/intermediate), and ecosystem processes (low/intermediate) were the only subgroups to be assigned risk ratings higher than low. Limited information on catch compositions and harvest rates were the key contributors of risk for target species, sharks and batoids. The low/intermediate risk rating for ecosystem processes is precautionary and considers the potential for regional communities to be impacted by cumulative fishing pressures. Similarly, the risk rating for marine habitats (low) accounts for direct habitat disturbance due to MAFF fishing activities and ancillary boating activities *e.g.* anchoring.

Data deficiencies identified in the Level 1 ERA are now being actively addressed through the *Marine Aquarium Fish Fishery Data Improvement Plan* (Department of Agriculture and Fisheries, 2022a). This plan includes a review of the current MAFF logbook and prioritises species-specific catch reporting. It will however take time to develop and implement initiatives instigated under this plan and the broader *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017a). In the interim, it is recommended that the target species ecological component be progressed to a Level 2, species-specific ERA. While sharks, rays and syngnathids are also retained in this

fishery, more expansive risk assessments involving these subgroups will require additional information on catch compositions, market demands and catch locations.

On 23 April 2021 the MAFF was accredited as a Wildlife Trade Operation (WTO) under Part 13A of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act; Department of Agriculture Water and the Environment, 2022). The completion and publication of this report contributes to the fulfillment of Condition 5 this WTO approval (Department of Agriculture Water and the Environment, 2022).

Summary of the outputs from the Level 1 (whole of fishery) Ecological Risk Assessment for the Marine Aquarium Fish Fishery (MAFF)

Ecological Component	Level 1 Risk Rating	Progression
Target	Intermediate	Level 2 ERA.
Bycatch (non-SOCC)	Negligible	Not progressed further.
Species of Conservation Concern (SOCC)		
Batoids	Low/Intermediate	Data Collection Plan
Cetaceans (Whales & Dolphins)	Negligible	Not progressed further.
Crocodiles	Negligible	Not progressed further.
Dugongs	Low	Not progressed further.
Marine turtles	Low	Not progressed further.
Protected teleosts	Negligible	Not progressed further.
Sea snakes	Negligible	Not progressed further.
Seabirds	Negligible	Not progressed further.
Sharks	Low/Intermediate	Data Collection Plan
Syngnathids	Low	Data Collection Plan
Terrestrial mammals	Negligible	Not progressed further.
Marine habitats	Low	Not progressed further.
Ecosystem processes	Low/Intermediate	Not progressed further.

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Definitions & Abbreviations

Active Licence	–	The definition of an active licence is the same as that used by DAF's data reporting system. An active licence is a licence that has reported catch and effort in the Marine Aquarium Fish Fishery through the logbook reporting system under the A1 or A2 fishery symbol irrespective of the amount of catch and effort.
CITES	–	*Convention on International Trade in Endangered Species of Wild Fauna and Flora.*
CMS	–	*Convention on the Conservation of Migratory Species of Wild Animals.*
DAF	–	Queensland Department of Agriculture and Fisheries
Ecological Component	–	Broad assessment categories that include *Target (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
False positive	–	The situation where a species at low risk is incorrectly assigned a higher risk rating due to the method being used, data limitation 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.
Fishery Symbol	–	The endorsement that permits a fisher to access a fishery and, at times, defines the type of gear that can be used *i.e.* A = Aquarium Fish Collection, N = Net, L = line, T = trawl. The number of fishing symbols represents the maximum number of operators that could (theoretically) access the fishery at a single point in time.
Fishing Licence	–	Effectively a fishing platform. A Fishing Licence can have multiple symbols attached *e.g.* an Aquarium collection (A), net (N) and line (L) fishing symbol.
GBR/GBRMP	–	Great Barrier Reef / Great Barrier Reef Marine Park
GBRMPA	–	Great Barrier Reef Marine Park Authority
Species of Conservation Concern (SOCC)	–	Broader risk assessment category used in the Level 1 assessments that incorporates marine turtles, sea snakes,

crocodiles, dugongs, cetaceans, teleosts, batoids, sharks, seabirds, syngnathids and terrestrial mammals. These species may or may not be subject to mandatory reporting requirements.

Species of Conservation Interest (SOCI) logbook	–	The SOCI logbook was the mechanism used by DAF to record interactions with non-target species subject to mandatory reporting requirements. In 2021, the SOCI logbook was replaced/superseded by the *Threatened, Endangered and Protected Animals* (TEPA) logbook.
Target species	–	The primary species or species groups that have been selectively fished for and retained for commercial, recreational and Aboriginal peoples' and Torres Strait Islander peoples' purposes.
TEPA logbook	–	The *Threatened, Endangered and Protected Animals Logbook*. The *TEPA Logbook* is used by operators to complete mandatory reporting requirements for key non-target species. The TEPA logbook replaced the previously used *Species of Conservation Interest* (SOCI) logbook.
TACC	–	Total Allowable Commercial Catch
WTO	–	Wildlife Trade Operation

1   Overview

The *Marine Aquarium Fish Fishery* (MAFF) is a hand-collection fishery that primarily operates within the confines of the Great Barrier Reef Marine Park (GBRMP; Department of Agriculture and Fisheries, 2023). Operators collect a diverse range of marine fish and invertebrates for the live aquarium trade including larger elasmobranchs (sharks and batoids). Most species are collected in coral reef and inter-reef habitats and sold in both international and domestic markets.

On 23 April 2021, the MAFF was accredited as a Wildlife Trade Operation (WTO) under Part 13A of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act; Department of Agriculture Water and the Environment, 2022). Condition 5 of this approval requires an Ecological Risk Assessment (ERA) to be completed for the MAFF and for it to be published by September 2023. This condition requires the assessment to consider risk at both a whole-of-fishery and regional level.

The following provides a whole-of-fishery (Level 1) qualitative assessment of the risks posed by fishing activities in the MAFF and their potential to influence key ecological components. The Level 1 assessment follows-on from the completion of a Scoping Study providing information on the current fishing environment, licencing trends and broader catch and effort analyses (Department of Agriculture and Fisheries, 2023). The outputs of the Level 1 ERA will determine if there is a need to progress the MAFF to a Level 2 ERA and, if applicable, the scope of the assessment.

2   Methods

In March 2018, Queensland released the *Ecological Risk Assessment Guidelines* (the Guidelines) as part of the broader *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017a; 2018). This Guideline provides an overview of the ERA strategy being employed by Queensland and includes a four-stage framework consisting of 1) a Scoping Study; 2) a Level 1, whole-of-fishery qualitative ERA; 3) a Level 2, species-specific semi-quantitative or low-data quantitative ERA; and 4) a Level 3, fully quantitative ERA (if applicable). The primary purpose of the Level 1 ERA is to establish a broader risk profile for each fishery documenting the key drivers of risk within each fishery and the ecological components most likely to be affected.

The MAFF Level 1 ERA examines the risk posed to five main ecological components: *target species*, *bycatch*, *marine habitats*, *ecosystem processes* and the multi-faceted *Species of Conservation Concern* (SOCC). The SOCC ecological component incorporates species classified as *Threatened, Endangered* or *Protected* and a number of other sub-groups with long-term conservation concerns.[1] In the MAFF Level 1 ERA, the SOCC assessment included 11 sub-components: *marine turtles*, *dugongs*, *cetaceans* (whales and dolphins), *sea snakes, crocodiles*, *protected teleosts*, *batoids*, *sharks*, *syngnathids*, *seabirds* and *terrestrial mammals.* When a SOCC subcomponent overlapped with target species (*e.g.* sharks and rays), the risk posed to the complex was assessed within their respective groups.

Of the five ecological components assessed, *ecosystem processes* represent the biggest challenge as they will be influenced by a range of factors outside the control of fisheries management *e.g.* climate

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[1] *Threatened, Endangered and Protected (TEP) refers specifically to species listed under the Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth), the Nature Conservation Act 1992 or Fisheries legislation. The SOCC ecological component is broader and may include (e.g.) species listed under international conventions like CITES or CMS and species not afforded additional legislative protections.*

change, pollution, extractive use of the marine resources, and urban, port and agricultural development. From an ERA perspective, this makes it difficult to quantify the level of impact each fishery has on these processes and by extension the accurate assignment of risk ratings. This problem is compounded by the fact that it is often difficult to identify measurable indicators of marine ecosystem processes (Evans *et al.*, 2016; Pears *et al.*, 2012a). For example, what parameters need to be measured to determine a) if an ecosystem process is in decline, stable or improving and b) how much of this change can be attributed to fishing activities or lack thereof?

In order to refine the Level 1 ERA for *ecosystem processes*, a preliminary assessment was undertaken. The preliminary assessment examined the potential for the fishery to impact 16 categories based on the *Great Barrier Reef Outlook Report* (Great Barrier Reef Marine Park Authority, 2014; 2019) and outlined in Pears *et al.* (2012b). The specific processes examined in response to fisheries related impacts were *sedimentation*, *nutrient cycling / microbial processes*, *particle feeding*, *primary production*, *herbivory*, *predation*, *bioturbation*, *detritivory*, *scavenging*, *symbiosis*, *recruitment*, *reef building*, *competition*, *connectivity*, *outbreaks of disease* and *species introductions*. Not all processes are applicable to this fishery, but all processes were considered before being eliminated. A full definition of each ecosystem process has been provided in Appendix 1.

The MAFF Level 1 ERA provides a more generalised overview of the fishing related risks. This was done using an abbreviated version of the qualitative risk assessment method established by Astles *et al.* (2006). For this fishery, the Level 1 ERA framework incorporates four distinct steps: *Risk Context*, *Risk Identification, Risk Characterisation* and *Likelihood*. A brief overview of each step has been provided below:

1. *Risk Context*—defines the broad parameters of the assessment including the risk that is to be analysed (*i.e.* management objectives trying to be achieved or the nature of the undesirable events), the spatial extent of the analysis, management regimes and assessment timeframes.

2. *Risk Identification*—identifies the aspects of each fishery or the sources of risk with the potential to contribute to the occurrence of an undesirable event. This aspect of the assessment deals explicitly with the sources of risk or potential hazards. Fishing activities / sources of risk considered as part of this section include *harvesting*, *discarding*, *contact without capture*, *loss of fishing gear*, *travel to and from fishing grounds*, *disturbance due to presence in the area* and *boat maintenance and emissions* and *cumulative fishing pressures* (Table 1).

   The *Risk Identification* stage also incorporates *cumulative impacts* as a key source of risk. The inclusion of *cumulative impacts* recognises the external factors will contribute to the level of risk including activities in other commercial fisheries or sectors and external factors outside the control of DAF *e.g.* climate change, urban runoff and land-based pollution.

   A full breakdown of the fishing activities considered in the MAFF Level 1 ERA has been provided in Table 1.

3. *Risk Characterisation*—provides an estimate (low, intermediate or high) of the likelihood that one or more of the identified sources of risk will make a substantial contribution to the occurrence of an undesirable event. The *Risk Characterisation* stage, in essence, provides an initial assessment of each fishing activity and the level of risk it poses to each ecological

component.[2] These scores were then used to assign each ecological component with a preliminary risk rating based on the highest score within their profile. Preliminary risk ratings are fishery-specific and help identify higher risk elements within each fishery. They were also used to identify low-risk elements within the MAFF.

4. *Likelihood*—provides a secondary evaluation of factors underpinning preliminary risk assessments, their relevance to the current fishing environment and the potential for the fishery to contribute to this risk in the short to medium term. This step recognises that preliminary scores assigned in the *Risk Characterisation* stage may overestimate the level of risk for some ecological components. In the Level 1 ERA, *Likelihood* is used to assign each ecological component with a final risk rating.

The above framework differs from Astles *et al.* (2006) in that it includes an additional step titled *Likelihood.* The inclusion of this additional step recognises the precautionary nature of qualitative assessments and the potential for risk levels to be overestimated in whole-of-fishery ERAs. This step, in effect, assesses the likelihood of the risk occurring in the current fishing environment and takes into consideration a) the key factors of influence and b) their relevance to the current fishing environment. In doing so, the *Likelihood* step helps differentiate between **actual** and **potential** high risks. This aligns with the objectives of *Ecological Risk Assessment Guideline* (Department of Agriculture and Fisheries, 2018) and helps limit the extent of false positives or the misclassification of low-risk elements as high risk.

Table 1. *Summary of the key fishing activities and their relation to risk. Table 1 is based on an extract from Pears et al. (2012a). * Cumulative risk scores are not considered when assigning preliminary risk ratings as these values relate specifically to the commercial fishing sector.*

Sources of Risk
Harvesting: capture and retaining of marine resources for sale.
Discarding: returning unwanted catch to the sea. This component of the catch is landed on the deck of the boat or brought to the side of the vessel before its release and the reference is applied to all sectors *e.g.* commercial, recreational, charter.
Contact without capture: contact of any part of the fishing gear with an ecological subcomponent (species, habitats etc.), but which do not result in the ecological components being captured and landed on deck.
Loss of fishing gear: partial or complete loss from the boat of gear including lines, nets, ropes, floats etc.
Travel to/from grounds: steaming of boat from port to fishing grounds and return.
Disturbance due to presence in the area: other influences of boat on organisms whilst fishing activities take place (*e.g.* underwater sound disturbances).
Boat maintenance and emissions: tasks that involve fuel, oil or other engine and boat-associated products that could be accidentally spilled or leaked into the sea or air.
Cumulative fishing pressure: Indirect external factors, including other fisheries or fishing sectors; and non-fisheries factors that apply across fishery sectors.

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[2] *Scores assigned as part of the Risk Characterisation stage relate directly to factors identified as part of the Risk Identification stage.*

Additional information on the assessment methodology is provided in Astles *et al.* (2006) and Pears *et al.* (2012a). A broad overview of the ERA strategy used in Queensland has been outlined in the Queensland *Ecological Risk Assessment Guideline* (Department of Agriculture and Fisheries, 2018).

3 Level 1 Qualitative Assessment

3.1 Risk Context

The risk context for the whole-of-fishery assessment has been framed at a higher level and takes into consideration the main purpose of the *Fisheries Act 1994* which is to: "*…provide for the use, conservation and enhancement of the community's fisheries resources and fish habitats in a way that seeks to: apply and balance the principles of ecologically sustainable development; and promote ecologically sustainable development.*"

In line with this objective, the risk context for the MAFF Level 1 ERA was defined as:

> *The potential for significant changes in the structural elements of the fishery or the likelihood that fishing activities in the Marine Aquarium Fish Fishery will contribute to a change to the fishery resources, fish habitats, environment, biodiversity or heritage values that is inconsistent with the objectives of the Fisheries Act 1994.*

The inclusion of 'potential' in the risk definition recognises the need to take into consideration both current and historic trends and the likelihood of a fishery deviating from these trends in the short to medium term. The reference to 'structural elements of a fishery' relates to the current fishing environment and the potential for it to change over the longer term *e.g.* the potential for effort to increase under the current management arrangements, effort displacements or the ability for effort to shift between regions and species.

The focus of this assessment relates specifically to A1 and A2 operations targeting vertebrate and invertebrate species (excluding hard corals, soft corals, anemones, live rock and coral rubble) for sale in the aquarium trade. It is recognised that licence holders operating under the A1 and A2 fishery symbol also retain hard corals, soft corals, anemones, live rock and coral rubble. These species/elements are subject to a separate ERA process (Department of Agriculture and Fisheries, 2022b; Morton *et al.*, 2022).

In order to frame the scope of the assessment, a 20-year period was assigned to all Level 1 ERAs. Under this scenario, the Level 1 ERA considers the likelihood that one or more of the ecological components will experience an undesirable change over the next 20 years due to fishing activities in the MAFF. For the purpose of the assessment, the Level 1 ERA assumes that management arrangements for the fishery will remain the same over this 20-year period. A 20-year timeframe has been used in previous ERAs developed under the *Queensland Sustainable Fisheries Strategy 2017–2027* and it is considered precautionary (Department of Agriculture and Fisheries, 2017a; 2022b).

3.2 Risk Identification

3.2.1 Whole of Fishery

Operators within the MAFF are restricted in terms of the area of operation and the apparatus permitted for use (Department of Agriculture and Fisheries, 2023). These restrictions limit the extent of the risk

posed by this fishery and the key contributors of risk. Of the activities identified in Table 1, *harvesting* will be the main driver of risk with *contact without capture* and *disturbance due to presence in the area* viewed as secondary factors of influence.

The fishery is highly selective meaning few ecological components, outside of the main target species, will be directly impacted by the MAFF. The immediately fished area will experience a degree of on-site disturbance and non-target species will likely be impacted by MAFF activities. These impacts will be localised, short in duration and temporary in nature *i.e.* disturbed animals are likely to return to region once the collection period has been completed. When compared to other fisheries, *discarding* is viewed as a lower-risk element in the MAFF.

Of the remaining fishing activities, the size of the fishery (*n* = 43 fishery symbols) limits the extent of the risk posed by *travel to/from the fishing grounds* and *boat maintenance and emissions*. Similarly, *loss of fishing gear* is considered a fishing activity of low or negligible risk.

3.2.2 Ecological Components

Target Species (teleosts and invertebrates)

Most fishing-related risks in the MAFF involve target species. To this extent, the profile for the broader fishery (section 3.2.2) will be influenced by risk traits and trends observed in this ecological component.

Over the 2010/11–2021/22 period, at least 20 families of marine fishes, elasmobranchs (sharks and rays), and marine invertebrates (Phylum Arthropoda, Mollusca and Echinodermata) were retained in the MAFF. Collectively, the diversity of species that can be retained from these groups is extensive. Data collected from the fishery indicates that approximately 70% were fishes (primarily damselfishes, *Family Pomacentridae*; and wrasses, *Family Labridae*), with invertebrates making up the remaining 30% (Department of Agriculture and Fisheries, 2023). In recent years, this proportion has shifted to approximately 60% marine fishes and 40% invertebrates. While noting this proportionate change, the number of individuals being retained each year has undergone a substantial decline. This decline was observed in both teleosts and invertebrates and was counterbalanced by a corresponding increase in the coral harvest (Department of Agriculture and Fisheries, 2022c; 2023).[3]

Harvesting is the key driver of risk for this subgroup with *discarding*, *contact without capture* and *disturbance due to presence in the area* viewed as secondary risk factors. Examples of where these secondary risks might come into consideration include when a fish/invertebrate is incidentally caught in conjunction with a priority target, when operators are selecting individuals based on marketability (*e.g.* preferred sizes or sexes) and due to operational constraints (*e.g.* holding tank space, retaining a portion of the fish within a netted area). These interactions will be temporary in nature and are not expected to have a significant, long-term or detrimental impact on the health of regional populations. Releasing (*discarding*) non-target species/individuals at or the near the site of capture would further assist in terms of minimising secondary risk factors including predation and post-interaction mortalities.

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[3] *MAFF operators also collect also collect hard corals, soft corals, anemones, live rock and coral rubble as part of the Queensland Coral Fishery. Fishing activities in the QCF will influence the MAFF and visa versa. Fishing activities in the Queensland Coral Fishery are subject to a separate ERA process (Department of Agriculture and Fisheries, 2022b; Morton et al., 2022).*

Management of the annual MAFF harvest relies on a system of input and output controls which incorporates limited licencing, gear restrictions, diver limits and spatial restrictions (Department of Agriculture and Fisheries, 2023). As the MAFF operates almost exclusively within the confines of the GBRMP, it is also subject to provisions governing the use of resources within the World Heritage Area (Department of Agriculture and Fisheries, 2022c; Great Barrier Reef Marine Park Authority, 2018; 2022b). These measures provide a strong framework to manage the general over-harvesting risk and provides species with considerable protection from commercial harvesting activities. For example, the *Representative Areas Program* prohibits commercial fish collection in around 38 per cent of the GBRMP with recreational harvesting prohibited in all areas of the marine park (Great Barrier Reef Marine Park Authority, 2020; 2022a)`

The MAFF management regime does not include total allowable effort caps or harvest limits for individual species (Department of Agriculture and Fisheries, 2023). Without these limits, total effort or harvest rates could (theoretically) increase beyond what is desired at a whole-of-fishery, regional or species level. There are tangible examples of this occurring in analogous fisheries, namely in the *Queensland Coral Fishery*. Market demand in this fishery resulted in a substantial increase in the harvest of *Homophyllia* cf. *australis*, *Trachyphyllia geoffroyi* and *Micromussa lordhowensis* (Department of Agriculture and Fisheries, 2022c). In response to these increases, the management regime for the *Queensland Coral Fishery* was reformed and the fishery transitioned to a more complex system of output controls (Queensland Government, 2022).

Without an effective limit, there is some potential for effort to increase across the entire MAFF. While noting this potential, the probability (or risk) of effort increasing substantially across the entire fishery is comparatively low. The MAFF already has a limited licencing policy in place ($n = 43$ licences maximum) and operations are subject to boat and diver number restrictions. Future expansions of the effort footprint are also confined through fisheries legislation and provisions governing the use of marine resources in the GBRMP. These measures exert a considerable level of influence on individual operations and restrict the extent of any (future) expansion of the effort footprint within the main fishing grounds. The capacity of the fishery to manage long-term harvest trends was further strengthened in 2021 with the introduction of the *Marine Aquarium Fish Fishery Harvest Strategy: 2021–2026* (Department of Agriculture and Fisheries, 2021). This strategy, among other things, includes decision rules and trigger limits that a) increase the capacity of the fishery to manage long-term sustainability risks and b) establishes safeguards to prevent catch exceeding acceptable limits.

In Queensland, an increasing number of fisheries have transitioned to a more complex system of output controls as part of the harvest strategy development program *e.g.* Total Allowable Commercial Catch (TACC) limits and Individual Transferrable Quotas (Department of Agriculture and Fisheries, 2017a; b; c; 2020a). While the MAFF has a harvest strategy, the use of catch limits has yet to be fully explored as a long-term management option for this fishery. Data used to monitor MAFF harvest rates are based on the number of individuals and it can be difficult to obtain accurate weights (or weight conversion factors) for species retained as part of the live-aquarium trade. QDAF further notes that the value of the MAFF product will depend on a range of factors including rarity, size, sex, distribution (*i.e.* endemic), colouration and aquaria suitability (*i.e.* aquaria safe / non-aggressive species). Consequently, harvest weights may be a less-useful indicator of catch trends, market desirability and inter-specific risk variability.

While increasing effort poses a lower risk across the entire MAFF, there is an inherent risk that a disproportionate amount of effort will be directed towards a smaller number of more marketable

species. This risk is compounded by the interconnected nature of the *Queensland Coral Fishery* and the MAFF.[4] While not universal, this interconnectivity means that management reforms imposed in one fishery may influence fishing activities in the other. For example, the recent tightening of catch limits in the *Queensland Coral Fishery* may cause a shift in effort back to the MAFF. If this were to occur, harvest rates for more marketable species will likely increase. The current challenge being that MAFF data has poor species resolution and it is difficult to determine what species are already experiencing increased fishing pressures.

For species with wide geographical distributions, stable populations and sufficient protection from commercial fishing, increasing seasonal catch and effort may not translate to an increased level of risk. For these species, arrangements applied at the whole-of-fishery level may be adequate in terms of managing the long-term sustainability risk. The key caveat being that any increase in risk will be dependent on the temporal and spatial scale of the event. Increasing regional catch and effort may elicit a different response from endemic species and rarer species with smaller populations, abundances or regional distributions. These species are often more marketable, are of higher value and are a more likely to be targeted/retained if observed in the immediately fished area. In these instances, increasing catch and exploitation rates may have longer-term implications in terms of species' ability to absorb fishing pressures or rebound after potential declines. Depending on the population dynamics, these impacts may occur without a discernible change in catch and effort at a whole-of-fishery level. This potential for catch rates to increase across one or more vulnerable species is viewed as a key area of risk within the MAFF.

The absence of species-specific data and catch limits places increased importance on the improvement of logbook reporting and data collection. Commercial fishers primarily report catch through physical logbooks and an *Automated Integrated Voice Response* (AIVR). However, commercial collectors are only required to report retained catch under broader species-groupings, by family or genus. This directly impacts the quality of the data and has resulted in the MAFF logbook data having poor species resolution. This is most evident in data documenting invertebrate retention rates and species compositions (Department of Agriculture and Fisheries, 2023).

As data is reported at a higher taxonomic level it can be difficult to assess species-specific harvest rates, provide insight into the targeting of key species or changing marked demands. This makes it difficult to determine the prevalence of fishing-related risks or quantify the extent of any intraspecific risk variability. Over the longer-term, the continued collection of higher-level data will be a limiting factor with regards to the overall effectiveness of the harvest strategy and the ability of management (if required) to constrain catch and effort for key species (Department of Agriculture and Fisheries, 2021).

Of significance, data deficiencies and reporting inadequacies are now being actively addressed as part of a broader *Marine Aquarium Fish Fishery Data Improvement Plan* (Department of Agriculture and Fisheries, 2022a). This plan includes a detailed review of the current logbook requirements and a significant enhancement of species-specific reporting. The updated logbook is due to come into effect on 1 July 2023 and follows on from updates undertaken in 2000 (logbook AQ03), 2006 (logbook AQ04) and 2010 (logbook AQ05). Subjecting the target species ecological component to a Level 2 ERA may also assist with this process (Department of Agriculture and Fisheries, 2018).

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[4] *Licence holders with a 'D' and 'A1' fishery symbol can and will retain a mixture of species managed under the MAFF and Queensland Coral Fishery. Harvest compositions i.e. MAFF versus Queensland Coral Fishery species will be dependent on the structure of the operation.*

Bycatch

As it is a hand collection fishery, there are minimal bycatch issues in the MAFF. In most cases, these interactions will involve the release of low-value fish or species that could theoretically be retained (*discarding, contact without capture event*). If for example, a low value species was simultaneously caught with a more marketable species, it may be released by the operator *versus* retaining if for sale.

Interactions with non-target species or unwanted fish will be relatively short and are not expected to have a long-term or detrimental impact on the affected individuals. The fact that the animals will be released (*discarding*) at or near the site of capture would increase their chances of survival. Given the above considerations, the MAFF will pose a lower risk to the bycatch ecological component.

Species of Conservation Concern

Marine turtles –

The MAFF poses a low to negligible risk to this subgroup with the main risk being boat strikes as operators *travel to/from the fishing grounds*. This risk is not limited to the MAFF and will apply to a wide range of marine activities. While *disturbance due to presence in the area* could be viewed as a secondary risk factor, the associated impacts will be minimal and have no discernible effect on the health of the animal or regional populations.

Dugongs –

The risk profile for dugongs is comparable to marine turtles. Key risks for this subgroup relate to boat strike (*travel to/from fishing grounds*) with few other fishing activities having a direct impact on regional populations. Given the area of operation and size of the fishery ($n = 43$), the MAFF will make a comparatively small contribution to this collective (boat strike) risk *i.e.* commercial and recreational use of the marine resources. Outside boat strike, the direct impact of the MAFF on regional dugong populations will be negligible.

Cetaceans (Whales & Dolphins) –

Cetacean interactions in the MAFF are viewed as highly unlikely. If an interaction were to occur in this fishery it will be with the vessel (*travel to/from fishing grounds*). Overall, the MAFF will present a negligible to low risk to this subgroup.

Sea Snakes –

MAFF operations cannot collect or retain sea snakes. The fishery will have a negligible impact on this subgroup with *disturbance due to presence in the area* the most likely risk factor.

Crocodiles –

N/A for this fishery.

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 (*Epinephelus tukula*) and barramundi cod (*Cromileptes altivelis*) are classified as no-take for

conservation reasons. 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 they are protected, the seven species cannot be retained for sale under the A1 or A2 fishery symbols. As the fishery operates within reef environments, the operators may encounter these species when actively fishing (*disturbance due to presence in the area*). However, there is a low probability of the species being caught incidentally or requiring assistance to extricate themselves from the apparatus. Overall, the MAFF will pose a low to negligible risk to this subgroup.

Batoids & Sharks –

The risk profile for batoids (stingrays, stingarees, skates) and sharks differs from the remaining SOCC subgroups in that they can be retained for sale (*harvesting*). For most of this subgroup, size and aquaria suitability will be limiting factors in terms of harvest rates and risk levels. In less frequent instances, operators may target and retain larger species on consignment *e.g.* for public aquaria.

While this subgroup is retained for sale, elasmobranch harvest rates in the MAFF are comparatively small. However, catch data for this complex has poor resolution and quantifying species-specific harvest rates can be difficult. Given the nature of the fishery, a higher proportion of this harvest will consist of smaller, more fecund species like the epaulette shark (*Hemiscyllium ocellatum*) and the bluespotted ribbontail ray (*Taeniura lymma*). Harvest rates for larger elasmobranchs will be lower and pose a much smaller risk when compared to fisheries where they are retained for human consumption *e.g.* the *East Coast Inshore Fishery* and the *Gulf of Carpentaria Inshore Fishery* (Department of Agriculture and Fisheries, 2019; 2020b; Pidd *et al.*, 2021; Walton *et al.*, 2021). The fishery though will still retain species with higher conservation concerns including CITES listed hammerhead sharks (F*amily Sphyrnidae)* and whaler (requiem) sharks (*Family Carchahinidae*). This risk posed to these groups, while still low, may vary from others.

For these species there is little evidence to suggest that MAFF fishing activities are having a long-term, detrimental impact on regional populations (Kyne *et al.,* 2021). With that said, this subgroup would benefit from improved catch reporting. Changes being implemented as part of the *Marine Aquarium Fish Fishery Data Improvement Plan* will assist with this process (Department of Agriculture and Fisheries, 2022a).

Syngnathids –

Syngnathids, as with sharks and batoids, can be retained for sale in the MAFF (*harvesting*). However, the take of this complex is heavily restricted and operators cannot target or retain syngnathids within the Great Barrier Reef Marine Park. The remaining fishing activities will have a low to negligible impact on this complex with *disturbance due to presence in the area* viewed as a minor, secondary risk factor (Table 1).

As with other target species, future risk assessments involving this complex (if applicable) would benefit from additional information on the catch compositions and species-specific harvest rates. These deficiencies are being actively addressed as part of the *Marine Aquarium Fish Fishery Data Improvement Plan* (Department of Agriculture and Fisheries, 2022a).

Seabirds –

While operators may disturb seabirds within the immediately fished area (*disturbance due to presence in the area*), the risk posed to this subgroup is viewed as negligible.

Terrestrial Mammals –

Not applicable for this fishery.

Marine Habitats

Coral reefs contribute significantly to the cultural and economic values of the Great Barrier Reef region, are a major sink for global carbon, and are a habitat for more than 1600 species of fish (Great Barrier Reef Marine Park Authority, 2014; 2019; Kinsey & Hopley, 1991).

In the MAFF, the extent of the long-term risk posed to regional marine habitats will be limited by the size of the fishery ($n = 43$ licences) and the apparatus used. However, some level of regional disturbance is expected at and around the site of collection *e.g.* localised damage to the substrate and reef structure when extracting target species and/or incidental damage caused by ancillary equipment (*disturbance due to presence in the area; contact without capture events*).

The level of disturbance during a single fishing event will be relatively minor and, when considered in isolation, will be of limited risk. Over the longer term, cumulative fishing effects may increase this risk at a regional level *e.g.* in areas that attract higher levels of effort within and across a given season. This longer-term risk is managed and mitigated through a range of measures (*e.g.* limited licencing, gear restrictions, spatial closures) and mitigated by industry who have an invested interest in protecting the ecological integrity of regularly accessed habitats.

Outside of fishing, the collective MAFF will impact regional habitats through general boating activities like anchoring (*disturbance due to presence in the area*). Anchors can damage coral reefs and the substratum, particularly during the setting and retrieval process. Corals can be broken and overturned and further damage is caused if the anchor is dragged or wrapped around structures. There is a significant relationship between areas of high boating activity and coral damage due to anchoring (Dinsdale & Harriott, 2004). DAF notes though that this risk is not limited to the MAFF, rather it will apply to a range of commercial and recreational (fishing and non-fishing) boating activities.

Ecosystem Processes

Marine environments, namely coral reef ecosystems are multifaceted, complex and incredibly diverse systems. These factors create challenges when assessing the level of risk associated with the collection of marine ornamental species. In the Level 1 assessment (Appendix 1), the primary risks for *ecosystem processes* related to the *harvesting* of target species. Harvesting has the potential to disrupt the stability and connectivity of ecosystems on a localised or regional scale. Secondary risks for this ecological component relate to more general fishing activities (*e.g. sedimentation*) and disruption due to presence in the area. These factors are directly linked, as activities involved with collection and removal of biomass can result in disturbances to fundamental ecosystem processes.

Coral reefs are rich tropical ecosystems that are often surrounded by nutrient poor waters (Roth, 2014; Sheppard *et al.*, 2017). Fishes provide and store nutrients on coral reefs and other coastal environments which contributes to nutrient cycling (Allgeier *et al.*, 2014; Pawlik *et al.*, 2016). In coral

dominant reefs, nutrient excretion by fishes can promote the growth of corals (Burkepile *et al.,* 2013). The opposite occurs on reefs with low coral cover. Furthermore, fish faecal matter deposited on the reef surface provides nutrients for benthic organisms (Froelich, 2002). These organisms metabolise and recycle nutrients which contributes to reef productivity. Nutrient loads and cycling in marine environments can therefore be impacted by removing biomass (*e.g.* by fishing; Allgeier *et al.*, 2016). There is an intimate link between marine environments and fish derived nutrients, although there are inherent challenges quantifying this. Given the diversity of the MAFF harvest, it is inevitable that the fishery will remove species that contribute to these ecological processes.

Overharvesting key functional groups can damage marine ecosystems by removing critical ecological functions. Fishes that exhibit herbivory [*i.e.* Acanthuridae (surgeonfishes), Labridae (namely parrotfishes) and Pomacentridae (damselfishes)] maintain coral reef health by inhibiting phase shifts and controlling various forms of algal growth that compete with corals (Thibaut *et al.*, 2012). Other ecologically important functional groups include particulate feeders, predators, bioturbators, detritivores and scavengers. Symbiotic relationships, particularly between anemonefishes (*Amphiprion spp. and Premnas spp.*) and anemones may be further affected by aquarium fish collection activities *e.g.* due to localised depletions. In this example, the stability of each organisms' population will be dependent on the other. If all anemonefish are harvested from an anemone, the chances of the anemones survival, and ultimately the recruitment of other anemonefishes decreases (Frisch *et al.,* 2016).

During fishing operations, the use of ancillary fishing apparatus (*e.g.* the dropping and dragging of anchors) disrupts the substratum resulting in the resuspension of sediments. Resuspended sediments decrease water quality and impact coral mortality, growth and recruitment (Erftemeijer *et al.,* 2012). Reduced coral cover decreases the integrity of coral reefs which can lead to declines in the biodiversity of fishes (Jones *et al.*, 2004). Although general fishing activities *e.g.* anchoring in the MAFF will contribute to these risks at a regional level, this impact will be minor given the small fishery footprint.

At a whole-of-fishery level, the MAFF retains species that help maintain the health and integrity of coral reef ecosystems and connectivity across regions. With the fishery reporting comparatively low catch numbers (Department of Agriculture and Fisheries, 2023), fishing activities in the MAFF are not expected to result in a substantive loss of ecological function. This situation may change into the future if, for example, effort was to increase at a regional level or across key groups. This increases the importance on improving catch monitoring and managing the long-term regional depletion risk.

3.2.3 Cumulative Impacts

A significant portion of fisheries-based ERAs are dedicated to understanding the potential impacts and risks posed by commercial fishing activities. There will however be a range of factors that contribute to an ecological component experiencing an undesirable event including the presence and size of other fishing sectors, broader environmental trends and operations that are not managed within the fisheries framework.

For the purpose of this assessment, the cumulative impacts section has been subdivided into '*Fisheries Related Impacts*' and *'External Risks'*. The inclusion of *Fisheries Related Impacts* as a cumulative fishing pressure reflects the fact that most of Queensland's fisheries have multiple sectors *e.g.* commercial, recreational, charter. These sectors, for the most part, are managed alongside the

commercial fishery and are subject to management regimes managed by the Department of Agriculture and Fisheries. The inclusion of *Fisheries Related Impacts* in the *Risk Characterisation* process reflects DAF's ability to mitigate potential risks through the broader management structure.

The establishment of a second cumulative risk category, *External Risks*, recognises that there are factors outside the control of DAF that have the potential to contribute to an undesirable event for one or more of the ecological components. These risks represent an accumulation of issues or activities that span across stakeholders, fisheries and (often) state and federal management bodies. For some of these external risks, fishing activities will be a contributing factor but are not the primary source of risk. In other instances, it will be difficult to address or resolve these risks through the fisheries management framework *e.g.* climate change.

External Risks are addressed in Queensland through a wide variety of forums and by various departments. Given their wide-ranging nature, these risks are not addressed directly through ERA framework (Department of Agriculture and Fisheries, 2018). They have however been included in the Level 1 assessment as they have the potential to either impact fisheries (*i.e.* pose a risk to the fishery) or are a factor that the fishery contributes to (*i.e.* risks posed by the fishery). When and where appropriate, the Queensland Government will contribute to these discussions including (among others) participating in the *Reef Plan 2050* process, broader management reform initiatives, national plans of action and recovery strategies. In these instances, DAF will continue to participate and represent the fishing interests of the state.

Fishing Related Impacts

The cumulative fishing risks for MAFF species are low. The recreational take of ornamental species is prohibited in key areas (*e.g.* the GBRMP) and the fishery does not have a corresponding charter fishing sector. While research will be a source of extraction/mortalities (*harvesting*), these activities are heavily regulated. The impact of non-extractive research (*e.g.* benthic surveys) will be low to negligible (*disturbance due to presence in the area*, *contact without capture events*).

Larger specimens of some teleosts, sharks and rays may be retained for sale (*i.e.* for consumption) in fisheries like the *East Coast Inshore Fishery* (Department of Agriculture and Fisheries, 2019; Jacobsen *et al.*, 2021; Pidd *et al.*, 2021). When compared to these fisheries, the MAFF will make a minor contribution to the overall level of risk. Similarly, key MAFF targets generally do not occur in areas where they are more like to be caught as bycatch *e.g.* in the *East Coast Otter Trawl Fishery*.

QDAF anticipates that take from Aboriginal peoples' and Torres Strait Islander peoples' will be low to negligible.

External Risks

Climate change

Anthropogenic climate change is expected to have significant and lasting effects on the marine environment. These will likely impact fisheries operations, with some effects already perceptible in recent years. In Queensland, the severity of storms, tropical cyclones and extreme rainfall events are predicted to increase by the end of the century (Steffen *et al.,* 2017). In the past, these events have led to population reductions in affected areas and reduced fish catchability for extended periods after these events (Holbrook & Johnson, 2014). Further to this, increased warming of the atmosphere also leads to increased sea surface temperatures. Temperatures have been steadily increasing around

Australia, and globally. This increase in temperature has been responsible for several largescale mass die-offs of coral, mangroves and seagrass (Arias-Ortiz *et al.*, 2018; Duke *et al.*, 2017; Hoegh-Guldberg *et al.*, 2007), which are critical spawning and nursery grounds for many species.

Changes in temperature and oceanic chemistry have been reported to affect physiology, growth and reproduction of fisheries species as well as the primary production that many species depend on (Sumaila *et al.,* 2011). This can lead to widespread shifts in fish and ecosystem productivity and stock distributions. There is also evidence of increased ocean acidity. Increased carbon dioxide in the atmosphere decreases the pH of seawater (*i.e.* increased acidity), leading to ocean acidification and dissolution of calcium based reef-building corals, molluscs and crustaceans (Hoegh-Guldberg *et al.,* 2007). Within this context, sustainably managed fisheries will be in a better position to respond to the effects of climate change. Fisheries already under significant stress due to, for example, overfishing, pollutants, and habitat degradation, may not have the resilience to deal with such a largescale threat (Sumaila *et al.,* 2011).

As most of the MAFF operates within the confines of the Great Barrier Reef Marine Park, climatic changes are a considered to be a high-threat element. Decreased coral cover and diversity as a result of marine heatwaves reduces the amount of habitat available for coral reef fishes that are collected in the MAFF. This is especially devastating for fishes that depend solely on coral reefs for survival, *i.e.* corallivores. This will ultimately cause a shift from coral dominance to algal dominance, which alters fish assemblages and decreases the diversity of coral reef fishes.

The effects of climate change are difficult to address within a fisheries management framework, due in part, to the largely unquantifiable nature of largescale climatic effects. However, these issues are important to consider when identifying risks and future management decisions for fisheries like the MAFF. The Queensland Government will continue to address these issues through a range of forums.

Boat strike

The effects of vessel use are similar regardless of whether they are used for commercial or recreational fishing, or some other form of recreational use. While the boat-strike risk is comparatively low for MAFF operations, it will be a contributor of risk. This cumulative risk (*i.e.* the risk posed by all vessel activity) will be higher for a number of the ecological components. For context, records of megafauna strandings show that mortalities attributed to vessel strike greatly outnumber fishing related mortalities (Department of Environment and Science, 2022).

For most air breathing species, the impact of boat strikes will be dependent on the region, habitat compositions, and vessel traffic. Turtle interactions are more likely in internesting habitats and whilst travelling through shallow coastal foraging areas *i.e.* traveling to or from the fishing grounds (United Nations Environment Program, 2014). Dugongs are also vulnerable in shallow coastal foraging areas. In the Queensland stranding database, stranded turtles with mortalities attributed to vessel strikes greatly outnumber fishing related mortalities. The greatest risk for humpback whales occurs in offshore areas around major ports and the offshore area between the Whitsundays and Shoalwater Bay (Department of the Environment and Energy, 2015).

The risk associated with boat strike mortalities is significant and it will involve a wide range of recreational and commercial services. The MAFF, as a whole, will be a minor contributor to this broader risk.

Coastal development & changes in land use

Stemming from Queensland's increasing population, which is highly concentrated along the coast, urban development remains a key issue for terrestrial and marine habitats that connect to fisheries. Impacts of urban development may include, but are not limited to, land/vegetation clearing, pollution/sediment run-off, and alteration of natural hydrogeological processes, pollutions originating from residential, industrial and agricultural sources. Key implications of these activities with respect to fisheries is the loss or damage to freshwater and marine habitats, including those that are critically important nursery habitats. Quantifying the full effect of urban development on Queensland's fisheries and their ecological components is inherently difficult. The extent of these impacts will arguably be more significant for fisheries that target species in inter-tidal waters or species that utilise these environments for nursery areas before recruiting to the fishery.

Farming, particularly sugarcane and grazing, and urban development in GBR catchment areas are the largest contributors to land based runoff. Excess nutrients, fine sediments and pesticides have increased substantially in the GBR since pre-development levels; resulting in a significant reduction in the overall water quality of the whole GBR region (Waterhouse *et al.,* 2017). Reduced water quality leads to loss of corals and seagrass cover, population declines in megafauna *i.e.* dugongs, increased crown of thorns outbreaks, and overall degradation to the GBR (Brodie *et al.,* 2017). As the majority of the MAFF fishing activity occurs within the Great Barrier Reef Marine Park, urban development/runoff *etc.* may have long-term implications for this fishery and the species they target.

3.3   Risk Characterisation

Used as part of the Level 1 assessment, the primary purpose of the *Risk Characterisation* stage is to assign a qualitative value to each fishing activity representing the potential (negligible, low, intermediate or high) for it to contribute to an undesirable event for each ecological component. The *Risk Characterisation* stage aims to identify the key sources of risk for each fishery to inform finer scale assessments. If, for example, an ecological subcomponent is identified as 'high risk' in the Level 2 *Productivity & Susceptibility Analysis* (PSA) or a *Sustainability Assessment for Fishing Effects* (SAFE), the results of the Level 1 assessment will identify the activities within each fishery that contribute to this risk.

The *Risk Characterisation* stage takes into consideration current fishing trends (*e.g.* current catch, effort and licensing), limitations of the current management regime (*e.g.* the potential for additional effort to be transferred into areas already experiencing higher levels of fishing mortality, substantial increases in fishing mortality for key species, changing target species) and the consequences of the interaction. The *Risk Characterisation* stage did not take into consideration any reform initiated as part of the *Marine Aquarium Fish Fishery Data Improvement Plan* that has not been fully implemented (Department of Agriculture and Fisheries, 2022a). When and where appropriate, these reforms will be taken into consideration in subsequent ERAs involving the MAFF.

Outputs of the *Risk Categorisation* stage were used to assign each ecological component and SOCC subcomponent with a preliminary risk rating based on the highest risk score in the profile (Table 2). If for example an ecological component received a 'high risk' for one or more of the fishing activities, it would be reflected in the preliminary risk ratings (Table 2). These preliminary risk ratings are conservative in nature and provide the first opportunity to remove low risk elements from the assessment process. The key considerations for each ecological component were discussed in more detail as part of the *Risk Identification* stage (section 3.2)

Table 2. *Summary of the risk scores assigned to each of the MAFF fishing activities across each of the respective ecological components.*

Ecological Component	MAFF – Risk Profiles							Preliminary Risk Rating
	Harvesting	Discarding	Contact without capture	Loss of fishing gear*	Travel to/from grounds	Disturbance due to presence in area	Boat maintenance & emissions	
Target & Byproduct	I	L	L	-	-	L/I	L	I
Bycatch (non-SOCC)	-	-	-	-	-	-	-	-
SOCC								
Batoids	L/I	-	-	-	-	L	L	L/I
Cetaceans	-	-	-	-	L	-	L	L
Crocodiles	-	-	-	-	-	-	-	-
Dugongs	-	-	-	-	L	-	L	L
Marine turtles	-	-	-	-	L	L	L	L
Protected teleosts	-	-	-	-	-	L	L	L
Sea snakes	-	-	-	-	-	L	L	L
Seabirds	-	-	-	-	-	L	L	L
Sharks	L/I	-	-	-	-	L	L	L/I
Syngnathids	L	-	-	-	-	L	L	L
Ter. mammals	-	-	-	-	-	-	-	-
Marine Habitats	-	-	-	-	-	L	L	L
Ecosystem Processes**	L/I	-	-	-	-	L	-	L/I

* Represents the risk that gear will be lost. However, the impacts of lost gear i.e. ghost nets will be much higher.

** Preliminary risk assessment for the ecosystem processes ecological component provided in the Appendix A.

Preliminary assessments for the MAFF demonstrate that the fishery poses a negligible to low risk to vast majority of ecological components (Table 2). Of the ecological components and subcomponents assessed, three were assigned a preliminary risk rating of negligible with a further eight assigned a low-risk rating. For a number of the ecological components, the low-risk rating reflects assessments involving *disturbance due to presence in the area* or *contact without capture* (Table 1 & 2). In the MAFF, both of these fishing activities are considered low impact.

At intermediate, the target species ecological component had the highest preliminary risk rating of the assessment. This rating takes into consideration current data deficiencies and associated challenges documenting harvest rates for individual species. Although data deficiencies also apply to sharks, batoids and syngnathids, these subgroups do not attract the same level of effort and are harvested in much smaller quantities. This was reflected in the preliminary scores assigned to these SOCC subcomponents (Table 2).

The following provides a general overview of the key findings of the risk characterisation stage:

- The MAFF is viewed as a low-risk fishery with *harvesting* considered the major contributor of risk. Harvesting-related risks are self-limiting in that they only apply to species that can be retained.

- Data deficiencies and uncertainty contributed to the target species ecological component being assigned an intermediate risk rating. This rating recognises the paucity of information on species compositions in the MAFF including for invertebrates (30–40% of the reported catch).

- The preliminary rating for target species should not be applied uniformly as this ecological component will display a wide degree of interspecific risk variability. This variability highlights the need to undertake a finer-scale assessment of the risk posed to key species.

- As it is a hand-collection fishery, the vast majority of fishing activities have a low to negligible impact on non-target species and/or have indirect impacts with minimal long-term consequences.

- Preliminary ratings assigned to marine habitats and ecosystem processes should be applied at a regional level. At a whole-of-fishery level, these ratings (likely) represent a false-positive result or risk overestimate.

- Fishing activities in the MAFF will pose some risk to the surrounding environment (marine habitats) and ecosystem processes. However, confounding factors make it difficult to quantify the extent of this risk at both a regional and whole-of-fishery level.

3.4 Likelihood

The *Risk Characterisation* stage takes into consideration what is occurring in the fishery and what can occur under the current management regime. This provides a more holistic account of the risks posed by the fishery and provides the Level 1 ERA with greater capacity to address the (potential) long-term consequences. The inherent trade off with this approach is that some of the ecological components may be assigned more conservative risk ratings. Otherwise known as false positives, these values are more representative of the potential risk *versus* an actual or real risk—something that is discussed at length in the *Ecological Risk Assessment Guideline* (Department of Agriculture and Fisheries, 2018).

False positives should not be discounted as they point towards areas where further monitoring and assessment may be required. However, triggering management changes or progressing an ecological component to a Level 2 (species-specific) ERA based on a conservative whole-of-fishery (Level 1) assessment may be unwarranted. This places added importance on examining the preliminary risk ratings and determine if they represent a real or potential high risk (Department of Agriculture and Fisheries, 2018).

In order to address the potential overestimation of risk for some ecological components, a secondary qualitative review of the preliminary risk ratings was undertaken. This review examined risk factors underpinning each assessment, their relevance to the current fishing environment and areas where risk may be overestimated. The purpose of the secondary review is not to dismiss the preliminary findings of the *Risk Characterisation* stage. Rather, this secondary assessment aims to assess the likelihood of the risk coming to fruition over the short to medium term. This will aid in the identification of priority risk areas and help to inform broader discussions surrounding the development of risk management strategies for key species. Given the extent of fisheries reforms outlined in the

Queensland Sustainable Fisheries Strategy 2017–2027 (Department of Agriculture and Fisheries, 2017a) and the available resources, this was considered to be an important and necessary step.

When mitigation measures and risk likelihood are given further consideration, the preliminary risk ratings for four ecological components were reduced (Table 2). The risk rating for cetaceans, sea snakes, seabirds and protected teleosts were reduced from low to negligible. The impact of the MAFF on these ecological components will be minor and have negligible long-term consequences for regional populations.

Ratings for the remaining ecological components were retained in the final risk assessment. While a risk-score reduction was considered for marine turtles and dugongs, the potential for the fishery to contribute to boat strikes was considered sufficient to retain the low-risk rating (Table 2). Similarly, some consideration was given to lowering the scores assigned to sharks and batoids. The risk rating for these two ecological subcomponents reflects uncertainty surrounding catch compositions and harvest rates (Table 2). However, a weight-of-evidence approach supported the adoption of a more precautionary risk rating for both sharks and batoids (Table 3). With improved information, risk ratings assigned to these two ecological subcomponents could be reduced.

A summary of the key findings of the Level 1 ERA have been provided in Table 3 along with a recommended progression plan for each of the respective ecological components.

Table 3. Level 1 risk ratings for the ecological components and subcomponents interacting with the *Marine Aquarium Fish Fishery (MAFF)* taking into consideration the likelihood of the risk coming to fruition in the short to medium term.

Ecological Component	Level 1 Risk Rating	Considerations of Likelihood and Mitigation Measures	Level 2 Required?
Target	Intermediate	• Ecological component most likely to impacted by fishing activities <u>within</u> the MAFF. • Fishing-related risks for this ecological component are being managed through a range of input and output controls including extensive closures implemented through legislation governing the use of resources within marine parks. • Across the fishery, harvest rates (number of fish/invertebrates) have declined (Department of Agriculture and Fisheries, 2023). While not universal, declining catch/effort will assist in terms of reducing risk at a whole-of-fishery level. • At a species level, risk levels are unlikely to be uniform and some may be more susceptible to the effects of commercial fishing. • There is a risk that a disproportionate amount of effort will be directed to a smaller number of species *e.g.* due to market demand.	Yes – Recommend that this subgroup is progressed to a Level 2 ERA examining interspecific risk variability.

Ecological Component	Level 1 Risk Rating	Considerations of Likelihood and Mitigation Measures	Level 2 Required?
		• An intermediate risk rating may be precautionary for this ecological component. However, catch data for the MAFF has poor species resolution and it is difficult to quantify harvest rates for individual species and/or assess the extent of any interspecific risk variability. • This rating considered the interconnected nature of the MAFF and the Queensland Coral Fishery. These linkages mean that management reforms implemented in one fishery may have a bearing on the other *e.g.* increased targeting of more marketable fish species to make up any economic shortfall. • The majority of data for invertebrate species are based at a very-high taxonomic level. This deficiency reflects current reporting requirements but may reflect broader deficiencies in our understanding of invertebrate taxonomy, distributions and biology. • These deficiencies are being addressed through the *Marine Aquarium Fish Fishery Data Improvement Plan* (Department of Agriculture and Fisheries, 2022a). • Undertaking a finer-scale risk assessment will improve the level of understanding on inter-specific risk variability. • Of notable importance, species targeted in the MAFF will experience fewer cumulative fishing pressures.	
Bycatch	Negligible	• Minimal bycatch-related risks in the MAFF. • Bycatch will largely consist of low-value species that could theoretically be retained in this fishery.	No
Species of Conservation Concern (SOCC)			
Batoids	Low / Intermediate	• Members of this subgroup can be retained for sale and will be impacted on by MAFF fishing activities. • Harvest rates will be lower than what is reported for teleosts and invertebrates (Department of Agriculture and Fisheries, 2023) and be limited by size / aquaria suitability. • Fishing-related risks for this ecological component are managed through a range of input and output controls which includes marine park closures. • Risk levels are unlikely to be as uniform and some species may be more susceptible to the effects of commercial fishing.	No – While subgroup may benefit from further assessment, it is considered a lower priority for additional assessment.

Ecological Component	Level 1 Risk Rating	Considerations of Likelihood and Mitigation Measures	Level 2 Required?
		• Risk rating may be precautionary for this SOCC sub-component. However, catch data for the MAFF has poor species resolution and it is difficult to quantify harvest rates for individual species and/or assess the extent of any interspecific risk variability. • Data deficiencies are being addressed through the *Marine Aquarium Fish Fishery Data Improvement Plan* (Department of Agriculture and Fisheries, 2022a). It will however take time to develop and implement initiatives instigated under this plan. • This subgroup will be exposed to a higher level of risk in fisheries that retain batoids for human consumption.	
Cetaceans	Negligible	• Direct impact of MAFF fishing activities will be low to negligible. • This subgroup is more likely to experience low-impact disturbance with negligible long-term implications (*disturbance due to presence in the area*). • The rating assigned to this subgroup was lower than marine turtles and dugongs as vessel/boat strike was viewed as a lower risk.	No
Crocodiles	Negligible	• N/A as ecological component will not interact with the MAFF.	No
Dugongs	Low	• Direct impact of MAFF fishing activities will be low to negligible with *travel to/from fishing grounds* considered the most likely source of risk. • While some consideration was given to reducing the rating to negligible, dugongs are particularly susceptible to vessel/boat strike and experience significant cumulative pressures (Department of Environment and Science, 2022). The MAFF will make a smaller contributor to this broader risk.	No
Marine turtles	Low	• Direct impact of fishing activities in the MAFF will be low to negligible. This subgroup is more likely to experience low-impact disturbance with negligible long-term implications *e.g. disturbance due to presence in the area*. • This subgroup is particularly susceptible to cumulative risks including vessel/boat strike (Department of Environment and Science, 2022). The MAFF will make a smaller contributor to this broader risk.	No

Ecological Component	Level 1 Risk Rating	Considerations of Likelihood and Mitigation Measures	Level 2 Required?
Protected teleosts	Negligible	• The MAFF poses a low to negligible risk to this subgroup, particularly since they cannot be retained for sale. • This subgroup is more likely to experience low-impact disturbance with negligible long-term implications (*disturbance due to presence in the area*).	No
Sea snakes	Negligible	• Direct impact of fishing activities in the MAFF will be negligible. This subgroup is more likely to experience low-impact disturbances *e.g. disturbance due to presence in the area*. • Overall, it is not anticipated that MAFF fishing activities will have a significant or long-term impact on regional sea snake populations.	No
Seabirds	Negligible	• The MAFF poses a low to negligible risk to this subgroup. • Members of this subgroup are more likely to experience low-impact disturbance with negligible long-term implications *e.g. disturbance due to presence in the area*.	No
Sharks	Low / Intermediate	• Members of this subgroup can be retained for sale and will be impacted on by MAFF fishing activities. • Harvest rates will be lower than what is reported for teleosts and invertebrates (Department of Agriculture and Fisheries, 2023) and be limited by size / aquaria suitability. • Fishing-related risks for this ecological component are managed through a range of input and output controls which includes marine park closures. • Risk levels are unlikely to be as uniform and some species may be more susceptible to the effects of commercial fishing. • Risk rating may be precautionary for this SOCC ecological sub-component. However, catch data for the MAFF has poor species resolution and it is difficult to quantify harvest rates for individual species and/or assess the extent of any interspecific risk variability. • Data deficiencies are being addressed through the *Marine Aquarium Fish Fishery Data Improvement Plan* (Department of Agriculture and Fisheries, 2022a). It will however take time to develop and implement initiatives instigated under this plan.	No – While subgroup may benefit from further assessment, it is considered a lower priority for additional assessment.

Ecological Component	Level 1 Risk Rating	Considerations of Likelihood and Mitigation Measures	Level 2 Required?
		• This subgroup will be exposed to a higher level of risk in fisheries that retain sharks for human consumption.	
Syngnathids	Low	• SOCC ecological subgroup provided significant protection from commercial aquaria collection *e.g.* no-take within the Great Barrier Reef Marine Park. • Members of this subgroup may be retained in smaller quantities outside the GBRMP. However, there is limited information on retention rates for individual species. • Going forward, this SOCC subgroup would benefit from additional information on catch compositions and locations. These (data) deficiencies are being actively addressed as part of the *Marine Aquarium Fish Fishery Data Improvement Plan* (Department of Agriculture and Fisheries, 2022a).	No
Terrestrial mammals	Negligible	• N/A as ecological component will not interact with the MAFF.	No
Marine Habitats	Low	• The risk rating assigned to marine habitats, reflects the potential long-term cumulative risk. The risk rating assigned to marine habitats is considered precautionary. • Across a single fishing event, operators will have a low impact on the immediate area. Longer-term, there is a risk that some regions will experience higher (cumulative) disturbance *e.g.* due to it being accessed over an extended period / multiple fishing events, general boating activities. • Measures are already in place to minimise this risk across the prescribed fishing area. This includes prohibitions of commercial fishing activities in key areas of the Great Barrier Reef Marine Park, gear restrictions and use of a limited licensing policy.	No
Ecosystem Processes	Low / Intermediate	• Risk rating more applicable/relevant at a localised or regional level and likely over-estimates the risk posed at a whole-of-fishery level. • Fishing activities involved with harvesting and presence in the area can result in disturbances to a range of ecological processes. • Overexploitation of marine fishes and invertebrates could lead to a decline in important ecological	No

Ecological Component	Level 1 Risk Rating	Considerations of Likelihood and Mitigation Measures	Level 2 Required?
		functions at a localised level without continued monitoring and management. • These risks are considered to be low-intermediate due to current catch and effort levels but may change into the future if and when catch levels increase.	

4 Summary & Recommendation

The whole-of-fishery (Level 1) ERA support the hypothesis that the MAFF is a low-risk fishery. This assessment reflects both the nature of the fishing methods and risk mitigation (management) strategies already employed in the fishery. These strategies include limited licencing, gear restrictions, minimising cumulative fishing pressures and prohibiting commercial collection across key sections of the Great Barrier Reef Marine Park.

Of the ecological components assessed, only target species and retainable SOCC ecological components (*i.e.* sharks and batoids) were assigned risk ratings higher than low. Target species (intermediate) registered the highest risk rating of the study using the weight of evidence approach applied in the Level 1 ERA. This rating, as with other retainable species, was influenced by catch reporting inadequacies and data deficiencies.

Data deficiencies are being actively addressed in this fishery through the *Marine Aquarium Fish Fishery Data Improvement Plan* (Department of Agriculture and Fisheries, 2022a). This plan includes a review of the current MAFF logbook and enhancing species-specific reporting. It will however take time to develop and implement initiatives instigated under this plan and the broader *Queensland Sustainable Fisheries Strategy 2017–2027* (Department of Agriculture and Fisheries, 2017a).

In the interim, it is recommended that the target species ecological component be progressed to Level 2 or species-specific ERA. In previous Level 1 ERAs, ecological components at intermediate risk are (generally) viewed as lower priorities for progression to a Level 2 assessment. In this instance, uncertainty surrounding harvest rates and interspecific risk variability warrants further investigation. The scope and extent of these assessments will be highly dependent on the available information. For instance, data deficiencies and catch composition uncertainties will be a limiting factor for most assessments involving invertebrates, elasmobranchs and syngnathids. Accordingly, it is recommended that species-specific risk assessment for these subgroups be delayed until there is better information on MAFF catch compositions and harvest rates.

5 References

Allgeier, J. E., Layman, C. A., Mumby, P. J. & Rosemond, A. D. (2014). Consistent nutrient storage and supply mediated by diverse fish communities in coral reef ecosystems. *Global Change Biology* **20**, 2459-2472.

Allgeier, J. E., Valdivia, A., Cox, C. & Layman, C. A. (2016). Fishing down nutrients on coral reefs. *Nature Communications* **7**.

Arias-Ortiz, A., Serrano, O., Masqué, P., Lavery, P. S., Mueller, U., Kendrick, G. A., Rozaimi, M., Esteban, A., Fourqurean, J. W., Marbà, N., Mateo, M. A., Murray, K., Rule, M. J. & Duarte, C. M.

(2018). A marine heatwave drives massive losses from the world's largest seagrass carbon stocks. *Nature Climate Change.*

Astles, K. L., Holloway, M. G., Steffe, A., Green, M., Ganassin, C. & Gibbs, P. J. (2006). An ecological method for qualitative risk assessment and its use in the management of fisheries in New South Wales, Australia. *Fisheries Research* **82**, 290-303.

Brodie, J. E., Lewis, S. E., Collier, C. J., Wooldridge, S., Bainbridge, Z. T., Waterhouse, J., Rasheed, M. A., Honchin, C., Holmes, G. & Fabricius, K. (2017). Setting ecologically relevant targets for river pollutant loads to meet marine water quality requirements for the Great Barrier Reef, Australia: A preliminary methodology and analysis. *Ocean & Coastal Management* **143**, 136-147.

Burkepile, D. E., Allgeier, J. E., Shantz, A. A., Pritchard, C. E., Lemoine, N. P., Bhatti, L. H. & Layman, C. A. (2013). Nutrient supply from fishes facilitates macroalgae and suppresses corals in a Caribbean coral reef ecosystem. *Scientific Reports* **3**, 9.

Department of Agriculture and Fisheries (2017a). *Queensland Sustainable Fisheries Strategy 2017–2027.* Available at https://www.daf.qld.gov.au/business-priorities/fisheries/sustainable/sustainable-fisheries-strategy-overview (Accessed 13 October 2020).

Department of Agriculture and Fisheries (2017b). *Queensland Harvest Strategy Policy.* Queensland Department of Agriculture and Fisheries. Brisbane. https://www.publications.qld.gov.au/dataset/queensland-fisheries-harvest-strategy/resource/1a6d9dc6-73ac-4d32-9422-065649c34bba

Department of Agriculture and Fisheries (2017c). *Queensland Harvest Strategy Guidelines.* Queensland Department of Agriculture and Fisheries. Brisbane. https://www.publications.qld.gov.au/dataset/queensland-fisheries-harvest-strategy/resource/bb2468d1-5b62-4a61-b17e-2c1497fa933b

Department of Agriculture and Fisheries (2018). Ecological Risk Assessment Guidelines. Available at https://www.daf.qld.gov.au/business-priorities/fisheries/sustainable/sustainable-fisheries-strategy-overview (Accessed 13 October 2020).

Department of Agriculture and Fisheries (2019). *Scoping Study - East Coast Inshore Fin Fish Fishery (ECIFFF).* Department of Agriculture and Fisheries, Queensland Government. Brisbane, Australia. http://era.daf.qld.gov.au/id/eprint/6968/

Department of Agriculture and Fisheries (2020a). Queensland Fisheries Harvest Strategy. Available at https://www.daf.qld.gov.au/business-priorities/fisheries/sustainable/harvest-strategy (Accessed 9 October 2020).

Department of Agriculture and Fisheries (2020b). *Scoping Study - Gulf of Carpentaria Developmental Fin Fish Trawl Fishery.* Department of Agriculture and Fisheries, Queensland Government. Brisbane, Australia.

Department of Agriculture and Fisheries (2021). *Marine aquarium fish fishery harvest strategy: 2021-2026.* Brisbane, Queensland: Government, Q. https://www.publications.qld.gov.au/ckan-publications-attachments-prod/resources/b8139a1b-090b-4a7a-adce-9e8207b8d916/marine-aquarium-fish-harvest-strategy.pdf?ETag=e2394c539ca57ab8ef6ec765074c8207

Department of Agriculture and Fisheries (2022a). *Queensland Marine Aquarium Fish Fishery Data Improvement Plan.* Fisheries Queensland, Department of Agriculture and Fisheries. . Brisbane, Queensland.

Department of Agriculture and Fisheries (2022b). Ecological Risk Assessment. Available at https://www.daf.qld.gov.au/business-priorities/fisheries/monitoring-research/data/ecological-risk-assessments (Accessed 11 January 2023).

Department of Agriculture and Fisheries (2022c). *Scoping Study - Queensland Coral Fishery*. Department of Agriculture and Fisheries, Queensland Government. Brisbane, Australia.

Department of Agriculture and Fisheries (2023). *Scoping Study - Marine Aquarium Fish Fishery.* Department of Agriculture and Fisheries, . Brisbane, Australia: Government, Q.

Department of Agriculture Water and the Environment (2022). *Queensland Aquarium Fish Fishery: Current Decisions.* Available at https://www.dcceew.gov.au/environment/marine/fisheries/qld/aquarium (Accessed 14 December 2022).

Department of Environment and Science (2022). Marine wildlife strandings annual reports. *State of Queensland.* Available at https://www.qld.gov.au/environment/plants-animals/wildlife/marine-strandings/stranding-data/annual-reports (Accessed 9 March 2023).

Department of the Environment and Energy (2015). *Reef 2050 Long-Term Sustainability Plan*. Department of Environment and Energy, Australian Government. Canberra, ACT.

Dinsdale, E. A. & Harriott, V. J. (2004). Assessing Anchor Damage on Coral Reefs: A Case Study in Selection of Environmental Indicators. *Environmental Management* **33**, 126-139.

Duke, N. C., Kovacs, J. M., Griffiths, A. D., Preece, L., Hill, D. J. E., van Oosterzee, P., Mackenzie, J., Morning, H. S. & Burrows, D. (2017). Large-scale dieback of mangroves in Australia's Gulf of Carpentaria: a severe ecosystem response, coincidental with an unusually extreme weather event. *Marine and Freshwater Research* **68**, 1816-1829.

Erftemeijer, P. L. A., Riegl, B., Hoeksema, B. W. & Todd, P. A. (2012). Environmental impacts of dredging and other sediment disturbances on corals: A review. *Marine Pollution Bulletin* **64**, 1737-1765.

Evans, K., Bax, N. J. & Smith, D. C. (2016). *Australia State of the Environment 2016: marine environment.* Department of the Environment and Energy, Australian Government. Canberra, ACT.

Frisch, A. J., Rizzari, J. R., Munkres, K. P. & Hobbs, J.-P. A. (2016). Anemonefish depletion reduces survival, growth, reproduction and fishery productivity of mutualistic anemone–anemonefish colonies. *Coral Reefs* **35**, 375-386.

Froelich, A. S. (2002). Functional aspects of nutrient cycling on coral reefs. *Environmental Science*.

Great Barrier Reef Marine Park Authority (2014). *Great Barrier Reef Outlook Report 2014*. Townsville.

Great Barrier Reef Marine Park Authority (2018). Overview of the RAP. Available at http://www.gbrmpa.gov.au/our-work/our-programs-and-projects/rap (Accessed 30 May 2019).

Great Barrier Reef Marine Park Authority (2019). *Great Barrier Reef Outlook Report 2019.* Great Barrier Reef Marine Park Authority, Australian Government. Townsville, Queensland.

Great Barrier Reef Marine Park Authority (2020). Zoning. Available at http://www.gbrmpa.gov.au/access-and-use/zoning (Accessed 4 September 2020).

Great Barrier Reef Marine Park Authority (2022a). Overview of the RAP. Australian Government. Available at https://www.gbrmpa.gov.au/our-work/our-programs-and-projects/rap (Accessed 10 March 2023).

Great Barrier Reef Marine Park Authority (2022b). Special Management Areas. Available at http://www.gbrmpa.gov.au/access-and-use/zoning/special-management-areas (Accessed 10 March 2023).

Hoegh-Guldberg, O., Mumby, P. J., Hooten, A. J., Steneck, R. S., Greenfield, P., Gomez, E., Harvell, C. D., Sale, P. F., Edwards, A. J., Caldeira, K., Knowlton, N., Eakin, C. M., Iglesias-Prieto, R., Muthiga,

N., Bradbury, R. H., Dubi, A. & Hatziolos, M. E. (2007). Coral Reefs Under Rapid Climate Change and Ocean Acidification. *Science* **318**, 1737-1742.

Holbrook, N. J. & Johnson, J. E. (2014). Climate change impacts and adaptation of commercial marine fisheries in Australia: a review of the science. *Climatic Change* **124**, 703-715.

Jacobsen, I., Walton, L. & Lawson, A. (2021). *East Coast Inshore Fishery Level 2 Ecological Risk Assessment (Large Mesh Net); Species of Conservation Concern.* Queensland Government. Brisbane, Queensland.

Jones, G. P., McCormick, M. I., Srinivasan, M. & Eagle, J. V. (2004). Coral decline threatens fish biodiversity in marine reserves. *Biological Sciences* **101**, 8251-8253.

Kinsey, D. W. & Hopley, D. (1991). The significance of coral reefs as global carbon sinks— response to Greenhouse. *Palaeogeography, Palaeoclimatology, Palaeoecology* **89**, 363-377.

Kyne, P. M., Heupel, M. R., White, W. T. & Simpfendorfer, C. A. (2021). *The Action Plan for Australian Sharks and Rays 2021.* National Environmental Science Program. Hobart, Australia.

Morton, J., Jacobsen, I. & Dedini, E. (2022). *Queensland Coral Fishery Ecological Risk Assessment Update: Phase 1.* Queensland Government. Brisbane, Queensland.

Pawlik, J. P., Burkepile, D. E. & Thurber, R. V. (2016). A Vicious Circle? Altered Carbon and Nutrient Cycling May Explain the Low Resilience of Caribbean Coral Reefs. *BioScience* **66**, 470-476.

Pears, R., Morison, A., Jebreen, E., Dunning, M., Pitcher, C., Courtney, A., Houlden, B. & Jacobsen, I. (2012a). Ecological risk assessment of the East Coast Otter Trawl Fishery in the Great Barrier Reef Marine Park: Data report.

Pears, R. J., Morison, A. K., Jebreen, E. J., Dunning, M. C., Pitcher, C. R., Courtney, A. J., Houlden, B. & Jacobsen, I. P. (2012b). *Ecological Risk Assessment of the East Coast Otter Trawl Fishery in the Great Barrier Reef Marine Park: Technical Report.* Great Barrier Reef Marine Park Authority. Townsville, Queensland.
http://elibrary.gbrmpa.gov.au/jspui/bitstream/11017/1148/1/ECOTF_ERA_Technical_web.pdf

Pidd, A., Jacobsen, I., Walton, L. & Lawson, A. (2021). *East Coast Inshore Fishery Level 2 Ecological Risk Assessment (Large Mesh Net); Target & Byproduct Species.* Queensland Government. Brisbane, Queensland.

Queensland Government (2022). *Coral Fishery: Commercial Fishing Rules in Queensland.* Department of Agriculture and Fisheries. Available at
https://www.daf.qld.gov.au/__data/assets/pdf_file/0005/1627043/Coral-fishery-fact-sheet-Jul2022.pdf
(Accessed 17 2023).

Roth, M. S. (2014). The engine of the reef: photobiology of the coral–algal symbiosis. *Frontiers in Microbiology* **5**.

Sheppard, C. R. C., Davy, S. K., Pilling, G. M. & Graham, N. A. J. (2017). Coral reefs: Biodiverse and productive tropical ecosystems. *The Biology of Coral Reefs*, 1-34.

Steffen, W., Hughes, L., Alexander, D. & Rice, M. (2017). *Cranking Up The Intensity: Climate Change and Extreme Weather Events.* Climate Council of Australia.

Sumaila, U. R., Cheung, W. W. L., Lam, V. W. Y., Pauly, D. & Herrick, S. (2011). Climate change impacts on the biophysics and economics of world fisheries. *Nature Climate Change* **1**, 449.

Thibaut, L. M., Connolly, S. R. & Sweatman, H. P. A. (2012). Diversity and stability of herbivorous fishes on coral reefs. *Ecology* **93**, 891-901.

United Nations Environment Program (2014). Single Species Action Plan for the Loggerhead Turtle (*Caretta caretta*) in the South Pacific Ocean. Available at https://www.cms.int/en/document/single-species-action-plan-loggerhead-turtle-south-pacific-ocean (Accessed 4 June 2019).

Walton, L., Jacobsen, I., Pidd, A. & Lawson, A. (2021). *Gulf of Carpentaria Inshore Fishery Level 2 Ecological Risk Assessment; Target & Byproduct Species.* Queensland Government. Brisbane, Queensland.

Waterhouse, J., Schaffelke, B., Bartley, R., Eberhard, R., Brodie, J., Star, M., Thorburn, P., Rolfe, J., Ronan, M., Taylor, B. & Kroon, F. (2017). *2017 Scientific Consensus Statement.*

Appendix 1 – Ecological Processes Preliminary Assessment

A1 – Ecological Processes Categories

Categories taken into consideration as part of the Level 1 preliminary ERA for the Ecological Processes ecological component. Definitions adopted from Pears *et al* (2012).

CATEGORY	DESCRIPTION
SEDIMENTATION	The inflow, dispersion, resuspension and consolidation of sediments
NUTRIENT CYCLING / MICROBIAL ACTION	The input, export and recycling of nutrients within the ecosystem. Removal of animals through harvesting is a direct loss of nutrients to the ecosystem
PARTICLE FEEDING	Feeding process targeted at particles suspended in the water column, or deposited on submerged surfaces
PRIMARY PRODUCTION	The conversion of the sun's energy into carbon compounds that are then available to other organisms
HERBIVORY	The consumption of plants
PREDATION	Includes the removal of mid and top order predators from the marine environment and the potential for animals to be subject to increased predation
BIOTURBATION	The biological reworking of sediments during burrow construction and feeding and bioirrigation (mixing of solutes) leading to the mixing of oxygen-bearing waters into sediments
DETRITIVORY	Feeding on detritus (decomposing organic matter)
SCAVENGING	Predators eating already dead animals
SYMBIOSIS	The interdependence of different organisms for the benefit of one or both participants
RECRUITMENT	The impact of the fishery on the ability of a species replenishment populations
REEF BUILDING	The process of creating habitats composed of coral and algae and includes the creation of all biogenic (*i.e.* of living origin) habitats
COMPETITION	Interactions between species that favour or inhibit mutual growth and functioning of populations
CONNECTIVITY	Migration, movement and dispersal of propagules between habitats at a range of scales; and functional connectivity which represents ontogenetic cycles of habitat use
OUTBREAKS OF DISEASE	The spread or introduction of disease to organisms or ecosystems
SPECIES INTRODUCTIONS	The introduction of exotic species and their spread once established

A2 – Ecosystem Processes Preliminary Assessment

Due to the difficulty of assessing the impacts of a fishery on ecosystem processes, a precautionary approach was adopted for the Level 1 assessment. In line with this approach, an initial or preliminary assessment was undertaken for 16 ecosystem processes that may be influenced by fishing activities. As with risk scores for the whole-of-fishery assessment (Table 2) each category was assigned a risk rating of Low (L), Intermediate (I), High (H), or negligible (-). This risk score describes the potential for each the fishing activity to impact negatively on the ecosystem process category.

For the Level 1 ERA, each fishing activity was assigned a final risk score that corresponded with the maximum risk rating assigned in the preliminary assessment. If for example 'Predation' received an 'H', then the final risk score for harvesting will be 'H'. To this extent, the final risk scores assigned to each fishing activity present the highest potential risk and therefore may not be applicable to all of the ecosystem processes categories. Used in this context, the Level 1 assessment for ecosystem processes should be considered as both precautionary and preliminary in nature. The following presents a summary of the preliminary risk scores assigned to the main fishing activities in the MAFF.

Ecosystem Processes Categories	Fishing – Main activities of the Fishery						
	Harvesting	Discarding	Contact without capture	Loss of fishing gear	Travel to/from grounds	Disturbance due to presence in area	Boat maintenance & emissions
Sedimentation	L	-	-	-	-	L	-
Nutrient cycling / Microbial action	L/I	-	-	-	-	-	-
Particle feeding	L	-	-	-	-	-	-
Primary production	L	-	-	-	-	-	-
Herbivory	L/I	-	-	-	-	-	-
Predation	L	-	-	-	-	-	-
Bioturbation	L	-	-	-	-	L	-
Detritivory	L	-	-	-	-	-	-
Scavenging	L	-	-	-	-	-	-
Symbiosis	L/I	-	-	-	-	-	-
Recruitment	L	-	-	-	-	-	-
Reef Building	L	-	-	-	-	L	-
Competition	-	-	-	-	-	-	-
Connectivity	L/I	-	-	-	-	-	-
Outbreaks of disease	-	-	-	-	-	-	-
Species introductions	-	-	-	-	-	-	-
EP (overall)	L/I	-	-	-	-	L	-